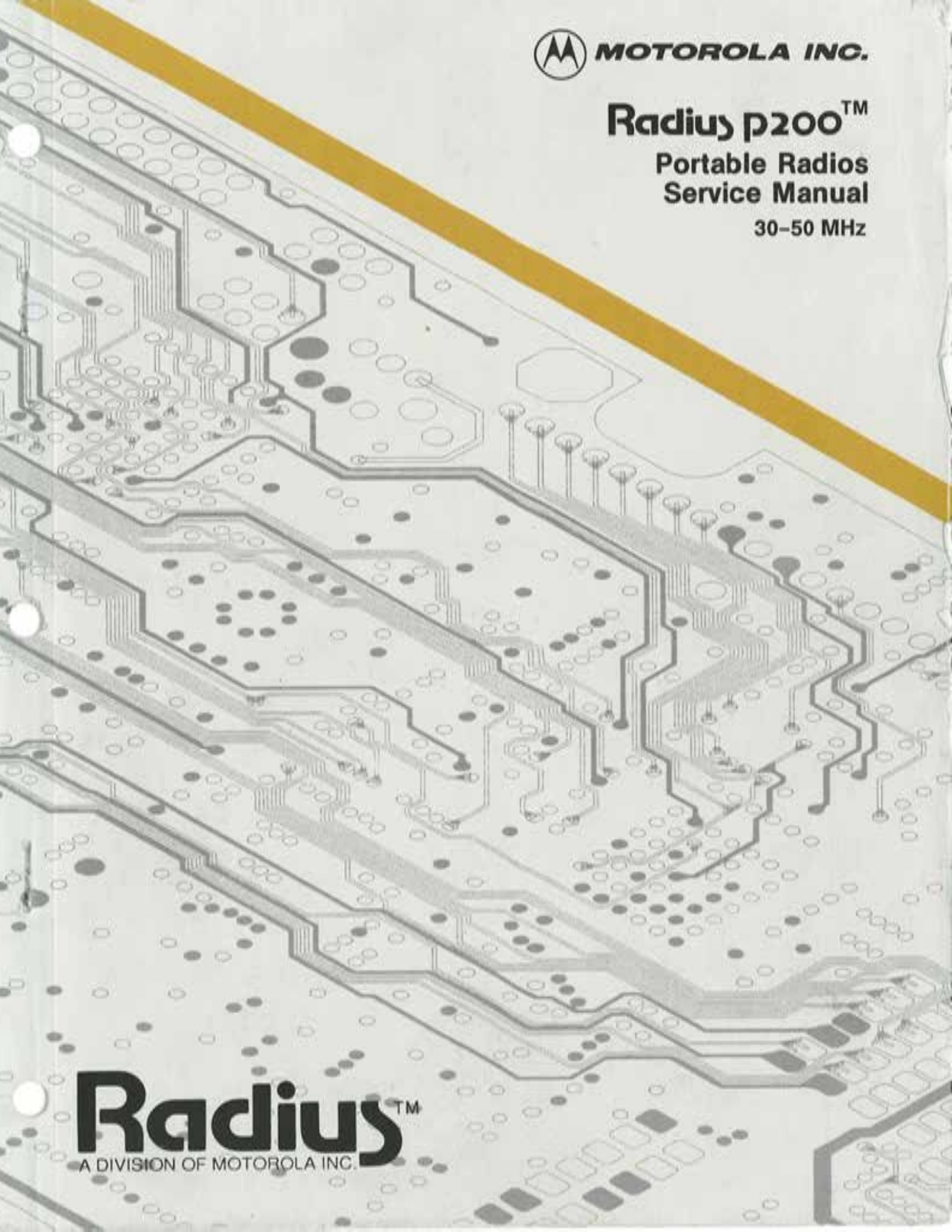
MOTOROLA INC.

Radius p200™

Portable Radios
Service Manual

30–50 MHz



Radius™
A DIVISION OF MOTOROLA INC.

LOWBAND SPECIFICATIONS

GENERAL	TRANSMITTER	RECEIVER
FREQUENCY RANGE: 30-50 MHz **BANDSPLITS:** 30-36 MHz 36-42 MHz 42-50 MHz **POWER SUPPLY:** Nickel-cadmium battery **BATTERY DRAIN** at 10 Vdc: Standby: *42 mA Standby In Scan: *52 mA Receive: *163 mA Transmit: **2000 mA *Add 15 mA with Remote Antenna **Add 30 mA with Remote Antenna **DIMENSIONS:** WIDTH: 2.63" (66.8 mm) DEPTH: 1.39" (35.3 mm) **HEIGHT:** Radio Only: 3.90" (99.0 mm) Radio with Battery: Medium Capacity: 6.35" (161.3 mm) High Capacity: 7.26" (184.4mm) **WEIGHT:** Radio Only: 13.5 oz. (383 g) Radio with Battery (Nickel-Cadmium): Medium Capacity: 21.6 oz. (612 g) High Capacity: 24.1 oz. (684 g)	**RF OUTPUT:** Nickel-cadmium 6.0 W at 10 Vdc battery: **MODULATION:** Type 16K OF 3E, ±5 kHz for 100% modulation at 1000 Hz (±4.0 kHz min.) including PL modulation for PL models **PL MODULATION:** ±1 kHz max. ±500 Hz min. **AUDIO DISTORTION:** Less than 3% at 1000 Hz, 3 kHz deviation **MAX. PERMISSIBLE CHANNEL SEPARATION:** 1 MHz (no degradation) **FREQUENCY STABILITY:** ±.0005% from -30°C to +60°C (+25°C ref.) **SPURIOUS & HARMONIC FREQUENCIES:** More than 53 dB below carrier **FM NOISE (COMPANION RECEIVER):** At least 45 dB below ±3.0 kHz deviation at 1000 Hz **AUDIO RESPONSE:** +1, -3 dB from 6 dB/octave pre-emphasis characteristic from 300-3000 Hz	**AUDIO OUTPUT:** 500 mW at less than 5% distortion **SECOND I-F FREQUENCY:** 450 kHz ±1.5 kHz measured at M1 **SENSITIVITY:** 12 dB SINAD 0.25 µV max. 20 dB Quieting 0.35 µV max. **NOISE SQUELCH SENSITIVITY:** Noise-compensated type. Programmable **MAX. PERMISSIBLE CHANNEL SEPARATION:** 1 MHz (no degradation) **FREQUENCY STABILITY:** ±.0005% from -30°C to +60°C (+25°C ref.) **USEABLE BANDWIDTH:** ±7 kHz **SPURIOUS FREQUENCY REJECTION:** More than 70 dB below carrier **IMAGE REJECTION:** More than 70 dB below carrier **SELECTIVITY:** More than 70 dB at ±20 kHz (12 dB SINAD) **INTERMODULATION:** More than 70 dB at adjacent channel **CHANNEL SPACING:** 20 kHz

Specifications Subject to Change Without Notice

NOTES:

- ALL BATTERIES MUST BE CHARGED PRIOR TO USE
- USE OF CHEMICALS (DETERGENTS, ALCOHOLS, AEROSOL SPRAYS, PETROLEUM PRODUCTS) MAY BE HARMFUL AND MAY DAMAGE THE RADIO HOUSING. WE RECOMMEND A MILD DISHWASHING SOAP FOR CLEANING THE EXTERIOR OF THE PRODUCT.
- O-RING SEALS MUST BE PROPERLY ASSEMBLED TO ENSURE CONFORMANCE TO MIL-810D SPECIFICATIONS FOR WATER INTRUSION.

MOTOROLA INC.
Communications
Sector

Radius P200
PORTABLE RADIOS
30–50 MHz

CONTENTS

technical writing services
1301 E. Algonquin Road, Schaumburg, IL 60196

68P81085E55-O
8/15/90–UP

FCC DESIGNATIONS

State that:

1. The rf power output of a radio transmitter shall be no more than that required for satisfactory technical operation considering the area to be covered and the local conditions.
2. Frequency and deviation of a transmitter must be checked before it is placed in service and rechecked once each year thereafter.

EPS-46042-O

FCC DESIGNATIONS

H41 Series Models AZ489FT1622

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EPS-34440-B

RELATED PUBLICATIONS AVAILABLE SEPARATELY

Operating Instructions 68P81059C05
Programmer/Tuner User's Manual (Lowband) 68P80901Z52

MODEL CHART FOR LOWBAND RADIUS P200 30-50 MHz

CODE
X = STANDARD
0 = OPTIONAL

MODEL NO. H41RFU7160AN	FREQS 6	POWER 6 W L.B	KIT NUMBER	DESCRIPTION
		X	NUB1061A	RF BOARD 30 - 35.999 MHz ALT OSC.
		X	NUB1002A	RF BOARD 36 - 41.999 MHz
		X	NUB1003A	RF BOARD 42 - 50.000 MHz
		X	NTN5718A	CONTROLLER BOARD
		X	NHN6472A	LOWBAND HOUSING
		X	NTN5942A	LOWBAND FRONT COVER
		O	NTN5941A	LOWBAND DTMF FRONT - CONSTANT TONE
		O	NTN5940A	LOWBAND DTMF FRONT COVER - ANI
		O	NTN5939A	LOWBAND DTMF FRONT COVER - STD TONE COVER
		X	NAB6061A	LOWBAND ANTENNA (UNCUT) 30 - 35.999 MHz
		X	NAB6062A	LOWBAND ANTENNA (UNCUT) 36 - 41.999 MHz
		X	NAB6063A	LOWBAND ANTENNA (UNCUT) 42 - 50.000 MHz
		X	NTN5718A	FRAME, CONTROL TOP
		X	NTN5782A	SHIELD KIT
		X	NTN5871A	RETAINER KIT
		X	NTN5540B	COMPACT CHARGER
		X	NTN4623A	HARDWARE KIT (MISC.)
		X	NTN5533A	3-INCH BELT CUP
		O	NTN5531B	NICAD RAPID CHARGING BATTERY MEDIUM CAPACITY
		O	NTN5561A	NICAD RAPID CHARGING BATTERY MEDIUM CAPACITY - F.M.
		X	NTN5521B	NICAD RAPID CHARGING BATTERY HIGH CAPACITY
		O	NTN5545B	NICAD RAPID CHARGING BATTERY HIGH CAPACITY - F.M.
		O	NTN5570A	ALKALINE BATTERY

AEPS-48009-O

OPTION TABLE

Option Number	Description
Battery options omit the battery supplied in the package model and add the battery ordered. Only one battery option listed may be ordered.	
H165	Delete Charger, Belt Clip, and Battery
H224	Medium–Capacity, Rapid–Charge Battery
H236	Intrinsically Safe
H297	*Touch Code*/DTMF Interconnect (Standard Tone)
H301	Omit 3–Inch Belt Clip
H437	Rapid–Rate Charger (Deletes Compact Charger)
H438	Delete Standard Compact Charger, Add 220–Volt Compact Charger
H439	Delete Standard Compact Charger, Add 220–Volt Single–Unit Charger
H713	*Touch Code*/DTMF Interconnect (Constant Tone)
H743	*Touch Code*/DTMF Interconnect (Constant Tone)
H753	Medium–Capacity, Rapid–Charge – Intrinsically Safe
H757	Factory Mutual Non–Incentive Rating
H844	Factory Programming Frequencies, Tone and Digital Squelch
H951	Omit Compact Charger

ACCESSORIES

The *Radius* system offers several accessories to increase communications efficiency. Many of the accessories are listed below, but for a complete list, consult your *Radius* dealer.

	Antennas
NAB6061A	Lowband Antenna (UNCUT) 30–35.999 MHz
NAB6062A	Lowband Antenna (UNCUT) 36–41.999 MHz
NAB6063A	Lowband Antenna (UNCUT) 42–50.000 MHz
NKN6419A	Mobile Antenna Cable
NTN5632A	Mobile Antenna Adapter
	Batteries
NTN5531B	Nickel–Cadmium, Medium–Capacity, Rapid–Charge
NTN5545B	Nickel–Cadmium, High–Capacity, Rapid–Charge, Intrinsically Safe/Factory Mutual Approved
NTN5521B	Nickel–Cadmium, High–Capacity, Rapid–Charge
NTN5561A	Nickel–Cadmium, Medium–Capacity, Rapid–Charge, Intrinsically Safe/Factory Mutual Approved
NTN5570A	1700 mAh Alkaline Battery
	Nickel–Cadmium Battery Chargers
NTN5538A	Single–Unit, Desktop (Rapid–Rate 117 V)
NTN5539A	Single–Unit, Desktop (Rapid–Rate 220 V) with European Plug
NTN5540A	Compact (110 V)
NTN5541A	Compact (220 V) with European Plug
NTN5536A	Multi–Unit (Rapid–Rate 117 V)
NTN5537A	Multi–Unit (Rapid–Rate 220 V/240 V)
	Carry Accessories
NTN5546A	Velcro–Type Patch Pin Attachment
NTN5542A	2" Belt Clip
NTN5547B	Belt Clip Carry Holder
NTN5533A	3" Belt Clip
NTN5550A	Carry Case (Large)
NTN5551A	Carry Case with Swivel (Medium)
NTN5552A	DTMF Access – Long (Swivel Only)
NTN5243A	Carry Case Strap (Lanyard)
NTN5593A	Carry Strap (Lanyard)
NTN5573A	T–Strap (Urethane)/Carry Holder
NTN5582A	Carry Case Spacer
NTN5583A	T–Strap (Nylon) Leather Cases
	Audio Accessories
NMN6153A	Remote–Speaker Microphone
NMN6168A	Remote–Speaker Microphone with 2.5–mm Earphone Jack (Uses NSN6057A)
NTN5557A	Earphone Jack Adaptor
NTN5558A	Earpiece w/Volume Control
NTN6057A	Earpiece w/o Volume Control (2.5–mm Plug, Used with NMN6168A)
NTN5560B	Two–Wire Surveillance Adapter
NSN6056A	Lapel Speaker

SPECIAL TERMS AND ABBREVIATIONS

The construction technology and circuits in the *P200* radio require the use of some special terms and abbreviations listed in the following table.

Term	Description
Alert Tones	Audible annunciators of radio status
Code Plug	That portion of the software that is coded for the individual user
DPL	*Digital Private-Line* (Digital Coded-Squelch)
DTMF	Dual-Tone, Multi-Frequency (Phone Interconnect Signaling)
Logic 1	A voltage level of approximately 5 V dc
Logic 0	A voltage level of approximately 0 V dc
PA	Power Amplifier
PL	*Private-Line* (Tone Coded Squelch)
PLL	Phase Locked Loop
RX	Receive
Transceiver Board	The printed circuit board containing the functional components of the receiver and transmitter
TX	Transmit
VCO	Voltage Controlled Oscillator

SAFETY INFORMATION

The Federal Communications Commission (FCC), with its action in General Docket 79-144, March 13, 1985, has adopted a safety standard for human exposure to radio frequency (RF) electromagnetic energy emitted by FCC-regulated equipment. Proper operation of this radio will result in user exposure substantially below the FCC recommended limits.

DO NOT hold the radio such that the antenna is very close to, or touching, exposed parts of the body, especially the face or eyes, while transmitting. The radio will perform best if the microphone is two or three inches away from the lips and the radio is vertical.

DO NOT hold the transmit (PTT) switch on when not actually desiring to transmit.

DO NOT allow children to play with any radio equipment containing a transmitter.

DO NOT operate a portable transmitter near unshielded electrical blasting caps or in an explosive atmosphere unless it is a type especially qualified for such use.

GAEPS-46044-O

CMOS PRECAUTIONS

THIS RADIO CONTAINS STATIC-SENSITIVE DEVICES. DO NOT OPEN THE RADIO UNLESS PROPERLY GROUNDED. TAKE THE FOLLOWING PRECAUTIONS WHEN WORKING ON THIS UNIT.

The red printed circuit boards indicate static sensitive devices are contained on these boards, and should only be handled with the following precautions.

(1) Store and transport all CMOS devices in conductive material so that all exposed leads are shorted together. Do not insert CMOS devices into conventional plastic "snow" or plastic trays used for storage and transportation of other semiconductor devices.

(2) Ground the working surface of the service bench to protect the CMOS device. We recommend using the Motorola P/N 0180386A82 Static Protection Kit which includes a wrist strap, 2 ground cords, a table mat, and a floor mat.

(3) Wear a conductive wrist strap in series with a 100k resistor to ground. Replacement Wrist Straps that connect to the bench top covering — Motorola P/N RSX-4015B.

(4) Do not wear nylon clothing while handling CMOS devices.

(5) Neither insert nor remove CMOS devices with power applied. Check all power supplies to be used for testing CMOS devices and be certain there are no voltage transients present.

(6) When straightening CMOS pins, provide ground straps for apparatus used.

(7) When soldering, use a grounded soldering iron.

(8) If at all possible, handle CMOS devices by the package and not by the leads. Prior to touching the unit, touch an electrical ground to remove any static charge that you 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.

CAUTION

DO NOT DEPRESS THE PTT OR SIDE SWITCHES WHILE INSERTING THE FRAME INTO THE HOUSING: DAMAGE TO THE SWITCHES COULD OCCUR.

FOR REASSEMBLY, USE ONLY THE TOOLS THAT ARE RECOMMENDED. USING UNAUTHORIZED TOOLS, IMPROPERLY USING AUTHORIZED TOOLS, OR FAILING TO ADHERE TO TORQUE SPECIFICATIONS MAY CAUSE IRREPAIRABLE DAMAGE.

DO NOT ATTEMPT TO REMOVE THE ANTENNA BUSHING FROM THE CONTROL TOP; IT IS ULTRASONICALLY WELDED IN PLACE.

DO NOT DESOLDER OR RESOLDER ANY CONNECTIONS BETWEEN THE VOLUME POT. FLEX AND THE ON/OFF-VOLUME POTENTIOMETER (37) WITH THE SWITCH IN THE OFF POSITION. MAKE SURE THAT THE SWITCH IS IN THE ON POSITION BEFORE APPLYING ANY HEAT; OTHERWISE THE INTERNAL PARTS OF THE SWITCH WILL BE DAMAGED.

SERVICE AIDS

The following table lists tools and service aids recommended for working on the *p200* Lowband portable radio. While all of these items are available from Motorola, most are standard shop equipment items, and any equivalent item capable of the same performance may be substituted for the item listed.

MOTOROLA PART NO.	DESCRIPTION	APPLICATION
RTK-4205B/HKN-9414	RIB/Radio/Test Set Cable	Connects radio to RTX-4005B Test Box and RIB.
RTL-4226B	Battery Eliminator	Interconnects radio to power supply.
15-80368B62	Battery Adapter	Connects radio to battery eliminator without main housing.
REN-4000A	Controller Flex Extender Fixture	Eases in troubleshooting of controller flex and rf board.
01-80371B37	Controller Flex Hold Down Fixture	Provides secure mount for controller flex during servicing.
RTX-4005B or both RTX-4005A and RPX-4665A field modification kit	Portable Test Set	Enables connection to the universal connector. Allows switching for radio testing.
01-80353A74/HLN-9214	Radio Interface Box	Enables communications between the radio and the computer's serial communications adapter. Requires 9-volt snap-type battery, Motorola part number 60-82728J01. (Also accepts power supply part number 01-80357A57).
01-80357A57/HSN-9412	Wall-Mounted Power Supply	Used to supply power to the RIB (117 Vac).
30-80369B72/HKN-9216 HLN-9390	Computer Interface Cable Adapter to 30-80369B72/ HKN-9216	Connects the computer's serial communications adapter to the RIB. Adapts 9-pin cable to 25-pin computers.
NKN6376A	Cloning Cable	Allows a *p200* radio to be duplicated from a master radio by transferring programmed data from one radio to another.
HVN-9793	Radio Service Software	Software on 5-1/4 inch floppy disk.
HVN-9794	Radio Service Software	Software on 3-1/2 inch floppy disk.
F.A.S.T. 47	"Using the RLN-4062A Hot Air Repair Station"	How to use the RLN-4062A to successfully remove and replace chip components.
01-80358A59	ANI Programming Tool	Used on DTMF ANI Options to program ANI codes.
60-82728J01	Battery	9-volt snap-type battery for RIB.
TT907	National Service Technical Guide	Repairing leadless component assemblies.
R-1070A or R-1080A	Hot Air Repair Station (Described in TT907)	
RPX-4726	Reference Oscillator Tuner Box	Tuning the alternate oscillator for low band.

RECOMMENDED TOOL LIST

The following table lists the tools recommended for working on the p200 Lowband portable radio; these also are available from Motorola. Note that the R-1070A workstation requires the use of a specific "heat focus head" for each of the components on which this item is used. **Each of these heat focus heads must be ordered separately.** The individual heat focus heads (and the components on which they are used) are listed at the end of the table.

MOTOROLA PART NO.	DESCRIPTION	APPLICATION
RSX-4013A	Torque Screwdriver	Handle for bits listed below
6680321B86	Phillips bit (0)	Radio screws
6680321B79	Phillips bit (1)	Radio screws
6680371B03	Hex socket bit	Volume and rotary switch nuts
6680371B34	Spanner bit	Antenna bushing spanner nut
6680370B95	Spanner bit	Toggle switch spanner nut
6605106N01	Tuning tool	Tunable coils and potentiometers
6680387A59	Extractor, 2-contact	Removal of discrete surface-mounted devices
6680387A64	Heat controller with safety stand or	
6680387A65	Safety stand only	
0180382A31	Portable desoldering unit	
6680375A74	0.025 replacement tip, 5/pk	For 0180382A31 portable desoldering unit
0180386A81	Miniature digital readout soldering station (incl. 1/64" micropoint tip)	
0180386A78	Illuminated magnifying glass with lens attachment	
0180386A82	Anti-static grounding kit	Used during all radio assembly and disassembly procedures
6684253C72 6680384A98	Straight prober Brush	
1010041A86	Solder (RMA-type) 63/37, 0.020" diameter - 1 lb spool	
1080370B43	RMA liquid flux	
R-1070A	Surface-mounted component IC removal/rework station)order all heat focus heads separately)	Removal of surface-mounted integrated circuits
HEAT FOCUS HEADS	**INSIDE DIMENSIONS OF HEADS**	
6680334B48	0.318" x 0.318" for U402, U408, and U409	
6680334B49	0.140" x 0.410" for U406	
6680334B51	0.492" x 0.492" for U401 and U405	
6680370B57	0.245" x 0.245" for U403 and U801	
6680370B66	0.180" x 0.180" for U404	

TORQUE AND TOOL SPECIFICATIONS CHART

PART DESCRIPTION	SIZE	NUMBER	QTY	RETIGHTEN WITH RSX-4043A TORQUE SCREWDRIVER AND	TORQUE (IN./LB)	EXP. VIEW NUMBER
Control Top Antenna Bushing Spanner		0205765L02	1	6680370B90	12	22
Volume Pot. Nut	0.75x8X1.6	0205629L01	1	6680371B03	5	17
Freq. Switch Nut Rotary Radios Only	0.75x8X1.6	0205629L01	1	6680371B03	5	17
Toggle Switch Spanner		0205163Q01	1	6680370B95	4	19
Control Top Screw Rotary Radios Display Radios	4-40x3/16" 2-56x5/16"	0300136785 0305573R01	1 1	6680321B79 6680321B86	5 3	6 26
Housing Battery Contact Screws	2-56x5/32"	0300139982	2	6680321B86	3	45
Bottom Front Cover Screws	2-56x1/4"	0300140041	2	6680321B86	3	87
Baseplate to Frame Screws	4-40 (captive)	0305941K01	2	6680321B79	5	49
Front Cover Post Screws	4-40x1/2"	0305137Q01	2	6680321B79	5	52
Controller Front Shield Screw	2-56x1/8"	0300140369	1	6680321B86	3	35
Controller Bottom Screws	2-56x5/16"	0300138620	2	6680321B86	3	67
Controller to Frame Screws	2-56x1/8"	0300140369	4	6680321B86	2	35
RF Board Back Shield Screws	2-56x5/16"	0300136772	5	6680321B86	3	65
PA Heatsink to PCB (VHF-LP)	2-56x3/16"	0300136771	2	6680321B86	3	15
PA Heatsink to PCB	2-56x3/16"	0300136771	1	6680321B86	3	15
PA to Heatsink (VHF-LP)	2-56x5/32"	0300139675	1	6680321B86	3	101
PA to Heatsink Nut (VHF-HP)	1/4	0200007007	1		5	97
Synthesizer Casting Screw	2-56x3/16"	0300136771	2	6680321B86	4	15
Front Cover Speaker/Mic. Tab Screws	2-56x5/32"	0300139982	4	6680321B86	3	45

P200™ LOWBAND ANTENNA CUT CHART

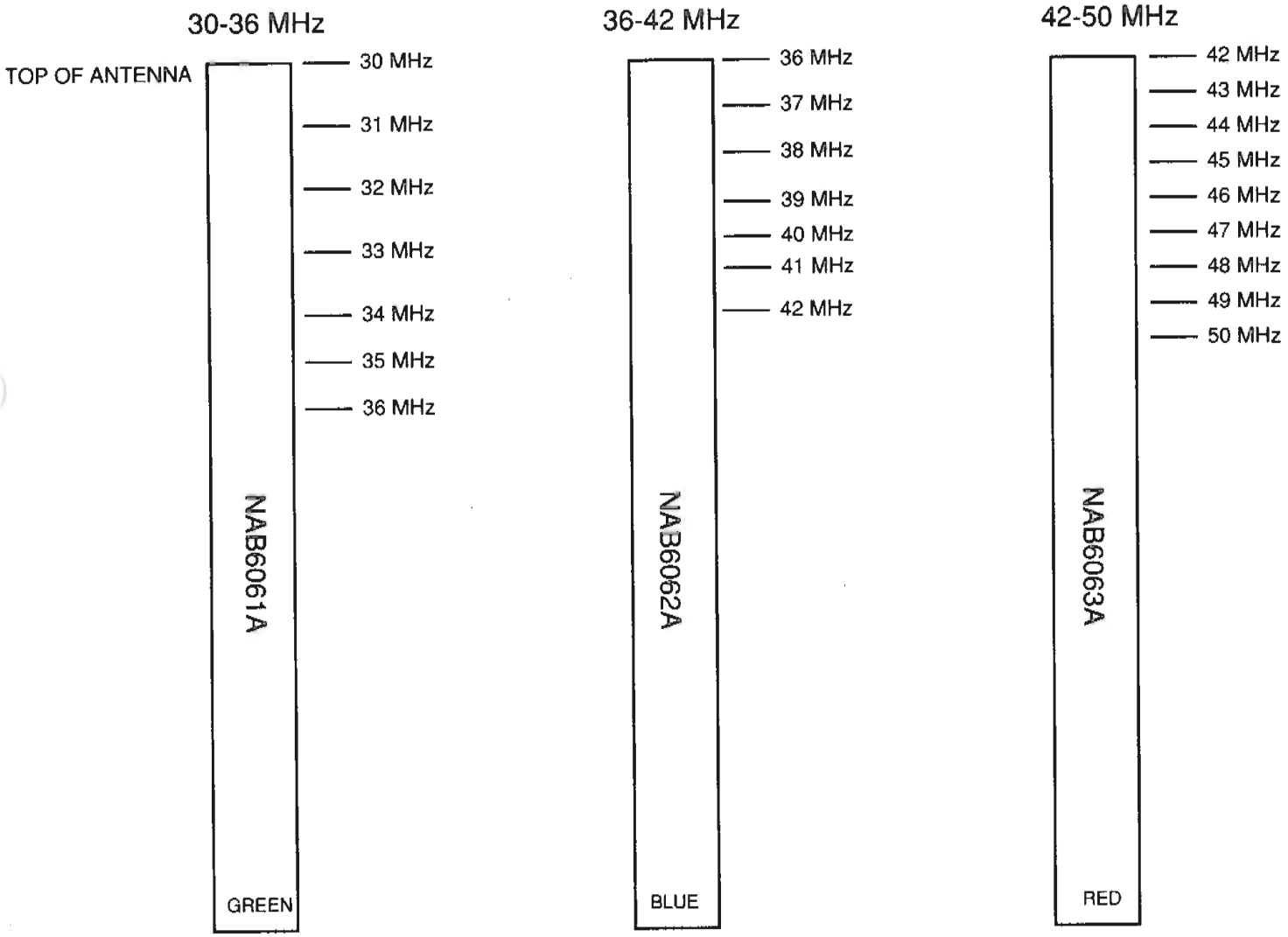
–IMPORTANT–
FOR OPTIMUM PERFORMANCE,
ANTENNA MUST BE CUT TO PROPER LENGTH BEFORE RADIO IS USED.

1 Remove antenna cap and align top of uncut antenna with top of corresponding cut diagram.

2 Mark antenna for the cutting length corresponding to the desired frequency scale on the chart.

3 Cut antenna.

4 If using adhesive strip, remove strip from white backing, wrap adhesive around top of antenna, remove second backing from adhesive, and replace antenna cap. If not using adhesive strip, apply glue (P/N 1100842335) to top of antenna and replace cap.



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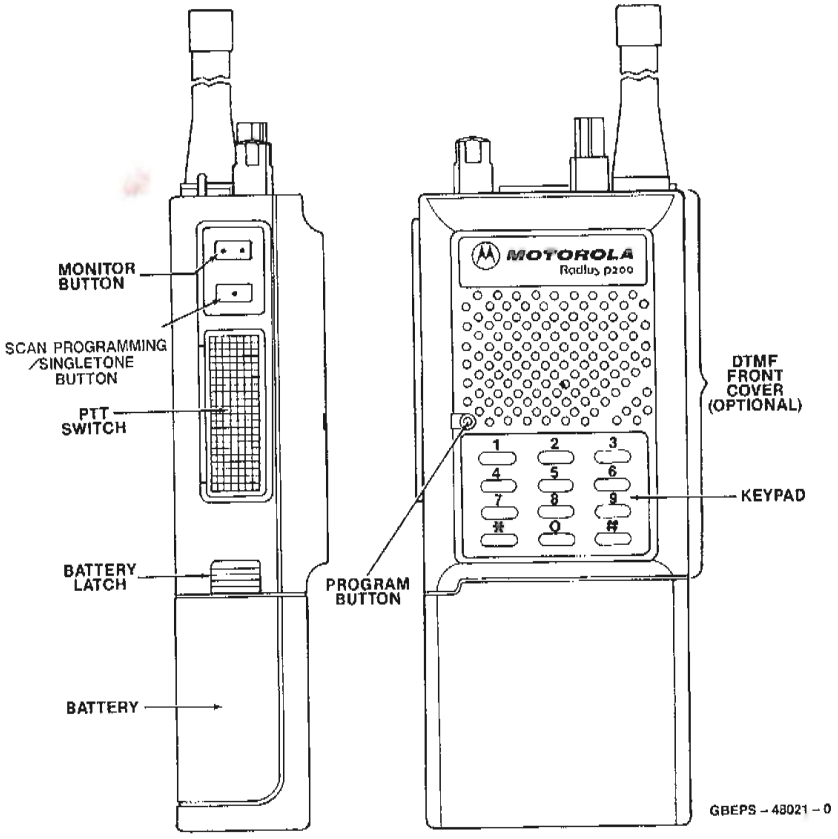

Figure 1. Typical p200 Series Radio

1. INTRODUCTION

The frequency-synthesized *p200* Lowband *Handie-Talkie* Radio is an advanced design, microcomputer-based transceiver that incorporates the latest technology available in two-way radio communications. All channel frequencies and squelch codes are stored in an Electrically Erasable Programmable Read Only Memory (EEPROM), with all transmit and receive operations controlled by a microcomputer.

The functions provided by the radio are identified by the model and option numbers shown in the model/option charts at the front of this manual. Model and option numbers are shown on the radio information sheet, which is shipped with each new radio.

a. Physical Description

All operating controls, except the Push-to-Talk (PTT) switch, the monitor button, scan program button, and the keypad (models with DTMF option), are located on top of the radio (see Figure 2). The PTT switch, monitor button, and scan program button are located on the left side of the radio (viewed from the front, see Figure 1), and the keypad (if so equipped) is an integral part of the front cover (see Figure 1).

The *p200* Lowband radio is small in size and weight, and constructed of a highly durable, impact-resistant, molded polycarbonate housing. O-rings and seals are utilized throughout the radio. All controls, including the PTT switch, the monitor buttons, and the keypad are weather resistant, and the microphone and speaker are covered with a special diaphragm to provide extra resistance against dirt, dust, and water intrusion. This proven rugged construction offers excellent protection against adverse environmental conditions.

The height of the radio varies with the size of the battery. All other dimensions are standard, except for those radios with a keypad option.

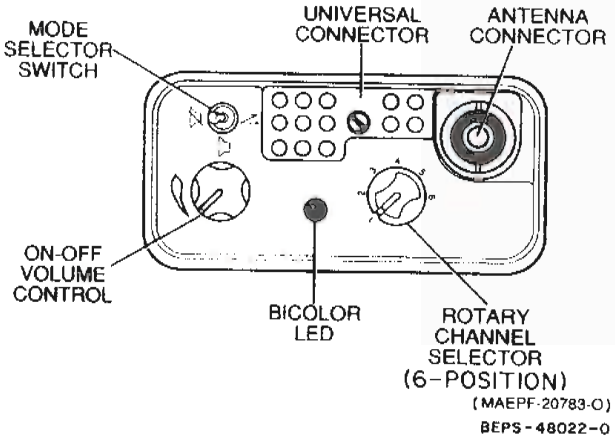

Figure 2. Top Panel Controls and Indicators

b. Electrical Description

Electrically, the radio can be divided into two basic sections: a transceiver board and a controller flexible circuit. The transceiver performs the transmit and receive functions, and the controller controls those functions.

The transceiver board includes an antenna switching circuit, a dual-conversion receiver, and a transmitter. The transmitter carrier and receiver first injection signals are generated by a common Phase-Locked Loop (PLL) consisting of a Voltage Controlled Oscillator (VCO) and a frequency synthesizer. In lowband radios, the VCO and synthesizer are combined to form a Frequency Generation Unit (FGU).

The controller flex assembly contains a microcomputer, an EEPROM that stores the channel frequencies and squelch codes, and an audio power amplifier Integrated Circuit (IC) that includes transmitter and receiver audio amplifiers. The controller flex also includes an audio filter IC which encodes and decodes (in conjunction with a microcomputer) squelch codes, adjusts and limits the audio level for correct transmitter deviation, and pre-emphasizes and de-emphasizes audio signals. Another circuit contained on the controller flex is a dc switch, which controls the radio's transmit and receive voltages.

2. STANDARD FEATURES

The *p200* Lowband radio has an internal microphone and speaker but can be operated with an optional external microphone and/or speaker. An external antenna connector and a top-mounted "universal connector" provide easy access for testing and for attaching a wide variety of audio accessories. Radio models are available with up to 6 channels of carrier, tone Private-Line®(PL), and or *Quik-Call II*™,and/or *Digital Private-Line*™ (DPL) squelch operation. Type of squelch is enabled on a per-channel basis with up to six code pairs available per radio. Power output level offered is high power (6 watts) only.

The battery pack slides onto the bottom of the radio and is held in place by a spring-loaded catch. Batteries are available in two different sizes, which correspond to the battery capacity (medium and high). The medium- and high-capacity batteries are available in standard and rapid-charge rates. The different size batteries affect the operating time between charges as well as the overall height and weight of the radio.

A bicolor LED on the top of the radio serves as user feedback. The LED indicates when the radio is in transmit mode (continuous red), a low-battery condition (flashing red), or channel-busy mode (flashing green - coded squelch application only).

3. SPECIAL STANDARD FEATURES

a. Radio Cloning

Each *p200* Lowband radio has a unique data-stored "personality" with frequencies, squelch code pairs, and other operating characteristics. Using a simple cloning cable, one radio's characteristics can be duplicated into another *p200* Lowband radio of the same bandsplit.

b. Field Programming

The *p200* Lowband radio utilizes a reprogrammable EEPROM codeplug, which permits operating characteristics to be changed without opening the radio. Programming is accomplished via a programming cable interface to IBM PC, Laptop PC, or Personal System/2 computers.

c. Multiple Digital Private-Line , Tone Private-Line Coded Squelch, and Single Combination of *Quik-Call II* Codes

Coded squelch allows only those calls with a radio's particular code to be heard, and can be enabled on a per-channel basis. So a *p200* Lowband radio can have carrier squelch on some channels, Digital PL squelch on others, Tone PL squelch on others, and *Quik-Call II* codes on even others. You can choose from 80 Digital Private-Line codes and 28 Tone Private-Line codes.

4. PRINTED CIRCUIT BOARDS AND FLEXIBLE CIRCUITS

a. General

Functional circuits in the *p200* Lowband radio are contained on (1) the Transceiver Board and (2) the Controller Flex. Five flexible printed circuits eliminate all discrete wiring, except the switched B+ wire to the Transceiver Board. Radios with keypad options have functional circuits contained on a board in the front cover.

b. Transceiver Board

The transceiver board is a two-layer or four-layer printed circuit board containing the rf and i-f portions of the radio. Almost all components are mounted on the top side of this board.

c. Controller Flex

The controller flex is packaged inside a protective flex carrier. It is a two-layer flexible printed circuit with the components surface-mounted on one side. When packaged in the flex carrier, it is folded in half with all components on the outside.

d. Interconnect Flexes

The interconnect flexes are two-layer flexible printed circuits. These include:

- PTT/B+ Flex
- Volume Pot Flex
- Frequency Switch Flex
- I-F interconnect Flex
- Front Cover Flex

e. Keypad Board (Optional)

The keypad option board is a four-layer printed circuit board mounted in the radio's front cover. All components are surface mounted on one side of the board.

5. BATTERIES

The rechargeable nickel-cadmium batteries available for the *p200* Lowband radio are listed in Table 1. Battery choice is governed by duty cycle, operating time, and maximum height and weight desired.

Table 1. Batteries for the p200 Radio

Model Number	Battery Capacity	Charge Time	*Typical Hours of Operation	
			2-Watt Radios	5-Watt Radios
NTN5561	Medium	1 Hr	8 Hrs	5 Hrs
NTN5531	Medium	1 Hr	8 Hrs	5 Hrs
NTN5521B	High	1 Hr	14 Hrs	8 Hrs
NTN5545B	High	1 Hr	14 Hrs	8 Hrs

* Based on a Duty Cycle of 5% Transmit, 5% Receive, and 90% Standby Time

BATTERY CHARGING

1. CHARGERS AVAILABLE

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

The chargers are available in slow-charge and rapid-charge models. The slow-charge models will charge the batteries, with or without the radio attached, in 16 hours (RADIO MUST BE TURNED OFF). The rapid-charge models will charge the dual-charge batteries in approximately 1 hour.

