US 20140307760A1

(19) United States
(12) Patent Application Publication
Sorrells et al.
(10) Pub. No.: US 2014/0307760 A1
(43) Pub. Date: Oct. 16, 2014

(54) **UNIVERSAL PLATFORM MODULE FOR A PLURALITY OF COMMUNICATION PROTOCOLS**

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(73) Assignee: **PARKERVISION, INC.**, Jacksonville, FL (US)

(21) Appl. No.: **14/075,535**

(22) Filed: **Nov. 8, 2013**

**Related U.S. Application Data**

(63) Continuation of application No. 13/550,501, filed on Jul. 16, 2012, now abandoned, which is a continuation of application No. 09/569,045, filed on May 10, 2000, now Pat. No. 8,295,406, which is a continuation-in-part of application No. 09/550,642, filed on Apr. 14, 2000, now Pat. No. 7,065,162, which is a continuation-in-part of application No. 09/521,878, filed on Mar. 9, 2000, now abandoned.

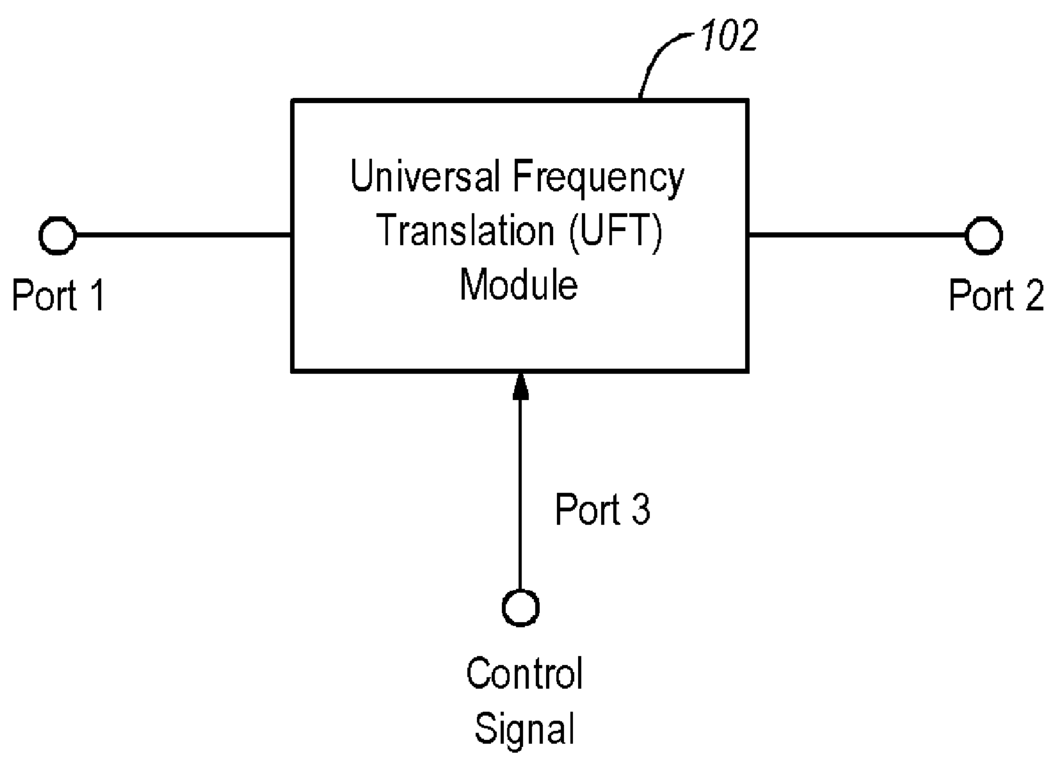
**Publication Classification**

(51) **Int. Cl.**
*H04L 27/26* (2006.01)

(52) **U.S. Cl.**
CPC .................................. ***H04L 27/2601*** (2013.01)
USPC ........................................................ **375/219**

(57) **ABSTRACT**

A communication system comprising a multi-protocol, multi-bearer sub-system is described herein. The sub-system is a universal platform module that can transmit and receive one or more information signals in one or more protocols using one or more bearer services. In one embodiment, the sub-system may form a portion of a transceiver that is composed of a transmitter and a receiver, and which is a gateway server between a personal area network (PAN) and the global wireless network.



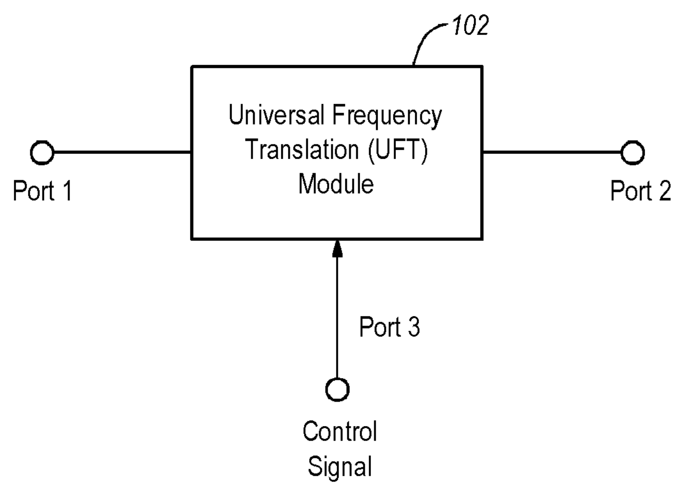

102
Universal Frequency Translation (UFT) Module
Port 1
Port 2
Port 3
Control Signal

FIG. 1A

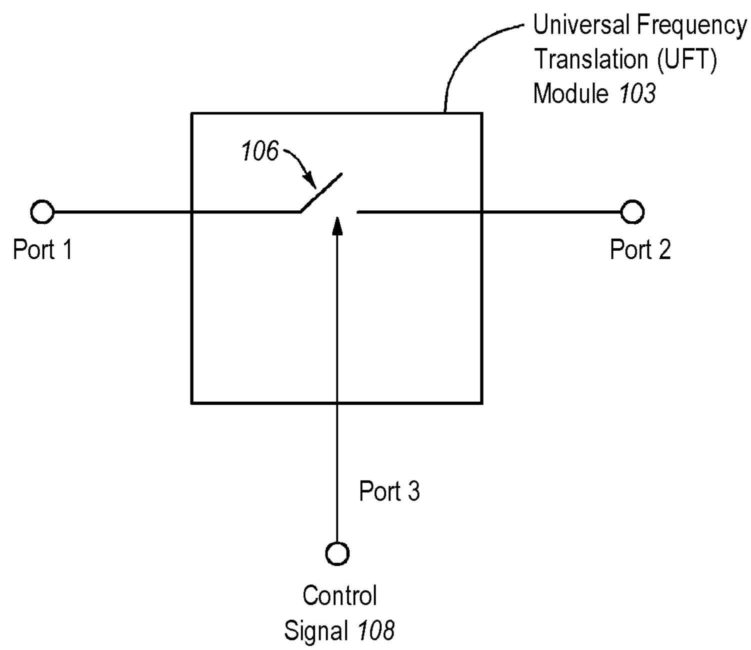

Universal Frequency
Translation (UFT)
Module 103
106
Port 1
Port 2
Port 3
Control
Signal 108

*FIG. 1B*

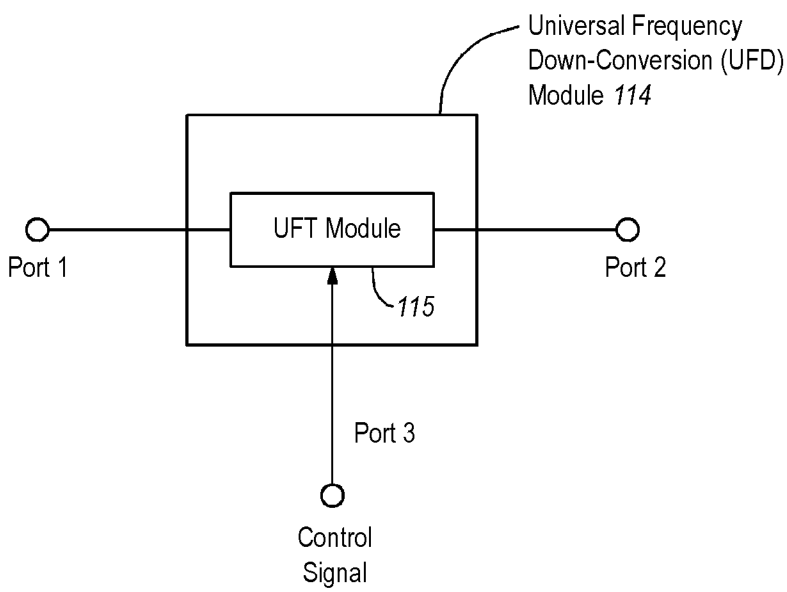

Universal Frequency
Down-Conversion (UFD)
Module 114
UFT Module
Port 1
Port 2
115
Port 3
Control
Signal

FIG. 1C

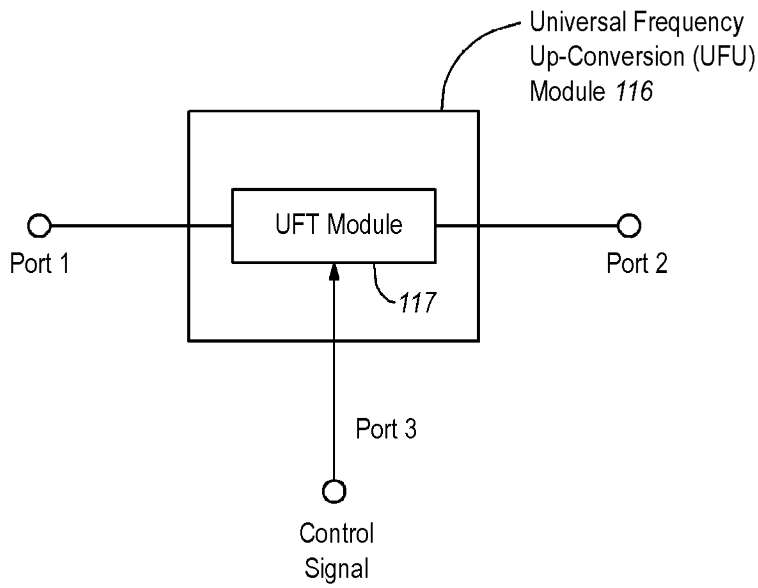

Universal Frequency
Up-Conversion (UFU)
Module 116
UFT Module
Port 1
Port 2
117
Port 3
Control
Signal

*FIG. 1D*

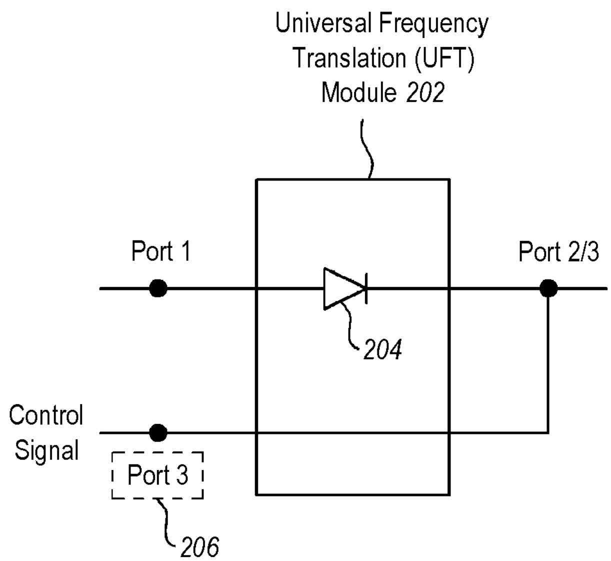
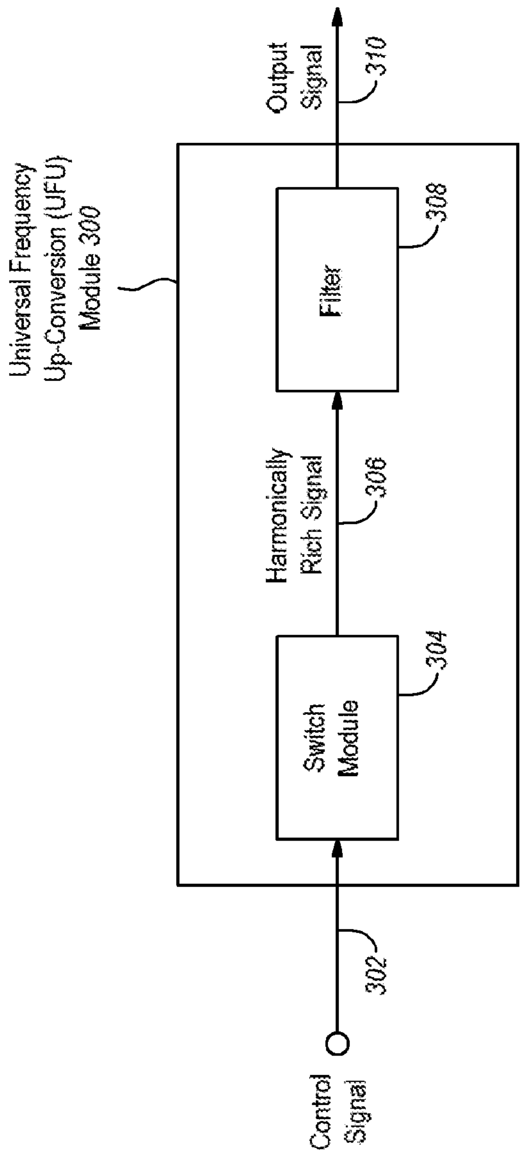

Universal Frequency
Translation (UFT)
Module 202
Port 1
Port 2/3
204
Control
Signal
Port 3
206

FIG. 2



Universal Frequency Up-Conversion (UFU) Module 300
Output Signal
310
Filter
308
Harmonically Rich Signal
306
Switch Module
304
302
Control Signal


FIG. 3

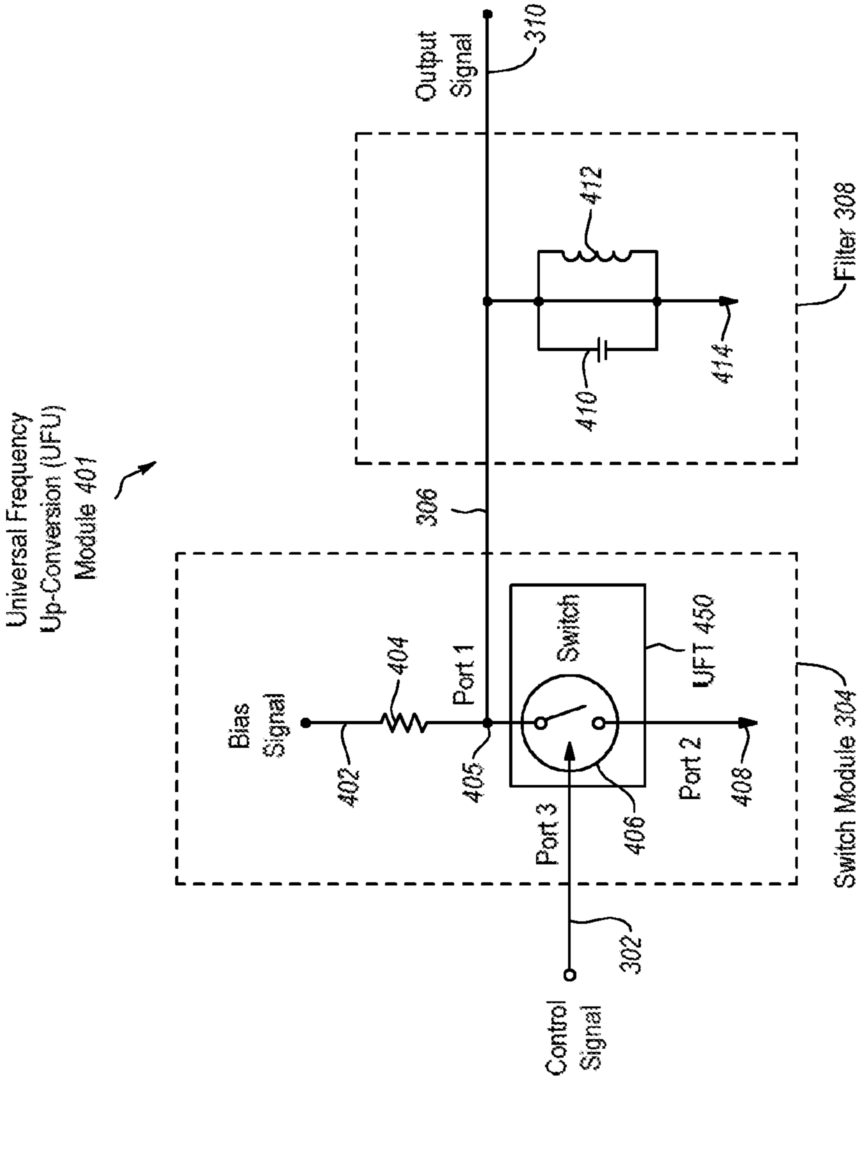

Universal Frequency
Up-Conversion (UFU)
Module 401
Output
Signal
310
412
Filter 308
410
414
306
Bias
Signal
402
404
Port 1
405
Switch
UFT 450
Port 3
406
Port 2
408
Switch Module 304
Control
Signal
302

FIG. 4

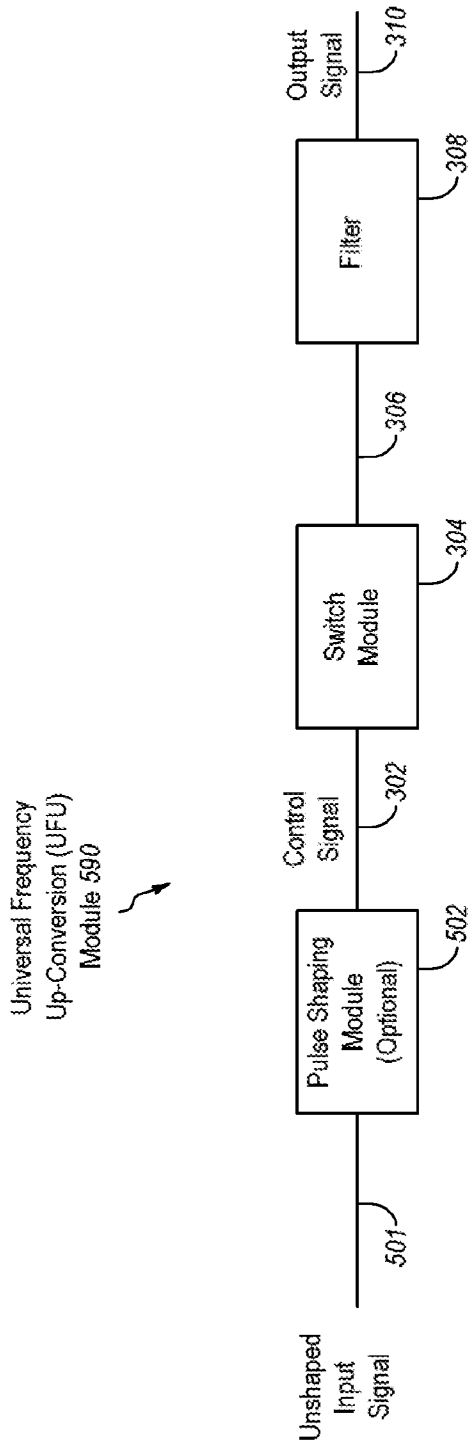

Universal Frequency Up-Conversion (UFU) Module 590
Unshaped Input Signal
501
Pulse Shaping Module (Optional)
502
Control Signal
302
Switch Module
304
306
Filter
308
Output Signal
310

FIG. 5

FIG. 6A

FIG. 6B

FIG. 6C

FIG. 6D

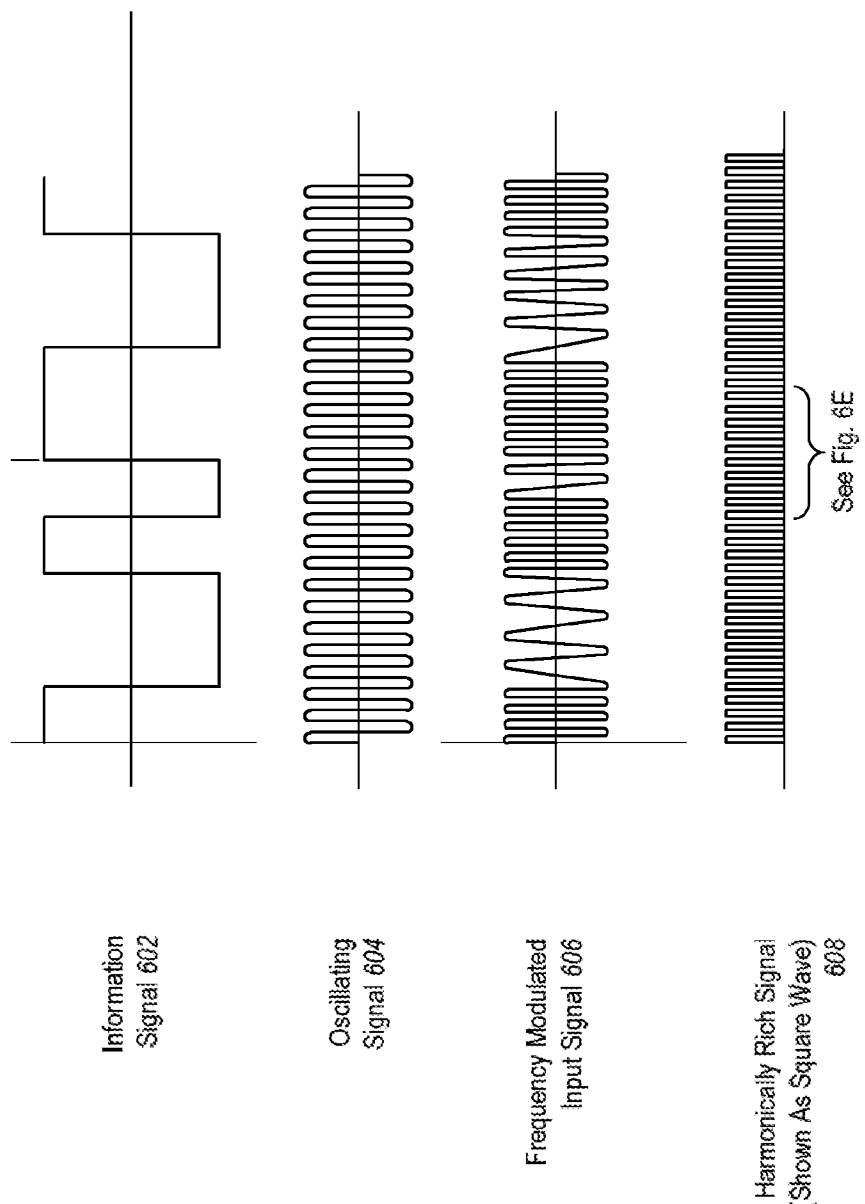



FIG. 6

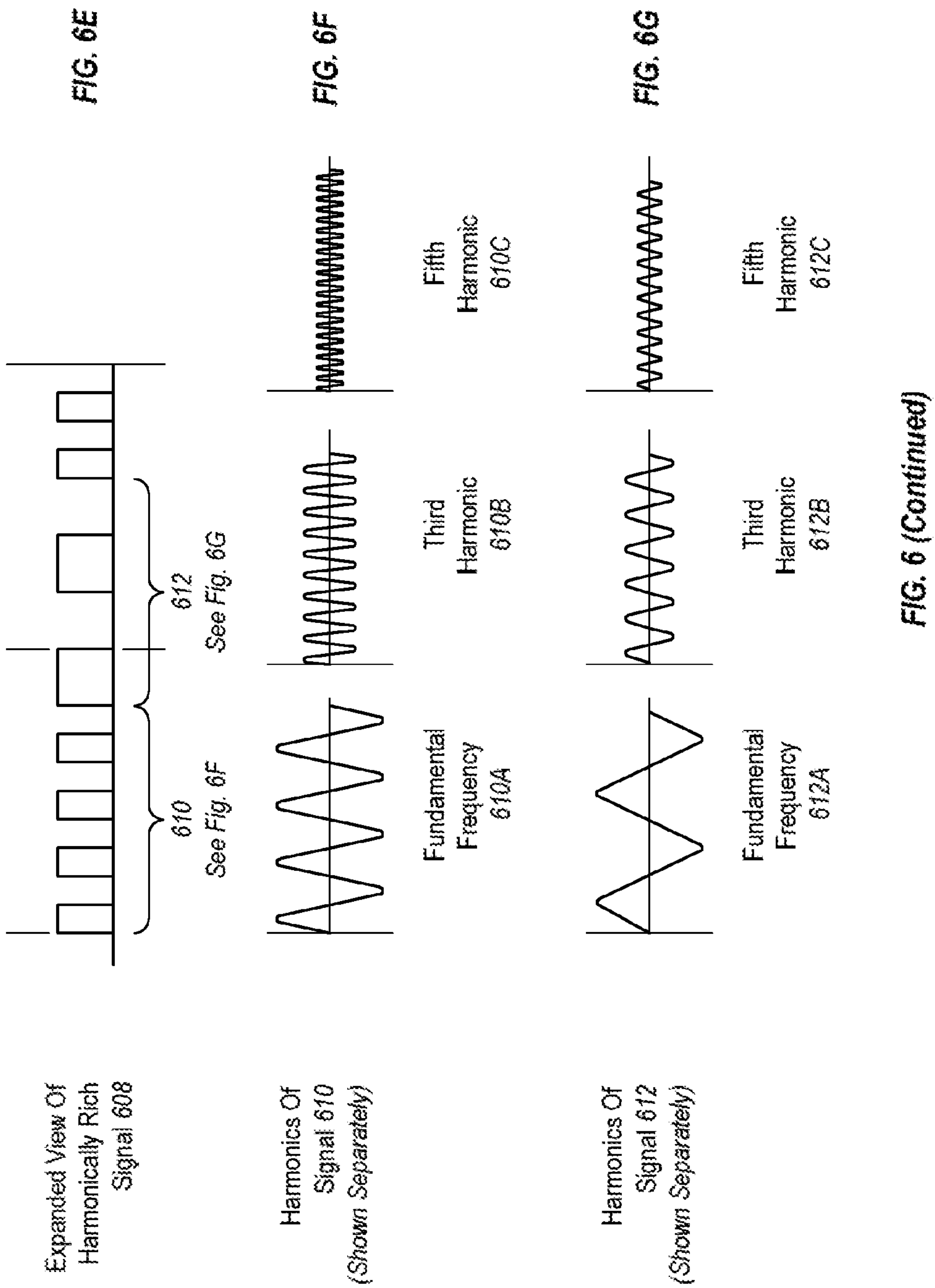



FIG. 6E

FIG. 6F

FIG. 6G

FIG. 6 (Continued)

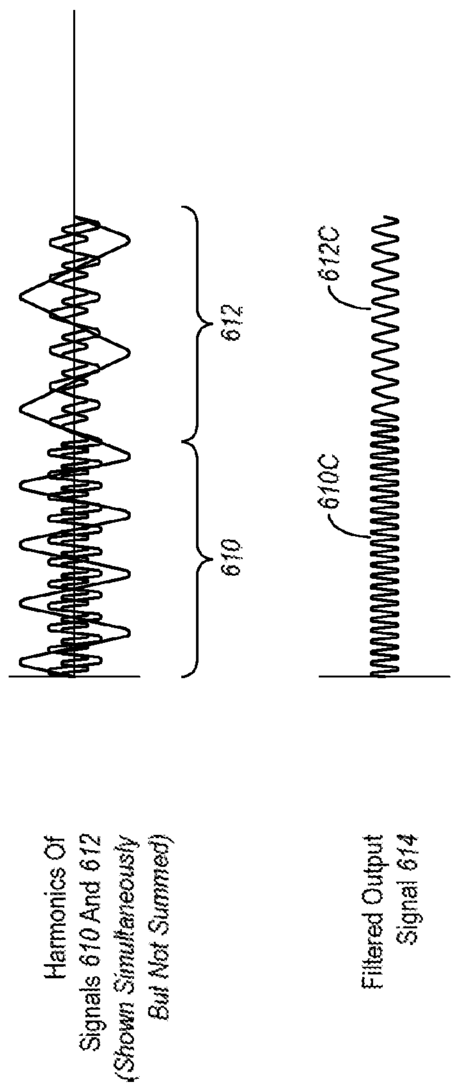



FIG. 6H

FIG. 6I

FIG. 6 (Continued)

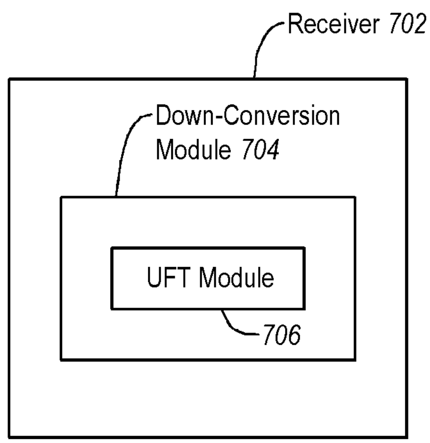



*FIG. 7*

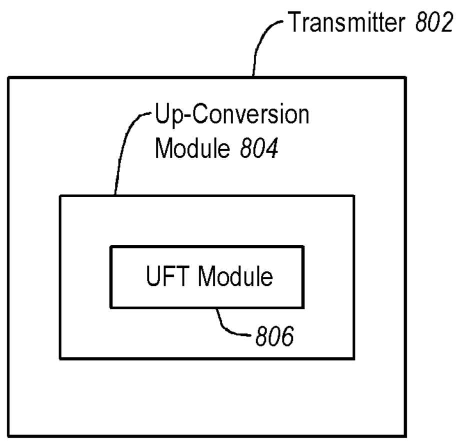



FIG. 8

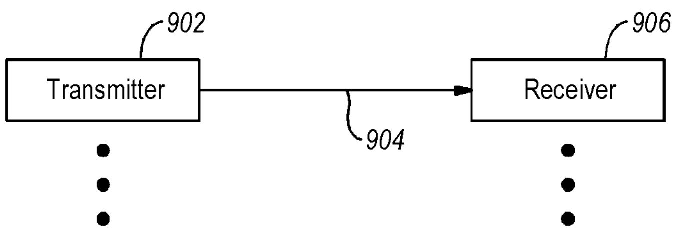



FIG. 9

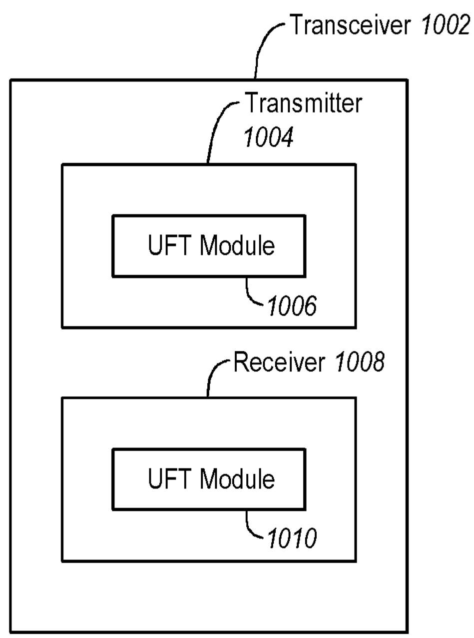

Transceiver 1002
Transmitter
1004
UFT Module
1006
Receiver 1008
UFT Module
1010

FIG. 10

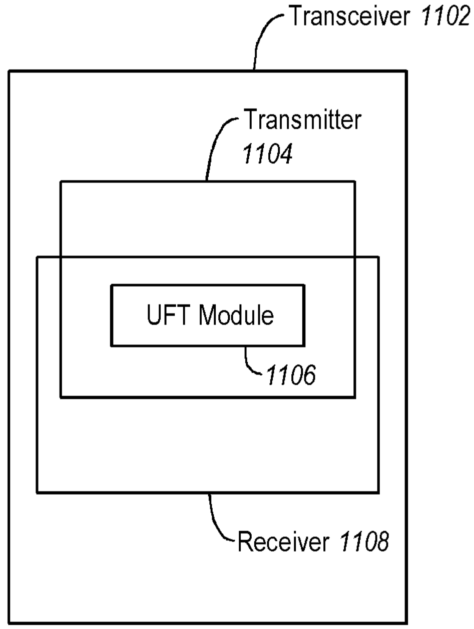

Transceiver 1102
Transmitter
1104
UFT Module
1106
Receiver 1108

FIG. 11

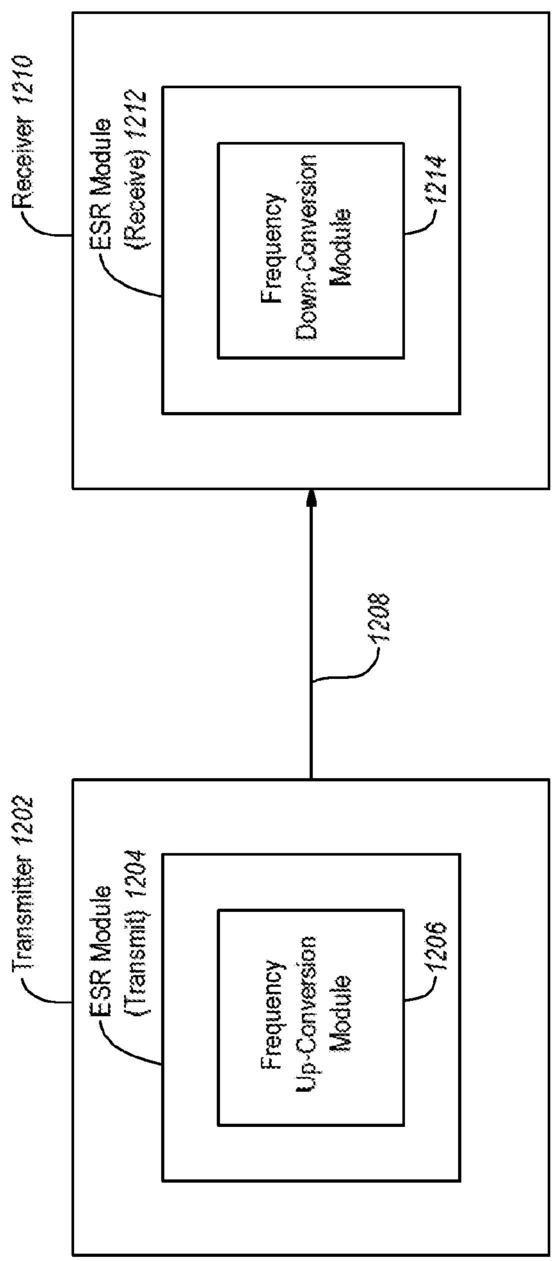

Receiver 1210
ESR Module (Receive) 1212
Frequency Down-Conversion Module
1214
1208
Transmitter 1202
ESR Module (Transmit) 1204
Frequency Up-Conversion Module
1206

FIG. 12

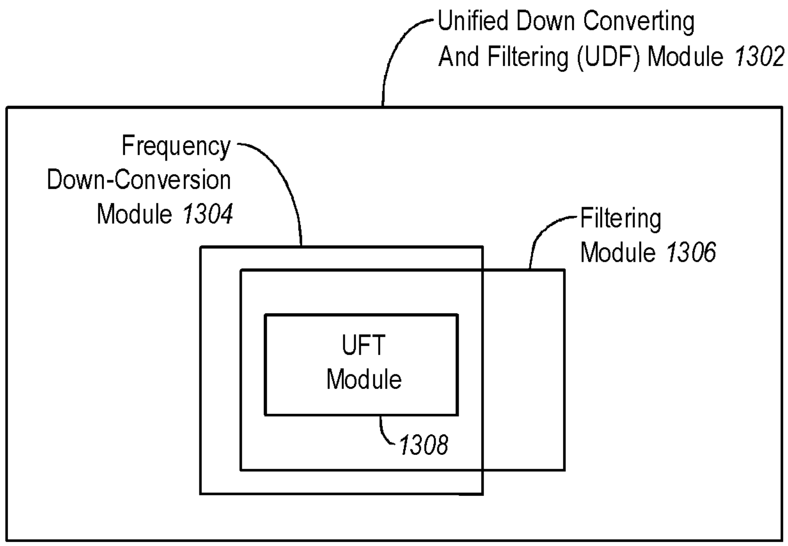

Unified Down Converting
And Filtering (UDF) Module 1302
Frequency
Down-Conversion
Module 1304
Filtering
Module 1306
UFT
Module
1308

FIG. 13

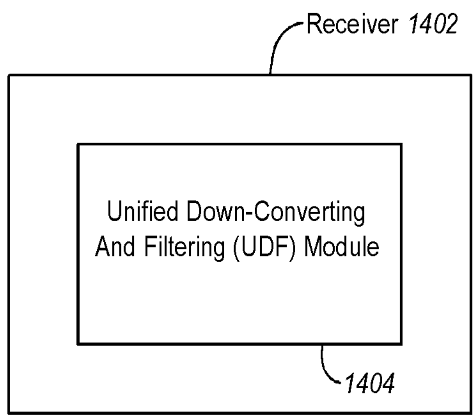

Receiver 1402
Unified Down-Converting
And Filtering (UDF) Module
1404

FIG. 14

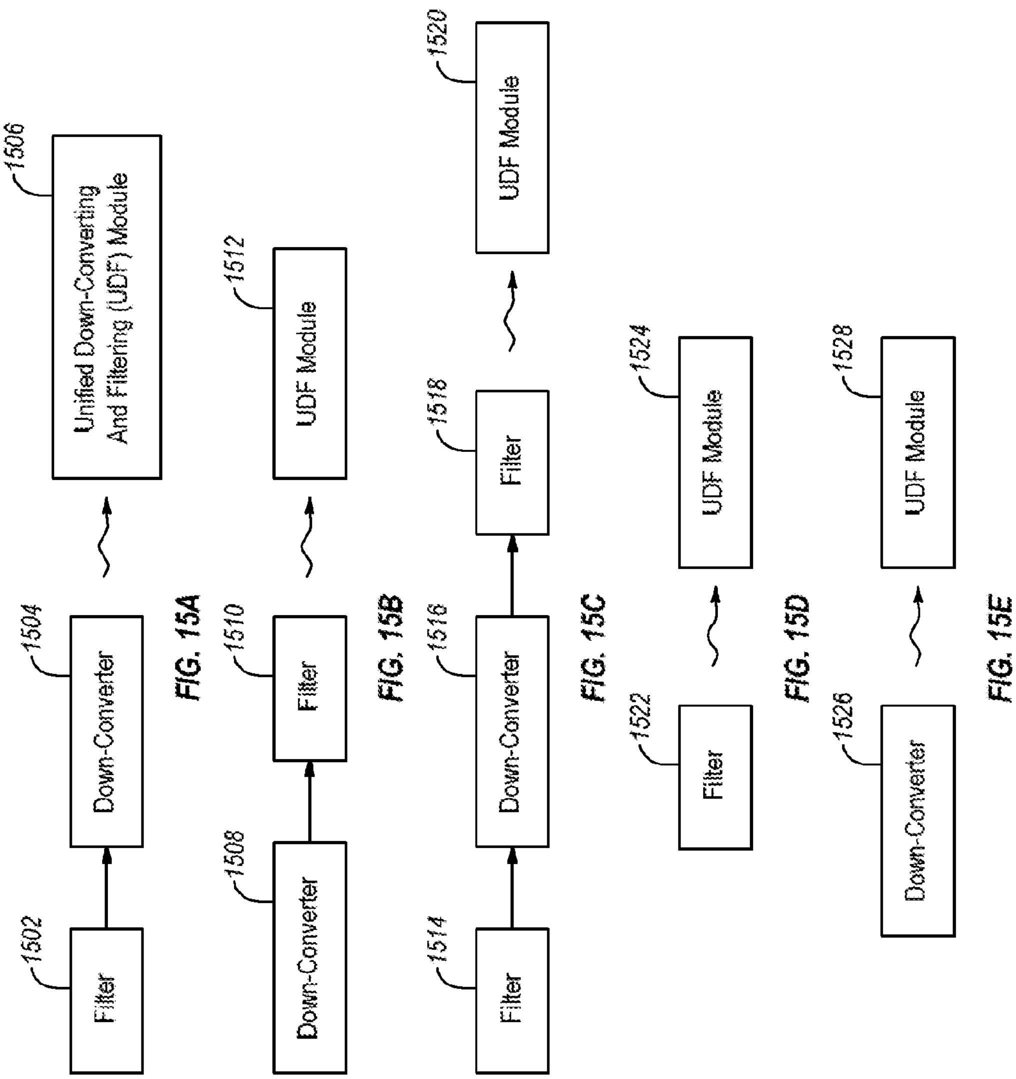



FIG. 15A

FIG. 15B

FIG. 15C

FIG. 15D

FIG. 15E

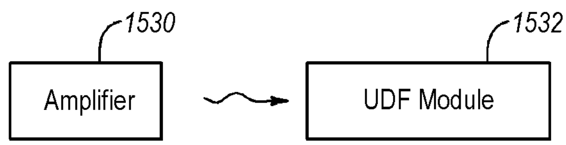



FIG. 15F

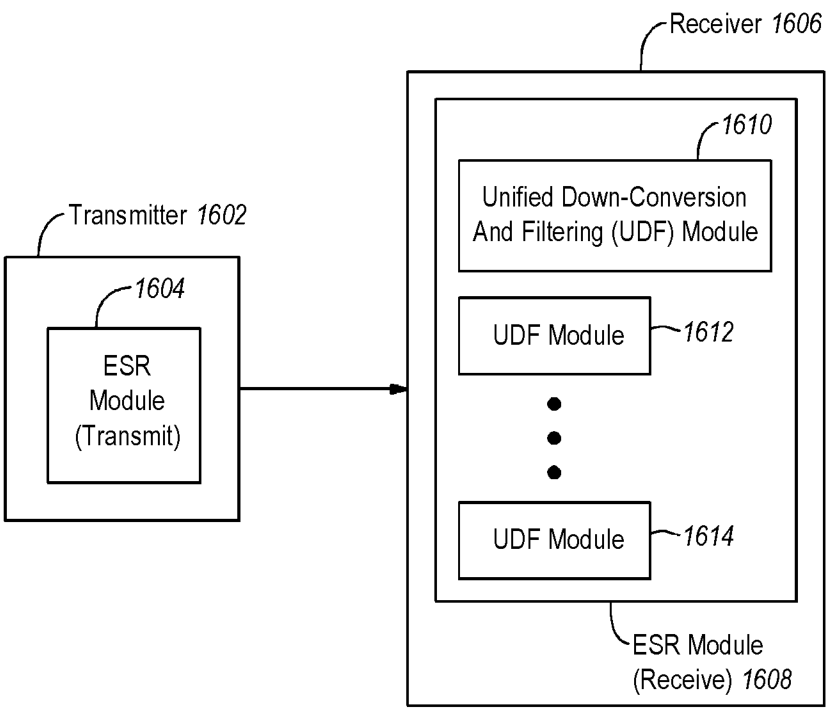

Receiver 1606
1610
Unified Down-Conversion And Filtering (UDF) Module
Transmitter 1602
1604
ESR Module (Transmit)
UDF Module
1612
UDF Module
1614
ESR Module (Receive) 1608

FIG. 16

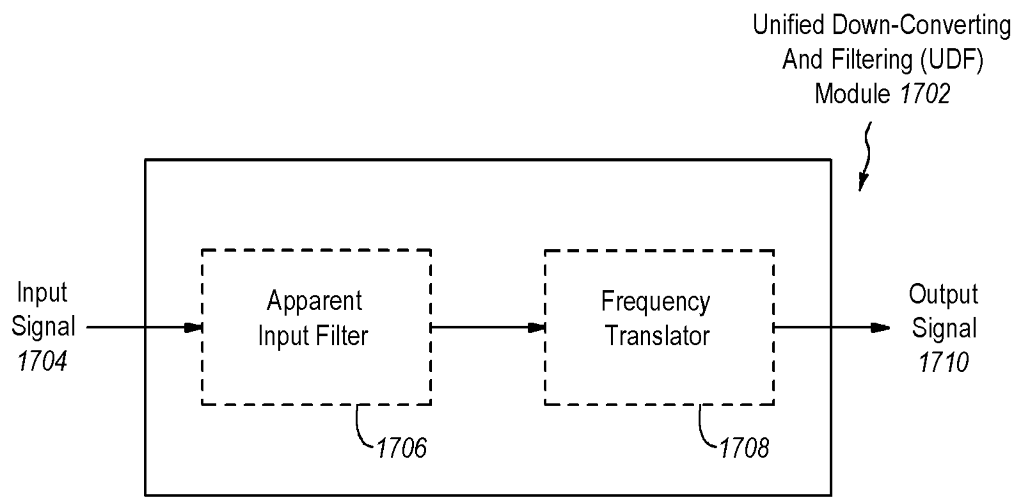

Unified Down-Converting
And Filtering (UDF)
Module 1702
Input
Signal
1704
Apparent
Input Filter
1706
Frequency
Translator
1708
Output
Signal
1710

FIG. 17

1802

| Time / Node | t-1 (Rising Edge Of $\phi_1$) | t-1 (Rising Edge Of $\phi_2$) | t (Rising Edge Of $\phi_1$) | t (Rising Edge Of $\phi_2$) | t+1 (Rising Edge Of $\phi_1$) |
|---|---|---|---|---|---|
| 1902 | $V1_{t-1}$ 1804 | $V1_{t-1}$ 1808 | $V1_t$ 1816 | $V1_t$ 1826 | $V1_{t+1}$ 1838 |
| 1904 | — | $V1_{t-1}$ 1810 | $V1_{t-1}$ 1818 | $V1_t$ 1828 | $V1_t$ 1840 |
| 1906 | $VO_{t-1}$ 1806 | $VO_{t-1}$ 1812 | $VO_t$ 1820 | $VO_t$ 1830 | $VO_{t+1}$ 1842 |
| 1908 | — | $VO_{t-1}$ 1814 | $VO_{t-1}$ 1822 | $VO_t$ 1832 | $VO_t$ 1844 |
| 1910 | — 1807 | — | $VO_{t-1}$ 1824 | $VO_{t-1}$ 1834 | $VO_t$ 1846 |
| 1912 | — | — 1815 | — | $VO_{t-1}$ 1836 | $V1_{t-1}$ 1848 |
| 1918 | — | — | — | — | $V1_{t\sim}$ 1850<br>$0.1 = VO_t$ -<br>$0.8 = VO_{t-1}$ |

FIG. 18

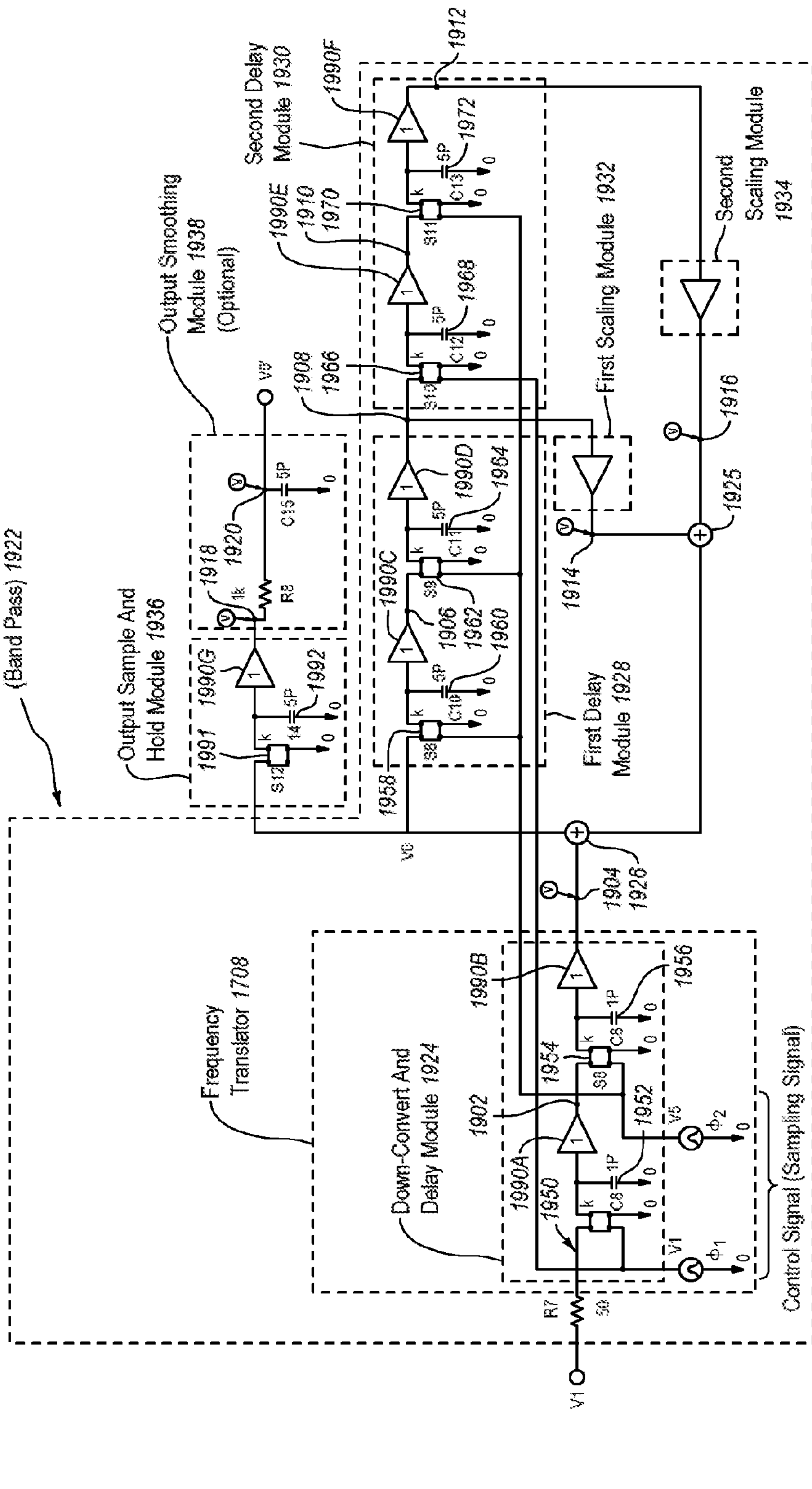

UDF Module
(Band Pass) 1922
Output Sample And
Hold Module 1936
Output Smoothing
Module 1938
(Optional)
Second Delay
Module 1930
First Scaling Module 1932
Second
Scaling Module
1934
First Delay
Module 1928
Frequency
Translator 1708
Down-Convert And
Delay Module 1924
Control Signal (Sampling Signal)
Input Filter 1706
1912
1990F
1972
1990E
1910
1970
1968
1908
1966
1916
1925
1914
1964
1990D
1990C
1906
1962
1960
1958
1991
1990G
1992
1918
1920
1904
1926
1990B
1956
1954
1902
1952
1990A
1950
V1
V5
V6
V9
R7
R8
1k
5P
1P
C8
C9
C10
C11
C12
C13
C14
C15
S8
S9
S10
S11
S12
k
0
Φ1
Φ2

FIG. 19

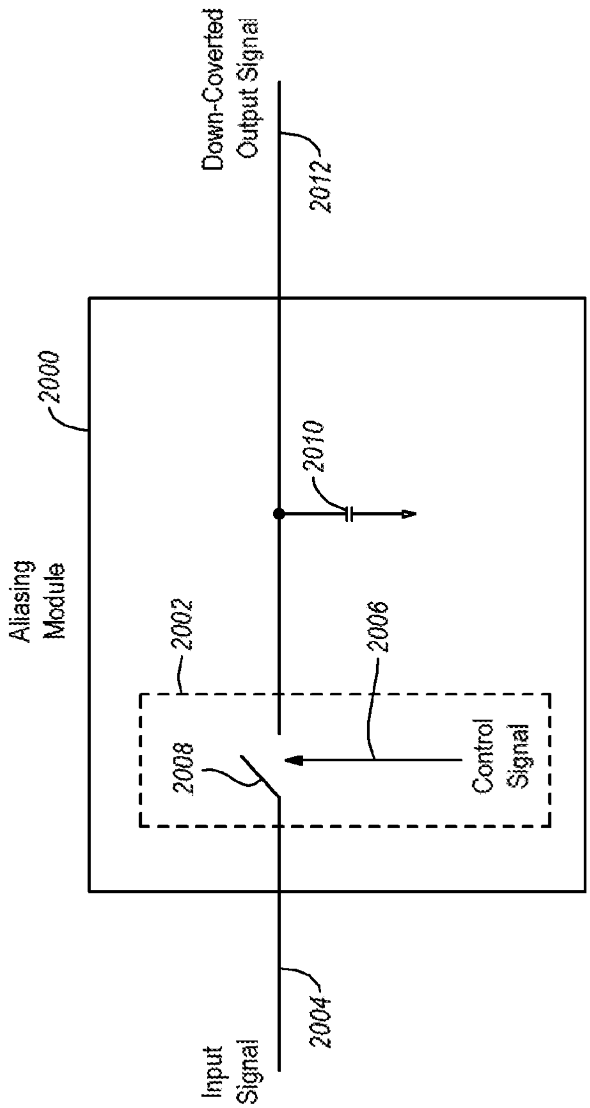

Down-Coverted
Output Signal
2012
2000
Aliasing
Module
2010
2002
2006
2008
Control
Signal
Input
Signal
2004

FIG. 20A

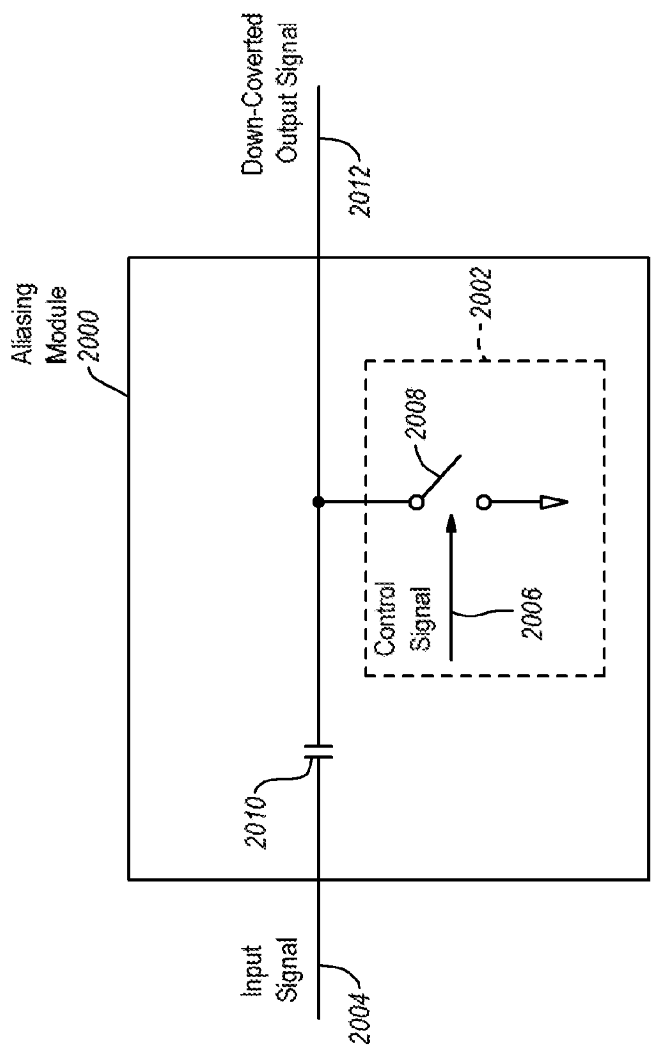

Down-Coverted Output Signal
2012
Aliasing Module
2000
2002
2008
Control Signal
2006
2010
Input Signal
2004

