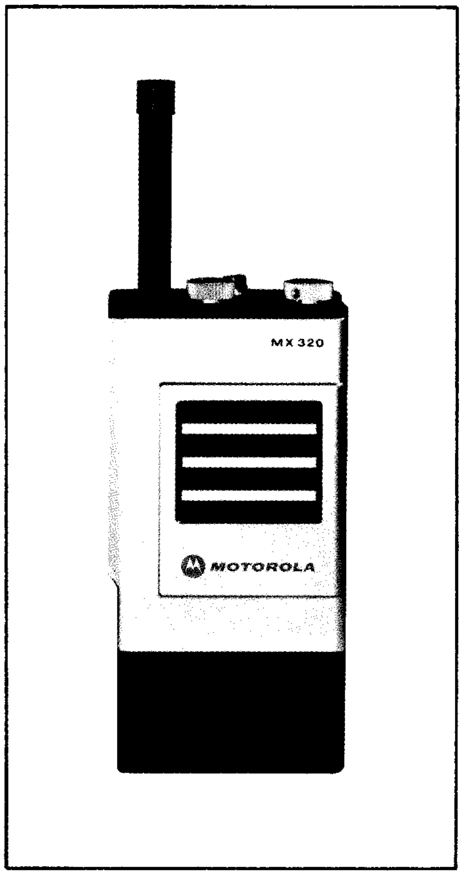
MOTOROLA

MX300 SERIES

"Handie-Talkie"

FM Two-Way Portable Radios

NOTE: THIS MANUAL APPLIES TO "APCOR" EMS REPEATERS AND TO THE MTR300 MOUNTAINTOP REPEATER.



Theory/Maintenance Manual

68P81013C70-A

MOTOROLA

MX300 SERIES

"Handie-Talkie"
FM Two-Way Portable Radios

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RELATED PUBLICATIONS
(Available Separately)

8000 W. Sunrise Blvd., Ft. Lauderdale, FL 33322
Printed in U.S.A. 3/7/80

LIST OF ILLUSTRATIONS

ACCESSORIES

Motorola offers several accessories to adapt to your particular needs. Consult your Motorola sales representative for a complete list of equipment.

Some of the more popular accessories are listed below.

MODEL	DESCRIPTION
NMN6050	Headset with Microphone; Safety Helmet/Face Mask Type
NMN6056	Headset with Microphone; Earpiece Type
NMN6064	Headset with Boom Microphone
NMN6065	Headset with Cup Microphone
NMN6070	Remote Speaker-Microphone (Straight Cord)
NMN6071	Remote Speaker-Microphone (Coiled Cord)
NMN6072	Public Safety Remote Speaker-Microphone (Uhf Radios)
NKN6223	External Antenna Adapter Cable
NLN8861	Radio Holder; Belt Loop
NLN8862	Radio Holder; Swivel, MX320 - MX360 Series
NLN8863	Carrying Case; Size 2, Belt Loop
NLN8864	Carrying Case; Size 3, Belt Loop
NLN8865	Carrying Case; Size 4, Belt Loop
NLN8866	Carrying Case; Size 5, Belt Loop
NLN8867	Carrying Case; Size 6, Belt Loop
NLN8868	Carrying Case; Size 7, Belt Loop
NLN8869	Carrying Case; Size 8, Belt Loop
NLN8870	Carrying Case; Size 9, Belt Loop
NLN8871	Carrying Case; Size 10, Belt Loop
NLN8872	Carrying Case; Size 11, Belt Loop
NLN8836	Carrying Case; Cover
NLN8837	Carrying Case; Strap
NLN4117	Carrying Case; Size 2, Swivel
NLN4118	Carrying Case; Size 3, Swivel
NLN4119	Carrying Case; Size 4, Swivel
NLN4120	Carrying Case; Size 5, Swivel
NLN4121	Carrying Case; Size 6, Swivel
NLN4122	Carrying Case; Size 7, Swivel
NLN4123	Carrying Case; Size 8, Swivel
NLN4124	Carrying Case; Size 9, Swivel
NLN4125	Carrying Case; Size 10, Swivel
NLN4126	Carrying Case; Size 11, Swivel
NSN6028	Earpiece; Without Volume Control
NKN6207	Adapter Cable for NMN6064 and NMN6065 Headsets
NAE6231	Antenna, Helical, 403 - 430 MHz (RED Color Code)
NAE6232	Antenna, Helical, 440 - 470 MHz (GREEN Color Code)
NAE6233	Antenna, Helical, 470 - 512 MHz (BLACK Color Code)
NLN8875	Push-To-Talk Unit for NMN6050 and NMN6056 Headsets
NLN4129	Strap, Wrist
NLN6349	Strap
NLN6042	Belt

MODEL CHART
FOR
MX300 SERIES VHF RADIOS

CODE:

[X] = ONE ITEM SUPPLIED

[A] = ALTERNATE ITEM SUPPLIED, CHOICE DEPENDS ON CARRIER FREQUENCY.

[O] = ONE ITEM SUPPLIED PER 20 OR LESS RADIOS

FOR HYBRID MODULE INFORMATION, REFER TO PARTS LIST IN APPLICABLE SUPPLEMENT.

MODEL NUMBER	RF OUTPUT POWER (WATTS)	TYPE OF SQUELCH	NO. OF CHANNELS	NLD6670A CIRCUIT BOARD (136-150.8 MHz)	NLD6810A CIRCUIT BOARD (136-150.8 MHz)	NLD6820A CIRCUIT BOARD (136-150.8 MHz)	NLD6830A CIRCUIT BOARD (136-150.8 MHz)	NLD7190A CIRCUIT BOARD (136-150.8 MHz)	NLD7200A CIRCUIT BOARD (136-150.8 MHz)	NLD7210A CIRCUIT BOARD (136-150.8 MHz)	NLD7220A CIRCUIT BOARD (136-150.8 MHz)	NLD6680A CIRCUIT BOARD (136-150.8 MHz)	NLD6840A CIRCUIT BOARD (136-150.8 MHz)	NLD6850A CIRCUIT BOARD (136-150.8 MHz)	NLD6860A CIRCUIT BOARD (136-150.8 MHz)	NLD6671B CIRCUIT BOARD (150.8-162 MHz)	NLD6811B CIRCUIT BOARD (150.8-162 MHz)	NLD6821B CIRCUIT BOARD (150.8-162 MHz)	NLD6831B CIRCUIT BOARD (150.8-162 MHz)	NLD7191A CIRCUIT BOARD (150.8-162 MHz)	NLD7201A CIRCUIT BOARD (150.8-162 MHz)	NLD7211A CIRCUIT BOARD (150.8-162 MHz)	NLD7221A CIRCUIT BOARD (150.8-162 MHz)	NLD6681B CIRCUIT BOARD (150.8-162 MHz)	NLD6841B CIRCUIT BOARD (150.8-162 MHz)	NLD6851B CIRCUIT BOARD (150.8-162 MHz)	NLD6861B CIRCUIT BOARD (150.8-162 MHz)	NLD6672A CIRCUIT BOARD (162-174 MHz)	NLD6812A CIRCUIT BOARD (162-174 MHz)	NLD6822A CIRCUIT BOARD (162-174 MHz)	NLD6832A CIRCUIT BOARD (162-174 MHz)	NLD7192A CIRCUIT BOARD (162-174 MHz)	NLD7202A CIRCUIT BOARD (162-174 MHz)	NLD7212A CIRCUIT BOARD (162-174 MHz)	NLD7222A CIRCUIT BOARD (162-174 MHz)	NLD6682B CIRCUIT BOARD (162-174 MHz)	NLD6842A CIRCUIT BOARD (162-174 MHz)	NLD6852A CIRCUIT BOARD (162-174 MHz)	NLD6862A CIRCUIT BOARD (162-174 MHz)	NLN4171B CONTROL FLEXIBLE CIRCUIT	NLD6571A PRESELECTOR (136-150.8 MHz)	NLD6572A PRESELECTOR (150.8-162 MHz)	NLD6573A PRESELECTOR (162-174 MHz)	NLN8784A FRAME (MX320 SERIES)	NLN8785A FRAME (MX330 SERIES)	NLN8786A FRAME (MX340 SERIES)	NLN8787A FRAME (MX350 SERIES)	NLN8788A FRAME (MX360 SERIES)	NLN8790A FRONT COVER (MX320 SERIES)	NLN8791A FRONT COVER (MX330 SERIES)	NLN8792A FRONT COVER (MX340 SERIES)	NLN8793A FRONT COVER (MX350 SERIES)	NLN8794A FRONT COVER (MX360 SERIES)	NLN8796A FRONT COVER (MX330 SERIES) HIGH POWER MODELS	NLN8797A FRONT COVER (MX340 SERIES) HIGH POWER MODELS	NLN8798A FRONT COVER (MX350 SERIES) HIGH POWER MODELS	NLN8799A FRONT COVER (MX360 SERIES) HIGH POWER MODELS	NLN8801A BACK COVER (MX320 SERIES)	NLN8802A BACK COVER (MX330 SERIES)	NLN8803A BACK COVER (MX340 SERIES)	NLN8804A BACK COVER (MX350 SERIES)	NLN8805A BACK COVER (MX360 SERIES)	NAD6282A HELICAL ANTENNA (136-150.8 MHz) (YELLOW CODE)	NAD6283A HELICAL ANTENNA (150.8-162 MHz) (BLACK CODE)	NAD6284A HELICAL ANTENNA (162-174 MHz) (BLUE CODE)	NLN8928A MISCELLANEOUS PARTS KIT	NLN8933A MISCELLANEOUS PARTS KIT	NLN8816A ESCUTCHEON AND KNOB KIT	NLN8817A ESCUTCHEON AND KNOB KIT	NLN8822A ESCUTCHEON AND KNOB KIT	NLN8842A ESCUTCHEON AND KNOB KIT	NLN4132A GROUND CLIP KIT	NLN8861A CARRY HOLDER	NLN8834B NICKEL-CADMIUM BATTERY	NLN5860A NICKEL-CADMIUM BATTERY (HIGH-CAPACITY CHARGE)	NLN4414A NAMEPLATE	NLN4416A NAMEPLATE	NLN4415A NAMEPLATE	NLN8819A FREQUENCY SELECT SWITCH (2-FREQ. MODELS)	NLD6881A FREQUENCY SELECT SWITCH AND FLEX (4-FREQ. MODELS)	NLD6891A FREQUENCY SELECT SWITCH AND FLEX (6-FREQ. MODELS)	NLD6901A FREQUENCY SELECT SWITCH AND FLEX (8-FREQ. MODELS)	NLN8923A "DIGITAL PRIVATE-LINE" MOUNTING BOARD	NLN4107A INTERCONNECT FLEXIBLE CIRCUIT	NLN4109A INTERCONNECT FLEXIBLE CIRCUIT	NLN4110A INTERCONNECT FLEXIBLE CIRCUIT	NLN4111A INTERCONNECT FLEXIBLE CIRCUIT	NLN4097A RAIL MOUNTING KIT	NLN4112A PAD KIT	NLN8820A TUNING TOOL
H23AAU1110BN	1.0	CARRIER	1	A												A												A												X	A	A	A	X					X									X					A	A	A	X		X				X	X	X		X														O
H23AAU1120BN	1.0	CARRIER	2	A												A												A												X	A	A	A	X					X									X					A	A	A	X			X			X	X	X		X			X											O
H23AAU1140BN	1.0	CARRIER	4		A												A												A											X	A	A	A			X					X									X			A	A	A		X		X			X	X	X			X			X										O
H23AAU1160BN	1.0	CARRIER	6			A												A												A										X	A	A	A				X					X									X		A	A	A		X		X			X	X	X			X				X									O
H23AAU1180BN	1.0	CARRIER	8				A												A												A									X	A	A	A					X					X									X	A	A	A		X		X			X	X	X			X					X								O
H23AAU3110BN	1.0	TONE "PRIVATE-LINE"	1	A												A												A												X	A	A	A	X					X									X					A	A	A	X				X		X	X	X		X														O
H23AAU3120BN	1.0	TONE "PRIVATE-LINE"	2	A												A												A												X	A	A	A	X					X									X					A	A	A	X					X	X	X	X		X			X											O
H23AAU3140BN	1.0	TONE "PRIVATE-LINE"	4		A												A												A											X	A	A	A			X					X									X			A	A	A		X				X	X	X	X			X			X										O
H23AAU3160BN	1.0	TONE "PRIVATE-LINE"	6			A												A												A										X	A	A	A				X					X									X		A	A	A		X				X	X	X	X			X				X									O
H23AAU3180BN	1.0	TONE "PRIVATE-LINE"	8				A												A												A									X	A	A	A					X					X									X	A	A	A		X				X	X	X	X			X					X								O
H23AAU6110BN	1.0	"DIGITAL PRIVATE-LINE"	1	A												A												A												X	A	A	A		X					X									X				A	A	A	X				X		X	X	X				X					X	X				X	X	O
H23AAU6120BN	1.0	"DIGITAL PRIVATE-LINE"	2	A												A												A												X	A	A	A		X					X									X				A	A	A	X					X	X	X	X				X	X				X	X				X	X	O
H23AAU6140BN	1.0	"DIGITAL PRIVATE-LINE"	4		A												A												A											X	A	A	A				X					X									X		A	A	A		X				X	X	X	X			X			X			X		X			X	X	O
H23AAU6160BN	1.0	"DIGITAL PRIVATE-LINE"	6			A												A												A										X	A	A	A				X					X									X		A	A	A		X				X	X	X	X			X				X		X			X		X	X	O
H23AAU6180BN	1.0	"DIGITAL PRIVATE-LINE"	8				A												A												A									X	A	A	A					X					X									X	A	A	A		X				X	X	X	X			X					X	X				X	X	X	O
H33AAU1110BN	2.5	CARRIER	1					A												A												A								X	A	A	A	X					X									X					A	A	A	X		X				X	X	X		X														O
H33AAU1120BN	2.5	CARRIER	2					A												A												A								X	A	A	A	X					X									X					A	A	A	X			X			X	X	X		X			X											O
H33AAU1140BN	2.5	CARRIER	4						A												A												A							X	A	A	A			X					X									X			A	A	A		X		X			X	X	X			X			X										O
H33AAU1160BN	2.5	CARRIER	6							A												A												A						X	A	A	A				X					X									X		A	A	A		X		X			X	X	X			X				X									O
H33AAU1180BN	2.5	CARRIER	8								A												A												A					X	A	A	A					X					X									X	A	A	A		X		X			X	X	X			X					X								O
H33AAU3110BN	2.5	TONE "PRIVATE-LINE"	1					A												A												A								X	A	A	A	X					X									X					A	A	A	X				X		X	X	X		X														O
H33AAU3120BN	2.5	TONE "PRIVATE-LINE"	2					A												A												A								X	A	A	A	X					X									X					A	A	A	X					X	X	X	X		X			X											O
H33AAU3140BN	2.5	TONE "PRIVATE-LINE"	4						A												A												A							X	A	A	A			X					X									X			A	A	A		X				X	X	X	X			X			X										O
H33AAU3160BN	2.5	TONE "PRIVATE-LINE"	6							A												A												A						X	A	A	A				X					X									X		A	A	A		X				X	X	X	X			X				X									O
H33AAU3180BN	2.5	TONE "PRIVATE-LINE"	8								A												A												A					X	A	A	A					X					X									X	A	A	A		X				X	X	X	X			X					X								O
H33AAU6110BN	2.5	"DIGITAL PRIVATE-LINE"	1					A												A												A								X	A	A	A		X					X									X				A	A	A	X				X		X	X	X				X					X	X				X	X	O
H33AAU6120BN	2.5	"DIGITAL PRIVATE-LINE"	2					A												A												A								X	A	A	A		X					X									X				A	A	A	X					X	X	X	X				X	X				X	X				X	X	O
H33AAU6140BN	2.5	"DIGITAL PRIVATE-LINE"	4						A												A												A							X	A	A	A				X					X									X		A	A	A		X				X	X	X	X			X			X			X		X			X	X	O
H33AAU6160BN	2.5	"DIGITAL PRIVATE-LINE"	6							A												A												A						X	A	A	A				X					X									X		A	A	A		X				X	X	X	X			X				X		X			X		X	X	O
H33AAU6180BN	2.5	"DIGITAL PRIVATE-LINE"	8								A												A												A					X	A	A	A					X					X									X	A	A	A		X				X	X	X	X			X					X	X				X	X	X	O
H43AAU1110BN	6.0	CARRIER	1									A												A												A				X	A	A	A	X										X					X				A	A	A	X		X				X	X		X			X												O
H43AAU1120BN	6.0	CARRIER	2									A												A												A				X	A	A	A	X										X					X				A	A	A	X			X			X	X		X			X	X											O
H43AAU1140BN	6.0	CARRIER	4										A												A												A			X	A	A	A				X									X					X		A	A	A		X		X			X	X		X		X			X										O
H43AAU1160BN	6.0	CARRIER	6											A												A												A		X	A	A	A				X									X					X		A	A	A		X		X			X	X		X		X				X									O
H43AAU1180BN	6.0	CARRIER	8												A												A												A	X	A	A	A					X									X					X	A	A	A		X		X			X	X		X		X					X								O
H43AAU3110BN	6.0	TONE "PRIVATE-LINE"	1									A												A												A				X	A	A	A	X										X					X				A	A	A	X				X		X	X		X			X												O
H43AAU3120BN	6.0	TONE "PRIVATE-LINE"	2									A												A												A				X	A	A	A	X										X					X				A	A	A	X					X	X	X	X		X			X	X											O
H43AAU3140BN	6.0	TONE "PRIVATE-LINE"	4										A												A												A			X	A	A	A				X									X					X		A	A	A		X				X	X	X		X		X			X										O
H43AAU3160BN	6.0	TONE "PRIVATE-LINE"	6											A												A												A		X	A	A	A				X									X					X		A	A	A		X				X	X	X		X		X				X									O
H43AAU3180BN	6.0	TONE "PRIVATE-LINE"	8												A												A												A	X	A	A	A					X									X					X	A	A	A		X				X	X	X		X		X					X								O
H43AAU6110BN	6.0	"DIGITAL PRIVATE-LINE"	1									A												A												A				X	A	A	A		X										X					X			A	A	A	X				X		X	X		X		X						X	X				X	X	O
H43AAU6120BN	6.0	"DIGITAL PRIVATE-LINE"	2									A												A												A				X	A	A	A		X										X					X			A	A	A	X					X	X	X		X		X		X				X	X				X	X	O
H43AAU6140BN	6.0	"DIGITAL PRIVATE-LINE"	4										A												A												A			X	A	A	A				X									X					X		A	A	A		X				X	X	X		X		X			X			X		X			X	X	O
H43AAU6160BN	6.0	"DIGITAL PRIVATE-LINE"	6											A												A												A		X	A	A	A					X									X					X	A	A	A		X				X	X	X		X		X				X		X			X		X	X	O

MODEL CHART
FOR
MX300 SERIES UHF RADIOS

CODE:

[X] = ONE ITEM SUPPLIED

[A] = ALTERNATE ITEM SUPPLIED, CHOICE DEPENDS ON CARRIER FREQUENCY.

[O] = ONE ITEM SUPPLIED PER 20 OR LESS RADIOS

FOR HYBRID MODULE INFORMATION, REFER TO PARTS LIST IN APPLICABLE SUPPLEMENT.

* MX360 SIZE FRAMES AND COVERS MAY BE USED IN SOME OPTION APPLICATIONS.

MODEL NUMBER	RF OUTPUT POWER (WATTS)	TYPE OF SQUELCH	NO. OF CHANNELS	NLE8580A CIRCUIT BOARD (403-430 MHz)	NLE8590A CIRCUIT BOARD (403-430 MHz)	NLE8600A CIRCUIT BOARD (403-430 MHz)	NLE8040A CIRCUIT BOARD (403-430 MHz)	NLE8230A CIRCUIT BOARD (403-430 MHz)	NLE8240A CIRCUIT BOARD (403-430 MHz)	NLE8050A CIRCUIT BOARD (403-430 MHz)	NLE8260A CIRCUIT BOARD (403-430 MHz)	NLE8270A CIRCUIT BOARD (403-430 MHz)	NLE8581A CIRCUIT BOARD (440-470 MHz)	NLE8591A CIRCUIT BOARD (440-470 MHz)	NLE8601A CIRCUIT BOARD (440-470 MHz)	NLE8041B CIRCUIT BOARD (440-470 MHz)	NLE8231B CIRCUIT BOARD (440-470 MHz)	NLE8241B CIRCUIT BOARD (440-470 MHz)	NLE8051B CIRCUIT BOARD (440-470 MHz)	NLE8261B CIRCUIT BOARD (440-470 MHz)	NLE8271B CIRCUIT BOARD (440-470 MHz)	NLE8582A CIRCUIT BOARD (470-512 MHz)	NLE8592A CIRCUIT BOARD (470-512 MHz)	NLE8602A CIRCUIT BOARD (470-512 MHz)	NLE8042A CIRCUIT BOARD (470-512 MHz)	NLE8232A CIRCUIT BOARD (470-512 MHz)	NLE8242A CIRCUIT BOARD (470-512 MHz)	NLE8052A CIRCUIT BOARD (470-512 MHz)	NLE8262A CIRCUIT BOARD (470-512 MHz)	NLE8272A CIRCUIT BOARD (470-512 MHz)
H24AAU1110BN	1.0	CARRIER	1	A									A									A								
H24AAU1120BN	1.0	CARRIER	2	A									A									A								
H24AAU1140BN	1.0	CARRIER	4		A									A									A							
H24AAU1160BN	1.0	CARRIER	6			A									A									A						
H24AAU1180BN	1.0	CARRIER	8			A									A									A						
H24AAU3110BN	1.0	TONE "PRIVATE-LINE"	1	A									A									A								
H24AAU3120BN	1.0	TONE "PRIVATE-LINE"	2	A									A									A								
H24AAU3140BN	1.0	TONE "PRIVATE-LINE"	4		A									A									A							
H24AAU3160BN	1.0	TONE "PRIVATE-LINE"	6			A									A									A						
H24AAU3180BN	1.0	TONE "PRIVATE-LINE"	8			A									A									A						
H24AAU6110BN	1.0	"DIGITAL PRIVATE-LINE"	1	A									A									A								
H24AAU6120BN	1.0	"DIGITAL PRIVATE-LINE"	2	A									A									A								
H24AAU6140BN	1.0	"DIGITAL PRIVATE-LINE"	4		A									A									A							
H24AAU6160BN	1.0	"DIGITAL PRIVATE-LINE"	6			A									A									A						
H24AAU6180BN	1.0	"DIGITAL PRIVATE-LINE"	8			A									A									A						
H34AAU1110BN	2.0	CARRIER	1				A									A									A					
H34AAU1120BN	2.0	CARRIER	2				A									A									A					
H34AAU1140BN	2.0	CARRIER	4					A									A									A				
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H34AAU1180BN	2.0	CARRIER	8						A									A									A			
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H34AAU3120BN	2.0	TONE "PRIVATE-LINE"	2				A									A									A					
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H34AAU6180BN	2.0	"DIGITAL PRIVATE-LINE"	8						A									A									A			
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H44AAU1120BN	5.0	CARRIER	2							A									A									A		
H44AAU1140BN	5.0	CARRIER	4								A									A									A	
H44AAU1160BN	5.0	CARRIER	6									A									A									A
H44AAU1180BN	5.0	CARRIER	8									A									A									A
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H44AAU3120BN	5.0	TONE "PRIVATE-LINE"	2							A									A									A		
H44AAU3140BN	5.0	TONE "PRIVATE-LINE"	4								A									A									A	
H44AAU3160BN	5.0	TONE "PRIVATE-LINE"	6									A									A									A
H44AAU3180BN	5.0	TONE "PRIVATE-LINE"	8									A									A									A
H44AAU6110BN	5.0	"DIGITAL PRIVATE-LINE"	1							A									A									A		
H44AAU6120BN	5.0	"DIGITAL PRIVATE-LINE"	2							A									A									A		
H44AAU6140BN	5.0	"DIGITAL PRIVATE-LINE"	4								A									A									A	
H44AAU6160BN	5.0	"DIGITAL PRIVATE-LINE"	6									A									A									A
H44AAU6180BN	5.0	"DIGITAL PRIVATE-LINE"	8									A									A									A

MODEL NUMBER	NLN4171B CONTROL FLEXIBLE CIRCUIT	NLE6931A PRESELECTOR (403-430 MHz)	NLE6932A PRESELECTOR (440-470 MHz)	NLE6933A PRESELECTOR (470-512 MHz)	NLN8784A FRAME (MX320 SERIES)	NLN8785A FRAME (MX330 SERIES)	NLN8786A FRAME (MX340 SERIES)	NLN8787A* FRAME (MX350 SERIES)	NLN8790A FRONT COVER (MX320 SERIES)	NLN8791A FRONT COVER (MX330 SERIES)	NLN8792A FRONT COVER (MX340 SERIES)	NLN8793A* FRONT COVER (MX350 SERIES)	NLN8796A FRONT COVER (MX330 SERIES) HIGH POWER MODELS	NLN8797A FRONT COVER (MX340 SERIES) HIGH POWER MODELS	NLN8798A* FRONT COVER (MX350 SERIES) HIGH POWER MODELS	NLN8801A BACK COVER (MX320 SERIES)	NLN8802A BACK COVER (MX330 SERIES)	NLN8803A BACK COVER (MX340 SERIES)	NLN8804A* BACK COVER (MX350 SERIES)	NAE6222A ANTENNA (WHIP)	NLN8928A MISCELLANEOUS PARTS KIT	NLN8933A MISCELLANEOUS PARTS KIT
H24AAU1110BN	X	A	A	A	X				X							X				X	X	
H24AAU1120BN	X	A	A	A	X				X							X				X	X	
H24AAU1140BN	X	A	A	A		X				X							X			X		X
H24AAU1160BN	X	A	A	A			X				X							X		X		X
H24AAU1180BN	X	A	A	A			X				X							X		X		X
H24AAU3110BN	X	A	A	A	X				X							X				X	X	
H24AAU3120BN	X	A	A	A	X				X							X				X	X	
H24AAU3140BN	X	A	A	A		X				X							X			X		X
H24AAU3160BN	X	A	A	A			X				X							X		X		X
H24AAU3180BN	X	A	A	A			X				X							X		X		X
H24AAU6110BN	X	A	A	A		X				X							X			X	X	
H24AAU6120BN	X	A	A	A		X				X							X			X	X	
H24AAU6140BN	X	A	A	A			X				X							X		X		X
H24AAU6160BN	X	A	A	A				X				X							X	X		X
H24AAU6180BN	X	A	A	A				X				X							X	X		X
H34AAU1110BN	X	A	A	A	X				X							X				X	X	
H34AAU1120BN	X	A	A	A	X				X							X				X	X	
H34AAU1140BN	X	A	A	A		X				X							X			X		X
H34AAU1160BN	X	A	A	A			X				X							X		X		X
H34AAU1180BN	X	A	A	A			X				X							X		X		X
H34AAU3110BN	X	A	A	A	X				X							X				X	X	
H34AAU3120BN	X	A	A	A	X				X							X				X	X	
H34AAU3140BN	X	A	A	A		X				X							X			X		X
H34AAU3160BN	X	A	A	A			X				X							X		X		X
H34AAU3180BN	X	A	A	A			X				X							X		X		X
H34AAU6110BN	X	A	A	A		X				X							X			X	X	
H34AAU6120BN	X	A	A	A		X				X							X			X	X	
H34AAU6140BN	X	A	A	A			X				X							X		X		X
H34AAU6160BN	X	A	A	A				X				X							X	X		X
H34AAU6180BN	X	A	A	A				X				X							X	X		X
H44AAU1110BN	X	A	A	A		X							X				X			X	X	
H44AAU1120BN	X	A	A	A		X							X				X			X	X	
H44AAU1140BN	X	A	A	A			X							X				X		X		X
H44AAU1160BN	X	A	A	A				X							X				X	X		X
H44AAU1180BN	X	A	A	A				X							X				X	X		X
H44AAU3110BN	X	A	A	A		X							X				X			X	X	
H44AAU3120BN	X	A	A	A		X							X				X			X	X	
H44AAU3140BN	X	A	A	A			X							X				X		X		X
H44AAU3160BN	X	A	A	A				X							X				X	X		X
H44AAU3180BN	X	A	A	A				X							X				X	X		X
H44AAU6110BN	X	A	A	A			X							X				X		X	X	
H44AAU6120BN	X	A	A	A			X							X				X		X	X	
H44AAU6140BN	X	A	A	A				X							X				X	X		X
H44AAU6160BN	X	A	A	A				X							X				X	X		X
H44AAU6180BN	X	A	A	A				X							X				X	X		X

MODEL NUMBER	NLN8816A ESCUTCHEON AND KNOB KIT	NLN8817A ESCUTCHEON AND KNOB KIT	NLN8822A ESCUTCHEON AND KNOB KIT	NLN8842A ESCUTCHEON AND KNOB KIT	NLN8861A CARRY HOLDER	NLN4131A GROUND CLIP KIT	NLN8834B NICKEL-CADMIUM BATTERY	NLN5860A NICKEL-CADMIUM BATTERY (HIGH-CAPACITY CHARGE)	NLN4414A NAMEPLATE	NLN4416A NAMEPLATE	NLN4415A NAMEPLATE	NLN8819A FREQUENCY SELECT SWITCH (2-FREQ. MODELS)	NLE8251A FREQUENCY SELECT SWITCH AND FLEX (4-FREQ. MODELS)	NLE8301A FREQUENCY SELECT SWITCH AND FLEX (6-FREQ. MODELS)	NLE8311A FREQUENCY SELECT SWITCH AND FLEX (8-FREQ. MODELS)	NLE8382A FREQUENCY SELECT SWITCH AND FLEX (4-FREQ., HI PWR)	NLE8392A FREQUENCY SELECT SWITCH AND FLEX (6-FREQ., HI PWR)	NLE8402A FREQUENCY SELECT SWITCH AND FLEX (8-FREQ., HI PWR)	NLN8923A "DIGITAL PRIVATE-LINE" MOUNTING BOARD	NLN4107A INTERCONNECT FLEXIBLE CIRCUIT	NLN4108A INTERCONNECT FLEXIBLE CIRCUIT	NLN4109A INTERCONNECT FLEXIBLE CIRCUIT	NLN4097A RAIL MOUNTING KIT	NLN4112A PAD KIT	NLN8820A TUNING TOOL
H24AAU1110BN	X				X	X	X		X																O
H24AAU1120BN		X			X	X	X		X			X													O
H24AAU1140BN		X			X	X	X			X			X												O
H24AAU1160BN		X			X	X	X			X				X											O
H24AAU1180BN		X			X	X	X			X					X										O
H24AAU3110BN			X		X	X	X		X																O
H24AAU3120BN				X	X	X	X		X			X													O
H24AAU3140BN				X	X	X	X			X			X												O
H24AAU3160BN				X	X	X	X			X				X											O
H24AAU3180BN				X	X	X	X			X					X										O
H24AAU6110BN			X		X	X	X				X								X	X			X	X	O
H24AAU6120BN				X	X	X	X				X	X							X	X			X	X	O
H24AAU6140BN				X	X	X	X			X			X						X		X		X	X	O
H24AAU6160BN				X	X	X	X			X				X					X			X	X	X	O
H24AAU6180BN				X	X	X	X			X					X				X			X	X	X	O
H34AAU1110BN	X				X	X	X		X																O
H34AAU1120BN		X			X	X	X		X			X													O
H34AAU1140BN		X			X	X	X			X			X												O
H34AAU1160BN		X			X	X	X			X				X											O
H34AAU1180BN		X			X	X	X			X					X										O
H34AAU3110BN			X		X	X	X		X																O
H34AAU3120BN				X	X	X	X		X			X													O
H34AAU3140BN				X	X	X	X			X			X												O
H34AAU3160BN				X	X	X	X			X				X											O
H34AAU3180BN				X	X	X	X			X					X										O
H34AAU6110BN			X		X	X	X				X								X	X			X	X	O
H34AAU6120BN				X	X	X	X				X	X							X	X			X	X	O
H34AAU6140BN				X	X	X	X			X			X						X		X		X	X	O
H34AAU6160BN				X	X	X	X			X				X					X			X	X	X	O
H34AAU6180BN				X	X	X	X			X					X				X			X	X	X	O
H44AAU1110BN	X				X	X		X			X														O
H44AAU1120BN		X			X	X		X			X	X													O
H44AAU1140BN		X			X	X		X		X						X									O
H44AAU1160BN		X			X	X		X		X							X								O
H44AAU1180BN		X			X	X		X		X								X							O
H44AAU3110BN			X		X	X		X			X														O
H44AAU3120BN				X	X	X		X			X	X													O
H44AAU3140BN				X	X	X		X		X						X									O
H44AAU3160BN				X	X	X		X		X							X								O
H44AAU3180BN				X	X	X		X		X								X							O
H44AAU6110BN			X		X	X		X		X									X	X			X	X	O
H44AAU6120BN				X	X	X		X		X		X							X	X			X	X	O
H44AAU6140BN				X	X	X		X		X						X			X		X		X	X	O
H44AAU6160BN				X	X	X		X		X							X		X			X	X	X	O
H44AAU6180BN				X	X	X		X		X								X	X			X	X	X	O

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MODEL CHART

FOR

MX300 SERIES RADIOS

806 - 815 AND 851 - 860 MHz

CODE:

☒ = ONE ITEM SUPPLIED

◙ = ONE ITEM SUPPLIED PER 20 OR LESS RADIOS

FOR HYBRID MODULE INFORMATION, REFER TO PARTS LIST IN APPLICABLE SUPPLEMENT.

* MX360 SIZE FRAMES AND COVERS MAY BE USED IN SOME OPTION APPLICATIONS.