Refer to the ACCESSORIES page at the beginning of this manual for a list of the available battery chargers and their applications. For further information, contact your Motorola sales representative.

2. BATTERY CONSTRUCTION

See Figure 1. The p200 dual-charge battery has four charger contacts, two of which receive the charging current. A 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 dual-charge batteries contain an internal current-limiting device (breaker) for protection. A diode in the battery prevents damage from an accidental short between the charging contacts.

CAUTION

Sustained shorts across the radio contacts (+,-) will cause excessive current, producing excessive heat. This will destroy the internal thermal fuse, which is not replaceable.

3. BATTERY CHARACTERISTICS

Each nickel-cadmium battery consists of eight cells connected in series to provide a nominal 10-Vdc output, which remains approximately constant under load until the battery approaches a discharged condition. At this time, a marked decrease in voltage occurs and the discharge condition (1.0 volt per cell) is reached abruptly.

A general characteristic of all rechargeable batteries in storage is self-discharge. If the battery is to be used after an unknown period of storage, it is recommended that it be charged at the full charging rate using an approved battery charger.

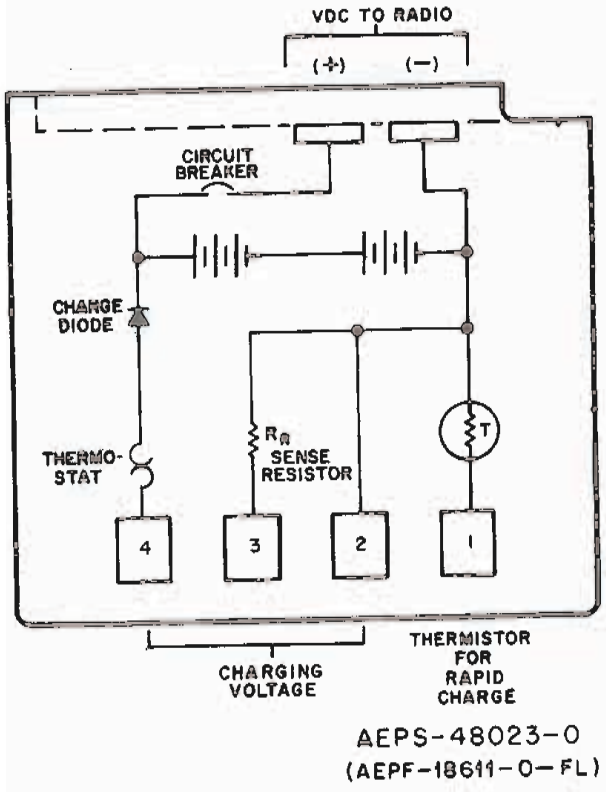

Figure 1. Typical Dual-Charge Battery Construction, Rear View

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4. MAINTENANCE

The battery cells 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 warranty and may result in permanent damage to the battery.

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 8 volts through a specified load, as described in the following procedure.

NOTE

This procedure requires using a 20-ohm, 1%, 10-watt load resistor to discharge medium-capacity batteries, and an 11-ohm, 1%, 15-watt load resistor to discharge high-capacity batteries.

a. Obtain a Radio Housing Adapter (Motorola part number 1580368B62) from your nearest Area Parts Office.

b. Connect the appropriate 20-ohm or 11-ohm load resistor (See Note above) between the gold (+) terminal and a solder lug (-) screw and nut of the housing adapter.

c. Connect a voltmeter across the load resistor and slide a fully charged battery onto the housing adapter.

d. Monitor the voltmeter as the battery discharges through the load resistor until the voltage is 8.0 volts.

e. Disconnect battery from the housing adapter (resistor load) when the cell pack reaches 8.0 volts.

CAUTION

Discharging the battery down to 4.0 volts can cause permanent cell pack damage.

f. Recharge the battery to a complete charge. This requires a 1-hour rapid charge followed by a 16-hour standard charge.

g. Re-attach the battery to the housing adapter (resistor load) and measure the elapsed time until the cell pack reaches 8.0 volts. Disconnect the battery.

h. A good battery requires 48 minutes or longer to discharge, indicating greater than 80% of rated capacity. A weak battery drops below 8.0 volts in less than 48 minutes.

1. INTRODUCTION

This section of the manual provides a functional description of the p200 Lowband radio. First, overall basic functions are discussed in general terms, with each circuit and its relationship to other parts of the radio described. Then, detailed circuit descriptions are given for each board, circuit, and module used in the radio.

2. BASIC FUNCTIONAL DESCRIPTION

a. DC Voltage Distribution *(See Figure 1)*

Operating power for the radio is derived from a 10-volt battery. This 10 volts (BATT B+), via the PTT/B+ Flex, the Frequency Switch Flex, and the Volume Pot Flex, is applied to the ON/OFF switch. When the radio is turned on, the voltage sources required to operate the various stages of the radio are distributed as shown in Figure 1. In the transmit mode (PTT actuated), a logical low on the R/T line enables the DC switch to provide the required 5 Vdc and 10 Vdc to the transmitter circuits.

b. Frequency Generation and Distribution Circuits *(See Figure 2)*

The frequency generation and distribution circuits in the p200 Lowband radio are common to both transmitter and receiver. They consist of two phase-locked loops (PLLs). One PLL provides the carrier frequency for the transmitter and the injection signal for the receiver first mixer stage. The other PLL generates the second local oscillator (LO) signal. Audio is modulated on the carrier in two different places (two-spot modulation): the VCO's frequency response allows it to modulate audio above 60 Hz, the reference modulator modulates audio below 60 Hz.

The frequency generation circuits include a reference oscillator (U106), a synthesizer (U202), and a VCO (U201). The synthesizer and VCO/Buffer are both part of a Frequency Generation Unit (FGU), U201. The reference oscillator/alternate reference oscillator generates a 16.8-MHz/2.1-MHz reference signal for the synthesizer. An external adjustment is provided to set the frequency at the output of the reference oscillator.

The following is a functional description of the transmitter first injection PLL. Initially, the VCO becomes active and generates a signal, part of which is coupled back to the synthesizer as a feedback signal. The synthesizer divides this signal and compares it to a reference frequency. If the frequencies differ, the synthesizer generates a control (error) voltage which causes the VCO to change frequency. When the VCO reaches the correct frequency, the synthesizer generates a constant control voltage signal, locking the VCO on frequency. In the transmit mode, voice audio is applied to a varactor on the VCO. The capacitance of the varactor changes in proportion to the instantaneous audio voltage, which results in a shift in carrier frequency at an audio rate. Audio below 60 Hz is modulated onto the synthesizer reference signal, which in turn causes a similar shift in the carrier frequency.

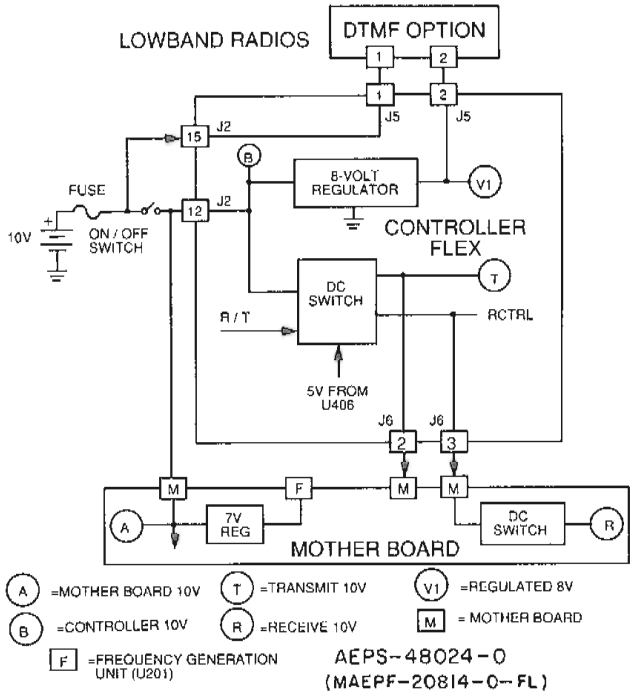

Figure 1. DC Voltage Distribution Block Diagram

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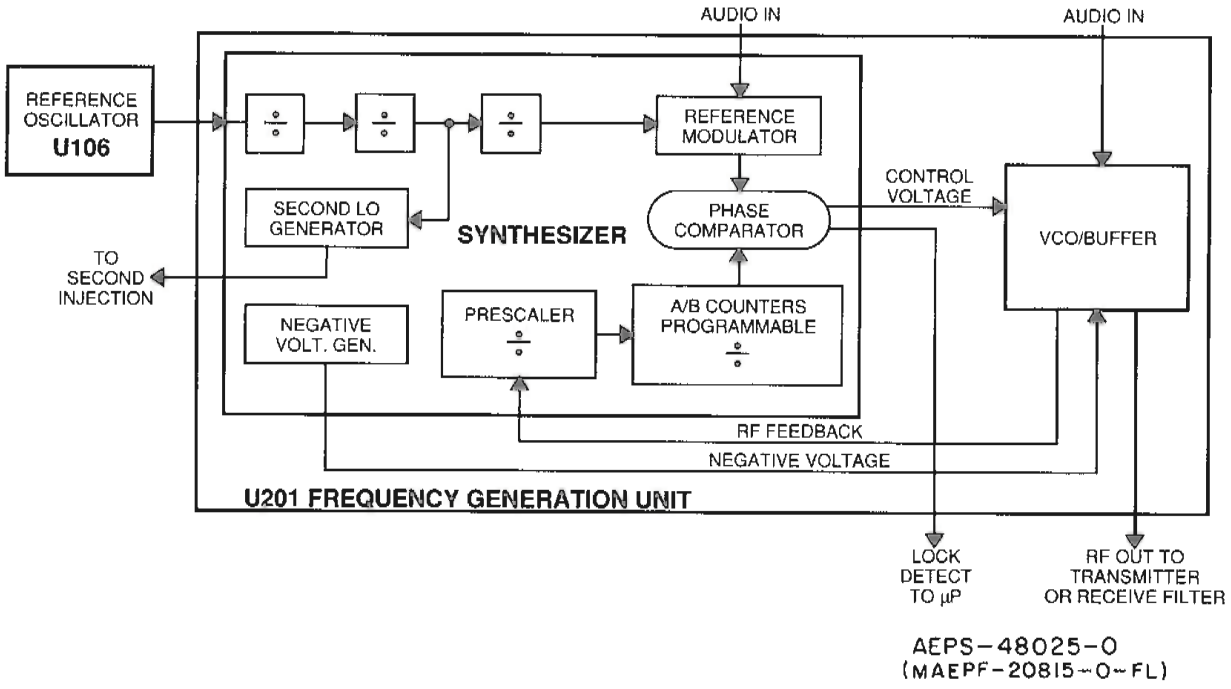


Figure 2. Frequency Generation Circuits

c. Basic Controller Functions

Module U401 is a single-chip microcomputer and is the heart of the p200 Lowband controller. It works in conjunction with the code plug (U402), which stores radio information. The controller's functions are to do the following:

- Read the PTT and channel selector switches and program the synthesizer for the desired operating frequency using the information stored in the code plug.
- Set the audio output levels for the VCO and synthesizer.
- Control the DC switch.
- Unsquelch the receiver's audio PA when a carrier is present, a correct PL/DPL/*Quik-Call* tone(s) is (are) decoded, an alert tone is generated, or the monitor button is pressed.
- Monitor the internal and external PTT.
- Control the Receive/Transmit LED.
- Monitor battery voltage.
- Perform a self-test during power-up.

d. Antenna Switch

The antenna switch consists of module U103. Through the use of pin diodes, the antenna switch directs incoming rf from either the standard or remote antenna to the receiver circuitry and directs outgoing rf from the transmitter to the remote or standard antenna.

e. Basic Receiver Operation *(See Figure 3)*

The p200 Lowband uses double-conversion superheterodyne receiver circuits to provide greater image-signal suppression and improved adjacent channel selectivity. The receiver consists of three main sections:

- Radio frequency (rf) circuits
- Intermediate frequency (i-f) circuits
- Audio frequency (af) circuits

(1) RF Signal Path

The rf signal is received by the antenna and coupled to a two-pole bandpass filter through the antenna switch. The output of the two-pole filter is amplified by an rf amplifier (Q1). The output of the amplifier is then coupled through a three-pole bandpass filter and applied to the rf input of the first mixer stage (Q2/CR5). An injection signal (FIRST LO) is applied to the second input of the mixer, resulting in an output difference frequency of19.95/16.65 MHz, which is the first i-f frequency.

(2) I-F Signal Path

The first i-f signal is passed through highly selective crystal filters (FL1 and FL2) to circuit module U1, where it is mixed with a second oscillator injection signal (SECOND LO) to produce the second i-f frequency of 450 kHz. The low conversion signal is then filtered via highly selective ceramic filters (FL3 and FL4), amplified, and demodulated. The resultant signal (RECOVERED AUDIO) is sent to the audio filter (U405) on the controller flex. Module U1 also contains a squelch detect circuit.

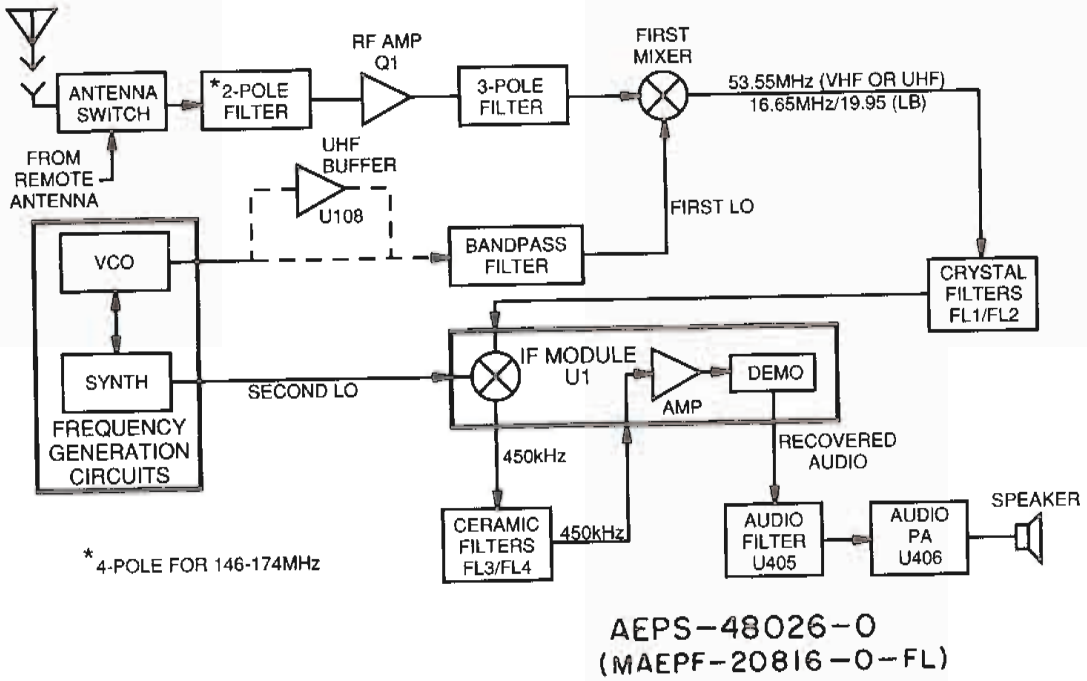


Figure 3. Frequency Generation Circuits

(3) Audio Signal Path

Recovered audio from U1 is received by the audio filter IC (U405). The audio filter performs basically two functions in the receive mode. (1)It filters, de-emphasizes, and attenuates the voice audio and routes the signal to the volume control. (2) If the radio is receiving a coded signal,

U405 low-pass filters the audio and separates the subaudible PL/DPL tones. The tones are filtered, sampled, and then sent to the microcomputer for decoding.

(4) Audio Signal Path

Recovered audio from U1 is received by the audio filter IC (U405). The audio filter performs basically two functions in the receive mode. (1)It filters, de-emphasizes, and attenuates the voice audio and routes the signal to the volume control. (2) If the radio is receiving a coded signal,U405 low-pass filters the audio and separates the subaudible PL/DPL tones. The tones are filtered, sampled, and then sent to the microcomputer for decoding.

After passing through the volume control, the audio is sent to audio PA IC (U406), which amplifies the audio and drives the speaker. The audio amplifier consists of three separate amplifiers: an internal speaker amplifier, an external speaker amplifier, and a common amplifier. If the internal speaker is selected, it is differentially driven by the internal and common amplifiers. If the external speaker is selected, it is driven by the external and common amplifiers.

Squelch circuitry resides in the i-f module (U1). Discriminator noise from U1 is sent to U405, where the noise is passed through a programmable attenuator (squelch control) and sent back to U1. The squelch circuits in U1 detect demodulator signal-to-noise ratio and produce a dc logic output (5 volts when carrier is present). This output is read by the microcomputer, which in turn programs the audio filter (U405) to enable the audio power amplifiers on U406.

f. Basic Transmitter Operation *(See Figure 4)*

The transmitter (excluding the frequency generation and distribution circuits described in earlier paragraphs) comprises two main circuits:

- Audio circuitry
- RF power amplifiers

(1) Audio Signal Path

When the PTT switch is pressed, audio from the microphone is fed to the input of the mic amplifier in U406. The amplified audio is then sent to an audio filter IC (U405), which pre-emphasizes, limits, and low-pass filters the audio. IC U405 also generates squelch codes, which are summed with the voice audio. The audio is then passed through programmable attenuators and sent to the reference modulator and VCO to be modulated.

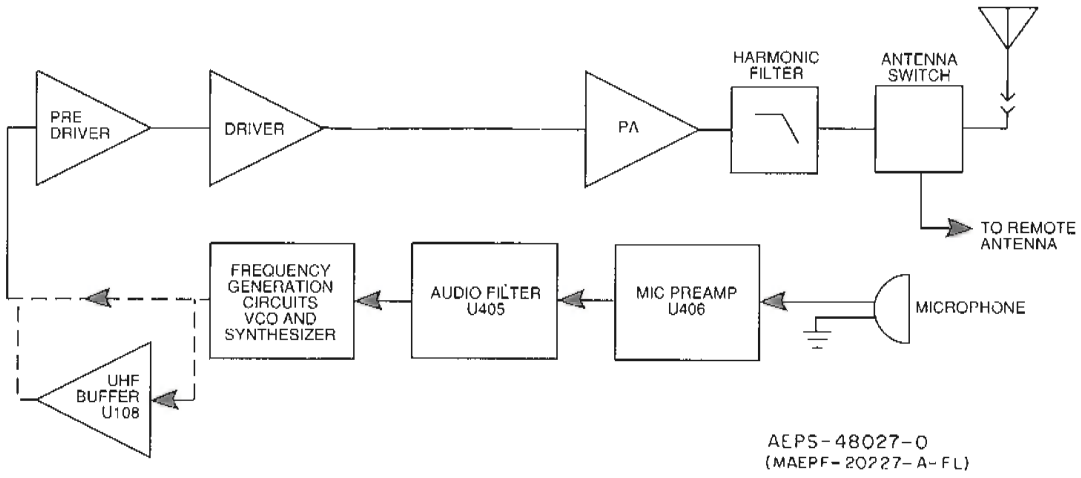


Figure 4. Transmitter Block Diagram

(2) Lowband Modulated RF Signal Path

The modulated rf carrier is applied directly from the FGU to three consecutive stages of amplification: pre-driver, driver, and final rf power amplifier.

3. DETAILED CIRCUIT DESCRIPTION

The circuit descriptions contained in the following paragraphs are supplemented with simplified schematic diagrams to help the service technician understand the signal processing in various parts of the radio. They are not intended for troubleshooting or servicing. Refer to the complete schematic diagram in this manual when repairing a radio. **When signal tracing on the schematic diagram, pay particular attention to the circles and squares around the module's pin numbers. Circles denote connections to the controller flex; squares denote connections to the main circuit board.**

a. DC Switch

Lowband radios utilize two dc switches: one on the transceiver board, the other on the controller flex.

The **transceiver dc switch** consists of module U3, diodes CR3 and CR4, and resistors R6 and R7. During receive, the RCTRL line is high, turning on module U3 to supply the receive voltage, R (10 V), to transistors Q1 and Q2. Diode CR4 is a protective device that guards against short circuiting. If the R voltage line should short, U3 pin 5 is pulled low (approximately 0.7 V), disabling B+ from the R line.

Another part of the transceiver dc switch is the 7-volt regulator, which consists of module U102, capacitor C137, and resistors R112 and R113. Module U102 is a 5-volt regulator that is offset to 8 volts through resistors R112 and R113. Capacitor C137 is used to bypass low-frequency noise. The 7-volt regulator supplies power to the frequency generation unit, U201

The **controller flex dc switch** consists of module U403, transistors Q403, Q405, and Q416, and associated circuitry. Transistors Q403 and Q405 drive the T voltage line. The dc switch receives its supply from fused 10 V, B, and the 5-volt regulator (Q400 collector). Module U403 responds to the R/T line from U405 pin 40, which is controlled by the microcomputer. The R/T line is low (0 V) in transmit and high (5 V) in receive.

The microcomputer monitors the $\overline{\text{LOCK DETECT}}$ line from the FGU (U201 pin 7). When the $\overline{\text{LOCK DETECT}}$ line is low, indicating a frequency lock condition, the microcomputer signals U405, via the microprocessor interface, to switch the output at U405 pin 39 low.

In transmit (synthesizer locked), the R/T line is at 0 volts. The R/T low is fed to the input of a NOR gate on U403. The R/T low and the lock low (U405 pin 39) are NORed to give a logic output 1. This turns on transistors Q416, Q403, and Q405 to activate the T voltage line.

In receive (synthesizer locked, Battery Saver off), the R/T line is at 5 volts. The R/T high is fed to the input of module U403, where it is NANDed with the high on the $\overline{\text{BATTERY SAVER}}$ line. The output is fed to the input of the inverter U403 pin 5 and inverted to activate the RCTRL line.

If the battery saver option is programmed into the radio, the microcomputer programs the synthesizer to strobe the RCTRL line via the $\overline{\text{BATTERY SAVER}}$ line. The battery saver signal is a square wave, which is NANDed with the 5 volts on the R/T line. The strobing of the receive voltages reduces current drain when the radio is in the stand by condition.

b. Frequency Generation and Distribution

(1) Frequency Generation Unit, FGU

The VCO, buffer, and synthesizer functions are performed by a single module, the Frequency Generation Unit (FGU), U201 (Figure 5). The FGU, in conjunction with the reference oscillator (U106), generates rf in both modes of operation (receive and transmit). In the FGU, two sections (a synthesizer section and a VCO/Buffer section) interact with each other to produce the necessary voltages and signals for rf generation. The FGU receives its power (VSS) from a 7.0-volt regulator at U102 pin 3, via interconnect point J8-4.

Within the VCO/buffer stage, an rf output is routed from the VCO to the buffer. A sample of this signal, PRESCALER OUT, is passed from the VCO/buffer to a prescaler circuit in the synthesizer section. After a frequency comparison in the synthesizer, a resultant control voltage is routed, via a loop filter in the synthesizer, back to the VCO/buffer. The voltage is between 0 and 5 volts when the PLL is locked on frequency. At the same time, a negative voltage from the synthesizer is applied to the VCO. The negative voltage and control voltage are applied at opposing ends of a varactor diode, which tunes the VCO to the correct frequency. These signals and voltages are not accessible on the main circuit board. The frequencies for respective -VEEs are shown in Table 1.

In the receive mode, 5 volts (VRX) from a dc switch in the synthesizer is applied to and enables the VCO buffer. The weak signal from the VCO is amplified by the buffer, and the resulting signal (RFF) is applied to the first injection filter via interconnect point J8-2.

During the transmit condition (PTT depressed), 5 volts (VTX) from a dc switch in the synthesizer is applied to and enables the transmit buffer. The resulting signal (TRF) is routed to the transmitter via interconnect point J8-1. Also in the transmit mode, the audio signal to be modulated onto the carrier (VCO MOD) is received in the synthesizer at interconnect point J4-1 and routed to a varactor in the VCO.

Synthesizer- The microcomputer (U401) reads the codeplug (U402) and sends setup signals, which are received by the synthesizer latch circuit. These setup signals determine the correct negative voltage and the A/B counter divide ratios needed to generate the proper rf frequencies.

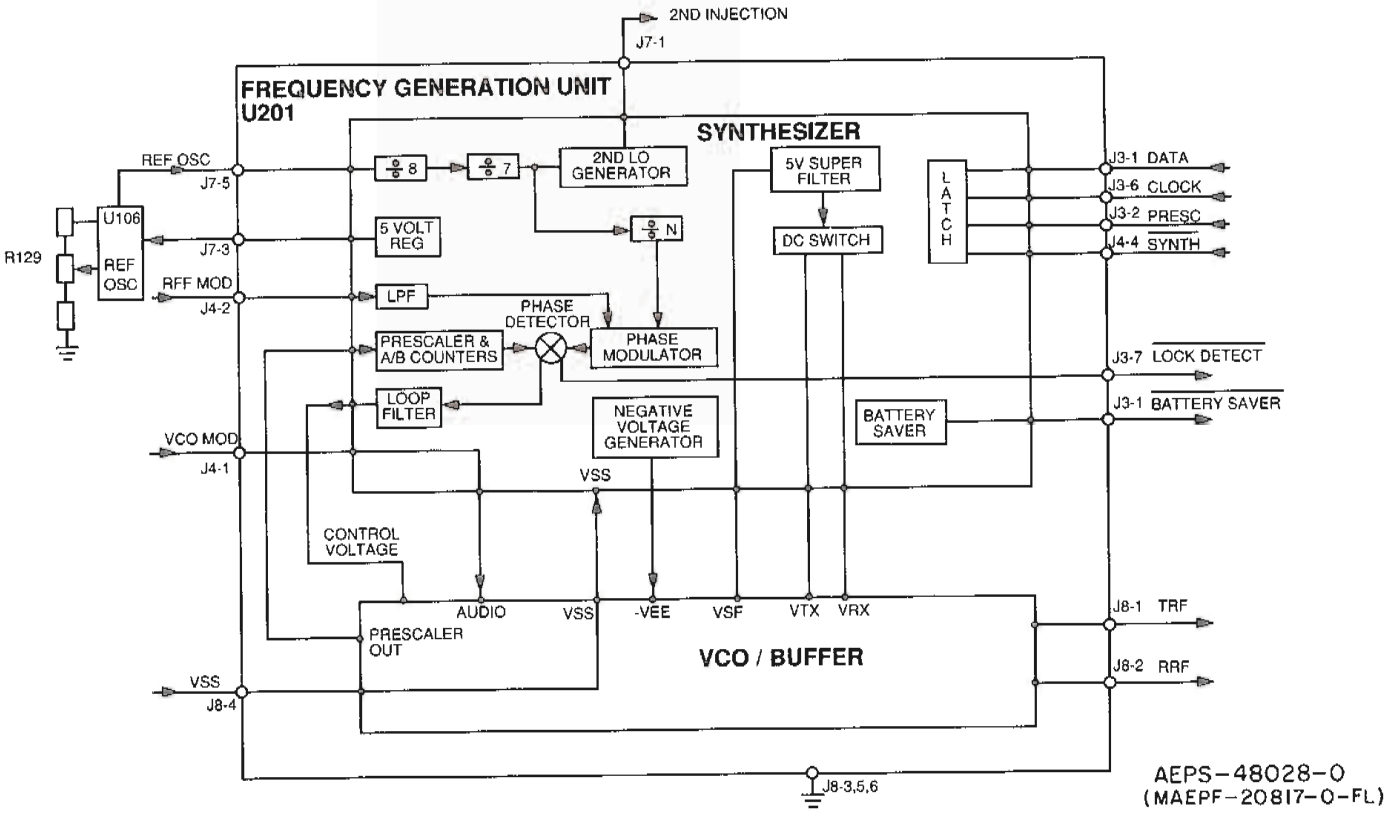


Figure 5. Frequency Generation Unit

Table 1. Negative Voltage vs User Rx and Tx Frequencies

BANDSPLIT	-VEE	Receive (MHz)	Transmit (MHz)
(LOWBAND) 30.0-36.0(MHz)	-2 -4 -6	30.00000-33.64900 33.65000-36.00000	30.00000-32.29900 32.30000-34.49900 34.50000-36.00000
36.0-42.0(MHz)	-2 -4 -6	36.00000-39.64900 39.65000-42.00000	36.00000-38.29900 38.30000-40.59900 40.60000-42.00000
42.0-50.0(MHz)	-2 -4 -6	42.00000-46.64900 46.65000-50.00000	42.00000-44.64900 44.70000-47.69900 47.70000-50.00000

The reference frequency for the synthesizer/VCO phase-locked loop is provided by a 16.8-MHz crystal oscillator (U106), which is fine tuned by resistor R120. The 16.8-MHz crystal oscillator frequency is divided first to 2.1 MHz (divide by 8) and then to 300 kHz. The 300-kHz signal is used for two different applications in the synthesizer. Lowsplit (30-36 MHz) radios may use a 2.1-MHz reference oscillator, which is fine tuned by an external fixture.

First, the 300kHz reference frequency is applied to an internal PLL circuit (within the synthesizer), which generates the receiver's second LO injection signal. The second LO is 19.5 MHz (for low-side injection) or 20.4 MHz (for high-side injection) for low-split radios and 16.2 MHz (LSI) or 17.1 (HSI) for mid- and high-split radios. This signal is routed to the i-f module U1 via interconnect point J7-1.

Second, the 300-kHz frequency is further divided to produce a VCO/synthesizer PLL reference frequency of 5.0 kHz (or 6.25 kHz), which is applied to a phase modulator. In the transmit mode, the phase modulator modulates audio below 60 Hz (PL/DPL tones) onto this reference signal. The reference signal is then fed, as one of the two inputs, to a phase detector. The second input to the phase detector comes from the VCO. This second signal is received by the synthesizer, divided by a prescaler circuit, divided again by an A/B counter circuit, and then applied to the phase detector. The phase detector circuit compares the two input signals. If the frequencies are not the same, a control voltage (error voltage) is generated and sent to the VCO, ultimately pulling the PLL on frequency. When the two frequencies are the same, the phase detector outputs a low on the LOCK DETECT line. This LOCK DETECT low is routed to the microcomputer, which in turn sets the radio transmit and receive voltages. Refer to the "DC Switch" section for a more detailed explanation.

c. Controller *(See Figure 6)*

Module U401 is a single chip, 8-bit microcomputer that performs control and processing functions. It works in conjunction with the code plug, which stores the radio personality in its non-volatile memory. The microcomputer controls three data buses: the code plug bus, the FGU/audio filter IC bus, and the radio programming bus..

The code plug data bus is bi-directional, meaning that data can be sent to or received from the code plug. When the microcomputer wants to access the code plug, it pulls $\overline{\text{CODE PLUG POWER}}$ (U401, pin 7) low, turning on the supply to the code plug(s) through Q402. The microcomputer then transmits the address of the data to the code plug on the data bus by toggling CODE PLUG CLOCK (U401, pin 4). The data then becomes available on CODE PLUG DATA (U401, pin 5). During a read instruction, data is input to the microcomputer from the code plug. During a write instruction, data is output from the microcomputer to the code plug(s)

The FGU/audio filter IC programming bus is uni-directional, meaning that data is sent from the microcomputer to the FGU (U201)/audio filter IC (U405). The bus is synchronous, and the flow of data is controlled by SPI CLOCK (U401, pin 23). The data appears on SPI DATA (U401, pins 21 and 22).

The FGU has two separate programming latch circuits, which are controlled by $\overline{\text{PRESC}}$ (U401, pin 17) and $\overline{\text{SYNTH}}$ (U401, pin 16). When programming the synthesizer module, the microcomputer first pulls $\overline{\text{PRESC}}$ low and sends data using SIP CLOCK and SIP DATA. $\overline{\text{PRESC}}$ is then pulled high and $\overline{\text{SYNTH}}$ is pulled low. The microcomputer again sends data using SIP CLOCK and SIP DATA. When data transfer is complete, $\overline{\text{SYNTH}}$ is pulled high. The synthesizer module is now programmed for the new operating frequency. To program the audio filter IC, $\overline{\text{AF SELECT}}$ (U401, pin 18) is pulled low. The data is transferred using SIP CLOCK and SIP DATA. When the data transfer is complete, $\overline{\text{AF SELECT}}$ goes high.

The radio programming bus is bi-directional, meaning that data can be sent to or received from the microcomputer. The bus is asynchronous and data is sent or received on SCI DATA (pins 20 and 19). The flow of data is controlled by BUSY (U401, pin 15). A low on the BUSY line indicates that a message exists on the DATA line.

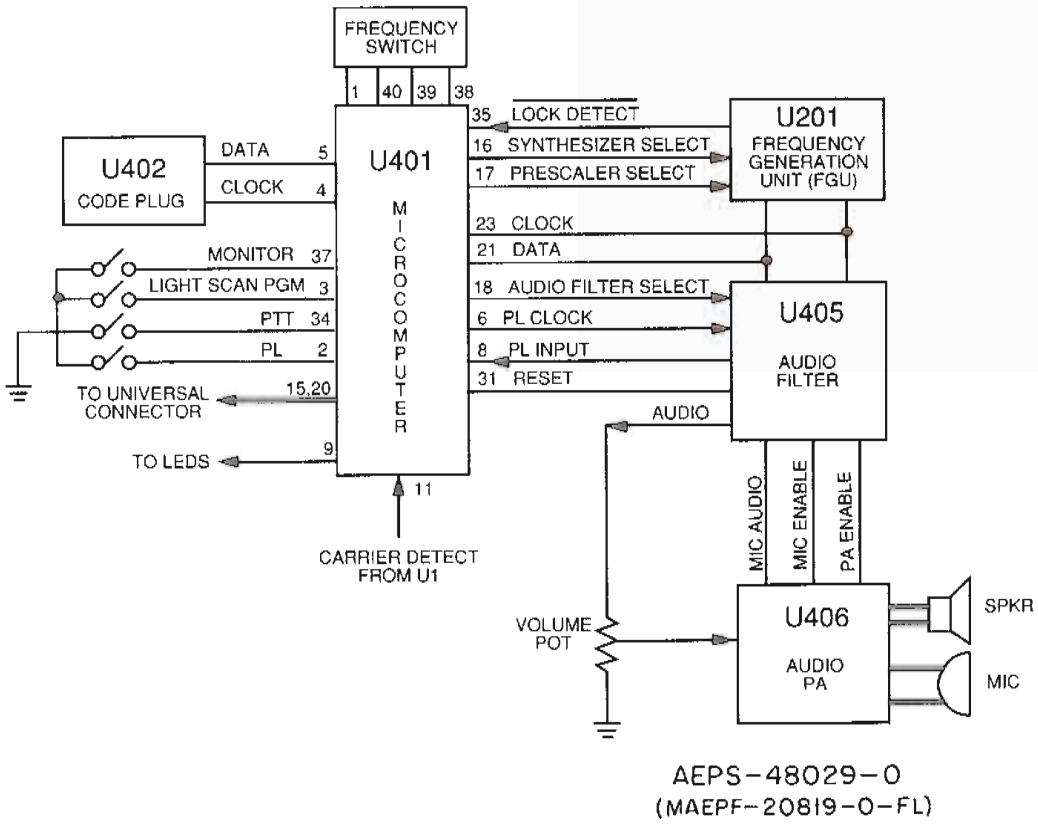


Figure 6. Microcomputer Interface

(1) Microcomputer (U401) functions

- Read the PTT and channel selector status and program the FGU (U201) for the desired operating frequency using the data stored in the code plug.
- Program the audio filter IC (U405) to set the audio output levels to the speaker or FGU module (U201).
- Control the dc switch circuits that supply B + and other voltages to the receiver and transmitter at various times. It does this by signaling the audio filter IC (U405) to set the R/T line (U405, pin 40) and the dc switch enable line at U405, pin 39.
- Program the audio filter IC (U405) to unsquelch the radio when a carrier is detected, when a squelch code is detected, when an alert tone is to be generated, or when the monitor button is pressed.
- Control the flashing of the LED by turning transistor Q401 on and off.

(2) Microcomputer (U401) Input/Output Pin Functions

- **Vss** (pin 10) – Ground for the microcomputer.
- **CARRIER DETECT** (pin 11) – This input to the microcomputer goes high when a carrier is present. It is used in conjunction with CHANNEL ACTIVITY to determine if the radio should be unsquelched.
- **$\overline{\text{CVC IN}}$** (pin12)–This input to the microcomputer is normally high. When the radio is put into a CVC, this line will be pulled low and the microcomputer will reprogram the volume attenuator in the audio filter IC (U405) to a preset value. A low on this pin causes pin 11 of U404 to go high and pin 2 of U404 to go low, resulting in audio being routed around the volume control.
- **CHANNEL ACTIVITY** ((pin 13) – This input to the microcomputer is used to determine if carrier is present. A high on this line indicates the presence of carrier. This line is sampled several times before sampling the CARRIER DETECT line to determine if the radio should be unsquelched.
- **SELECTIVE CALL DECODE** (pin 14) – This input to the microcomputer is a filtered and limited signal from the demodulator used by the microcomputer to decode a selective call.
- **$\overline{\text{BUSY}}$** ((pin 15) – This line is bi-directional and is used to indicate the presence of data on the programming bus.
- **$\overline{\text{SYNTH}}$** (pin 16) – This output from the microcomputer is used when programming the FGU module (U201).
- **BIPOLAR SEL** (pin 8) or **$\overline{\text{PRESC}}$** (pin 17) – This output from the microcomputer is used when programming the synthesizer module (U202) for uhf and vhf, or FGU module (U201) for lowband radios.