FIG. 20A-1

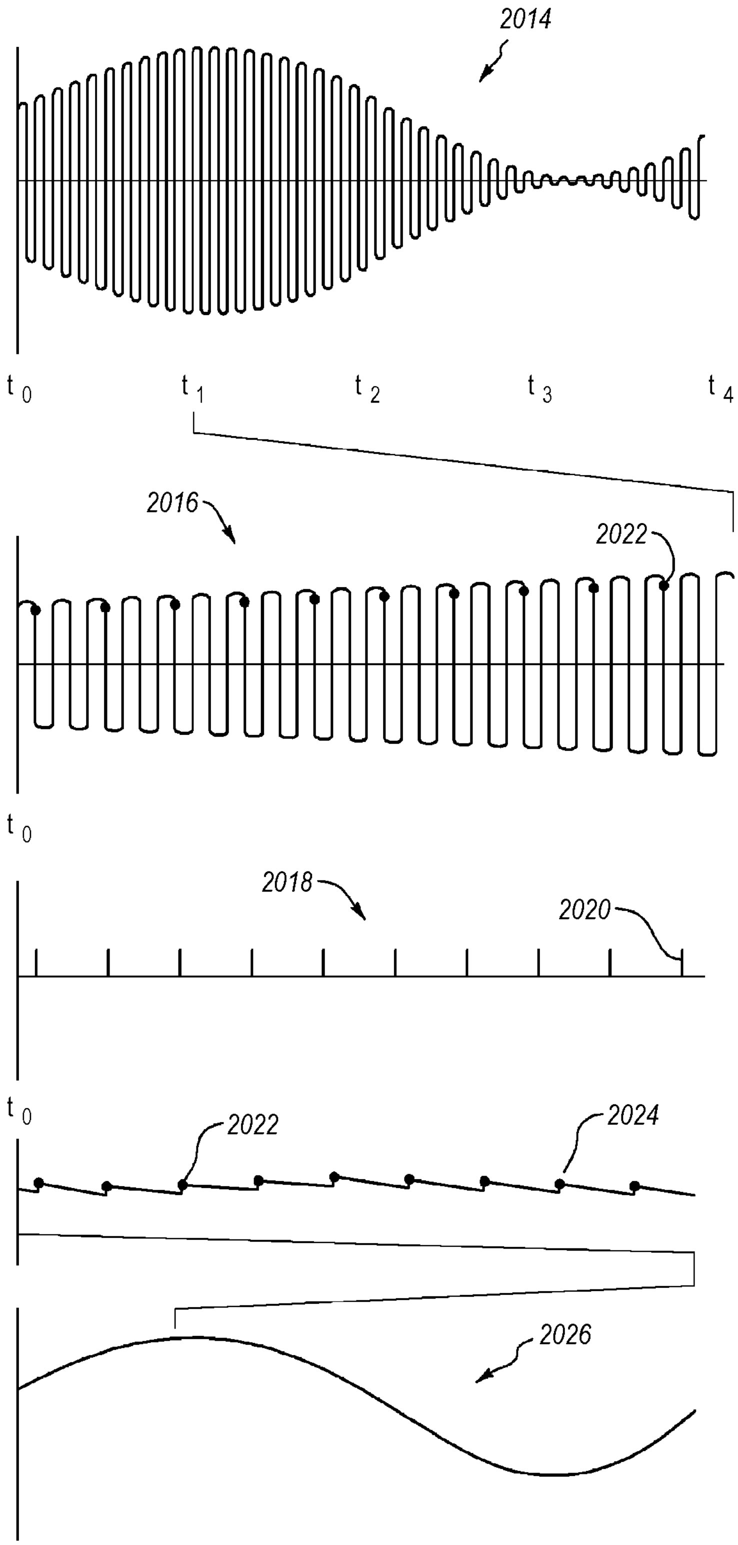



FIG. 20B

FIG. 20C

FIG. 20D

FIG. 20E

FIG. 20F

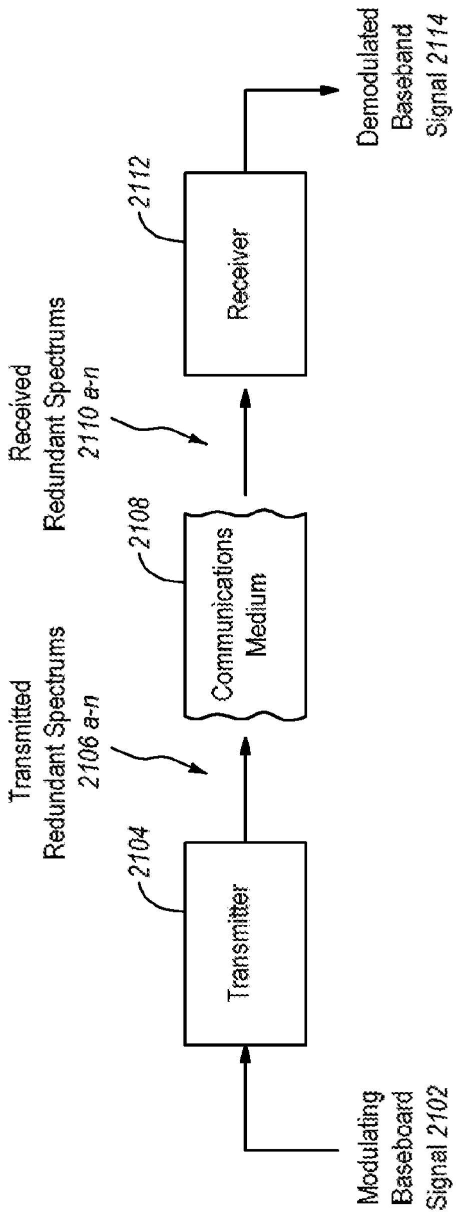

Modulating
Baseboard
Signal 2102
Transmitter
2104
Transmitted
Redundant Spectrums
2106 a-n
Communications
Medium
2108
Received
Redundant Spectrums
2110 a-n
Receiver
2112
Demodulated
Baseband
Signal 2114

*FIG. 21*

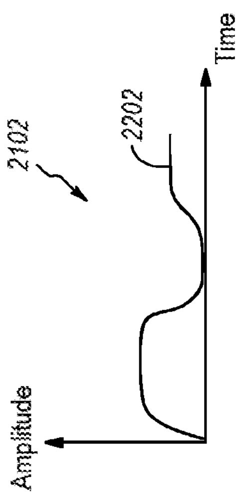



FIG. 22A

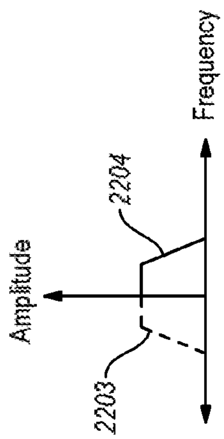



FIG. 22B

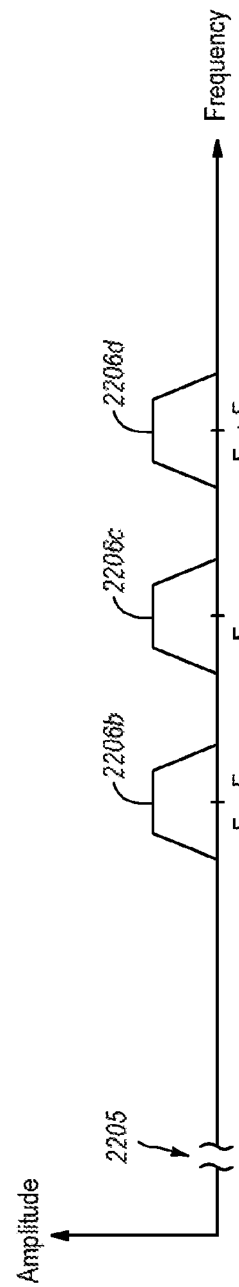



FIG. 22C

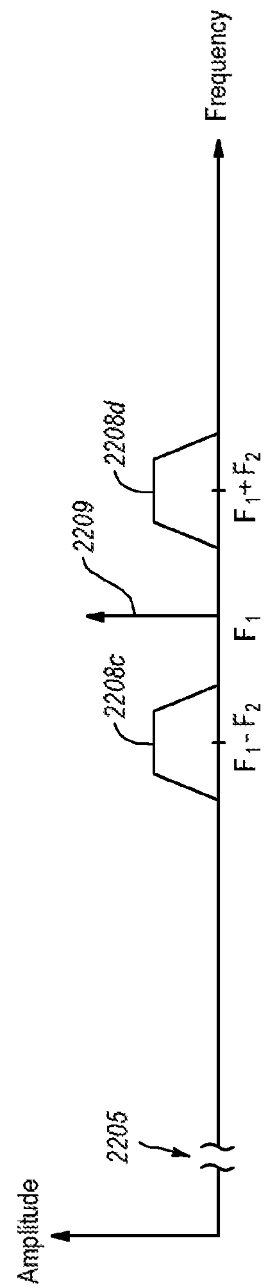



FIG. 22D

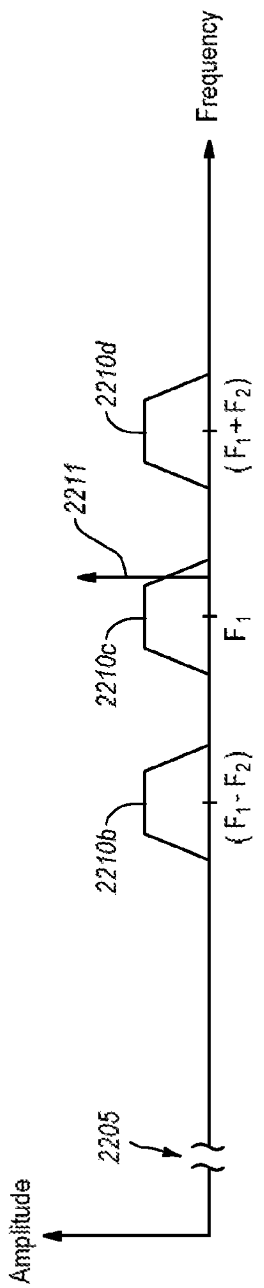



FIG. 22E

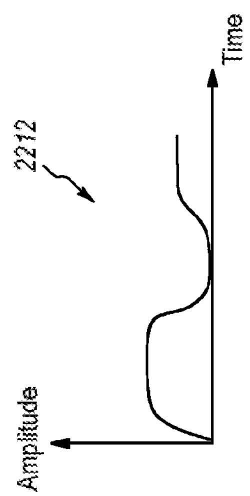



FIG. 22F

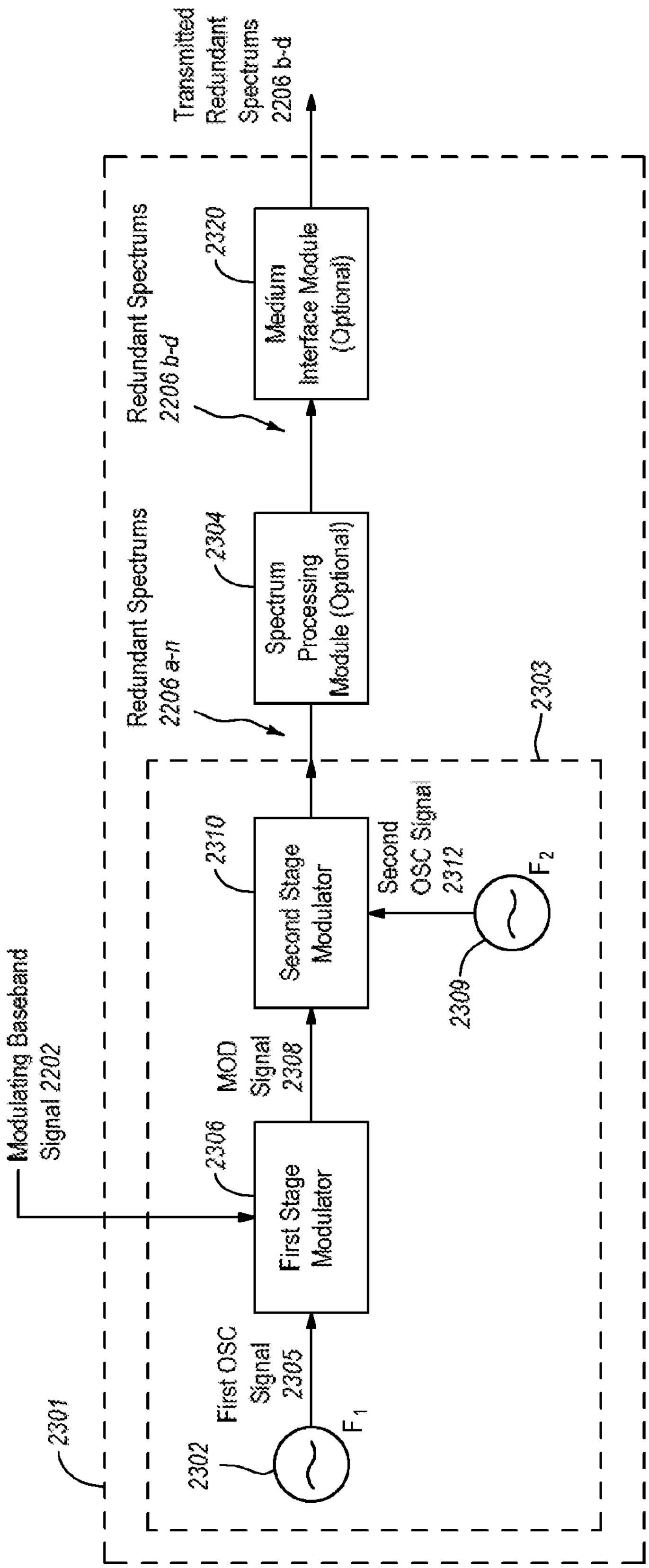

Transmitted Redundant Spectrums 2206 b-d
Redundant Spectrums 2206 b-d
2320
Medium Interface Module (Optional)
Redundant Spectrums 2206 a-n
2304
Spectrum Processing Module (Optional)
2303
2310
Second Stage Modulator
Second OSC Signal 2312
F2
2309
Modulating Baseband Signal 2202
MOD Signal 2308
2306
First Stage Modulator
First OSC Signal 2305
F1
2302
2301

FIG. 23A

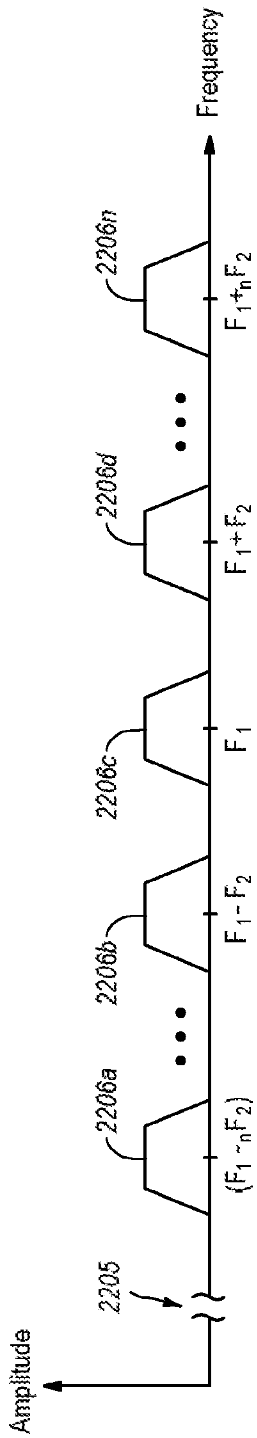



FIG. 23B

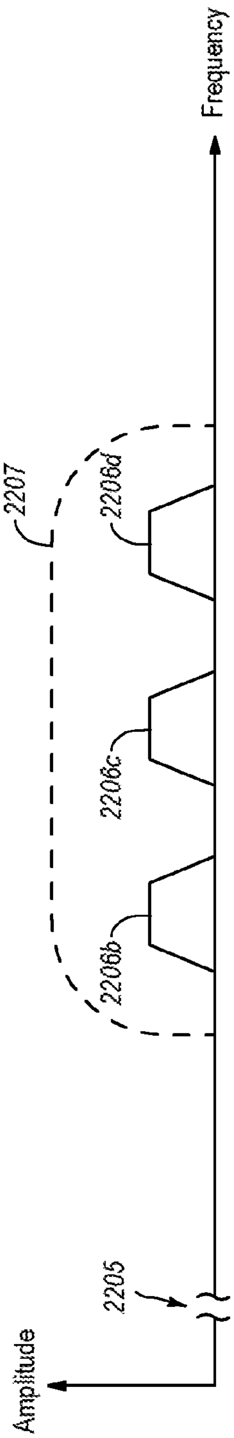



FIG. 23C

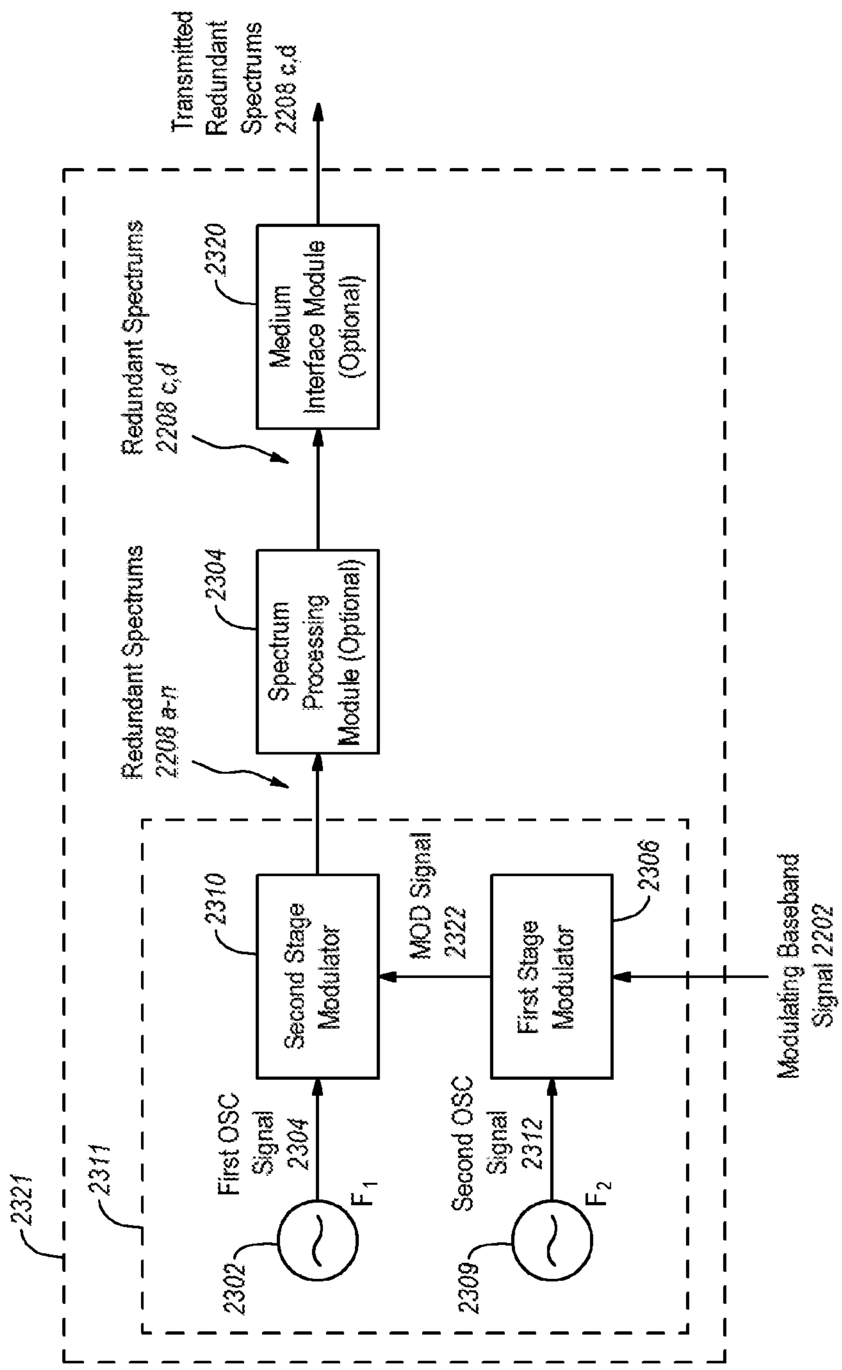

Transmitted Redundant Spectrums 2208 c,d
Redundant Spectrums 2208 c,d
Redundant Spectrums 2208 a-n
2320
Medium Interface Module (Optional)
2304
Spectrum Processing Module (Optional)
2321
2311
2310
Second Stage Modulator
MOD Signal 2322
2306
First Stage Modulator
Modulating Baseband Signal 2202
First OSC Signal 2304
Second OSC Signal 2312
2302
2309
$F_1$
$F_2$

*FIG. 23D*

FIG. 23E

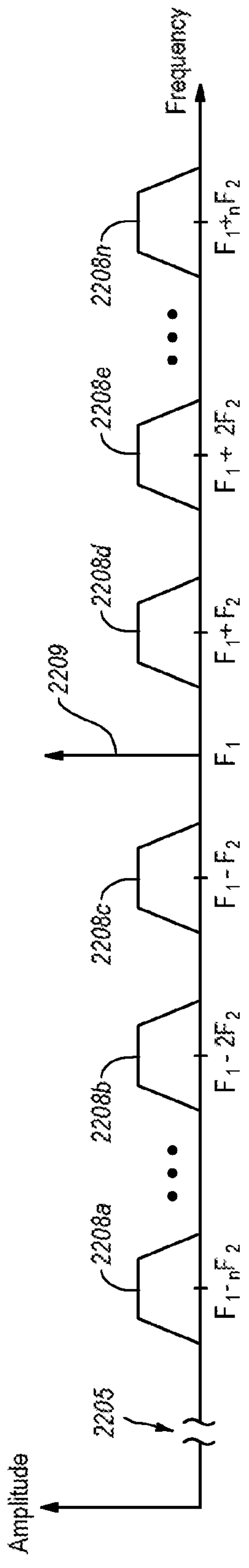
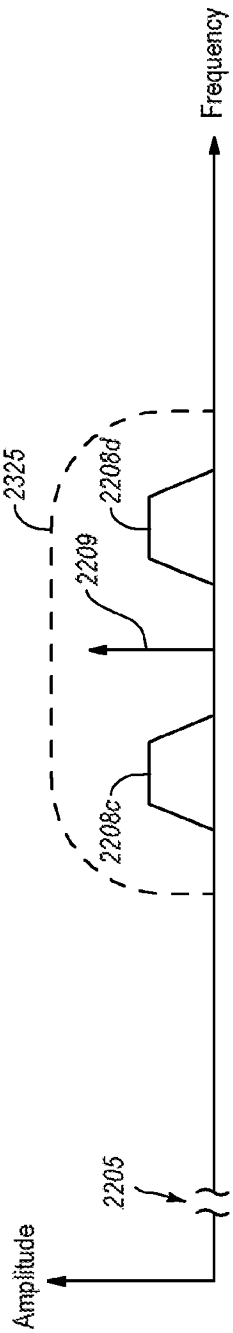



FIG. 23F



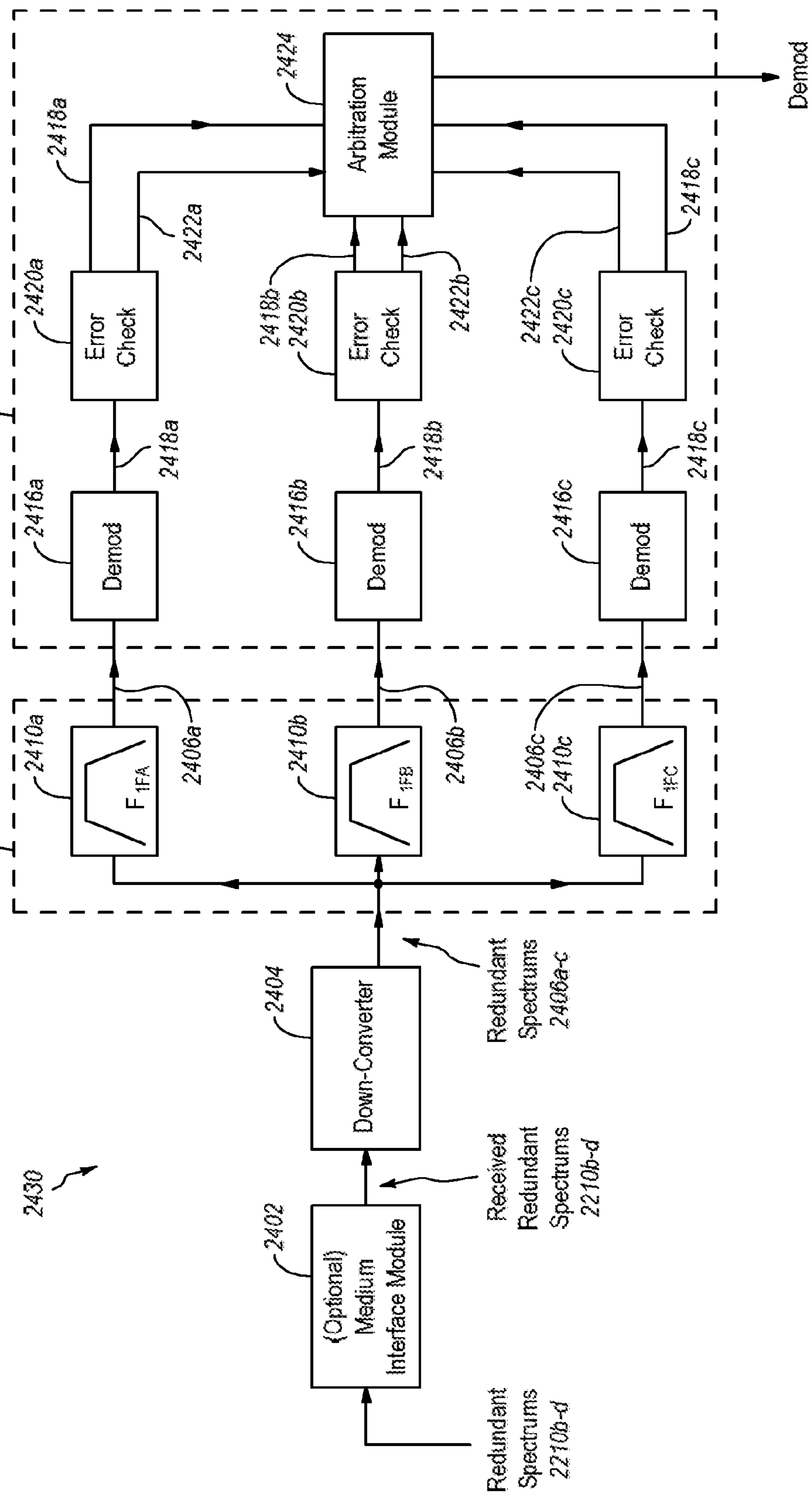

2430
(Optional) Medium Interface Module
2402
Redundant Spectrums 2210b-d
Received Redundant Spectrums 2210b-d
Down-Converter
2404
Redundant Spectrums 2406a-c
2408
$F_{1FA}$
$F_{1FB}$
$F_{1FC}$
2410a
2410b
2410c
2406a
2406b
2406c
2414
Demod
Demod
Demod
2416a
2416b
2416c
2418a
2418b
2418c
Error Check
Error Check
Error Check
2420a
2420b
2420c
2422a
2422b
2422c
Arbitration Module
2424
Demod Baseband Signal 2212

FIG. 24A

FIG. 24B

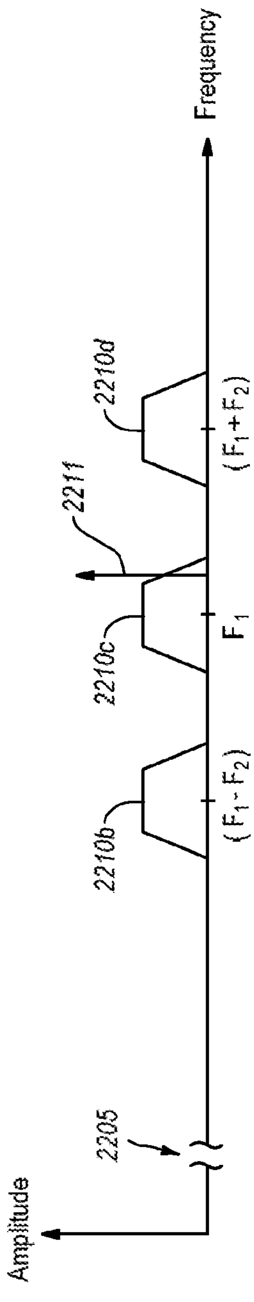
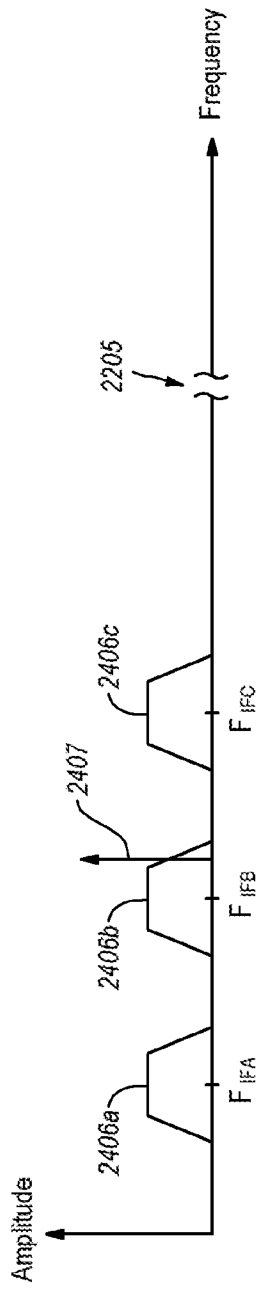



FIG. 24C



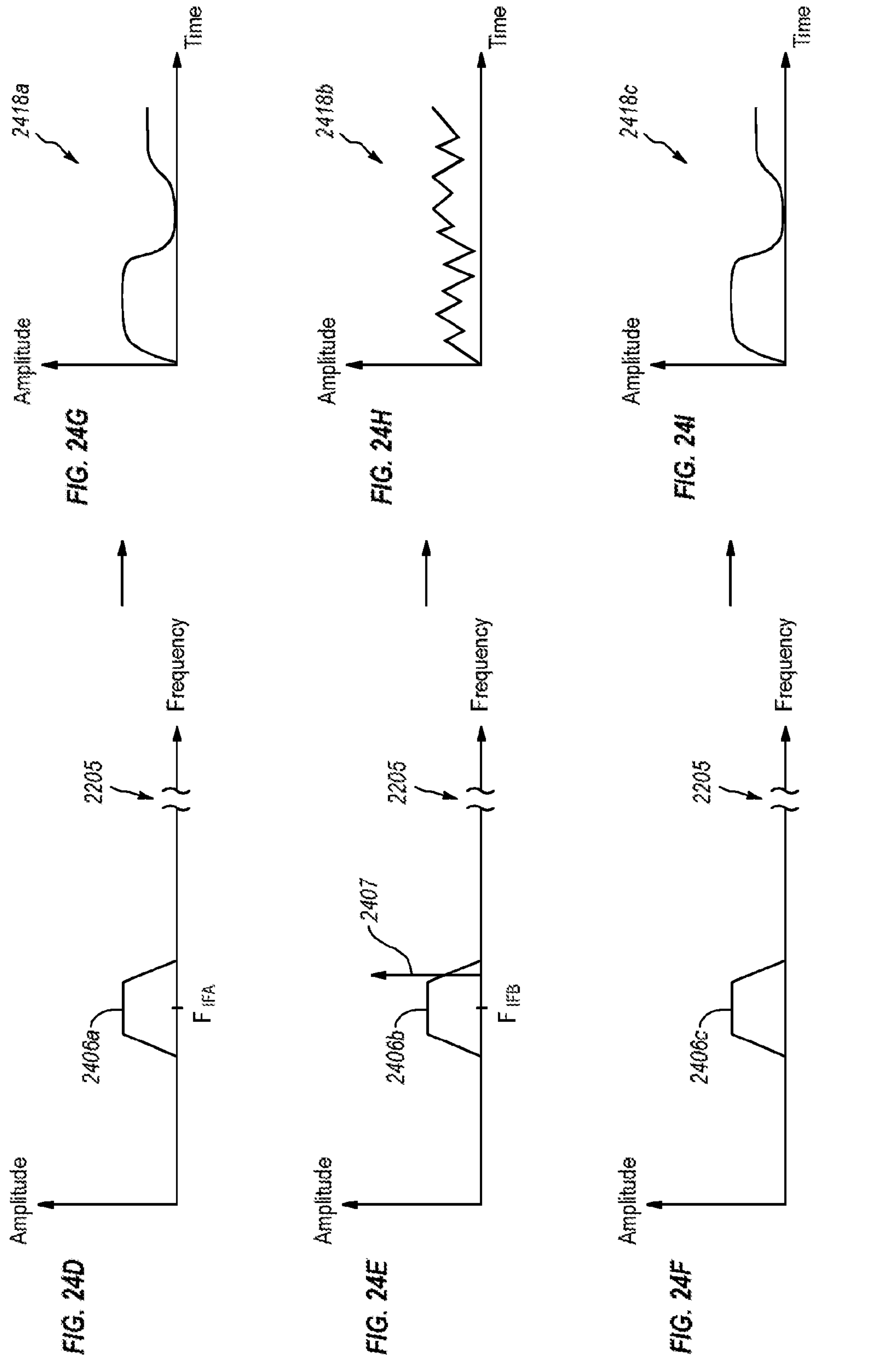



FIG. 24D
FIG. 24E
FIG. 24F
FIG. 24G
FIG. 24H
FIG. 24I

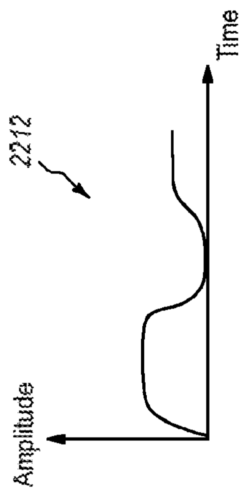



FIG. 24J

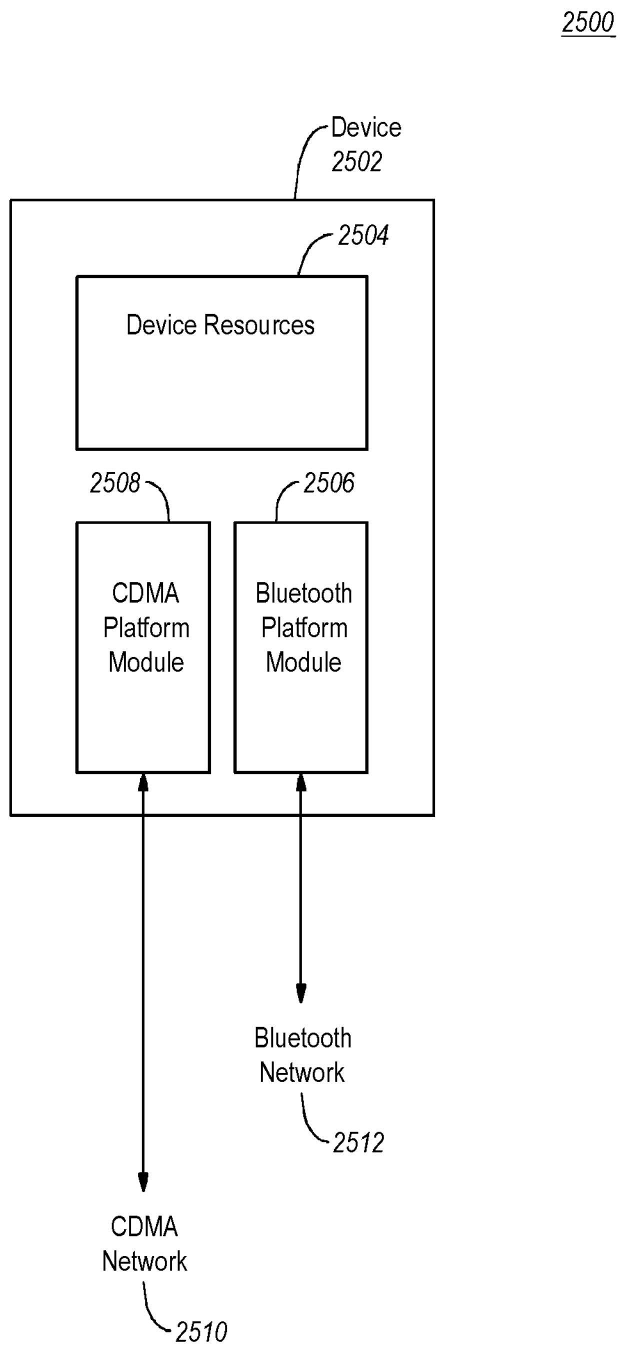

2500
Device
2502
2504
Device Resources
2508
2506
CDMA
Platform
Module
Bluetooth
Platform
Module
Bluetooth
Network
2512
CDMA
Network
2510

FIG. 25A

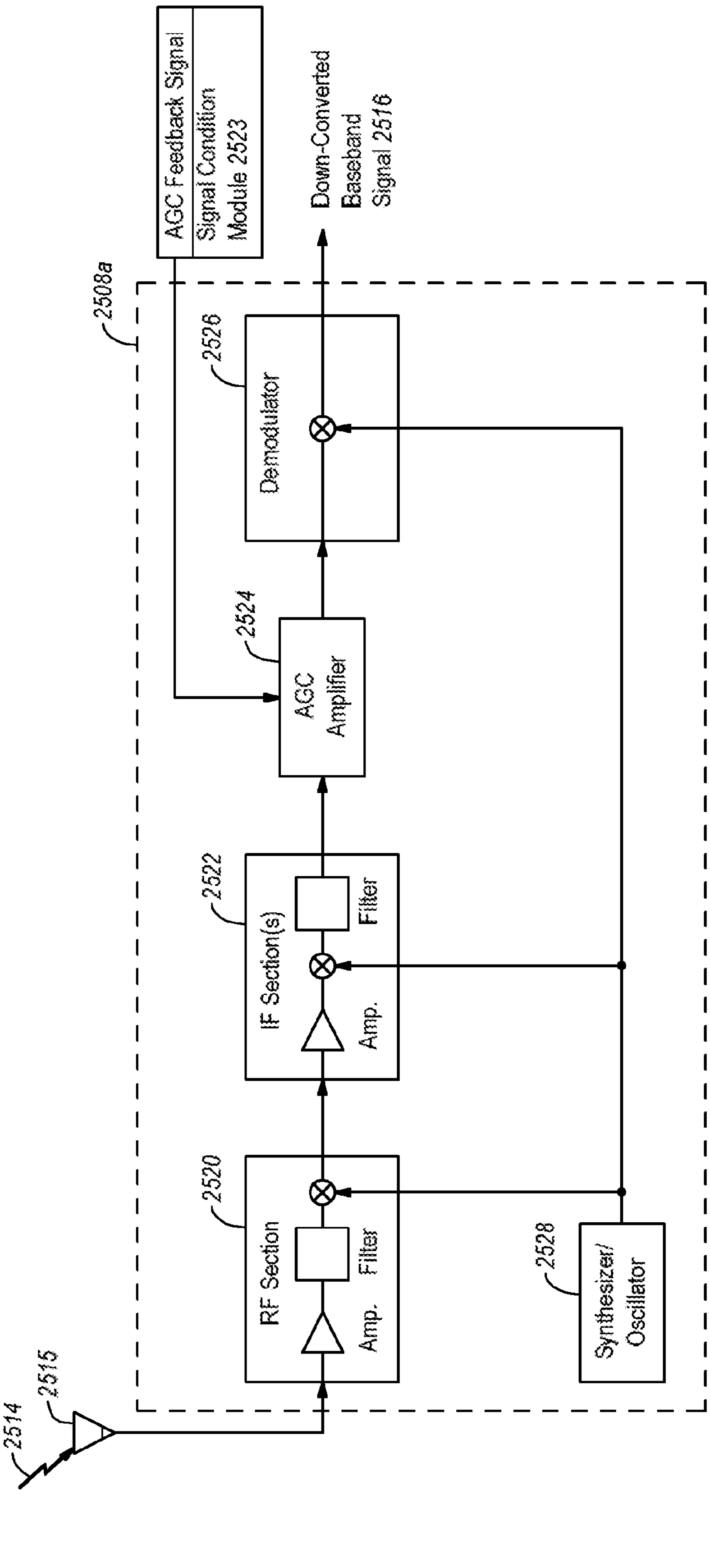

AGC Feedback Signal
Signal Condition Module 2523
Down-Converted Baseband Signal 2516
2508a
2526
Demodulator
2524
AGC Amplifier
2522
IF Section(s)
Amp.
Filter
2520
RF Section
Amp.
Filter
2528
Synthesizer/ Oscillator
2514
2515

FIG. 25B

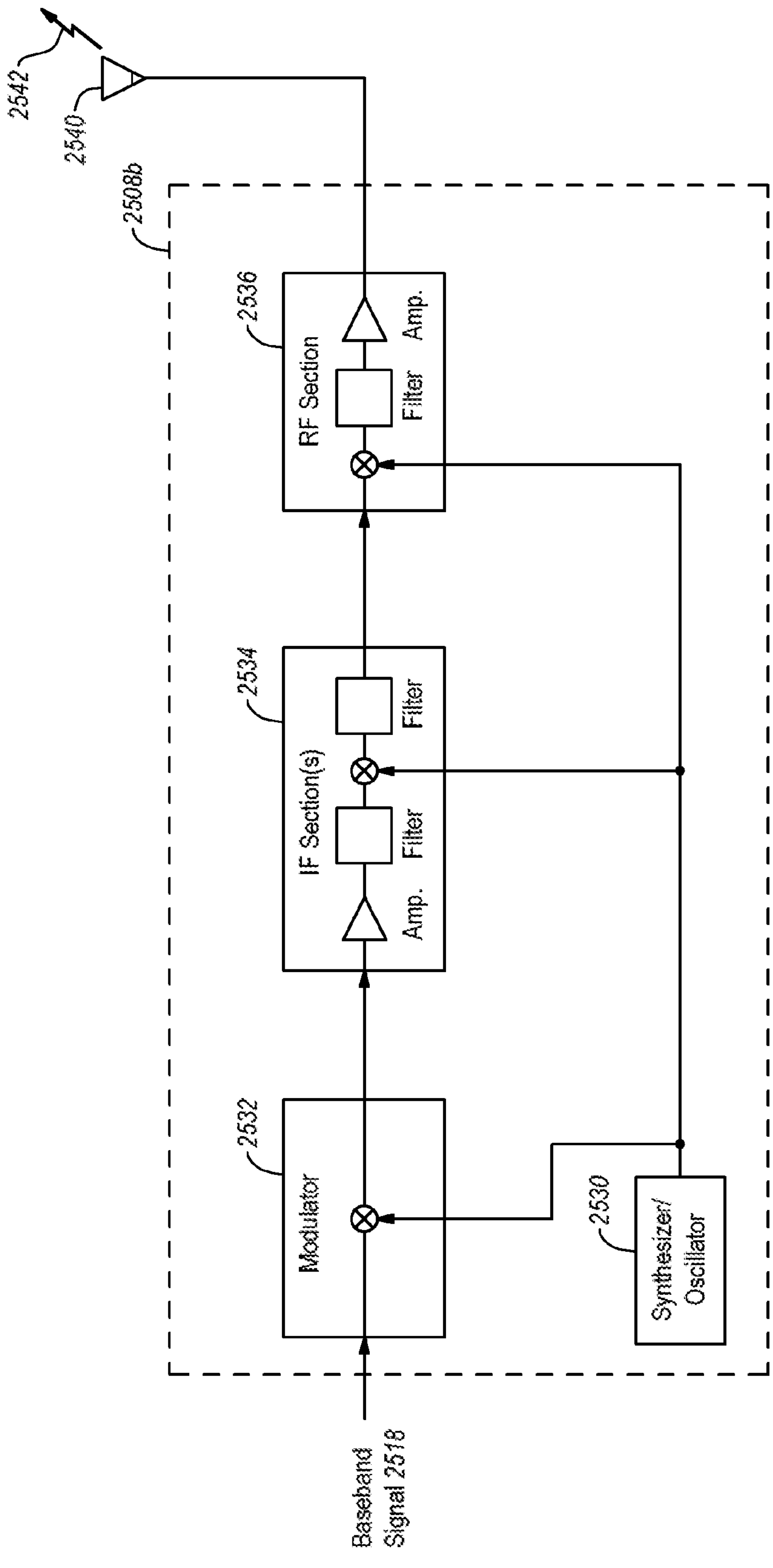

2542
2540
2508b
2536
RF Section
Filter
Amp.
2534
IF Section(s)
Filter
Filter
Amp.
2532
Modulator
2530
Synthesizer/
Oscillator
Baseband
Signal 2518

FIG. 25C

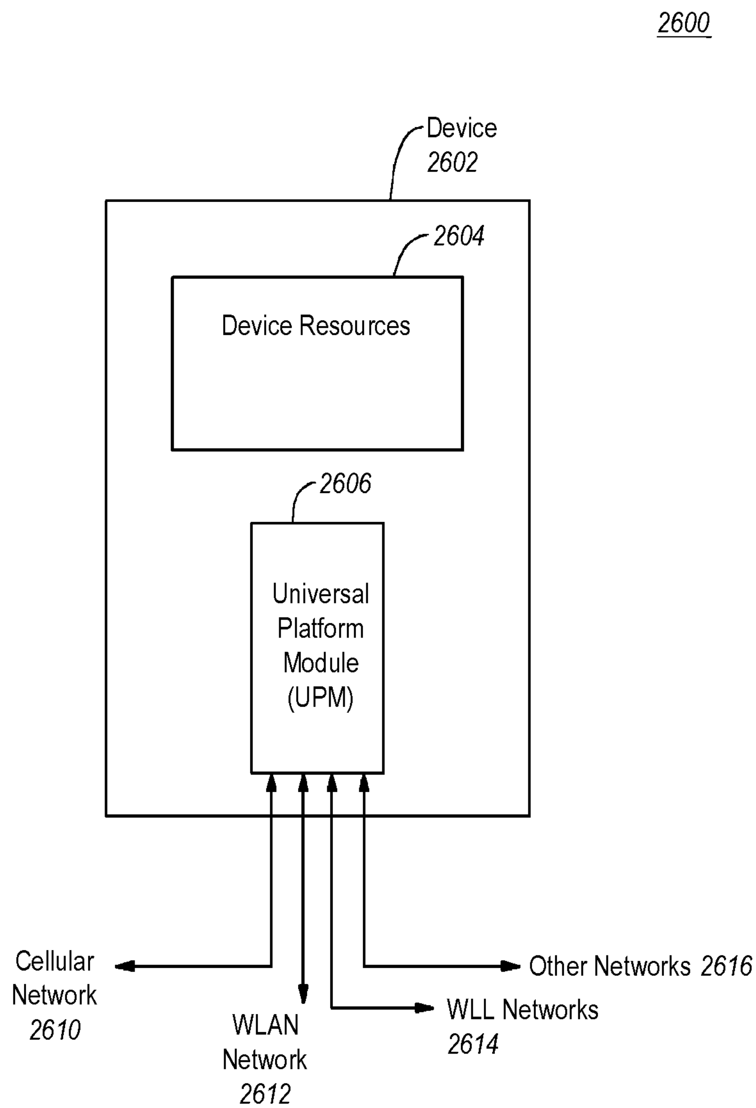

2600
Device
2602
2604
Device Resources
2606
Universal
Platform
Module
(UPM)
Cellular
Network
2610
WLAN
Network
2612
WLL Networks
2614
Other Networks 2616

*FIG. 26A*

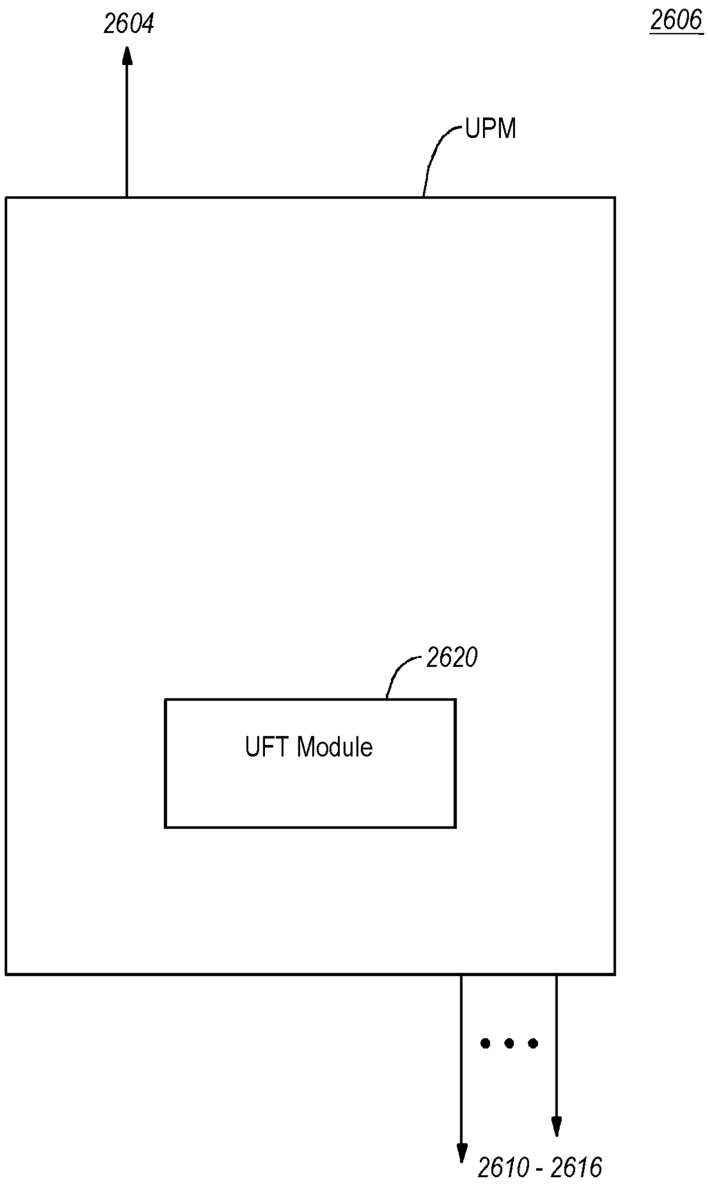



*FIG. 26B*

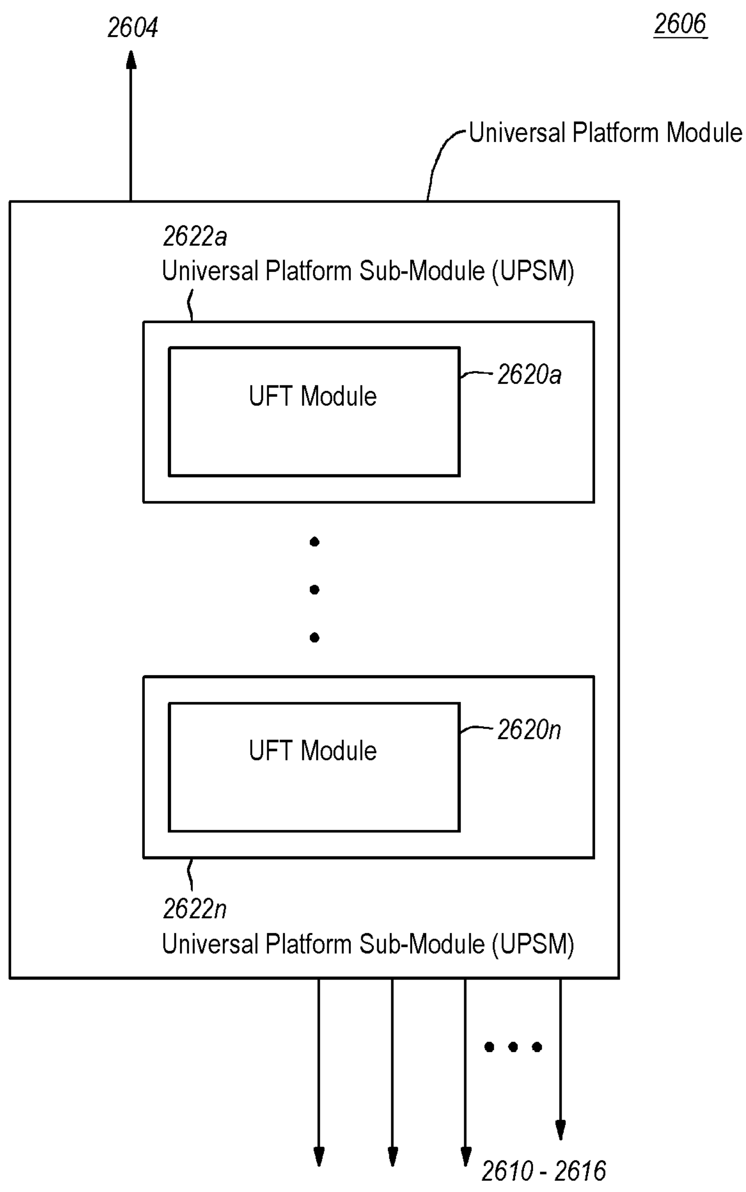

2604
2606
Universal Platform Module
2622a
Universal Platform Sub-Module (UPSM)
UFT Module
2620a
UFT Module
2620n
2622n
Universal Platform Sub-Module (UPSM)
2610 - 2616

FIG. 26C

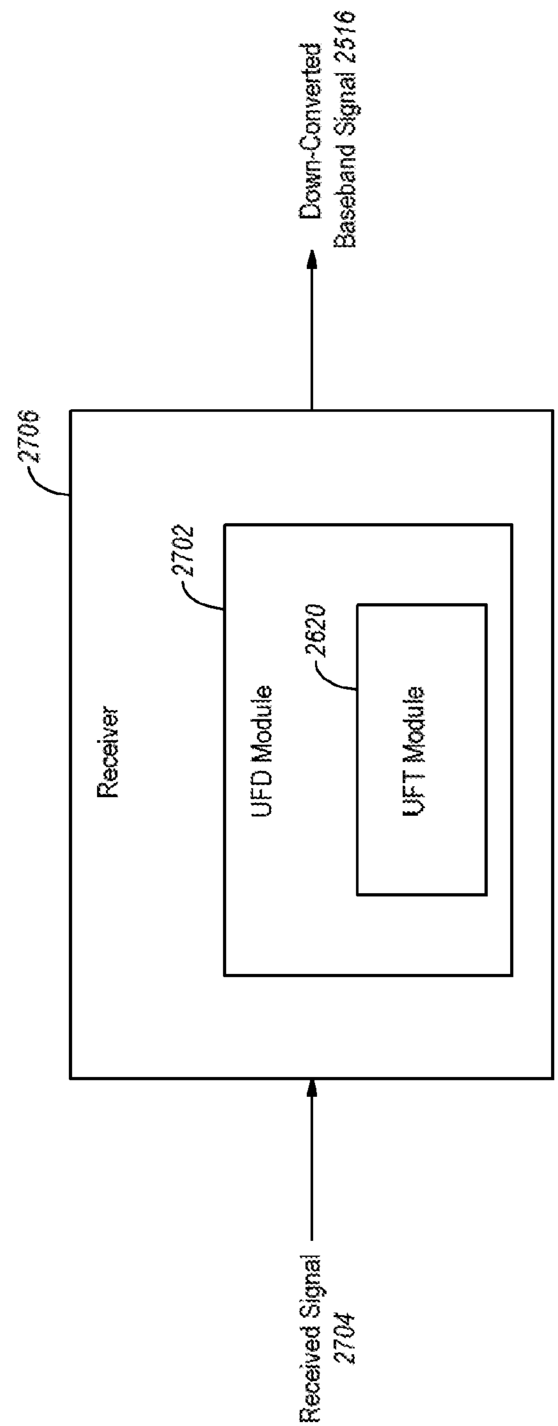

Down-Converted
Baseband Signal 2516
2706
Receiver
2702
UFD Module
2620
UFT Module
Received Signal
2704

