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(54) **Title:** AN IMPROVED SYSTEM AND METHOD FOR DUAL POLARIZATION RADAR WITH AUTOMATIC BUILT-IN TEST EQUIPMENT AND CALIBRATION

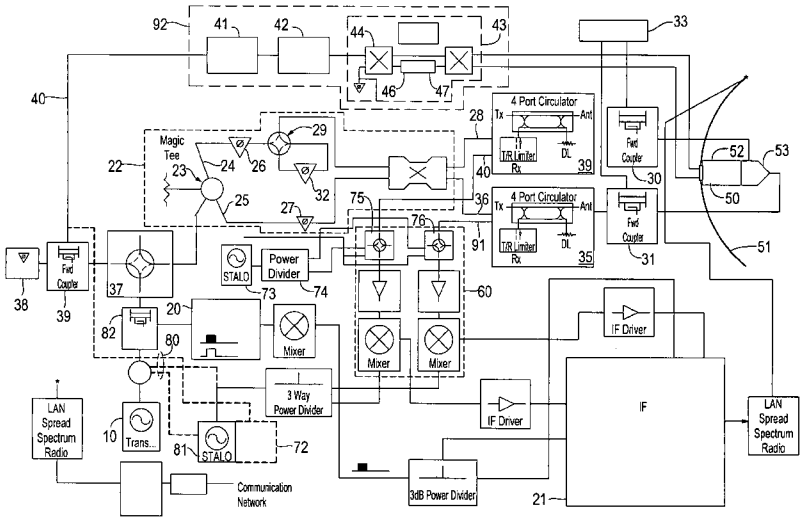


FIG. 1

(57) **Abstract:** A calibration system for the receiver of a dual polarization radar system has been developed. The system includes a radar transmitter that transmits signals in horizontal and vertical polarizations and a radar receiver that receives the horizontal and vertical polarization signals. The system also includes a test signal generator that generates a continuous wave test signal. A calibration circuit for the radar receiver modifies the test signal to simulate weather conditions by adjusting the attenuation and Doppler phase shift of a continuous wave test signal.

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AN IMPROVED SYSTEM AND METHOD FOR DUAL POLARIZATION RADAR WITH AUTOMATIC BUILT-IN TEST EQUIPMENT AND CALIBRATION

FIELD OF THE INVENTION

[0001] The present invention relates generally to the field of radar systems. More particularly, the invention provides a system and method for dual polarization weather radar with automatic built-in test and calibration capabilities.

BACKGROUND ART

[0002] Dual polarization radar systems, also known as polarimetric radar, offer advantages over conventional radar in many ways. In addition to detecting storms and measuring radial wind velocities, polarimetric radar has been proven by scientists to be the superior radar instrument for measurement of rainfall rate (accumulation) and to determine the classification of hydrometeors, such as wet snow, dry snow, small hail, large hail, graupel, light rain and heavy rain. Many polarimetric radar systems have been developed and fielded by scientists as instruments to study atmospheric sciences, and now some commercial weather radar users such as television stations are employing polarimetric radar to more accurately measure weather phenomena and to warn the general public of inclement weather.

[0003] Testing and calibration of dual polarization radar instruments have been major difficulties with polarimetric radar. One prior art method for polarimetric calibration is performed by "bird bathing" the antenna (*i.e.*, directing the antenna straight up into the atmosphere) at a time when light-to-medium strataform rainfall covers the radar site. Because rain drops are almost perfect spheroids, they provide almost equal backscatter to all radar polarizations (HV/HH = HH/HV). A disadvantage of this prior art calibration method is that it can only be performed during a period of light-to-medium strataform

rainfall at the radar site, and cannot therefore be performed on a regular or as-needed basis.

[0004] Another prior art calibration method trains the radar antenna on the sun, which radiates equal amounts of energy in all polarizations. This method is commonly called "sun tracking" or "sun calibration." With this method, HH/HV HV/HH, except that this measurement only measures the received signals without regard to the balance of the transmitted signal. A disadvantage of the sun tracking method of calibration is that there are only short periods of time during each day that the sun is positioned such that an accurate calibration of the receiver can be made.

[0005] It would be desirable to have system and method for calibration of dual polarization radar that overcomes the disadvantages of the prior art methods. More specifically, it would be desirable to have method and system for calibrating the receiver that can be performed at regular intervals or at any desired time. Another challenge with dual polarization radar is balancing the power on the horizontal and vertical transmit channels. It would be desirable to have built-in test equipment that adjusts for unequal losses in the horizontal and vertical transmit channels and provides equal power output to both polarizations.

SUMMARY OF THE INVENTION

[0006] In some aspects, the invention relates to a calibration system for a dual polarization radar system, comprising: a radar transmitter that transmits signals in horizontal and vertical polarizations; a radar receiver that receives the horizontal and vertical polarization signals; a test signal generator that generates a continuous wave test signal; and a calibration system for the radar receiver that simulates weather conditions by adjusting the attenuation and Doppler phase shift of a continuous wave test signal.

[0007] In other aspects, the invention relates to a calibration system for a dual polarization radar system comprising: a radar transmitter that transmits signals in horizontal and vertical polarizations; a radar receiver that receives the horizontal and vertical polarization signals; a noise source generator that produces a background noise

signal that is 30 dB higher than standard atmospheric noise; a 3 dB power divider that divides the background noise signal; and a calibration system for the radar receiver that calibrates the system to compensate for atmospheric background noise with the divided background noise signal.

[0008] Other aspects and advantages of the invention will be apparent from the following description and the appended claims.

BRIEF DESCRIPTION OF DRAWINGS

[0009] It should be noted that identical features in different drawings are shown with the same reference numeral.

[0010] Figure 1 is a schematic representation of the components of a system according to one embodiment of the present invention.

[0011] Figure 2 is a graphical plot of the power output when the horizontal and vertical transmit channels are balanced according to one embodiment of the present invention.

[0012] Figure 3 is a graphical plot showing the power output when 100% of the power is applied to the horizontal transmit channel.

[0013] Figure 4 is a block diagram representation of the system with built in calibration components according to one embodiment of the present invention.

[0014] Figure 5 is a schematic representation of the Variable Ratio Power Divider circuit according to one embodiment of the present invention.

[0015] Figure 6 is a schematic representation of the components of a system for an alternative embodiment of the present invention.