- **$\overline{\text{AF SELECT}}$** (pin 18) – This output from the microcomputer is used when programming the audio filter IC (U405). It is also used to reset a watchdog timer in the audio filter IC (U405), ensuring that the microcomputer is operating properly. When the microcomputer is operating properly, this line is pulsed at a periodic rate.
- **SCI DATA** (pins 19, 20) – These lines are the asynchronous, bi-directional lines used for communicating with the microcomputer.
- **SPI DATA** (pins 21, 22) – These lines are the synchronous uni-directional lines used for communicating with the FGU (U201) and the audio filter IC (U405).
- **SPI CLOCK** (pin 23) – This output from the microcomputer is the clock line used when programming the FGU (U202) or audio filter IC (U405).
- **SLAVE SELECT** (pin 24) – This input to the microcomputer enables the SPI CLOCK and SPI DATA lines.
- **ADAPT** (pin 25) – This output from the microcomputer goes high whenever the channel changes and when going from transmit to receive mode. It causes the squelch circuitry to go into a fast mode of operation.
- **$\overline{\text{LOW BATTERY}}$** (pin 26) – This input to the microcomputer goes low when the radio battery voltage drops below approximately 8.5 volts. The microcomputer responds by flashing the red LED when in the transmit mode.
- **OSC1, OSC2** (pins 28, 29) – These two lines are connected to the 3.6864-MHz crystal that provides the reference clock frequency for the microcomputer.
- Vcc (pin 30) – 5-Vdc power for the microcomputer.
- **$\overline{\text{RESET}}$** ((pin 31) – A low on this line resets the microcomputer. The microcomputer is reset by the watch dog timer on the audio filter IC (U404).
- **$\overline{\text{IRQ}}$** (pin 32) – This pin is not used and is pulled to 5 volts through a resistor.
- **$\overline{\text{PTT}}$** (pin 34) – This input to the microcomputer goes low when the PTT switch is pressed and signals the microcomputer to enable the transmitter circuitry.
- **$\overline{\text{LOCK DETECT}}$** (pin 35) – This input to the microcomputer goes low when the synthesizer is locked on frequency.
- **LIGHT/SCAN PROGRAMMING** (pin 36) – This input to the microcomputer goes low when the light/scan programming button is pressed. It is used to put the radio into scan programming mode.
- **MONITOR** (pin 37) – This input to the microcomputer goes low when the monitor button is pressed. The microcomputer responds by turning on the audio.
- **CHANNEL SELECT** (pins 1, 38, 39, 40) – On rotary radios, channel selection is made via the freq sw (S3). Channel 1 corresponds to all pins being low, while channel 16 corresponds to all pins being high.
- **PL SWITCH** (pin 2) – This input to the microcomputer goes low when the mode select switch is in the PL mode. The microcomputer responds by turning on the PL CLOCK (pin 6) when carrier is detected.
- **SCAN SWITCH** (pin 3) – This input to the microcomputer goes low when the mode select switch is in the scan mode.
- **CODE PLUG CLOCK** (pin 4) – This output from the microcomputer is used to clock data in and out of the code plug(s).
- **CODE PLUG DATA** (pin 5) – This input/output from the microcomputer receives data from or sends data to the code plug(s).
- **PL CLOCK** (pin 6) – This output from the microcomputer is the reference clock used when encoding/decoding PL.
- **$\overline{\text{CODE PLUG POWER}}$** (pin 7) – This output from the microcomputer is used to power-up the code plug(s).
- **PL DECODE** (pin 8) – This input to the microcomputer receives filtered and limited squelch code signal from the audio filter IC (U405).
- **LED CONTROL** (pin 9) – This output from the microcomputer turns on the LEDs through Q401.

d. Antenna Switch and Filters

In transmit, 10 volts (T) is supplied to diodes CR101/CR102 via resistor R116 and coils L121 and L117. This puts a high impedance in the receiver path, which allows transmitter power to be delivered to the standard or remote port. When T is removed, the antenna switch reverts to the receive mode. Grounding the REMOTE ANTENNA SELECT line (pin 1) selects the remote antenna, while an open circuit selects the standard antenna. With the remote antenna selected, a low impedance path exists between pin 4 and pin 5. When the standard antenna is selected, a low-impedance path exists between pin 4 and pin 2. Coil L120 and capacitors C126, C127, and C128 match the output of U103 to the standard antenna. Inductor L118 and capacitors C123, C124, and C125 match the remote port of U103 to the universal connector. When the remote antenna is selected, current flows via resistor R115 to turn on the remote port.

e. Receiver Selectivity and RF Amplifier

The received signal at the antenna is routed through the antenna switch and antenna matching networks and applied to the receiver rf front end for filtering and amplification.

There are five poles of filtering for rf front end selectivity. Coils L1, L2, L3 and capacitors C1 through C4 form a two-pole tuned Butterworth filter with a bandwidth greater than 6 MHz (for low- and mid-split radios) or

greater than 8 MHz (for high-split radios). Coils L4, L5, and L6, together with their associated components, form a three-pole Chebyshev filter. Different coupling techniques are used on the three band splits. On low-split radios, the filters are capacitively coupled using capacitors C33 and C34; on mid-split radios, mixed coupling is used with capacitor C33 and inductor L15; on high-split radios, inductive coupling is used with coils L14 and L15. The three different coupling approaches are used to obtain the best image rejection.

The rf amplifier (Q1) is a low-noise rf transistor, configured in the common-emitter mode for high gain. Collector voltage shunt feedback through resistor R15 and capacitor C35 is used to improve the linearity of the rf amplifier for better intermodulation. Resistors R1, R2, and R3 provide the dc biasing for transistor Q1. The incoming rf signal from the two-pole filter is fed to the base of transistor Q1, and the resultant amplified signal at the collector of Q1 is coupled to the three-pole filter using capacitive, inductive, or mixed coupling, which is dependent on the band split of the radio.

f. Receiver, First Mixer, Crystal Filter, and Injection Buffer

A double-balanced mixer (CR5) is used to down convert the carrier to the intermediate frequency. The carrier and LO are coupled to the mixer via balanced transformers T1 and T2. The output of CR5 is routed to a diplexer consisting of components L9, C25, R9, R10, and C26. This diplexer is designed to terminate the mixer to 50 ohms at off-channel frequencies. The i-f signal is then amplified by an i-f amplifier (Q2), which is configured in the common-base mode. Transistor Q2 is biased via resistors R12 and R13 and inductor L12.

The output signal from the first i-f is fed to filters FL1/FL2, which are four-pole quartz crystal filters resonant at the i-f frequency. Lowband radios use two different i-f frequencies, 19.95 MHz for the low-split frequency range or 16.65 MHz for the mid- and high- split frequency ranges. The FL1/FL2 filter provides approximately 35-dB adjacent channel protection. Components C15, C16, L12, C31, L13, and C19 provide impedance matching between the output of the crystal filter and the input to the i-f module, U1, pin 7. The i-f signal is passed to the i-f module (U1) for further signal processing.

A receive buffer module in the frequency generation unit (U201) outputs the injection signal (RRF) to the ring mixer, CR5. The RRF signal output at interconnect point J6-2 is applied to the ring mixer via a two-pole capacitively coupled filter, which is comprised of components R5, C12, L7, C22, L8, C13, and C14. The filter circuit provides buffering to the injection frequency and rejection to the unwanted harmonics of the injection string.

g. Receiver Second I-F and Signal Processing *(See Figure 7)*

Module U1 contains the second mixer, i-f amplifier, PLL demodulator, noise amplifier and filters, and squelch circuitry. The first i-f signal (19.95 MHz/16.65 MHz) is received at U1, pin7. The second LO injection signal from the FGU (U201, pin 1) is received by the mixer at U1, pin 9. The desired output frequency from the mixer is 450 kHz. Therefore, the oscillator injection frequency must be 450 kHz above or below the first i-f frequency. The second oscillator frequency is 19.5 MHz (low-side injection) or 20.4 MHz (high-side injection) for the low split, or 16.2 MHz (low-side injection) or 17.1 MHz (high-side injection) for the mid and high splits.

The resulting 450-kHz second i-f signal is filtered by the ceramic filter FL3 and FL4 to reject unwanted mixing products. The second i-f signal is then amplified and can be monitored at M1 (U1, pin 4 or 12). The signal is then demodulated, and the resultant audio can be monitored at U1, pin 1. The audio is then passed to the audio filter IC(U405)

The squelch controller circuit contained in module U1 is a noise detection circuit. The noise output from the squelch controller at U1, pin 5 is routed to U405 to be attenuated by a programmable squelch attenuator. It is then fed back through U1, pin 7 to the carrier detect circuitry. When the noise level exceeds the threshold level set by the squelch pot on U405, U1, pin 9 (CARRIER DETECT line) goes low, indicating the absence of a carrier signal. The microcomputer reads this CARRIER DETECT low and programs the audio filter (U405) to turn off the power amplifiers on U406 by pulling the PA EN line (U405, pin 3) low. If the noise is less than the threshold level set by the attenuator on U405, U1, pin 9 (CARRIER DETECT line) goes high, indicating the presence of a carrier signal. The microcomputer reads this CARRIER DETECT high and programs the audio filter (U405) to turn on the power amplifiers (U406) by outputting a high PA EN signal (U405, pin 3).

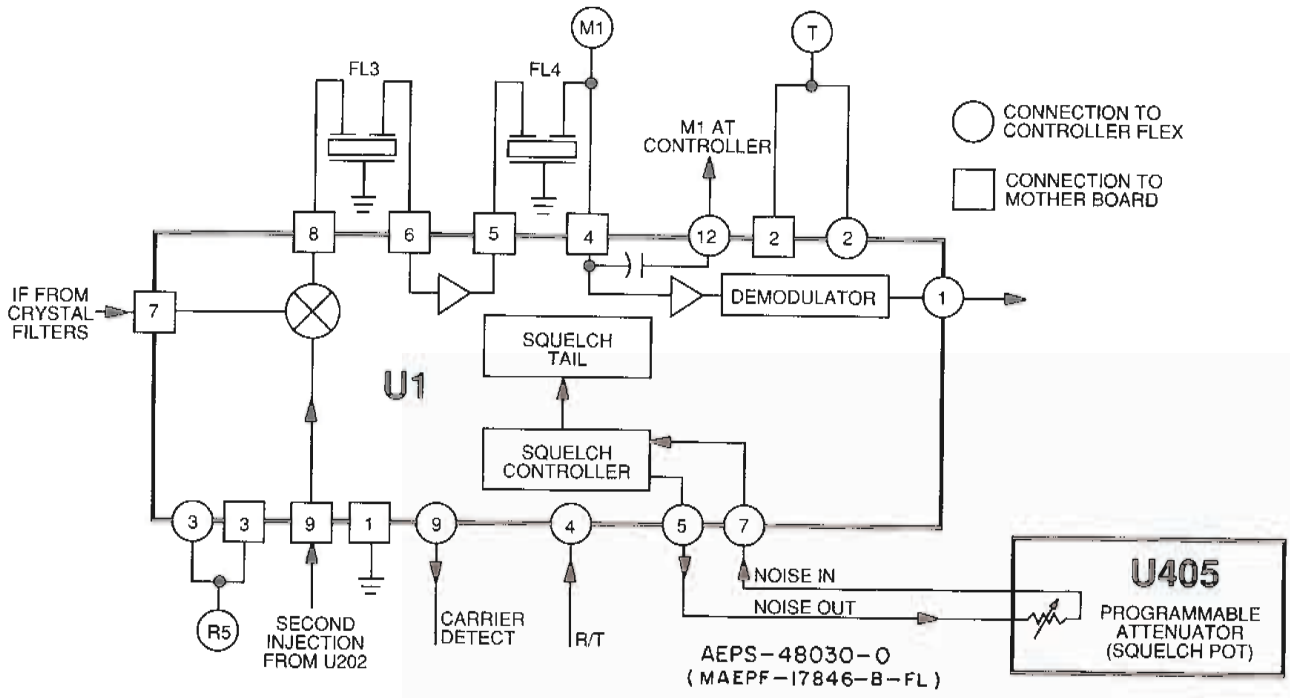


Figure 7. U1, I-F Module

h. Receiver Audio Circuitry *(See Figure 8)*

The recovered audio from U1 is routed to the audio filter IC (U405, pins 7 and 8). The audio is low-pass filtered to separate squelch codes, and high-pass filtered to separate voice. Squelch codes are filtered, sampled, and sent to the microcomputer (U401, pin 38). If the radio is in the PL/DPL squelch mode, the microcomputer turns on its decoding circuitry. When the squelch codes are decoded, the microcomputer sends program signals to a microprocessor interface circuit in the audio filter module (U405). The audio filter IC, via the PA EN line, turns on the audio PA IC (U406).

After high-pass filtering, voice audio is de-emphasized, filtered, sent through a programmable attenuator (volume control), and then passed from the audio filter to the volume pot (U405, pin 23 to R140) or through the analog switch (U404) if CVC sense is actuated. Audio is routed from the volume pot to the audio PA IC (U406, pin 10) and applied to three audio power amplifiers: internal PA, external PA, and common PA. The common PA is active for both internal and external speaker applications. Without an external speaker connected, a high input on the EXTERNAL SPEAKER SELECT line (U406, pin 24) biases the internal PA, and audio from the internal and common power amplifiers is 180 degrees out of phase, which drives the internal speaker (LS1) differentially. Audio from the common power amplifier and external power amplifier is in phase.

If an external speaker is attached to the radio's universal connector, the EXTERNAL SPEAKER SELECT line (U406, pin 24) is pulled low. This low biases the external PA and shifts the audio output of the common amplifier 180 degrees. This phase shift does two things. First, it puts the audio output from the common amplifier 180 degrees out of phase with the audio output from the external amplifier, and the external speaker is driven differentially. Second, audio from the common power amplifier and internal power amplifier is in phase, which results in no audio drive for the internal speaker.

i. Transmitter Audio Circuitry *(See Figure 9)*

Audio from the microphone is routed to the audio power amplifier (U406), which contains two microphone amplifiers (internal and external). Pressing the PTT switch (internal or external) pulls U401, pin 34 low. The microcomputer reacts by programming the microprocessor interface on U405 to output a low on the R/T line (U405, pin 39). This low is inverted by U403 and applied to U406, pin 18, which enables the microphone circuits. If the internal PTT switch is pressed, a high is present at U406, pin 20, enabling the internal amplifier. If the external PTT switch is pressed, U406, pin 20 is pulled low, and the external microphone amplifier is enabled. Module U406 amplifies and high-pass filters the audio. The audio signal is then routed from U406, pin 19 to the audio filter (U405, pin 10), where it is pre-emphasized, limited, and sent through a splatter filter. In PL/DPL applications, the audio is summed with the squelch codes, which are generated in U405. The audio is then attenuated by two programmable attenuators, and the resultant audio signal is routed from U405, pin 20 to the VCO modulation port (U201, pin 5), and from U405, pin 19 to the reference modulator input at U202, pin 9.

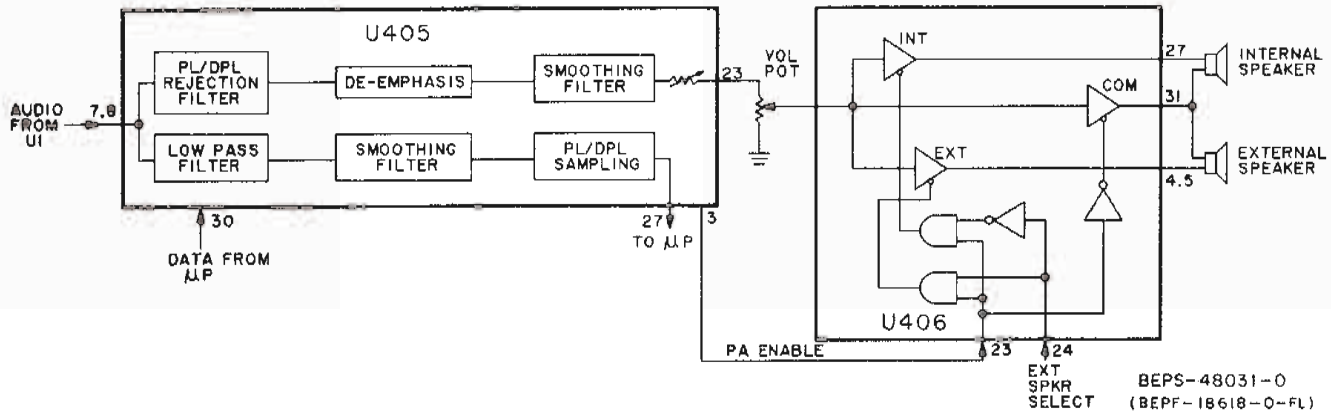


Figure 8. Receiver Audio Circuitry

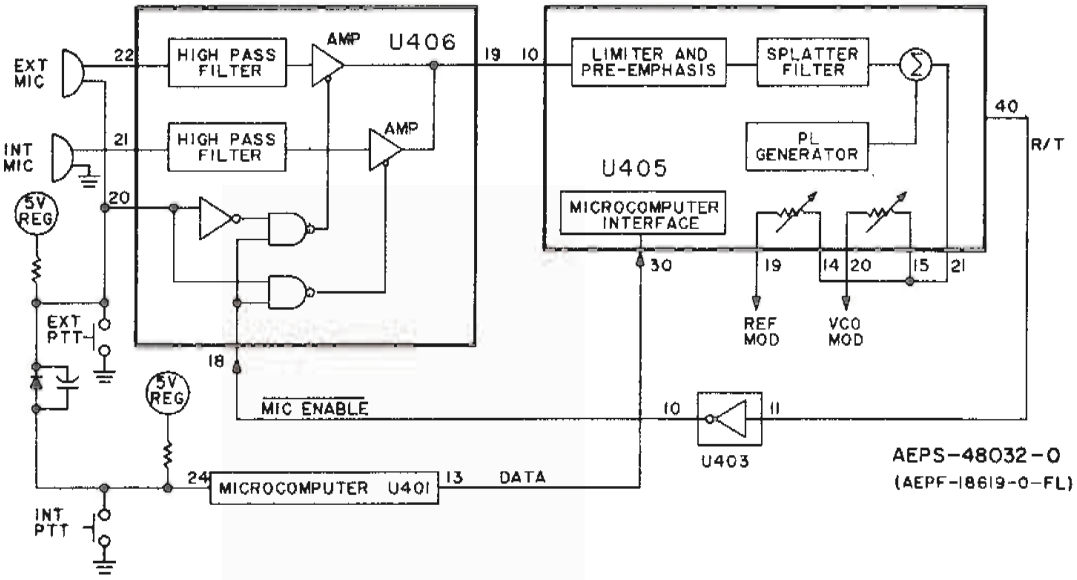


Figure 9. Transmitter Audio Circuitry

j. Transmitter

Transmit rf (TRF), originated in the FGU, is routed from interconnect point J8–1 to the base of the predriver stage, transistor Q101. Impedance matching between the FGU buffer and the predriver is accomplished by components L101, L102, C102, C103, C104, and C105. Transistor Q101 operates in the class AB mode and is turned on via the T voltage line. The collector of Q101 is biased through inductor L103. The output on the collector of Q101 is matched to the input on the base of Q102 by coils L104 and L105 and capacitors C106, C107, C108, and C109. Transistor Q102 is powered via the B+ line and operates in the class C mode. Capacitor C138 and resistors R107, R122, and R124 provide stage stability. A dc ground return for the base is provided by inductor L106 and resistor R106. The output on the collector of Q102 is matched to the input on the base of driver Q103 by coils L108 and L109 and capacitors C111 and C112. Components R109, R111, R121, C114, and C160 provide PA stage stability. Transistor Q103 is powered via the B+ line and operates in the class C mode. A dc ground return for the base of Q103 is provided by inductor L123 and resistor R108. Power adjust is accomplished at Q102 and Q103 by trimmer capacitors C159 and C115, respectively. Nominal output power is 6.0 watts. A five-pole elliptical filter, consisting of inductors L115 and L116 and capacitors C117, C118, C119, C120, and C121 is used to reject unwanted harmonics. The output on the collector of transistor Q103 is matched to the input of the elliptical filter by inductors L115 and L116 and capacitor C116. The output of the fil-

ter is matched to the input of the antenna switch (U103) through coil L124 and capacitor C129.

k. Dual-Tone Multiple Frequency (DTMF) Circuits (Optional) *(See Figure 10)*

(1) Timed Tone Option

The DTMF circuit receives its power from unswitched battery B+ and an 8-volt regulator (U407) on the controller flex, via connector plug P701. When the radio is turned on, the regulated 8 volts supplied to the DTMF board is routed through a low-pass filter network (R729 and C725). The 8 volts is applied to audio amplifier U702, pin 6 and to the 5-volt regulator (U706). The regulated 5 volts is used throughout the circuit. Module U701, the heart of the DTMF circuit, receives its supply voltage (5 volts) through steering diode CR702. When the radio is turned off, the 5 volts is removed and U701 is supplied with memory retention voltage from the radio's unswitched B+ through resistor R701 and steering diode CR701. Resistor R706 and capacitor C701 act as a low-pass filter to keep noise off the IC's supply line. Capacitor C701 is also a memory retention cap. When the radio's battery is removed, C701 will hold memory retention voltage for 2 minutes. **If the battery is not replaced within 2 minutes, memory will be lost.** All of the 47-pF capacitors are used for rf bypassing.

Transistor Q701 and resistors R722 and R716 lock and unlock the keypad. When the radio is on, Q701 is saturated, U701, pin 22 is pulled low, and the keypad is unlocked. When the radio is turned off, Q701 is off, U701, pin 22 is pulled high through resistor R716, and the keypad is locked up.

Integrated circuit U701 is a CMOS tone generator. Components Y701, R726, C722, and C723 form the oscillator circuit for the tone generator. When a key is pressed, U701 goes into the encode mode and outputs the appropriate tone on pin 21. Module U701 also sends a low (MUTE output) from pin 23 to NOR gate U703D, pin 3. The tone (DTMF OUT) is routed through the deviation adjusting network of R720 and potentiometer R709 and applied to pin 6 of isolation switch U704B. If the control "C" input at U704B, pin 4 is high, the switch closure is made and the DTMF tone output at U704B at pin 7 is applied to the radio's INT MIC IN line via connector plug P701, pin 3.

The purpose of the isolation gate (NOR gate U703D) is to prevent the transmission of beep tones. Therefore, the switch (U704B) will only close when a DTMF tone is to be transmitted, which is determined by a high output of NOR gate U703D at pin 4. This high output is achieved when both inputs are low. One input (pin 3) goes low every time a DTMF tone is generated. The other input (pin 2) goes low whenever the radio is in transmit, via the saturation of transistor Q703.

The function of FET transistor Q702 is to mute the microphone during tone transmission. If the microphone was not muted, noise could get mixed with the DTMF tones and prevent successful decoding. Transistor Q702 is controlled by the MUTE output (U701, pin 23). When no tone is present, the mute line is pulled high by resistor R728, transistor Q702 is on, and the microphone has a low- impedance path to ground. When a DTMF tone is generated, the mute line goes low, Q702 is turned off, and the microphone is no longer grounded. Therefore, the microphone is muted. It is also necessary to mute the microphone when beep tones are generated. When a beep tone is present, switch U704C closes and transistor Q702 turns off. The time that Q702 stays off is controlled by the RC network of C724 and R719.

The combination of U703B, U703C, U704A, R707, R708, C705,C703, and R723 is the beep-tone oscillator circuit. When a "*" or a "#" command key is pressed, or when any key is pressed during the program mode, module U701 generates a pacifier tone. This tone, which lasts for approximately 30 milliseconds, is applied to beep tone gate U704A, which responds with a low output at pin 9. The low at U704A, pin 9 is applied to the beep-tone oscillator (U703B, pin 10), which responds by generating a 2000-Hz beep tone. The beep tone continues until U703B, pin 10 goes high, which is determined by the RC network of C703 and R723 (approximately 57 milliseconds).

DTMF and beep tones are routed to the sidetone/beep-tone amplifier U702. This IC amplifies the tones and sends them to the speaker. Amplifier U702 is enabled when pin 1 is pulled low through CR704A or CR704B, which occurs when module U701 is in the program mode or when the radio is in transmit. Resistor R702 and capacitor C702 control the duration of the DTMF tones and the rate at which the tones are generated during automatic dialing. Tone duration is set at 150 ms.

Program switching is accomplished by U704D, U703A, U705, R703, R704, R705, and CR703. Pressing the program button puts the DTMF circuit in the program mode by grounding the control line of U704D, which in turn causes pin 39 of U701 to be pulled high through resistor R705. With module U701 in the program mode (U701, pin 39 high), numbers can be stored in the memory registers. When the program button is not pressed, the control line of U704D is pulled high through R727, the switch (U704D) is closed, pin 39 of U701 is grounded, and U701 is in tone mode.

R731 is removed in radios with the ANI version DTMF circuit to prevent programming DTMF functions. In order to put module U701 into the program mode (a high at U701, pin 39), both inputs (pins 6 and 8) of U703A must be low. This can be accomplished only by using the ANI programming fixture to push the program button.

(2) Continuous Tone Option

Integrated circuit U801 is a DTMF tone generator that accepts inputs from the keypad. The option is supplied from the radio's 8-volt line. During tone generation, the IC outputs a high on its MUTE line 1 (pin 8). This output mutes the microphone by saturating Q804 which turns off Q802, resulting in a high-impedance path to ground for the microphone. The MUTE line also turns on Q801, which supplies a path to ground for the resistor divider network of R804 and R805.

The tone generator outputs a tone on pin 16 of U801. This tone level is reduced by R804 and R805 and is applied to the radio's MIC line to be transmitted. The tones are also divided by R806 and R807 and routed to the side-tone amplifier (U802). The amplified tones are then sent to the radio's speaker for user feedback.

The amplifier is enabled by the radio's MIC line. In the transmit mode, the MIC line is at 5 volts. This turns on Q803 and pulls pin 1 of U802 low, enabling the amplifier.

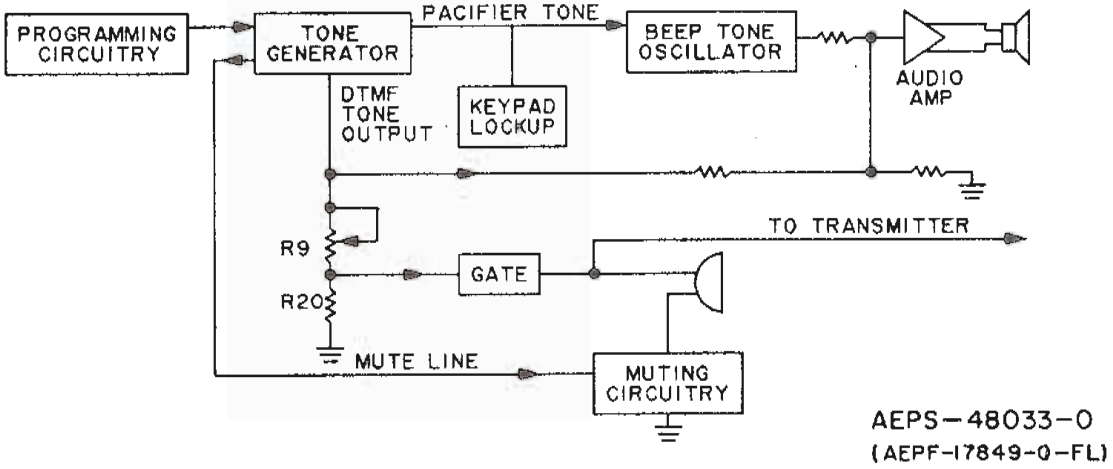


Figure 10. DTMF Option Diagram

1. INTRODUCTION

This section of the manual describes disassembly and reassembly procedures, recommended repair procedures, and special precautions regarding maintenance. Each of these topics provides information vital to the successful operation and maintenance of the p200 radio.

2. PREVENTIVE MAINTENANCE

The p200 radio does not require a scheduled preventive maintenance program; however, periodic visual inspection and cleaning is recommended.

a. Inspection

Check that the external surfaces of the radio are clean and that all external controls and switches are functional. A detailed inspection of the interior electronic circuitry is not needed or desired.

b. Cleaning

The following procedures describe the recommended cleaning agents and the methods to be used when cleaning the external and internal surfaces of the radio. External surfaces include the front cover, housing assembly, and battery case. These surfaces should be cleaned whenever a periodic visual inspection reveals the presence of smudges, grease, and/or grime. Internal surfaces should be cleaned only when the radio is disassembled for servicing or repair.

The only recommended agent for cleaning the external radio surfaces is a 0.5% solution of a mild dishwashing detergent, such as JOY® detergent, in water. The only factory recommended liquid for cleaning the printed circuit boards and their components is ISOPROPYL alcohol (70% by volume).

JOY is a registered trademark of Proctor and Gamble

CAUTION

The effects of certain chemicals and their vapors can have harmful results on certain plastics. Aerosol sprays, tuner cleaners, and other chemicals should be avoided.

(1) Cleaning External Surfaces

(a) Polycarbonate Surfaces

The detergent-water solution should be applied sparingly with a stiff, non-metallic, short-bristled brush to work all loose dirt away from the radio. A soft, absorbent, lintless cloth or tissue should be used to remove the solution and dry the radio. Make sure that no water remains entrapped near the connectors, cracks, or crevices.

(b) Silverized Surfaces

A non-metallic, soft-bristled brush should be used to apply the detergent-water solution to silverized surfaces, and a second non-metallic soft-bristled brush (free of detergent or rinsed in clean water) should be used to remove the detergent-water solution.

Upon completion of the cleaning process, a soft, absorbent, lintless cloth or tissue should be used (with a blotting action) to dry the frame and covers. The blotting action will prevent damage to the silverized conductive coating.

(2) Cleaning Internal Circuit Boards and Components

Isopropyl alcohol may be applied with a stiff, non-metallic, short-bristled brush to dislodge embedded or caked materials located in hard-to-reach areas. The brush stroke should direct the dislodged material out and away from the inside of the radio.

Alcohol is a high-wetting liquid and can carry contamination into unwanted places if an excessive quantity is used.

Make sure that controls or tunable components are not soaked with the liquid. Do not use high-pressure air to hasten the drying process since this could cause the liquid to puddle and collect in unwanted places.

Upon completion of the cleaning process, use a soft, absorbent, lintless cloth to dry the area. Do not brush or apply any isopropyl alcohol to the frame, front cover, or back cover.

NOTE

Always use a fresh supply of alcohol and a clean container to prevent contamination by dissolved material (from previous usage).

3. DISASSEMBLY (Refer to Figure 1)

Disassembly of the radio involves removal of the major components listed below, one at a time, in the sequence described in the following paragraphs. In the following instructions, "item 1," "item 2," etc., refer to the items indicated by circled numbers in Figure 1.

NOTE

1. Several special tools are required to completely disassemble the radio. Refer to the "Test Equipment and Service Aids" and "Torque and Tool Specifications Chart" in the front of this manual.
2. Before proceeding, make sure that the radio is turned off.

a. Battery Removal

To remove the battery (item 2) from the radio, proceed as follows:

Step 1. Turn the radio off (item 1).

Step 2. Hold the radio with the front of the radio facing up.

Step 3. Disengage the battery latch from the battery by pushing and holding the latch towards the top of the radio.

Step 4. With the battery latch disengaged, slide the battery from left to right to remove it from the baseplate on the bottom of the radio housing.

b. Gaining Access to Internal Components

CAUTION

The p200 Lowband radio contains complementary metal-oxide semiconductor (CMOS) devices, which are highly susceptible to damage in handling due to static discharge. The entire printed circuit board should be treated as static sensitive. Damage can be latent, resulting in failures occurring weeks or months later.

DO NOT attempt to disassemble the radio without first referring to "Safe Handling of CMOS Devices" in the front of the manual.

Step 1. Remove the battery as described in paragraph a.

Step 2. Remove the two screws (item 3) from the back of the radio.

Step 3. Remove the two screws (item 4) on the bottom of the radio (baseplate corners).

Step 4. Loosen the two captive screws (item 5) on the bottom of the radio (middle of each baseplate). Do not completely remove the captive screws from the baseplate.

Step 5. Lift the front cover (item 6) from the radio housing, being careful not to pull against the speaker/microphone flex.

Step 6. Disconnect the speaker/microphone connector from the controller flex (item 7) by grasping the speaker flex strain relief (near the plug) and pulling the plug straight out and away from the circuit board.

Step 7. With a thumb and forefinger, grasp the antenna (item 8) at its base and pull lightly to remove the frame assembly from the radio housing. Do not press the PTT switch during removal.

Step 8. Remove the antenna by unscrewing it counterclockwise.

Step 9. Remove the four screws that secure the main back shield to the frame.

Step 10. Remove the main back shield by pulling it straight out and away from the radio.

c. Removing the Controller Assembly (item 9)

Step 1. Perform steps 1 through 8 of paragraph b.

Step 2. Remove the plastic retainer clip that holds the two connectors in place at the top of the controller.

Step 3. Remove the four screws (two on each side) that secure the controller carrier to the frame.

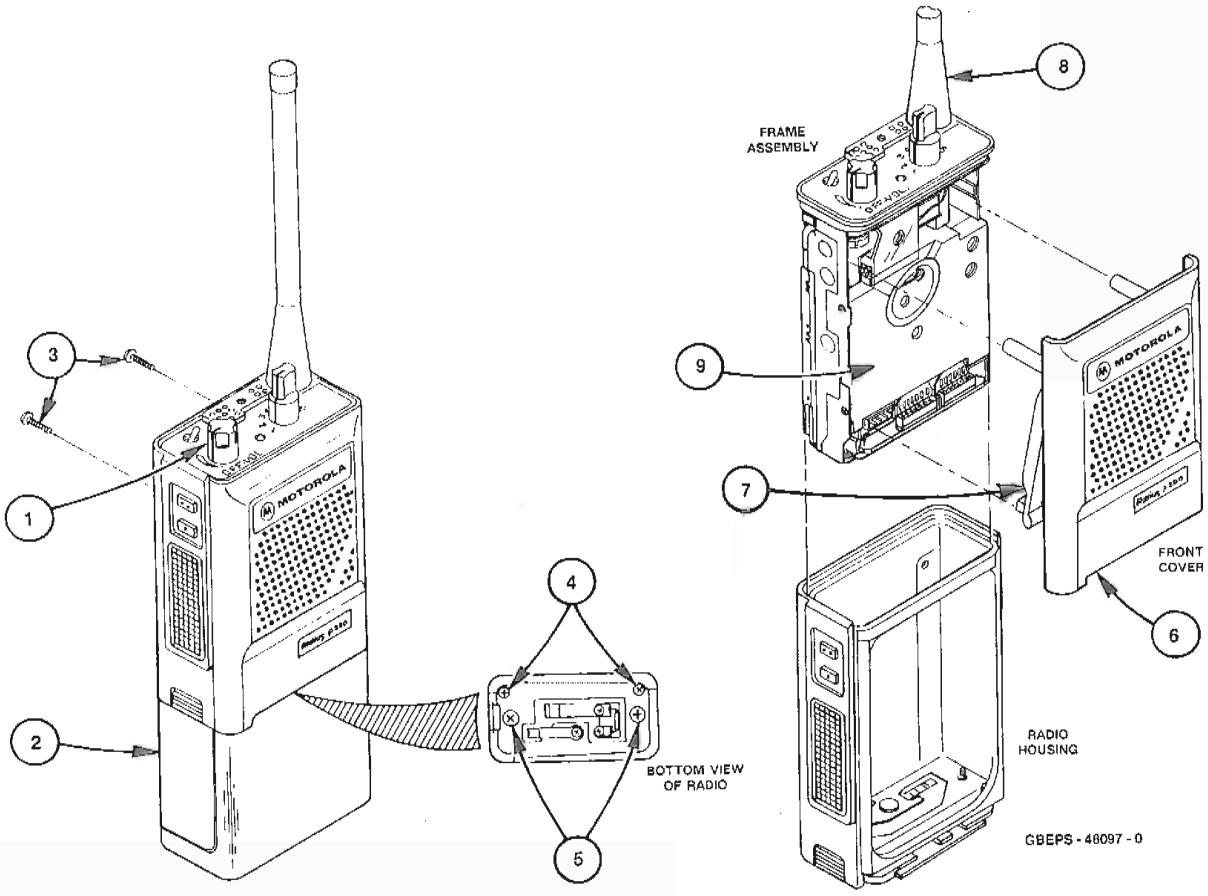


Figure 1. Disassembly Detail

NOTE

Be careful to pull each connector straight out and away from the mating socket so as not to bend or break the connector pins.

Step 4. Disconnect the two bottom flex connectors by carefully sliding them away from the synthesizer.

Step 5. Lift the controller circuit (nearest the bottom of the radio) away from the radio just enough to gain access to the connector under the controller.

Step 6. Disconnect the connector under the controller.

Step 7. Disconnect the two connectors at the top of the controller.

Step 8. Lift the controller assembly totally away from the radio.

d. Gaining Access to the Controller Flexible Circuit

Step 1. Perform steps 1 through 8 of paragraph c.

Step 2. Remove the screws that secure the bottom shield to the top flex carrier.

Step 3. Along the top edge of the controller assembly (edge nearest speaker clearance indentation), gently pry the bottom shield away from the top flex carrier.

Step 4. Pull the bottom shield completely away from the top flex carrier and remove the controller flexible circuit.

e. Removing the Transceiver Board from the Frame

Step 1. Perform steps 1 through 8 of paragraph c.

Step 2. Remove the four screws that secure the main back shield and remove the shield.

Step 3. Unsolder four contacts (two pins and one frame ground connection) located next to the screw (top–center rear of transceiver board). Also, unsolder the antenna ferrule located on the top–left rear corner of the transceiver board.

Step 4. Remove one screw (top–center rear of transceiver board) that secures the transceiver board to the frame.

Step 5. Unsolder and remove the red B+ wire (controller side of radio) from the On–Off / Volume switch potentiometer.

CAUTION

Always place the On–Off/Volume switch potentiometer in the 'On' position before soldering to this switch and return to the 'Off' position when finished soldering.

Step 6. Gently pull the transceiver circuit board straight out and away from the frame.

f. Removing the Control–Top Panel Components

Step 1. Perform steps 1 through 6 of paragraph e.

NOTE

All control–top panel components, except the antenna jack, are connected on two flexible circuits, which are connected together and should be removed as one unit.

Step 2. Remove the control knob(s) by pulling straight out and away from the control–top panel.

Step 3. Remove the Teflon washer(s).

Step 4. The escutcheon is stuck to the top surface of the control–top panel with adhesive. Gently pry one corner of the escutcheon away from the control–top panel and then peel the escutcheon completely away. Notice that washer(s) are stuck on the back side of the escutcheon.

Step 5. Remove the hex nut and washer from the volume potentiometer.

Step 6. On rotary radios, remove the hex nut and washer from the frequency switch.

Step 7. Using a spanner wrench, remove the spanner nut and washer from the PL switch.

Step 8. Unsolder and remove the black wire from the volume potentiometer flex.

Step 9. Unsolder the nine solder joints between the flex and the universal connector pins, then remove the flex.

Step 10. Unsolder the three legs of the LED and pull the flex away from the LED's legs.

Step 11. Unsolder the nine solder joints between the PC board and the universal connector pins, then remove the PC board.

NOTE

Be careful not to apply too much heat to the pins.

Step 12. The frequency switch flex connects to the PTT/B + flex with five solder tabs located along the side of the frame near the monitor popple switch.

