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(54) **APPLICATIONS OF UNIVERSAL FREQUENCY TRANSLATION**

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(51) **Int. Cl.**[7] **H04B 1/26**; H04B 1/40
(52) **U.S. Cl.** **455/323**; 455/313; 327/113
(58) **Field of Search** 327/113; 455/313, 455/323, 333

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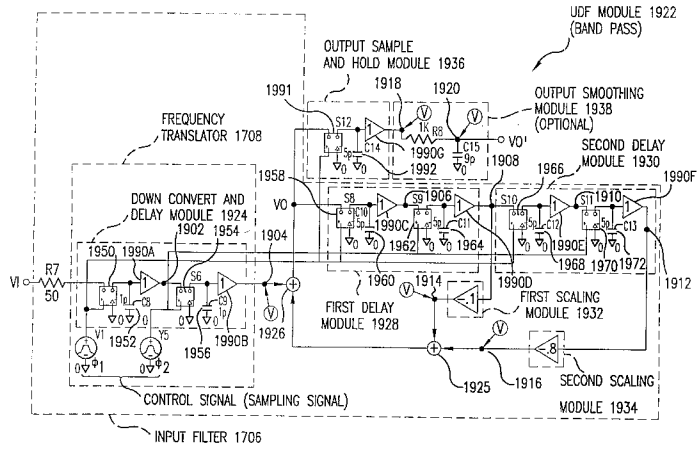
(57) **ABSTRACT**

Frequency translation and applications of same are described herein. 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.

68 Claims, 58 Drawing Sheets



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Press Release, "Parkervision's Cameraman Well–Received By Distance Learning Market," 2 pages, Apr. 8, 1994.

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Press Release, "Parkervision, Inc. Announces Second Quarter and Six Months Financial Results," 3 pages, Aug. 9, 1994.

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Press Release, "Parkervision, Inc. Announces Fourth Quarter and Year End Results," 2 pages, Mar. 1, 1995.

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Press Release, "Parkervision Announces New Camera Control Technology," 2 pages, Oct. 25, 1995.
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Press Release, "Parkervision, Inc. Announces Second Quarter and Six Months Financial Results," 3 pages, Aug. 1, 1996.
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Press Release, "Parkervision, Inc. Announces Third Quarter Financial Results," 3 pages, Oct. 30, 1997.
Press Release, "ParkerVision Announces Breakthrough in Wireless Radio Frequency Technology," 3 pages, Dec. 10, 1997.
Press Release, "Parkervision, Inc. Announces the Appointment of Joseph F. Skovron to the Position of Vice President, Licensing—Wireless Technologies," 2 pages, Jan. 9, 1998.
Press Release, "Parkervision Announces Existing Agreement with IBM Terminates—Company Continues with Strategic Focus Announced in Dec.," 2 pages, Jan. 27, 1998.
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Press Release, "Parkervision, Inc. Announces Fourth Quarter and Year End Financial Results," 3 pages, Mar. 5, 1998.
Press Release, "Parkervision Awarded Editors' Pick of Show for NAB 98," 2 pages, Apr. 15, 1998.
Press Release, "Parkervision Announces First Quarter Financial Results," 3 pages, May 4, 1998.
Press Release, "Parkervision 'DIRECT2DATA' Introduced in Response to Market Demand," 3 pages, Jul. 9, 1998.
Press Release, "Parkervision Expands Senior Management Team," 2 pages, Jul. 29, 1998.
Press Release, "Parkervision Announces Second Quarter and Six Month Financial Results," 4 pages, Jul. 30, 1998.
Press Release, "Parkervision Announces Third Quarter and Nine Month Financial Results," 3 pages, Oct. 30, 1998.
Press Release, "Questar Infocomm, Inc. Invests $5 Million in Parkervision Common Stock," 3 pages, Dec. 2, 1998.
Press Release, "Parkervision Adds Two New Directors," 2 pages, Mar. 5, 1999.
Press Release, "Parkervision Announces Fourth Quarter and Year End Financial Results," 3 pages, Mar. 5, 1999.
Press Release, "Joint Marketing Agreement Offers New Automated Production Solution," 2 pages, Apr. 13, 1999.
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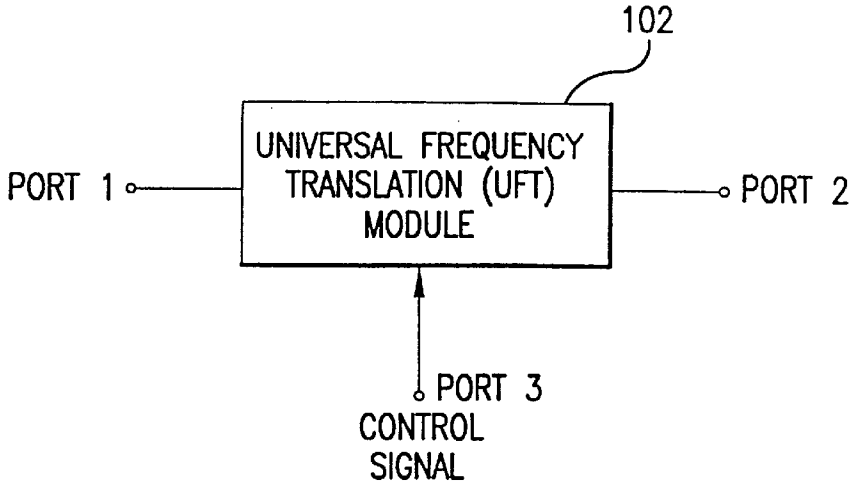

102
UNIVERSAL FREQUENCY TRANSLATION (UFT) MODULE
PORT 1
PORT 2
PORT 3
CONTROL SIGNAL

FIG. 1A

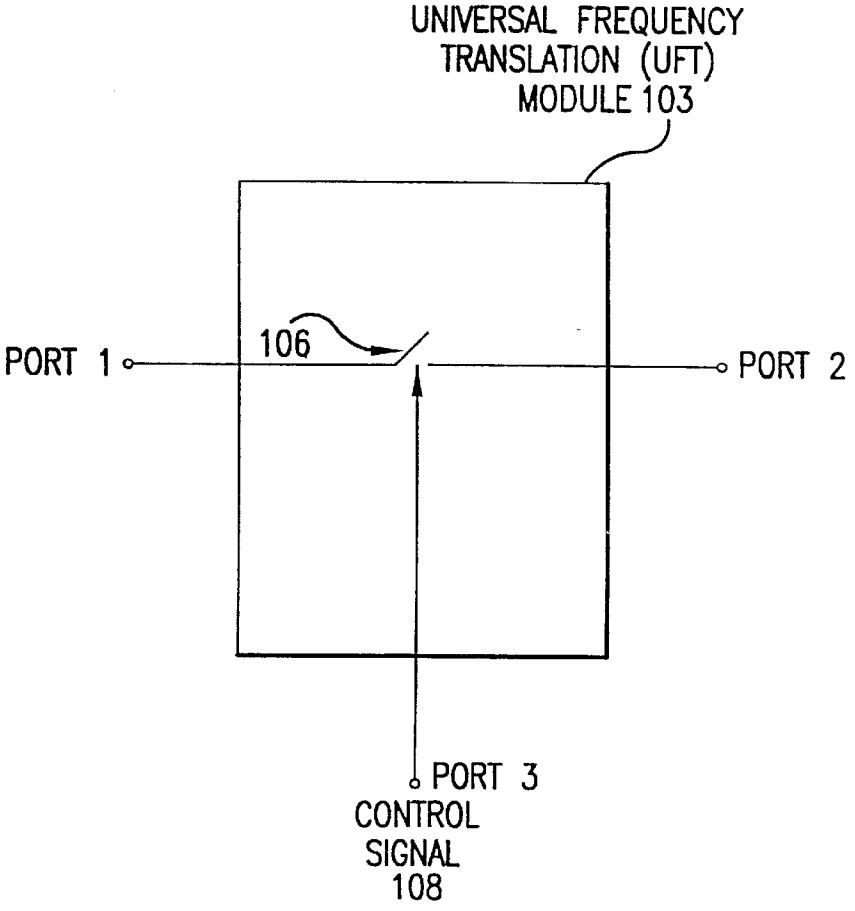

UNIVERSAL FREQUENCY TRANSLATION (UFT) MODULE 103
106
PORT 1
PORT 2
PORT 3
CONTROL SIGNAL 108

FIG. 1B

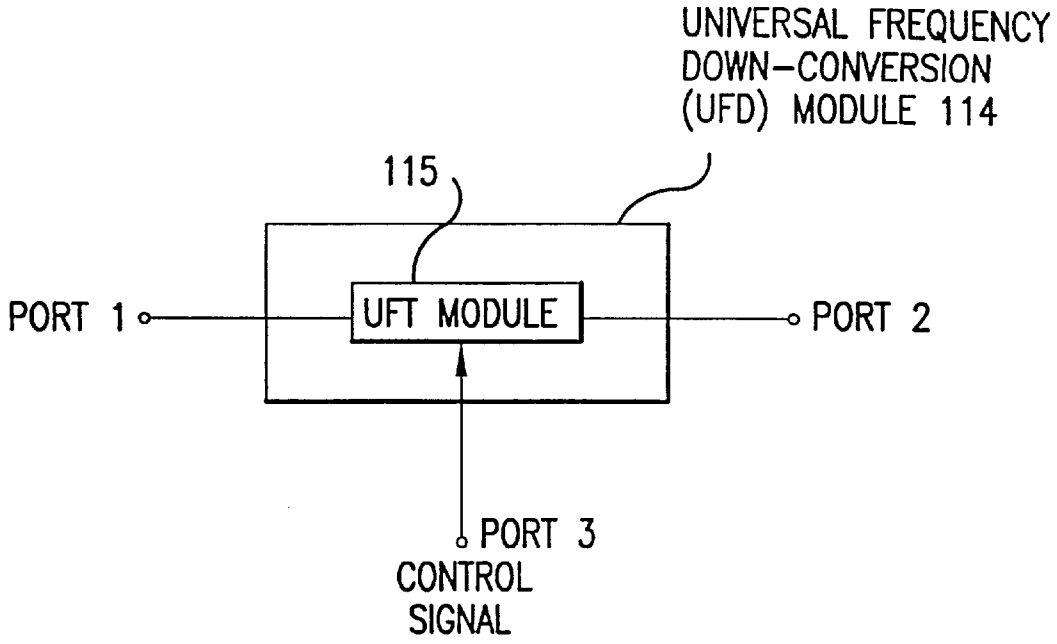

UNIVERSAL FREQUENCY
DOWN-CONVERSION
(UFD) MODULE 114
115
UFT MODULE
PORT 1
PORT 2
PORT 3
CONTROL
SIGNAL

FIG. 1C

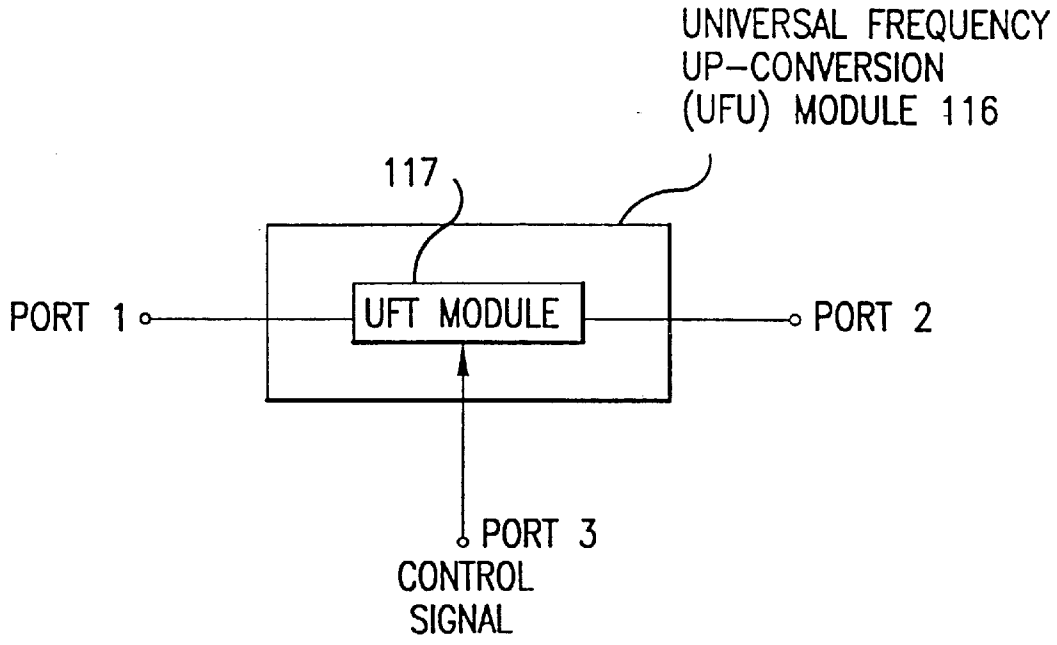

UNIVERSAL FREQUENCY
UP-CONVERSION
(UFU) MODULE 116
117
UFT MODULE
PORT 1
PORT 2
PORT 3
CONTROL
SIGNAL

FIG. 1D

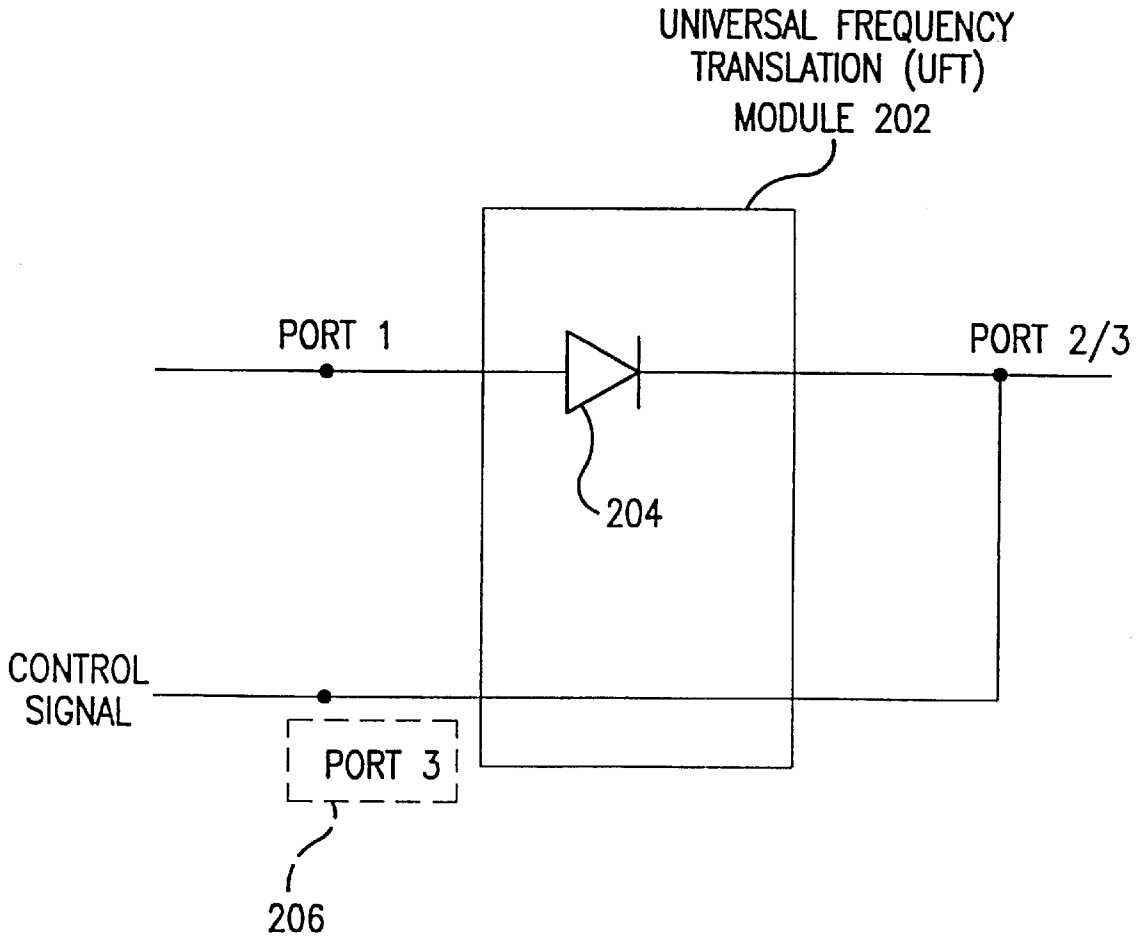

UNIVERSAL FREQUENCY
TRANSLATION (UFT)
MODULE 202
PORT 1
PORT 2/3
204
CONTROL
SIGNAL
PORT 3
206

FIG. 2

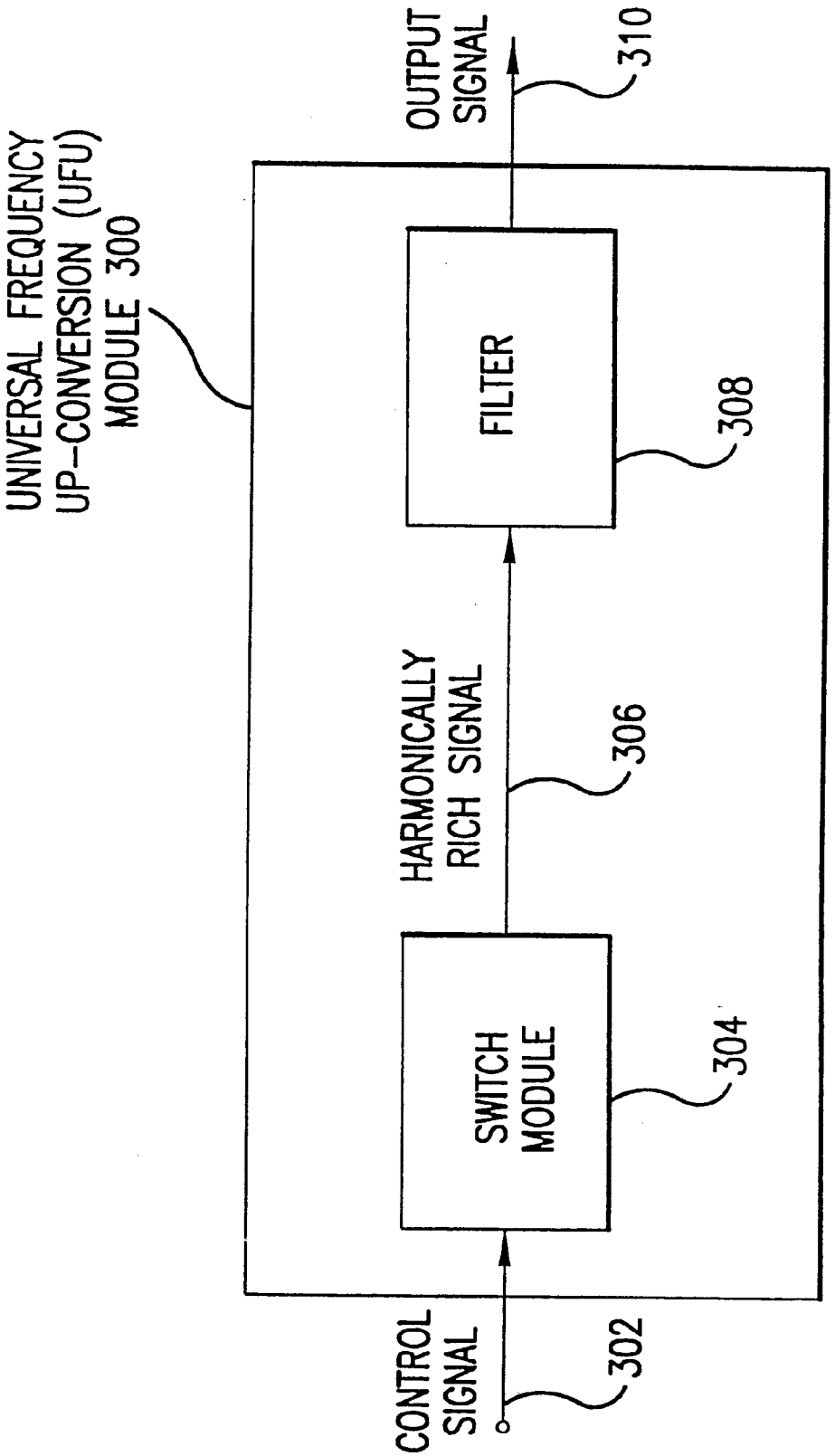

UNIVERSAL FREQUENCY
UP-CONVERSION (UFU)
MODULE 300
CONTROL
SIGNAL
302
SWITCH
MODULE
304
HARMONICALLY
RICH SIGNAL
306
FILTER
308
OUTPUT
SIGNAL
310

FIG. 3

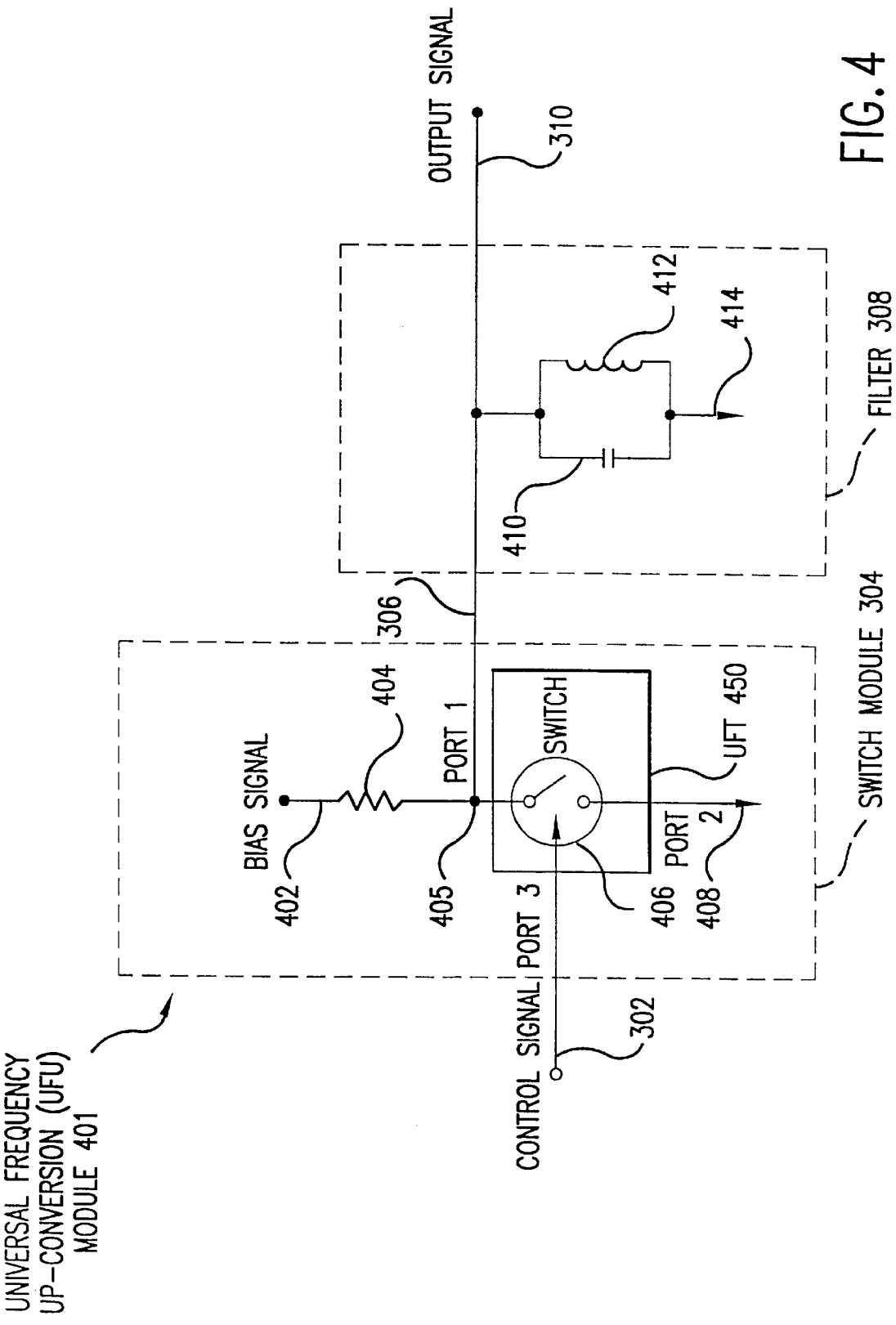

UNIVERSAL FREQUENCY
UP-CONVERSION (UFU)
MODULE 401
OUTPUT SIGNAL
310
FILTER 308
412
414
410
306
SWITCH MODULE 304
BIAS SIGNAL
402
404
PORT 1
405
SWITCH
406
PORT 3
CONTROL SIGNAL
302
UFT 450
PORT 2
408

FIG. 4

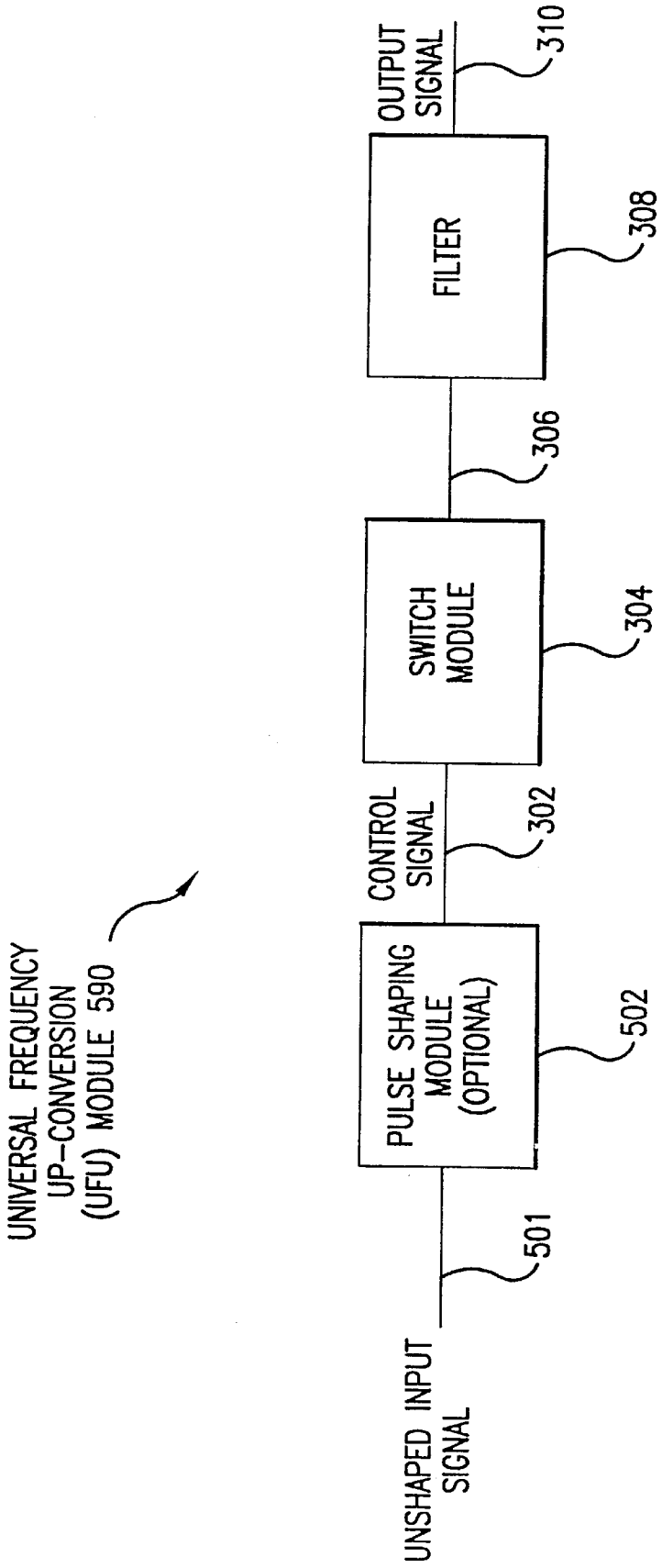

UNIVERSAL FREQUENCY UP-CONVERSION (UFU) MODULE 590
UNSHAPED INPUT SIGNAL
501
PULSE SHAPING MODULE (OPTIONAL)
502
CONTROL SIGNAL
302
SWITCH MODULE
304
306
FILTER
308
OUTPUT SIGNAL
310