MODEL NUMBER	RF OUTPUT POWER (WATTS)	TYPE OF SQUELCH	NO. OF CHANNELS	NLF4190A CIRCUIT BOARD	NLF4200A CIRCUIT BOARD	NLF4210A CIRCUIT BOARD	NLF4220A CIRCUIT BOARD	NAF4000A ANTENNA (FLEXIBLE WHIP)	NLN5266A CONTROL FLEXIBLE CIRCUIT	NLN5889A FREQUENCY SELECT SWITCH (4-FREQUENCY MODELS)	NLN5890A FREQUENCY SELECT SWITCH (5-FREQUENCY MODELS)	NLN5892A FREQUENCY SELECT SWITCH (2-FREQUENCY MODELS)	NLN5278A FRAME KIT (MX320 SERIES)	NLN5279A FRAME KIT (MX330 SERIES)	NLN5283A FRONT COVER (MX320 SERIES)	NLN5284A FRONT COVER (MX330 SERIES)	NLN7011A BACK COVER (MX320 SERIES)	NLN7012A BACK COVER (MX330 SERIES)	NLN5743A ESCUTCHEON KIT	NLN5275A ESCUTCHEON KIT	NLN5276A ESCUTCHEON KIT	NLN5682A ESCUTCHEON KIT	NLN5740A ESCUTCHEON KIT	NLN5741A ESCUTCHEON KIT	NLN5269A MISCELLANEOUS PARTS KIT	NLN5288A MISCELLANEOUS PARTS KIT	NLN8861A CARRY HOLDER	NLN8834A NICKEL-CADMIUM BATTERY (MEDIUM CAPACITY)	NLN5914A SWITCH KIT (PL AND DPL)	NLN4414A NAMEPLATE	NLN5723A NAMEPLATE	NLN5918A KNOB KIT (SHORT) (SQUELCH, FREQUENCY, VOLUME)	NLN5919A KNOB KIT (SHORT) (SQUELCH, VOLUME)	NLN5270A PAD (DPL)	NLN8820A TUNING TOOL	NLN4131A GROUND CLIP KIT	NLN5788A ANTENNA PLUG
H35AAU1110AN	1.5	CARRIER	1	X				X	X				X		X		X					X			X		X	X		X			X		O	X	X
H35AAU1120AN	1.5	CARRIER	2	X				X	X			X	X		X		X						X		X		X	X		X			X		O	X	X
H35AAU1140AN	1.5	CARRIER	4			X		X	X	X				X		X		X		X						X	X	X			X	X			O	X	X
H35AAU1150AN	1.5	CARRIER	5			X		X	X		X			X		X		X		X						X	X	X			X	X			O	X	X
H35AAU3110AN	1.5	TONE "PRIVATE-LINE"	1	X				X	X				X		X		X		X						X		X	X	X	X			X		O	X	X
H35AAU3120AN	1.5	TONE "PRIVATE-LINE"	2	X				X	X			X	X		X		X							X	X		X	X	X	X			X		O	X	X
H35AAU3140AN	1.5	TONE "PRIVATE-LINE"	4			X		X	X	X				X		X		X			X					X	X	X	X		X	X			O	X	X
H35AAU3150AN	1.5	TONE "PRIVATE-LINE"	5			X		X	X		X			X		X		X			X					X	X	X	X		X	X			O	X	X
H35AAU6110AN	1.5	"DIGITAL PRIVATE-LINE"	1		X			X	X				X		X		X		X						X		X	X	X	X			X	X	O	X	X
H35AAU6120AN	1.5	"DIGITAL PRIVATE-LINE"	2		X			X	X			X	X		X		X							X	X		X	X	X	X			X	X	O	X	X
H35AAU6140AN	1.5	"DIGITAL PRIVATE-LINE"	4				X	X	X	X				X		X		X			X					X	X	X	X		X	X		X	O	X	X
H35AAU6150AN	1.5	"DIGITAL PRIVATE-LINE"	5				X	X	X		X			X		X		X			X					X	X	X	X		X	X		X	O	X	X

EPF-9939-O

DESCRIPTION

1. INTRODUCTION

The MX300 Series "Handie-Talkie" radios described in this manual are the most advanced two-way radios available. Hybrid modular construction is used throughout, reflecting the latest achievements in microelectronic technology. The plug-in modules provide greater flexibility, greater reliability, and easier maintenance.

Each radio contains at least 17 plug-in hybrid modules. These modules contain over 90% of the electronics — providing faster service and less down-time. Guide pins are provided on the modules to assist replacement and prevent incorrect insertion.

Instead of complex wiring harnesses, printed flexible circuits are used in the radio. These durable, thin plastic films eliminate broken, pinched, or frayed wires — with a neat easy-to-service interior.

The vhf and uhf radios are available in three power ratings, and with 1 to 8 channels. The "800 MHz" radios are available with 1.5 W power rating, with 1 to 5 channels.

NOTE

The term "800 MHz" radios will be used in this manual, to denote radios designed to operate in the 806-815 and 851-860 MHz ranges.

All operating controls (except PTT switch) are conveniently located on top of the radio. The PTT switch on the side of the radio is covered with a weather-sealed boot, permitting operation in all environmental conditions.

The radios are available in five different sizes, known as MX320 through MX360. This designation does not define what is in the radio, but designates the housing size, which varies only in height. The type radio and the functions provided in the radio are identified by the model number (e.g., H33AAU1120) and the associated option codes (e.g., H423). As additional channels or functions are added to the basic radio, increasingly taller housings are used until the MX360 radio is reached.

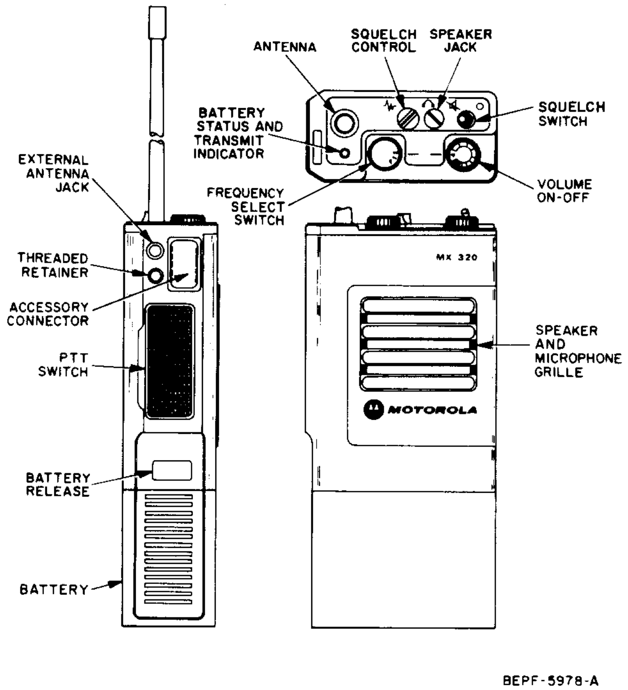

Figure 1. Typical Two-Frequency Radio

The receiver utilizes monolithic crystal filters and hybrid technology to eliminate all i-f and discriminator tuning adjustments. In vhf and uhf receivers, only the rf circuits require tuning. The 800 MHz receiver has no rf circuit tuning.

The transmitter contains a phase-locked-loop circuit to generate the carrier frequency without need for multiplication in the rf amplifiers. This produces a transmitter that is very simple to align; set power output, set deviation, and warp the channel element to frequency.

The primary differences in basic radios involve the frequency band, the number of channels, the type squelch, and the transmitter rf power output. These variations require different module complements, and different printed circuit board layouts. Radio size is determined by the number of channels, transmitter power, signalling options, and other system related options. The different radio sizes are shown in Figure 2. The battery height is not shown, and will further vary the height depending upon the battery used.

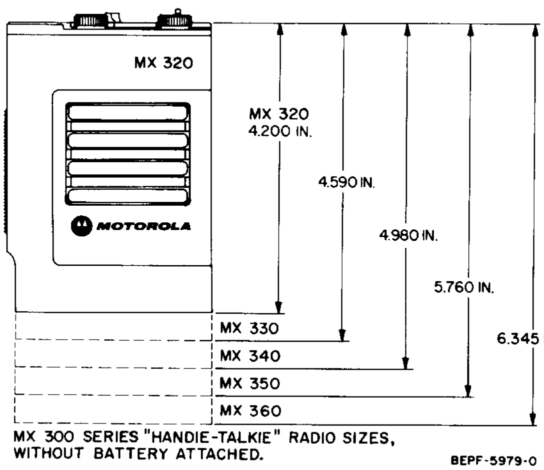

Figure 2. Basic Radio Sizes

2. STANDARD FEATURES

All radios in the series appear similar and have several common features. Every radio has an internal speaker and microphone, and will also operate with an external speaker-microphone. Every radio also has an external speaker jack, an external antenna jack, and will operate in a vehicular "Converta-Com" console designed for the MX300 series radios. Every standard radio also has a red LED (light-emitting diode) that glows when the push-to-talk switch is pressed. The LED is also a battery status indicator and does not light when the battery has less than about 5 to 10% charge remaining.

The antenna input impedance on all MX300 series radios is 50 ohms. This permits attaching 50-ohm cables and test equipment to the antenna jack without impedance matching adapters. This feature also permits using some accessories with any MX300 series radio regardless of the radio frequency.

Since the battery attaches to the bottom of the radio, every radio can operate with any battery manufactured for the MX300 series radios. However, batteries NLN8841A and NLN5860A are recommended for the high power models. Batteries are available in several sizes with two different charge rates. Refer to the "Batteries" description (paragraph 6). The different size batteries affect the overall height of the radio and the operating time between charges.

Every radio has a fuse in the dc power input circuit. The fuse is on the bottom of the radio and is replaceable without opening the radio.

Wide-spaced channel capability is standard in the radio. Refer to the specifications for each radio for details on spacing and degradation.

3. RF POWER OUTPUT

Vhf and uhf radios described in this manual are available in three rf power ranges, referred to as low, medium, and high. Refer to the specifications in the service literature for your particular radio. The following chart lists nominal values.

LEVEL	VHF	UHF	800 MHz
Low	1.0 Watt	1.0 Watt	
Medium	2.5 Watts	2.0 Watts	1.5 Watts
High	6.0 Watts	5.0 Watts	

4. PRINTED CIRCUIT BOARDS AND FLEXIBLE CIRCUITS

a. General

All functional circuit stages are in hybrid modules which are plugged into a rigid printed circuit board, called the main circuit board. Very few wires are used in the radio. Flexible printed circuits provide most point-to-point wiring between components which are not on the main circuit board. This results in greater uniformity in construction and fewer broken wires during maintenance. There are four basic different types of flexible circuits employed in the radio; the control flexible circuit, the interconnect flexible circuit, the power flexible circuit, and the multiple frequency flexible circuit. Each type may vary in size or shape depending on the radio model and function. Also, these "flex" circuits" may be used in various combinations depending on the model and options.

b. Main Circuit Board

The main printed circuit board is a new concept in portable radio construction, involving four printed layers bonded together to form a single four-layer printed circuit board. With most of the foil pattern inside the four-layer board, less circuit is exposed to damage. Common connection points for options are provided where necessary on the back side of each board.

c. Control Flexible Circuit (Control Flex)

Wiring between the main circuit board and the controls on the frame is provided by a flexible circuit wrapped around the inside of the frame. This circuit is called the control flexible circuit, or more briefly, just "control flex."

All radios contain the same control flex, regardless of frequency band, number of channels, or radio power. However, some of the controls may be missing or repositioned, and some tabs on the control flex may be cut depending on the model radio. The control flex attaches to the main circuit board at one side with 18 pins. This permits the main circuit board to swing out of the frame when necessary for servicing. The control flex also attaches to the controls on the side of the radio and on the top of the radio.

In radios with more than two channels, an additional flexible circuit is added to provide connections for the more complex frequency select switch.

d. Multiple Frequency Flexible Circuit (Multi-Freq Flex)

Radios having more than two channels require this additional circuit, installed along the side of the frame and over the control flex. The multi-freq flex on vhf and uhf radios contains a diode matrix that provides connections between the frequency select switch and the channel elements on the main circuit board. The number of diodes on the circuit depends on the number of transmit and receive channels in the radio. Vhf radios with eight transmit and receive channels require sixteen diodes on the flexible circuit, one for each channel element. Uhf radios still require the same number of diodes even though the transmitter does not have a channel element for each different channel. The diodes on the uhf radio may be physically positioned to select either of the two offset oscillator channel elements employed in the uhf transmitter scheme. The 800 MHz radios have no diodes on the frequency flex circuit. Radios with several channels on the same frequency may be jumpered to a common channel element. This technique is called "Strapping." The strapping jumpers are located on the bottom of the multi-freq flex for vhf and uhf radios and on the printed circuit board for 800 MHz radios. There are several different multi-freq flex circuits used in the radios, depending on the number of channels and the frequency band.

Refer to the appropriate model chart at the beginning of this manual for flexible circuit usage.

e. Interconnect Flexible Circuit (Interconnect Flex)

The following paragraph illustrates the use of this flexible circuit, which appears only in radios with an added function or option board at the bottom of the main circuit board.

Different interconnect flexible circuits are required to fit the radios in the MX300 series. The number of channels and the transmitter output power level of the radio determines the length of the main circuit board, and that length is different for vhf, uhf, and 800 MHz radios with more than two channels. The length of the main circuit board affects the interconnect flexible circuit usage. Each interconnect flexible circuit has tabs that may be trimmed off during manufacture, depending on the application.

The different interconnect flexible circuits are used on radios as follows:

TYPICAL FLEX NUMBER	FREQ. BAND	NO. OF CHANNELS	RADIO RF POWER OUTPUT
NLN4107	VHF	1 or 2	All Levels
	UHF	1 or 2	All Levels
NLN4109	VHF	4	All Levels
	UHF	6 and 8	All Levels
NLN4108	UHF	4	All Levels
NLN4110	VHF	6	All Levels
NLN4111	VHF	8	Low and Medium Only
NLN5125	800 MHz	1 and 2 (DPL)	Medium
NLN5126	800 MHz	4 and 5 (DPL)	Medium
NLN5127	800 MHz	1 and 2 (PL/CS)	Medium
NLN5128	800 MHz	4 and 5 (PL/CS)	Medium

f. Power Flexible Circuit (Power Flex)

This flexible circuit contains two high-current conductors for supplying battery voltage to the radio. The circuit attaches to the battery and fuse at the bottom of the radio and wraps around the housing to the on/off switch; two short wires connect switched B+ and ground to the top of the circuit board.

The radios are constructed in five different housing sizes. Each housing size requires a different power flex to reach from the bottom to the top of the radio. The power flex part number can be found in the parts list of the appropriate service manual.

5. MODEL VARIATIONS AND OPTIONS

a. General

Many options are available for the radio; including selective call (tone paging), special "Private-Line" circuits, unit ID circuits, battery options, size options, and even a sensitivity option on vhf radios.

When the radio is ordered, option codes are used to specify the option in the radio. The option code consists of the letter H followed by three digits. The first digit defines the general catagory and the other two numbers describe the specific option in the category. The general categories are listed in the following table.

CODE DIGIT	CATEGORY
H1	Antennas
H2	Batteries
H3	Cases and Clips
H4	Housings
H5	Channel Elements
H6	International
H7	Signalling Options
H8	Tone PL and Digital PL Squelch Options
H9	Other Internal Options

When some options or circuit functions are added to the radio, an additional printed circuit board is required. This additional printed circuit board is attached below the main circuit board, at the bottom of the radio. Electrical connections to the main circuit board are provided by the interconnect flexible circuit previously described. The construction is unique. Refer to Figure 3. Special long pins are provided for soldering the flexible circuit to the back of the main circuit board. These pins are identified by a hexagon (⬡) on circuit board diagrams and on schematic diagrams.

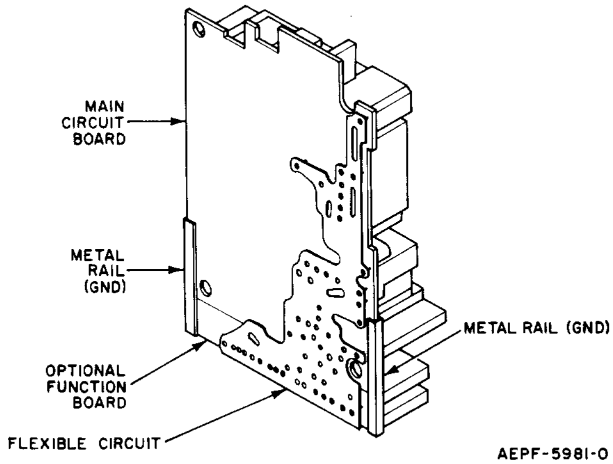

Figure 3. Typical Interconnect Flexible Circuit

The added printed circuit board at the bottom of the radio increases the overall height of the radio, requiring a taller housing. The amount of additional space required for the board depends upon the options. The following table lists several popular options and the number of "units" of space required. A "unit" is defined as 5 millimeters (0.195 inch).

Typical Option Space Requirements in Housing

OPTION OR FUNCTION		UNITS OF SPACE REQUIRED
CODE	DESCRIPTION	
---	"Digital Private-Line" Squelch	2
H560	Talkaround	0, 2*
H701	Selective-Call: Individual	2
H702	Selective-Call: Individual (Dual Address)	4
H703	Selective-Call: Group (Long Tone B)	2
H902	Unit ID	2
H905	ID/Emergency	4
H850	"Digital Private-Line" Coded Squelch – Transmit Only	2

1 Unit = 0.195 inch (5.0 mm)

* Model H35AAU6120 radios

Once the number of units required for an option is known, the following chart reveals the relationship between radio size, housing size, and the option possibilities in the housing. The chart also tells you that some housing and radio combinations have no room for added options (e.g., a two-channel, medium power radio in an MX320 housing.)

EXAMPLE: Consider radio model H33AAU1120. This is a vhf (136-174 MHz), 2.5 watt, carrier squelch, two channel radio normally constructed in an MX320 housing. With option code H701 added, the radio is constructed in an MX330 housing. With this option code added, the additional 2 units of room required for the extra circuits is provided by the larger housing.

b. Selective Call Options

The selective call option for the MX300 Series "Handie-Talkie" radios provides a two-tone pager circuit in the radio. The additional circuits required are contained on two small printed circuit boards attached at the bottom of the main circuit board in the radio. The two circuit boards are mounted on top of each other in a piggyback configuration. The bottom board in the assembly is attached to the main circuit board with two metal rails which provide the ground connection between the circuits. A flexible circuit interconnects the main circuit board to the electrical circuits via the bottom board in the assembly (see Figure 4).

Housing Size, Radio, and Option Space Relationships

NO. OF CHANNELS	RF POWER	UNITS OF SPACE IN RADIO HOUSINGS				
		MX320 HOUSING	MX330 HOUSING	MX340 HOUSING	MX350 HOUSING	MX360 HOUSING
UHF RADIOS						
1 or 2	Low or Medium	0	2	4	8	11
1 or 2	High	-	0	2	6	9
4	Low or Medium	-	0	2	6	9
4	High	-	-	0	4	7
6	Low or Medium	-	-	0	4	7
6	High	-	-	-	2	5
8	Low or Medium	-	-	0	4	7
8	High	-	-	-	2	5
VHF RADIOS						
1 or 2	Low or Medium	0	2	4	8	11
1 or 2	High	-	0	2	6	9
4	Low or Medium	-	-	0	4	7
4	High	-	-	-	2	5
6	Low or Medium	-	-	-	2	5
6	High	-	-	-	0	3
8	Low or Medium	-	-	-	-	2
8	High	-	-	-	-	0
800 MHz RADIOS						
1 or 2	Medium	0	2	4	8	11
4 or 5	Medium	-	0	2	6	9

"0" means radio will fit in that housing with no extra room for options.

1 Unit = 0.195 inch (5.0 mm). A dash (-) = radio will not fit in housing listed at top of column.

As shown in Figure 5, the top board is mechanically attached to the bottom board by two threaded studs and spanner nuts. Electrical connections between the two selective call circuit boards are provided by six pin-type plugs and jacks. The plug-in "Permacode" tone filters, which determine the paging code for the circuit, are located on the top board. These filters are the same as used in the "Pageboy" II radio pagers.

The selective call circuit is primarily a receiver decoder circuit which detects and decodes the two-tone sequential paging signal transmitted to the receiver. The decoded signal controls the squelch circuit in the receiver, permitting the alert tone and voice message to appear at the speaker only when the proper code is received.

The following table lists selective call option numbers and the items added to the radio for incorporating the circuits. The dual-address selective call circuit is basically two single-address circuits connected in parallel. The circuit for the second address has a slight modification to eliminate the initiating tone when the radio is turned on and to produce a continuous alert tone when the second code is received.

Selective Call Option Items

OPTION		ITEMS ADDED	
NO.	DESCRIPTION	NUMBER	DESCRIPTION
H701	Single-Address, Individual Call	NLN4136	Single Decoder Board Assembly
		NLN4140	Pad
		NLN8503	Active Filter (2)
		NLN4168	Switch Kit
		NLN4097	Rail Kit
H702	Dual-Address, Individual Call	NLN4136	Single Decoder Board Assembly (2 req'd)
		NLN4140	Pad (2 req'd)
		NLN8503	Active Filter (4)
		NLN4168	Switch Kit
		NLN4099	Rail Kit
H703	Single-Address, Individual Call With Group Call	NLN4136	Single Decoder Board Assembly
		NLN4140	Pad
		NLN8503	Active Filter (2)
		NLN4168	Switch Kit
		NLN6959	Group Call Decoder
		NLN4097	Rail Kit

The selective call option may be installed in radios also containing transmit-only tone "Private-Line" or transmit-only "Digital Private-Line" options (H820 and H850).

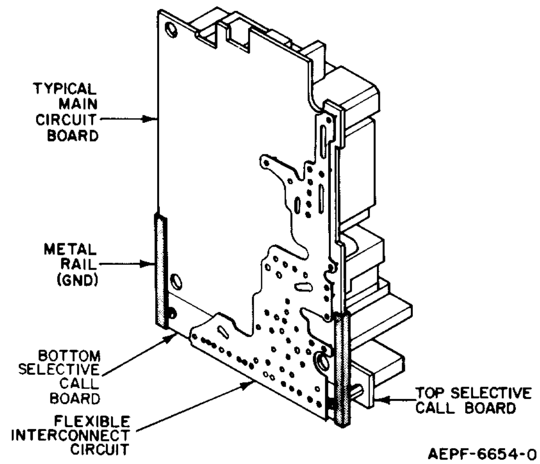

Figure 4. Typical Selective Call Installation

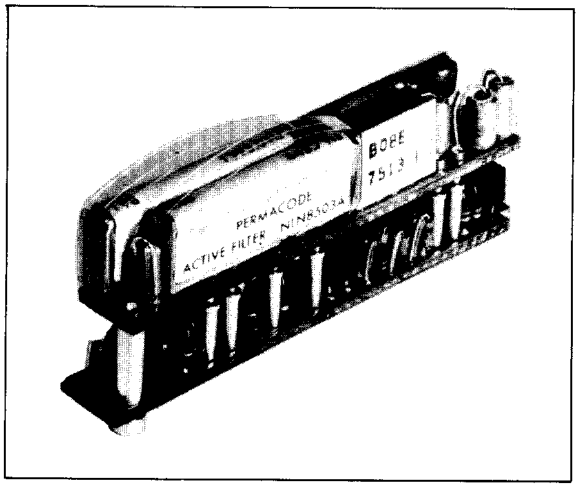

Figure 5. Typical Selective Call Boards

c. <u>Unit ID Options (Vhf and Uhf Radios)</u>

The Unit Identification (ID) options for the MX300 Series "Handie-Talkie" Radios provide sequential tone data signalling circuits in the radio. A printed circuit mother board, with a plug-in printed circuit encoder board and a hybrid code plug, is attached at the bottom of the main circuit board in the radio. The mother board in the ID assembly is attached to the main circuit board with two metal rails which also provide the ground connection between the circuits. A flexible circuit interconnects the assembly with the main circuit board to provide for all other electrical connections. A 23-pin connector, including three guide pins, provides all interconnections between the two ID boards.

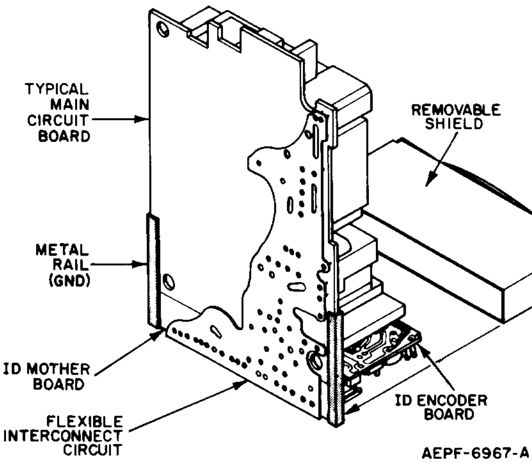

Figure 6. Typical Unit ID Assembly

The ID circuit is primarily a transmitter encoder circuit which encodes a digital identifier for transmission over an rf carrier. The identifier is a serially-formed sequence of audio tones which is fully compatible with either the "Modat," ZVEI, or CCIR type sequential tone data systems. The radio sends the tones to the base station, where they are decoded and processed to identify the originator. The data transmission is a fraction of a second in duration and automatically precedes voice transmission.

An emergency call option is also available for use with the unit ID feature. In this mode, the ID/emergency code is transmitted by actuating a special emergency switch on the top of the radio. This causes an ID/emergency message to be transmitted repeatedly even after the switch is released. Nothing will be heard at the radio, but two messages are sent every five seconds for 30 seconds. To stop the sequence early, the on/off switch can be turned to the off position momentarily, and then on again to resume normal operation. Alternatively, the sequence can be stopped by depressing the PTT switch until the ID tones are heard. At that time voice transmission can be resumed and normal operation is restored. Actuating the emergency switch again (later) restarts the emergency operation.

The following table lists the unit ID option numbers and the items which are added to the radio for each option. The ZVEI and CCIR options are used to provide a special international code format that is employed extensively in European communications systems. The metal rail and flexible circuit kits, which are used to interconnect the unit ID assembly to the main radio board, will vary depending on the radio model and other options in the radio.

Unit ID and Emergency Option Items

OPTION										ITEMS ADDED
H711	H721	H709	H718	H902	H905	H908	H909	H920	H922	
		1	1							NLN4328 Encoder Board (ZVEI)
					1	1				NLN4329 ID and Emergency Mother Board
					1					NLN4330 Emergency Control Board
1	1	1	1	1				1		NLN4331 ID Shield
					1					NLN4332 ID and Emergency Shield
	1		1		1	1		1	1	Escutcheon and Knob Kits (one item only): NLN4333 (1-Freq. PL Models) or NLN4334 (Multi-Freq. PL Models) or NLN4335 (1-Freq. Carrier Squelch Models) or NLN4336 (Multi-Freq. Carrier Squelch Models)
		1	1							NLN4360 Programmed Code Plug (ZVEI)
1	1	1	1	1			1	1	1	NLN4361 ID Mother Board
					1					NLN4536 Miscellaneous Parts Kit (Non PL Models)
				1	1			1		NLN8998 Encoder Board ("Modat")
				1	1			1		NLN8999 Programmed Code Plug ("Modat")
1	1									NLN4523 Programmed Code Plug (CCIR)
1	1									NLN4524 Encoder Board (CCIR)

6. BATTERIES

Several rechargeable nickel-cadmium batteries are available for the radio, as well as a non-chargeable mercury battery. All batteries will attach to all model radios. The following table lists some of the batteries available for the MX300 series radios. The larger batteries are designed for higher powered radios or to provide longer operation per charge. Battery choice is governed by duty cycle, operating time desired and maximum size (height) desired. Most of the nickel-cadmium batteries are available as standard models rechargeable in one hour, except the ultra-high capacity model which is rechargeable in two hours. All the batteries can be trickle-charged in about 14 hours. The non-chargeable mercury battery (NLN8838) is only recommended for low and medium power vhf and uhf radios.

New batteries may be offered. Refer to your Motorola Sales Representative for current list of available batteries.

Typical Batteries for MX300 Series Radios

BATTERY			TYPICAL HOURS OF OPERATION							
MODEL	CAPACITY	MINIMUM CHARGE TIME	DUTY CYCLE	1 W VHF	1 W UHF	1.5 W 800 MHz	2.5 W VHF	2.0 W UHF	6.0 W VHF	5.0 W UHF
NLN4002	Light	1 Hour	5-5-90	9	8	6	6	6	**	**
			10-10-80	6	5	4	4	4	**	**
NLN8840 or NLN8834*	Medium	1 Hour	5-5-90	13	11	8	9	9	**	**
			10-10-80	8	7	5	5	5	**	**
NLN8841 or NLN5860	High	1 Hour	5-5-90	24	19	19	16	15	10	9
			10-10-80	14	12	12	9	9	5	5
NLN5320	Ultra-High	2 Hours	5-5-90	38	31	31	25	25	15	14
			10-10-80	23	19	19	14	15	8	8
NLN8838***	3500 mAH Mercury	Non-chargeable	5-5-90	66	54	--	44	43	Not Recommended	

NOTE: A 5-5-90 duty cycle refers to 5% transmit, 5% receive, and 90% standby time.
* Indicates standard battery supplied.
** Indicates not recommended battery-radio combination.
*** NLN8838 available for vhf and uhf radios only.

Figure 7. NLN8861 Radio Carrying Holder

7. RADIO CARRYING HOLDER AND OPTIONAL CASES

The NLN8861 Radio Carrying Holder is supplied with each radio, unless deleted by a leather carrying case option code. This holder contains a belt loop for attaching to a belt. When the radio is placed in the holder, a spring clip engages the top of the radio and secures it in the holder. The holder will hold any radio in the MX320 through MX360 series. An optional holder is available with a swivel belt loop.

There are several sizes of optional leather cases available to cover all possible combinations of radios and batteries and overall height variations. The cases offered are numbered 3 through 11. The relationship between battery size, housing size, and case number is shown in the following table.

Battery, Housing Size, and Carrying Case Size Relationships

BATTERY		CASE SIZE FOR HOUSING/BATTERY COMBINATIONS				
NUMBER	TYPE	MX320 HOUSING	MX330 HOUSING	MX340 HOUSING	MX350 HOUSING	MX360 HOUSING
NLN4002	Light Capacity, 1 Hour	3	3	4	5	7
NLN8840	Medium Capacity, 1 Hour	3	3	4	5	7
NLN8834	Medium Capacity, 1 Hour	3	4	4	6	7
NLN8841	High Capacity, 1 Hour	4	5	6	7	8
NLN5860	High Capacity, 1 Hour	6	7	8	9	10
NLN5320	Ultra-High Capacity, 2 Hour	8	9	9	10	11
NLN8838	Non-Chargeable Mercury	4	4	5	7	8

8. SPECIAL TERMS AND ABBREVIATIONS

The new construction techniques and circuits in the radio require some special terminology. Some of the terms and abbreviations used in describing the radio are listed in the following table.

TERM	DESCRIPTION
ALC	Automatic Level Control circuit
Control Flex	Flexible circuit connecting the radio controls to the main circuit board.
CVC	"Converta-Com"
DPL	"Digital Private-Line" circuit
IDC	Instantaneous Deviation Control circuit
Interconnect Flex	Flexible circuit used to interconnect the main circuit board to circuit boards added at the bottom of the radio when other functions are added to the basic radio.
LED	Light-Emitting Diode. Used as an indicator lamp.
Main Circuit Board	The 4-layer printed circuit board
"Modat"	Motorola coded squelch
Multi-Freq Flex	Flexible circuit containing switching diodes and connecting frequency select switch to the main circuit board. Used only on radios with more than two transmit and receive channels.
PL	"Private-Line" circuit, tone coded
PLL	Phase-Locked-Loop
Power Flex	Flexible circuit connecting the battery on the bottom of the radio to the on-off switch and the main circuit board.
TOT	Time-Out Timer
VCO	Voltage-Controlled Oscillator
ZVEI – CCIR	International coded squelch

BATTERY CHARGING

1. CHARGERS AVAILABLE

Available chargers include single-unit desk chargers and multiple-unit chargers that may be mounted on a wall or on a bench. The multiple-unit chargers will charge up to six nickel-cadmium batteries at one time.

The chargers are available in 14-hour charge and 1-hour charge models. The 14-hour chargers will charge any of the batteries, with or without the radio attached, in 14 hours. The 1-hour chargers will charge the rapid-charge batteries in 1 hour, except for the ultra-high capacity battery (NLN5320), which takes 2 hours. Refer to the following table.

Charging Times for Typical Charger-Battery Combinations

BATTERY	CHARGERS	
MODEL	NLN4036A NLN8856A NLN8990A (14 Hour)	NLN4038A NLN8858A NLN8988A (1 Hour)
NLN4002	14 Hours	1 Hour
NLN8840	14 Hours	1 Hour
NLN8834	14 Hours	1 Hour
NLN8841	14 Hours	1 Hour
NLN5860	14 Hours	1 Hour
NLN5320	14 Hours	2 Hours

There are four single-unit desk chargers available. Two models operate from 115 V ac and two models operate from 230 V ac. Two multiple-unit chargers are available. These multiple-unit chargers contain a switch for selecting 115 V ac or 230 V ac operating voltage.

2. BATTERIES AVAILABLE

Batteries are available with a rapid charge rate of 1 hour and are available in different sizes to provide various duty cycles and operating times, depending upon the radio power and operating conditions.

Charging voltage is applied to the battery through contacts in the side of the battery. The batteries have four contacts on the side. Two of the contacts receive charging voltage. The third contact connects an internal resistor (R_R) to the charger, automatically setting the charging current output to match the capacity of the battery.

The fourth contact connects an internal thermistor to the charger. The thermistor senses battery temperature and automatically controls the charger output to permit maximum charger output without overheating the battery.

All rapid charge batteries contain an internal fuse for protection. A diode in the battery prevents damage from accidentally shorting pins 2 and 3.

CAUTION

Sustained shorts across the radio contacts (-, +), excessive currents, or excessive heat will destroy the internal thermal fuse, which is not replaceable.

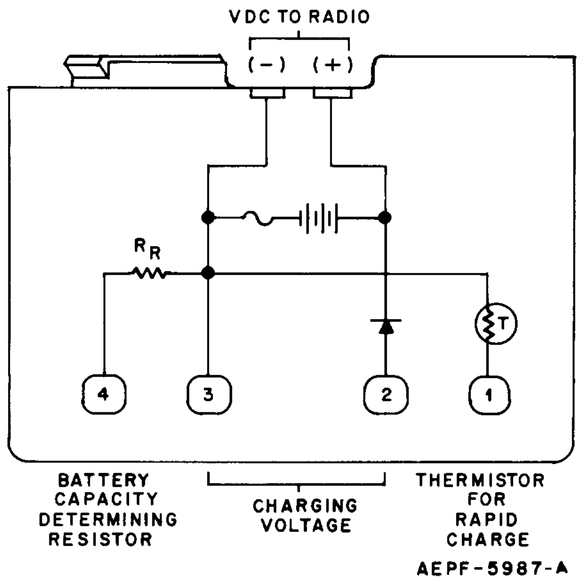

Figure 8.
Typical Battery Construction, Rapid Charge, Side View

3. CHARACTERISTICS

Each nickel-cadmium battery consists of 6 cells connected in series to provide a nominal 7.5-volt dc output.

The voltage of a nickel-cadmium battery remains approximately constant under load until the battery approaches the discharged condition. At this time, a marked decrease in the voltage occurs and the discharged condition (1.0 V per cell) is reached abruptly. Metering to determine the state of charge in this type of battery is difficult and is not normally performed. A general characteristic of all rechargeable batteries in storage is self discharge. If the battery is used after unknown periods of storage, it is recommended that it be charged at the full charging rate using an approved battery charger.

4. MAINTENANCE

The battery cells will never require additional electrolyte. The only maintenance required is recharging the battery and keeping the contacts clean.

Use only a Motorola approved charger. The use of other chargers, unless approved, will void the battery guarantee and may result in permanent damage to the battery. Follow the charging instructions which accompany the charger.

5. STORAGE

The battery may be stored at room temperature in any state of charge without damage. As previously stated, however, the battery is subject to self discharge and should be recharged after extended storage.