DETAILED DESCRIPTION

[0016] The present invention provides a system and method for reliable, built-in calibration and testing of dual polarization radar systems. The present invention achieves

this object with a unique calibration method in which both the balance of the transmitted energy and the balance of the received energy can be measured precisely and accounted for in the constants of the radar signal processor. This calibration can be done at regular intervals and at any time of day. The invention provides for the absolute balance of power of the transmitted signals. The invention also provides for "closed loop" testing of the receiver by simulating polarimetric radar signals and injecting the signals into the antenna. Consequently, the present invention enables the radar system to "self calibrate" without the use of any external test equipment and in a fashion that the radar can function, calibrate and test in the manner of a remotely located "robot."

[0017] The invention includes a variable ratio power divider that provides the ability to completely balance the transmitted power in the horizontally- and vertically- polarized channels by shifting and combining the two phases of microwave signals. Test results, shown in Figure 2 and Figure 3, demonstrate the vertically and horizontally transmitted power balance obtained is better than 1120th of a decibel. Specifically, Figure 2 is a plot of the power output when the horizontal and vertical transmit channels are balanced. Figure 3 is a plot showing the power output when 100% of the power is applied to the horizontal transmit channel. The power measurement is only limited by the accuracy of the test points and laboratory test equipment employed in the measurement.

[0018] The invention also includes a "snippet circuit" that obtains a short snippet or sample (*e.g.*, 30 to 100 meters in width) of the transmitter sample pulse to use as a transmitter phase burst pulse, or "lock pulse." The normal polarimetric radar system transmits pulses ranging in width from approximately 100 meters to several hundreds of meters. A short snippet of the transmitter pulse is captured and saved to be used as a reference for comparison with the received transmission. Using the snippet circuit, the system can self-measure the phase droop or phase delay across the remainder of the transmitted pulse.

[0019] Figure 1 is a schematic representation of one embodiment of a dual polarization radar according to the present invention. In a coherent radar system, a STALO **81** signal would be sent upstairs (*i.e.*, above the rotary coupler, not illustrated) and would be used

to convert the signals to an IF frequency. The transmitted signal would come from transmitter **10** through forward coupler **82** to sample port **20** where a very short snippet of the transmitted pulse would be "picked off." For example, for a transmitted pulse that is 300 meters wide, the user may choose to snip off the first 30 or 40 meters of the transmission pulse. The "snipped" signal would be transmitted to the IF digitizer **21** to set up a reference for development of Doppler signals.

[0020] The remaining pulse would pass through waveguide switch **37** and then through Variable Ratio Power Divider ("VRPD") circuit **22** en route to the antenna. The VRPD circuit **22** splits the signal two ways in a zero-degree phase relationship. One arm **24** of the VRPD circuit **22** contains a 90 degree phase shifter **26**. The other arm **25** of the VRPD circuit **22** contains a variable phase shifter **27** capable of varying the phase from zero to 180 degrees.

[0021] If the signals in arms **24** and **25** of the VRPD circuit **22** are in phase, they will come out arm **28** on the VPRD and go on to transmit in horizontal polarization. The waveguide switch **29** can be activated to put an additional 90 degree phase shift (via phase shifter **32**) in the signal in arm **24** of the VRPD circuit **22**. Then the phase shifter **32** can be adjusted to equally divide the signal measured at ports **30** and **31** feeding the H and V ports on the antenna. For example, with a 750 kilowatt transmitter, all of the signal could be transmitted through the horizontal, or 375 kilowatts could be transmitted through each of the horizontal and vertical, with the phase shifter **32** allowing a precise balance. Another component of the built-in test equipment is a dual-sensor peak power meter **33** that is reading the transmitted power down to the third digit, a very accurate level of measurement.

[0022] One of the problems in conventional dual polarization radar is that once the power is divided, there is no way to balance the power. So if the losses inherent in components on the horizontal channel (such as 4-port circulator **34** and couplers **30**) are different from the losses in components on the vertical channel (such as 4-port circulator **35** and coupler **31**), then unequal power is transmitted. The present invention achieves the goal of transmitting exactly equal power on the vertical and horizontal channels.

[0023] Signals sent from the radar would go out and propagate out in space and would hit some type of weather event and the radar would receive backscattered energy from the weather event. The backscattered energy will be captured by the radar signals that are reflected to the dish **51** back to the feed **53**. The signals travel through individual vertical and horizontal channels **90** and **91** respectively, and down through receiver **60** where they are amplified and then to the IF digitizer **21** where they are digitized and compared with the snippet that was transmitted to the IF digitizer earlier.

[0024] When comparing the snippet with the received signal, the different phase shifts in the signal represent velocity. The width of the spectrum represents turbulence. The amount of signal in each channel represents the amount of rainfall or reflectivity. The signal also provides information regarding the shape of the raindrop and whether it is frozen or unfrozen, because all that energy is on the reflected signal coming back in.

[0025] In the present invention, the signals are simulated by taking the transmitted signal from transmitter **10** and activating waveguide switch **37** to switch from the normal path of transmit (through the VRPD circuit **22**) over to a dummy load **38** via directional coupler **39**. Then, a small portion of the transmitted signal is directed through leg **40** into calibration circuit **92**. Optionally, this signal path may also employ a microwave delay line to delay the pulse. For example, if the transmitted signal is 750 kilowatts in the dummy load, 20 milliwatts (typical value) of this signal could be directed out of the directional coupler **39** into the calibration circuit **92** through leg **40**. In the calibration circuit **92**, the signal can be modified in phase and amplitude, and can be transmitted from test signal antenna **50** mounted in the vertex of the radar antenna **51**.

[0026] The test antenna is centered at the vertex of the radar antenna in such a position that it falls within the shadow of the operational antenna feed, which consists of an Orthomode Transducer or multi-mode (polarization diverse, multiple simultaneous polarizations or variable polarizations) antenna feed assembly. The test antenna is used to radiate a small low level signal directly to the normal antenna feed. The calibration circuit is mounted on the antenna above the rotary coupler in a fashion similar to the AN/FPS-16, AN/MPS-T9, M-33, NIKE and numerous other Military radar systems that

have been around for many years. In some cases, the stable local oscillator ("STALO") and/or reference clock are mounted below the rotary coupler.

[0027] The invention includes a built in test point to accept the full transmitted pulse width and power and an associated calibration circuit that extracts a portion of the signal and manipulates the signal such that the signature in phase and amplitude are representative of what is found in backscattered energy from a meteorological hydrometeor. In other words, the invention can simulate microwave backscatter that exists in weather conditions of interest to the user. The calibration circuit then transmits these signals from a test antenna to the main antenna feed.

