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(71) Applicant: GEC PLESSEY SEMICONDUCTORS, INC. [US/US]; 1500 Green Hills Road, Scotts Valley, CA 95067-0017 (US).

(72) Inventor: ZAVREL, Robert, J.; 117 Locatelli Lane, Scotts Valley, CA 95066 (US).

(74) Agents: FERNANDEZ, Dennis, S. et al.; Fenwick & West, Suite 500, Two Palo Alto Square, Palo Alto, CA 94306 (US).

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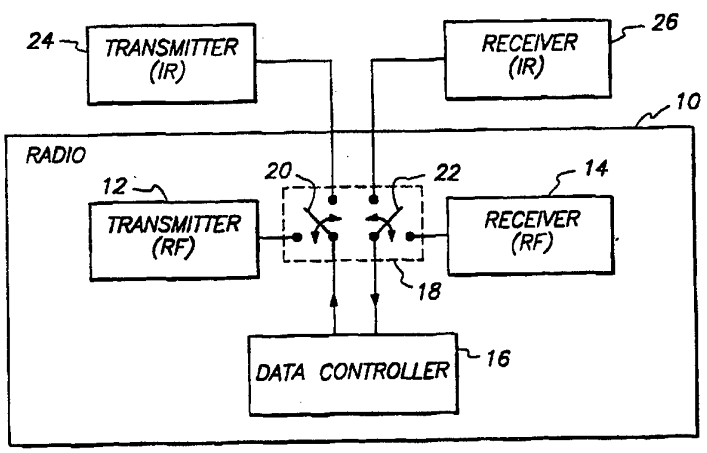

(57) Abstract

A digital, radio-frequency (RF) transceiver is modified by coupling an infrared (IR) communication subsystem thereto. The subsystem includes an IR transmitter and receiver which may be coupled selectably by a switch to a data signal channel or source in the transceiver. Preferably, the IR receiver includes an inductor and a diode coupled in parallel, such that the IR receiver detects an IR signal, in significant part, by resonating such signal substantially at a detection or RF baseband frequency.

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IMPROVED IR/RF RADIO TRANSCEIVER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to radio electronics, particularly to improved radio transceivers combining infra-red (IR) and radio-frequency (RF) communication and signal detection techniques.

2. Description of the Background Art

In conventional radio systems, data signals are modulated for communication by transceivers over allocated RF signal bands. Conventional radio systems, however, do not easily provide signal transmission or reception over IR frequencies. It would be desirable, therefore, to provide an improved radio system, and particularly, related signal detection subsystems, whereby both RF and IR signals may be communicated.

SUMMARY OF THE INVENTION

The invention resides in coupling an infra-red (IR) communication subsystem to a radio-frequency (RF) transceiver. The IR subsystem includes an IR transmitter and receiver which may be coupled selectably by a switch to a data signal channel or source in the transceiver. Preferably, the IR receiver includes an inductor and a diode coupled in parallel, such that the IR receiver detects an IR signal, in significant part, by resonating such signal substantially at a detection frequency.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a generalized block diagram of an improved radio-frequency (RF) communication system having infra-red (IR) transmitter 24 and receiver 26.

FIG. 2 is a block diagram of a prior-art digital radio transceiver, namely transceiver model DE6003 available from

GEC Plessey Semiconductors.

FIG. 3 is a block diagram of the digital radio transceiver shown in FIG. 2, but modified for IR/RF signal communication according to the present invention.

FIG. 4 is a block diagram of alternate IR detector 103.

FIG. 5 is a simplified frequency response chart of sensed signal 70 according to the present invention.

FIG. 6 is a simplified frequency response chart of output signal 80 according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 shows a generalized block diagram of an improved radio-frequency (RF) communication system 10 having infra-red (IR) transmitter 24 and receiver 26 coupled thereto. System 10 may be a conventional digital radio transceiver, such as the DE6003 Digital Radio Transceiver available commercially from GEC Plessey Semiconductors located in Scotts Valley, California. FIG. 2 is a generalized block diagram of the prior-art DE6003 transceiver, showing conventional components, as configured presently, prior to modification according to the present invention.