NOTE

A capacitor is placed across the last two tabs.

Unsolder the five contact tabs and, with "solder–wick," remove the solder and separate the two flexes.

Step 13. Push the switch shaft(s) until clear of the mounting holes and remove the flex circuits and control–top panel components from the frame.

g. Removing the Control–Top Panel and LED

Step 1. Perform steps 1 through 10 of paragraph f.

Step 2. On rotary radios, unsolder the ground pin of the universal connector contacting the frame (near the antenna bushing).

Step 3. Remove the screw and washer located near the antenna receptacle.

Step 4. Gently pull the control–top panel away from the frame.

Step 5. Push the LED and rubber boot out of the control–top panel and pull the LED out of the rubber boot.

Step 6. In display radios, remove the screw by the antenna ferrule to release the control top from the frame.

h. Removing the Battery Latch

Step 1. Perform steps 1 through 7 of paragraph b.

Step 2. Remove the ground contact screw that holds the negative battery contact. Be careful not to lose the lockwasher, contact, and rubber pad (under the contact).

Step 3. While holding the latch slide, carefully pull the baseplate assembly away from the housing.

Step 4. Carefully slide the latch out of the housing.

Step 5. Remove the exposed latch springs.

i. Removing the PTT / B + Flex

Step 1. Perform steps 1 through 7 of paragraph b.

Step 2. Two corners of the PTT / B + flex are soldered to the frame. Remove the solder, using "solder–wick."

Step 3. The PTT / B + flex connects to the frequency switch flex with five solder tabs located along the top side

of the frame near the PL switch. Unsolder the five contact tabs and, with "solder-wick," remove the solder and separate the two flexes.

NOTE

A capacitor is placed across the last two tabs.

Step 4. The PTT / B+ flex is stuck to the frame with adhesive. Carefully peel the PTT / B+ flex away from the frame.

4. REASSEMBLY (Refer to Figure 1)

1. DO NOT attempt to reassemble the radio without first referring to the "Safe Handling of CMOS Devices" paragraph in the front of this manual.

2. DO NOT attempt to reassemble the radio without first referring to the "TORQUE AND TOOL SPECIFICATIONS CHART."

3. Inspect all O-rings and replace if obvious damage exists.

a. Reinstalling the Battery Latch and Base Plate

Step 1. Insert the two springs into their proper holes and replace the slide latch.

Step 2. Position the base plate and hold it firmly to compress the springs.

Step 3. Holding the base plate in place, install the negative battery contact, being sure that the rubber pad is in place in the cup of the contact.

Step 4. Reinstall the screw and lockwasher in the negative battery contact. Tighten the screw per the "TORQUE AND TOOL SPECIFICATIONS CHART."

b. Reinstalling the PTT / B+ Flex

Step 1. Position the PTT / B+ flex to the frame such that the five contact tabs line up with the corresponding tabs on the frequency switch flex. Note that a little oval hole in the corner of the flex (near the solder tabs) mates with a round dot on the frame.

Step 2. Press the flex to the frame. Note that two more places, holes in the flex, correspond to dots on the frame.

Step 3. Resolder the five solder tabs connecting the PTT / B+ flex to the frequency switch flex.

NOTE

A capacitor is placed across the last two tabs.

Step 4. Resolder the two corners of the flex to the frame.

c. Reinstalling the LED and Control-Top Panel (Rotary Radios)

Step 1. Insert the LED into the rubber boot such that the flat edge of the LED's base mates with the flat edge inside the boot.

Step 2. Insert the LED and boot into the control-top panel.

Step 3. Place the control-top panel on the frame.

Step 4. Reinstall the screw and washer located near the antenna receptacle and tighten the screw per the "TORQUE AND TOOL SPECIFICATIONS CHART."

Step 5. Resolder the ground pin of the universal connector to the frame.

d. Reinstalling the LCD and Control-Top Panel (Display Radios)

Step 1. Insert the LCD into the molded control-top panel.

Step 2. Place the control-top and LCD board on the frame.

Step 3. Reinstall the screw located near the antenna receptacle and tighten the screw per the "TORQUE AND TOOL SPECIFICATIONS CHART."

e. Reinstalling the Control-Top Panel Components

Step 1. Insert the switch shafts into the proper holes.

Step 2. Slide the universal connector PC board over the interconnect pins and solder the board to the nine pins.

Step 3. Resolder the three LED legs to the frequency switch flex.

Step 4. Solder the volume potentiometer flex to the nine universal connector pins.

Step 5. Resolder the black ground wire to the volume potentiometer flex.

Step 6. Resolder the five solder tabs of the frequency switch flex to the corresponding tabs of the PTT/B+ flex.

Step 7. Reinstall the PL switch washer and spanner nut and tighten per the "TORQUE AND TOOL SPECIFICATIONS CHART."

Step 8. Reinstall the frequency switch (rotary radios only), volume potentiometer washers, and hex nuts and

tighten each screw per the "TORQUE AND TOOL SPECIFICATIONS CHART."

Step 9. Reinstall the escutcheon.

Step 10. Reinstall the Teflon washer(s) on the frequency switch (rotary radios only) and volume potentiometer shafts.

Step 11. Reinstall the switch knob(s).

f. Reinstalling the Transceiver Board

Step 1. With the frame's backside lying down, and viewing the transceiver board from the solder side with the assembly upright, slightly spread the sides of the frame and slide the transceiver into the frame.

Step 2. Turn the unit over and resolder the loose end of the red B+ wire to the On–Off/Volume switch potentiometer.

CAUTION

Always place the On–Off/Volume switch potentiometer in the 'On' position before soldering to this switch and return to the 'Off' position when finished soldering.

Step 3. Reinstall one screw (top–center rear of transceiver board) that secures the transceiver board to the frame and tighten securely.

Step 4. Resolder four contacts (two pins and one frame ground connection) located next to the screw (top–center rear of transceiver board). Also, resolder the antenna ferrule contact (top–left rear corner of board).

Step 5. Press the main back shield (edges over the frame) flush to the transceiver board.

Step 6. Reinstall the four screws that secure the main back shield to the frame and tighten each screw per the "TORQUE AND TOOL SPECIFICATIONS CHART."

g. Reassembling the Controller Assembly

CAUTION

Make sure that the flex insulator is installed around the controller flex before placing the controller flex into the carrier.

Step 1. With the outside surface of the carrier lying down and the controller flex folded over (shield–to–shield), align the holes in the flex with the corresponding holes in the carrier and place the flex into the carrier. Make sure that the grooves of the P1 and P2 jacks slide into the tabs of the carrier. Also, make sure that the J5 jack is seated properly in the carrier.

Step 2. Align the controller bottom shield to the controller flex and carrier. In the J5 jack area, slide the tab of the shield under the slot in the carrier and press the bottom shield into place (sides of the bottom shield fit inside the sides of the carrier).

Step 3. Reinstall the screws that secure the bottom shield to the controller carrier and tighten each screw per the "TORQUE AND TOOL SPECIFICATIONS CHART."

h. Reinstalling the Controller Assembly

NOTE

Be careful to push each connector straight into the mating socket so as not to bend or break the connector pins.

Step 1. Reconnect the two top flex connectors, firmly seating both plug/jack connections.

Step 2. Reconnect the connector under the controller, firmly seating the plug/jack connection.

Step 3. Press the controller into place (inside of frame sides).

Step 4. Reconnect the two bottom flex connectors, firmly seating both plug / jack connections.

Step 5. Reinstall the four screws (two on each side) that secure the controller carrier to the frame and tighten each screw per the "TORQUE AND TOOL SPECIFICATIONS CHART."

Step 6. Insert the plastic retainer that holds the top two connectors in place.

i. Final Reassembly

Step 1. Insert the internal radio unit into its housing and tighten the two screws on the baseplate per the "TORQUE AND TOOL SPECIFICATIONS CHART."

Step 2. Reconnect the speaker / microphone connector, being careful to push the connector straight into the mating socket so as not to bend or break the connector pins.

Step 3. Reinstall the front cover.

Step 4. Reinstall the two screws on the bottom of the radio (baseplate corners), and tighten the screws per the "TORQUE AND TOOL SPECIFICATIONS CHART."

Step 5. Reinstall the two screws that secure the front cover to the housing and tighten each screws per the "TORQUE AND TOOL SPECIFICATIONS CHART."

Step 6. Reinstall the antenna.

Step 7. Reinstall the battery.

5. REPAIR PROCEDURES AND TECHNIQUES

CAUTION

Leadless component technology requires the use of specialized equipment and procedures for repair and servicing of the p200 Lowband radio. If you are not totally familiar with leadless component repair techniques, it is strongly recommended that you either defer maintenance to qualified service personnel and service shops or take the recommended video taped leadless component repair training program, MAV-PACK 3 (VIC-952) (see **Service Aids and Recommended Tools** in the front of this manual). This is of paramount importance, as irreparable damage to the radio can result from service by unauthorized persons. Unauthorized attempts to remove or repair parts may void any existing warranties or extended performance agreements with the manufacturer.

a. Parts Replacement and Substitution

Special care should be taken to be as certain as possible that a suspected component is actually the one at fault. This special care will eliminate unnecessary unsoldering and removal of parts, which could damage or weaken other components or the printed circuit board itself. When damaged parts are replaced, identical parts should be used. If the identical replacement component is not locally available, check the parts list for the proper Motorola part number and order the component from the nearest Motorola Communications Parts office listed in the "Replacement Parts Ordering" section of this manual.

b. Rigid Circuit Boards

The p200 radio uses bonded multilayer printed circuit boards. Since the inner layers are not accessible, some special considerations are required when soldering and unsoldering components. The printed-through holes may interconnect multiple layers of the printed circuit. Therefore, care should be exercised to avoid pulling the plated circuit out of the hole.

When soldering near the module socket pins, use care to avoid accidentally getting solder in the socket. Also, be careful not to form solder bridges between the module socket pins. Closely examine your work for shorts due to solder bridges. When removing modules with metal enclosures, be sure to desolder the enclosure ground tabs as well as the module pins.

c. Flexible Circuits

The flexible circuits are made from a different material than the rigid boards, and different techniques must be used when soldering. Excessive prolonged heat 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-degree tip and use small-diameter solder such as ST-633. The smaller-size solder melts faster, which has the advantage that less heat need be applied to the circuit. To replace a component on a flexible circuit, grasp the edge of the flexible circuit with seizers (hemostats) near the part to be removed, 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. Prolonged application of heat may damage the flexible circuit.

MOTOROLA INC.
Communications
Sector

ALIGNMENT PROCEDURES

1. RECOMMENDED TEST EQUIPMENT

The list of equipment contained in Table 1 includes all of the standard test equipment required for servicing two-way portable radios, as well as several unique items designed specially for servicing the P200 radio. Battery operated test equipment is recommended when available. The "Characteristics" column is included so that equivalent equipment may be substituted; however, when no information is provided in this column, the specific Motorola model listed is either a unique item or substitution is not recommended.

2. GENERAL

THIS RADIO HAS BEEN FACTORY ALIGNED AND DOES NOT REQUIRE ANY ADJUSTMENTS. Realignment may be required if components are replaced or have aged, or if any transmitter/receiver frequencies are changed. If it is necessary to realign the radio, perform the following procedures:

1. When using the RTX-4005 test box, place the **MT PL** switch in the **OFF** position.
2. Remove the battery and front cover as described in the "DISASSEMBLY" paragraphs located in the maintenance section of this manual.

Table 1. Test Equipment

Motorola Model No.	Description	Characteristics	Application
R2200, R2400, or R2001D with Trunking Option	Service Monitor	This monitor will substitute for items with an asterisk (*)	Frequency/deviation meter and signal generator for wide-range troubleshooting and alignment
*R1049A	Digital Multimeter		Two meters recommended for ac/dc voltage and current measurements
*S1100A	Audio Oscillator	67-Hz to 161.4-Hz tones	Used with service monitor for injection of PL tones
*S1053D *SKN6009A *SKN6001A	AC Voltmeter Power Cable for Meter Test Leads for Meter	1 mV to 300 V, 10-megohm input impedance	Audio voltage measurements
R1053	Dual-Trace Oscilloscope	20-MHz bandwidth 5 mV/cm - 20 V/cm	Waveform measurements
*S1350C *T1013A	Wattmeter	50 ohm, ±5% accuracy	Transmitter power output measurements
S1339A	RF Millivolt Meter	100 µV to 3 V rf 10 kHz to 1.2 GHz	RF level measurements
*R1013A	SINAD Meter		Receiver sensitivity measurements
S1347D or S1348D (programmable)	DC Power Supply	0-20 Vdc, 0-5 amperes current limited	Bench supply for 7.5 Vdc
RTX4005B RTK4205A	Portable Test Set and Test Cable		Enables convenient connection to the accessory jack, with switching for complete testing of radio

*R2200, R2400, or R2001D will substitute for items with an asterisk (*)

3. Refer to the Test Set-Up Detail illustration and connect the test equipment and Computer/RIB to the radio as illustrated.

4. Connect a dc power supply to the battery eliminator and attach the battery eliminator to the radio.

5. Adjust the power supply for 10.0 Vdc. Set current limit to 2.0 A.

6. Turn the radio off then on to reinitialize the radio.

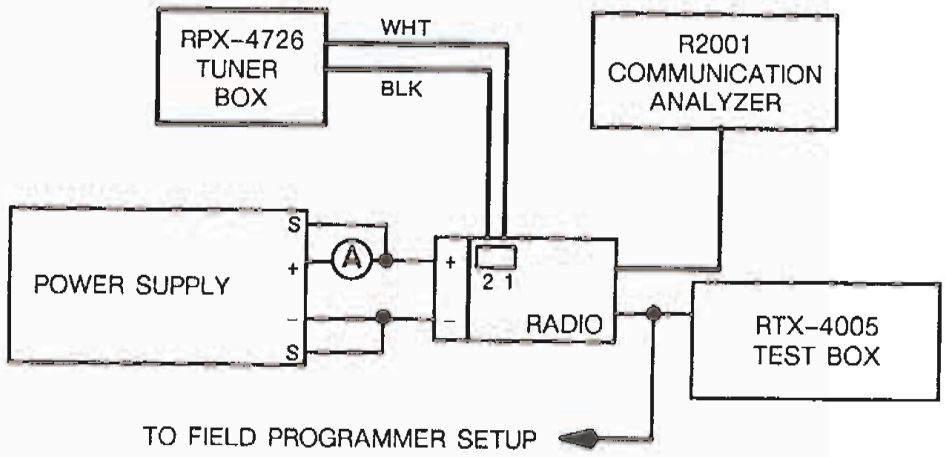
7. **Frequency Adjust (Synthesizer)** – Terminate the program/test cable (RTK-4205A), RF lines (pins 10 and 12), through a 30-dB pad to a frequency counter or service monitor. Set the radio to any channel. Key the radio using the external PTT switch. Compare the frequency reading on the counter (or service monitor) to the customer frequency assigned to that channel. The frequency difference should be less than ±300 Hz. Adjust R129 if the frequency difference is more than ±300 Hz.

8. Perform either the "RECEIVER ALIGNMENT" procedure or "TRANSMITTER ALIGNMENT" procedure or both procedures as required.

ALTERNATE LOWBAND REFERENCE OSCILLATOR FREQUENCY ADJUST

If your lowband radio has reference oscillator adjustment potentiometer R120, return to and perform step 7 of the GENERAL procedure. If your lowband radio has a two-pin connector in place of R120, perform the following alternate procedure.

ALTERNATE TEST SETUP



PRESET:

Communications Analyzer to:

- MODE– Monitor
- MONITOR– Frequency

Portable Test Box to:

MT PL– Off
PTT switch– Continuous

RESULT: Read frequency error on Service Monitor. Desired result is nominal frequency ±300 Hz.

PROCEDURE: With the Alternate Test Setup above, use the UP/DOWN and COARSE/FINE switches on the Tuner Box to bring the measurement within tolerance (300 Hz). Adjust by holding the POWER button depressed and simultaneously pressing and releasing the TUNE button. Adjust to nominal frequency +50 Hz to allow for drift.

Table 2. Power Output Adjustment

STEP	ADJUST	FOR	USING	NOTE
1	Check power output of all channels. NOTE: You must dekey before changing channels for the synthesizer to change frequencies. Set the frequency switch to the channel with the lowest output power.			
2	C159 TRIMMER CAPACITOR	Maximum power output with least current drain	RF Wattmeter and Amplifier	Use wide end of tuning tool.
3	*C115 TRIMMER CAPACITOR	Maximum power output with least current drain	RF Wattmeter and Amplifier	Use narrow end of tuning tool. If the power exceeds 7.8 W, tune C115 to 7.8 W.
4	*C159 TRIMMER CAPACITOR	Power output of 6.8 to 7.0 W	RF Wattmeter and Amplifier	If power does not make the 6.8 to 7.0 W window, peak C159.
5	C115 TRIMMER CAPACITOR	Power output of 6.2 to 6.4 W	RF Wattmeter and Amplifier	Two possible peaks: choose peak with least current drain. Adjust from component side.
6	Check both ends of the customer frequency to ensure a minimum power output of 6.2 W.		RF Wattmeter and Amplifier	Maximum frequency separation is 1 MHz.

*When tuning capacitor C115, be careful not to touch the leg of C115 and the heatsink with a metal tuning tool. Refer to the Alignment and Metering Point Locations.

3. TRANSMITTER ALIGNMENT

Review "GENERAL" information paragraph before performing TRANSMITTER ALIGNMENT

Preliminary Adjustments:

1. Terminate the program/test cable, RF lines (pins 10 and 12), to a power meter through a 30-dB pad.
2. Make all measurements at the Universal Interface Connector (pins 10 and 12), with radio keyed through the external PTT switch.
3. Program new customer frequencies (if necessary).

DEVIATION CHECK:

1. Terminate the program/test cable through a 30-dB pad to a service monitor or deviation meter.
2. Place the **METER SELECTOR** switch on the test box (RTK-4005) to the MIC position. Insert a 1-kHz tone at the **AUDIO IN** port of the test box. Use an ac voltmeter to monitor the voltage at the **AC/DC METER** port of the test box. Using the PTT switch on the RTX box to key the radio, adjust the level of the 1-kHz tone until 45 millivolts RMS is present at the **AC/DC METER** port. Dekey the radio.
3. If the radio requires a change in frequency or options, make the appropriate changes to the work space and program the radio.

NOTE

The RTK-4000 test box has a resistive divider between the **AUDIO IN** port and the **AC/DC METER** port. To accurately set deviation, 45 mV must be present at the the **AC/DC METER** port. This means that approximately 450 VRMS must be applied to the **AUDIO IN** port.

4. With the 1-kHz tone applied, check the total transmit deviation. It should be greater than 4.0 kHz but less than 5.0 kHz. If any of the deviations are not in the proper range, perform the **Radio Wide Deviation Alignment.**
5. For channels with Transmit PL, remove the 1-kHz tone from the **AUDIO IN** port of the test box. Check the deviation of the PL signal; it should be greater than 500 Hz but less than 1000 Hz. If any of the deviations are not in the proper range, perform the **Radio Wide Deviation Alignment.**

Channel Deviation Alignment:

ONLY PERFORM CHANNEL DEVIATION ALIGNMENT ON THOSE CHANNELS THAT FAILED THE RADIO DEVIATION ALIGNMENT.

1. Press the **F7** key in the MAIN/SERVICE menu to enter the CHANNEL DEVIATION Alignment menu to realign an individual channel. The cursor will be at TRANSMIT DEV position.
2. Set the radio on the channel to be aligned.
3. Set the service monitor(or deviation meter) to the transmit frequency (displayed in the upper right-hand

corner of the screen) of the channel to be aligned. Press and hold down the PTT switch on the test box to continuously key the radio.

4. Withe the 1-kHz tone applied, use the up/down arrow keys to adjust the peak deviation to the limits displayed on the screen. Release the PTT switch on the test box to dekey the radio. Press the **ENTER** key to move the cursor to the REFERENCE DEV position.

5. Disconnect the 1-kHz tone from the **AUDIO IN** port of the test box.

6. Press and hold down the PTT switch on the test box to continuously key the radio.

7. Use the up/down arrow keys to adjust the peak deviation to the limits displayed on the screen. Release the PTT switch on the test box to dekey the radio.

8. Press **F8** to program the deviation values for this channel into the radio.

9. Press F10 to exit the menu.

10. With the 1-kHz tone applied, check the peak deviation for this channel. It should be greater than 4 kHz but less than 5 kHz.

11. For channels with Transmit PL, remove the 1-kHz tone from the **AUDIO IN** port of the test box. Check the deviation of the PL signal. It should be greater than 500 Hz but less than 1000 Hz.

12. Repeat steps 1 through 11 for all channels that failed the deviation check in the **Radio Wide Deviation Alignment** procedure

Deviation Adjustment for DTMF Radios:

1. Follow the deviation procedure detailed above.

2. Press the number 1 key on the DTMF pad and continuously key the radio's PTT switch. Adjust R709 for 3.0 to 3.2 kHz deviation.

NOTE

DTMF memory is volatile. If the battery is left off for more than 2 minutes, the memory will be erased.

4. RECEIVER ALIGNMENT

Review "GENERAL" information paragraph before performing RECEIVER ALIGNMENT.

Preliminary Adjustments:

1. The receiver is factory-tuned to operate over the entire bandsplit and should not need retuning. Perform the "Receiver Check" to determine if "RECEIVER ALIGNMENT" (tuning any portion of the receiver) is necessary.

2. Connect the program/test cable (RTK-4205A) to the Radio Interface Box (RIB). Use the radio service software to read the radio.

3. When using the RTX-4005 test box, place the **AUDIO OUT** switch in the **B** position to set for proper speaker loading. Place the meter selector in the **AUDIO PA** position for receiver tests.

4. Connect the rf cable of the test cable to an rf generator or service monitor.

NOTE

Some interference conditions can be eliminated by changing the second injection. The second injection can be changed using the radio service software. Refer to the RSS manual for more details.

Receiver Check:

1. Use the radio service software to program for new customer frequencies, if necessary.

2. Set the rf generator (or service monitor) for the appropriate frequency at a 1-mV level with a 1-kHz tone modulated at 3-kHz deviation.

3. Connect the **AC/DC METER** port of the RTX-4005 to an ac voltmeter. Adjust the volume potentiometer (R140) for an ac voltmeter reading of 4.47 Vrms.

4. Connect a SINAD meter to the **AC/DC METER** port of the RTX-4005.

5. Reduce the rf level until 12 dB of SINAD is obtained; record the rf level reading. Depress the monitor button while taking this measurement to ensure that the radio is not squelched. Also, temporarily disconnect the test cable from the RIB to ensure that computer noise does not affect the measurement.

6. Perform SINAD measurements on all channels.

7. If the rf level required to produce 12-dB SINAD is 0.25 µV or less, DO NOT REALIGN THE RECEIVER; instead, proceed directly to "Squelch Sensitivity/ Check Adjustment." If the rf level required to produce 12-dB SINAD is greater than 0.25 µV, perform the "Receiver Alignment."

DO NOT PERFORM RECEIVER ALIGNMENT UNTIL THE "RECEIVER CHECK" HAS BEEN PERFORMED.

NOTE

The receiver back end coils (L12 and L13) and the receiver front end coil L2 are factory tuned to cover the entire bandsplit and should not need retuning. Should the rf amp, mixer, crystal filters, i-f module, or accompanying parts need replacing, it may be necessary to perform the following tuning procedure.

Receiver Alignment (Back End):

1. Remove the radio from its housing as described in the "DISASSEMBLY" paragraphs located in the maintenance section of this manual, then remove the backplane shield.

2. Attach the battery adapter to the radio frame, then attach the battery eliminator to the battery adapter.

3. Selecting any one of the customer frequencies, adjust the rf generator or service monitor for the appropriate frequency. Then, place the radio front side down so that the solder side (side 2) of the PC board is facing up.

4. Tune coils L12 and L13 flush with the solder side of the PC board.

5. With an ac voltmeter, monitor **M1** on the solder side of the PC board. Set the ac voltmeter to the -40 dB scale and adjust the rf level so that the voltage can be monitored at M1. During the following procedure, adjust the rf level to keep the ac voltage at M1 within the -40 dB scale.

6. Peak coils L12 and L13 (in that order) for maximum ac voltage at M1.

7. Perform the "Receiver Check" procedure, then repeat Steps 4-6 of the "Back End" procedure, if necessary.

Receiver Alignment (Front End):

NOTE

Perform the following procedure only if the radio fails the "Receiver Check" and the "Receiver Back End Alignment" tests. The radio should already have been removed from the housing.

1. Tune coil L2 flush with the solder side (side 2) of the PC board.

2. Program the radio to a frequency centered between the highest and lowest customer frequencies. Then adjust coil L2 for the maximum ac voltage level at M1. Select the peak where the slug of the coil is closest to the solder side of the PC board.

3. Program the radio back to the original customer frequency.

4. Perform the "Receiver Alignment (Back End)" procedure and then the "Receiver Check."

Squelch Sensitivity Check/Adjustment:

1. Set the radio frequency to the channel determined to have the poorest sensitivity on the "Receiver Check." Place the PL/SCAN switch in the carrier squelch position (▷).

2. Connect an ac voltmeter to the **AC/DC METER** port of the test box (RTX-4005).

3. Set the rf generator or service monitor for the appropriate frequency and no modulation. Reduce the rf level to a minimum.

4. Depress the monitor button on the side of the radio and adjust the noise level for 2.2 Vrms. Make a note of the level on the dB scale; this will be the reference level for quieting measurements.

5. Press the **F3** key in the MAIN/SERVICE menu to enter the SQUELCH and VOLUME Alignment menu. The cursor will be at the CARRIER SQUELCH position. Increase the rf level until squelch break occurs. Note the quieting level at squelch break. If squelch break occurs between 8 and 18 dB of quieting, proceed directly to step 8. If the quieting level is not within the 7- to 16-dB range, proceed to step 6.

6. Press the up/down arrow keys to adjust the CARRIER SQUELCH setting to 0. Adjust the rf level for 8 dB of quieting.

7. Holding the rf level constant, press the up arrow key to increment the CARRIER SQUELCH setting one step at a time until the radio squelches. This will be the CARRIER SQUELCH setting.

8. Reduce the rf level to a minimum. The radio should be squelched.

9. Press the **ENTER** key to proceed to the TONE SQUELCH position on the menu.

10. The TONE SQUELCH setting should be the same as the CARRIER SQUELCH setting. If not, use the up/down arrows to set the TONE SQUELCH setting to the same value as the CARRIER SQUELCH setting.

11. Press the **ENTER** key to proceed to the SCAN SQUELCH position on the menu.

12. The SCAN SQUELCH setting should be the same as the CARRIER SQUELCH setting. If not, use the up/

down arrows to set the SCAN SQUELCH setting to the same value as the CARRIER SQUELCH setting.

13. If the squelch settings require modification, program the radio.

Cloning procedure:

(The content of radio A is to be duplicated into radio B)

1. Turn off radio A and turn on radio B.

2. Connect the cloning cable (NKN6376A to the Universal Connector of both radio A and radio B.

3. Simultaneously depress the PTT and either monitor button on radio A and hold.

4. Turn on radio A. The green LED on radio B will flash, indicating that cloning is in progress.

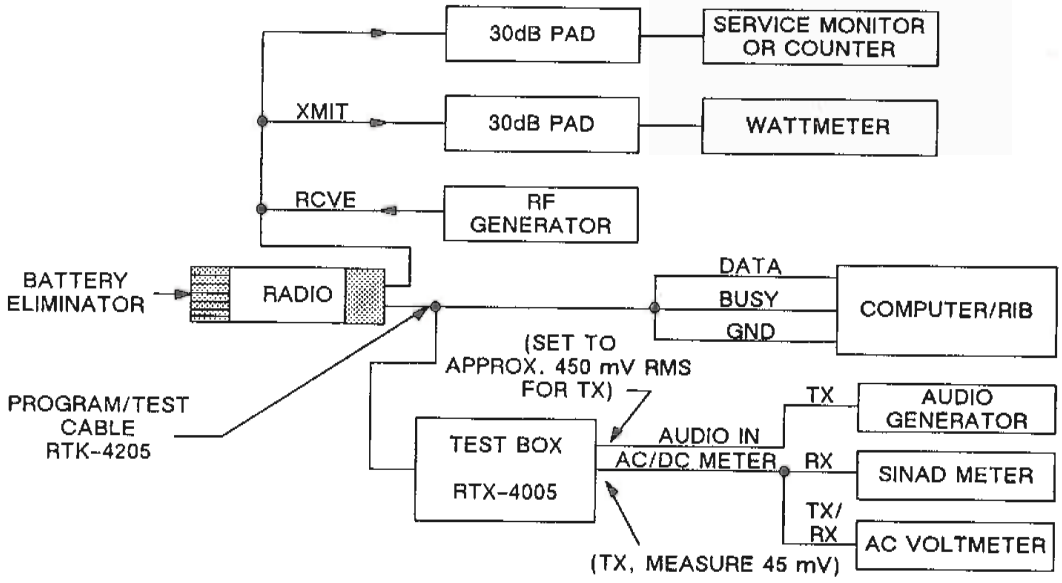
5. Cloning is complete once the green LED turns off. Release both the PTT and the monitor buttons on radio A. Turn radio A off and on to reset.

NOTE

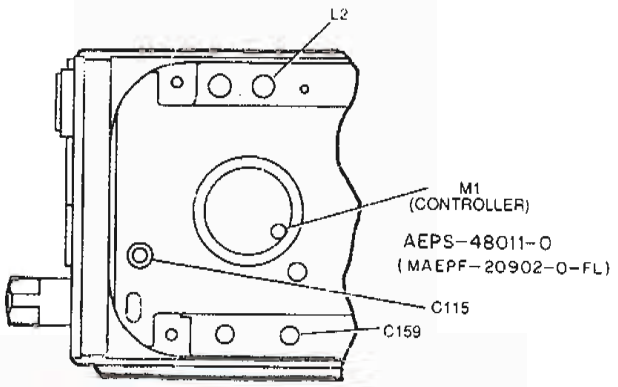
Cloning procedure does not duplicate the deviation and squelch settings.

6. Disconnect the cloning cable and turn on both radios to resume normal operation

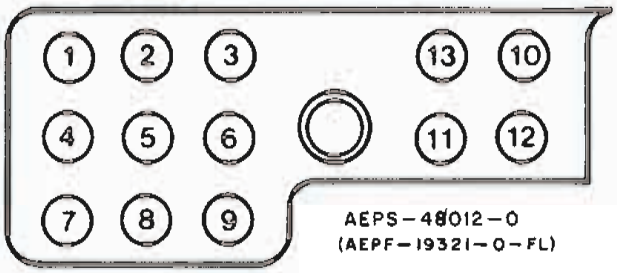
TEST SETUP DETAIL



ALIGNMENT AND METERING POINT LOCATION (CONTROLLER)

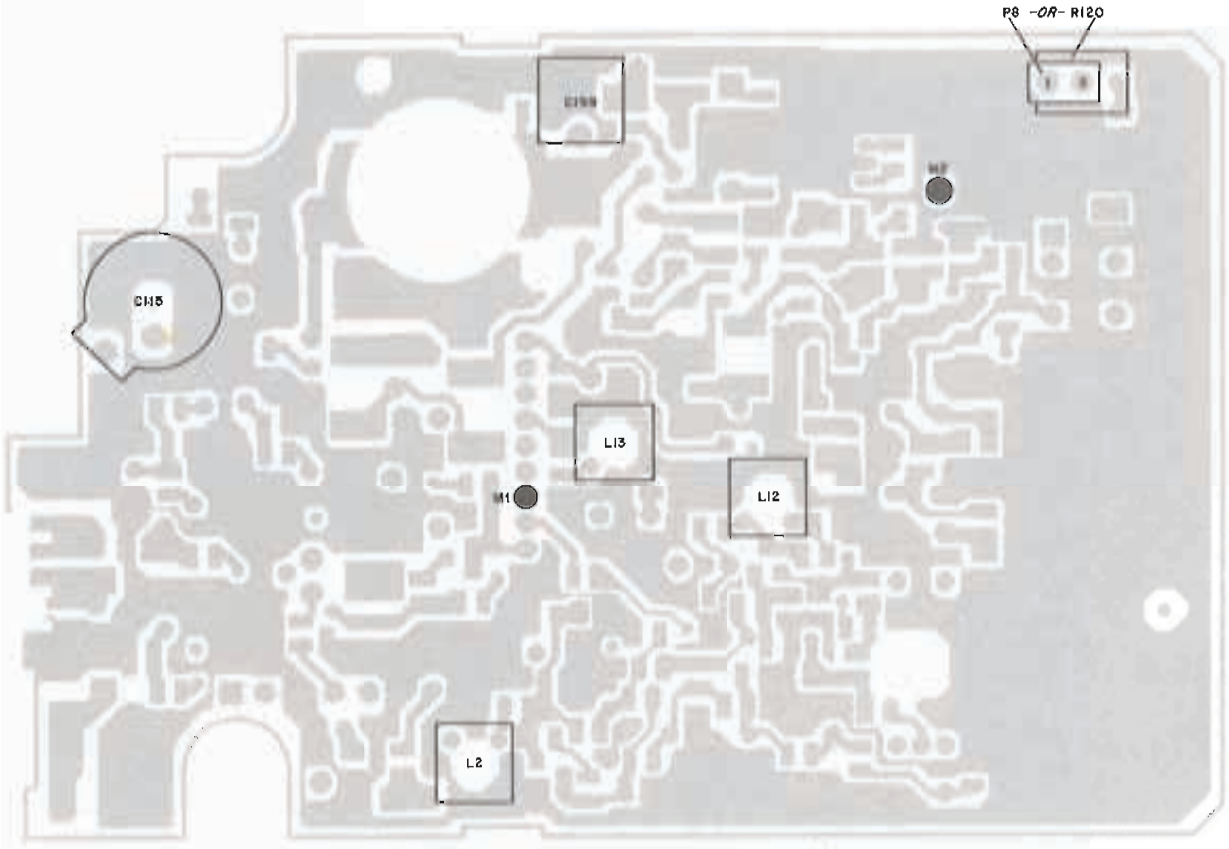


UNIVERSAL CONNECTOR DETAIL AND PIN NUMBER ASSIGNMENT



1	EXTERNAL MICROPHONE
2	EXTERNAL SPEAKER
3	OPTION B+
4	EXTERNAL PTT
5	GROUND (to controller board)
6	DATA
7	EXTERNAL SPEAKER SELECT
8	SPEAKER COMMON
9	BUSY
10	REMOTE ANTENNA
11	CVC SENSE
12	RF GROUND (to mother board)
13	SENSE

ALIGNMENT ADJUSTMENT LOCATIONS



1. INTRODUCTION

Servicing the P200 Series radio requires the localizing of the malfunctioning circuit before the defective component can be isolated and replaced. Since localizing and isolating a defective component constitutes the most time-consuming part of troubleshooting, a thorough understanding of the circuits involved will aid the technician in performing efficient servicing. The technician must know how one function affects another; he must be familiar with the overall operation of the radio and the procedures necessary to place it back in operation in the shortest possible time

The radio functional block diagrams, schematic diagrams, and troubleshooting charts provide valuable information for troubleshooting purposes. The functional diagrams provide signal flow information in a simplified format whereas the schematic diagrams provide the detailed circuitry and the biasing voltages required for isolating malfunctioning components. The troubleshooting charts further isolate malfunctioning components. By use of the diagrams, troubleshooting charts, and deductive processes, the suspected circuit may be readily found.

To determine whether analyzing of the P200 radio is required, perform checks such as 20-dB quieting, 12-dB SINAD, noise, and PL squelch sensitivity for the receiver and current drain for the transmitter. These should give the technician a general indication of where the problem is located.

NOTE

See Figure 1. Troubleshooting, Test Equipment, and Programming Set-Up Detail.

After the general problem area of the radio has been identified, careful use of a dc voltmeter, rf millivoltmeter, and an oscilloscope should isolate the problem to an individual component

2. TROUBLESHOOTING PROCEDURE

Each time the radio is turned on, a microcomputer self-test occurs. A 1600-Hz alert tone is generated for approximately 500 milliseconds to indicate that the microcomputer is functioning properly. If the alert tone is not heard (and the alert tones have not been disabled via the Radio Service Software), there is a problem with the radio.

Following the microcomputer self-test, a synthesizer self-test occurs. A continuous 1600-Hz alert tone is generated if the synthesizer test is **not** successful. If this condition occurs (continuous alert tone), refer to the VCO/synthesizer troubleshooting chart.

When a radio performs unsatisfactorily, the following procedures should help localize the fault.

a. Check Batteries

The first step in localizing a trouble is to check the battery voltage under load. With the transmitter turned on (keyed), check the battery voltage. A convenient way to do this is to remove the front cover and monitor the B+ line with a voltmeter (with respect to ground). The measured loaded voltage should not be less than 8 volts. Even though the transmitter may operate at a lower voltage, operation would be marginal and for only a short period of time. Low-voltage transmit operation is indicated by the flashing LED on top of the radio. If the measured voltage is 0 volts, check the battery and battery fuse. The recommended procedure is to replace or recharge the batteries if the voltage is below that mentioned when under load.

b. Alignment

Strict adherence to the published procedures is a prerequisite to accurate alignment and proper evaluation of the performance of the radio. The selection of test equipment is critical. The use of equipment other than that recommended should be cleared through the Motorola Area Representative to ensure that it is of equivalent quality.

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The service technician must observe good servicing techniques. The use of interconnecting cables that are too long, poorly positioned (dressed), or improperly terminated will result in erratic meter readings. As a result, it will not be possible to tune the radio to the desired specifications.

Use the recommended test equipment setup and proper connections for alignment and adjustments. Refer to the detailed procedures supplied in this manual

c. Check Overall Transmitter Operation

If the battery voltage is sufficient, check the overall performance of the transmitter. A good overall check of the transmitter is the rf power output measurement. This check indicates the proper operation of the transmitter amplifier stages. A properly tuned and operating transmitter will produce the rated rf output into a 50-ohm load with a dc input of 10 volts (refer to "Transmitter Alignment Procedure" located in the Alignment manual for specific rf output). If the power is less than rated rf output, refer to the applicable transmitter troubleshooting chart.

d. Check Overall Receiver Operation

(1) 20-dB Quieting Sensitivity Check

A good overall check of receiver operation is the 20-dB quieting sensitivity measurement. This check will indicate that the receiver has sufficient gain and that all the included circuitry is working properly. The quieting signal is that rf signal input necessary to reduce the audio output at the speaker by 20 dB. This measurement should be made with no modulation. It is necessary to hold the monitor button during this test or the radio's squelch circuitry will remove the noise from the speaker.