[0028] The test signal antenna **50** is in the shadow **52** of the feed **53** and therefore does not affect the overall performance of the radar antenna **51** as far as side lobes and distortion of the beam, so it has no effect on the normal radar operations. In the calibration circuit **92**, various components and circuitry are used to modify the signal to take on characteristics simulating attributes of various weather phenomena, such as Z_{DR}, PHV, ϕ_{DP} and K_{DP}, where:

Z_{DR} = differential reflectivity;

PHV (Rho_{HV}) = H-V correlation coefficient;

ϕ_{DP} (PHI_{DP}) = differential propagation phase; and

KDp = phase differential with distance or specific phase differential that is used to estimate the amount of precipitation in the scanned volume of atmosphere.

[0029] For example, step attenuator **41** can be adjusted to attenuate the signal to simulate rainfall intensity or reflectivity. The resultant signal can be transmitted through test antenna **50** into the feed **53** and received through normal circuitry via receiver **60**. Then the amount of attenuation received could be measured to calibrate the reflectivity of the

radar (*i.e.*, to test that the reflectivity range of the radar and accuracy are within specification). Attenuator **41** can then be set back to zero.

[0030] The calibration circuit **92** also contains a digital phase shifter **42** that can be used to impose a Doppler phase shift in the signal. The signal can then be transmitted from test signal antenna **50** into the feed **53** and back through the normal channels to the receiver **60** and the Doppler velocity would be read out in the equipment below in the normal radar.

[0031] Using digital phase shifter **42**, a very noisy sine wave can be imposed on the signal instead of a pure sine wave, in order to widen the spectrum. Using multiple frequencies mixed together, the Gaussian distribution of the waveform can be expanded. The velocity of the spectrum width can be simulated by the modulation of the phase shifter, by the way the signals are serrodyning.

[0032] Another feature of calibration circuit **92** is the digital beam forming circuit **43**, which is very similar to VRPD circuit **22**, except that the digital beam forming circuit is made with coaxial components and uses low microwave power (*e.g.*, 1 milliWatt) instead of high power (*e.g.*, 200 Watts). In the digital beam forming circuit **43**, the signals coming out of a 90 degree hybrid coupler **44** are in phase, and on one arm **45** of the circuit **43**, a constant length of transmission line provides a fixed phase from coupler **44** to coupler **48**. On arm **46** of the circuit **43**, instead of having a phase shifter as in the VRPD circuit **22** for the high power transmission; there is a low power digital phase shifter **47**. Using the low power digital phase shifter **47**, the phases that are recombining in this part of the digital beam forming circuit **43** can be varied. If the phases are in phase, the signal goes out the "H" port **70**. If they are 90 degrees out of phase, the signal goes out the "V" port **71**. If they are 45 degrees out of phase, the signal goes out of both ports. By changing the phase in the low power digital phase shifter **47**, a phase lag can be imposed on one channel or the other. This phase lag can be used to simulate other characteristics of a received weather event signal, such as K_{dp} and Phi_{dp}. Therefore, by controlling the phase shifter **47**, different phases and amplitudes can be generated. In fact,

the phase shifter **47** can be serrodyned and the phases will actually "roll" the polarization or generate a circular polarization.

[0033] The resultant signals arc transmitted by the test antenna **50**, are received by the main antenna feed **53**, come back through the normal processing to receiver **60**, and the radar can be calibrated using the received signals. In operation, each different characteristic is simulated and the system is calibrated for that characteristic one at a time, and all of the characteristics can be tested in as little as ten seconds. With the radar doing a volumetric scan, the system can be programmed to calibrate the radar fully at the end of the each scan. For a non-coherent radar system, the transmission signals are generated via the up-converter option **72**, then "pumped" into the same circuit as the coherent radar, discussed above. As shown in Figure 1, dotted lines **80** illustrate a system used for a non-coherent radar.

[0034] The system according to the present invention also includes a digital noise source **73** and a power divider **74** that will, through coax switches **75** and **76**, provide a noise signal into the receiver to check each channel and subsequently allow calibration of the transmitter of the system. This is an alternative calibration of the receiver similar to the sun-tracking calibration. Using the system and method according to the present invention, the transmitted power signal can be completely balanced during the calibration process. Further, the receiver calibration system and method disclosed herein can simulate "bird bathing" of the radar antenna by amplitude modulation and phase modulation, by polarization modulation, and imposition of RF phase lead/lag in the beam forming network.

[0035] Figure 4 shows a block diagram of one example of the present invention a built in calibration system **100**. The calibration system **100** includes a Variable Ratio Power Divider (VPRD) **102** that is similar to the VRPD **22** previously described and shown in Figure 1. Figure 5 shows a detailed schematic **104** of the VRPD. The VRPD as shown in Figure 4 and Figure 6 uses separate 0-180° adjustable phase shifters **106a**, **106b** and **106c.** For a full transfer of power to the horizontal output **108a**, the VRPD targets a 0° phase shift of the input **110**. For an equal split power split between horizontal and

vertical outputs **108a** and **108b**, a 45° phase shift of the input is targeted by the VRPD. For a full transfer of power to the horizontal output **108b**, the VRPD targets a 90° phase shift between the horizontal and vertical outputs **108a** and **108b**. For a full power transfer to either to either the horizontal or vertical outputs **108a** and **108b** (with a 0° or a 90° phase shift), the waveguide switch **112** is placed in "position 1" and the signal bypasses a phase shifter **106b**. For a power split between the horizontal or vertical outputs **108a** and **108b** (with a 45° phase shift), the waveguide switch **112** is placed in "position 2" and the signal engages the phase shifter **106b**. In this example, the signal input **110** from the radar transmitter operates in a frequency range of 2.7-2.9 GHz. The input also operates with a 1000 kW peak pulse and a 1500 W average power levels. The tolerance for power division in $1/20^{th}$ dB.

[0036] Figure 6 shows a schematic of one example of the system that is used to calibrate the receiver of the dual polarization radar system. The system uses two separate methods: attenuation of a test signal; and using simulated background noise in conjunction with a test signal. The method involves sampling a test signal **114** to calibrate the receiver **116** of the system. The test signal may either be a continuous wave or a pulse. The test signal is attenuated or "stepped down" linearly to check both the horizontal and vertical polarizations. This method can be used to simulate various weather conditions (e.g., wind speed) with a digital RF attenuator **118** and digital RF phase shifter **120**. This simulates the Doppler shift of the desired weather condition in the horizontal and vertical polarities. Once the test signal is adjusted to the desired conditions, it is transmitted by the test feed **122** to the receiver **116**.

[0037] The second method of calibrating the receiver involves the use of a recorded level of background atmospheric noise **124**. In this example, the background noise has a 30 dB ENR (excess noise ratio). The noise is feed to a 3 dB power divider and the signal power is divided evenly between between the horizontal and vertical changes for a noise level of 27 dB in each channel. This noise level is then feed to the receiver **116** to serve as a calibration signal.

