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Sabat, Jr. et al.

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(54) **MONITORING AND COMMAND SYSTEM FOR TRANSCEIVERS USED TO INTERCONNECT WIRELESS TELEPHONES TO A BROADBAND NETWORK**

(75) Inventors: **John Sabat, Jr.**, Merrimack, NH (US); **Timothy R. Locascio**, Osterville, MA (US); **Clifford M. Lo Verme**; **Glenn T. Flebotte**, both of Merrimack, NH (US)

(73) Assignee: **Transcept, Inc.**, Manchester, NH (US)

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Related U.S. Application Data

(63) Continuation of application No. 08/998,878, filed on Dec. 24, 1997.

(51) **Int. Cl.**[7] **H04O 7/20**; H04M 11/00

(52) **U.S. Cl.** **455/403**; 455/420; 455/507; 455/525; 455/422; 455/88; 455/9; 370/338; 370/349

(58) **Field of Search** 455/525, 524, 455/500, 422, 507, 9, 403, 3.03, 88; 370/338, 339, 349; 348/12, 14

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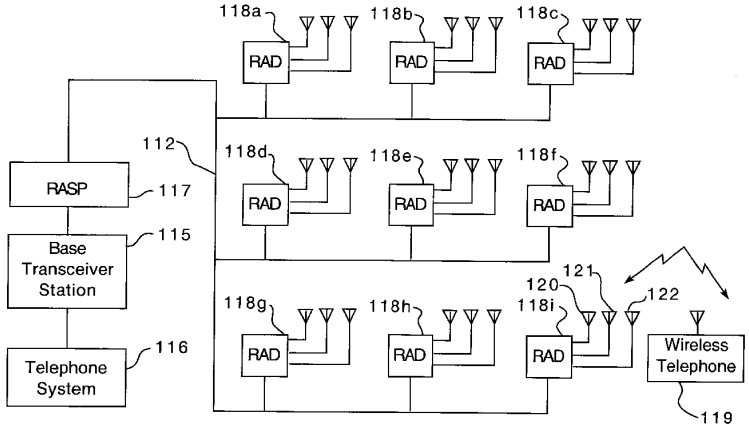
Primary Examiner—William Trost
Assistant Examiner—Marleen Milord
(74) *Attorney, Agent, or Firm*—Kirkpatrick & Lockhart LLP

(57) **ABSTRACT**

A monitoring and command system for use in a wireless communications system including remotely located transceivers for transmitting and receiving telephony signals to and from wireless telephones wherein each of the remote transceivers is connected to a broadband distribution network. A central location includes remote antenna signal processors connected to the broadband distribution network and a control unit is connected to the remote antenna signal processor, and the monitoring and command system controls operations of the remote antenna signal processors and the remote transceivers. The control unit exchanges control and monitoring messages with the remote antenna signal processors, and each exchange of messages comprises a completed exchange of messages with one remote antenna signal processor before initiation of an exchange of messages with another remote antenna signal processor. Each remote antenna signal processor exchanges control and monitoring messages with the remote transceivers associated therewith, and the messages to all associated remote transceivers are interspersed. Each control and monitoring message includes a message number field identifying the meaning of the message, a unique message tag field used by the remote antenna signal processors to identify each remote transceivers, and a plurality of data fields containing message information wherein the contents of each data field are defined by the contents of the message number field.

4 Claims, 13 Drawing Sheets



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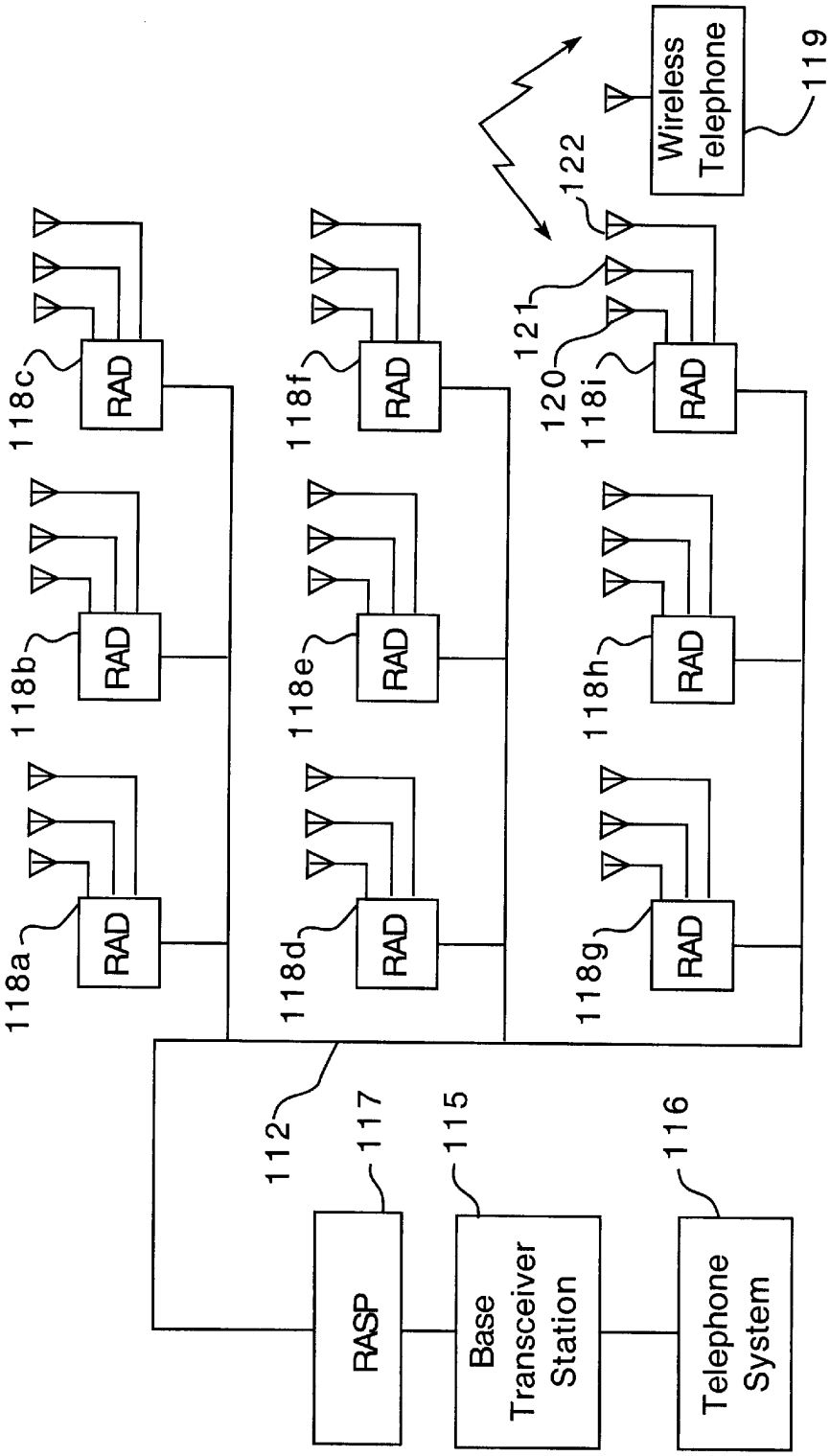

FIG. 1

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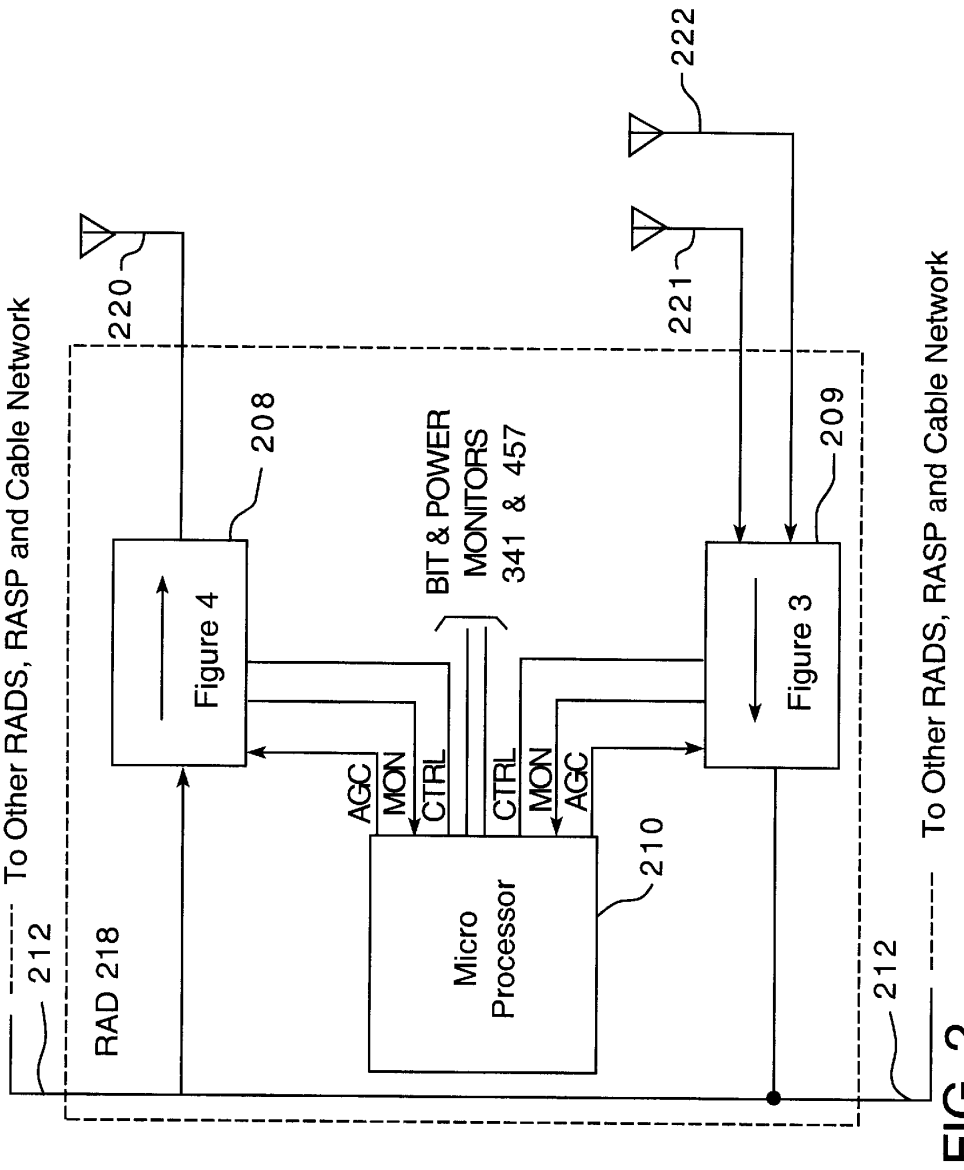