Make the actual measurement (using an ac voltmeter) by setting the noise voltage across the test box speaker load (with no rf signal received at the antenna) to 1/4 of the rated audio power output (2.24 Vrms). Sufficient carrier signal from a generator is then introduced via the universal connector (remote antenna port) to reduce the noise output voltage to 1/10 of the previous reading. If all the circuitry is operating correctly, this reading should be 0.35 µV or less. If the radio does not meet this specification, try to retune the receiver using the procedure indicated in the Alignment manual. If this does not solve the problem, refer to the receiver troubleshooting chart.

(2) 12-dB SINAD

This procedure is a standard method for evaluating the performance of an FM receiver since it provides a check of the rf, i-f, and audio stages. The measurement consists of finding the lowest modulated signal necessary to produce 50% of the radio's rated audio output with a 12-dB or better ratio of signal + noise + distortion/noise + distortion. This is termed "usable sensitivity."

To perform this measurement, connect the leads from a SINAD meter to the audio output of the test box. Set the Motorola service monitor or rf signal generator to output a 1-millivolt signal. Modulate the rf signal with a 1-kHz tone at 3-kHz deviation. Introduce the signal to the radio at the exact channel frequency through the universal connector. Set the volume control for rated audio output (4.47 Vrms). Decrease the rf signal level until the SINAD meter reads 12 dB. The signal generator output (12-dB SINAD measurement) should be less than 0.25 µV. If the radio does not meet this specification, try to retune the receiver using the procedure indicated in the Alignment manual. If this does not solve the problem, refer to the receiver troubleshooting chart.

3. VOLTAGE MEASUREMENT AND SIGNAL TRACING

To aid in troubleshooting, ac and dc voltage readings are provided (in red) on the transceiver schematic diagram in this manual. When making these voltage checks, pay particular attention to any notes that may accompany the voltage reading of a particular stage.

If receiver sensitivity is high or if the rf power output is lower than normal for a fully tuned transceiver, the dc voltages on the printed circuit board should be checked. These voltages should be referenced to ground.

CAUTION

When checking a transistor or module, either in or out of the circuit, do not use an ohmmeter having more than 1.5 volts dc appearing across the test leads or an ohms scale of less than X 100.

It is recommended that a transistor or module not be replaced before a thorough check is made. Read the voltages around the suspected stage. If these voltages are not reasonably close to those specified, the associated components should be checked.

A low-impedance meter should not be used for measurement. If all dc voltages are correct, the signal should be traced through the circuit to show any possibility of breaks in the signal path.

CAUTION

The microcomputer is a static-sensitive device contained on the controller flex assembly. DO NOT attempt to troubleshoot or disassemble the microcomputer/controller flex assembly without first referring to the CMOS Precautions in the **Maintenance** section of this manual.

When troubleshooting the microcomputer/controller flex circuits, it is necessary to disconnect the flex from the

radio main circuit board and reconnect it via a flex extender fixture. Also, many of the measurements referred to in the microcomputer troubleshooting charts that follow are short in duration. Therefore, it will be necessary to use an oscilloscope set for 1 V/division and 5ms/division.

4. TROUBLESHOOTING CHARTS

The troubleshooting charts on the following pages will help isolate troubles in the different sections of the radio. Start at the top of the appropriate chart and make the checks as indicated. Most usual malfunctions will respond to the systematic approach to troubleshooting. Also, a flow chart is provided to aid in choosing the proper troubleshooting chart.

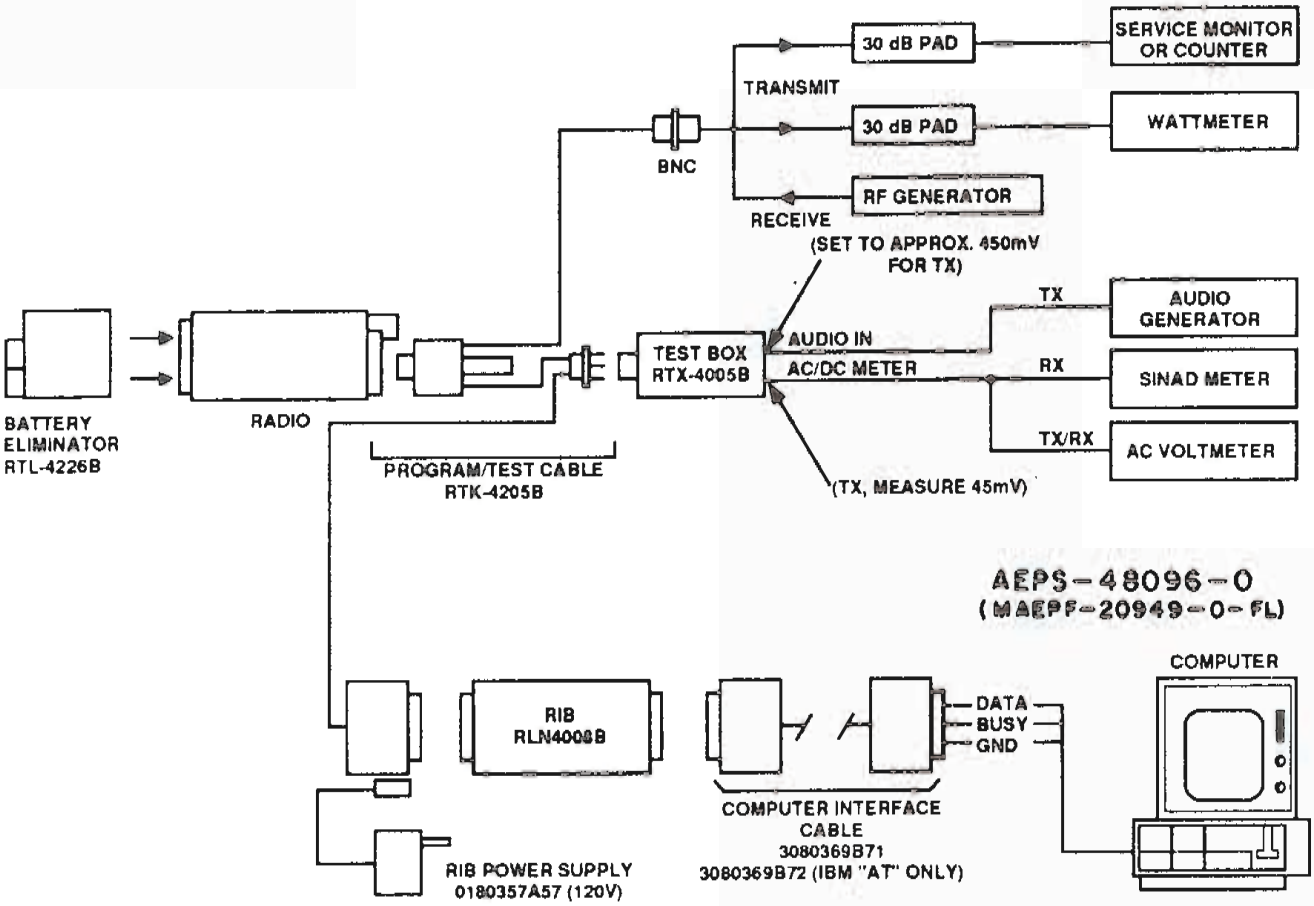
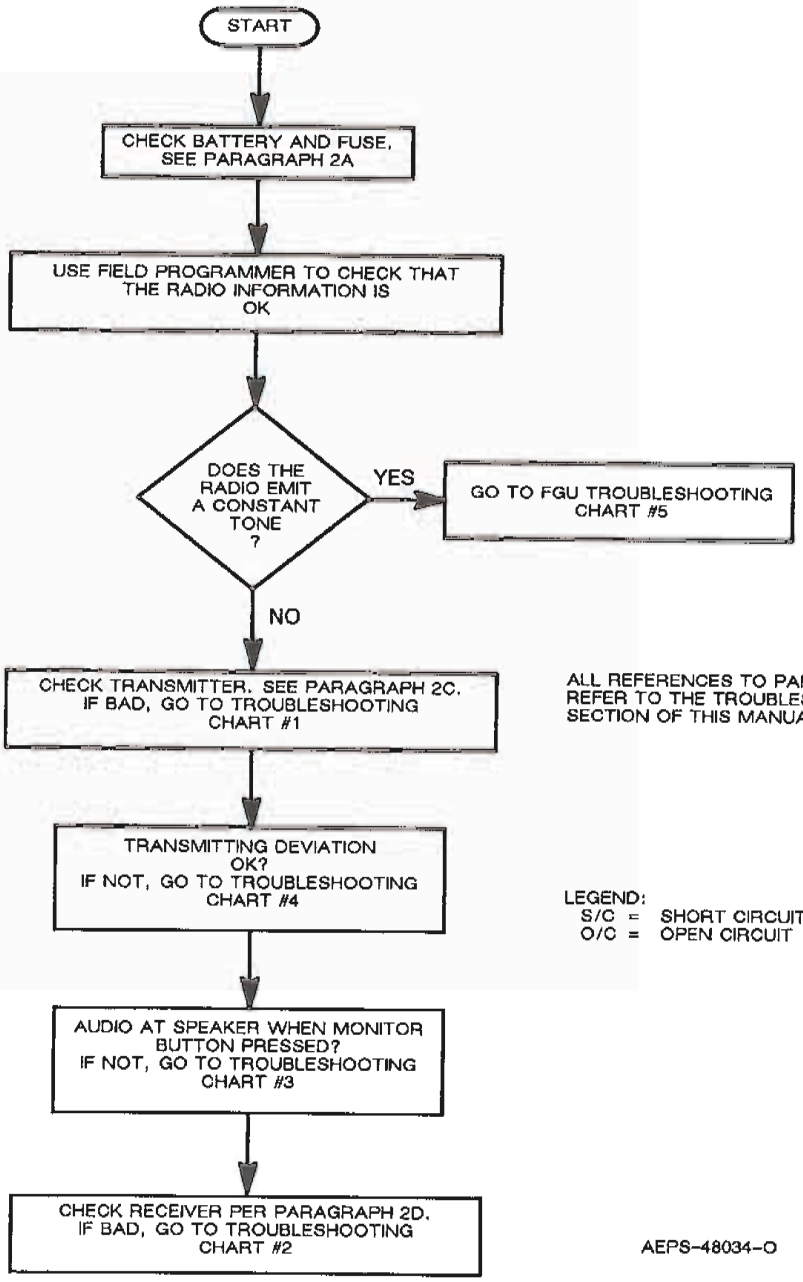


Figure 1. Troubleshooting, Test Equipment, and Programming Setup Detail

TROUBLESHOOTING FLOW CHART



ALL REFERENCES TO PARAGRAPHS (I.E., 2A) REFER TO THE TROUBLESHOOTING SECTION OF THIS MANUAL

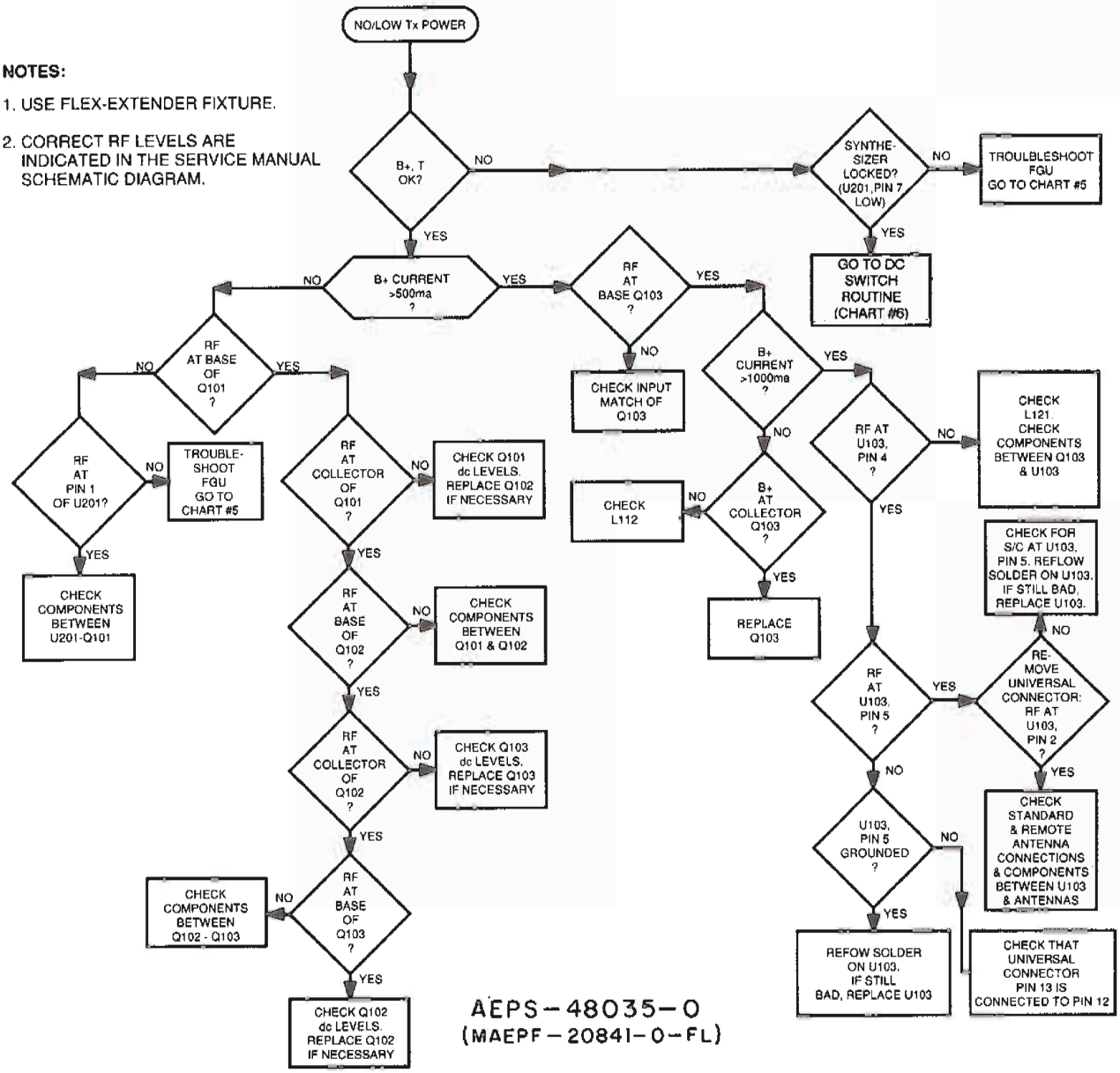
LEGEND:
S/C = SHORT CIRCUIT
O/C = OPEN CIRCUIT

AEPS-48034-O

CHART #1
TRANSMITTER (RF)

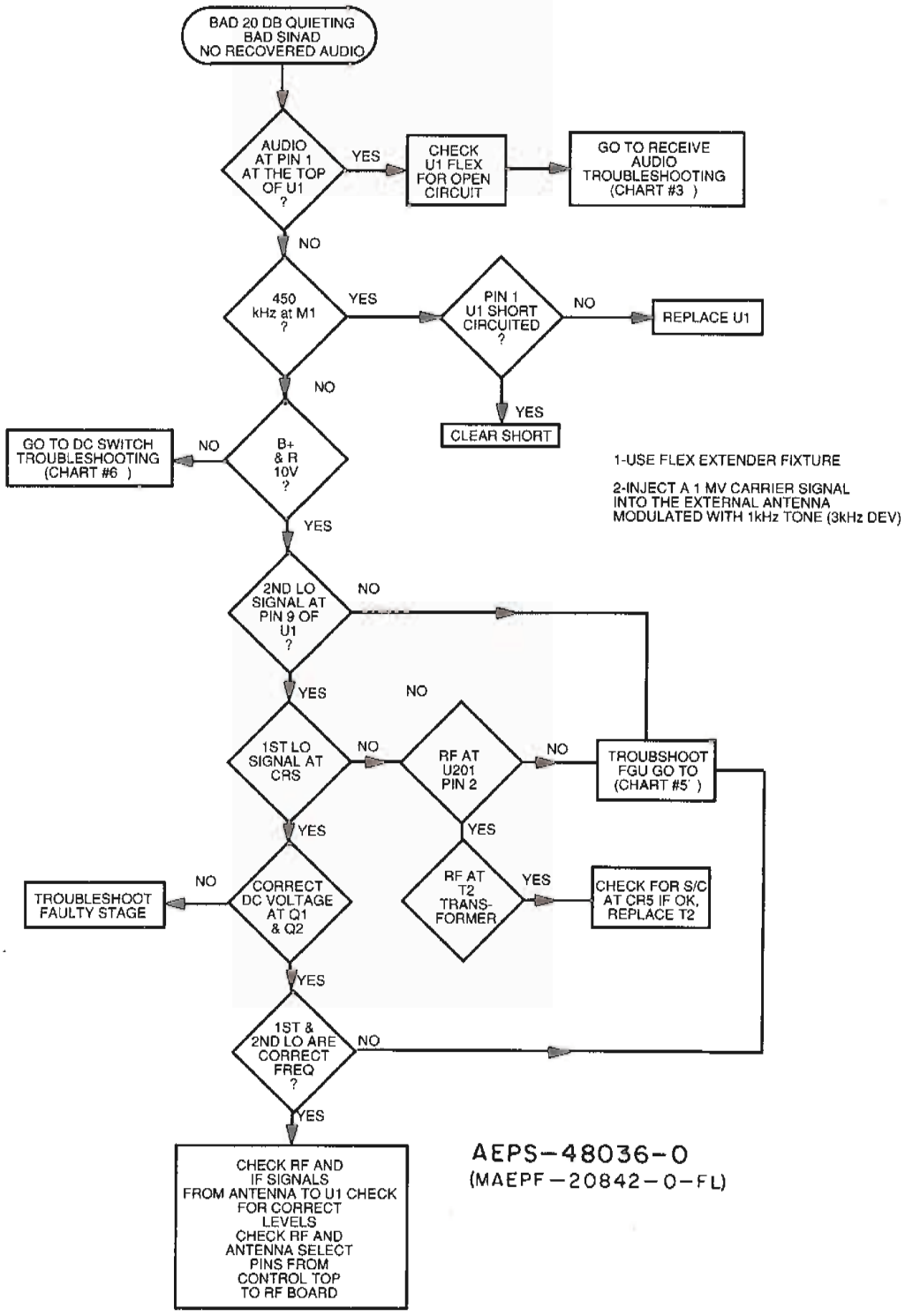
NOTES:

1. USE FLEX-EXTENDER FIXTURE.
2. CORRECT RF LEVELS ARE INDICATED IN THE SERVICE MANUAL SCHEMATIC DIAGRAM.



AEPS-48035-O
(MAEPF-20841-O-FL)

CHART #2
RECEIVER (RF)

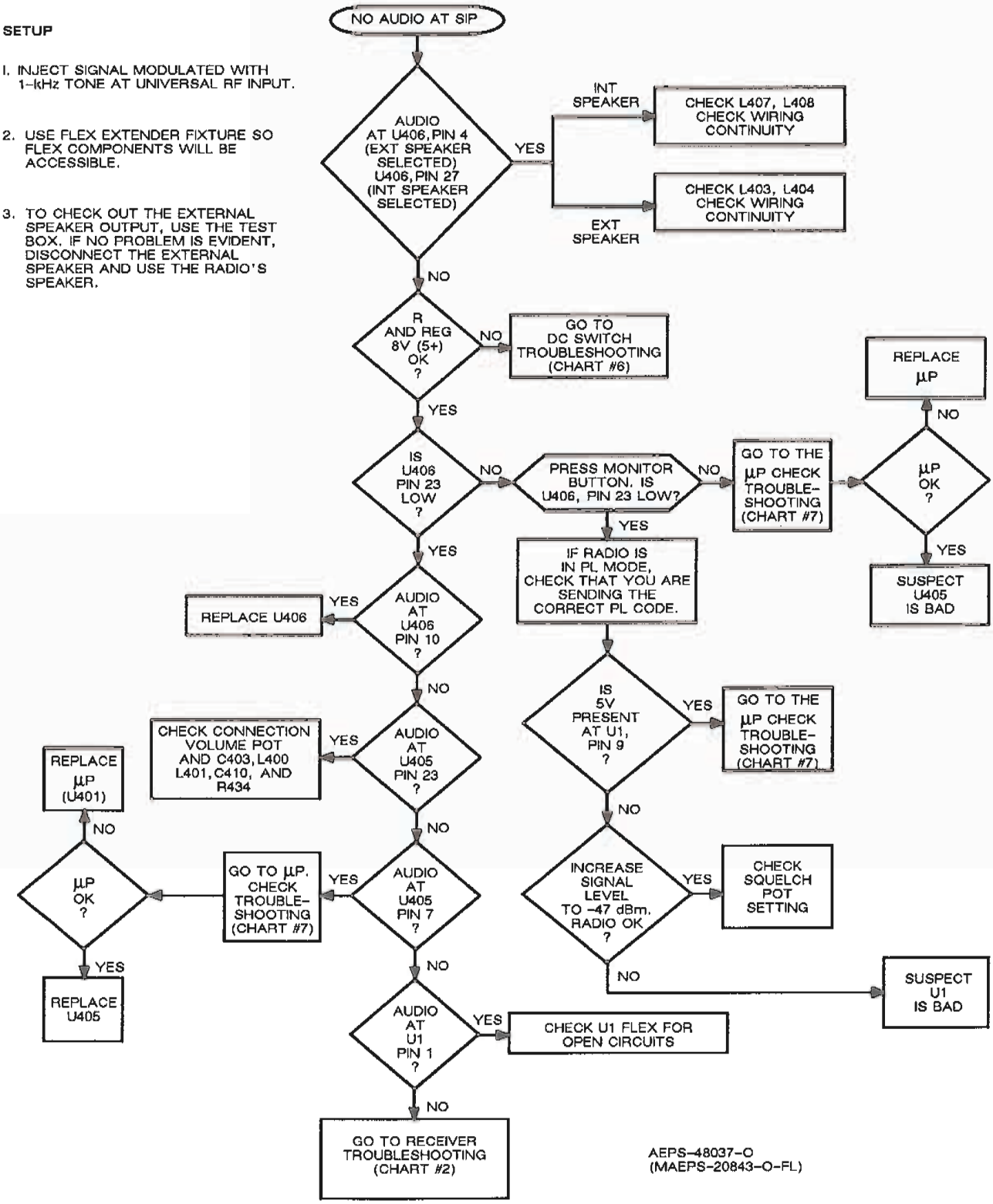


AEPS-48036-0
(MAEPF-20842-0-FL)

CHART #3
RECEIVER (AUDIO)

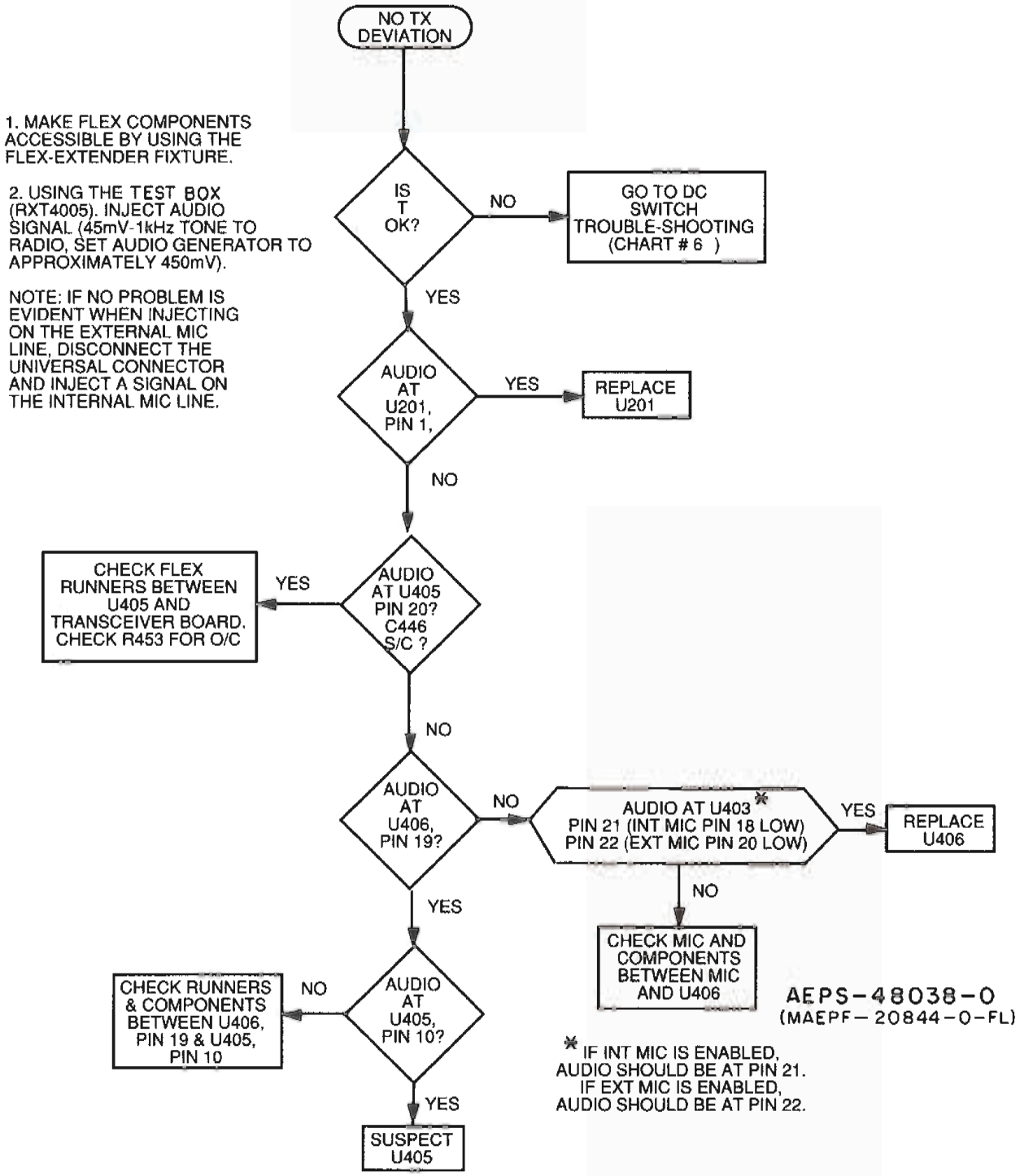
SETUP

1. INJECT SIGNAL MODULATED WITH 1-kHz TONE AT UNIVERSAL RF INPUT.
2. USE FLEX EXTENDER FIXTURE SO FLEX COMPONENTS WILL BE ACCESSIBLE.
3. TO CHECK OUT THE EXTERNAL SPEAKER OUTPUT, USE THE TEST BOX. IF NO PROBLEM IS EVIDENT, DISCONNECT THE EXTERNAL SPEAKER AND USE THE RADIO'S SPEAKER.



AEPS-48037-O
(MAEPS-20843-O-FL)

CHART #4
TRANSMITTER (AUDIO)



AEPS-48038-O
(MAEPF-20844-O-FL)

CHART #5
FREQUENCY GENERATION UNIT

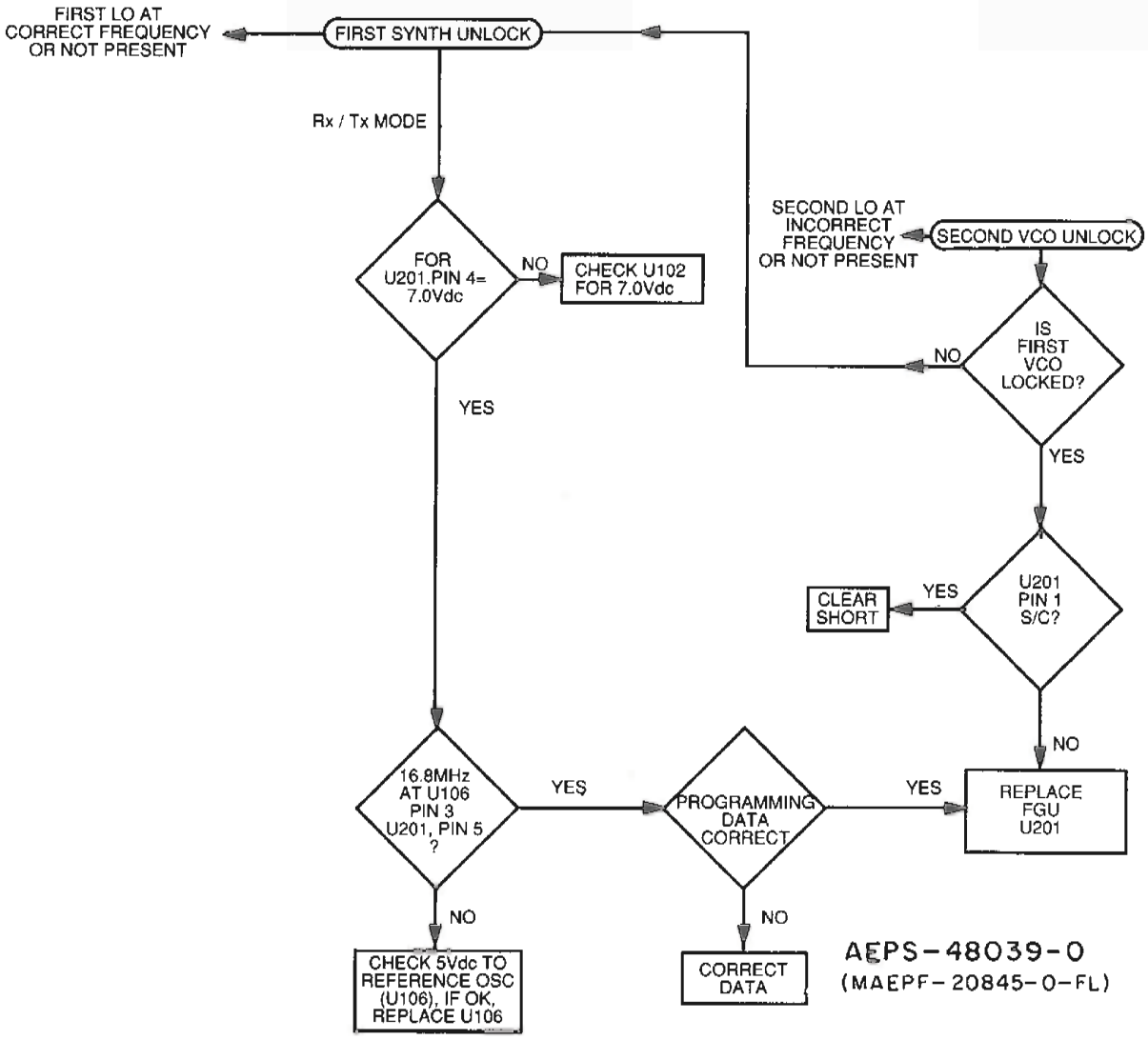


CHART #6
DC SWITCH

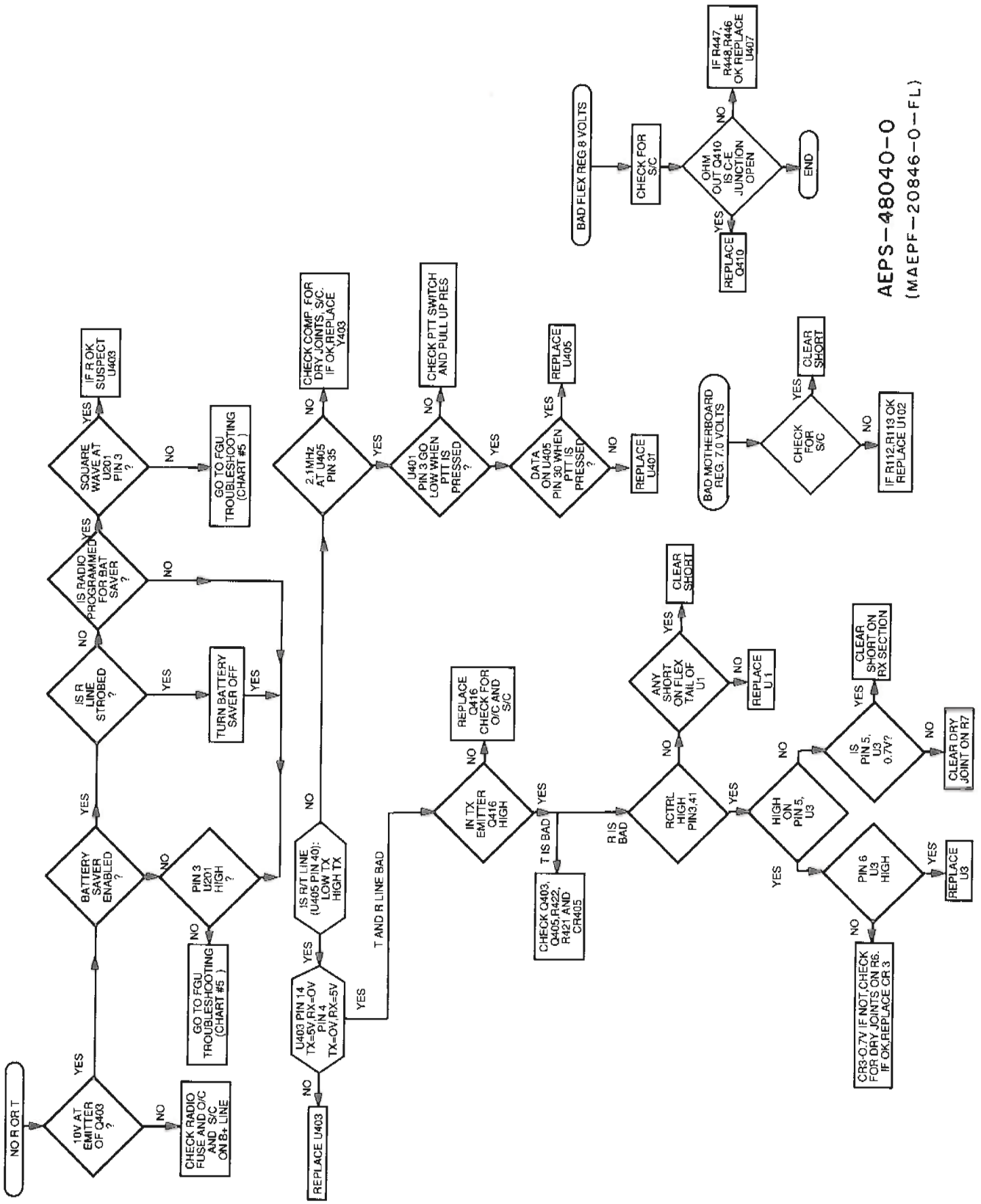


CHART #7
MICROCOMPUTER

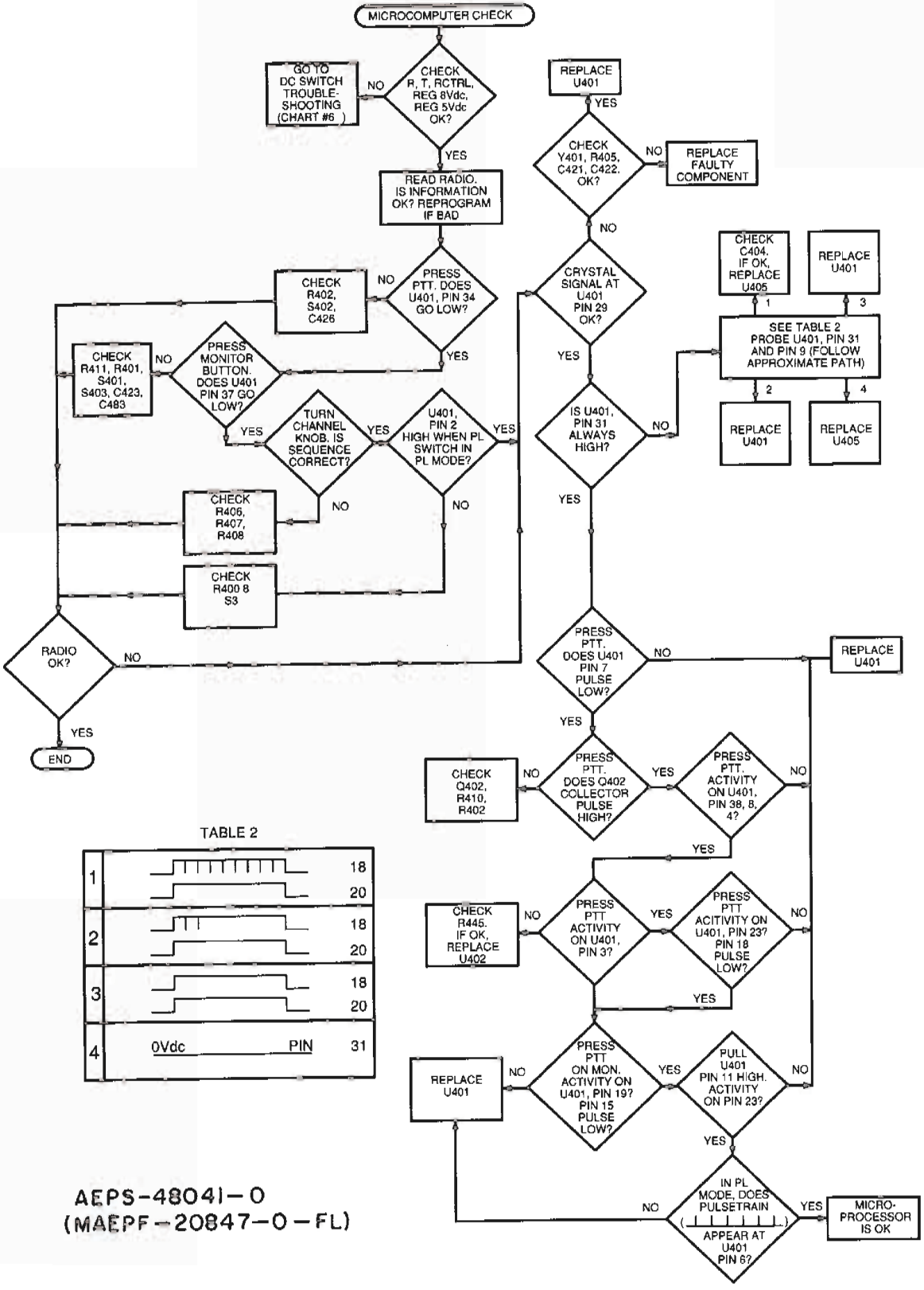
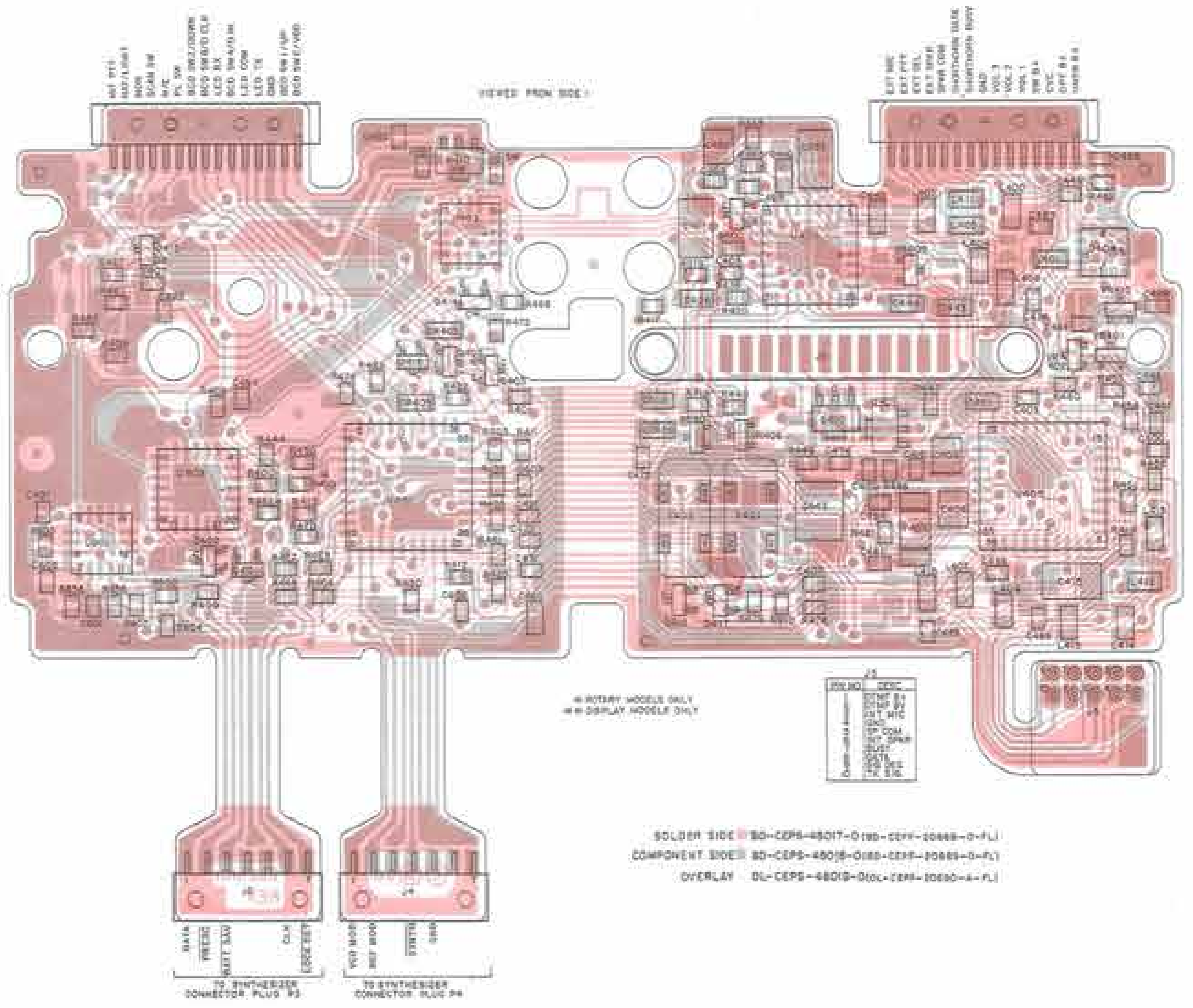