6. DETERMINING BATTERY CAPACITY

Battery capacity is determined by measuring the time that a fully-charged battery requires to discharge to 6 volts through a specified load, as described in the Battery Test Table.

Battery Test Table

STEP	PROCEDURE
1	Discharge the battery to +6 volts through the applicable resistor listed below:
2	Charge the battery fully, using approved charger NLN8858.
3	Discharge the battery through the resistor listed in step 1 until the terminal voltage reaches 6 volts. Check the time required. If battery is defective, time will be less than 48 minutes.

BATTERY MODEL	RESISTOR
NLN4002	15.0 ohms, 5 W, 1%
NLN8834	10.7 ohms, 10 W, 1%
NLN5860	6.0 ohms, 15 W, 1%
NLN8840	10.7 ohms, 10 W, 1%
NLN8841	6.0 ohms, 15 W, 1%
NLN5320	3.75 ohms, 25 W, 1%

NOTE:

1. Time measured in step 3 is measured from the time that the resistor is connected across terminals.
2. Remove the resistor load after completing step 3.

TONE CODING DESCRIPTION

1. INTRODUCTION

The selective call radios require two-tone sequential signalling. Two discrete audio tones are transmitted for a specific period of time.

TRANSMISSION TIME		INTERPAGE GAP
TONE A	TONE B	
1 sec	3 sec	1.3 sec

Each radio in the system responds to a unique combination of tones. This combination is determined by the active filters installed in the radio.

There are 60 unique tone frequencies from which tones A and B may be selected. Each tone is assigned a code number. This number is usually referred to as the "Filter Code" and is stamped on the body of the active filter. The tone frequency is also stamped on the filter body.

The number that appears on the radio is the paging code number. The Tone A and Tone B active filter code and frequency can be determined from this number. Refer to the following tables and paragraphs.

Index of Encoding Methods

PAGE CODE TYPE	ENCODING METHOD USED
Three-digit code (625)	Modified General Encoding Method (paragraph 2)
Three-digit code with a letter prefix (D476)	High Capacity Encoding Method (paragraph 3)
Three-digit code where the second and third digits are the same (366)	General Alternate Encoding Method (paragraph 4)
Three-digit code where the second and third digits are the same and include a letter prefix (B455)	High Capacity Alternate Encoding Method (paragraph 4c)

2. MODIFIED GENERAL ENCODING METHOD

Each radio in the system is assigned a three-digit "page code." The relationship between the "page code and the filter installed in the radio is established by the modified general encoding method.

The first digit of the three-digit page code determines the tone groups from which Tones A and B are to be selected. The tone groups indicated for each first digit are shown in Table 1. The next two digits of the page code are the specific paging tones for Tones A and B respectively. The paging tone frequencies and their filter code number are shown in Table 2.

Table 1. Modified General Encoding Plan

FIRST DIGIT OF PAGE CODE	GROUP FROM WHICH TONE A IS SELECTED	GROUP FROM WHICH TONE B IS SELECTED
1	1	1
2	2	2
3	3	3
4	4	4
5	5	5
6	6	6

To determine which tone frequencies or filter codes are associated with a given page code, proceed as follows:

a. Locate the first digit of the page code in Table 1, column 1. Note the tone group number for Tones A and B which are indicated in columns 2 and 3 respectively.

b. Refer to the top row of Table 2, and locate the tone group number that was noted for Tone A in Table 1.

c. Refer to the first column of Table 2, and locate the tone number that corresponds to the second digit of the page code.

d. The filter code and tone frequency are found where the tone group column intersects the second digit tone number row.

e. The filter code and tone frequency for the third digit of the page code can be determined by repeating steps (b), (c), and (d).

Table 2. Tone Groups

TONE NUMBER	TONE GROUP 1		TONE GROUP 2		TONE GROUP 3		TONE GROUP 4		TONE GROUP 5		TONE GROUP 6	
	FILTER CODE	FREQ. (Hz)	FILTER CODE	FREQ. (Hz)	FILTER CODE	FREQ. (Hz)	FILTER CODE	FREQ. (Hz)	FILTER CODE	FREQ. (Hz)	FILTER CODE	FREQ. (Hz)
1	111	349.0	121	600.9	138	288.5	141	339.6	151	584.8	191	1153.4
2	112	368.5	122	634.5	108	296.5	142	358.6	152	617.4	192	1185.2
3	113	389.0	123	669.9	139	304.7	143	378.6	153	651.9	193	1217.8
4	114	410.8	124	707.3	109	313.0	144	399.8	154	688.3	194	1251.4
5	115	433.7	125	746.8	160	953.7	145	422.1	155	726.8	195	1285.8
6	116	457.9	126	788.5	130	979.9	146	445.7	156	767.4	196	1321.2
7	117	483.5	127	832.5	161	1006.9	147	470.5	157	810.2	197	1357.6
8	118	510.5	128	879.0	131	1034.7	148	496.8	158	855.5	198	1395.0
9	119	539.0	129	928.1	162	1063.2	149	524.6	159	903.2	199	1433.4
0	110	330.5	120	569.1	189	1092.4	140	321.7	150	553.9	190	1122.5

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EXAMPLE: Page Code 625; According to Table 1, the first digit of this code (6) indicates that Tone A is selected from tone group 6, and Tone B is also selected from tone group 6. The second digit (2) indicates that tone number 2 of group 6 is used for Tone A, and the third digit (5) shows tone number 5 of group 6 is used for Tone B.

6 2 5

FROM TABLE 1;
TONE A IN TONE GROUP 6
TONE B IN TONE GROUP 6

TONE A
FROM TABLE 2;
(TONE 2, GROUP 6)
FILTER CODE = 192
FREQ. = 1185.2 Hz

TONE B
FROM TABLE 2;
(TONE 5, GROUP 6)
FILTER CODE = 195
FREQ. = 1285.8 Hz

EXAMPLE: Page Code D476 would have the following filters installed:

Tone A = Filter Code 117, Frequency 483.5 Hz

Tone B = Filter Code 156, Frequency 767.4 Hz

D 4 7 6

FROM TABLE 3
(CODE TYPE D;
FIRST DIGIT 4)
TONE A IN GROUP 1
TONE B IN GROUP 5

TONE A
FROM TABLE 2
(TONE 7; GROUP 1)
FILTER CODE = 117
FREQ. = 483.5 Hz

TONE B
FROM TABLE 2
(TONE 6; GROUP 5)
FILTER CODE = 156
FREQ. = 767.4 Hz

3. HIGH CAPACITY ENCODING METHOD

This encoding method was devised to accommodate the larger number of units used in high capacity paging systems such as the L08 Encoder, the L09 Dial Interconnected Pager Terminal, or the Ultra High Capacity Computer Controlled "Metro-Page" Radio Paging Terminal. Receivers encoded by this method are assigned a letter prefix. This prefix is the "Code Type" designation. In the modified general encoding method, the relationship between the first digit of the page code and the groups selected is arbitrary. In the code assignment method, the selected groups depend on the system code type. Table 3 shows the group selection scheme by code type. In essence, each code type column in this table is used in the same way as Table 1 was used in the modified general encoding method. In the column for the page prefix and on the line corresponding to the first digit of the page code, are the groups from which Tones A and B will be selected. Table 2 and the second and third digits of the page code determine the exact filter codes as outlined in paragraph 2.

4. ALTERNATE CODING

a. Introduction

Dial interconnected paging terminals provide spare radios to substitute for regular radios that are temporarily out of service. Spare radios are encoded with an alternate page code so they will not duplicate codes within the system, yet will easily substitute for system radios. Spare tones used for Tone A are not part of any regular tone groups. Tone B is selected from the regular tone groups. Alternate page codes always have repeating second and third digits. The first digit of an alternate page code determines both the spare tone to be used for Tone A and the regular tone group from which Tone B will be selected. The second or third digit indicates the specific filter to be used for Tone B.

Two alternate encoding methods are used for spare radios; a modified general encoding method for medium capacity systems, and the high capacity encoding method for high capacity systems. Generally, spare radios will have a three-digit code with no letter prefix. High capacity alternate page codes are prefixed with the

Table 3. High Capacity Code Type Plan

CODE TYPE	B		C		D		E		F		G		H		J		K		L	
FIRST DIGIT	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	1	3	1	3	1	3	1	4	1	4	1	5
3	3	3	1	2	1	2	1	2	3	3	3	3	3	3	4	1	4	1	5	1
4	1	2	4	4	1	5	2	1	4	4	3	1	3	1	4	4	4	4	1	6
5	1	3	1	4	5	5	1	6	3	1	5	5	1	6	5	5	1	6	5	5
6	2	1	2	1	2	1	6	6	1	4	1	5	6	6	1	5	6	6	6	6
7	3	1	4	1	5	1	6	1	4	1	5	1	6	1	4	5	6	1	6	1
8	2	3	2	4	2	5	2	6	3	4	3	5	3	6	5	4	4	6	5	6
9	3	2	4	2	5	2	6	2	4	3	5	3	6	3	5	1	6	4	6	5

CODE TYPE	M		N		P		Q		R		S		T		U		V		W		Z		AZ	
FIRST DIGIT	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
1	2	3	2	3	2	3	2	4	2	4	2	5	3	4	3	4	3	5	4	6	7	8	17	18
2	2	2	2	2	2	2	2	2	2	2	2	2	4	3	4	3	5	3	6	4	7	9	17	9
3	3	3	3	3	3	3	4	2	4	2	5	2	3	3	3	3	3	3	5	6	8	7	18	17
4	4	4	3	2	3	2	4	4	4	4	2	6	4	4	4	4	3	6	4	4	9	7	9	17
5	3	2	5	5	2	6	5	5	2	6	5	5	5	5	3	6	5	5	5	5	8	9	18	9
6	2	4	2	5	6	6	2	5	6	6	6	6	3	5	6	6	6	6	6	6	9	8	9	18
7	4	2	5	2	6	2	4	5	6	2	6	2	4	5	6	3	6	3	4	5	7	7	17	17
8	3	4	3	5	3	6	5	4	4	6	5	6	5	4	4	6	5	6	5	4	8	8	18	18
9	4	3	5	3	6	3	5	2	6	4	6	5	5	3	6	4	6	5	6	5	9	9	9	9

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Table 4. Alternate Page Code Plan

FIRST DIGIT OF ALTERNATE PAGE CODE	TONE A		TONE GROUP FROM WHICH TONE B IS SELECTED
	CODE	FREQ. (Hz)	
1	160	953.7	1
2	160	953.7	2
3	130	979.9	2
4	160	953.7	4
5	160	953.7	5
6	130	979.9	1
7	130	979,9	5
8	130	979.9	4

system code type letter. To find the filter assignment for a spare radio, with an alternate page code, refer to the following applicable paragraphs.

b. General Alternate Encoding Method

Look up the first digit of the alternate page code in Table 4. On the row corresponding to this digit, the Tone A filter and the group from which Tone B is selected are listed. Then look up the second or third digit of the alternate page code in Table 2. Refer to the group indicated in the previous step for Tone B.

EXAMPLE: Alternate Page Code 366; Refer to Table 4, first digit (3) indicates filter code 130 and frequency 979.9 Hz for Tone A, and Tone B selection is from tone group 2. Refer to Table 2. The second or third digit (6) indicates filter code 126, frequency 788.5 Hz, for Tone B.

Alternate Page Code 366 has the following filters installed:

Tone A = Filter Code 130, Frequency 979.9 Hz
Tone B = Filter Code 126, Frequency 788.5 Hz

c. High Capacity Alternate Encoding Method

Spare radios in systems using this type of encoding have page codes prefixed with the system code type letter. The Tone A filter and group specified by the first digit of this page code vary with the code type letter. This is always an S20, CQ, or S22 active filter code. To obtain this information, refer to Table 5. To determine Tone B, proceed as outlined in the General Alternate Encoding Method.

EXAMPLE: Alternate Page Code B455; Refer to Table 5 in the code type B column. On row 4, Tone A filter code is CQ, Frequency is 1550 Hz and Tone B selection from tone group 3 is indicated. In Table 2, on row 5, tone group 3 filter code 160 and frequency 953.7 Hz is indicated for Tone B.

SUMMARY: Alternate Page Code B455 requires the following filters. Refer to Table 5.

Tone A = Filter Code CQ, Frequency 1550 Hz
Tone B = Filter Code 160, Frequency 953.7 Hz

5. CODE LABEL ON RADIO

The label on the back cover of the radio is marked with the page codes used in the radio.

EXAMPLE:
Single-address radio (H701, H703) = SC625
Dual-address radio (H702) = SC625/476
Group Call = SC625/155

Table 5. High Capacity Alternate Page Code Type Plan

CODE TYPE DESIGNATION		B		C		D		E		F		G		H		J		K	
SEQUENTIAL TONES FILTER CODE		A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
FIRST DIGIT OF PAGE CODE	1	S20	1	S20	1	S20	1	S20	1	S20	1	S20	1	S20	1	S20	1	S20	1
	2	S20	2	S20	2	S20	2	S20	2	S20	3	S20	3	S20	3	S20	4	S20	4
	3	S20	3	CQ	2	CQ	2	CQ	2	CQ	3	CQ	3	CQ	3	CQ	1	CQ	1
	4	CQ	2	S20	4	S20	5	CQ	1	S20	4	CQ	1	CQ	1	CQ	4	CQ	4
	5	CQ	3	CQ	4	CQ	5	S20	6	CQ	1	S20	5	S20	6	S20	5	S20	6
	6	CQ	1	CQ	1	CQ	1	CQ	6	CQ	4	CQ	5	CQ	6	CQ	5	CQ	6
	7	S22	1	S22	1	S22	1	S22	1	S22	1	S22	1	S22	1	S22	5	S22	1
	8	S22	3	S22	4	S22	5	S22	6	S22	4	S22	5	S22	6	S22	4	S22	6
	9	S22	2	S22	2	S22	2	S22	2	S22	3	S22	3	S22	3	S22	1	S22	4

CODE TYPE DESIGNATION		L		M		N		P		Q		R		S		T		U		V		W		Y	
SEQUENTIAL TONES FILTER CODE		A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
FIRST DIGIT OF PAGE CODE	1	S20	1	S20	3	S20	3	S20	3	S20	4	S20	4	S20	5	S20	4	S20	4	S20	5	S20	6	S20	A
	2	S20	5	S20	2	S20	2	S20	2	S20	2	S20	2	S20	2	S20	3	S20	3	S20	3	S20	4	S20	B
	3	CQ	1	CQ	3	CQ	3	CQ	3	CQ	2	CQ	2	CQ	2	CQ	3	CQ	3	CQ	3	CQ	6	S20	Z
	4	S20	6	S20	4	CQ	2	CQ	2	CQ	4	CQ	4	S20	6	CQ	4	CQ	4	S20	6	CQ	4	CQ	B
	5	CQ	5	CQ	2	S20	5	S20	6	S20	5	S20	6	CQ	5	S20	5	S20	6	CQ	5	S20	5	CQ	Z
	6	CQ	6	CO	4	CQ	5	CQ	6	CO	5	CQ	6	CQ	6	CO	5	CQ	6	CQ	6	S22	6	CQ	A
	7	S22	1	S22	2	S22	2	S22	2	S22	5	S22	2	S22	2	S22	5	S22	3	S22	3	CQ	5	S22	A
	8	S22	6	S22	4	S22	5	S22	6	S22	4	S22	6	S22	6	S22	4	S22	6	S22	6	S22	4	S22	Z
	9	S22	5	S22	3	S22	3	S22	3	S22	2	S22	4	S22	5	S22	3	S22	4	S22	5	S22	5	S22	B

S20 = 1500 HZ (TONE FREQ.) CQ = 1550 HZ (TONE FREQ.) S22 = 1600 HZ (TONE FREQ.)

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THEORY OF OPERATION

1. GENERAL

The MX300 series radios incorporate the most advanced technology available. This results in a new appearance; an almost totally modularized radio. Each module usually performs a complete function, such as, an amplifier having an input and an amplified output. When a module performs more than one function, brief details are presented in the block representing the module on the schematic diagram.

While most other two-way radio circuits are similar, the MX300 series radios incorporate some new concepts, described in the following paragraphs. Complete details of each module are presented in the Hybrid Modules section.

2. OVERALL RECEIVER CIRCUIT

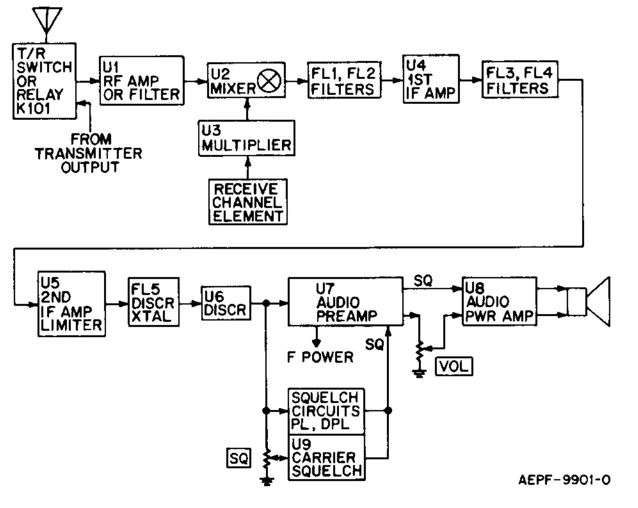


Figure 9. Overall Receiver Circuit Signal Flow

a. RF Circuits, Receivers (All frequency ranges)

The received signal at the antenna is coupled through the antenna jack to the K101 relay (vhf and uhf radios) or transmit-receive switch U105 (800 MHz radios), which directs the rf signal, through coaxial cable, to the U1 (filter or rf amplifier) input. The filtered output signal (which may also be amplified) is then applied to the U2 (mixer) input, where it is again filtered and mixed with injection signal from U3 (multiplier). The injection signal is composed of $2f_o$ for vhf, $6f_o$ for uhf, or $12f_o$ for 800 MHz radios. The multiplier input is from a channel element (f_o). The multiplier output is filtered to remove unwanted harmonics.

The received rf and the local oscillator signal are mixed in U2, producing the 21.4 MHz i-f signal, which is applied to crystal filter FL1/FL2. The uhf and 800 MHz radios also use receiver injection during the transmit mode. In this mode, the transmit carrier frequency is dependent upon the receiver oscillator frequency; therefore, the receiver circuit must be aligned before aligning the transmitter.

b. I-F Circuits, Receivers

The i-f circuits are functionally identical in vhf, uhf, and 800 MHz receivers and use identical modules. Circuit board layouts are slightly different and decoupling circuits external to the modules vary slightly.

The received signal from the mixer passes through crystal filters FL1 and FL2 which form a four-pole bandpass filter centered at 21.4 MHz. The overall bandwidth of the filter is about 13 kHz and the maximum insertion loss is 2 dB. A typical response curve is shown in Figure 10.

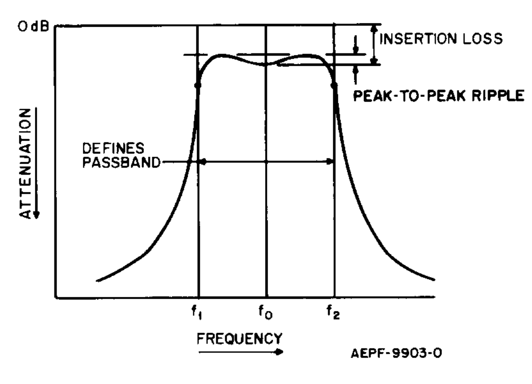


Figure 10. Typical Crystal Filter Response Curve

The filter output is applied to the first i-f amplifier U4, where the 21.4 MHz signal is amplified. This amplifier receives B+ only during the receive operating mode. The amplifier provides only gain, since selectivity and unwanted signal rejection is provided by the crystal filters.

The output of U4 is applied to crystal filters FL3 and FL4, which operate the same as FL1 and FL2, providing additional i-f bandpass selectivity. Amplifier U5 provides additional gain and also contains a limiter. Limiting occurs at low noise levels, providing a constant amplitude output.

The amplified i-f signal from U5 is applied to a crystal discriminator, incorporating 3-pole filter FL5. This crystal provides two outputs that vary in complementary fashion with the input frequency change and when applied to U6, forms a discriminator that produces the recovered audio output signal.

c. Audio Circuits, Receivers

The recovered audio is applied through R4 to module U7. This module contains a high-pass filter circuit which attenuates frequencies below 300 Hz, preventing low frequency PL tones from reaching the speaker. The filtered audio output is applied to a low-pass filter and amplifier circuit in the module which produces the desired audio response characteristic. The amplified audio output is applied across a volume control and a small series resistor. The volume control forms a voltage divider and applies a portion of the audio signal to audio power amplifier module U8. The small series resistor connected to the volume control provides some audio signal to U8 even when the volume control is turned all the way down. This avoids missing messages by accidentally having the control turned down.

Module U7 also contains a dc voltage regulator circuit and a squelch switch circuit. The +7.5-volt battery voltage is applied to U7 during all operating modes. The regulator circuit in U7 develops +4.6 volts from the battery supply voltage and is present during all operating modes (F power).

The squelch switch circuit receives inputs from U9 (squelch module) or selective call circuits, and produces an output which squelches or unsquelches the audio amplifier circuits in module U8. In the transmit mode for vhf and uhf radios, power is removed from the output circuit in U8 and receiver audio to the speaker is squelched. For 800 MHz radios in the transmit mode, the output protection circuit is connected to dc power, and squelching of the audio is accomplished by switching the power amplifier reference voltage to ground through CR7.

Module U8 has an audio output that is not referenced to ground, but is a balanced output produced by a bridge amplifier. This audio signal is applied to the speaker in the front cover via the speaker jack and the normally closed switch (S401) located in accessory connector J402. The switch is opened when a mating connector is attached to J402. This disables the internal speaker when accessories such as an external speaker-microphone are attached to the radio.

d. Squelch Circuits, Receiver

Circuits that accomplish receiver squelching reside in the audio preamplifier module (U7) and the audio power amplifier module (U8). They are activated by applying voltage to the squelch input to U7. Activation can come from: carrier squelch circuitry (U9), tone PL circuitry (U121, U122, U123), digital PL circuitry (U131, U132, U133, U134), or selective call circuitry. The squelch feature reduces operator fatigue, and coded squelch (PL or DPL) offers privacy. The use of squelch also reduces current drain, thereby extending battery life.

The carrier squelch circuitry causes squelch action when a high level of noise is present at the discriminator output of U6. When a message signal is received, the discriminator noise is suppressed and the carrier squelch circuitry (U9) senses this suppression and unsquelches the receiver. A variable squelch control is used to engage the circuitry and affects reception as follows: when set fully clockwise ("tight" squelch), only strong rf signals will unsquelch the receiver; when the squelch is adjusted counterclockwise (threshold), reception of even weak signals with high noise content is possible.

Other methods of receiver squelching, tone PL, digital PL, and selective call, rely on coded low frequency audio tones or pulses present at the discriminator output. Tone PL and digital PL methods transmit these coded signals. The selective call option is similar to a pager feature in that alerting tones are heard prior to unsquelching the receiver audio.

The carrier squelch circuitry can be retained with any of the other squelch schemes. Receiver unsquelching then occurs only when two conditions are satisfied; i.e., when the proper coded signal is acknowledged and when the proper rf signal strength is present (depends upon squelch control setting). No two of the other schemes can be combined on a radio.

3. CHANNEL ELEMENTS

a. General

Radios with more than one channel have a frequency selector switch that selects the desired channel element.

b. Receiver

Receiver channel elements provide input to the receiver multiplier. Vhf receiver channel element outputs are inhibited during the transmit mode. Uhf and 800 MHz receiver channel elements are on during both receive and transmit modes.

c. Transmitter

Transmit channel elements provide injection signals directly to the PLL processor with no multiplication. Modulation of the rf signal occurs in the transmitter channel element. Each transmitter channel element contains a crystal-controlled oscillator, varactor modulators, temperature compensation circuits, and an output buffer amplifier. Vhf radios having more than two channels have a buffer amplifier module (U109) between the channel elements and the phase-lock-loop module.

When the transmitter is keyed by the PTT switch, the PLL module (U102) generates regulated +4.6-volt power. This voltage is applied to all channel elements and activates only the channel element selected by the frequency selector switch. In one- or two-channel vhf radios, this +4.6 volts is applied directly to the channel elements, but in vhf radios with more than two channels it is applied to buffer amplifier U109 and passed from there to the channel elements. The modulated rf output of the selected channel element is applied to phase-lock-loop module U102.

4. FREQUENCY RELATIONSHIPS (Standard Models)

a. Receivers

The receive frequency (f_r) is some multiple (n) times the receive channel element frequency (f_o) plus the intermediate frequency (f_{if}).

$f_r = nf_o + f_{if}$ (where $f_{if} = 21.4$ MHz)

FREQUENCY BAND	N
Vhf	2
Uhf	6
800 MHz	12

b. Transmitters

The transmit frequency (f_t) is some multiple (n) times the receive channel element frequency (f_o) plus the offset channel element frequency (f_{os}).

$f_t = nf_o + f_{os}$

FREQUENCY BAND	N	f_{os}
Vhf	3*	0
Uhf	6	+21.4 MHz
800 MHz	12**	-23.6 MHz

* Vhf has no offset element. A separate transmit element is used and the receive element is disabled. The offset input of the PLL processor is connected to f_o. For vhf, $f_t = 3f_o$.

** 800 MHz has negative offset where transmit frequency is 45 MHz below receive frequency and the offset frequency (f_{os}) is subtracted from the injection frequency.

5. OVERALL TRANSMITTER CIRCUIT

a. General

All MX300 series transmitter circuits are functionally the same; containing channel elements, an instantaneous deviation control (IDC) module, a phase-lock-loop (PLL) module, a voltage controlled oscillator (VCO) module, rf amplifier modules, a harmonic filter and detector module (vhf and uhf), and an automatic level control (ALC) module (vhf and uhf). The primary difference between uhf and vhf radios involves the channel element and the phase-lock-loop operation. The primary difference between radios with different rf power output is the number of rf amplifiers and the output power.

The voltage-controlled oscillator in module U103 oscillates at the rf carrier frequency. The following rf amplifiers therefore simply amplify the VCO output, without multiplication or tuning. The transmitter alignment is also simplified by this system. The only adjustments required to align the transmitter are: (1) set the deviation, (2) warp the channel elements, and (3) set the rf power level.

When the VCO is not providing rf power amplifier input (during receive mode or transmit search mode), no battery current is being drawn by the rf power amplifiers. The relatively low current supplied to the VCO and PLL is switched on during transmit mode via relay K101 (vhf and uhf) or dc switch U11 (800 MHz).

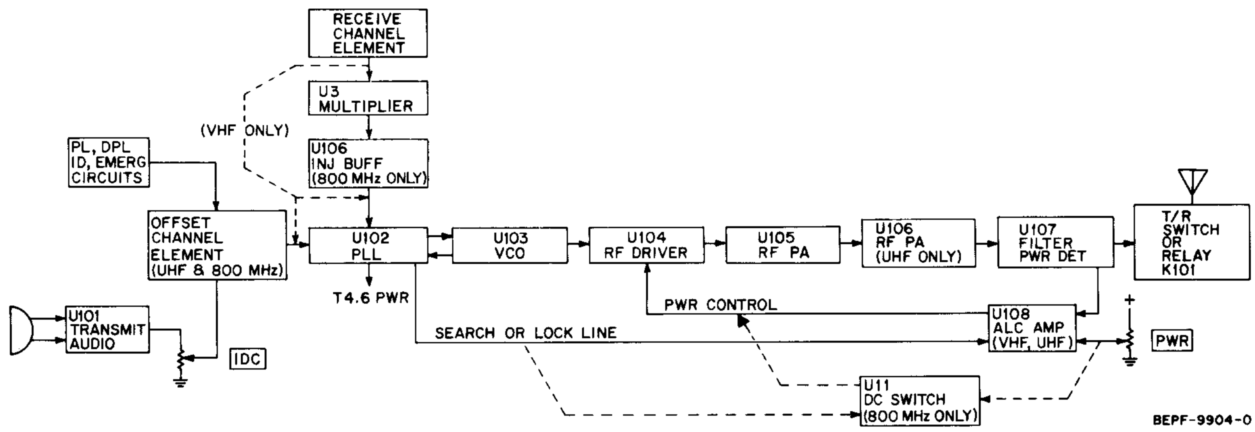


Figure 11. Overall Transmitter Circuit Signal Flow

b. PTT Operation

Refer to the PTT circuitry diagrams below.

When the push-to-talk (PTT) switch is pressed, three functions are performed: (1) the microphone is attached to the modulation input, (2) the dc supply voltage is switched from receiver circuitry to transmitter circuitry, and (3) the antenna is switched from the receiver input to the transmitter output.

In vhf and uhf radios, antenna and dc supply switching functions are performed by a relay (K101). In 800 MHz radios the antenna switching function is performed by the PA-T/R switch module (U105), and the dc supply switching function is performed by the dc switch module (U11). U105 switches the antenna when the transmitter supply input is energized.

The microphone circuit (all models) is completed when the PTT switch (S304) is depressed. The microphone output is coupled through R306/

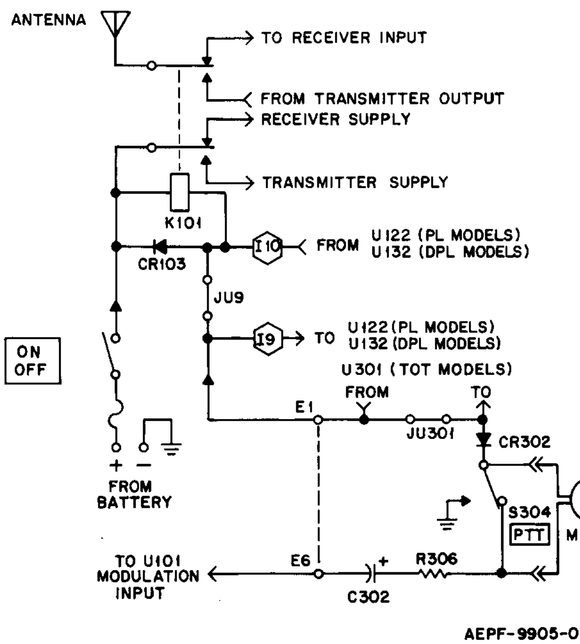


Figure 12. PTT Circuitry, Vhf and Uhf Models

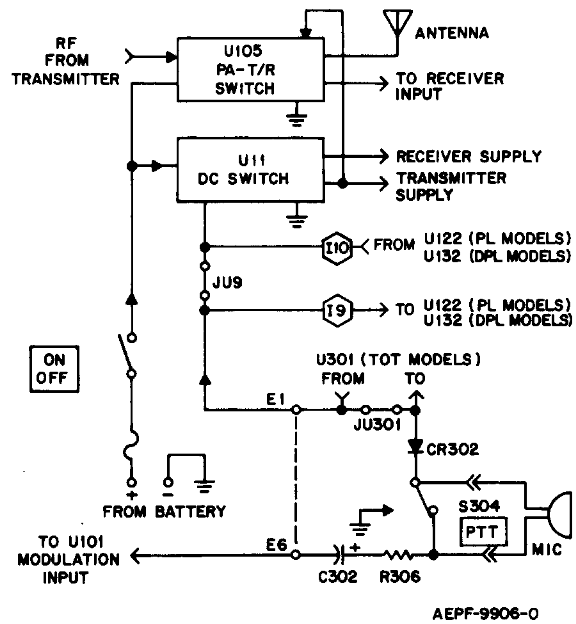


Figure 13. PTT Circuitry, 800 MHz Models

C302 to the transmit audio module (U101) input via terminal E6 on the main circuit board. A potentiometer (R102) allows deviation adjustment of the transmitter channel element, therefore the deviation of the transmitter rf signal.

In PL and DPL models, the switching functions are not influenced directly by the PTT switch. That is, the PTT switch initiates switching action in the PL or DPL processor module (U122 or U132) which, in turn, enables the antenna and dc switching functions. These options require some de-key delay for transmission of turn-off codes, performed by the code processor modules.

In TOT (time-out timer) models, the PTT switch enables the TOT circuitry (U301) which, in turn, actuates circuitry previously described, just as the PTT switch would on a standard radio. A timer in the TOT circuitry then times out and de-energizes the switching functions, which limits the duration of a transmission.

c. Phase-Lock-Loop (PLL) Processor and Voltage Controlled Oscillator (VCO) Circuits

The purpose of these circuits is to generate a stable transmitter carrier frequency. Vhf radios use PLL injection directly from the transmitter channel element. In uhf and 800 MHz radios, the receiver channel element is multiplied by module U3 and then is used as a reference frequency for PLL injection. The uhf and 800 MHz radios also require an input to the PLL from the offset channel element.

Initially, in the transmit mode, the PLL processor causes the VCO to sweep across the band (search mode). When the VCO reaches a frequency that causes a zero-degree phase comparison with PLL reference frequencies, the PLL processor causes the VCO to stop sweeping and remain at that frequency (lock mode). The PLL processor causes the VCO to stay phase-locked to the modulated transmit channel element, which results in transferring the modulation to the transmitter carrier frequency. (See "Hybrid Modules" section for a more detailed description of operation.)

When phase lock occurs, the PLL processor SEARCH/LOCKED output signal changes state and enables the power control function. All vhf radios and some international uhf radios have VCO circuits with rf output gates. This gate is also controlled by the PLL.

d. Rf Amplifiers

The VCO output is applied to the input of an rf power amplifier section. The first of the amplifiers, U104, is called the rf power amplifier driver (vhf and uhf) or exciter buffer (800 MHz). In addition to performing a driver or amplification function, this module is responsible for maintaining a constant power level. A voltage-controlled gain stage within this module allows a dc level control voltage to influence its output power level and, therefore, the transmitter output power. This stage also has a buffer feature designed to reduce the antenna load variations on the VCO frequency by providing some isolation. Rf power amplifiers that follow the driver determine the power level of the radio and are all class C amplifiers.

e. Automatic Level Control (ALC) Circuitry

When the transmitter is in the search mode, the PLL processor module provides a disable signal to the ALC module U108, inhibiting the control voltage to driver/buffer U104 which prevents any transmitter output during the search mode. (In domestic uhf radios, there is a slight exception to this upon initial key-up. Capacitor C112 has to be charged and this allows a few milliseconds of transmitter output).

When the transmitter is in the lock mode, the PLL processor module provides an enable signal to ALC amplifier module U108. The output signal level is determined by the PWR adjust potentiometer (R107) setting and the rf output level at the harmonic filter. The ALC amplifier processes this signal and outputs it to the driver/buffer (U104) with a controlling voltage that corrects the output power level until it equals the desired level per the PWR adjust setting.