As shown in FIG. 1, system 10 contains transceiver circuitry 12, 14 for digital signal communication over allocated RF bands. Data controller 16 serves as a data signal source or receptor for sending or receiving signals to RF transmitter 12 or from RF receiver 14 respectively, in accordance with normal radio operation of system 10.

In accordance with the present invention, IR transceiver 24 and receiver 26 may be coupled user-selectably by switches 20, 22 or connecting circuit 18 to data controller 16 for signal communication therebetween. Thus, during radio operation, switch 22 may couple data controller 16 to IR receiver 26, instead of RF receiver 14, to enable data signal reception over IR spectrum, instead of RF spectrum (or vice versa). Similarly, switch 20 may couple data controller 16 to IR transmitter 24, instead of RF transmitter 12, to enable data signal reception over IR spectrum, instead of RF spectrum (or vice versa).

In FIG. 3, the DE6003 transceiver is modified functionally for coupling to IR transmitter 121, including photo-emitting diode 120 and buffer 122, or IR receiver or photo-sensitive diode 102, thereby providing combined RF and IR signal communication. In particular, DE6003 is re-configured to include IR receiver 102 and IR transmitter 121, which may be coupled to DE6003 transceiver through switch 134 and switch 124 respectively.

As shown in FIG. 3, switch 134 is switched to transmit mode (TX), but may be switched to receive mode (RX) to couple IR receiver 102 to the DE6003 transceiver. Thus, during RX mode, IR receiver 102 functions to receive IR signals for the DE6003 transceiver. Additionally, during TX mode, IR transmitter 121 functions to transmit IR signals for the DE6003 transceiver.

Furthermore, to enable changing radio operation between IR and RF transmit or receive modes, the conventional components of the DE6003 transceiver may be re-configured to include switches 130, 124, as shown in FIG. 3. In particular, switches 124, 130 may each be switched from RF transmit or receive mode, as shown, to IR transmit or receive mode. In this way, for example, during IR transmit or receive mode, switches 124, 130 are switched from the shown configuration to couple conventional components of the DE6003, thereby enabling RF transmit or receive mode.

Preferably, IR detector 102 includes inductor circuit 114 and infra-red radiation detecting photo-diode 110, of a square-law type infra-red detector, and coupled thereto in parallel. In this way, IR receiver 102 may detect an incoming, modulated IR signal, in significant part, by resonating such signal substantially at an RF baseband or carrier frequency or signal. IR detector 102 couples the resonant structure 110, 114 to power 112 and ground 116, and provides detection signal 118 through capacitor 108 and buffer 106. The received infra-red signal, which is modulated at the RF baseband, is amplitude-shift keyed (ASK), and frequency-shift keyed (FSK) by specified data.

Thus, the frequency of the RF baseband is amplified by the resonating effect of inductive circuit 114 coupled to detecting diode 110 and its inherent capacitance, and detector 102 is thereby more sensitive to data frequency-shift keyed (FSK) about the carrier signal. The increased sensitivity is illustrated in FIGs. 5 an 6, where sensed signal 70 is compared to increased-voltage output signal 80 which is resonated and amplified at a particular RF baseband frequency, f_C, over the infra-red spectrum at which resonance occurs.

In FIG. 4, an alternate IR receiver or detector 103 is shown, including inductor 114, IR signal photo-sensitive diode 110, capacitor 141, variable resistor 142, and transistor 140, coupled to power 112 and ground 116, to provide IR detection or sensed signal 118. In this way, IR receiver 103 also functions generally as a so-called Colpitts oscillator.

Similarly to the functions of capacitor 108 and buffer 106 in IR detector 102, IR detector 103 provides components 140, 141, 142 to inhibit conduction of direct current, and inhibit loading of the resonating effect. Additionally, such components 140, 141, 142 provide for increased amplification in output signal 118, beyond that which may be provided by the resonating effect of infra-red radiation-detecting diode 110 and inductor 114.