[0038] While the invention has been described with respect to a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments can be devised which do not depart from the scope of the invention as disclosed here. Accordingly, the scope of the invention should be limited only by the attached claims.

CLAIMS

What is claimed is:

[c1] A method of calibrating a dual polarization radar system, comprising:

generating a transmission pulse from the radar system;

modifying the transmission pulse to generate a test signal that simulates a desired atmospheric condition;

transmitting the test signal directly into the radar system from a test antenna; and

calibrating the radar system according to the test signal.

[c2] The method of claim 1, the test signal is generated by capturing a portion of the transmission pulse.

[c3] The method of claim 2, where the transmission pulse has a wavelength of about 300 meters.

[c4] The method of claim 3, where the captured portion of the transmission pulse is about 30 meters in length.

[c5] The method of claim 1, where the desired atmospheric condition is simulated by manipulating the phase and amplitude of the test signal.

[c6] The method of claim 1, where the simulated atmospheric condition is backscattered energy from a meteorological hydrometer.

[c7] A calibration system for a dual polarization radar system, comprising:

a dual polarization radar transmitter antenna that generates a transmission pulse;

a snipper circuit that captures a sample of the transmission pulse and stores the sample for use in generating a test signal;

a calibration circuit that receives the sample of the transmission pulse and generates a test signal that simulates a desired atmospheric condition; and

a test antenna that transmits the test signal to the dual polarization radar transmitter antenna for calibration of the system.

[c8] The calibration system of claim 7, where the calibration circuit comprises a variable ratio power divider circuit.

[c9] The calibration system of claim 7, where the calibration circuit comprises a digital beam forming circuit.

[c10] The calibration system of claim 9, where the digital beam forming circuit utilizes coaxial circuitry.

[c11] The calibration system of claim 9, where the digital beam forming circuit uses a low power microwave signal.

[c12] The calibration system of claim 7, where the transmission pulse has a wavelength of about 300 meters.

[c13] The calibration system of claim 7, where the sampled portion of the transmission pulse is about 30 meters in length.

[c14] The calibration system of claim 7, where the calibration circuit further comprises a digital phase shifter that compensates for Doppler shift in the test signal.

[c15] The calibration system of claim 7, where the calibration circuit further comprises a dual sensor peak power meter that reads transmitted power from the system.

[c16] The calibration system of claim 7, where the test antenna is centered in the vertex of the radar transmitter antenna so that the test antenna is located within the shadow of an operational feed of the radar transmitter antenna.

[c17] A calibration system for a dual polarization radar system, comprising:

a radar transmitter that transmits signals in horizontal and vertical polarizations;

a radar receiver that receives the horizontal and vertical polarization signals;

a test signal generator that generates a continuous wave test signal; and

a calibration circuit for the radar receiver that simulates a weather condition by adjusting the attenuation and Doppler phase shift of a continuous wave test signal.

[c18] The system of claim 17, where the test signal generator generates a pulse wave test signal.

[c19] The system of claim 17, where the simulated weather condition comprises wind speed.

[c20] The system of claim 17, where the simulated weather condition comprises rainfall.

[c21] A calibration system for a dual polarization radar system comprising:

a radar transmitter that transmits signals in horizontal and vertical polarizations;

a radar receiver that receives the horizontal and vertical polarization signals;

a noise source generator that produces a background noise signal that is 30 dB higher than standard atmospheric noise;

a 3 dB power divider that divides the background noise signal; and

a calibration circuit for the radar receiver that calibrates the system to compensate for atmospheric background noise with the divided background noise signal.

[c22] The system of claim 21, where the test signal generator generates a pulse wave test signal.

[c23] The system of claim 21, where the power level of the background noise signal is evenly divided between a horizontal polarization channel and a vertical polarization channel.

[c24] The system of claim 23, where the background noise signal noise level in both the horizontal polarization channel and the vertical polarization channel is 27 dB.

[c25] A variable ratio power divider used for adjusting a calibration signal for a dual polarization radar system, comprising:

an input line that receives a calibration signal and splits the calibration signal into a first test signal and a second test signal, where the test signals have a 0° phase shift;

a horizontal polarization output port for a horizontal calibration signal;

a vertical polarization output port for a vertical calibration signal;

a waveguide switch that receives the first test signal;

where the waveguide switch may be configured to operate in an open position and

pass the first test signal through a variable 0° - 180° phase shifter so that the power of the first and second test signals is evenly divided between the horizontal polarization output port and the vertical polarization output port; and

where the waveguide switch may be configured to operate in a closed position and cause the first test signal to bypass the variable 0° - 180° phase shifter so that the entire power of the first and second test signals is directed entirely to either the horizontal polarization output port or the vertical polarization output port.

[c26] The variable ratio power divider of claim 25, where the phase shift between the first test signal and the second test signal is 45° when the waveguide switch is operating in the open position.

[c27] The variable ratio power divider of claim 25, where the calibration signal comprises a pulse wave signal.

[c28] The variable ratio power divider of claim 25, where the calibration signal comprises a continuous wave signal.

[c29] The variable ratio power divider of claim 25, where the calibration signal is between 2.7-2.9 GHz.