FIG. 5

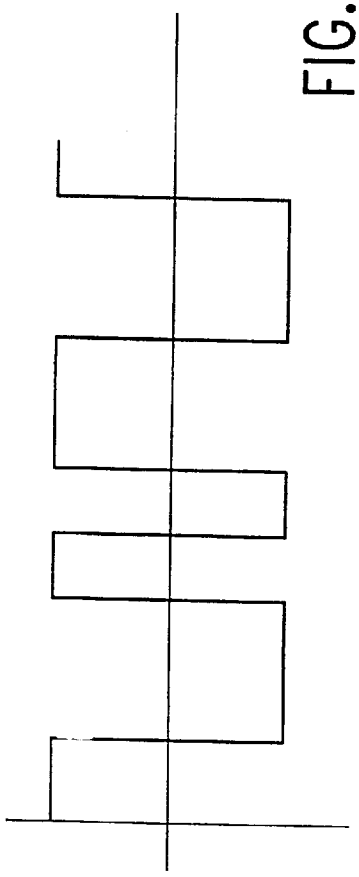


FIG. 6A

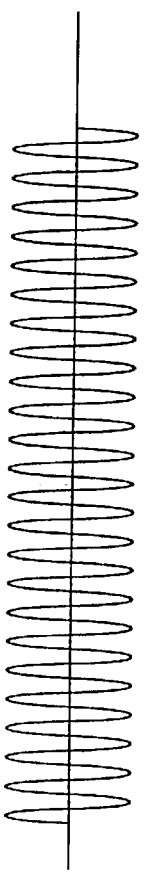


FIG. 6B

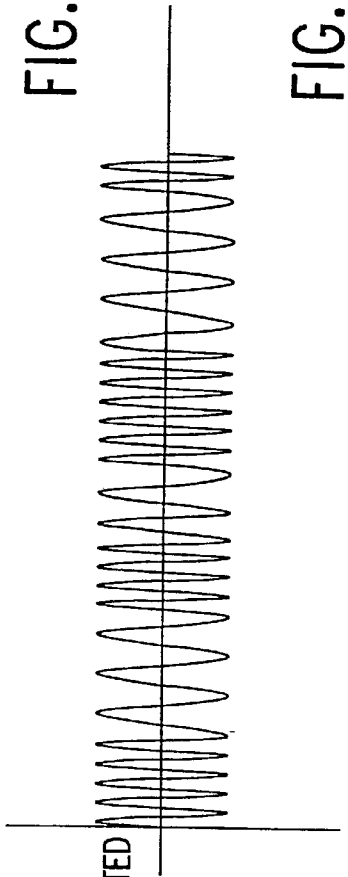


FIG. 6C

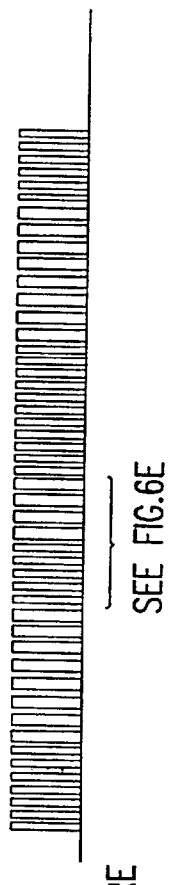


FIG. 6D

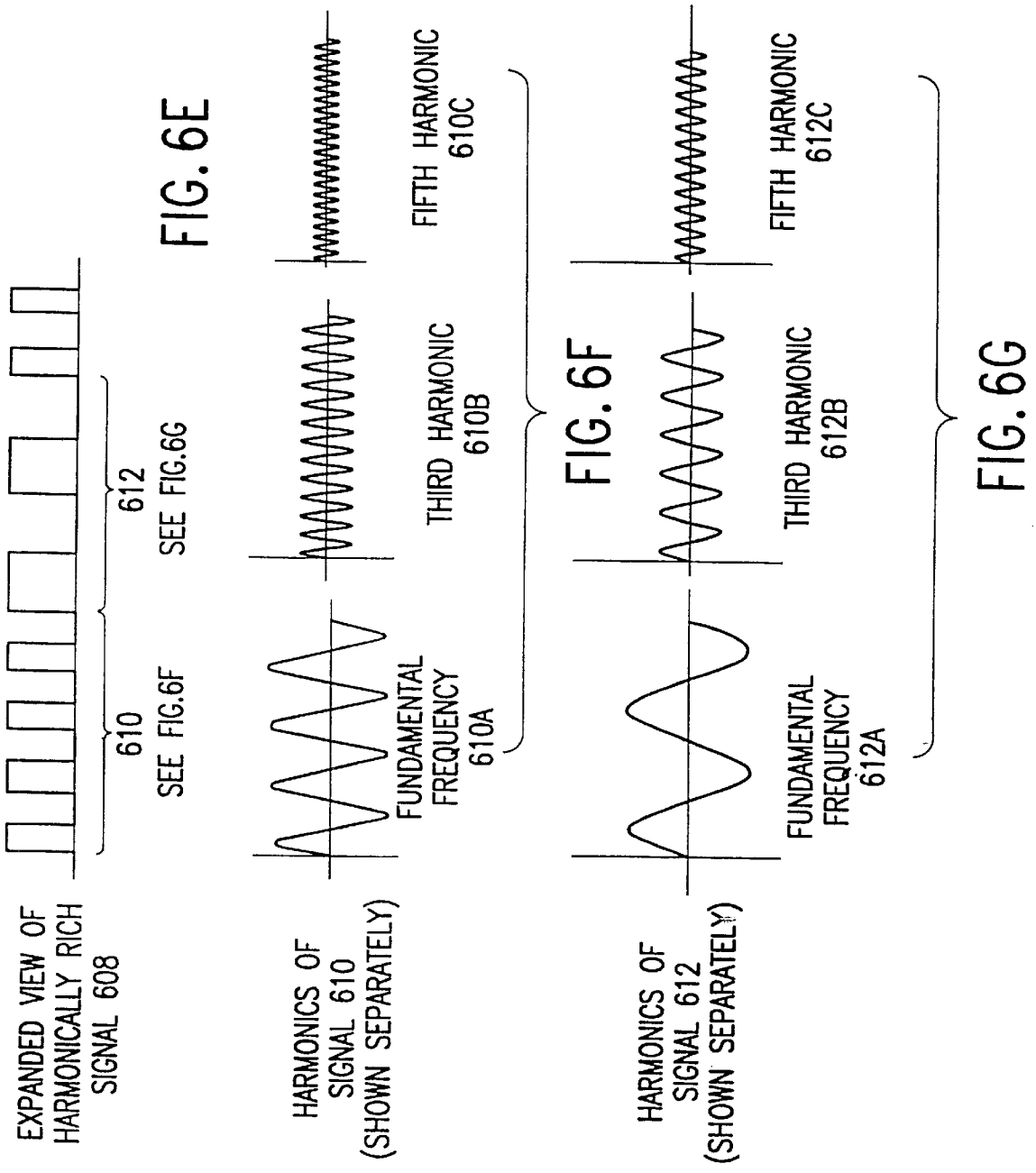


FIG. 6E

FIG. 6F

FIG. 6G

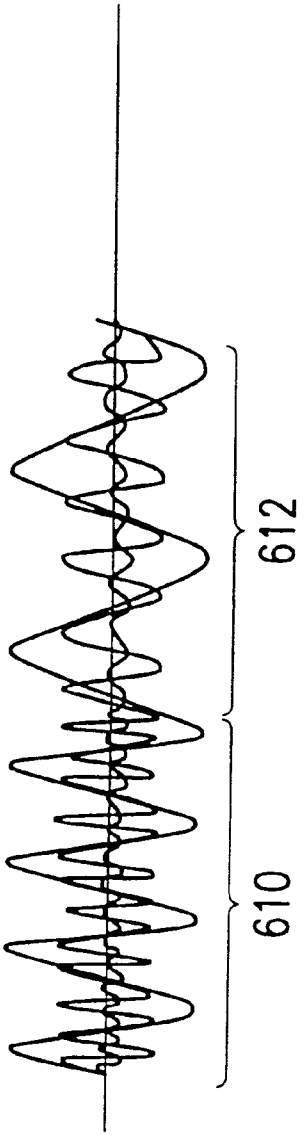

HARMONICS OF
SIGNALS 610 AND
612
(SHOWN SIMULTANEOUSLY
BUT NOT SUMMED)
610
612

FIG. 6H

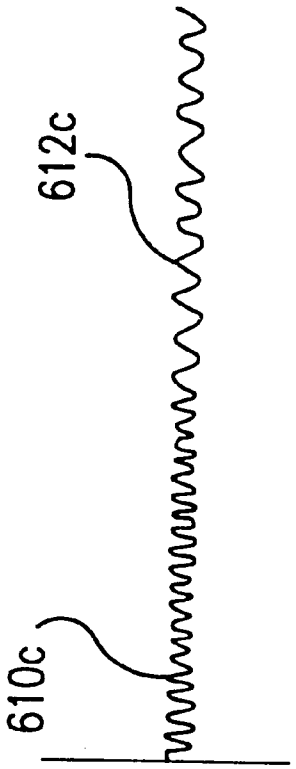

610c
612c
FILTERED
OUTPUT
SIGNAL
614

FIG. 6I

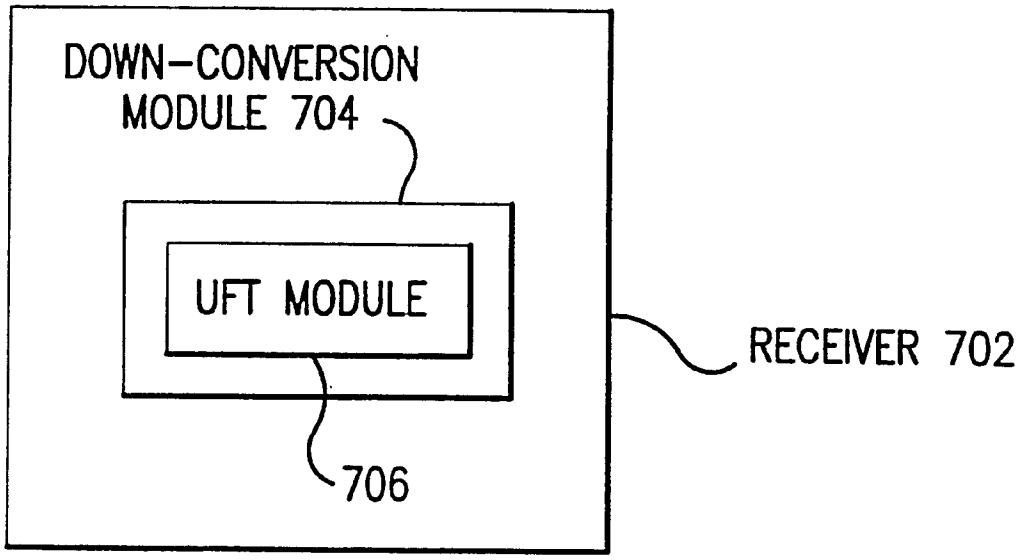

DOWN-CONVERSION
MODULE 704
UFT MODULE
706
RECEIVER 702

FIG. 7

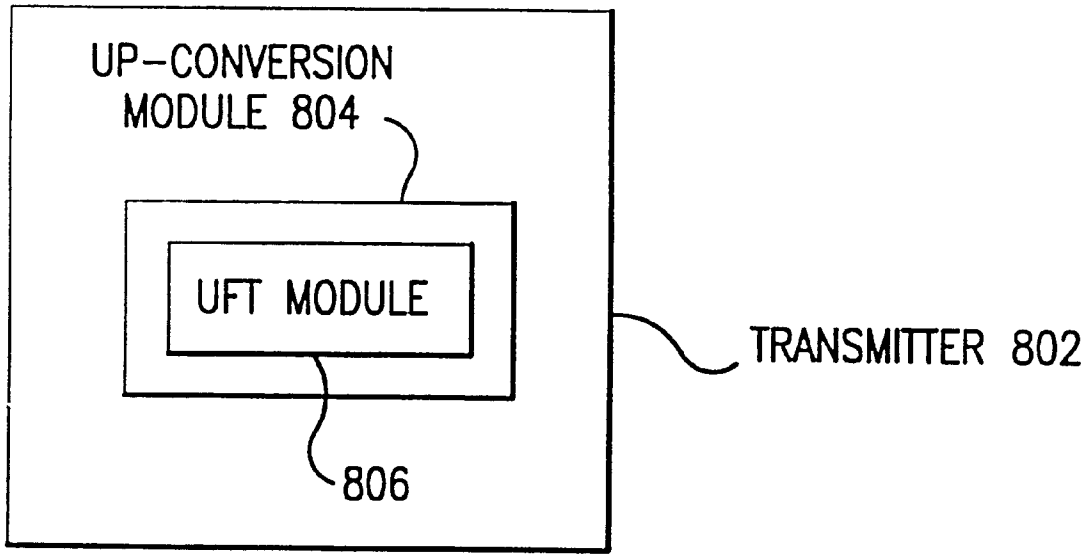

UP-CONVERSION
MODULE 804
UFT MODULE
806
TRANSMITTER 802

FIG. 8

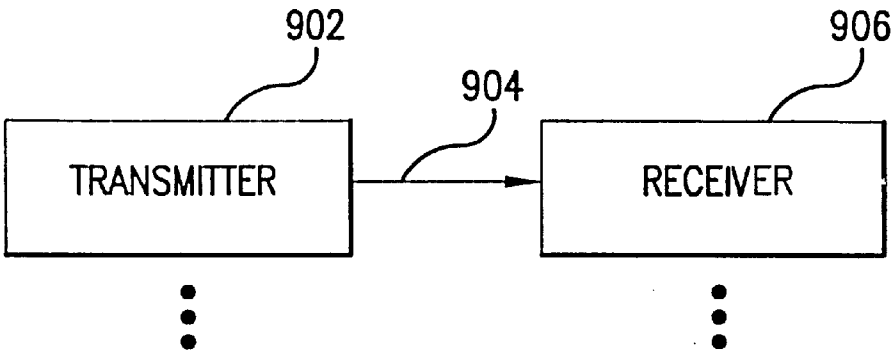

902
904
906
TRANSMITTER
RECEIVER

FIG. 9

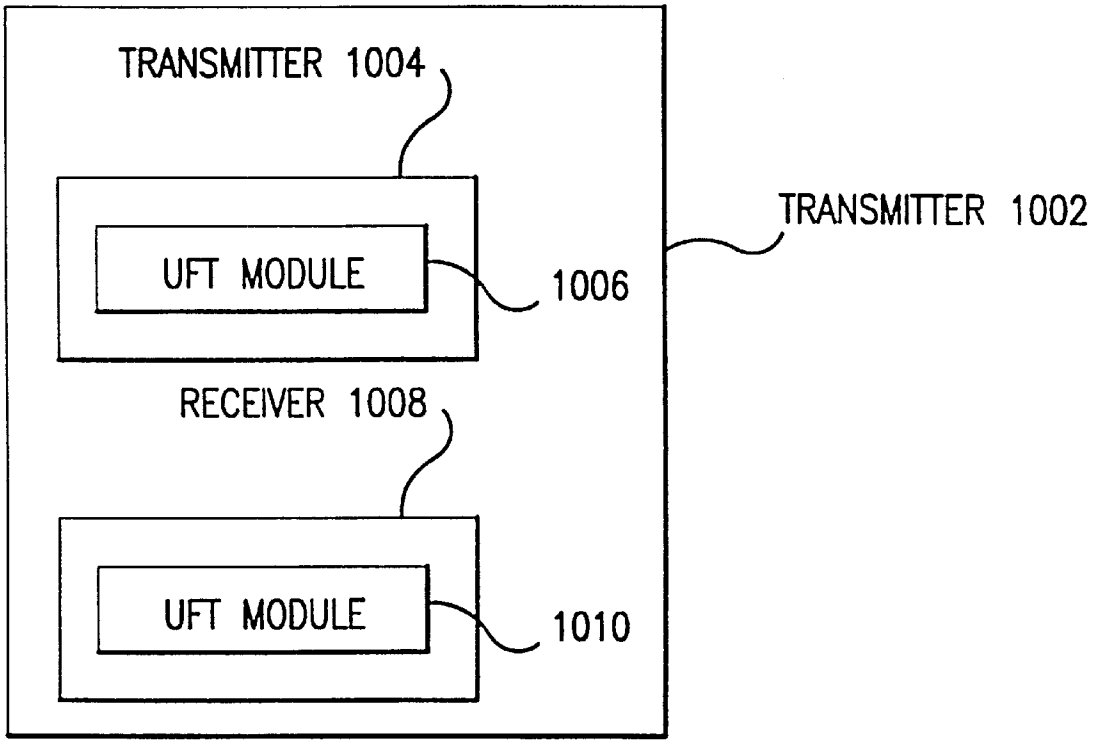

TRANSMITTER 1004
UFT MODULE
1006
TRANSMITTER 1002
RECEIVER 1008
UFT MODULE
1010

FIG. 10

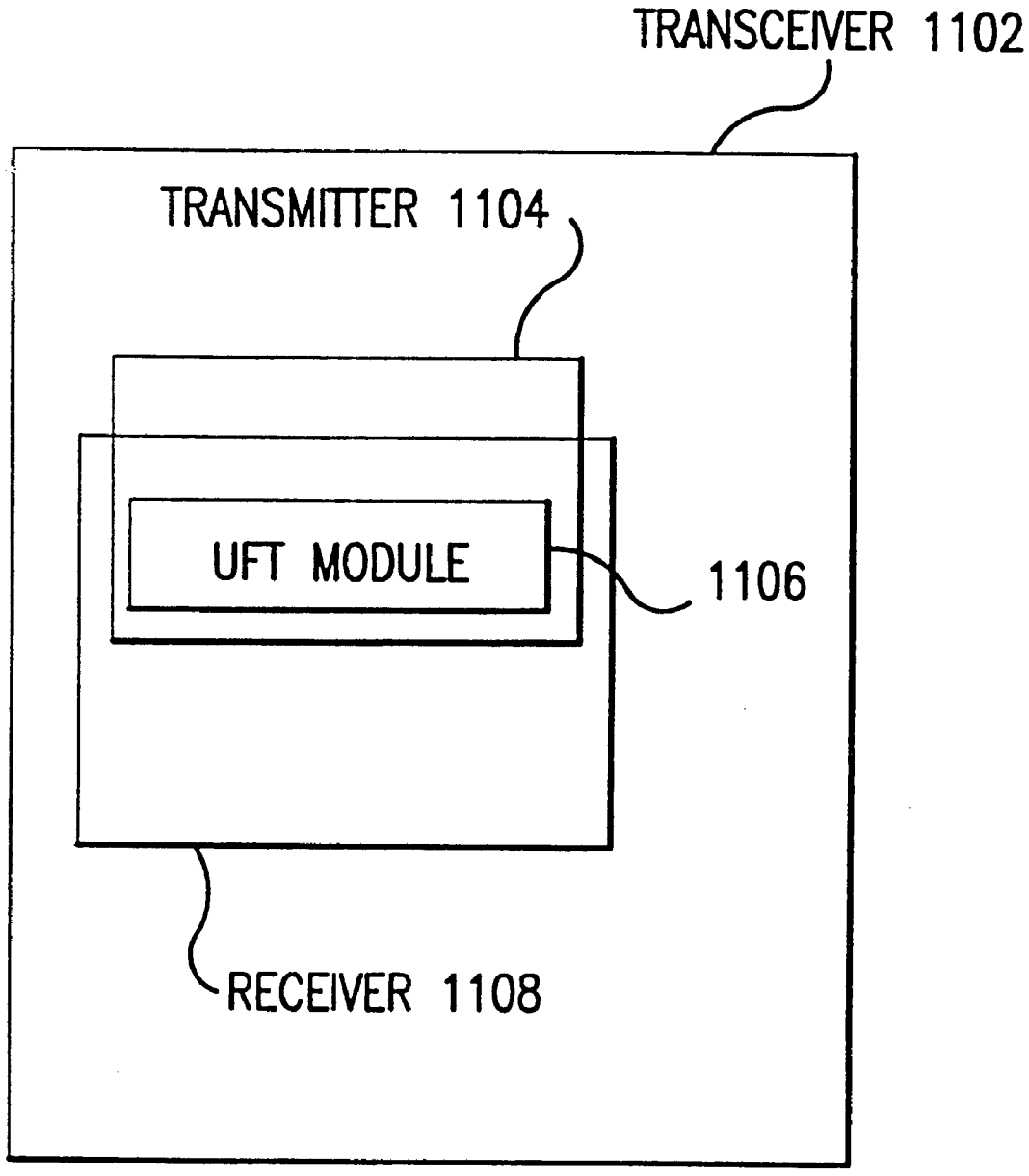

TRANSCEIVER 1102
TRANSMITTER 1104
UFT MODULE
1106
RECEIVER 1108

FIG. 11

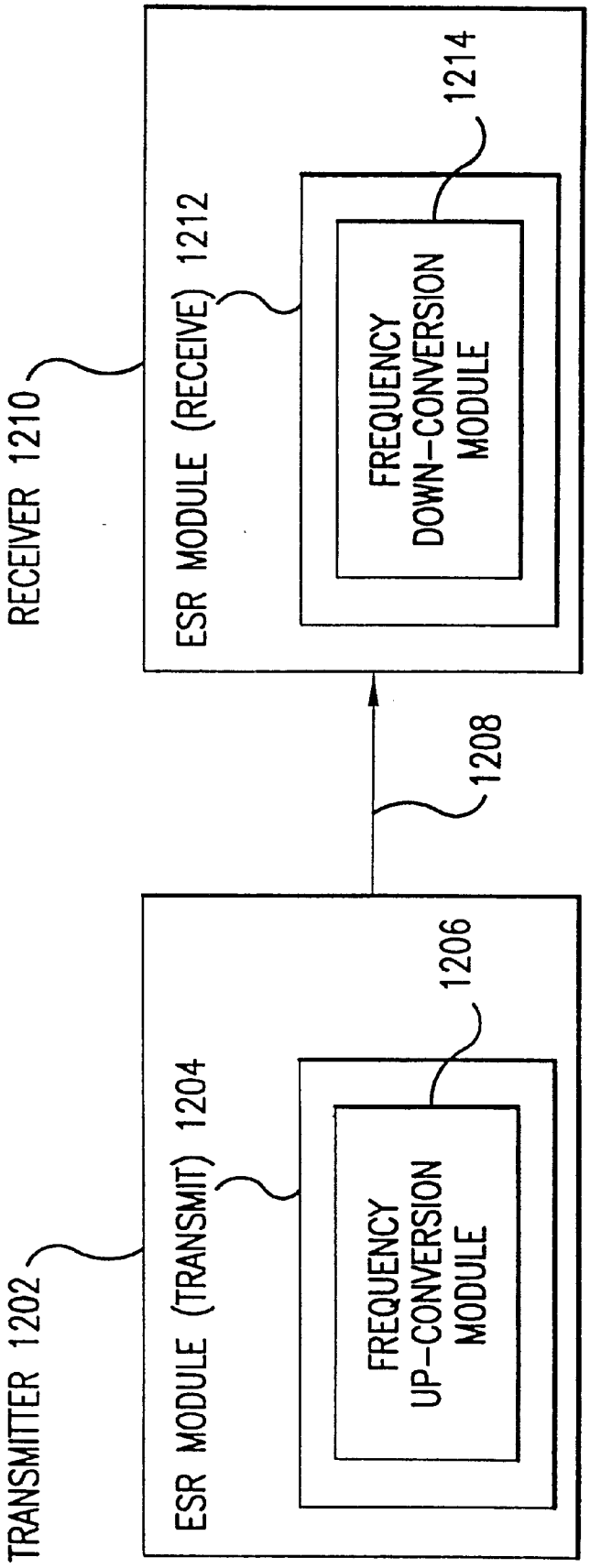

TRANSMITTER 1202
ESR MODULE (TRANSMIT) 1204
FREQUENCY UP-CONVERSION MODULE
1206
1208
RECEIVER 1210
ESR MODULE (RECEIVE) 1212
FREQUENCY DOWN-CONVERSION MODULE
1214

FIG. 12

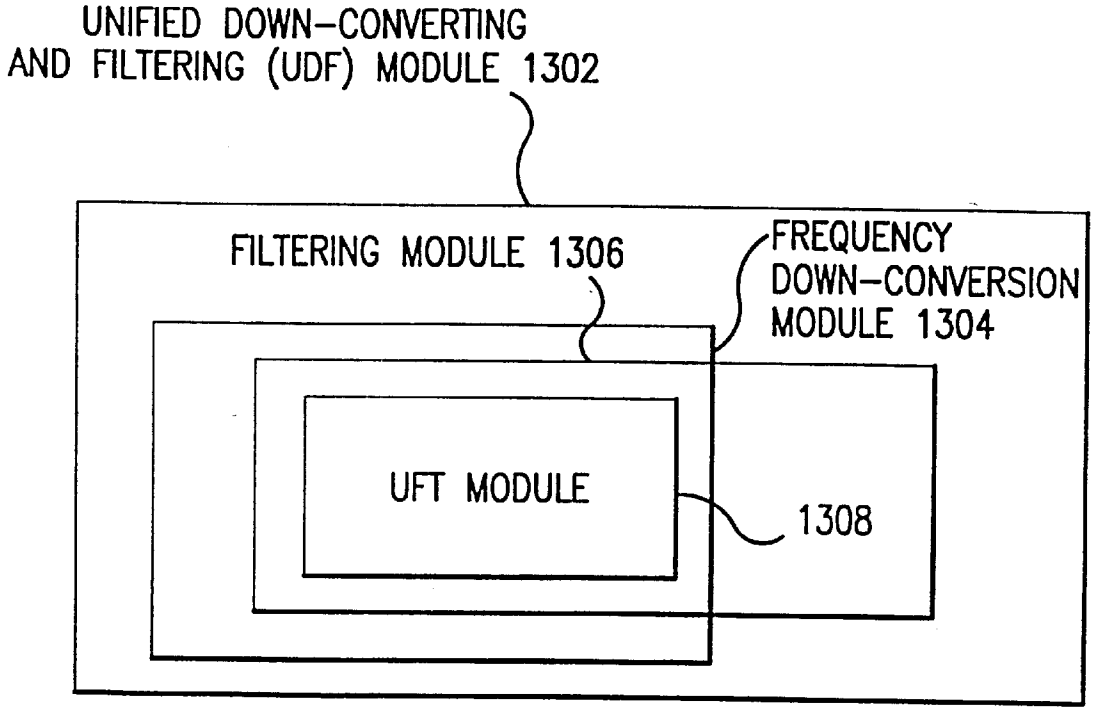

UNIFIED DOWN-CONVERTING
AND FILTERING (UDF) MODULE 1302
FILTERING MODULE 1306
FREQUENCY
DOWN-CONVERSION
MODULE 1304
UFT MODULE
1308

FIG. 13

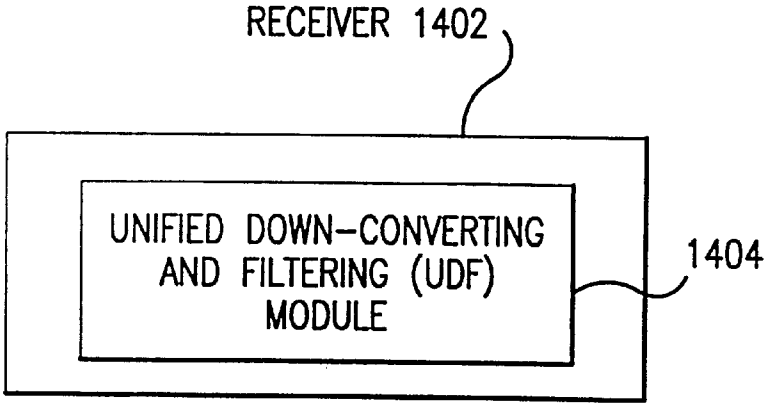

RECEIVER 1402
UNIFIED DOWN-CONVERTING
AND FILTERING (UDF)
MODULE
1404

FIG. 14

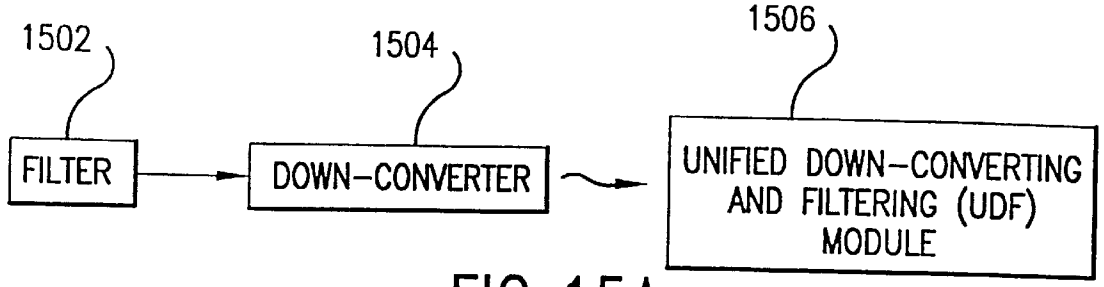


FIG. 15A

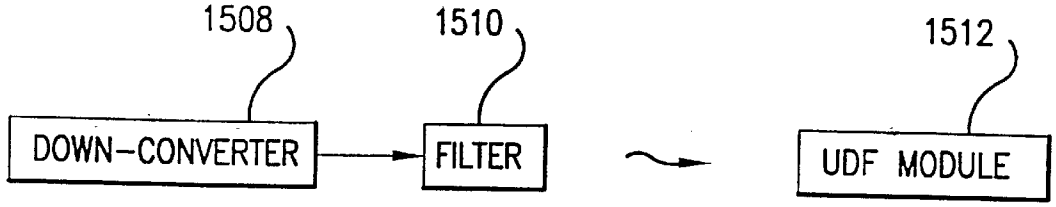


FIG. 15B

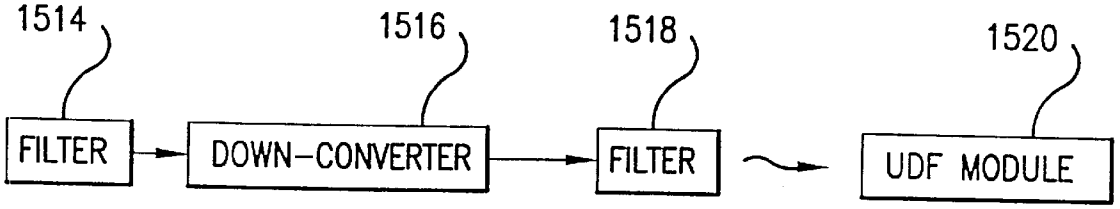


FIG. 15C

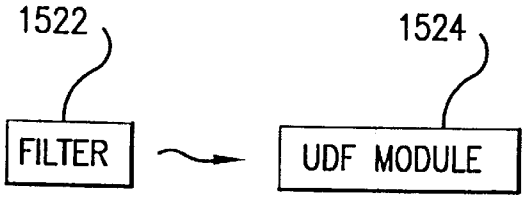


FIG. 15D

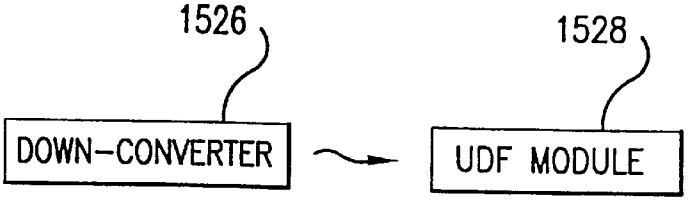


FIG. 15E

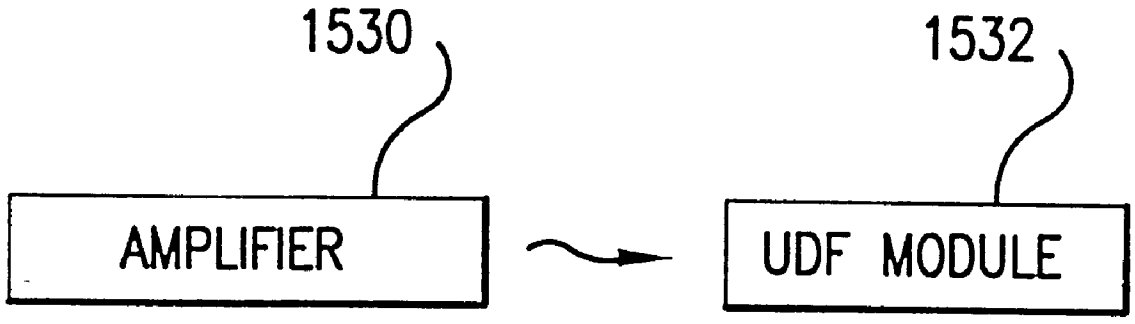


FIG. 15F

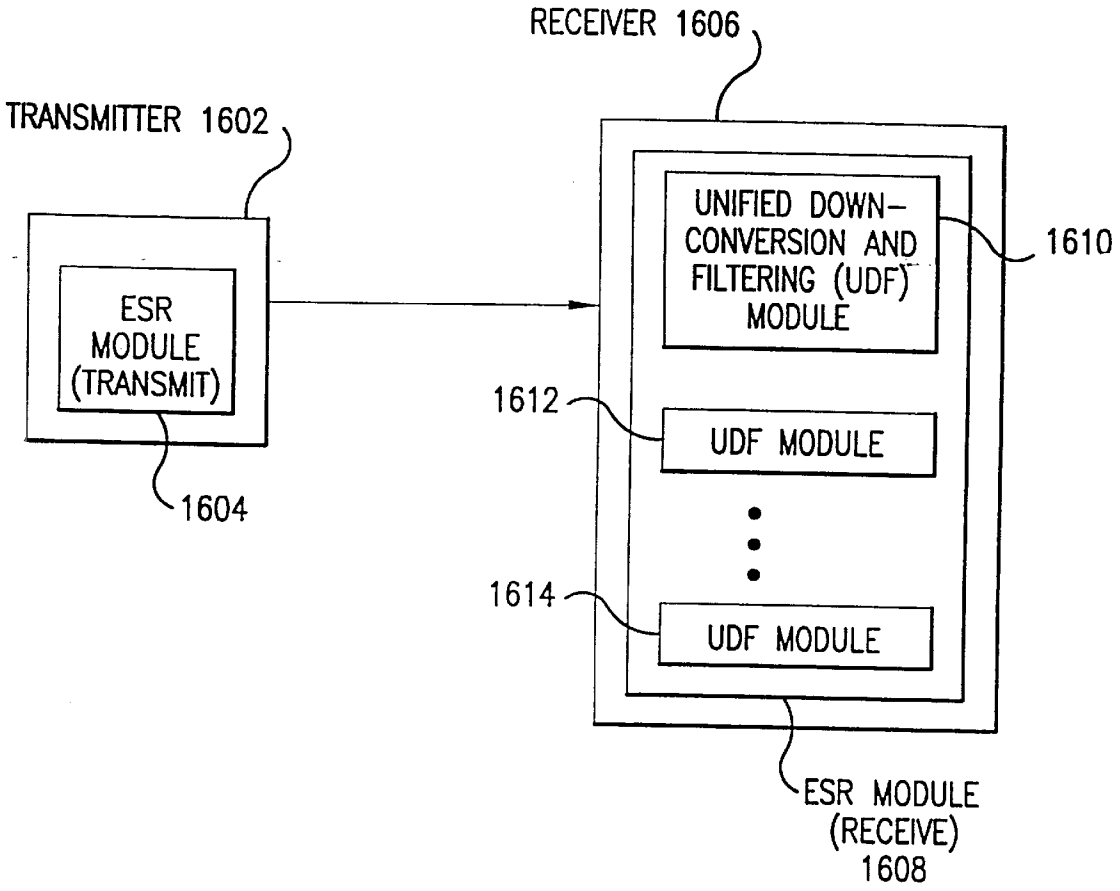

RECEIVER 1606
TRANSMITTER 1602
UNIFIED DOWN-CONVERSION AND FILTERING (UDF) MODULE
1610
ESR MODULE (TRANSMIT)
1612
UDF MODULE
1614
UDF MODULE
1604
ESR MODULE (RECEIVE) 1608

FIG. 16

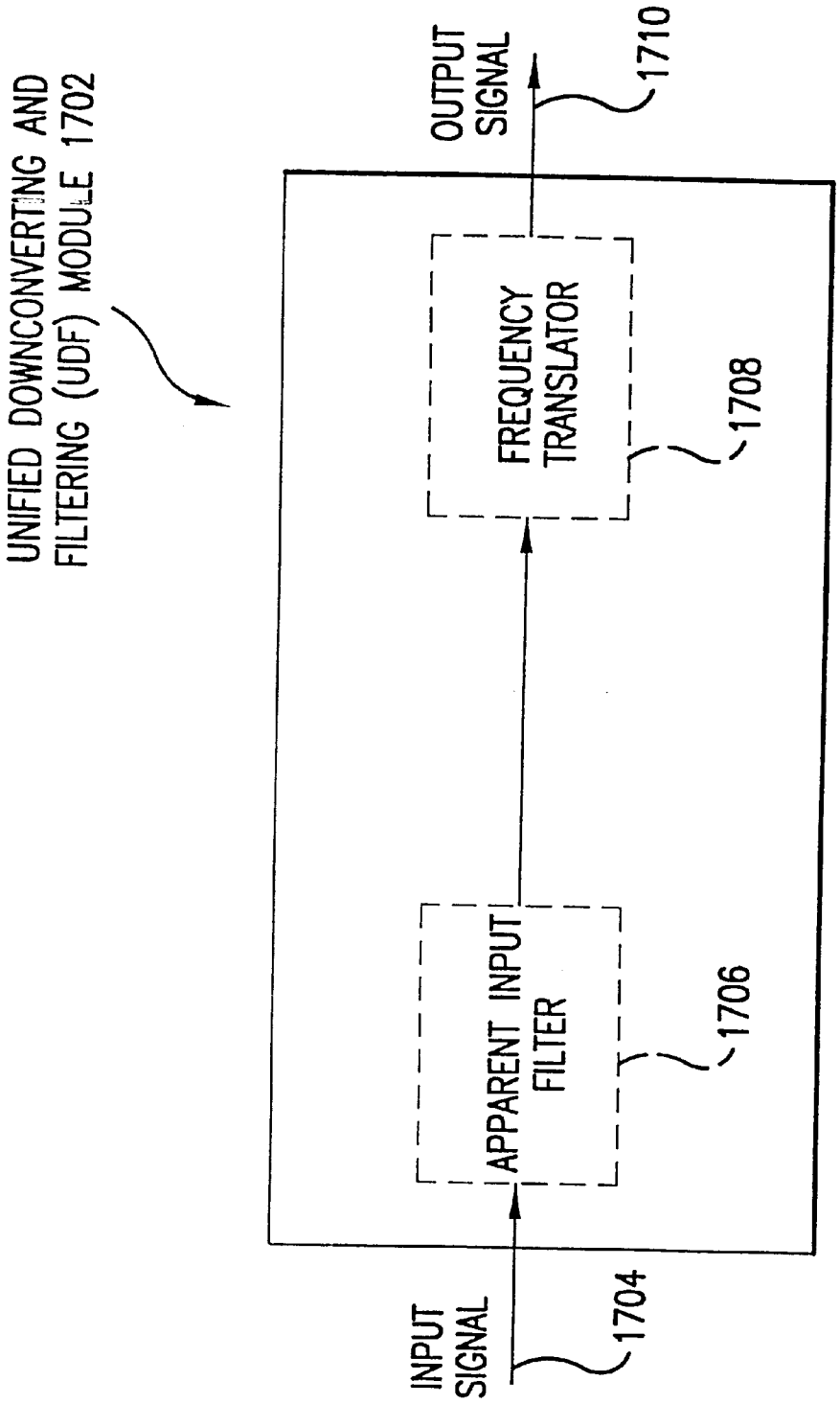
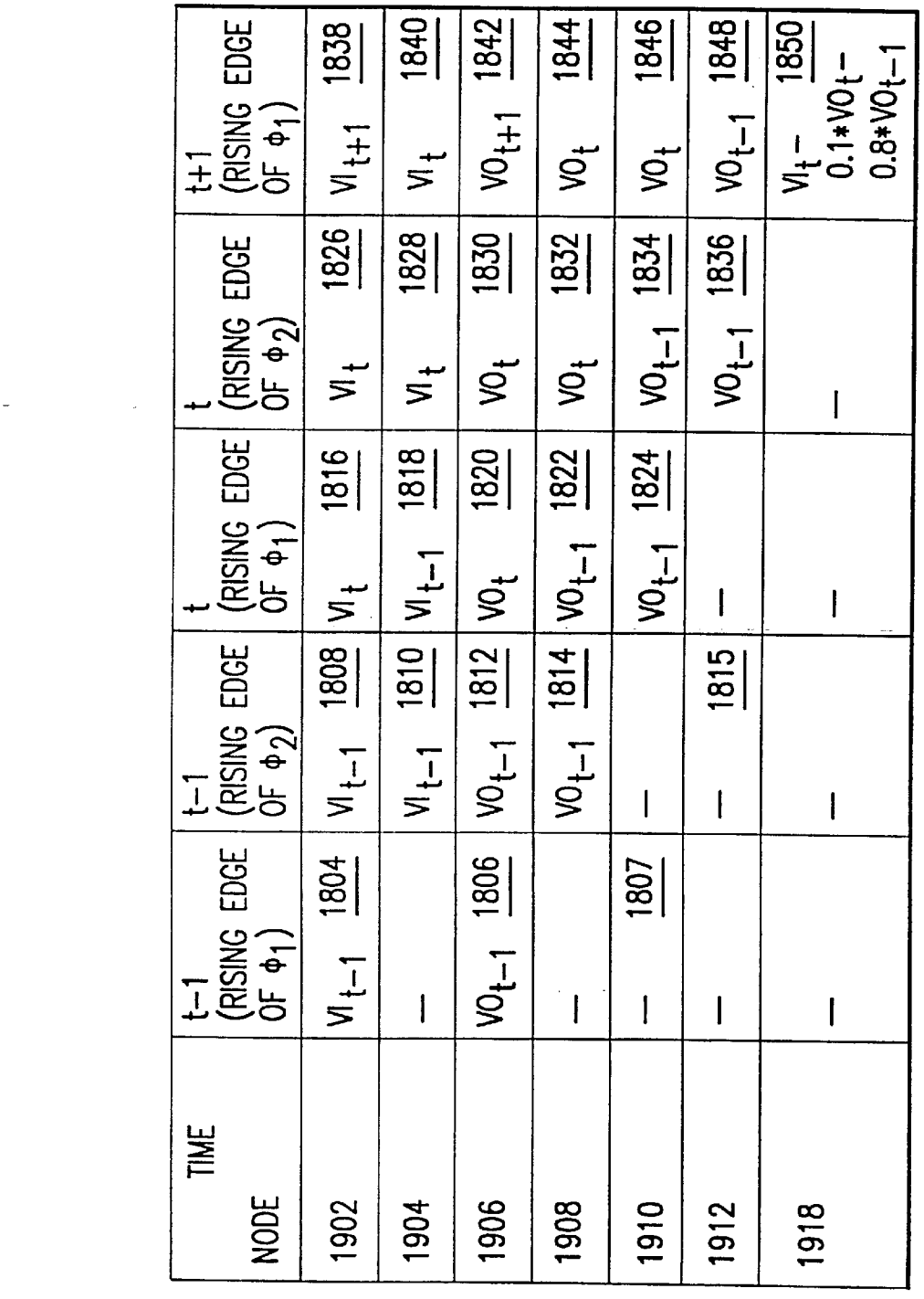