Preferably, the incoming, received infra-red signal contains a carrier signal that is amplitude-shift keyed (ASK) and that is frequency-shift keyed (FSK) by modulating data information. The resonating effect occurs at the frequency of the carrier signal, such that output signal 118 is amplified substantially at this frequency.

Thus, when operating, a remote transmitter (not shown) emits an infra-red signal that is amplitude-shift keyed (ASK) and that is frequency-shift keyed (FSK) by data information. The infra-red radiation-detecting diode 114 of the invention, then senses this incoming signal, possibly including present infra-red "noise." Because of such noise, it may be be difficult conventionally to distinguish the carrier signal from the noise. In accordance with the present invention, however, the resonating effect at the frequency of the carrier signal facilitates IR signal detection, particularly by increasing effectively the detected amplitude of the carrier signal relative to the amplitude of the background noise.

Preferably, the frequency of the carrier signal within the infrared spectrum is "atypical" (i.e., a frequency at which levels of noise that are sufficiently high to prevent conventional IR signal detection are not usually present.) The atypical frequency may correspond to frequencies used in RF-based wide and local area networks, such that switching between RF and IR is easily accomplished. In the present embodiment, the preferred RF baseband frequency is 38 MHz.

Additionally, the data information which is frequency-shift keyed (FSK) about the carrier signal includes frequencies w_1 and w_2 which may be provided in binary form, such that such frequencies correspond to logical high or low (1/0) signals.

Thus, when operating, a remote transmitter emits an infra-red signal at 38 MHz, which is amplitude-shift keyed (ASK) and that is frequency-shift keyed (FSK) by data information including a series of frequencies w_1 and w_2.

Infra-red radiation-detecting diode 110 senses the incoming signal, along with infra-red noise. The resonating effect of inductor 114 together with the effective capacitance of diode 110 resonates the incoming, sensed signal at 38 MHz, which is the frequency of the carrier signal. The amplified sensed signal may then be further amplified and buffered.

CLAIMS

I claim:

1. A communication system comprising:

infra-red (IR) communication means;

radio frequency (RF) communication means;

a signal controller; and

a switch for selectably coupling the signal controller to the IR communication means or the RF communication means.

2. The system of Claim 1 wherein:

the IR communication means comprises an IR transmitter and an IR receiver.

3. The system of Claim 2 wherein:

the IR receiver comprises an inductor and a diode coupled in parallel, such that the IR receiver detects an IR signal by resonating such signal substantially at a detection frequency.

4. The system of Claim 1 wherein:

the RF communication means comprises an RF transmitter and an IR receiver.

5. A radio communication apparatus comprising:

an infra-red (IR) receiver;

a radio frequency (RF) receiver;

a signal controller; and

a switch for selectably coupling the signal controller to the IR receiver or the RF receiver,

wherein the IR receiver comprises an inductor and a diode coupled in parallel, the IR receiver detecting an IR signal by resonating such signal substantially at a detection frequency.

6. A signal detection system comprising:

a detector for receiving an infra-red signal having an

RF baseband signal that is amplitude-shift keyed (ASK) and frequency-shift keyed (FSK) by information, for producing a sensed signal indicative of received infra-red radiation and having an amplitude representative of the intensity of the received infrared radiation; and

a resonator coupled to the detector for resonating therewith substantially at a frequency of the RF baseband signal, thereby amplifying a magnitude of the sensed signal at the frequency of the RF baseband signal.

7. The signal detection system of Claim 6 wherein:

the resonator is connected in parallel with the detector.

8. The signal detection system of Claim 6 wherein:

the detector comprises a diode;

the resonator comprises an inductor and a capacitor coupled to the diode to inhibit conduction of direct current relative to the detector means and resonator means; and

a buffer coupled to the detector and resonator through the capacitor, for amplifying received signal to produce an output signal therefrom representative of the modulating information.