FIG. 27A

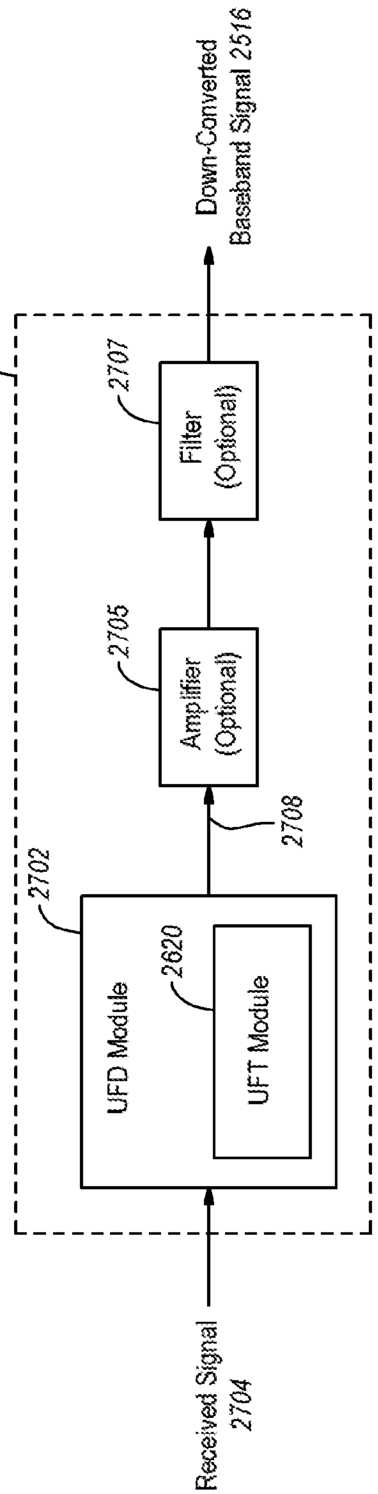



FIG. 27B

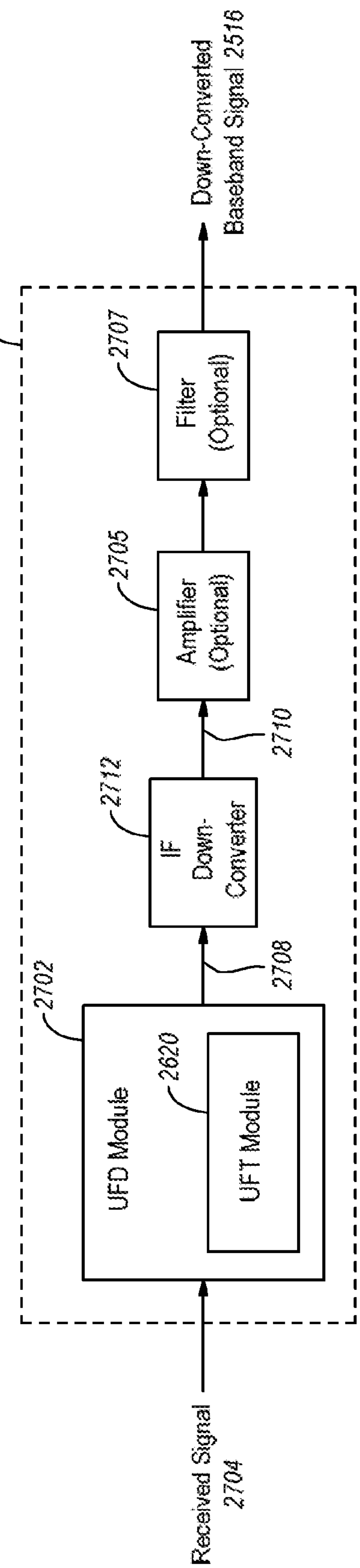



FIG. 27C

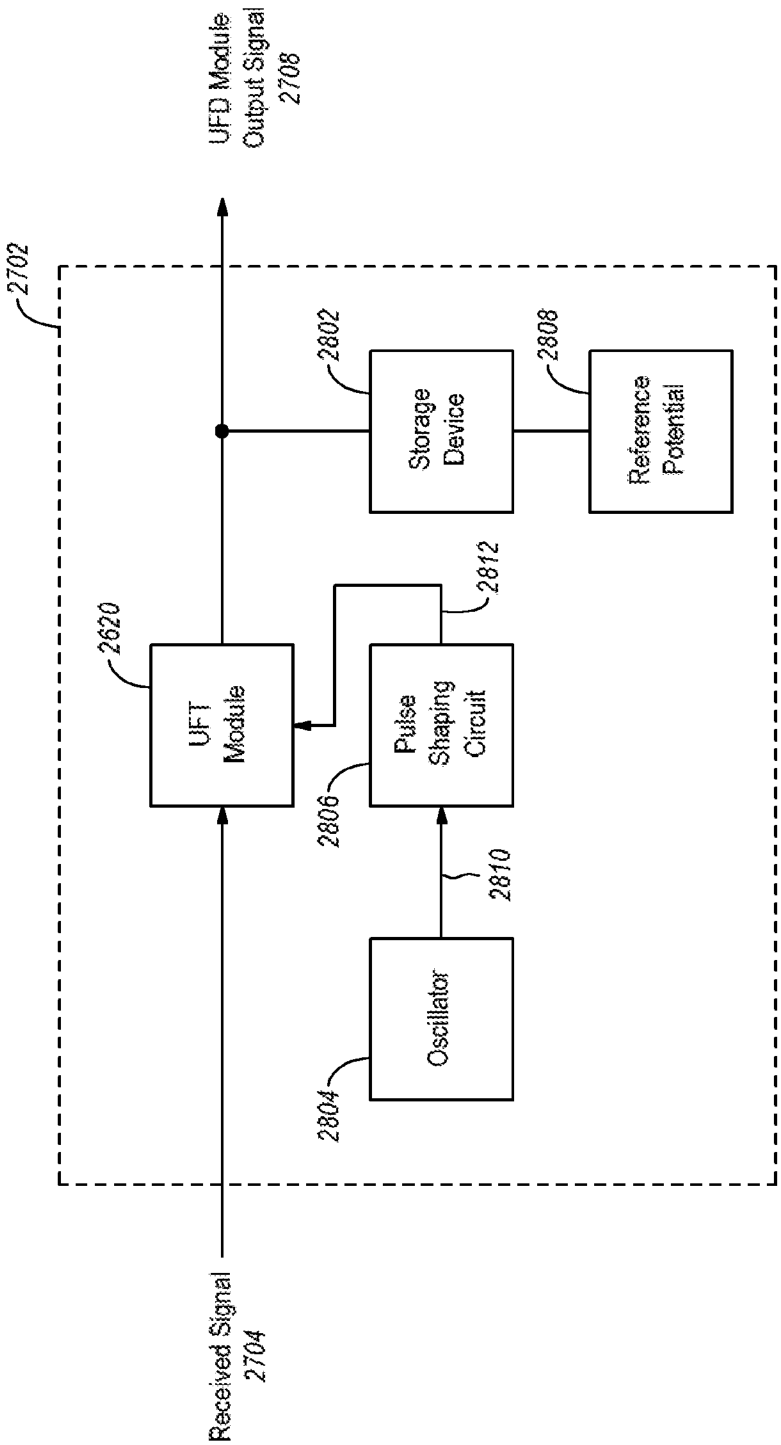

UFD Module
Output Signal
2708
2702
2802
Storage
Device
2808
Reference
Potential
2812
2620
UFT
Module
Pulse
Shaping
Circuit
2806
2810
Oscillator
2804
Received Signal
2704

FIG. 28

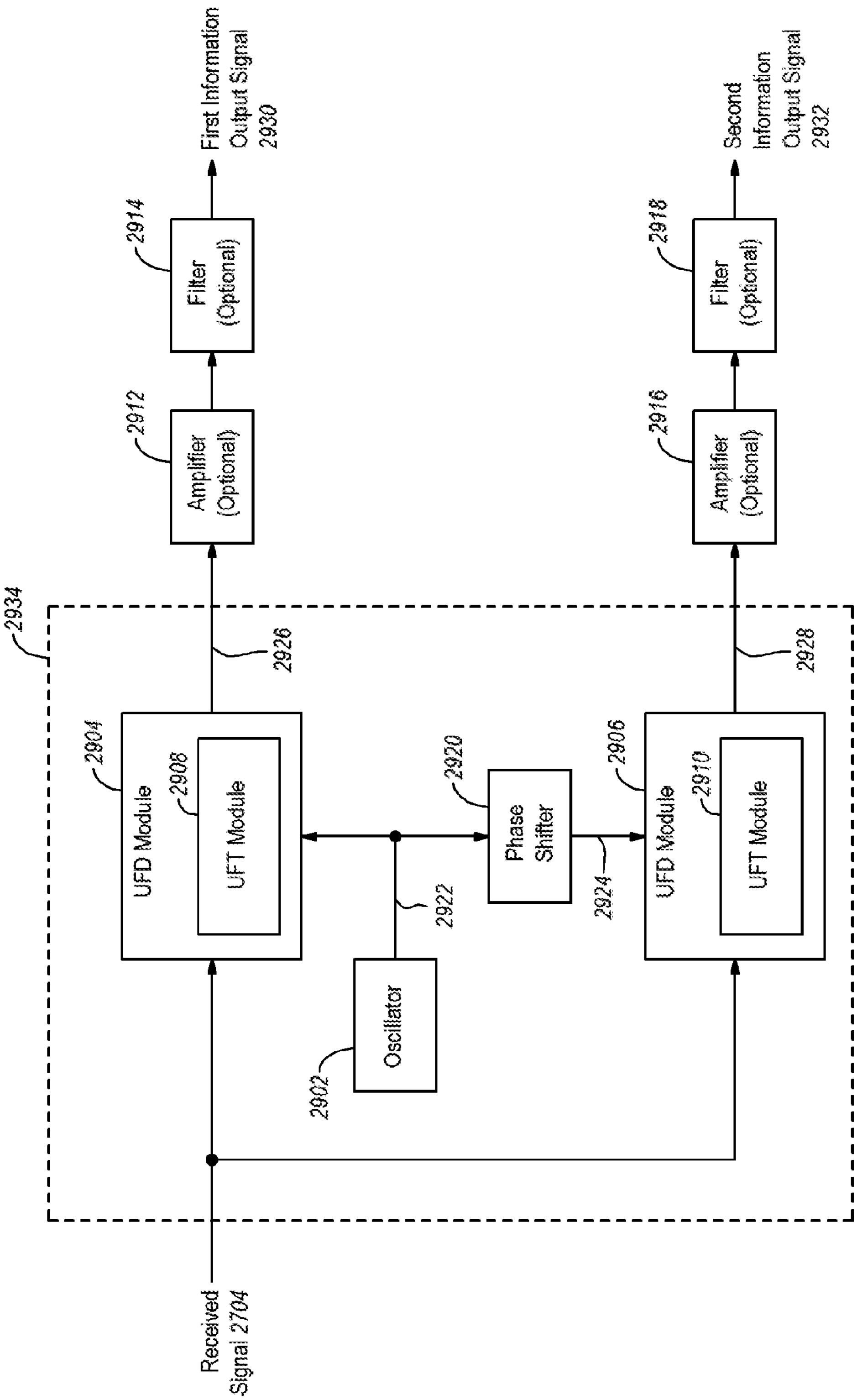

Received Signal 2704
2934
Oscillator
2902
2922
UFD Module
2904
UFT Module
2908
Phase Shifter
2920
2924
UFD Module
2906
UFT Module
2910
2926
2928
Amplifier (Optional)
2912
Filter (Optional)
2914
First Information Output Signal 2930
Amplifier (Optional)
2916
Filter (Optional)
2918
Second Information Output Signal 2932

FIG. 29

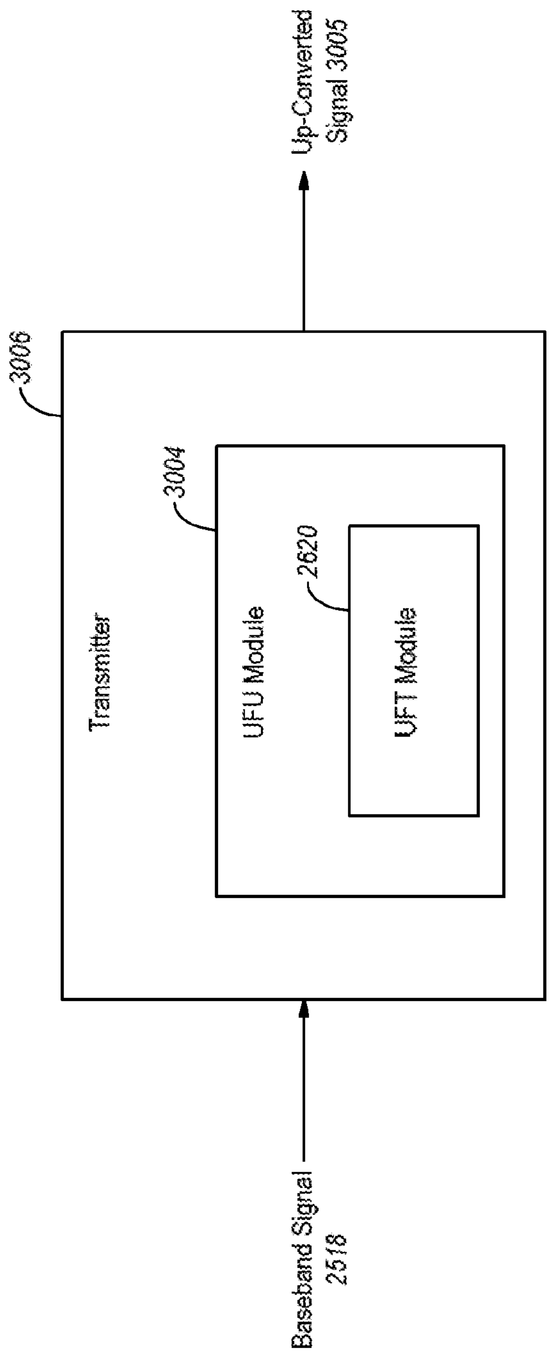

Up-Converted Signal 3005
3006
Transmitter
3004
UFU Module
2620
UFT Module
Baseband Signal 2518

FIG. 30A

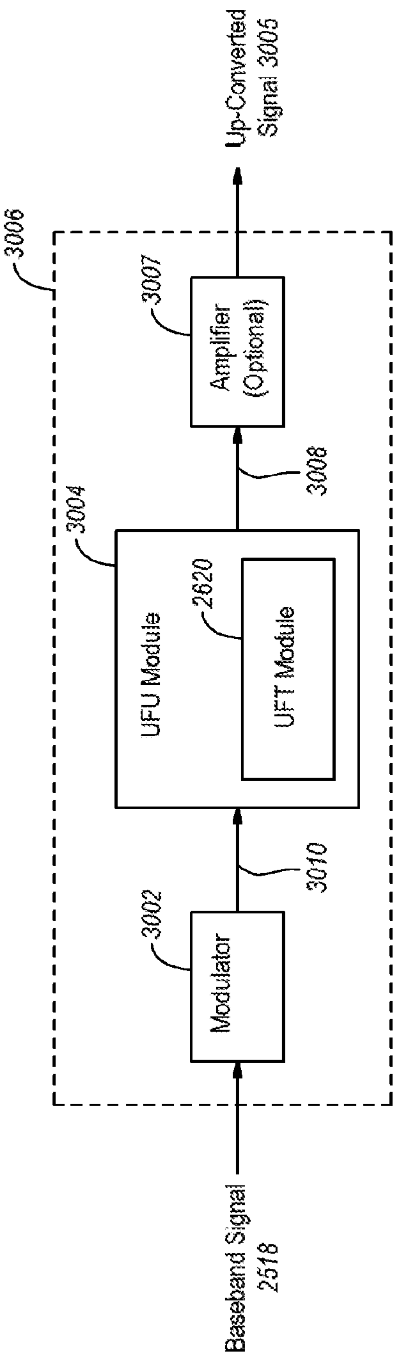



FIG. 30B

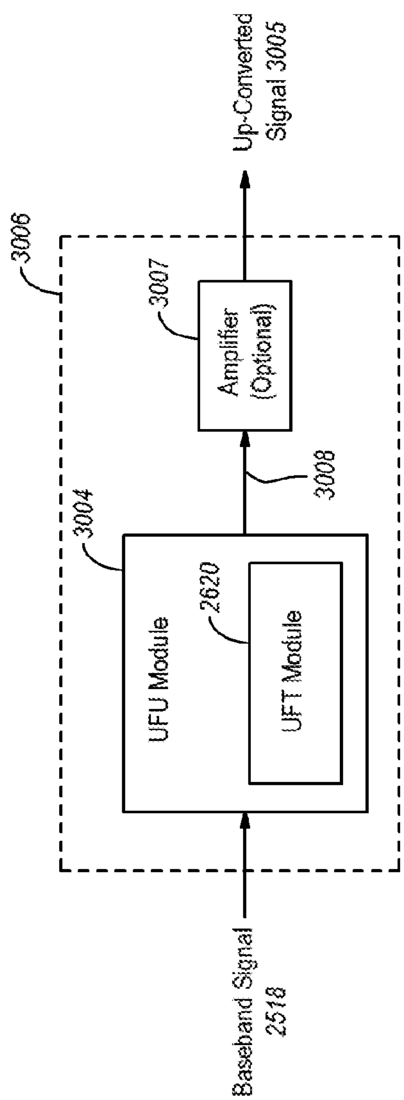



FIG. 30C

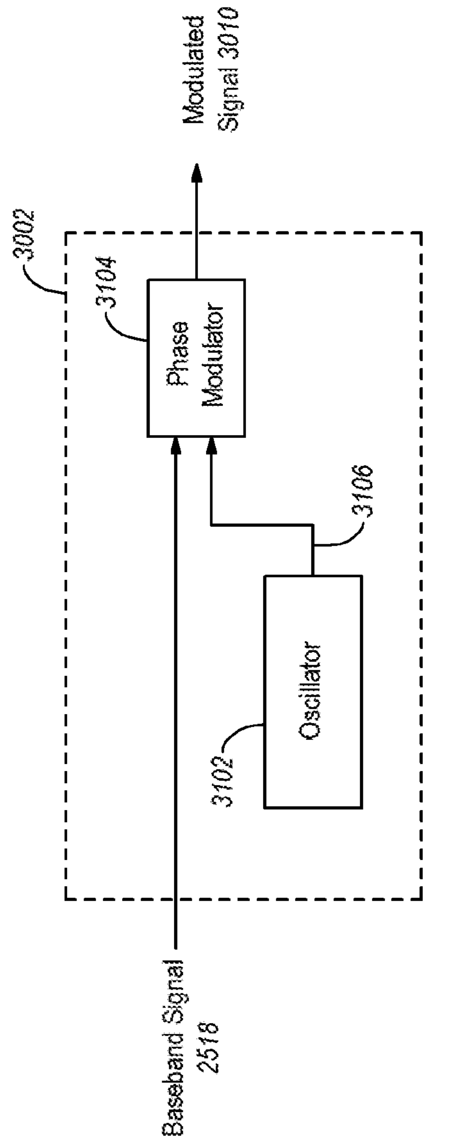

Modulated Signal 3010
3002
3104
Phase Modulator
3106
Oscillator
3102
Baseband Signal 2518

FIG. 31

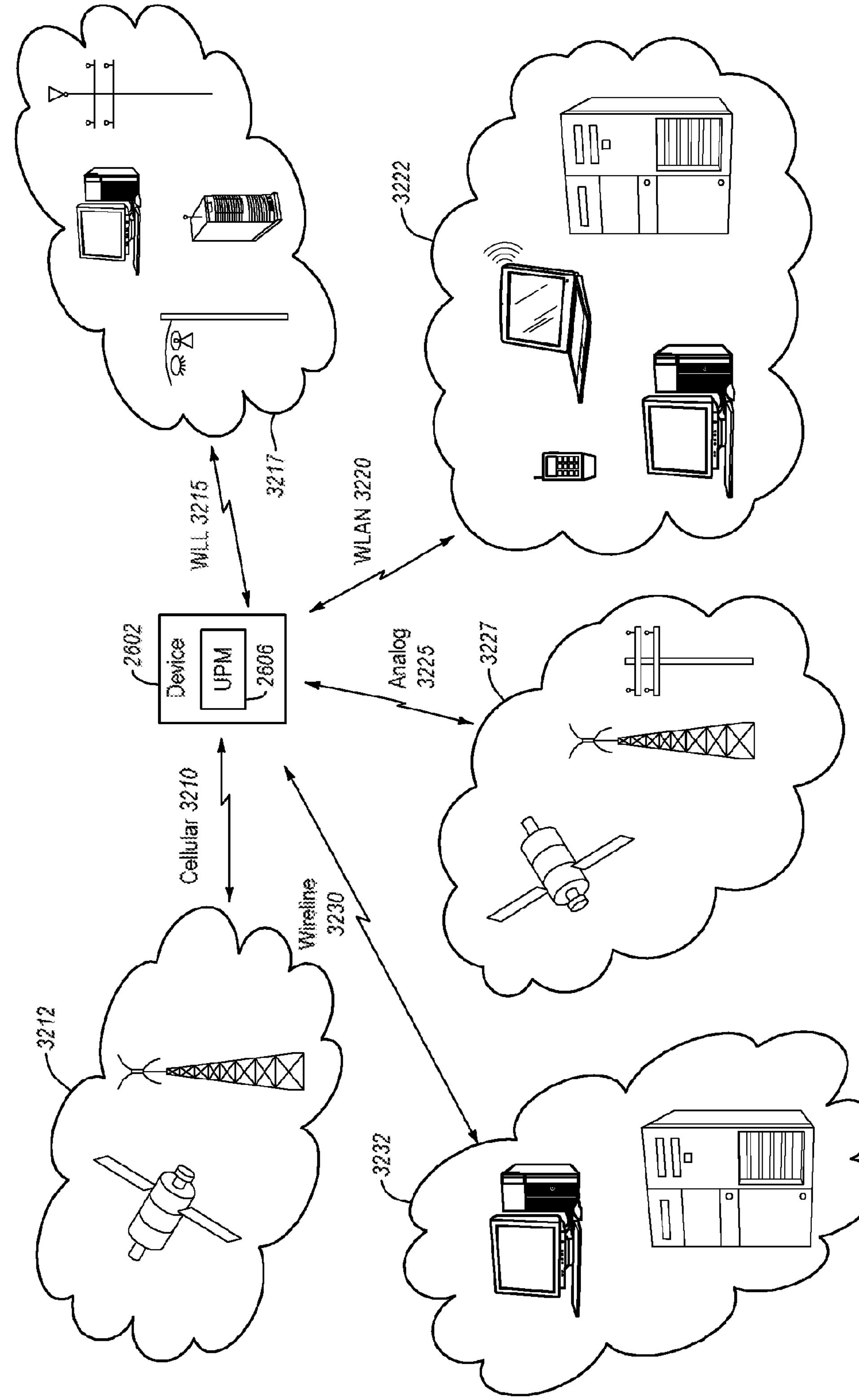

Device
UPM
2602
2606
WLL 3215
3217
WLAN 3220
3222
Analog
3225
3227
Cellular 3210
3212
Wireline
3230
3232

FIG. 32

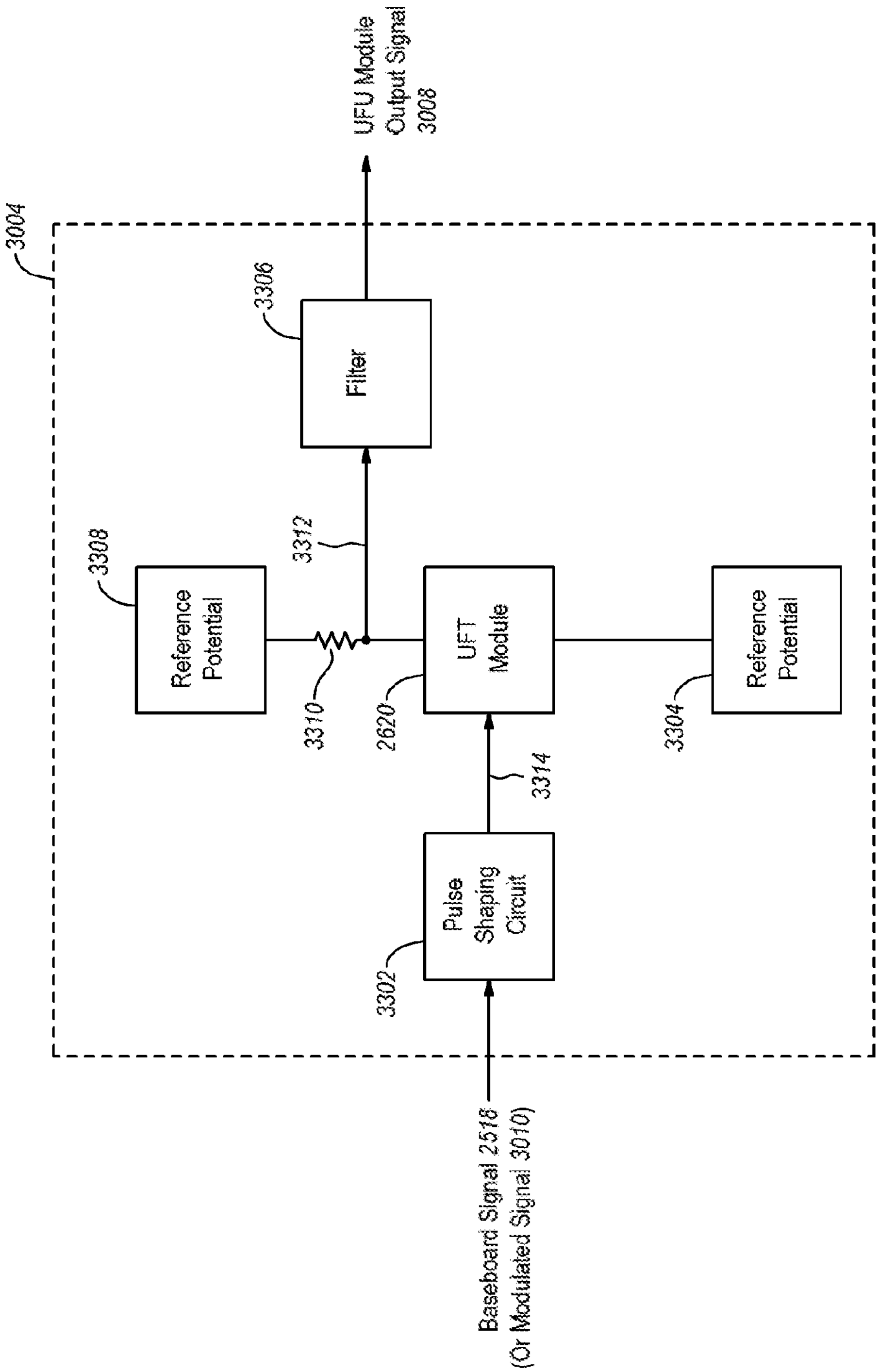

UFU Module
Output Signal
3008
3004
3306
Filter
3308
Reference
Potential
3312
3310
2620
UFT
Module
3304
Reference
Potential
3314
3302
Pulse
Shaping
Circuit
Baseboard Signal 2518
(Or Modulated Signal 3010)

FIG. 33

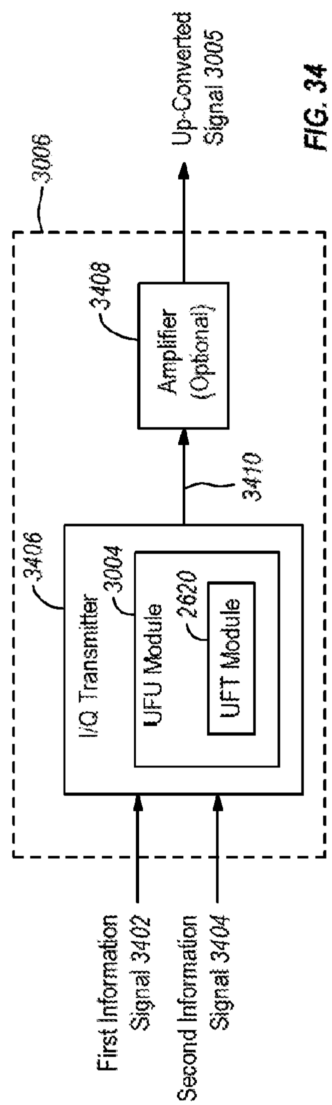

First Information Signal 3402
Second Information Signal 3404
3006
3406
I/Q Transmitter
3004
UFU Module
2620
UFT Module
3410
3408
Amplifier (Optional)
Up-Converted Signal 3005

FIG. 34

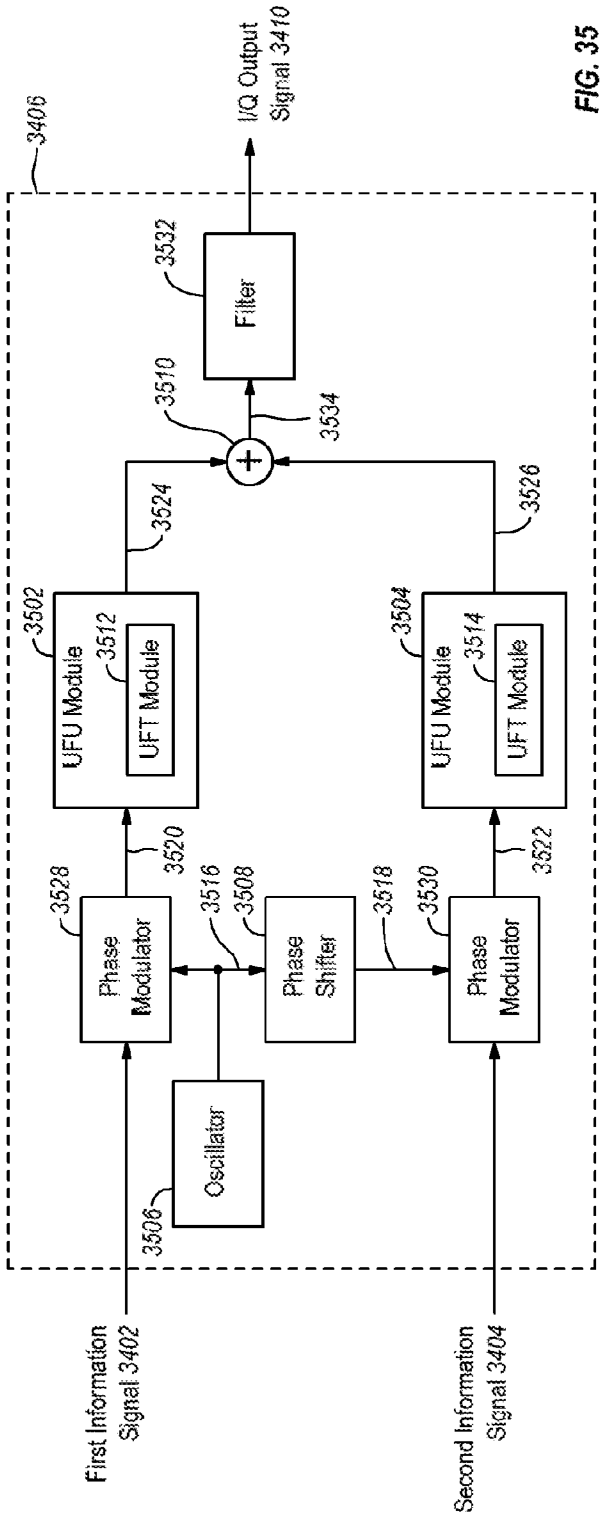

First Information Signal 3402
Second Information Signal 3404
3406
3506
Oscillator
3528
Phase Modulator
3516
3508
Phase Shifter
3518
3530
Phase Modulator
3520
3522
3502
UFU Module
3512
UFT Module
3504
UFU Module
3514
UFT Module
3524
3526
3510
3534
3532
Filter
I/Q Output Signal 3410

FIG. 35

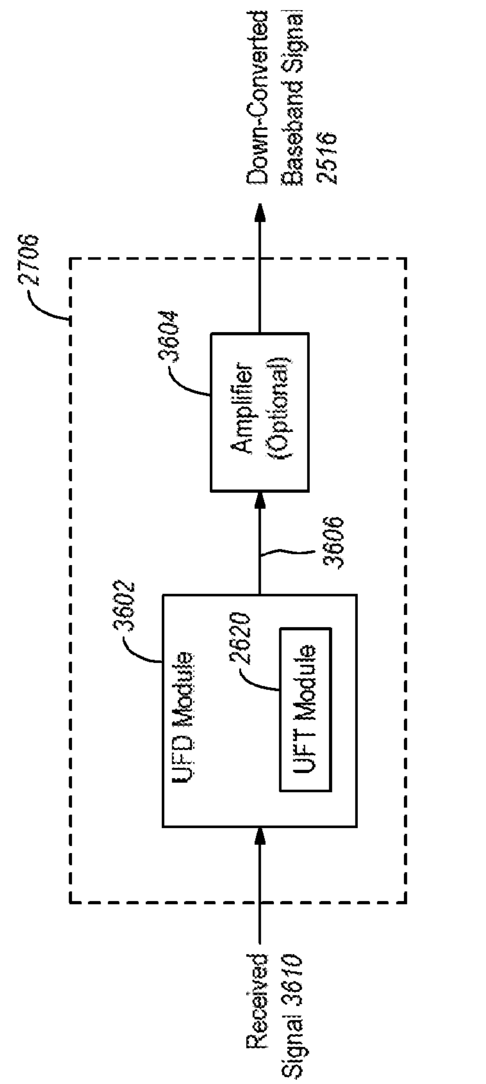

2706
Received Signal 3610
UFD Module
3602
UFT Module
2620
3606
Amplifier (Optional)
3604
Down-Converted Baseband Signal 2516

FIG. 36

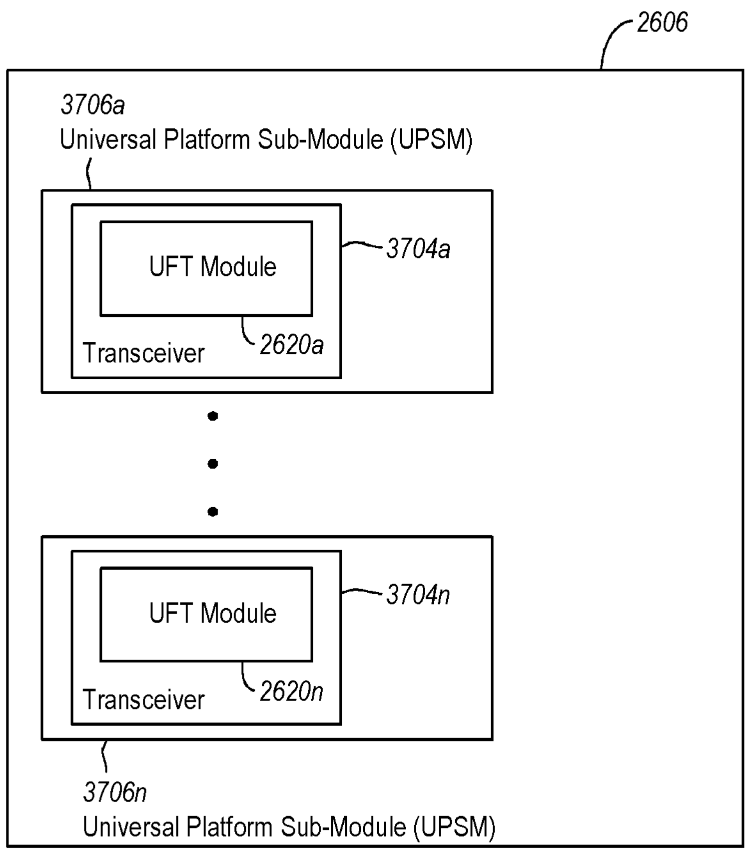

2606
3706a
Universal Platform Sub-Module (UPSM)
UFT Module
3704a
Transceiver
2620a
UFT Module
3704n
Transceiver
2620n
3706n
Universal Platform Sub-Module (UPSM)

FIG. 37

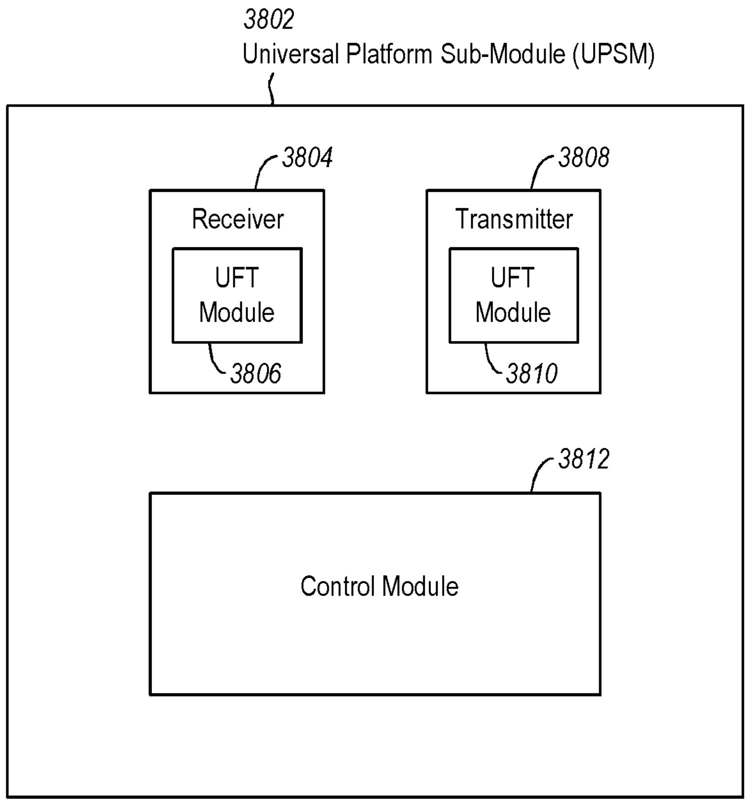

3802
Universal Platform Sub-Module (UPSM)
3804
Receiver
UFT
Module
3806
3808
Transmitter
UFT
Module
3810
3812
Control Module

FIG. 38

3900

| Protocol / Bearer | Bluetooth | WAP | 802.11 | AT Command | • • • | • • • | • • • |
|---|---|---|---|---|---|---|---|
| Bluetooth | X | | | X | | | |
| GSM | | X | | | | | |
| CDMA | | X | | | | | |
| TDMA | | X | | | | | |
| 802.11 | | | X | | | | |
| PHS | | X | | | | | |
| CDPD | | X | | | | | |
| PDC-P | | X | | | | | |
| iDEN | | X | | | | | |
| FLEX | | X | | | | | |
| AMPS | | X | | X | | | |
| ⋮ | | | | | | | |

*FIG. 39*

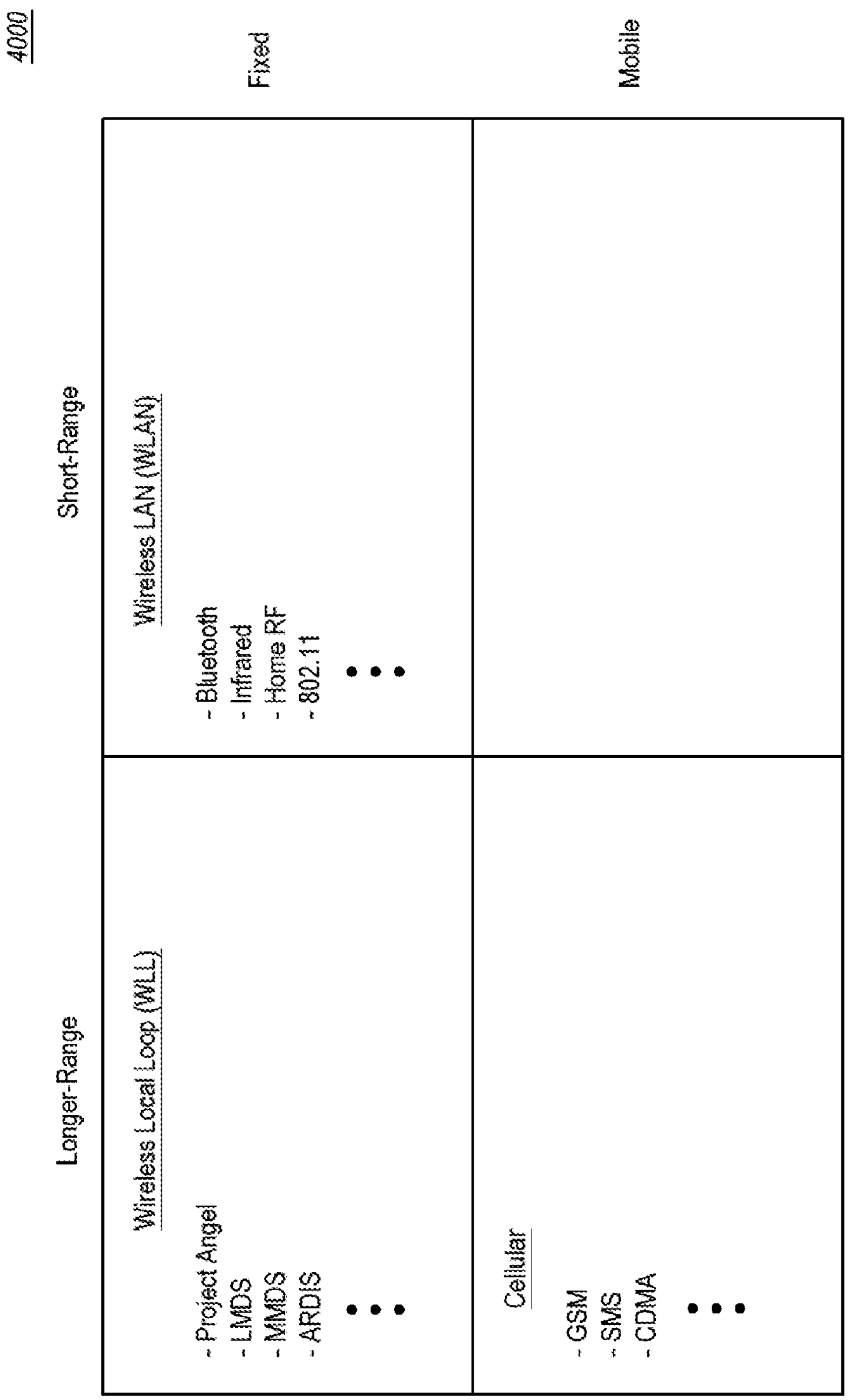

4000
Longer-Range
Short-Range
Fixed
Mobile
Wireless Local Loop (WLL)
- Project Angel
- LMDS
- MMDS
- ARDIS
Wireless LAN (WLAN)
- Bluetooth
- Infrared
- Home RF
- 802.11
Cellular
- GSM
- SMS
- CDMA

FIG. 40

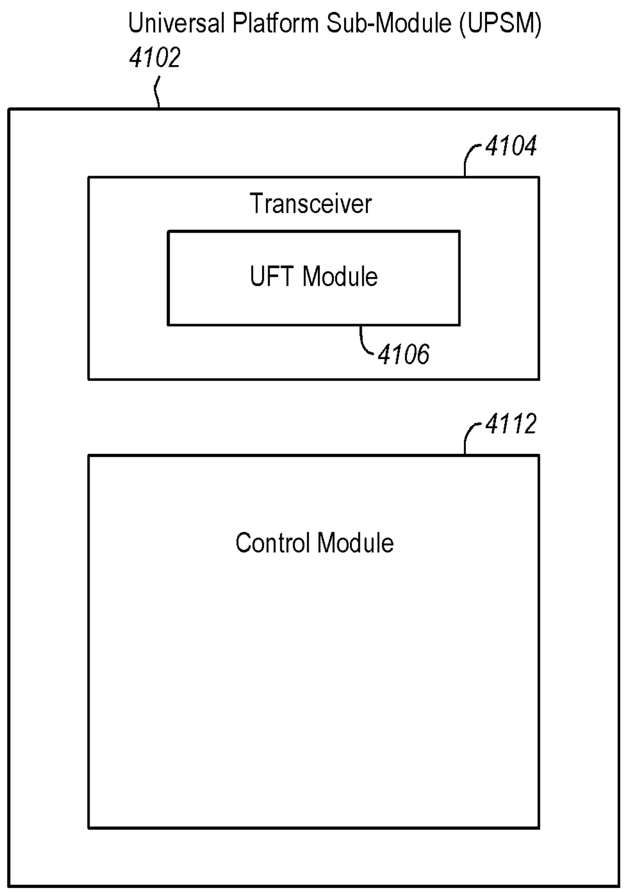

Universal Platform Sub-Module (UPSM)
4102
4104
Transceiver
UFT Module
4106
4112
Control Module

FIG. 41

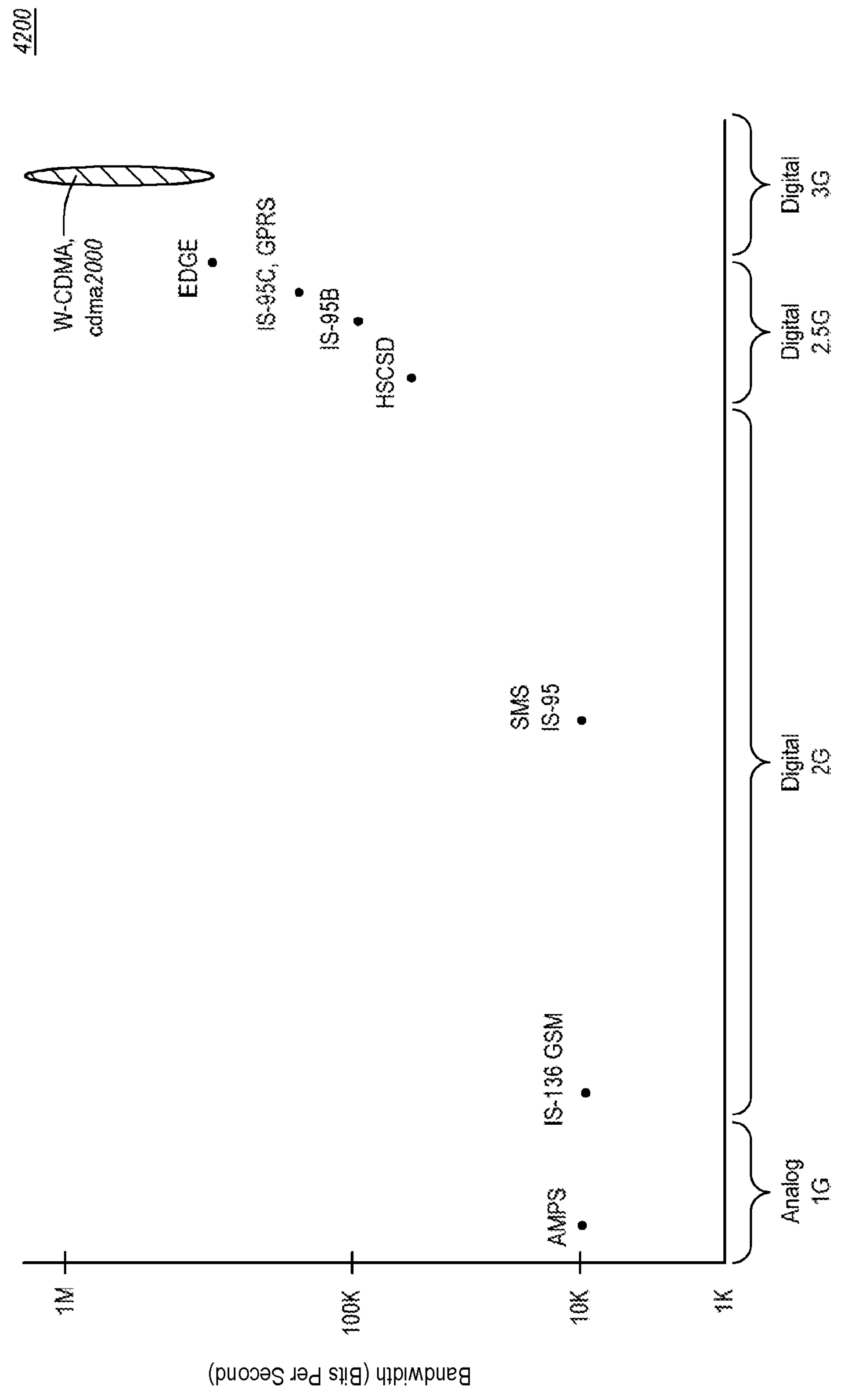

4200
Bandwidth (Bits Per Second)
1M
100K
10K
1K
AMPS
IS-136 GSM
SMS
IS-95
HSCSD
IS-95B
IS-95C, GPRS
EDGE
W-CDMA,
cdma2000
Analog
1G
Digital
2G
Digital
2.5G
Digital
3G

*FIG. 42*

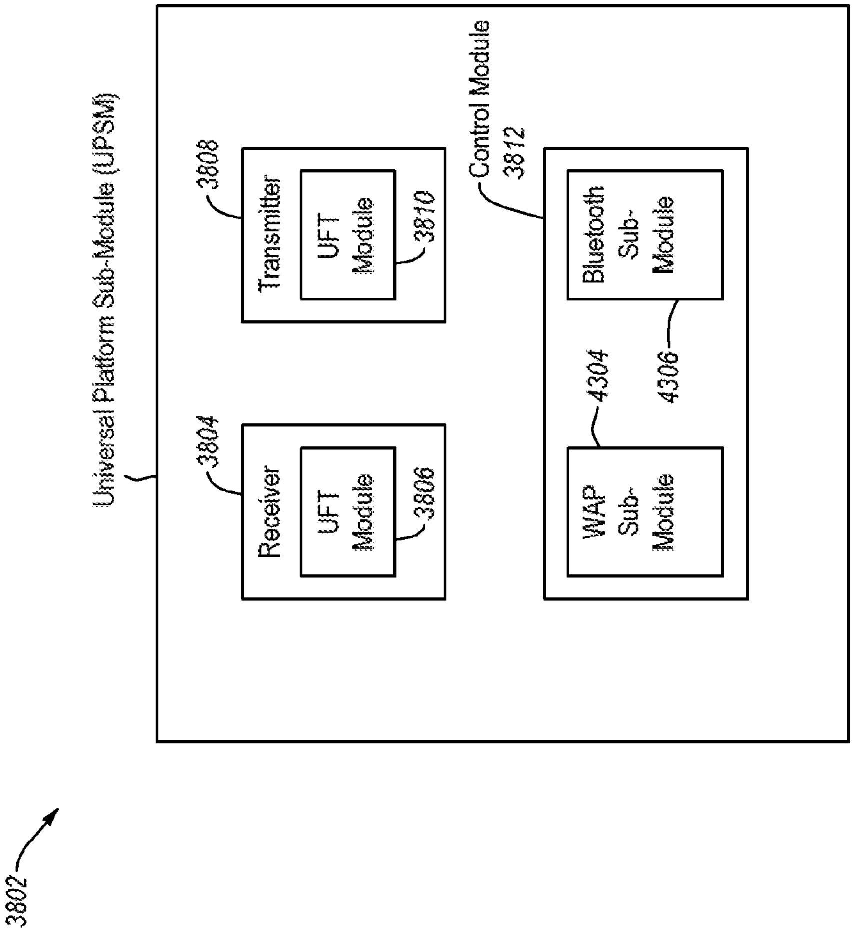

3802
Universal Platform Sub-Module (UPSM)
3804
Receiver
UFT Module
3806
3808
Transmitter
UFT Module
3810
Control Module
3812
WAP Sub-Module
4304
Bluetooth Sub-Module
4306

FIG. 43

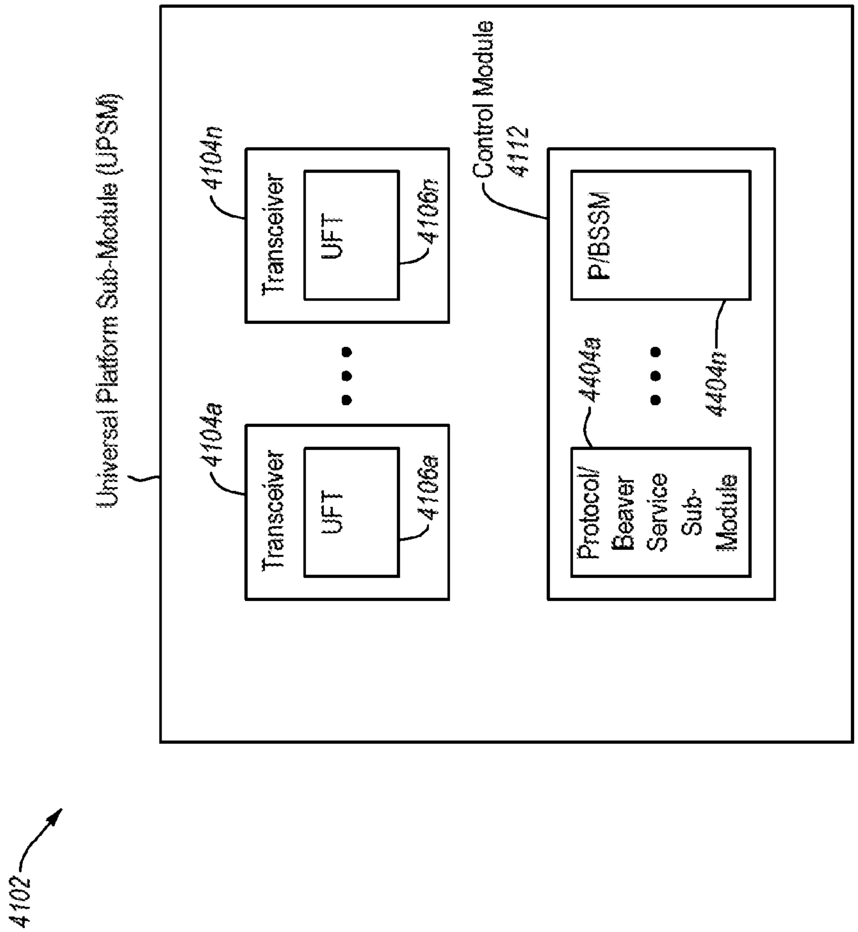

4102
Universal Platform Sub-Module (UPSM)
4104a
Transceiver
UFT
4106a
4104n
Transceiver
UFT
4106n
Control Module
4112
P/BSSM
4404a
4404n
Protocol/
Beaver
Service
Sub-
Module

FIG. 44

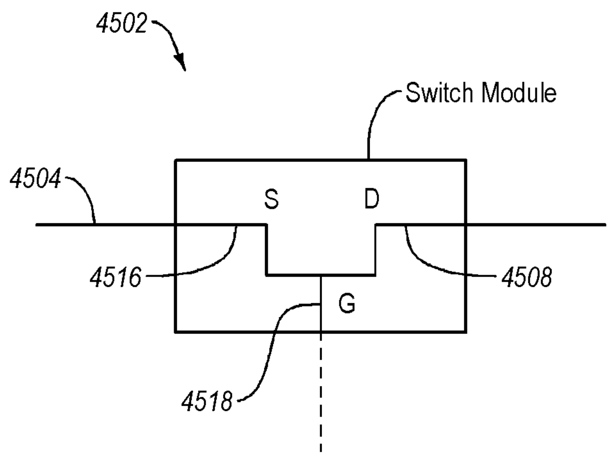



FIG. 45A

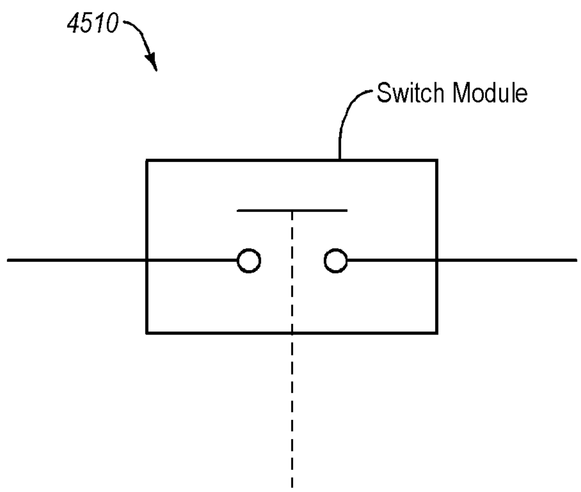



FIG. 45B

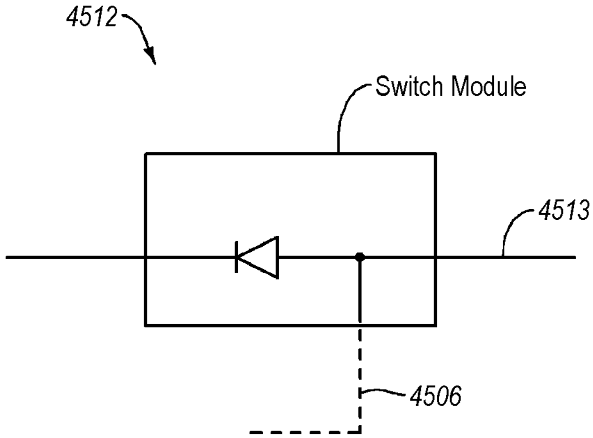



FIG. 45C

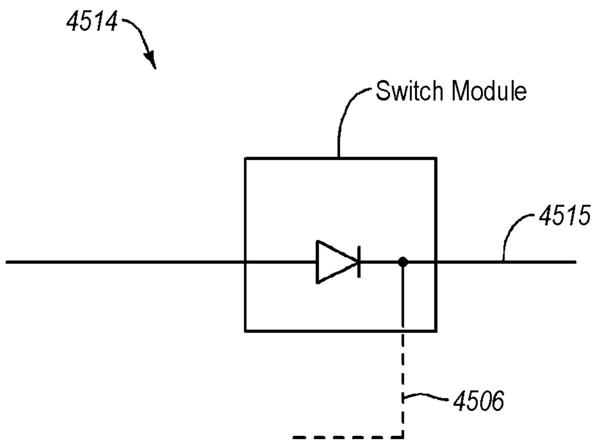
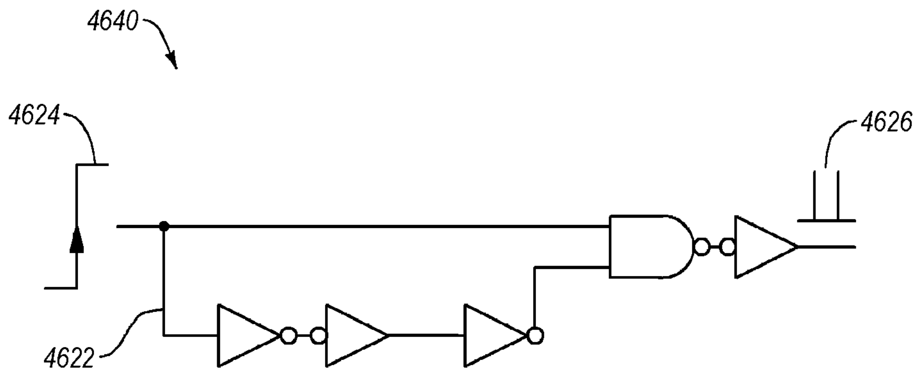
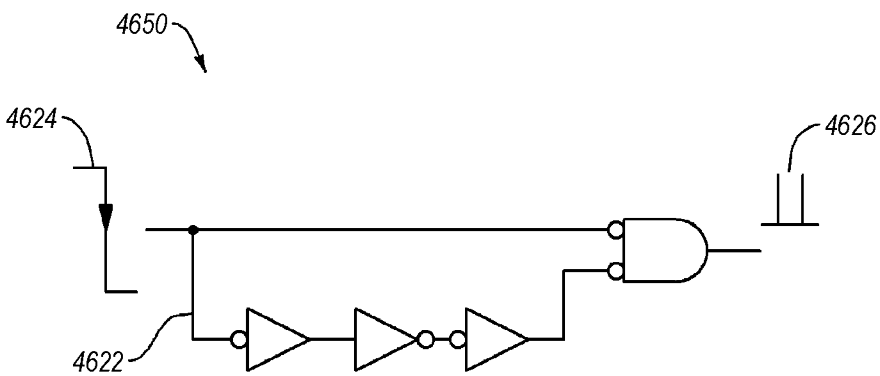



FIG. 45D




A. Rising Edge Pulse Generator

*FIG. 46A*




B. Falling-Edge Pulse Generator

*FIG. 46B*

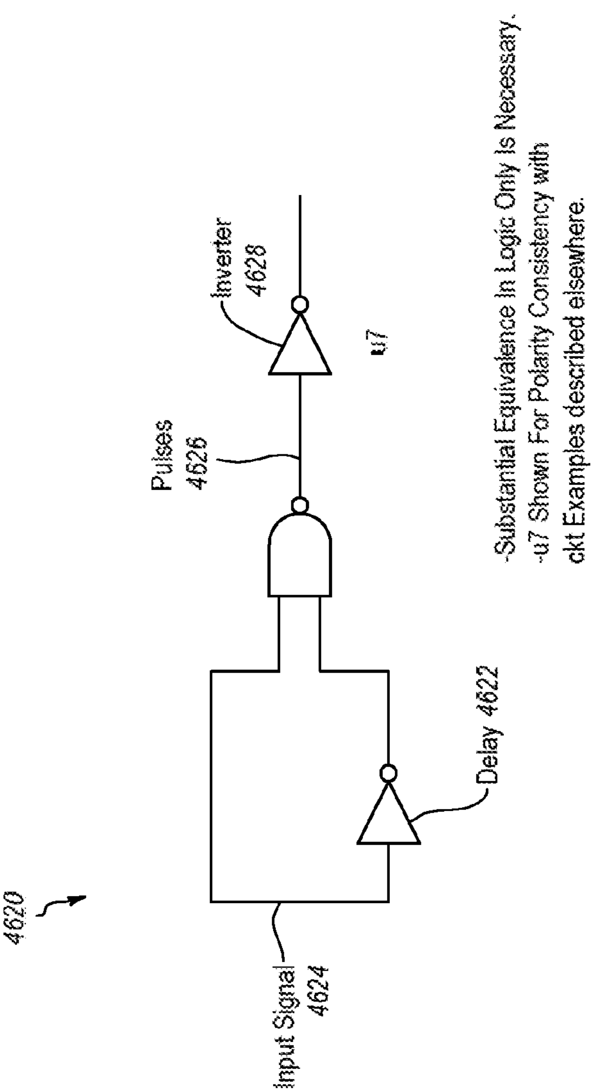

4620
Input Signal
4624
Delay 4622
Pulses
4626
Inverter
4628
u7
-Substantial Equivalence In Logic Only Is Necessary.
-u7 Shown For Polarity Consistency with
ckt Examples described elsewhere.