UNIFIED DOWNCONVERTING AND FILTERING (UDF) MODULE 1702
OUTPUT SIGNAL
1710
FREQUENCY TRANSLATOR
1708
APPARENT INPUT FILTER
1706
INPUT SIGNAL
1704

FIG. 17



TIME / NODE	t−1 (RISING EDGE OF Φ_1)		t−1 (RISING EDGE OF Φ_2)		t (RISING EDGE OF Φ_1)		t (RISING EDGE OF Φ_2)		t+1 (RISING EDGE OF Φ_1)	
1902	VI_{t-1}	1804	VI_{t-1}	1808	VI_t	1816	VI_t	1826	VI_{t+1}	1838
1904	—		VI_{t-1}	1810	VI_{t-1}	1818	VI_t	1828	VI_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	VO_{t-1}	1848
1918	—		—		—		—		$VI_t - 0.1*VO_t - 0.8*VO_{t-1}$	1850

FIG. 18

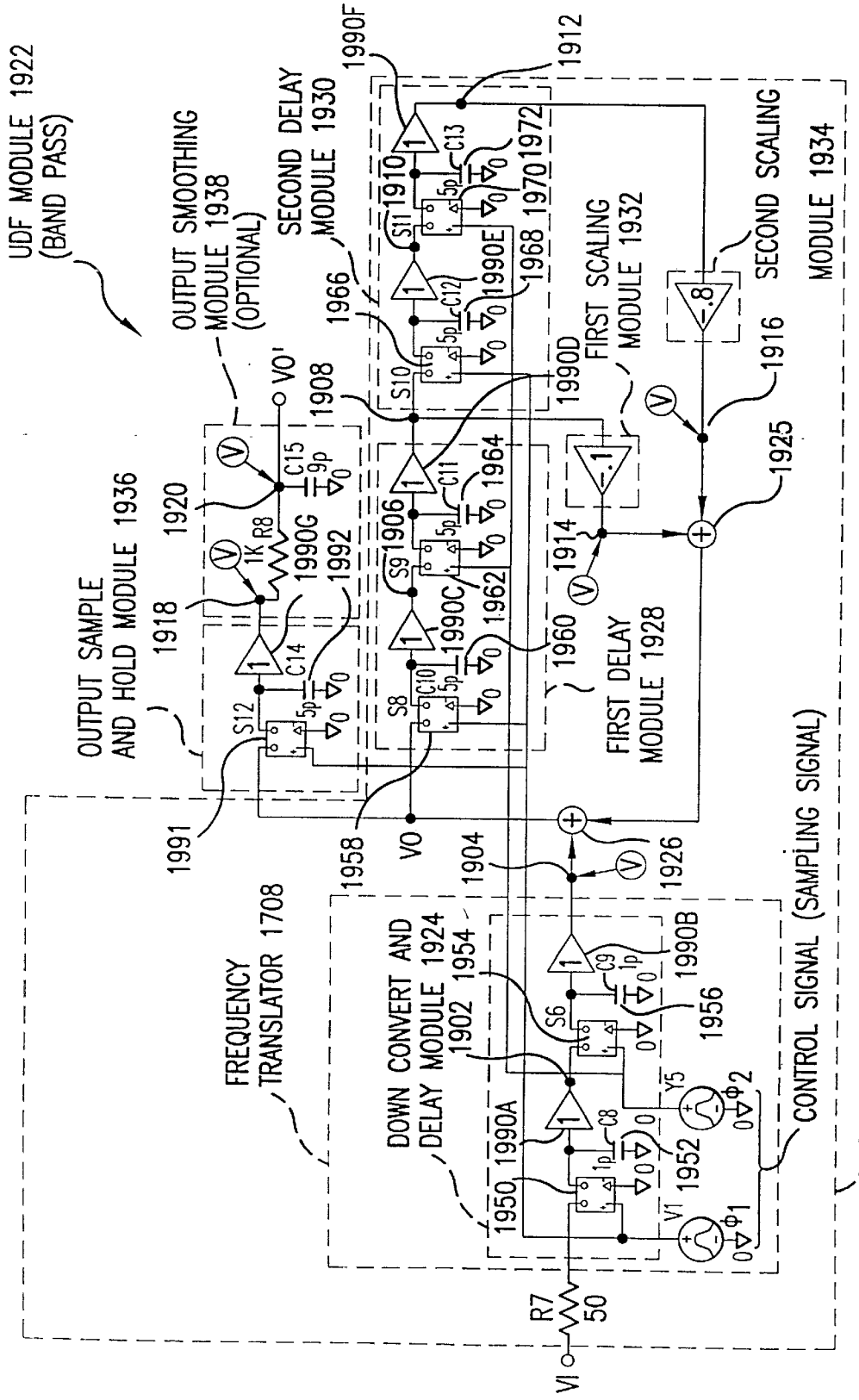

UDF MODULE 1922
(BAND PASS)
OUTPUT SAMPLE
AND HOLD MODULE 1936
OUTPUT SMOOTHING
MODULE 1938
(OPTIONAL)
SECOND DELAY
MODULE 1930
FIRST SCALING
MODULE 1932
SECOND SCALING
MODULE 1934
FIRST DELAY
MODULE 1928
DOWN CONVERT AND
DELAY MODULE 1924
FREQUENCY
TRANSLATOR 1708
INPUT FILTER 1706
CONTROL SIGNAL (SAMPLING SIGNAL)
VI
VO
VO'
R7
50
R8
1K
C14
C15
9p
C8
C9
C10
C11
C12
C13
5p
1p
S6
S8
S9
S10
S11
S12
Y5
V1
Φ1
Φ2
.1
.8
1902
1904
1906
1908
1910
1912
1914
1916
1918
1920
1925
1926
1928
1930
1932
1934
1936
1938
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1990A
1990B
1990C
1990D
1990E
1990F
1990G
1991
1992

FIG. 19

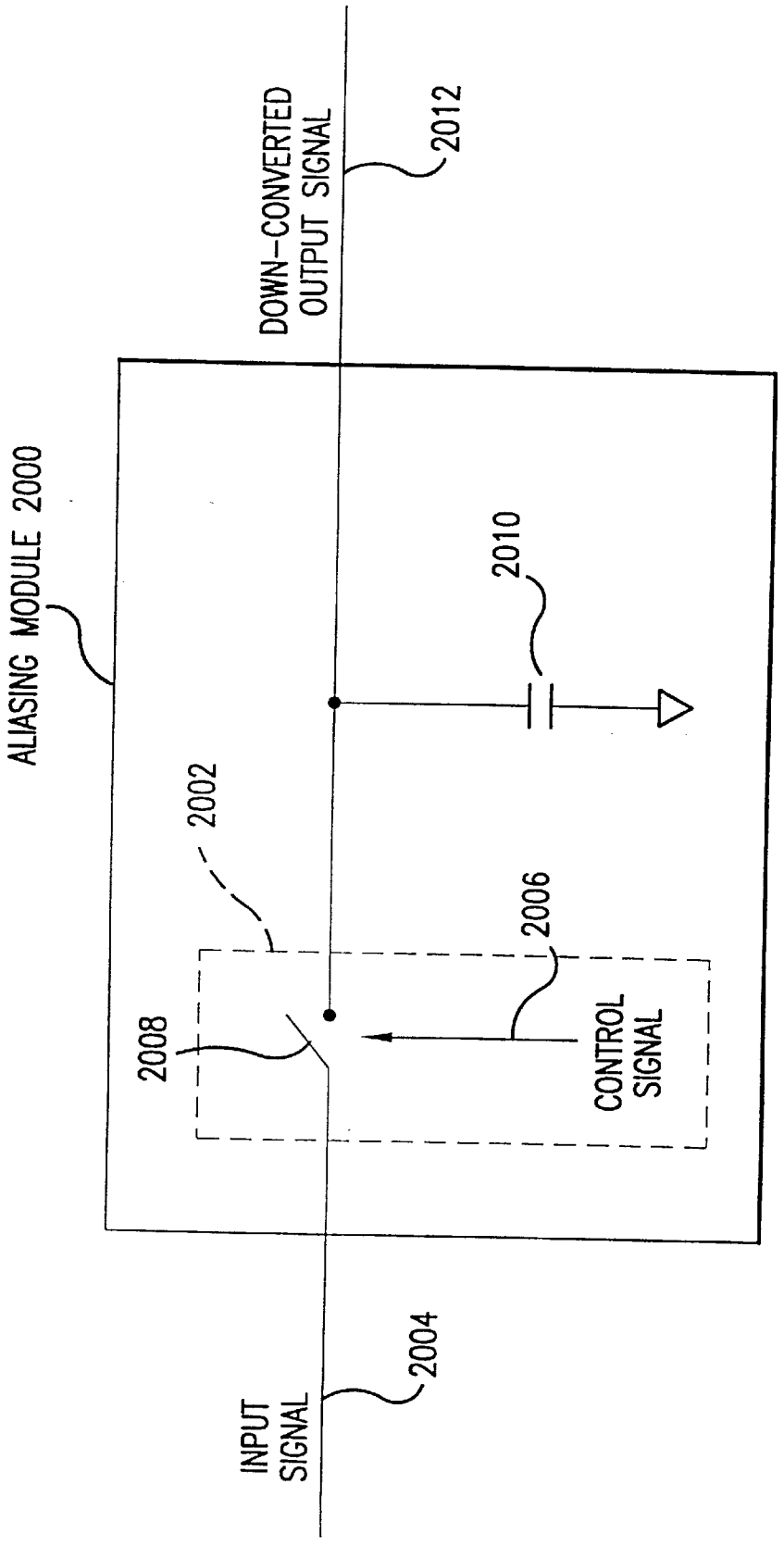

ALIASING MODULE 2000
DOWN-CONVERTED OUTPUT SIGNAL
2012
2010
2002
2006
2008
CONTROL SIGNAL
INPUT SIGNAL
2004

FIG. 20A

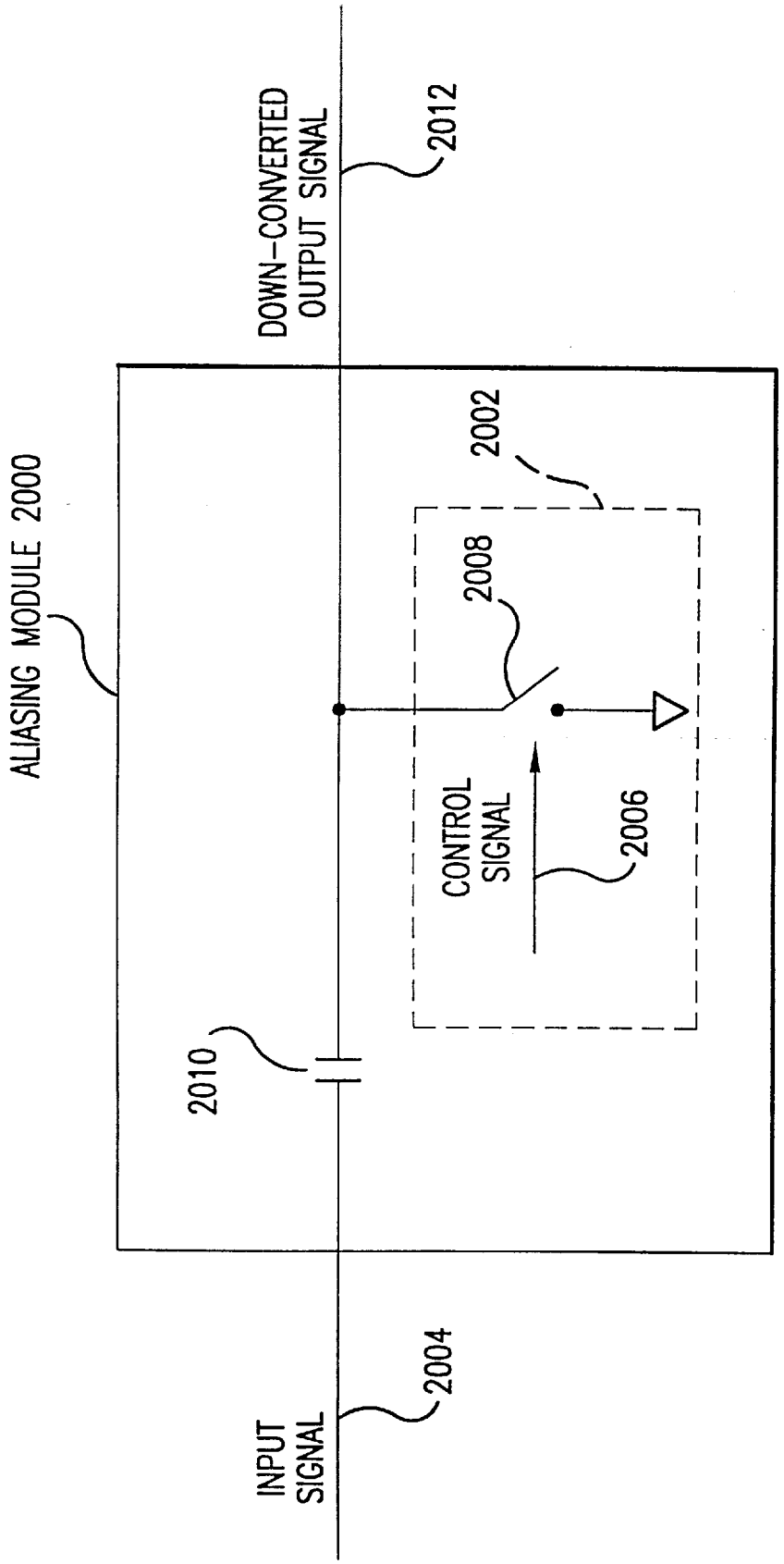

ALIASING MODULE 2000
DOWN-CONVERTED OUTPUT SIGNAL
2012
2002
2008
CONTROL SIGNAL
2006
2010
INPUT SIGNAL
2004

FIG. 20A-1

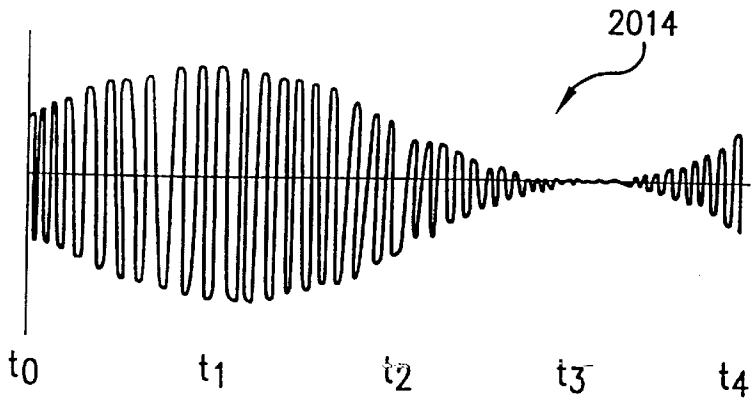


FIG. 20B

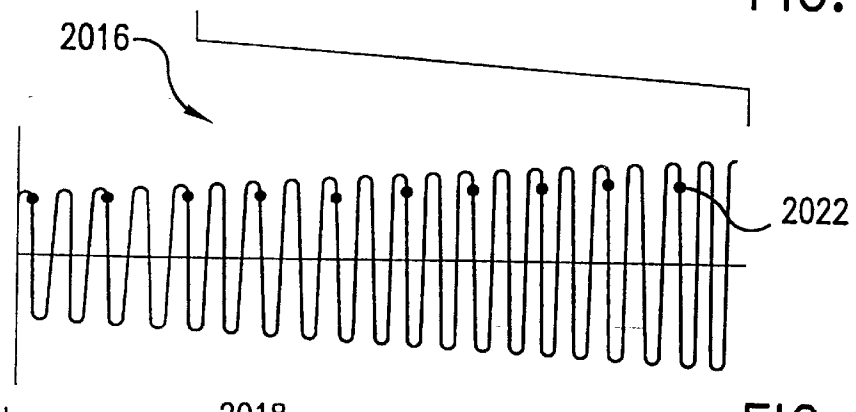


FIG. 20C

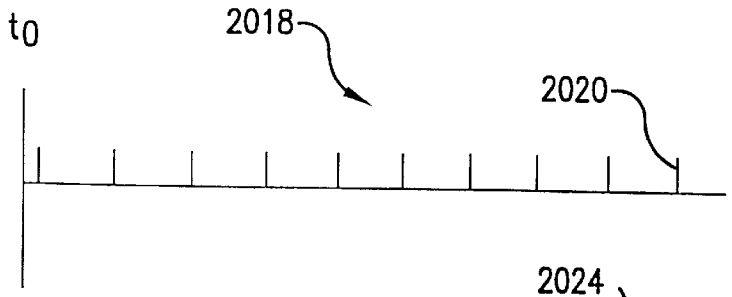


FIG. 20D

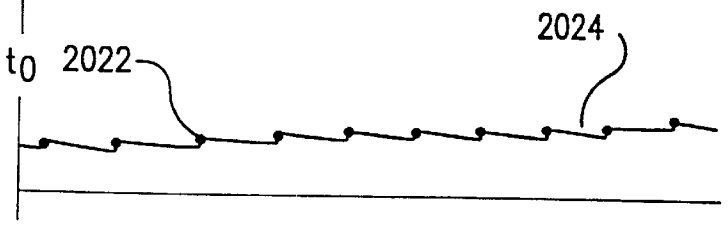


FIG. 20E

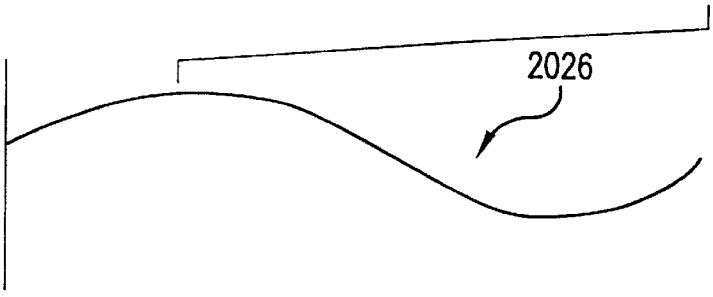


FIG. 20F

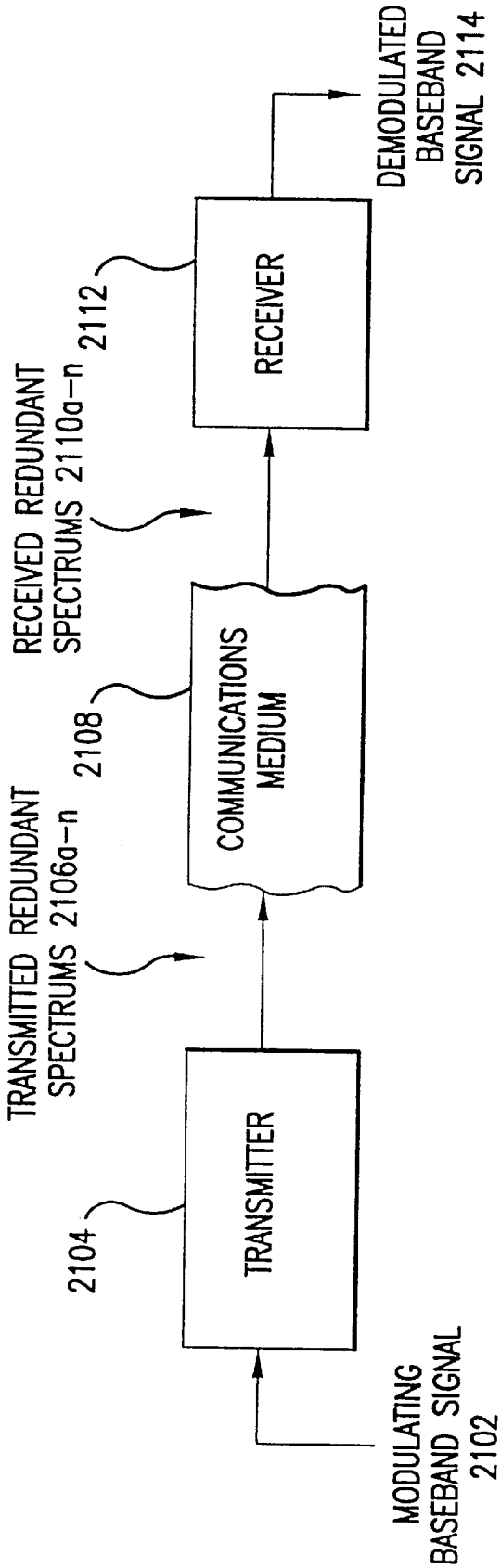

MODULATING BASEBAND SIGNAL 2102
2104
TRANSMITTER
TRANSMITTED REDUNDANT SPECTRUMS 2106a–n
2108
COMMUNICATIONS MEDIUM
RECEIVED REDUNDANT SPECTRUMS 2110a–n
2112
RECEIVER
DEMODULATED BASEBAND SIGNAL 2114

FIG. 21

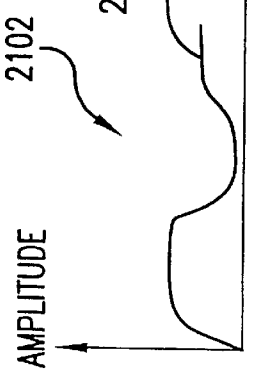


FIG. 22A

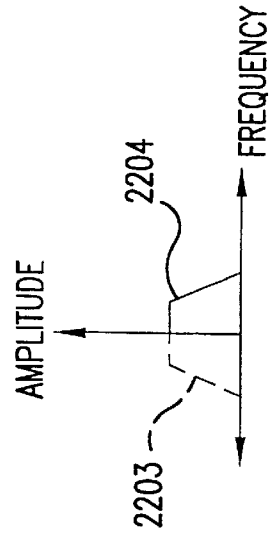


FIG. 22B

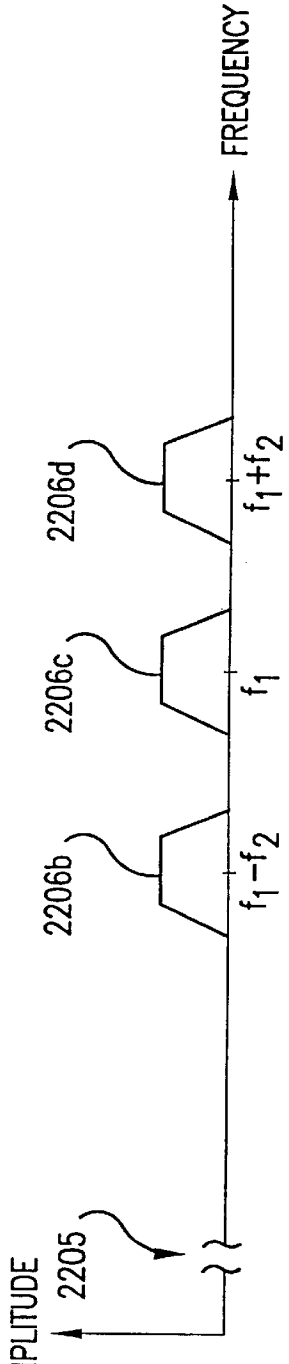


FIG. 22C

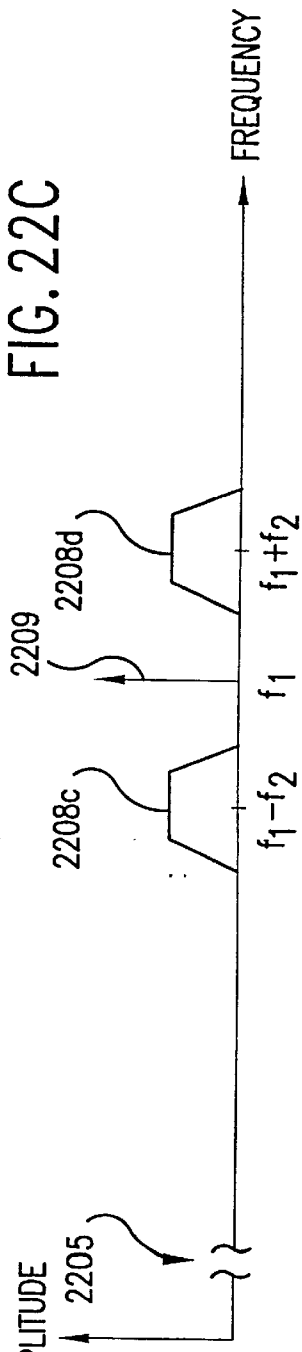


FIG. 22D

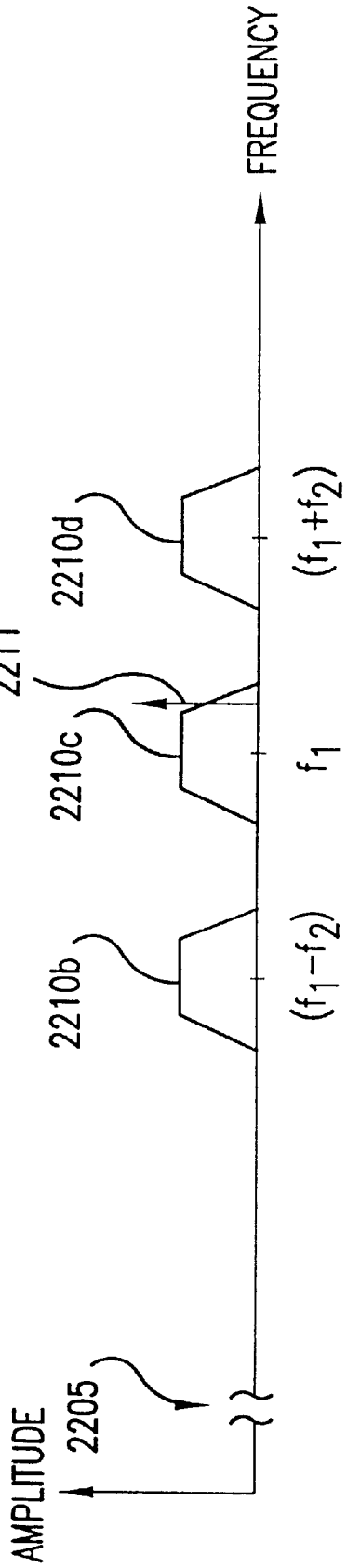


FIG. 22E

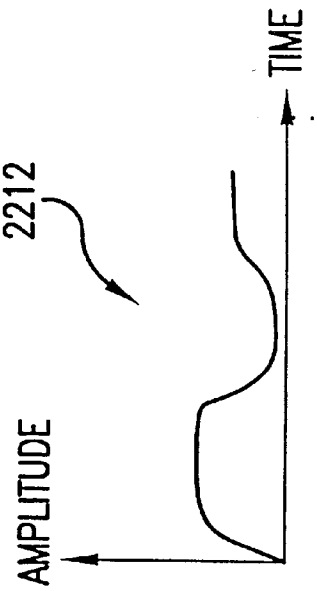


FIG. 22F

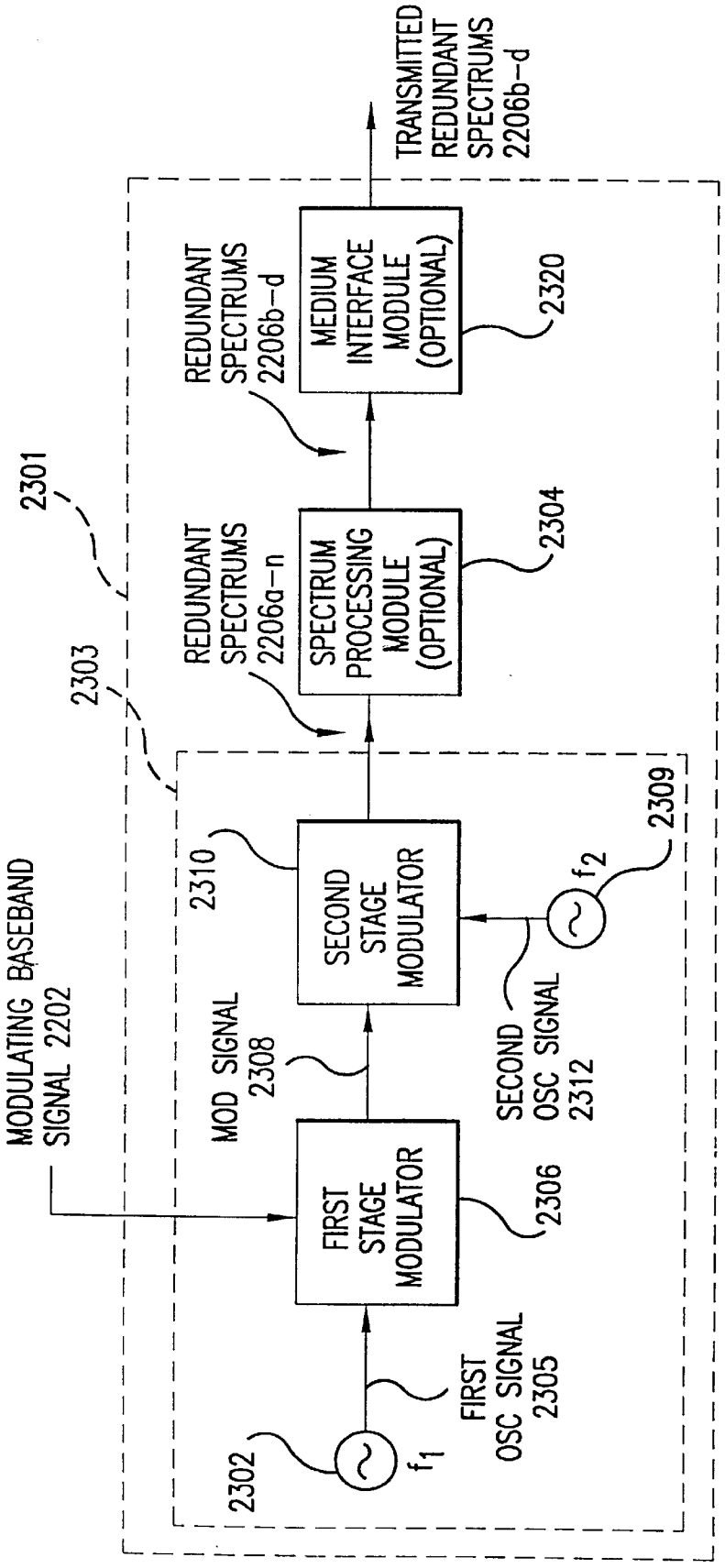

TRANSMITTED REDUNDANT SPECTRUMS 2206b–d
MEDIUM INTERFACE MODULE (OPTIONAL)
2320
REDUNDANT SPECTRUMS 2206b–d
SPECTRUM PROCESSING MODULE (OPTIONAL)
2304
REDUNDANT SPECTRUMS 2206a–n
2301
2303
2310
SECOND STAGE MODULATOR
2309
f_2
SECOND OSC SIGNAL 2312
MOD SIGNAL 2308
MODULATING BASEBAND SIGNAL 2202
FIRST STAGE MODULATOR
2306
FIRST OSC SIGNAL 2305
f_1
2302