FIG. 2

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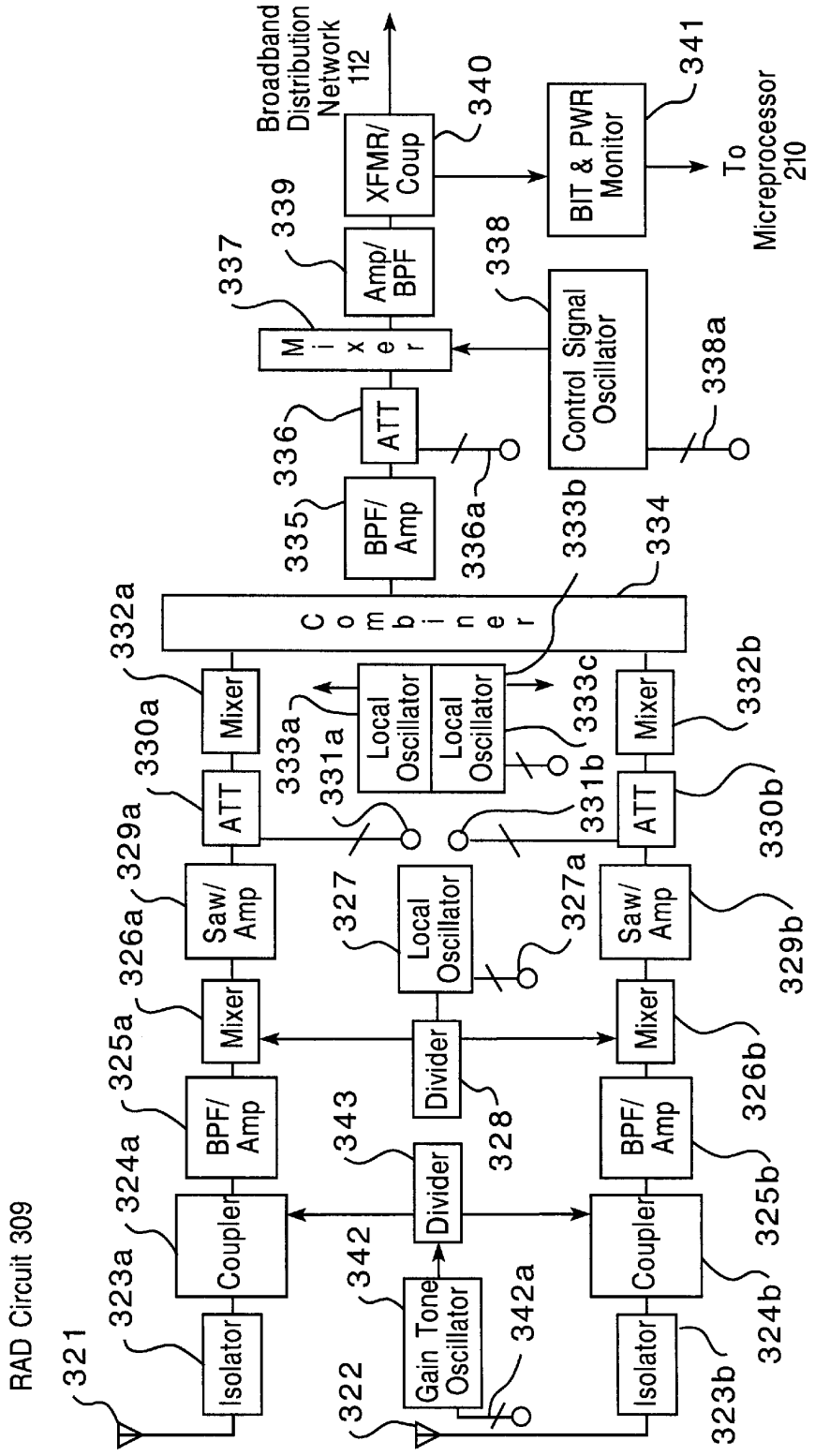

FIG. 3

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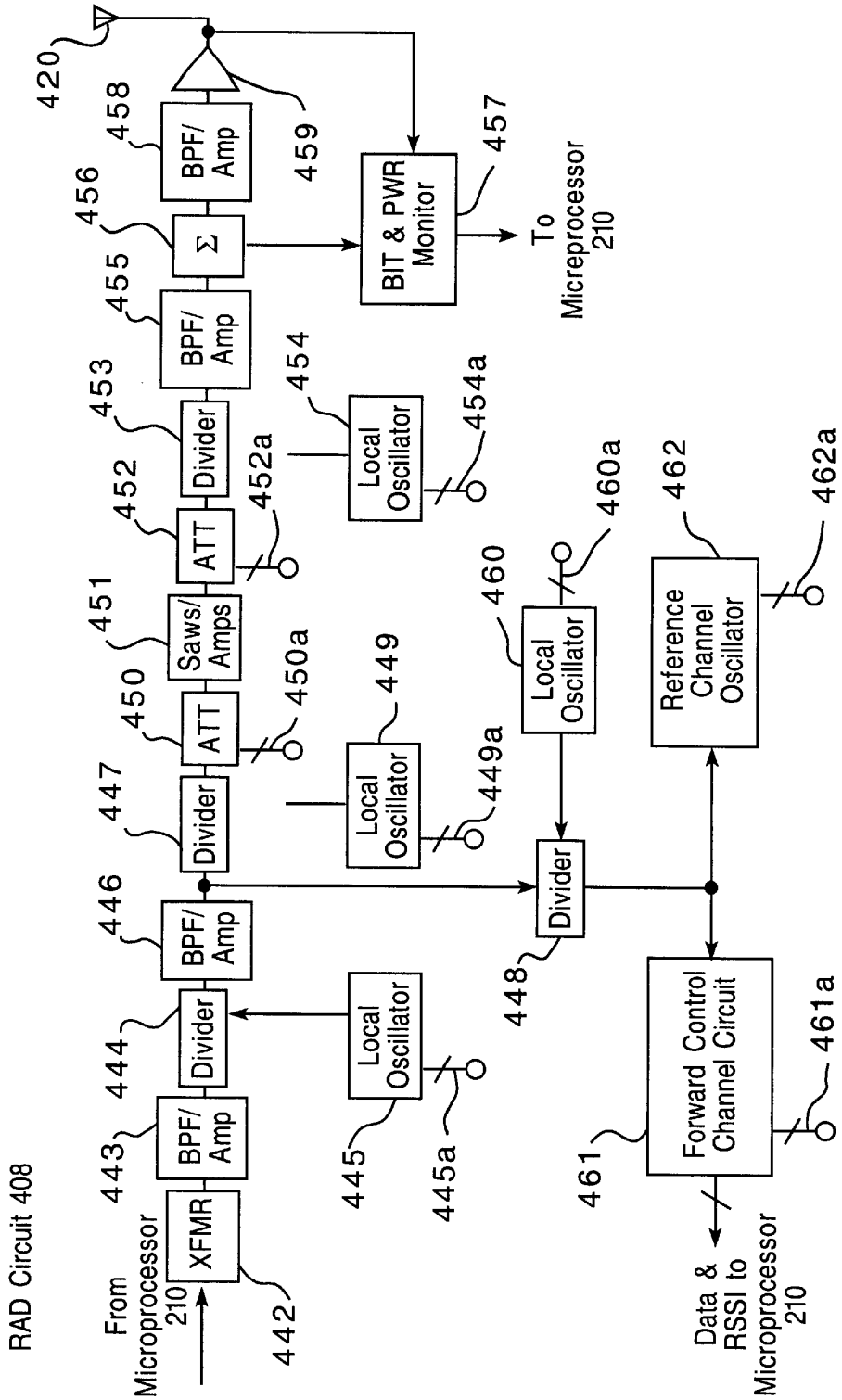

FIG. 4

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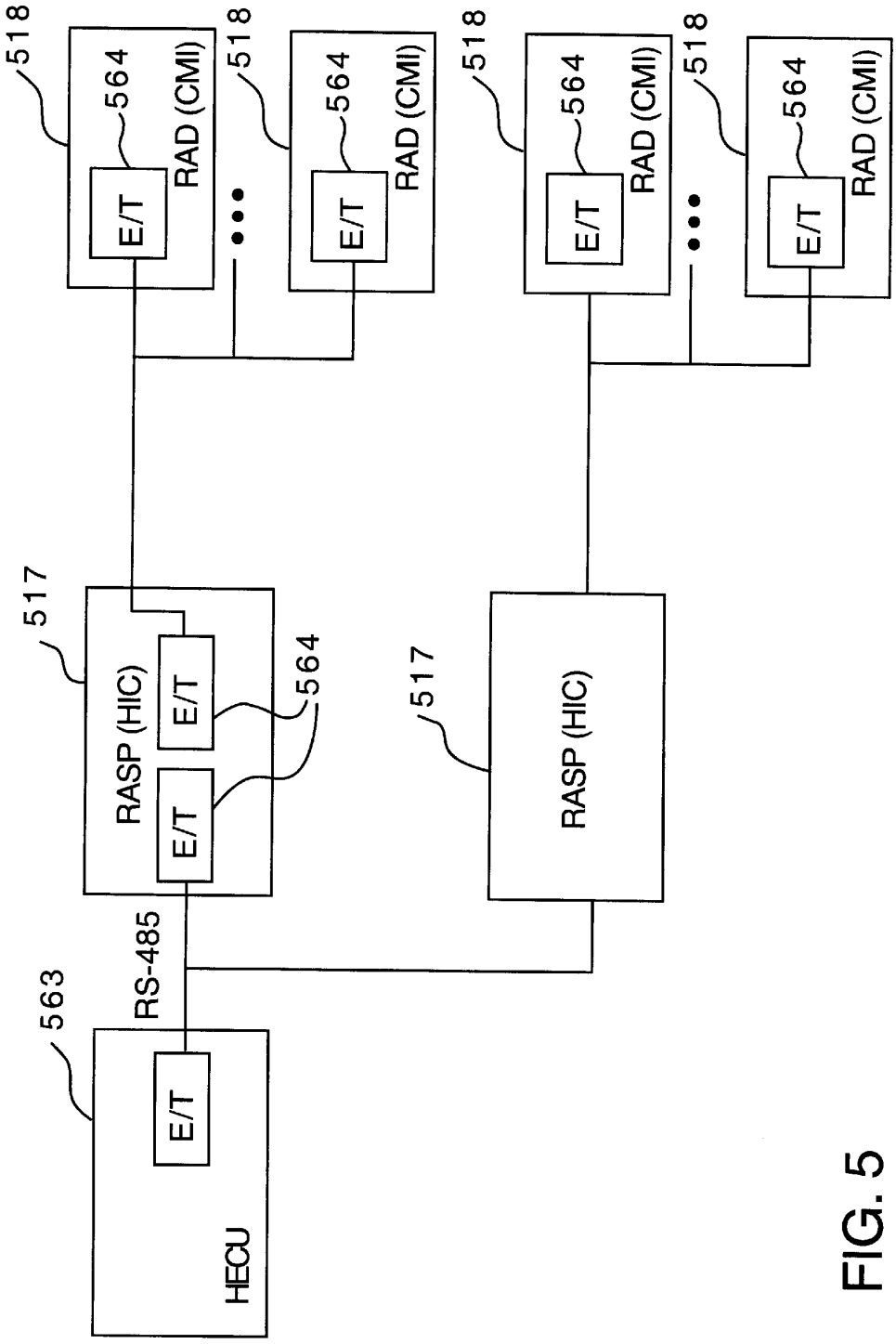