9. The signal detection system of Claim 6 wherein:

the detector comprises a photo-responsive diode; and

the resonator comprises an inductor and an amplifier coupled to the detector and resonator, for increasing the magnitude of received RF baseband signal to produce an output signal therefrom representative of the modulating information, without loading the resonance of the resonator.

10. The signal detection system of Claim 6 wherein:

the carrier frequency comprises an atypical frequency within the infra-red spectrum.

11. A method for detecting modulating information on an infra-red carrier signal, comprising the steps of:

generating a sensed signal in response to detecting information that frequency-shift keys (FSK) infra-red radiation about an RF baseband signal that is amplitude-shift keyed (ASK) to provide the sensed signal having an amplitude indicative of the intensity of the received infra-red radiation; and

resonating the sensed signal about the RF baseband frequency to provide an amplified output RF baseband signal including the modulating information within a selected waveband.

12. The method of Claim 11 wherein:

the carrier frequency comprises an atypical frequency within the infra-red spectrum.

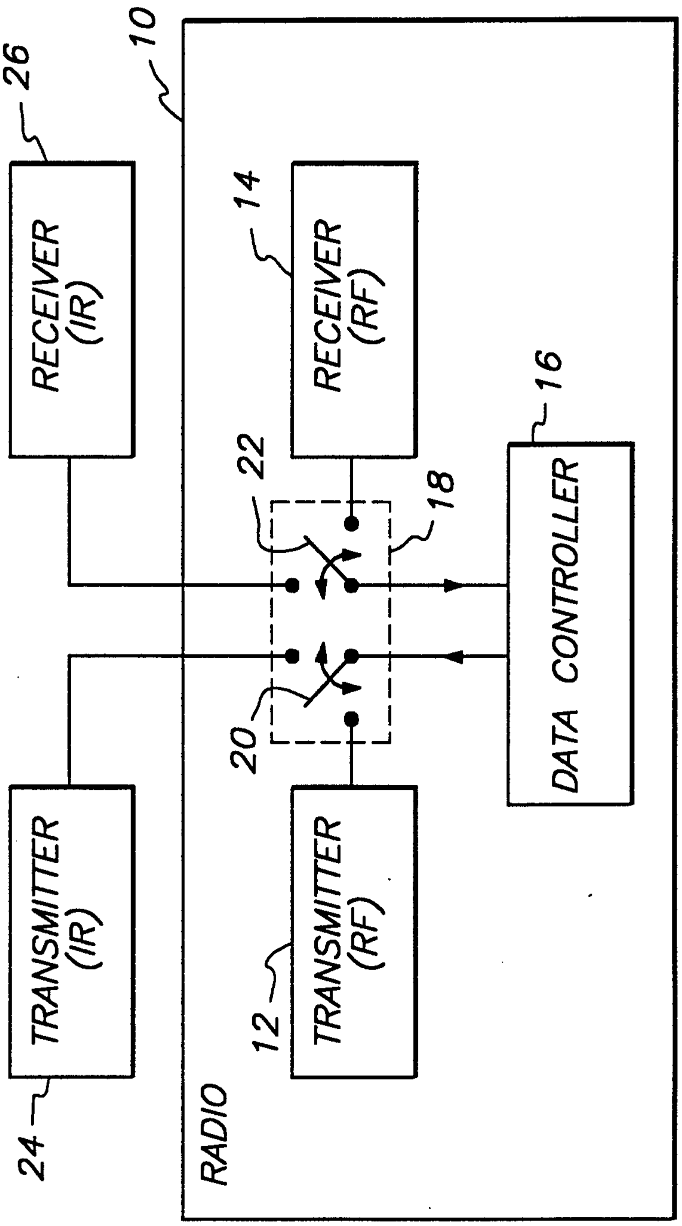
RECEIVER (IR)
26
10
RECEIVER (RF)
14
16
DATA CONTROLLER
22
18
20
TRANSMITTER (IR)
24
TRANSMITTER (RF)
12
RADIO