In 800 MHz radios, the SEARCH/LOCKED signal controls power-set circuitry in the dc switch module. Once the power-set circuitry is enabled, a dc control voltage related only to the PWR adjust setting is supplied to exciter buffer module (U104). The control voltage determines the output of this module which, in turn, determines the output power of the transmitter. There is no output power when the power set circuitry is disabled during the search mode.

f. Tone "Private-Line" Circuit

This circuit resides on the main circuit board in the MX300 series radios. The "Private-Line" (PL) tone circuit consists of three thick-film hybrid modules (U121, U122, and U123). This circuit decodes subaudible PL tones in the receive mode and encodes PL tones in the transmit mode. The operating mode of the PL circuit is determined by dc voltages applied to the PL processor module (U122) from the PL switch, the PTT switch, and relay K101 (U11 dc switch module in 800 MHz radios).

If the radio is a "Private-Line" model, and the circuit is turned on, the receiver will remain squelched until a carrier signal is received that is modulated by a specific low-frequency (subaudible) tone. The PL circuit decodes this tone (if it is the correct tone for the radio) and produces an output that unsquelches the radio. The carrier squelch circuit is still operative in the PL mode and should be set to the threshold position for optimum receiver operation. In the transmit mode, the circuit generates the proper PL tone which continuously modulates the transmitted carrier.

g. "Digital Private-Line" Circuit

This circuit is constructed on a separate printed circuit board and attached below the main circuit board on 6000 series vhf and uhf radios, and is on the main circuit board for 800 MHz radios. Four hybrid modules are used (U131, U132, U133, and U134). The circuit function is similar to the tone "Private-Line" previously described, except digital information is used instead of tones to identify a particular radio. This permits more codes than is possible with the low frequency tones.

When the digital PL circuit is in the radio, the tone "Private-Line" modules (U121, U122, and U123) are not installed in vhf and uhf radios. For 800 MHz radios, a DPL main circuit board is used.

The digital PL circuit is described in detail in the Hybrid Module section.

6. OPTIONS

The following paragraphs describe the theory of operation of some of the more popular options.

a. Selective Call Radios

(1) General

When a radio contains this optional feature the user gains the alerting feature of a pager and only the receiver circuit is modified. Modules U7 and U8 are involved. The functional block diagram (Figure 14) illustrates the electrical interconnections between the selective call circuits and a typical radio receiver.

Refer to the schematic diagram in the Selective Call Service Supplement (68P81010C55) for a single-code decoder using two active filters (U1 and U2). The tones in each pager code and the corresponding active filters are designated A for the first tone and B for the second tone. Tone A is transmitted for one second followed within 400 milliseconds by tone B, which is transmitted for three seconds. The tones must appear in the proper sequence to produce an alert tone at the speaker.

There are 60 unique frequencies from which tones A and B are selected. Each tone is assigned a code number; called the "Filter Code." Refer to the Tone Coding Description section in this manual.

(2) Active Tone Filters

The "Permacode" active filter is an extremely narrow band audio amplifier, with the center frequency corresponding to a specific paging tone frequency. The frequency and the code number are stamped on each filter. The specific filters installed in each decoder depend on the system code type and the pager number.

The receiver discriminator output is applied to the limiter circuit via interconnect point I1. The limiter provides constant amplitude squarewave output. This signal is divided and routed to the active filters. If this signal has a center frequency the same as one of the filters, a sinewave output is produced at the filter output. The filter output is applied to the two-tone decoder module (U3) to start the paging alert process.

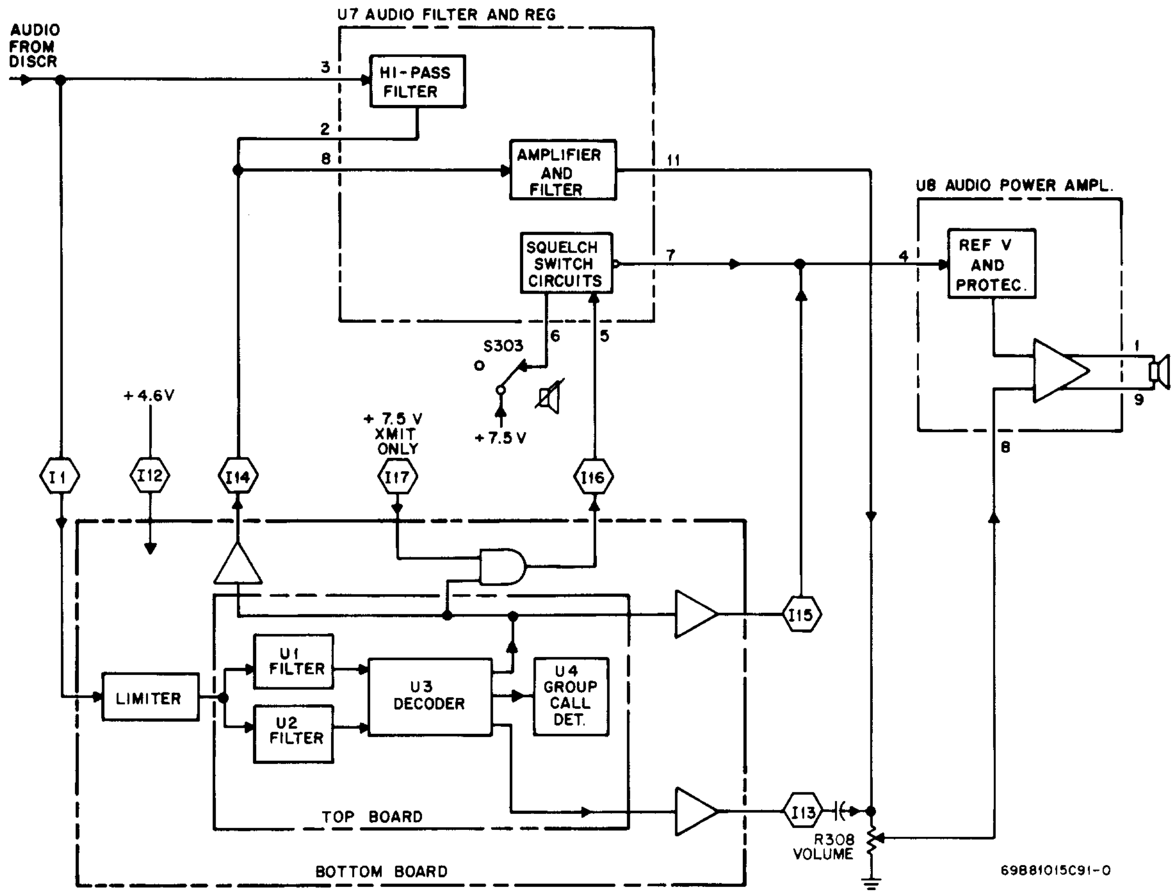


Figure 14. Selective Call Functional Block Diagram

(3) Decoder Circuit

This module alerts the receiver and controls the audio circuits when the proper sequential tones are received. When Tone A is received, the limiter output is routed through the Tone A filter to the decoder. The Tone A input biases the decoder in preparation for Tone B. If the Tone B input occurs immediately after the end of Tone A, the decoder will trigger. When triggered, the decoder produces an alert tone and a dc output. The alert tone is a 2 kHz signal, alternately gated on for approximately 180 ms and off for 80 ms.

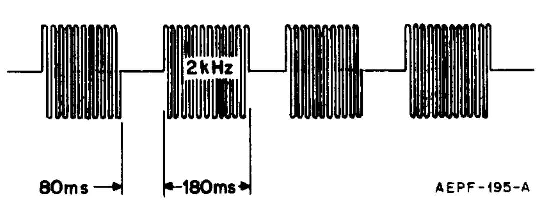


Figure 15. Alert Tone Waveforms

b. Unit ID Radios

When a radio contains this option, additional circuits are added as shown in the functional block diagram (Figure 16), which also illustrates the electrical interconnections between the ID circuits and a typical radio. The interconnecting points are identified by a hexagon and a number with the letter "I" prefix. This hexagon symbol and number appears on all schematic diagrams and applicable printed circuit board details.

When the radio is turned on and +4.6 V appears at I12, a power-up reset function initializes the ID circuits. Operation of the automatic unit ID is started when the PTT switch is depressed to energize relay K101 in the radio. This turns on +7.5 V (T) which appears at I17 as the encode-enable signal for the synthesizer (IC1). Circuit IC1 is a CMOS chip that includes control and reset logic circuits, a time-slot generator, and a programmable divider. The encode-enable signal sets a flip-flop which generates a "mic-mute"

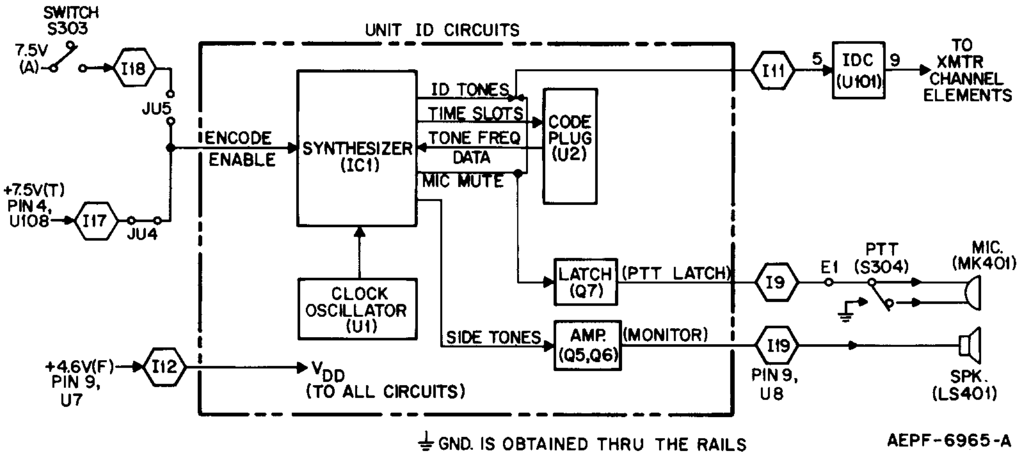


Figure 16. Unit ID Functional Block Diagram

signal that disables the radio microphone circuit, and triggers a transmitter latch circuit (Q7) on the encoder board.

The time-slot generator produces a series of accurately-timed output pulses whose period varies according to whether "Modat," ZVEI, or CCIR type data is to be transmitted. For "Modat" systems, seven 40-millisecond time-slot outputs are generated, while for ZVEI and CCIR systems, five time-slot outputs are generated for 70-milliseconds and 100-milliseconds, respectively. The time-slot signals are applied to the code plug circuit (U2) sequentially to select stored data for each of the tones to be transmitted. Each data location in U2 consists of 8-bit frequency data which represents in binary form the frequency of the audio tones available for transmission. The 8-bit outputs from U2 are applied in parallel to the programmable divider in IC1. This presets the divider network with a specific value so that the clock oscillator frequency can be divided down to the desired tone frequency. The time base for the clocking of the counters in the divider network is a crystal-controlled oscillator (U1) which operates at 246.65 kHz for "Modat" and ZVEI, and 248.945 kHz for CCIR. The resulting output from the synthesizer is a squarewave signal for each of the ID tones to be transmitted. These ID tones then appear at I11; from there they are connected to the IDC module in the radio. The ID output tones are also fed to a 2-stage side-tone amplifier (Q5 and Q6) to provide for monitoring of the ID output (via I19) on the radio's loudspeaker. After the tones are completed, the "mic-mute" signal is reset and the microphone circuit is enabled, or the transmitter is de-keyed if the PTT switch has been deactivated during the ID transmission.

c. <u>Talkaround Radios</u>

Standard uhf and 800 MHz radios operate with the transmitter frequency offset from the receiver frequency. This normally requires the use of a repeater. Since some users may desire communications directly from portable unit to portable unit, the talkaround option (H560) is provided on 800 MHz models. This option allows the user to select which mode of transmission is used. A toggle switch set to "R" (repeater) transmits an offset frequency to the repeater. With the toggle switch set to "D" (direct), the radio transmits on its receive frequency for reception directly by another portable.

To accommodate this feature the transmit frequency is switched from an offset (repeater mode) to zero offset (direct mode). In uhf radios, the standard offset frequency is usually 3, 5, or 5.0125 MHz. The standard transmitter PLL and VCO circuits are designed to accommodate up to 5 MHz of frequency spacing. In some uhf bands, the zero offset channel element frequency (21.4 MHz) can cause transmitter spurious emissions, if used. For these bands, the function of zero offset is accomplished by using a non-standard offset channel element. The receiver channel element is also changed so that the proper transmit frequency is obtained. This technique is covered in detail in supplemental manual 68P81011C61.

In 800 MHz radios, the customary offset is 45 MHz. Because of this large offset frequency, dual-band PLL and VCO modules are required to accomplish talkaround. Also, an additional offset (zero) channel element is required.

HYBRID MODULES

CAUTION

The hybrid modules in this radio require very specialized equipment for repair. Do not attempt to disassemble.

1. CONSTRUCTION

The following module construction information is presented to help the serviceman better understand the radio.

The hybrid circuit modules used in this radio are sealed complex circuits, consisting of both integrated circuits and discrete components. The resulting module usually performs a complete function in the radio. The modules vary in size, depending on complexity, and have different pin configurations. The modules plug into the main printed circuit board and are easily removed for replacement.

Both thick film and thin film technologies are employed in module construction. Both types have an aluminum oxide substrate that forms the base for the circuit. The circuit paths are printed on the substrate with conductive ink in thick film modules and are vacuum deposited with metal in thin film modules.

Chip components are then reflow soldered onto the substrate. Resistors on thin film circuits are chip components, but in thick film modules, most resistors are formed by applying resistive paste between the desired points in the circuit. The paste is usually designed to provide less resistance than desired, and the resistor is trimmed later by removing excess resistive material with a laser or sandblaster until the desired value is obtained.

Thick film capacitors are formed by printing a sandwich composed of two conductive layers separated by an insulating film. Where other capacitor values are required, chip tantalum or ceramic capacitors are attached to the circuit.

Small inductors are produced by screening spiral patterns of conductive material. When large inductors are required, discrete coils or toroids are attached to the circuit.

Active devices (transistors and integrated circuits) are bonded to the thin film substrate in chip form and connected to the circuit with hair-like gold wires. The chips are protected with epoxy.

After the components are soldered in place, most of the modules are coated to keep out moisture. The assembly is then sealed in a metal can for protection and the identifying numbers or label is applied.

2. MODULE CIRCUIT DESCRIPTIONS

The following paragraphs describe the more complex module circuits with simplified circuit diagrams where necessary. The descriptions are provided to help understand signal processing in the module, not for module repair purposes. Refer to schematic diagrams in the appropriate service manual.

3. U1; FILTER MODULE (VHF RADIOS) NFD6011 OR NFD6012

This module is used only in vhf radio receivers. The module contains a passive low-pass filter to provide attenuation for received and conducted spurs. The NFD6011 module is used in 136-150.8 MHz receivers, and the NFD6012 module is used in 150.8-174 MHz receivers.

The insertion loss across the band is about 0.7 dB. Input and output impedance is approximately 50 ohms.

4. U1; RF AMPLIFIER MODULE

a. Vhf Radios, NLN6561 or NLN6562 (0.25 uV Option)

This module contains an rf amplifier, providing extra gain in vhf radios with the 0.25 uV sensitivity option. A two-pole bandpass filter is also contained in this module for spur attenuation. The NLD6562 module is used in 150.8-174 MHz receivers and provides about 12 dB gain across the band. It requires about 2.5 mA power supply current. The NLN6561 module is used in 136-150.8 MHz receivers.

The rf input is applied at pin 1, and the amplified output appears at pin 5. Decoupled B+ is applied at pin 3, and pins 2 and 4 are grounded.

b. Uhf Radios

Radios operating in this frequency band have the rf amplifier circuit incorporated into preselector module A1. A two-pole bandpass filter precedes this rf stage to provide image rejection. This bandpass filter circuit is also part of the preselector module.

c. 800 MHz Radios, NLF4071

This module contains an rf amplifier circuit to provide gain, and a bandpass stripline filter network to provide spurious signal attenuation.

5. U2; MIXER MODULE

Mixer circuits for MX300 series radios are lowside-injected and produce a 21.4 MHz i-f signal.

a. Vhf Radios

Radios operating in this frequency band have the mixer stage included in preselector module A1. A four-pole bandpass filter network precedes this stage and is also contained within the preselector module.

b. Uhf Radios

Radios operating in this frequency band have the mixer stage included in preselector module A1. A three-pole bandpass filter network precedes the mixer stage and is also part of the preselector module.

c. 800 MHz Radios, NLF4091

This module contains a mixer, preceded by a stripline, bandpass filter. The mixer receives injection via a directional coupler, which also provides injection for the transmitter system.

6. U3; MULTIPLIER MODULE

a. Vhf Radios

Radios operating in this frequency band have the multiplier circuit, together with an output three-pole bandpass filter, included in the preselector module. This circuit doubles the fundamental channel element frequency to $2f_o$ for use as receiver mixer injection.

b. Uhf Radios

Radios operating in this frequency band have the multiplier circuit, together with a two-pole bandpass filter, included in the preselector module. This circuit doubles the third harmonic of the channel element frequency producing $6f_o$. An output is also available to source the transmitter PLL module with a $6f_o$ injection signal.

c. 800 MHz Radios, NLF4081

This module contains a multiplier followed by a stripline, bandpass filter. This circuit quadruples the third harmonic of the channel element frequency, producing $12f_o$. The module provides the input signal to a directional coupler in mixer U2. The coupler routes the signal to the mixer or to the transmitter injection buffer (U106), depending upon radio mode status, receive or transmit.

7. U4; FIRST I-F AMPLIFIER MODULE NLN8917

The first i-f amplifier is a hybrid module with a frequency bandpass between 10 MHz and 30 MHz. The amplifier provides approximately 45 dB of gain at 21.4 MHz. The input signal is supplied from a crystal filter and the output signal is applied to a crystal filter.

8. U5; SECOND I-F AMPLIFIER AND LIMITER MODULE NLN8773

This is a hybrid module containing two amplifiers, providing a total gain of about 90 dB. The first amplifier provides about 45 dB gain. The amplified signal is applied to the last amplifier which amplifies and limits the signal. The limiter removes the amplitude modulations in the signal and produces a constant amplitude output. Due to the high overall gain of the module, limiting occurs even with low noise level inputs.

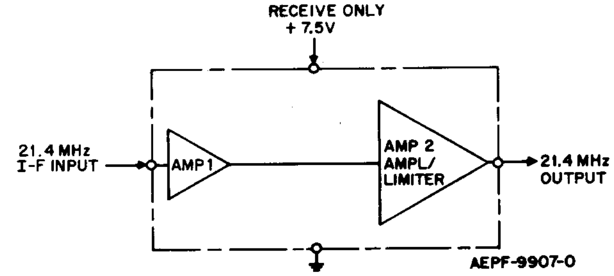


Figure 17. I-F Amplifier and Limiter

9. U6; DISCRIMINATOR MODULE NLN5925

This module is used in conjunction with a three-pole monolithic crystal to form the fm demodulator. Detection is accomplished by applying the two signals from crystal FL5 (180 degrees out-of-phase) to the input of the differential amplifier in the module. The recovered audio appears at the module output. This circuit provides a high level of recovered audio output with inputs having low level deviations. Also, the circuit contains no coils and requires no adjustments.

Refer to the simplified waveforms (Figure 18). Crystal filter FL5 has two resonant circuits; 10 kHz above 21.4 MHz, and 10 kHz below 21.4 MHz. As the frequency-modulated 21.4 MHz i-f signal goes up in frequency, the crystal output amplitude at pin 2 of U6 becomes greater (point F) than the other crystal output in pin 1 of U6 (point C). These levels result in a differential amplifier output (F-C) at pin 7 as shown.

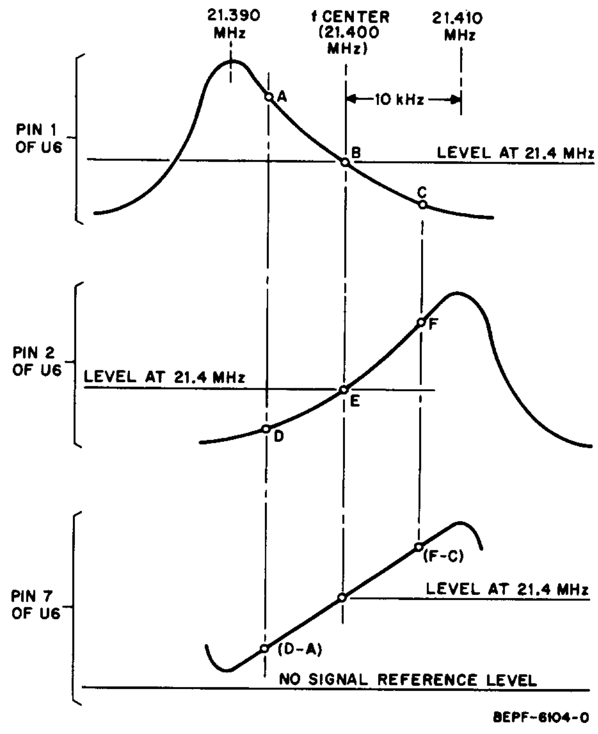


Figure 18. Discriminator Simplified Waveforms

If the signal goes down in frequency, the level at pin 1 (A) is greater than at pin 2 (D) and the resultant (D-A) at pin 7 is as shown.

10. U7; AUDIO FILTER AND REGULATOR MODULE NLN8777 OR NLN8946

This hybrid module performs three discrete functions: (1) shaping of the audio frequency, (2) switching of recovered audio and squelching or unsquelching the audio amplifier, and (3) generating the regulated +4.6-voltage.

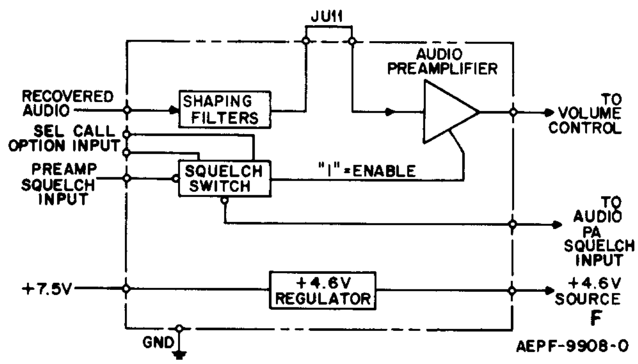


Figure 19. U7; Audio Filter and Regulator Module

Refer to the simplified diagram of the audio filter and regulator module, U7 (Figure 19). Recovered audio is applied to shaping filters, (PL tone hi-pass and de-emphasis) amplified, and is outputted to the volume control. A logic low (less than one volt) will gate the amplifier "on" and will also produce a logic low at the audio PA squelch input. The audio power amplifier module (U8) is enabled when the PA squelch input is low. Jumper JU11 may be removed for some options. Domestic radios use module NLN8777 and international radios use audio shaping module NLN8946.

11. U8; AUDIO POWER AMPLIFIER MODULE NLN8775

This module contains a bridge amplifier with a balanced output. The design eliminates large capacitors in the circuit. About 140 mA of current are required from the 7.5-volt supply for 500 mW output. The standby current in the squelched mode is about 1.0 mA. The circuit input sensitivity is about 25 mV input for 500 mW output. Speaker load is 24 ohms.

Three features are accommodated by circuitry within this audio power amplifier module: (1) power amplification of shaped audio, (2) squelching of speaker audio, and (3) self protection if the output is faulted.

Power amplification is accomplished when the shaped audio from the radio volume control is applied to a phase splitter that produces two outputs, 180 degrees out-of-phase. These two signals are applied to amplifiers in the bridge circuit. The output of these amplifiers are connected directly to the speaker.

Squelch action is accomplished as follows. A reference voltage is first developed from the supply voltage. When the voltage at the squelch input is less than one volt (unsquelched) the reference voltage is applied to the amplifiers and an audio output appears across the speaker. A positive voltage at the squelch input (typically 3 volts) turns off the reference voltage and squelches the amplifiers.

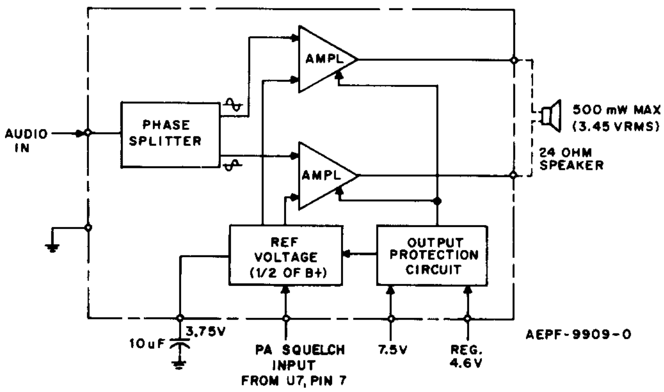


Figure 20. U8; Audio Power Amplifier

CAUTION

The protection circuit DOES NOT protect the amplifier from shorts to the supply voltage.

The output protection circuit samples the +7.5-volt supply current. If the current exceeds a preset value, it interrupts the reference voltage (the same as squelching) and turns off the amplifiers. A monostable multivibrator is also triggered which holds the amplifiers off for about 30 msec. If the output is still shorted when the monostable resets, it is immediately triggered again and the cycle repeats. When either of the outputs is shorted to ground, a harsh low - frequency tone is produced at the speaker.

12. U9; SQUELCH MODULE NLN8776

This module processes a portion of the discriminator output developed across the squelch control resistor R311. It provides a logic output to enable or disable the squelch circuits in the audio preamplifier (U7), depending upon the presence of discriminator noise.

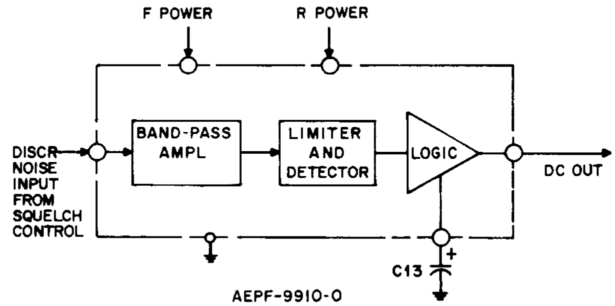


Figure 21. U9; Squelch Module

The input signal from the discriminator is passed through a high-pass filter and any fm noise above the audio band is eliminated in the limiter stage. The limited noise signal is detected and applied to a logic circuit which includes external capacitor C13. When noise is present (no carrier received), the capacitor charges to a high dc voltage. When a carrier is received the voltage drops. This output is applied to the squelch switch circuits in U7.

13. CHANNEL ELEMENTS

a. General

The channel elements contain a crystal-controlled, actively compensated oscillator and a buffer output circuit. Transmitter channel elements also contain varactors for modulating the oscillator. Primary differences involve output frequency and the crystal harmonic being used.

b. Receiver Channel Elements Vhf Radios, KXN1040; Uhf Radios, KXN1039 and KXN1067; 800 MHz Radios, KXN1089

Refer to the simplified channel element diagram (Figure 22). The crystal-controlled oscillator employs the fifth overtone of the crystal and produces an rf output via the buffer circuit. In vhf receivers, the rf output is multiplied two times in the preselector. In uhf receivers the third harmonic of the rf output is multiplied two times in the preselector to produce a $6f_0$ signal. 800 MHz receivers use the third harmonic of the channel element which is then multiplied four times in U3. The channel element receives several dc voltages. The channel select voltage is supplied from a frequency selector switch (multiple frequency models) and enables only the selected channel element. In vhf receivers, +7.5 V is applied to all receiver channel elements in the transmit mode, inhibiting the receiver channel elements during transmission. In uhf and 800 MHz radios, the selected receiver channel element output must be present in the transmit mode, since the multiplied output is used in the transmitter PLL circuit. Therefore, the +7.5 V inhibit input is not used in uhf radios, except when non-standard transmitter offset is used (with the KXN1067 receiver element only).

The primary power source to the channel element is the regulated +4.6V supply. This voltage is present at all receiver channel elements during all modes of operation, but only the selected one having +4.6 V, or transmit only 4.6 V on 800 MHz radios, at channel select inputs will operate.

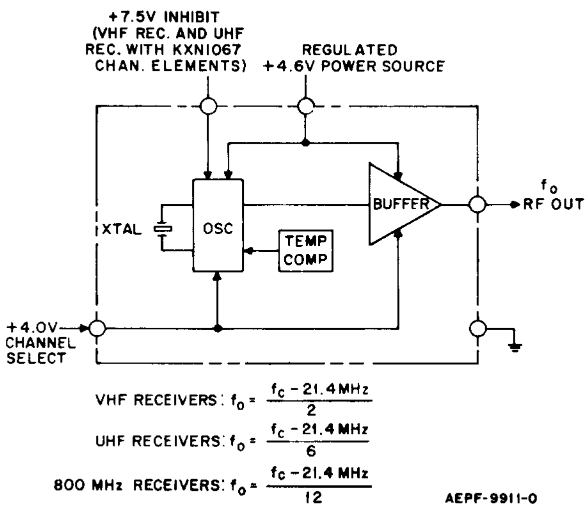


Figure 22. Receiver Channel Element

c. Vhf Transmitter Channel Elements KXN1099

The vhf transmitter channel element is similar to the receiver channel element, except it has two audio inputs that are applied to varactors in the oscillator. Also, the third overtone (fourth harmonic) mode of the crystal is employed in the oscillator.

A portion of the IDC circuit output developed across R102 is applied to the speech audio input. In "Private-Line" models, tones or digital information is applied to the "Private-Line" tone input. Both of these inputs frequency modulate the oscillator, resulting in an fm output.

A bias voltage, +4.6 V (F power) is applied to transmitter channel elements in all operating modes. Radios with more than one channel have a frequency selector switch that selects the desired channel element. The switch applies F power to the anode of a selected diode, which conducts and applies voltage to the channel select input enabling only the selected channel element. When the PTT switch is pressed (transmit mode), F power is applied through an inductor to the rf output. This supplies collector voltage to the stages in all transmitter channel elements, but only the selected channel element will operate.

The rf output is frequency modulated and is one third of the transmitter carrier frequency.

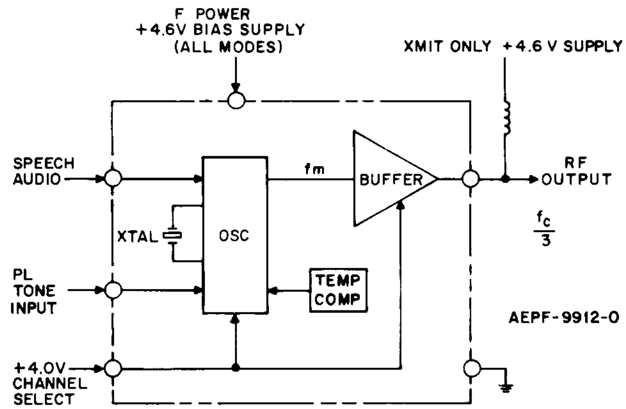


Figure 23. Vhf Transmitter Channel Element; CE101, CE102

d. Uhf Transmitter Offset Channel Elements NLE6972, NLE6973, NLE6975, NLE6976

The uhf transmitter offset channel elements operate somewhat differently then the vhf channel elements. Only two transmitter channel elements are normally used in uhf radios having up to eight channels. This is possible in the uhf band since the transmitter carrier frequency is either the same as the receiver frequency or 3 or 5 MHz above it (standard offset). Radios operating between 403 and 430 MHz use the 3 MHz offset, while those operating in the 440 to 470 MHz range use either the 0 or 5 MHz offset. For radios operating in the 470 to 512 MHz range, the offset will normally be either 0 or 3 MHz. Other (non-standard) offsets are available.

In application, the transmitter offset channel element output supplies the modulation and the offset information to the transmitter PLL circuit. Refer to the simplified diagram for the uhf transmitter offset channel element (Figure 24). Functional operation is the same as previously described for the vhf transmitter channel element except for module pin numbers and dc voltage application. Transmit only +4.6 V supply is applied to the enable input on the oscillator when the transmitter is keyed.

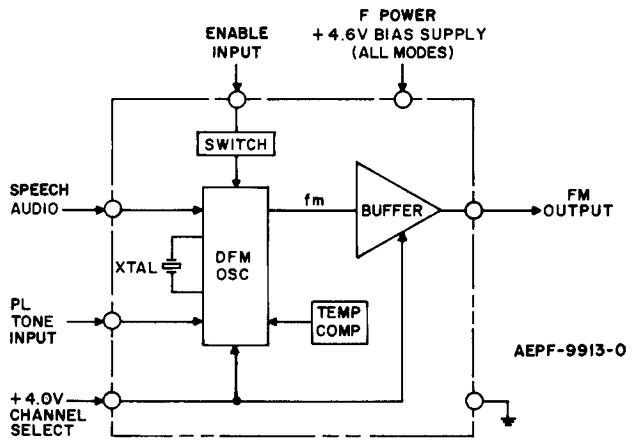


Figure 24.
UHF/800 MHz Transmitter Channel Element; CE101, CE102

e. Transmitter Offset Channel Elements (800 MHz Radios) NXN6085, NXN6086

The 800 MHz transmitter offset channel elements operate similar to the uhf offset channel elements. The primary difference between them is that the 800 MHz radios have a constant 45 MHz separation between transmit and receive frequencies, except during direct (without use of repeater) operation. For repeater operation, 23.6 MHz offset is used, and 21.4 MHz offset is used for direct operation.

The transmitter offset channel element output supplies the modulation and the offset information to the transmitter PLL circuit. Refer to the simplified diagram for the uhf/800 MHz channel element (Figure 24). Operation of both, including pin function, is essentially the same.

14. U11; DC SWITCH MODULE (800 MHz RADIOS) NLF4060

This module has two functions; dc power distribution and control of the transmitter output power. The dc switching circuitry in this module directs dc power to either the receiver circuitry (R power) or transmitter circuitry (T power), depending upon the status of the PTT input.

The transmitter output is controlled by the power-set output signal from module U11, which develops a voltage across R107, PWR adjust, and is then routed to exciter buffer U104. This output signal is supplied only when the gate input is enabled, once transmitter lock is achieved. Transmitter output power is gated off when the gate input is disabled.

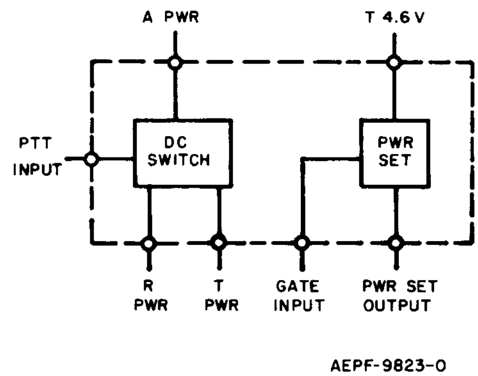


Figure 25. U11; DC Switch Module

15. U101; INSTANTANEOUS DEVIATION CONTROL (IDC) MODULE NLN5832

This module amplifies and shapes the audio modulating waveform applied to the channel elements (speech audio input). The low-level audio signal from the microphone is capacitively coupled to a preamplifier in the module. The second amplifier stage adds 6 dB/octave pre-emphasis to signals between 300 and 3000 Hz, and attenuates frequencies above 3000 Hz.