FIG. 5

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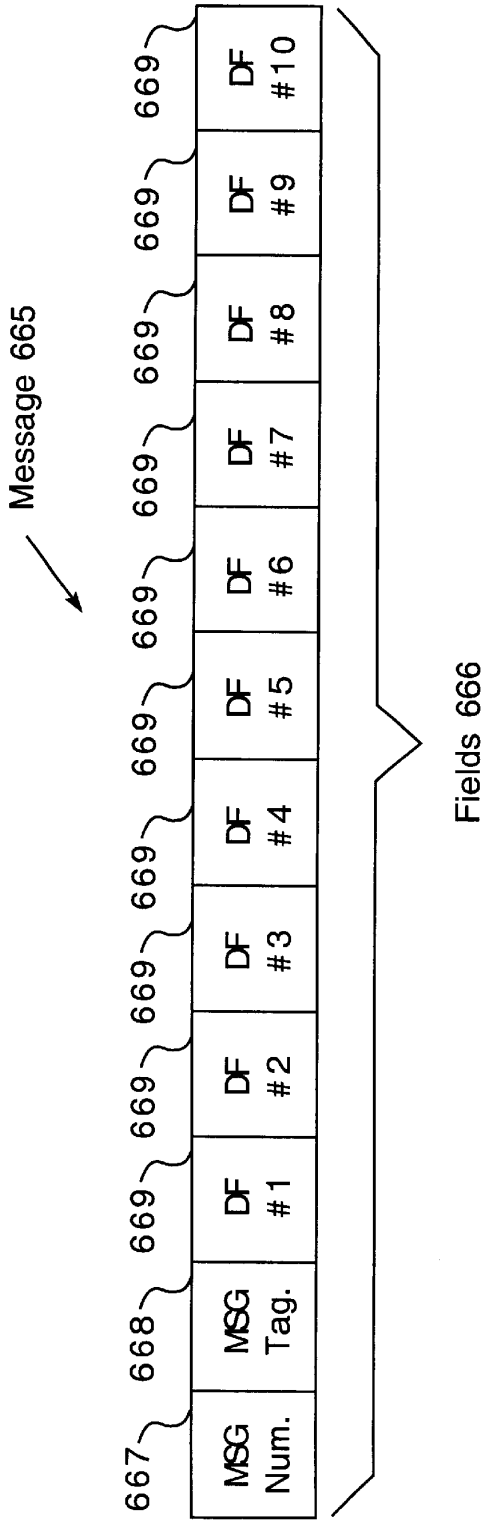

FIG. 6

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MSG# HEX	MSG# DEC	Message Name	Usage	Page
0x00	0	MSG_FAIL	S	4
0x01	1	ALARM_STATUS_REQUEST_MSG	S	4
0x02	2	ADD_HIC_MSG	S, ATP	5
0x03	3	HIC_DS_OUTPUT_POWER_MSG	S, ATP	6
0x04	4	HIC_US_POWER_CTL_MSG	S, ATP	6
0x05	5	HIC_SET_ALARM_MSG	S, ATP	7
0x06	6	ADD_CMI_MSG	S. ATP	8
0x07	7	ACT_CMI_MSG	S, ATP	9
0x08	8	CMI_US_ATT_MSG	S, ATP	10
0x09	9	CMI_DS_ATT_MSG	S, ATP	10
0x0A	10	CMI_SET_ALARM_MSG	S. ATP	10
0x0B	11	CMI_HIC_GAIN_MSG	S, ATP	11
0x0C	12	HIC_CODE_DL_MSG	S	12
0x0D	13	HIC_SET_TD_MSG	ATP	13
0x0E	14	HIC_SET_CAL_MSG	ATP	13
0x0F	15	CMI_CODE_DL_MSG	S, ATP	14
0x10	16	CMI_SET_TD_MSG	ATP	14
0x11	17	CMI_SET_CAL_MSG	ATP	15
0x12	18	HIC_REPORT_ALARM_MSG	S	16
0x13	19	HIC_COMM_STAT_MSG	S	17
0x14	20	HIC_ATTENUATION_STAT_MSG	S, ATP	17
0x15	21	HIC_FREQUENCY_STAT_MSG	S, ATP	18
0x16	22	HIC_POWER_STAT_MSG	S, ATP	18
0x17	23	HIC_MISC_STAT_MSG	S, ATP	19
0x18	24	HIC_TD_STAT_MSG	ATP	19
0x19	25	HIC_READ_CAL_MSG	ATP	19
0x1A	26	HIC_VER_NUM_MSG	S. ATP	20
0x1B	27	CMI_COMM_STAT_MSG	S	20
0x1C	28	CMI_ATT_STAT_MSG	S. ATP	21
0x1D	29	CMI_REPORT_ALARM_MSG	S	22
0x1E	30	CMI_FREQ_STAT_MSG	S. ATP	24
0x1F	31	CMI_POWER_STAT_MSG	S. ATP	24
0x20	32	CMI_MISC_STAT_MSG	S. ATP	25
0x21	33	CMI_READ_CAL_MSG	ATP	25
0x22	34	CMI_READ_TD_MSG	ATP	26
0x23	35	CMI_READ_VER_MSG	S, ATP	26
0x24	36	HIC_TUNE_PLL_MSG	S	27
0x25	37	HIC_POKE_MEM_MSG	TD	27
0x26	38	HIC_PEEK_MEM_MSG	TD	27
0x27	39	HIC_COPY_TO_EEPROM_MSG	TD	27
0x28	40	CMI_TUNE_PLL_MSG	TD	28
0x29	41	CMI_POKE_MEM_MSG	TD	28
0x2A	42	CMI_PEEK_MEM_MSG	TD	29
0x2B	43	CMI_READ_NID_MSG	TD	29
0x2C	44	WINK_HIC_MSG	TD	29
0x2D	45	HIC_UPSTREAM_TONE_POWER	TD	30
0x2E	46	HIC_FLASH_DAT_WR_MSG	TD	30
0x2F	47	HIC_FLASH_DAT_RD_MSG	TD	30
0x30	48	HIC_FLASH_UNLOC_MSG	TD	31
0x31	49	HIC_CAL_MODE_MSG	Not used	32
0x32	50	HIC_REBOOT_MSG	ATP	33
0x33	51	HIC_MSG_DUMP_MSG	TD	33
0x34	52	CMI_US_SETPOINT_MSG	S	33

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Usage Legend:
S = Required for normal System operation
ATP = Required by Automated Test Procedure, Hardware Qualification
TD = Test and Debug use only

FIG. 7A

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Message	MSG_FAIL		This message is a RESPONSE only. If a message failed to be processed by the receiving device, this RESPONSE will be returned.
Msg. Num.	0x00		
Msg Tag	Tag number	(7:0)	(0-255)
	********* RESPONSE *********		
DF # 1	*error type*	(7:0)	1- Poll Neuron Timeout
			2- BPSK Demodulator Timeout
			3- Multiple Message Error (DF #2-10 indicate the CMIs in which errors were reported)
			5- Requested CMI is not online (test only)
	If DF # 1 = 3		Bit set if CMI didn't respond to msg sent to it
DF # 2		(7:0)	Alpha CMI, (8-1) Bit-mapped
DF # 3		(7:0)	Alpha CMI, (16-9) Bit-mapped
DF # 4		(7:0)	Alpha CMI, (24-17) Bit-mapped
DF # 5		(7:0)	Beta CMI, (8-1) Bit-mapped
DF # 6		(7:0)	Beta CMI, (16-9) Bit-mapped
DF # 7		(7:0)	Beta CM, (24-17) Bit-mapped
DF # 8		(7:0)	Gamma CMI, (8-1) Bit-mapped
DF # 9		(7:0)	Gamma CMI, (16-9) Bit-mapped
DF # 10		(7:0)	Gamma CMI, (24-17) Bit-mapped

FIG. 7B

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Message	ADD_HIC_MSG		This message is used at installation, and to change the HIC's State and Channel parameters.
Msg. Num.	0x02		
Msg Tag	Tag number	(7:0)	(0-255)
	********* REQUEST *********		
DF # 1	hic_state	(0)	0=Offline, 1=Online
		(1)	Downstream power: 0=off / 1=on
		(2)	Reference tone: 0=off / 1=on
		(3)	Control tone: 0=off / 1=on
		(4)	CMI Data Base: 0=leave alone / 1=clear
		(5)	Power up state: 0=from defaults / 1=from last state
		(7:6)	Channel Type: 0=STD, 1=HRC, 2=IRC
DF # 2	alpha_upstr_pri_freq	(7:0)	Alpha Upstream Primary Freq: (see notes below)
DF # 3	alpha_upstr_div_freq	(7:0)	Alpha Upstream Diversity Freq: (see notes below)
DF # 4	beta_upstr_pri_freq	(7:0)	Beta Upstream Primary Freq: (see notes below)
DF # 5	beta_upstr_div_freq	(7:0)	Beta Upstream Diversity Freq: (see notes below)
DF # 6	gamma_upstr_pri_freq	(7:0)	Gamma Upstream Primary Freq: (see notes below)
DF # 7	gamma_upstr_div_freq	(7:0)	Gamma Upstream Diversity Freq: (see notes below)
DF # 8	dnstr_chan	(7:0)	Downstream Channel: (70-120)
	USA Channels		
DF # 9	indicator	(7:5)	USA Channel indicator (000)
	pcs_tx_chan	(4:0)	PCS Channel MSB (0-1) (see notes below)
DF # 10	pcs_tx_chan	(7:0)	PCS Channel LSB (0-255) (see notes below)
	Korean FAs		
DF # 9	indicator	(7:5)	Korean FA indicator (001)
		(4:0)	unused (send zeroes)
DF # 10	pcs_tx_chan	(7:0)	Korean FA (1-21) (see notes below)

Notes:

When any of the Frequency and Channel parameters are changed, the appropriate values of any attached CMIs will automatically be changed, i.e. an ACT_CMI_MSG with changed data is sent to each attached CMI.

Upstream CATV Frequency:

5 to 42 MHz in 250 kHz steps, (I.e. for desired upstream freq of 23.5 MHz (23.5 MHz / .250 MHz) = 94), maintain at least 2 MHz between all sectors and channels, Diversity channel 2 MHz min. above its corresponding Primary channel.

United States PCS Channel:

Band A: Channels 25 to 275, Tx freq = (PCS Chan x .05 MHz) + 1930 MHz, Rx Freq is 80 MHz below. (i.e. for PCS channel 275 set DF#9 to 1 (256) and DF#10 to 19)

Korean PCS FA:

Band A: FAs 1 to 7, Tx freq = (PCS FA x 1.25 MHz) + 1840 MHz, Rx Freq is 90 MHz below.
Band B: FAs 8 to 14, Tx freq = ((PCS FA - 7) x 1.25 MHz) + 1850 MHz, Rx Freq is 90 MHz below.
Band C: FAs 15 to 21, Tx freq = ((PCS FA - 14) x 1.25 MHz) + 1860 MHz, Rx Freq is 90 MHz below.