FIG. 46C

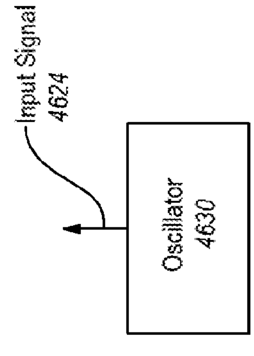



*FIG. 46E*

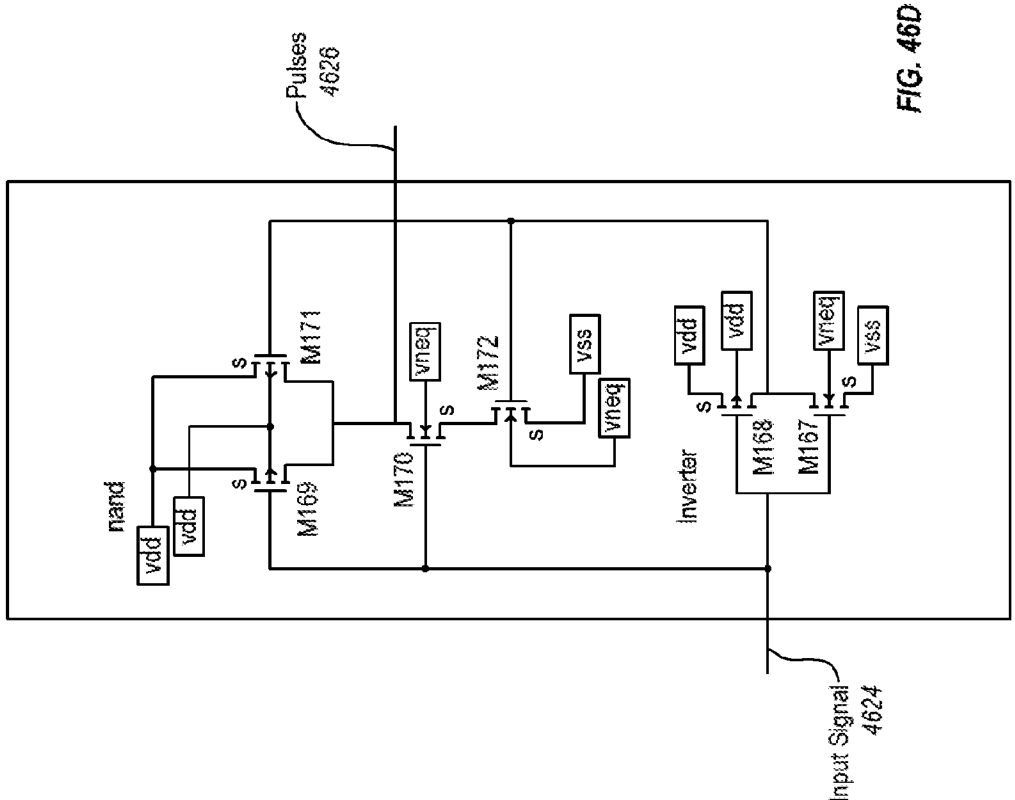



*FIG. 46D*

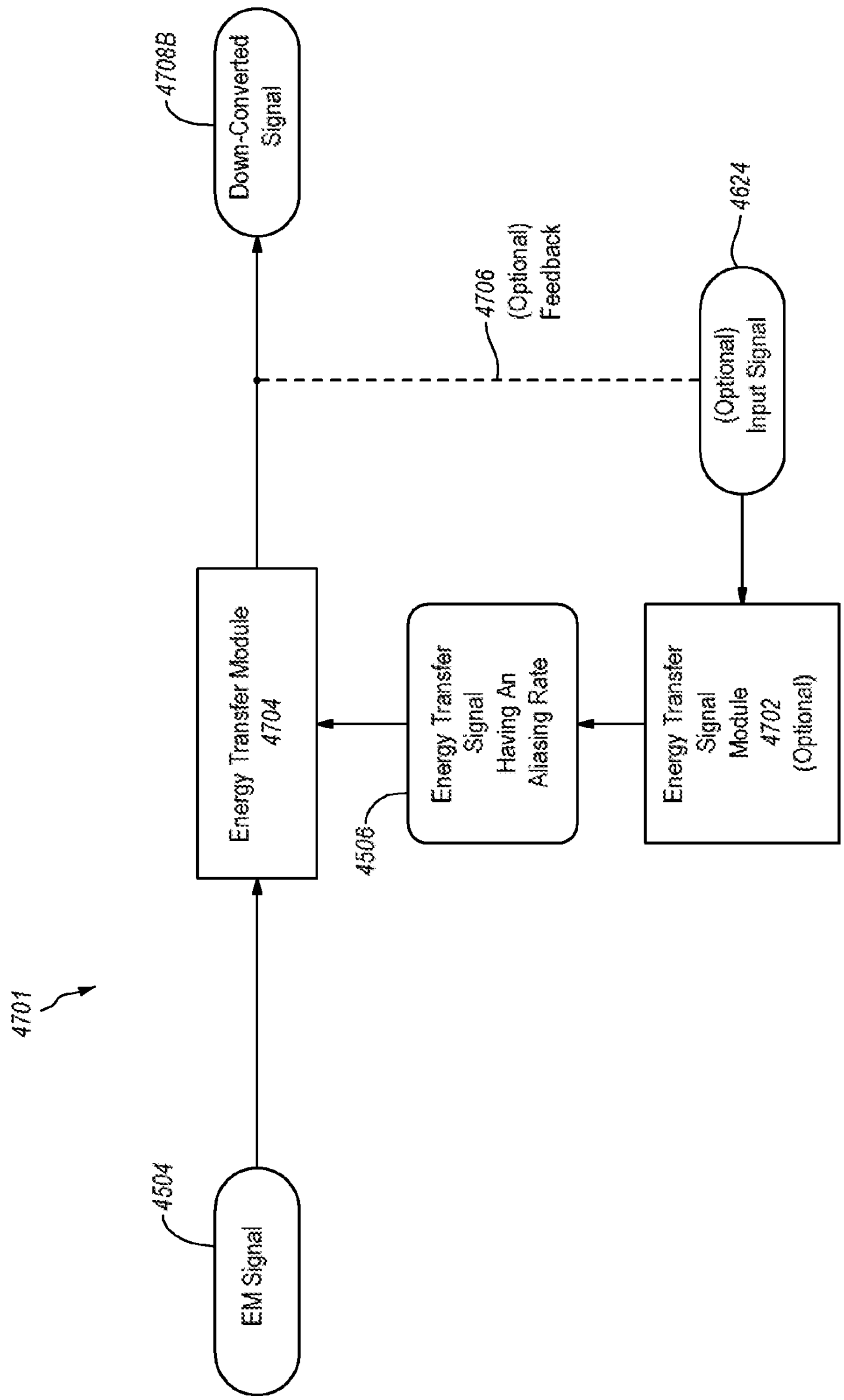

4701
4504
EM Signal
Energy Transfer Module
4704
4506
Energy Transfer Signal Having An Aliasing Rate
Energy Transfer Signal Module
4702
(Optional)
4708B
Down-Converted Signal
4706
(Optional) Feedback
4624
(Optional) Input Signal

FIG. 47

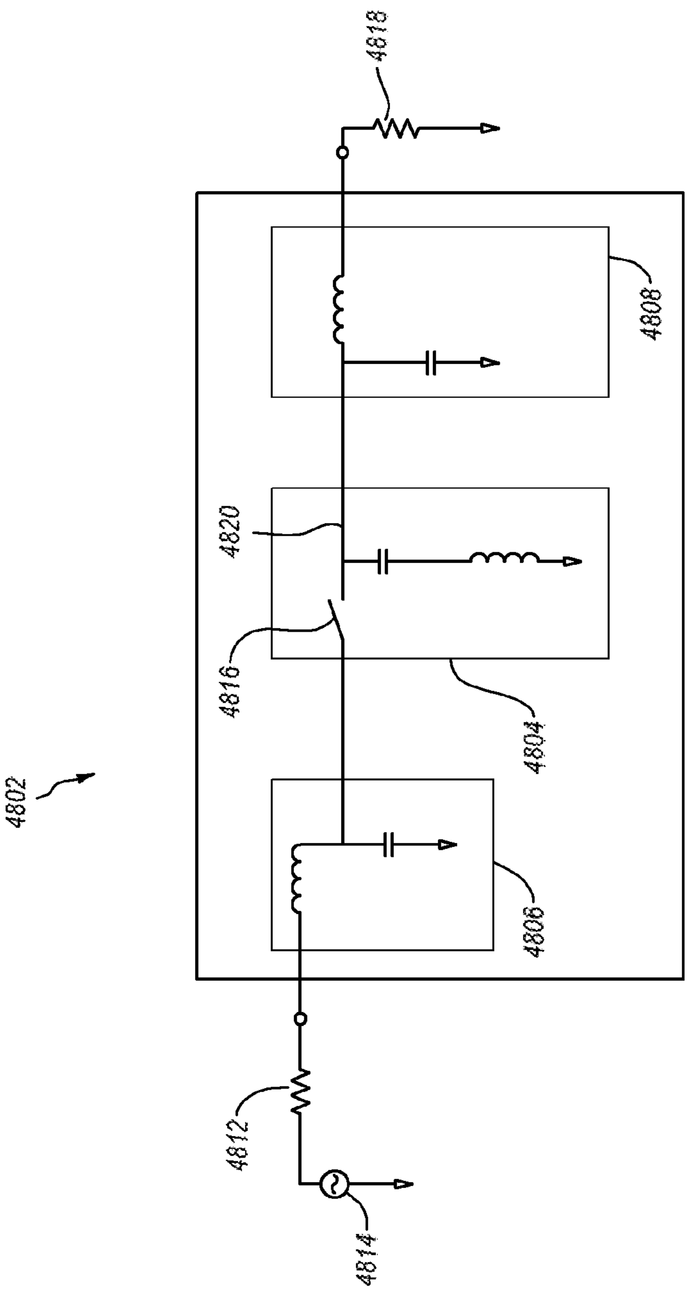



FIG. 48

Impedance Matched Aliasing Module

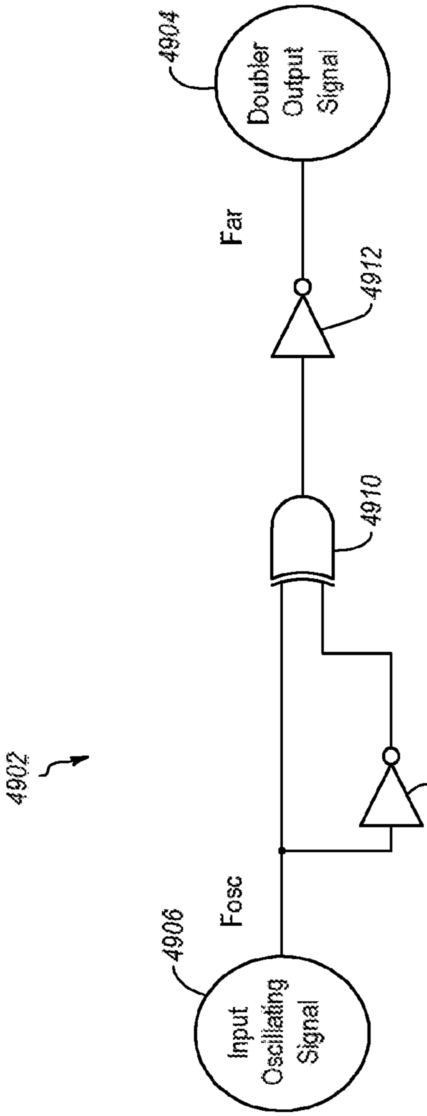

4902
Input Oscillating Signal
4906
Fosc
4908
4910
4912
Far
Doubler Output Signal
4904

FIG. 49A

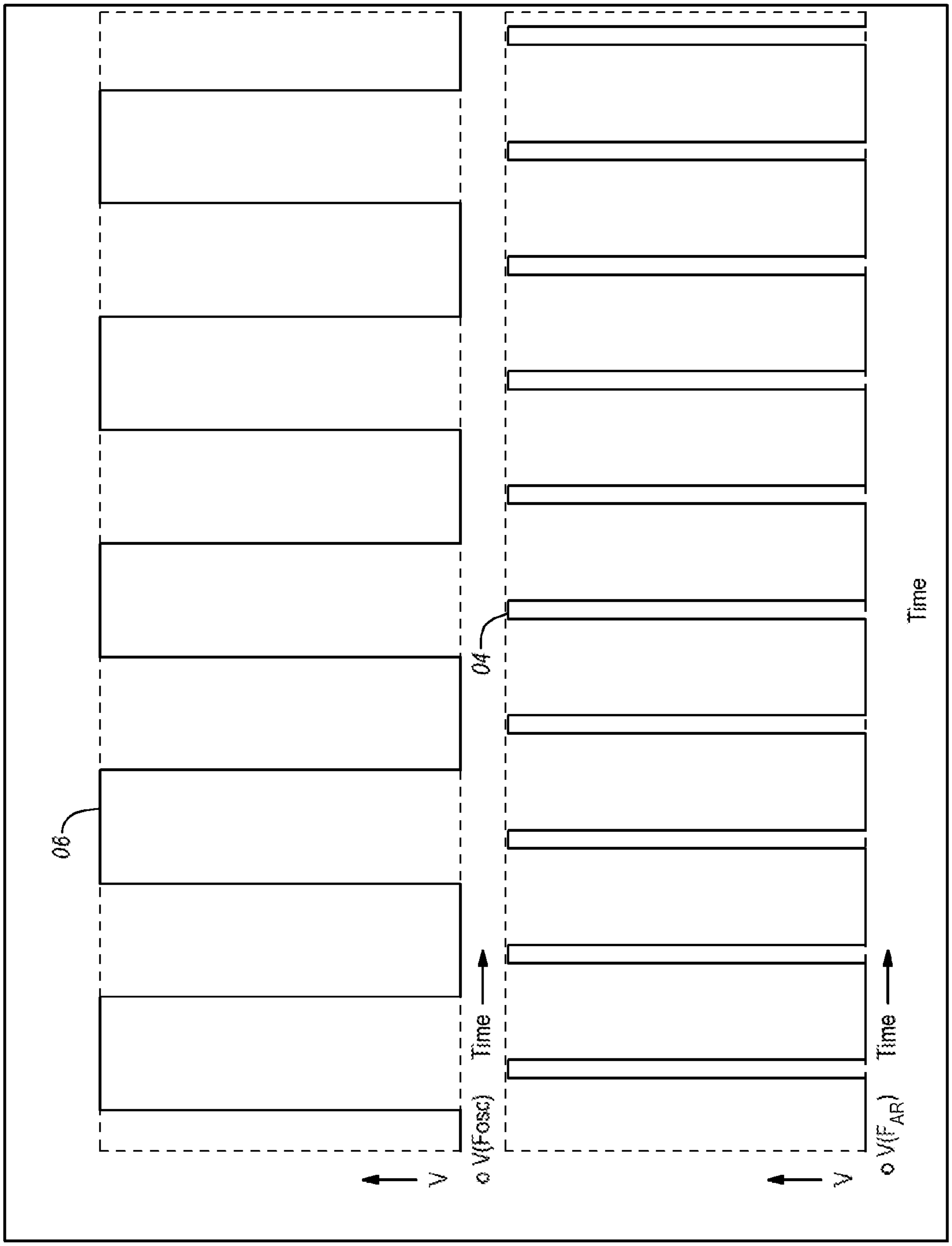



FIG. 49B

FIG. 49C

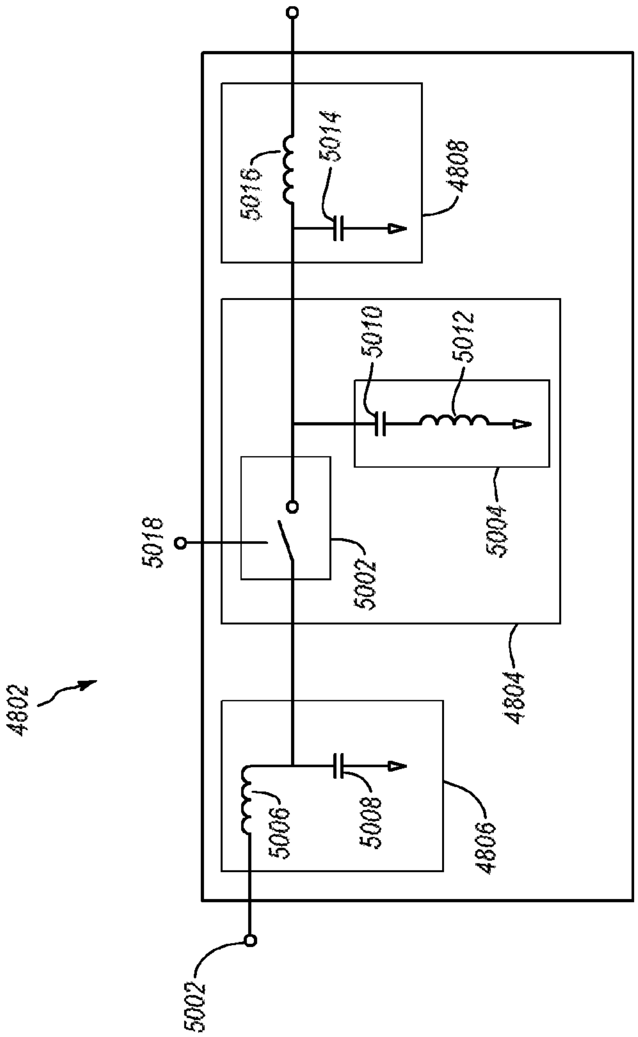



**FIG. 50**

Aliasing Module

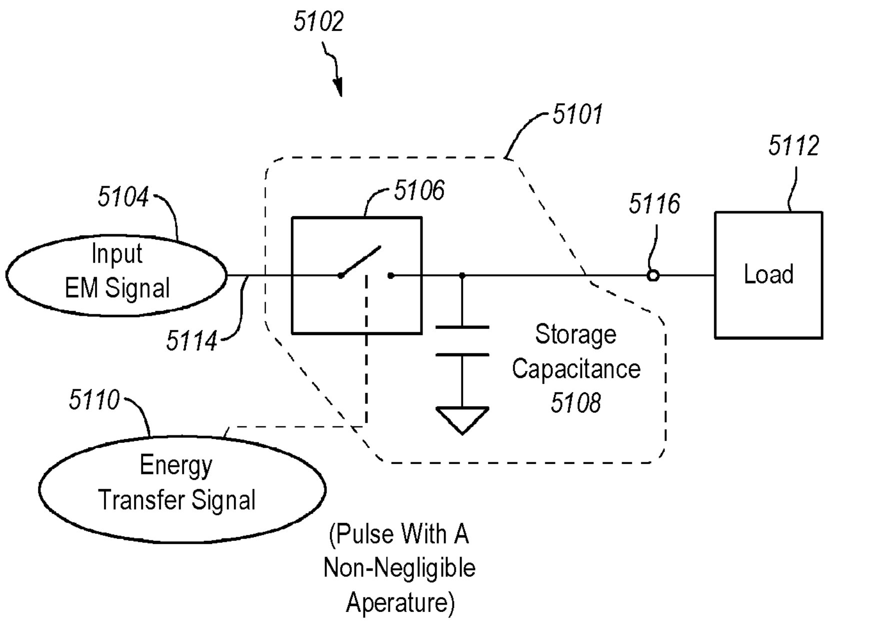



FIG. 51A

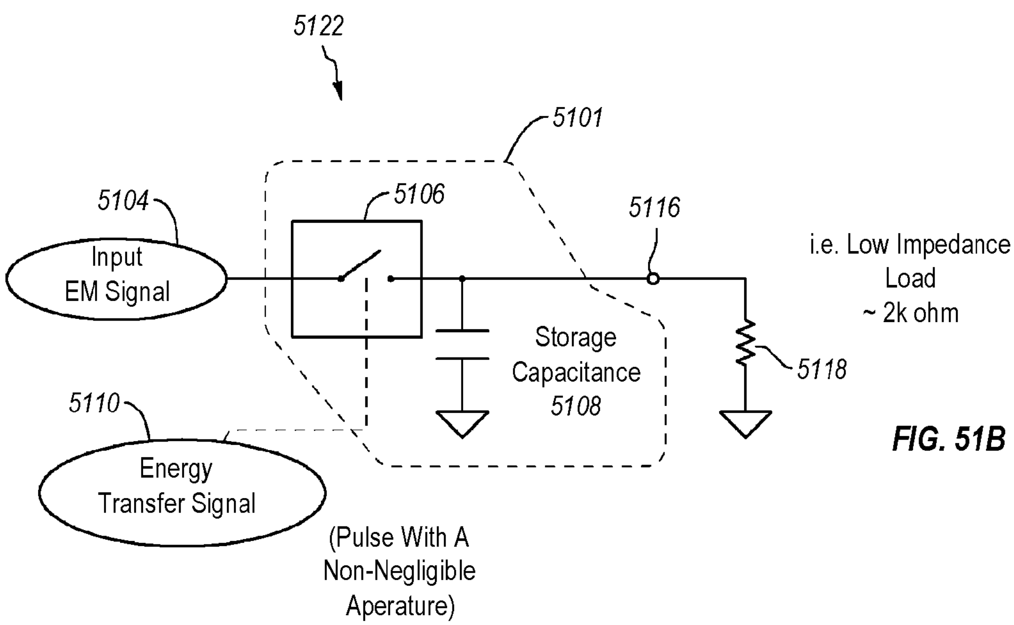



FIG. 51B

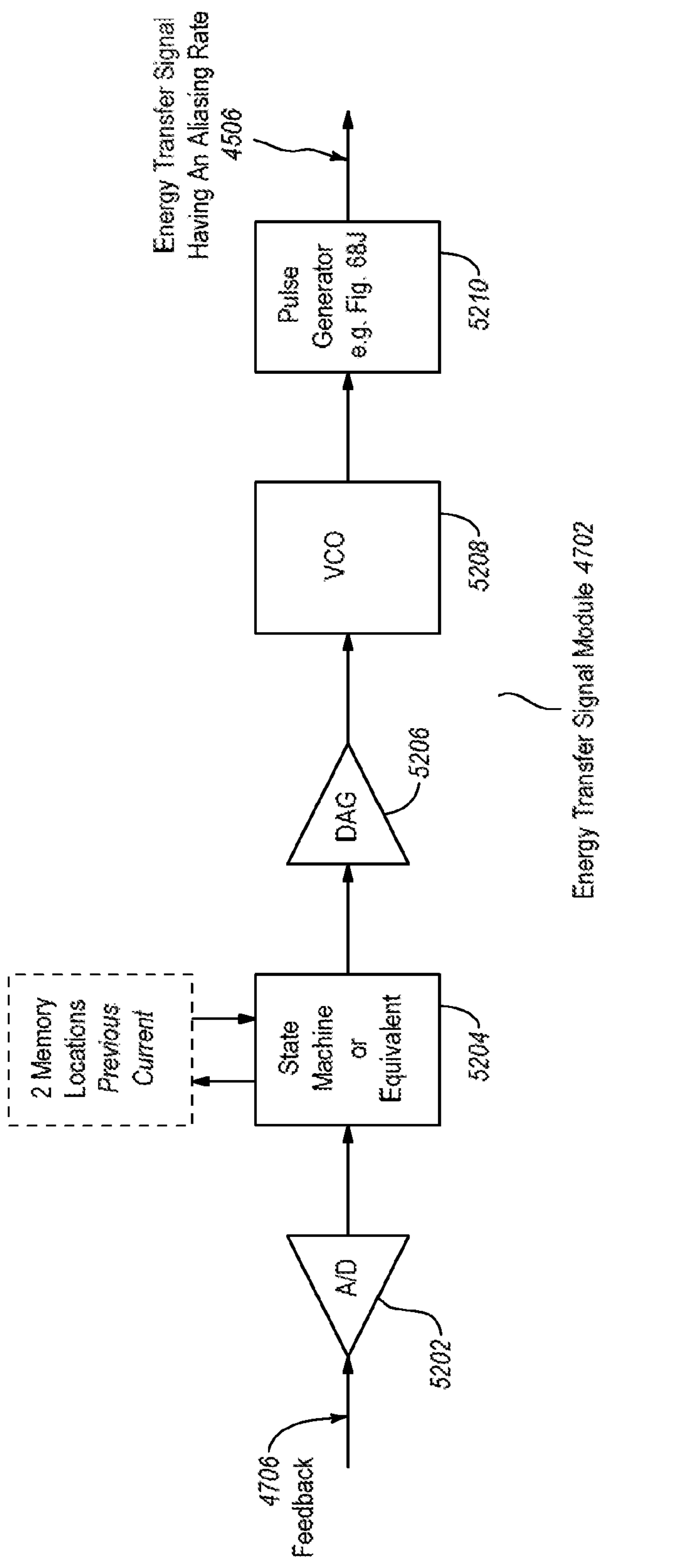
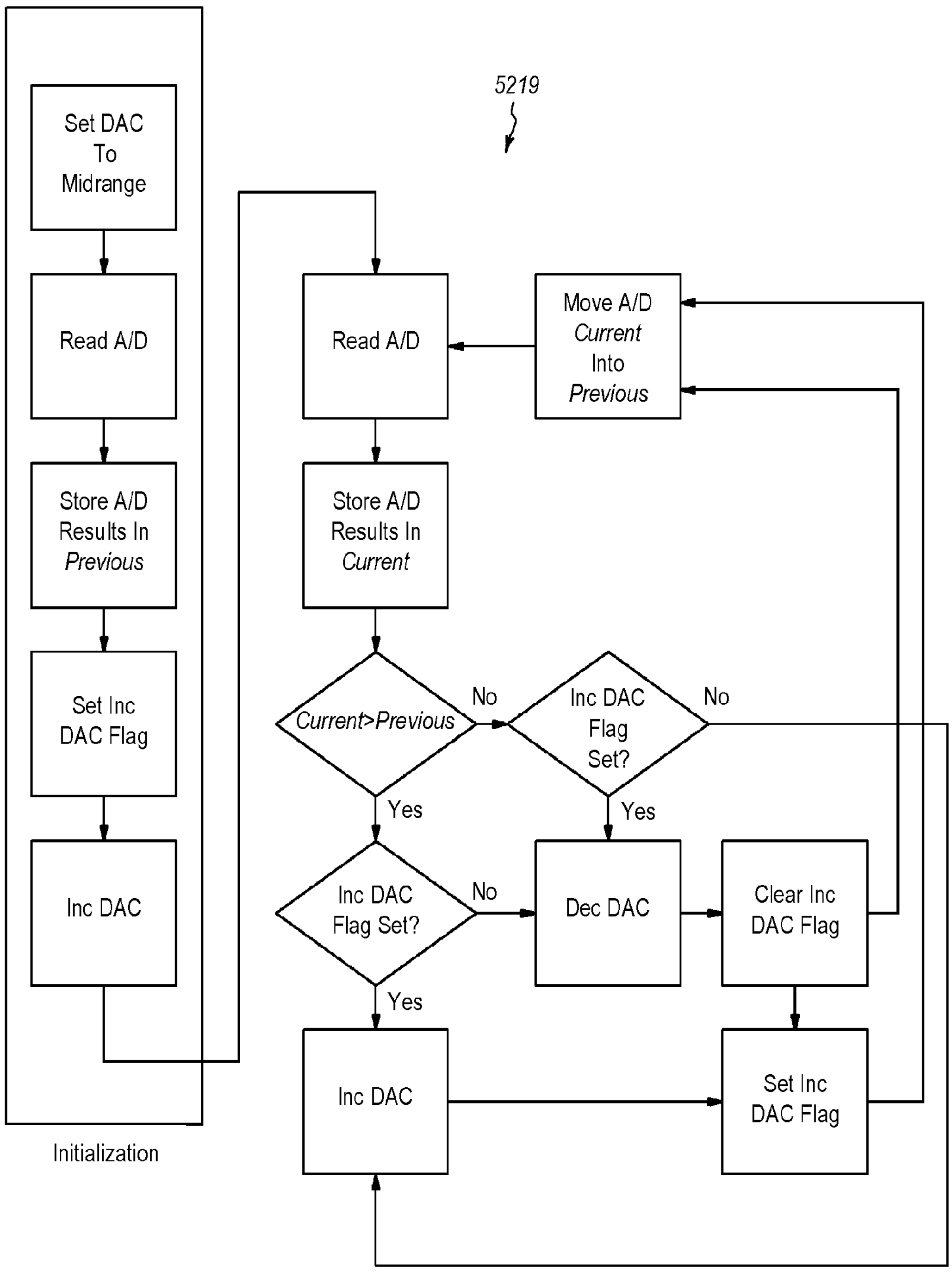
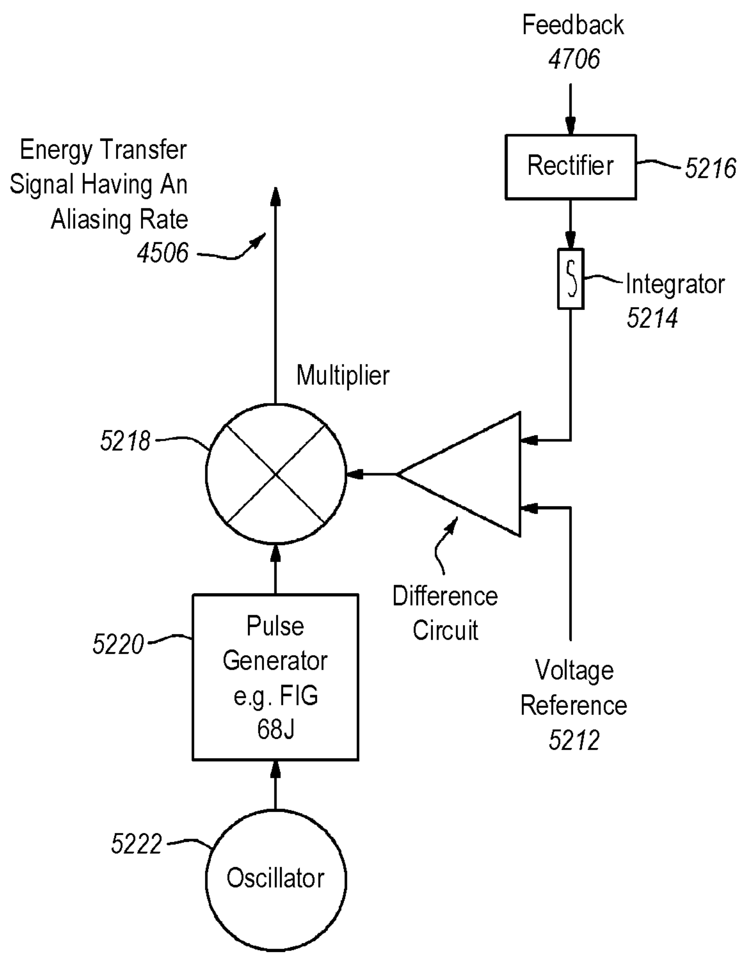

Feedback
4706
A/D
5202
State Machine or Equivalent
5204
2 Memory Locations
*Previous*
*Current*
DAG
5206
VCO
5208
Pulse Generator e.g. Fig. 68J
5210
Energy Transfer Signal Having An Aliasing Rate
4506
Energy Transfer Signal Module 4702

**FIG. 52A**




State Machine Flowchart

*FIG. 52B*




Energy Transfer Signal Module 4702

*FIG. 52C*

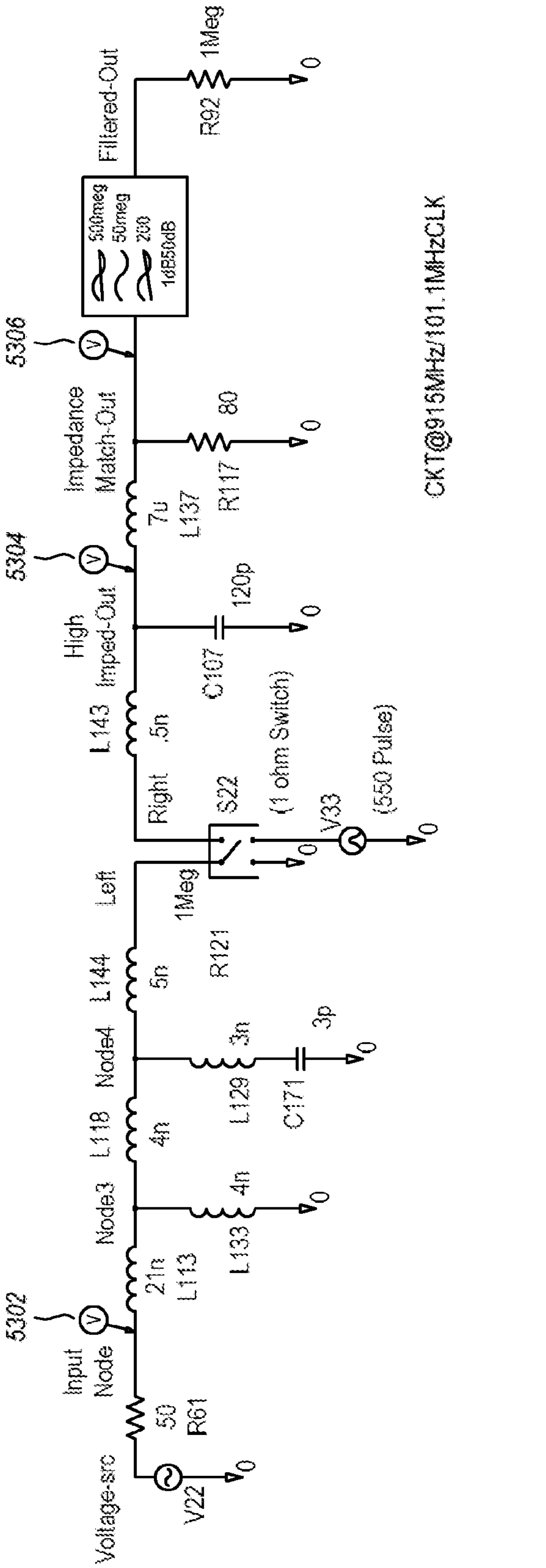

Voltage-src
V22
0
R61
50
Input Node
5302
21n
L113
Node3
L133
4n
0
L118
4n
Node4
L129
3n
C171
3p
0
L144
5n
R121
1Meg
Left
0
S22
(1 ohm Switch)
Right
V33
(550 Pulse)
0
L143
.5n
High Imped-Out
C107
120p
0
5304
7u
L137
Impedance Match-Out
R117
80
0
5306
500meg
50meg
200
1dB50dB
Filtered-Out
R92
1Meg
0
CKT@915MHz/101.1MHzCLK

*FIG. 53*

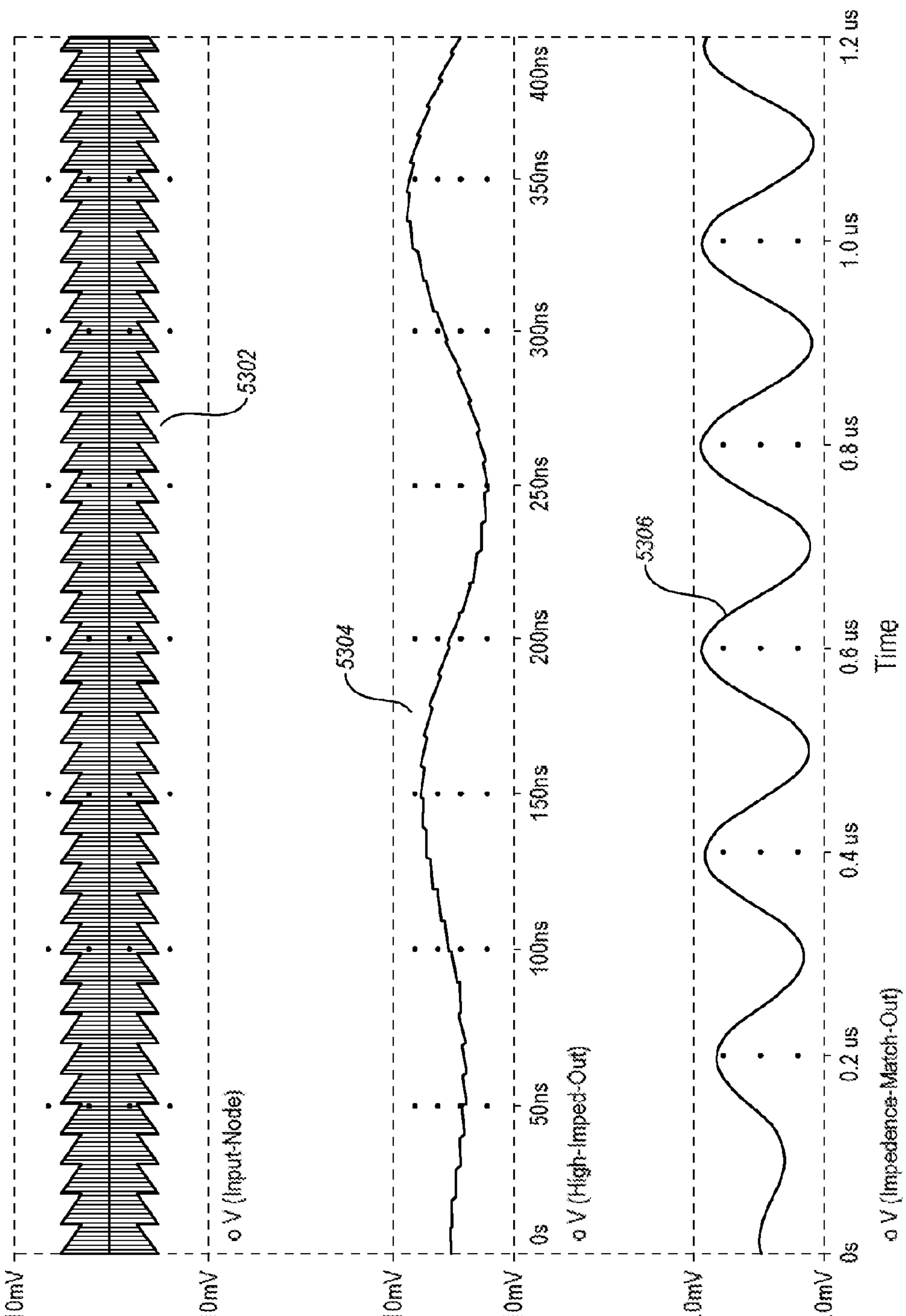

10mV
-10mV
o V (Input-Node)
5302
10mV
-10mV
o V (High-Imped-Out)
5304
0s
50ns
100ns
150ns
200ns
250ns
300ns
350ns
400ns
2.0mV
-2.0mV
o V (Impedence-Match-Out)
5306
0s
0.2 us
0.4 us
0.6 us
0.8 us
1.0 us
1.2 us
Time

*FIG. 54*

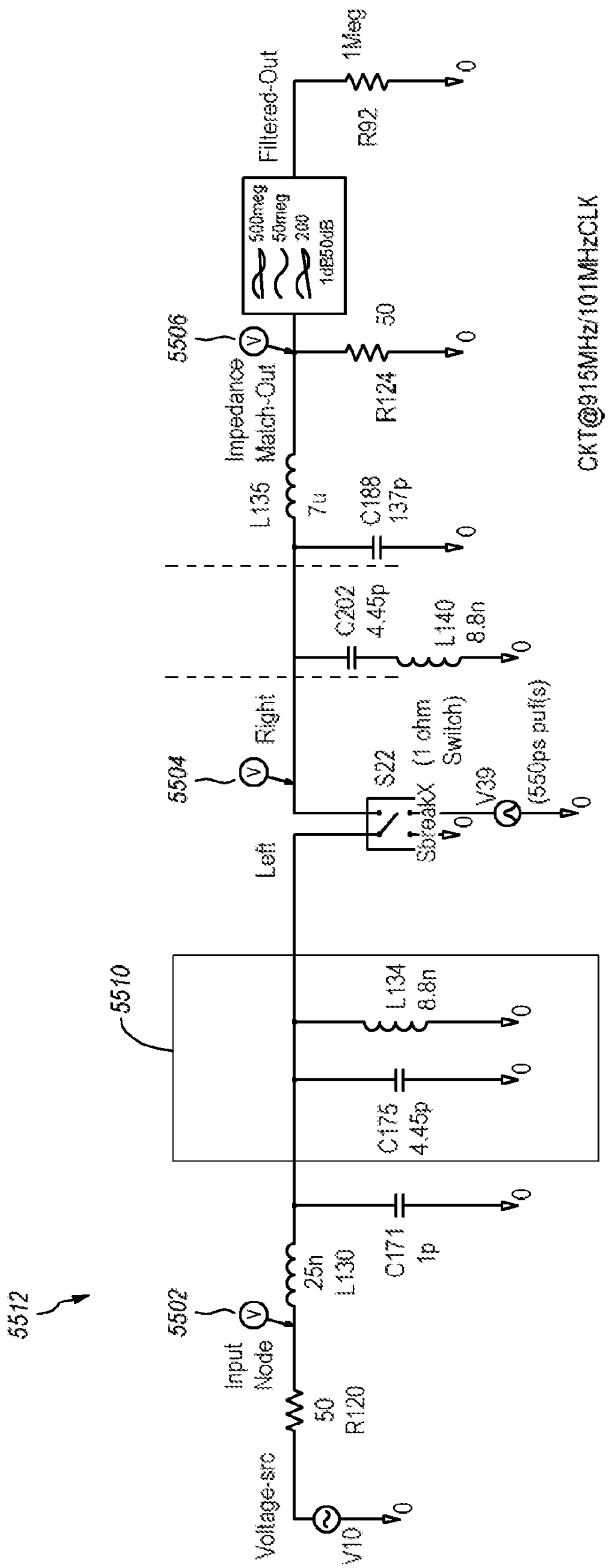
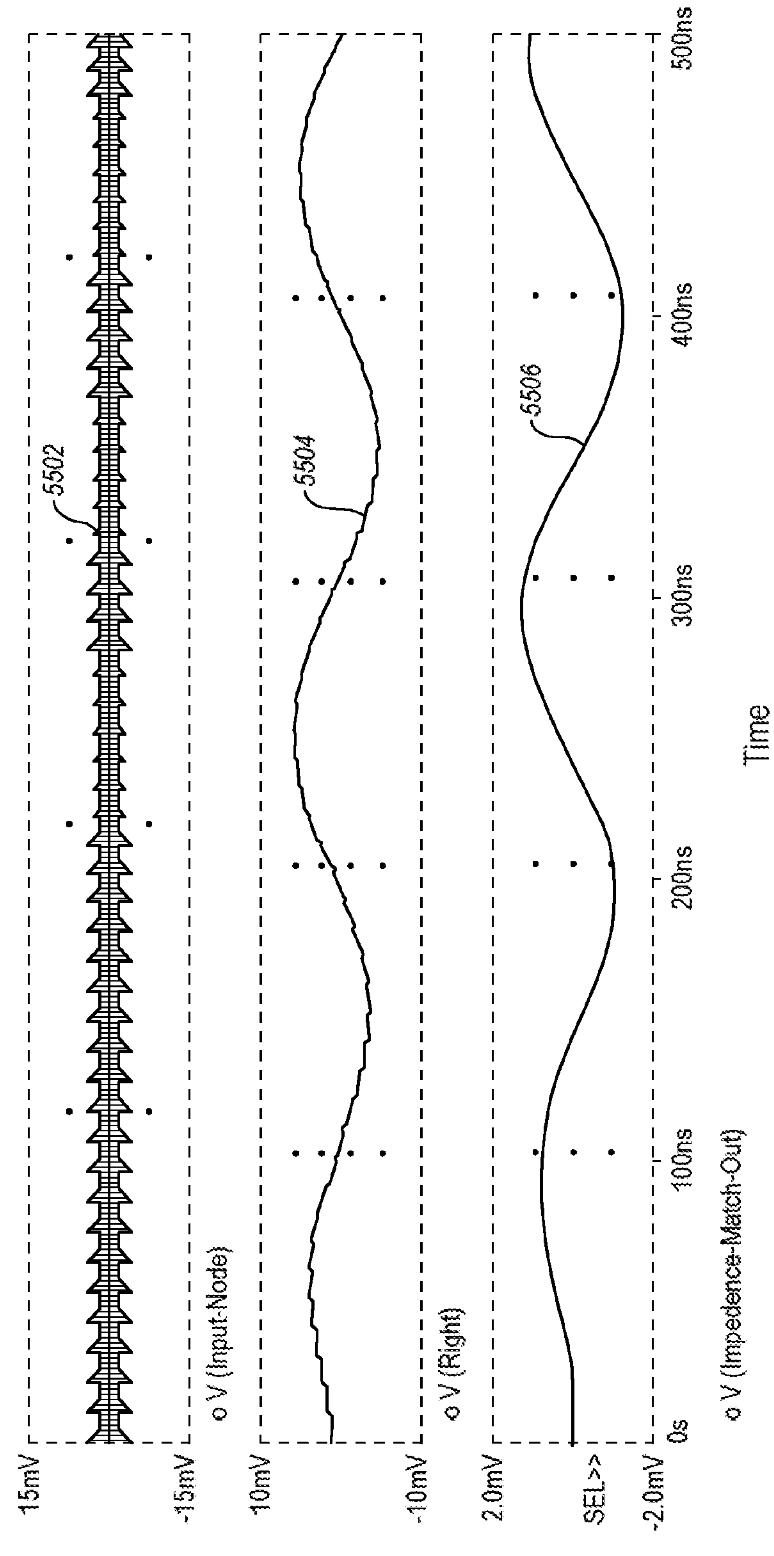

5512
Voltage-src
V10
0
50
R120
Input Node
5502
25n
L130
C171
1p
5510
C175
4.45p
L134
8.8n
Left
S22
SbreakX
(1 ohm Switch)
V39
(550ps puf(s))
5504
Right
C202
4.45p
L140
8.8n
L135
7u
C188
137p
Impedance Match-Out
5506
R124
50
500meg
50meg
200
1dB50dB
Filtered-Out
R92
1Meg
CKT@915MHz/101MHzCLK

*FIG. 55*



15mV
-15mV
o V (Input-Node)
5502
10mV
-10mV
o V (Right)
5504
2.0mV
SEL>>
-2.0mV
o V (Impedence-Match-Out)
5506
0s
100ns
200ns
300ns
400ns
500ns
Time