FIG. 1

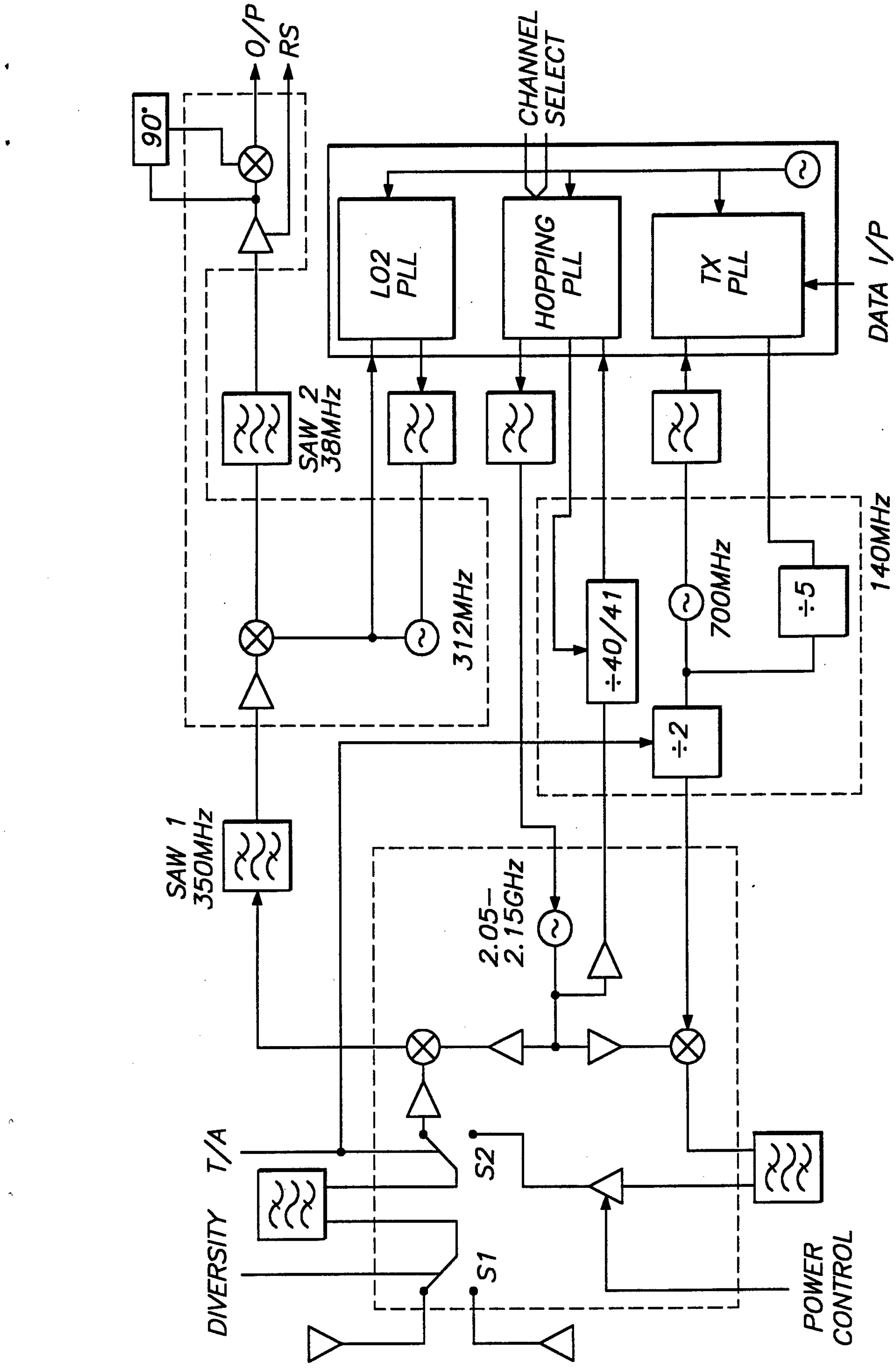

FIG. 2 (PRIOR ART)