FIG. 23A

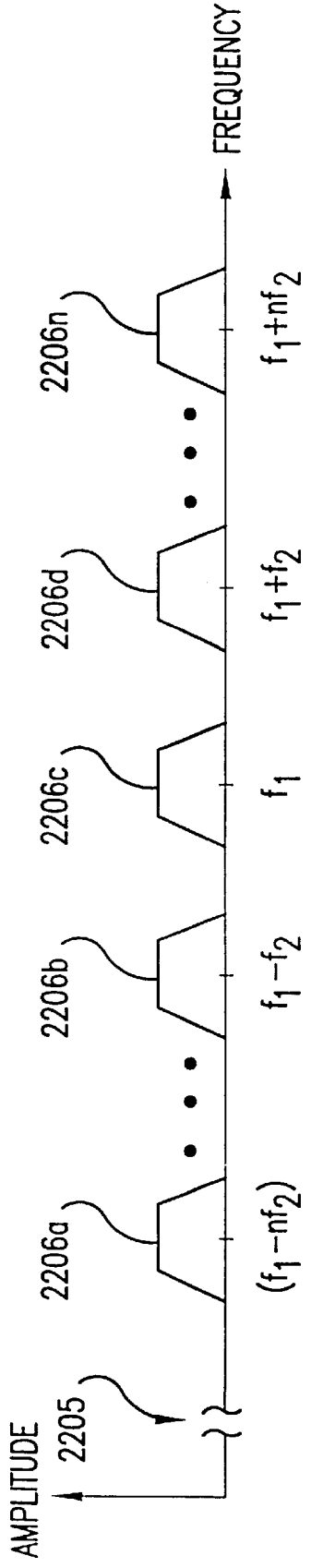


FIG. 23B

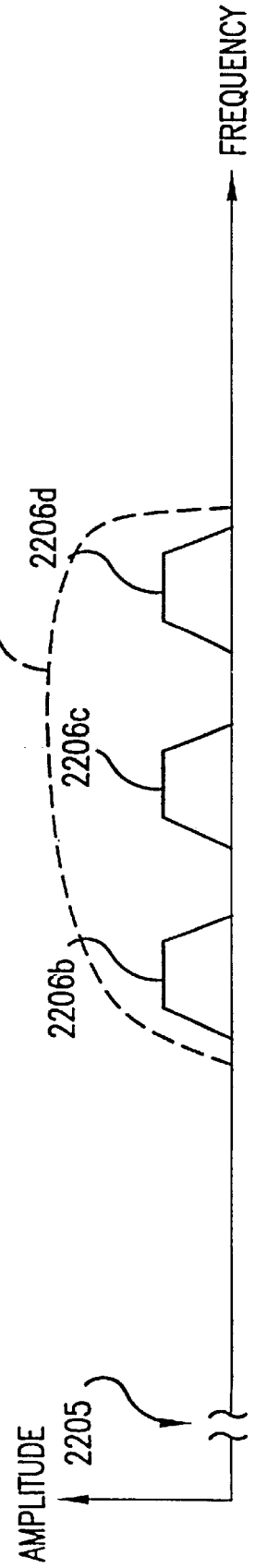


FIG. 23C

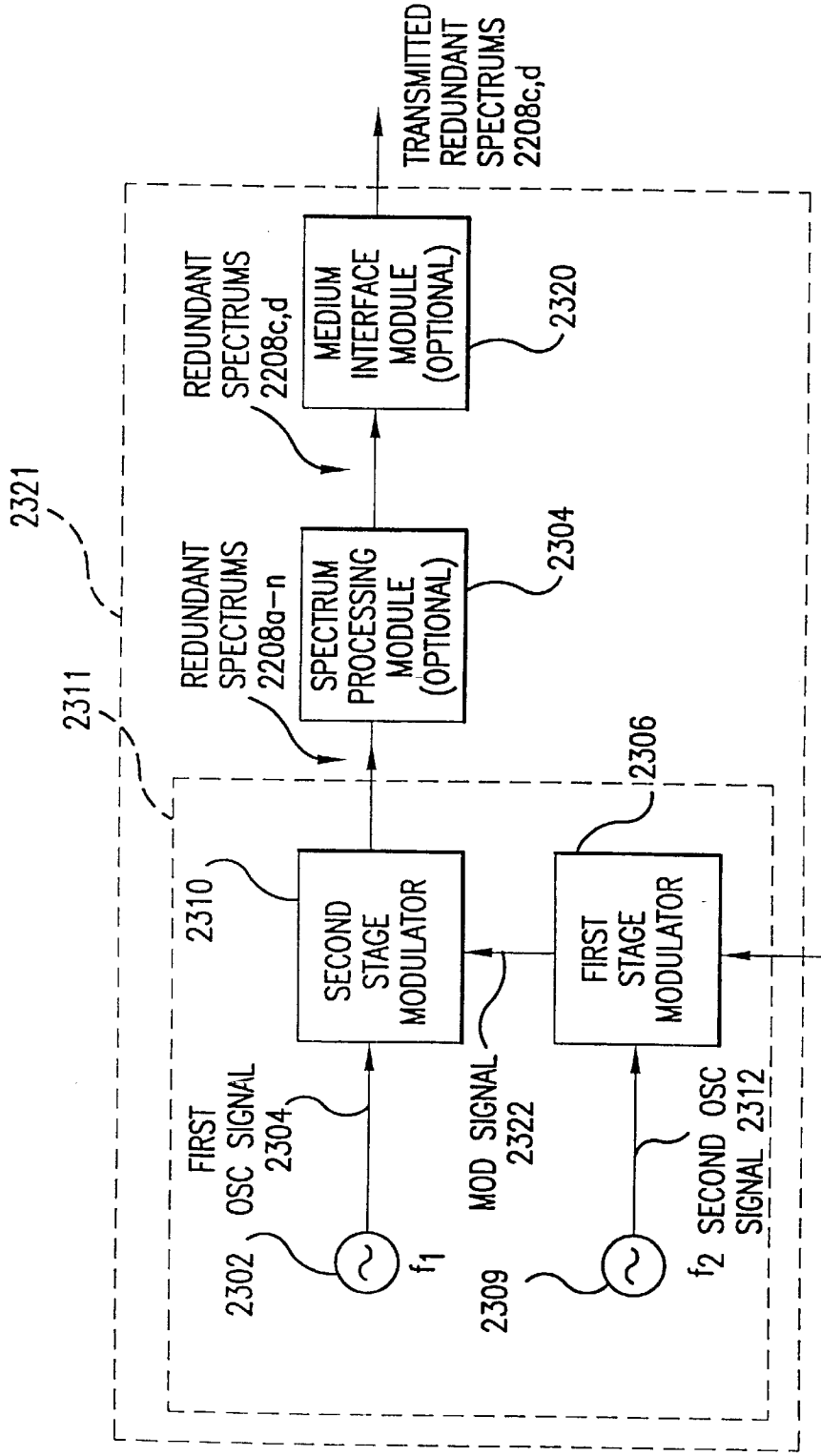

TRANSMITTED REDUNDANT SPECTRUMS 2208c,d
MEDIUM INTERFACE MODULE (OPTIONAL)
2320
REDUNDANT SPECTRUMS 2208c,d
SPECTRUM PROCESSING MODULE (OPTIONAL)
2304
REDUNDANT SPECTRUMS 2208a-n
2321
2311
2310
SECOND STAGE MODULATOR
2306
FIRST STAGE MODULATOR
MODULATING BASEBAND SIGNAL 2202
FIRST OSC SIGNAL 2304
2302
f1
MOD SIGNAL 2322
2309
f2 SECOND OSC SIGNAL 2312

FIG. 23D

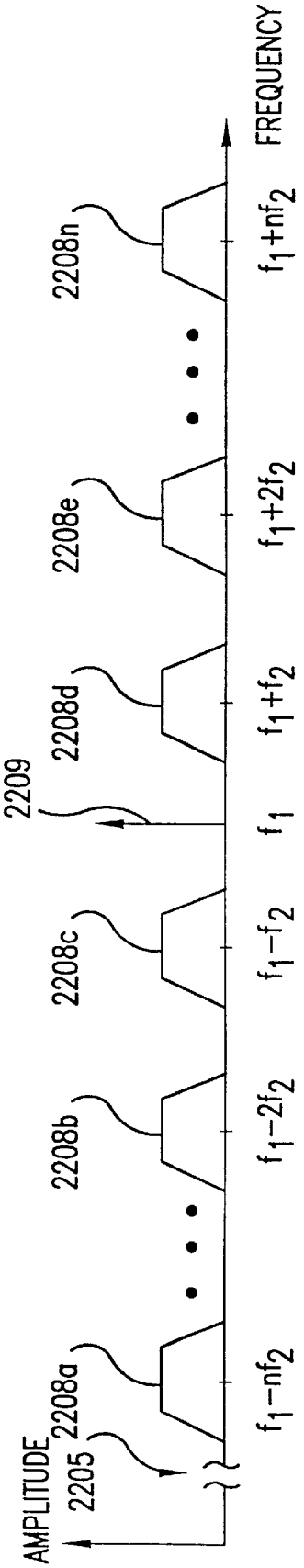


FIG. 23E

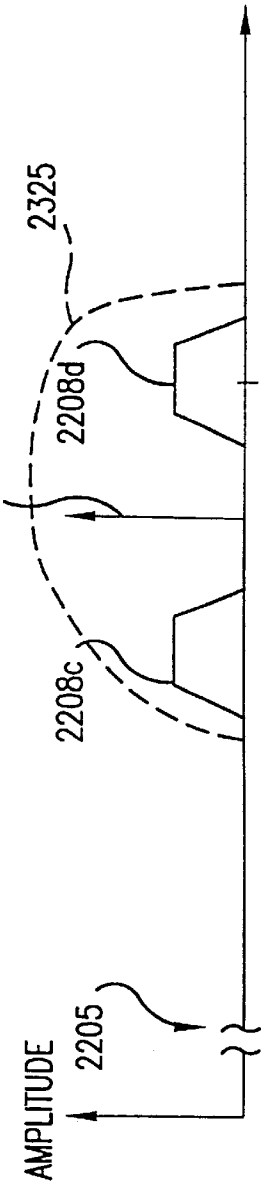


FIG. 23F

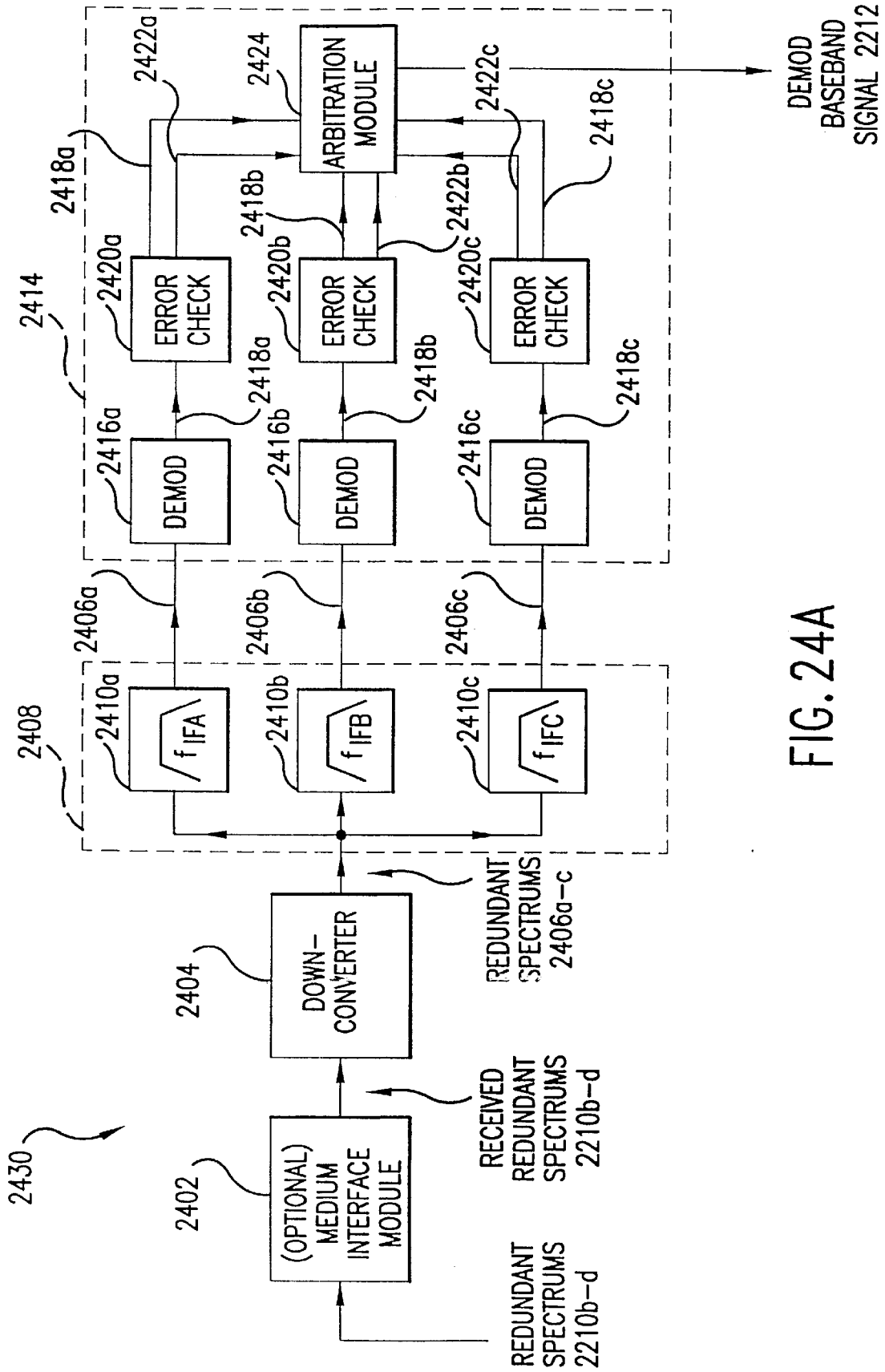

2430
2402
(OPTIONAL) MEDIUM INTERFACE MODULE
REDUNDANT SPECTRUMS 2210b-d
RECEIVED REDUNDANT SPECTRUMS 2210b-d
2404
DOWN-CONVERTER
REDUNDANT SPECTRUMS 2406a-c
2408
2410a
f_{IFA}
2410b
f_{IFB}
2410c
f_{IFC}
2406a
2406b
2406c
2414
2416a
DEMOD
2416b
DEMOD
2416c
DEMOD
2418a
2418b
2418c
2420a
ERROR CHECK
2420b
ERROR CHECK
2420c
ERROR CHECK
2422a
2422b
2422c
2424
ARBITRATION MODULE
DEMOD BASEBAND SIGNAL 2212

FIG. 24A

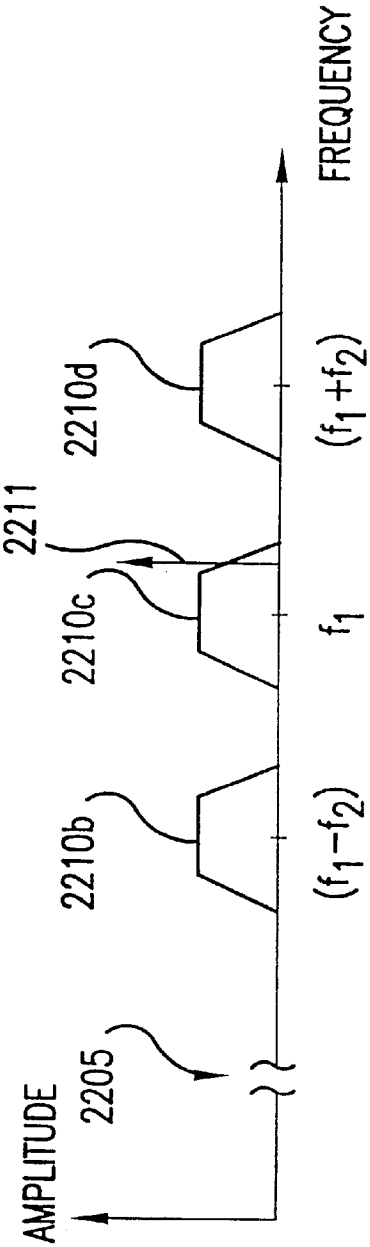


FIG. 24B

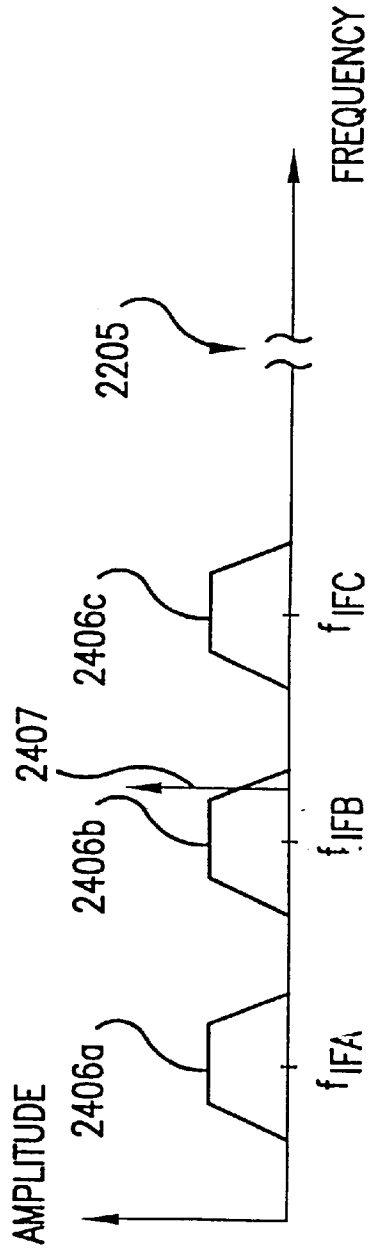


FIG. 24C

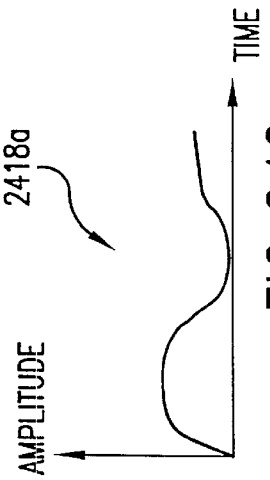


FIG. 24G

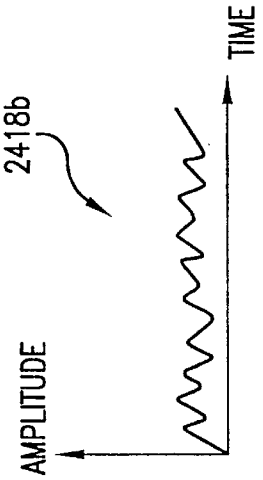


FIG. 24H

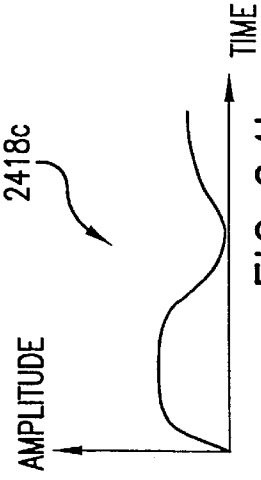


FIG. 24I

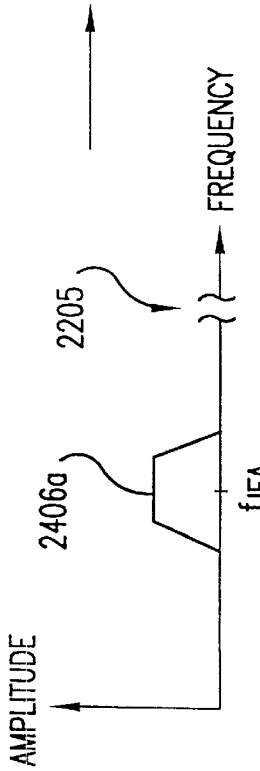


FIG. 24D

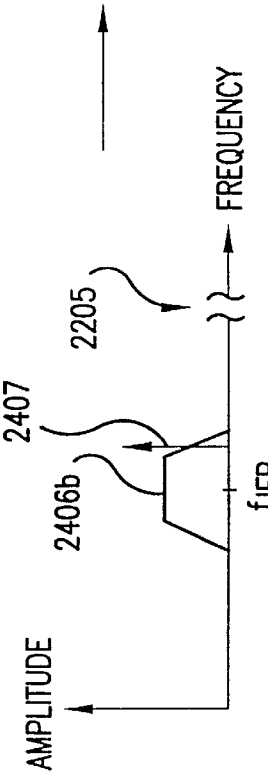


FIG. 24E

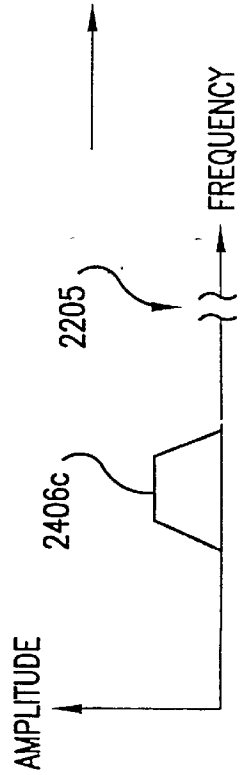


FIG. 24F

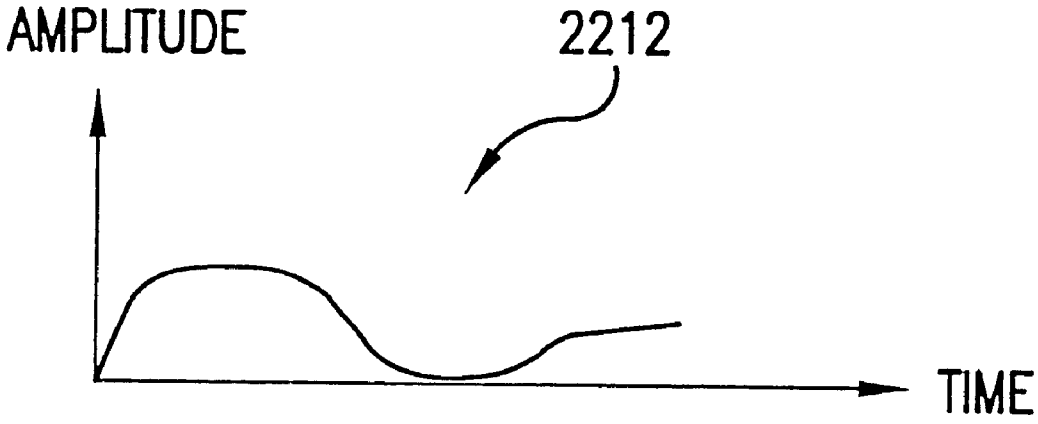


FIG. 24J

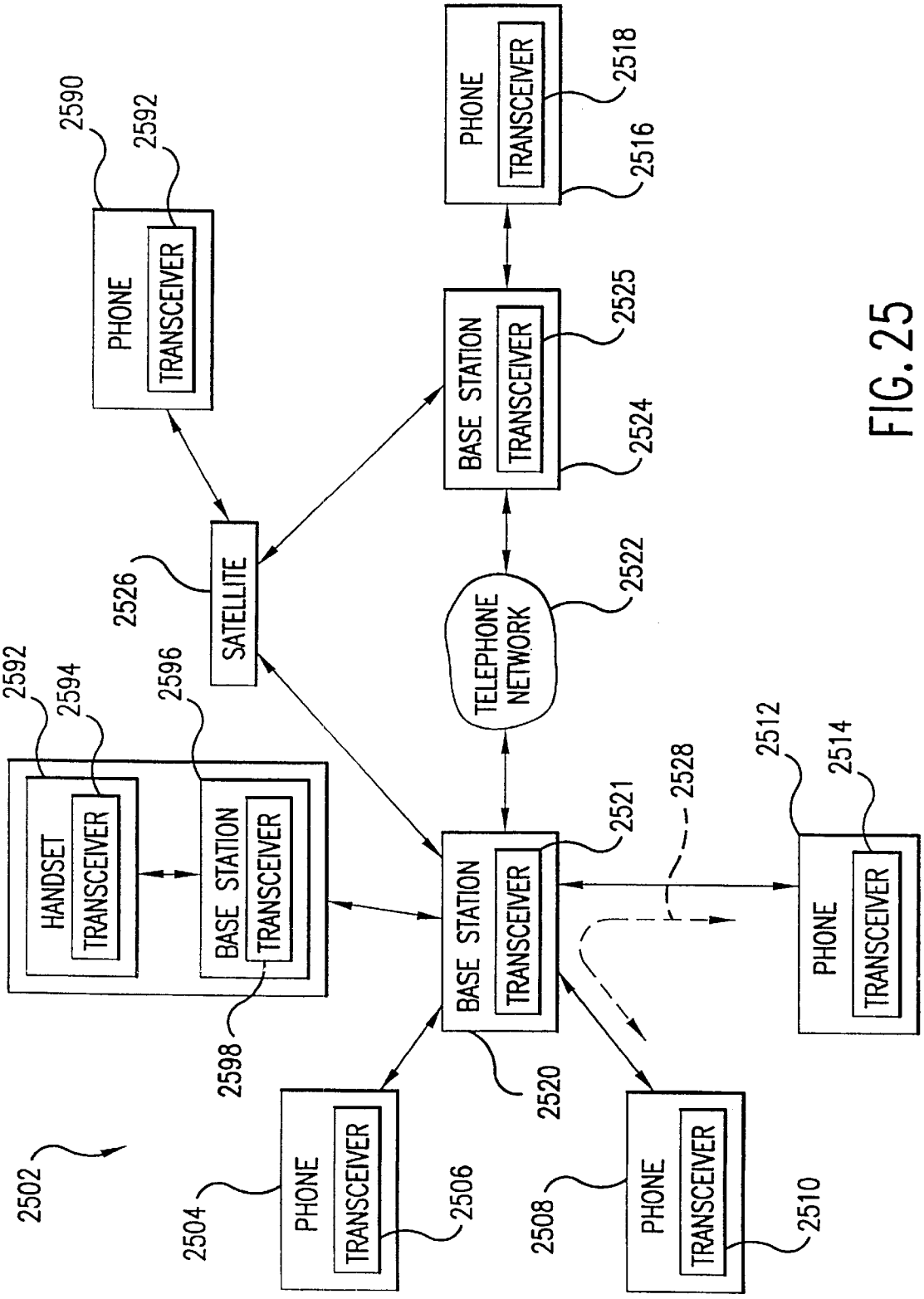

2502
2504
PHONE
TRANSCEIVER
2506
2508
PHONE
TRANSCEIVER
2510
2512
PHONE
TRANSCEIVER
2514
2516
PHONE
TRANSCEIVER
2518
2520
BASE STATION
TRANSCEIVER
2521
2522
TELEPHONE NETWORK
2524
BASE STATION
TRANSCEIVER
2525
2526
SATELLITE
2528
2590
PHONE
TRANSCEIVER
2592
2592
HANDSET
TRANSCEIVER
2594
2596
BASE STATION
TRANSCEIVER
2598

FIG. 25

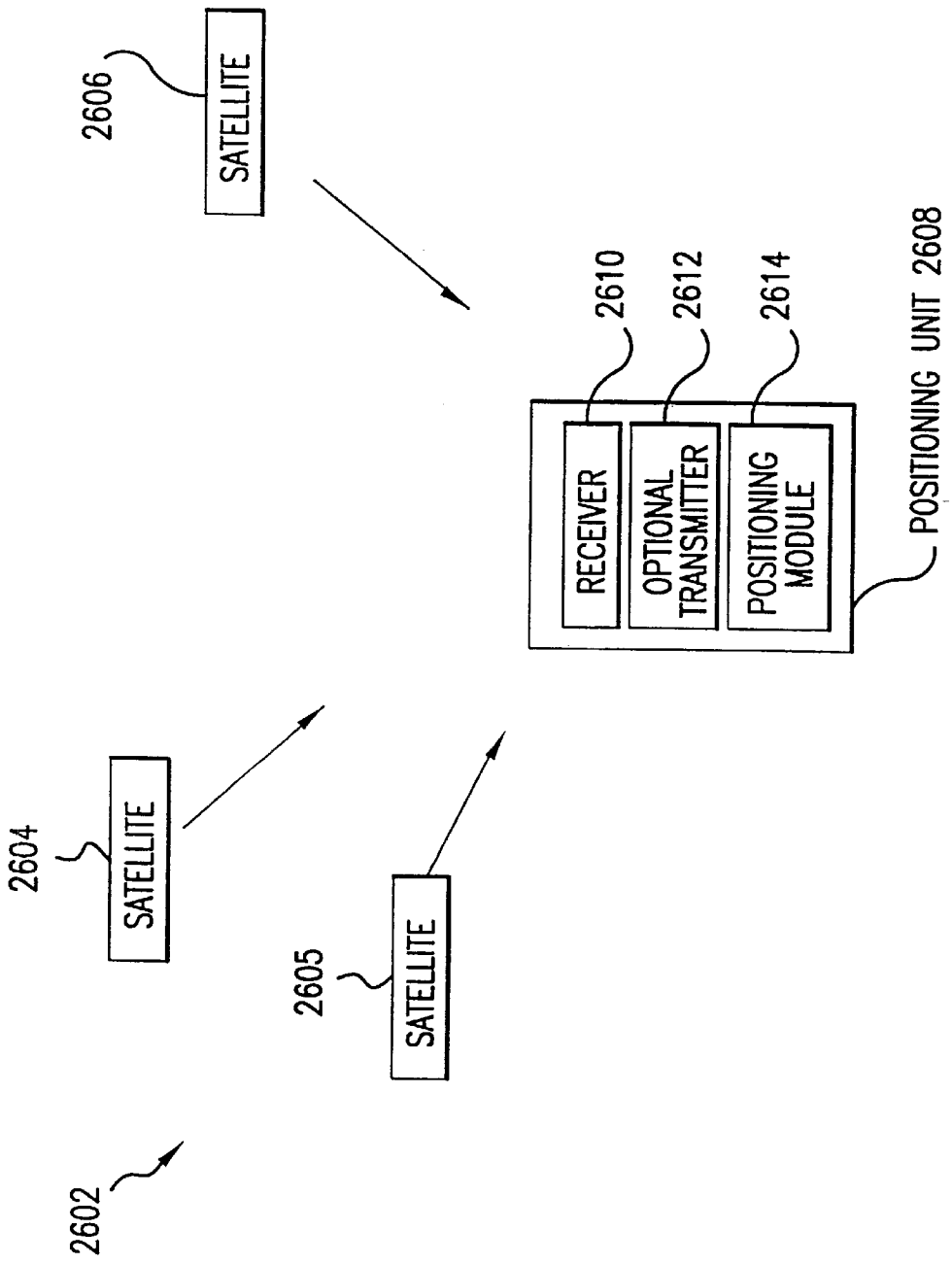

2602
2604
SATELLITE
2605
SATELLITE
2606
SATELLITE
2610
2612
2614
RECEIVER
OPTIONAL TRANSMITTER
POSITIONING MODULE
POSITIONING UNIT 2608

FIG. 26

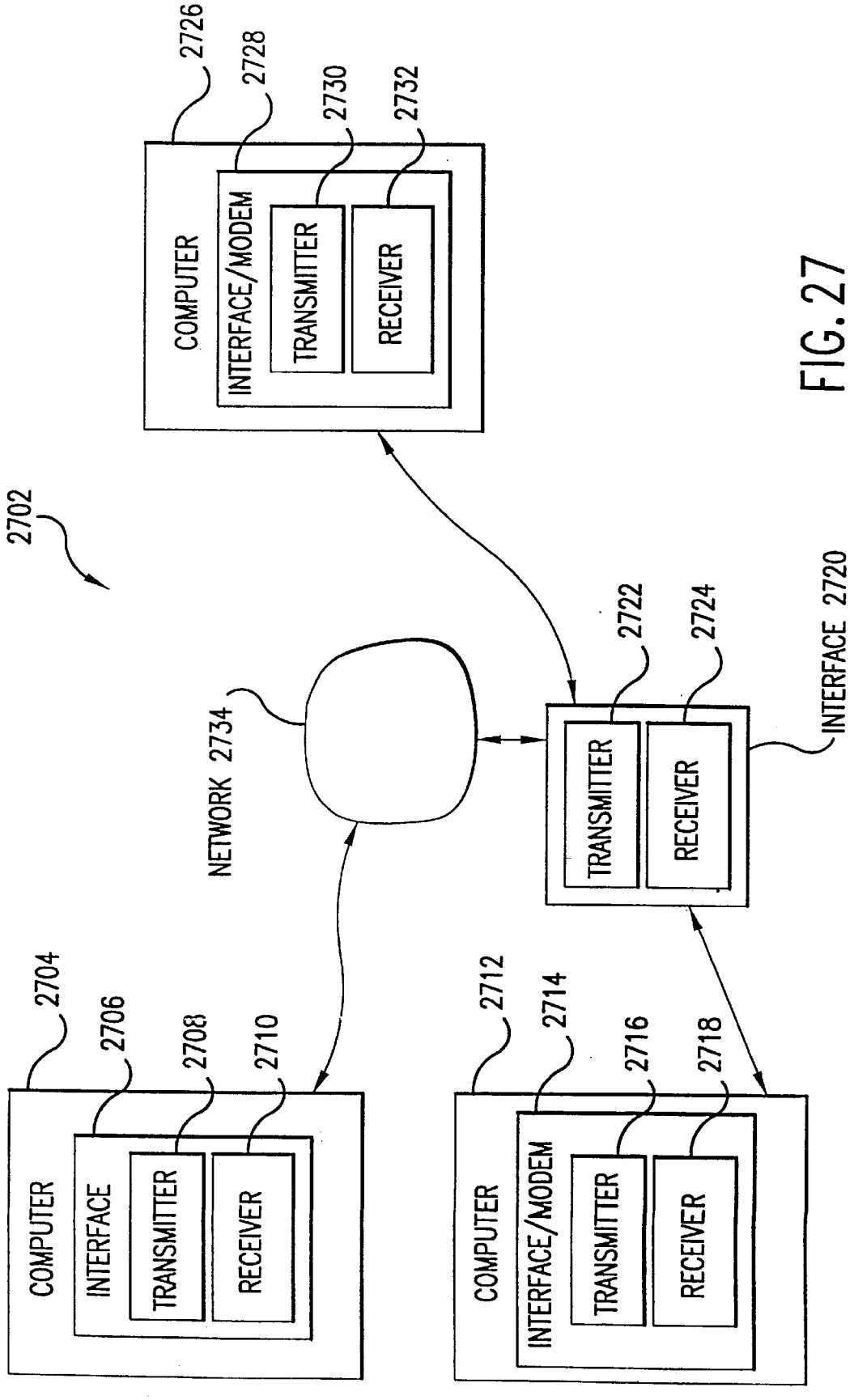

2726
2728
2730
2732
COMPUTER
INTERFACE/MODEM
TRANSMITTER
RECEIVER
2702
NETWORK 2734
2722
2724
INTERFACE 2720
TRANSMITTER
RECEIVER
2704
2706
2708
2710
COMPUTER
INTERFACE
TRANSMITTER
RECEIVER
2712
2714
2716
2718
COMPUTER
INTERFACE/MODEM
TRANSMITTER
RECEIVER

FIG. 27

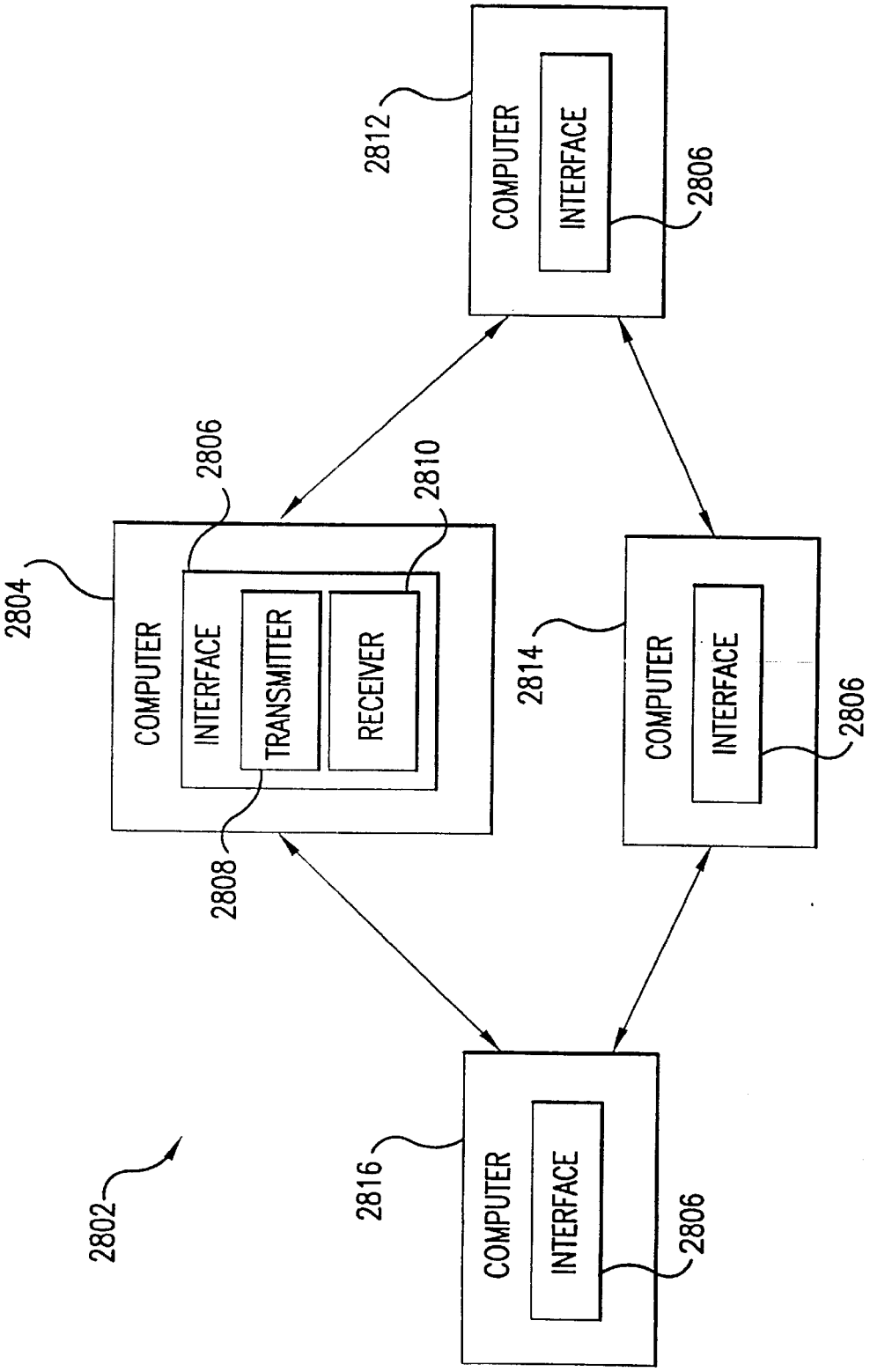

2802
2804
COMPUTER
INTERFACE
TRANSMITTER
RECEIVER
2806
2808
2810
2812
COMPUTER
INTERFACE
2806
2814
COMPUTER
INTERFACE
2806
2816
COMPUTER
INTERFACE
2806