*FIG. 56*

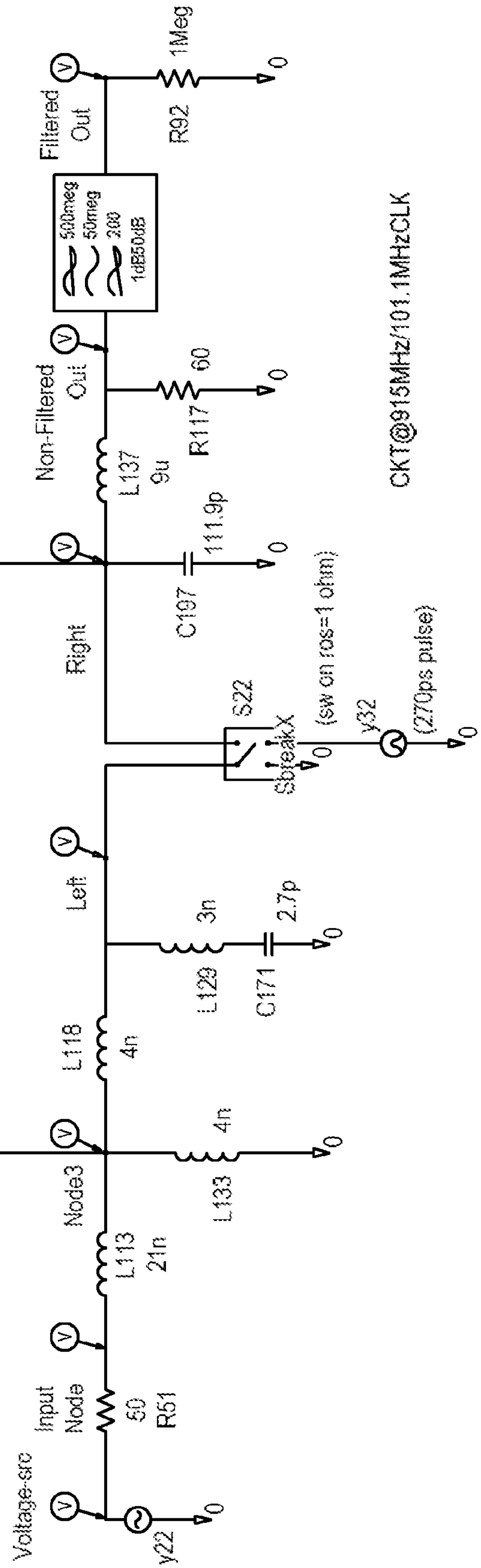

Voltage-src
y22
Input
Node
50
R51
L113
21n
Node3
L133
4n
L118
4n
C200
1.3p
L129
3n
C171
2.7p
Left
L141
4n
S22
SbreakX
(sw on ros=1 ohm)
y32
(270ps pulse)
Right
C197
111.9p
L137
9u
Non-Filtered
Out
R117
60
500meg
50meg
2.00
1dB50dB
Filtered
Out
R92
1Meg
CKT@915MHz/101.1MHzCLK

FIG. 57

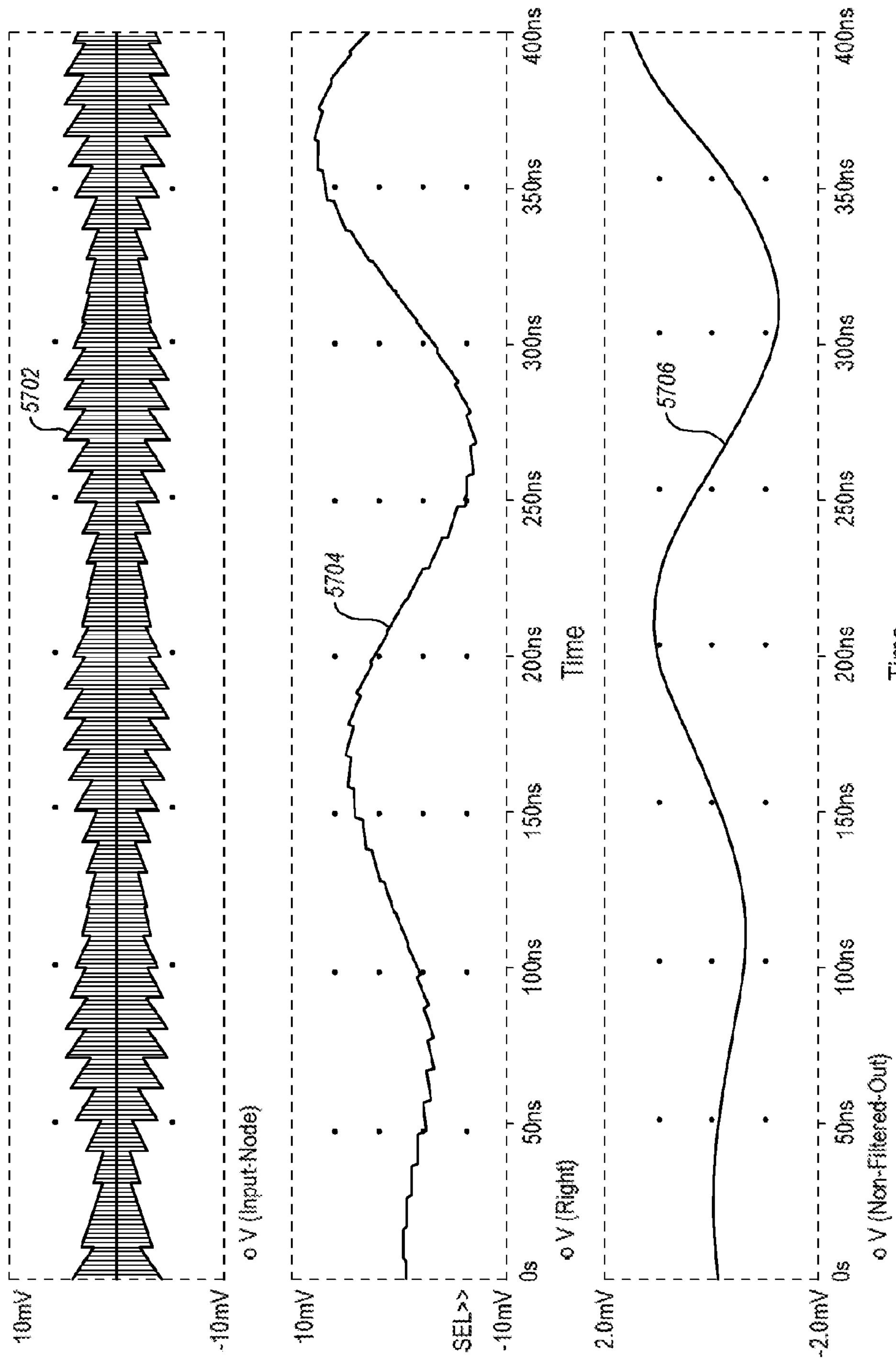

10mV
-10mV
o V (Input-Node)
5702
10mV
SEL>>
-10mV
o V (Right)
5704
0s
50ns
100ns
150ns
200ns
250ns
300ns
350ns
400ns
Time
2.0mV
-2.0mV
o V (Non-Filtered-Out)
5706
0s
50ns
100ns
150ns
200ns
250ns
300ns
350ns
400ns
Time

*FIG. 58*

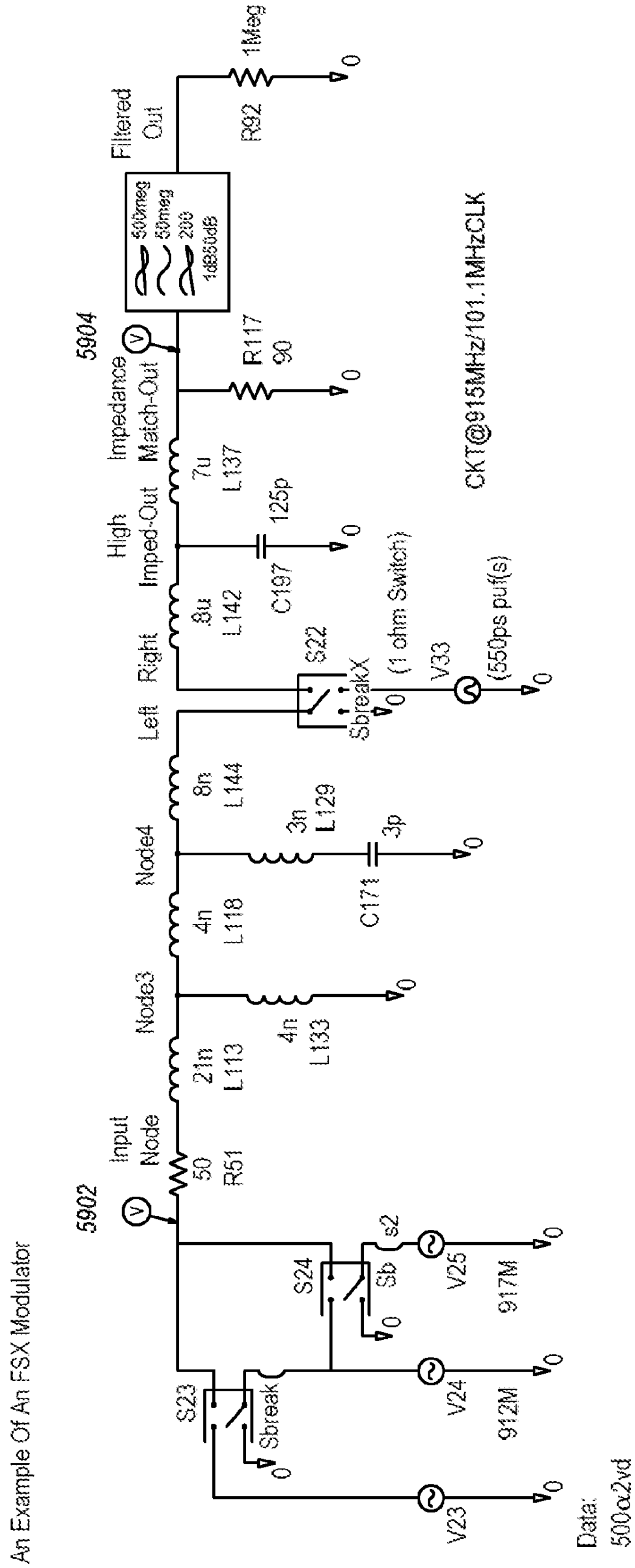
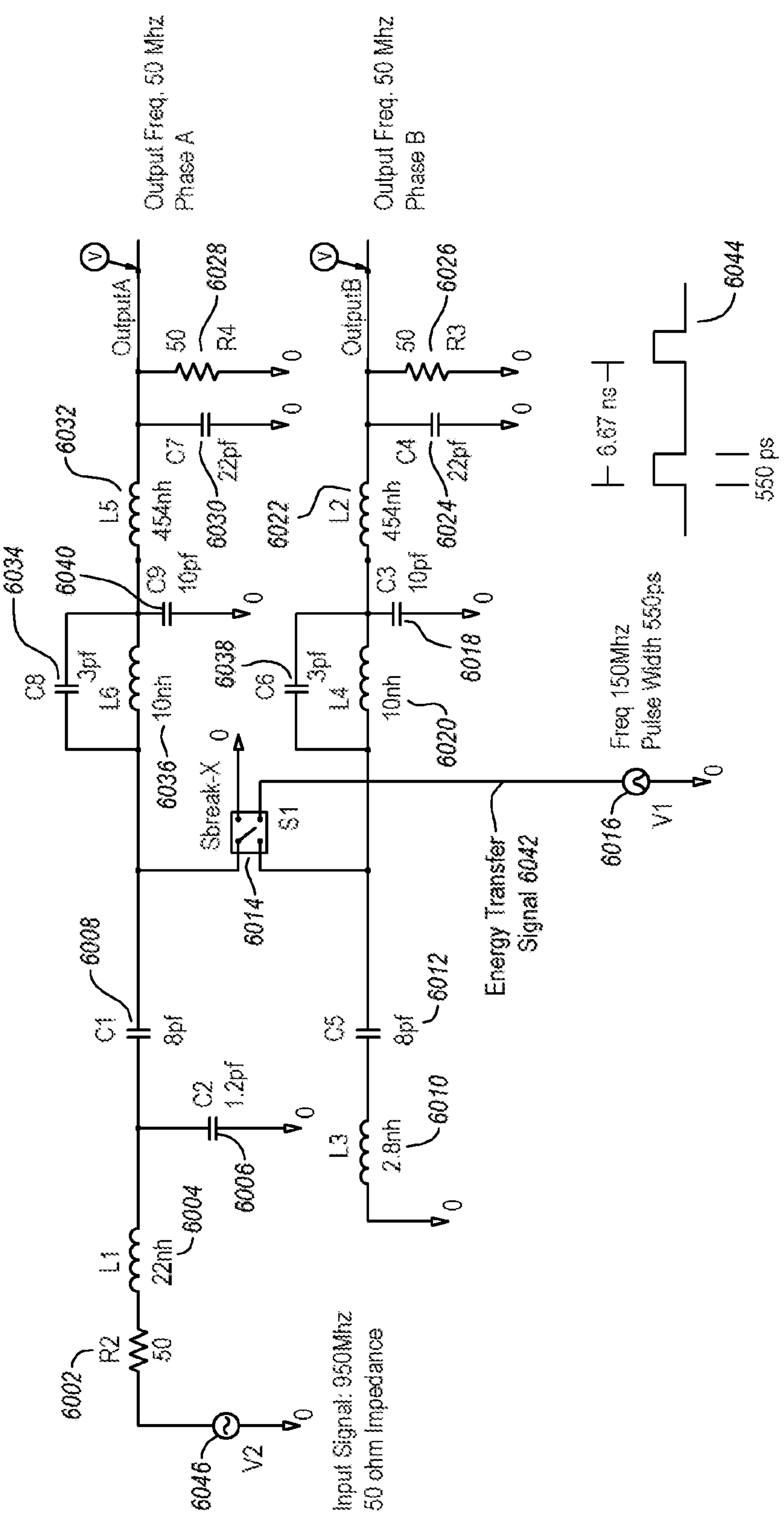

An Example Of An FSX Modulator
5902
V
Input
Node
50
R51
21n
L113
Node3
4n
L133
4n
L118
Node4
3n
L129
3p
C171
8n
L144
Left
Right
S22
SbreakX
(1 ohm Switch)
V33
(550ps puf(s))
8u
L142
High
Imped-Out
C197
125p
7u
L137
Impedance
Match-Out
R117
90
5904
V
500meg
50meg
200
1d850dB
Filtered
Out
R92
1Meg
CKT@915MHz/101.1MHzCLK
S23
Sbreak
S24
Sb
s2
V23
V24
912M
V25
917M
Data:
500ɑ2vd
0

FIG. 59



Output Freq. 50 Mhz
Phase A
Output Freq. 50 Mhz
Phase B
OutputA
OutputB
50
R4
6028
50
R3
6026
6032
L5
454nh
C7
6030
22pf
6022
L2
454nh
C4
6024
22pf
6.67 ns
550 ps
6044
6034
6040
C9
10pf
C8
3pf
L6
10nh
6036
6038
C6
3pf
L4
10nh
6020
C3
10pf
6018
Sbreak-X
S1
6014
Energy Transfer
Signal 6042
Freq 150Mhz
Pulse Width 550ps
6016
V1
C1
6008
8pf
C5
8pf
6012
C2
1.2pf
6006
L3
2.8nh
6010
L1
22nh
6004
R2
50
6002
6046
V2
Input Signal: 950Mhz
50 ohm Impedance
0


FIG. 60A

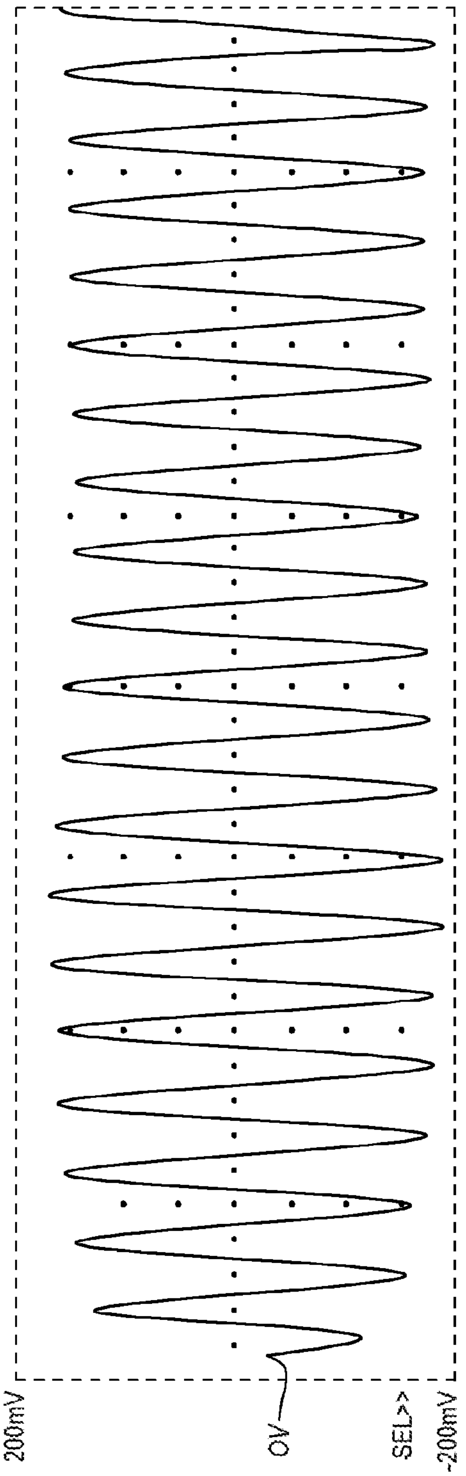



FIG. 60B

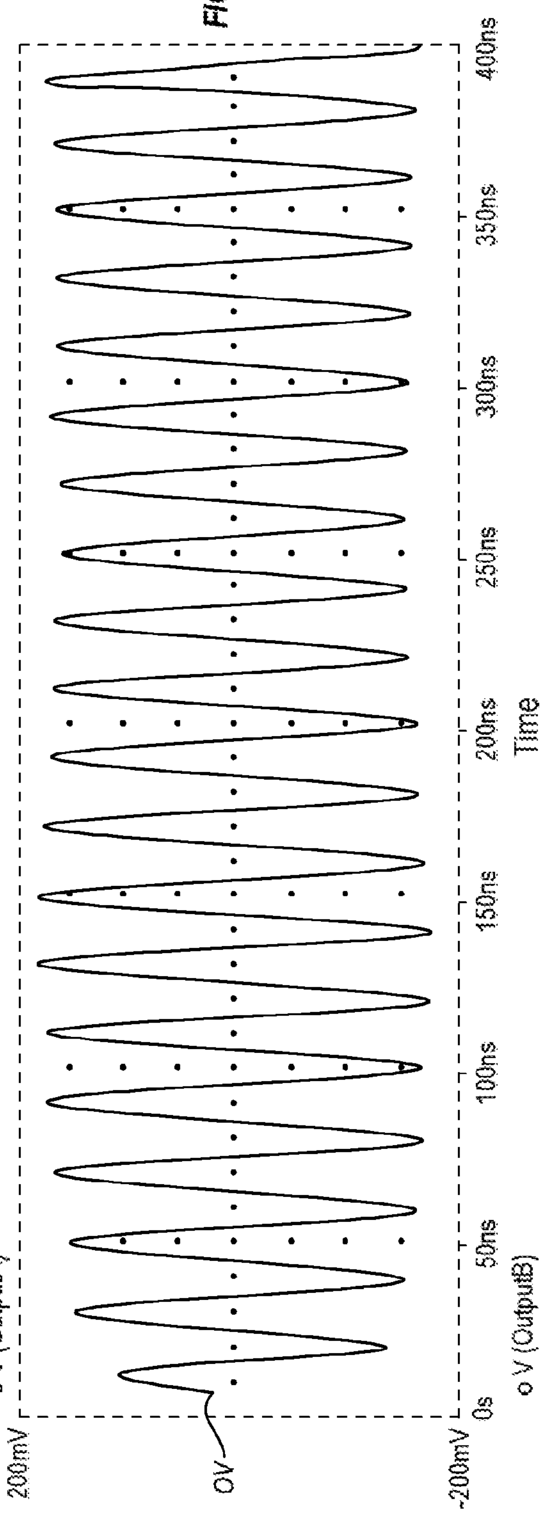



FIG. 60C

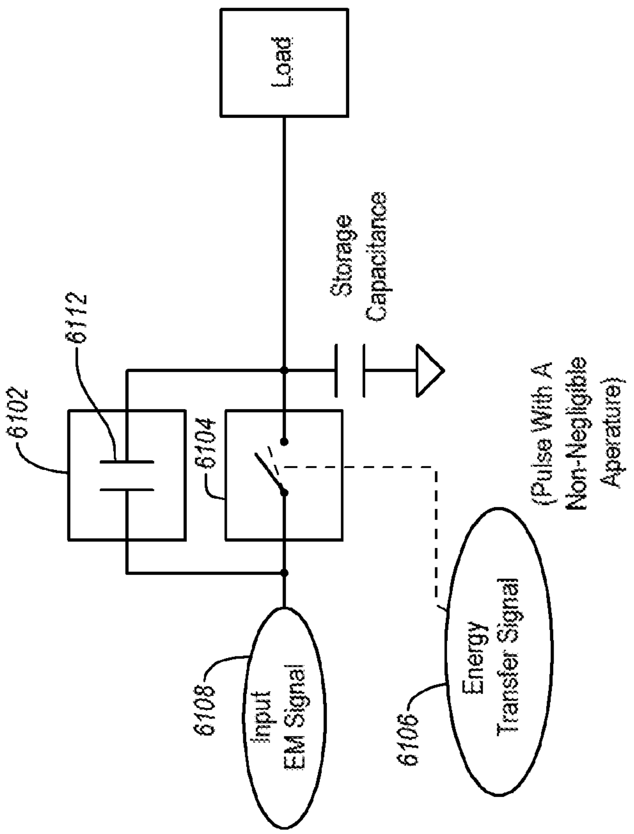

Load
Storage
Capacitance
6112
6102
6104
Input
EM Signal
6108
Energy
Transfer Signal
6106
(Pulse With A
Non-Negligible
Aperature)

FIG. 61

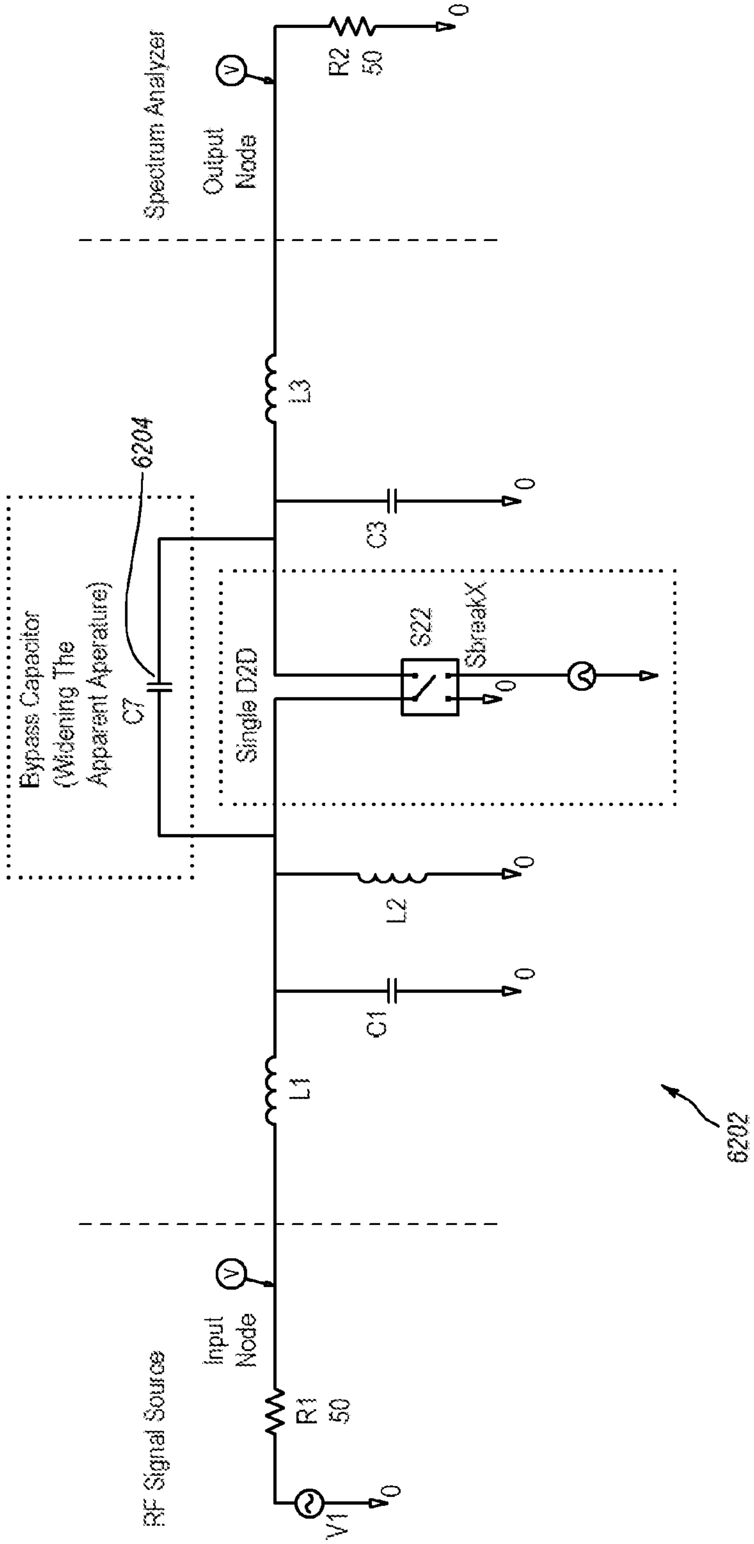
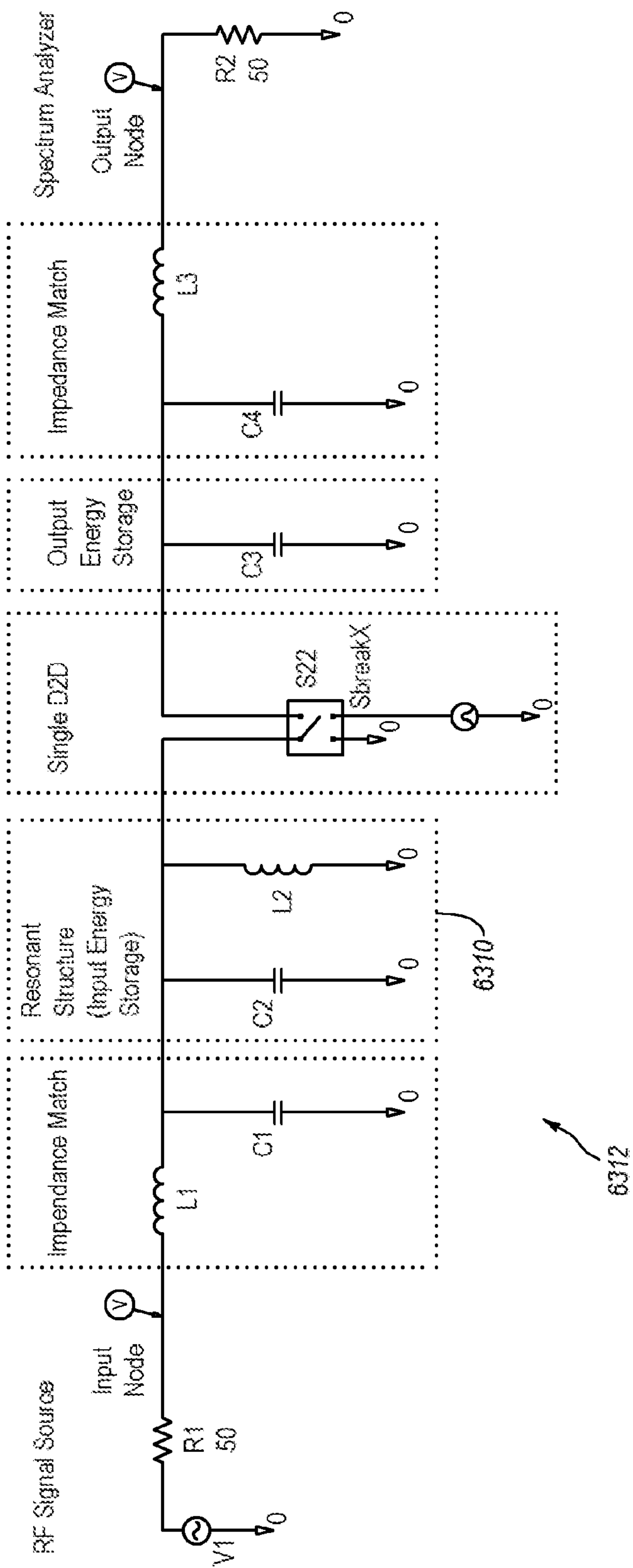

Spectrum Analyzer
Output Node
R2
50
L3
6204
Bypass Capacitor
(Widening The
Apparent Aperature)
C7
C3
Single D2D
S22
SbreakX
L2
C1
L1
6202
RF Signal Source
Input Node
R1
50
V1

*FIG. 62*



RF Signal Source
V1
0
R1
50
Input
Node
V
Impendance Match
L1
C1
0
Resonant
Structure
(Input Energy
Storage)
C2
0
L2
0
6310
6312
Single D2D
S22
SbreakX
0
0
Output
Energy
Storage
C3
0
Impedance Match
C4
0
L3
Output
Node
V
Spectrum Analyzer
R2
50
0


FIG. 63

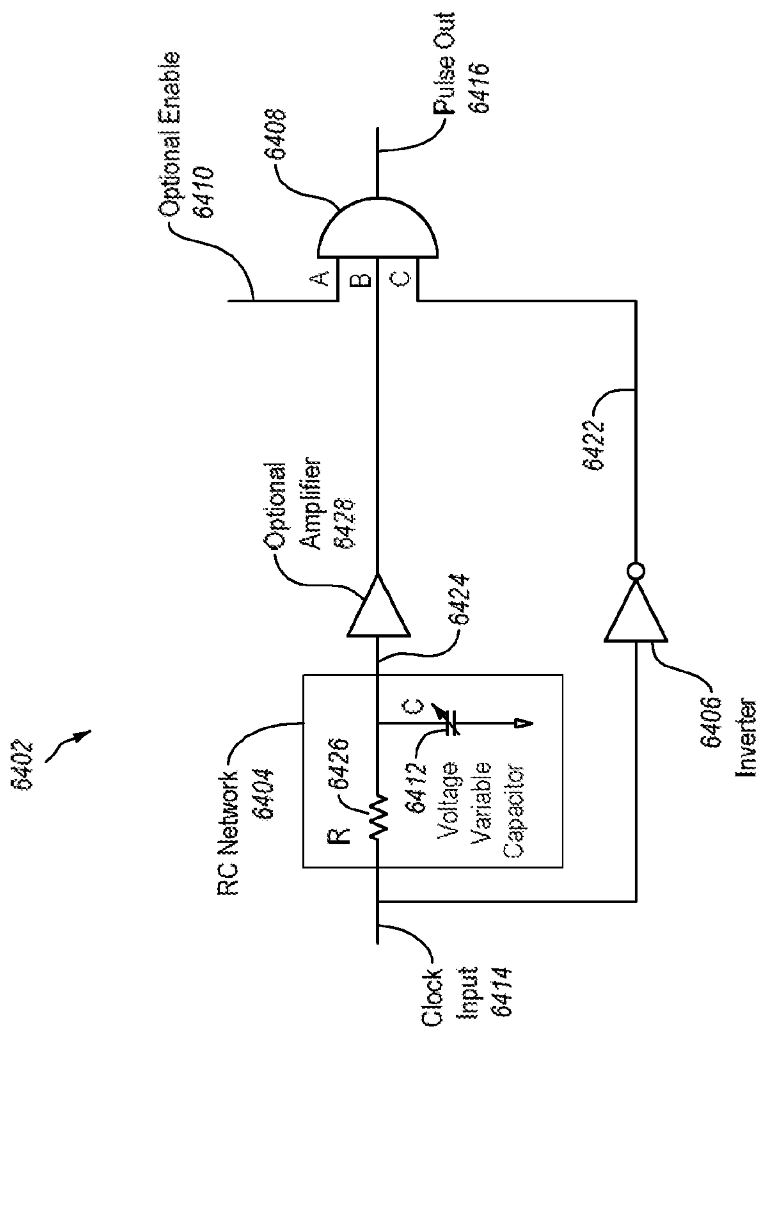

6402
RC Network
6404
R
6426
C
6412
Voltage
Variable
Capacitor
Clock
Input
6414
6424
Optional
Amplifier
6428
6406
Inverter
6422
Optional Enable
6410
A
B
C
6408
Pulse Out
6416

FIG. 64A

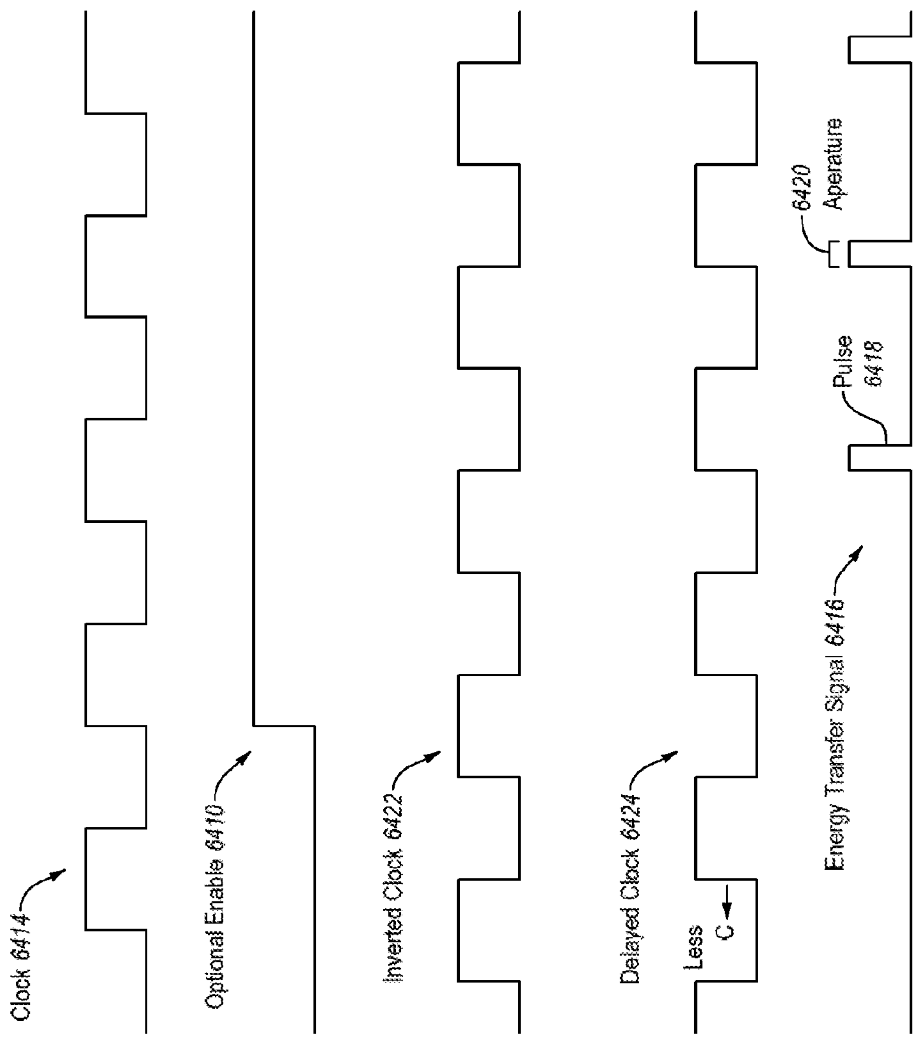


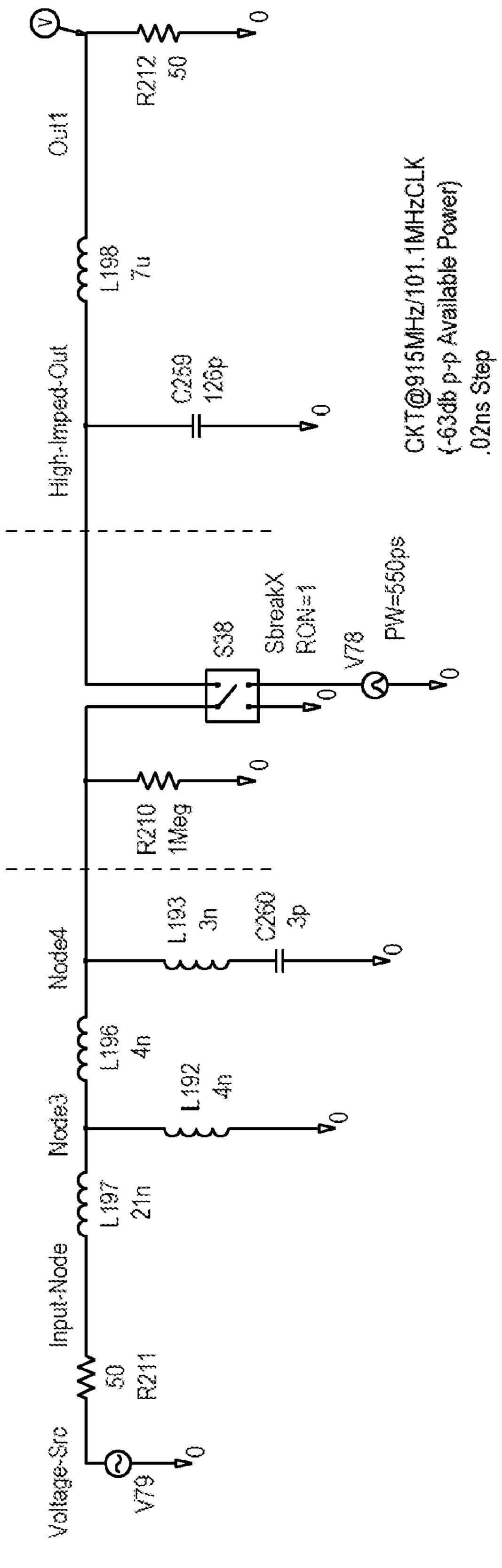

FIG. 64B

FIG. 64C

FIG. 64D

FIG. 64E

FIG. 64F



V
Out1
R212
50
0
L198
7u
High-Imped-Out
C259
126p
0
CKT@915MHz/101.1MHzCLK
(-63db p-p Available Power)
.02ns Step
S38
SbreakX
RON=1
V78
PW=550ps
0
0
R210
1Meg
0
Node4
L193
3n
C260
3p
0
L196
4n
Node3
L192
4n
0
L197
21n
Input-Node
50
R211
Voltage-Src
V79
0


FIG. 65

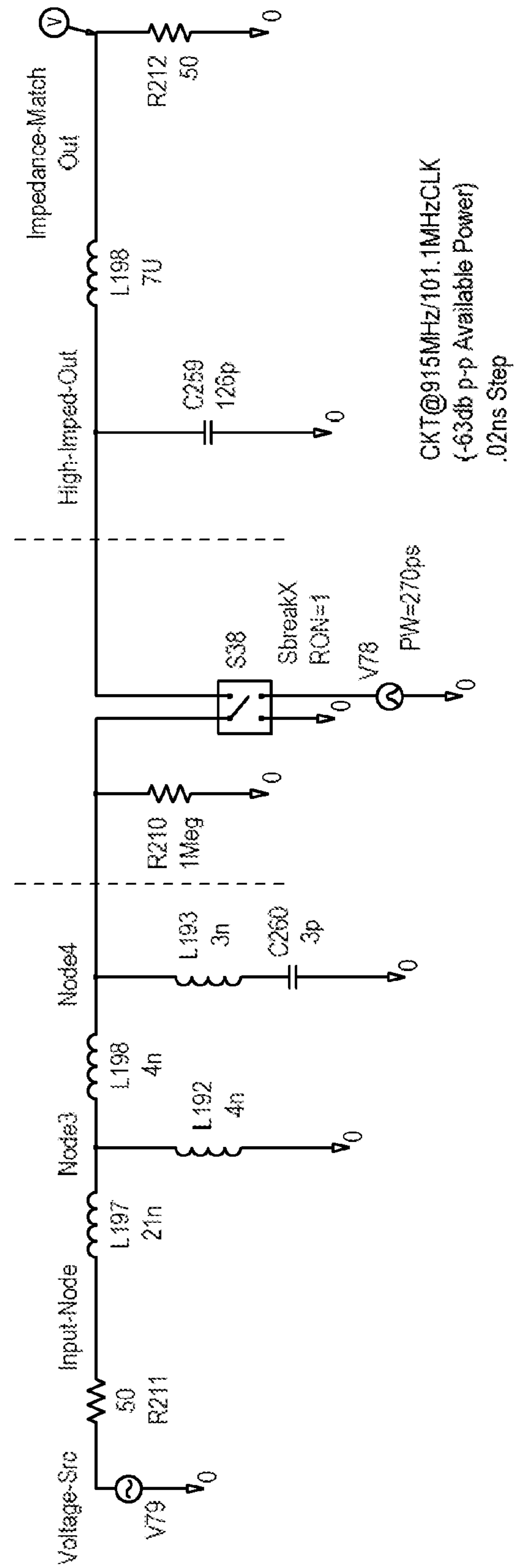

V
R212
50
0
Impedance-Match
Out
L198
7U
CKT@915MHz/101.1MHzCLK
(-63db p-p Available Power)
.02ns Step
High-Imped-Out
C259
126p
0
S38
SbreakX
RON=1
V78
PW=270ps
0
0
R210
1Meg
0
Node4
L193
3n
C260
3p
0
L198
4n
Node3
L192
4n
0
L197
21n
Input-Node
50
R211
Voltage-Src
V79
0

FIG. 66

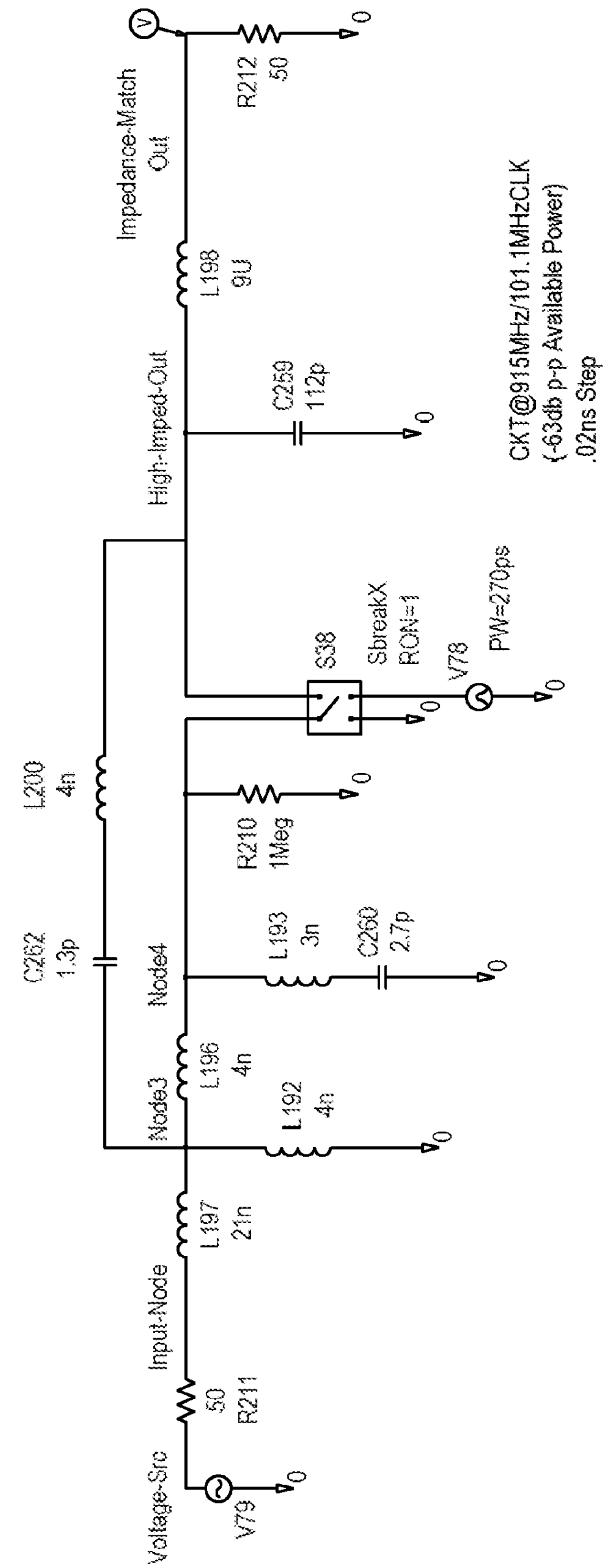

Voltage-Src
V79
R211
50
Input-Node
L197
21n
Node3
L192
4n
L196
4n
Node4
L193
3n
C260
2.7p
C262
1.3p
L200
4n
R210
1Meg
S38
SbreakX
RON=1
V78
PW=270ps
High-Imped-Out
C259
112p
L198
9U
Impedance-Match
Out
R212
50
CKT@915MHz/101.1MHzCLK
(-63db p-p Available Power)
.02ns Step
0

FIG. 67

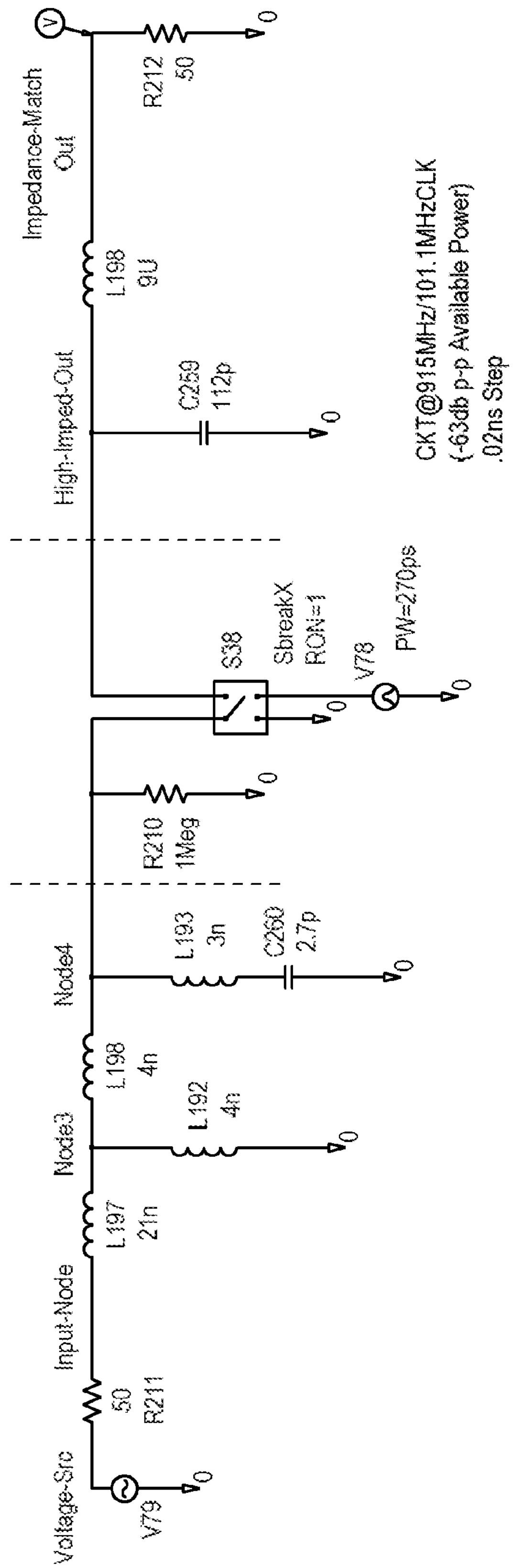

Voltage-Src
V79
50
R211
Input-Node
L197
21n
Node3
L192
4n
L198
4n
Node4
L193
3n
C260
2.7p
R210
1Meg
S58
SbreakX
RON=1
V78
PW=270ps
High-Imped-Out
C259
112p
L198
9U
Impedance-Match
Out
R212
50
CKT@915MHz/101.1MHzCLK
(-63db p-p Available Power)
.02ns Step
0

FIG. 68

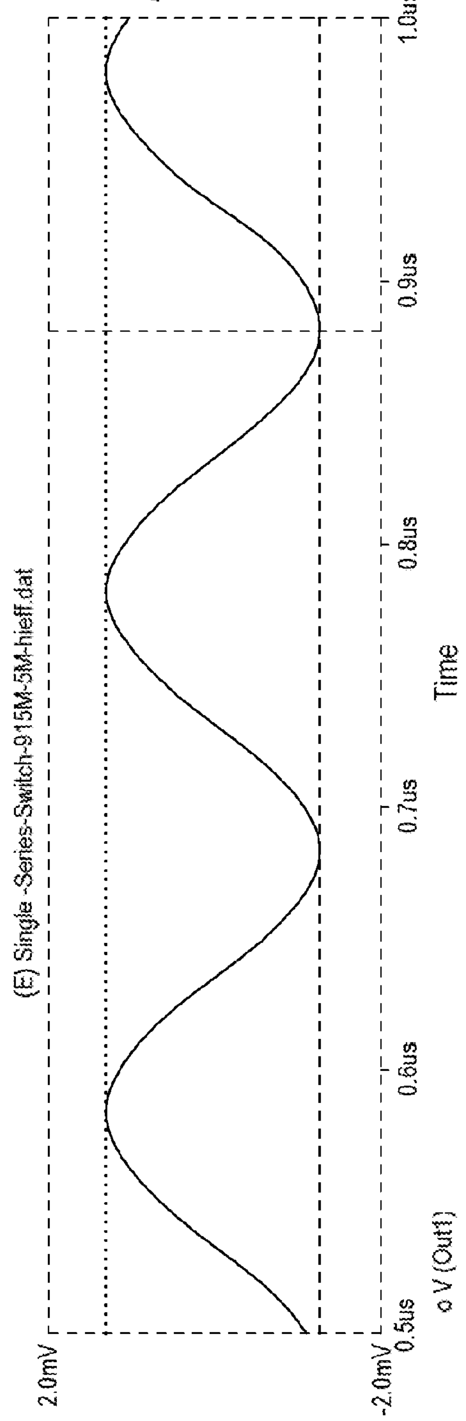



FIG. 69A

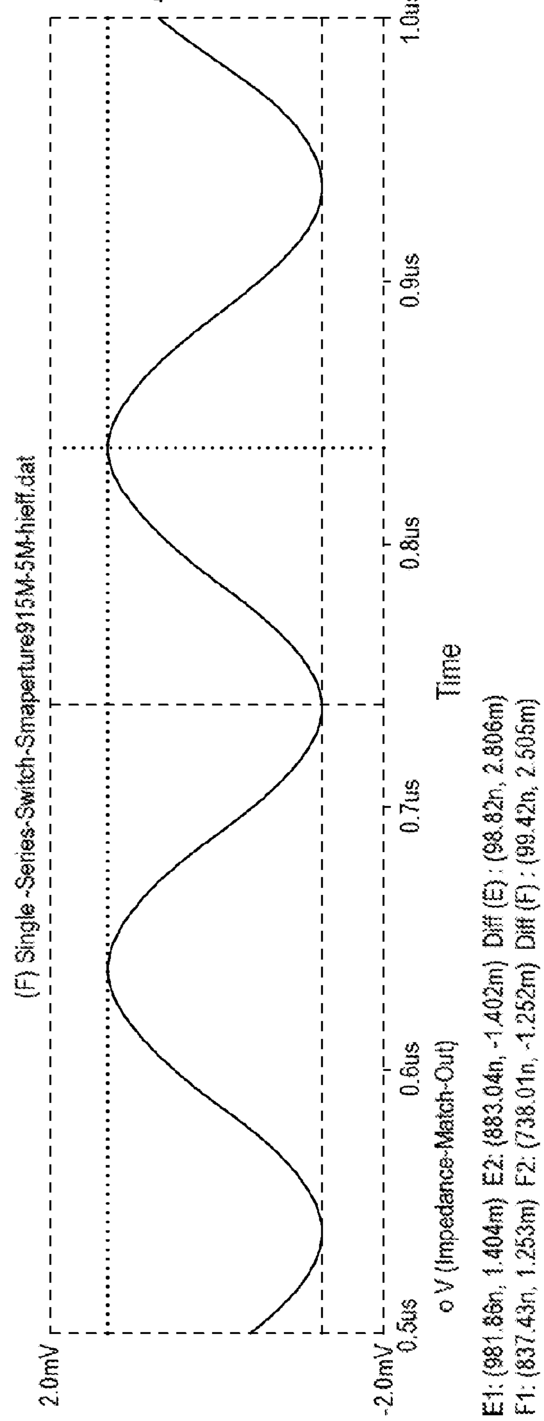



FIG. 69B

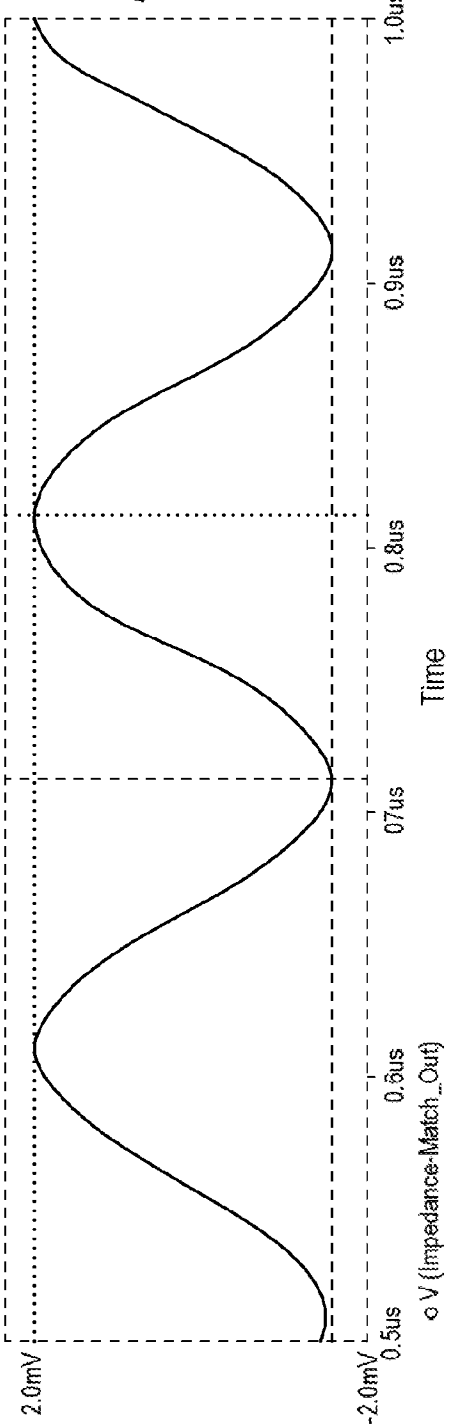



FIG. 70A

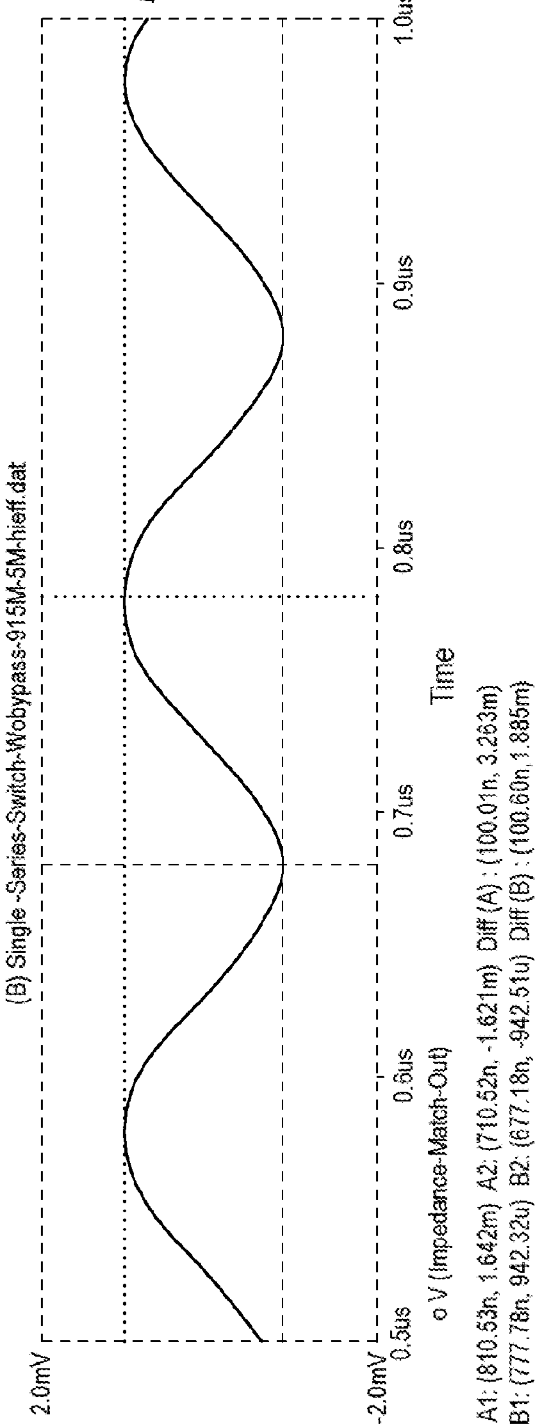



FIG. 70B

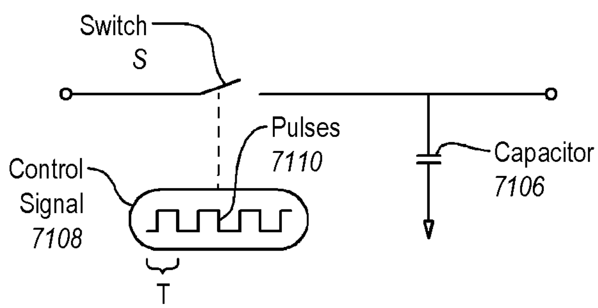



FIG. 71A

$q = C \cdot V$ EQ. 10

$V = A \cdot \sin(t)$ EQ. 11

$q(t) = C \cdot A \cdot \sin(t)$ EQ. 12

$\Delta q(t) = C \cdot A \cdot \sin(t) - ,C \cdot A \cdot (t - T)$ EQ. 13

$\Delta q(t) = C \cdot A \cdot (\sin(t) - \sin(t-T))$ EQ. 14

$$\sin(\alpha) - \sin(\beta) = 2 \cdot \sin\left(\frac{\alpha - \beta}{2}\right) \cdot \cos\left(\frac{\alpha + \beta}{2}\right) \quad \text{EQ. 15}$$

$$\Delta q(t) = 2 \cdot C \cdot A \cdot \sin\left[\frac{t - (t - T)}{2}\right] \cdot \cos\left[\frac{t + (t - T)}{2}\right] \quad \text{EQ. 16}$$

$$\Delta q(t) = 2 \cdot C \cdot A \cdot \sin\left(\frac{1}{2} \cdot T\right) \cdot \cos\left(t - \frac{1}{2} \cdot T\right) \quad \text{EQ. 17}$$