Other Countries' PCS channel allocations can be added by assigning DF # 9 bits 7:5. Six possibilities remain (010 - 111)

FIG. 7C

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Message	HIC_DS_OUTPUT_POWER_MSG		This message is to set up the HIC's downstream attenuators and power control.
Msg. Num.	0x03		
Msg Tag	Tag number	(7:0)	(0-255)
	********* REQUEST *********		
DF # 1	hic_state	(0)	0 = Offline / 1 = Online
		(1)	Downstream power: 0=off / 1=on
		(2)	Reference tone: 0=off / 1=on
		(3)	Control tone: 0=off / 1=on
		(4)	CMI Data Base: 0=leave alone / 1=clear
		(5)	Power up state: 0=from defaults / 1=from last state
		(7:6)	Channel Type: 0=STD, 1=HRC, 2=IRC
DF # 2	*save to flash*	(0)	DS Atten: 0 = don't change / 1 = change
		(1)	Ref/Cntl Atten: 0 = don't change / 1 = change
DF # 3	dnstr_att_value	(7:0)	Downstream attenuator: (0-44) 2 dB steps
DF # 4	ref_ctrl_tone	(7:0)	Ref/Ctrl attenuator: (0-44) 2 dB steps

FIG. 7D

Message	HIC_US_POWER_CTL_MSG		This message is to set up the HIC's upstream attenuators and power control.
Msg. Num.	0x04		
Msg Tag	Tag number	(7:0)	(0-255)
	********* REQUEST *********		
DF # 1	*save to flash*	(0)	0 = don't change / 1 = change (saves DF#2 - #8)
DF # 2	upstr_alpha_att	(7:0)	fixed value (0-44) 2 dB steps
DF # 3	upstr_beta_att	(7:0)	fixed value (0-44) 2 dB steps
DF # 4	upstr_gamma_att	(7:0)	fixed value (0-44) 2 dB steps
DF # 5	not used	(7:0)	formerly US AGC Alpha setpoint
DF # 6	not used	(7:0)	formerly US AGC Beta setpoint
DF # 7	not used	(7:0)	formerly US AGC Gamma setpoint
DF # 8	ingress_level_threshold	(7:0)	Ingress threshold fixed value (1-10) 0.5 dB steps

FIG. 7E

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Message **ADD_CMI_MSG**

This message is sent to the HIC at installation of a CMI. The Neuron ID is loaded into the CMI data base within the HIC. If Ping is set (DF#10 MSB) the HIC then builds and sends an ACT_CMI_MSG to the CMI.

Msg. Num.	0x06		
Msg Tag	Tag number	(7:0)	(0-255)
	********* REQUEST *********		
DF # 1	*sector* / cmi_num	(7:6) (4:0)	Sector Number: 0=Alpha, 1=Beta, 2=Gamma CMI Number: (0-23)
DF # 2	NID5	(7:0)	Neuron ID MSW
DF # 3	NID4	(7:0)	Neuron ID
DF # 4	NID3	(7:0)	Neuron ID
DF # 5	NID2	(7:0)	Neuron ID
DF # 6	NID1	(7:0)	Neuron ID
DF # 7	NID0	(7:0)	Neuron ID LSW
DF # 8	state	(0)	0 = Not active / 1 = Active
		(1)	Auto stats: 0 = off / 1 = on
		(2)	Dwnstrm autogain: 0 = off / 1 = on
		(3)	Power up state: 0 =from defaults / 1 = from last state
		(4)	CMI alarms: 0 = leave alone / 1 = clear
		(5)	Upstrm autogain: 0 = off / 1 = on
DF # 9	tx_state	(0)	PA: 0 = off / 1 = on
		(1)	Primary Receive: 0 = off / 1 = on
		(2)	Diversity Receive: 0 = off / 1 = on
DF # 10	*ping / gain*	(6:0)	Dwnstrm AGC Setpoint: (HIC input to CMI output)
		(7)	Ping CMI: 0 = yes / 1 = no

FIG. 7F

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Message	ACT_CMI_MSG		This message is used at installation and to change the CMI State, CATV and PCS frequencies, Tx state and CMI gain.
Msg. Num.	0x07		
Msg Tag	Tag number	(7:0)	(0-255)
	********** REQUEST **********		
DF # 1	*sector* / cmi_num	(7:6) (4:0)	Sector Number: 0=Alpha, 1=Beta, 2=Gamma CMI Number: (0-23)
DF # 2	state	(0)	0 = Not active / 1 = Active
		(1)	Auto stats: 0 = off / 1 = on
		(2)	Dwnstrm autogain: 0 = off / 1 = on
		(3)	Power up state: 0 =from defaults / 1 = from last state
		(4)	CMI alarms: 0 = leave alone / 1 = clear
		(5)	Upstrm autogain: 0 = off / 1 = on
DF # 3	up_pri_freq	(7:0)	Upstream Primary Freq: (see notes below)
DF # 4	up_div_freq	(7:0)	Upstream Diversity Freq: (see notes below)
DF # 5	dn_chn	(7:0)	Downstream Channel: 70 to 120 (see notes below)
DF # 6	dn_chn_type	(1:0)	Downstream Channel Type: 0 = STD, 1 = HRC, 2=IRC (see notes below)
	US Channels		
DF # 7	indicator	(7:5)	US Channel indicator (000)
	pcs_tx_chan	(4:0)	PCS Channel MSB (0-1) (see notes below)
DF # 8	pcs_tx_chan	(7:0)	PCS Channel LSB (0-255) (see notes below)
	Korean FAs		
DF # 7	indicator	(7:5)	Korean FA indicator (001)
		(4:0)	unused (send zeroes)
DF # 8	pcs_tx_chan	(7:0)	Korean FA (1-21) (see notes below)
DF # 9	tx_state	(0)	PA: 0 = off / 1 = on
		(1)	Primary Receive: 0 = off / 1 = on
		(2)	Diversity Receive: 0 = off / 1 = on
DF # 10	gain	(6:0)	Dwnstrm AGC Setpoint: (HIC input to CMI output)

Note:

If a CMI is attached to a HIC, it is then necessary to match all the Frequency and Channel parameters to the current values of the HIC.

Upstream CATV Frequency:

5 to 42 MHz in 250 kHz steps, (i.e. for desired upstream freq of 23.5 MHz (23.5 MHz / .250 MHz) = 94) Diversity channel 2 MHz min. above its corresponding Primary channel.

PCS Channel:

Band A: Channels 25 to 275, Tx freq = (PCS Chan x .05 MHz) + 1930 MHz, Rx Freq is 80 MHz below. (i.e. for PCS channel 275 set DF#9 to 1 (256) and DF#10 to 19)

Korean PCS FA:

Band A: FAs 1 to 7, Tx freq = (PCS FA x 1.25 MHz) + 1840 MHz, Rx Freq is 90 MHz below.
Band B: FAs 8 to 14, Tx freq = ((PCS FA - 7) x 1.25 MHz) + 1850 MHz, Rx Freq is 90 MHz below.
Band C: FAs 15 to 21, Tx freq = ((PCS FA - 14) x 1.25 MHz) + 1860 MHz, Rx Freq is 90 MHz below.

FIG. 7G

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Message **CMI_HIC_GAIN_MSG**

This message is used by the HIC for the auto gain function. The message data is different from HIC to CMI, than it is from CMI to HIC.

Msg. Num.	0x0B		
Msg Tag	Tag number	(7:0)	(0-255)
	******** HIC to CMI **********		
DF # 1	enumerator	(7:0)	0, >5 = Turn Gain Tone off
			1 = Tell CMI to calculate average power amp value
			2,3 = Turn Gain Tones on
			4 = set the US and DS attenuators
			5 = Turn Gain Tone off, set US attenuators, turn on/off PA and Rcvrs, Tune PCS channel and save it to flash.
DF # 2	time	(7:0)	Gain time (enum = 1)
DF # 3	freq	(7:0)	Gain tone Freq MSB (enum = 2 or 3, see notes below)
DF # 4	freq	(7:0)	Gain tone Freq LSB (enum = 2 or 3, see notes below)
DF # 5	*sector* / cmi_num	(7:0)	Sector Number 0=Alpha, 1=Beta, 2=Gamma CMI Number (0-23)
DF # 6	up_pri_att	(7:0)	Upstream Primary Attenuation (enum = 4,5)
DF # 7	up_div_att	(7:0)	Upstream Diversity Attenuation (enum = 4,5)
DF # 8	up_com_att	(7:0)	Upstream Combined Attenuation (enum = 4,5)
DF # 9	dn_pre_att	(7:0)	Downstream Attenuation pre SAW (enum = 4)
DF # 10	dn_pos_att	(7:0)	Downstream Attenuation post SAW (enum = 4)
DF # 3	freq	(7:0)	PCS Channel MSB (enum = 5, see notes below)
DF # 4	freq	(7:0)	PCS Channel LSB (enum = 5)
DF # 9	tx_state (see note below)	(0)	PA: 0 = off / 1 = on (enum = 5)
		(1)	Primary Receive: 0 = off / 1 = on (enum = 5)
		(2)	Diversity Receive: 0 = off / 1 = on (enum = 5)
	******** CMI to HIC ********		enum=0,2,3,4,>5 (see note below)
DF # 1	pa_tx_pwr	(7:0)	Power Amp Transmit Power
DF # 2	tone_pwr	(7:0)	Gain Tone power
DF # 3	up_pwr	(7:0)	Upstream power
DF # 4	pri_cal_fac	(7:0)	Primary cal factor
DF # 5	div_cal_fac	(7:0)	Diversity cal factor
DF # 6	up_pri_att	(7:0)	Upstream Primary Attenuation
DF # 7	up_div_att	(7:0)	Upstream Diversity Attenuation
DF # 8	up_com_att	(7:0)	Upstream Combined Attenuation
DF # 9	dn_pre_att	(7:0)	Down stream Attenuation pre SAW
DF # 10	dn_pos_att	(7:0)	Down stream Attenuation post SAW

Notes:
Gain tone frequency: (enum = 2 or 3)
GainFreq = (int[PCS Chan / 3] x 3) - 7; i.e. If PCS Channel equals 100, then (int[100 / 3] x 3) - 7 = 92
Puts the gain tones at approx. 350 to 450 kHz above the center of the upstream CATV pedestals.
For enum=1 & 5, CMI echoes back the HIC to CMI message data.
For enum=5, DF#9 affects PA and Receivers, but tx_state is NOT CHANGED to reflect what this message has done. This is part of a gain tone calibration procedure that is not used.

FIG. 7H

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MONITORING AND COMMAND SYSTEM FOR TRANSCEIVERS USED TO INTERCONNECT WIRELESS TELEPHONES TO A BROADBAND NETWORK

RELATED APPLICATIONS

This is a continuation of U.S. patent application Ser. No. 08/998,878 filed Dec. 24, 1997.

FIELD OF THE INVENTION

The present invention relates to wireless communications systems, and more particularly to a monitoring and command system for transceivers that carry telephony signals between wireless telephones and a broadband distribution network.