FIG. 28

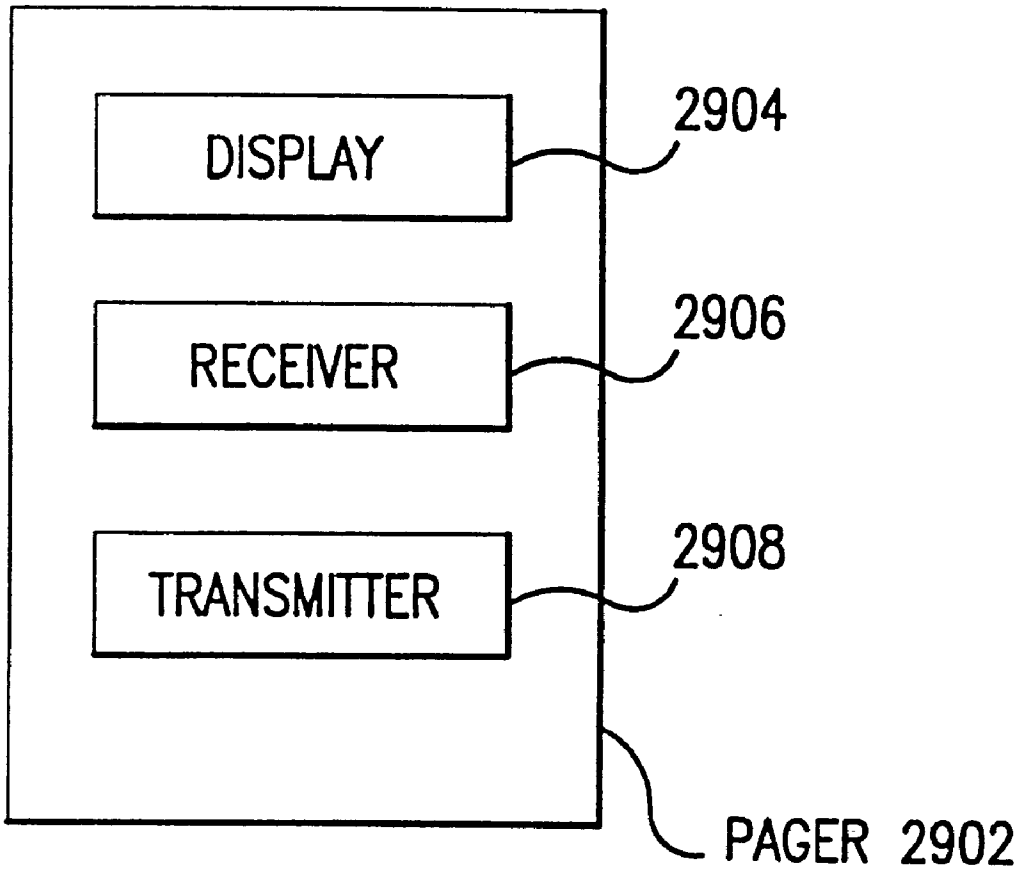


FIG. 29

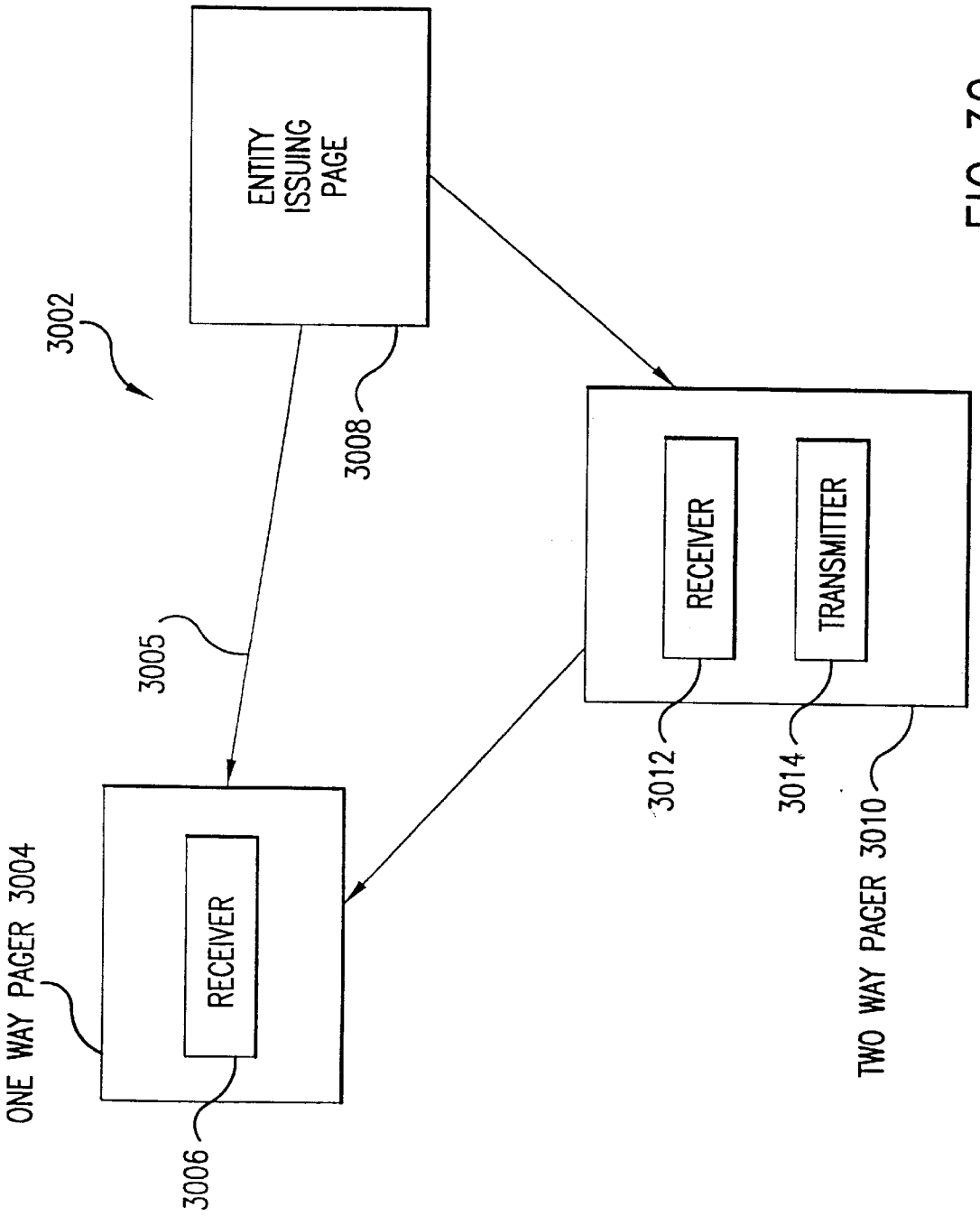

ENTITY ISSUING PAGE
3002
3008
3005
RECEIVER
TRANSMITTER
3012
3014
TWO WAY PAGER 3010
ONE WAY PAGER 3004
RECEIVER
3006

FIG. 30

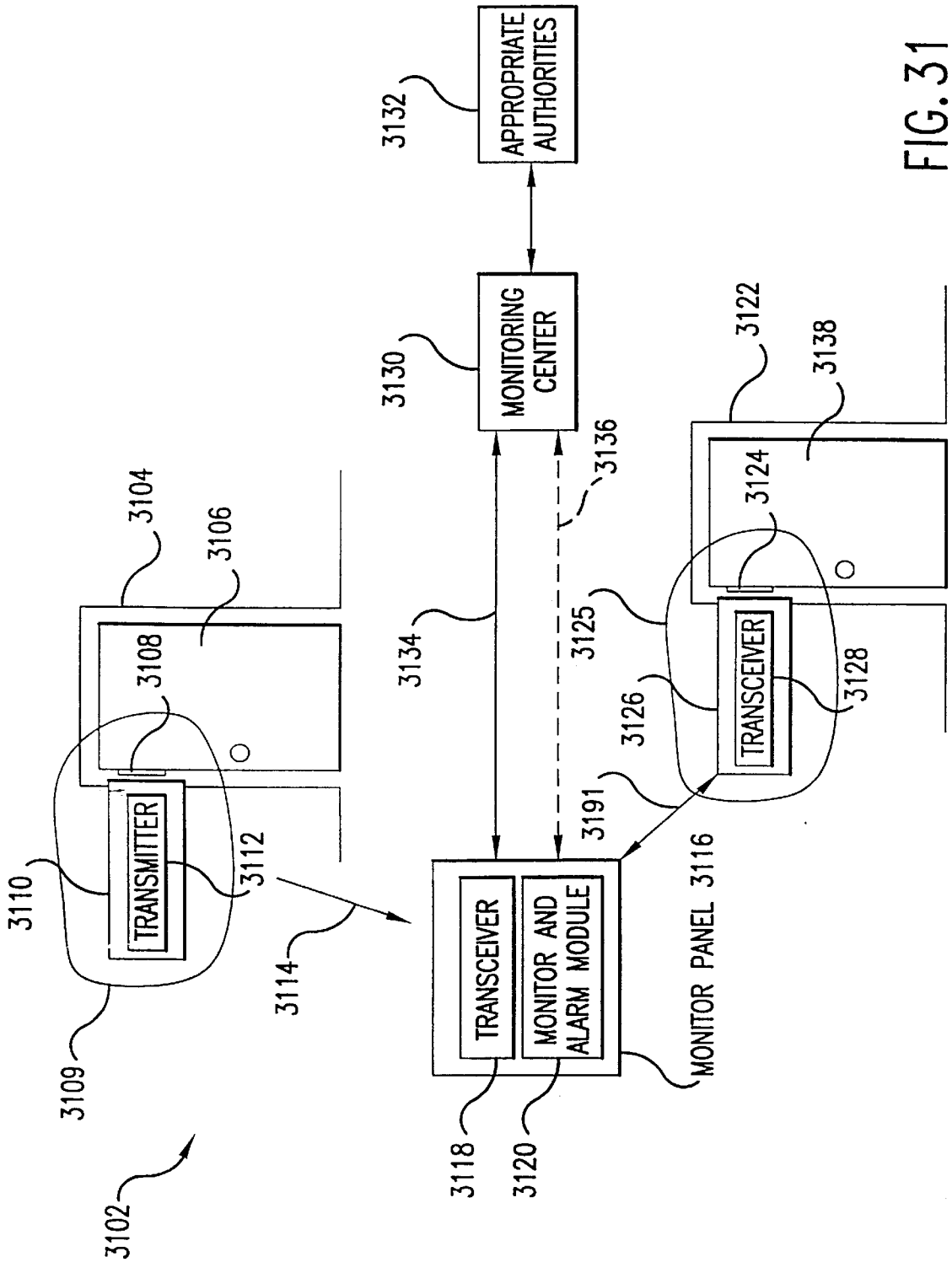

APPROPRIATE AUTHORITIES
3132
MONITORING CENTER
3130
3136
3134
3104
3106
3108
3110
TRANSMITTER
3112
3114
3109
3102
3122
3138
3124
3125
3126
TRANSCEIVER
3128
3191
TRANSCEIVER
MONITOR AND ALARM MODULE
MONITOR PANEL 3116
3118
3120

FIG. 31

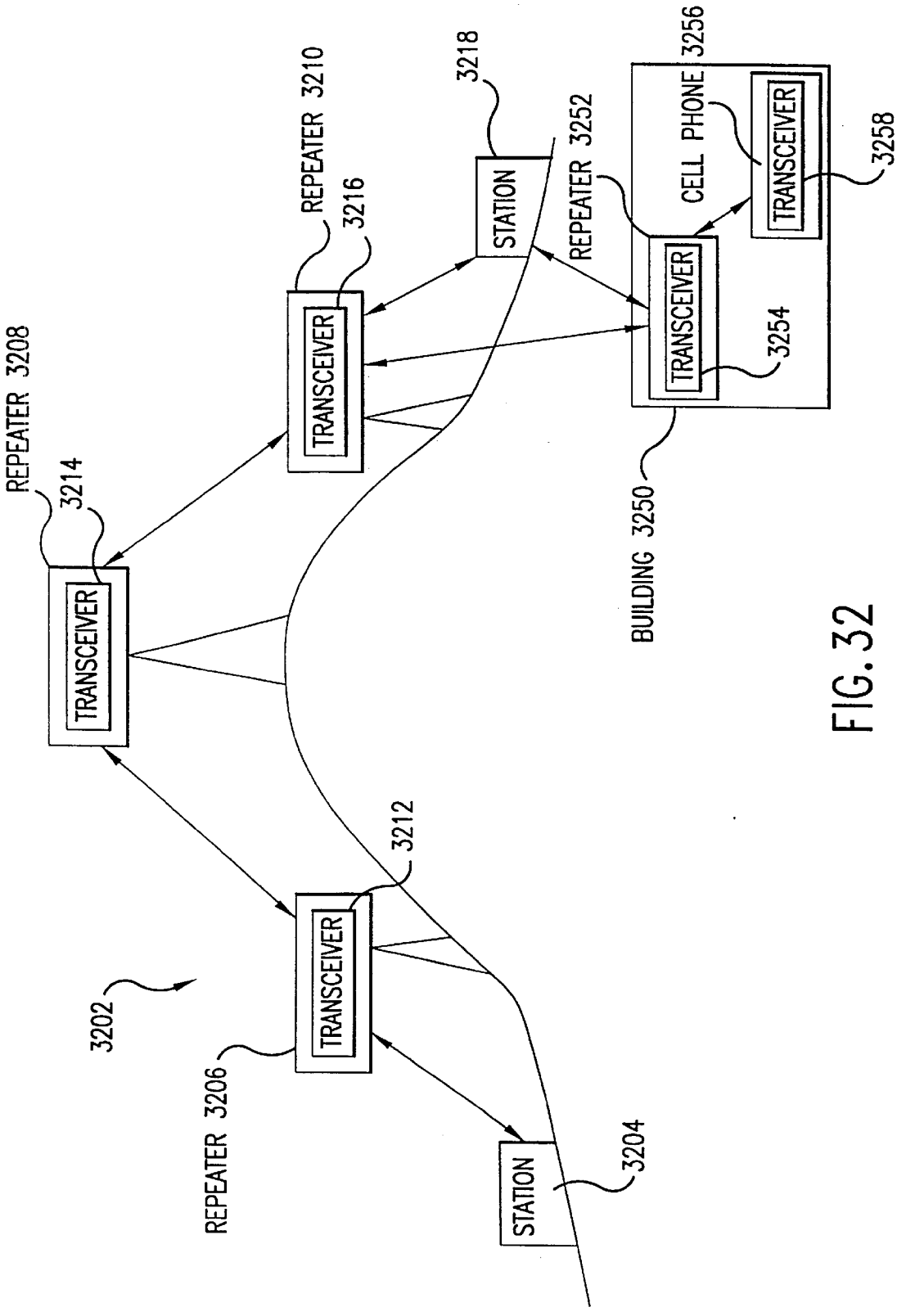

REPEATER 3208
3214
TRANSCEIVER
REPEATER 3210
3216
TRANSCEIVER
3218
STATION
REPEATER 3252
3256
CELL PHONE
TRANSCEIVER
3258
TRANSCEIVER
3254
BUILDING 3250
3202
3212
TRANSCEIVER
REPEATER 3206
STATION
3204

FIG. 32

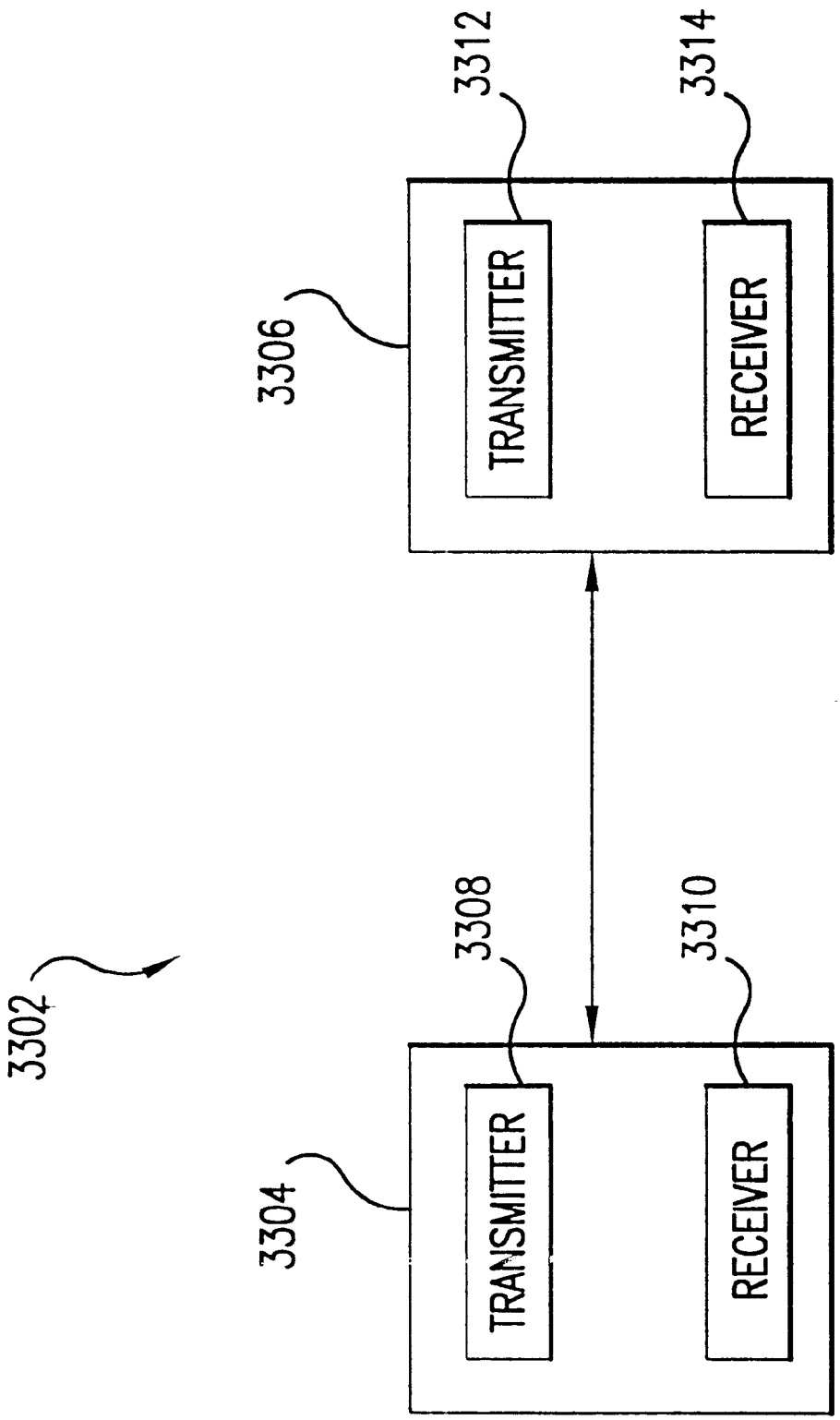

3302
3304
TRANSMITTER
RECEIVER
3306
TRANSMITTER
RECEIVER
3308
3310
3312
3314

FIG. 33

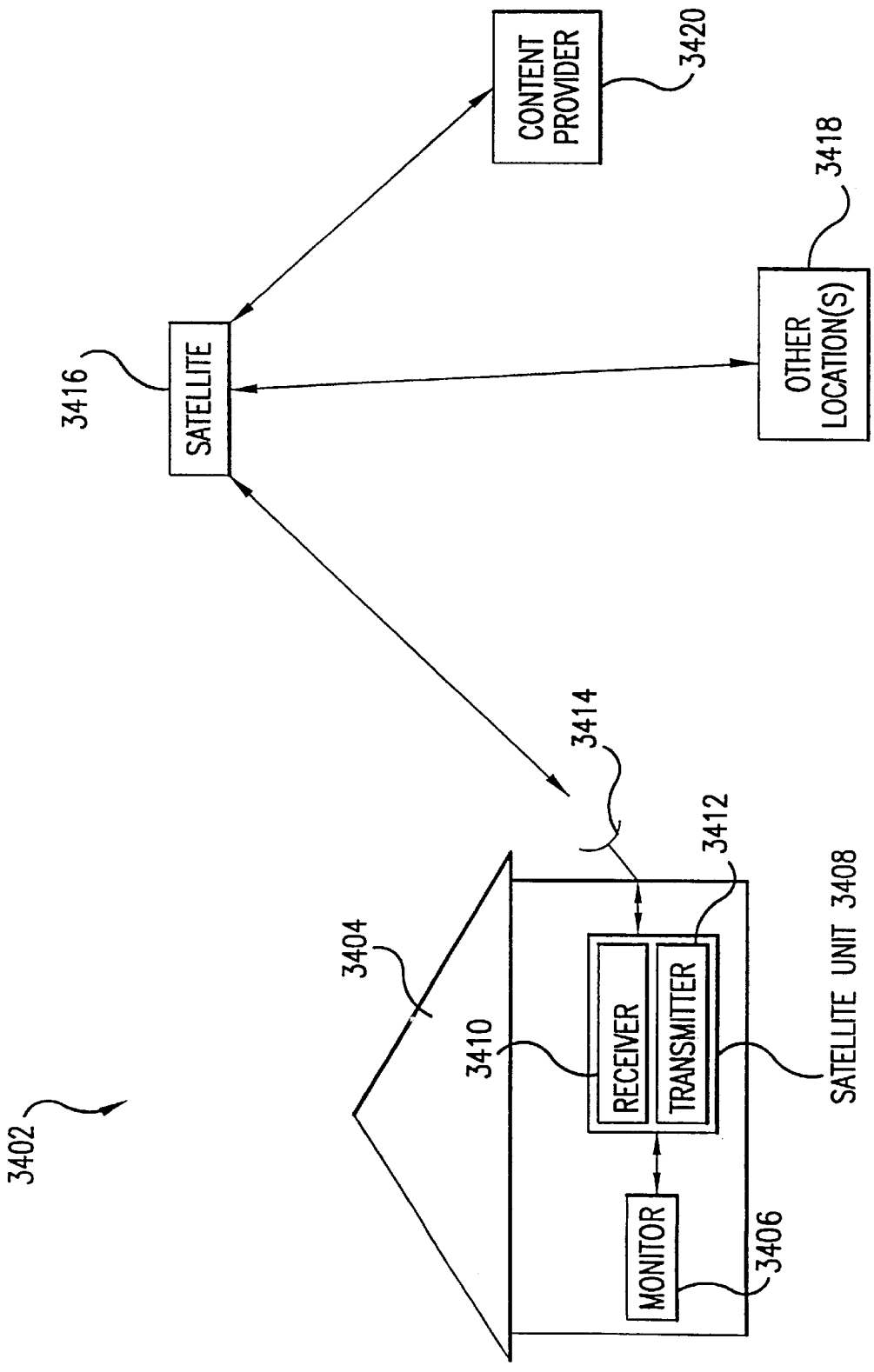

3402
3404
3406
MONITOR
3410
RECEIVER
TRANSMITTER
3412
SATELLITE UNIT 3408
3414
3416
SATELLITE
CONTENT PROVIDER
3420
OTHER LOCATION(S)
3418

FIG. 34

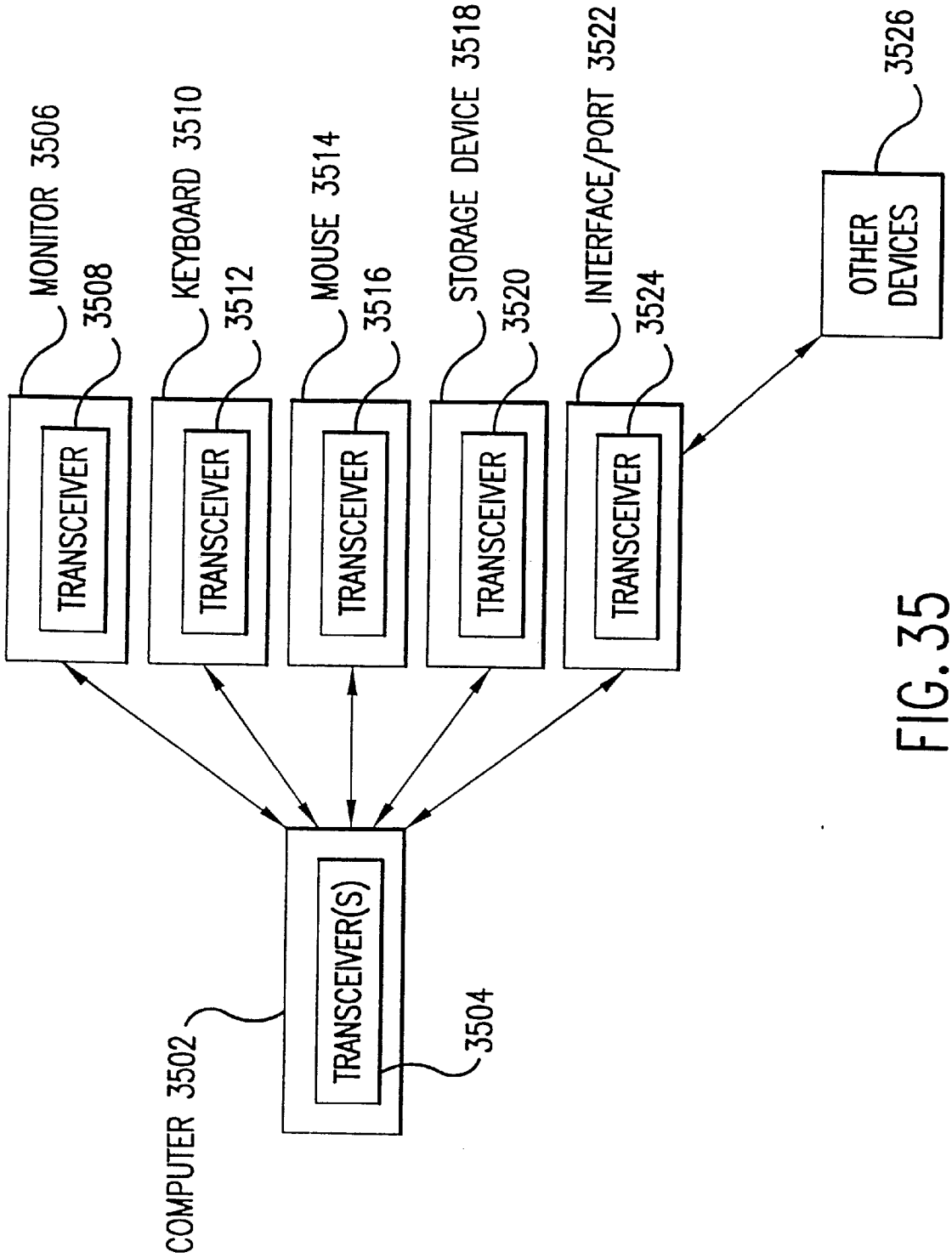

MONITOR 3506
3508
KEYBOARD 3510
3512
MOUSE 3514
3516
STORAGE DEVICE 3518
3520
INTERFACE/PORT 3522
3524
3526
OTHER DEVICES
TRANSCEIVER
TRANSCEIVER
TRANSCEIVER
TRANSCEIVER
TRANSCEIVER
TRANSCEIVER(S)
3504
COMPUTER 3502

FIG. 35

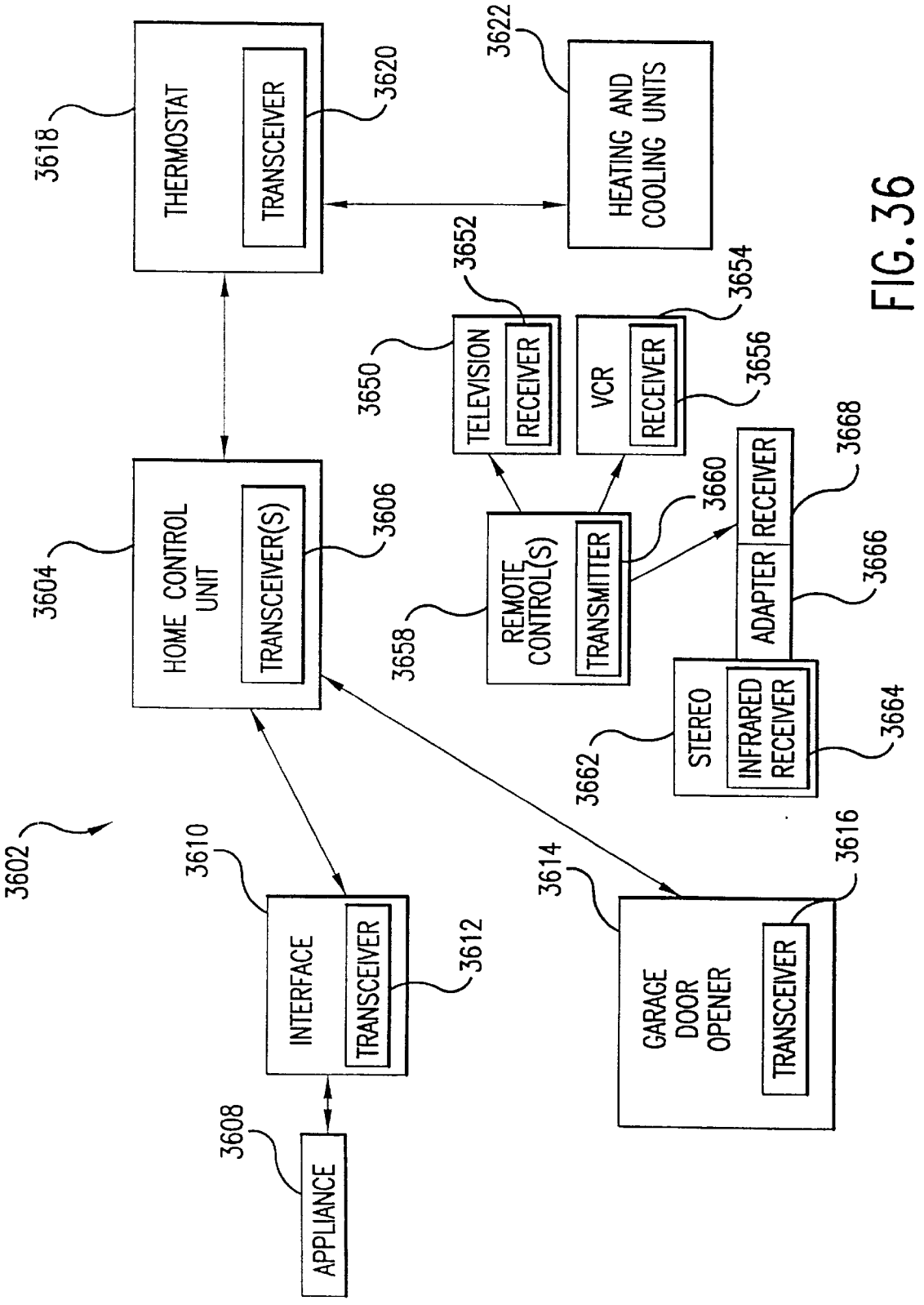

3602
3604
HOME CONTROL UNIT
TRANSCEIVER(S)
3606
3608
APPLIANCE
3610
INTERFACE
TRANSCEIVER
3612
3614
GARAGE DOOR OPENER
TRANSCEIVER
3616
3618
THERMOSTAT
TRANSCEIVER
3620
3622
HEATING AND COOLING UNITS
3650
TELEVISION
RECEIVER
3652
3654
VCR
RECEIVER
3656
3658
REMOTE CONTROL(S)
TRANSMITTER
3660
3662
STEREO
INFRARED RECEIVER
3664
3666
ADAPTER
RECEIVER
3668