TABLE 2

1		18
		20
2		18
		20
3		18
		20
4	0Vdc	PIN 31

AEPS-48041-O
(MAEPF-20847-O-FL)



LOWBAND TRANSCEIVER PARTS LIST AND LOWBAND CONTROLLER COMPONENT LOCATION DIAGRAM

LOWBAND Electrical Parts List, Transceiver Board

L = 30-36MHz
M = 36-42MHz
H = 42-50MHz

PL-11653

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
		CAPACITOR, Fixed: pF ±5%;50V 1/10W unless stated
C1	2113740A65	270 (L)
	or 2113740A62	200 (M)
	or 2113740A59	150 (H)
C2	2113740A67	330 (L)
	or 2113740A62	200 (M)
	or 2113740A58	130 (H)
C3	2113741A25	1500 (L)
	or 2113740A72	510 (M)
	or 2113740A66	300 (H)
C4	2113740A59	150(L)
	or 2113740A57	120 (M)
	or 2113740A54	91 (H)
C5	2113741A25	1500 (L)
	or 2113740A77	820 (M)
	or 2113740A70	430 (H)
C7	2113740A56	100 (L)
	or 2113740A56	110 (M)
	or 2113740A53	82 (H)
C9	2113740A52	75 (L)
	or 2113740A54	91 (M,H
C10	2113740A62	200 (L)
	or 2113740A56	110 (M,H)
C11	2113740A66	300 (L)
	or 2113740A59	150 (M)
	or 2113740A64	240 (H)
C12	2113740A20	5.1 (L,M)
	or 2113740A19	4.7 (H)
C13	2113740A50	62 (L)
	or 2113740A33	15 (M)
	or 2113740A43	39 (H)
C14	2113740A57	120 (L,H)
	or 2113740A46	47 (M)
C15	2113740A69	390 (L)
	or 2113740A62	200 (M)
	or 2113741A31	2700 (H)
C16	2113740A55	85 (L)
	or 2113740A61	180 (M)
	or 2113740A54	91(H)
C18	2113740A59	150 (L)
	or 2113740A62	200 (M)
	or 2113740A63	220 (H)
C19	2113740A54	91 (L)
	or 2113740A59	150 (M)
	or 2113740A60	160 (H)
C20,21	2113741A45	.01uF
C22	2113740A23	6.2 (L)
	or 2113740A13	2.7 (M)
	or 2113740A20	5.1 (H)
C23	2113741A45	.01uF
C24	2311049J08	3.3uF; Tant.
C25	2113740A52	75 (L)
	or 2113740A56	110 (M,H)
C26	2113740A66	300 (L)
	or 2113740A69	390 (M,H)
C27	2113740A69	390
C28	2113741A45	.01uF
C29	2113741A45	.01uF
C30	2113740A29	10
C31	2113740A25	7.5 (L)
	or 2113740A21	5.6 (M)
	or 2113740A20	5.1 (H)
C32	2113741A45	.01uF (L)
	or 2113741A53	22000 (M)
	or 2113741A47	12000 (H)
C33	2113740A38	24 (L)
C34	2113740A38	24 (L)
	or 2113740A36	20 (M)
C35	2180521G37	0.1+80-20%;25V
C37	2113741A45	.01uF
C101	2113741A45	.01uF
C102	2113741A45	.01uF
C103	2113740A33	15 (L)
	or 2113740A36	20 (M)
	or 2113740A23	6.2 (H)
C104	2113740A32	13 (L,M)
	or 2113740A36	20 (H)
C105	2113740A42	36 (L)
C106	2113741A45	.01uF
C107	2113740A59	150 (L)
	or 2113740A60	160 (M)
	or 2113740A39	27 (H)
C108	2113740A73	560 (L)
	or 2113740A71	470 (M)
	or 2113740A57	120 (H)
C109	2113740A64	240 (L)
	or 2113740A58	130 (M)
	or 2113740A53	82 (H)
C110	2113740A56	110
C111	2113740A49	56 (L)
	or 2113740A52	75 (M)
C112	2113740A72	510 (L,M)
	or 2113740A68	360 (H)
C114	2113740A59	150 (L)
	or 2113740A61	180 (M)
	or 2113740A59	150 (H)
C115	2005568P01	Trimmer,5.5-55pF
C116	2113740A61	180 (L,M)
	or 2113740A60	160 (H)
C117	2113740A51	68 (L)
	or 2113740A54	91 (M,H)
C118	2113740A42	36 (L,M)
	or 2113740A38	24 (H)
C119	2113740A57	120 (L)
	or 2113740A53	82 (M)
	or 2113740A56	110 (H)
C120	2113740A42	36 (L,M)
	or 2113740A38	24 (H)
C121	2113740A49	56 (L)
	or 2113740A46	47 (M)
	or 2113740A50	62 (H)
C123	2113741A45	.01uF
C124	2113740A53	82 (L,M)
	or 2113740A51	68 (H)
C125	2113740A53	82 (L,M)
	or 2113740A51	68 (H)
C126	2113740A51	68 (L)
	or 2113740A53	82 (M)
	or 2113740A38	24 (H)
C127	2113740A51	68 (L,M)
	or 2113740A44	43 (H)
C128	2113741A45	.01uF
C129	2113740A52	75 (L)
	or 2113740A51	68 (M)
	or 2113740A46	47 (H)
C130	2113740A56	100 (L)
	or 2113740A53	82 (M)
	or 2113740A50	62 (H)
C131	2113740A56	100 (L)
	or 2113740A53	82 (M)
	or 2113740A50	62 (H)
C132	2113741A45	.01uF
C134	2360562B01	.01uF;Tant.
C135,136	2113741A45	.01uF
C137	2311049A37	1uF
C138,152,155	2160521G37	0.1uF
C157	2113741A45	.01uF
C158	2311049J08	3.3uF; 16V
C159	2002407J01	Trimmer; 10-120pF
C160	2305499G20	10uF±20%; 20V Tant.
		DIODE: See Note
CR1	4805119G34	Silicon
CR2	4805490G62	Silicon
CR3,4	4805494Q04	Silicon
CR5	4880236E16	Quad Ring Array
CR101,102	0102712J05	Unitrode,8401and Heat Shrink
CR103	4805119G34	Silicon
CR104	4805119G34	Silicon (M, H Only)
CR301A, 301B	4805729G24	LED, Bicolor (Rotary Radios Only)
		FILTER:
FL1, 2	4805245J26	Crystal,19.96MHz (L)
	or 4805245J27	Crystal,16.65MHz (M,H)
FL3	9105725Q02	Ceramic, 450kHz
FL4	9105726Q01	Ceramic, 450kHz
		COIL, RF: unless stated
L1	2402406J05	6- turns, spacewound
L2	2402406J11	11- turns, spacewound
L3 thru 6	2402406J05	6- turns, spacewound
L7	2402406J10	Tunable, Choke (L,M)
	or 2402406J09	Tunable, Choke (H)
L8	2402406J05	6- turns, spacewound (L,H)
	or 2402406J10	Tunable, Choke (M)
L9	2411087B25	0.82uH Choke
L10	2411087B18	0.220uH Choke
L11	2411087B25	0.82uH Choke
L12,13	2405063H13	1.2uH Choke
L14	2411087B25	0.82uH Choke
L15	2411087B25	0.85uH Choke (M, H Only)
L16	2411087B37	8.2uH Choke
L100	2411087B36	6.8uH Choke
L101	2411087B27	1.2uH Choke (L,M)
	or 2411087B26	1uH Choke (H)
L102	2411087B27	1.2uH Choke (L)
	or 2411087B26	1.5uH Choke (M,H)
L103	0102710J48	1.2uH Choke and Heat Shrink(L)
	or 0102710J46	8.2uH Choke and Heat Shrink (M,H)
L104	2411087B16	0.15uH Choke (L)
	or 2411087B15	0.12uH Choke (M)
	or 2411087B21	0.39uH Choke (H)
L105	2411087B13	0.82uH Choke (L)
	or 2411087B12	.068uH Choke (M)
	or 2411087B16	0.15uH Choke (H)
L106	2411087B37	8.2uH Choke (L,H)
	or 2411087B36	6.8uH Choke (M)
L107	0102710J48	Assy., 1.2µH Choke and Heat Shrink (L)
	or 0102710J46	Assy., 8.2µH Choke and Heat Shrink (M,H)
L108	0102710J83	Assy.,6-1/2 turns, airwound (L,M)
	or 0102710J82	Assy.,5-1/2 turns, airwound (H)
L109	0102710J79	Assy.,2-1/2 turns, airwound
L112	2482723H48	.085uH Choke (L,H)
	or 0102712J04	Assy.,085uH Choke and Heat Shrink (M)
L113	0102710J69	4-1/2 turns, airwound (L)
	or 0102710J68	3-1/2 turns, airwound (M,H)
L114	0102710J74	9-1/2 turns, airwound (L)
	or 0102710J72	7-1/2 turns, airwound (M,H)
L115	0102710J73	8-1/2 turns, airwound (L)
	or 0102710J71	6-1/2 turns, airwound (M,H)
L116	0102710J73	8-1/2 turns, airwound (L)
	or 0102710J71	6-1/2 turns, airwound (M,H)
L117	0102710J73	8-1/2 turns, airwound (L)
	or 0102710J72	7-1/2 turns, airwound (M)
	or 0102710J71	6-1/2 turns, airwound (H)
L119	0102710J75	10-1/2 turns, airwound (L)
	or 0102710J74	9-1/2 turns, airwound (M)
	or 0102710J72	7-1/2 turns, airwound (H)
L120	0102710J75	10-1/2 turns, airwound (L,M)
	or 0102710J74	9-1/2 turns, airwound (H)
L121,122	2411087B36	6.8uH Choke
L123	0102710J48	1.2uH Choke and Heat Shrink (M, H Only)
L124	0102710J76	11-1/2 turns, airwound (L)
	or 0102710J75	10-1/2 turns, airwound (M)
	or 0102710J74	9-1/2 turns, airwound (H)
LS1	5005155Q03	**TRANSDUCER**
MK1	0105956P37	**MICROPHONE ASSEMBLY**
		PLUG:
P1, 2	2805466R01	Connector, Flex Top; 15-pin
P3, 4	2805144Q01	Connector, FGU; 7-pin
P5	2805433R02	Connector, Front Cover
P6	2805247Q01	Connector, I-F
P7	----------	Not field replaceable, order Top Control Panel Assembly 0102700J59 (Rotary Radios) or 0105958N64 (Display Radios)
P8*	2805507R01	Connector, 2-pin (replaces R120 in radios with alternate reference oscillator)
		TRANSISTOR: See Note
Q1,2	4802245J05	NPN,Type MMBR941L
Q101	4802233J11	NPN,Type MRF0211
Q102	4800869859	Driver
Q103	4802245J03	NPN,Type MRF0233
		RESISTOR, Fixed: Ω ± 5%; 1/10W unless stated
R1	0660076A83	27k
R2	0660076A65	4.7k
R3	0660076A60	3k
R5	0660076A63	3.9k
R6	0660076A83	27k
R7	0660076A53	1.5k
R9,10	0660076A18	51
R11	0660076A57	2.2k (L,M)
	or 0660076A60	3k (H)
R12	0660076A85	33k
R13	0660076A84	30k
R14	0660076A60	3k
R15	0660076A53	1.5k
R100	0660076A71	8.2k
R101	0660076A87	39k
R102	0660076A49	1k
R103	0660076A73	10k (L,M)
	or 0660076A76	13k (H)
R105	0602432J27	120;1/2W (L,M)
	or 0602432J29	150;1/2W (H)
R106	0660076A01	10 (L,M)
	or 0660076A15	39 (H)
R107	0660076A29	150
R108	0660076A01	10 (L)
	or 0660076A10	24 (M, H)
R109	0602433J29	150;1W (L)
	or 0602433J28	130;1W (M,H)
R111	0602433J28	130;1W (L)
	or 0602433J29	150;1W (M)
	or 0602433J25	100;1W (H)
R112	0660076E75	12k±1%
R113	0660076E84	30k±1%
R114,115	0660076A44	620
R116	0660076A37	330
R120	1805559S02	Pot., 50k
R121	0660076A10	24 (M,H)
	or 0660076A01	10 (L)
R122	0611072A33	220; 1/4W (L)
	or 0611072A32	200 (M)
	or 0611072A34	240 (H)
R123	0660076A49	1k (L)
	or 0660076A41	470 (M,H)
R124	0660076A41	470 (L,M)
	or 0660076A34	240 (H)
R125	0660076M01	0
R140	1805100Q04	Pot., 25k
		SWITCH:
S1	----------	On/Off, Part of R140
S2	4005265Q02	16-position, Hexadecimal (Rotary Radios Only)
S3	4005101Q02	Toggle, PL Disable/Scan
S301	3905834K06	Snap Dome, Monitor
S302	3905834K06	Snap Dome, PTT
S303	3905834K06	Snap Dome, Light/Scan
T1,2	2580163M02	**TRANSFORMER:**
		CIRCUIT MODULE: See Note
U1	5102001J12	I-F
U3	4802245J01	Dual Transistor
U102	5160880B01	Regulator (5V)
U103	5102001J36	Antenna Switch (L)
	or 5102001J37	Antenna Switch (M)
	or 5102001J38	Antenna Switch (H)
U106*	5105729E52	Ref. Oscillator, 16.8MHz
	or 5102463J01	Ref. Oscillator (alternate), 2.1MHz
U201*	5102001J47	Freq. Generator (L)
	or 5102001J64	Freq. Generator (L); alternate
	or 5102001J48	Freq. Generator (M)
	or 5102001J49	Freq. Generator (H)

NONREFERENCED ITEMS

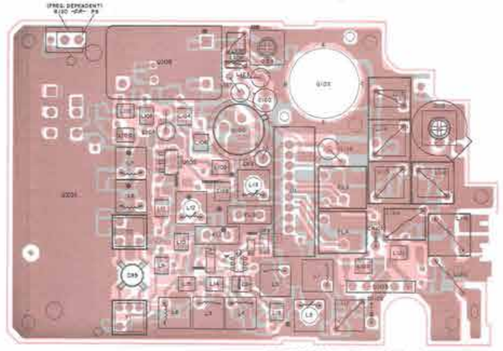
	1402428J01	INSULATOR
	1405511R02	SHIELD
	2602240J01	HEATSINK (PA)
	2605296Q01	HEATSINK (Driver)
	2682671D21	CAN, for L113 thru 116 and L119
	2805507R01*	CONNECTOR, 2-Pin (used with alternate low split reference oscillator only)
	7505295B07	PAD, for FL1, FL2
	8402214J01	BOARD, Printed Circuit

NOTE: For optimum performance, order replacement diodes, transistors, and circuit modules by Motorola part number only.

* In the (L) frequency split, radios operating on 33.6 MHz will be equipped with three alternate parts:
- U106
- U201
- P8 a 2-pin connector that replaces resistor R120

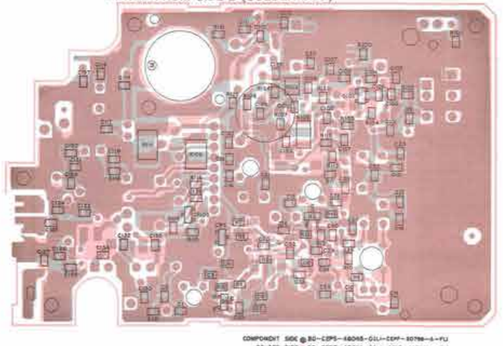
If the radio is not equipped with the alternate parts, it will not perform properly on 33.6 MHz.

VIEWED FROM SIDE 1 (COMPONENT SIDE)

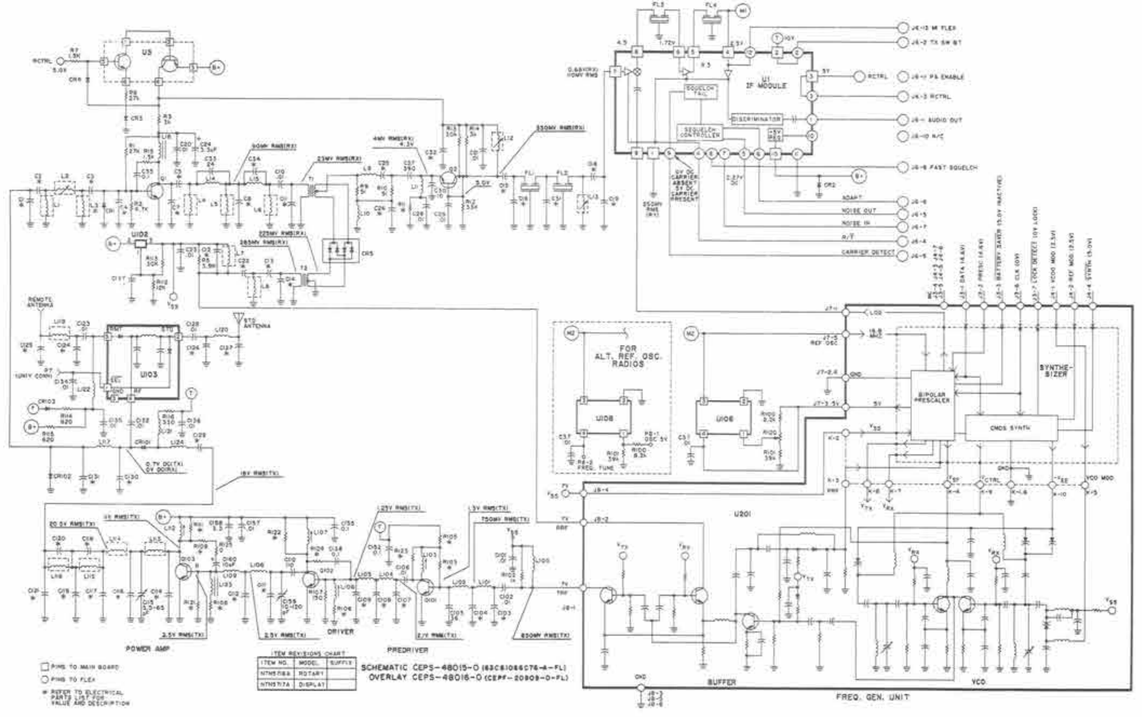


COMPONENT SIDE @ 8D-CEPS-48043-O (LI-CEPF-30786-A-FL)
SOLDER SIDE @ 8D-CEPS-48043-O (LI-CEPF-30787-A-FL)
OVERLAY 0L-CEPS-48044-O (0L-CEPF-30788-A-FL)

VIEWED FROM SIDE 2 (SOLDER SIDE)

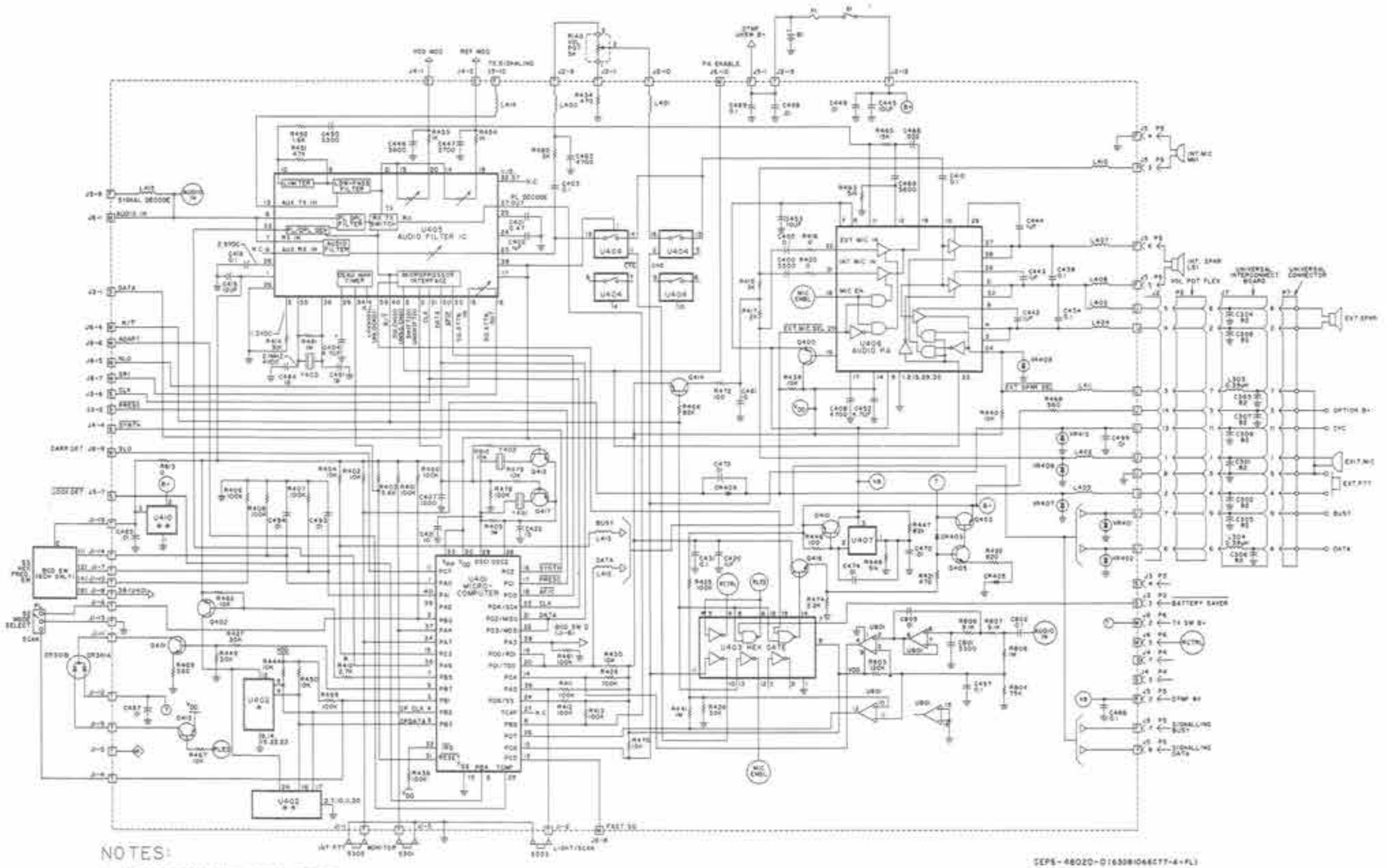


COMPONENT SIDE @ 8D-CEPS-48065-O (LI-CEPF-30786-B-FL)
SOLDER SIDE @ 8D-CEPS-48066-O (LI-CEPF-30787-B-FL)
OVERLAY 0L-CEPS-48067-O (0L-CEPF-30788-B-FL)



SCHEMATIC CEPS-48015-O (63C81085C76-A-FL)
OVERLAY CEPS-48016-O (CEPF-30809-D-FL)

LOWBAND TRANSCEIVER CIRCUIT BOARDS AND SCHEMATIC DIAGRAM



NOTES:

1. * FOR NTN5718A ONLY (ROTARY RADIOS)
   ** FOR NTN5717A ONLY (DISPLAY RADIOS)
2. R813 & R423 ARE 0 OHM JUMPER.
3. U402 ORIENTATION FOR NTN5717A IS ROTATED 180°

SEPS-46020-D163081066TT-4-FL)

LOWBAND CONTROLL
SCHEMATIC DIAGR

8/15/90

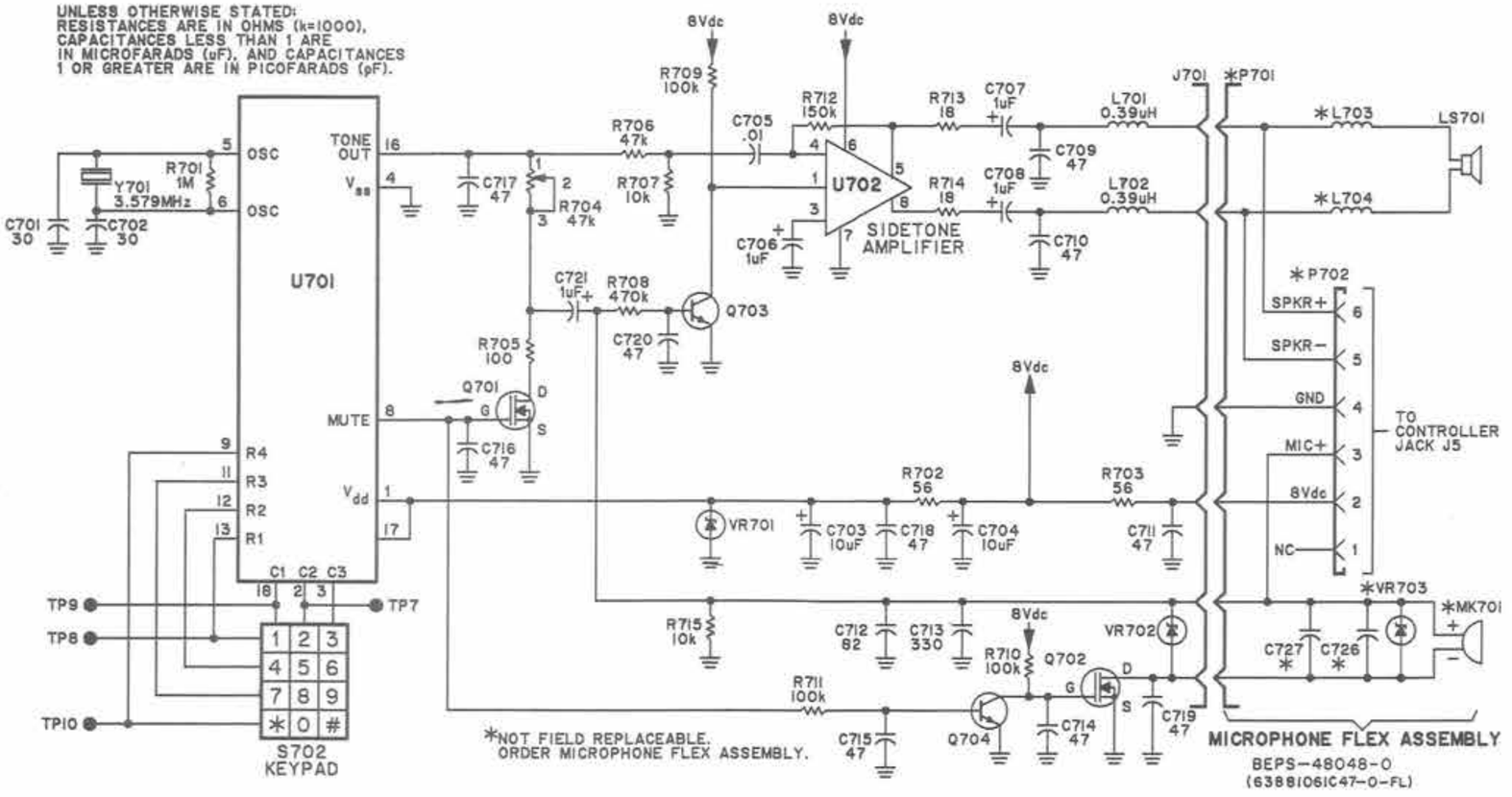
68P81085E61

Electrical Parts List
Lowband Controller Flex
NTN5716A Rotary Radios

PL-11654

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
		CAPACITOR, Fixed: μF ±5%; 50V unless stated
C400	2113741A33	3300pF;±10%
C401	2311049A35	0.47±20%; 25V
C402	2311049A37	1.0; 16V
C403	2160521G37	0.1+80-20%; 25V
C404	2311049J12	4.7; 10V
C405, 406	2111032B13	0.1 +80 -20%
C407	2113741A21	1000pF
C408	2113741A37	.0047±10%
C410	2111032B13	0.1 +80 -20%
C415	2311049J26	10; 16V
C416	2160521G37	0.1+80-20%; 25V
C420	2311049A37	1; 16V
C421	2113740A29	10pF
C422	2113740A33	15pF
C431, 434, 438	2160521G37	0.1+80-20%; 25V
C442, 443, 444	2311049A37	1; 16V
C445	2369562A35	10; 25V
C446	2113741A39	5600pF
C447	2113741A31	2700pF
C449	2113741A45	.01
C452	2311049J12	4.7; 10V
C453	2311049J26	10; 16V
C461	2113740A35	18pF
C463	2113741A37	4700pF
C468	2113741A53	22000pF
C469	2113741A39	5600pF
C470	2113741A45	.01
C472, 474	2113741A45	.01
C481	2360562A43	10; 16V Tant.
C484	2113740A35	18pF
C485	2113741A45	.01
C487	2113741A45	.01
C488, 489	2160521G37	0.1+80-20%; 25V
C493, 494	2113741A45	.01
C497	2160521G37	0.1+80-20%; 25V
C498	2113741J26	10; 16V Tant.
C499	2113741A45	.01
C801	2113741A33	3300pF
C802	2160521G37	0.1+80-20%; 25V
C805	2113741A45	0.01
		DIODE: See Note I
CR403, 405	4805494Q04	Silicon
CR409,	4805494Q04	Silicon
		JACK:
J1,2	0905467R01	Socket, 15-position
J3	0905577P01	Connector, Synthesizer; 7-pin
J4	0905577P01	Connector, Synthesizer; 7-pin
J5	0905504R01	Connector, 10-pin
J8	0105959M27	Receptacle,10-pin
		COIL, RF:
L400,401	0611024B23	0Ω
L402 thru 405	2462575A07	10uH
L407,410	0611024B23	0Ω
L408, 411	2462575A07	10uH
L412,413	0611024A01	10Ω
L414,415	0611024B23	0Ω
		TRANSISTOR: See Note I
Q400	4802245J04	PNP
Q401	4805128M12	NPN
Q402	4805128M94	PNP
Q403	4880141L03	PNP
Q405	4805128M12	NPN
Q410	4805128M10	PNP
Q412 thru 414	4805128M94	PNP
Q416,417	4805128M12	NPN
		RESISTOR, Fixed: Ω±5%; 1/8W unless stated
R400,401	0660076B01	100k
R402	0660076A73	10k
R403	0660076A87	5.6k
R404	0660076A73	10k
R405	0660076H49	10 Meg
R406 thru 408	0660076B01	100k
R409	0660076E39	390±1%
R410	0660076A59	2.7k
R411 thru 413	0660076B01	100k
R414	0660076A90	51k
R417	0660076A56	2k
R418	0660076M01	0
R419	0660076A56	2k
R420	0660076M01	0
R421	0660076A41	470;1/10W
R422	0611076A47	820
R425	0660076F01	100k±1%
R426,427	0660076E84	30k±1%;1/10W
R429	0660076B01	100k
R430	0660076A73	10k
R434	0660076A41	470
R438	0660076B01	100k
R439,440	0660076A73	10k;1/10W
R441	0660076B25	1 Meg; 1/10W
R444	0660076A73	10k
R446	0660076A25	100;1/10W
R447	0660076E95	82k
R448	0660076E90	51k
R449	0660076E84	30k;1/10W
R450	0660076A73	10k;1/10W
R451	0660076A89	47k;1/10W
R452	0660076A54	1.6k
R453,454	0660076A49	1k;1/10W
R461	0660076B01	100k
R462	0660076A73	10k; 1/10W
R463	0660076A90	51k
R465	0660076A77	15k
R466	0660076A85	82k;1/10W
R467	0660076A73	10k;1/10W
R468	0660076A43	560;1/10W
R469	0660076B01	100k;1/10W
R470	0660076A73	10k; 1/10W
R472	0660076A25	100; 1/10W
R474	0660076A57	2.2k
R476	0660076B01	100k
R479	0660076A73	10k; 1/10W
R480	0660076A56	2k
R481	0660076B25	1Meg;1/10W
R803	0660076F03	120k±1%
R804	0660076E94	75k±1%
R806,807	0660076A72	9.1k;1/10W
R808	0660076B25	1Meg;1/10W
R810	0660076A73	10k;1/10W
R813	0660076M01	0 (Rotary Radios)
		CIRCUIT MODULE: See Note I
U401	0102712J01	Microcomputer
U402		
	0105658N07	EEPROM (Rotary Radios)
U403	0105957N87	Hex Gate
U404	0105954P13	Analog Gate
U405	0105954R66	Audio Filter
U406	0105958P03	Audio PA
U407	5160880B01	5V Regulator, CMOS
U801	0105957N83	Quad Op Amp
		DIODE: See Note I
VR401, 402	4880140L09	Zener, 6.2V
VR407,408, 409	4880140L09	Zener, 6.2V
VR413	4880140L09	Zener, 6.2V
		CRYSTAL: See Note II
Y401	4802297J01	3.6864MHz
Y402	4802297J02	3.6914MHz
Y403	4805719G05	2.1MHz Murata
	NONREFERENCED ITEMS	
	0300136820	SCREW, Flat Head
	1405264Q01	INSULATOR, Flex
	1405585S01	INSULATOR, Flex Tail
	1505765R02	CARRIER, FlexTop
	2602229J01	ASSEMBLY, Bottom Shield
	2605185S01	SHIELD
	1405582S01	INSULATOR

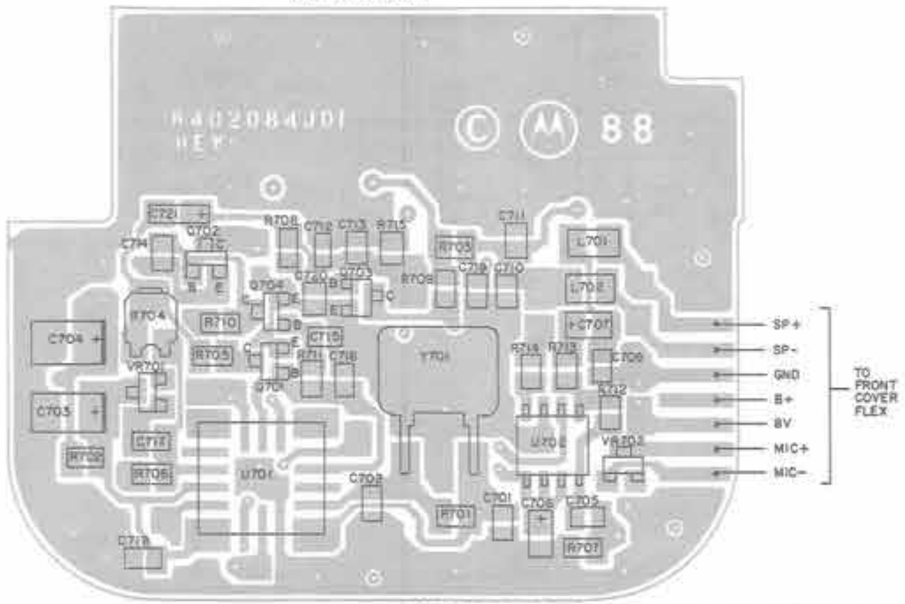
NOTES:
1. For optimum performance, order replacement diodes, transistors, and circuit modules by Motorola part number only.
2. When ordering crystal units, specify carrier frequency, crystal frequency, crystal type number, and Motorola part number.