BACKGROUND OF THE INVENTION

The prior art teaches the use of existing cable television network cables to carry telephony signals between a telephone network and remote transceiver sites in defined cells or sectors. The remote transceivers are used to establish wireless telephony communication links with wireless telephones that are operating within an area covered by each remote transceiver. To increase the number of wireless telephone subscribers that can use the wireless telephone system it has been suggested to decrease the size and operational range of each cell or sector, and to increase the number of cells or sectors required to provide wireless telephone service to a given area. Having cells or sectors of decreased size permits greater reuse of the limited number of frequency channels allocated for wireless telephone service because other cells or sectors located at a closer range can reuse the same frequency channels for additional calls without signal interference. The advantages of reducing cell or sector size to increase the call carrying capacity of the wireless telephone network is offset by the requirement for additional remote transceivers for the additional cells. This offset is minimized by utilizing an existing broadband distribution network to provide the communications path between remote transceivers in each of the cells or sectors and a central transceiver. The central transceiver acts as the interface with the remote transceivers, via the broadband distribution network, and a base transceiver station acts as the interface between the telephone network and the central transceivers.

To carry wireless telephony signals over a broadband distribution network, as described above, a predetermined bandwidth on the network is typically allocated for this purpose. However, as required, more bandwidth may be allocated to carry wireless telephony signals. To most efficiently use a given bandwidth to carry wireless telephony signals between wireless telephones and the telephone network, a combination of frequency and time division multiplexing, and other forms of signal multiplexing, is utilized. This requires base transceiver station equipment that acts as the interface with the telephone network and the wireless telephone system. With the base transceiver station equipment is a central transceiver (RASP), also called a Headend Interface Converter (HIC), that interfaces with the broadband distribution network, and it must function with telephony signals in the wide frequency spectrum of radio frequency signals on the telephone network, and up to 1000 Mhz over the broadband distribution network. This system also requires a plurality of remote transceivers, also called cable microcell integrators (CMI) or Remote Antenna Drivers (RADs), in each of the cells or sectors that can carry

many channels of telephony signals between the wireless telephones and the central transceiver via the broadband distribution network, without creating signal interference with the telephony signals in adjacent cells or sectors. In addition, the remote transceivers (RADs) must function with and translate telephony signals in the wide frequency spectrums of up to 1000 Mhz on the broadband distribution network and between 1850–1990 MHz for the radio link between remote transceivers and wireless telephones. To function together properly in such a system wireless telephone system there is a need for efficient operational communication between the central transceiver and remote transceivers.

SUMMARY OF THE INVENTION

Thus, there is a need in the art for means to monitor and control the operations of the central transceiver and remote transceivers. In this respect, a recurring problem of the prior art is the creation of a flexible and reliable means for encoding data and commands to be received from and transmitted to the remote transceivers, for receiving information from the remote transceivers, for monitoring the operation of the transceivers, and for sending commands to the remote transceivers to control their operation. It is necessary for the encoding means to convey data and commands in as flexible and compact a form as possible to preserve communications bandwidth and thereby to allow a large number of remote transceivers to be monitored and controlled from each base station, and it is preferable that the encoding allow a flexible a network configuration as possible.

The present invention is directed to a monitoring and command system for use in a wireless communications system including at least one central transceiver and a plurality of remote transceivers used for transmitting and receiving telephony signals to and from wireless telephones.

According to the present invention, each of the remote transceivers (RADs) are connected to a broadband distribution network that carries telephony signals between the remote transceivers (RADs) and the central transceiver (RASP). The central transceiver includes at least one remote antenna signal processor (RASP) connected to the broadband distribution network and a control unit connected to the at least one remote antenna signal processor, and the monitoring and command system controls operations of the remote antenna signal processor and the remote transceivers.

The monitoring and command system includes the control unit, which exchanges messages with each of the remote antenna signal processors for controlling operations of the remote antenna signal processors, including monitoring the operation of the antenna signal processors and the central and remote transceivers, and controlling signal levels and frequencies of the telephony signals. Each exchange of messages between the control unit and a remote antenna signal processor comprises a completed exchange of messages between the control unit and the remote antenna signal processor before initiation of an exchange of messages between the control unit and a next remote antenna signal processor.

The monitoring and command system further includes the at least one antenna signal processor, which exchanges messages with the remote transceivers for controlling operations of each of the remote transceivers, including monitoring operations of each of the remote transceivers, relaying messages between the control unit and each one of the remote transceivers, and controlling the signal levels and

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frequencies of the telephony signals. The messages of an exchange of messages between the at least one remote antenna signal processor and a selected one of the remote transceivers are interspersed with the messages of an exchange of messages between the at least one remote antenna signal processor and at least one other of the remote transceivers.

The messages exchanged among the control unit, the remote signal signal processors and the central and remote transceivers includes a message number field containing a value identifying the meaning of the message, a message tag field containing a value identifying a given message in a sequence of messages, wherein the message tag field is used in an exchange of messages between a remote antenna signal processor and a remote transceiver, and a plurality of data fields containing message information wherein the contents of each data field are defined by the contents of the message number field. The data fields contain information including an identification of a remote transceiver intended as a recipient of a message, information determining the operating parameters of the remote transceivers, and information pertaining to the status and operation of the remote transceivers.

DESCRIPTION OF THE DRAWINGS

The invention will be better understood upon reading the following Detailed Description in conjunction with the drawings in which:

FIG. **1** is a block diagram of a wireless telephony system integrated with a broadband distribution network;

FIG. **2** is a simplified block diagram of a remote transceiver used with the wireless telephony system, and having a microprocessor that communicates with a central transceiver via a broadband distribution network to carry telephony signals and control signals between the wireless telephones and the central transceiver;

FIG. **3** is a detailed block diagram of the portion of the remote transceiver that transmits to wireless telephones, wireless telephony signals received via a broadband distribution network from the central transceiver, base transceiver station, and telephone network;

FIG. **4** is a detailed block diagram of the portion of the remote transceiver that receives telephony signals from wireless telephones and forwards them via the broadband distribution network to the central transceiver, base transceiver station, and telephone network;

FIG. **5** is a block diagram of a typical network showing a base transceiver station and a plurality of remote antenna signal processors (RASPs), each of which is associated with one of a plurality of remote antenna drivers (RADs), wherein the base transceiver station includes a head end control unit and monitoring/command communications are through network communications Encoder/Transceiver (E/T)s;

FIG. **6** is a diagrammatic illustration of a message format used for encoding commands and monitored data according to the present invention; and

FIGS. **7**A through **7**H are illustrations of messages used by the communication and control encoding system of the present invention.

DETAILED DESCRIPTION

In the drawing and the following detailed description all elements are assigned three digit reference numbers. The first digit of each reference number indicates in which figure of the drawing an element is located. The second and third digits of each reference number indicate specific elements. If the same element appears in more than one figure of the drawing, the second and third digits remain the same and only the first digit changes to indicate the figure of the drawing in which the element is located. As used herein the term "telephony signals" includes voice, data, fax and any other types of signals that are sent over a telephone network now or in the future. Throughout the Figures and the following description, reference is made, for one example, to a combined band pass filter and amplifier **325***a*. There are a number of other such combined band pass filters and amplifiers. They are shown and referenced this way for ease of presentation only. In reality they are each a discrete, separate filter the output of which is input to an amplifier.

In FIG. **1** is shown a simple block diagram of an exemplary broadband distribution network **112** integrated with a wireless telephone system which include a plurality of remote transceivers known as Remote Antenna Drivers (RAD) **118** *a–i*, a central transceiver known as Remote Antenna Signal Processor (RASP) **117**, and a Base Transceiver Station (BTS) **115**. There are different types of broadband distribution networks in use. Such networks may utilize coaxial cable, fiber optic cable, microwave links, and a combination of these. In the embodiment of the invention disclosed herein a conventional hybrid fiber coaxial (HFC) cable television signal distribution system is utilized. Electrical power is distributed along broadband distribution network **112** to power line amplifiers (not shown) of the cable television distribution network. This electrical power source, or alternate power sources, are used to provide power to RADs **118** *a–i*.

Integrated with broadband distribution network **112** is a wireless telephony system in which the present invention is utilized. One such wireless telephony system is taught in U.S. patent application Ser. No. 08/695,175, filed Aug 1, 1996, and entitled "Apparatus And Method For Distributing Wireless Communications Signals To Remote Cellular Antennas". The telephony system disclosed herein includes a base transceiver station **115** which is connected to a telephone system **116**. Base transceiver station **115** is also connected to a Remote Antenna Signal Processor (RASP) **117** which is the interface to a broadband distribution network **112**. Telephony signals carried between telephone system **116** and wireless telephones **119** are carried via base transceiver station **115**, RASP **117**, broadband network **112**, and RADs **118** *a–i*.

As is known in the prior art, including the above cited prior patent application, one or more frequency bands or channels of the broadband distribution network **112** are reserved to carry telephony signals between telephone system **116** and wireless telephones **119**. Telephony signals originating from telephone system **116** are transmitted by RASP **117** over broadband distribution network **112** in frequency division multiplexing format. Telephony signals originating at wireless telephones **119** are frequency multiplexed together by RADs **118** *a–i* and transmitted along with control and gain tones via broadband network **112** to RASP **117**, and thence to base transceiver station **115** and telephone system **116**.

In base transceiver station **115** there are a plurality of transceiver modules (not shown), as is known in the wireless telephony art, each of which operates at a single channel frequency at a time, and which can handle a predetermined maximum number of telephone calls from wireless telephones. In the wireless telephone system described and claimed herein, the frequency that the RADs **118** are

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assigned to operate at must correspond to the operating frequency of the assigned BTS transceiver module and are set by control signals received from RASP **117** and base transceiver station **115**. If a particular RAD **118** is re-assigned to function with a different transceiver module within base transceiver station **115**, circuit settings within the particular RAD **118** must be changed to function with the different transceiver module. In the wireless telephony, art transceiver modules in the base transceiver station are also referred to as channel card modules and radio modules.

When wireless telephony traffic in a first sector or cell increases to the point where adequate service is not provided to wireless telephone subscribers in the first sector or cell, like during rush hour traffic on a highway, in accordance with the teaching of the present invention the wireless telephone system may be remotely reconfigured by RASP **117** to reassign one or more RADs **118** from one or more nearby sectors or cells, where those RADs **118** have overlapping signal coverage with the first sector or cell, to handle the excess wireless telephony traffic in the first sector cell.

In FIG. **1** are shown three rows of RADs **118**. Typically a number of RADs **118** are spaced along, and connected to, broadband distribution network **112** to provide overlapping signal transmission and reception coverage for the entire wireless telephone system. Some of the RADs **118** are physically located near the boundary between two or more cells or sectors and, depending on the frequency of operation they are set to, can be used to handle wireless telephony traffic in one or more of the sectors or cells. Let us assume that RADs **118** *g,h,i* in the bottom row are physically located along broadband distribution system **112** and are configured to handle wireless telephony traffic in a first sector that includes a highway. During early morning and late afternoon every work day there is rush hour traffic that creates peak wireless telephone traffic that causes unacceptable service delays in the first sector. Let us also assume that the RADs **118** *d,e,f* in the middle row in FIG. **1** are configured and located to handle wireless telephone traffic in a second, adjacent sector but they each have an area of signal operation that overlaps the highway in the first sector.