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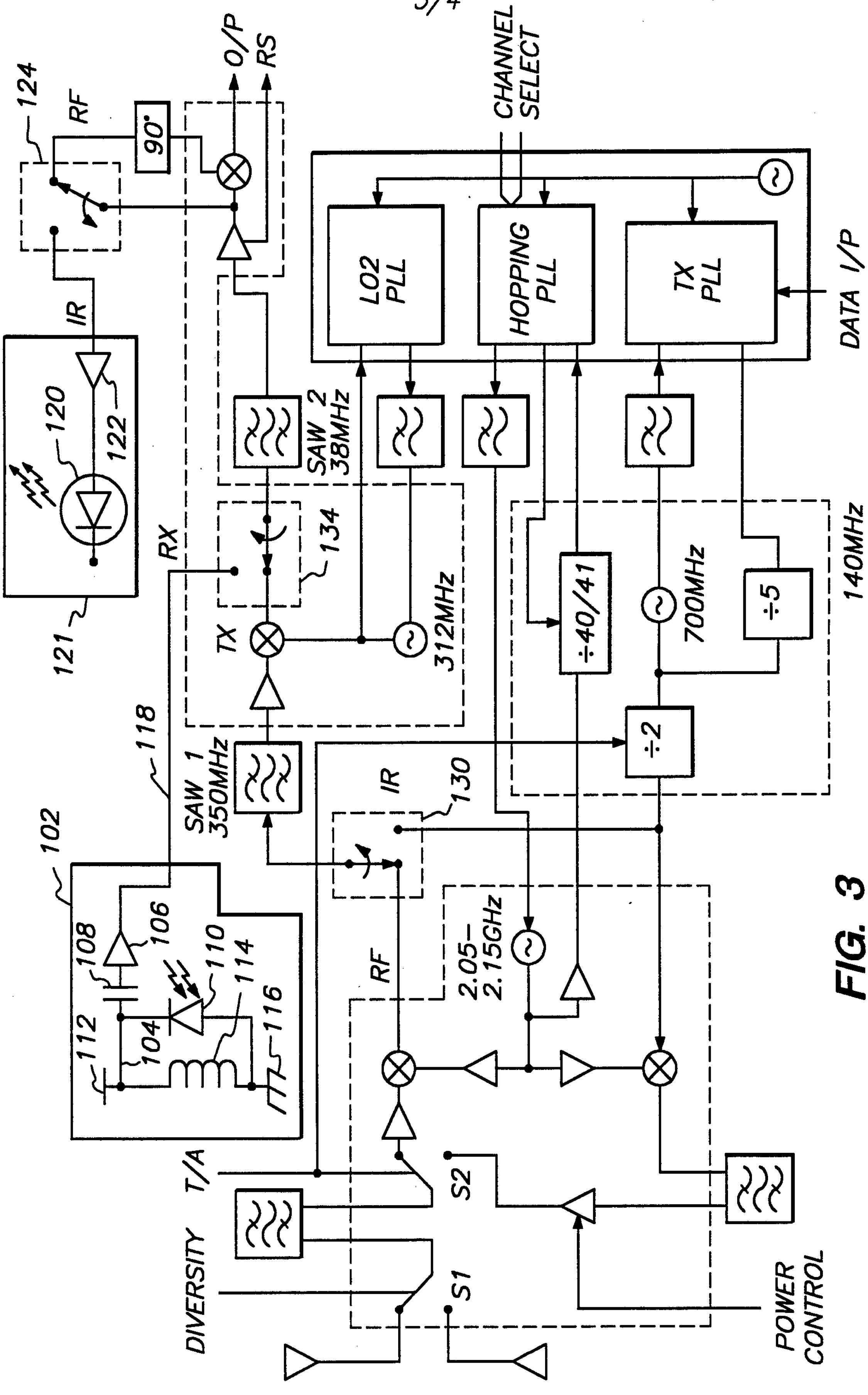
124
RF
90°
O/P
RS
CHANNEL SELECT
LO2 PLL
HOPPING PLL
TX PLL
DATA I/P
IR
120
122
121
RX
134
SAW 2 38MHz
TX
312MHz
÷40/41
700MHz
÷5
140MHz
118
SAW 1 350MHz
IR
130
÷2
102
106
108
110
114
112
104
116
RF
2.05–2.15GHz
T/A
S2
DIVERSITY
S1
POWER CONTROL