$q(t) = \int C \cdot A \cdot (\sin(t) - \sin(t - T))dt$ EQ. 18

$q(t) = (\cos(t) \cdot C \cdot A + \cos(t - T) \cdot C \cdot A$ EQ. 19

$q(t) = C \cdot A \ (\cos(t - T) - \cos(t))$ EQ. 20

*FIG. 71B*

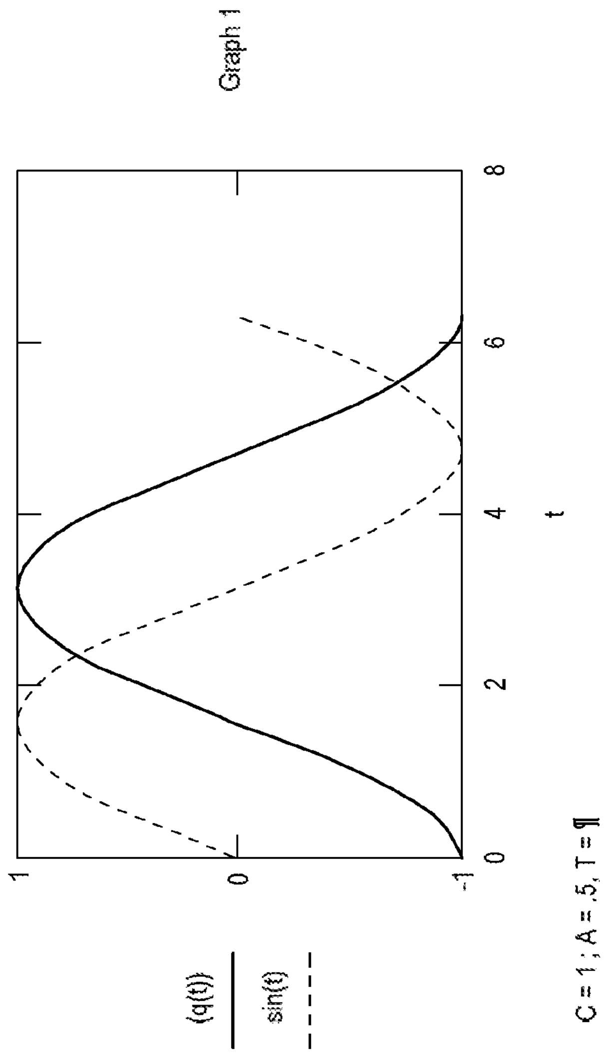



*FIG. 71C*

For Graph 2: C = 1, A = .5, T = π / 10:

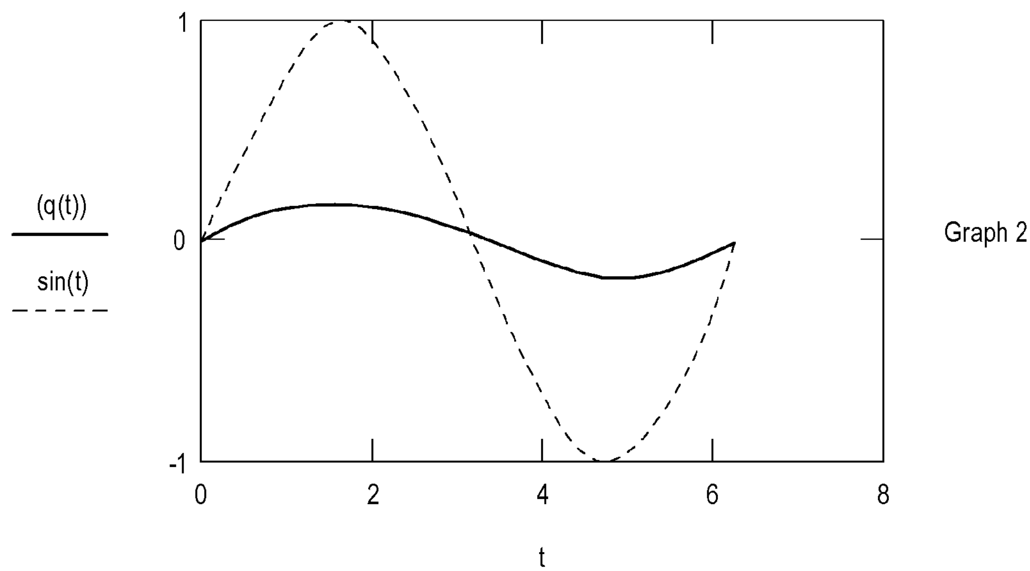



*FIG. 71D*

Power - Charge Relationship

$$q = c \cdot v \qquad \text{EQ. 21}$$

$$v = \frac{q}{2} \qquad \text{EQ. 22}$$

$$v = \frac{J}{q} \qquad \text{EQ. 23}$$

$$J = \frac{q^2}{C} \qquad \text{EQ. 24}$$

$$P = \frac{J}{S} \qquad \text{EQ. 25}$$

$$P = \frac{q^2}{C \cdot S} \qquad \text{EQ. 26}$$

*FIG. 71E*

# Insertion Loss

Insertion Loss In dB Is Expressed By:

$$ILdB = 10 \cdot \log \frac{Pin}{Pout} \qquad \text{EQ. 27}$$

Or

$$ILdB = 10 \cdot \log \left[ \frac{\left( \frac{Vin^2}{Rin} \right)}{\left( \frac{Vout^2}{Rout} \right)} \right] \qquad \text{EQ. 28}$$

*FIG. 71F*

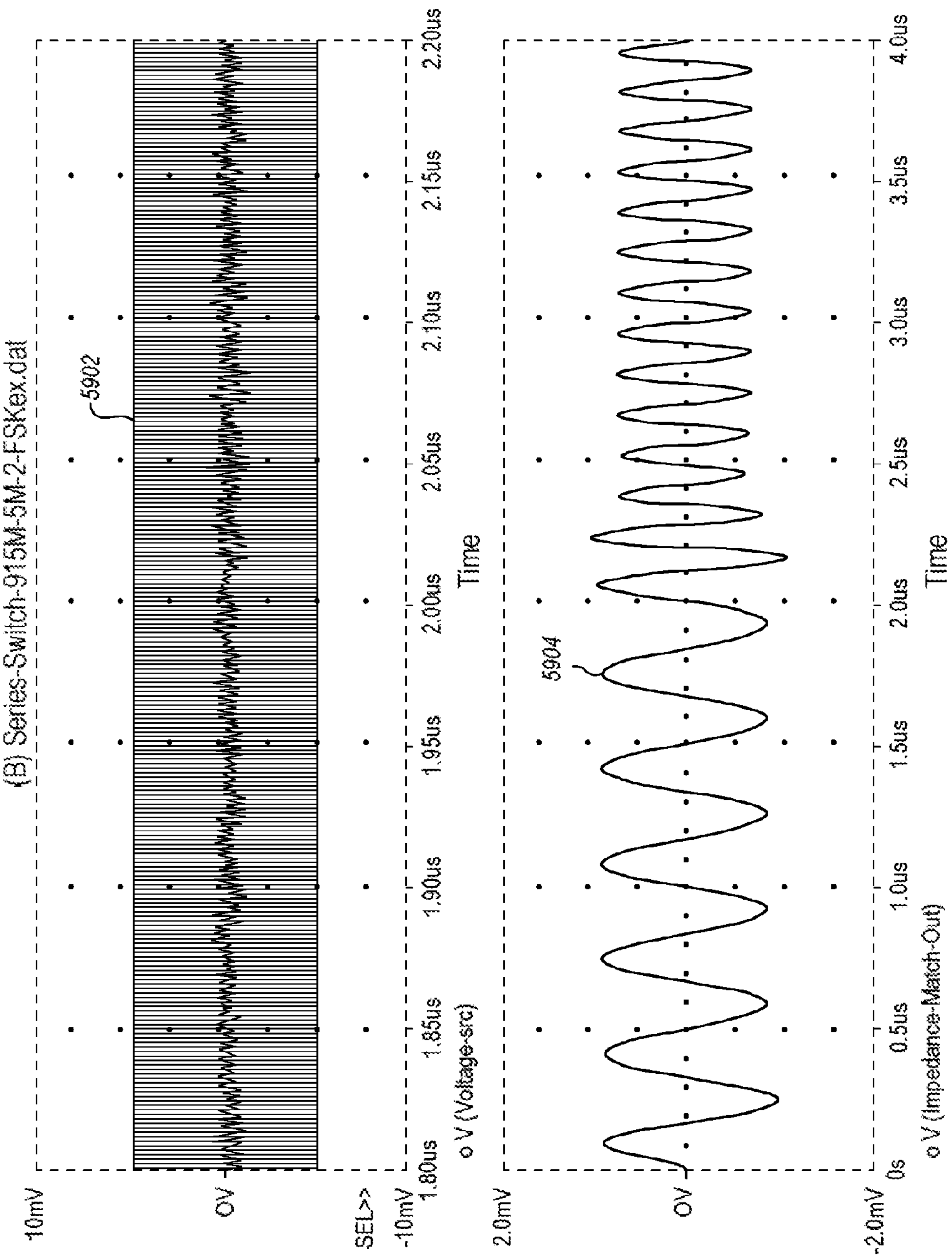

(B) Series-Switch-915M-5M-2-FSKex.dat
5902
10mV
0V
SEL>>
-10mV
1.80us
1.85us
1.90us
1.95us
2.00us
2.05us
2.10us
2.15us
2.20us
o V (Voltage-src)
Time
5904
2.0mV
0V
-2.0mV
0s
0.5us
1.0us
1.5us
2.0us
2.5us
3.0us
3.5us
4.0us
o V (Impedance-Match-Out)
Time

FIG. 72

# UNIVERSAL PLATFORM MODULE FOR A PLURALITY OF COMMUNICATION PROTOCOLS

## CROSS-REFERENCE TO OTHER APPLICATIONS

**[0001]** This is a continuation of pending U.S. patent application Ser. No. 13/550,501 titled "Universal Platform Module for a Plurality of Communication Protocols", filed Jul. 16, 2012, which is a continuation of U.S. patent application Ser. No. 09/569,045, titled "Universal Platform Module for a Plurality of Communication Protocols," filed on May 10, 2000, now U.S. Pat. No. 8,295,406, which is a continuation-in-part application of U.S. patent application Ser. No. 09/5550,642, titled "Method and System for Down Converting an Electromagnetic Signal and Transforms for Same," filed on Apr. 14, 2000, now U.S. Pat. No. 7,065,162, which is a continuation-in-part application of U.S. application Ser. No. 09/521,878, titled "Matched Filter Characterization and Implementation of Universal Frequency Translation Method and Apparatus," filed Mar. 9, 2000, abandoned, all of which are herein incorporated by reference in their entireties.

**[0002]** The following applications of common assignee are related to the present application, and are all herein incorporated by reference in their entireties:

**[0003]** "Wireless Local Area Network (LAN) Using Universal Frequency Translation Technology," Ser. No. 60/147,129, filed Aug. 4, 1999, Attorney Docket No. 1744.0630000.

**[0004]** "Method, System, and Apparatus for Balanced Frequency Up-Conversion of a Baseband Signal," Ser. No. 09/525,615, filed Mar. 14, 2000, Attorney Docket No. 1744.0450003

**[0005]** "Wireless Telephone Using Universal Frequency Translation," Ser. No. 60/195,328, filed Apr. 10, 2000, Attorney Docket No. 1744.0070000.

## BACKGROUND OF THE INVENTION

**[0006]** 1. Field of the Invention

**[0007]** The present invention is generally related to multi-mode communications devices, and more particularly, to multi-mode communications devices implemented using universal frequency translation technology.

**[0008]** 2. Related Art

**[0009]** Recent developments in computing and communications systems seek to enhance the performance and interoperability of devices. These devices, which include personal digital assistants (PDAs), mobile phones, set-top boxes, handheld personal computers, pagers, laptop personal computers, as well as home and office appliances, are being constructed to handle the tasks of traditional systems. These systems are currently constructed for receiving information signals for only a few platforms. Typically, the platforms available for a given device are predetermined. These systems can suffer from the disadvantage of being obsolete within a year or so of production, as well as being relatively expensive in terms of cost and power consumption. Conventional wireless communications circuitry is complex and has a large number of circuit parts. This complexity and high parts count increases overall cost. Additionally, higher part counts result in higher power consumption, which is undesirable, particularly in battery powered units.

**[0010]** Consequently, it is desirable to provide a method and apparatus for a universal platform module (UPM) for devices.

## SUMMARY OF THE INVENTION

**[0011]** The present invention is directed to a universal platform module (UPM). The UPM includes at least one universal frequency translation (UFT) module implemented for signal reception, transmission and/or processing. In one embodiment, the UMP also includes a control module for operating the UFT module for any selected platform or combination of platforms.

**[0012]** Further features and advantages of the invention, as well as the structure and operation of various embodiments of the invention, are described in detail below with reference to the accompanying drawings.

## BRIEF DESCRIPTION OF THE FIGURES

**[0013]** The invention shall be described with reference to the accompanying figures, wherein:

**[0014]** FIG. **1**A is a block diagram of a universal frequency translation (UFT) module according to an embodiment of the invention;

**[0015]** FIG. **1**B is a more detailed diagram of a universal frequency translation (UFT) module according to an embodiment of the invention;

**[0016]** FIG. **1**C illustrates a UFT module used in a universal frequency down-conversion (UFD) module according to an embodiment of the invention;

**[0017]** FIG. **1**D illustrates a UFT module used in a universal frequency up-conversion (UFU) module according to an embodiment of the invention;

**[0018]** FIG. **2** is a block diagram of a universal frequency translation (UFT) module according to an alternative embodiment of the invention;

**[0019]** FIG. **3** is a block diagram of a universal frequency up-conversion (UFU) module according to an embodiment of the invention;

**[0020]** FIG. **4** is a more detailed diagram of a universal frequency up-conversion (UFU) module according to an embodiment of the invention;

**[0021]** FIG. **5** is a block diagram of a universal frequency up-conversion (UFU) module according to an alternative embodiment of the invention;

**[0022]** FIGS. **6**A-**6**I illustrate example waveforms used to describe the operation of the UFU module;

**[0023]** FIG. **7** illustrates a UFT module used in a receiver according to an embodiment of the invention;

**[0024]** FIG. **8** illustrates a UFT module used in a transmitter according to an embodiment of the invention;

**[0025]** FIG. **9** illustrates an environment comprising a transmitter and a receiver, each of which may be implemented using a UFT module of the invention;

**[0026]** FIG. **10** illustrates a transceiver according to an embodiment of the invention;

**[0027]** FIG. **11** illustrates a transceiver according to an alternative embodiment of the invention;

**[0028]** FIG. **12** illustrates an environment comprising a transmitter and a receiver, each of which may be implemented using enhanced signal reception (ESR) components of the invention;

**[0029]** FIG. **13** illustrates a UFT module used in a unified down-conversion and filtering (UDF) module according to an embodiment of the invention;

**[0030]** FIG. **14** illustrates an example receiver implemented using a UDF module according to an embodiment of the invention;

**[0031]** FIGS. **15**A-**15**F illustrate example applications of the UDF module according to embodiments of the invention;

**[0032]** FIG. **16** illustrates an environment comprising a transmitter and a receiver, each of which may be implemented using enhanced signal reception (ESR) components of the invention, wherein the receiver may be further implemented using one or more UFD modules of the invention;

**[0033]** FIG. **17** illustrates a unified down-converting and filtering (UDF) module according to an embodiment of the invention;

**[0034]** FIG. **18** is a table of example values at nodes in the UDF module of FIG. **17**;

**[0035]** FIG. **19** is a detailed diagram of an example UDF module according to an embodiment of the invention;

**[0036]** FIGS. **20**A and **20**A-**1** are example aliasing modules according to embodiments of the invention;

**[0037]** FIGS. **20**B-**20**F are example waveforms used to describe the operation of the aliasing modules of FIGS. **20**A and **20**A-**1**;

**[0038]** FIG. **21** illustrates an enhanced signal reception system according to an embodiment of the invention;

**[0039]** FIGS. **22**A-**22**F are example waveforms used to describe the system of FIG. **21**;

**[0040]** FIG. **23**A illustrates an example transmitter in an enhanced signal reception system according to an embodiment of the invention;

**[0041]** FIGS. **23**B and **23**C are example waveforms used to further describe the enhanced signal reception system according to an embodiment of the invention;

**[0042]** FIG. **23**D illustrates another example transmitter in an enhanced signal reception system according to an embodiment of the invention;

**[0043]** FIGS. **23**E and **23**F are example waveforms used to further describe the enhanced signal reception system according to an embodiment of the invention;

**[0044]** FIG. **24**A illustrates an example receiver in an enhanced signal reception system according to an embodiment of the invention;

**[0045]** FIGS. **24**B-**24**J are example waveforms used to further describe the enhanced signal reception system according to an embodiment of the invention;

**[0046]** FIG. **25**A illustrates a high level block diagram of an example conventional multi-mode device;

**[0047]** FIG. **25**B illustrates a detailed block diagram of a conventional receiver;

**[0048]** FIG. **25**C illustrates a detailed block diagram of a conventional transmitter;

**[0049]** FIG. **26**A-**26**C illustrate example universal platform modules according to embodiments of the invention;

**[0050]** FIGS. **27**A-**27**C illustrate example universal platform sub-module receivers according to embodiments of the invention;

**[0051]** FIG. **28** illustrates an example UFD module in greater detail according to an embodiment of the invention;

**[0052]** FIG. **29** illustrates an exemplary I/Q modulation embodiment of a receiver, according to the invention;

**[0053]** FIGS. **30**A-**30**C illustrate example universal platform sub-module transmitters according to embodiments of the invention;

**[0054]** FIG. **31** illustrates further detail of an example modulator of FIG. **30**B, operating in a pulse modulation (PM) mode, according to an embodiment of the invention;

**[0055]** FIG. **32** illustrates an universal platform module according to an embodiment of the invention;

**[0056]** FIG. **33** illustrates an UFU module in greater detail according to an embodiment of the invention;

**[0057]** FIGS. **34** and **35** illustrate exemplary block diagrams of a transmitter operating in an I/Q modulation mode, according to embodiments of the invention;

**[0058]** FIG. **36** illustrates a block diagram of a receiver incorporating unified down-convert and filtering according to an embodiment of the invention;

**[0059]** FIG. **37** illustrates a high level block diagram of an universal platform sub-module transceiver implementation according to an embodiment of the invention;

**[0060]** FIG. **38** illustrates a high level block diagram of universal platform sub-module receiver and transmitter implementations according to an embodiment of the invention;

**[0061]** FIG. **39** shows some possible protocol/bearer service combinations;

**[0062]** FIG. **40** shows possible representative groupings of network links;

**[0063]** FIG. **41** illustrates a high level block diagram of an universal platform sub-module transceiver implementation according to an embodiment of the invention;

**[0064]** FIG. **42** shows a chart of some standards, protocols, and bearer services;

**[0065]** FIG. **43** illustrates a high level block diagram of a specific implementation of device employing a universal platform module;

**[0066]** FIG. **44** illustrates a high level block diagram of a flexible implementation of a device employing a universal platform module;

**[0067]** FIGS. **45**A-D illustrate example implementations of a switch module according to embodiments of the invention;

**[0068]** FIGS. **46**A-D illustrate example aperture generators;

**[0069]** FIG. **46**E illustrates an oscillator according to an embodiment of the present invention;

**[0070]** FIG. **47** illustrates an energy transfer system with an optional energy transfer signal module according to an embodiment of the invention;

**[0071]** FIG. **48** illustrates an aliasing module with input and output impedance match according to an embodiment of the invention;

**[0072]** FIG. **49**A illustrates an example pulse generator;

**[0073]** FIGS. **49**B and C illustrate example waveforms related to the pulse generator of FIG. **49**A;

**[0074]** FIG. **50** illustrates an example energy transfer module with a switch module and a reactive storage module according to an embodiment of the invention;

**[0075]** FIGS. **51**A-B illustrate example energy transfer systems according to embodiments of the invention;

**[0076]** FIG. **52**A illustrates an example energy transfer signal module according to an embodiment of the present invention;

**[0077]** FIG. **52**B illustrates a flowchart of state machine operation according to an embodiment of the present invention;

**[0078]** FIG. **52**C is an example energy transfer signal module;

**[0079]** FIG. **53** is a schematic diagram of a circuit to down-convert a 915 MHZ signal to a 5 MHZ signal using a 101.1 MHZ clock according to an embodiment of the present invention;

**[0080]** FIG. **54** shows example simulation waveforms for the circuit of FIG. **53** according to embodiments of the present invention;

**[0081]** FIG. **55** is a schematic diagram of a circuit to down-convert a 915 MHZ signal to a 5 MHZ signal using a 101 MHZ clock according to an embodiment of the present invention;

**[0082]** FIG. **56** shows example simulation waveforms for the circuit of FIG. **55** according to embodiments of the present invention;

**[0083]** FIG. **57** is a schematic diagram of a circuit to down-convert a 915 MHZ signal to a 5 MHZ signal using a 101.1 MHZ clock according to an embodiment of the present invention;

**[0084]** FIG. **58** shows example simulation waveforms for the circuit of FIG. **57** according to an embodiment of the present invention;

**[0085]** FIG. **59** shows a schematic of the circuit in FIG. **53** connected to an FSK source that alternates between 913 and 917 MHZ at a baud rate of 500 Kbaud according to an embodiment of the present invention;

**[0086]** FIG. **60**A illustrates an example energy transfer system according to an embodiment of the invention;

**[0087]** FIGS. **60**B-C illustrate example timing diagrams for the example system of FIG. **60**A;

**[0088]** FIG. **61** illustrates an example bypass network according to an embodiment of the invention;

**[0089]** FIG. **62** illustrates an example bypass network according to an embodiment of the invention;

**[0090]** FIG. **63** illustrates an example embodiment of the invention;

**[0091]** FIG. **64**A illustrates an example real time aperture control circuit according to an embodiment of the invention;

**[0092]** FIG. **64**B illustrates a timing diagram of an example clock signal for real time aperture control, according to an embodiment of the invention;

**[0093]** FIG. **64**C illustrates a timing diagram of an example optional enable signal for real time aperture control, according to an embodiment of the invention;

**[0094]** FIG. **64**D illustrates a timing diagram of an inverted clock signal for real time aperture control, according to an embodiment of the invention;

**[0095]** FIG. **64**E illustrates a timing diagram of an example delayed clock signal for real time aperture control, according to an embodiment of the invention;

**[0096]** FIG. **64**F illustrates a timing diagram of an example energy transfer including pulses having apertures that are controlled in real time, according to an embodiment of the invention;

**[0097]** FIG. **65** illustrates an example embodiment of the invention;

**[0098]** FIG. **66** illustrates an example embodiment of the invention;

**[0099]** FIG. **67** illustrates an example embodiment of the invention;

**[0100]** FIG. **68** illustrates an example embodiment of the invention;

**[0101]** FIG. **69**A is a timing diagram for the example embodiment of FIG. **65**;

**[0102]** FIG. **69**B is a timing diagram for the example embodiment of FIG. **66**;

**[0103]** FIG. **70**A is a timing diagram for the example embodiment of FIG. **67**;

**[0104]** FIG. **70**B is a timing diagram for the example embodiment of FIG. **68**;

**[0105]** FIG. **71**A illustrates and example embodiment of the invention;

**[0106]** FIG. **71**B illustrates example equations for determining charge transfer, in accordance with the present invention;

**[0107]** FIG. **71**C illustrates relationships between capacitor charging and aperture, in accordance with an embodiment of the present invention;

**[0108]** FIG. **71**D illustrates relationships between capacitor charging and aperture, in accordance with an embodiment of the present invention;

**[0109]** FIG. **71**E illustrates power-charge relationship equations, in accordance with an embodiment of the present invention;

**[0110]** FIG. **71**F illustrates insertion loss equations, in accordance with an embodiment of the present invention; and

**[0111]** FIG. **72** shows the original FSK waveform **5902** and the down-converted waveform **5904**;

**[0112]** The invention will now be described with reference to the accompanying drawings. In the drawings, like reference numbers generally indicate identical, functionally similar, and/or structurally similar elements. The drawing in which an element first appears is generally indicated by the left-most digit(s) in the corresponding reference number.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

**[0113]**

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-continued



## 1. OVERVIEW OF THE INVENTION

**[0114]** The present invention is directed to a universal platform module (UPM) that operates for and/or within a device. Devices include, without limitation, phones, personal digital/data assistants (PDAs), smart appliances, personal computers (PCs), set-top boxes, networked outlets (printers, projectors, facsimiles), servers, gateways, other computing and/or data processing devices, etc. The UPM may include one or more receivers, transmitters, and/or transceivers, as well as other components such as local oscillators, switches, amplifiers, etc. According to embodiments of the invention, at least some of these components are implemented using universal frequency translation (UFT) modules. The UFT module performs frequency translation operations. Embodiments of the present invention incorporating various applications of the UFT module are described below. The UPM provides new functionality, and/or optionally works alternatively to existing components. The UPM utilizes protocols and/or bearer services and/or combinations thereof to exchange and/or process information with other components on any given network or networks (or any communication medium, for that matter). Generally, protocols, such as but not limited to Wireless Application Protocol (WAP), Jini, Java Virtual Machine (JVM), Bluetooth, IEEE 802.11, TCP/IP, UDP, HAVi, Salutation, Infrared (IR, IRDA), Service Location Protocol (SLP), Universal Plug-n-Play (UPnP, Simple Service Discovery Protocol (SSDP)), etc., provide the format for the transfer of data. Other procedures, methods, protocols, and/or standards may be combined with these protocols to enable and/or support this, similar, and additional functionalities. For example, in the case of Bluetooth, the transport standard is also supplied.

**[0115]** Generally, protocols call upon bearer services (also known as standards), such as CDMA (IS-95, IS-707), US-TDMA (IS-136), W-CDMA, EDGE, IS-95C, SMS, GSM (900, 1800, 1900 MHz), DataTAC, iDEN (ESMR), CDPD, dDECT, Project Angel, LMDS, MMDS, ARDIS, Mobitex, AMPS, etc. These bearer services can be classified into generations (Gs), several of which are shown in FIG. **42**. The bearer services are called upon to provide the communication pipeline (such as a wired or wireless pipeline) for the device to interact with the network. It is noted that, while the invention is sometimes described herein for example purposes as involving wireless communication, the invention is applicable to any communication medium, including without limitation any wireless or wired communication medium.

**[0116]** Generally, platforms are layers on which protocols and bearer services are implemented and/or enabled. Platforms may be implemented using hardware, software, or combinations thereof. Conventional platforms require specialized circuitry for each type of protocol and/or bearer service. According to the invention, a UPM is enabled by one or more UFT modules on a layer with logic and/or circuitry and/or software (or combinations thereof) for any number/combination of protocols and bearer services.

**[0117]** In one embodiment, the UPM includes a UFT module for connecting to/interacting with any network using any protocol/bearer service combination. This embodiment provides the benefit of reduced circuitry over conventional implementations. Furthermore, the UPM can perform multi-platform operations nearly simultaneously. Such operation by the invention is sometimes referred to herein as "apparent simultaneous operation" or "virtual simultaneous operation." For example, the UFT module can switch between a wireless local area network (WLAN) and a wide area network (WAN) and thus, communicate with components on both networks.

**[0118]** In another embodiment, through the use of more than one UFT module, multiple protocols and multiple bearer services can be employed simultaneously. Thus, actual simultaneous multi-operation is possible. Further, components for specific protocols and/or bearer services are included in the UPM's control module which may be upgraded and/or reprogrammed to provide support for additional platforms.

**[0119]** Universal platform modules exhibit multiple advantages by using UFT modules. These advantages include, but are not limited to, lower power consumption, longer power source life, fewer parts, lower cost, less tuning, and more effective signal transmission and reception. The UPM of the present invention can receive and transmit signals across a broad frequency range. The structure and operation of embodiments of the UFT module, and various applications of the same are described in detail in the following sections.

## 2. UNIVERSAL FREQUENCY TRANSLATION

**[0120]** The present invention is related to frequency translation, and applications of same. Such applications include, but are not limited to, frequency down-conversion, frequency up-conversion, enhanced signal reception, unified down-conversion and filtering, and combinations and applications of same.

**[0121]** FIG. **1**A illustrates a universal frequency translation (UFT) module **102** according to embodiments of the invention. (The UFT module is also sometimes called a universal frequency translator, or a universal translator.)

**[0122]** As indicated by the example of FIG. **1**A, some embodiments of the UFT module **102** include three ports (nodes), designated in FIG. **1**A as Port 1, Port 2, and Port 3. Other UFT embodiments include other than three ports.

**[0123]** Generally, the UFT module **102** (perhaps in combination with other components) operates to generate an output signal from an input signal, where the frequency of the output signal differs from the frequency of the input signal. In other words, the UFT module **102** (and perhaps other components) operates to generate the output signal from the input signal by translating the frequency (and perhaps other characteristics) of the input signal to the frequency (and perhaps other characteristics) of the output signal.

**[0124]** An example embodiment of the UFT module **103** is generally illustrated in FIG. **1**B. Generally, the UFT module **103** includes a switch **106** controlled by a control signal **108**. The switch **106** is said to be a controlled switch.

**[0125]** As noted above, some UFT embodiments include other than three ports. For example, and without limitation, FIG. **2** illustrates an example UFT module **202**. The example UFT module **202** includes a diode **204** having two ports, designated as Port 1 and Port 2/3. This embodiment does not include a third port, as indicated by the dotted line around the "Port 3" label.

**[0126]** The UFT module is a very powerful and flexible device. Its flexibility is illustrated, in part, by the wide range of applications in which it can be used. Its power is illustrated, in part, by the usefulness and performance of such applications.

**[0127]** For example, a UFT module **115** can be used in a universal frequency down-conversion (UFD) module **114**, an example of which is shown in FIG. **1**C. In this capacity, the UFT module **115** frequency down-converts an input signal to an output signal.

**[0128]** As another example, as shown in FIG. **1**D, a UFT module **117** can be used in a universal frequency up-conversion (UFU) module **116**. In this capacity, the UFT module **117** frequency up-converts an input signal to an output signal.

**[0129]** These and other applications of the UFT module are described below. Additional applications of the UFT module will be apparent to persons skilled in the relevant art(s) based on the teachings contained herein. In some applications, the UFT module is a required component. In other applications, the UFT module is an optional component.

## 3. FREQUENCY DOWN-CONVERSION

**[0130]** The present invention is directed to systems and methods of universal frequency down-conversion, and applications of same.

**[0131]** In particular, the following discussion describes down-converting using a Universal Frequency Translation Module. The down-conversion of an EM signal by aliasing the EM signal at an aliasing rate is fully described in co-pending U.S. patent application entitled "Method and System for Down-Converting Electromagnetic Signals," Ser. No. 09/176,022, filed Oct. 21, 1998, issued as U.S. Pat. No. 6,061,551, the full disclosure of which is incorporated herein by reference, as well as other cases cited above. A relevant portion of the above mentioned patent application is summarized below to describe down-converting an input signal to produce a down-converted signal that exists at a lower frequency or a baseband signal.

**[0132]** FIG. **20**A illustrates an aliasing module **2000** for down-conversion using a universal frequency translation (UFT) module **2002** which down-converts an EM input signal **2004**. In particular embodiments, aliasing module **2000** includes a switch **2008** and a capacitor **2010**. The electronic alignment of the circuit components is flexible. That is, in one implementation, the switch **2008** is in series with input signal **2004** and capacitor **2010** is shunted to ground (although it may be other than ground in configurations such as differential mode). In a second implementation (see FIG. **20A-1**), the capacitor **2010** is in series with the input signal **2004** and the switch **2008** is shunted to ground (although it may be other than ground in configurations such as differential mode). Aliasing module **2000** with UFT module **2002** can be easily tailored to down-convert a wide variety of electromagnetic signals using aliasing frequencies that are well below the frequencies of the EM input signal **2004**.

**[0133]** In one implementation, aliasing module **2000** down-converts the input signal **2004** to an intermediate frequency (IF) signal. In another implementation, the aliasing module **2000** down-converts the input signal **2004** to a demodulated baseband signal. In yet another implementation, the input signal **2004** is a frequency modulated (FM) signal, and the aliasing module **2000** down-converts it to a non-FM signal, such as a phase modulated (PM) signal or an amplitude modulated (AM) signal. Each of the above implementations is described below.

**[0134]** In an embodiment, the control signal **2006** includes a train of pulses that repeat at an aliasing rate that is equal to, or less than, twice the frequency of the input signal **2004**. In this embodiment, the control signal **2006** is referred to herein as an aliasing signal because it is below the Nyquist rate for the frequency of the input signal **2004**. Preferably, the frequency of control signal **2006** is much less than the input signal **2004**.

**[0135]** A train of pulses **2018** as shown in FIG. **20**D controls the switch **2008** to alias the input signal **2004** with the control signal **2006** to generate a down-converted output signal **2012**. More specifically, in an embodiment, switch **2008** closes on a first edge of each pulse **2020** of FIG. **20**D and opens on a second edge of each pulse. When the switch **2008** is closed, the input signal **2004** is coupled to the capacitor **2010**, and charge is transferred from the input signal to the capacitor **2010**. The charge stored during successive pulses forms down-converted output signal **2012**.

**[0136]** Exemplary waveforms are shown in FIGS. **20**B-**20**F.

**[0137]** FIG. **20**B illustrates an analog amplitude modulated (AM) carrier signal **2014** that is an example of input signal **2004**. For illustrative purposes, in FIG. **20**C, an analog AM carrier signal portion **2016** illustrates a portion of the analog AM carrier signal **2014** on an expanded time scale. The analog AM carrier signal portion **2016** illustrates the analog AM carrier signal **2014** from time $t_0$ to time $t_1$.

**[0138]** FIG. **20**D illustrates an exemplary aliasing signal **2018** that is an example of control signal **2006**. Aliasing signal **2018** is on approximately the same time scale as the analog AM carrier signal portion **2016**. In the example shown in FIG. **20**D, the aliasing signal **2018** includes a train of pulses **2020** having negligible apertures' that tend towards zero (the invention is not limited to this embodiment, as discussed below). The pulse aperture may also be referred to as the pulse width as will be understood by those skilled in the art(s). The pulses **2020** repeat at an aliasing rate, or pulse repetition rate of aliasing signal **2018**. The aliasing rate is determined as described below, and further described in co-pending U.S. patent application entitled "Method and System for Down-converting Electromagnetic Signals," Ser. No. 09/176,022, issued as U.S. Pat. No. 6,061,551.

**[0139]** As noted above, the train of pulses **2020** (i.e., control signal **2006**) control the switch **2008** to alias the analog AM carrier signal **2016** (i.e., input signal **2004**) at the aliasing rate of the aliasing signal **2018**. Specifically, in this embodiment, the switch **2008** closes on a first edge of each pulse and opens on a second edge of each pulse. When the switch **2008** is closed, input signal **2004** is coupled to the capacitor **2010**, and charge is transferred from the input signal **2004** to the capacitor **2010**. The charge transferred during a pulse is referred to herein as an under-sample. Exemplary under-samples **2022** form down-converted signal portion **2024** (FIG. **20**E) that corresponds to the analog AM carrier signal portion **2016** (FIG. **20**C) and the train of pulses **2020** (FIG. **20**D). The charge stored during successive under-samples of AM carrier signal **2014** form the down-converted signal **2024** (FIG. **20**E) that is an example of down-converted output signal **2012** (FIG. **20**A). In FIG. **20**F, a demodulated baseband signal **2026** represents the demodulated baseband signal **2024** after filtering on a compressed time scale. As illustrated, down-converted signal **2026** has substantially the same "amplitude envelope" as AM carrier signal **2014**. Therefore, FIGS. **20**B-**20**F illustrate down-conversion of AM carrier signal **2014**.

**[0140]** The waveforms shown in FIGS. **20**B-**20**F are discussed herein for illustrative purposes only, and are not limiting. Additional exemplary time domain and frequency domain drawings, and exemplary methods and systems of the invention relating thereto, are disclosed in co-pending U.S. patent application entitled "Method and System for Down-converting Electromagnetic Signals," Ser. No. 09/176,022, issued as U.S. Pat. No. 6,061,551.

**[0141]** The aliasing rate of control signal **2006** determines whether the input signal **2004** is down-converted to an IF signal, down-converted to a demodulated baseband signal, or down-converted from an FM signal to a PM or an AM signal. Generally, relationships between the input signal **2004**, the aliasing rate of the control signal **2006**, and the down-converted output signal **2012** are illustrated below:

$$(\text{Freq. of input signal 2004}) = n\cdot(\text{Freq. of control signal 2006}) \pm (\text{Freq. of down-converted output signal 2012})$$

For the examples contained herein, only the "+" condition will be discussed. The value of n represents a harmonic or sub-harmonic of input signal **2004** (e.g., n=0.5, 1, 2, 3, . . . ).

**[0142]** When the aliasing rate of control signal **2006** is off-set from the frequency of input signal **2004**, or off-set from a harmonic or sub-harmonic thereof, input signal **2004** is down-converted to an IF signal. This is because the under-sampling pulses occur at different phases of subsequent cycles of input signal **2004**. As a result, the under-samples form a lower frequency oscillating pattern. If the input signal **2004** includes lower frequency changes, such as amplitude, frequency, phase, etc., or any combination thereof, the charge stored during associated under-samples reflects the lower frequency changes, resulting in similar changes on the down-converted IF signal. For example, to down-convert a 901 MHZ input signal to a 1 MHZ IF signal, the frequency of the control signal **2006** would be calculated as follows:

$$(\text{Freq}_{input} - \text{Freq}_{IF})/n = Freq_{control}$$

$$(901\ \text{MHZ} - 1\ \text{MHZ})/n = 900/n$$

For n=0.5, 1, 2, 3, 4, etc., the frequency of the control signal **2006** would be substantially equal to 1.8 GHz, 900 MHZ, 450 MHZ, 300 MHZ, 225 MHZ, etc.

**[0143]** Exemplary time domain and frequency domain drawings, illustrating down-conversion of analog and digital AM, PM and FM signals to IF signals, and exemplary methods and systems thereof, are disclosed in co-pending U.S. patent application entitled "Method and System for Down-converting Electromagnetic Signals," Ser. No. 09/176,022, issued as U.S. Pat. No. 6,061,551.

**[0144]** Alternatively, when the aliasing rate of the control signal **2006** is substantially equal to the frequency of the input signal **2004**, or substantially equal to a harmonic or sub-harmonic thereof, input signal **2004** is directly down-converted to a demodulated baseband signal. This is because, without modulation, the under-sampling pulses occur at the same point of subsequent cycles of the input signal **2004**. As a result, the under-samples form a constant output baseband signal. If the input signal **2004** includes lower frequency changes, such as amplitude, frequency, phase, etc., or any combination thereof, the charge stored during associated under-samples reflects the lower frequency changes, resulting in similar changes on the demodulated baseband signal. For example, to directly down-convert a 900 MHZ input signal to a demodulated baseband signal (i.e., zero IF), the frequency of the control signal **2006** would be calculated as follows:

$$(\text{Freq}_{input} - \text{Freq}_{IF})/n = Freq_{control}$$

$$(900\ \text{MHZ} - 0\ \text{MHZ})/n = 900\ \text{MHZ}/n$$

For n=0.5, 1, 2, 3, 4, etc., the frequency of the control signal **2006** should be substantially equal to 1.8 GHz, 900 MHZ, 450 MHZ, 300 MHZ, 225 MHZ, etc.

**[0145]** Exemplary time domain and frequency domain drawings, illustrating direct down-conversion of analog and digital AM and PM signals to demodulated baseband signals, and exemplary methods and systems thereof, are disclosed in the co-pending U.S. patent application entitled "Method and System for Down-converting Electromagnetic Signals," Ser. No. 09/176,022, issued as U.S. Pat. No. 6,061,551.

**[0146]** Alternatively, to down-convert an input FM signal to a non-FM signal, a frequency within the FM bandwidth must be down-converted to baseband (i.e., zero IF) As an example, to down-convert a frequency shift keying (FSK) signal (a subset of FM) to a phase shift keying (PSK) signal (a subset of PM), the mid-point between a lower frequency $F_1$ and an upper frequency $F_2$ (that is, $[(F_1+F_2)\div 2]$) of the FSK signal is down-converted to zero IF. For example, to down-convert an FSK signal having $F_1$ equal to 899 MHZ and $F_2$ equal to 901 MHZ, to a PSK signal, the aliasing rate of the control signal **2006** would be calculated as follows:

$$\begin{aligned}\text{Frequency of the input} &= (F_1 + F_2) \div 2\\ &= (899\ \text{MHZ} + 901\ \text{MHZ}) \div 2\\ &= 900\ \text{MHZ}\end{aligned}$$

Frequency of the down-converted signal=0 (i.e., baseband)

$$(\text{Freq}_{input} - \text{Freq}_{IF})/n = Freq_{control}$$

$$(900\ \text{MHZ} - 0\ \text{MHZ})/n = 900\ \text{MHZ}/n$$

For n=0.5, 1, 2, 3, etc., the frequency of the control signal **2006** should be substantially equal to 1.8 GHz, 900 MHZ, 450 MHZ, 300 MHZ, 225 MHZ, etc. The frequency of the down-converted PSK signal is substantially equal to one half the difference between the lower frequency $F_1$ and the upper frequency $F_2$.

**[0147]** As another example, to down-convert a FSK signal to an amplitude shift keying (ASK) signal (a subset of AM), either the lower frequency $F_1$ or the upper frequency $F_2$ of the FSK signal is down-converted to zero IF. For example, to down-convert an FSK signal having $F_1$ equal to 900 MHZ and $F_2$ equal to 901 MHZ, to an ASK signal, the aliasing rate of the control signal **2006** should be substantially equal to:

(900 MHZ−0MHZ)/*n*=900 MHZ/*n*, or

(901 MHZ−0 MHZ)/*n*=901 MHZ/*n*.

For the former case of 900 MHZ/n, and for n=0.5, 1, 2, 3, 4, etc., the frequency of the control signal **2006** should be substantially equal to 1.8 GHz, 900 MHZ, 450 MHZ, 300 MHZ, 225 MHZ, etc. For the latter case of 901 MHZ/n, and for n=0.5, 1, 2, 3, 4, etc., the frequency of the control signal **2006** should be substantially equal to 1.802 GHz, 901 MHZ, 450.5 MHZ, 300.333 MHZ, 225.25 MHZ, etc. The frequency of the down-converted AM signal is substantially equal to the difference between the lower frequency $F_1$ and the upper frequency $F_2$ (i.e., 1 MHZ).

**[0148]** Exemplary time domain and frequency domain drawings, illustrating down-conversion of FM signals to non-FM signals, and exemplary methods and systems thereof, are disclosed in the co-pending U.S. patent application entitled "Method and System for Down-converting Electromagnetic Signals," Ser. No. 09/176,022, issued as U.S. Pat. No. 6,061,551.

**[0149]** In an embodiment, the pulses of the control signal **2006** have negligible apertures that tend towards zero. This makes the UFT module **2002** a high input impedance device. This configuration is useful for situations where minimal disturbance of the input signal may be desired.

**[0150]** In another embodiment, the pulses of the control signal **2006** have non-negligible apertures that tend away from zero. This makes the UFT module **2002** a lower input impedance device. This allows the lower input impedance of the UFT module **2002** to be substantially matched with a source impedance of the input signal **2004**. This also improves the energy transfer from the input signal **2004** to the down-converted output signal **2012**, and hence the efficiency and signal to noise (s/n) ratio of UFT module **2002**.

**[0151]** Exemplary systems and methods for generating and optimizing the control signal **2006**, and for otherwise improving energy transfer and s/n ratio, are disclosed in the co-pending U.S. patent application entitled "Method and System for Down-converting Electromagnetic Signals," Ser. No. 09/176,022, issued as U.S. Pat. No. 6,061,551.

**[0152]** When the pulses of the control signal **2006** have non-negligible apertures, the aliasing module **2000** is referred to interchangeably herein as an energy transfer module or a gated transfer module, and the control signal **2006** is referred to as an energy transfer signal. Exemplary systems and methods for generating and optimizing the control signal **2006** and for otherwise improving energy transfer and/or signal to noise ratio in an energy transfer module are described below.

**[0153]** 3.1. Optional Energy Transfer Signal Module

**[0154]** FIG. **47** illustrates an energy transfer system **4701** that includes an optional energy transfer signal module **4702**, which can perform any of a variety of functions or combinations of functions including, but not limited to, generating the energy transfer signal **4506**.

**[0155]** In an embodiment, the optional energy transfer signal module **4702** includes an aperture generator, an example of which is illustrated in FIG. **46**C as an aperture generator **4620**. The aperture generator **4620** generates non-negligible aperture pulses **4626** from an input signal **4624**. The input signal **4624** can be any type of periodic signal, including, but not limited to, a sinusoid, a square wave, a saw-tooth wave, etc. Systems for generating the input signal **4624** are described below.

**[0156]** The width or aperture of the pulses **4626** is determined by delay through the branch **4622** of the aperture generator **4620**. Generally, as the desired pulse width increases, the difficulty in meeting the requirements of the aperture generator **4620** decrease. In other words, to generate non-negligible aperture pulses for a given EM input frequency, the components utilized in the example aperture generator **4620** do not require as fast reaction times as those that are required in an under-sampling system operating with the same EM input frequency.

**[0157]** The example logic and implementation shown in the aperture generator **4620** are provided for illustrative purposes only, and are not limiting. The actual logic employed can take many forms. The example aperture generator **4620** includes an optional inverter **4628**, which is shown for polarity consistency with other examples provided herein.

**[0158]** An example implementation of the aperture generator **4620** is illustrated in FIG. **46**D. Additional examples of aperture generation logic are provided in FIGS. **46**A and **46**B. FIG. **46**A illustrates a rising edge pulse generator **4640**, which generates pulses **4626** on rising edges of the input signal **4624**. FIG. **46**B illustrates a falling edge pulse generator **4650**, which generates pulses **4626** on falling edges of the input signal **4624**.

**[0159]** In an embodiment, the input signal **4624** is generated externally of the energy transfer signal module **4702**, as illustrated in FIG. **47**. Alternatively, the input signal **4724** is generated internally by the energy transfer signal module **4702**. The input signal **4624** can be generated by an oscillator, as illustrated in FIG. **46**E by an oscillator **4630**. The oscillator **4630** can be internal to the energy transfer signal module **4702** or external to the energy transfer signal module **4702**. The oscillator **4630** can be external to the energy transfer system **4701**. The output of the oscillator **4630** may be any periodic waveform.

**[0160]** The type of down-conversion performed by the energy transfer system **4701** depends upon the aliasing rate of the energy transfer signal **4506**, which is determined by the frequency of the pulses **4626**. The frequency of the pulses **4626** is determined by the frequency of the input signal **4624**. For example, when the frequency of the input signal **4624** is substantially equal to a harmonic or a sub-harmonic of the EM signal **4504**, the EM signal **4504** is directly down-converted to baseband (e.g. when the EM signal is an AM signal or a PM signal), or converted from FM to a non-FM signal. When the frequency of the input signal **4624** is substantially equal to a harmonic or a sub-harmonic of a difference frequency, the EM signal **4504** is down-converted to an intermediate signal.

**[0161]** The optional energy transfer signal module **4702** can be implemented in hardware, software, firmware, or any combination thereof.

**[0162]** 3.2 Smoothing the Down-Converted Signal

**[0163]** Referring back to FIG. **20**A, the down-converted output signal **2012** may be smoothed by filtering as desired.

**[0164]** 3.3. Impedance Matching

**[0165]** The energy transfer module **2000** has input and output impedances generally defined by (1) the duty cycle of the switch module (i.e., UFT **2002**), and (2) the impedance of the storage module (e.g., capacitor **2010**), at the frequencies of interest (e.g. at the EM input, and intermediate/baseband frequencies).

**[0166]** Starting with an aperture width of approximately ½ the period of the EM signal being down-converted as a preferred embodiment, this aperture width (e.g. the "closed time") can be decreased. As the aperture width is decreased, the characteristic impedance at the input and the output of the energy transfer module increases. Alternatively, as the aperture width increases from ½ the period of the EM signal being down-converted, the impedance of the energy transfer module decreases.

**[0167]** One of the steps in determining the characteristic input impedance of the energy transfer module could be to measure its value. In an embodiment, the energy transfer module's characteristic input impedance is 300 ohms. An impedance matching circuit can be utilized to efficiently couple an input EM signal that has a source impedance of, for example, 50 ohms, with the energy transfer module's impedance of, for example, 300 ohms. Matching these impedances can be accomplished in various manners, including providing the necessary impedance directly or the use of an impedance match circuit as described below.

**[0168]** Referring to FIG. **48**, a specific embodiment using an RF signal as an input, assuming that the impedance **4812** is a relatively low impedance of approximately 50 Ohms, for example, and the input impedance **4816** is approximately 300 Ohms, an initial configuration for the input impedance match module **4806** can include an inductor **5006** and a capacitor **5008**, configured as shown in FIG. **50**. The configuration of the inductor **5006** and the capacitor **5008** is a possible configuration when going from a low impedance to a high impedance. Inductor **5006** and the capacitor **5008** constitute an L match, the calculation of the values which is well known to those skilled in the relevant arts.

**[0169]** The output characteristic impedance can be impedance matched to take into consideration the desired output frequencies. One of the steps in determining the characteristic output impedance of the energy transfer module could be to measure its value. Balancing the very low impedance of the storage module at the input EM frequency, the storage module should have an impedance at the desired output frequencies that is preferably greater than or equal to the load that is intended to be driven (for example, in an embodiment, storage module impedance at a desired 1 MHz output frequency is 2K ohm and the desired load to be driven is 50 ohms). An additional benefit of impedance matching is that filtering of unwanted signals can also be accomplished with the same components.

**[0170]** In an embodiment, the energy transfer module's characteristic output impedance is 2K ohms. An impedance matching circuit can be utilized to efficiently couple the down-converted signal with an output impedance of, for example, 2K ohms, to a load of, for example, 50 ohms. Matching these impedances can be accomplished in various manners, including providing the necessary load impedance directly or the use of an impedance match circuit as described below.

**[0171]** When matching from a high impedance to a low impedance, a capacitor **5014** and an inductor **5016** can be configured as shown in FIG. **50**. The capacitor **5014** and the inductor **5016** constitute an L match, the calculation of the component values being well known to those skilled in the relevant arts.

**[0172]** The configuration of the input impedance match module **4806** and the output impedance match module **4808** are considered to be initial starting points for impedance matching, in accordance with the present invention. In some situations, the initial designs may be suitable without further optimization. In other situations, the initial designs can be optimized in accordance with other various design criteria and considerations.

**[0173]** As other optional optimizing structures and/or components are utilized, their affect on the characteristic impedance of the energy transfer module should be taken into account in the match along with their own original criteria.

**[0174]** 3.4 Tanks and Resonant Structures

**[0175]** Resonant tank and other resonant structures can be used to further optimize the energy transfer characteristics of the invention. For example, resonant structures, resonant about the input frequency, can be used to store energy from the input signal when the switch is open, a period during which one may conclude that the architecture would otherwise be limited in its maximum possible efficiency. Resonant tank and other resonant structures can include, but are not limited to, surface acoustic wave (SAW) filters, dielectric resonators, diplexers, capacitors, inductors, etc.

**[0176]** An example embodiment is shown in FIG. **60**A. Two additional embodiments are shown in FIG. **55** and FIG. **63**. Alternate implementations will be apparent to persons skilled in the relevant art(s) based on the teachings contained herein. Alternate implementations fall within the scope and spirit of the present invention. These implementations take advantage of properties of series and parallel (tank) resonant circuits.

**[0177]** FIG. **60**A illustrates parallel tank circuits in a differential implementation. A first parallel resonant or tank circuit consists of a capacitor **6038** and an inductor **6020** (tank1). A second tank circuit consists of a capacitor **6034** and an inductor **6036** (tank2).

**[0178]** As is apparent to one skilled in the relevant art(s), parallel tank circuits provide:

- **[0179]** low impedance to frequencies below resonance;
- **[0180]** low impedance to frequencies above resonance; and
- **[0181]** high impedance to frequencies at and near resonance.

**[0182]** In the illustrated example of FIG. **60**A, the first and second tank circuits resonate at approximately 920 MHz. At and near resonance, the impedance of these circuits is relatively high. Therefore, in the circuit configuration shown in FIG. **60**A, both tank circuits appear as relatively high impedance to the input frequency of 950 MHz, while simultaneously appearing as relatively low impedance to frequencies in the desired output range of 50 MHz.