One or more of RADs **118** *d,e,f* may be dynamically reassigned by RASP **117** to the first sector to handle the increased telephony traffic originating from the highway. In addition, as necessary, additional RASP **117** channels may be assigned, and additional modules in base transceiver station **115** may be assigned to handle the excess wireless telephony traffic from the first sector. To do this RASP **117** sends control signals to the selected remote RADs *d,e,f* which will cause the frequency at which they operate to be changed to match the frequency of RADS **118** *g,h,i* that are normally assigned to handle wireless telephone traffic in the first sector. At the end of the peak traffic period RASP **117** may send control signals to the previously reallocated ones of RADs **118** *d,e,f* to change the frequency at which they operate back to their original settings so they are reassigned to handle wireless telephony traffic in the second sector. However, the re-assignment may be permanent depending on traffic patterns encountered.

Typically there are a number of RADs **118** *a–i* spaced along, and connected to, broadband distribution network **112** to provide overlapping wireless telephony signal transmission and reception coverage for the entire wireless telephone system in a number of cells or sectors. In this arrangement individual RADs **118** may be re-assigned to handle wireless telephony signals from an adjacent cell or sector with which it provides overlapping signal coverage. Each RAD **118** *a–i* has antennas **120**, **121**, **122** used to transmit to and receive signals from remote wireless telephones **119**. Antenna **120** is used to transmit telephony signals to wireless telephones **119**, while antennas **121** and **122** are used to receive telephony signals from wireless telephones **119**. Antenna **121** is called the primary antenna, and antenna **122** is called the diversity antenna. Antennas **121** and **122** are physically spaced and cooperate to minimize signal fading and thereby provide continuous signal reception from wireless telephones **119**.

In FIG. **2** is shown a general block diagram of a Remote Antenna Driver (RAD) **218**. There is a first circuit **208** of RAD **218**, that is shown in detail in FIG. **4**, that receives telephony signals originating at telephone system **116** and carried via base transceiver station **115**, RASP **117**, and broadband distribution network **212**, and then re-transmitted via antenna **220** of a RAD **118** to a wireless telephone **119** (not shown). There is also a second circuit **209** of RAD **218**, that is shown in detail in FIG. **3**, that receives wireless telephony signals originating from a wireless telephone **119**, and transmits them via broadband network **212** to RASP **117**, and via base transceiver station **115** to telephone system **116**.

RAD circuitry **208** and **209** are connected to and controlled by a microprocessor **210**.

Frequency multiplexed with the wireless telephony signals carried between RASP **117** and RAD **218** are operational signals of different types that are used for controlling the operation of each RAD **218** per the teaching of the present invention. These operations include circuit monitoring, gain control, circuit operation, and setting the frequency of operation, of each RAD **218**.

The first of the control operations listed in the previous paragraph is gain control to compensate for losses and gains in a RAD **218** and broadband distribution network **112**. As one part of this gain control operation RASP **117** sends a frequency multiplexed control signal to RAD **218** that is received by microprocessor **210** on leads CTRL from circuit **208**. Responsive thereto microprocessor **210** sends a signal via leads AGC to circuit **209** which causes the output of a gain tone oscillator **342**, with known signal level, to be inserted into the signal path, along with telephony signals, and be returned to RASP **117** via broadband distribution network **112**. The signal level output from gain control oscillator **342** (FIG. **3**) is of a low enough amplitude that it does not interfere with telephony signals passing through RAD **218**, but is separated from the telephony signals at RASP **117**. RASP **117** analyzes the amplitude of the gain control oscillator **342** signal received at the RASP, which will reflect gains and losses in RAD **218** and broadband distribution network **212**, as part of a determination whether or not to change gain control attenuators in RAD **218**.

As part of monitoring circuit gain levels, as requested by a control signal received from RASP **117**, microprocessor **210** receives information from RAD circuits **208** and **209** on leads MON indicating the gain level of signals only within these circuits, and reports this information to RASP **117** as described in the last paragraph. Using this circuit gain level information, and the gain tone information described in the previous paragraph, RASP **117** can determine gains and losses introduced in broadband distribution network **212**.

Responsive to the gain level information described in the previous two paragraphs RASP **117** can send other control signals back to RAD **218**, in accordance with the teaching of the present invention, which are received by microprocessor **210** on leads CTRL. Microprocessor **210** uses the control information received from RASP **117** to send signals via

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leads AGC to RAD circuits **208** and **209** which results in adjustments being made to attenuators to adjust the signal gain levels in these circuits.

RAD **218** receives an interrogation control signal, as previously described, which cause microprocessor **210** to send back information about RAD circuit **208** (FIG. **4**) and circuit **209** (FIG. **3**). This information indicates the settings of attenuator pads, the temperature at which each RAD **218** is operating, and the frequency of local oscillators within RAD circuits **208** and **209**.

Microprocessor **210** may receive other control signals from RASP **117**, in accordance with the teaching of the present invention, and respond thereto to change the frequency of some of the local oscillators within RAD circuitry **208** and **209** to change the frequency on which telephony signals and control signals are carried over broadband distribution network **112** to and from RASP **117**. In this manner the sector which each RAD **118** is assigned to may be changed to handle peak traffic loads and for other reasons.

In FIG. **3** is shown a detailed block diagram of circuit **309** within Remote Antenna Driver (RAD) **118** that carries telephony signals from a wireless telephone **119**, via broadband communications network **112**, to central transceiver RASP **117**. This is the circuit shown as RAD circuit **209** in FIG. **2**.

Briefly, primary receive antenna **321** is connected to a first portion of the circuitry in FIG. **3**, and that circuitry is identical to a second portion of the circuitry that is connected to diversity receive antenna **322**. The telephony signals received by both antennas **321** and **322** from a wireless telephone **119** (not shown in FIG. **3**) are initially processed in parallel, then the two signals are frequency multiplexed together and are both returned via broadband distribution network **112** (shown in FIG. **1**) to remote RASP **117** and base transceiver station **115** (FIG. **1**) to be processed.

Built into RAD circuitry **309** in FIG. **3** is circuitry which is enabled by microprocessor **210** in FIG. **2**, responsive to a control signal received from remote RASP **117**, to provide gain control for the telephony signal as it appears at the input of RASP **117**. Further, RASP **117** can send other frequency multiplexed control signals to each RAD **118** which microprocessor **210** responds to and changes the frequency at which RAD **118** transmits and receives telephony signals over broadband distribution network **112** to and from RASP **117**, and can also change the frequency at which each RAD **118** communicates with wireless telephones.

Telephony signals from a wireless telephone **119** (not shown in FIG. **3**) operating in a sector assigned to one or more RAD **118***s* are received by primary receive antenna **321**. These signals are input to an isolator **333***a* which isolates antenna **321** from RAD circuit **309**. The telephony signal is then input to directional coupler **324***a* that has a second signal input thereto from power divider **343** which is used for the aforementioned gain control purposes.

The telephony signal (modulated RF carrier) received from remote wireless telephone **119**, and the gain tone, low level signal, are applied via directional coupler **324***a* to a combined band pass filter and amplifier **325***a*. The signals are amplified and extraneous signals are filtered from the received telephony signal by bandpass filter **325***a*. The operation just described also applies to isolator **333***b*, coupler **324***b* and bandpass filter and amplifier **325***b*.

The amplified and filtered telephony signal is then input to mixer **326***a* which is used along with SAW filter **329***a* primarily to assist in filtering of the spread spectrum, digital telephony signal in accordance with the teaching of present invention. Mixer **326***a* also has input thereto a signal from local oscillator **327**. This signal from local oscillator **327** is input to power divider **328** which applies the signal to both mixers **326***a* and **326***b* while providing isolation between these two mixers.

The frequency of local oscillator **327** is digitally controlled and is determined by a binary control word applied to its control input **327***a* from microprocessor **210** (FIG. **2**), responsive to control signals received from RASP **117**. Similarly, control signals from remote RASP **117** causes microprocessor **210** to set the frequency of digitally controlled local oscillators **333***a* and **333***b*.

The operation of mixer **326***a* results in multiple frequencies being output from the mixer as is known in the art, but due to the frequency of oscillator **327**, most of the signals present at the input of RAD circuit **309** from antenna **321** are shifted far outside the band of frequencies which can pass through SAW filter **329**. Only the desired signals can pass through SAW filter **329**. This frequency shift also helps to prevent leak through of unwanted signals present at the front end of circuit **309** because they are blocked by narrow bandpass filter **325** which is passing signals of a frequency far from the signals applied to SAW filter **329**. Due to the sharp filtering action of SAW filter **329**, even spurious signals close to the desired telephony and control tone signals are removed. The same filtering operation applies to mixer **326***b* and SAW filter **329***b*.

The filtered telephony signal is then amplified by amplifier **339***a* and input to step attenuator **330***a* which is used to adjust the gain level of the signal in one-half dB steps. The amount of attenuation provided by step attenuator **330***a* is controlled by a binary word at its control input **331***a* from microprocessor **210**. The control of step attenuators **330***a*, **330***b*, and **336** is all accomplished responsive to control signals from RASP **117** as part of the gain control operation that assures that the signal level of telephony signals appearing at the input to RASP **117** from all RADs **118** *a–i* are within an acceptable range. Attenuator **330***b* in the parallel channel handling the telephony signals from diversity antenna **322** performs the same function.

The telephony signal that is output from step attenuator **330***a* is input to mixer **332***a* along with a fixed frequency signal from local oscillator **333***a*. Mixer **332***a* is used to shift the frequency of the telephony and gain tone signals to the frequency required to apply the signals to broadband distribution network **112**. This same operation applies to the telephony and gain tone signals output from mixer **332***b*.

The frequency of oscillators **333***a* and **333***b* is determined by binary words applied to their control input **333***c*. A control signal is sent from RASP **117** which causes microprocessor **210** to set the frequency of local oscillators **333***a* and **333***b*. The frequency of the telephony signal output from step attenuator **330***a* is the same as the frequency of the telephony signal output from step attenuator **330***b*. However, the frequency of local oscillator **333***a* is different from the frequency of local oscillator **333***b*. The result is that the carrier frequency of the telephony and gain tone signals output from mixer **332***a* is different than the carrier frequency of the telephony and gain tone signals output from mixer **332***b*. This is done so that both primary antenna **321** and diversity antenna **322** signals are both sent to RASP **117** and base transceiver station **115** for processing. However, all carrier frequencies are within the assigned wireless telephony channel on broadband distribution network **112**.

The telephony signals received by primary antenna **321** and diversity antenna **322** are frequency multiplexed

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together and sent via broadband network **112** to RASP **117**. To accomplish this, combiner **334** is utilized. Combiner **334** has the telephony and gain tone signals output from both mixers **332***a* and **332***b* input thereto. As described in the previous paragraph these two telephony signals modulate carriers that are at different frequencies, but both frequencies are in an assigned channel of broadband distribution network **112**. Combiner **334** combines the two sets of signals so they are all frequency multiplexed together.

The combined signal is input to bandpass filter and amplifier **335** which removes spurious frequencies created by the mixing action in circuits **332***a* and **332***b*, and amplifies the signals that pass through the filter. The combined and filtered telephony and gain tone signals are input to step attenuator **336** to adjust the gain level of signals. Similar to the operation of the previously described step attenuators, this digitally controlled attenuator is set responsive to control signals received from remote RASP **112** as part of the gain control operation.