The clipper is a differential amplifier which limits the amplitude of the positive and negative peaks. The limited signal is applied to an active low-pass (splatter) filter, and then to an emitter follower output stage. The audio output is applied to the deviation adjust control, which permits adjusting the transmitter frequency devia on to the appropriate value depending upon channel width requirements (for domestic radios this is usually ±5 kHz).

The encoded input is used to input optional digital scrambler signals.

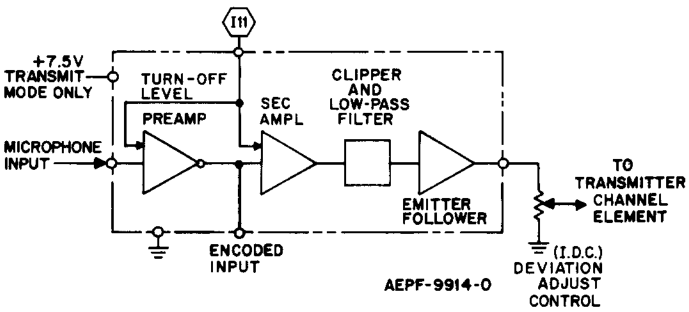


Figure 26. U101; IDC Module

16. U102; PHASE-LOCK-LOOP (PLL) PROCESSOR MODULE

a. General

This module contains the frequency control circuitry for the transmitter and is directly connected to the voltage-controlled oscillator (VCO). The PLL module compares the phase of the feedback signal from the VCO with a reference oscillator and produces a dc control voltage which is applied to the VCO. The output of the VCO is therefore phase-locked with the stable reference signal. To arrive at the correct frequency at key-up, a sweeper circuit in the PLL module causes the control voltage to assume a triangle waveform. This varying voltage sweeps the VCO back and forth across the band. When the VCO crosses the desired frequency the phase/lock detector turns off the sweep voltage and phase lock occurs. The control voltage signal under locked conditions consists of the dc voltage necessary to maintain the desired frequency with the transmit audio voltage superimposed on it.

Two other features of this module are: (1) an output gate that changes state once phase lock is achieved, which is useful for enabling output power only when the transmitter is on the correct frequency, and (2) an internal regulator that provides transmit-only +4. 6 V for use in other parts of the radio.

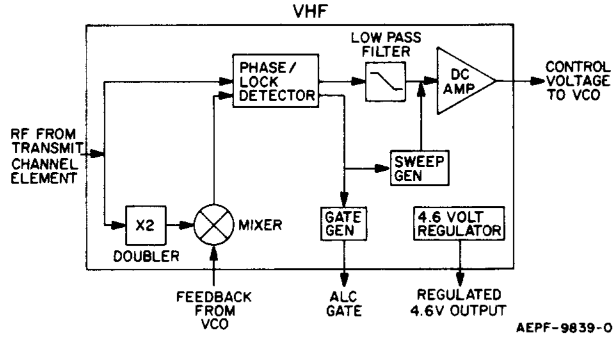


Figure 27. U102; Phase-Lock-Loop Module, Vhf

b. U102; PLL Processor Module (Vhf Radios) NLD6592

In the vhf PLL, the stable reference is supplied by the transmit channel element at approximately 50 MHz (44. 5 to 58 MHz), or one-third of the desired transmit frequency. In order to compare a 150 MHz carrier with a 50 MHz signal, VCO feedback is applied to a mixer. The other input to the mixer consists of the same transmit channel element signal (approximately 50 MHz) which has been doubled. Thus, a 150 MHz carrier mixing with the 100 MHz doubled channel element signal produces a 50 MHz signal which is compared to the 50 MHz channel element for phase difference.

When the transmitter is first keyed, a saw-tooth sweep voltage is applied to the VCO module (U103). This causes the VCO to sweep across the band. When the VCO frequency is equal to 3 times the channel element frequency, the lock detector shuts off the sweep circuit. The phase detector output in U102 then drives the VCO and, when on frequency, consists only of modulating audio. If the VCO is off frequency, an error signal is produced which tends to move the VCO towards the desired frequency.

When lock is achieved, the ALC gate output of U102 turns on the automatic level control (ALC) circuit in U108. After a delay sufficient for the ALC circuit to turn on the final rf power amplifier, the VCO gate output of U102 can be used to turn on the gate in U103 (VCO); vhf and international uhf radios only.

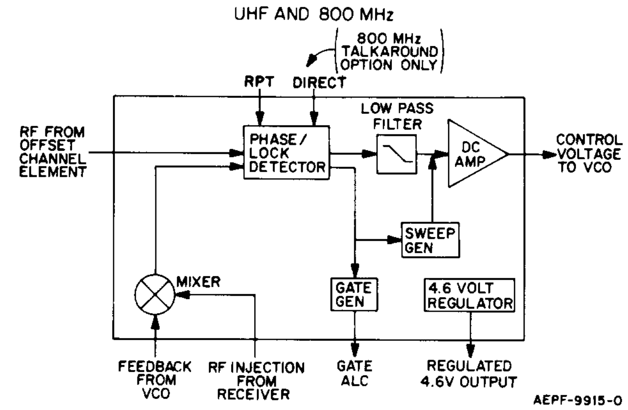


Figure 28. U102; Phase-Lock-Loop Module, Uhf and 800 MHz

c. U102; PLL Processor Module (Uhf Radios) NLE8342

The transmitter carrier frequency will normally be the same as the receiver frequency or 5 MHz higher than the receiver frequency in 403-470 MHz radios (3 MHz higher in 470-512 MHz radios). This offset (f_t - f_r) is assigned by the federal government.

Since the transmitter frequency normally has a fixed relationship to the receiver frequency, a signal from the receiver oscillator multiplier in the preselector is used to develop the transmitter carrier frequency. When the transmitter is first keyed a sawtooth sweep voltage is applied to the VCO module (U103). This causes the VCO to sweep across the band. A portion of the VCO output is applied back to the mixer circuit in U102. A second input to the mixer is supplied from the receiver preselector, rf injection output. The $6f_o$ signal from the preselector will be 21.4 MHz lower than the receiver channel frequency. These two inputs ($6f_o$ and VCO) are mixed and the difference frequency is applied to the phase/lock detector circuits where it is phase compared with the output from the selected transmitter offset channel element (21.4, 24.4, or 26.4 MHz).

When zero offset is required for the transmitter, a 21.4 MHz offset channel element will be activated and the output will be applied to the offset rf input of U102. When the VCO output frequency becomes equal to the receiver frequency, the mixer output in U102 will be 21.4 MHz. This mixer output is phase compared (in the phase lock detector circuit with the 21.4 MHz offset channel element output and lock occurs shutting off the sweep voltage to the VCO. The phase/lock detector output now contains only modulation information for the VCO.

Similarly, if the transmitter frequency is offset 5 MHz, 26.4 MHz will be applied to the offset rf input of U102. When the VCO sweeps to the desired frequency, the mixer output will be 5 MHz higher than before (26.4 MHz). This is phase compared with the signal from the offset channel element, which is also now 26.4 MHz, and lock occurs at the offset channel frequency.

When lock is achieved, the ALC gate output of U102 enables the automatic level control (ALC) circuit in U108. For international uhf radios, after a delay sufficient for the ALC circuit to turn on the driver rf power amplifier the ALC gate output enables the gate in U103 (VCO).

d. U102; PLL Processor Module (800 MHz Radios) NLF4010, NLF4111

In this frequency band, the transmitter carrier frequency will normally be 45 MHz below the receiver frequency. This offset (f_t - f_r) is negative and is assigned by the federal government.

With the transmitter frequency below receiver frequency, rather than above as in uhf radios, the phase detector in this module has reversed phase sense. Otherwise, the configuration and operation of NLF4111 is the same as described for uhf radios. Rf injection to the module from injection buffer U106 is $12f_o$ for 800 MHz radios.

An optional feature for this band is switchable "direct" communication to another unit, thus avoiding use of a repeater. This is accomplished when f_t-f_r = 0 MHz offset. For this application the NLF4010 kit is used. With this feature the phase sense of the phase detector can be switched to cause the transmit frequency to be above or below receiver injection frequency. For direct mode operation, a 21.4 MHz offset element is applied to the PLL processor (phase detector switched to standard phase sense). In repeater mode operation, a 23.6 MHz offset element is applied to the PLL processor (phase detector switched to reverse phase sense) and lock occurs when the carrier is 23.6 MHz below the injection frequency, or 45 MHz below the receive frequency.

17. U103; VOLTAGE-CONTROLLED OSCILLATOR (VCO) MODULE

a. General

This module produces a signal at carrier frequency, is bandsplit, and has the following characteristics. An oscillator transistor is used with varactor diode tuning in the input circuit. A transistor buffer stage produces a high power output through an internal pad to provide approximately 50 mW power at 50-ohm output impedance. (VCO modules for international use have p-i-n diode output gates.) A portion of the output signal is coupled to the feedback output pin for use in the PLL processor.

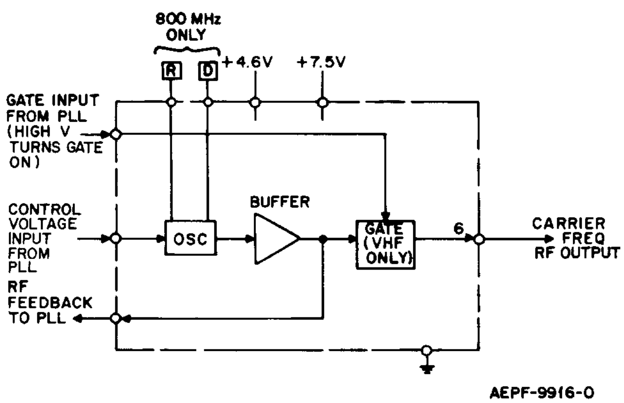


Figure 29. U103; VCO Module

b. U103; VCO Module (Vhf Radios) NLD6601, NLD6602, NLD6603

These VCO modules have an internal gate. When a sawtooth signal from the PLL is applied to the control voltage input, it causes the rf output to sweep across the band. The PLL and VCO are in the search mode under this condition and the gate input voltage is low, disabling the gate and preventing any power output.

When the VCO rf output reaches the desired frequency, a favorable phase comparison between the VCO rf feedback signal and channel element signal occurs in the PLL module. This favorable phase comparison causes the PLL lock detector circuit to activate. The PLL and VCO are now in the lock mode and the control voltage changes from a sawtooth signal to a dc voltage with audio impressed upon it. The gate input voltage is high, enabling the gate to provide output power. (The control voltage line cannot be monitored with conventional test equipment due to sensitivity to stray probe capacitance).

c. U103; VCO Module (Uhf Radios) NLE8801, NLE8802, NLE8803

These modules have no internal gate, as do the vhf modules. As a result, when the PLL module provides a low-voltage VCO gate output during the search mode, the VCO module outputs a sweeping rf signal at the carrier frequency. This sweeping signal is not available at the transmitter output because the rf driver amplifier module (U104) is disabled by the automatic level control (ALC) circuitry.

Otherwise, these modules operate the same as the vhf modules described in paragraph b.

d. U103; VCO Module (800 MHz Radios) NLF4101, NLF4020

(1) NLF4101

This module operates the same as the uhf modules described in paragraph c, except for the different operating frequency.

(2) NLF4020 (Option H560)

This module operates the same as NLF4101, except that it contains a dual-band feature. Mode switch input pins on this module allow for selection of the operating frequency range. With 4.6 V applied to the "R" input (repeater mode) the operating frequency range is 806-815 MHz. With 4.6 V applied to the "D" input (direct mode) the operating frequency range is 851-860 MHz.

18. RF POWER AMPLIFIER MODULES

a. General

The VCO output is amplified by power amplifiers U104, U105, and U106 as applicable. Low power models use only one rf power amplifier, U104. All medium power radios and high power vhf radios use two rf power amplifiers, U104 and U105. The uhf high power radio uses all three rf power amplifiers. Except for U104, the rf power amplifiers function the same. They are all class C amplifiers that are normally biased off without an input drive signal. They have different power outputs and have different bandsplits.

b. U104; Power Amplifier Module (Vhf Radios) NLD6621, NLD6622, NLD6623, NLD6610, NLD6611, NLD6612, and U104; Power Amplifier Module (Uhf Radios) NLE8181, NLE8182, NLE8183, NLE8331, NLE8332, NLE8833

Amplifier U104 contains a class A amplifier driving a class C amplifier in the same module. The gain of the class A stage is controlled by varying the B+ supplied from the ALC module, thus providing control of output power.

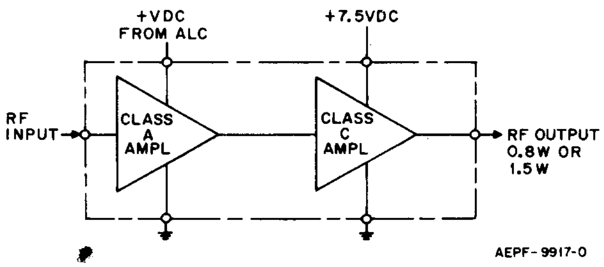


Figure 30. U104; Typical First RF Amplifier

c. U104; Exciter Buffer Module (800 MHz Radios) NLF4030

This module is not bandsplit and covers the entire transmitter band. Both internal stages operate class AB. Otherwise, this module operates the same as the vhf and uhf radios described in paragraph b.

d. U105; Rf Power Amplifier Modules (Vhf Radios) NLD6631, NLD6632, NLD6633 (2.5 W), and NLD6641, NLD6642, NLD6643 (6 W) and U105; Rf Power Amplifier Modules (Uhf Radios) NLE8001, NLE8002, NLE8003 (2 W)

These amplifiers are all class C stages and are all similar except for power output and frequency range. Due to the difference in power handling requirements, some modules vary in size due to the size of the heat sink attached to the module. (Module U106, used only in high power uhf radios, also contains a harmonic filter.)

e. U105; Rf Power Amplifier/Transmit-Receive Switch Module, (800 MHz Radios) NLF4040

This module contains two circuits, each of which has a separate function. The rf power amplifier circuit is a two-stage class C amplifier which provides final power amplification across the entire transmitter band. The transmit-receive switch is a solid state rf switch that switches the antenna jack to either the transmitter output (rf power amplifier) or the receiver input U1.

f. U106; Rf Power Amplifier Module (Uhf Radios) NLE8011, NLE8012, NLE8013 (5 W)

See discussion in paragraph d.

g. U106; Injection Buffer Module (800 MHz Radios) NLF4050

This module operates during the transmit mode. The input to this module comes from the mixer module (U2). The $12f_o$ output signal from the injection buffer provides a strong injection signal level to the PLL processor module (U102) across the entire transmitter band.

19. U107; FILTER AND DETECTOR MODULE: VHF RADIOS NFD6021, NFD6022, AND UHF RADIOS NFE6001, NFE6002, NFE6022

With the exception of the NFE6022 module, these modules contain a multiple-pole, passive, low-pass filter which attenuates harmonics of the carrier frequency. The NFE6022 module, which is used in all high power radios, does not contain a filter, since the high power amplifier module (U106) contains the necessary filtering. Because of the frequency characteristics of the filter, several models are required to cover all portions of the vhf and uhf bands. Neither a low-pass filter nor an rf power detector is used for 800 MHz radios. This module also is part of the output power level control circuitry.

Referring to Figure 31, the module contains an rf rectifier, and a dc compensation and summing circuit. A sample of the rf energy at the filter input is coupled and rectified, producing a dc voltage (A) that is proportional to the carrier signal amplitude. The rectified dc voltage is applied to a summing circuit. A positive dc voltage (B) from the power adjust control is also applied to the summing circuit. The circuit produces an output that is a function of voltages A + B. Since the output voltage depends on the power setting and the rf output level, it is applied to the automatic level control (ALC) module where it develops a control signal to maintain output carrier level at the desired amplitude.

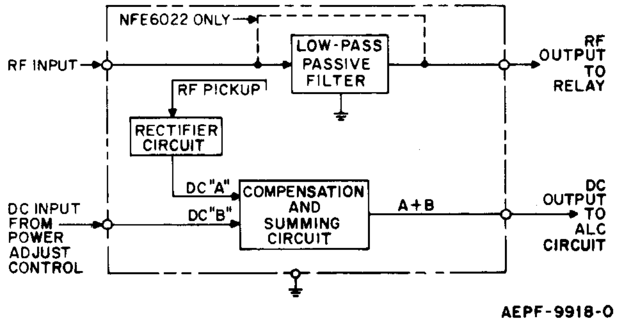


Figure 31. U107; Filter and Detector Module

20. U108; AUTOMATIC LEVEL CONTROL (ALC) MODULE (VHF AND UHF RADIOS) NLN8779

This module provides the comparison action and gain required in the transmitter output power control loop.

A differential amplifier circuit compares the input dc level from power detector U107 to an internal reference voltage. The result is used to control conduction of a transistor that provides the supply voltage to the first stage of U104 (rf power amplifier).

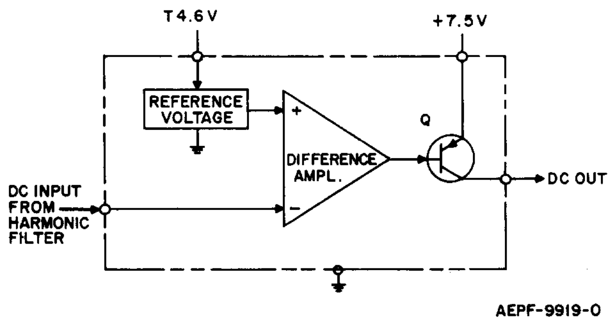


Figure 32. U108; Automatic Level Control Module

21. U109; CHANNEL ELEMENT BUFFER (VHF RADIOS) NLD6921

This module is used in vhf radios that have more than four channel elements. Its purpose is to reduce the loading effect of the multiplier input on the active channel element. A uniform output level is provided to the multiplier input, avoiding variations in performance due to the number of channels. Also, a constant multiplier input impedance is maintained using the buffer, thus avoiding the need for many values of matching components to compensate for the number of channel elements used.

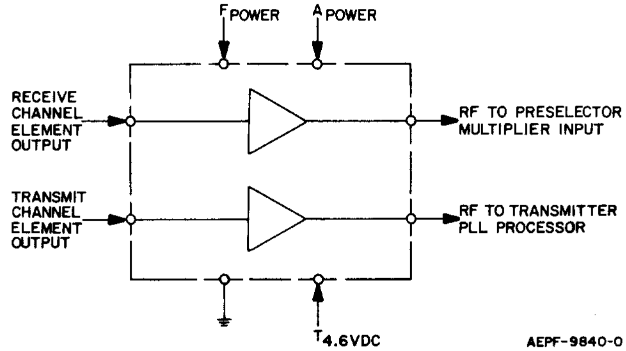


Figure 33. U109; Vhf Channel Element Buffer

22. U121, U122, AND U123; TONE "PRIVATE-LINE" MODULES

a. Receiver Decoding Operation

Refer to the receive (decode) mode diagram (Figure 34). The low-pass filter (U123) is an active filter-amplifier which produces about 12 dB gain at frequencies below 200 Hz, and provides over 20 dB attenuation at frequencies above 300 Hz. The filter module receives operating dc voltage (+4. 6 V) from U7 during all operating modes. Recovered audio from the discriminator is applied to the input of the filter, but due to the low-pass characteristics, only the low frequency PL tones are amplified. The amplified PL tones at the filter output are applied to the input of the PL processor, where they are amplified and amplitude-limited by the receiver-limiter circuit in U122.

The limited subaudible tones from the receiver/limiter U122 provide the input to the PL tone filter in U121, which will pass only one selected subaudible PL tone at almost unity gain (-1 dB). Attenuation of all other tones is greater than 20 dB. If the carrier is being modulated with the correct tone, an output (140 mV maximum) appears at the output of U121. The tone is then amplified through the buffer amplifier and sensed at the threshold detector in U122. A logic high condition is applied to the input of the audio switch gate, which results in a low voltage level (below +1. 8 volts) at the gate output of U122. This low voltage condition unsquelches the receiver.

If the PL squelch switch is in the off position, +7. 5 volts is applied to the audio switch gate in U122, producing a continuous low voltage output.

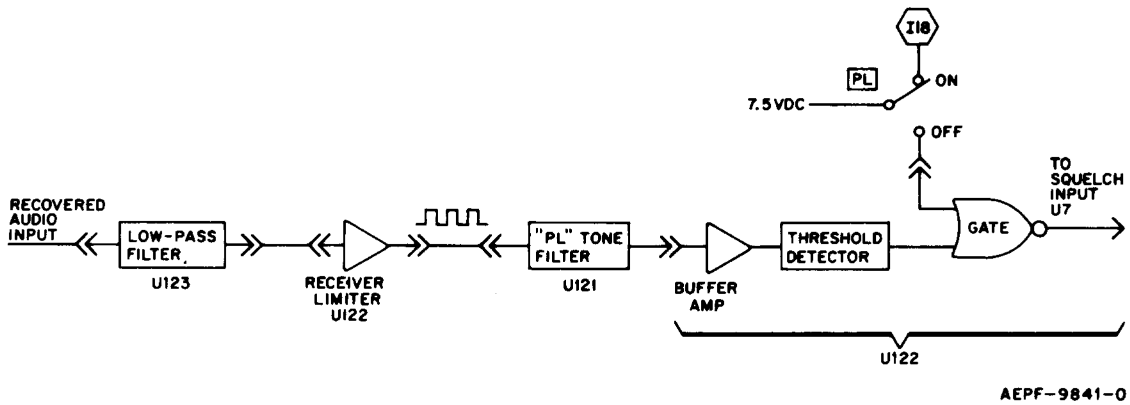


Figure 34. Tone "Private-Line" Circuit, Receive (Decode) Mode

This bypasses the tone decoder circuit and the receiver operates as a carrier squelched radio without PL.

The logic in squelch module U9 is such that "Private-Line" sensitivity is controlled by carrier squelch sensitivity. Therefore, for best PL sensitivity, the squelch control on the radio must be set to threshold sensitivity.

b. Transmitter Encoder Operation

Refer to the transmit (encode) mode diagram (Figure 35). The PL processor functions are altered when the transmitter is keyed.

NOTE

If referring to the schematic diagram, observe that jumper JU9 is cut for the following description.

When the PTT switch is depressed, a ground is applied to the PTT input of U122. This produces an output from the "xmit turn-off delay" circuit which (1) enables the tone oscillator circuit, (2) saturates a driver transistor that provides a ground to K101 or U11, (3) squelches the receiver during transmit, and (4) turns on the DQ control circuit.

The ground to K101 or U11 switches the radio to the transmit mode.

The tone oscillator operates continuously while the transmitter is keyed and is not affected by the PL switch. The oscillator is formed by the transmitter-limiter in U122, the PL tone filter in U121, and the buffer amplifier in U122. The tone filter is the frequency determining device in the oscillator. It is a high Q, narrow bandpass filter that passes its center frequency and blocks all other frequencies. Positive feedback is employed to sustain oscillation and to keep the oscillator out of limiting, producing a sinusoidal output at the tone output of U122 while the transmitter is keyed. The tone output is applied to the PL tone input of the transmit channel element (see Figures 23 and 24).

The DQ control circuit produces a negative-going 20 msec pulse to the tone oscillator DQ input when the PTT switch is pressed, and a negative-going 20 msec pulse 140 msec after the PTT switch is released. The pulse acts upon the PL tone filter to lower the Q of the circuit. This results in faster oscillator start-up initially and produces a rapid decay at the end of a transmission.

When the PTT switch is released, the phase-shift network produces a signal that is 240 degrees out-of-phase with the original tone. The PTT switch release signal is delayed 140 msec before being applied to the "xmit-turn-off delay" circuit, causing the tone oscillator circuit to remain active for 140 msec. This is called transmitting the reverse burst. The receiving radio decoder recognizes this as a turn-off code and immediately squelches, eliminating the "squelch tail" effect.

23. U131, U132, U133, AND U134; "DIGITAL PRIVATE-LINE" MODULES

NOTE

Additional details of system operation and servicing are contained in Technical Information Bulletin TT500 "Portable Products Digital Private-Line Coded Squelch," available from:

Motorola Communications & Electronics, Inc.
1301 E. Algonquin Road
Schaumburg, IL 60172

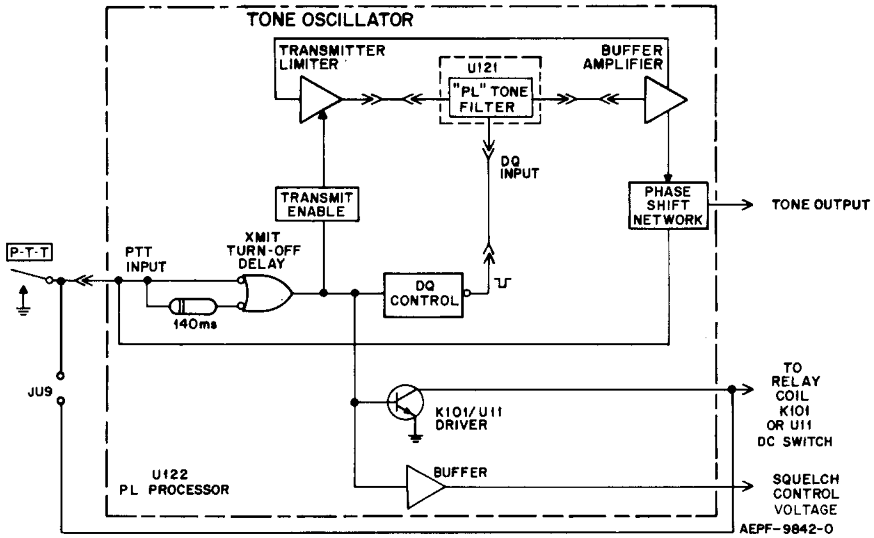


Figure 35. Tone "Private-Line" Circuit, Transmit (Encode) Mode

a. General

The digital PL circuit is a digital coded squelch system which consists of four thick-film hybrid plug-in modules used to encode and decode a 23-bit, binary "Private-Line" communications network.

The digital PL transmitter and receiver are nonsynchronous in that data is transmitted continuously without the conventional "sync" or burst signals which identify the beginning or end of a digital series. Each digital code word consists of 23 bits; 12 data bits followed by 11 parity bits. The processor logic acts as a mini-computer; it receives, stores, and compares recovered code data with that stored in the code plug memory to determine its validity. In the transmit mode, the mini-computer functions as a word generator, producing a 23-bit continuous code. The code sequence is generated by the encoder logic circuits in the processor module, and is determined by the "Permacode" code plug module. The first nine bits are the octal equivalent of the number marked on the code plug, while the next three bits are always the same. The 11 parity bits are constructed by the processor which uses a fixed algorithm to operate on the first 12 bits.

b. Code Conditioner Module; U133

In the receive mode, recovered audio is applied to the input of the code conditioner module where an active, low-pass filter attenuates signals above 150 Hz. The remaining signal (code) is amplified and applied to an amplitude limiter. A Test point is provided at the amplifier output. The amplitude limited code is available at DATA output. The logic convention for the code word is such that an increase in frequency at the receiver antenna is recognized as a logic one (high) at the data input of the code conditioner. A code inverter is provided to accommodate both low and high side receiver mixer injection to maintain the logic convention into the PLL.

The purpose of the phase-lock-loop (PLL) circuit in U133 is to sense the incoming frequency and to lock onto the code word. Initially, before a code is detected, the PLL functions in a low sensitivity mode and permits only a percentage of the code word to be presented to the decoder in U132. When a valid code is detected by the decoder, a detect signal appears as a logic high at the detect input of the code conditioner, and remains high while the correct code is present. Upon detecting the high level, the control circuit will change the PLL to a higher sensitivity mode and permit all of the code to be applied to the decoder. The voltage at I5 will then drop low and unsquelch the receiver. The higher sensitivity mode provides additional immunity to audible interference when the detected code is present. Should the receiver momentarily lose data because of flutter, fade or poor quieting, the switching circuit will hold the PLL in the higher sensitivity mode for approximately 500 milliseconds. With the PL squelch switch in the off position, B+ is applied to I8 and causes I5 to be low, effectively defeating or overriding the DPL receive function. The switch does not, however, affect the processor, and the encoder will always produce code in the transmit mode.

c. Processor Module; U132

In the receive mode, the decoder logic receives and continuously samples data from the PLL output. The decoding scheme is a basic system of comparing the incoming data with the preselected code stored in the code plug module (U134).

The processor, which employs MOS/LSI logic, contains a 50 kHz crystal-controlled oscillator to provide timing (clock) pulses which control the logic in both the receive and transmit modes.

In the transmit mode, the PTT switch applies ground to I9. Circuitry in the processor (U132) applies a ground to I10 causing K101/U11 to change to the transmit mode. A 23-bit binary code is produced by the encoder and provided at the code output. When the PTT switch is released, the current path is maintained through I10 of the processor for 120 milliseconds. The length of time is controlled by a timer in the processor. During the 120 milliseconds, the crystal-controlled 134.4 Hz square wave is gated to the code output, passed through encode filter module U131, and is transmitted. The receiving radio decoder recognizes the 134.4 Hz signal as a turn-off code, and the receiver is immediately squelched.

d. Encode Filter Module; U131

The encode filter contains an amplifier, an active low-pass filter, and an inverter which are used only in the transmit mode. The code from the code output of the DPL processor (typically 5 volts peak-to-peak) is coupled through an r-c coupling network to the code input of the encode filter. The code is then amplified and filtered to remove higher order audible components. This will cause the corners of the coded output pulses to be slightly rounded. Overall module gain is -10 dB; typical output amplitude is one volt peak-to-peak.

The filtered code at DATA OUT is applied to the PL tone input of the transmitter channel element (see Figures 23 and 24). Both DATA OUT and $\overline{\text{DATA OUT}}$ signals are used in 800 MHz radios. These radios, with option H560 (talkaround), use two transmit channel elements. In the "R" (repeater) mode, the transmitter offset is negative and the data signal is coupled through a capacitor to the PL tone input of the "R" mode transmit channel element. In the "D" (direct) mode, however, the transmitter offset is switched to positive. Therefore, the $\overline{\text{DATA OUT}}$ signal is coupled directly to the PL tone input of the "D" mode transmit channel element. This wiring configuration maintains proper code sense for both transmit modes.

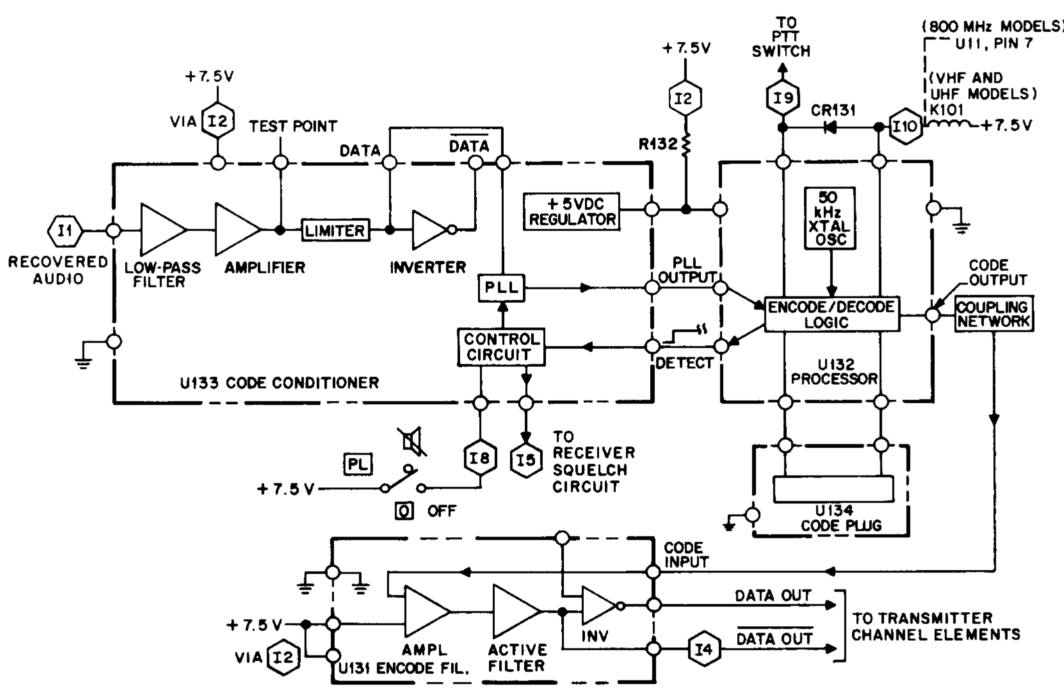


Figure 36. "Digital Private-Line" Circuit

24. U301 (OPTION H901); TIME-OUT TIMER MODULE NLN8947

This module (and timing capacitor) is installed on the control flex in radios equipped with option number H901. The added circuit turns off the transmitter and applies an alert tone to the receiver after continuously transmitting for about 30 seconds. Circuit operation is as follows.

When the press-to-talk (PTT) switch is pressed, a ground is applied via CR302 to the timer input of U301. This turns on the relay amplifier which provides a ground at E1 energizing relay K101, or U11 in 800 MHz radios (which turns on the transmitter). Simultaneously, timing capacitor C303 begins charging towards the applied B+ via the timer in U301. In about 30 seconds, the capacitor charges sufficiently to operate the timer, which turns on the switch.

NOTE

> The RC charge time is determined by an internal resistor and the external capacitor C303. The capacitance is normally selected to provide a timed interval of approximately 30 seconds.

An output from the switch turns off the relay amplifier and de-energizes relay K101, or U11 in 800 MHz radios, switching the radio from the transmit mode to the receive mode. At the same time the switch enables the squelch defeat switch and audio oscillator. The squelch defeat switch unsquelches the radio receiver. The audio oscillator produces an alert tone (about 1300 Hz at 25 mV rms minimum). This tone is injected into the receiver audio circuit at pin 8 of U7 and will be heard at the speaker. The alert tone signals the operator that the transmitter is turned off. This condition remains as long as the PTT switch is held pressed.

If the PTT switch is released, the timer discharges capacitor C303, turns off the oscillator and squelch defeat switch, and the receiver operates normally. Another transmission may be initiated immediately after releasing the PTT switch.

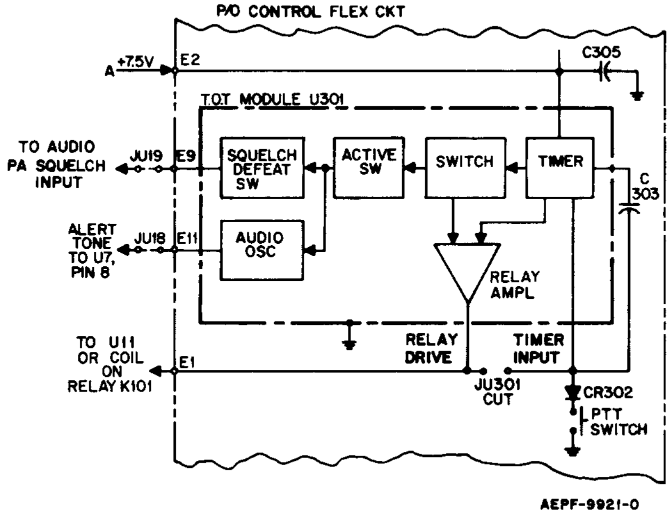


Figure 37. Typical Time-Out Timer Circuit

25. SELECTIVE CALL RADIOS

Refer to schematic diagram in supplemental manual 68P81010C55.

a. <u>Decoder Module, U3</u>

When the decoder module is in the quiescent (standby) condition, no output is produced at either of the threshold detectors (pins 12 and 8) and both C2 and C3 are charged to their high-voltage condition. The normally low output from the 50 ms monostable causes the output of inverter A (pin 11) to be high, which in turn causes the output of inverter B to be low. The "AND" gate D requires a high level at both inputs to produce a high dc output; therefore, since both inputs are low at this time, the output at pin 9 will be low.