NTN5941A CONTINUOUS TONE
ENCODE ONLY DTMF FRONT COVER
SCHEMATIC DIAGRAM

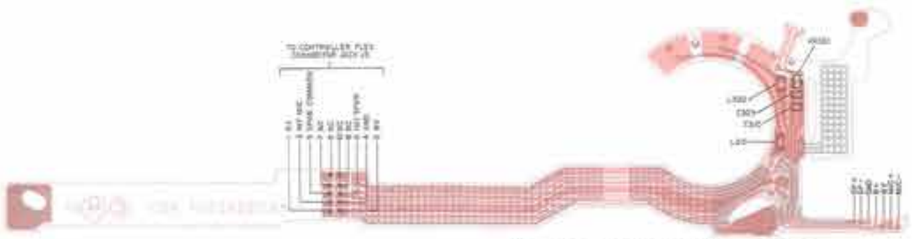
NTN5941A CIRCUIT BOARD COMPONENT LOCATION DETAIL

VIEWED FROM SIDE 1



COMPONENT SIDE 8D-8EPS-48049-0 (8D-8EPF-19308-0-FL)
OVERLAY 0L-8EPS-48050-0 (8D-8EPF-19309-0-FL)

MICROPHONE FLEX ASSEMBLY



COMPONENT SIDE 8D-8EPS-48051-0 (8D-8EPF-19310-0-FL)
SOLDER SIDE 8D-8EPS-48053-0 (8D-8EPF-19311-0-FL)
OVERLAY 0L-8EPS-48053-0 (0L-8EPF-19312-0-FL)

NTN5941A DTMF FRONT COVER (CONTINUOUS TONE) ELECTRICAL PARTS LIST

PL-11655

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
		CAPACITOR, Fixed:pF±5%; 50V unless stated
C701, 702	2113740A40	30
C703, 704	2362998B73	10µF±20%, 16V
C705	2113741A45	.01µF
C706, 707, 708	2362998C09	1µF±10%, 16V
C709, 710, 711	2113740A46	47
C712	2113740A53	82
C713	2113740A57	330
C714 thru 720	2113740A46	47
C721	2362998C09	1µF±10%, 16V
C726**	-----	
C727**	-----	
		COIL, RF:
L701, 702	2462575A01	0.39µH
L703, 704**	-----	0.39µH
LS701	5005155Q03	**TRANSDUCER**
MK701**	-----	**MICROPHONE**
		PLUG
P701**	-----	Contacts, flex circuit plating
P702**	-----	Socket, 10-Pin
		TRANSISTOR: See Note I
Q701, 702	4805218N11	D-MOS FET
Q703, 704	4805128M11	NPN
		RESISTOR, Fixed: Ω±5%; 1/10W unless stated
R701	0660078B25	1M
R702, 703	0660078A19	56
R704	1860502A17	47k Pot.
R705	0660078A25	100
R706	0660078A89	47k
R707	0660078A73	10k
R708	0660078B17	470k
R709, 710, 711	0660078B01	100k
R712	0660078B05	150k
R713, 714	0660078A07	18
R715	0660078A73	10k
		SWITCH:
S701	-----	Program, Non-Functional (Not replaceable, order DTMF Front Cover Kit)
S702	-----	Keypad (Not replaceable, order DTMF Front Cover Kit)
		CIRCUIT MODULE: See Note I
U701	0105951Q06	Tone Generator
U702	5105469E51	Audio Amplifier
		DIODE: See Note I
VR701	4805129M49	Zener
VR702	4805129M42	Zener, 5.6V
VR703**	-----	Zener, 5.6V
		CRYSTAL: See Note II
Y701	4805719G04	Resonator: 3.579 MHz

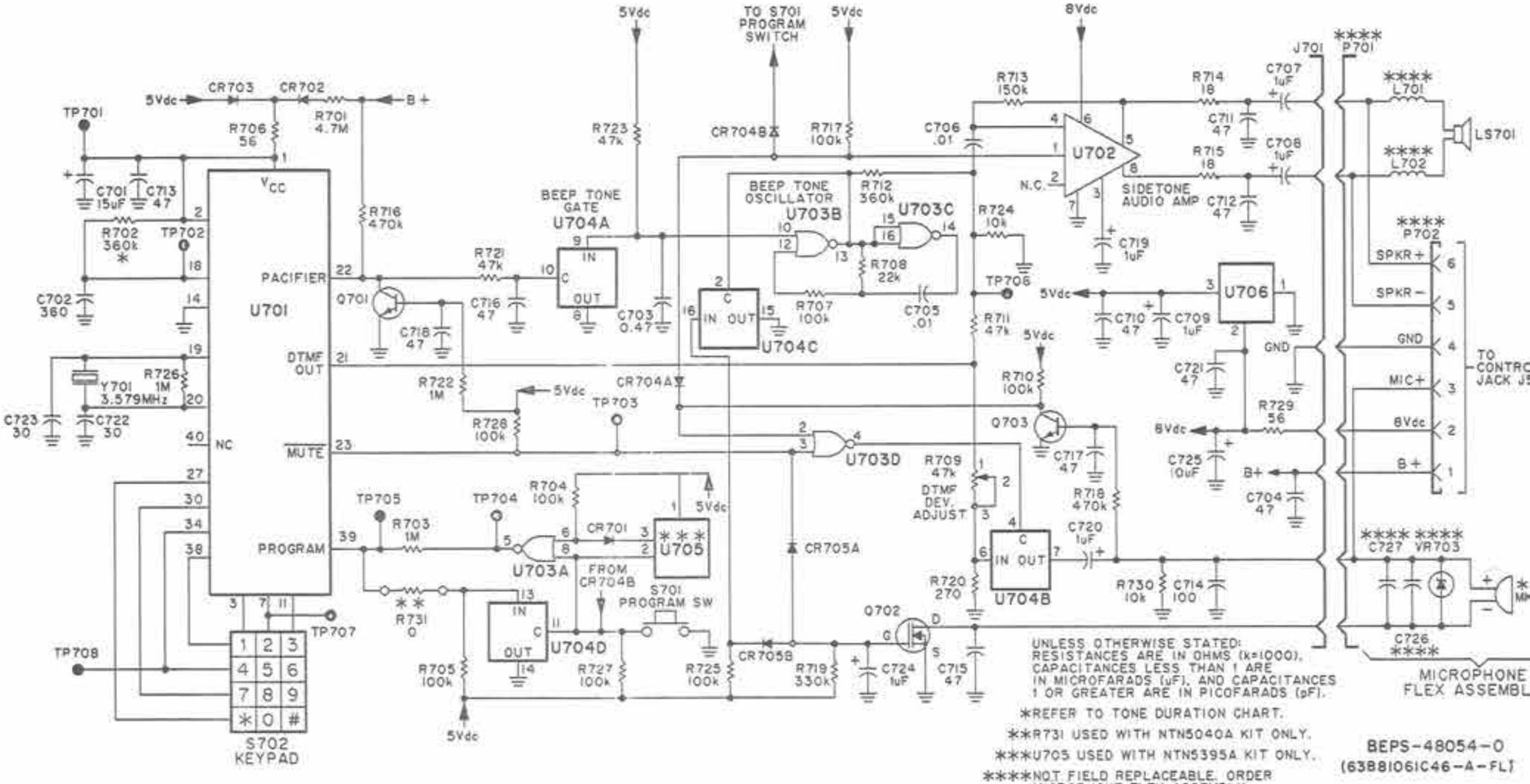
NOTES:

I. For optimum performance, order replacement diodes, transistors, and circuit modules by Motorola part number only.

II. When ordering crystal units, specify carrier frequency, crystal frequency, crystal type number, and Motorola part number.

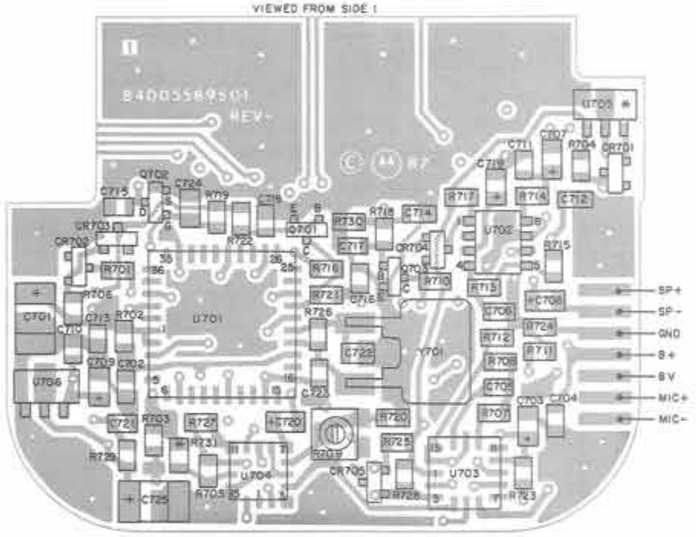
** Not field replaceable, order microphone flex assembly 0102700J18.

N5941A CIRCUIT BOARD
MPONENT LOCATION DETAIL,
ROPHONE FLEX ASSEMBLY,
D ELECTRICAL PARTS LIST



NTN5939AA AND NTN5940A STANDARD
ANI DTMF FRONT COVER SCHEMATIC DIAGI

NTN5939A AND NTN5940A CIRCUIT BOARDS COMPONENT LOCATION DETAIL

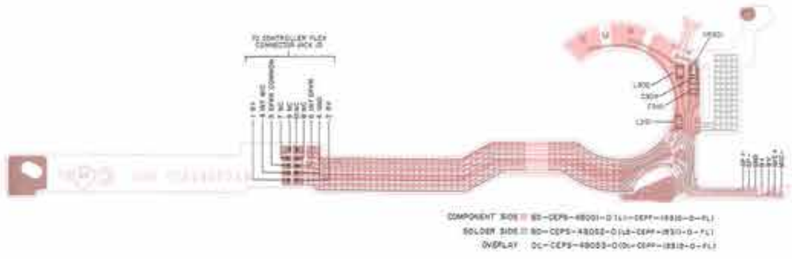


NOTE # REFER TO TABLE BELOW

KIT NO	R731	U705
NTN5395A	NOT USED	USED
NTN5040A	USED	NOT USED

COMPONENT SIDE ● 80-BEPS-48055-O(80-8EPF-19313-O-FL)
OVERLAY 0L-BEPS-48056-O(0L-8EPF-19314-A-FL)

MICROPHONE FLEX ASSEMBLY



COMPONENT SIDE ● 80-CEPS-48001-O(L)-(8EPF-19310-O-FL)
SOLDER SIDE ● 80-CEPS-48002-O(L8-8EPF-19311-O-FL)
OVERLAY 0L-CEPS-48003-O(0L-8EPF-19312-O-FL)

NTN5939A DTMF FRONT COVER
NTN5940A DTMF with ANI FRONT COVER
PL-11656

Electrical Parts List

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
		CAPACITOR, Fixed: uF±10%; 16V unless stated
C701	2362998C24	15;10V; Tant.
C702	2113740A68	360pF±2%;25V
C703	2362998C05	0.47;35V
C704	2113740A46	47pF±5%;50V
C705, 706	2113741A45	.01;25V
C707 thru 709	2362998C09	1
C710 thru 713	2113740A46	47pF±5%;50V
C714	2113740A55	100pF±5%
C715 thru 718	2113740A46	47pF±5%;50V
C719, 720	2362998C09	1
C721	2113740A46	47pF±5%;50V
C722, 723	2113740A40	30pF±5%;50V
C724	2362998C09	1
C725	2362998B73	10±20%
C726 **	-----	
C727 **	-----	
CR701 thru 705	4805129M24	**DIODE:** See Note I Switching
L701, 702 **	-----	**COIL:** 0.39uH Choke
LS701	5005155C03	**TRANSDUCER**
MK701 **	-----	**MICROPHONE**
		PLUG:
P701 **	-----	Contacts, flex circuit plating
P702 **	-----	Socket, 10-Pin
		TRANSISTOR: See Note I
Q701	4805128M11	SOT
Q702	4805218N11	D-MOS
Q703	4805128M11	SOT
		RESISTOR, Fixed: Ω ±5%;1/10W unless stated
R701	0660076H41	4.7Meg
R702	0660076B14	360k: See Note III
R703	0660076B25	1Meg
R704, 705	0660076B01	100k
R706	0660076A19	56;1/8W
R707	0660076B01	100k
R708	0660076A81	22k
R709	1660502A17	Pot., 47k
R710	0660076B01	100k
R711	0660076A89	47k
R712	0660076B14	360k
R713	0660076B05	150k
R714, 715	0660076A07	18
R716	0660076B17	470k
R717	0660076B01	100k
R718	0660076B17	470k
R719	0660076B13	330k
R720	0660076A35	270
R721	0660078A89	47k
R722	0660076B25	1Meg
R723	0660076A89	47k
R724	0660076A73	10k
R725	0660076B01	100k
R726	0660076B25	1Meg
R727, 728	0660078B01	100k
R729	0660076A19	56
R730	0660076A73	10k
R731	0660078M01	0 (NTN5040A only)
S701	-----	**SWITCH:** Program, Single-Pole (Not replaceable, order DTMF Front Cover Kit)
S702	-----	Keypad (Not replaceable, order DTMF Front Cover Kit)
		CIRCUIT MODULE: See Note I
U701	0105953P31	Tone Generator
U702	5105469E51	Audio Amplifier
U703	0105953P32	Quad NOR Gate
U704	0105954P13	Analog Switch
U705	5105469E52	Hall Effect Digital Switch (NTN5940A only)
U706	5160880B01	5-Volt Regulator
VR703 **	-----	**DIODE:** See Note I Zener, 5.6V
Y701	4805719G04	**CRYSTAL:** See Note II 3.579 MHz Resonator

NOTES:

I. For optimum performance, order replacement diodes, transistors, and circuit modules by Motorola part number only.

II. When ordering crystal units, specify carrier frequency, crystal frequency, crystal type number, and Motorola part number.

III. DTMF radios transmit timed DTMF tones. These tones are preset at the factory for 150ms. duration. To accommodate equipment with timing requirements other than 150ms., the tone duration can be changed by changing resistor R702, which is located between pins 2 and 18 of U701. Refer to the TONE DURATION CHART for specific values.

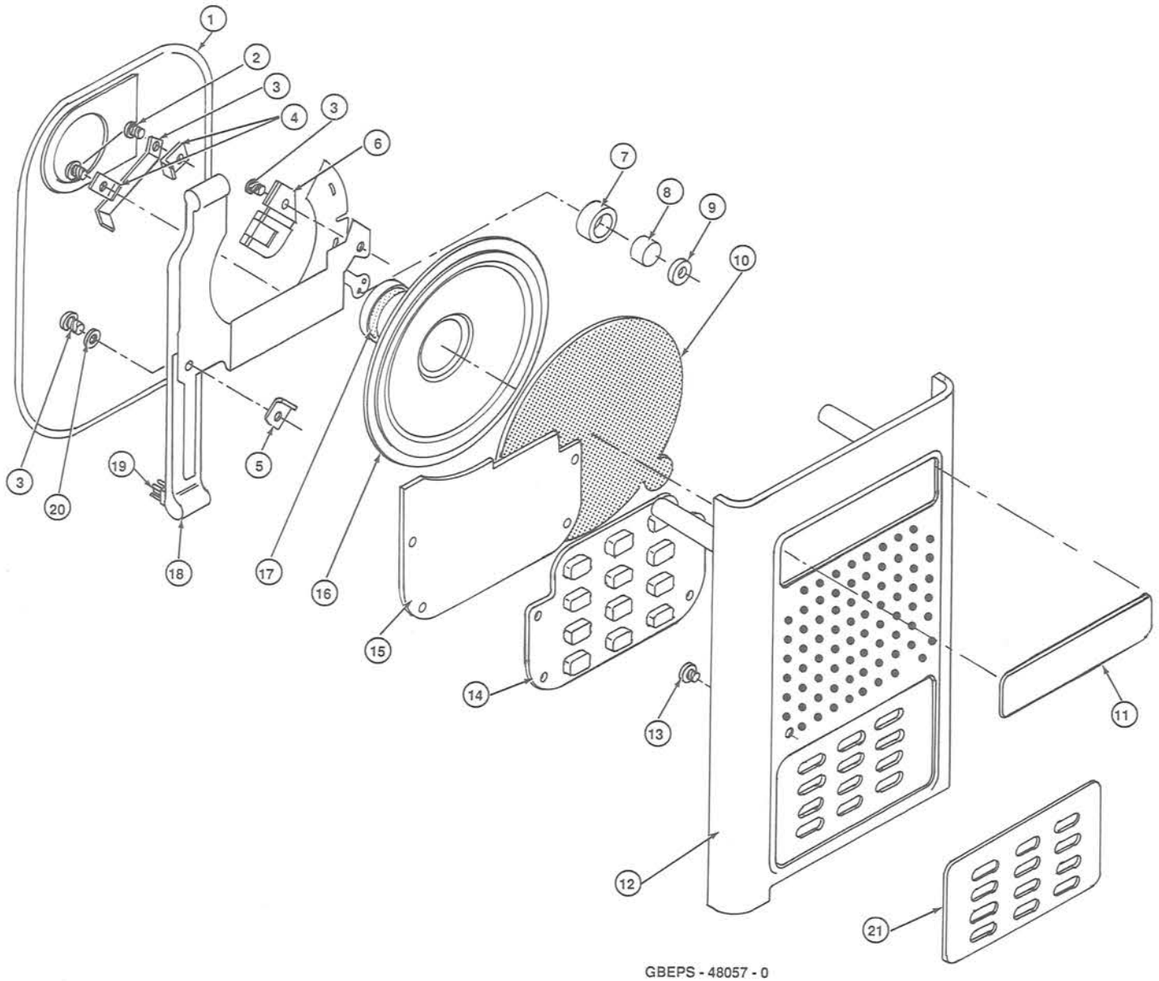
** Not field replaceable, order microphone flex assembly 0102700J18

TONE DURATION CHART

R702 USER-SELECTABLE VALUES			
MOTOROLA PART NUMBER	VALUE OHMS ±5%	TONE DURATION RANGE (ms)	TONE DURATION NOMINAL Tn (ms)
0660076B10	240k	94 - 108	101
0660076B12	300k	117 - 135	126
0660076B14	360k	141 - 162	150
0660076B16	430k	168 - 193	180
0660076B17	470k	184 - 211	197
0660076B18	510k	199 - 229	214
0660076B19	560k	219 - 252	235
0660076B20	620k	242 - 279	260
0660076B21	680k	266 - 306	285
0660076B22	750k	293 - 337	315
0660076B23	820k	320 - 368	344
0660076B24	910k	355 - 409	382

TEPF-18743-O

NTN5939A AND NTN5940A CIRCUIT BOARDS COMPONENT LOCATION DETAIL, MICROPHONE FLEX ASSEMBLY, AND ELECTRICAL PARTS LIST



GBEPS - 48057 - 0

Exploded View Parts List **PL-11657**

ITEM NO.	MOTOROLA PART NO.	DESCRIPTION
1	3205141Q01	O-RING, Front Cover
2	1405299Q01	INSULATOR, Speaker
3	0300139444	SCREW, #2-56x5/32"
4	3905178S01	CONTACT, Front Cover
5	4205166S01	CLAMP, Speaker
6	4205167S01	RETAINER, Microphone
7	1405299L01	BOOT, Microphone
8	--------	MICROPHONE, part of Item 18
9	7505564S01	PAD, Microphone
10	3505152J01 1105776R01	FELT, Speaker ADHESIVE, Speaker Felt, part of Item 10
11	1305540S03	NAMEPLATE
12	--------	* FRONT COVER
13	--------	* SWITCH, Actuator
14	--------	*SWITCH, Keypad
15	--------	*CIRCUIT BOARD
16	See Note	SPEAKER
17	7505501R02	PAD, Speaker
18	See Note	FLEX, Microphone (MK701), Includes Items 7, 8, 16, & 19
19	2805433R02	PLUG, PCB
20	0484345A06	WASHER, Seal
21	1305728R02	ESCUTCHEON

NOTE: See Electrical Parts List for number and description.
*Not field replaceable. Order applicable DTMF Front Cover.

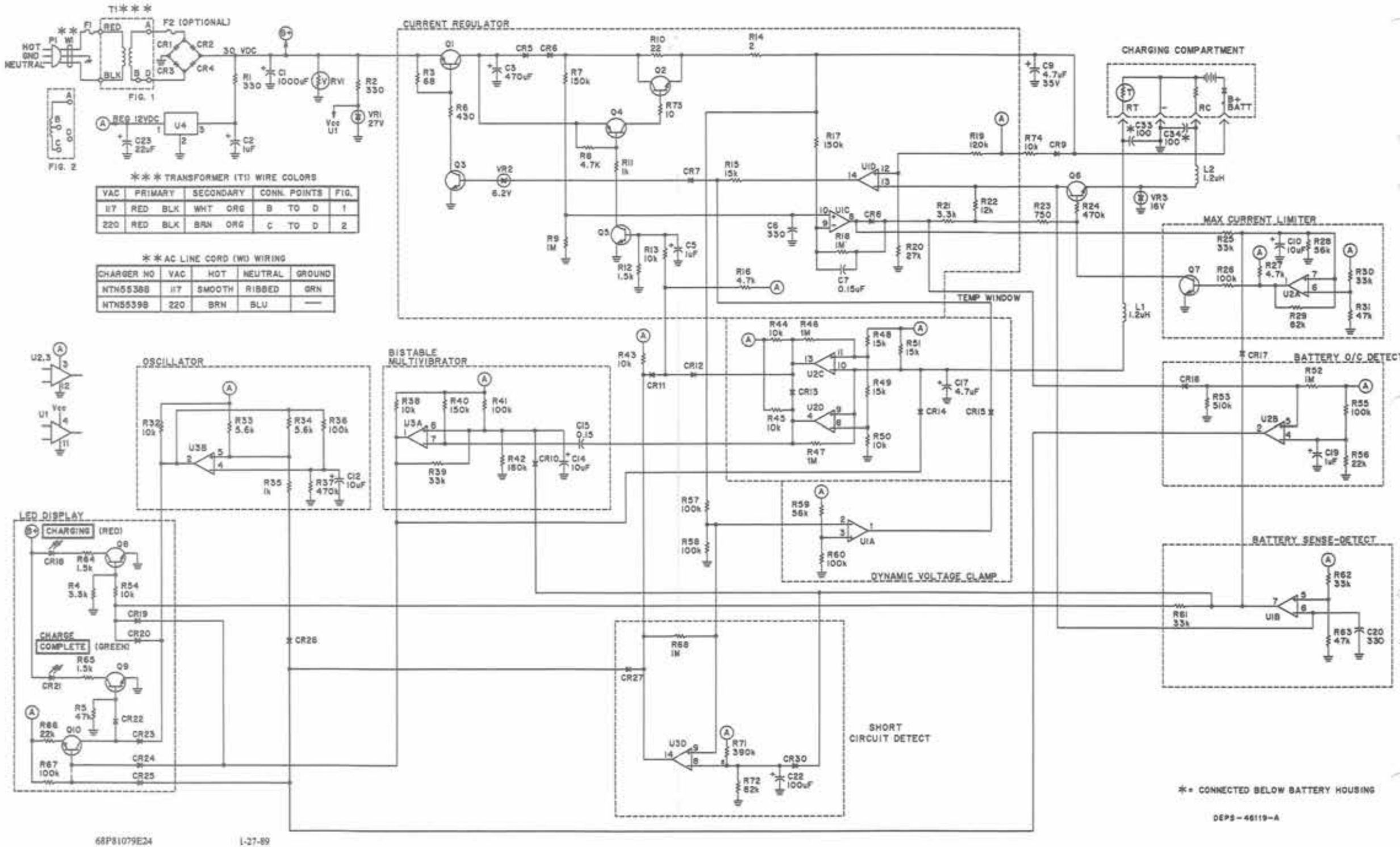
NTN5939A, NTN5940A, AND NTN5941A
DTMF FRONT COVER EXPLODED VIEW DIAGRAM AND PARTS LIST

DC VOLTAGE MEASUREMENT CHARTS

			Q1			Q2		Q3	Q4	Q5	Q6			Q7	Q8		Q9		Q10		VR1
Battery and Condition	B+ Batt	Chrg. Cur. mA	E	B	C	B	E	B	B	B	B	C	E	B	C	B	C	B	B	C	
No Battery	10.76	—	28.2	28.2	1.9	1.89	10.76	0.00	1.92	0.08	9.28	9.69	9.25	0.06	26.8	0.03	26.6	0.00	11.73	0.53	11.84
Rapid Charge 500 mAh	12.85	563.5	22.3	21.6	15.79	14.87	14.07	0.62	14.80	0.70	2.70	2.18	2.10	0.06	0.09	0.71	20.7	0.00	11.74	0.02	11.85
Complete Charge 500 mAh	12.84	51.14	26.8	26.2	15.55	3.99	12.94	0.60	15.55	0.17	2.70	2.18	2.10	0.07	25.4	0.15	0.08	0.71	0.60	1.25	11.85
Rapid Charge 900 mAh	12.86	805.5	20.8	20.00	16.40	15.44	14.62	0.63	15.39	0.71	0.05	2.18	0.05	0.65	0.10	0.71	19.10	0.00	11.74	0.02	11.86
Complete Charge 900 mAh	12.83	72.51	26.5	25.8	16.09	9.03	12.99	0.60	16.09	0.17	0.05	2.18	0.00	0.63	25.1	0.15	0.08	0.72	0.60	1.25	11.85

	U1													U2												U3											
Battery and Condition	B+	1	2	3	5	6	7	8	9	10	12	13	14	1	2	4	5	6	7	8	9	10*	11	13	14	1	2	4	5	6	7	8	9	10	11	13	14
No Battery	26.8	25.5	5.66	7.61	6.97	9.64	.061	0.00	10.60	9.23	2.17	9.68	0.00	0.06	11.52	2.14	3.93	6.88	0.00	2.91	11.83	11.83	7.32	0.08	11.83	11.83	11.73	9.61	11.49	1.11	11.80	1.10	5.66	0	5.67	11.77	11.77
Rapid Charge 500 mAh	21.5	20.2	6.67	7.61	6.97	2.18	20.1	8.56	12.09	12.36	2.17	2.18	7.30	0.06	11.54	2.14	3.93	6.88	4.34	2.96	6.89	6.89	7.44	11.80	11.79	11.84	11.74	9.63	11.79	7.63	11.81	2.18	6.67	0	6.67	11.79	11.79
Complete Charge 500 mAh	25.9	24.6	6.65	7.61	6.98	2.18	24.5	8.69	12.07	12.23	2.17	2.18	6.88	0.07	11.48	2.14	3.93	6.89	4.41	2.92	0.62	0.62	7.33	0.75	0.11	0.06	11.74	9.63	11.79	7.64	2.23	2.18	6.65	0	6.65	11.79	11.79
Rapid Charge 900 mAh	19.10	17.79	6.69	7.61	6.98	2.18	17.71	12.12	12.57	12.75	2.17	2.18	7.49	11.19	11.55	2.14	3.93	6.89	8.40	2.95	6.90	6.90	7.44	11.80	11.79	11.85	11.74	9.63	11.79	7.64	11.82	2.18	6.69	0	6.69	11.79	11.79
Complete Charge 900 mAh	24.8	23.6	6.65	7.61	6.98	2.18	23.5	12.13	12.51	12.67	2.17	2.18	7.01	11.19	11.48	2.14	3.93	6.89	8.40	2.92	0.62	0.62	7.33	0.75	0.11	0.06	11.74	9.63	11.79	7.63	2.23	2.18	6.65	0	6.65	11.79	11.79

SCHEMATIC DIAGRAM



parts list

Electrical Parts List
NTN5538B (117 V ac) Single-Unit Charger (Rapid)
NTN5538B (230 V ac) Single-Unit Charger (Rapid) PL-11093-A

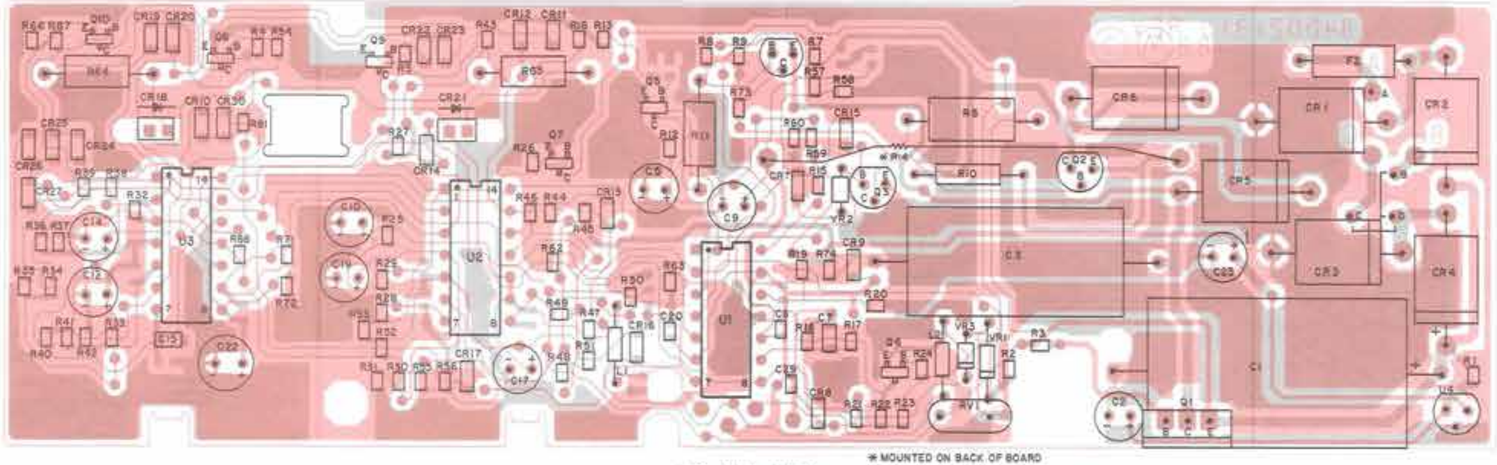
REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
		capacitor, fixed: pF ±5%, 50 V; unless stated
C1	2360563A01	1000 uF
C2	2360561M09	1 uF
C3	2360561M02	470 uF; 35 V
C5	2360561M09	1 uF
C8	2180820C13	330
C7	2180821H39	0.1 uF +80-20%; 25 V
C9	2360561M15	4.7 uF; 35 V
C10	2360561M19	10 uF; 35 V
C12	2360561M19	10 uF; 35 V
C14	2360561M19	10 uF; 35 V
C15	2180821H39	0.1 uF +80-20%; 25 V
C17	2360561M15	4.7 uF; 35 V
C19	2360561M09	1 uF
C20	2180820C13	330
C22	2360561M44	100 uF; 16 V
C23	2360561M33	22 uF; 16 V
C33, 34	2106480G12	100; 63 V
		diode: (see note)
CR1 thru 6	4805746G16	silicon
CR7 thru 17	4805494Q14	silicon
CR18	4805729G06	LED, red
CR19, 20	4805494Q04	silicon
CR21	4805729G09	LED, green
CR22 thru 27	4805494Q04	silicon
CR30	4805746G13	silicon
		fuse:
F1	6500892099	3/4 amp; 125 V (NTN5538B)
	or 6505384M02	1/4 amp; 250 V (NTN5539B)
F3	6505214E07	3-amp (optional)
		choke, rf:
L1, 1	2482723H01	1.2 uH
		plug, ac:
P1	----	connector, part of W1
		transistor: (see note)
Q1	4805709G09	PNP
Q2	4805474G43	NPN
Q3	4805474G42	NPN
Q4	4805474G41	PNP
Q5 thru 9	4805128M62	NPN
Q10	4805128M67	PNP
		resistor, fixed: ohms ±5%; 1/8 W; unless stated
R1, 2	0660078A37	330
R3	0660078A21	68
R4	0660078A61	3.3k
R5	0660078A88	47k
R6	1760471A01	430; 2 W
R7	0660078F06	150k ±1%
R8	0660078A65	4.7k
R9	0660078F25	1 Meg ±1%
R10	0660078N01	22 ±2%; 1 W
R11	0660078L49	1k; 3/4 W
R12	0660078A53	1.5k
R13	0660078A73	10k
R14	1805228C01	2; 7 W; wire-wound
R15	0660078A77	15k
R16	0660078A65	4.7k
R17	0660078F05	150k ±1%
R18	0660078F25	1 Meg ±1%
R19	0660078F03	120k ±1%
R20	0660078E63	27k ±1%
R21	0660078E81	3.3k
R22	0660078E75	12k ±1%
R23	0660078E45	750 ±1%
R24	0660078R17	470k ±10%
R25	0660078A59	33k
R26	0660078B01	100k
R27	0660078A65	4.7k
R28	0660078A91	56k
R29	0660078A96	82k
R30	0660078A85	33k
R31	0660078A89	47k
R32	0660078A73	10k
R33, 34	0660078A67	5.6k
R35	0660078A49	1k
R36	0660078B01	100k
R37	0660078R17	470k ±1%
R38	0660078A73	10k
R39	0660078A85	33k
R40	0660078B05	150k
R41	0660078B01	100k
R42	0660078B07	180k

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
R43,44,45	0660078A73	10k
R46, 47	0660078B25	1 Meg
R48, 49	0660078E77	15k ±1%
R50	0660078S73	10k
R51	0660078E77	15k ±1%
R52	0660078B25	1 Meg
R53	0660078B18	510k
R54	0660078A73	10k
R55	0660078B01	100k
R56	0660078A81	22k
R57, 58	0660078FC1	100k ±1%
R59	0660078E91	56k ±1%
R60	0660078FC1	100k ±1%
R61, 62	0660078A89	33k
R63	0660078A89	47k
R64, 65	0660078L53	1.5k; 3/4 W
R66	0660078A81	22k
R67	0660078B01	100k
R68	0660078B25	1 Meg
R71	0660078B15	390k
R72	0660078E99	82k ±1%
R73	0660078A01	10
R74	0660078A73	10k
		varistor: (see note)
RV1	0656220M01	35 V
		transformer, power
T1	2606178Q01	for (NTN5538B)
	or 2505491R01	for (NTN5539B)
		circuit module: (see note)
U1	5184220A80	quad operational amplifier
U2, 3	5184220A51	quad comparator
U4	5105489E49	voltage regulator, 12 V
		Zener diode:
VR1	4863481E12	27 V
VR2	4805249R04	5.2 V
VR3	4805249R14	16 V
		cable assembly:
W1	0100687M12	3-conductor, includes ac cord, plug P1, and red crimp lug (NTN5538B)
	or 3005026R01	3-conductor, includes ac cord and plug P1 (NTN5539B)

note: For optimum performance, diodes, transistors, and integrated circuits must be ordered by Motorola part numbers.