FIG. 36

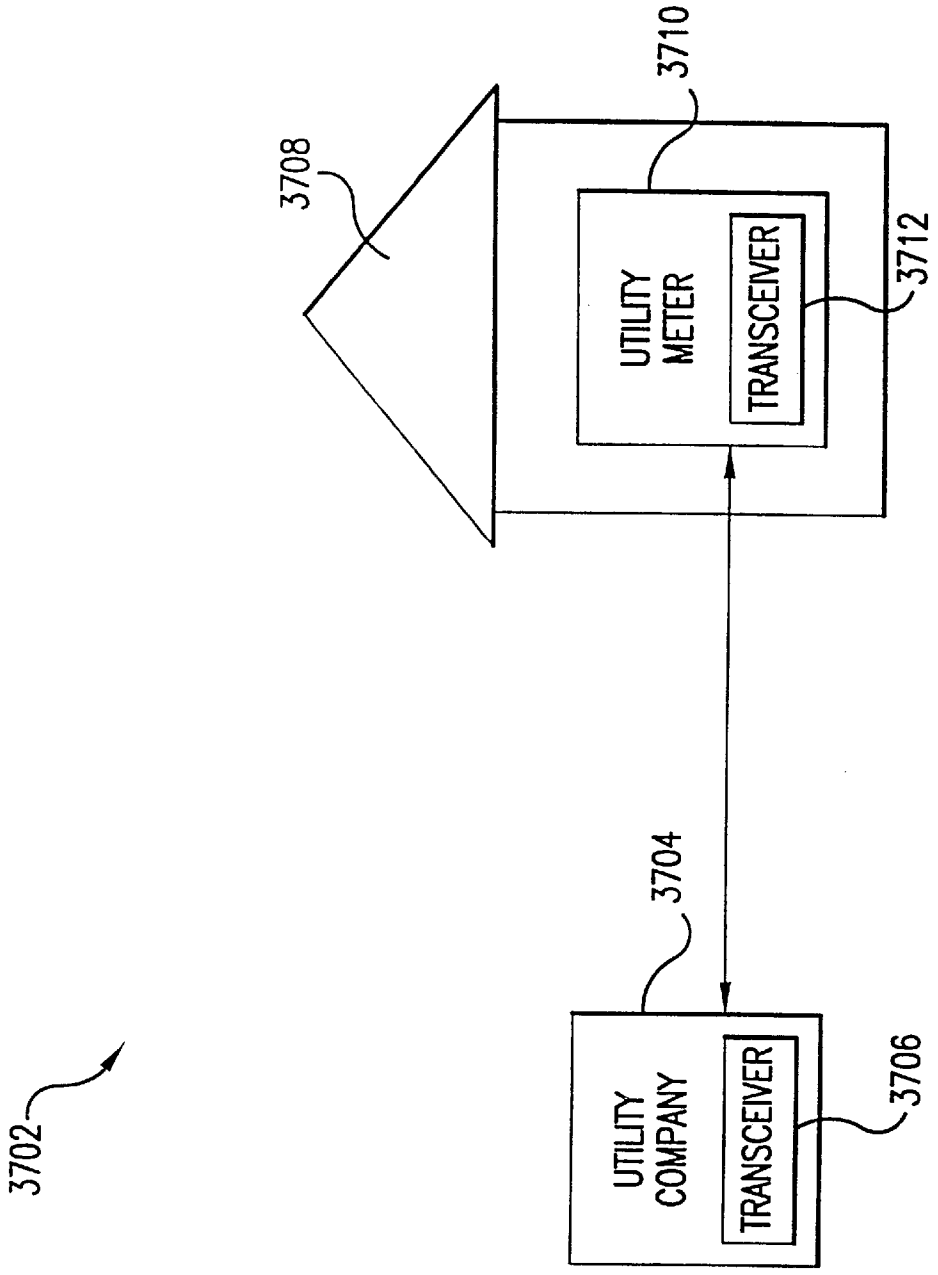

3702
3704
UTILITY COMPANY
TRANSCEIVER
3706
3708
3710
UTILITY METER
TRANSCEIVER
3712

FIG. 37

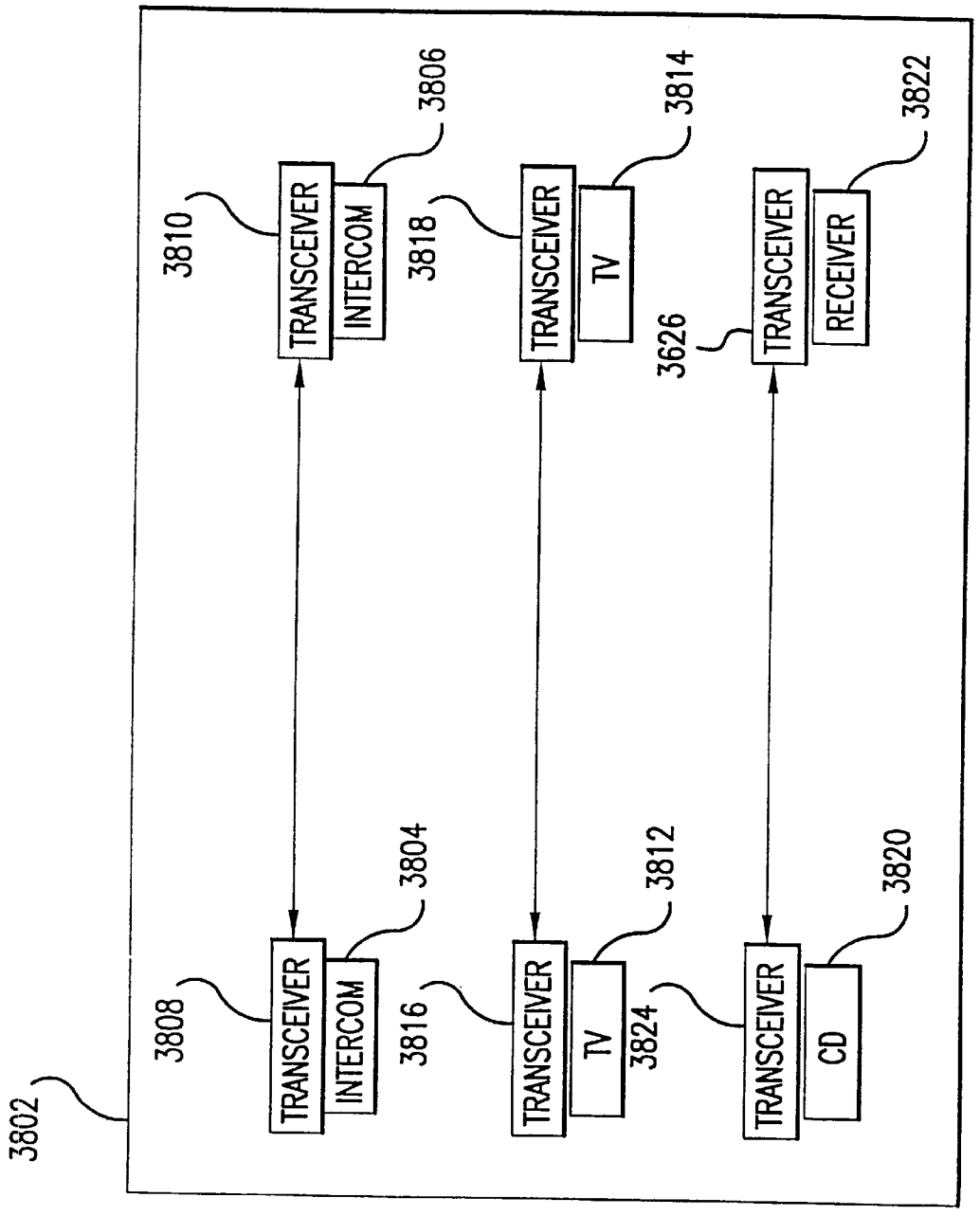

3802
3808
TRANSCEIVER
INTERCOM
3804
3816
TRANSCEIVER
TV
3812
3824
TRANSCEIVER
CD
3820
3810
TRANSCEIVER
INTERCOM
3806
3818
TRANSCEIVER
TV
3814
3626
TRANSCEIVER
RECEIVER
3822

FIG. 38

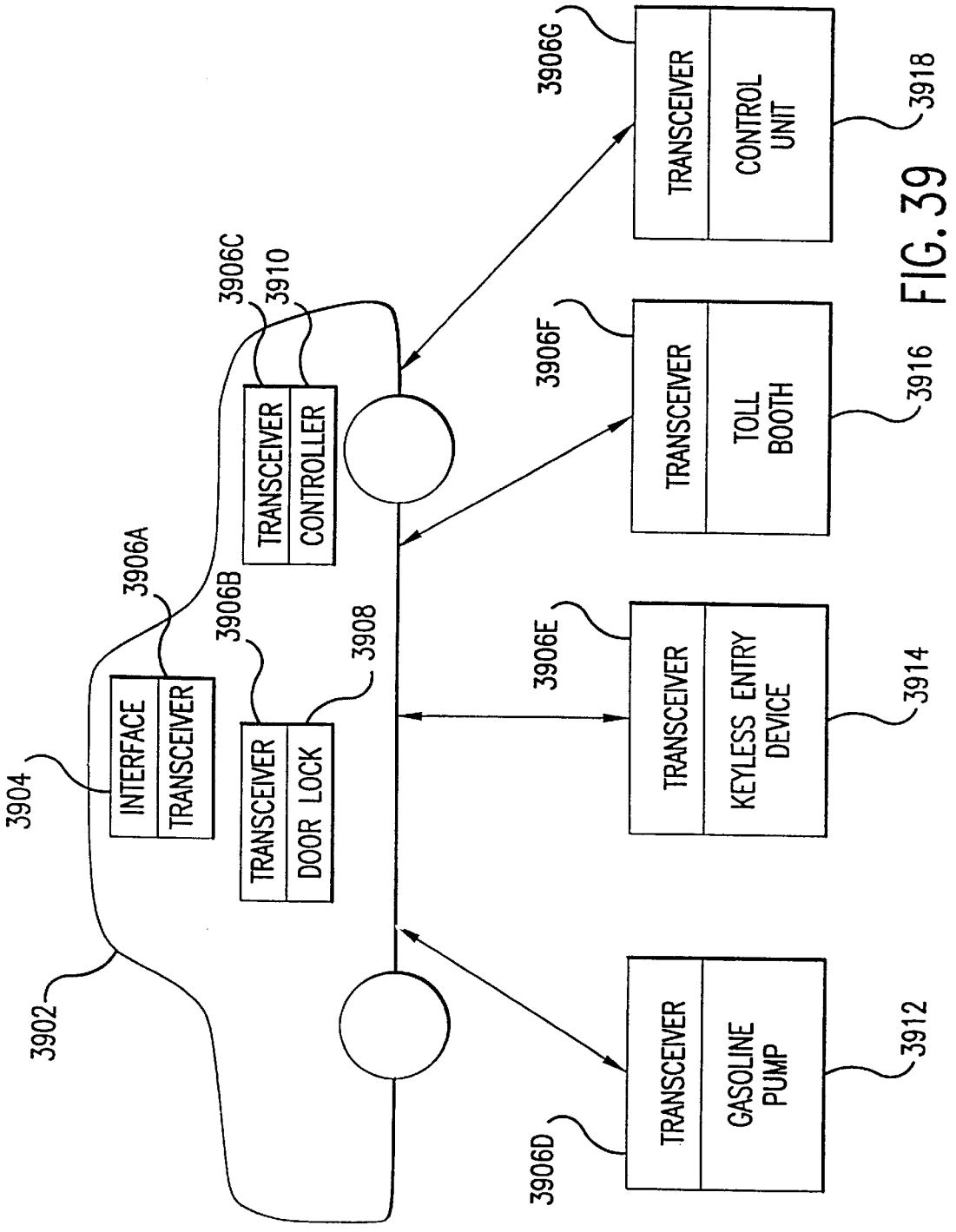

3902
3904
INTERFACE
TRANSCEIVER
3906A
3906B
TRANSCEIVER
DOOR LOCK
3908
3906C
3910
TRANSCEIVER
CONTROLLER
3906D
TRANSCEIVER
GASOLINE PUMP
3912
3906E
TRANSCEIVER
KEYLESS ENTRY DEVICE
3914
3906F
TRANSCEIVER
TOLL BOOTH
3916
3906G
TRANSCEIVER
CONTROL UNIT
3918

FIG. 39

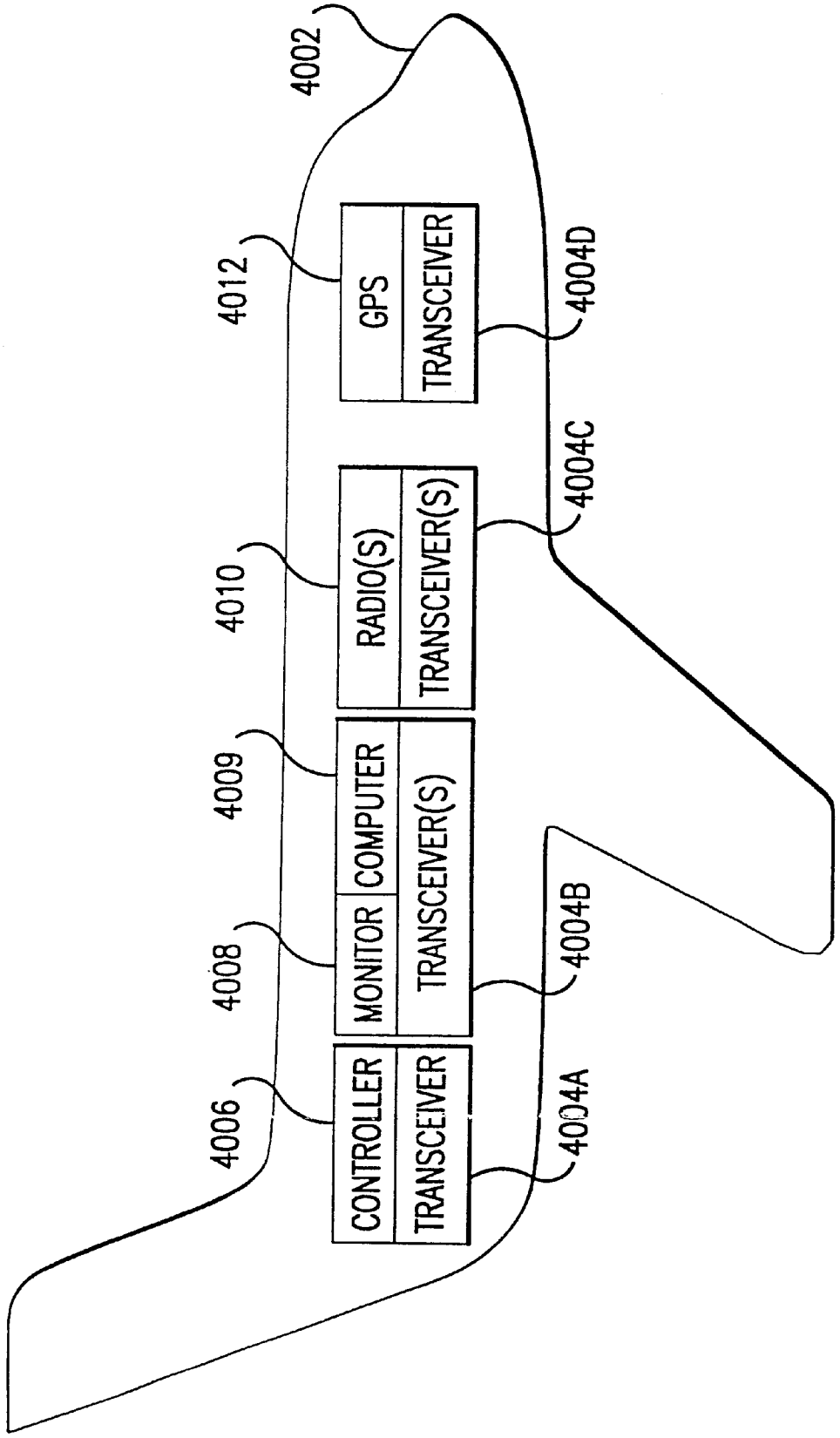

4002
4012
GPS
TRANSCEIVER
4004D
4010
RADIO(S)
TRANSCEIVER(S)
4004C
4009
MONITOR
COMPUTER
4008
TRANSCEIVER(S)
4004B
4006
CONTROLLER
TRANSCEIVER
4004A

FIG. 40A

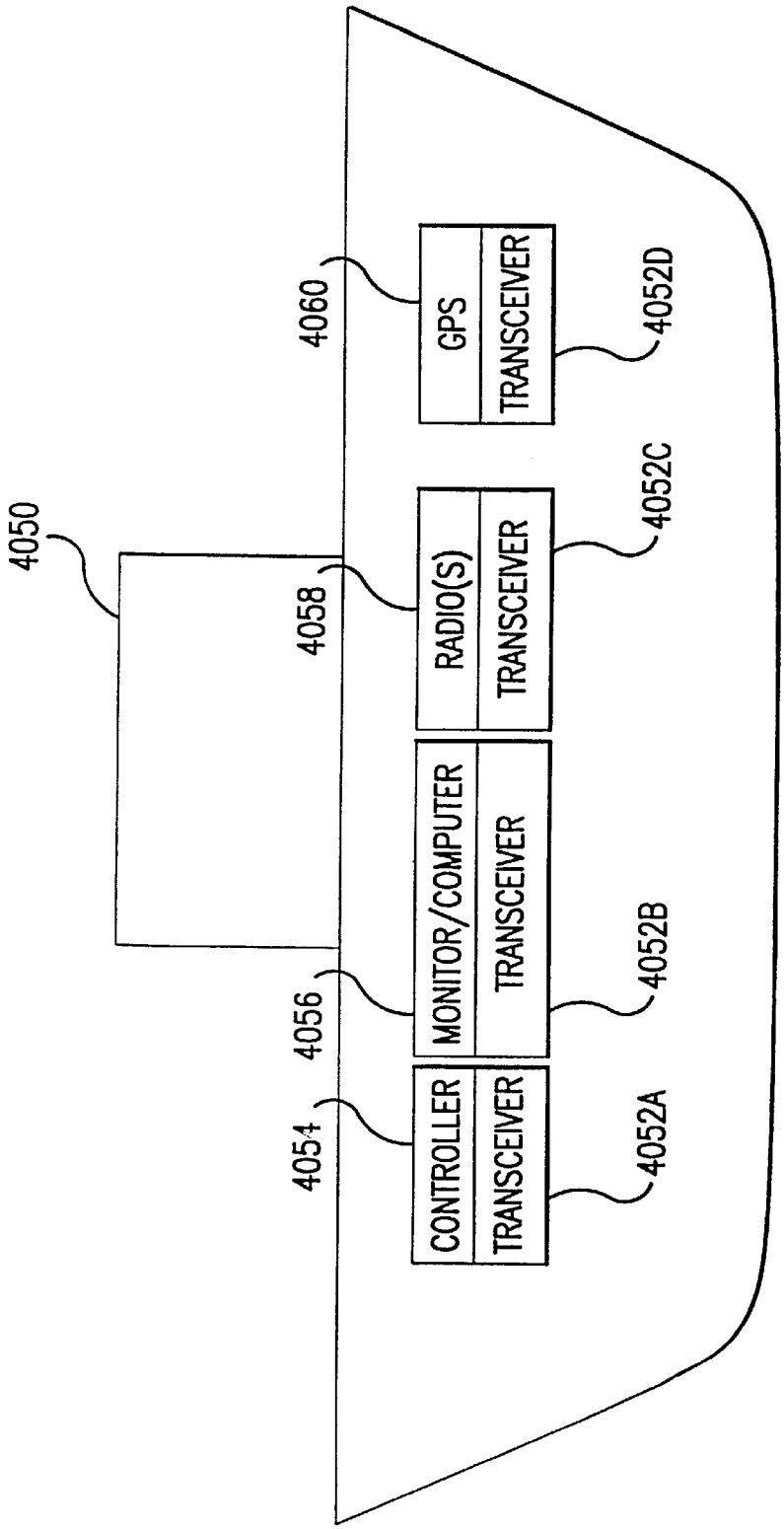

4050
4052A
CONTROLLER
TRANSCEIVER
4054
4052B
MONITOR/COMPUTER
TRANSCEIVER
4056
4052C
RADIO(S)
TRANSCEIVER
4058
4052D
GPS
TRANSCEIVER
4060

FIG. 40B

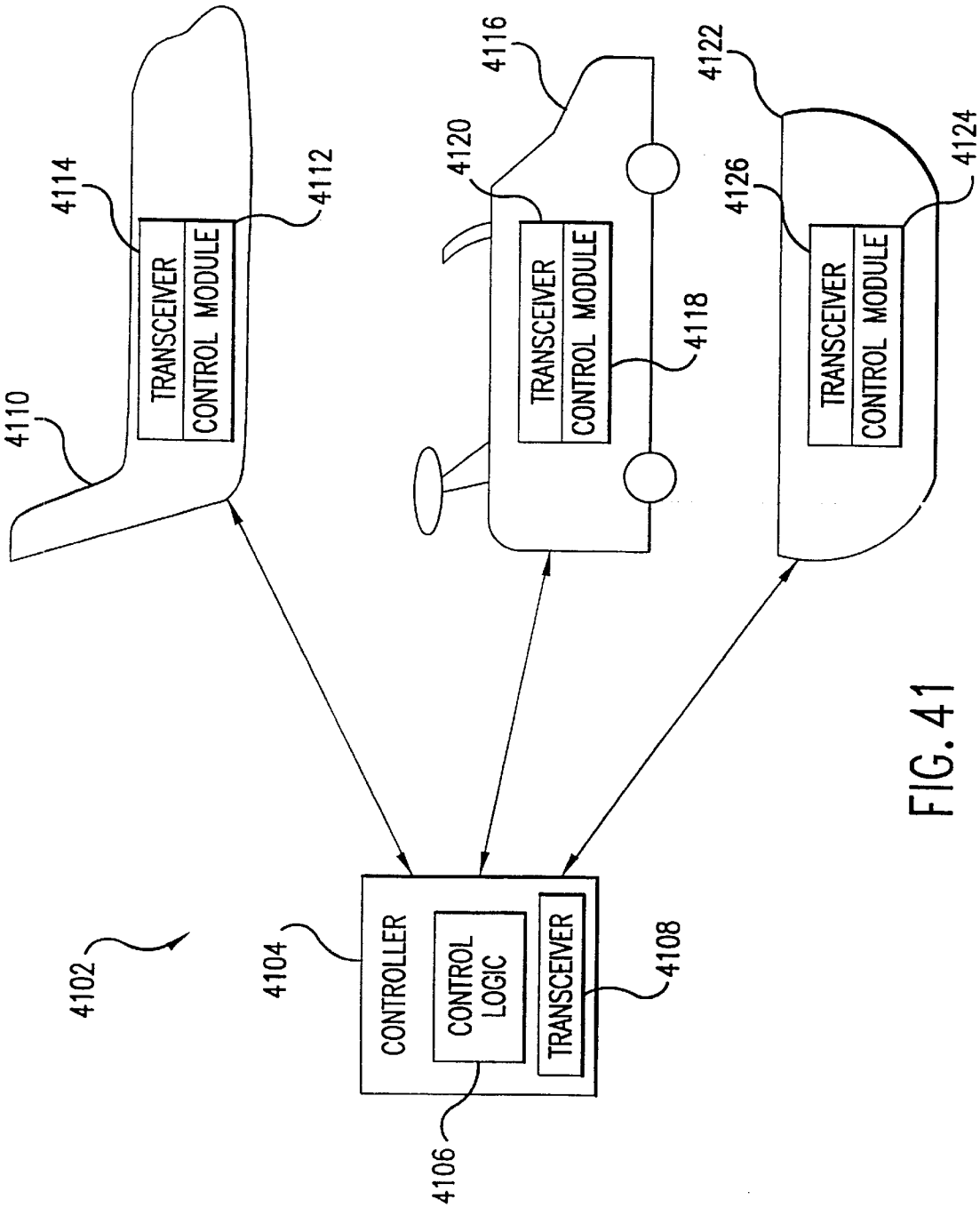

4102
4104
CONTROLLER
CONTROL LOGIC
TRANSCEIVER
4106
4108
4110
4112
4114
TRANSCEIVER
CONTROL MODULE
4116
4118
4120
TRANSCEIVER
CONTROL MODULE
4122
4124
4126
TRANSCEIVER
CONTROL MODULE

FIG. 41

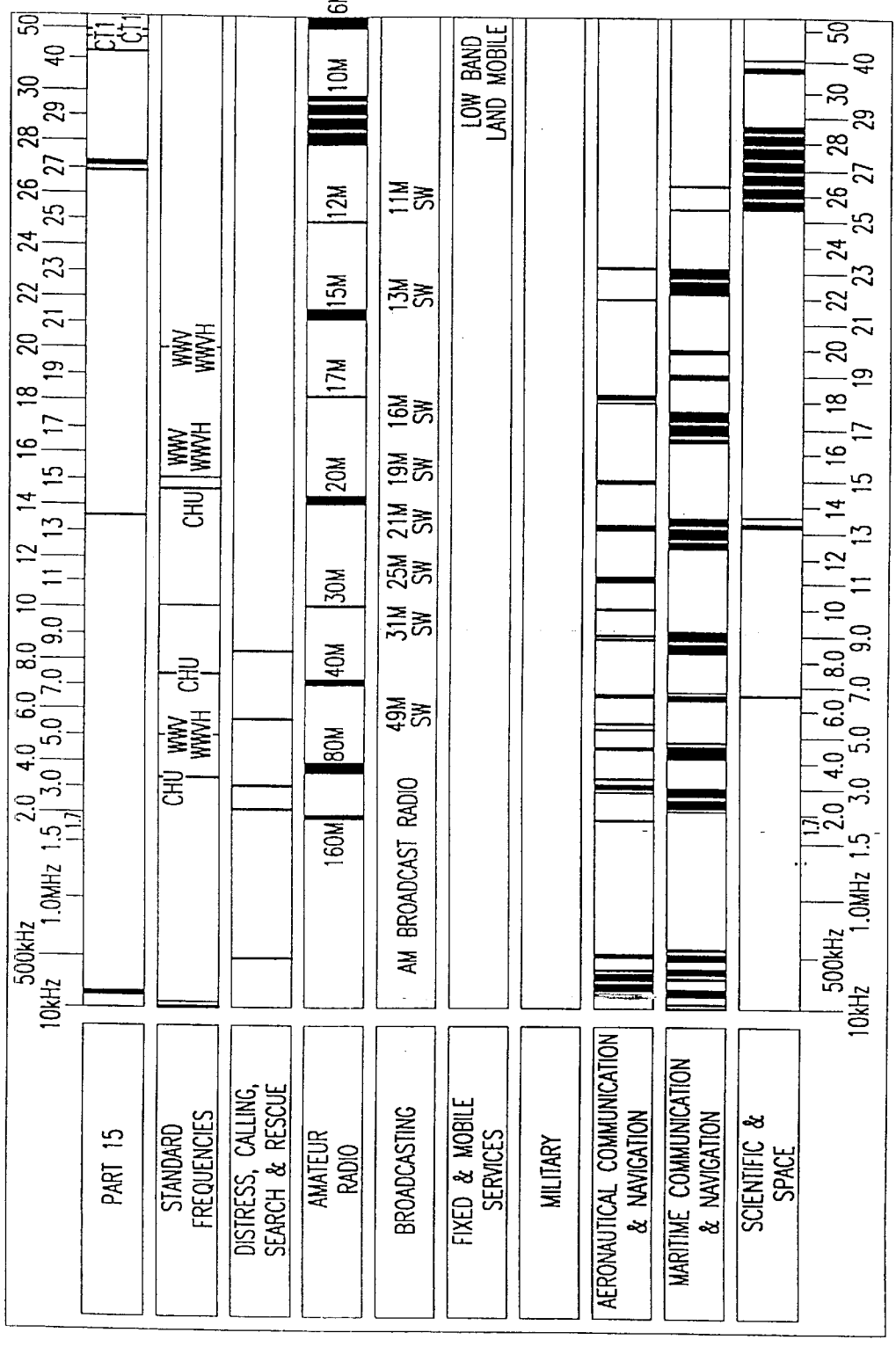

PART 15
STANDARD FREQUENCIES
DISTRESS, CALLING, SEARCH & RESCUE
AMATEUR RADIO
BROADCASTING
FIXED & MOBILE SERVICES
MILITARY
AERONAUTICAL COMMUNICATION & NAVIGATION
MARITIME COMMUNICATION & NAVIGATION
SCIENTIFIC & SPACE
10kHz
500kHz
1.0MHz
1.5
1.7
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
40
50
CHU
WWV
WWVH
160M
80M
40M
30M
20M
17M
15M
12M
10M
6M
49M SW
31M SW
25M SW
21M SW
19M SW
16M SW
13M SW
11M SW
AM BROADCAST RADIO
LOW BAND LAND MOBILE

FIG. 42A

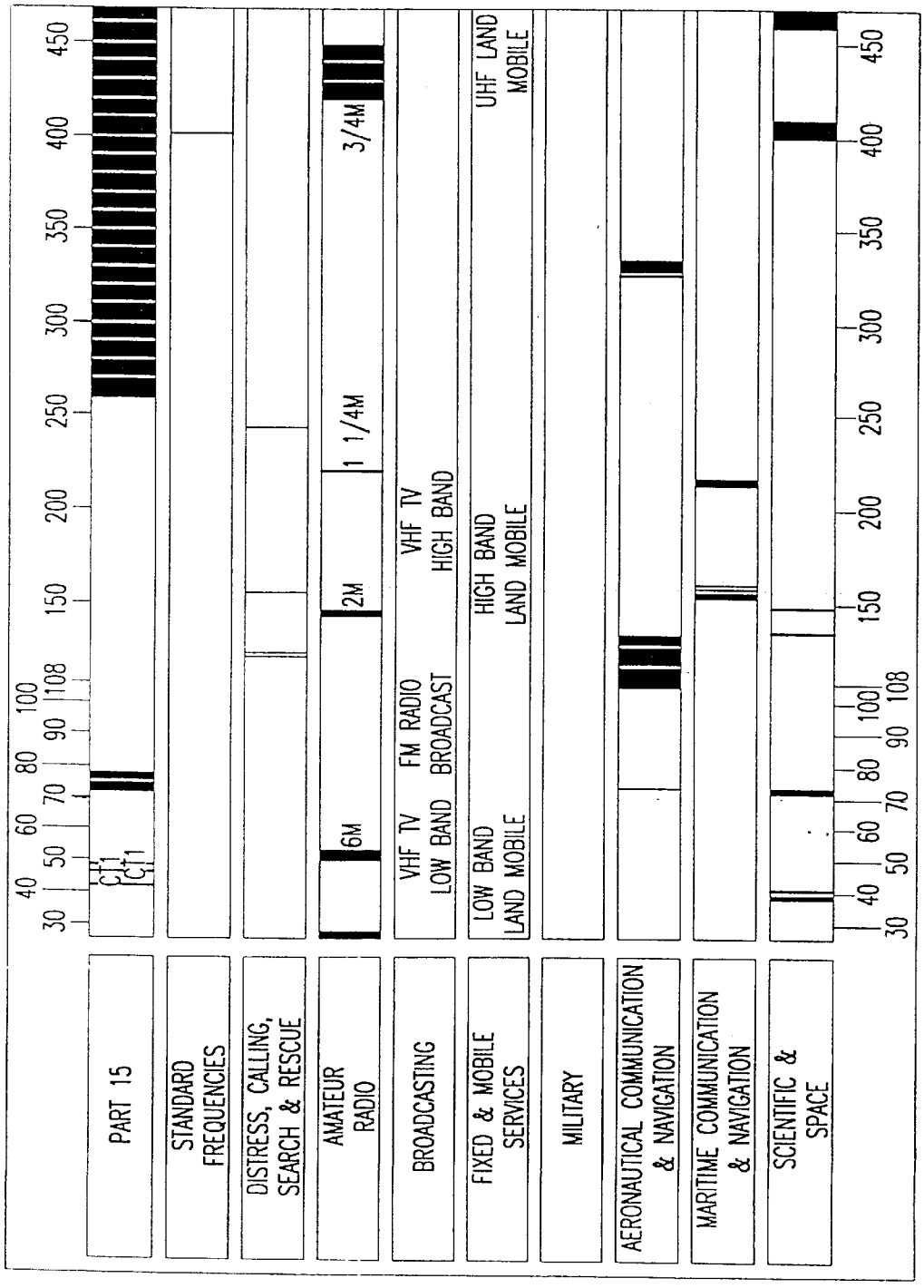

PART 15
STANDARD FREQUENCIES
DISTRESS, CALLING, SEARCH & RESCUE
AMATEUR RADIO
BROADCASTING
FIXED & MOBILE SERVICES
MILITARY
AERONAUTICAL COMMUNICATION & NAVIGATION
MARITIME COMMUNICATION & NAVIGATION
SCIENTIFIC & SPACE
CT1
CT+1
6M
2M
1 1/4M
3/4M
VHF TV LOW BAND
FM RADIO BROADCAST
VHF TV HIGH BAND
LOW BAND LAND MOBILE
HIGH BAND LAND MOBILE
UHF LAND MOBILE
30 40 50 60 70 80 90 100 108 150 200 250 300 350 400 450

FIG. 42B

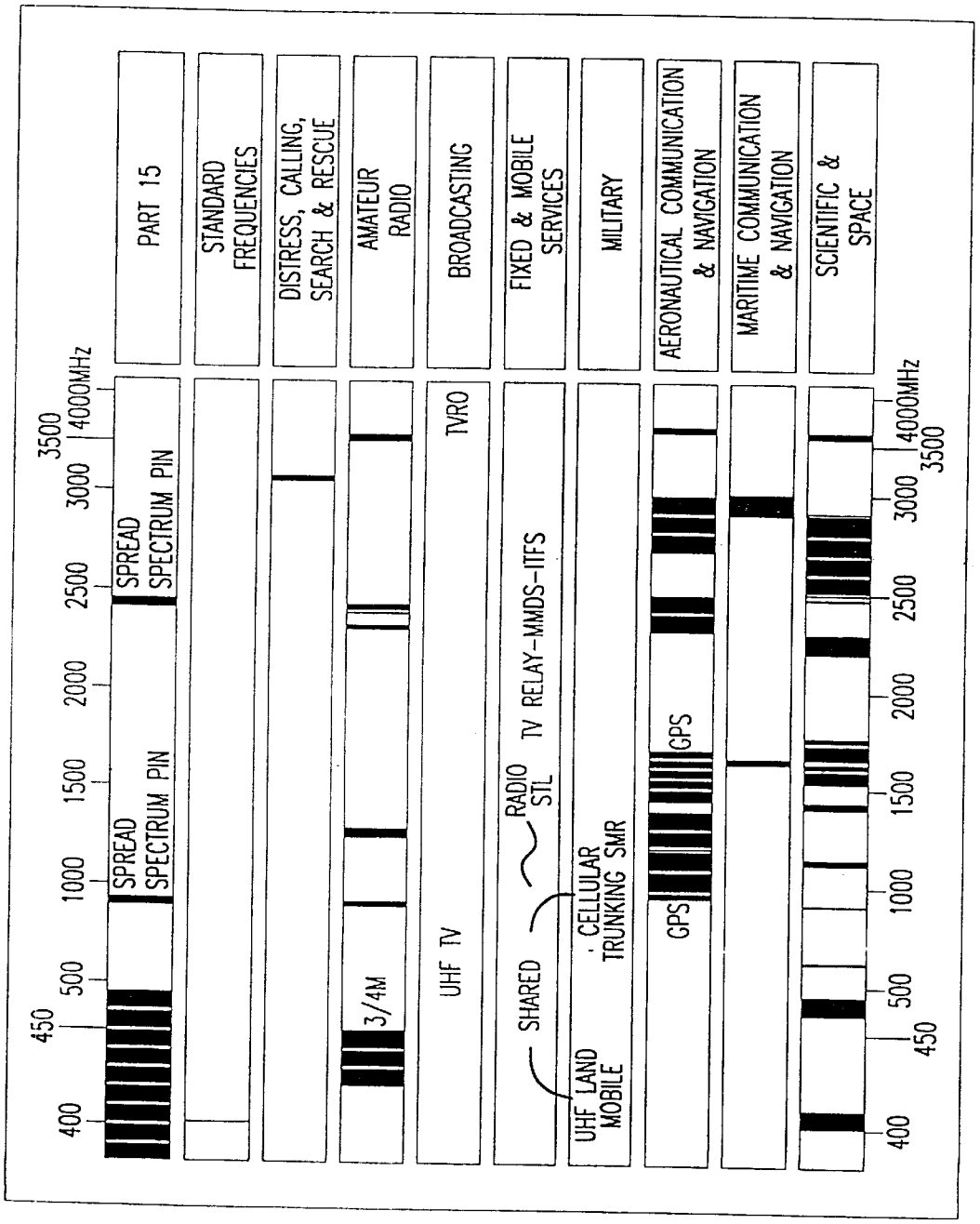

400
450
500
1000
1500
2000
2500
3000
3500
4000MHz
SPREAD SPECTRUM PIN
SPREAD SPECTRUM PIN
PART 15
STANDARD FREQUENCIES
DISTRESS, CALLING, SEARCH & RESCUE
AMATEUR RADIO
3/4M
BROADCASTING
UHF TV
TVRO
FIXED & MOBILE SERVICES
SHARED
RADIO STL
TV RELAY-MMDS-ITFS
MILITARY
UHF LAND MOBILE
CELLULAR TRUNKING SMR
AERONAUTICAL COMMUNICATION & NAVIGATION
GPS
GPS
MARITIME COMMUNICATION & NAVIGATION
SCIENTIFIC & SPACE