**[0183]** An energy transfer signal **6042** controls a switch **6014**. When the energy transfer signal **6042** controls the switch **6014** to open and close, high frequency signal components are not allowed to pass through tank1 or tank2. However, the lower signal components (50 Mhz in this embodiment) generated by the system are allowed to pass through tank1 and tank2 with little attenuation. The effect of tank1 and tank2 is to further separate the input and output signals from the same node thereby producing a more stable input and output impedance. Capacitors **6018** and **6040** act to store the 50 MHz output signal energy between energy transfer pulses.

**[0184]** Further energy transfer optimization is provided by placing an inductor **6010** in series with a storage capacitor

6012 as shown. In the illustrated example, the series resonant frequency of this circuit arrangement is approximately 1 GHz. This circuit increases the energy transfer characteristic of the system. The ratio of the impedance of inductor **6010** and the impedance of the storage capacitor **6012** is preferably kept relatively small so that the majority of the energy available will be transferred to storage capacitor **6012** during operation. Exemplary output signals A and B are illustrated in FIGS. **60**B and **60**C, respectively.

**[0185]** In FIG. **60**A, circuit components **6004** and **6006** form an input impedance match. Circuit components **6032** and **6030** form an output impedance match into a 50 ohm resistor **6028**. Circuit components **6022** and **6024** form a second output impedance match into a 50 ohm resistor **6026**. Capacitors **6008** and **6012** act as storage capacitors for the embodiment. Voltage source **6046** and resistor **6002** generate a 950 MHz signal with a 50 ohm output impedance, which are used as the input to the circuit. Circuit element **6016** includes a 150 MHz oscillator and a pulse generator, which are used to generate the energy transfer signal **6042**.

**[0186]** FIG. **55** illustrates a shunt tank circuit **5510** in a single-ended to-single-ended system **5512**. Similarly, FIG. **63** illustrates a shunt tank circuit **6310** in a system **6312**. The tank circuits **5510** and **6310** lower driving source impedance, which improves transient response. The tank circuits **5510** and **6310** are able store the energy from the input signal and provide a low driving source impedance to transfer that energy throughout the aperture of the closed switch. The transient nature of the switch aperture can be viewed as having a response that, in addition to including the input frequency, has large component frequencies above the input frequency, (i.e. higher frequencies than the input frequency are also able to effectively pass through the aperture). Resonant circuits or structures, for example resonant tanks **5510** or **6310**, can take advantage of this by being able to transfer energy throughout the switch's transient frequency response (i.e. the capacitor in the resonant tank appears as a low driving source impedance during the transient period of the aperture).

**[0187]** The example tank and resonant structures described above are for illustrative purposes and are not limiting. Alternate configurations can be utilized. The various resonant tanks and structures discussed can be combined or utilized independently as is now apparent.

**[0188]** 3.5 Charge and Power Transfer Concepts

**[0189]** Concepts of charge transfer are now described with reference to FIGS. **71**A-F. FIG. **71**A illustrates a circuit **7102**, including a switch S and a capacitor **7106** having a capacitance C. The switch S is controlled by a control signal **7108**, which includes pulses **19010** having apertures T.

**[0190]** In FIG. **71**B, Equation 10 illustrates that the charge q on a capacitor having a capacitance C, such as the capacitor **7106**, is proportional to the voltage V across the capacitor, where:

- **[0191]** q=Charge in Coulombs
- **[0192]** C=Capacitance in Farads
- **[0193]** V=Voltage in Volts
- **[0194]** A=Input Signal Amplitude

**[0195]** Where the voltage V is represented by Equation 11, Equation 10 can be rewritten as Equation 12. The change in charge $\Delta q$ over time t is illustrated as in Equation 13 as $\Delta q(t)$, which can be rewritten as Equation 14. Using the sum-to-product trigonometric identity of Equation 15, Equation 14 can be rewritten as Equation 16, which can be rewritten as equation 17.

**[0196]** Note that the sin term in Equation 11 is a function of the aperture T only. Thus, $\Delta q(t)$ is at a maximum when T is equal to an odd multiple of $\pi$ (i.e., $\pi$, $3\pi$, $5\pi$, . . . ). Therefore, the capacitor **7106** experiences the greatest change in charge when the aperture T has a value of it or a time interval representative of 180 degrees of the input sinusoid. Conversely, when T is equal to $2\pi$, $4\pi$, $6\pi$, . . . , minimal charge is transferred.

**[0197]** Equations 18, 19, and 20 solve for q(t) by integrating Equation 10, allowing the charge on the capacitor **7106** with respect to time to be graphed on the same axis as the input sinusoid sin(t), as illustrated in the graph of FIG. **71**C. As the aperture T decreases in value or tends toward an impulse, the phase between the charge on the capacitor C or q(t) and sin(t) tend toward zero. This is illustrated in the graph of FIG. **71**D, which indicates that the maximum impulse charge transfer occurs near the input voltage maxima. As this graph indicates, considerably less charge is transferred as the value of T decreases.

**[0198]** Power/charge relationships are illustrated in Equations 21-26 of FIG. **71**E, where it is shown that power is proportional to charge, and transferred charge is inversely proportional to insertion loss.

**[0199]** Concepts of insertion loss are illustrated in FIG. **71**F. Generally, the noise figure of a lossy passive device is numerically equal to the device insertion loss. Alternatively, the noise figure for any device cannot be less that its insertion loss. Insertion loss can be expressed by Equation 27 or 28. From the above discussion, it is observed that as the aperture T increases, more charge is transferred from the input to the capacitor **7106**, which increases power transfer from the input to the output. It has been observed that it is not necessary to accurately reproduce the input voltage at the output because relative modulated amplitude and phase information is retained in the transferred power.

**[0200]** 3.6 Optimizing and Adjusting the Non-Negligible Aperture Width/Duration

**[0201]** 3.6.1 Varying Input and Output Impedances

**[0202]** In an embodiment of the invention, the energy transfer signal (i.e., control signal **2006** in FIG. **20**A), is used to vary the input impedance seen by the EM Signal **2004** and to vary the output impedance driving a load. An example of this embodiment is described below using a gated transfer module **5101** shown in FIG. **51**A. The method described below is not limited to the gated transfer module **5101**.

**[0203]** In FIG. **51**A, when switch **5106** is closed, the impedance looking into circuit **5102** is substantially the impedance of a storage module, illustrated here as a storage capacitance **5108**, in parallel with the impedance of a load **5112**. When the switch **5106** is open, the impedance at point **5114** approaches infinity. It follows that the average impedance at point **5114** can be varied from the impedance of the storage module illustrated in parallel with the load **5112**, to the highest obtainable impedance when switch **5106** is open, by varying the ratio of the time that switch **5106** is open to the time switch **5106** is closed. The switch **5106** is controlled by an energy transfer signal **5110**. Thus the impedance at point **5114** can be varied by controlling the aperture width of the energy transfer signal in conjunction with the aliasing rate.

**[0204]** An example method of altering the energy transfer signal **5106** of FIG. **51**A is now described with reference to FIG. **49**A, where a circuit **4902** receives an input oscillating signal **4906** and outputs a pulse train shown as doubler output signal **4904**. The circuit **4902** can be used to generate the energy transfer signal **5106**. Example waveforms of **4904** are shown on FIG. **49**C.

**[0205]** It can be shown that by varying the delay of the signal propagated by the inverter **4908**, the width of the pulses in the doubler output signal **4904** can be varied. Increasing the delay of the signal propagated by inverter **4908**, increases the width of the pulses. The signal propagated by inverter **4908** can be delayed by introducing a R/C low pass network in the output of inverter **4908**. Other means of altering the delay of the signal propagated by inverter **4908** will be well known to those skilled in the art.

**[0206]** 3.6.2 Real Time Aperture Control

**[0207]** In an embodiment, the aperture width/duration is adjusted in real time. For example, referring to the timing diagrams in FIGS. **64**B-F, a clock signal **6414** (FIG. **64**B) is utilized to generate an energy transfer signal **6416** (FIG. **64**F), which includes energy transfer pluses **6418**, having variable apertures **6420**. In an embodiment, the clock signal **6414** is inverted as illustrated by inverted clock signal **6422** (FIG. **64**D). The clock signal **6414** is also delayed, as illustrated by delayed clock signal **6424** (FIG. **64**E). The inverted clock signal **6414** and the delayed clock signal **6424** are then ANDed together, generating an energy transfer signal **6416**, which is active—energy transfer pulses **6418**—when the delayed clock signal **6424** and the inverted clock signal **6422** are both active. The amount of delay imparted to the delayed clock signal **6424** substantially determines the width or duration of the apertures **6420**. By varying the delay in real time, the apertures are adjusted in real time.

**[0208]** In an alternative implementation, the inverted clock signal **6422** is delayed relative to the original clock signal **6414**, and then ANDed with the original clock signal **6414**. Alternatively, the original clock signal **6414** is delayed then inverted, and the result ANDed with the original clock signal **6414**.

**[0209]** FIG. **64**A illustrates an exemplary real time aperture control system **6402** that can be utilized to adjust apertures in real time. The example real time aperture control system **6402** includes an RC circuit **6404**, which includes a voltage variable capacitor **6412** and a resistor **6426**. The real time aperture control system **6402** also includes an inverter **6406** and an AND gate **6408**. The AND gate **6408** optionally includes an enable input **6410** for enabling/disabling the AND gate **6408**. The RC circuit **6404**. The real time aperture control system **6402** optionally includes an amplifier **6428**.

**[0210]** Operation of the real time aperture control circuit is described with reference to the timing diagrams of FIGS. **64**B-F. The real time control system **6402** receives the input clock signal **6414**, which is provided to both the inverter **6406** and to the RC circuit **6404**. The inverter **6406** outputs the inverted clock signal **6422** and presents it to the AND gate **6408**. The RC circuit **6404** delays the clock signal **6414** and outputs the delayed clock signal **6424**. The delay is determined primarily by the capacitance of the voltage variable capacitor **6412**. Generally, as the capacitance decreases, the delay decreases.

**[0211]** The delayed clock signal **6424** is optionally amplified by the optional amplifier **6428**, before being presented to the AND gate **6408**. Amplification is desired, for example, where the RC constant of the RC circuit **6404** attenuates the signal below the threshold of the AND gate **6408**.

**[0212]** The AND gate **6408** ANDs the delayed clock signal **6424**, the inverted clock signal **6422**, and the optional Enable signal **6410**, to generate the energy transfer signal **6416**. The apertures **6420** are adjusted in real time by varying the voltage to the voltage variable capacitor **6412**.

**[0213]** In an embodiment, the apertures **6420** are controlled to optimize power transfer. For example, in an embodiment, the apertures **6420** are controlled to maximize power transfer. Alternatively, the apertures **6420** are controlled for variable gain control (e.g. automatic gain control—AGC). In this embodiment, power transfer is reduced by reducing the apertures **6420**.

**[0214]** As can now be readily seen from this disclosure, many of the aperture circuits presented, and others, can be modified as in circuits illustrated in FIGS. **46** H-K. Modification or selection of the aperture can be done at the design level to remain a fixed value in the circuit, or in an alternative embodiment, may be dynamically adjusted to compensate for, or address, various design goals such as receiving RF signals with enhanced efficiency that are in distinctively different bands of operation, e.g. RF signals at 900 MHZ and 1.8 GHz.

**[0215]** 3.7 Adding a Bypass Network

**[0216]** In an embodiment of the invention, a bypass network is added to improve the efficiency of the energy transfer module. Such a bypass network can be viewed as a means of synthetic aperture widening. Components for a bypass network are selected so that the bypass network appears substantially lower impedance to transients of the switch module (i.e., frequencies greater than the received EM signal) and appears as a moderate to high impedance to the input EM signal (e.g., greater that 100 Ohms at the RF frequency).

**[0217]** The time that the input signal is now connected to the opposite side of the switch module is lengthened due to the shaping caused by this network, which in simple realizations may be a capacitor or series resonant inductor-capacitor. A network that is series resonant above the input frequency would be a typical implementation. This shaping improves the conversion efficiency of an input signal that would otherwise, if one considered the aperture of the energy transfer signal only, be relatively low in frequency to be optimal.

**[0218]** For example, referring to FIG. **61** a bypass network **6102** (shown in this instance as capacitor **6112**), is shown bypassing switch module **6104**. In this embodiment the bypass network increases the efficiency of the energy transfer module when, for example, less than optimal aperture widths were chosen for a given input frequency on the energy transfer signal **6106**. The bypass network **6102** could be of different configurations than shown in FIG. **61**. Such an alternate is illustrated in FIG. **57**. Similarly, FIG. **62** illustrates another example bypass network **6202**, including a capacitor **6204**.

**[0219]** The following discussion will demonstrate the effects of a minimized aperture and the benefit provided by a bypassing network. Beginning with an initial circuit having a 550 ps aperture in FIG. **65**, its output is seen to be 2.8 mVpp applied to a 50 ohm load in FIG. **69**A. Changing the aperture to 270 ps as shown in FIG. **66** results in a diminished output of 2.5 Vpp applied to a 50 ohm load as shown in FIG. **69**B. To compensate for this loss, a bypass network may be added, a specific implementation is provided in FIG. **67**. The result of this addition is that 3.2 Vpp can now be applied to the 50 ohm load as shown in FIG. **70**A. The circuit with the bypass network in FIG. **67** also had three values adjusted in the surrounding circuit to compensate for the impedance changes introduced by the bypass network and narrowed aperture. FIG. **68** verifies that those changes added to the circuit, but without the bypass network, did not themselves bring about the increased efficiency demonstrated by the embodiment in FIG. **67** with the bypass network. FIG. **70**B shows the result of using the circuit in FIG. **68** in which only 1.88 Vpp was able to be applied to a 50 ohm load.

**[0220]** 3.8 Modifying the Energy Transfer Signal Utilizing Feedback

**[0221]** FIG. **47** shows an embodiment of a system **4701** which uses down-converted Signal **4708**B as feedback **4706** to control various characteristics of the energy transfer module **4704** to modify the down-converted signal **4708**B.

**[0222]** Generally, the amplitude of the down-converted signal **4708**B varies as a function of the frequency and phase differences between the EM signal **4504** and the energy transfer signal **4506**. In an embodiment, the down-converted signal **4708**B is used as the feedback **4706** to control the frequency and phase relationship between the EM signal **4504** and the energy transfer signal **4506**. This can be accomplished using the example logic in FIG. **52**A. The example circuit in FIG. **52**A can be included in the energy transfer signal module **4702**. Alternate implementations will be apparent to persons skilled in the relevant art(s) based on the teachings contained herein. Alternate implementations fall within the scope and spirit of the present invention. In this embodiment a state-machine is used as an example.

**[0223]** In the example of FIG. **52**A, a state machine **5204** reads an analog to digital converter, A/D **5202**, and controls a digital to analog converter, DAC **5206**. In an embodiment, the state machine **5204** includes 2 memory locations, Previous and Current, to store and recall the results of reading A/D **5202**. In an embodiment, the state machine **5204** utilizes at least one memory flag.

**[0224]** The DAC **5206** controls an input to a voltage controlled oscillator, VCO **5208**. VCO **5208** controls a frequency input of a pulse generator **5210**, which, in an embodiment, is substantially similar to the pulse generator shown in FIG. **46**C. The pulse generator **5210** generates energy transfer signal **4506**.

**[0225]** In an embodiment, the state machine **5204** operates in accordance with a state machine flowchart **5219** in FIG. **52**B. The result of this operation is to modify the frequency and phase relationship between the energy transfer signal **4506** and the EM signal **4504**, to substantially maintain the amplitude of the down-converted signal **4708**B at an optimum level.

**[0226]** The amplitude of the down-converted signal **4708**B can be made to vary with the amplitude of the energy transfer signal **4506**. In an embodiment where the switch module **6502** is a FET as shown in FIG. **45**A, wherein the gate **4518** receives the energy transfer signal **4506**, the amplitude of the energy transfer signal **4506** can determine the "on" resistance of the FET, which affects the amplitude of the down-converted signal **4708**B. The energy transfer signal module **4702**, as shown in FIG. **52**C, can be an analog circuit that enables an automatic gain control function. Alternate implementations will be apparent to persons skilled in the relevant art(s) based on the teachings contained herein. Alternate implementations fall within the scope and spirit of the present invention.

**[0227]** 3.9 Other Implementations

**[0228]** The implementations described above are provided for purposes of illustration. These implementations are not intended to limit the invention. Alternate implementations, differing slightly or substantially from those described herein, will be apparent to persons skilled in the relevant art(s) based on the teachings contained herein. Such alternate implementations fall within the scope and spirit of the present invention.

**[0229]** 3.10 Example Energy Transfer Down-Converters

**[0230]** Example implementations are described below for illustrative purposes. The invention is not limited to these examples.

**[0231]** FIG. **53** is a schematic diagram of an exemplary circuit to down convert a 915 MHZ signal to a 5 MHZ signal using a 101.1 MHZ clock.

**[0232]** FIG. **54** shows example simulation waveforms for the circuit of FIG. **53**. Waveform **5302** is the input to the circuit showing the distortions caused by the switch closure. Waveform **5304** is the unfiltered output at the storage unit. Waveform **5306** is the impedance matched output of the down-converter on a different time scale.

**[0233]** FIG. **55** is a schematic diagram of an exemplary circuit to down-convert a 915 MHZ signal to a 5 MHZ signal using a 101.1 MHZ clock. The circuit has additional tank circuitry to improve conversion efficiency.

**[0234]** FIG. **56** shows example simulation waveforms for the circuit of FIG. **55**. Waveform **5502** is the input to the circuit showing the distortions caused by the switch closure. Waveform **5504** is the unfiltered output at the storage unit. Waveform **5506** is the output of the down-converter after the impedance match circuit.

**[0235]** FIG. **57** is a schematic diagram of an exemplary circuit to down-convert a 915 MHZ signal to a 5 MHZ signal using a 101.1 MHZ clock. The circuit has switch bypass circuitry to improve conversion efficiency.

**[0236]** FIG. **58** shows example simulation waveforms for the circuit of FIG. **57**. Waveform **5702** is the input to the circuit showing the distortions caused by the switch closure. Waveform **5704** is the unfiltered output at the storage unit. Waveform **5706** is the output of the down-converter after the impedance match circuit.

**[0237]** FIG. **59** shows a schematic of the example circuit in FIG. **53** connected to an FSK source that alternates between 913 and 917 MHZ, at a baud rate of 500 Kbaud. FIG. **72** shows the original FSK waveform **5902** and the down-converted waveform **5904** at the output of the load impedance match circuit.

## 4. FREQUENCY UP-CONVERSION

**[0238]** The present invention is directed to systems and methods of frequency up-conversion, and applications of same.

**[0239]** An example frequency up-conversion system **300** is illustrated in FIG. **3**. The frequency up-conversion system **300** is now described.

**[0240]** An input signal **302** (designated as "Control Signal" in FIG. **3**) is accepted by a switch module **304**. For purposes of example only, assume that the input signal **302** is a FM input signal **606**, an example of which is shown in FIG. **6**C. FM input signal **606** may have been generated by modulating information signal **602** onto oscillating signal **604** (FIGS. **6**A and **6**B). It should be understood that the invention is not limited to this embodiment. The information signal **602** can be analog, digital, or any combination thereof, and any modulation scheme can be used.

**[0241]** The output of switch module **304** is a harmonically rich signal **306**, shown for example in FIG. **6**D as a harmonically rich signal **608**. The harmonically rich signal **608** has a continuous and periodic waveform.

**[0242]** FIG. **6**E is an expanded view of two sections of harmonically rich signal **608**, section **610** and section **612**. The harmonically rich signal **608** may be a rectangular wave, such as a square wave or a pulse (although, the invention is not limited to this embodiment). For ease of discussion, the term "rectangular waveform" is used to refer to waveforms that are substantially rectangular. In a similar manner, the term "square wave" refers to those waveforms that are substantially square and it is not the intent of the present invention that a perfect square wave be generated or needed.

**[0243]** Harmonically rich signal **608** is comprised of a plurality of sinusoidal waves whose frequencies are integer multiples of the fundamental frequency of the waveform of the harmonically rich signal **608**. These sinusoidal waves are referred to as the harmonics of the underlying waveform, and the fundamental frequency is referred to as the first harmonic. FIG. **6**F and FIG. **6**G show separately the sinusoidal components making up the first, third, and fifth harmonics of section **610** and section **612**. (Note that in theory there may be an infinite number of harmonics; in this example, because harmonically rich signal **608** is shown as a square wave, there are only odd harmonics). Three harmonics are shown simultaneously (but not summed) in FIG. **6**H.

**[0244]** The relative amplitudes of the harmonics are generally a function of the relative widths of the pulses of harmonically rich signal **306** and the period of the fundamental frequency, and can be determined by doing a Fourier analysis of harmonically rich signal **306**. According to an embodiment of the invention, the input signal **606** may be shaped to ensure that the amplitude of the desired harmonic is sufficient for its intended use (e.g., transmission).

**[0245]** A filter **308** filters out any undesired frequencies (harmonics), and outputs an electromagnetic (EM) signal at the desired harmonic frequency or frequencies as an output signal **310**, shown for example as a filtered output signal **614** in FIG. **6**I.

**[0246]** FIG. **4** illustrates an example universal frequency up-conversion (UFU) module **401**. The UFU module **401** includes an example switch module **304**, which comprises a bias signal **402**, a resistor or impedance **404**, a universal frequency translator (UFT) **450**, and a ground **408**. The UFT **450** includes a switch **406**. The input signal **302** (designated as "Control Signal" in FIG. **4**) controls the switch **406** in the UFT **450**, and causes it to close and open. Harmonically rich signal **306** is generated at a node **405** located between the resistor or impedance **404** and the switch **406**.

**[0247]** Also in FIG. **4**, it can be seen that an example filter **308** is comprised of a capacitor **410** and an inductor **412** shunted to a ground **414**. The filter is designed to filter out the undesired harmonics of harmonically rich signal **306**.

**[0248]** The invention is not limited to the UFU embodiment shown in FIG. **4**.

**[0249]** For example, in an alternate embodiment shown in FIG. **5**, an unshaped input signal **501** is routed to a pulse shaping module **502**. The pulse shaping module **502** modifies the unshaped input signal **501** to generate a (modified) input signal **302** (designated as the "Control Signal" in FIG. **5**). The input signal **302** is routed to the switch module **304**, which operates in the manner described above. Also, the filter **308** of FIG. **5** operates in the manner described above.

**[0250]** The purpose of the pulse shaping module **502** is to define the pulse width of the input signal **302**. Recall that the input signal **302** controls the opening and closing of the switch **406** in switch module **304**. During such operation, the pulse width of the input signal **302** establishes the pulse width of the harmonically rich signal **306**. As stated above, the relative amplitudes of the harmonics of the harmonically rich signal **306** are a function of at least the pulse width of the harmonically rich signal **306**. As such, the pulse width of the input signal **302** contributes to setting the relative amplitudes of the harmonics of harmonically rich signal **306**.

**[0251]** Further details of up-conversion as described in this section are presented in pending U.S. application "Method and System for Frequency Up-Conversion," Ser. No. 09/176,154, filed Oct. 21, 1998, incorporated herein by reference in its entirety.

## 5. ENHANCED SIGNAL RECEPTION

**[0252]** The present invention is directed to systems and methods of enhanced signal reception (ESR), and applications of same.

**[0253]** Referring to FIG. **21**, transmitter **2104** accepts a modulating baseband signal **2102** and generates (transmitted) redundant spectrums **2106***a-n*, which are sent over communications medium **2108**. Receiver **2112** recovers a demodulated baseband signal **2114** from (received) redundant spectrums **2110***a-n*. Demodulated baseband signal **2114** is representative of the modulating baseband signal **2102**, where the level of similarity between the modulating baseband signal **2114** and the modulating baseband signal **2102** is application dependent.

**[0254]** Modulating baseband signal **2102** is preferably any information signal desired for transmission and/or reception. An example modulating baseband signal **2202** is illustrated in FIG. **22**A, and has an associated modulating baseband spectrum **2204** and image spectrum **2203** that are illustrated in FIG. **22**B. Modulating baseband signal **2202** is illustrated as an analog signal in FIG. **22***a*, but could also be a digital signal, or combination thereof. Modulating baseband signal **2202** could be a voltage (or current) characterization of any number of real world occurrences, including for example and without limitation, the voltage (or current) representation for a voice signal.

**[0255]** Each transmitted redundant spectrum **2106***a-n* contains the necessary information to substantially reconstruct the modulating baseband signal **2102**. In other words, each redundant spectrum **2106***a-n* contains the necessary amplitude, phase, and frequency information to reconstruct the modulating baseband signal **2102**.

**[0256]** FIG. **22**C illustrates example transmitted redundant spectrums **2206***b-d*. Transmitted redundant spectrums **2206***b-d* are illustrated to contain three redundant spectrums for illustration purposes only. Any number of redundant spectrums could be generated and transmitted as will be explained in following discussions.

**[0257]** Transmitted redundant spectrums **2206***b-d* are centered at $f_1$, with a frequency spacing $f_2$ between adjacent spectrums. Frequencies $f_1$ and $f_2$ are dynamically adjustable in real-time as will be shown below. FIG. **22**D illustrates an alternate embodiment, where redundant spectrums **2208***c,d* are centered on unmodulated oscillating signal **2209** at $f_1$ (Hz). Oscillating signal **2209** may be suppressed if desired using, for example, phasing techniques or filtering techniques. Transmitted redundant spectrums are preferably above baseband frequencies as is represented by break **2205** in the frequency axis of FIGS. **22**C and **22**D.

**[0258]** Received redundant spectrums **2110***a-n* are substantially similar to transmitted redundant spectrums **2106***a-*

*n*, except for the changes introduced by the communications medium **2108**. Such changes can include but are not limited to signal attenuation, and signal interference. FIG. **22**E illustrates example received redundant spectrums **2210***b-d*. Received redundant spectrums **2210***b-d* are substantially similar to transmitted redundant spectrums **2206***b-d*, except that redundant spectrum **2210***c* includes an undesired jamming signal spectrum **2211** in order to illustrate some advantages of the present invention. Jamming signal spectrum **2211** is a frequency spectrum associated with a jamming signal. For purposes of this invention, a "jamming signal" refers to any unwanted signal, regardless of origin, that may interfere with the proper reception and reconstruction of an intended signal. Furthermore, the jamming signal is not limited to tones as depicted by spectrum **2211**, and can have any spectral shape, as will be understood by those skilled in the art(s).

**[0259]** As stated above, demodulated baseband signal **2114** is extracted from one or more of received redundant spectrums **2210***b-d*. FIG. **22**F illustrates example demodulated baseband signal **2212** that is, in this example, substantially similar to modulating baseband signal **2202** (FIG. **22**A); where in practice, the degree of similarity is application dependent.

**[0260]** An advantage of the present invention should now be apparent. The recovery of modulating baseband signal **2202** can be accomplished by receiver **2112** in spite of the fact that high strength jamming signal(s) (e.g. jamming signal spectrum **2211**) exist on the communications medium. The intended baseband signal can be recovered because multiple redundant spectrums are transmitted, where each redundant spectrum carries the necessary information to reconstruct the baseband signal. At the destination, the redundant spectrums are isolated from each other so that the baseband signal can be recovered even if one or more of the redundant spectrums are corrupted by a jamming signal.

**[0261]** Transmitter **2104** will now be explored in greater detail. FIG. **23**A illustrates transmitter **2301**, which is one embodiment of transmitter **2104** that generates redundant spectrums configured similar to redundant spectrums **2206***b-d*. Transmitter **2301** includes generator **2303**, optional spectrum processing module **2304**, and optional medium interface module **2320**. Generator **2303** includes: first oscillator **2302**, second oscillator **2309**, first stage modulator **2306**, and second stage modulator **2310**.

**[0262]** Transmitter **2301** operates as follows. First oscillator **2302** and second oscillator **2309** generate a first oscillating signal **2305** and second oscillating signal **2312**, respectively. First stage modulator **2306** modulates first oscillating signal **2305** with modulating baseband signal **2202**, resulting in modulated signal **2308**. First stage modulator **2306** may implement any type of modulation including but not limited to: amplitude modulation, frequency modulation, phase modulation, combinations thereof, or any other type of modulation. Second stage modulator **2310** modulates modulated signal **2308** with second oscillating signal **2312**, resulting in multiple redundant spectrums **2206***a-n* shown in FIG. **23**B. Second stage modulator **2310** is preferably a phase modulator, or a frequency modulator, although other types of modulation may be implemented including but not limited to amplitude modulation. Each redundant spectrum **2206***a-n* contains the necessary amplitude, phase, and frequency information to substantially reconstruct the modulating baseband signal **2202**.

**[0263]** Redundant spectrums **2206***a-n* are substantially centered around $f_1$, which is the characteristic frequency of first oscillating signal **2305**. Also, each redundant spectrum **2206***a-n* (except for **2206***c*) is offset from $f_1$ by approximately a multiple of $f_2$ (Hz), where $f_2$ is the frequency of the second oscillating signal **2312**. Thus, each redundant spectrum **2206***a-n* is offset from an adjacent redundant spectrum by $f_7$ (Hz). This allows the spacing between adjacent redundant spectrums to be adjusted (or tuned) by changing $f_2$ that is associated with second oscillator **2309**. Adjusting the spacing between adjacent redundant spectrums allows for dynamic real-time tuning of the bandwidth occupied by redundant spectrums **2206***a-n*.

**[0264]** In one embodiment, the number of redundant spectrums **2206***a-n* generated by transmitter **2301** is arbitrary and may be unlimited as indicated by the "a-n" designation for redundant spectrums **2206***a-n*. However, a typical communications medium will have a physical and/or administrative limitations (i.e. FCC regulations) that restrict the number of redundant spectrums that can be practically transmitted over the communications medium. Also, there may be other reasons to limit the number of redundant spectrums transmitted. Therefore, preferably, the transmitter **2301** will include an optional spectrum processing module **2304** to process the redundant spectrums **2206***a-n* prior to transmission over communications medium **2108**.

**[0265]** In one embodiment, spectrum processing module **2304** includes a filter with a passband **2207** (FIG. **23**C) to select redundant spectrums **2206***b-d* for transmission. This will substantially limit the frequency bandwidth occupied by the redundant spectrums to the passband **2207**. In one embodiment, spectrum processing module **2304** also up converts redundant spectrums and/or amplifies redundant spectrums prior to transmission over the communications medium **2108**. Finally, medium interface module **2320** transmits redundant spectrums over the communications medium **2108**. In one embodiment, communications medium **2108** is an over-the-air link and medium interface module **2320** is an antenna. Other embodiments for communications medium **2108** and medium interface module **2320** will be understood based on the teachings contained herein.

**[0266]** FIG. **23**D illustrates transmitter **2321**, which is one embodiment of transmitter **2104** that generates redundant spectrums configured similar to redundant spectrums **2208***c-d* and unmodulated spectrum **2209**. Transmitter **2321** includes generator **2311**, spectrum processing module **2304**, and (optional) medium interface module **2320**. Generator **2311** includes: first oscillator **2302**, second oscillator **2309**, first stage modulator **2306**, and second stage modulator **2310**.

**[0267]** As shown in FIG. **23**D, many of the components in transmitter **2321** are similar to those in transmitter **2301**. However, in this embodiment, modulating baseband signal **2202** modulates second oscillating signal **2312**. Transmitter **2321** operates as follows. First stage modulator **2306** modulates second oscillating signal **2312** with modulating baseband signal **2202**, resulting in modulated signal **2322**. As described earlier, first stage modulator **2306** can effect any type of modulation including but not limited to: amplitude modulation frequency modulation, combinations thereof, or any other type of modulation. Second stage modulator **2310** modulates first oscillating signal **2304** with modulated signal **2322**, resulting in redundant spectrums **2208***a-n*, as shown in FIG. **23**E. Second stage modulator **2310** is preferably a phase or frequency modulator, although other modulators could used including but not limited to an amplitude modulator.

**[0268]** Redundant spectrums **2208***a-n* are centered on unmodulated spectrum **2209** (at $f_1$ Hz), and adjacent spectrums are separated by $f_2$ Hz. The number of redundant spectrums **2208***a-n* generated by generator **2311** is arbitrary and unlimited, similar to spectrums **2206***a-n* discussed above. Therefore, optional spectrum processing module **2304** may also include a filter with passband **2325** to select, for example, spectrums **2208***c,d* for transmission over communications medium **2108**. In addition, optional spectrum processing module **2304** may also include a filter (such as a bandstop filter) to attenuate unmodulated spectrum **2209**. Alternatively, unmodulated spectrum **2209** may be attenuated by using phasing techniques during redundant spectrum generation. Finally, (optional) medium interface module **2320** transmits redundant spectrums **2208***c,d* over communications medium **2108**.

**[0269]** Receiver **2112** will now be explored in greater detail to illustrate recovery of a demodulated baseband signal from received redundant spectrums. FIG. 24A illustrates receiver **2430**, which is one embodiment of receiver **2112**. Receiver **2430** includes optional medium interface module **2402**, down-converter **2404**, spectrum isolation module **2408**, and data extraction module **2414**. Spectrum isolation module **2408** includes filters **2410***a-c*. Data extraction module **2414** includes demodulators **2416***a-c*, error check modules **2420***a-c*, and arbitration module **2424**. Receiver **2430** will be discussed in relation to the signal diagrams in FIGS. **24**B-**24**J.

**[0270]** In one embodiment, optional medium interface module **2402** receives redundant spectrums **2210***b-d* (FIG. 22E, and FIG. 24B). Each redundant spectrum **2210***b-d* includes the necessary amplitude, phase, and frequency information to substantially reconstruct the modulating baseband signal used to generated the redundant spectrums. However, in the present example, spectrum **2210***c* also contains jamming signal **2211**, which may interfere with the recovery of a baseband signal from spectrum **2210***c*. Down-converter **2404** down-converts received redundant spectrums **2210***b-d* to lower intermediate frequencies, resulting in redundant spectrums **2406***a-c* (FIG. 24C). Jamming signal **2211** is also down-converted to jamming signal **2407**, as it is contained within redundant spectrum **2406***b*. Spectrum isolation module **2408** includes filters **2410***a-c* that isolate redundant spectrums **2406***a-c* from each other (FIGS. 24D-24F, respectively). Demodulators **2416***a-c* independently demodulate spectrums **2406***a-c*, resulting in demodulated baseband signals **2418***a-c*, respectively (FIGS. 24G-24I). Error check modules **2420***a-c* analyze demodulate baseband signal **2418***a-c* to detect any errors. In one embodiment, each error check module **2420***a-c* sets an error flag **2422***a-c* whenever an error is detected in a demodulated baseband signal. Arbitration module **2424** accepts the demodulated baseband signals and associated error flags, and selects a substantially error-free demodulated baseband signal (FIG. **24**J). In one embodiment, the substantially error-free demodulated baseband signal will be substantially similar to the modulating baseband signal used to generate the received redundant spectrums, where the degree of similarity is application dependent.

**[0271]** Referring to FIGS. **24**G-I, arbitration module **2424** will select either demodulated baseband signal **2418***a* or **2418***c*, because error check module **2420***b* will set the error flag **2422***b* that is associated with demodulated baseband signal **2418***b*.

**[0272]** The error detection schemes implemented by the error detection modules include but are not limited to: cyclic redundancy check (CRC) and parity check for digital signals, and various error detections schemes for analog signal.

**[0273]** Further details of enhanced signal reception as described in this section are presented in pending U.S. application "Method and System for Ensuring Reception of a Communications Signal," Ser. No. 09/176,415, filed Oct. 21, 1998, incorporated herein by reference in its entirety.

## 6. UNIFIED DOWN-CONVERSION AND FILTERING

**[0274]** The present invention is directed to systems and methods of unified down-conversion and filtering (UDF), and applications of same.

**[0275]** In particular, the present invention includes a unified down-converting and filtering (UDF) module that performs frequency selectivity and frequency translation in a unified (i.e., integrated) manner. By operating in this manner, the invention achieves high frequency selectivity prior to frequency translation (the invention is not limited to this embodiment). The invention achieves high frequency selectivity at substantially any frequency, including but not limited to RF (radio frequency) and greater frequencies. It should be understood that the invention is not limited to this example of RF and greater frequencies. The invention is intended, adapted, and capable of working with lower than radio frequencies.

**[0276]** FIG. **17** is a conceptual block diagram of a UDF module **1702** according to an embodiment of the present invention. The UDF module **1702** performs at least frequency translation and frequency selectivity.

**[0277]** The effect achieved by the UDF module **1702** is to perform the frequency selectivity operation prior to the performance of the frequency translation operation. Thus, the UDF module **1702** effectively performs input filtering.

**[0278]** According to embodiments of the present invention, such input filtering involves a relatively narrow bandwidth. For example, such input filtering may represent channel select filtering, where the filter bandwidth may be, for example, 50 KHz to 150 KHz. It should be understood, however, that the invention is not limited to these frequencies. The invention is intended, adapted, and capable of achieving filter bandwidths of less than and greater than these values.

**[0279]** In embodiments of the invention, input signals **1704** received by the UDF module **1702** are at radio frequencies. The UDF module **1702** effectively operates to input filter these RF input signals **1704**. Specifically, in these embodiments, the UDF module **1702** effectively performs input, channel select filtering of the RF input signal **1704**. Accordingly, the invention achieves high selectivity at high frequencies.

**[0280]** The UDF module **1702** effectively performs various types of filtering, including but not limited to bandpass filtering, low pass filtering, high pass filtering, notch filtering, all pass filtering, band stop filtering, etc., and combinations thereof.

**[0281]** Conceptually, the UDF module **1702** includes a frequency translator **1708**. The frequency translator **1708** conceptually represents that portion of the UDF module **1702** that performs frequency translation (down conversion).

**[0282]** The UDF module **1702** also conceptually includes an apparent input filter **1706** (also sometimes called an input filtering emulator). Conceptually, the apparent input filter **1706** represents that portion of the UDF module **1702** that performs input filtering.

**[0283]** In practice, the input filtering operation performed by the UDF module **1702** is integrated with the frequency translation operation. The input filtering operation can be viewed as being performed concurrently with the frequency translation operation. This is a reason why the input filter **1706** is herein referred to as an "apparent" input filter **1706**.

**[0284]** The UDF module **1702** of the present invention includes a number of advantages. For example, high selectivity at high frequencies is realizable using the UDF module **1702**. This feature of the invention is evident by the high Q factors that are attainable. For example, and without limitation, the UDF module **1702** can be designed with a filter center frequency $f_C$ on the order of 900 MHZ, and a filter bandwidth on the order of 50 KHz. This represents a Q of 18,000 (Q is equal to the center frequency divided by the bandwidth).

**[0285]** It should be understood that the invention is not limited to filters with high Q factors. The filters contemplated by the present invention may have lesser or greater Qs, depending on the application, design, and/or implementation. Also, the scope of the invention includes filters where Q factor as discussed herein is not applicable.

**[0286]** The invention exhibits additional advantages. For example, the filtering center frequency $f_C$ of the UDF module **1702** can be electrically adjusted, either statically or dynamically.

**[0287]** Also, the UDF module **1702** can be designed to amplify input signals.

**[0288]** Further, the UDF module **1702** can be implemented without large resistors, capacitors, or inductors. Also, the UDF module **1702** does not require that tight tolerances be maintained on the values of its individual components, i.e., its resistors, capacitors, inductors, etc. As a result, the architecture of the UDF module **1702** is friendly to integrated circuit design techniques and processes.

**[0289]** The features and advantages exhibited by the UDF module **1702** are achieved at least in part by adopting a new technological paradigm with respect to frequency selectivity and translation. Specifically, according to the present invention, the UDF module **1702** performs the frequency selectivity operation and the frequency translation operation as a single, unified (integrated) operation. According to the invention, operations relating to frequency translation also contribute to the performance of frequency selectivity, and vice versa.

**[0290]** According to embodiments of the present invention, the UDF module generates an output signal from an input signal using samples/instances of the input signal and samples/instances of the output signal.

**[0291]** More particularly, first, the input signal is under-sampled. This input sample includes information (such as amplitude, phase, etc.) representative of the input signal existing at the time the sample was taken.

**[0292]** As described further below, the effect of repetitively performing this step is to translate the frequency (that is, down-convert) of the input signal to a desired lower frequency, such as an intermediate frequency (IF) or baseband.

**[0293]** Next, the input sample is held (that is, delayed).

**[0294]** Then, one or more delayed input samples (some of which may have been scaled) are combined with one or more delayed instances of the output signal (some of which may have been scaled) to generate a current instance of the output signal.

**[0295]** Thus, according to a preferred embodiment of the invention, the output signal is generated from prior samples/instances of the input signal and/or the output signal. (It is noted that, in some embodiments of the invention, current samples/instances of the input signal and/or the output signal may be used to generate current instances of the output signal.). By operating in this manner, the UDF module preferably performs input filtering and frequency down-conversion in a unified manner.

**[0296]** FIG. **19** illustrates an example implementation of the unified down-converting and filtering (UDF) module **1922**. The UDF module **1922** performs the frequency translation operation and the frequency selectivity operation in an integrated, unified manner as described above, and as further described below.

**[0297]** In the example of FIG. **19**, the frequency selectivity operation performed by the UDF module **1922** comprises a band-pass filtering operation according to EQ. 1, below, which is an example representation of a band-pass filtering transfer function.

$$VO=\alpha_1 z^{-1} VI-\beta_1 z^{-1} VO-\beta_0 z^{-2} VO \qquad \text{EQ. 1}$$

**[0298]** It should be noted, however, that the invention is not limited to band-pass filtering. Instead, the invention effectively performs various types of filtering, including but not limited to bandpass filtering, low pass filtering, high pass filtering, notch filtering, all pass filtering, band stop filtering, etc., and combinations thereof. As will be appreciated, there are many representations of any given filter type. The invention is applicable to these filter representations. Thus, EQ. 1 is referred to herein for illustrative purposes only, and is not limiting.

**[0299]** The UDF module **1922** includes a down-convert and delay module **1924**, first and second delay modules **1928** and **1930**, first and second scaling modules **1932** and **1934**, an output sample and hold module **1936**, and an (optional) output smoothing module **1938**. Other embodiments of the UDF module will have these components in different configurations, and/or a subset of these components, and/or additional components. For example, and without limitation, in the configuration shown in FIG. **19**, the output smoothing module **1938** is optional.

**[0300]** As further described below, in the example of FIG. **19**, the down-convert and delay module **1924** and the first and second delay modules **1928** and **1930** include switches that are controlled by a clock having two phases, $\phi_1$ and $\phi_2$. $\phi_1$ and $\phi_2$ preferably have the same frequency, and are non-overlapping (alternatively, a plurality such as two clock signals having these characteristics could be used). As used herein, the term "non-overlapping" is defined as two or more signals where only one of the signals is active at any given time. In some embodiments, signals are "active" when they are high. In other embodiments, signals are active when they are low.

**[0301]** Preferably, each of these switches closes on a rising edge of $\phi_1$ or $\phi_2$, and opens on the next corresponding falling edge of $\phi_1$ or $\phi_2$. However, the invention is not limited to this example. As will be apparent to persons skilled in the relevant art(s), other clock conventions can be used to control the switches.

**[0302]** In the example of FIG. **19**, it is assumed that $\alpha_1$ is equal to one. Thus, the output of the down-convert and delay module **1924** is not scaled. As evident from the embodiments described above, however, the invention is not limited to this example.

**[0303]** The example UDF module **1922** has a filter center frequency of 900.2 MHZ and a filter bandwidth of 570 KHz. The pass band of the UDF module **1922** is on the order of 899.915 MHZ to 900.485 MHZ. The Q factor of the UDF module **1922** is approximately 1879 (i.e., 900.2 MHZ divided by 570 KHz).

**[0304]** The operation of the UDF module **1922** shall now be described with reference to a Table **1802** (FIG. **18**) that indicates example values at nodes in the UDF module **1922** at a number of consecutive time increments. It is assumed in Table **1802** that the UDF module **1922** begins operating at time t−1. As indicated below, the UDF module **1922** reaches steady state a few time units after operation begins. The number of time units necessary for a given UDF module to reach steady state depends on the configuration of the UDF module, and will be apparent to persons skilled in the relevant art(s) based on the teachings contained herein.

**[0305]** At the rising edge of $\phi_1$ at time t−1, a switch **1950** in the down-convert and delay module **1924** closes. This allows a capacitor **1952** to charge to the current value of an input signal, $VI_{t-1}$, such that node **1902** is at $VI_{t-1}$. This is indicated by cell **1804** in FIG. **18**. In effect, the combination of the switch **1950** and the capacitor **1952** in the down-convert and delay module **1924** operates to translate the frequency of the input signal VI to a desired lower frequency, such as IF or baseband. Thus, the value stored in the capacitor **1952** represents an instance of a down-converted image of the input signal VI.

**[0306]** The manner in which the down-convert and delay module **1924** performs frequency down-conversion is further described elsewhere in this application, and is additionally described in pending U.S. application "Method and System for Down-Converting Electromagnetic Signals," Ser. No. 09/176,022, filed Oct. 21, 1998, issued as U.S. Pat. No. 6,061, 551, which is herein incorporated by reference in its entirety.

**[0307]** Also at the rising edge of $\phi_1$ at time t−1, a switch **1958** in the first delay module **1928** closes, allowing a capacitor **1960** to charge to $VO_{t-1}$, such that node **1906** is at $VO_{t-1}$. This is indicated by cell **1806** in Table **1802**. (In practice, $VO_{t-1}$ is undefined at this point. However, for ease of understanding, $VO_{t-1}$ shall continue to be used for purposes of explanation.)

**[0308]** Also at the rising edge of $\phi_1$ at time t−1, a switch **1966** in the second delay module **1930** closes, allowing a capacitor **1968** to charge to a value stored in a capacitor **1964**. At this time, however, the value in capacitor **1964** is undefined, so the value in capacitor **1968** is undefined. This is indicated by cell **1807** in table **1802**.

**[0309]** At the rising edge of $\phi_2$ at time t−1, a switch **1954** in the down-convert and delay module **1924** closes, allowing a capacitor **1956** to charge to the level of the capacitor **1952**. Accordingly, the capacitor **1956** charges to $VI_{t-1}$, such that node **1904** is at $VI_{t-1}$. This is indicated by cell **1810** in Table **1802**.

**[0310]** The UDF module **1922** may optionally include a unity gain module **1990**A between capacitors **1952** and **1956**. The unity gain module **1990**A operates as a current source to enable capacitor **1956** to charge without draining the charge from capacitor **1952**. For a similar reason, the UDF module **1922** may include other unity gain modules **1990**B-**1990**G. It should be understood that, for many embodiments and applications of the invention, these unity gain modules **1990**A-**1990**G are optional. The structure and operation of the unity gain modules **1990** will be apparent to persons skilled in the relevant art(s).

**[0311]** Also at the rising edge of $\phi_2$ at time t−1, a switch **1962** in the first delay module **1928** closes, allowing a capacitor **1964** to charge to the level of the capacitor **1960**. Accordingly, the capacitor **1964** charges to $VO_{t-1}$, such that node **1908** is at $VO_{t-1}$. This is indicated by cell **1814** in Table **1802**.

**[0312]** Also at the rising edge of $\phi_2$ at time t−1, a switch **1970** in the second delay module **1930** closes, allowing a capacitor **1972** to charge to a value stored in a capacitor **1968**. At this time, however, the value in capacitor **1968** is undefined, so the value in capacitor **1972** is undefined. This is indicated by cell **1815** in table **1802**.

**[0313]** At time t, at the rising edge of $\phi_1$, the switch **1950** in the down-convert and delay module **1924** closes. This allows the capacitor **1952** to charge to $VI_t$, such that node **1902** is at $VI_t$. This is indicated in cell **1816** of Table **1802**.

**[0314]** Also at the rising edge of $\phi_1$ at time t, the switch **1958** in the first delay module **1928** closes, thereby allowing the capacitor **1960** to charge to $VO_t$. Accordingly, node **1906** is at $VO_t$. This is indicated in cell **1820** in Table **1802**.

**[0315]** Further at the rising edge of $\phi_1$ at time t, the switch **1966** in the second delay module **1930** closes, allowing a capacitor **1968** to charge to the level of the capacitor **1964**. Therefore, the capacitor **1968** charges to $VO_{t-1}$, such that node **1910** is at $VO_{t-1}$. This is indicated by cell **1824** in Table **1802**.

**[0316]** At the rising edge of $\phi_2$ at time t, the switch **1954** in the down-convert and delay module **1924** closes, allowing the capacitor **1956** to charge to the level of the capacitor **1952**. Accordingly, the capacitor **1956** charges to $VI_t$, such that node **1904** is at $VI_t$. This is indicated by cell **1828** in Table **1802**.

**[0317]** Also at the rising edge of $\phi_2$ at time t, the switch **1962** in the first delay module **1928** closes, allowing the capacitor **1964** to charge to the level in the capacitor **1960**. Therefore, the capacitor **1964** charges to $VO_t$, such that node **1908** is at $VO_t$. This is indicated by cell **1832** in Table **1802**.

**[0318]** Further at the rising edge of $\phi_2$ at time t, the switch **1970** in the second delay module **1930** closes, allowing the capacitor **1972** in the second delay module **1930** to charge to the level of the capacitor **1968** in the second delay module **1930**. Therefore, the capacitor **1972** charges to $VO_{t-1}$, such that node **1912** is at $VO_{t-1}$. This is indicated in cell **1836** of FIG. **18**.

**[0319]** At time t+1, at the rising edge of $\phi_1$, the switch **1950** in the down-convert and delay module **1924** closes, allowing the capacitor **1952** to charge to $VI_{t+1}$. Therefore, node **1902** is at $VI_{t+1}$, as indicated by cell **1838** of Table **1802**.

**[0320]** Also at the rising edge of $\phi_1$ at time t+1, the switch **1958** in the first delay module **1928** closes, allowing the capacitor **1960** to charge to $VO_{t+1}$. Accordingly, node **1906** is at $VO_{t+1}$, as indicated by cell **1842** in Table **1802**.

**[0321]** Further at the rising edge of $\phi_1$ at time t+1, the switch **1966** in the second delay module **1930** closes, allowing the capacitor **1968** to charge to the level of the capacitor **1964**. Accordingly, the capacitor **1968** charges to $VO_t$, as indicated by cell **1846** of Table **1802**.

**[0322]** In the example of FIG. **19**, the first scaling module **1932** scales the value at node **1908** (i.e., the output of the first delay module **1928**) by a scaling factor of −0.1. Accordingly, the value present at node **1914** at time t+1 is $-0.1*VO_t$. Similarly, the second scaling module **1934** scales the value present at node **1912** (i.e., the output of the second scaling module **1930**) by a scaling factor of −0.8. Accordingly, the value present at node **1916** is $-0.8*VO_{t-1}$ at time t+1.

**[0323]** At time t+1, the values at the inputs of the summer **1926** are: $VI_t$ at node **1904**, $-0.1*VO_t$ at node **1914**, and $-0.8*VO_{t-1}$ at node **1916** (in the example of FIG. **19**, the values at nodes **1914** and **1916** are summed by a second summer **1925**, and this sum is presented to the summer **1926**). Accordingly, at time t+1, the summer generates a signal equal to $VI_t-0.1*VO_t-0.8*VO_{t-1}$.

**[0324]** At the rising edge of $\phi_1$ at time t+1, a switch **1991** in the output sample and hold module **1936** closes, thereby allowing a capacitor **1992** to charge to $VO_{t+1}$. Accordingly, the capacitor **1992** charges to $VO_{t+1}$, which is equal to the sum generated by the adder **1926**. As just noted, this value is equal to: $VI_t-0.1*VO_t-0.8*VO_{t-1}$. This is indicated in cell **1850** of Table **1802**. This value is presented to the optional output smoothing module **1938**, which smooths the signal to thereby generate the instance of the output signal $VO_{t+1}$. It is apparent from inspection that this value of $VO_{t+1}$ is consistent with the band pass filter transfer function of EQ. 1.

**[0325]** Further details of unified down-conversion and filtering as described in this section are presented in pending U.S. application "Integrated Frequency Translation And Selectivity," Ser. No. 09/175,966, filed Oct. 21, 1998, incorporated herein by reference in its entirety.

## 7. EXAMPLE APPLICATION EMBODIMENTS OF THE INVENTION

**[0326]** As noted above, the UFT module of the present invention is a very powerful and flexible device. Its flexibility is illustrated, in part, by the wide range of applications in which it can be used. Its power is illustrated, in part, by the usefulness and performance of such applications.

**[0327]** Example applications of the UFT module were described above. In particular, frequency down-conversion, frequency up-conversion, enhanced signal reception, and unified down-conversion and filtering applications of the UFT module were summarized above, and are further described below. These applications of the UFT module are discussed herein for illustrative purposes. The invention is not limited to these example applications. Additional applications of the UFT module will be apparent to persons skilled in the relevant art(s), based on the teachings contained herein.

**[0328]** For example, the present invention can be used in applications that involve frequency down-conversion. This is shown in FIG. **1**C, for example, where an example UFT module **115** is used in a down-conversion module **114**. In this capacity, the UFT module **115** frequency down-converts an input signal to an output signal. This is also shown in FIG. **7**, for example, where an example UFT module **706** is part of a down-conversion module **704**, which is part of a receiver **702**.

**[0329]** The present invention can be used in applications that involve frequency up-conversion. This is shown in FIG. **1**D, for example, where an example UFT module **117** is used in a frequency up-conversion module **116**. In this capacity, the UFT module **117** frequency up-converts an input signal to an output signal. This is also shown in FIG. **8**, for example, where an example UFT module **806** is part of up-conversion module **804**, which is part of a transmitter **802**.

**[0330]** The present invention can be used in environments having one or more transmitters **902** and one or more receivers **906**, as illustrated in FIG. **9**. In such environments, one or more of the transmitters **902** may be implemented using a UFT module, as shown for example in FIG. **8**. Also, one or more of the receivers **906** may be implemented using a UFT module, as shown for example in FIG. **7**.

**[0331]** The invention can be used to implement a transceiver. An example transceiver **1002** is illustrated in FIG. **10**. The transceiver **1002** includes a transmitter **1004** and a receiver **1008**. Either the transmitter **1004** or the receiver **1008** can be implemented using a UFT module. Alternatively, the transmitter **1004** can be implemented using a LIFT module **1006**, and the receiver **1008** can be implemented using a UFT module **1010**. This embodiment is shown in FIG. **10**.

**[0332]** Another transceiver embodiment according to the invention is shown in FIG. **11**. In this transceiver **1102**, the transmitter **1104** and the receiver **1108** are implemented using a single UFT module **1106**. In other words, the transmitter **1104** and the receiver **1108** share a UFT module **1106**.

**[0333]** As described elsewhere in this application, the invention is directed to methods and systems for enhanced signal reception (ESR). Various ESR embodiments include an ESR module (transmit) in a transmitter **1202**, and an ESR module (receive) in a receiver **1210**. An example ESR embodiment configured in this manner is illustrated in FIG. **12**.

**[0334]** The ESR module (transmit) **1204** includes a frequency up-conversion module **1206**. Some embodiments of this frequency up-conversion module **1206** may be implemented using a UFT module, such as that shown in FIG. **1**D.

**[0335]** The ESR module (receive) **1212** includes a frequency down-conversion module **1214**. Some embodiments of this frequency down-conversion module **1214** may be implemented using a UFT module, such as that shown in FIG. **1**C.