The frequency multiplexed telephony and gain tone signals output from step attenuator **336** are input to signal combiner **337** which has a second input from control signal oscillator **338**. The frequency of control signal oscillator **338** is set responsive to a binary signal on its control leads **338***a* from microprocessor **210**. RASP **117** is the origin from which the control signal is received to set the frequency of control signal oscillator **338**. The frequency chosen is different than the frequencies used for the telephony signals received via the primary and the diversity antennas and for the gain tone signal.

Responsive to different control signals received from RASP **117**, microprocessor **210** (FIG. **2**) sends signals on control inputs **338***a*. These microprocessor **210** signals cause control signal oscillator **338** to produce an information signal. The information signal indicates various information about RAD **218**, but particularly including the settings of step attenuators **330***a*, **330***b* and **336**, to RASP **117** as part of the novel gain control operation. RASP **117** uses this information to keep an updated status regarding each of the RADs **118** *a–i*.

The output from combiner **337** now has five signals frequency multiplexed together to be returned via broadband network **112** to RASP **117**. The signals are the telephony signal received by primary antenna **321**, the telephony signal received by diversity antenna **322**, the gain tone signal output from gain tone oscillator **342** as applied to both primary and diversity paths, and the system information signal output from control signal oscillator **338**. This frequency multiplexed signal output from combiner **337** is input to band pass filter and amplifier **339** to remove any extraneous signals and amplify the desired signals before they are input to broadband distribution network **112** and sent to RASP **117**.

Transformer and coupler **340** is used to couple the frequency multiplexed signals described in the previous paragraphs to broadband distribution network **112**. The transformer is an impedance matching transformer having 50 ohm primary and 75 ohm secondary windings. When broadband distribution network **112** uses coaxial cable, the secondary winding of transformer **340** is wired in series with the center conductor of the video distribution coaxial cable. As previously described, RAD **118** hangs from the coaxial cabling of the broadband distribution network **112** to which it is connected. In other applications, such as with fiber optic cable, other well known frequency conversion and signal coupling techniques are used.

A small portion of the frequency multiplexed signals passing through transformer and coupler **340** is coupled to Built In Test (BIT) and power monitor **341**. Monitor **341** samples the signal level of the combined signals that are being input to broadband distribution network **112** and reports this information to RASP **117** via control signal oscillator **338** which has been previously described. If the output signal level is too high and the level cannot be corrected, microprocessor **210** will shut down RAD **118** and report this to RASP **117**.

In FIG. **4** is shown a detailed block diagram of circuit **408** in RAD **118** that carries telephony signals originating at RASP **117** via broadband distribution network **112** and circuit **408** to wireless telephones **119** (not shown). As previously described, RAD **118** hangs from and is connected to broadband distribution network **112**. Transformer **442** is an impedance matching transformer having 75 ohm primary and 50 ohm secondary windings. When broadband distribution network **112** is coaxial cable, the primary winding of transformer **442** is wired in series with the center conductor of the coaxial cable. Transformer **442** is used to connect frequency multiplexed telephony and control signals carried on broadband distribution network **112** to the input of RAD circuit **408**. Only the RADs **118**, the receive frequency which has been tuned to the particular frequency of telephony and control signals on broadband distribution network **112** can actually receive and forward the telephony signals to a wireless telephone **119**.

All RADs **118** assigned to a sector receive control signals directed toward any one of the RADs in the sector. However, each RAD **118** has a unique address that prefixes each control signal and is used by the RAD **118** to accept only control signals directed specifically to it by RASP **117**.

The frequency multiplexed telephony and control signals received by RAD circuit **408** from broadband distribution network **112** are input to band pass filter and amplifier **443**. The combination of mixers **444** and **447**, and filters **443**, **446** and **451** are primarily used to provide filtering of the digital, spread spectrum telephony signal in accordance with the teaching of present invention.

Filter **443** passes all possible frequency multiplexed telephony and control signals that are carried on broadband distribution network **112**, and excludes most other unwanted signals carried on broadband distribution network **112**. Circuit **443** also amplifies the signals that pass through the filter.

The signals output from filter **443** are input to mixer **444** along with a signal from local oscillator **445**. Alike the local oscillators shown in FIG. **2** and described with reference to that Figure, the frequency of local oscillator **445** is digitally controlled at its input **445***a* by microprocessor **210** in FIG. **2** responsive to control signals received from RASP **117**.

The operation of mixer **444** results in multiple frequencies being output from the mixer as is known in the art and unwanted frequencies are blocked by band pass filter **446** which passes only desired signals. The selected set of telephony and control signals are now input to mixer **447**. Alike other local oscillators in FIGS. **3** and **4**, oscillator **449** is digitally controlled at its control input **449***a* by microprocessor **210** responsive to control signals received from RASP **117**. In a manner well-known in the art, mixer **447** combines the signals input to it and provides a number of output signals at different frequencies. All these frequencies are input to an attenuator **450** which is used to adjust the gain level of the signals. Attenuator **450** is part of the gain control system and is digitally controlled at its input **450***a* in 1/2 dB steps by microprocessor **210**, responsive to control signals

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received from RASP **117**, alike the digitally controlled attenuator **336** in FIG. **3**.

The gain adjusted signal output from attenuator **450** is input to SAW filter and amplifier **451**. Due to the sharp filtering action of SAW filter **451**, even spurious signals close to the desired telephony and control tone signals are removed. Control signals frequency multiplexed with the telephony signal do not pass through SAW filter **451**. Instead, the control signals are input to mixer **448** as is described further in this specification.

The telephony signals passed through SAW filter **451** are input to digitally controlled attenuator **452** to adjust the gain level of the signal before it is input to mixer **453** along with the output of digitally controlled local oscillator **454**. Attenuator **452** is part of the gain control system and is digitally controlled at its control input **452***a* in 2 dB steps by microprocessor **210**, responsive to control signals received from RASP **117**.

The amplitude adjusted telephony signal output from attenuator **452** is input to mixer **453** along with a signal from digitally controlled **454***a* oscillator **454**. Oscillator **454** is controlled by microprocessor **210**, responsive to control signals received from RASP **117**, in the same manner as local oscillators **445** and **449**. Mixer **453** combines the two signals in a manner well-known in the art to produce several output signals, one of which is the telephony signal now having the desired carrier frequency for transmission of the communications signal to a remote wireless telephone **119**. The signals output from mixer **453** are input to band pass filter and amplifier **455**. Band pass filter **455** passes only the desired carrier frequency. The signal is also amplified before being input to signal divider **456**.

A portion of the telephony signal input to divider **456** is divided and input to bit and power monitor **457**, while the remainder of the signal is input to band pass filter and amplifier **458**. Bandpass filter **458** assures that there are no extraneous signals combined with the desired telephony signal, amplifies same, and applies it to power amplifier **459**. Power amplifier **459** amplifies the telephony signal and couples it to transmit antenna **420**. The signal is transmitted within the physical area of the cell or sector covered by this RAD **118** and is received by a remote wireless telephone **119** which is in the area covered by this RAD **118**.

The telephony signal input to bandpass filter **458** is sampled by divider **456** and the sample is input to BIT and Power Monitor **457**. The level of signal is reported by microprocessor **210** to RASP **117**. In addition, the output of power amplifier **459** is also sampled and input to BIT and Power Monitor **457**. A signal level measurement is used in concert with attenuators **450** and **452**, as commanded by RASP **117**, to adjust the power level of the telephony signal to be applied to transmit antenna **420**. If the signal level output from power amplifier **459** is too high microprocessor will shut down this RAD **118**.

A portion of the signal output from bandpass filter and amplifier **446**, and still including any control signals, is input to mixer **448** along with a signal from local oscillator **460**. The output of mixer **448** is input to reference channel oscillator **462** and forward control channel circuit **461**. Circuit **461** accepts only control signals sent from RASP **117** and sends them to microprocessor **210**. Control signals have a prefix RAD address as part of the control signals and each RAD **118** has a unique address. Therefore, microprocessor **210** in each RAD **118** can recognize and accept only control signals directed to it.

When a RAD **118** receives control signals directed to it, microprocessor **210** responds thereto to perform the action required by RASP **117**. The control signal may ask for the settings of the local oscillators and attenuators, and this information is returned to RASP **117** using control signal oscillator **338** as previously described. The control signal from RASP **117** may also indicate revised settings for local oscillators and attenuators. Microprocessor **210** makes the required changes and then sends a confirmation signal back to RASP **117** indicating that the requested changes have been made. As part of the gain control operation the control signal from RASP **117** may also request information concerning the outputs from bit and power monitors **341** and **457**, and request that the output from gain tone oscillator **342** be added to the telephony communications signals. Responsive to any of these control signals, microprocessor **210** performs the requests.

Reference channel oscillator **462** processes the output of mixer **448** to generate a phase lock loop reference signal that is used to provide a master frequency to all local oscillators within all RAD **118**s to match their frequency of operation with RASP **117**.

Having considered the design and operation of a RASP **117** and a RAD **118** in a wireless telephone system, the following will next consider the means by which the operation of RASPs **117** and RADs **118** are monitored and controlled and, in particular, the presently preferred embodiment of the means by which commands and monitored data are encoded and communicated over the network.

Referring first to FIG. **5**, therein is illustrated a generalized block diagram of a wireless telephony system integrated with a broadband distribution network according to a presently preferred embodiment of the present invention. As shown therein, the system will include at least one Head End Control Unit (HECU) **563** which may be implemented, for example, by program control in a computer, and which receives and monitors data from RASPs **517** and RADs **518** representing the states of operation of these elements of the wireless telephone system, and which generates and transmits commands to RASPs **517** and RADs **518** controlling their operation. As indicated, HECU **563**, which is part of Base Transceiver Station **115**, includes an Encoder/Transceiver (E/T) **564** that communicates monitored data and commands between the HECU **563** and the RASPs **517** and RADs **518** through the broadband distribution network **112**. In the presently preferred embodiment of the invention, Encoder/Transceiver (E/T) **564** may be, for example, a commercially available LONWorks neuron circuit which executes a communications protocol similar to the ethernet protocol.

The physical connection between the HECU **563** and RASPs **517** may be, for example, a RS-**485** link, as is well known to those of skill in the relevant arts.

As also shown in FIG. **5**, the HECU **563** may be connected to one or a plurality of RASPs **517**, each of which may in turn be connected to one or a plurality of RADs **518**. As indicated in FIG. **5**, each RASP **517** will include a first Encoder/Transceiver (E/T) **564** for communicating with the HECU **563** and a second Encoder/Transceiver (E/T) **564** for communicating with the RADs **518** associated with the RASP **517**. As indicated in a single, exemplary one of the RADs **518** of FIG. **5**, each RAD **518** will, in turn, include an Encoder/Transceiver (E/T) **564** connected between the RAD **518** receive and transmit circuits **508** and **509** and the RAD Microprocessor **210** for communicating between the RAD microprocessor **210** and the associated RASP **517**. As indicated in FIG. **5**, the communications links between a RASP **517** and the associated RADs **518** may also include a

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RS-232 link directly between the RASP 517 and one or more of the RAD microprocessors 210, which does not require the use of Encoders/Transceivers 564.