FIG. 42C

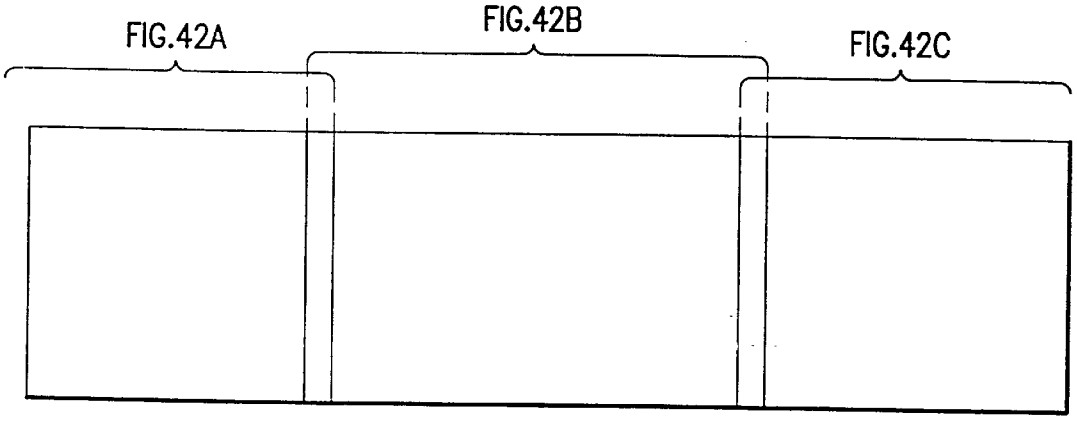


FIG. 42D

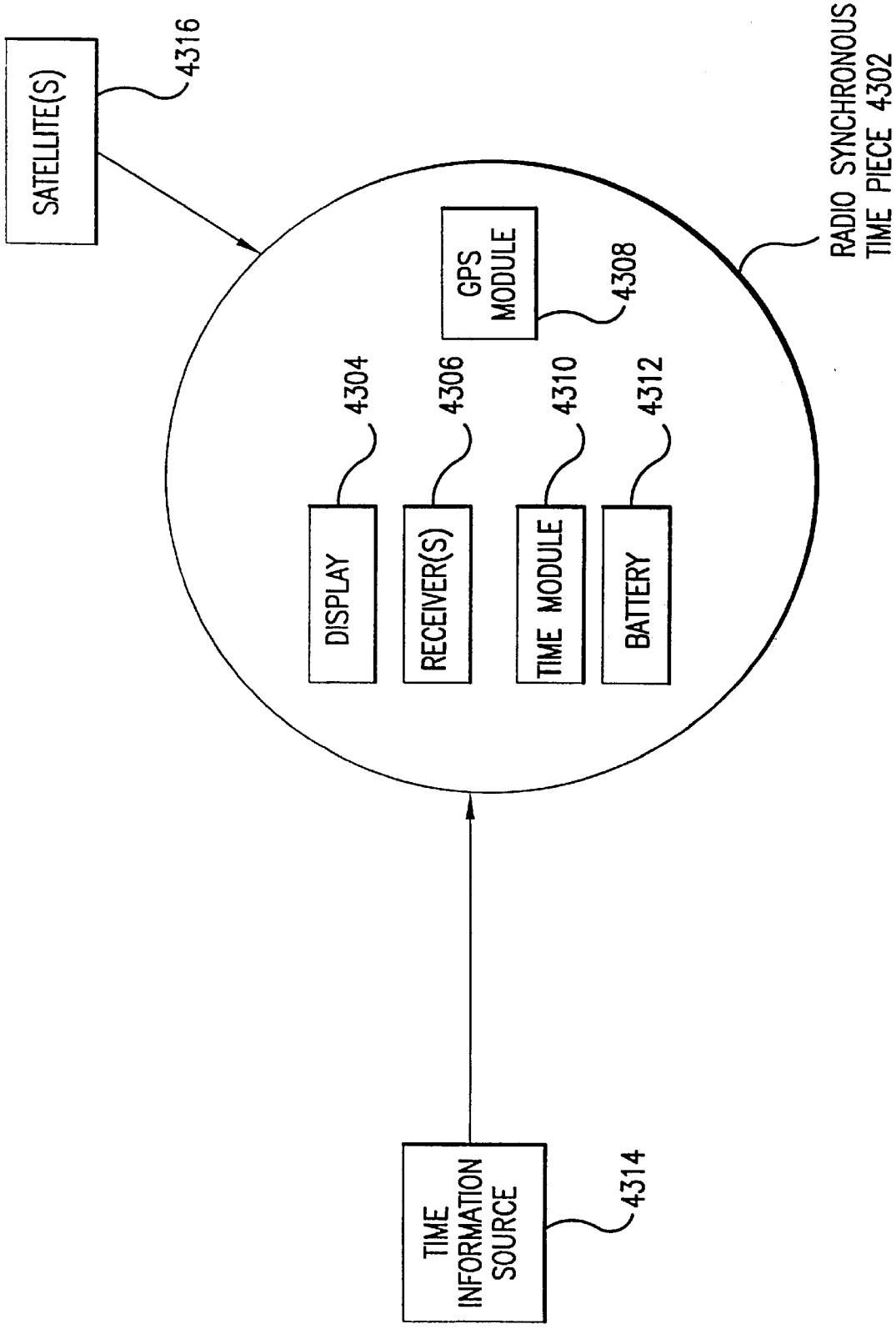

SATELLITE(S)
4316
RADIO SYNCHRONOUS TIME PIECE 4302
GPS MODULE
4308
DISPLAY
4304
RECEIVER(S)
4306
TIME MODULE
4310
BATTERY
4312
TIME INFORMATION SOURCE
4314

FIG. 43

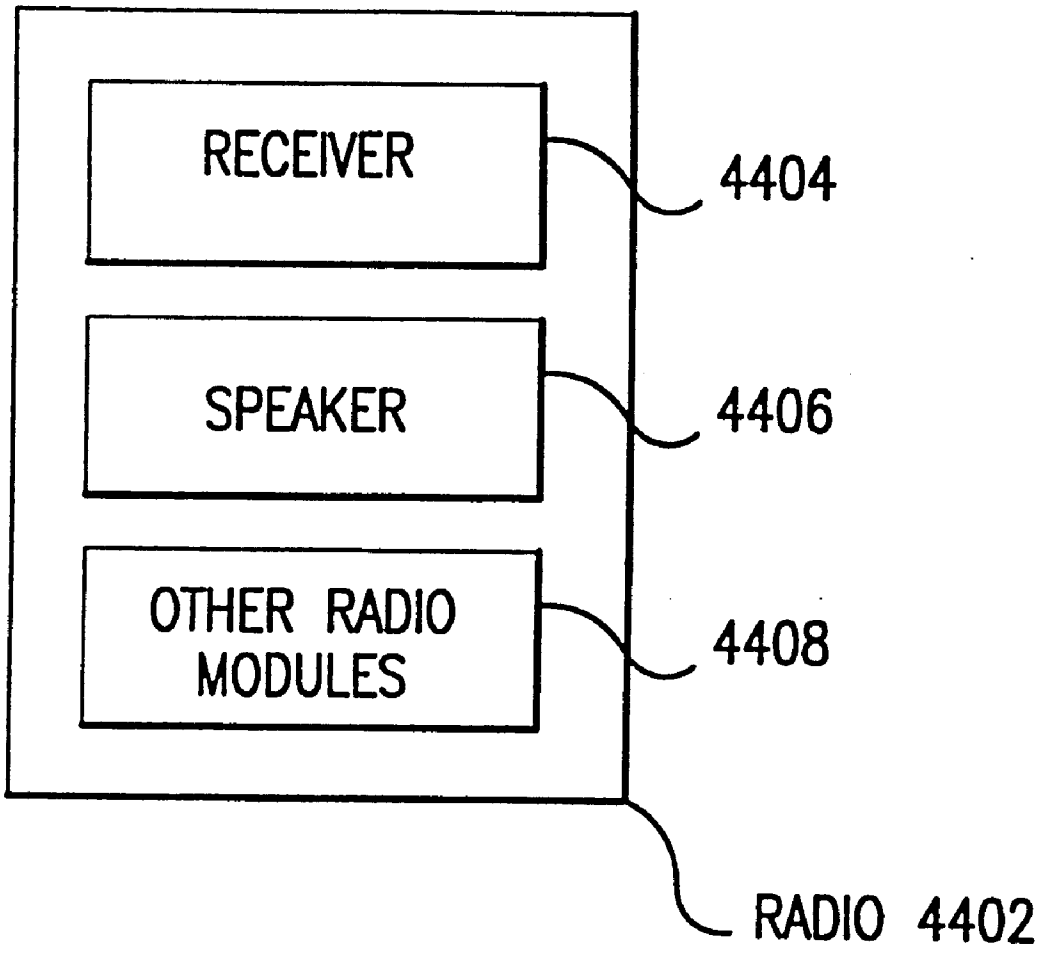

RECEIVER
4404
SPEAKER
4406
OTHER RADIO MODULES
4408
RADIO 4402

FIG. 44

APPLICATIONS OF UNIVERSAL FREQUENCY TRANSLATION

The present application is a continuation-in-part of pending U.S. application "Universal Frequency Translation, and Applications of Same," Ser. No. 09/176,027, filed Oct. 21, 1998, incorporated herein by reference in its entirety, now abandoned.

CROSS-REFERENCE TO OTHER APPLICATIONS

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

"Method and System for Down-Converting Electromagnetic Signals," Ser. No. 09/176,022, filed Oct. 21, 1998, now U.S. Pat. No. 6,061,551.

"Method and System for Frequency Up-Conversion," Ser. No. 09/176,154, filed Oct. 21, 1998, now U.S. Pat. No. 6,091,940.

"Method and System for Ensuring Reception of a Communications Signal," Ser. No. 09/176,415, filed Oct. 21, 1998, now U.S. Pat. No. 6,061,555.

"Integrated Frequency Translation And Selectivity," Ser. No. 09/175,966, filed Oct. 21, 1998, now U.S. Pat. No. 6,049,706.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention is generally related to frequency translation, and applications of same.

2. Related Art

Various communication components exist for performing frequency down-conversion, frequency up-conversion, and filtering. Also, schemes exist for signal reception in the face of potential jamming signals.

SUMMARY OF THE INVENTION

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.

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. The drawing in which an element first appears is typically indicated by the leftmost character (s) and/or digit(s) in the corresponding reference number.

BRIEF DESCRIPTION OF THE FIGURES

The present invention will be described with reference to the accompanying drawings, wherein:

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

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

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

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

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

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

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

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

FIGS. **6**A–**6**I illustrate example waveforms used to describe the operation of the UFU module;

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

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

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

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

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

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;

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

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

FIGS. **15**A–**15**F illustrate example applications of the UDF module according to embodiments of the invention;

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;

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

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

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

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

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**;

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

FIGS. **22**A–**22**F are example waveforms used to describe the system of FIG. **21**;

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

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;

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

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;

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

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

FIG. **25** illustrates an environment comprising telephones and base stations according to an embodiment of the invention;

FIG. **26** illustrates a positioning unit according to an embodiment of the invention;

FIGS. **27** and **28** illustrate communication networks according to embodiments of the invention;

FIGS. **29** and **30** illustrate pagers according to embodiments of the invention;

FIG. **31** illustrates a security system according to an embodiment of the invention;

FIG. **32** illustrates a repeater according to an embodiment of the invention;

FIG. **33** illustrates mobile radios according to an embodiment of the invention;

FIG. **34** illustrates an environment involving satellite communications according to an embodiment of the invention;

FIG. **35** illustrates a computer and its peripherals according to an embodiment of the invention;

FIGS. **36**–**38** illustrate home control devices according to embodiments of the invention;

FIG. **39** illustrates an example automobile according to an embodiment of the invention;

FIG. **40**A illustrates an example aircraft according to an embodiment of the invention;

FIG. **40**B illustrates an example boat according to an embodiment of the invention;

FIG. **41** illustrates radio controlled devices according to an embodiment of the invention;

FIGS. **42**A–**42**D illustrate example frequency bands operable with embodiments of the invention, where FIG. **42**D illustrates the orientation of FIGS. **42**A–**42**C (some overlap is shown in FIGS. **42**A–**42**C for illustrative purposes);

FIG. **43** illustrates an example radio synchronous watch according to an embodiment of the invention; and

FIG. **44** illustrates an example radio according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

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Universal Frequency Translation

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.

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.)

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.

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.

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.

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.

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.

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.

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.

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.

Frequency Down-conversion

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

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, the full disclosure of which is incorporated herein by reference. 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.

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. **20**A-**1**), the capacitor **2010** is in series with the input signal **2004** and the switch **2008** is shunted to ground (although it maybe 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**.

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.

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**.

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**.

Exemplary waveforms are shown in FIGS. **20**B–**20**F.

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.

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," application Ser. No. 09/176,022, Attorney Docket Number 1744.0010000.

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**.

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," application Ser. No. 09/176,022, Attorney Docket Number 1744.0010000.

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:

(Freq. of input signal **2004**)=n·(Freq. of control signal **2006**)±(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, . . .).

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:

$$(Freq_{input}-Freq_{IF})/n=Freq_{control}(901\ MHZ-1\ MHZ)/n=900/n$$

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.

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," application Ser. No. 09/176,022, Attorney Docket Number 1744.0010000.

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:

$$(Freq_{input}-Freq_{IF})/n=Freq_{control}(900\ MHZ-0\ MHZ)/n=900\ MHZ/n$$

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.

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," application Ser. No. 09/176,022, Attorney Docket Number 1744.0010000.

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 sub-set 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)

$$(Freq_{input}-Freq_{IF})/n=Freq_{control}(900\ MHZ-0\ MHZ)/n=900\ MHZ/n$$

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.

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−0 MHZ)/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).

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," application Ser. No. 09/176,022, Attorney Docket Number 1744.0010000.

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.

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**.

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," application Ser. No. 09/176,022, Attorney Docket Number 1744.0010000.

Frequency Up-conversion

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

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

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.

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.

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.

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.

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).

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.

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**.

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**.

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

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.

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**.

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.

Enhanced Signal Reception

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

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.

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.

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**.

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.

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.

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).

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.

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.

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**.

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**.

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_2 (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*.

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**.

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.

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 umnodulated 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**.

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.

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**.

Receiver **2112** will now be explored in greater detail to illustrate recovery of a demodulated baseband signal from received redundant spectrums. FIG. **24**A 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.

In one embodiment, optional medium interface module **2402** receives redundant spectrums **2210***b–d* (FIG. **22**E, and FIG. **24**B). 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. **24**C). 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. **24**D–**24**F, respectively). Demodulators **2416***a–c* independently demodulate spectrums **2406***a–c*, resulting in demodulated baseband signals **2418***a–c*, respectively (FIGS. **24**G–**24**I). 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.

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*.

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.

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.

Unified Down-conversion and Filtering

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

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.

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.

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.

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.

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.

The UDF module **1702** effectively performs various types of filtering, including but not limited to bandpass filtering,

low pass filtering, highpass filtering, notch filtering, all pass filtering, band stop filtering, etc., and combinations thereof.

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).

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.

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**.

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).

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.

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.

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

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.

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.

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.

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.

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.

Next, the input sample is held (that is, delayed).

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.

Thus, according to 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.

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.

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.

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

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.

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.

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, ϕ_1 and ϕ_2. ϕ_1 and ϕ_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.

Preferably, each of these switches closes on a rising edge of ϕ_1 or ϕ_2, and opens on the next corresponding falling edge of ϕ_1 or ϕ_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.

In the example of FIG. **19**, it is assumed that α_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.

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).

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.

At the rising edge of ϕ_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.

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, which is herein incorporated by reference in its entirety.

Also at the rising edge of ϕ_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.)

Also at the rising edge of ϕ_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**.

At the rising edge of ϕ_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**.

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).

Also at the rising edge of ϕ_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**.

Also at the rising edge of ϕ_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**.

At time t, at the rising edge of ϕ_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**.

Also at the rising edge of ϕ_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**.

Further at the rising edge of ϕ_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**.

At the rising edge of ϕ_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**.

Also at the rising edge of ϕ_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**.

Further at the rising edge of ϕ_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**.

At time t+1, at the rising edge of ϕ_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**.

Also at the rising edge of ϕ_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**.

Further at the rising edge of ϕ_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**.

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.

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}.

At the rising edge of ϕ_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.

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.

Example Application Embodiments of the Invention

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.

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.

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**.

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**.

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**.

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 UFT module **1006**, and the receiver **1008** can be implemented using a UFT module **1010**. This embodiment is shown in FIG. **10**.

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**.

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**.

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.

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.

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**.

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.

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**.

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.

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.

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**.

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.

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.

Additional example applications are described below.

Telephones

The present invention is directed to telephones that employ the UFT module for performing down-conversion and/or up conversion operations. According to embodiments of the invention, telephones include a receiver that uses a UFT module for frequency down-conversion (see, for example, FIG. **7**), and/or a transmitter that uses a UFT module for frequency up-conversion (see, for example, FIG. **8**). Alternatively, telephone embodiments of the invention employ a transceiver that utilizes one or more UFT modules for performing frequency down-conversion and/or up-conversion operations, as shown, for example, in FIGS. **10** and **11**.

Any type of telephone falls within the scope and spirit of the present invention, including but not limited to cordless phones (wherein UFT modules can be used in both the base unit and the handset to communicate therebetween, and in the base unit to communicate with the telephone company via wired or wireless service), cellular phones, satellite phones, etc.

FIG. **25** illustrates an example environment **2502** illustrating cellular phones and satellite phones according to embodiments of the invention. Cellular phones **2504**, **2508**, **2512** and **2516** each include a transceiver **2506**, **2510**, **2514**, and **2518**, respectively. Transceivers **2506**, **2510**, **2514**, and **2518** enable their respective cellular phones to communicate via a wireless communication medium with base stations **2520**, **2524**. According to the invention, the transceivers **2506**, **2510**, **2514**, and **2518** are implemented using one or more UFT modules. FIGS. **10** and **11** illustrate example transceivers **1002** and **1102** operable for use with the cellular phones of the present invention. Alternatively, one or more of cellular telephones **2504**, **2508**, **2512**, and **2516** may employ transmitter modules and receiver modules. Either or both of such transmitter modules and receiver modules may be implemented using UFT modules as shown in FIGS. **7** and **8**, for example.

FIG. **25** also illustrates a satellite telephone **2590** that communicates via satellites, such as satellite **2526**. The satellite telephone **2590** includes a transceiver **2592**, which is preferably implemented using one or more UFT modules, such as shown in FIGS. **10** and **11**, for example. Alternatively, the satellite phone **2590** may include a receiver module and a transmitter module, wherein either or both of the receiver module and the transmitter module is implemented using a UFT module, as shown, for example, in FIGS. **7** and **8**.

FIG. **25** also illustrates a cordless phone **2590** having a handset **2592** and a base station **2596**. The handset **2592** and the base station **2596** include transceivers **2594**, **2598** for communicating with each other preferably over a wireless link. Transceivers **2594**, **2598** are preferably implemented using one or more UFT modules, such as shown in FIGS. **10** and **11**, for example. Alternatively, transceivers **2594**, **2598** each may be replaced by a receiver module and a transmitter module, wherein either or both of the receiver module and the transmitter module is implemented using a UFT module, as shown, for example, in FIGS. **7** and **8**. In embodiments, the base station **2596** of the cordless phone **2590** may communicate with the base station **2520** via transceivers **2598**, **2521**, or using other communication modules.

Base Stations

The invention is directed to communication base stations that generally represent interfaces between telephones and telephone networks. Example base stations **2520**, **2524** according to the invention are illustrated in FIG. **25**. The invention is directed to other types of base stations, such as but not limited to base stations in cordless phones (see, for example, base station **2596** in cordless phone **2590** in FIG. **25**). The base stations **2520**, **2524**, **2596** each include a transceiver **2521**, **2525**, **2598**. According to embodiments of the invention, the transceivers **2521**, **2525**, **2598** are each implemented using one or more UFT modules (see, for example, FIGS. **10** and **11**). Alternatively, the base stations **2520**, **2524**, **2596** can be implemented using receiver modules and transmitter modules, wherein either or both of the receiver and transmitter modules are implemented using UFT modules (see, for example, FIGS. **7** and **8**).

As illustrated in FIG. **25**, base stations **2520**, **2524**, **2596** operate to connect telephones together via telephone networks **2522**, satellites **2526**, or other communication mediums, such as but not limited to data networks (such as the Internet). Also, the base stations **2520**, **2524**, enable telephones (such as cellular telephones **2508**, **2512**) to communicate with each other via a base station **2520** and not through a network or other intermediate communication medium. This is illustrated, for example, by dotted data flow line **2528**.

The invention is directed to all types of base stations, such as macro base stations (operating in networks that are relatively large), micro base stations (operating in networks that are relatively small), satellite base stations (operating

with satellites), cellular base stations (operating in a cellular telephone networks), data communication base stations (operating as gateways to computer networks), etc.

Positioning

The invention is directed to positioning devices that enable the determination of the location of an object.

FIG. **26** illustrates an example positioning unit **2608** according to an embodiment of the invention. The positioning unit **2608** includes a receiver **2610** for receiving positioning information from satellites, such as satellites **2604**, **2606**. Such positioning information is processed in a well known manner by a positioning module **2614** to determine the location of the positioning unit **2608**. Preferably, the receiver **2610** is implemented using a UFT module for performing frequency down-conversion operations (see, for example, FIG. **7**).

The positioning unit **2608** may include an optional transmitter **2612** for transmitting commands and/or other information to satellites **2604**, **2606**, or to other destinations. In an embodiment, the transmitter **2612** is implemented using a UFT module for performing frequency up-conversion operations (see, for example, FIG. **8**).

In an embodiment, the receiver **2610** and the optional transmitter **2612** are replaced in the positioning unit **2608** by a transceiver which includes one or more UFT modules (see, for example, FIGS. **10** and **11**).

The invention is directed to all types of positioning systems, such as but not limited to global positioning systems (GPS), differential GPS, local GPS, etc.

Data Communication

The invention is directed to data communication among data processing devices. For example, and without limitation, the invention is directed to computer networks (such as, for example, local area networks and wide area networks), modems, etc.

FIG. **27** illustrates an example environment **2702** wherein computers **2704**, **2712**, and **2726** are communicating with one another via a computer network **2734**. In the example of FIG. **27**, computer **2704** is communicating with the network **2734** via a wired link, whereas computers **2712** and **2726** are communicating with the network **2734** via wireless links.

In the teachings contained herein, for illustrative purposes, a link may be designated as being a wired link or a wireless link. Such designations are for example purposes only, and are not limiting. A link designated as being wireless may alternatively be wired. Similarly, a link designated as being wired may alternatively be wireless. This is applicable throughout the entire application.

The computers **2704**, **2712** and **2726** each include an interface **2706**, **2714**, and **2728**, respectively, for communicating with the network **2734**. The interfaces **2706**, **2714**, and **2728** include transmitters **2708**,**2716**, and **2730** respectively. Also, the interfaces **2706**, **2714** and **2728** include receivers **2710**, **2718**, and **2732** respectively. In embodiments of the invention, the transmitters **2708**, **2716** and **2730** are implemented using UFT modules for performing frequency up-conversion operations (see, for example, FIG. **8**). In embodiments, the receivers **2710**, **2718** and **2732** are implemented using UFT modules for performing frequency down-conversion operations (see, for example, FIG. **7**).

As noted above, the computers **2712** and **2726** interact with the network **2734** via wireless links. In embodiments of the invention, the interfaces **2714**, **2728** in computers **2712**, **2726** represent modems.

In embodiments, the network **2734** includes an interface or modem **2720** for communicating with the modems **2714**, **2728** in the computers **2712**, **2726**. In embodiments, the interface **2720** includes a transmitter **2722**, and a receiver **2724**. Either or both of the transmitter **2722**, and the receiver **2724** are implemented using UFT modules for performing frequency translation operations (see, for example, FIGS. **7** and **8**).

In alternative embodiments, one or more of the interfaces **2706**,**2714**,**2720**, and **2728** are implemented using transceivers that employ one or more UFT modules for performing frequency translation operations (see, for example, FIGS. **10** and **11**).

FIG. **28** illustrates another example data communication embodiment **2802**. Each of a plurality of computers **2804**, **2812**, **2814** and **2816** includes an interface, such as an interface **2806** shown in the computer **2804**. It should be understood that the other computers **2812**, **2814**, **2816** also include an interface such as an interface **2806**. The computers **2804**, **2812**, **2814** and **2816** communicate with each other via interfaces **2806** and wireless or wired links, thereby collectively representing a data communication network.

The interfaces **2806** may represent any computer interface or port, such as but not limited to a high speed internal interface, a wireless serial port, a wireless PS2 port, a wireless USB port, etc.

The interface **2806** includes a transmitter **2808** and a receiver **2810**. In embodiments of the invention, either or both of the transmitter **2808** and the receiver **2810** are implemented using UFT modules for frequency up-conversion and down-conversion (see, for example, FIGS. **7** and **8**). Alternatively, the interfaces **2806** can be implemented using a transceiver having one or more UFT modules for performing frequency translation operations (see, for example, FIGS. **10** and **11**).

Pagers

The invention is directed to pagers that employ UFT modules for performing frequency translation operations.

FIG. **29** illustrates an example pager **2902** according to an embodiment of the invention. Pager **2902** includes a receiver **2906** for receiving paging messages. In embodiments of the invention, the receiver **2906** is implemented using a UFT module for performing frequency down-conversion operations (see, for example, FIG. **7**).

The pager **2902** may also include a transmitter **2908** for sending pages, responses to pages, or other messages. In embodiments of the invention, the transmitter **2908** employs a UFT module for performing up-conversion operations (see, for example, FIG. **8**).

In alternative embodiments of the invention, the receiver **2906** and the transmitter **2908** are replaced by a transceiver that employs one or more UFT modules for performing frequency translation operations (see, for example, FIGS. **10** and **11**).

The pager **2902** also includes a display **2904** for displaying paging messages. Alternatively, or additionally, the pager **2902** includes other mechanisms for indicating the receipt of a page such as an audio mechanism that audibly indicates the receipt of a page, or a vibration mechanism that causes the pager **2902** to vibrate when a page is received.

The invention is directed to all types of pagers, such as and without limitation, one way pagers, two way pagers, etc. FIG. **30** illustrates a one way pager **3004** that includes a receiver **3006**. The one way pager **3004** is capable of only receiving pages. In the scenario of FIG. **30**, the one way pager **3004** receives a page **3005** from an entity which issues pages **3008**. The one way pager **3004** includes a receiver **3006** that is implemented using a UFT module for performing frequency down-conversion operations (see, for example, FIG. **7**).

FIG. **30** also illustrates a two way pager **3010**. The two way pager **3010** is capable of receiving paging messages and of transmitting pages, responses to paging messages, and/or other messages. The two way pager **3010** includes a receiver **3012** for receiving messages, and a transmitter **3014** for transmitting messages. One or both of the receiver **3012** and the transmitter **3014** may be implemented using UFT modules for performing frequency translation operations (see, for example, FIGS. **7** and **8**). Alternatively, the receiver **3010** and the transmitter **3014** can be replaced by a transceiver that employs one or more UFT modules for performing frequency translation operations (see, for example, FIGS. **10** and **11**).

Security

The invention is directed to security systems having components which are implemented using UFT modules for performing frequency translation operations. FIG. **31** illustrates an example security system **3102** which will be used to describe this aspect of the invention.

The security system **3102** includes sensors which sense potential intrusion/hazard events, such as the opening of a window, the opening of a door, the breakage of glass, motion, the application of pressure on floors, the disruption of laser beams, fire, smoke, carbon monoxide, etc. Upon detecting an intrusion/hazard event, the sensors transmit an intrusion/hazard event message to a monitor panel **3116** that includes a monitor and alarm module **3120**. The monitor and alarm module **3120** processes intrusion/hazard event messages in a well known manner. Such processing may include, for example, sending messages via a wired link **3134** or a wireless link **3136** to a monitoring center **3130**, which may in turn alert appropriate authorities **3132** (such as the police, the fire department, an ambulance service, etc.).

FIG. **31** illustrates a one way sensor **3109** that is positioned, for example, to detect the opening of a door **3106**. The one way sensor **3109** is not limited to this application, as would be apparent to persons skilled in the relevant arts. The one way sensor **3109** includes contacts **3108** and **3110** that are positioned on the door **3106** and the frame **3104** of the door **3106**. When the contacts **3108** and **3110** are displaced from one another, indicating the opening of the door **3106**, a transmitter **3112** contained in the contact **3110** transmits an intrusion/hazard event message **3114** to the monitor panel **3116**.

In an embodiment, the one way sensor **3109** also transmits status messages to the monitor panel **3116**. Preferably, these status messages are transmitted during a time period that is assigned to the one way sensor **3109**. The status messages include information that indicates the status of the one way sensor **3109**, such as if the sensor **3109** is operating within normal parameters, or if the sensor **3109** is damaged in some way. The monitor panel **3116**, upon receiving the status messages, takes appropriate action. For example, if a status message indicates that the sensor **3109** is damaged, then the monitor panel **3116** may display a message to this effect, and/or may transmit a call for service. If the monitor panel **3116** does not receive a status message from the one way sensor **3109** in the time period assigned to the one way sensor **3109**, then the monitor panel **3116** may issue an alarm indicating a potential intrusion or other breach in perimeter security.

Preferably, the transmitter **3112** is implemented using a UFT module to perform frequency up-conversion operations (see, for example, FIG. **8**).

The one way sensor **3109** is capable of only transmitting. The invention is also directed to two way sensors, an example of which is shown as **3125**. The two way sensor **3125** is shown in FIG. **31** as being positioned to detect the opening of a door **3138**. The two way sensor **3125** is not limited to this application, as would be apparent to persons skilled in the relevant arts.

The two way sensor **3125** includes contacts **3124** and **3126** for detecting the opening of the door **3138**. Upon detection of the opening of the door **3138**, a transceiver **3128** in contact **3126** sends an intrusion/hazard event message to the monitor panel **3116**. Preferably, the transceiver **3128** is implemented using one or more UFT modules for performing frequency translation operations (see, for example, FIGS. **10** and **11**). Alternatively, the two way sensor **3125** may employ a receiver and a transmitter, wherein one or both of the receiver and transmitter includes UFT modules for performing frequency translation operations (see, for example, FIGS. **7** and **8**).

The two way sensor **3125** is capable of both receiving and transmitting messages. Specifically, as just discussed, the transceiver **3128** in the two way sensor **3125** sends intrusion/hazard event messages to the monitor panel **3116**. Additionally, the two way sensor **3125** may receive commands or other messages (such as polls) from the monitor panel **3116** via the transceiver **3128**.

In an embodiment, the two way sensor **3125** also transmits status messages to the monitor panel **3116**. In an embodiment, these status messages are transmitted during a time period that is assigned to the two way sensor **3125**. The nature of these status message is described above.

In an alternative embodiment, the monitor panel **3116** polls for status messages. When the two way sensor **3125** receives an appropriate polling message, it transmits its status message to the monitor panel **3116**. If the monitor panel **3116** does not receive a status message in response to a polling message, then it may issue an alarm indicating a potential intrusion or other breach in perimeter security.

The monitor panel **3116** includes a transceiver **3118** for communicating with sensors, such as sensors **3109** and **3125**, and for also communicating with external entities, such as monitoring center **3130**, appropriate authorities **3132**, etc. The transceiver **3118** is preferably implemented using one or more UFT modules for performing frequency translation operations (see, for example, FIGS. **10** and **11**). Alternatively, the transceiver **3118** may be replaced by a receiver and a transmitter, wherein one or both of the receiver and transmitter is implemented using UFT modules for performing frequency translation operations (see, for example, FIGS. **7** and **8**).

In an embodiment, the monitor panel **3116** communicates with the monitoring center **3130** via a wired telephone line **3134**. However, communication over the telephone line **3134** may not always be possible. For example, at times, the telephone line **3134** may be inoperative due to natural events, failure, maintenance, sabotage, etc. Accordingly, embodiments of the invention include a back-up communication mechanism. For example, in FIG. **31**, the monitor panel **3116** includes a cellular phone backup system for communication with the monitoring center **3130**. This wireless link between the monitor panel **3116** and the monitoring center **3130** is represented by dotted line **3136**. The transceiver **3118** (or perhaps another transceiver contained in the monitoring panel **3116** or located proximate thereto) communicates with the monitor center **3130** via the wireless link **3136**. As noted, the transceiver **3118** is preferably implemented using one or more UFT modules for performing frequency translation operations (see, for example, FIGS. **10** and **11**).

Repeaters

The invention is directed to communication repeaters which, generally, receive a signal, optionally amplify the signal, and then transmit the amplified signal at the same or different frequency or frequencies. A repeater is of ten used in combination with one or more other repeaters to transmit a signal from a first point to a second point, where the first and second points are widely spaced from one another and/or are not in line of sight with one another.

This is illustrated, for example, in FIG. **32**, where a signal is being transmitted from a station **3204** to another station **3218**, where stations **3204**, **3218** are separated by a mountain. Signals from station **3204** are sent to station **3218** via repeaters **3206**,**3208**, and **3210**. Similarly, signals from station **3218** are sent to station **3204** via repeaters **3206**, **3208**, and **3210**.

Each of the repeaters **3206**, **3208**, **3210** includes a transceiver **3212**, **3214**, **3216**, respectively. In embodiments of the invention, the transceivers **3212**, **3214**, **3216** are implemented using UFT modules for performing frequency translation operations (see, for example, FIGS. **10** and **11**). Alternatively, the transceivers **3212**, **3214**, **3216** may be replaced by receivers and transmitters, wherein the receivers and transmitters are implemented using UFT modules for performing frequency translation operations (see, for example, FIGS. **7** and **8**).