When Tone A is applied, the Tone A threshold detector produces a low output rapidly discharging C3. When Tone A is removed, the threshold detector no longer produces a low output and C3 begins recharging through R5. When C3 has charged to 0.65 V dc (about 1.5 sec) the monostable is triggered, producing a short positive pulse. This pulse is processed through inverters A and B, resulting in a positive pulse being applied to input 1 of "AND" gate D. If Tone B has been received, the Tone B threshold detector has a low output, resulting in a high output from inverter E which is routed through gate F to input 2 of gate D. Gate F is an "OR" gate which produces a high output if either input is high. If

Tone B has been received when the 50 ms monostable triggers, both inputs to D will be high, resulting in a high output at pin 9.

The high dc output (1.3 V) at pin 9 is applied to inverter C and a ground is produced at pin 11 to maintain a positive level at input number one (1) of gate D. Gate D will now remain activated for the duration of Tone B. The dc output is applied to the astable and tone oscillator circuits in the two-tone decoder module. The astable is activated, and a ground is alternately applied for 180 ms and removed for 80 ms at pin 7. This signal is inverted through inverter G and a recurrent positive pulse is applied at gate H. Gate H produces an output when a positive level is present at both inputs. The output of gate H activates the tone oscillator. Therefore, the tone oscillator is alternately turned on for 180 ms, and off for 80 ms as input number two (2) of gate H shifts in response to the astable output. A pulsating alert tone is produced. Input number one (1) of gate H remains at a constant level due to the dc output of gate D. When Tone B ends, the threshold detector output switches from a ground, and C2 begins charging to the supply level. After about 0.5 sec, this produces a low level at the output of inverter E and a low level at input number two (2) of Gate D. Gate D deactivates at this time, and the dc output is removed from pin 9.

b. Switching Stages

Transistors Q3 through Q8 receive the decoder outputs for controlling the receiver squelch circuits and for alert tone application.

When the decoder is activated by a tone filter, the high output at pin 9 turns on Q6 and Q8. With Q6 saturated, point I15 is at ground, which is applied to pin 4 of U8 and unsquelches the audio amplifier in U8. Transistor Q8 turns on Q7 which turns on Q3, Q4, and Q5. When Q7 conducts, diode CR2 is forward biased and a positive dc level is applied to interconnect point 16 which turns off the squelch switch circuits in U7 (via pin 5). When Q5 is turned on, the ground at I14 clamps pins 2 and 8 of the audio filter in U7, preventing the demodulated tone B output of the discriminator from reaching the speaker while the alert tone is being generated.

The alert tone from pin 4 of the decoder is amplified by enabled Q3 and Q4 and appears at interconnect point I13. The tone is applied to the receiver volume control and amplified by the audio amplifier in U8 (which is unsquelched by the ground at I15).

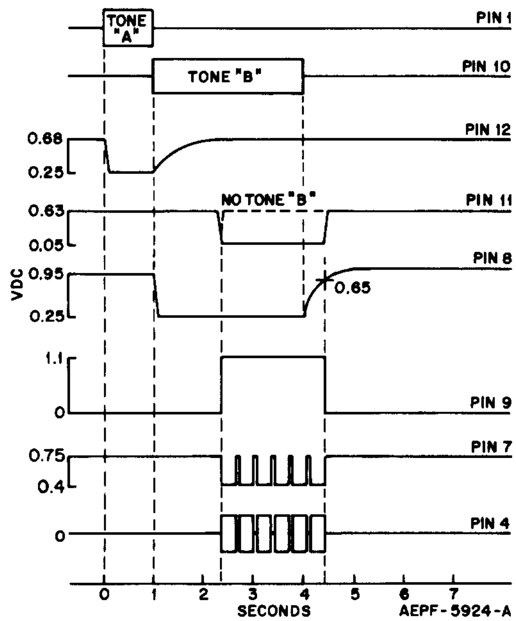


Figure 38. Decoder Module Timing Diagram

Shortly after tone B ends, the alert tone is turned off. Pin 9 of the decoder switches to a low voltage and turns off Q3 through Q8. The radio now operates in the carrier squelch mode since grounds are removed from I14, I15, and I16. The receiver remains in this mode until reset by momentarily operating the monitor-reset switch on the radio.

c. Group Call Circuits

The group call detector module (U4) is installed when the radio includes this option in the selective call circuit.

When the optional group call module is used, decoder logic is modified to provide a response in the normal manner or when only tone B is transmitted for eight seconds. Tone B produces a ground at pin 8 and through inverter E; a positive output is produced and routed to gate D, input 2. This positive level has no effect since input 1 of gate D is not positive at this time.

This ground at pin 8 of the two-tone detector module is routed directly to the group call module, U4. If this ground is present more than five seconds, the group call module applies a ground potential to pin 11 of the two-tone detector module. This results in a high output from inverter B to turn on gate D which provides the necessary dc output. At the same time, the group call module applies a ground to pin 7 (astable clamp) and a

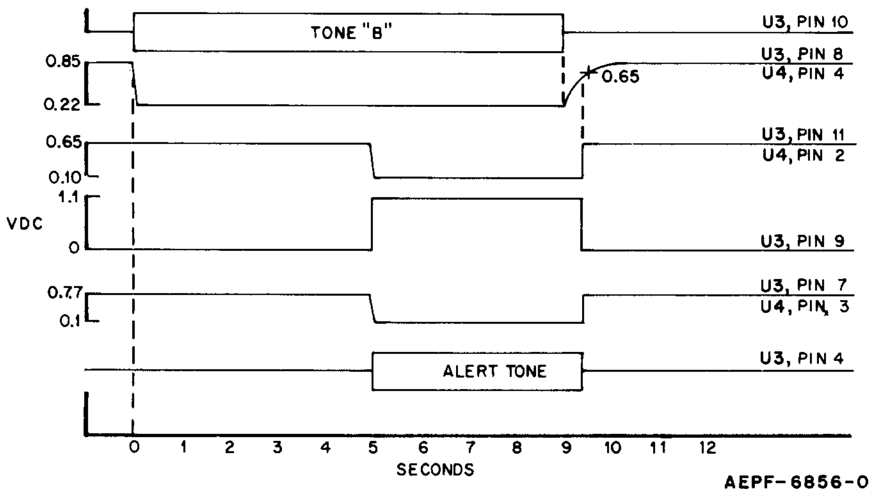


Figure 39. Group Call Signal Timing Diagram

steady high output is applied to input 2 of gate H. This input, along with the dc output of gate D, turns on gate H, and a steady alert tone is produced by the oscillator. This steady alert tone continues for the duration of tone B (approximately 2.5 seconds). When tone B ends, the low inputs (ground) at pins 7 and 11 are removed, and the decoder turns off.

26. UNIT ID RADIOS

a. Detailed Circuit Description

Refer to the schematic diagram in the Unit ID Service Supplement (68P81010C65). With the radio turned on, +4.6 V (F) is present on the ID mother board via interconnect point I12. This provides a general operating voltage (V_{DD}) for the ID circuits. The RC circuit consisting of R11 and C7 provides a delay before resetting the synthesizer logic (pin L, IC1), after power is first turned on. When the PTT switch in the radio is depressed, transmitter power (+7.5 V) is enabled which is connected to the mother board at I17. From pin 21 on the encoder board, this voltage is applied at pin I of IC1 to provide the encode-enable signal for the synthesizer chip. R1 and R2, combined with C1, provide a nominal false protection integration time of 100 milliseconds before the mic-mute flip-flop on IC1 is set. A high output (+4.6 V nominal) at pin D of IC1 then inhibits the mic input to the IDC circuit in the radio via summing input to the IDC circuit in the radio via summing resistor R15 and connection point I11. The level at pin D of IC1 is also integrated by R8 and C2 to provide the encoder turn-on delay (Resistor R8 is factory-selected to provide a nominal 400-millisecond delay for "Modat" or 400 milliseconds for ZVEI and CCIR). The turn-on delay, combined with the false protection integration time, is needed to allow for transmitter, PL, and repeater attack times etc., before the ID tones are transmitted. After the delay, a high level at pin G of IC1 enables the time-slot generator. The high level at pin D of IC1 also turns on transistor Q7 which then provides a ground output at pin 12 on the encoder board and interconnect point 19. This ground is applied to relay K101 or U11 in the radio to provide a latch for the PTT circuit.

The time-slot generator in IC1 generates sequential time-slot output pulses (TS1 through TS7) which are connected to the encoder board pins 14 through 20. This period of these outputs is set for the "Modat," ZVEI, or CCIR mode by proper selection of the value of resistor R10 (see Parts List). Resetting of the time-slot generator is controlled by jumper JU1 or JU2 depending on mode. For the "Modat" mode, JU1 is in the circuit which applies a ground level at pin BB of IC1. This has the effect of resetting the time-slot generator back to TS1 after TS7 has been generated. For the ZVEI and CCIR modes, JU2 is in the circuit instead of JU1 which applied +4.6 V to pin BB of IC1. With this condition, the time-slot generator is reset after TS5 is generated.

Unit ID Frequency Data

TONE CODE NUMBER	TONE FREQUENCY (Hz)			8-BIT FREQUENCY DATA																							
	"MODAT"	ZVEI	CCIR	"MODAT"								ZVEI								CCIR							
				D7	D6	D5	D4	D3	D2	D1	D0	D7	D6	D5	D4	D3	D2	D1	D0	D7	D6	D5	D4	D3	D2	D1	D0
0	637.5	2400	1981	L	L	H	H	H	H	H	L	H	H	L	L	H	H	L	L	H	H	L	L	L	L	L	L
1	787.5	1060	1124	L	H	H	L	L	L	H	L	H	L	L	L	H	L	H	H	H	L	L	H	L	L	L	L
2	937.5	1160	1197	L	H	H	H	H	L	H	H	H	L	L	H	L	H	L	H	H	L	L	H	L	H	H	H
3	1087.5	1270	1275	H	L	L	L	H	H	H	L	H	L	L	H	H	H	H	L	H	L	L	H	H	H	L	H
4	1237.5	1400	1358	H	L	L	H	H	L	H	H	H	L	H	L	L	H	H	H	H	L	H	L	L	L	H	H
5	1387.5	1530	1446	H	L	H	L	L	H	H	L	H	L	H	L	H	H	H	L	H	L	H	L	H	L	L	H
6	1537.5	1670	1540	H	L	H	L	H	H	H	H	H	L	H	H	L	H	L	H	H	L	H	L	H	H	H	L
7	1687.5	1830	1640	H	L	H	H	L	H	H	L	H	L	H	H	H	H	L	L	H	L	H	H	L	L	H	H
8	1837.5	2000	1747	H	L	H	H	H	H	L	L	H	H	L	L	L	L	L	H	H	L	H	H	H	L	L	L
9	1987.5	2200	1860	H	H	L	L	L	L	L	H	H	H	L	L	L	H	H	H	H	L	H	H	H	H	L	L
R	487.5	2600	2110	L	L	L	L	L	L	H	L	H	H	L	H	L	L	L	L	H	H	L	L	L	H	L	L

L = Low logic level (0 V)
H = High logic level (4.6 V)

Oscillator Reference Frequency = 246.65 kHz for "MODAT" and ZVEI
= 248.945 kHz for CCIR

As each time-slot output pulse is generated, it is applied to the code plug to select the 8-bit frequency data (D0 - D7) stored at each location. The code plug must be programmed for the proper mode of operation ("Modat," ZVEI, or CCIR, and for the particular 3-digit ID code assigned to the unit. The NLN8999A Programmed Code Plug is supplied for "Modat" systems, the NLN4360A Programmed Code Plug is supplied for ZVEI systems and the NLN4523A Programmed Code Plug is supplied for CCIR systems. The following table (Unit ID Frequency Data) gives the complete listing of the frequency values and the corresponding 8-bit readout from the code plug for the "Modat," ZVEI, and CCIR formats. The repeat tone (R) is used when two successive code digits are the same; e.g., an ID code of 225 would be encoded 2R5. The Motorola Type TEK-81 Unit ID Code Plug Verifier is available for checking the 8-bit pattern of the programmed code plug.

The 8-bit frequency data from the code plug (D0 - D7) is read out in parallel and fed to the programmable divider circuit on IC1 via pins 4 through 11 on the encoder board. The clock oscillator output from U1 is also fed to the programmable divider via choke coil L1 and pin K of IC1. The clock frequency of U1 is used to drive a programmable divide-by-256 and a divide-by-2 counter that comprise the overall divider. The 8-bit frequency data from the code plug is loaded into the divide-by-256 counter to preset it with a specific count, which is than counted down at the rate determined by the master clock frequency. The result of the counting process is to produce an output squarewave whose frequency is equal to the desired tone frequency for each time-slot. This final output frequency, from pin AA of IC1, is fed through summing resistor R16 to pin 13 on the encoder board, from where it is connected (via I11) to pin 5 of U101 (IDC module) in the radio. The ID tone output frequency is also connected to the base of emitter follower Q5 on the encoder board to enable the sidetone amplifier circuit. From the emitter of Q5, the signal is connected to the sidetone driver stage Q6 on the mother board. The collector output of Q6 is then coupled through C4 to the radio speaker, via connection point I19, to provide for monitoring of the ID tones.

b. Emergency Call Circuit Operation

Refer to the schematic diagram for the "Emergency Call" option in the Unit ID Service Supplement, and also to the emergency board timing diagram in the Troubleshooting section of the manual.

When the radio is first turned on, +4.6 V (F) is present on the ID/emergency mother board via interconnect point I12. This provides a general operating voltage (V_{DD}) for the ID/emergency circuitry and resets the logic circuits for initial activation. When the emergency switch (S303) is activated, +7.5 V (A) is applied to the emergency mother board via interconnect point I18, which sets a logic high level at pin 3 of the emergency control board. This starts emergency operation by setting flip-flops U5A, U5B, and U6A, while resetting U6B. With U5B set, its Q output (pin 13) goes high and turns on transistor Q1. The resulting saturation of Q1 grounds interconnect point I9, thereby simulating the actuation of the PTT switch on the radio; i.e., the +7.5 V (T) voltage is connected to the mother board at I17 to provide the encode-enable signal (high logic level) for the synthesizer chip (pin I of U3) on the encoder board.

From pin 8 on the emergency board, the $\overline{Q}$ output from U6B (flip-flop is in the reset state) turns on transistor Q8 which, in turn, holds Q6 off. With Q6 off, the sidetone output at pin 23 on the encoder board is defeated and the sidetone amplifier is inoperative for the duration of the emergency operation. The high level at pin 8 on the mother board is also connected to pin P of the synthesizer chip (U3) on the encoder board (via pin 3), which causes the encoder to transmit in the emergency mode; i.e., the emergency tone (tone 7) is automatically transmitted in time-slot 3 of the unit ID code pattern. For example, if the code plug is programmed for an ID code of 69$\underline{8}$R123 (where R is the repeat tone and 123 is the actual 3-digit ID code), the synthesizer will automatically change the code to 69$\underline{7}$R123 to implement the emergency mode transmission. The high present at pin P of the synthesizer accomplishes this by forcing divider input D3 low and D1 high during time-slot 3.

NOTE

For proper operation of the emergency mode, the code plug must be programmed for tone 8 in time-slot 3.

When time-slot 7 of emergency message A goes high, this level is fed back to the emergency board (via pin 4) to turn on transistor Q2 and thereby pull pin 21 of the encoder board low. When time-slot 7 goes low, Q2 turns off and the voltage at pin 21 charges up through R1, C1 and the associated circuitry connected to pin 6 of the emergency board. The integration time for this action is nominally about 60 milliseconds. The negative-going edge of time-slot 7 coincides with the positive-going edge of time-slot 1 which resets U5B via the one-shot circuit consisting of R27 and C18. The discharge time constant of circuit elements R29 and C17 then holds transistor Q1 fully on (saturated), overlapping the maximum time required to initiate message B of the emergency sequence. In this way the sequence is transmitted as a pair of tone bursts every five seconds. If the emergency switch (S303) is held in the emergency position, the sequence is repeated continuously until the switch is released. After release of the switch, two final messages (A and B) are transmitted.

Circuit element U4 is a 24-stage frequency divider that is used as the basic timer for the sequence. The circuit is operated in the RC oscillator mode at a frequency of about 105 kHz. Each flip-flop in the divider chain causes the frequency to be divided by 2 so that the output available at pin 10 of U4 is equivalent to a frequency division of 2^{18}. The divider (counter) advances on a negative-going edge so that when 2^{18} goes low, 2^{19} goes high. The 2^{19} output (pin 11) is connected to the data (D) input, while the 2^{18} output (pin 10) is connected to the clock (C) input of U5B. The Q output of U5B then goes high every five seconds, pulling the collector of transistor Q1 low and the +7.5 V (T) line high at interconnect point I17. The clock input of U5A is pulsed each time an emergency sequence is transmitted. On the sixth sequence, the 2^{22} output of U4 (pin 14) is at a logic high level. This causes the Q output of U5A to go high, resetting U4.

If the PTT switch on the radio is depressed and held while the emergency tones are being transmitted, capacitor C13 starts to charge through R32 after the collector of Q1 goes high. When flip-flop U6B is clocked, its Q output goes high while its $\overline{Q}$ output goes low. This provides a pulse to the one-shot circuit. (R9 and C20) at the base of transistor Q9 which pulls the encode-enable signal at pin 21 on the encoder board low and then back high, allowing the transmission of an ID message with sidetones. If the PTT switch is depressed when the radio is in the receive mode, a one-shot circuit consisting of C24 and R38 clocks U6B, The high Q output from U6B then resets U4 and the emergency operation is disabled. Depressing the emergency switch at any time restarts the operation.

DISASSEMBLY

1. GENERAL

For most servicing, only the front and rear covers need to be removed. This provides access to both sides of the main circuit board and the modules on the board may be replaced without further disassembly. Turn the radio off and remove battery before disassembly and before reassembly.

2. PROCEDURE

a. Loosen the four captive screws on the back cover until the back cover is free.

b. Remove the back cover. There is a captive washer on each screw. Do not remove or lose the washers. They protect the cover against excessive pressure from the front cover studs.

c. Carefully lift the front cover away from the frame.

d. Unplug the front cover assembly if necessary.

e. When reassembling the radio, use care to replace the front cover, insuring that the cover is reconnected and the speaker/microphone cable is fitted into place with the clip placed on the transmit audio module. Slide it straight into the frame. Be sure the pad is in place around the speaker.

f. Tighten covers per the torque specifications listed in the Torque Specifications table.

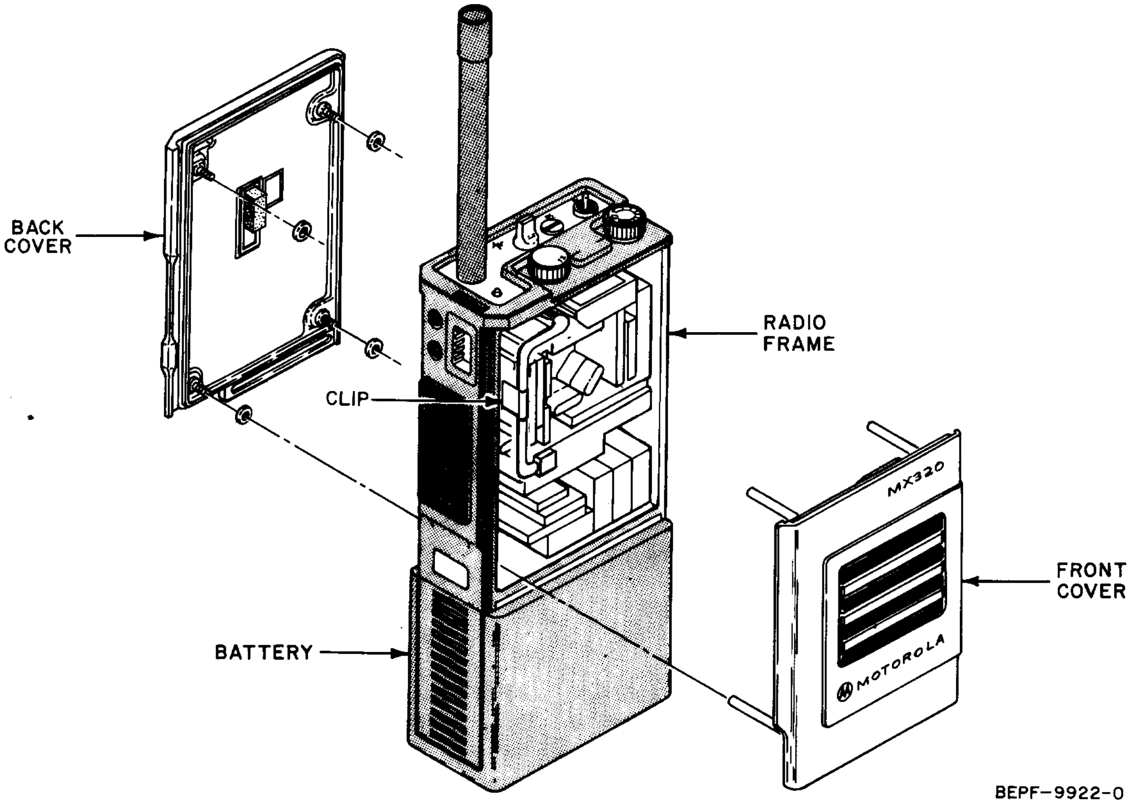


Figure 40. Front and Back Cover Disassembly

Torque Specifications Using Driver RSX-4043A

USE BIT NUMBER	APPLICATION	TORQUE (In Lbs.)
6680342A63	All Top Control Mounting Nuts	3.0
6680342A68	Back Cover Mounting Screws	4.0
	PTT Switch Mounting Screws	2.0
	Battery Contacts Mounting Screws	4.5
	Base Plate Mounting Screws	2.0
	Microphone Mounting Screws	2.0
	Speaker Bracket Mounting Screws	4.0
6680342A64	Preselector Mounting Nuts (Vhf/Uhf)	2.0
6680342A65	Fuse Cap	2.0
6680342A67	Front Cover Posts	4.0
6680342A61	Antenna Bushing Nut, Top	8.0
6680342A62	RF Jack Side Nut	4.0
6680342A66	Antenna Connector Bushing (800 MHz)	4.0

NOTE: RSX-4044A is the torque screwdriver with the bit set.
RSX-4043A is the torque screwdriver.

3. REMOVING THE MAIN CIRCUIT BOARD FROM THE HOUSING

Most servicing, all module replacement, and all alignment can be performed by simply removing the covers as explained in the previous paragraph. Proceed as follows when necessary to remove the main circuit board from the housing to obtain access to the flexible circuits or controls.

a. Remove the front and back covers as previously explained.

b. Unsolder the B+ and B- leads at the top of the main circuit board. These leads are soldered to pins on the back side of the board.

c. Unsolder the wires (vhf and uhf) or coaxial cable (800 MHz) connecting the antenna jack to the main circuit board in two places.

d. Unsolder ground wire at the bottom of main circuit board (some models).

e. Unsolder three wires from the top of the main circuit board (800 MHz radios with option H560).

f. For convenience, remove module U104 (vhf and uhf).

g. Place the radio on the bench (modules up) and with the operating controls away from you.

h. Pick up the radio with one hand on each side of the housing (near the center of each side) and with the thumbs pressing against the preselector on the main circuit board.

CAUTION

When the board and module assembly is released from the housing, it is still attached to the control flex circuit and may damage the flex circuit if the weight is not supported. Hold the radio close to the bench or other surface as instructed in the following step. Remove the heavy modules from the board to reduce the weight.

i. Hold the radio in a horizontal position about one inch above the bench or table and gently pull the sides of the housing apart while gently pressing on the preselector with the thumbs. When the sides have been flexed far enough, the board will clear the retaining notches on the sides of the housing.

j. Carefully unfold the main circuit board while supporting its weight with one hand. The board will still be attached to the control flexible circuit and the multi-freq flexible circuit (if applicable).

4. REMOVING THE CONTROL FLEX CIRCUIT

Do not remove the control flex circuit from the housing unless a defective part or control requires replacement. If necessary, refer to the repair and replacement procedures in a later section of this manual.

5. REMOVING THE POWER FLEX CIRCUIT

Refer to the exploded view in the applicable service manual and proceed as follows.

a. Remove the battery and the front and back covers from the radio.

b. Unscrew the fuse cap and remove the fuse.

c. Remove the two battery contacts, held by screws in the bottom of the radio.

d. Remove modules at the top of the radio to provide access to the volume control.

e. Remove modules at the bottom to provide clearance for removing the flex circuit.

NOTE

In radios with optional boards at the bottom, it may be necessary to carefully remove the main circuit board before removing the flex circuit.

f. Carefully unsolder the flex circuit from the volume control contacts.

g. Unsolder the red (B+) and the black (B-) wires from the main circuit board.

h. Using the module pusher tool, carefully push each fuse clip out by pushing on them from the bottom of the radio.

i. The flex circuit is now held only by tape to the side of the housing and can be peeled loose.

NOTE

If the fuse clips must be replaced, refer to the repair and replacement procedures in a later section of this manual.

j. Reverse the above procedure to replace the power flex circuit. If a new flex circuit is being installed, bend it in three places using the old flex circuit as a guide.

6. OPTIONAL SELECTIVE CALL CIRCUIT BOARDS

The top circuit board may be removed from the bottom board when necessary to service the circuit.

a. Remove the two spanner nuts and lockwashers that attach the top board to the bottom board.

b. Using the module pusher tool supplied with the radio, push the two spacer posts through the bottom board and carefully separate the two boards.

7. OPTIONAL UNIT ID CIRCUIT

To gain access to the unit ID circuits, remove the metal shield by its handle. Guide pins are provided on the encoder and each end of the code plug housing. To avoid damaging these modules, use the standard ST-1179 Module Pusher when removing them.

TEST EQUIPMENT AND SERVICE AIDS

1. GENERAL

This section describes all the test equipment and service aids required for maintaining the MX300 Series "Handie-Talkie" portable radios. See your Motorola sales representative for aid in ordering test equipment. He will analyze your requirements and help you select the latest available equipment to suit your individual needs. He can also advise you of new test equipment and service aids that become available after the printing of this manual.

2. TEST EQUIPMENT

Refer to the list of test equipment. Battery operated test equipment is recommended when available. The listed items or equivalents may be used.

Test Equipment Table

MOTOROLA MODEL NO.	NAME	CHARACTERISTICS	APPLICATION
R-2001 or R-1200 (X option req'd for 800 MHz radios)	Service Monitor	--- X option for high stability	Signal generator and frequency/deviation meter for wide-range troubleshooting and alignment
S-1347 or S-1348	DC Power Supply	0-20 Vdc, 0-5 Amps, Current limited	Bench supply for 7.5 Vdc
S-1053	Solid-State AC Voltmeter	1 mV - 300 V, 10 meg-ohm input impedance	Audio voltage measurements
S-1063	Solid-State DC Multimeter	100 mV min. full scale, 1 uA - 300 mA, 11 megohms input resistance, 0.2 ohm - 50 megohm resistance	DC voltage, current, and resistance measurements
SLN-6055 with SLN-6083 termination	RF Probe	0.3 to 10 volts full scale, 10 MHz to 400 MHz	Plugs into S-1063 DC Multimeter for making rf measurements
or S-1339	RF Millivoltmeter	100 uV to 3 V rf 10 kHz to 1.2 GHz	
R-1004	Dual-Trace Oscilloscope	10 MHz bandwidth, 10 mV/cm	Waveform measurements
SLN-6413	Digital Encoder/Decoder	---	For servicing "Digital Private-Line" circuit
T-1013	Dummy rf load	0 - 1,000 MHz, 300 W	Transmitter power output measurements
S-1067	Audio oscillator	67 to 1161.4 Hz tones	For servicing audio circuit and tone "Private-Line" circuit
S-1333	Digital tone generator	---	For testing selective call radios
RTX-4005 RTK-4021	Portable Test Set and Test Cable	---	Enables convenient connection to the accessory jack, with switching function for complete testing of radio
RSX-4044	Torque screwdriver with bit set	---	For reassembly of radio to factory torque specifications
S-1350	Wattmeter	50 ohm, ±5 % accuracy	Transmitter power output measurements
ST-1213	Wattmeter plug-in element	100 - 250 MHz, 10 W	Transmitter power output measurements
ST-1223	Wattmeter plug-in element	200 - 550 MHz, 10 W	Transmitter power output measurements
ST-1231	Wattmeter plug-in element	500 - 1000 MHz, 2.5 W	Transmitter power output measurements

Special Service Aids

ITEM	FUNCTION
ST-1175 Dummy Battery Block	Interconnects radio to bench 7.5 V power supply.
ST-1176 Battery Charger Tester	Permits rapidly checking the significant charger parameters.
ST-1177 Battery Tester	Checking the MX300 series radio batteries.
ST-1178 Microphone Tester Adapter	Permits connecting the NMN6070 or NMN6071 external speaker-microphone to the ST-855 microphone tester.
ST-1179 Module Pusher	To push module guide pins for easy extraction without damage.
ST-1180 RF Jack Wrench/Preselector Spanner Wrench (Vhf and Uhf models)	To remove the antenna jack and the nuts securing the preselector to the printed circuit board.
ST-1181 Tuning Tool Kit	To tune the preselector and the channel elements.

3. SPECIAL SERVICE AIDS

Several service aids have been designed especially for servicing the MX300 series radios. These aids are available from the Motorola Communications Division Parts Department. Refer to the preceding table.

4. ST-1175 DUMMY BATTERY BLOCK

The ST-1175 Dummy Battery Block attaches to the radio like a battery, but contains a cable for connecting to an external 7.5-volt power supply. An overvoltage protection circuit is built into the ST-1175 for protecting the radio if greater than 9.0 volts is applied from the external power supply. The battery block is also internally fused at about 4 amps to protect the radio. A current limiting power supply is recommended, set at 4 amperes maximum.

Remote sensing leads are provided for external power supplies capable of remote voltage sensing, such as the model S-1348. Remote sensing will compensate for any voltage drop between the external power supply and the radio.

5. RTK-4021 TEST CABLE

This cable contains a connector that mates with the antenna side jack on the radio. The cable is designed to interconnect the radio with 50-ohm rf test equipment such as a wattmeter or signal generator, with the BNC connector on the cable. This cable has about 0.13 dB loss with vhf signals. With uhf and 800 MHz signals, the loss is 0.50 dB.

6. RTX-4005 PORTABLE TEST SET

The MX300 series radios have an accessory connector on the side of the housing. This connector contains several inputs and outputs to the IDC circuit, an external push-to-talk contact for keying the transmitter, the receiver discriminator output, and audio inputs and outputs to the final audio amplifier. The RTX-4005 Test Set attaches to the accessory connector and permits injecting inputs of monitoring outputs to troubleshoot the radio. The test provides a convenient place to attach other test equipment and allows the technician to perform the following basic service operations.

a. Key the transmitter; either momentarily or continuously.

b. Modulate the transmitter; via an external audio oscillator for setting and measuring transmitter deviation.

c. Measure the modulation input voltage; to adjust transmitter deviation and measure modulation sensitivity.

d. Measure the internal microphone output; to check the microphone.

e. Measure receiver audio output; for aligning the receiver, checking receiver sensitivity, and measuring rated audio output. The test set contains an isolation transformer for properly connecting to the balanced audio output.

f. Measure discriminator ac voltage; for troubleshooting.

g. Measure discriminator dc voltage.

h. Measure ac output from the audio filter and regulator module U7.

i. Inject audio into audio power amplifier module U8 for troubleshooting.

7. ADDITIONAL TEST EQUIPMENT FOR RADIOS WITH OPTIONS

a. Selective Call Radios

In addition to the test equipment required to service the radio, a tone generator and active filter tester are needed for servicing the selective call circuits.

EQUIPMENT		FUNCTION
MODEL	NAME	
TEK-34 or R-1100	Tone Generator	Uses "Vibrasender" reeds to generate paging tones.
	Audio Synthesizer	Generates all two-tone paging codes automatically.
TEK-61	Active Filter Tester	Permits checking band-pass frequency, insertion loss or gain of active tone filters. (Requires R-1100 and ac voltmeter.)

b. Unit ID Radios

In addition to the test equipment listed in the test equipment table, the following equipment (or their equivalents) are recommended for servicing the ID circuits.

MODEL	NAME	FUNCTION
0180300A84	Extender Board	Facilitates mounting of Unit ID board.
TEK-81	Code Verifier	Used to check Unit ID code number.
TEK-83	Sequencer	Generates Unit ID code numbers.

c. "Digital Private-Line" Radios

The following items are recommended for servicing "Digital Private-Line" radios.

MODEL	NAME	FUNCTION
SLN-6413	Test Set	Used to test DPL radios.
TEKA-106	PTT Delay Option	Used with SLN-6413 for checking turn-off code.

USING THE RTX-4005 PORTABLE TEST SET

1. RECEIVER ALIGNMENT APPLICATIONS

a. Connect the test set to the accessory connector on the side of the radio.

b. Connect an ac voltmeter to the audio out and dc metering jack on the test set.

c. Set the test set controls as follows:

(1) Meter Selector - Any position

(2) Spkr/Load Switch - Either position

(3) MT/MX Switch - MX position

(4) PTT Switch - Unkeyed center position

(5) MT PL Switch - Off

d. The receiver audio output is now connected to the ac voltmeter through an isolation transformer. This provides a convenient method of making quieting checks and adjustments. Refer to the alignment procedure in the applicable service supplement for your radio.

2. TYPICAL PERFORMANCE CHECKS

Several circuits in the radio can be quickly checked for overall performance using the test set. The following table lists several checks that will quickly isolate faulty performance to a functional circuit.

a. Connect the test set to the accessory connector on the side of the radio.

b. Connect an ac voltmeter or audio oscillator to the test set as instructed in the chart. A wattmeter or dummy load should be connected at the antenna jack on the radio when checking transmitter operation.

c. Refer to the other colums for test set control settings and interpretation.