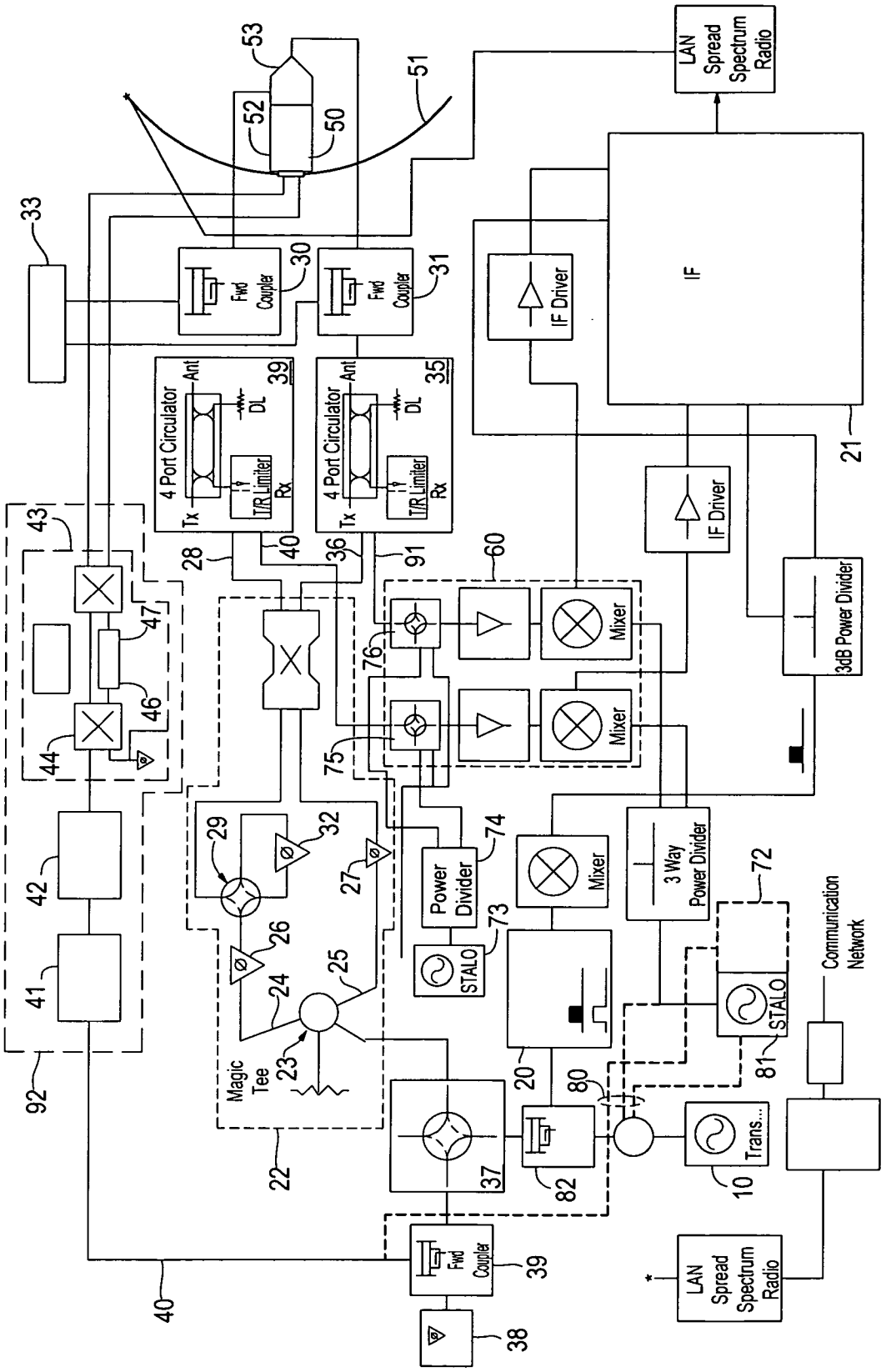

LAN Spread Spectrum Radio
IF
IF Driver
IF Driver
3dB Power Divider
Fwd Coupler
Fwd Coupler
4 Port Circulator
Ant
DL
T/R Limiter
Tx
Rx
Mixer
Mixer
Mixer
3 Way Power Divider
Power Divider
STALO
STALO
Trans...
Magic Tee
Communication Network
LAN Spread Spectrum Radio
Fwd Coupler
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FIG. 1

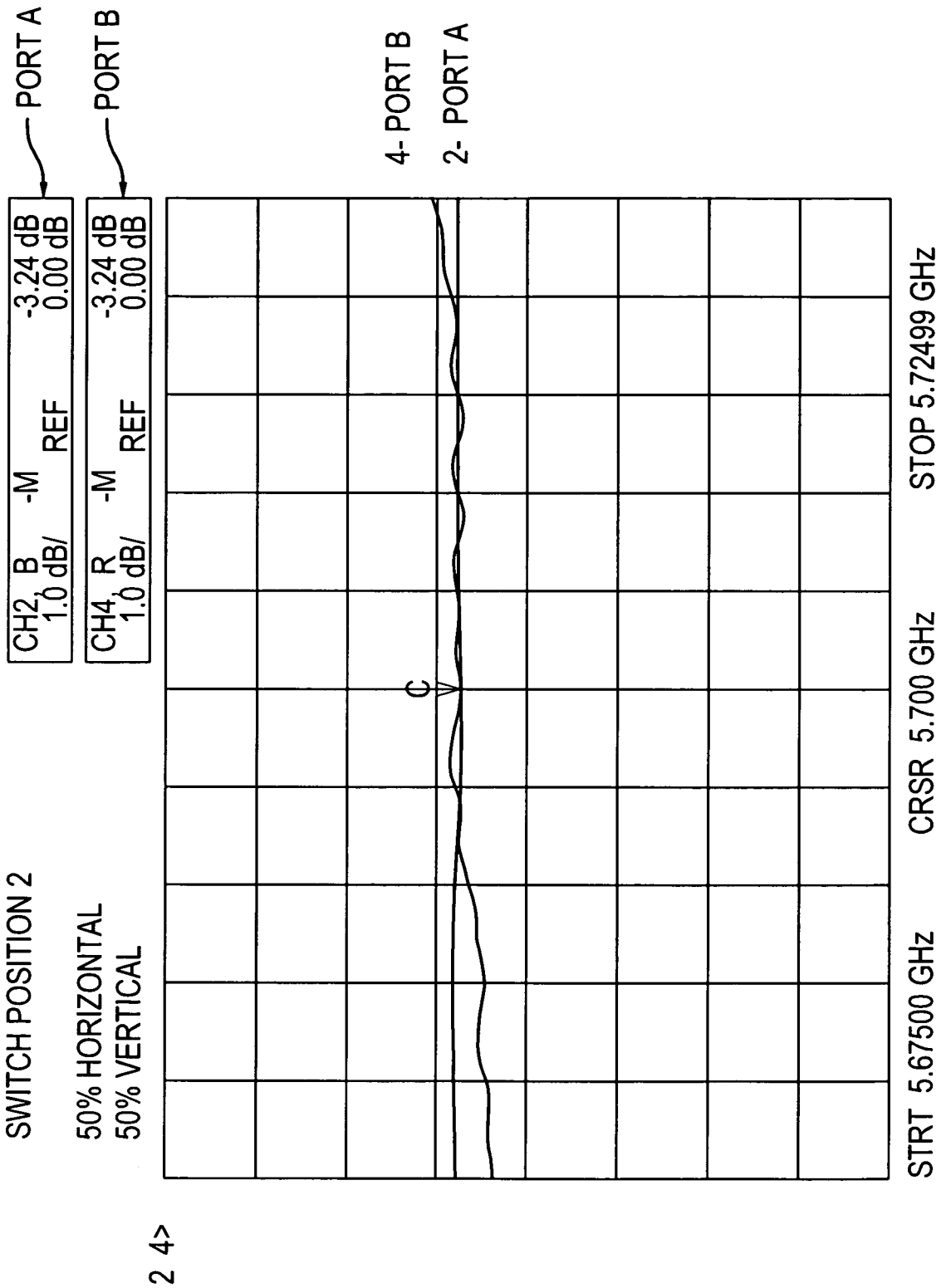

PORT A
PORT B
CH2, B -M -3.24 dB
1.0 dB/ REF 0.00 dB
CH4, R -M -3.24 dB
1.0 dB/ REF 0.00 dB
4- PORT B
2- PORT A
SWITCH POSITION 2
50% HORIZONTAL
50% VERTICAL
STRT 5.67500 GHz
CRSR 5.700 GHz
STOP 5.72499 GHz
2 4>