**[0336]** As described elsewhere in this application, the invention is directed to methods and systems for unified down-conversion and filtering (UDF). An example unified down-conversion and filtering module **1302** is illustrated in FIG. **13**. The unified down-conversion and filtering module **1302** includes a frequency down-conversion module **1304** and a filtering module **1306**. According to the invention, the frequency down-conversion module **1304** and the filtering module **1306** are implemented using a UFT module **1308**, as indicated in FIG. **13**.

**[0337]** Unified down-conversion and filtering according to the invention is useful in applications involving filtering and/or frequency down-conversion. This is depicted, for example, in FIGS. **15**A-**15**F. FIGS. **15**A-**15**C indicate that unified down-conversion and filtering according to the invention is useful in applications where filtering precedes, follows, or both precedes and follows frequency down-conversion. FIG. **15**D indicates that a unified down-conversion and filtering module **1524** according to the invention can be utilized as a filter **1522** (i.e., where the extent of frequency down-conversion by the down-converter in the unified down-conversion and filtering module **1524** is minimized). FIG. **15**E indicates that a unified down-conversion and filtering module **1528** according to the invention can be utilized as a down-converter **1526** (i.e., where the filter in the unified down-conversion and filtering module **1528** passes substantially all frequencies). FIG. **15**F illustrates that the unified down-conversion and filtering module **1532** can be used as an amplifier. It is noted that one or more UDF modules can be used in applications that involve at least one or more of filtering, frequency translation, and amplification.

**[0338]** For example, receivers, which typically perform filtering, down-conversion, and filtering operations, can be implemented using one or more unified down-conversion and filtering modules. This is illustrated, for example, in FIG. **14**.

**[0339]** The methods and systems of unified down-conversion and filtering of the invention have many other applications. For example, as discussed herein, the enhanced signal reception (ESR) module (receive) operates to down-convert a signal containing a plurality of spectrums. The ESR module (receive) also operates to isolate the spectrums in the down-converted signal, where such isolation is implemented via filtering in some embodiments. According to embodiments of the invention, the ESR module (receive) is implemented using one or more unified down-conversion and filtering (UDF) modules. This is illustrated, for example, in FIG. **16**. In the example of FIG. **16**, one or more of the UDF modules **1610**, **1612**, **1614** operates to down-convert a received signal. The UDF modules **1610**, **1612**, **1614** also operate to filter the down-converted signal so as to isolate the spectrum(s) contained therein. As noted above, the UDF modules **1610**, **1612**, **1614** are implemented using the universal frequency translation (UFT) modules of the invention.

**[0340]** The invention is not limited to the applications of the UFT module described above. For example, and without limitation, subsets of the applications (methods and/or structures) described herein (and others that would be apparent to persons skilled in the relevant art(s) based on the herein teachings) can be associated to form useful combinations.

**[0341]** For example, transmitters and receivers are two applications of the UFT module. FIG. **10** illustrates a transceiver **1002** that is formed by combining these two applications of the UFT module, i.e., by combining a transmitter **1004** with a receiver **1008**.

**[0342]** Also, ESR (enhanced signal reception) and unified down-conversion and filtering are two other applications of the UFT module. FIG. **16** illustrates an example where ESR and unified down-conversion and filtering are combined to form a modified enhanced signal reception system.

**[0343]** The invention is not limited to the example applications of the UFT module discussed herein. Also, the invention is not limited to the example combinations of applications of the UFT module discussed herein. These examples were provided for illustrative purposes only, and are not limiting. Other applications and combinations of such applications will be apparent to persons skilled in the relevant art(s) based on the teachings contained herein. Such applications and combinations include, for example and without limitation, applications/combinations comprising and/or involving one or more of: (1) frequency translation; (2) frequency down-conversion; (3) frequency up-conversion; (4) receiving; (5) transmitting; (6) filtering; and/or (7) signal transmission and reception in environments containing potentially jamming signals.

**[0344]** Additional examples are set forth below describing applications of the UFT module in the area of universal platform modules.

## 8. UNIVERSAL PLATFORM MODULE (UPM)

**[0345]** The invention is directed to devices which, generally, provide some information technology and communicate on a network or over any other communication medium (such as wireless and wired communication mediums). In order to communicate, the devices receive a signal, optionally modify the signal or otherwise process the signal in an application specific manner, display the information, allow modification of the information, and then transmit a modified signal at the same or different frequency or frequencies. As will be appreciated, at least some of these operations are optional. A device is often used in an off-line manner where it is disconnected from the network or networks (or, more generally, when the device is not in communication with other devices/external entities).

**[0346]** A device **2602** is illustrated, for example, in FIG. **32**, where an example UPM **2606** enables communication with networks using cellular **3210**, wireless local loop (WLL) **3215**, wireless local area network (WLAN) **3220**, wireline (LAN, WAN, etc.) **3230**, and analog **3225** network links. These network links and/or topologies are described herein for example purposes only, although it should be understood that the invention is applicable to any communication medium. Device **2602** communicates using these links to any of the components (PCs, servers, other devices) which are available on the respective networks **3212**, **3217**, **3222**, **3227**, and **3232**. Such communication may be simultaneous, either actual or apparent.

**[0347]** The UPM **2606** may include a receiver, transmitter, and/or transceiver. Such components employ one or more UFT modules for performing frequency translation operations. See, for example, FIGS. **10** and **11** in the case of transceivers. See, for example, FIGS. **7** and **8** for receivers and transmitters.

**[0348]** 8.1 Conventional Multi-Mode Usage Model

**[0349]** FIG. **25**A illustrates a high level block diagram of an example conventional multi-mode device **2502**. Multi-mode device **2502** includes device resources **2504**, a CDMA platform module **2508**, and a Bluetooth platform module **2506**. CDMA platform module **2508** is constructed to perform cellular telephone operations with the cellular CDMA network **2510**. Bluetooth platform module **2506** is constructed to perform WLAN operations with other Bluetooth devices on the Bluetooth Network **2512**.

**[0350]** FIG. **25**B illustrates a more detailed block diagram of a platform module **2508*a*** employing a conventional receiver implemented with heterodyne components. Platform module **2508*a*** frequency down-converts and demodulates a first EM signal **2514** received by first antenna **2515**. First EM signal **2514** generally comprises a electromagnetic (EM) signal broadcast at a carrier frequency modulated by a baseband information signal.

**[0351]** FIG. **25**C illustrates a more detailed block diagram of a platform module **2508*b*** employing a conventional transmitter implemented with heterodyne components. Platform module **2508*b*** operates similarly to platform module **2508*a***. Platform module **2508*b*** modulates and frequency up-converts baseband signal **2518**, and outputs an EM signal **2542** that is transmitted by an antenna **2540**.

**[0352]** Conventional platform module **2508**, whether implemented as a receiver or transmitter (and/or transceiver (not shown)), suffers from the disadvantages of conventional wireless communication methods and systems. For instance, receivers and transmitters are conventionally implemented with heterodyne components. As previously described, heterodyne implementations are complex, are expensive to design, manufacture, and tune, and suffer from additional deficiencies well known in the art.

[0353] 8.2 Universal Platform Module of the Present Invention

[0354] FIG. **26** illustrates a high level block diagram embodiment of an exemplary universal platform enabled device **2602** according to an embodiment of the present invention.

[0355] Universal platform enabled device **2602** includes device resources **2604** and a UPM **2606**. UPM **2606** comprises at least one UFT module **2620** (as shown in FIG. **26**B). UPM **2606** is shown linking to various network types: cellular network **2610**, WLAN network **2612**, WLL network **2614**, and other networks **2616**. Other networks **2616** include personal area networks (PANs), other non-IP networks, and any network resulting without limitation from the connection of devices through any communication medium, wired or wireless.

[0356] UPM **2606** receives signals and transmits signals using the UFT module **2620** as described herein.

[0357] In another embodiment, additional UFT modules **2620** may be employed, as shown in FIG. **26**C. Persons skilled in the relevant art(s) will recognize after reading this disclosure that in particular applications, additional UFT modules may be used.

[0358] Furthermore, FIG. **26**C illustrates another embodiment where universal platform sub-modules (UPSM) **2622**, each containing a UFT module **2620**, are employed. Each UPSM **2622** would be capable of maintaining one or more links to the various networks/communication mediums disclosed herein.

[0359] The UPM **2606** of the present invention is also directed to digital signal applications. In a further embodiment, optional signal conditioning module **2523** comprises an analog-to-digital converter (A/D), a digital signal processor (DSP), a digital-to-analog (D/A) converter, and storage. Optional signal conditioning module **2523** inputs down-converted baseband signal **2518** to A/D. A/D converts down-converted baseband signal **2518** to a digital signal on interconnection. DSP can perform any digital signal processing function on the digital signal for signal amplification, filtering, error correction, etc. DSP may comprise a digital signal processing chip, a computer, hardware, software, firmware, or any combination thereof, or any other applicable technology known to persons skilled in the relevant art(s). Storage provides for storing digital signals at any stage prior to digital-to-analog conversion by D/A. These digital signals include the digital signal received from A/D, the digital signal to be output to D/A, or any intermediate signal provided by DSP. The interconnection may be configured between the components of optional signal conditioning module **2523** in a variety of ways as required by the present application, as would be understood by persons skilled in the relevant art(s).

[0360] D/A inputs the digital signal to be transmitted from interconnection, and converts it to analog, outputting baseband signal **2518**. Optional signal conditioning module **2523** provides for digital signal processing and conditioning of a received signal prior to its re-transmission. Persons skilled in the relevant art(s) will recognize that a variety of digital signal conditioning configurations exist for optional signal conditioning module **2523**. Any other digital signal conditioning function may be performed by optional signal conditioning module **2523**, as would be known to persons skilled in the relevant art(s).

[0361] Furthermore, persons skilled in the relevant art(s) will recognize that optional signal conditioning module **2523** can be configured to handle a combination of analog and digital signal conditioning functions.

[0362] Exemplary embodiments of the UPM **2606** and UPSM **2622** of the present invention are described below. However, it should be understood that these examples are provided for illustrative purposes only. The invention is not limited to these embodiments. Alternate embodiments (including equivalents, extensions, variations, deviations, etc., of the embodiments described herein) will be apparent to persons skilled in the relevant art(s) based on the teachings contained herein. The invention is intended and adapted to include such alternate embodiments.

[0363] 8.2.1 Universal Platform Module Embodiments

[0364] The universal platform module of the present invention is directed to applications of universal platform modules and sub-modules. The universal platform module of the present invention may be implemented in devices which are land-based, and air- and space-based, or based anywhere else applicable. For example, the universal platform module of the present invention may be implemented in devices employed in ground stations, satellites, spacecraft, watercraft, and aircraft. The universal platform module of the present invention is applicable to any number of common household consumer appliances and goods, including phones and wireless modems. The universal platform module of the present invention may be implemented in any applicable manner known to persons skilled in the relevant art(s).

[0365] The universal platform module of the present invention is preferably directed to analog signal applications, although the invention is also applicable to digital applications. UPSM **3802** in the example embodiment shown in FIG. **38** is specific to a particular protocol and a particular bearer combination. The UPSM **3802** includes a receiver **3804** and a transmitter **3808** each including one or more UFT modules (as indicated by **3806** and **3810**) as described herein and in the cited patent applications. Alternatively, the UPSM **3802** includes a transceiver having one or more UFT modules as described herein (as shown in FIG. **37** and discussed below).

[0366] The UPSM **3802** also includes a control module **3812** that enables the UPSM **3802** to operate in conformance with the particular protocol/bearer service combination. In particular, the control module **3812** includes hardware, software, or combinations thereof to cause the UPSM **3802** to receive, transmit, process, and otherwise interact with signals according to the particular protocol/bearer service combination. Implementation of the control module **3812** will be apparent to persons skilled in the relevant art(s) based on at least the teachings contained herein.

[0367] Examples of the UPSM **3802** include ones that operate according to the example protocol/bearer service combinations shown in FIG. **39**. It should be understood that the examples shown in FIG. **39** are provided for illustrative purposes only, and are not limiting. The invention is intended and adapted to operate with other protocol/bearer service combinations, and these will be apparent to persons skilled in the relevant art(s) based on at least the teachings contained herein.

[0368] Also, FIG. **40** is a representation of groups of communication links or types. The control module **3812** of the UPSM **3802** enables the UPSM **3802** to operate in conformance with any such communication link/type. In particular, the control module **3812** includes hardware, software, or combinations thereof to cause the UPSM **3802** to receive, transmit, process, and otherwise interact with signals according to the communication link/type. Implementation of the control module **3812** will be apparent to persons skilled in the relevant art(s) based on at least the teachings contained herein. It should be understood that the examples shown in FIG. **40** are provided for illustrative purposes only, and are not limiting. The invention is intended and adapted to operate with other communication links/types, and these will be apparent to persons skilled in the relevant art(s) based on at least the teachings contained herein.

**[0369]** An example embodiment of a USPM **3802** that operates according to the WLAN communication type/link is described in greater detail in U.S. provisional application Ser. No. 60/147,129 filed Aug. 4, 1999, which is herein incorporated by reference in its entirety. It should be understood that this description is provided for illustrative purposes only are is not limiting. In particular, the invention is not limited to this combination.

**[0370]** An example embodiment of a USPM **3802** that operates according to the CDMA communication type/link is described in greater detail in U.S. patent application Ser. No. 09/525,185 filed Mar. 14, 2000 and Ser. No. 09/525,615 filed Mar. 14, 2000, which are herein incorporated by reference in its entirety. Another example embodiment of a USPM **3802** that operates according to the CDMA communication type/link is described in greater detail in U.S. patent application "Wireless Telephone Using Universal Frequency Translation," filed Apr. 10, 2000, Attorney Docket Number 1744.0070000, incorporated herein by reference in its entirety. It should be understood that this description is provided for illustrative purposes only and is not limiting. In particular, the invention is not limited to this combination.

**[0371]** The UPSM **3802**; and in particular the control module **3812**, for the WAP/Bluetooth combination, shall now be described in greater detail. It should be understood that this description is provided for illustrative purposes only are is not limiting. In particular, the invention is not limited to this combination.

**[0372]** FIG. **43** illustrates an embodiment of the invention for the UPSM **3802** and control module **3812**. Control module **3812** includes sub-modules which contain implementation and operational instructions for UPSM **3802**. In one embodiment, WAP sub-module **4304** and Bluetooth sub-module **4306** are employed such that the UPSM may operate using either Bluetooth or one of the number of bearer services available to WAP.

**[0373]** In an embodiment, WAP sub-module **4304** contains the WAP protocol stack and specification information about the WAP architecture. For instance, the wireless application environment (WAE) or application layer, session layer (WSP), transaction layer (WTP), security layer (WTLS), and transport layer (WDP). This information would enable control module **3812** to operate the components of UPSM **3802** in a manner that conforms to both the requirements of the protocol, but also to the requirements of the operating environment. The operating environment includes, but is not limited to, the available bearer services, content encoders and decoders employed, available protocol gateways, etc.

**[0374]** In an embodiment, Bluetooth sub-module **4306** contains the Bluetooth protocol stack and specification information about the Bluetooth architecture. For instance, Bluetooth sub-module **4306** includes: 1) the link manager protocol (LMP), which is responsible for link setup between Bluetooth-enabled devices, including authentication and encryption; 2) the logical link control and adaptation protocol (L2CAP), which serves as an adapter between the upper layer protocols and the Bluetooth baseband protocol and permits the higher level protocols to transmit and receive L2CAP data packets; 3) the service discovery protocol (SDP), which discovers information about the devices and services available in the local Bluetooth network, and then enables a connection between two or more Bluetooth-enabled devices; 4) the cable replacement protocol (RFCOMM); 5) the telephony control protocol (TCS BIN); and 6) the telephony control-AT commands.

**[0375]** The Bluetooth sub-module **4306** is not limited to these protocols. Additional protocol and specification information can be included to enhance the functionality of the UPSM **3802**. Implementation of the sub-modules of control module **3812** will be apparent to persons skilled in the relevant art(s) based on at least the teachings contained herein. It should be understood that the examples shown in FIGS. **39** and **40** are provided for illustrative purposes only, and are not limiting. The invention is intended and adapted to operate with other communication links/types, and these will be apparent to persons skilled in the relevant art(s) based on at least the teachings contained herein.

**[0376]** A device containing at least one UPM, which contains at least one UPSM **3802** of FIG. **43**, is capable of linking to wireless networks using any of the bearer services available for the protocols for which it is programmed and/or encoded. In one example, the device is communicating point-of-sale information by operating the receiver **3804** and transmitter **3808** components of UPSM **3802** for Bluetooth. In a nearly simultaneous fashion, the same device is switching the same receiver **3804** and transmitter **3808** components of UPSM **3802** using the wireless application protocol (WAP) to link the device to a cellular network using a CDMA standard bearer service.

**[0377]** In an additional embodiment, a device is able to employ WAP sub-module **4304** to maintain two or more nearly simultaneous links to the same or different bearer services using the same or different standards. For instance, a device is using AMPS to send and receive facsimiles, while a voice call is being maintained over GSM.

**[0378]** UPSM **4102** in the example embodiment shown in FIG. **41** contains a control module **4112** to enable the UPSM **4102** to operate according to multiple protocol/bearer service combinations (FIG. **39**) and/or multiple communication link/types (FIG. **40**).

**[0379]** In an embodiment, the UPSM **4102** operates according to one such protocol/bearer service combination or communication link/type at any given time. In this embodiment, the UPSM **4102** may operate in a multi-threaded manner so that it switches between protocol/bearer service combination or communication link/type over time. This enables the UPSM **4102** to effectively perform virtual or apparent simultaneous processing of multiple protocol/bearer service combinations and/or communication link/types.

**[0380]** Thus, the control module **4112** enables the UPSM **4102** to operate in conformance with any combination of protocol/bearer service combinations and communication link/types. In particular, the control module **4112** includes hardware, software, or combinations thereof to cause the UPSM **4102** to receive, transmit, process, and otherwise interact with signals according to any such protocol/bearer service combination or communication link/type. Implementation of the control module **4112** will be apparent to persons skilled in the relevant art(s) based on at least the teachings contained herein.

**[0381]** In the example shown in FIG. **41**, the UPSM **4102** includes a transceiver **4104** having one or more UFT **4106** modules. Alternatively, the UPSM **4102** could have one or more receivers and one or more transmitters each having one or more UFT modules. In some of such embodiments, the UPSM **4102** operates according to one or more protocol/bearer service combinations and/or communication link/types simultaneously at any given time. This enables the UPSM **4102** to perform simultaneous processing of multiple protocol/bearer service combinations and/or communication link/types.

**[0382]** Examples of the UPSM include ones that operate according to the example protocol/bearer service combinations shown in FIG. **39**. It should be understood that the examples shown in FIG. **39** are provided for illustrative purposes only, and are not limiting. The invention is intended and adapted to operate with other protocol/bearer service combinations, and these will be apparent to persons skilled in the relevant art(s) based on at least the teachings contained herein.

**[0383]** Also, FIG. **40** is a representation of groups of communication links or types. The control module **4112** of the UPSM **4102** enables the UPSM **4102** to operate in conformance with any such communication link/type. In particular, the control module **4112** includes hardware, software, or combinations thereof to cause the UPSM **4102** to receive, transmit, process, and otherwise interact with signals according to the communication link/type. Implementation of the control module **4112** will be apparent to persons skilled in the relevant art(s) based on at least the teachings contained herein. It should be understood that the examples shown in FIG. **40** are provided for illustrative purposes only, and are not limiting. The invention is intended and adapted to operate with other communication links/types, and these will be apparent to persons skilled in the relevant art(s) based on at least the teachings contained herein.

**[0384]** An example embodiment of a USPM **4102** that operates according to the WLAN communication type/link is described in greater detail in U.S. provisional application Ser. No. 60/147,129 filed Aug. 4, 1999, which is herein incorporated by reference in its entirety. It should be understood that this description is provided for illustrative purposes only are is not limiting. In particular, the invention is not limited to this combination.

**[0385]** An example embodiment of a USPM **4102** that operates according to the CDMA communication type/link is described in greater detail in U.S. patent application Ser. No. 09/525,185 filed Mar. 14, 2000 and Ser. No. 09/525,615 filed Mar. 14, 2000, which are herein incorporated by reference in its entirety. Another example embodiment of a USPM **3802** that operates according to the CDMA communication type/link is described in greater detail in U.S. patent application "Wireless Telephone Using Universal Frequency Translation," filed Apr. 10, 2000, Attorney Docket Number 1744.0070000, incorporated herein by reference in its entirety. It should be understood that this description is provided for illustrative purposes only are is not limiting. In particular, the invention is not limited to this combination.

**[0386]** UPSM **4102**, and in particular the control module **4112**, for the CDMA/GSM combination, shall now be described in greater detail. It should be understood that this description is provided for illustrative purposes only are is not limiting. In particular, the invention is not limited to this combination.

**[0387]** FIG. **44** illustrates an embodiment of the invention for the UPSM **4102** and control module **4112**. Control module **4112** includes protocol/bearer service sub-modules (P/BSSM) **4404** which contain implementation and operational instructions for UPSM **4102**. In one embodiment, any number of P/BSSM **4404** are employed such that the UPSM may operate using any number of networks.

**[0388]** In an embodiment, P/BSSM **4404** contains the WAP protocol stack and specification information about the WAP architecture. For instance, the wireless application environment (WAE) or application layer, session layer (WSP), transaction layer (WTP), security layer (WTLS), and transport layer (WDP). This information would enable control module **4112** to operate the components of UPSM **4102** in a manner that conforms to both the requirements of the protocol, but also to the requirements of the operating environment. The operating environment includes, but is not limited to, the available bearer services, content encoders and decoders employed, available protocol gateways, etc.

**[0389]** In an embodiment, P/BSSM **4404** contains the Bluetooth protocol stack and specification information about the Bluetooth architecture. For instance, P/BSSM **4404** includes: 1) the link manager protocol (LMP), which is responsible for link setup between Bluetooth-enabled devices, including authentication and encryption; 2) the logical link control and adaptation protocol (L2CAP), which serves as an adapter between the upper layer protocols and the Bluetooth baseband protocol and permits the higher level protocols to transmit and receive L2CAP data packets; 3) the service discovery protocol (SDP), which discovers information about the devices and services available in the local Bluetooth network, and then enables a connection between two or more Bluetooth-enabled devices; 4) the cable replacement protocol (RFCOMM); 5) the telephony control protocol (TCS BIN); and 6) the telephony control-AT commands.

**[0390]** The P/BSSM **4404** is not limited to these protocols. Additional protocol and specification information can be included to enhance the functionality of the UPSM **4102**. Implementation of the sub-modules of control module **4112** will be apparent to persons skilled in the relevant art(s) based on at least the teachings contained herein. It should be understood that the examples shown in FIGS. **39** and **40** are provided for illustrative purposes only, and are not limiting. The invention is intended and adapted to operate with other communication links/types, and these will be apparent to persons skilled in the relevant art(s) based on at least the teachings contained herein.

**[0391]** A device containing at least one UPM, which contains at least one UPSM **4102** of FIG. **44**, is capable of linking to networks using any of the bearer services available for the protocols for which it is programmed and/or encoded. In one example, the device is communicating point-of-sale information by operating the transceiver **4104** component of UPSM **4102**. Simultaneously, the same device is switching another of the transceiver **4104** components of UPSM **4102** using the wireless application protocol (WAP) to link the device to a cellular network using a CDMA standard bearer service.

**[0392]** In an additional embodiment, a device is able to employ P/BSSM **4404** to maintain two or more simultaneous links to the same or different bearer services using the same or different standards. For instance, a device is using AMPS to send and receive facsimiles, while a voice call is being maintained over GSM.

**[0393]** It is noted that in the embodiments of FIGS. **43** and **44** the instructions programmed and/or encoded into the submodules of the control modules may be update, upgraded, replaced, and/or modified in order to provide additional and/or new functionality. The functionality may take the form of new network availability, altered performance characteristics, changes in information exchange formats, etc.

**[0394]** These example embodiments and other alternate embodiments (including equivalents, extensions, variations, deviations, etc., of the example embodiments described herein) will be apparent to persons skilled in the relevant art(s) based on the referenced teachings and the teachings contained herein, and are within the scope and spirit of the present invention. The invention is intended and adapted to include such alternate embodiments.

**[0395]** 8.2.2 Universal Platform Module Receiver

**[0396]** The following discussion describes down-converting signals using a Universal Frequency Down-conversion (UFD) Module. The down-conversion of an EM signal by aliasing the EM signal at an aliasing rate is described above, and is more fully described in co-pending U.S. patent application entitled "Method and System for Down-converting an Electromagnetic Signal," Ser. No. 09/176,022, issued as U.S. Pat. No. 6,061,551, which is incorporated herein by reference in its entirety.

**[0397]** Exemplary embodiments of the UPM receiver are described below. However, it should be understood that these examples are provided for illustrative purposes only. The invention is not limited to these embodiments. Alternate embodiments (including equivalents, extensions, variations, deviations, etc., of the embodiments described herein) will be apparent to persons skilled in the relevant art(s) based on the teachings contained herein. The invention is intended and adapted to include such alternate embodiments.

**[0398]** 8.2.2.1 Universal Platform Module Receiver Embodiments

**[0399]** FIG. **27**A illustrates an embodiment of the receiving UPSM **2706**. Receiving UPSM **2706** is described herein for purposes of illustration, and not limitation. Alternate embodiments (including equivalents, extensions, variations, deviations, etc., of the embodiments described herein) will be apparent to persons skilled in the relevant art(s) based on the teachings contained herein. The invention is intended and adapted to include such alternate embodiments.

**[0400]** Receiving UPSM **2706** of FIG. **27**A comprises at least one UFD module **2702**. UFD module **2702** comprises at least one UFT module **2620**. Numerous embodiments for receiving UPSM **2706** will be recognized by persons skilled in the relevant art(s) from the teachings herein, and are within the scope of the invention.

**[0401]** FIG. **27**B illustrates an embodiment of the receiving UPSM **2706**, in greater detail. Receiving UPSM **2706** comprises a UFD module **2702**, an optional amplifier **2705**, and an optional filter **2707**. UFD module **2702** comprises at least one UFT module **2620**.

**[0402]** UFD module **2702** inputs received signal **2704**. UFD module **2702** frequency down-converts received signal **2704** to UFD module output signal **2708**.

**[0403]** UFD module output signal **2708** is optionally amplified by optional amplifier **2705** and optionally filtered by optional filter **2707**, and a down-converted baseband signal **2516** results. The amplifying and filtering functions may instead be provided for in optional signal conditioning module **2523**, when present.

**[0404]** Received signals of a variety of modulation types may be down-converted directly to a baseband signal by receiving UPSM **2706** of FIG. **27**B. These modulation types include, but are not limited to phase modulation (PM), phase shift keying (PSK), amplitude modulation (AM), amplitude shift keying (ASK), and quadrature amplitude modulation (QAM), and combinations thereof.

**[0405]** In embodiments, UFD module **2702** frequency down-converts received signal **2704** to a baseband signal. In alternative embodiments, UFD module **2702** down-converts received signal **2704** to an intermediate frequency.

**[0406]** FIG. **27**C illustrates an alternative embodiment of receiving UPSM **2706** comprising a UFD module **2702** that down-converts received signal **2704** to an intermediate frequency. Receiving UPSM **2706** of FIG. **27**C comprises an intermediate frequency (IF) down-converter **2712**. IF down-converter **2712** may comprise a UFD module and/or a UFT module, or may comprise a conventional down-converter. In this embodiment, UFD module output signal **2708** is output by UFD module **2702** at an intermediate frequency. This is an offset frequency, not at baseband. IF down-converter **2712** inputs UFD module output signal **2708**, and frequency down-converts it to baseband signal **2710**.

**[0407]** Baseband signal **2710** is optionally amplified by optional amplifier **2705** and optionally filtered by optional filter **2707**, and a down-converted baseband signal **2516** results.

**[0408]** Receiving UPSM **2706** may further comprise a third stage **1**F down-converter, and subsequent IF down-converters, as would be required or preferred by some applications. It will be apparent to persons skilled in the relevant art(s) how to design and configure such further IF down-converters from the teachings contained herein. Such implementations are within the scope of the present invention.

**[0409]** 8.2.2.1.1 Detailed UFD Module Block Diagram

**[0410]** FIG. **28** illustrates an embodiment of UFD module **2702** of FIG. **27** in greater detail. This embodiment is described herein for purposes of illustration, and not limitation. Alternate embodiments (including equivalents, extensions, variations, deviations, etc., of the embodiments described herein) will be apparent to persons skilled in the relevant art(s) based on the teachings contained herein. The invention is intended and adapted to include such alternate embodiments.

**[0411]** UFD module **2702** comprises a storage device **2802**, an oscillator **2804**, a pulse-shaping circuit **2806**, a reference potential **2808**, and a UFT module **2620**. As described above, many embodiments exist for UFD module **2702**. For instance, in embodiments, oscillator **2804**, or both oscillator **2804** and pulse-shaping circuit **2806**, may be external to UFD module **2702**.

**[0412]** Oscillator **2804** outputs oscillating signal **2810**, which is input by pulse-shaping circuit **2806**. The output of pulse-shaping circuit **2806** is a control signal **2812**, which preferably comprises a string of pulses. Pulse-shaping circuit **2806** controls the pulse width of control signal **2812**.

**[0413]** In embodiments, UFT module **2620** comprises a switch. Other embodiments for UFT module **2620** are within the scope of the present invention, such as those described above. One terminal of UFT module **2620** is coupled to a received signal **2704**, and a second terminal of UFT module

**2620** is coupled to a first terminal of storage device **2802**. A second terminal of storage device **2802** is coupled to a reference potential **2808** such as a ground, or some other potential. In a preferred embodiment, storage device **2802** is a capacitor. In an embodiment, the switch contained within UFT module **2620** opens and closes as a function of control signal **2812**. As a result of the opening and closing of this switch, a down-converted signal, referred to as UFD module output signal **2708**, results. Additional details pertaining to UFD module **2702** are contained in co-pending U.S. patent application entitled "Method and System for Down-Converting an Electromagnetic Signal," Ser. No. 09/176,022, issued as U.S. Pat. No. 6,061,551, which is incorporated herein by reference in its entirety.

**[0414]** 8.2.2.2 In-Phase/Quadrature-phase (I/Q) Modulation Mode Receiver Embodiments

**[0415]** FIG. **29** illustrates an exemplary I/Q modulation mode embodiment of a receiving UPSM **2706**, according to the present invention. This I/Q modulation mode embodiment is described herein for purposes of illustration, and not limitation. Alternate I/Q modulation mode embodiments (including equivalents, extensions, variations, deviations, etc., of the embodiments described herein), as well as embodiments of other modulation modes, will be apparent to persons skilled in the relevant art(s) based on the teachings contained herein. The invention is intended and adapted to include such alternate embodiments.

**[0416]** Receiving UPSM **2706** comprises an I/Q modulation mode receiver **2934**, a first optional amplifier **2912**, a first filter **2914**, a second optional amplifier **2916**, and a second filter **2918**.

**[0417]** I/Q modulation mode receiver **2934** comprises an oscillator **2902**, a first UFD module **2904**, a second UFD module **2906**, a first UFT module **2908**, a second UFT module **2910**, and a phase shifter **2920**.

**[0418]** Oscillator **2902** provides an oscillating signal used by both first UFD module **2904** and second UFD module **2906** via the phase shifter **2920**. Oscillator **2902** generates an "I" oscillating signal **2922**.

**[0419]** "I" oscillating signal **2922** is input to first UFD module **2904**. First UFD module **2904** comprises at least one UFT module **2908**. In an embodiment, first UFD module **2904** is structured similarly to UFD module **2702** of FIG. **28**, with oscillator **2902** substituting for oscillator **2804**, and "I" oscillating signal **2922** substituting for oscillating signal **2810**. First UFD module **2904** frequency down-converts and demodulates received signal **2514** to down-converted "I" signal **2926** according to "I" oscillating signal **2922**.

**[0420]** Phase shifter **2920** receives "I" oscillating signal **2922**, and outputs "Q" oscillating signal **2924**, which is a replica of "I" oscillating signal **2922** shifted preferably by 90°.

**[0421]** Second UFD module **2906** inputs "Q" oscillating signal **2924**. Second UFD module **2906** comprises at least one UFT module **2910**. In an embodiment, second UFD module **2906** is structured similarly to UFD module **2702** of FIG. **28**, with "Q" oscillating signal **2924** substituting for oscillating signal **2810**. Second UFD module **2906** frequency down-converts and demodulates received signal **2514** to down-converted "Q" signal **2928** according to "Q" oscillating signal **2924**.

**[0422]** Down-converted "I" signal **2926** is optionally amplified by first optional amplifier **2912** and optionally filtered by first optional filter **2914**, and a first information output signal **2930** is output.

**[0423]** Down-converted "Q" signal **2928** is optionally amplified by second optional amplifier **2916** and optionally filtered by second optional filter **2918**, and a second information output signal **2932** is output.

**[0424]** In the embodiment depicted in FIG. **29**, first information output signal **2930** and second information output signal **2932** comprise down-converted baseband signal **2516** of FIGS. **27**A-**27**C. In an embodiment, optional signal conditioning module **2523** receives first information output signal **2930** and second information output signal **2932**. These signals may be separately amplified/conditioned by optional signal conditioning module **2523**. Optionally amplified and conditioned first information output signal **2930** and second information output signal **2932** may then be individually modulated and up-converted, and subsequently individually transmitted by one or more transmitters. Alternatively, optionally amplified and conditioned first information output signal **2930** and second information output signal **2932** may be modulated, up-converted, recombined into a single signal, and transmitted by a single transmitting UPSM **3006** as shown in FIG. **30** and discussed herein. For example, optionally amplified and conditioned first information output signal **2930** and second information output signal **2932** may be recombined into an I/Q modulated signal for re-transmission, as further described below. In embodiments, optionally amplified and conditioned first information output signal **2930** and second information output signal **2932** may be modulated by the same or different modulation schemes before retransmission, or before recombination and retransmission.

**[0425]** Alternate configurations for I/Q modulation mode receiver **2934** will be apparent to persons skilled in the relevant art(s) from the teachings herein. For instance, an alternate embodiment exists wherein phase shifter **2920** is coupled between received signal **2704** and UFD module **2906**, instead of the configuration described above. This and other such I/Q modulation mode receiver embodiments will be apparent to persons skilled in the relevant art(s) based upon the teachings herein, and are within the scope of the present invention.

**[0426]** Reference is made to pending U.S. application Ser. No. "Method, System, and Apparatus for Balanced Frequency Up-conversion of a Baseband Signal," Ser. No. 09/525,615, filed Mar. 14, 2000, for other teachings relating to this I/Q embodiment, which is herein incorporated by reference in its entirety.

**[0427]** 8.2.2.3 Unified Down-Convert and Filter Receiver Embodiments

**[0428]** As described above, the invention is directed to unified down-conversion and filtering (UDF). UDF according to the invention can be used to perform filtering and/or down-conversion operations.

**[0429]** Many if not all of the applications described herein involve frequency translation operations. Accordingly, the applications described above can be enhanced by using any of the UDF embodiments described herein.

**[0430]** Many if not all of the applications described above involve filtering operations. Accordingly, any of the applications described above can be enhanced by using any of the UDF embodiments described herein.

**[0431]** Accordingly, the invention is directed to any of the applications described herein in combination with any of the UDF embodiments described herein.

**[0432]** For example, a block diagram of a receiving UPSM **2706** incorporating unified down-convert in filtering according to an embodiment of the present invention is illustrated in FIG. **36**. Receiving UPSM **2706** comprises a UDF module **3602** and an optional amplifier **3604**. UDF Module **3602** both down-converts and filters received signal **3610** and outputs UDF module output signal **3606**. UDF module output signal **3606** is optionally amplified by optional amplifier **3604**, outputting down-converted baseband signal **2516**.

**[0433]** The unified down-conversion and filtering of a signal is described above, and is more fully described in co-pending U.S. patent application entitled "Integrated Frequency Translation And Selectivity," Ser. No. 09/175,966, issued as U.S. Pat. No. 6,049,706, which is incorporated herein by reference in its entirety.

**[0434]** These example embodiments and other alternate embodiments (including equivalents, extensions, variations, deviations, etc., of the example embodiments described herein) will be apparent to persons skilled in the relevant art(s) based on the referenced teachings and the teachings contained herein, and are within the scope and spirit of the present invention. The invention is intended and adapted to include such alternate embodiments.

**[0435]** 8.2.2.4 Other Receiver Embodiments

**[0436]** The UPSM receiver embodiments described above are provided for purposes of illustration. These embodiments are not intended to limit the invention. Alternate embodiments, differing slightly or substantially from those described herein, will be apparent to persons skilled in the relevant art(s) based on the teachings contained herein. Such alternate embodiments include, but are not limited to, down-converting different combinations of modulation techniques in an "I/Q" mode. Such alternate embodiments fall within the scope and spirit of the present invention.

**[0437]** For example, other UPSM receiver embodiments may down-convert signals that have been modulated with other modulation techniques. These would be apparent to one skilled in the relevant art(s) based on the teachings disclosed herein, and include, but are not limited to, amplitude modulation (AM), frequency modulation (FM), quadrature amplitude modulation (QAM), time division multiple access (TDMA), frequency division multiple access (FDMA), code division multiple access (CDMA), down-converting a signal with two forms of modulation embedding thereon, and combinations thereof.

**[0438]** 8.2.3 Universal Platform Module Transmitter Embodiments

**[0439]** The following discussion describes frequency up-converting signals to be transmitted by an UPSM, using a Universal Frequency Up-conversion (UFU) Module. Frequency up-conversion of an EM signal is described above, and is more fully described in co-pending U.S. patent application entitled "Method and System for Frequency Up-Conversion," Ser. No. 09/176,154, the full disclosure of which is incorporated herein by reference in its entirety.

**[0440]** Exemplary embodiments of the UPSM transmitter are described below, including PM and I/Q modulation modes. However, it should be understood that these examples are provided for illustrative purposes only. The invention is not limited to these embodiments. Alternate embodiments (including equivalents, extensions, variations, deviations, etc., of the embodiments described herein) will be apparent to persons skilled in the relevant art(s) based on the teachings contained herein. The invention is intended and adapted to include such alternate embodiments.

**[0441]** 8.2.3.1 Various Modulation Mode Transmitter Embodiments, Including Phase Modulation (PM)

**[0442]** FIG. **30**A illustrates an exemplary embodiment of the transmitting UPSM **3006**. Transmitting UPSM **3006** is described herein for purposes of illustration, and not limitation. Alternate embodiments (including equivalents, extensions, variations, deviations, etc., of the embodiments described herein) will be apparent to persons skilled in the relevant art(s) based on the teachings contained herein. The invention is intended and adapted to include such alternate embodiments.

**[0443]** Transmitting UPSM **3006** of FIG. **30**A comprises at least one UFU module **3004**. UFU module **3004** comprises at least one UFT module **2620**. Numerous embodiments for transmitting UPSM **3006** will be known to persons skilled in the relevant art(s) from the teachings herein, and are within the scope of the invention.

**[0444]** FIG. **30**B illustrates in greater detail an exemplary embodiment of the transmitting UPSM **3006** of FIG. **30**A. Transmitting UPSM **3006** comprises a modulator **3002**, a UFU module **3004**, and an optional amplifier **3007**.

**[0445]** Modulator **3002** of transmitting UPSM **3006** receives a baseband signal **2518**. Modulator **3002** modulates baseband signal **2518**, according to any modulation scheme, such as those described above. FIG. **31** illustrates an embodiment of modulator **3002**. In this exemplary embodiment, the modulation scheme implemented may be phase modulation (PM) or phase shift keying (PSK) modulation. Modulator **3002** comprises an oscillator **3102** and a phase modulator **3104**. Phase modulator **3104** receives baseband signal **2518** and an oscillating signal **3106** from oscillator **3102**. Phase modulator **3104** phase modulates oscillating signal **3106** using baseband signal **2518**. Phase modulators are well known to persons skilled in the relevant art(s). Phase modulator outputs modulated signal **3010**, according to PM or PSK modulation.

**[0446]** In FIG. **30**B, modulated signal **3010** is received by UFU module **3004**. UFU module **3004** includes at least one UFT module **2620**. UFU module **3004** frequency up-converts the modulated signal, outputting UFU module output signal **3008**.

**[0447]** When present, optional amplifier **3006** amplifies UFU module output signal **3008**, outputting up-converted signal **3005**.

**[0448]** In alternate embodiments, transmitting UPSM **3006** does not require a modulator **3002** because UFU module **3004** performs the modulation function. FIG. **30**C illustrates such an alternate embodiment of transmitting UPSM **3006** of FIG. **30**A. Transmitting UPSM **3006** includes a UFU module **3004** and an optional amplifier **3007**. UFU module **3004** includes at least one UFT module **2620**. UFU module **3004** frequency modulates and up-converts baseband signal **2518** to UFU module output signal **3008**. For instance, and without limitation, UFU module **3004** may provide for frequency up-conversion and modulation in an AM modulation mode. AM modulation techniques and other modulation techniques are more fully described in co-pending U.S. patent application entitled "Method and System for Frequency Up-Conversion," Ser. No. 09/176,154, the full disclosure of which is incorporated herein by reference in its entirety.

[0449] 8.2.3.1.1 Detailed UFU Module Embodiments

[0450] FIG. 33 illustrates a more detailed exemplary circuit diagram of an embodiment of UFU module **3004** of FIG. 30A. UFU module **3004** is described herein for purposes of illustration, and not limitation. Alternate embodiments (including equivalents, extensions, variations, deviations, etc., of the embodiments described herein) will be apparent to persons skilled in the relevant art(s) based on the teachings contained herein. The invention is intended and adapted to include such alternate embodiments.

[0451] UFU module **3004** comprises a pulse-shaping circuit **3302**, a first reference potential **3304**, a filter **3306**, a second reference potential **3308**, a resistor **3310**, and a UFT module **2620**.

[0452] In FIG. 33, pulse shaping circuit **3302** receives baseband signal **2518**. Pulse shaping circuit **3302** outputs control signal **3314**, which is preferably comprised of a string of pulses. Control signal **3314** controls UFT module **2620**, which preferably comprises a switch. Various embodiments for UFT module **2620** are described above. One terminal of UFT module **2620** is coupled to a first reference potential **3304**. The second terminal of UFT module **2620** is coupled through resistor **3310** to a second reference potential **3308**. In a PM or PSK modulation embodiment, second reference potential **3308** is preferably a constant voltage level. In other embodiments, such as in an amplitude modulation (AM) mode, second reference potential **3308** may be a voltage that varies with the amplitude of the information signal.

[0453] The output of UFT module **2620** is a harmonically rich signal **3312**. Harmonically rich signal **3312** has a fundamental frequency and phase substantially proportional to control signal **3314**, and an amplitude substantially proportional to the amplitude of second reference potential **3308**. Each of the harmonics of harmonically rich signal **3312** also have phase proportional to control signal **3314**, and in an PM or PSK embodiment are thus considered to be PM or PSK modulated.

[0454] Harmonically rich signal **3312** is received by filter **3306**. Filter **3306** preferably has a high Q. Filter **3306** preferably selects the harmonic of harmonically rich signal **3312** that is at the approximate frequency desired for transmission. Filter **3306** removes the undesired frequencies that exist as harmonic components of harmonically rich signal **3312**. Filter **3306** outputs UFU module output signal **3008**.

[0455] Further details pertaining to UFU module **3004** are provided in co-pending U.S. patent application entitled "Method and System for Frequency Up-Conversion," Ser. No. 09/176,154, which is incorporated herein by reference in its entirety.

[0456] 8.2.3.2 In-Phase/Quadrature-Phase (I/Q) Modulation Mode Transmitter Embodiments

[0457] In FIG. 34, an I/Q modulation mode embodiment is presented. In this embodiment, two information signals are accepted. An in-phase signal ("I") is modulated such that its phase varies as a function of one of the information signals, and a quadrature-phase signal ("Q") is modulated such that its phase varies as a function of the other information signal. The two modulated signals are combined to form an "I/Q" modulated signal and transmitted. In this manner, for instance, two separate information signals could be transmitted in a single signal simultaneously. Other uses for this type of modulation would be apparent to persons skilled in the relevant art(s).

[0458] FIG. 34 illustrates an exemplary block diagram of a transmitting UPSM **3006** operating in an I/Q modulation mode. In FIG. 34, baseband signal **2518** comprises two signals, first information signal **3402** and second information signal **3404**. Transmitting UPSM **3006** comprises an I/Q transmitter **3406** and an optional amplifier **3408**. I/Q transmitter **3406** comprises at least one UFT module **2620**. I/Q transmitter **3406** provides I/Q modulation to first information signal **3402** and second information signal **3404**, outputting I/Q output signal **3410**. Optional amplifier **3408** optionally amplifies I/Q output signal **3410**, outputting up-converted signal **3005**.

[0459] FIG. 35 illustrates a more detailed circuit block diagram for I/Q transmitter **3406**. I/Q transmitter **3406** is described herein for purposes of illustration, and not limitation. Alternate embodiments (including equivalents, extensions, variations, deviations, etc., of the embodiments described herein) will be apparent to persons skilled in the relevant art(s) based on the teachings contained herein. The invention is intended and adapted to include such alternate embodiments.

[0460] I/Q transmitter **3406** comprises a first UFU module **3502**, a second UFU module **3504**, an oscillator **3506**, a phase shifter **3508**, a summer **3510**, a first UFT module **3512**, a second UFT module **3514**, a first phase modulator **3528**, and a second phase modulator **3530**.

[0461] Oscillator **3506** generates an "I"-oscillating signal **3516**.

[0462] A first information signal **3402** is input to first phase modulator **3528**. The "I"-oscillating signal **3516** is modulated by first information signal **3402** in the first phase modulator **3528**, thereby producing an "I"-modulated signal **3520**.

[0463] First UFU module **3502** inputs "I"-modulated signal **3520**, and generates a harmonically rich "I" signal **3524** with a continuous and periodic wave form.

[0464] The phase of "I"-oscillating signal **3516** is shifted by phase shifter **3508** to create "Q"-oscillating signal **3518**. Phase shifter **3508** preferably shifts the phase of "I"-oscillating signal **3516** by 90 degrees.

[0465] A second information signal **3404** is input to second phase modulator **3530**. "Q"-oscillating signal **3518** is modulated by second information signal **3404** in second phase modulator **3530**, thereby producing a "Q" modulated signal **3522**.

[0466] Second UFU module **3504** inputs "Q" modulated signal **3522**, and generates a harmonically rich "Q" signal **3526**, with a continuous and periodic waveform.

[0467] Harmonically rich "I" signal **3524** and harmonically rich "Q" signal **3526** are preferably rectangular waves, such as square waves or pulses (although the invention is not limited to this embodiment), and are comprised of pluralities of sinusoidal waves whose frequencies are integer multiples of the fundamental frequency of the waveforms. These sinusoidal waves are referred to as the harmonics of the underlying waveforms, and a Fourier analysis will determine the amplitude of each harmonic.

[0468] Harmonically rich "I" signal **3524** and harmonically rich "Q" signal **3526** are combined by summer **3510** to create harmonically rich "I/Q" signal **3534**. Summers are well known to persons skilled in the relevant art(s).

[0469] Filter **3532** filters out the undesired harmonic frequencies, and outputs an I/Q output signal **3410** at the desired harmonic frequency or frequencies.

[0470] It will be apparent to persons skilled in the relevant art(s) that an alternative embodiment exists wherein the harmonically rich "I" signal **3524** and the harmonically rich "Q" signal **3526** may be filtered before they are summed, and further, another alternative embodiment exists wherein "I"-modulated signal **3520** and "Q"-modulated signal **3522** may be summed to create an "I/Q"-modulated signal before being routed to a switch module. Other "I/Q"-modulation embodiments will be apparent to persons skilled in the relevant art(s) based upon the teachings herein, and are within the scope of the present invention. Further details pertaining to an I/Q modulation mode transmitter are provided in co-pending U.S. patent application entitled "Method and System for Frequency Up-Conversion," Ser. No. 09/176,154, which is incorporated herein by reference in its entirety.

**[0471]** Reference is made to pending U.S. application Ser. No. "Method, System, and Apparatus for Balanced Frequency Up-conversion of a Baseband Signal," Ser. No. 09/525,615, filed Mar. 14, 2000, for other teachings relating to this I/Q embodiment, which is herein incorporated by reference in its entirety.

**[0472]** 8.2.3.3 Other Transmitter Embodiments

**[0473]** The UPSM transmitter embodiments described above are provided for purposes of illustration. These embodiments are not intended to limit the invention. Alternate embodiments, differing slightly or substantially from those described herein, will be apparent to persons skilled in the relevant art(s) based on the teachings contained herein. Such alternate embodiments include, but are not limited to, combinations of modulation techniques in an "I/Q" mode. Such alternate embodiments fall within the scope and spirit of the present invention.

**[0474]** For example, other UPSM transmitter embodiments may utilize other modulation techniques. These would be apparent to one skilled in the relevant art(s) based on the teachings disclosed herein, and include, but are not limited to, amplitude modulation (AM), frequency modulation (FM), quadrature amplitude modulation (QAM), time division multiple access (TDMA), frequency division multiple access (FDMA), code division multiple access (CDMA), embedding two forms of modulation onto a signal for up-conversion, etc., and combinations thereof.

**[0475]** 8.2.4 Enhanced Signal Reception Universal Platform Embodiments

**[0476]** In additional embodiments of the present invention, enhanced signal reception (ESR) according to the present invention may be used. As discussed above, the invention is directed to methods and systems for ESR. Any of the example applications discussed above can be modified by incorporating ESR therein to enhance communication between transmitters and receivers. Accordingly, the invention is also directed to any of the applications described above, in combination with any of the ESR embodiments described above. Enhanced signal reception using redundant spectrums is described above, and is fully described in co-pending U.S. patent application entitled "Method and System for Ensuring Reception of a Communications Signal," Ser. No. 09/176,415, which is incorporated herein by reference in its entirety.

**[0477]** For example, in an embodiment, transmitting UPSM **3006** may comprise a transmitter configured to transmit redundant spectrums, and receiving UPSM **2706** may be configured to receive and process such redundant spectrums, similarly to the system shown in FIG. **21**. In an alternative embodiment, UPM **2606** may include transceivers configured to transmit, and to receive and process redundant spectrums. Accordingly, the invention is directed to any of the applications described herein in combination with any of the ESR embodiments described herein.

**[0478]** These example embodiments and other alternate embodiments (including equivalents, extensions, variations, deviations, etc., of the example embodiments described herein) will be apparent to persons skilled in the relevant art(s) based on the referenced teachings and the teachings contained herein, and are within the scope and spirit of the present invention. The invention is intended and adapted to include such alternate embodiments.

**[0479]** 8.2.5 Universal Platform Transceiver Embodiments

**[0480]** As discussed above, in other embodiments of the present invention, UPM **2606** may include a transceiver unit, rather than a separate receiver and transmitter. Furthermore, the invention is directed to any of the applications described herein in combination with any of the transceiver embodiments described herein.

**[0481]** An exemplary embodiment of a transceiving UPSM **3706** of the present invention is illustrated in FIG. **37**. Transceiving UPSM **3706** includes a UFT module **2620**. In one embodiment, UPM **2606** includes more than one transceiver UPSM **3706**.

**[0482]** Transceiving UPSM **3706** frequency down-converts first EM signal **2514**, and outputs down-converted baseband signal **2516**. In an embodiment (not shown), each transceiving UPSM **3706** comprises one or more UFT modules **2620** at least for frequency down-conversion.

**[0483]** Transceiving UPSM **3706** frequency up-converts down-converted baseband signal **2518**. UFT module **2620** provides at least for frequency up-conversion. In alternate embodiments, UFT module **2620** only supports frequency down-conversion, and at least one additional UFT module **2620** provides for frequency up-conversion. The up-converted signal is output by transceiving UPSM **3706**.

**[0484]** Further example embodiments of receiver/transmitter systems applicable to the present invention may be found in co-pending U.S. patent application entitled "Method and System for Frequency Up-Conversion," Ser. No. 09/176,154, incorporated by reference in its entirety.

**[0485]** These example embodiments and other alternate embodiments (including equivalents, extensions, variations, deviations, etc., of the example embodiments described herein) will be apparent to persons skilled in the relevant art(s) based on the referenced teachings and the teachings contained herein, and are within the scope and spirit of the present invention. The invention is intended and adapted to include such alternate embodiments.

**[0486]** Reference is made to pending U.S. application Ser. No. "Method, System, and Apparatus for Balanced Frequency Up-conversion of a Baseband Signal," Ser. No. 09/525,615, filed Mar. 14, 2000, for other teachings relating to this embodiment, which is herein incorporated by reference in its entirety.

**[0487]** 8.2.6 Other Universal Platform Module Embodiments

**[0488]** The UPM and UPSM embodiments described above are provided for purposes of illustration. These embodiments are not intended to limit the invention. Alternate embodiments, differing slightly or substantially from those described herein, will be apparent to persons skilled in the relevant art(s) based on the teachings contained herein. Such alternate embodiments include, but are not limited to, receiving a signal of a first modulation type and re-transmitting the signal in a different modulation mode. Another such alternate embodiment includes receiving a signal of a first frequency and re-transmitting the signal at a different frequency. Such alternate embodiments fall within the scope and spirit of the present invention.

**[0489]** 8.3 Multi-Mode Infrastructure

**[0490]** The invention is also directed to multi-mode infrastructure embodiments for interacting with the devices discussed above. Such infrastructure embodiments include, but are not limited to, servers, routers, access points, and any other components for enabling multi-mode operation as described herein.

**[0491]** For example, consider a scenario of a commercial airplane. The passengers traveling in the airplane may have devices where they (1) receive flight information, (2) receive telephone calls, and/or (3) receive email. There may be a number of mediums by which such information can be received. For example, such information might be received via a wireless telephone network, or via a WLAN internal to the airplane, or via a short range wireless communication medium. The airplane may have infrastructure components to receive and route such information to the passengers' devices. The infrastructure components include control modules for enabling such operation.

**[0492]** In an embodiment, such infrastructure embodiments include one or more receivers, transmitters, and/or transceivers that include UFTs as described herein. In embodiments, such infrastructure embodiments include UPMs and UPSMs as described herein.

**[0493]** 8.4 Additional Multi-Mode Teachings

**[0494]** Additional teachings relating to multi-mode methods, apparatuses, and systems according to embodiments of the invention are described in the following applications (as well as others cited above), which are all herein incorporated by reference in their entireties:

**[0495]** "Family Radio System with Multi-Mode and Multi-Band Functionality," Ser. No. 09/476,093, filed Jan. 3, 2000, Attorney Docket No. 1744.0260001.

**[0496]** "Multi-Mode, Multi-Band Communications System," Ser. No. 09/476,330, filed Jan. 3, 2000, Attorney Docket No. 1744.0330001.

## 9. CONCLUSION

**[0497]** While various embodiments of the present invention have been described above, it should be understood that they have been presented by way of example only, and not limitation. It will be apparent to persons skilled in the relevant art that various changes in form and detail can be made therein without departing from the spirit and scope of the invention. Thus, the breadth and scope of the present invention should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims and their equivalents.

What is claimed is:

**1**. A universal platform module, comprising:

at least one universal platform sub-module, comprising at least one universal frequency conversion module that frequency converts a signal; and

a control module that provides operating information for said at least one universal platform sub-module.

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