FIG. 3

4/4

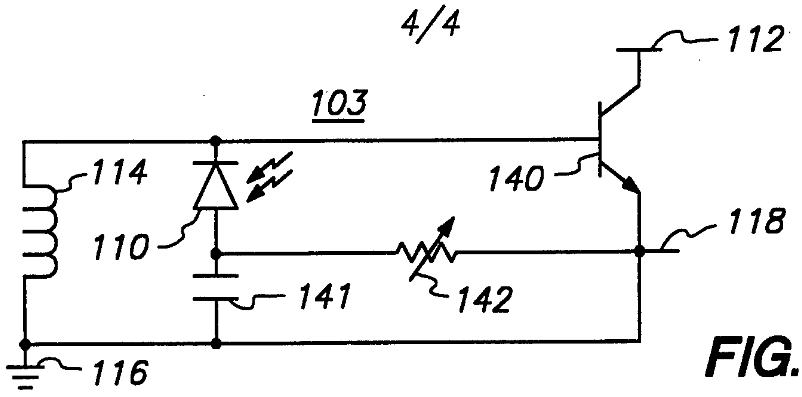

FIG. 4

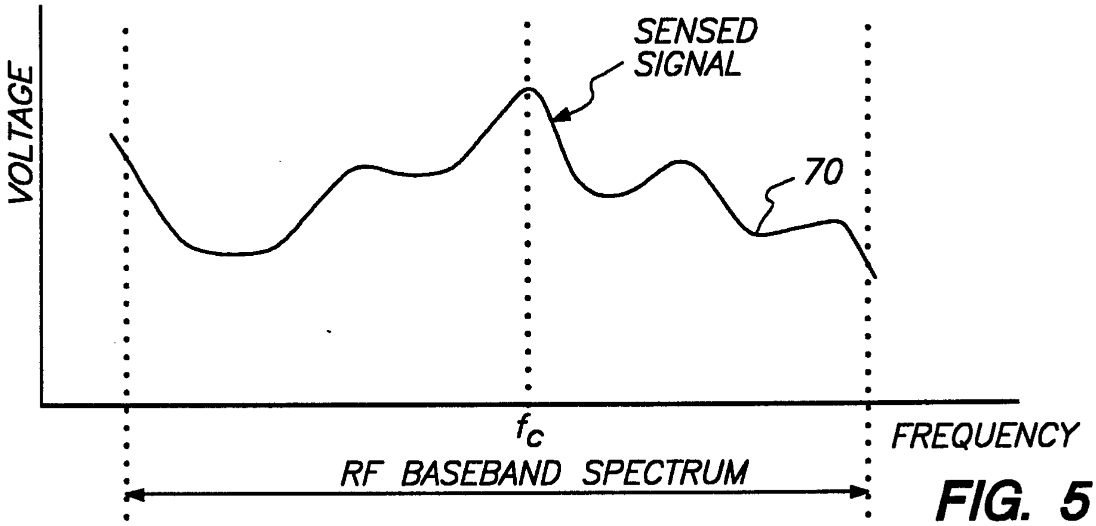

FIG. 5

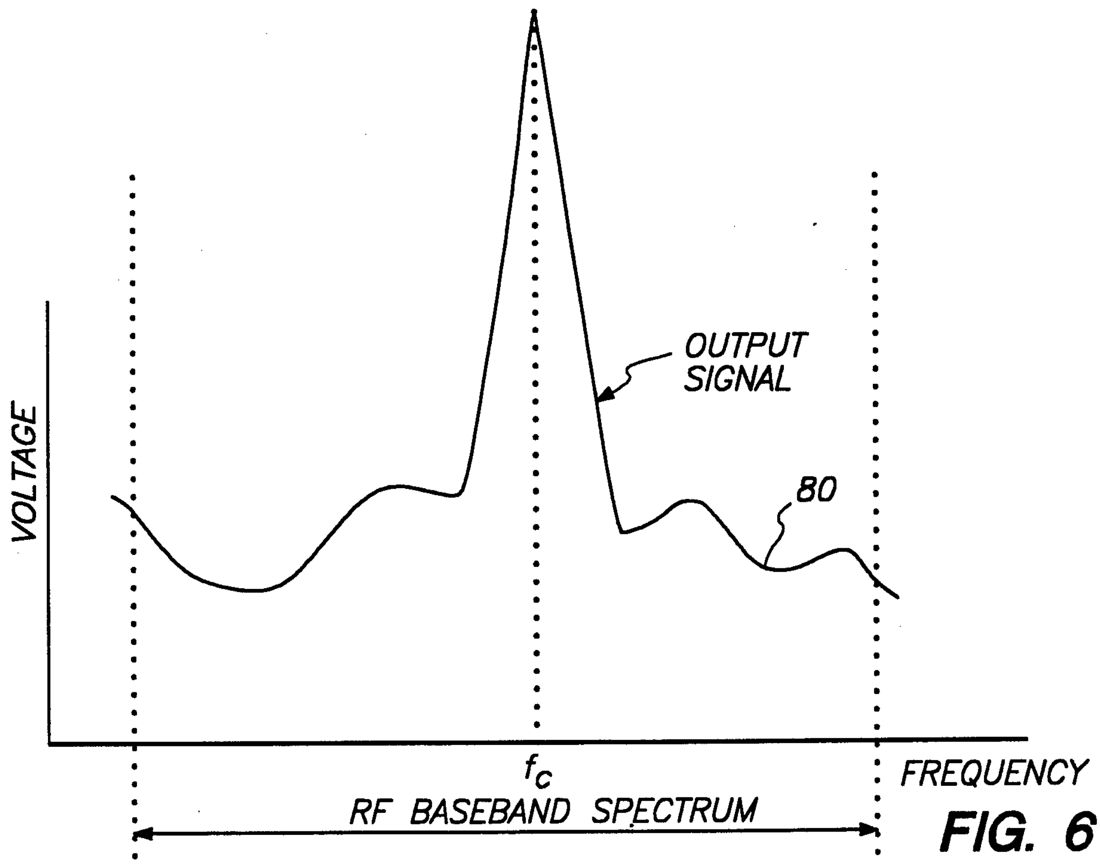

FIG. 6

INTERNATIONAL SEARCH REPORT

Inter… nal Application No
PCT/US 94/09180

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04B10/10 H04B7/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP,A,0 338 765 (VICTOR COMPANY OF JAPAN) 25 October 1989 see column 7, line 47 - column 8, line 18 see column 8, line 31 - line 37 see column 9, line 11 - line 32 see column 14, line 19 - line 39 see figures 5,6,14,15	1-5
Y		6-9,11
X	PATENT ABSTRACTS OF JAPAN vol. 7, no. 200 (E-196) 3 September 1983 & JP,A,58 099 038 (OKI DENKI KOGYO) 13 June 1983 see abstract	1,2,4

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
7 December 1994	10.01.95

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	ELECTRONICS LETTERS., vol.29, no.11, 27 May 1993, STEVENAGE GB pages 973 - 975 SOREL ET AL '10 Bbit/s transmission experiment over 165km of dispersive fibre using ASK-FSK modulation and direct detection' see page 974, left column, line 23 - line 25	6-9,11
Y	GB,A,2 222 734 (PHILIPS) 14 March 1990 see abstract	7-9
A		3,5,6,11

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 94/09180

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A-0338765	25-10-89	US-A- 5034997	23-07-91
GB-A-2222734	14-03-90	NONE	