FIG. 2

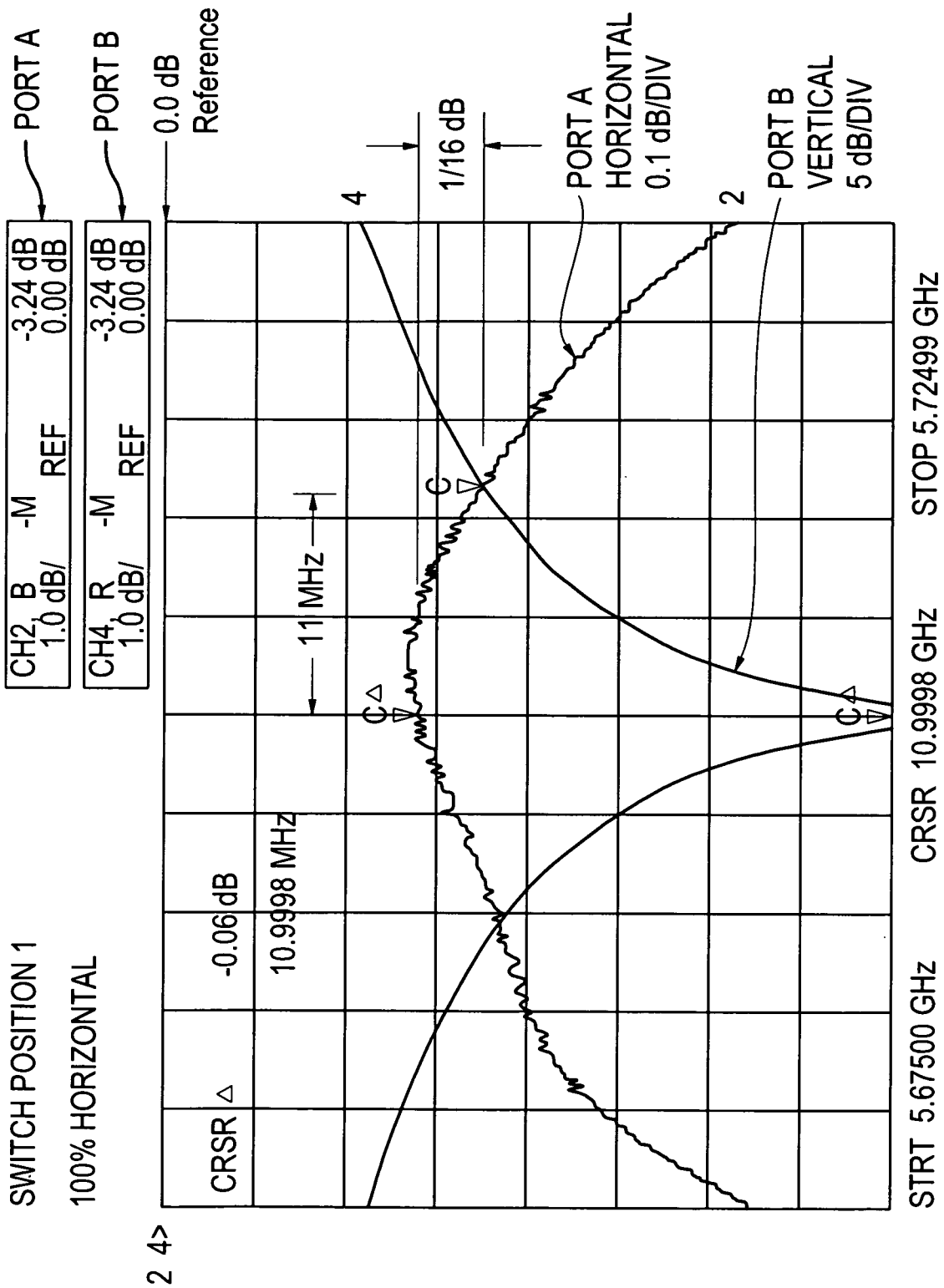

PORT A
PORT B
0.0 dB
Reference
CH2 B -M -3.24 dB
1.0 dB/ REF 0.00 dB
CH4 R -M -3.24 dB
1.0 dB/ REF 0.00 dB
1/16 dB
PORT A
HORIZONTAL
0.1 dB/DIV
PORT B
VERTICAL
5 dB/DIV
11 MHz
SWITCH POSITION 1
100% HORIZONTAL
CRSR △ -0.06 dB
10.9998 MHz
STRT 5.67500 GHz
CRSR 10.9998 GHz
STOP 5.72499 GHz
2 4>