The invention includes all types of repeaters. For example, the repeater scenario described above represents a long distance or long range use of repeaters (for example, macro use). The invention is also applicable to short distance use of repeaters (for example, micro use). An example of this is shown in FIG. **32**, where a repeater **3252** having a transceiver **3254** is positioned in a building or home **3250**. The repeater **3252** relays signals from a cell phone **3256** or other communication device (such as a computer with a modem, a television with an input for programming, a security system, a home control system, etc.) to a base station **3218** and/or another repeater **3210**. In the example scenario of FIG. **32**, the combination of the cell phone **3256** and the repeater **3252** is generally similar to a cordless telephone. In embodiments of the invention, the transceivers **3254**, **3258** are implemented using UFT modules for performing frequency translation operations (see, for example, FIGS. **10** and **11**). Alternatively, the transceivers **3254**, **3258** may be replaced by receivers and transmitters, wherein the receivers and transmitters are implemented using UFT modules for performing frequency translation operations (see, for example, FIGS. **7** and **8**).

Mobile Radios

The invention is directed to mobile radios that use UFT modules for performing frequency translation operations. The invention is applicable to all types of mobile radios operating in any and all bands for any and all services, such as but not limited to walkie-talkies, citizen band, business, ISM (Industrial Scientific Medical), amateur radio, weather band, etc. See FIGS. **42**A–**42**D for example frequency bands operable with the present invention (the invention is not limited to these bands).

FIG. **33** illustrates an example scenario **3302** where a first mobile radio **3304** is communicating with a second mobile radio **3306**. Each of the mobile radios **3304**,**3306** includes a transmitter **3308**, **3312** and a receiver **3310**, **3314**, respectively. The transmitter **3308**, **3312**, and/or the receivers **3310**, **3314** are implemented using UFT modules for performing frequency translation operations (see, for example, FIGS. **7** and **8**). Alternatively, the transmitters **3308**, **3312** and the receivers **3310**, **3314** can be replaced by transceivers which utilize one or more UFT modules for performing frequency translation operations (see, for example, FIGS. **10** and **11**).

The invention is also directed to receive-only radios, such as the radio **4402** shown in FIG. **44**. The radio **4402** includes a receiver **4404** to receive broadcasts. The radio **4402** also includes a speaker **4406** and other well known radio modules **4408**. The radio **4402** may work in any band, such as but not limited to AM, FM, weather band, etc. See FIGS. **42**A–**42**D for an example of the bands. The receiver **4404** is preferably implemented using a UFT module (see, for example, FIG. **7**).

Satellite Up/Down Links

The invention is directed to systems and methods for communicating via satellites. This includes, for example, direct satellite systems (DSS), direct broadcast satellite (DBS), ultra wideband public/private services, etc.

FIG. **34** illustrates an example environment **3402** where content transmitted from a content provider **3420** is received by a private home **3404** via a satellite **3416**. A satellite unit **3408** is located in the home **3404**. The satellite unit **3408** includes a receiver **3410** for receiving signals from the satellite **3416** and a transmitter **3412** for transmitting signals to the satellite **3416**.

In operation, the content provider **3420** transmits content to the satellite **3416**, which then broadcasts that content. The content is received at the home **3404** by an antenna or satellite dish **3414**. The received signals are provided to the receiver **3410** of the satellite unit **3408**, which then down-converts and demodulates, as necessary, the signal. The data is then provided to a monitor **3406** for presentation to the user. The monitor **3406** may be any device capable of receiving and displaying the content from the content provider **3420**, such as a TV, a computer monitor, etc.

In embodiments of the invention, the receiver **3410** and/or the transmitter **3412** are implemented using UFT modules for performing frequency translation operations (see, for example, FIGS. **7** and **8**). In other embodiments, the receiver **3410** and the transmitter **3412** are replaced by a transceiver which employs one or more UFT modules for performing frequency translation operations (see, for example, FIGS. **10** and **11**).

The satellite unit **3408** can be used to send and receive large amounts of data via ultra wide band satellite channels. For example, in addition to receiving content from the content provider, is possible to use the satellite unit **3408** to exchange data with other locations **3418** via the satellite links provided by satellites (such as satellite **3416**).

Command and Control

The invention is directed to command and control applications. Example command and control applications are described below for illustrative purposes. The invention is not limited to these examples.

PC Peripherals

The present invention is directed to computer peripherals that communicate with a computer over a wireless communication medium. FIG. **35** illustrates an example computer **3502** which includes a number of peripherals such as but not limited to a monitor **3506**, a keyboard **3510**, a mouse **3514**, a storage device **3518**, and an interface/port **3522**. It should be understood that the peripherals shown in FIG. **35** are presented for illustrative purposes only, and are not limiting. The invention is directed to all devices that may interact with a computer.

The peripherals shown in FIG. **35** interact with a computer **3502** via a wireless communication medium. The computer **3502** includes one or more transceivers **3504** for

communicating with peripherals. Preferably, the transceivers **3504** are implemented using UFT modules for performing frequency translation operations (see, for example, FIGS. **10** and **11**). Alternatively, the transceiver **3504** in the computer **3502** may be replaced by receivers and transmitters, wherein any of the receivers and transmitters are implemented by using UFT modules for performing frequency translation operations (see, for example, FIGS. **7** and **8**).

Each of the peripherals includes a transceiver for communicating with the computer **3502**. In embodiments of the invention, the transceivers are implemented using UFT modules for performing frequency translation operations (see, for example, FIGS. **10** and **11**). In other embodiments, the transceivers are replaced by receivers and transmitters which are implemented by UFT modules for performing frequency translation operations (see, for example, FIGS. **7** and **8**).

The computer **3502** may send a signal to the peripherals that indicates that it is receiving signals from the peripherals. The peripherals could then provide an indication that a link with the computer **3502** is established (such as, for example, turning a green light on).

In some embodiments, some peripherals may be transmit-only, in which case they would include a transmitter instead of a transceiver. Some peripherals which may be transmit only include, for example, the keyboard **3510**, the mouse **3514**, and/or the monitor **3506**. Preferably, the transmitter is implemented using a UFT module for performing frequency up-conversion operations (see, for example, FIG. **8**).

Building/Home Functions

The invention is directed to devices for controlling home functions. For example, and without limitation, the invention is directed to controlling thermostats, meter reading, smart controls, including C-Bus and X-**10**, garage door openers, intercoms, video rabbits, audio rabbits, etc. These examples are provided for purposes of illustration, and not limitation. The invention includes other home functions, appliances, and devices, as will be apparent to persons skilled in the relevant art(s) based on the teachings contained herein.

FIG. **36** illustrates an example home control unit **3604**. The home control unit **3604** includes one or more transceivers **3606** for interacting with remote devices. In embodiments of the invention, the transceivers **3606** are implemented using UFT modules for performing frequency translation operations (see, for example, FIGS. **10** and **11**). In other embodiments, the transceivers **3606** are replaced by receivers and transmitters that employ UFT modules for performing frequency translation operations (see, for example, FIGS. **7** and **8**). In some embodiments, the home control unit **3604** can be transmit only, in which case the transceiver **3606** is replaced by a transmitter which is preferably implemented using a UFT module.

The home control unit **3604** interacts with remote devices for remotely accessing, controlling, and otherwise interacting with home functional devices. For example, the home control unit **3604** can be used to control appliances **3608** such as, but not limited to, lamps, televisions, computers, video recorders, audio recorders, answering machines, etc. The appliances **3608** are coupled to one or more interfaces **3610**. The interfaces **3610** each includes a transceiver **3612** for communicating with the home control **3604**. The transceiver **3612** includes one or more UFT modules for performing frequency translation operations (see, for example, FIGS. **10** and **11**). Alternatively, the interfaces **3610** each includes a receiver and a transmitter, either or both of which include UFT modules for performing frequency translation operations (see, for example, FIGS. **7** and **8**).

The home control unit **3604** can also remotely access and control other home devices, such as a thermostat **3618** and a garage door opener **3614**. Such devices which interact with the home control unit **3604** include transceivers, such as transceiver **3620** in the thermostat **3618**, and transceiver **3616** in the garage opener **3614**. The transceivers **3620,3616** include UFT modules for performing frequency translation operations (see, for example, FIGS. **10** and **11**). Alternatively, the transceivers **3616**, **3620** can be replaced by receivers and transmitters for performing translation operations (see, for example, FIGS. **7** and **8**).

The invention is also directed to the control of home electronic devices, such as but not limited to televisions, VCRs, stereos, CD players, amplifiers, tuners, computers, video games, etc. For example, FIG. **36** illustrates a television **3650** and a VCR **3654** having receivers **3652**, **3656** for receiving control signals from remote control(s) **3658**, where each of the remote control(s) **3658** includes a transmitter **3660**. The receivers **3652**, **3656** are preferably implemented using UFT modules (see, for example, FIG. **7**), and the transmitter **3660** is preferably implemented using a UFT module (see, for example, FIG. **8**).

In some cases, it may be necessary to install an adapter **3666** to enable a device to operate with remote control(s) **3658**. Consider a stereo **3662** having an infrared receiver **3664** to receive infrared control signals. Depending on their implementation, some embodiments of the remote control(s) **3658** may not transmit signals that can be accurately received by the infrared receiver **3664**. In such cases, it is possible to locate or affix a receiver **3668** (preferably implemented using a UFT module) and an adapter **3666** to the stereo **3662**. The receiver **3668** operates to receive control signals from the remote control(s) **3658**. The adapter **3666** converts the received signals to signals that can be received by the infrared receiver **3664**.

The invention can also be used to enable the remote access to home control components by external entities. For example, FIG. **37** illustrates a scenario **3702** where a utility company **3704** remotely accesses a utility meter **3710** that records the amount of utilities used in the home **3708**. The utility company **3704** may represent, for example, a service vehicle or a site or office. The utility meter **3710** and the utility company **3704** include transceivers **3712**, **3706**, respectively, for communicating with each other. Preferably, the transceivers **3706,3712** utilize UFT modules for performing frequency translation operations (see, for example, FIGS. **10** and **11**). Alternatively, the transceivers **3706,3712** are replaced by receivers and transmitters, wherein the receivers and/or transmitters are implemented using UFT modules for performing frequency translation operations (see, for example, FIGS. **7** and **8**).

The invention is also directed to other home devices. For example, and without limitation, the invention is directed to intercoms. As shown in FIG. **38**, intercoms **3804**, **3806** include transceivers **3808**, **3810**, respectively, for communicating with other. In embodiments of the invention, the transceivers **3808,3810** include UFT modules for performing frequency translation operations (see, for example, FIGS. **10** and **11**). In other embodiments, the transceivers **3808**, **3810** are replaced by receivers and transmitters, wherein the receivers and/or transmitters are implemented using UFT modules for performing frequency translation operations (see, for example, FIGS. **7** and **8**).

The invention can also be used to transmit signals from one home device to another home device. For example, the

invention is applicable for propagating video and/or audio signals throughout a home. This is shown, for example, in FIG. **38**, where TVs **3812**, **3814** include transceivers **3816**, **3818** for communicating with one another. The transceivers **3816**, **3818** enabled video signals to be sent from one of the TVs to another. In embodiments of the invention, the transceivers **3816**, **3818** are implemented using UFT modules for performing frequency translation operations (see, for example, FIGS. **10** and **11**). In other embodiments, the transceivers **3816**, **3818** are replaced by receivers and transmitters, wherein the receivers and/or transmitters are implemented using UFT modules for performing frequency translation operations (see, for example, FIGS. **7** and **8**).

FIG. **38** also illustrates an embodiment where transceivers **3824**, **3826** are used to communicate audio signals between a CD player **3820** and a multi-media receiver **3822**. In embodiments, the transceivers **3824**, **3826** are implemented using UFT modules for performing frequency translation operations (see, for example, FIGS. **10** and **11**). In other embodiments, the transceivers **3824**, **3826** are replaced by receivers and transmitters, wherein the receivers and/or transmitters are implemented using UFT modules for performing frequency translation operations (see, for example, FIGS. **7** and **8**).

In the figures described above, many of the components are shown as including transceivers. In practice, however, some components are receive only or transmit only. This is true for some of the devices discussed throughout this application, as will be apparent to persons skilled in the relevant art(s). In such cases, the transceivers can be replaced by receivers or transmitters, which are preferably implemented using UFT modules for performing frequency translation operations (see, for example, FIGS. **7** and **8**).

Automotive Controls

The invention is directed to automotive controls, and other devices of ten used in or with automobiles.

FIG. **39** illustrates an example car **3902** according to an embodiment of the invention. The car **3902** includes a number of devices that communicate with objects.

For example, the car **3902** includes an interface **3904** (or multiple interfaces) for communicating with external devices, such as but not limited to gasoline pumps **3912** and toll booths **3916**. In operation, for example, when the car **3902** approaches the toll booth **3916**, the interface **3904** communicates with the toll booth **3916** in an appropriate and well known manner to enable the car **3902** to pass through the toll booth **3916**. Also, when the car **3902** is proximate to the gasoline pump **3912**, the interface **3904** interacts with the gas pump in an appropriate and well known manner to enable the driver of the car **3902** to utilize the gas pump **3912** to fill the car **3902** with gas.

The car also includes a controllable door lock **3908**. Upon receipt of an appropriate signal from a keyless entry device **3914**, the controllable door lock **3908** locks or unlocks (based on the signal received).

The car further includes a controller **3910**, which controls and interacts with the systems, instrumentation, and other devices of the car **3902**. The controller **3910** communicates with a control unit **3918**. It is possible to control the car **3902** via use of the control unit **3918**. The control unit **3918** sends commands to the controller **3910**. The controller **3910** performs the functions specified in the commands from the control unit **3918**. Also, the control unit **3918** sends queries to the controller **3910**. The controller **3910** transmits to the control unit **3918** the car-related information specified in the queries. Thus, any car functions under the control of the controller **3910** can be controlled via the control unit **3918**.

It is noted that the features and functions described above and shown in FIG. **39** are provided for illustrative purposes only, and are not limiting. The invention is applicable to other car related devices, such as but not limited to security systems, GPS systems, telephones, etc.

The interface **3904**, the door lock **3908**, the controller **3910**, and any other car devices of interest include one or more transceivers **3906**A, **3906**B, **3906**C for communicating with external devices. Also, the gasoline pump **3912**, keyless entry device **3914**, toll booth **3916**, control unit **3918**, and any other appropriate devices include transceivers **3906**D, **3906**E, **3906**F, **3906**G for communicating with the car **3902**.

Preferably, the transceivers **3906** are implemented using UFT modules for performing frequency translation operations (see FIGS. **10** and **11**). Alternatively, one or more of the transceivers **3906** can be replaced by receiver(s) and/or transmitter(s), wherein the receiver(s) and/or transmitter(s) are implemented using UFT modules for performing frequency translation operations (see, for example, FIGS. **7** and **8**).

Aircraft Controls

The invention is directed to aircraft controls, and other devices of ten used in or with aircrafts.

FIG. **40**A illustrates an example aircraft **4002** according to an embodiment of the invention. The aircraft **4002** includes, for example, a GPS unit **4012** for receipt of positioning information. The GPS unit **4012** is coupled to a transceiver **4004**D for receiving positioning information.

The aircraft **4002** also includes one or more radio(s) **4010** for communication with external entities. The radio(s) **4010** include one or more transceivers **4004**C for enabling such communication.

The aircraft **4002** also includes monitors **4008** for displaying, for example, video programming, and computers **4009** that transmit and receive information over a communication network. The monitors **4008** and computers **4009** include one or more transceiver(s) **4004**B for communicating with external devices, such as video programming sources and/or data communication networks.

The aircraft **4002** includes a controller **4006** for controlling the systems, instrumentation, and other devices of the aircraft **4002**. The controller **4006** can communicate with external devices via a transceiver **4004**A. External devices may control the aircraft **4002** by sending appropriate commands, queries, and other messages to the controller **4006**.

It is noted that the features and functions described above and shown in FIG. **40**A are provided for illustrative purposes only, and are not limiting. The invention is applicable to other aircraft related devices, such as but not limited to security systems, telephones, etc.

Preferably, the transceivers **4004** are implemented using UFT modules for performing frequency translation operations (see FIGS. **10** and **11**). Alternatively, one or more of the transceivers **4004** can be replaced by receiver(s) and/or transmitter(s), wherein the receiver(s) and/or transmitter(s) are implemented using UFT modules for performing frequency translation operations (see, for example, FIGS. **7** and **8**).

Maritime Controls

The invention is directed to maritime controls, and other maritime-related devices.

FIG. **40**B illustrates an example boat **4050** according to an embodiment of the invention. The devices in the example boat **4050** of FIG. **40**B are similar to the devices in the example aircraft **4002** of FIG. **40**A. Accordingly, the description above relating to FIG. **40**A applies to FIG. **40**B.

Radio Control

The invention is directed to radio controlled devices, such as but not limited to radio controlled cars, planes and boats.

FIG. **41** illustrates radio controlled devices according to embodiments of the invention. A controller **4104** includes control logic **4106** for generating commands to control various devices, such as a plane **4110**, a car **4116**, and a boat **4122**. The controller **4104** includes a transceiver **4108** for communication with the plane **4110**, car **4146**, and boat **4122**.

The plane **4110**, the car **4116**, and the boat **4122** includes control modules **4112**,**4118** and **4124** for processing commands received from the controller **4104**. Also, control modules **4112**, **4118**, and **4124** maintain status information that can be communicated back to the control **4104**. The plane **4110**, the car **4116** and boat **4122** include transceivers **4114**, **4120**, and **4126**, respectively, for communicating with the controller **4104**.

Preferably, the transceivers **4108**, **4114**, **4120**, and **4126** are implemented using UFT modules for performing frequency translation operations (see FIGS. **10** and **11**). Alternatively, the transceivers **4108**, **4114**, **4120**, and **4126** can be replaced by receivers and transmitters, wherein the receivers and/or transmitters are implemented using UFT modules for performing frequency translation operations (see, for example, FIGS. **7** and **8**).

Radio Synchronous Watch

The invention is directed to radio synchronous time devices. Radio synchronous time devices are time pieces that receive signals representative of the current time. An example source of such time signals is radio station WWV in Boulder, Colo. Radio synchronous time devices update their internal clocks with the current time information contained in the signals.

The invention is directed to all types of radio synchronous time devices, such as alarm clocks, clocks in appliances and electronic equipment such as clocks in computers, clocks in televisions, clocks in VCRs, wrist watches, home and office clocks, clocks in ovens and other appliances, etc.

FIG. **43** illustrates an example radio synchronous time piece **4302**, an example of which is shown in FIG. **43**. The radio synchronous time piece **4302** includes a display **4304** to display the current time and time zone (and perhaps the position of the time piece **4302**), receiver(s) **4306**, a time module **4310**, a GPS module **4308**, and a battery **4312**.

The receiver **4306** receives time signals from a time information source **4314**. Based on the time signals, the time module **4310** determines the current time in a well known manner. Depending on the nature of the received time signals, the current time may be GMT. The current time is displayed in display **4304**.

The receiver **4306** may receive the time signals continuously, periodically, upon user command, or sporadically (depending on the signal strength of the time information source **4314**, for example). At times when the receiver **4306** is not receiving time signals, the time module **4310** determines the current time in a well known manner (i.e., the time module **4310** operates as a clock), using the indication of time in the last received time signal. In some embodiments, the time piece **4302** may provide some indication when it is receiving time signals from the time information source **4314**. For example, the time piece **4302** may provide a visual or audible indication (such as lighting an LED or beeping when time signals are being received). The user can elect to disable this feature.

The receiver **4306** may also receive positioning information from global positioning satellites **4316**. The GPS module **4308** uses the received positioning information to determine the location of the time piece **4302**. The time module **4310** uses the location information to determine the time zone and/or the local time. The time zone, the local time, and/or the location of the time piece **4302** may be displayed in the display **4304**.

Preferably, the receiver(s) **4306** are implemented using UFT modules for performing frequency translation operations (see, for example, FIG. **7**).

The invention is particularly well suited for implementation as a time piece given the low power requirements of UFT modules. Time pieces implemented using UFT modules increase the effective life of the battery **4312**.

Other Example Applications

The application embodiments described above are provided for purposes of illustration. These applications and embodiments are not intended to limit the invention. Alternate and additional applications and 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. For example, such alternate and additional applications and embodiments include combinations of those described above. Such combinations will be apparent to persons skilled in the relevant art(s) based on the herein teachings.

Additional applications and embodiments are described below.

Applications Involving Enhanced Signal Reception

As discussed above, the invention is directed to methods and systems for enhanced signal reception (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.

Applications Involving Unified Down-conversion and Filtering

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

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.

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.

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

Conclusion

Example implementations of the systems and components of the invention have been described herein. As noted elsewhere, these example implementations have been described for illustrative purposes only, and are not limiting. Other implementation embodiments are possible and covered by the invention, such as but not limited to software and software/hardware implementations of the systems and components of the invention. Such implementation embodiments will be apparent to persons skilled in the relevant art(s) based on the teachings contained herein.

While various application 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. 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. An apparatus, comprising:

a universal frequency down-converter (UFD), including a switch, an integrator coupled to said switch, and a pulse generator coupled to said switch; and

wherein said pulse generator outputs to said switch at an aliasing rate that is determined according to:

(a frequency of a carrier signal +/− a frequency of a lower frequency signal) divided by N;

wherein said pulses have apertures and said causes switch to close and sub-sample the carrier signal over said apertures, and wherein energy is transferred from the carrier signal and integrated using said integrator during said apertures said pulses, and wherein the lower frequency signal is generated from the transferred energy; and

means for operating said UFD to perform at least frequency translation operations for at least one of (a)–(l);

(a) a telephone;

(b) a communication base station;

(c) a positioning unit;

(d) a data communication device;

(d1) a communication network;

(e) a pager;

(f) a security system component;

(g) a repeater;

(h) a mobile radio;

(i) a satellite communication system;

(j) a command and control unit;

(k) a radio controlled device; and

(l) a radio synchronous time piece.

2. An apparatus, comprising:

at least one universal frequency down-conversion module, including a switch, an integrator coupled to said switch, and a pulse generator coupled to said switch; and

wherein said pulse generator outputs pulses to said switch at an aliasing rate that is determined according to:

(a frequency of a carrier signal +/− a frequency of a lower frequency signal) divided by N;

wherein said pulses have apertures and cause said switch to close and sub-sample the carrier signal over said apertures, and wherein energy is transferred from the carrier signal and integrated using said integrator during said apertures of said pulses, and wherein the lower frequency signal is generated from the transferred energy.

3. The apparatus of claim **2**, further comprising:

at least one universal frequency up-conversion module.

4. The apparatus of claim **2**, further comprising:

a positioning unit that receives positioning information from at least one satellite to determine the location of an object, said positioning unit comprising said at least one universal frequency down-conversion module.

5. The apparatus of claim **4**, wherein said positioning unit further comprises at least one universal frequency up-conversion module.

6. The apparatus of claim **2**, wherein said apparatus represents a pager.

7. The apparatus of claim **6**, wherein said apparatus further comprises at least one universal frequency up-conversion module.

8. The apparatus of claim **2**, wherein said apparatus represents a mobile radio.

9. The apparatus of claim **8**, wherein said apparatus further comprises at least one universal frequency up-conversion module.

10. The apparatus of claim **2**, further comprising:

a peripheral device comprising said at least one universal frequency up-conversion module;

whereby said peripheral device communicates via a wireless medium with a computer through an interface comprising at least one universal frequency down-conversion module, whereby said interface is coupled to the computer.

11. The apparatus of claim **10**, wherein said peripheral device is a mouse, a keyboard, a monitor, or a storage device.

12. The apparatus of claim **2**, wherein said apparatus represents a wireless interface for a home device.

13. The apparatus of claim **12**, wherein the home device is a lamp, a television, a computer, a video recorder, an audio recorder, or an answering machine.

14. The apparatus of claim **2**, wherein said apparatus represents a home electronic device that can be remotely accessed and controlled.

15. The apparatus of claim **14**, wherein said home electronic device is a lamp, a television, a computer, a video recorder, an audio recorder, an answering machine, a thermostat, a garage door opener, a stereo, a CD player, an amplifier, a tuner, a video game, or a wireless home device adaptor.

16. The apparatus of claim **14**, further comprising at least one universal frequency up-conversion module.

17. The apparatus of claim **2**, wherein said apparatus represents a global positioning system unit in an aircraft.

18. The apparatus of claim **2**, wherein said apparatus represents a global positioning system unit in a boat.

19. The apparatus of claim **2**, further comprising:

a time piece that comprises

a receiver that comprises said at least one universal frequency down-conversion module,

a time module that determines a current time from a first signal received by said receiver, and

a display that displays said determined current time;

whereby said apparatus represents a radio synchronous time device.

20. The apparatus of claim **19**, wherein said time piece further comprises:

a global positioning system module that determines a location from a second signal received by said receiver, wherein said display displays said determined location.

21. The apparatus of claim **19**, wherein said time piece is a computer clock, a television clock, a video cassette recorder clock, a wrist watch, a home clock, an office clock, an oven clock, or an appliance clock.

22. The apparatus of claim **2**, wherein each of said at least one universal frequency down-conversion module comprises:

an energy transfer signal generator;

a switch module controlled by said energy transfer signal generator; and

a storage module coupled to said switch module.

23. The apparatus of claim **22**, wherein said each of said at least one universal frequency down-conversion module further comprises:

an input impedance match circuit coupled to an input of said each of said at least one universal frequency down-conversion module.

24. The apparatus of claim 22, wherein said each of said at least one universal frequency down-conversion module further comprises:

an output impedance match circuit coupled to an output of said each of said at least one universal frequency down-conversion module.

25. The apparatus of claim 22, wherein said switch module is coupled between an input of said each of said at least one universal frequency down-conversion module and said storage module.

26. The apparatus of claim 22, wherein said each of said at least one universal frequency down-conversion module further comprises:

a tank circuit coupled between an input of said each of said at least one universal frequency down-conversion module and said switch module.

27. The apparatus of claim 22, wherein said each of said at least one universal frequency down-conversion module further comprises:

a feed forward circuit in parallel with said switch module.

28. The apparatus of claim 22, wherein said storage module is coupled between an input of said each of said at least one universal frequency down-conversion module and said switch module.

29. The apparatus of claim 22, wherein said each of said at least one universal frequency down-conversion module is tuned for at least one frequency greater than one Giga Hertz.

30. The apparatus of claim 22, wherein said each of said at least one universal frequency down-conversion module is tuned for at least one frequency between 10 Mega Hertz and 10 Giga Hertz.

31. The apparatus of claim 22, wherein said energy transfer signal generator comprises an asynchronous energy transfer signal generator.

32. The apparatus of claim 3, wherein each of said at least one universal frequency up-conversion module comprises:

a switch module that receives an oscillating signal, wherein said oscillating signal controls gating of said switch module to thereby generate a periodic signal having a plurality of harmonics; and

a filter coupled to said switch module to isolate at least one of said plurality of harmonics.

33. The apparatus of claim 32, wherein said switch module gates a bias signal, said bias signal being a function of an information signal, and wherein the amplitude of said periodic signal is a function of said bias signal.

34. The apparatus of claim 32, wherein said oscillating signal is a modulated oscillating signal, wherein said periodic signal is modulated substantially the same as said modulated oscillating signal, and wherein each of said plurality of harmonics is modulated substantially the same as said periodic signal.

35. The apparatus of claim 34, wherein said modulated oscillating signal is a function of a first information signal, wherein said switch module gates a bias signal, wherein said bias signal is a function of a second information signal, and wherein the amplitude of said periodic signal is a function of said bias signal.

36. The apparatus of claim 3, further comprising:

a handset comprising said at least one first universal frequency up-conversion module and said at least one first universal frequency down-conversion module; and

a base unit that communicates with said handset via wireless links, said base unit comprising at least one second universal frequency up-conversion module and at least one second universal frequency down-conversion module;

whereby said apparatus represents a cordless telephone apparatus.

37. The apparatus of claim 3, further comprising:

a telephone comprising said at least one universal frequency up-conversion module and said at least one universal frequency down-conversion module.

38. The apparatus of claim 37, wherein said telephone is a cellular telephone or a satellite telephone.

39. The apparatus of claim 3, further comprising:

a base station that interfaces with telephones via wireless links, said base station comprising said at least one universal frequency up-conversion module and said at least one universal frequency down-conversion module.

40. The apparatus of claim 3, further comprising:

a network; and

an interface coupled to said network, whereby said interface connects data processing devices to said network via wireless links, said interface comprising said at least one universal frequency up-conversion module and said at least one universal frequency down-conversion module;

whereby said apparatus represents a data communication network.

41. The apparatus of claim 3, further comprising:

a monitor panel comprising

said at least one first universal frequency up-conversion module, and

said at least one universal frequency down-conversion module; and

at least one sensor that transmits intrusion/hazard event signals to said monitor panel, each of said at least one sensor comprising at least one second universal frequency up-conversion module;

whereby said apparatus represents a security system.

42. The apparatus of claim 3, wherein said apparatus represents a repeater.

43. The apparatus of claim 3, wherein said apparatus represents a satellite unit.

44. The apparatus of claim 3, further comprising:

a wireless home control unit that comprises said at least one universal frequency up-conversion module and said at least one universal frequency down-conversion module;

whereby said apparatus represents an apparatus for home control.

45. The apparatus of claim 44, wherein said wireless home control unit is a remote control unit.

46. The apparatus of claim 3, further comprising:

a home control unit that comprises said at least one universal frequency up-conversion module; and

a home electronic device that comprises said at least one first first universal frequency down-conversion module, wherein said home electronic device communicates with said home control unit via a wireless medium;

whereby said apparatus represents a home control system.

47. The apparatus of claim 46, wherein said home control unit further comprises at least one second universal frequency down-conversion module.

48. The apparatus of claim 47, wherein said home electronic device further comprises at least one second universal frequency up-conversion module.

49. The apparatus of claim 48, wherein said home electronic device is a lamp, a television, a computer, a video recorder, an audio recorder, an answering machine, a

thermostat, a garage door opener, a stereo, a CD player, an amplifier, a tuner, a video game, or a wireless home device adaptor.

50. The apparatus of claim **49**, wherein said home control unit is a remote control unit.

51. The apparatus of claim **3**, wherein said apparatus is a wireless utility meter that communicates with a utility company, comprising:

said at least one first universal frequency up-conversion module; and

said at least one first universal frequency down-conversion module.

52. The apparatus of claim **3**, further comprising:

a plurality of intercoms communicating with each other via a wireless medium, each of said plurality of intercoms comprising

said at least one universal frequency up-conversion module, and

said at least one universal frequency down-conversion module;

whereby said apparatus represents an intercom communication system.

53. The apparatus of claim **3**, further comprising:

an interface that communicates with at least one external device via a wireless medium, said interface comprising

said at least one universal frequency down-conversion module, and

said at least one universal frequency up-conversion module;

whereby said apparatus represents an apparatus in an automobile for communicating with external devices.

54. The apparatus of claim **3**, further comprising:

a device that communicates with an automobile communication interface via a wireless medium, said device comprising

said at least one universal frequency down-conversion module, and

said at least one universal frequency up-conversion module;

whereby said apparatus represents an apparatus for communicating with an automobile.

55. The apparatus of claim **54**, wherein said device is a gasoline pump or a toll booth.

56. The apparatus of claim **3**, further comprising:

a door lock that comprises

said at least one first universal frequency down-conversion module, and

said at least one first universal frequency up-conversion module; and

a keyless entry device that communicates with said door lock via a wireless medium, said keyless entry device comprising

at least one second universal frequency down-conversion module, and

at least one second universal frequency up-conversion module;

whereby said apparatus represents a controllable door lock apparatus.

57. The apparatus of claim **3**, further comprising:

an automobile controller that comprises

said at least one first universal frequency down-conversion module, and

said at least one first universal frequency up-conversion module; and

a control unit that communicates with said automobile controller via a wireless medium, said control unit comprising

at least one second universal frequency down-conversion module, and

at least one second universal frequency up-conversion module;

whereby said apparatus represents an apparatus for controlling an automobile.

58. The apparatus of claim **3**, wherein said apparatus represents an aircraft radio apparatus.

59. The apparatus of claim **3**, wherein said apparatus represents a monitor in an aircraft.

60. The apparatus of claim **3**, wherein said apparatus represents a computer in an aircraft.

61. The apparatus of claim **3**, further comprising:

a aircraft controller that comprises

said at least one first universal frequency down-conversion module, and

said at least one first universal frequency up-conversion module; and

a control unit that communicates with said aircraft controller via a wireless medium, said control unit comprising

at least one second universal frequency down-conversion module, and

at least one second universal frequency up-conversion module;

whereby said apparatus represents an apparatus for controlling an aircraft.

62. The apparatus of claim **3**, wherein said apparatus represents a boat radio apparatus.

63. The apparatus of claim **3**, wherein said apparatus represents a monitor in a boat.

64. The apparatus of claim **3**, wherein said apparatus represents a computer in a boat.

65. The apparatus of claim **3**, further comprising:

a boat controller that comprises

said at least one first universal frequency down-conversion module, and

said at least one first universal frequency up-conversion module; and

a control unit that communicates with said boat controller via a wireless medium, said control unit comprising

at least one second universal frequency down-conversion module, and

at least one second universal frequency up-conversion module;

whereby said apparatus represents an apparatus for controlling a boat.

66. The apparatus of claim **3**, further comprising:

a controller that comprises

said at least one universal frequency up-conversion module; and a radio controlled device that comprises

said at least one universal frequency down-conversion module;

whereby said apparatus represents an apparatus for radio control.

67. The apparatus of claim **66**, wherein said controller further comprises at least one second universal frequency down-conversion module, and wherein said radio controlled device further comprises at least one second universal frequency up-conversion module.

68. The apparatus of claim **67**, wherein said radio controlled device is a plane, a car, or a boat.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,370,371 B1
DATED : April 9, 2002
INVENTOR(S) : Sorrells et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Title page,
Item [56], **References Cited**, U.S. PATENT DOCUMENTS, please add the following:
-- 5,841,811 --
FOREIGN PATENT DOCUMENTS, please add the following:
-- DE 35 41 031 A1
EP 0 732 803 A1 --
OTHER PUBLICATIONS, please add the following:
-- Fest, Jean-Pierre, "Le Convertisseur A/N Revolutionne Le Recepteur Radio," *Electronique*, No. 54, December 1995, Paris, France, pp. 40-42.
Translation of DE Patent No. 35 41 031 A1, 22 pages.
Translation of EP Patent No. 0 732 803 A1, 9 pages.
Fest, Jean-Pierre, "The A/D Converter Revolutionizes the Radio Receiver," *Electronique*, No. 54, December 1995, Paris, France, 3 pages. (Translation of Doc. AQ50). --
In the "Sabel, L.P.," reference, please replace "225" with -- 223 --.

Column 35,
Line 11, after "outputs" insert -- pulses --.
Line 15, change "said causes" to -- cause said --.
Line 18, after "apertures" insert -- of --.
Line 55, delete the second occurrence of "first".

Signed and Sealed this

Ninth Day of December, 2003

JAMES E. ROGAN
Director of the United States Patent and Trademark Office