As has been discussed, the control and monitoring of a large network containing a large number of remote antenna drivers (RADs) and remote antenna signal processors (RASPs) requires a flexible and reliable means for encoding and communicating data and commands to be received from and transmitted to the remote antenna signal processors (RASPs) and the remote antenna drivers (RADs). It is necessary for the encoding means to convey data and commands in as flexible and compact a form as possible to preserve communications bandwidth and thereby to allow a large number of remote antenna drivers (RADs) to be monitored and controlled from each base transceiver station 115, and it is preferable that the encoding allow a flexible a network configuration as possible.

As described previously, a primary function of each RASP 517 is to act as an intermediary for communications between a HECU 563 and the RADs 518 connected to the RASP 517, for which purpose the RASP 517 passes command information from the HECU 563 to the RADs 518 connected to the RASP 517 and collects status information from the RADs 518. A second primary function of a RASP 517 is to control the RADs 518 connected to the RASP 517, such as tuning the RAD 518 transmitting and receiving frequencies, controlling the attenuation levels of the telephony signals and collecting and maintaining operational status information.

The monitoring and command communications and encoding system of the present invention accommodates two forms of communications traffic in order to perform the above described functions, wherein the two forms of traffic result from the types of communications between a HECU 563, the RASPs 517, and the RADs 518 and the resulting concentration patterns of telephony signals in the system. That is, the HECU 563 communicates not only with the RASPs 517, but also with each of the RADs 518. Each RASP 517, however, is generally a communications node for a plurality of RADs 518, that is, monitors and controls a plurality of RADs 518 as well as operating as a relay and concentration point for communications between the HECU 563 and the RADs 518 connected to RASP 517.

As such, there is a first traffic pattern of infrequent but high volume of command and control communications between the HECU 563 and each individual RASP 517, comprising, for each RASP 517, communications between the HECU 563 and the RASP 517 and communications between the HECU 563 and the RADs 518 that are relayed through the RASP 517. Each exchange of command and control communications traffic between a HECU 563 and a RASP 177 may comprise a relatively high volume of traffic with a given RASP 517 and an exchange between a HECU 563 and a RASP 517 will typically complete all current outstanding communications with that RASP 517. Such an exchange will usually be comprised of a sequence of messages exchanges, such as a command message from the HECU 563 to the RASP and a return message, such as an acknowledgment or reply or response from the RASP 517 to the HECU 563. The HECU 563 will then switch to another RASP 517 and repeat the process, and so on. The command and control communications between a HECU 563 and a RASP 517 will thereby typically be of the form of a completed exchange of transmissions and replies between the HECU 563 and the RASP 517 before the HECU 563 begins communication with the next RASP 517.

There is a second traffic pattern between each RASP 517 and the RADs 518 connected to the RASP 517, however, comprised of commands and monitoring data messages exchanged between the RASP 518 and the RADs 518 connected from the RASP 517 and messages between the HECU 563 to the individual RADs 518, for which the RASP 517 operates as a relay node. Accordingly, the total volume of communication traffic between a RASP 517 and the associated RADs 518 may be relatively greater. Each RASP 517 will typically exchange a relatively small volume of messages with each RAD 518, such as a sequence of commands, before switching to a next RAD 518 to issue a sequence of commands, and so on, and will return to each RAD 518 at a later time to receive the replies, acknowledgments ,or responses to the initial commands.

Finally in this regard, it will be noted that the variety of messages that must be exchanged between the HECU 563, RASPs 517 and RADs 518 is, by the nature of the wireless telephony system, relatively limited, being essentially restricted to commands and replies to commands. As such, the messages are encoded in the form of a relative compact unique code for each message, together with such associated data as is necessary to fully specify a command. A command issued by a RASP 517, for example, may include a code directing a RAD attenuator setting together with data representing the value to which the attenuator is to be set, or a code identifying monitored data, such as a signal level, together with data representing the measured value of the signal level.

Referring now to FIG. 6, therein is illustrated a message as exchanged between HECUs 563, RASPs 517 and RADs 518 according to the present invention. As shown therein, a Message 665 includes twelve Fields 666 which, in turn, are comprised of a Message Number (MSG. Num.) 667 field, a Message Tag (MSG Tag) 668 field and a plurality of Data Fields (DFs) 669, which are represented in the presently preferred embodiment by 10 data fields indicated as DFs 669 #1 through DF 669 #10). In the presently preferred embodiment, each Field 666 contains one byte, that is, 8 bits, of information.

The MSG Number 667 field contains a numeric value, for example, a hexadecimal number, representing the meaning of the message, such as "message failed", "set up downstream attenuators and power control" or "read frequency status". The presently preferred embodiment of the monitoring and command communications and encoding system of the present invention provides fifty-three messages, that is, defines fifty-three different, unique message codes that may appear in a MSG Number 667 field, each of which is defined in Appendix A.

The MSG Tag 668 field of a Message 665, in turn, contains a numeric value that is assigned to a given message for the purpose of identifying that message out of a sequence of messages. As described above, the MSG Tag 668 field of a Message 563 contains eight bits and is therefore capable of uniquely identifying each Message 563 in a sequence of two-hundred fifty-six messages, whereupon, in the present embodiment of the invention, the system returns to the beginning of the sequence and repeats the sequence, and so on.

As has been described above, a communication exchange between a HECU 563 and a RASPs 517 in the presently preferred embodiment will complete all current outstanding communications with that RASP 517 and will be of the form of a completed exchange of transmissions and replies between the HECU 563 and the RASP 517 before the HECU 563 begins communication with a next RASP 517. It is therefore not necessary to track the individual messages

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exchanged between a HECU **563** and the RASPs **517** as each exchange of one or more messages between a HECU **563** and a RASP **517** will be sequential and complete and, as such, the MSG Tag **668** field is not used, that is, is essentially ignored, in communications between a HECU **563** and the RASPs **517**.

As has also been described above, however, each RASP **517** will typically exchange a relatively small volume of messages with each RAD **518**, such as a sequence of commands, before switching to a next RAD **518** to issue a sequence of commands, and so on, and will return to the RADs **518** at a later time to receive the replies, acknowledgments or responses to the initial commands. As such, a transmission of messages between a RASP **517** and a RAD **518** will typically be partial and the messages sent to or received from a RAD **518** by a RASP **517** will be interspersed with messages sent to or received from one or more other RADs **518**. As such, the MSG Tag **668** field is used for communications between a RASP **517** and its associated RADs **518** in order to track and coordinate the messages sent to or received from each RAD **518**.

The DFs **669**, in turn, contain numeric or alphanumeric data pertaining to the meaning of the message, such as the reason for a message failing, the identification of a RAD **518** whose downstream attenuators and power levels are to be set and the settings for the attenuators and power levels, or a command for a RAD **518** or RASP **517** to report upon operating parameters identified in the message.

The possible range of messages, uses, and content of DFs **669** are illustrated in FIGS. **7**A through **7**H. For example, FIG. **7**A is a tabulation of the fifty-three messages implemented in the presently preferred embodiment of the invention, the left hand column of which expresses the fifty-three different hexadecimal numbers that may appear in the MSG Number **767** field of a Message **563** to identify the meaning or contents of a message. FIG. **7**B, in turn, is MSG Number 0×00, that is, message "0", which is a response only message identifying that a message failed to be processed by the intended recipient of the message and expressing, in the DF **769** fields of the message, the reason for the failure.

FIGS. **7**C, **7**D and **7**E are messages transmitted to RASPs **517**, identified in the messages as "HICs", by a HECU **563** to respectively set or change the RASP **117**'s state and channel parameters, to set the RASP **117**'s downstream attenuators and power control, and to set the RASP **117**'s upstream attenuators and power control.

FIG. **7**F is a message transmitted to a RASP **517**, at the installation of a new RAD **518**,and illustrates the loading of an identification code for the new RAD **518**, identified as a "Neuron ID", into a database in the RASP **517**. In this regard, it should be noted that, as described previously, the present implementation of the system uses Neuron circuits for communication between HECU **563**, RASPs **517**, and RADs **518**, and that each HECU **563**, RASP **517** and RAD **518** thereby contains a Neuron circuit. Each HECU **563**, RASP **517**, or RAD **518** is thereby identified and addressed, for example, as the intended recipient of a Message **563**, by the corresponding stored Neuron Chip identification code, or "Neuron ID".

FIG. **7**G illustrates a message used at installation of a RAD **118**, and subsequently to initialize, and change the state, frequencies and other parameters of the RAD **518**, also referred to as a "CMI", as may be seen from the contents defined for the DF **769** fields. It will be noted that this message, as would be typical for a message to a RAD **518**, contains a message tag **(0–255)** in MSG Tag **768** field and an identification (Neuron ID) of the RAD **518** intended as the recipient of the message in the form of a Sector Number and a CMI Number, forming a Neuron ID, in DF **769** field #2.

Finally, FIG. **7**H illustrates a message used to control the gain settings of RASPs **517** and RADs **518**.

In conclusion, while the invention has been particularly shown and described with reference to preferred embodiments of the apparatus and methods thereof, it will be also understood by those of ordinary skill in the art that various changes, variations and modifications in form, details and implementation may be made therein without departing from the spirit and scope of the invention as defined by the appended claims. Therefore, it is the object of the appended claims to cover all such variation and modifications of the invention as come within the true spirit and scope of the invention.

What is claimed is:

1. In a wireless telephone system including a plurality of remotely located transceivers for transmitting and receiving telephony signals to and from wireless telephones, each of the plurality of remote transceivers being connected to a broadband distribution network that carries the telephony signals between the remote transceivers and a central location, the central location including at least one remote antenna signal processor connected to the broadband distribution network and a control unit connected to the at least one remote antenna signal processor, a monitoring and command system for controlling operations of the at least one remote antenna signal processor and all the remote transceivers, said monitoring and command system comprising:

the control unit for exchanging messages with said at least one remote antenna signal processor and all of said remote transceivers for monitoring and controlling their operations, wherein

each exchange of messages between the control unit and said at least one remote antenna signal processor comprises a completed exchange of messages between the control unit and said at least one remote antenna signal processor before initiation of an exchange of messages between the control unit and another remote antenna signal processor, and

the at least one remote antenna signal processor for exchanging messages with each of the plurality of remote transceivers for monitoring and controlling operations of each of the remote transceivers, and for relaying messages between the control unit and each of the remote transceivers, wherein

the messages of an exchange of messages between the at least one remote antenna signal processor and a selected one of the remote transceivers being interspersed with the messages of an exchange of messages between the at least one remote antenna signal processor and others of the remote transceivers,

wherein the messages exchanged among the control unit, the at least one remote antenna signal processor, and the remote transceivers includes;

a message number field containing a value identifying the meaning of the message,

a message tag field containing a value identifying a given message in a sequence of messages,

wherein the message tag field is used in an exchange of messages between the at least one remote antenna signal processor and each of the remote transceivers, and

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a plurality of data fields containing message information wherein the contents of each data field are defined by the contents of the message number field.

2. The monitoring and command system of claim **1** wherein the data fields contain information comprising:

an identification of a remote transceiver intended as a recipient of a message.

3. The monitoring and command system of claim **1** wherein the data fields contain information comprising:

information determining the operating parameters of the remote transceivers.

4. The monitoring and command system of claim **1** wherein the data fields contain information comprising:

information pertaining to the status and operation of the remote transceivers.

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