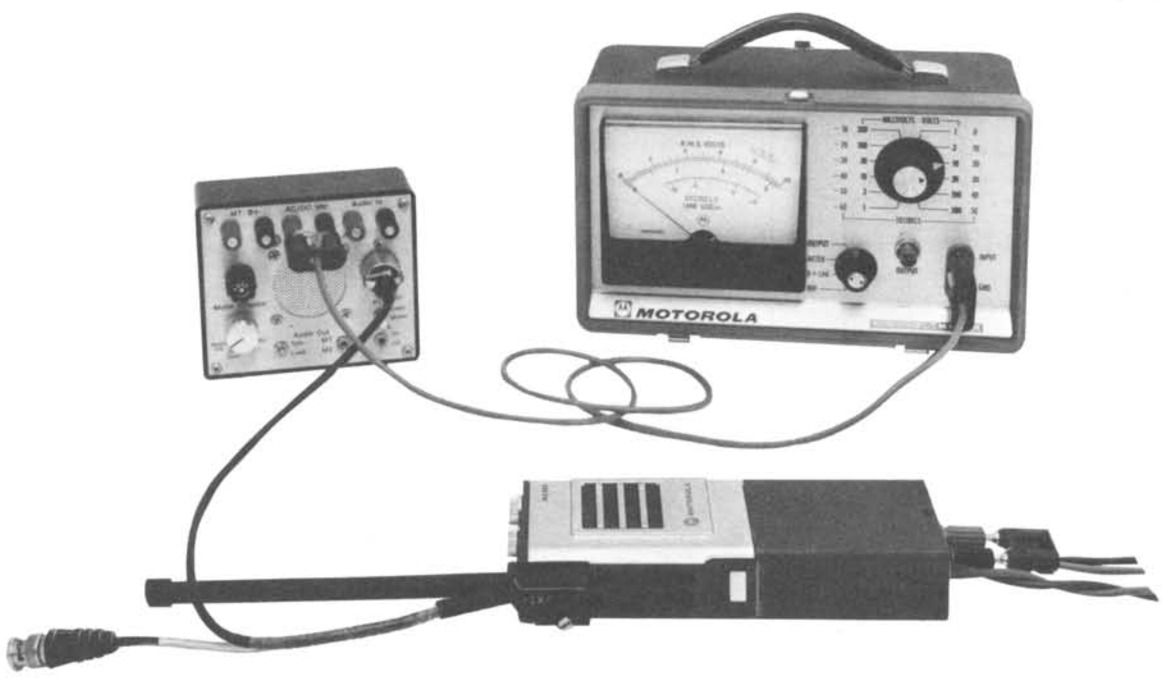


Figure 41. Using the RTX-4005 Test Set

Typical Performance Checks Chart

FUNCTION BEING CHECKED	TEST SET CONTROL SETTING								COMMENTS
	MT B+	AC/DC MTR	AUDIO IN	METER SELECTOR	SPKR LOAD	MT MX	MT PL	PTT	
Receiver Alignment	Not Used	To ac voltmeter	Not Used	AUDIO PA	Any	MX	Not Used	Center	Receiver audio output measured on ac voltmeter. Adjust for best quieting.
Receiver Sensitivity	Not Used	To ac voltmeter or SINAD meter	Not Used	AUDIO PA	Any	MX	Not Used	Center	Receiver audio output measured on ac voltmeter. Check for 20 dB quieting or 12 dB SINAD.
Receiver Audio Output	Not Used	To ac voltmeter	Not Used	AUDIO PA	Any	MX	Not Used	Center	Apply 100 uV on-frequency carrier modulated with 1000 Hz tone @ ±5 kHz deviation to the radio. Set VOLUME control to maximum. The ac voltmeter should indicate no less than 3.74 Vac.
Transmitter Frequency and Power Output	Not Used	Not Used	Not Used	Any	Any	MX	Not Used	CONT or MOMT	Makes it possible to key transmitter for test purposes.
Transmitter Deviation Adjustment	Not Used	To ac voltmeter	Audio Oscillator at 1000 Hz and 25 mV	MIC	Any	MX	Not Used	CONT or MOMT	Adjust IDC for ±5 kHz deviation.
Transmitter Modulation Sensitivity	Not Used	To ac voltmeter	Audio Oscillator at 1000 Hz and 3.5 mV	MIC	Any	MX	Not Used	CONT or MOMT	With PL tone filter removed, deviation should be no less than ±3 kHz.
Discriminator Output Measurement	Not Used	To ac voltmeter and then to a dc voltmeter	Not Used	DISC	Any	MX	Not Used	Center	ACVM should indicate 250 to 400 mV of noise (audible from speaker) or recovered audio if 100 uV carrier frequency is applied with a 1000 Hz tone @ ±5 kHz deviation. The dc voltmeter should indicate 1.2 to 1.8 Vdc with no carrier applied.
Audio Filter and Regulator Module U7 Output Check	Not Used	To ac voltmeter	Not Used	VOL	Any	MX	Not Used	Center	Apply a 100 uV on-frequency carrier modulated with 1000 Hz tone @ ±3 kHz. The ac voltmeter should indicate more than 62 mV.
To Inject Audio into Audio Power Amplifier	Not Used	To ac voltmeter	Audio Oscillator at 1000 Hz and 325 mV	VOL	Any	MX	Not Used	Center	Adjust audio input to 325 mV. Set VOLUME to maximum. The ac voltmeter should indicate 3.74 Vac minimum.
Microphone Output Measurement	Not Used	To ac voltmeter	Not Used	MIC	Any	MX	Not Used	Center	Key transmitter with PTT switch on *radio*. AC voltmeter measures microphone output. A loud whistle or "four" into microphone should cause a meter indication of 25 mV minimum.

TROUBLESHOOTING

1. GENERAL

The MX300 series radios are designed for high reliability and for rapid service when trouble does occur. The best troubleshooting aid is a thorough understanding of the radio and the function of each module. The plug-in modular construction eliminates the laborious, time consuming, troubleshooting procedures previously required to find a defect. Since the plug-in modules can be rapidly replaced the following procedures are provided to help quickly isolate troubles to a defective stage.

2. ACCESSORY CONNECTOR J401

The accessory connector pins provide several signal outputs and also provide points for injecting signals. The Motorola RTX-4005 Portable Test Set uses this capability for rapid troubleshooting. Refer to the accessory connector troubleshooting diagram for information on each pin of the connector.

3. PRESELECTOR TROUBLESHOOTING

Refer to the troubleshooting diagram of the preselector circuit.

A change in the dc voltage at test point M2 in both uhf and vhf preselectors is an indication of injection. The dc voltage reading at M2 should decrease by approximately 0.25 Vdc when the channel element output is shorted to ground using a .001 uF capacitor.

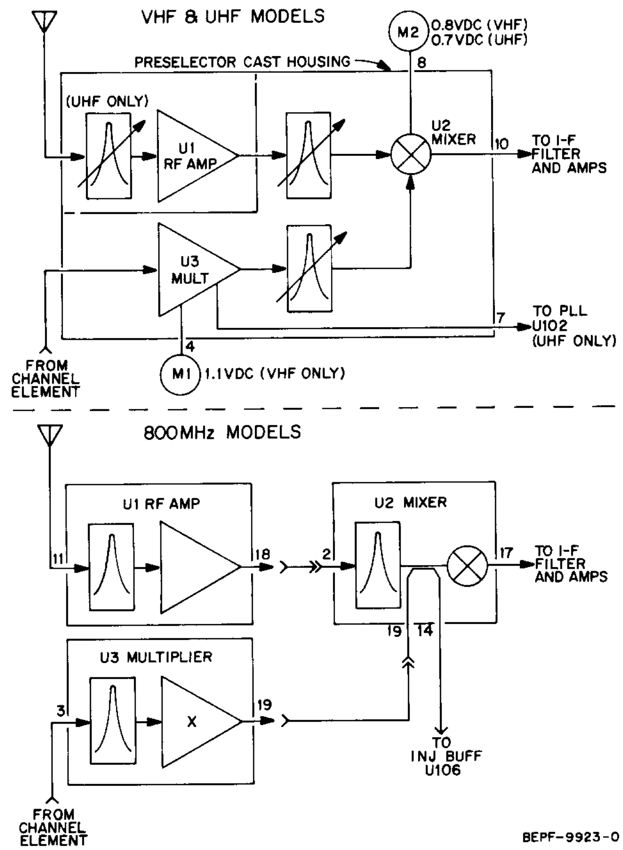


Figure 43. Preselector Troubleshooting Circuit Diagram

The vhf receiver injection frequency can be checked at M1 to insure multiplier operation. Use a high impedance probe or capacitively couple the probe. A dc probe must be 1 k ohm or greater. The uhf receiver injection frequency can be monitored at pin 7 of the preselector to insure multi-

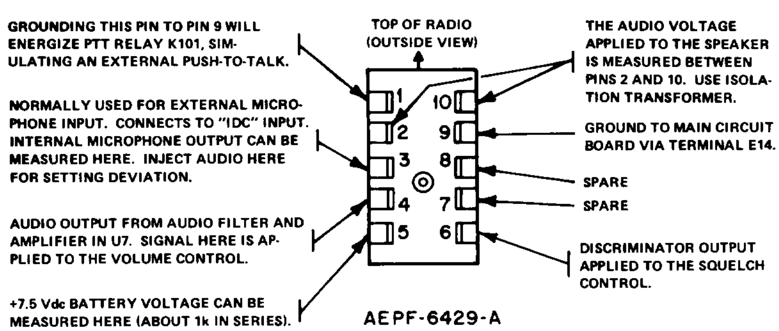


Figure 42. Accessory Connector Troubleshooting Diagram

plier operation. The frequency out of the uhf and vhf multipliers is 21.4 MHz below carrier frequency. In vhf radios, a properly operating preselector will read a peak dc voltage of 1.1 Vdc minimum at M1 (1.29 V for 136-150.8 MHz receivers) and a peak dc voltage of about 0.8 V at M2. In uhf radios, a properly operating preselector will read a peak dc voltage of about 0.7 Vdc at M2.

The preselector in 800 MHz radios is comprised of three individual plug-in modules, rather than a cast housing containing circuitry as in vhf and uhf radios. The filters in the plug-in modules have no adjustments and there are no test points. The receiver injection frequency can be monitored at U3 pin 19, but if further confirmation of proper multiplier operation is desired, press the PTT switch for transmit mode. If the transmitter locks to a carrier frequency, the multiplier performance can be assumed adequate. To resolve a sensitivity problem, U1 and then U2 modules must be substituted with known good modules.

4. RECEIVER I-F AND AUDIO CIRCUIT

The i-f circuit consists of modules U4, U5, and crystal filters FL1 through FL5. The idealized gain of U4 and U5 combined is over 135 dB. Because of this high gain, the possibility of oscillation exists when test equipment is connected to pins on the modules. With a 21.4 MHz i-f input signal present, and with oscillation occurring, you cannot tell which signal is being measured. This can lead you to believe that the input signal is being amplified when, in fact, you are measuring the self-sustained oscillation caused by connecting the test equipment. To avoid this condition, remove module U5 when making measurements around U4.

Making rf measurements at U4 is affected by other factors. The crystal filters present a source impedance to U4 of about 1 k ohms at the i-f frequency of 21.4 MHz. The input capacitance of your test equipment (if larger than 10 pF) will present some reactance at 21.4 MHz and load the circuit enough to cause erroneous readings - in addition to possible oscillation.

If trouble is suspected in U4 or U5, replace the suspected module with a known good module. If new modules do not solve the problem, replace the crystal filters.

NOTE

Crystal filters FL1/FL2 and FL3/FL4 are matched pairs. Refer to your radio parts list and always replace both filters as a pair. Observe the color dot marking orientation indicated on the circuit board layout of applicable service supplement.

Receiver noise levels are a valuable troubleshooting aid. These noise levels will change should a problem occur in the receiver. By knowing the normal and abnormal levels at key points in the receiver, you can quickly isolate a receiver problem.

The following chart lists the normal and abnormal noise levels at both the discriminator output (pin 6 of J402) and audio output (to the speaker). The readings are taken with a standard ac voltmeter connected to the RTX-4005 Test Set.

The chart does not cover all possible failure modes; however, it will aid in troubleshooting most receiver problems.

Typical I-F and Audio Circuit Voltages

CONDITION	VOLTAGE MEASUREMENT	
	DISCR OUTPUT PIN 6 OF J402	AUDIO OUTPUT USING TEST SET (Vol Control to max)
Normal	250-400 mV ac	4.5 V ac
U4 failed	10- 40 mV ac	150-300 mV ac
U5 failed	less than 10 mV ac	less than 10 mV ac
U6 failed	less than 10 mV ac	less than 10 mV ac
U7 failed	250-400 mV ac	0 V
U8 failed	250-400 mV ac	0 V

5. CARRIER AND TONE "PRIVATE-LINE" SQUELCH CIRCUITS

Refer to the squelch circuit troubleshooting diagram.

a. Carrier Squelch

NOTE

Noise voltages are obtained with no rf signal to the receiver.

Approximately 30 mV of noise is required at pin 6 of U9, the squelch module, for squelch action. With the proper input to U9, the output should be 4 Vdc, turning off the audio stages. The dc voltage reading at pin 4 of U9 should also change from 0 Vdc to 4 Vdc as the squelch control is rotated clockwise. If the discriminator output is 250-400 mV ac and the above change does not occur, replace U9.

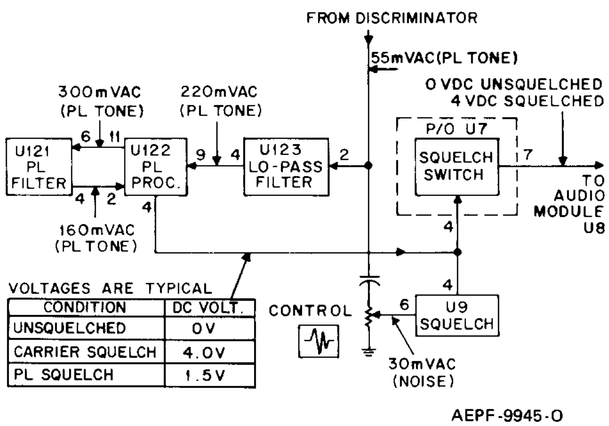


Figure 44. Squelch Circuit Troubleshooting Diagram

b. <u>"Private-Line" Squelch</u>

NOTE

"Private-Line" voltages referenced are minimum values obtained with a 100 uV rf input signal with PL encoded modulation.

For tone "Private-Line" circuit troubleshooting, refer to the diagram for mimimum tone levels. The dc voltage output at pin 4 of U122, the PL processor module, controls audio turn-off in the same manner as the noise squelch circuit. The dc voltage reading at pin 4 of U122 will also change from 0 Vdc to 1.5 Vdc as the PL is switched on.

Due to module design, the dc output of U122 is 1.5 Vdc and the dc output of U9 is 4 Vdc. Because either one of these outputs can control the squelch switch circuit, a dc voltage reading at pin 4 of U7, the first audio module, will be either 1.5 Vdc or 4 Vdc when the radio is squelched. The squelch module U9 can maintain 4 Vdc at U7 pin 4 if a noisy signal is present at the discriminator (even if the PL circuitry has decoded and switched). To test PL circuitry a strong rf signal (100 uV) should be used and the squelch control should be set to off.

6. "DIGITAL PRIVATE-LINE" SQUELCH CIRCUIT

a. <u>General</u>

When a decoding problem is suspected, first turn off the "Private-Line" and check the receiver quieting to be sure the receiver rf circuits are working normally. Inspect the flexible circuit connections and measure the B+ voltage and ground connections to each module.

b. <u>Processor Oscillator</u>

The regulated +5.2 volts at pin 11 of U133 provides power to the processor. Measure this voltage before proceeding.

In the receive mode, the output of the processor (U132, pin 12) should be a symmetrical, 134.4 ±1 Hz, 5 volts peak-to-peak square-wave. A distorted or off-frequency signal indicates a defective processor module.

c. <u>Encode Filter</u>

The encode filter module (U131) attenuates the processor output signal. The signal at U131 pin 1 is a 5-volt squarewave coupled from U132 pin 12. The encode filter output (U131 pin 2) is typically 1 ±0.05 volts peak-to-peak. The output waveform may resemble a sinewave. Pin 5 (used in 800 MHz radios only) should be an inverted pin 2 waveform.

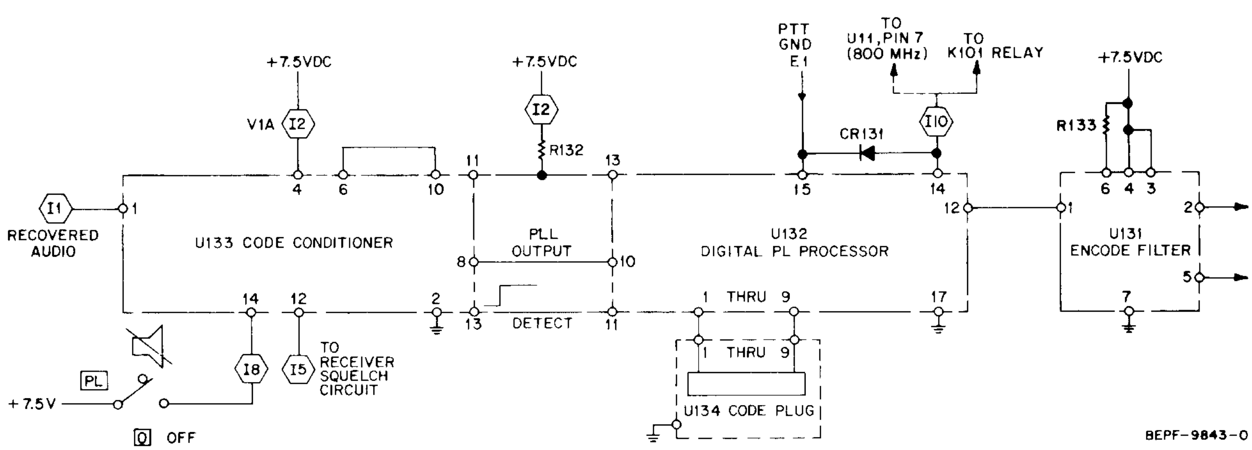


Figure 45. "Digital Private-Line" Circuit Troubleshooting Diagram

d. Receiver Squelch Output

Measure the voltage at pin 12 of U133. Pin 12 will be low (less than 1 volt) when either U133 pin 13 is high (5 volts) or when the PL switch is in the 0 (off) position, applying +7.5 volts to U133 pin 14.

e. Decode Function Check

Connect the test equipment to the radio as illustrated in the test setup diagram. Modulate the carrier with 134.4 Hz from the digital encoder/decoder and adjust the service monitor for ±1 kHz deviation.

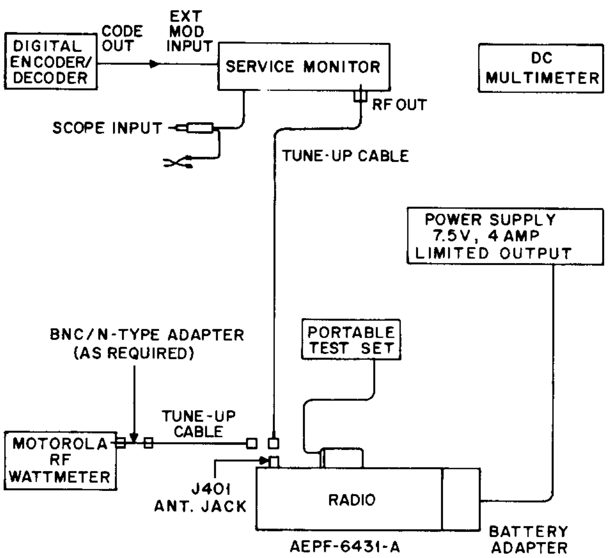


Figure 46. Digital PL Test Setup Diagram

NOTE

The basic S-1327 Service Monitors require modification for servicing Digital PL circuits. The R-1200 or basic S-1327 models are useable without modification. All the SLN6350 Deviation Meter and SLN6351 Oscilloscope plug-ins also require modification. Check with your Communications Group Parts Department representative for further information.

Be certain that the "invert" switch on the digital encoder/decoder is in the proper position to maintain compatible logic convention between the radio and the test equipment.

DPL Code Box Mode Switch Table

CARRIER FREQ (MHz)	MODE
130 - 140	Invert
140 - 180	Normal
400 - 420	Invert
420 - 450	Normal
450 - 470	Invert
470 - 520	Normal
806 - 860	Normal

Use the service monitor oscilloscope to trace the demodulated signal through the code conditioner (U133) and processor (U132) modules. A symmetrical 135 Hz squarewave should be present at U133 pins 6, 7, 10, and 8; and at U132 pin 10. A defective code conditioner module will be evident if the signal at U133 pin 8 drifts in frequency or varies in pulse width, pulse shape, or in amplitude. (The service monitor oscilloscope indication of frequency drift or pulse width variation may be the inability to maintain a stable sync display.)

Monitor the detect signal at U133, pin 13, while applying a modulated code from the digital encoder/decoder. The detect signal should be high (5 volts). If the detect signal is high, but the output at U133, pin 12, remains high (squelched) replace the code conditioner module. If a detect signal is not present, use the digital encoder/decoder to check the code plug module as described in the associated equipment manual.

f. Code Plug Module

Remove power from the radio and extract the code plug module. Apply power to the radio and use a Motorola S-1063 DC Multimeter to measure the voltage at the code plug sockets. Pins 1 through 9 should be 5 volts; pin 10 is ground.

The pins of the code plug are either a high voltage level (logic 1) or a low voltage level (logic 0), depending upon the code. To determine if the code plug is good, measure the dc voltage with power applied and the plug installed, using a high impedance voltmeter (1 megohm or greater). Refer to the following table for interpreting the pin measurements. The values of the pins having a logic 1 (high) are added to obtain the number for each digit. For example, if the first digit in the code is 5, pin 8 is high (value = 4) and pin 6 is high (value = 1). When added together (4 + 1), the digit 5 is obtained.

Logic Levels at Code Plug Pins

CODE EXAMPLES	1ST DIGIT			2ND DIGIT			3RD DIGIT		
	PINS			PINS			PINS		
	8	7	6	4	3	5	2	1	9
531	1	0	1	0	1	1	0	0	1
025	0	0	0	0	1	0	1	0	1
226	0	1	0	0	1	0	1	1	0
Value for logic 1 =	4	2	1	4	2	1	4	2	1

NOTE: Logic 0 = Low level voltage
Logic 1 = High level voltage

g. Turn-off Code

Adjust the service monitor to receive and display transmitted code from the radio under test. Press and release the push-to-talk switch several times and observe the code, followed by a 134.4 Hz burst for 80 to 120 milliseconds after the push-to-talk switch is released. If the burst (turn-off code) is not present, check external diode CR131 and the associated relay circuit, or U11 dc switch (800 MHz radios). Replace the processor (U132) if the external circuit components are functional.

7. TRANSMITTER CURRENT ANALYSIS

Since transmitter currents are relatively large, monitoring the 7.5-volt power supply current provides a quick analysis of overall transmitter operation. This is especially true with the rf power amplifier modules, which require 350 mA or more when operating normally.

With a wattmeter or dummy load connected at the antenna jack, key the transmitter and observe the total current supplied to the radio. Refer to the following chart for possible defective modules.

To check the IDC module (U101), inject a 25 mV 1000 Hz signal at pin 3. The output at pin 9 of U101 should be about 1.2 Vac. The input injection to pin 3 can be conveniently made through the RTX-4005A Test Set.

Transmitter Troubleshooting by Current Measurement

TOTAL RADIO CURRENT READING IN mA							ANALYSIS
VHF RADIOS			UHF RADIOS			800 MHz	
1 W	2.5 W	6.0 W	1 W	2 W	5 W	1.5 W	
Less than 200	Less than 200	Less than 200	Less than 200	Less than 200	Less than 200	Less than 200	There is probably no VCO output and power amplifiers U104, U105, and U106 (as applicable) are turned off. Suspect a defective channel element, U102, or U103.
200	200	200	200	200	200	375	U104 is not turned on, which keeps U105 and U106 (as applicable) turned off even through there is a VCO output. Suspect defective U104, U107, or U108.
520	450	700	550	575	600	450	U104 (final in 1 W radios) is turned on, meaning that VCO output is present and ALC circuit is working. Suspect defective U105 or U106 as applicable (both are used in 5 W uhf radios).
520	1000	2200	550	1225	2200	1050	This is normal current for transmitter. In vhf and uhf radios, U107 contains a passive filter. If power output is not present, suspect U107, or rf jack J401.
							NOTE: Current readings are nominal and may vary slightly. Relay K101 draws about 40 mA (U11 dc switch in 800 MHz radios draws about 30 mA), LED CR303 draws about 15 mA, IDC module U101 draws about 10 mA, channel elements take about 6.0 mA, and VCO U103 about 43 mA in vhf radios, 70 mA in uhf radios, or 195 mA in 800 MHz radios. PLL processor U102 draws about 70 mA in uhf radios and in 136-150.8 MHz vhf radios; about 60 mA in other vhf radios, and 50 mA in 800 MHz radios.

8. PHASE-LOCKED-LOOP AND VCO CIRCUIT

The phase-locked-loop (PLL) circuit uses two modules to generate the transmitted carrier frequency. Phase-lock-loop processor module U102 and VCO module U103 operate in a closed loop, with an output from U102 driving U103, and an output from U103 fed back to U102. Due to signal levels and loading between the two modules, there is no convenient way to determine which of the two modules has failed when trouble is experienced in this circuit. Refer to Figure 47.

There are two conditions that occur during operation; search and lock. Search begins when the transmitter is keyed, and lock occurs almost instantly if the circuit is operating properly.

To determine if the VCO is locked on frequency or in the search condition, monitor the signal at pin 1 of U103 (vhf and uhf radios), pin 5 of U103 (800 MHz radios), input to the VCO with an oscilloscope. This signal will be a triangular waveform at about 4 volts p-p if there is a problem and the VCO is NOT LOCKED on frequency. If the saw-tooth voltage is present, if the channel element frequency is present to U102, and if dc operating voltages are present, then U102 or U103 is probably defective. Since U102 contains the most circuitry, try substituting this module first. If the triangular voltage is still present, replace module U103. If lock is present, the dc voltages in the diagram should be measured.

NOTE

If the VCO is not locked on frequency, the rf amplifiers will be turned off and total transmitter current will be around 200 mA or less.

9. MAIN CIRCUIT BOARD TROUBLESHOOTING

The main circuit board (four-layer board) contains two internal layers that are not accessible or visible. Point-to-point circuit tracing is not difficult since all module pins are available from the back side of the board.

Signal paths are usually from the output of one module to the input of the next module and are easily followed with the schematic diagram and the circuit board detail in the applicable instruction manual supplement.

10. SELECTIVE CALL DECODER CIRCUIT TEST

a. Using the TEK-34 Tone Generator

(1) Insert Motorola "Vibrasender" reeds (with frequencies corresponding to decoder under test) into the Tone 1 and Tone 2 receptacles of the tone generator.

(2) Connect a test cable from the tone generator output to the Ext Mod (external modulation) receptacle of the FM signal generator.

(3) Connect the FM signal generator output to the rf input (antenna jack) of the radio under test using proper tune-up cable.

(4) Adjust FM signal generator to the radio frequency at 3.3 kHz deviation, and rf output level at 0.2 uV (0.13 uV on vhf radios with rf preamplifier option). Set radio squelch to threshold or off.

(5) Depress the tone generator TONE 1 pushbutton, hold down for 1 second, then release. Depress tone generator TONE 2 pushbutton, hold down for 3 seconds, then release.

NOTE

There should be no marked time lapse between the release of TONE 1 pushbutton and the depressing of TONE 2 pushbutton; as the TONE 1 button is released immediately depress TONE 2.

(6) The radio should respond, if not, perform the 20 dB quieting check for the receiver to determine if the trouble is in the decoder or the receiver circuit.

b. Using the S1333 Audio Synthesizer

(1) Set the thumbwheel switches and the adjacent frequency multiplier switches to the desired tone frequencies.

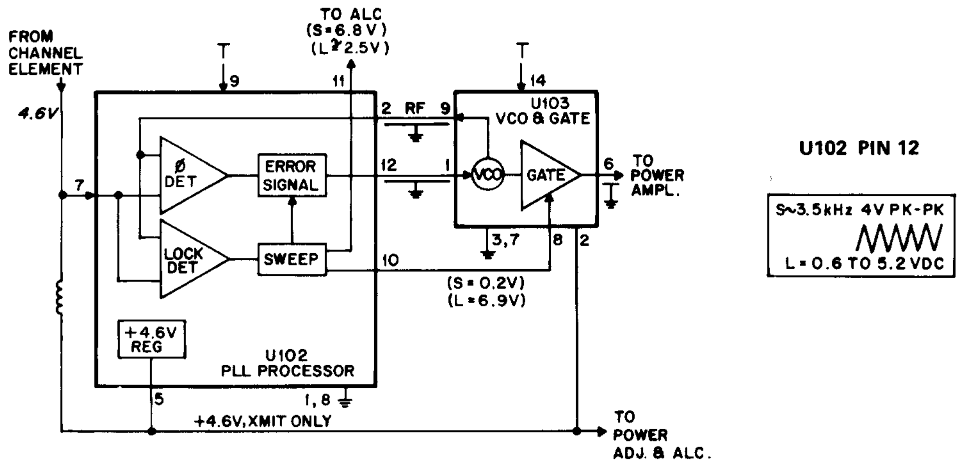
(2) Set the mode switch to CONT A and adjust LEVEL A to the desired output voltage (sufficient to drive the Motorola S1318 Signal Generator at 3.3 kHz deviation).

(3) Set the mode switch to CONT B and adjust LEVEL B to the desired output voltage (same as LEVEL A).

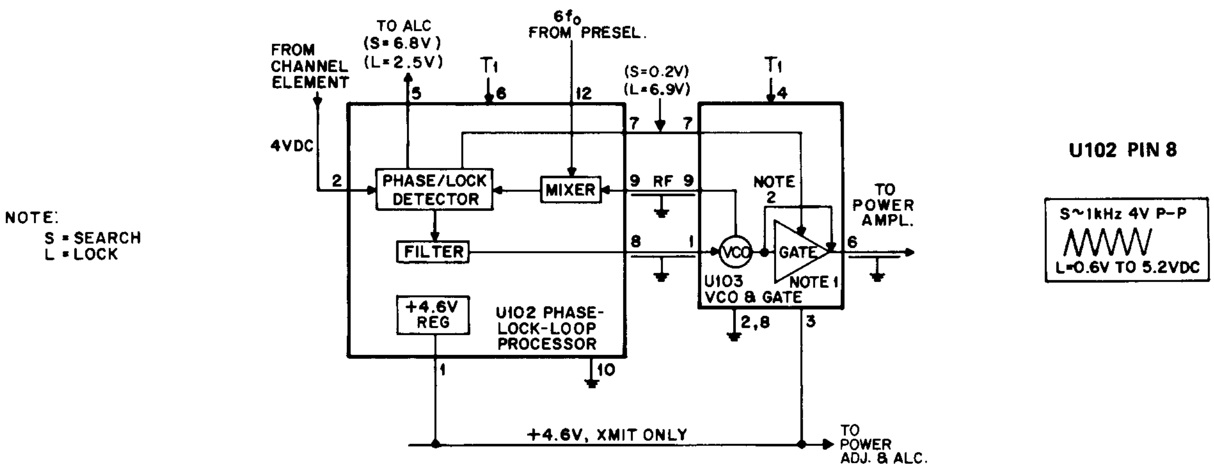
(4) Set mode switch to BURST.

(5) Set cycle switch to A and B.

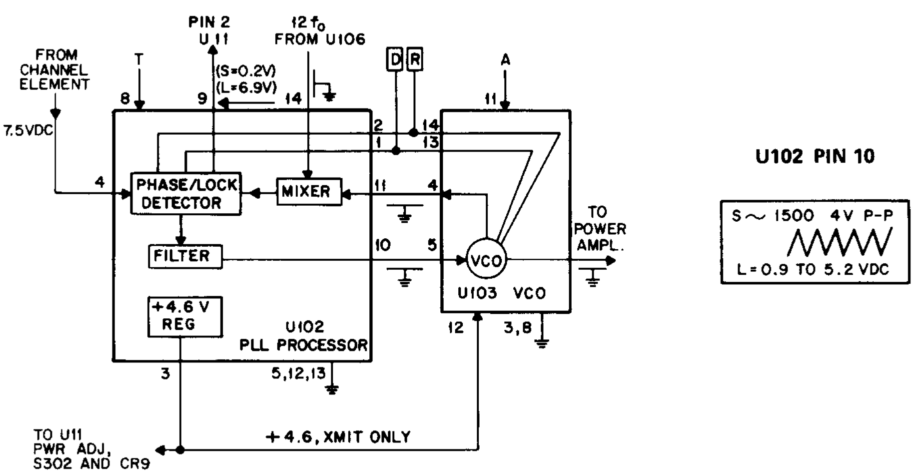
VHF RADIOS



UHF RADIOS



800 MHz RADIOS



NOTES:
1. INTERNATIONAL GATE OPTION VCO; NLE8351, NLE8352, OR NLE8353.
2. STANDARD VCO; NLE8801, NLE8802, OR NLE8803.

CEPF-9844-0

Figure 47. PLL Troubleshooting Diagram

(6) Set Tone 1 duration to 1 second, set the delay between pulses to 0.1 second. Set Tone 2 to 3.0 seconds.

(7) Connect the test cable from the audio synthesizer output jack to the Ext Mod (external modulation) receptacle of the FM signal generator.

(8) Connect the FM signal generator output to the rf input of the radio under test using proper tune-up cable.

(9) Adjust the FM signal generator to the radio frequency at 3.3 kHz deviation, and rf output level at 0.2 uV (0.13 uV on vhf radios with rf preamplifier option). Set radio squelch to threshold or off.

(10) Press the Cycle Clear pushbutton twice, the first time the button is actuated initiates the cycle, the second time prevents the unit from cycling again.

NOTE

Occasional circuit transients occurring during internal or external switching will turn on two or more of the light emitting diodes. Should this occur, clear the cycle by pressing the Clear/Cycle switch. When all lights are "off," press the Clear/Cycle switch to resume normal operation.

(11) The radio should respond, if not, perform the 20 dB quieting check on the receiver to determine if the trouble is in the decoder or the receiver circuit.

11. SELECTIVE CALL HYBRID MODULE PERFORMANCE CHECKS

a. Active Filter Check

(1) With no signal applied to the radio, the output (pin 4) should read less than 2 mV ac.

(2) Apply a signal at the input of the radio modulated at the frequency of the active filter with ±3.3 kHz deviation.

(3) The output (pin 4) should read at least 45 mV ac.

(4) Change modulation frequency to the adjacent tone frequency.

(5) The output (pin 4) should read less than 5 mV ac.

Typical Filter Voltages

PIN NO.	DESCRIPTION	DC VOLTAGE	AC VOLTAGE
1	Input	.60	2 mV
2	B+	1.40	
3	Ground	0	
4	Output	.62	1 mV/ 50 mV*
*With the proper input signal applied.			

b. Decoder Channel A Check

(1) Apply 100 uV rf signal to radio with "Tone A" modulation at ±3.3 kHz deviation.

(2) Tone A Integrator Timer (pin 12) should drop to 0.25 Vdc or less.