FIG. 3

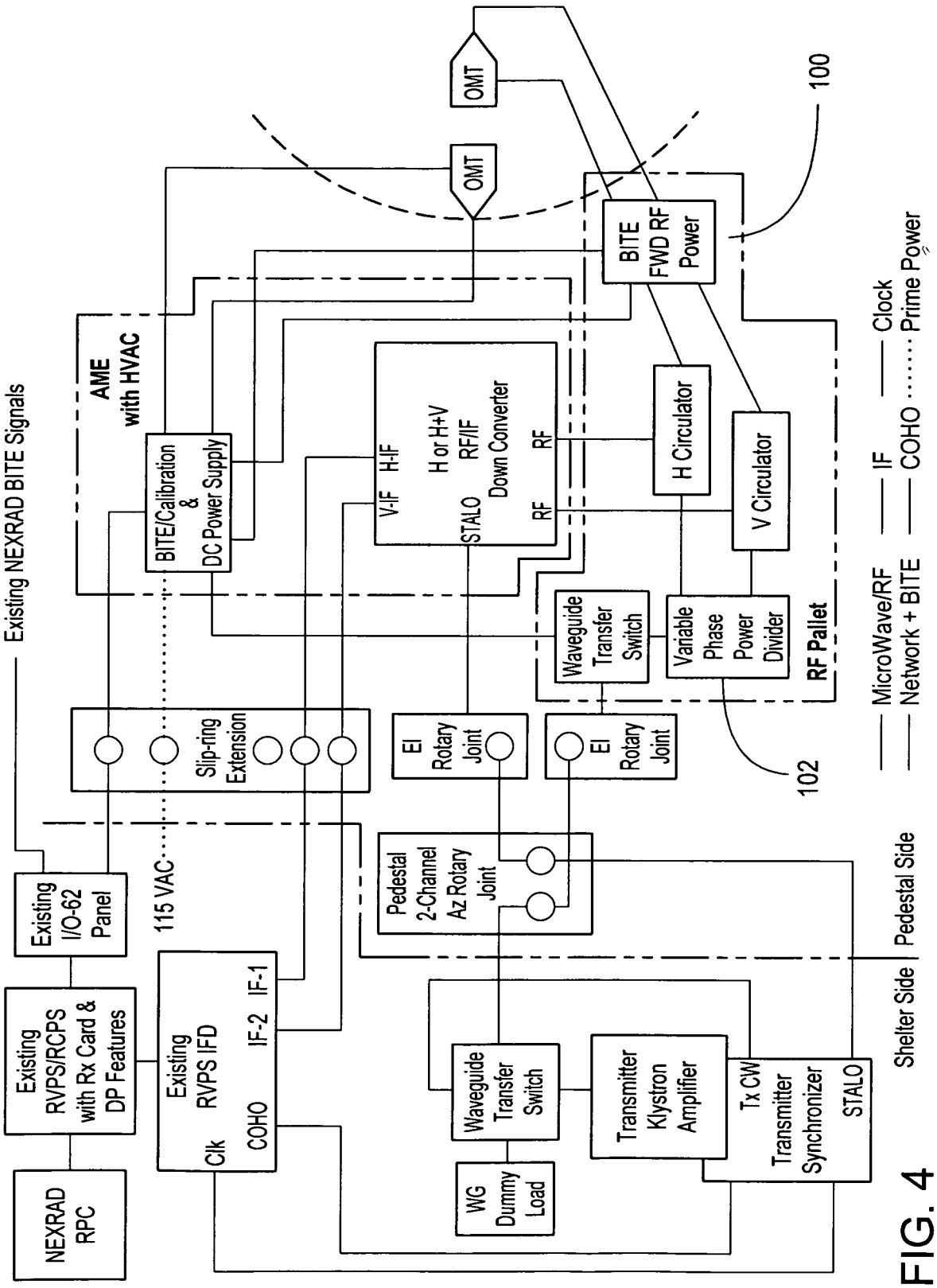

Existing NEXRAD BITE Signals
AME with HVAC
BITE/Calibration & DC Power Supply
H or H+V RF/IF Down Converter
V-IF H-IF
STALO RF RF
OMT
OMT
100
BITE FWD RF Power
H Circulator
V Circulator
Waveguide Transfer Switch
Variable Phase Power Divider
RF Pallet
Slip-ring Extension
EI Rotary Joint
EI Rotary Joint
102
115 VAC
Existing I/O-62 Panel
Pedestal 2-Channel Az Rotary Joint
Existing RVPS/RCPS with Rx Card & DP Features
Existing RVPS IFD
IF-1
IF-2
COHO
Clk
Waveguide Transfer Switch
Transmitter Klystron Amplifier
Tx CW Transmitter Synchronizer
STALO
WG Dummy Load
NEXRAD RPC
Shelter Side
Pedestal Side
MicroWave/RF
Network + BITE
IF
COHO
Clock
Prime Power

FIG. 4

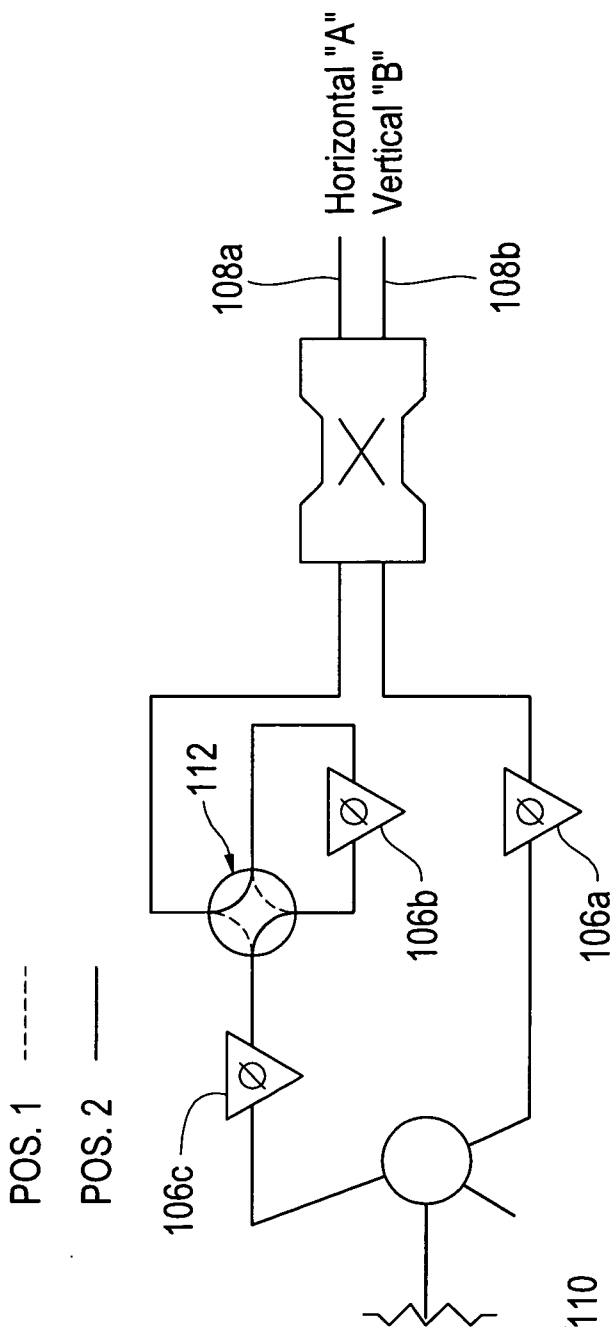

Horizontal "A"
Vertical "B"
108a
108b
112
106b
106a
106c
110
POS. 1
POS. 2

FIG. 5

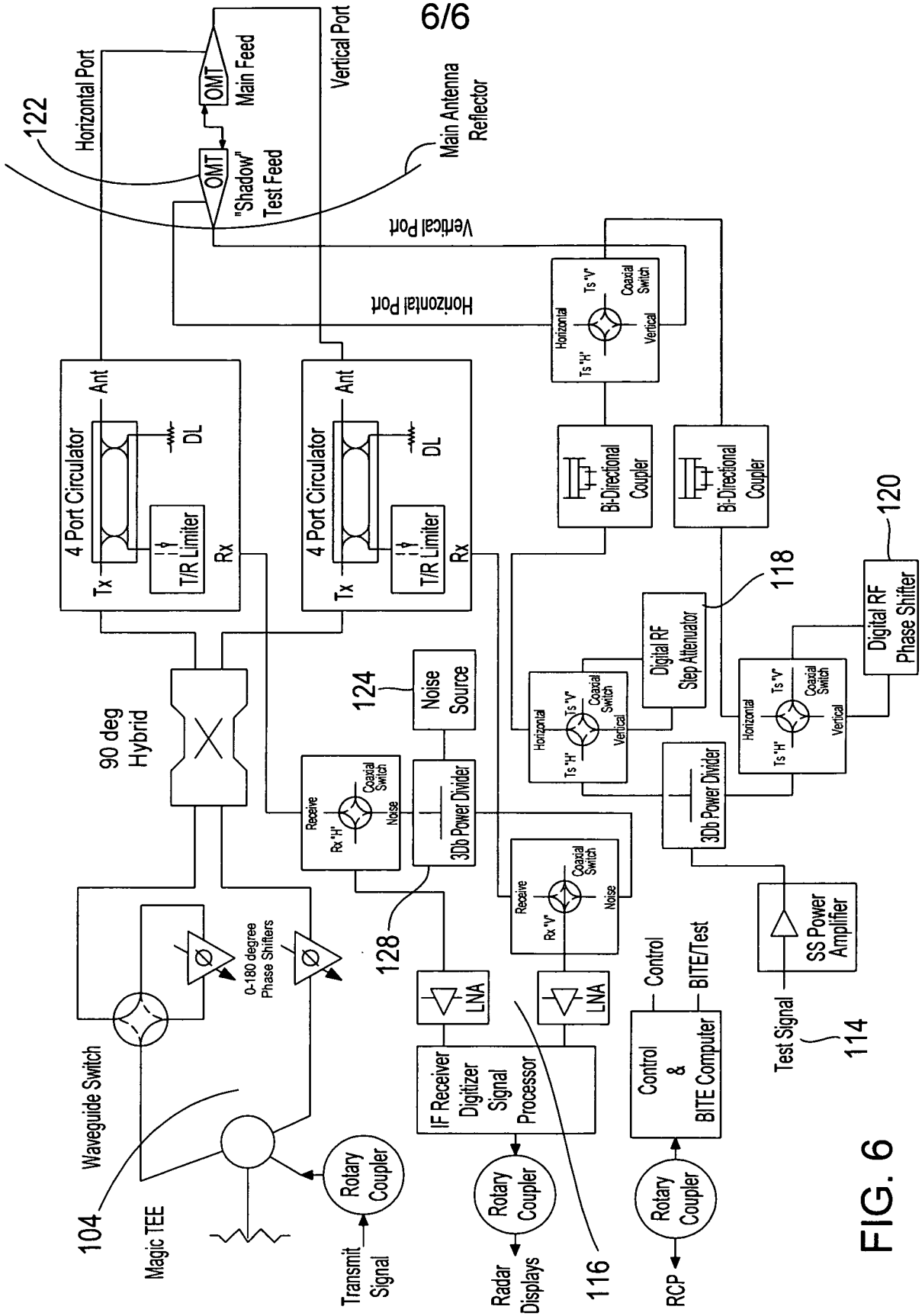

122
Horizontal Port
OMT
Main Feed
Vertical Port
OMT
"Shadow" Test Feed
Main Antenna Reflector
Vertical Port
Horizontal Port
4 Port Circulator
Ant
DL
T/R Limiter
Rx
Tx
4 Port Circulator
Ant
DL
T/R Limiter
Rx
Tx
Horizontal
Ts "V"
Coaxial Switch
Vertical
Ts "H"
Bi-Directional Coupler
Bi-Directional Coupler
120
Digital RF Phase Shifter
118
Digital RF Step Attenuator
90 deg Hybrid
124
Noise Source
Receive
Rx "H"
Coaxial Switch
Noise
3Db Power Divider
Horizontal
Ts "V"
Coaxial Switch
Vertical
Ts "H"
Receive
Rx "V"
Coaxial Switch
Noise
3Db Power Divider
Horizontal
Ts "V"
Coaxial Switch
Vertical
Ts "H"
0-180 degree Phase Shifters
128
LNA
LNA
SS Power Amplifier
Waveguide Switch
IF Receiver Digitizer Signal Processor
Control
BITE/Test
Control & BITE Computer
Test Signal
114
104
Magic TEE
Rotary Coupler
Transmit Signal
Rotary Coupler
Radar Displays
116
Rotary Coupler
RCP

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 08/03084

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - G01S 7/40 (2008.04)
USPC - 342/174
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(8): G01S 7/40 (2008.04)
USPC: 342/174

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
IPC(8): G01S 13/95 (2008.04)
USPC: 342/26R, 342/188, 250/225, 343/895

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PubWest (USPB, USPT, USOC, EPAB, JPAB), DialogPro, GoogleScholar; method calibrating dual polarization radar system generating transmission pulse modifying test signal simulates desired atmospheric condition antenna capturing portion wavelength 300 meters 30 phase amplitude Doppler backscattered energy meteorological variable

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2007/0152867 A1 (Randall), 05 July 2007 (05.07.2007), para [0028]-[0033]; [0036]	1-24
Y	US 2007/0222661 A1 (Stagliano, Jr. et al.), 27 September 2007 (27.09.2007), para [0003]; [0006]; [0008]; [0010]; [0015]-[0023]; [0027]-[0030]; [0050]; [0055]-[0056]; [0058]-[0059]; [0061]-[0064]	1-29
Y	US 2004/0056791 A1 (Alford et al.), 25 March 2004 (25.03.2004), para [0030]; [0032]; [0034]-[0040]	7-16, 25-29
A	US 2007/0222660 A1 (Stagliano, Jr. et al.), 27 September 2007 (27.09.2007), entire document	1-29
A	US 2005/0093734 A1 (Alford et al.), 05 May 2005 (05.05.2005), entire document	1-29
A	US 2004/0201515 A1 (Testud et al.), 14 October 2004 (14.10.2004), entire document	1-29

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 May 2008 (18.05.2008)	11 JUN 2008
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (April 2007)