(3) Check Channel "A" sensitivity by reducing the deviation to produce 15 mV at pin 1. Pin 12 must remain below 0.30 Vdc. Reset deviation after completion of this test.

(4) Remove modulation.

(5) Pin 12 should charge back toward 0.67 Vdc. As the voltage at pin 12 approaches 0.67 Vdc a negative going spike should appear at the gate timer (pin 11).

c. Decoder Channel B Check

(1) Modulate input signal with "Tone B".

(2) Tone B Integrator Timer (pin 8) should drop to 0.25 Vdc or less.

(3) Check sensitivity of Channel B as in step 3 of Channel A.

d. Paging Check

(1) Module input signal with "Tone A" and "Tone B" in sequence with proper timing; (1 sec, 3 sec).

(2) To page, a negative spike at pin 11 must occur when voltage at pin 8 is low.

(3) Pin 11 should remain at less than 0.1 Vdc at the time of the negative spike when a page occurs.

(4) DC output (pin 9) should rise to 1.1 Vdc.

(5) Tone output (pin 4) should have a pulsating 2000 Hz ac signal of amplitude 1.0 V p-p.

(6) Astable (pins 5 and 7) should alternate at a rate of 3 to 5 times a second.

(7) The Tone Output may be latched on continuously at this time by grounding pin 7.

Typical Selective Call Decoder Voltages

PIN NO.	DESCRIPTION	DC VOLTAGE	AC VOLTAGE
1	Tone A Input	.62	
2	B+	1.40	
3	Ground	0	
4	Alert Tone Output	1.15	1.0 V* p-p
5	Astable	.77	
6	Timeout	0	
7	Astable	.77	
8	Tone B Integrator	.85	
9	DC Output	0/1.1*	
10	Tone B Input	.62	
11	Gate Timer	.65	
12	Tone A Integrator	.67	

All measurements taken during standby conditions unless otherwise specified.

*While page is being received.

12. UNIT ID PERFORMANCE TEST

CAUTION

Components on the encoder and emergency control boards contain CMOS circuitry, making them susceptible to damage by static electricity discharge. For this reason, these boards should be handled with extreme care. Refer to handling precautions in next section.

a. Preliminary Setup

(1) Make sure radio is turned off.

(2) Remove the encoder board and plug it into the extender board. If the emergency option is used, remove the emergency control board and plug it into its extender board.

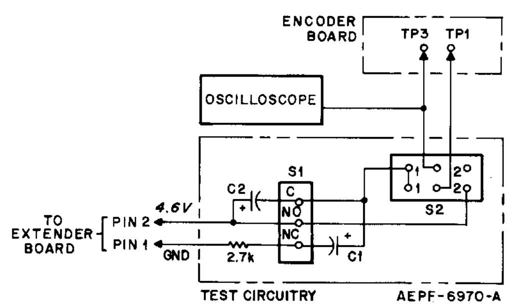
(3) Plug the extender board(s) into the radio.

(4) Attach the external circuitry (S1, S2, C1, and C2), as shown in the Unit ID Test Circuit Diagram. (Circuitry shown is in the TEK-83 Unit ID sequencer.)

(5) Connect the test equipment as shown in the Unit ID Test Equipment Setup Diagram.

NOTE

To prevent the rf carrier from interfering with the ID circuitry, couple the rf signal from the radio to the service monitor via the 50-ohm jack, 50-ohm cable, and the attenuator. Do not allow the rf carrier to be radiated from the antenna during this test.



PARTS LIST

SYMBOL	DESCRIPTION	Motorola Part No.
S1	SPDT, Subminiature, momentary	40-82159D01
S2	DPDT, Switch, toggle	40-05351A01
C1, C2	0.1uF, Capacitor	23-83397D05

Figure 48. Unit ID Test Circuit Diagram

b. Procedure

NOTE

The stationary position of switch S1 is normally closed (NC).

(1) Set switch S2 to position 1.

(2) Turn the radio on.

(3) Depress the PTT switch.

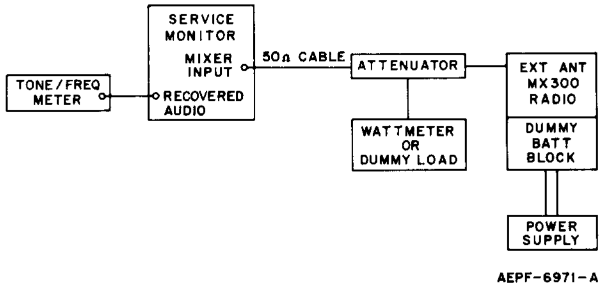


Figure 49. Unit ID Test Equipment Setup Diagram

(4) Depress S1 once and release. Check the code plug label for proper tones and verify the tone frequency on the frequency meter. The tone frequency should be within ±0.5% (for "Modat" and CCIR codes) or ±1.5% (for ZVEI codes) of the tone frequencies list in the Unit ID Frequency Data table on page 40.

(5) The code plug can be checked for accuracy via the bit pattern (D0 through D7), as indicated in the Unit ID Frequency Data table on page 40.

(6) Measure the tone deviation. For "Modat" and CCIR codes it is nominally ±3 kHz when maximum voice deviation is set at ±4 kHz. Repeat steps 4, 5, and 6 seven times for "Modat" or five times for ZVEI and CCIR.

(7) Set switch S2 to position 2. Measure the time-slot period. It should be 40 milliseconds ±5 milliseconds for "Modat," 70 milliseconds ±5 milliseconds for ZVEI or 100 milliseconds ±6 milliseconds for CCIR.

If the emergency option is used, continue with the following four steps:

(8) Depress the emergency switch momemtarily and repeat step (4), but tone 7 should be monitored during time-slot 3 instead of tone 8.

(9) Turn off the radio. Remove the boards from the extender boards, reinsert them in the radio, and turn the radio on.

(10) Depress the emergency switch momentarily. Check for the transmission of two emergency messages (with no sidetones), followed by four seconds in the receive mode, repeated five times, for a total of 12 emergency messages within 30 seconds.

(11) Depress the PTT switch and monitor the sidetones over the radio's speaker.

CAUTION

When re-inserting the encoder board or emergency control board back into the radio, make sure that the ground spring located on the solder side does not become deformed or broken by adjacent modules, such as channel elements or foam pads.

13. TROUBLESHOOTING UNIT ID CIRCUIT (See Figure 51)

Using switches S1 and S2 as required, measure dc levels on the encoder board as outlined in the troubleshooting chart. Applicable waveforms are given in the Unit ID Encoder Timing Diagram. The waveforms assume a "Modat" code of 698R123. (The actual code label on the code plug would read 6988123.) The timing diagram shown represents typical values for a "Modat" tone sequence. The voltage levels are representative of "Modat," ZVEI, and CCIR codes during manual sequencing or normal operation.

Unit ID Troubleshooting Chart

ENCODER PIN	DESCRIPTION	RECEIVE MODE	TRANSMIT MODE	COMMENT
1	Ground	0.0 V	0.0 V	
2	4.6 V Supply	4.6 V	4.6 V	
3	Emergency	0.0 V	0.0 V	High during emergency
4-11	8-Bit Frequency Data	T.S. 1 Code	T.S. 1-7 Code	See Unit ID frequency data table
12	PTT Latch	–	–	See note
13	Transmit ID	0.0 V	1.0 V + Tone Sq. Wave	See waveform on schematic diagram in service supplement
14	T.S. 1	H	H/L	See waveform
15-19	T.S. 2 to T.S. 6	L	L/0.6 V/L	See waveform
20	T.S. 7	L	L/H/L	See waveform
21	Encode Enable	0.0 V	>3.7 V	
22	4.6 V During ID Transmission	0.0 V	0/4.6/0 V	See waveform
23	Sidetones	< 0.1 V	0.6 V pp	

Note: Voltage level depends on "PL" option. The voltage level during transmit must be lower than the receive mode in all radios. (H=4.6 V nominal; L≤1.0 V nominal.)

Emergency Board Troubleshooting Chart

PIN	DESCRIPTION	EMERGENCY OFF	EMERGENCY ON		COMMENT
			TRANSMIT	RECEIVE	
1	Ground	0.0 V	0.0 V	0.0 V	Connected to radio via rails
2	4.6 V Supply	4.6 V	4.6 V	4.6 V	Regulated power supply
3	Emergency Enable	0.0 V	>3.7 V/0.0 V	0.0 V	Initiates sequence
4	T.S. 7	*	L/H/L/H/L	L	See emergency waveforms
5	T.S. 1	*	H/L/H/L/H	H	See emergency waveforms
6	Encode Enable	*	> 3.7 V	0.0 V	See emergency waveforms
7	PTT Latch				See note
8	Emergency Code	L	H/L	H/L	Indicates emergency mode when high
9	Emergency Disable	H	L/H	L/H	H - Resets emergency mode
10	Not Used				
11	Not Used	L	H	H	
12	Not Used				
U4:					
2	Reset	H	H/L	L	
4	Clock Output	L	105 kHz	105 kHz	See emergency waveforms
10,11 14	Control Output	L	L/H/L	L/H/L	See emergency waveforms

Note: Voltage level depends on "PL" option. The voltage level during transmit must be lower than the receive mode in all radios. (H=4.6 V nominal; L≤1.0 V nominal.)

*See encoder timing diagram.

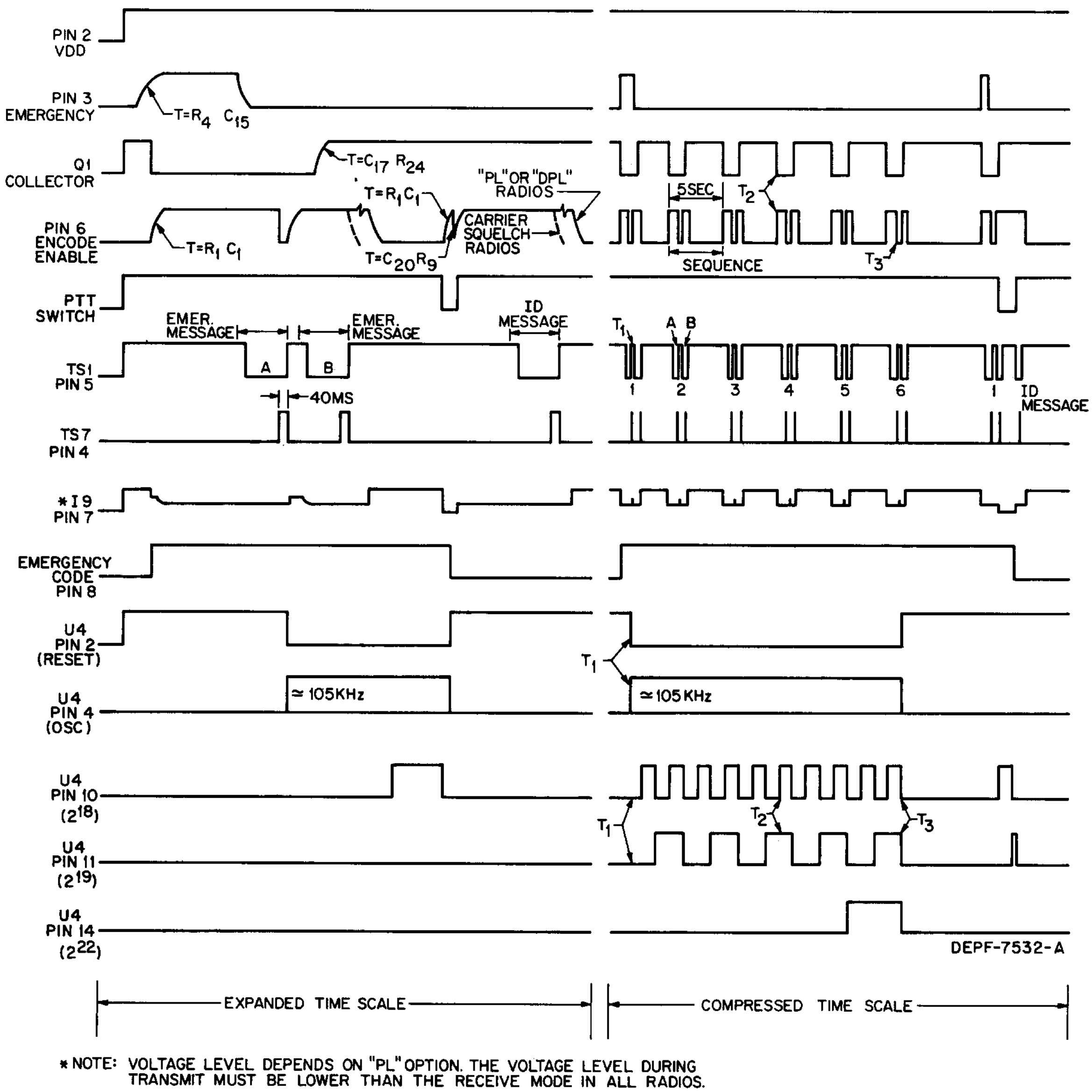


Figure 50. Emergency Control Board Timing Diagram

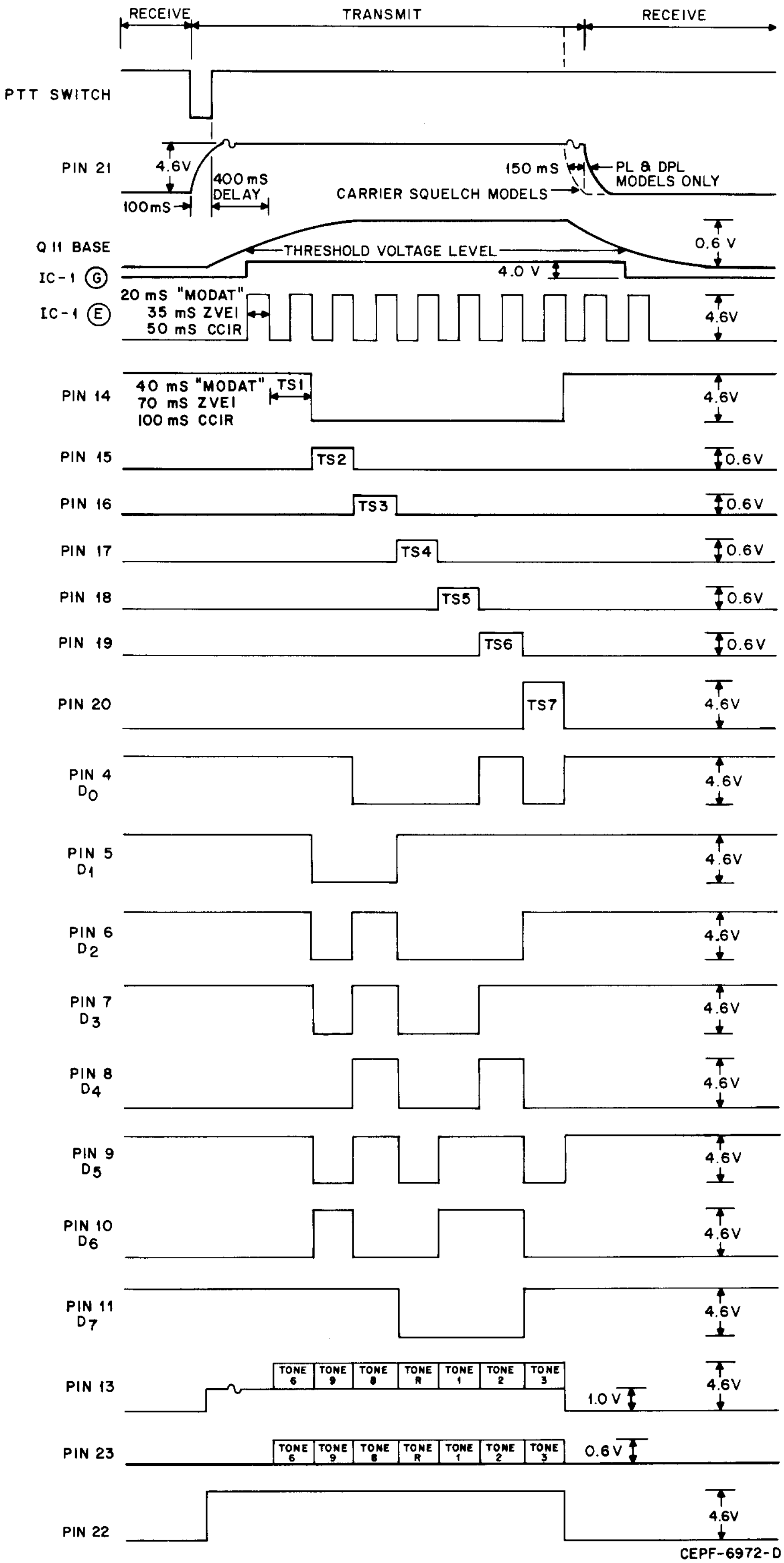


Figure 51. Unit ID Encoder Timing Diagram

14. ALIGNMENT FOR VHF RECEIVERS WITH WIDE SPACED CHANNELS

The service supplement available separately contains standard alignment procedures for radios with channels spaced less than 4 MHz apart. If the channels are spaced more than 4 MHz, use the following alignment procedure to assure that the highest and the lowest frequency channels are both within specification. The primary objective is to tune the receiver preselector to a frequency midway between the highest and the lowest channel frequency.

15. ALIGNMENT FOR UHF RECEIVERS WITH WIDE SPACED CHANNELS

The service supplement available separately contains standard alignment procedures for radios with channels spaced less than 1 MHz apart. If the channels are spaced more than 1 MHz, use the following alignment procedure to assure that the highest and the lowest frequency channels are both within specification. The primary objective is to tune the receiver preselector to a frequency midway between the highest and the lowest channel frequency.

NOTES

VHF RECEIVER ALIGNMENT, WIDE SPACED CHANNELS

Preliminary Adjustments:

1. Turn PL switch off (if applicable). Set squelch control to maximum counterclockwise position.
2. Set S501 to select F1.
3. Turn L4 until it is flush with the circuit board.
4. Turn Z1, Z2, Z3, Z4, Z5, Z6, and Z7 to their maximum clockwise position.

STEP	ADJUST	FOR	MEASURED AT	USING	NOTE
1	Freq. dial on service monitor	Channel element CE1 output frequency. See NOTE below (f_c marked on CE1).	–	Motorola service monitor	Connect a TEK-10 probe to the PRESELECTOR input on the service monitor.
2	CE1	Zero error	M1	Error meter on the service monitor	S501 set at F1 to adjust CE1.
3	Repeat steps 1 and 2 for each channel in the radio as applicable: CE2/F2, CE3/F3, CE4/F4, CE5/F5, CE6/F6, CE7/F7, CE8/F8.				
4	S501	Lowest frequency channel in the receiver	–	–	–
5	Connect a jumper wire from pin 5 on the lowest frequency channel element to pin 5 on the highest frequency channel element. This turns on both channel elements.				
6	FM signal generator frequency	$\frac{F_{Hi} + F_{Low}}{2}$ = Freq.	–	–	F_{Hi} = highest freq. carrier F_{Low} = lowest freq. carrier
7	Signal generator output level	About 30 dB quieting	J402 pin 10 to pin 2	AC voltmeter with 1:1 isolation transformer	Inject generator freq. at J401.
8	Z5, Z6, and Z7	Best quieting (lowest ac voltage)	J402 pin 10 to pin 2	AC voltmeter with 1:1 isolation transformer	If a coil does not peak, turn the slug until the change in quieting is small. Reduce signal generator level as necessary to maintain initial quieting level in step 7.
9	Z1, Z2, Z3, and Z4	Best quieting (lowest ac voltage)	J402 pin 10 to pin 2	AC voltmeter with 1:1 isolation transformer	While tuning Z1 thru Z4, reduce signal generator level as necessary to maintain 30 dB quieting.
10	Remove the jumper between the channel elements and set the signal generator to the lowest channel frequency. Reduce signal generator level as necessary to maintain initial quieting level in step 7.				
11	Z1, Z4, and L4	Best quieting (lowest ac voltage)	J402 pin 10 to pin 2	AC voltmeter with 1:1 isolation transformer	S501 is still set to the lowest frequency channel.
12	Perform the 20 dB quieting test (steps 13-15) for the lowest frequency channel and for the highest frequency channel. If the highest frequency channel does not meet specifications, tune Z5, Z6, and Z7 counterclockwise about ½ turn and recheck quieting. If the lowest frequency channel does not meet specifications, tune Z5, Z6, and Z7 clockwise about ½ turn and recheck quieting.				
			20 dB QUIETING TEST		
13	Volume control	1.73 Vac noise out	J402 pin 10 to pin 2	AC voltmeter with 1:1 isolation transformer	Establish reference noise level on ac voltmeter.
14	Signal generator	Carrier freq., 0 output level	J401	Signal generator	There should be no change in ac voltmeter indication yet. If there is some change (>2 dB), the rf cable ground or signal generator is defective.
15	Signal generator	Slowly increase until noise decreases 20 dB	J402	AC voltmeter with 1:1 isolation transformer	Signal must be less than: (see table below)

Frequency Separation (Maximum)				
Standard Radio		With RF Preamp Option		
3 MHz	4 MHz	6 MHz	10 MHz	12 MHz
.56 uV	.70 uV	.28 uV	.35 uV	.50 uV

NOTE: RECEIVER CHANNEL ELEMENT (CE1, CE2, etc.) OUTPUT FREQUENCY = f_c - 21.4 MHz / 2

UHF RECEIVER ALIGNMENT, WIDE SPACED CHANNELS

Preliminary Adjustments:

1. Turn PL switch off (if applicable). Set squelch control to maximum counterclockwise position.
2. Set S501 to select F1.
3. Turn Z1, Z2, Z3, Z4, Z5, Z6, and Z7 to their maximum clockwise position.

STEP	ADJUST	FOR	MEASURED AT	USING	NOTE
1	Freq. dial on service monitor	Channel element CE1 output frequency. See NOTE below (f_c marked on CE1).	–	Motorola service monitor	Connect a TEK-10 probe to the PRESELECTOR input on the service monitor.
2	CE1	Zero error	M1	Error meter on the service monitor	S501 set at F1 to adjust CE1.
3	Repeat steps 1 and 2 for each channel in the radio as applicable: CE2/F2, CE3/F3, CE4/F4, CE5/F5, CE6/F6, CE7/F7, CE8/F8.				
4	S501	Lowest frequency channel in the receiver	–	–	–
5	Install a tuning channel element into CE1 location $F_T = \frac{F_{Hi} + F_{Low}}{2}$				
6	FM signal generator frequency	$\frac{F_{Hi} + F_{Low}}{2}$ = Freq.	–	–	F_{Hi} = highest freq. carrier F_{Low} = lowest freq. carrier
7	Signal generator output level	About 30 dB quieting	J402 pin 10 to pin 2	AC voltmeter with 1:1 isolation transformer	Inject generator freq. at J401.
8	Z6 and Z7	Best quieting (lowest ac voltage)	J402 pin 10 to pin 2	AC voltmeter with 1:1 isolation transformer	If a coil does not peak, turn the slug until the change in quieting is small. Reduce signal generator level as necessary to maintain initial quieting level in step 7.
9	Z1, Z2, Z3, Z4, and Z5	Best quieting (lowest ac voltage)	J402 pin 10 to pin 2	AC voltmeter with 1:1 isolation transformer	While tuning Z1 thru Z5, reduce signal generator level as necessary to maintain 30 dB quieting.
10	Remove the tuning channel element and install F1 into CE1 and set the signal generator to the lowest channel frequency. Reduce signal generator level as necessary to maintain initial quieting level in step 7.				
11	Z1, Z2, Z3, and Z5	Best quieting (lowest ac voltage)	J402 pin 10 to pin 2	AC voltmeter with 1:1 isolation transformer	S501 is still set to the lowest frequency channel.
12	Perform the 20 dB quieting test (steps 13-15) for the lowest frequency channel and for the highest frequency channel. If the highest frequency channel does not meet specifications, tune Z6 and Z7 counterclockwise about ½ turn and recheck quieting. If the lowest frequency channel does not meet specifications, tune Z6 and Z7 clockwise about ½ turn and recheck quieting.				
	20 dB QUIETING TEST				
13	Volume control	1.73 Vac noise out	J402 pin 10 to pin 2	AC voltmeter with 1:1 isolation transformer	Establish reference noise level on ac voltmeter.
14	Signal generator	Carrier freq., 0 output level	J401	Signal generator	There should be no change in ac voltmeter indication yet. If there is some change (>2 dB), the rf cable ground or signal generator is defective.
15	Signal generator	Slowly increase until noise decreases 20 dB	J402	AC voltmeter with 1:1 isolation transformer	Signal must be less than: Frequency Separation (Maximum) Standard Radio 3 MHz: .56 uV 5 MHz: .70 uV

NOTE: RECEIVER CHANNEL ELEMENT (CE1, CE2, etc.) OUTPUT FREQUENCY = f_c - 21.4 MHz / 6

REPAIR AND PARTS REPLACEMENT

1. MOS CIRCUIT HANDLING PRECAUTIONS

The following handling precautions are recommended for MOS circuits:

NOTE

These precautions are especially important in low humidity conditions.

a. All MOS devices should be stored or transported in conductive material so that all exposed leads are shorted together. MOS devices must not be inserted into conventional plastic "snow" or plastic trays of the type used for storage and transportation of other semiconductor devices.

b. All MOS devices should be placed on a grounded bench surface and the technicians should ground themselves prior to handling devices. This is done most effectively by having the technician wear a conductive wrist strap in series with 100 k ohms to ground. (Motorola ST-1191 Wrist Strap is recommended.)

c. Nylon clothing should not be worn while handling MOS circuits.

d. Do not insert or remove MOS devices with power applied. Check all power supplies to be used for testing MOS devices and be certain there are no voltage transients present.

e. When lead straightening, provide ground straps for the apparatus used.

f. When soldering, use a grounded soldering iron.

g. All power should be turned off in a system before printed circuit boards containing MOS devices are inserted or removed.

h. All printed circuit boards containing MOS devices should be provided with shorting straps across the edge connector when being carried or transported.

i. MOS devices should be handled by their packages and not by the leads, if at all possible. Prior to touching the unit, the technician should touch an electrical ground to remove any static charge that may have accumulated. The package and substrate may be electrically common. If so, the reaction of a discharge to the case would cause the same damage as touching the leads.

2. MAIN CIRCUIT BOARD REPAIR

The four-layer main circuit board presents some new considerations when soldering and unsoldering components. The printed through holes may interconnect two, three, or all four layers of printed circuit. Care should be exercised to avoid pulling the plated circuit out of the hole. Also, on some radios the interconnect flexible circuit may be attached to the back side of the main circuit board. If parts under the flex circuit must be replaced, it may be necessary to unsolder part of the flex circuit covering the desired area on the main circuit board. Refer to the following paragraph regarding flexible circuits.

When soldering near the module socket pins, use care to avoid accidentally getting solder in the guide pin socket, which is open on the end. Insert the module pusher tool into the hole while soldering. Also, be careful not to form solder bridges between module socket pins. Inspect your work for shorts due to solder bridges.

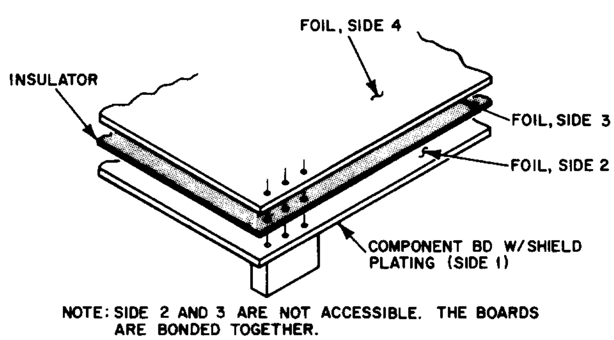


Figure 52. Typical Four-Layer Board Construction

3. FLEXIBLE CIRCUIT REPAIR

a. General

NOTE

To remove the flex circuit from the frame it is not necessary to unsolder socket J302. This socket plugs into the pins on the external accessory connector and can be removed by gently prying it apart.

The flexible circuits are made from a different material than the rigid main circuit board and different techniques must be used when soldering.

Excessive prolonged head on the flexible circuit can damage the material. Avoid excessive heat and excessive bending.

For parts replacement, use the ST-1087 Temperature Controlled Solder Station with a 600° or 700° tip, and using small diameter solder such as ST-633. The smaller size solder will melt faster and require less heat applied to the circuit.

b. Removing Flex Circuits from Main Circuit Board

Use care when unsoldering a flex circuit from the printed circuit board. The ST-1144 Soldering Iron with the large reservoir tip, Part No. 6684208D37 is recommended for this operation. Use the ST-1146 Stand to hold the soldering iron. For best results keep the reservoir tip full of solder and the solder skimmed clean.

c. Removing Parts on Control Flex

To replace a part on the control flex circuit, such as a volume control or frequency switch, grasp the edge of the flex circuit near the part to be removed with seizers and pull gently. Apply the tip of the soldering iron to the component connections while pulling with the seizers. Do not attempt to puddle out components off the control flex circuit. Prolonged heat applied to the flex circuit may cause damage.

d. Replacing Parts on Multi-Freq Flex

To replace a part on the multi-freq flex, bend up the protective flap and grasp the body of the part with seizers and pull gently. Apply the tip of a soldering iron to the component connection while pulling with the seizers. Do not attempt to puddle out the component, since prolonged heat applied to the flex circuit may damage the circuit.

e. Replacing Fuse Clips on Power Flex Circuit

The fuse clips are small and difficult to align properly in the flex circuit prior to soldering. The following procedure uses the radio housing as an alignment fixture.

(1) Remove the bottom of the power flex circuit as described in the disassembly section of this manual.

(2) Unsolder the old fuse clips and clean the holes.

(3) Temporarily place a piece of adhesive tape over the clip holes on the soldered (top) side of the flex circuit.

(4) Insert the fuse clips (from the bottom side) into the holes in the flex circuit with the tabs on the clips towards the outside edges of the flex circuit.

(5) Position the flex circuit in the housing and press the fuse clips into the holes in the housing until they snap in place.

(6) Remove the tape from the clip holes.

(7) Carefully solder the fuse clips to the flex circuit.

CAUTION

Avoid excessive or prolonged heat to prevent melting the radio housing.

(8) If a new power flex circuit is being installed, solder the threaded battery contact studs to the flex circuit at this time.

f. Replacing Radial Lead Fuse Sockets on the Power Flex Circuit

The fuse sockets are small and difficult to install properly in the flex circuit. The following procedure uses the radio housing as an installation fixture.

(1) Do not remove power flex circuit from the radio housing.

(2) Remove the fuse cap, located at the bottom of the radio housing.

CAUTION

Avoid excessive or prolonged heat to prevent melting the radio housing.

(3) Unsolder the fuse sockets and push them out through the frame into the fuse compartment area. Clean the holes on the power flex circuit.

(4) Place the new sockets on the leads of a fuse and insert into the frame and power flex circuit holes. Solder into place.

4. REPLACING THE ESCUTCHEON

a. Removing the Old Escutcheon

(1) Unscrew the antenna from the antenna bushing.

(2) Remove the knobs and retaining nuts on any controls that are mounted through the escutcheon.

(3) At the outside corner, next to the antenna bushing, carefully lift the edge of the escutcheon with a sharp instrument such as a small jewelers screwdriver.

(4) Carefully pry up the old escutcheon.

b. Installing New Escutcheon

The new escutcheon is supplied with a piece of two-sided adhesive which must be first attached to the escutcheon. Proceed as follows:

(1) Remove the paper backing from the side of the adhesive strip that will attach to the under side of the escutcheon.

(2) Carefully position the adhesive strip in place on the under side of the escutcheon.

(3) Remove the paper backing from the other side of the adhesive strip now affixed to the escutcheon.

(4) Carefully position the escutcheon in place over the controls and press firmly in place.

(5) Replace the antenna, control nuts, and control knobs as applicable.

5. REPLACING CONTROLS

a. General

Most of the operating controls are attached to the control flex. Each control presents a slightly different situation and procedures may vary slightly depending on the radio model and the options in the radio. The following procedures present general techniques which may require slight modification in some radios. In all cases, first remove the battery and disassemble the covers and main circuit board as previously described in the Disassembly section.

CAUTION

When servicing controls it is recommended that all water seals, "O" rings, etc., that are disturbed in the procedure be replaced to ensure maintaining radio sealing features.

b. Volume Control

(1) Remove the knob and retaining nut from the top of the control.

(2) Unsolder the two wires connecting the power flex to the switch on the control.

(3) Carefully fold the power flex back from the control to obtain working room.

(4) Carefully unsolder the control from the flex circuit at three points.

(5) Lift the volume control out and replace.

c. Squelch Switch ("Private-Line")

(1) Remove the retaining nut on the switch.

(2) Unsolder the flex circuit from the switch.

(3) Remove and replace the switch.

d. Squelch Control On One-Frequency Models

(1) Remove the knob and retaining nut from the top of the control.

(2) Carefully unsolder the flex circuit tab from the control and fold the tab away from the control.

(3) Lift the control out and replace.

e. Squelch Control On Multiple-Frequency Models

(1) Remove the knob from the control.

(2) Carefully remove the escutcheon as described in this section.

(3) Remove the retaining nut from the top of the control.

(4) Carefully unsolder the flex circuit tab from the control and fold the tab away from the control.

NOTE

Some radios have a shrink tube strain relief around the control and the wires to the frequency selector. The strain relief may have to be cut.

(5) Remove the control and replace.

f. Battery Status Transmit Indicator LED

(1) Carefully remove the escutcheon as explained in this section.

(2) Unsolder the two leads from the control flex.

(3) Remove the LED from the top of the radio.

(4) Insert the new LED into the holes from the top of the radio. Observe the polarity markings on the control flex.

(5) Solder the new LED in place and replace the escutcheon.

g. Push-To-Talk Switch

(1) Carefully pry off the protective boot and actuator.

(2) Remove the two exposed screws under the boot and actuator.

(3) Inside the radio, pry off the white strain relief that holds the flex circuit against the frame.

(4) Unsolder the flex circuit from the switch and fold the flex circuit back to remove the switch.

h. Accessory Connector On Side of Radio

(1) Remove the indicator LED as previously explained in paragraph e.

(2) Remove the push-to-talk switch boot and actuator and the strain relief as previously described in steps (1) - (3) of paragraph f.

(3) Fold the flex circuit inward to obtain access to the connector.

(4) Carefully unsolder the connector from the flex circuit.

6. EQUIPMENT IDENTIFICATION

When production changes and engineering changes are incorporated into the equipment, a revision number is assigned to the chassis or kit; -1, -2, -3, etc. The chassis number, complete with applicable revision number, is stamped on the chassis when manufactured. The revision number becomes an integral part of the chassis identifier. The applicable suffix revisions are listed on the schematic diagram.

When options are added to a basic radio, the letter "O" is added after the standard model number. This indicates that an option (e.g., H701) has been added to the radio.

7. INSTRUCTION MANUAL REVISIONS

Changes which occur after an instruction manual is printed are described in manual revisions. These bulletins give complete information on the change, including applicable parts list data. Before changing or ordering parts, always check the revisions supplied.

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