CIRCUIT BOARD DET
AND PARTS

VIEWED FROM COMPONENT SIDE

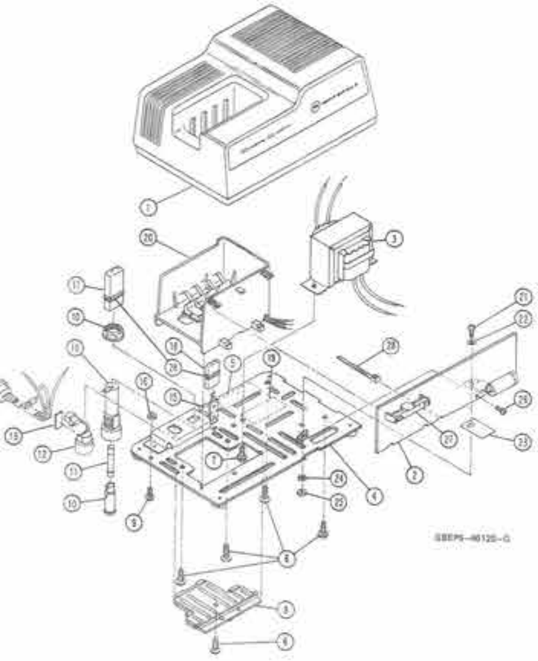


* MOUNTED ON BACK OF BOARD

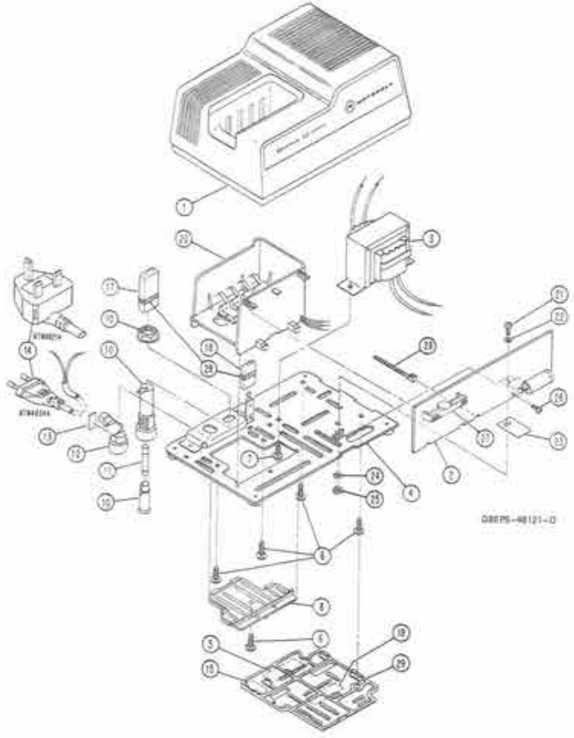
CS – CEPS – 46116 – A
SS – CEPS – 46117 – A
OL – CEPS – 46118 – A

PLODED VIEWS
D PARTS LISTS

NTN5538B



NTN5539B



parts list

Exploded View Parts List
NTN5538B (117 V ac)
Single-Unit Charger (Rapid) PL11084-A

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
1	0105952Q84	ASSEMBLY, top housing; includes: Housing, Escutcheon, Thermal Partition, and Fastener Clip
2	0105957M06	ASSEMBLY, circuit board
3	See Note	TRANSFORMER (T1)
4	0105957M16	ASSEMBLY, base plate; includes: Brackets, Single Lug Terminal Strip, Base Plate, and 4 Rubber Bumpers
5	5405228Q01	LABEL, caution
6	0300138574	SCREW, phillips hd.; 8-32 × 3/8" (5 req'd)
7	0300131632	SCREW, tapping; slotted hd.; 8-32 × 3/8" (2 req'd)
8	1305130Q01	GRILL, base
9	0300138039	SCREW, phillips hd.; 8-32 × 3/8"
10	0905724C02	RECEPTACLE, fuse holder
11	See Note	FUSE (F1)
12	4205723C01	RETAINER, cable
13	4305233C01	SPACER
14	See Note	ASSEMBLY, cable (P1, W1)
15	5405229Q01	LABEL, fuse
16	0200007008	NUT, hex; 6-32 × 1/4" x 3/32"
17	3805637M02	CAP GUARD, fuse holder
18	3805637M01	CAP GUARD, terminal
19	5405230Q01	LABEL, info
20	0105957M07	ASSEMBLY, partition; includes: Thermal Partition, Charging Contacts, Fastener Clip, and Capacitors C33, C34
21	0300120936	SCREW, phillips hd.; 4-40 × 5/16"
22	.....	BUSHING, nylon (part of Q1, see note)
23	.....	INSULATOR, mica (part of Q1, see note)
24	0400007687	LOCKWASHER, #4 external tooth
25	0300120486	NUT, hex; 4-40 × 1/4 × 3/32"
26	0300120936	SCREW, phillips hd.; 4-40 × 5/16"
27	0705687P01	HOLDER, LED
28	4210217A26	TIE WRAP

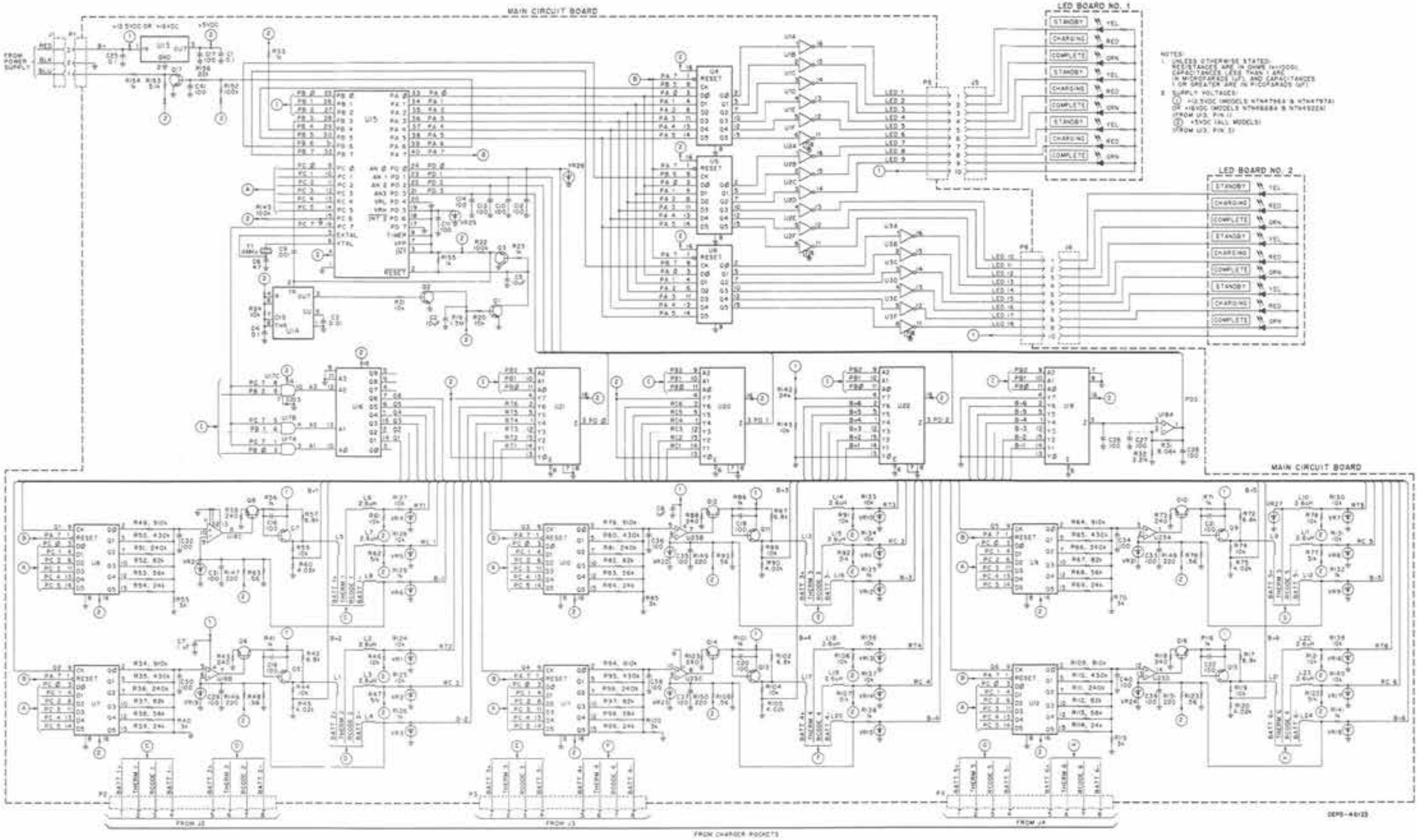
note: Refer to Electrical Parts List for part number and description.

Exploded View Parts List
NTN5539B (220 V ac) Single-Unit Charger (Rapid) PL11095-A

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
1	0105952Q84	ASSEMBLY, top housing; includes: Housing, Escutcheon, Thermal Partition, and Fastener Clip
2	0105957M06	ASSEMBLY, circuit board
3	See Note	TRANSFORMER (T1)
4	0105957M14	ASSEMBLY, base plate; includes: Brackets, Single Lug Terminal Strip, Base Plate, and 4 Rubber Bumpers
5	5405228Q01	LABEL, caution
6	0300138574	SCREW, phillips hd.; 8-32 × 3/8" (5 req'd)
7	0300131632	SCREW, tapping; slotted hd.; 8-32 × 3/8" (2 req'd)
8	1305130Q01	GRILL, base
9	.....	NOT USED
10	0905490R01	RECEPTACLE, fuse holder
11	See Note	FUSE (F1)
12	4205723C01	RETAINER, Cable
13	4305233C01	SPACER
14	See Note	ASSEMBLY, cable (P1, W1)
15	5405229Q03	LABEL, fuse
16	.....	NOT USED
17	3805637M02	CAP GUARD, fuse holder
18	3805637M01	CAP GUARD, terminal
19	5405230Q01	LABEL, info
20	0105957M07	ASSEMBLY, partition; includes: Thermal Partition, Charging Contacts, Fastener Clip, and Capacitors C33, C34
21	0300120936	SCREW, phillips Hd.; 4-40 × 5/16"
22	.....	BUSHING, nylon (part of Q1, See Note)
23	.....	INSULATOR, mica (part of Q1, See Note)
24	0400007687	LOCKWASHER, #4 external tooth
25	0300120486	NUT, hex; 4-40 × 1/4 × 3/32"
26	0300120619	SCREW, phillips Hd.; 4-40 × 5/16"
27	0705687P01	HOLDER, LED
28	4210217A26	TIE WRAP
29	1305412R01	GRILL, thermal

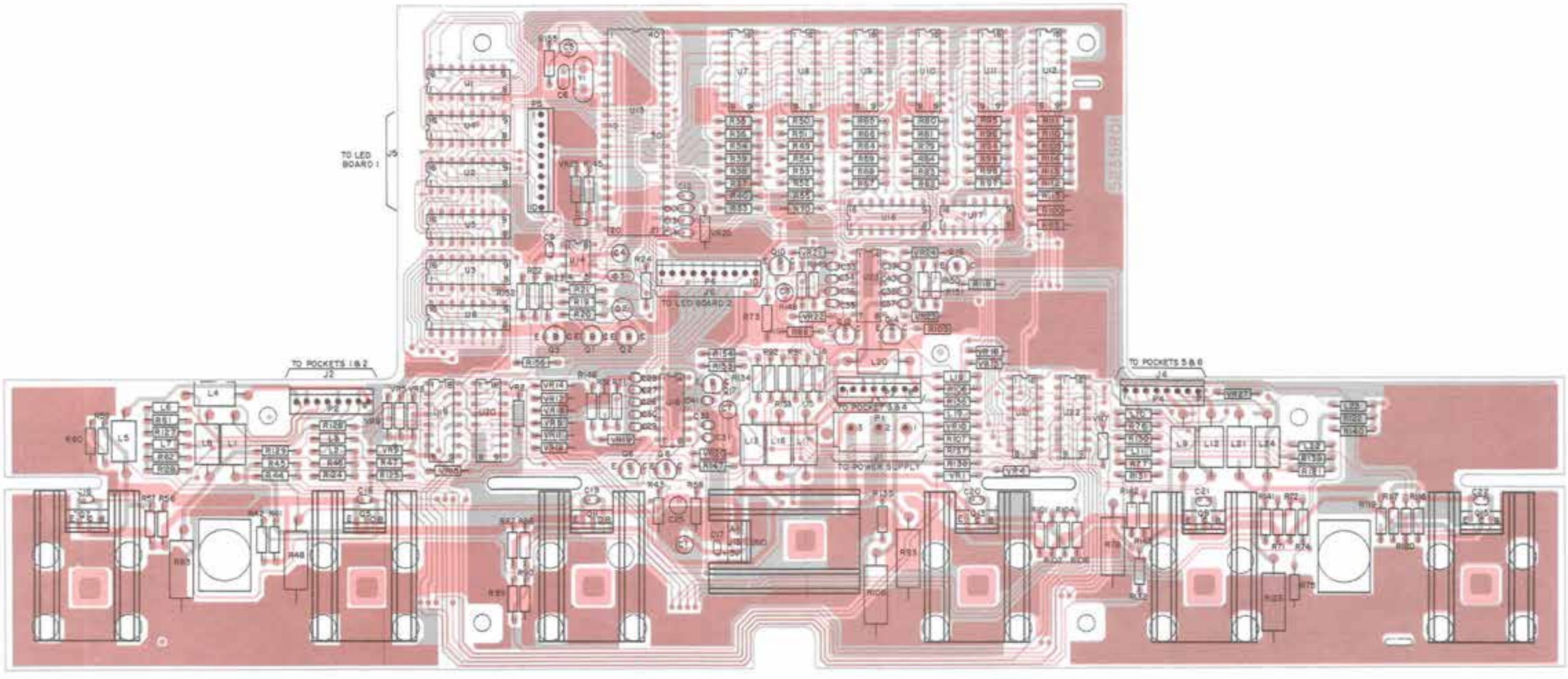
note: Refer to Electrical Parts List for part number and description.

MAIN BOARD
SCHEMATIC DIAGRAM



MAIN CIRCUIT BOARD
COMPONENT LAYOUT DIAGRAM

VIEWED FROM COMPONENT SIDE



* SS - DEPS-46124-O
* CS - DEPS-46125-O
OL - DEPS-46126-O

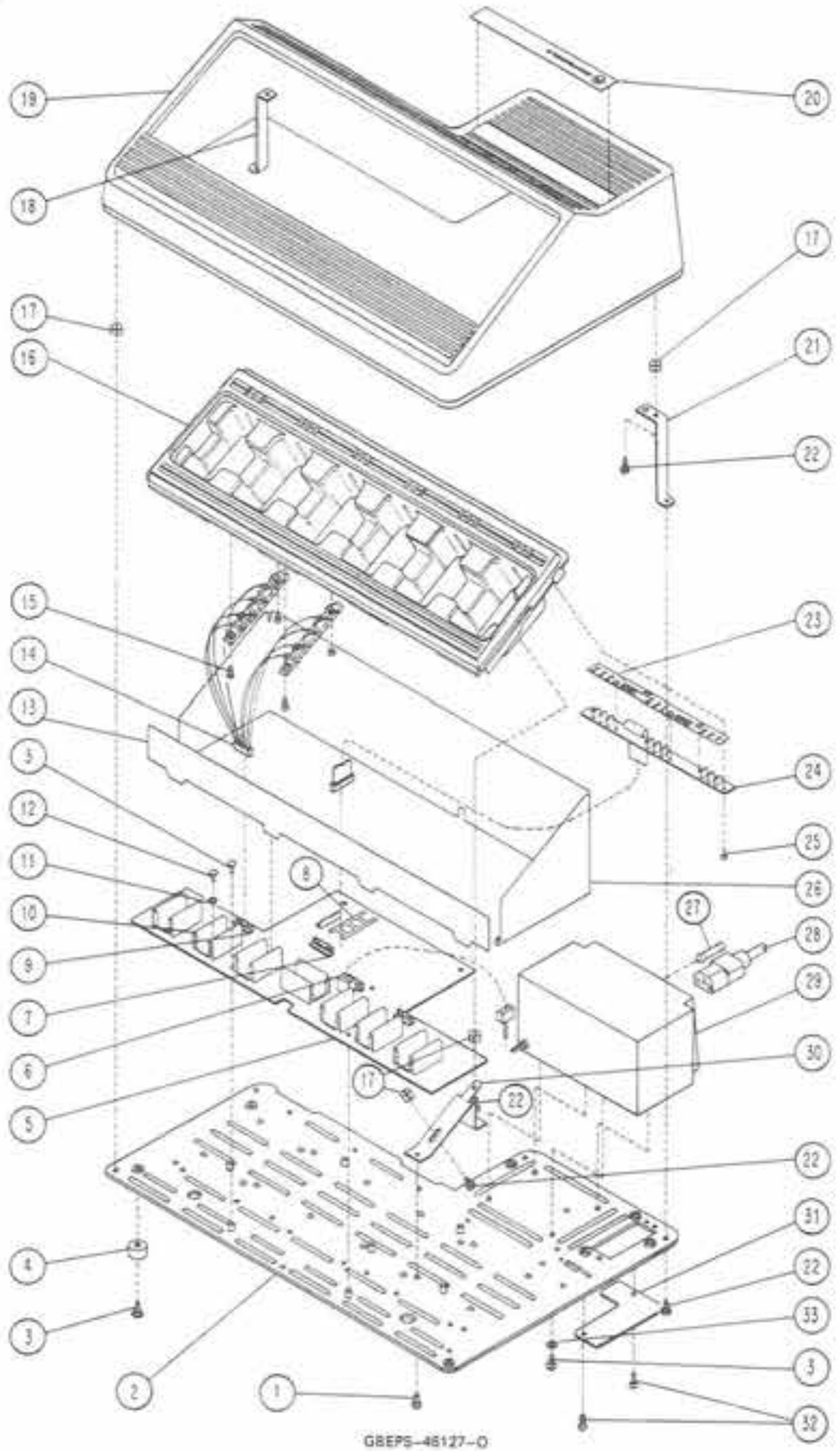
parts list

Electrical Parts List — PL-11096-O

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
		capacitor, fixed: uF ± 10%; 63 V: unless otherwise stated
C1	2383441B20	0.1 ±20%; 35 V
C2	2305499G16	10; 16 V
C3	2105457G14	.01 +30-80%
C4	2383441B20	0.1 ±20%; 35 V
C5	2305499G16	10; 16 V
C6	2105529B11	47 pF ±5%; N150
C7, 8	2383441B15	1 ±20%; 35 V
C9	2105457G09	1000 pF
C10 thru 14	2105455G12	100 pF; N750
C15		NOT USED
C16 thru 22	2105455G12	100 pF; N750
C23, 24		NOT USED
C25	2383441B30	0.1 ±20%; 35 V
C26 thru 41	2105455G12	100 pF; N750
		coil, rf: unless otherwise stated
L1	2483977B02	choke
L2, 3	2482723H39	2.6 uH
L4, 5	2483977B02	choke
L6, 7	2482723H39	2.6 uH
L8, 9	2483977B02	choke
L10, 11	2482723H39	2.6 uH
L12, 13	2483977B02	choke
L14, 15	2482723H39	2.6 uH
L16, 17	2483977B02	choke
L18, 19	2482723H39	2.6 uH
L20, 21	2483977B02	choke
L22, 23	2482723H39	2.6 uH
L24	2483977B02	choke
		plug:
P1	0905367R01	connector, 3-position
P2 thru 4	2805350R03	connector, 8-position
P5, 6	2805350R04	connector, 10-position
P7 thru 11	2805350R01	connector, header, right-angle; 4-position
		transistor: (see note)
Q1, 2	4800869642	NPN; type M9642
Q3	4800869643	PNP; type M9643
Q4		NOT USED
Q5	4800869807	PNP; type M9807
Q6	4800869642	NPN; type M9642
Q7	4800869807	PNP; type M9807
Q8	4800869642	NPN; type M9642
Q9	4800869807	PNP; type M9807
Q10	4800869642	NPN; type M9642
Q11	4800869807	PNP; type M9807
Q12	4800869642	NPN; type M9642
Q13	4800869807	PNP; type M9807
Q14	4800869642	NPN; type M9642
Q15	4800869807	PNP; type M9807
Q16, 17	4800869642	NPN; type M9642
		resistor, fixed: ohms ±5%; 1/4 W: unless otherwise stated
R1 thru 18		NOT USED
R19	0610184K38	1.5M
R20, 21	0611009C73	10k
R22	0611009C97	100k
R23	0611009C49	1k
R24	0611009C73	10k
R25 thru 30		NOT USED
R31	0610621C62	8.06k ±1%
R32	0610621C28	2.21k ±1%
R33	0611009C49	1k
R34	0611009D21	910k
R35	0611009D13	430k
R36	0611009D07	240k
R37	0611009C95	82k
R38	0611009C91	56k
R39	0611009C82	24k
R40	0611009C60	3k
R41	0611009C69	6.8k
R42	0611009C49	1k
R43	0611009C34	240
R44	0610621C91	10k ±1%
R45	0610621C53	4.02k ±1%
R46	0610621C91	10k ±1%
R47	0611009C90	51k
R48	1782036G18	0.56; 2 W
R49	0611009D21	910k
R50	0611009D13	430k
R51	0611009D07	240k
R52	0611009C95	82k
R53	0611009C91	56k
R54	0611009C82	24k
R55	0611009C60	3k
R56	0611009C49	1k
R57	0611009C69	6.8k
R58	0611009C34	240
R59	0610621C91	10k ±1%
R60	0610621C53	4.02k ±1%
R61	0610621C91	10k ±1%
R62	0611009C90	51k
R63	1782036G18	0.56; 2 W
R64	0611009D21	910k
R65	0611009D13	430k
R66	0611009D07	240k
R67	0611009C95	82k
R68	0611009C91	56k
R69	0611009C82	24k
R70	0611009C60	3k
R71	0611009C49	1k
R72	0611009C69	6.8k
R73	0611009C34	240
R74	0610621C91	10k ±1%
R75	0610621C53	4.02k ±1%
R76	0610621C91	10k ±1%
R77	0611009C90	51k
R78	1782036G18	0.56; 2 W
R79	0611009D21	910k
R80	0611009D13	430k
R81	0611009D07	240k
R82	0611009C95	82k
R83	0611009C91	56k
R84	0611009C82	24k
R85	0611009C60	3k
R86	0611009C49	1k
R87	0611009C69	6.8k
R88	0611009C34	240
R89	0610621C91	10k ±1%
R90	0610621C53	4.02k ±1%
R91	0610621C91	10k ±1%
R92	0611009C90	51k
R93	1782036G18	0.56; 2 W
R94	0611009D21	910k
R95	0611009D13	430k
R96	0611009D07	240k
R97	0611009C95	82k
R98	0611009C91	56k
R99	0611009C82	24k
R100	0611009C60	3k
R101	0611009C49	1k
R102	0611009C69	6.8k
R103	0611009C34	240
R104	0610621C91	10k ±1%
R105	0610621C53	4.02k ±1%
R106	0610621C91	10k ±1%
R107	0611009C90	51k
R108	1782036G18	0.56; 2 W
R109	0611009D21	910k
R110	0611009D13	430k
R111	0611009D07	240k
R112	0611009C95	82k
R113	0611009C91	56k
R114	0611009C82	24k
R115	0611009C60	3k
R116	0611009C49	1k
R117	0611009C69	6.8k
R118	0611009C34	240
R119	0610621C91	10k ±1%
R120	0610621C53	4.02k ±1%
R121	0610621C91	10k ±1%
R122	0611009C90	51k
R123	1782036G18	0.56; 2 W
R124, 125	0611009C73	10k
R126	0611009C49	1k
R127, 128	0611009C73	10k
R129	0611009C49	1k
R130, 131	0611009C73	10k
R132	0611009C49	1k
R133, 134	0611009C73	10k
R135	0611009C49	1k
R136, 137	0611009C73	10k
R138	0611009C49	1k
R139, 140	0611009C73	10k
R141	0611009C49	1k
R142	0611009C82	24k
R143	0611009C73	10k
R144		NOT USED
R145	0611009C97	100k
R146 thru 151	0611009C33	220
R152	0611009C97	100k
R153	0611009C86	5.1k
R154	0611009C49	1k
R155	0611009C73	10k
R156	0611009C81	22k
		circuit module: (see note)
U1 thru 3	5183629M93	IC, Peripheral Driver Array; MC1413
U4 thru 12	5184887K70	IC, Hex D Flip-Flop; MC14174
U13	5184320A47	IC, 5 V Regulator; MC7805
U14	5184320A35	IC, Timing; NE555
U15	0105956P09	IC, Microcomputer; MC68705R3
U16	0105461G33	IC, Binary-to-Octal Decoder; MC14028
U17	5184887K75	IC, Quad 2-Input AND Gate; MC14081
U18	5184561L75	IC, Quad Low-Power Op Amp; MC34074
U19 thru 22	5105461G33	IC, 8-Channel Analog Mux/Demux; MC14051
U23	5184561L75	IC, Quad Low Power Op Amp; MC34074
		diode: (see note)
VR1 thru 27	4811034G13	Zener, 6.2 V
Y1	4805664G25	**crystal:** 4 MHz
		non-referenced items
	0905035J13	SOCKET, IC
	2505237R01	POWER SUPPLY, switch mode, 120-watt (includes J1)
	3005351R01	ASSEMBLY, cable (includes J2 thru 4, J7 thru 11)
	3060665A04	CORD, power; 110 V ac
	or 3060665A05	CORD, power; 220 V ac
	3905560Q05	CONTACT
	8505700Q09	FUSE, Fast-Blo; 3-Amp, 250 V
	0105952P61	ASSEMBLY, main PCB
	8405236R01	PRINTED CIRCUIT BOARD, contact
	8405366R01	PRINTED CIRCUIT BOARD, LED (includes J5, 6)
	0105955N09	ASSEMBLY, contact (includes J2 thru J4)

note: For optimum performance, diodes, transistors, and integrated circuits must be ordered by Motorola part numbers.

MODELS NTN5536A AND NTN5537A
EXPLODED VIEW DIAGRAM AND PARTS LIST



GBEPS-46127-O

parts list

NTN5536A and NTN5537A Exploded View Parts List PL-11097-O

ITEM NO.	MOTOROLA PART NO.	DESCRIPTION
1	0300129890	SCREW, machine; 10-32 × 0.375" (4 req'd.)
2	0105952P82	ASSEMBLY, baseplate
3	0300121057	SCREW, machine: 6-32 × 0.375" (16 req'd.)
4	7505413C01	BUMPER, rubber (5 req'd.)
5	see note	ASSEMBLY, main PCB (includes items 6 thru 12)
6	see note	CONNECTOR, 3-position (P1) (part of item 5)
7	see note	CONNECTOR, 10-position (P5, 6) (2 req'd.) (part of item 5)
8	see note	SOCKET, IC (part of item 5)
9	see note	CONNECTOR, 8-position (P2 thru 4) (3 req'd.) (part of item 5)
10	2605239R01	HEAT SINK, 5-watt (7 req'd.) (part of item 5)
11	0410057A13	WASHER, shoulder; plastic (7 req'd.) (part of item 5)
12	0300002951	SCREW, machine: 4-40 × 0.250" (7 req'd.) (part of item 5)
13	2605541L02	SHIELD, thermal
14	see note	ASSEMBLY, cable (includes J2 thru 4) (3 req'd.)
15	0300139982	SCREW, machine: 2-56 × 5/32" (12 req'd.)
16	1505411R02	HOUSING, pocket
17	4205722C02	CLIP, fastener (10 req'd.)
18	0705486G01	BRACKET, charger housing
19	1505277L02	HOUSING, multi-unit charger
20	3305543L06	NAMEPLATE, charger
21	0705193L01	BRACKET, cover, tin-plated (2 req'd.)
22	0300131632	SCREW, tapping; 6-32 × 0.375" (13 req'd.)
23	2605407S01	SHIELD, static (2 req'd.)
24	see note	PRINTED CIRCUIT BOARD, LED (2 req'd.)
25	0300135922	SCREW, tapping; 4-24 × 0.25" (6 req'd.)
26	2605238R01	SHIELD, thermal
27	see note	FUSE, power supply
28	see note	CORD, ac power (110 V ac or 220 V ac)
29	see note	POWER SUPPLY, switch mode; 120-watt
30	0705189L01	BRACKET, pocket (2 req'd.)
31	6405636L03	COVER, switch
32	0300002941	SCREW, machine: 6-32 × 0.25" (2 req'd.)
33	0400007666	WASHER, external tooth; #6 (4 req'd.)

note: refer to electrical parts list for part number and description.

MOTOROLA INC.
Communications Sector

REMOTE SPEAKER MICROPHONE

MODEL NMN6153A
MODEL NMN6168A

1. DESCRIPTION

Remote Speaker Microphones NMN6153A and NMN6168A include a speaker, a microphone, a push-to-talk (PTT) switch and associated circuitry. A cable, terminated with a special plug, is provided for attaching to the universal connector on the portable radio.

When the remote speaker microphone is attached to the radio, the speaker in the radio is disabled, and receiver audio is connected to the accessory speaker. Similarly, the accessory microphone is connected to the transmitter, and the accessory PTT switch can now control the PTT function in the radio. The radio microphone and PTT switch are still operational, but you can listen to the radio only through the accessory speaker.

The NMN6168A Microphone also contains a 2.5mm earphone jack which is attached to and located on the special plug. When a secondary receiver audio accessory is plugged into the NMN6168A Earphone Jack, audio to the remote speaker is disconnected and rerouted to the secondary audio accessory.

NOTE
Observe safety information in the radio operating instructions.

2. OPERATION

a. Attach the microphone's accessory connector to the universal connector on top of the radio.

b. Firmly tighten the captive screw of the accessory connector into the threaded hole (middle of universal connector). The maximum recommended torque is 4 in. lbs.

c. While listening to the accessory speaker, turn the radio on and operate it as explained in the operating instructions supplied with the radio.

d. The microphone will perform best if it is worn as shown in Figure 1.


GAEPS—46109—O

Figure 1.

3. HANDLING PRECAUTIONS

To avoid damage to circuits, observe the following handling, shipping, and servicing precautions.

a. Prior to and while servicing a remote speaker microphone, particularly after moving within the service area, momentarily place both hands on a bare metal, earth-grounded surface. This will discharge any static charge which may have accumulated on the person doing the service.

NOTE
Wearing a conductive wrist strap (Motorola No. RSX-4015A) will minimize static buildup during servicing.

WARNING

When wearing a conductive wrist strap, be careful near high voltage sources. The good ground provided by the wrist strap will also increase the danger of lethal shock from accidentally touching high voltage sources.

b. Whenever possible, avoid touching any electrically conductive part of the unit with your hands.

c. When servicing a unit, avoid carpeted areas, dry environments, and certain types of clothing (silk, nylon, etc.) because they contribute to static buildup.

d. All electrically powered test equipment should be grounded. Apply the ground lead from the test equipment to the unit before connecting the test probe. Similarly, disconnect the test probe prior to removing the ground lead.

e. If the microphone cartridge is removed from the unit, place it on a conductive surface, such as a sheet of aluminum foil which is connected to ground through 100k ohms of resistance.

WARNING

If the aluminum foil is connected directly to ground, be cautious of possible electrical shock from contacting the foil at the same time as other electrical circuits.

f. When soldering, be sure the soldering iron is grounded.

g. Prior to replacing circuit components or touching the microphone cartridge, be sure to discharge any static buildup. Since voltage differences can exist across the human body, it is recommended that only one hand be used if it is necessary to touch the microphone cartridge and associated wiring.

h. Replacement microphone cartridges should be kept in conductive packaging until they are placed in the unit.

4. MAINTENANCE

Refer to the schematic diagram (shown in Figure 2), the exploded view (shown in Figure 3), and the parts lists. Every part in the microphone is identified and illustrated for assistance in removal and replacement.

If necessary, the external surfaces of the remote speaker microphone may be cleaned with a 0.5% solution of mild dishwashing detergent in water (one teaspoon of detergent in a gallon of water).

5. OPTION

An optional thumbscrew is available that replaces the captive screw, exploded view item 7. The Motorola part number for the replacement thumbscrew is:

—0305202T02	NMN6168A
—0305202T03	NMN6153A

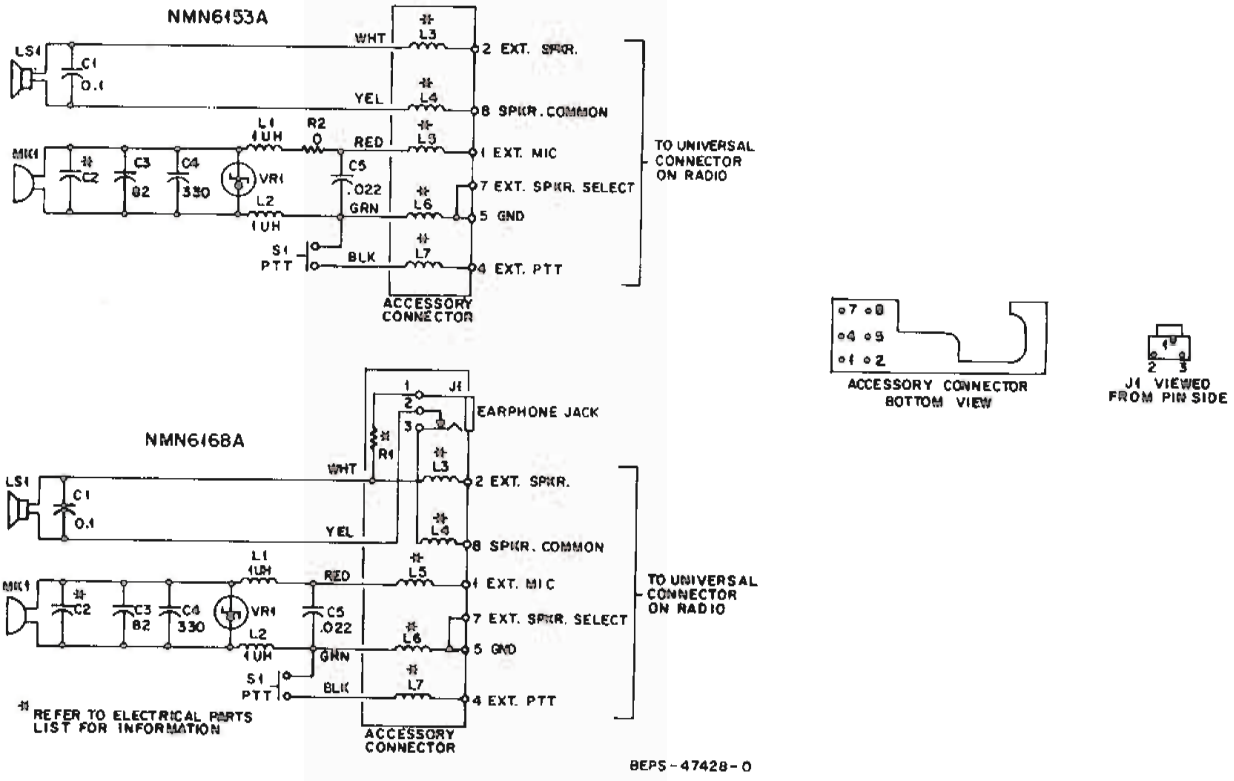


Figure 2. Schematic Diagram

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
		capacitor, fixed: pF±5%: unless otherwise stated
C1	2160521D37	0.1µF
C2	- - - - -	Not field repairable (order microphone assembly MK1)
C3	2160520B23	82
C4	2160520C13	330
C5	2160521A29	.022µF
		jack, earphone:
J1	0902126J02	2.5mm mono (NMN6168A only)
		coil, rf: unless otherwise stated
L1, 2	2462575A04	choke, 1µH
L3 thru 7	- - - - -	not field repairable (order cable and connector assembly, exploded view item 6)
		speaker:
LS1	5005910P03	1 3/4"; 28Ω
		assembly, microphone:
MK1	0105953N48	electret; Includes: capacitor C2
		resistor, fixed:
R1	- -	NMN6168A only (Not field repairable. Order cable and connector assembly exp. view item no. 6.)
R2	0660076M01	0Ω (NMN6153A only)
		switch:
S1	3905834K06	dome, PTT
		diode:
VR1	4880140L14	Zener; 9.1V

NOTE: For optimum performance, order replacement diodes and circuit modules by Motorola part number only.

Exploded View Parts List PL-11090-B

ITEM NO.	MOTOROLA PART NO.	DESCRIPTION
1	0102201J97	ASSEMBLY, front housing; includes items 1 thru 5
2	3305259Q01	NAMEPLATE, Motorola
3	0102701J96	LEVER, PTT
4	3505152J01	GRILLE, cloth
5	1105461R01	ADHESIVE
6	0102701J45	ASSEMBLY, cable and connector (NMN6153A); includes items 7 and 8
	or 0102701J87	ASSEMBLY, cable and connector (NMN6168A); includes items 7 and 8
7	0305425R03	SCREW, slotted (NMN6153A)
	or 0305202T03	SCREW, thumb (optional, see text paragraph 5)
	or 0305425R02	SCREW, slotted (NMN6168A)
	or 0305202T02	SCREW, thumb (optional, see text paragraph 5)
8	3205378T01	SEAL
9	0105953N46	ASSEMBLY, PC board, includes electrical components
10	3905834K06	SWITCH, snap dome contact (S1)
11	3205231Q01	SEAL, dome
12	1405219Q01	BOOT, microphone
13	0105953N48	ASSEMBLY, microphone (MK1) includes items 12 and 13
14	5005910P03	SPEAKER (LS1)
15	7505283Q02	PAD, speaker
16	3205690R01	GASKET
17	6405689R01	PLATE, mounting (NMN6153A)
	or 6505148S03	PLATE, mounting (NMN6168A)
18	0300139982	SPEAKER, Phillips head; 2-56 x 5/32"; (3 req'd.)
19	1505172Q01	HOUSING, back
20	0484345A06	WASHER, seal (3 req'd.)
21	0305137Q02	SCREW, Phillips Hd. (3 req'd.)
22	5405258Q07	LABEL, kit number (NMN6153A)
	or 5405258Q15	LABEL, kit number (NMN6168A)
23	0105957Q44	BELT CLIP
24	0300139982	SCREW, 2-56 x 5/32"; 4 req'd.)

NOTE: Refer to electrical parts list for part number and description.

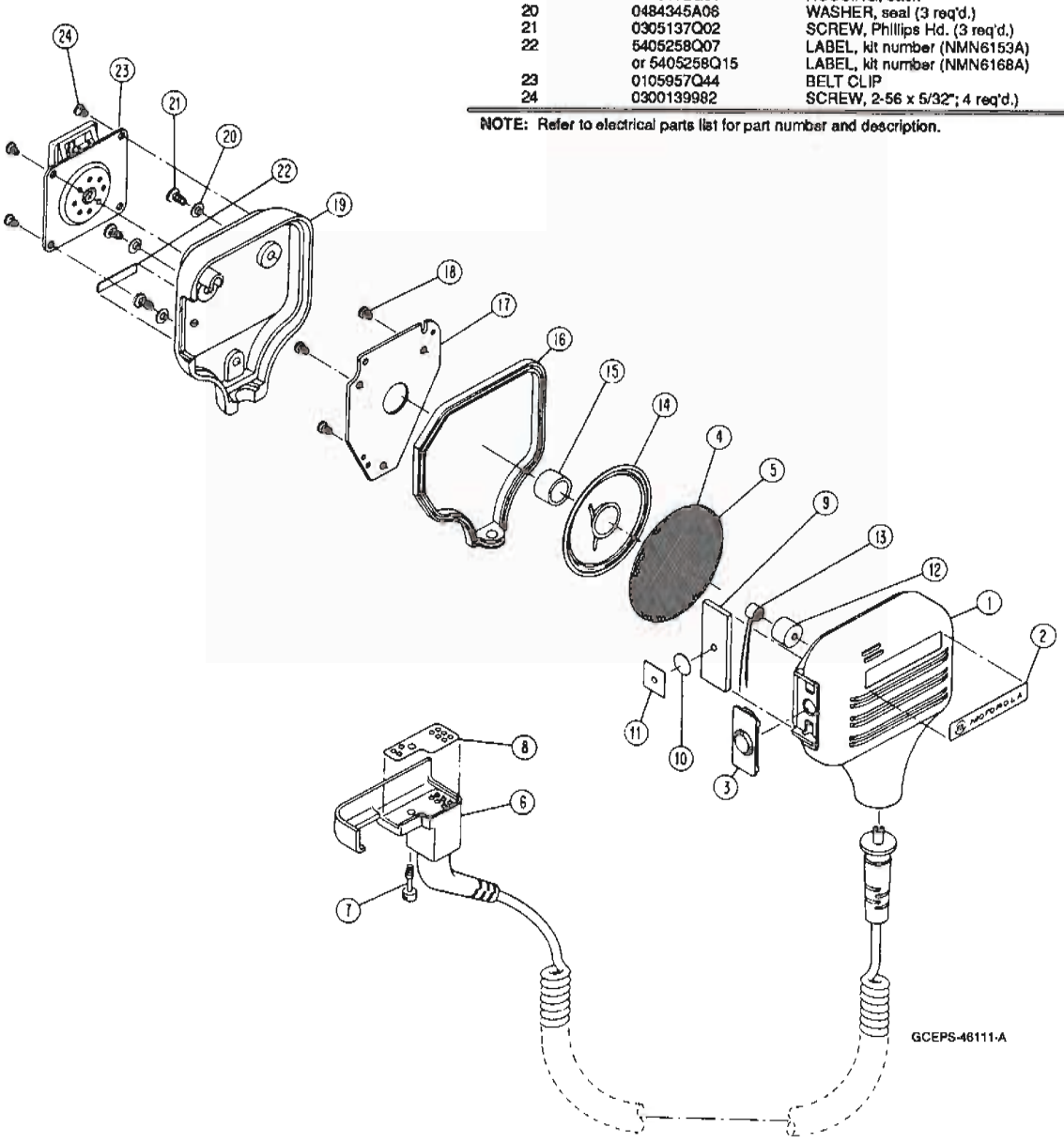


Figure 3. Exploded View

MOTOROLA INC.
Communications Sector

ADAPTERS
MODELS NTN5557A, NTN5560B & NTN5632A

DESCRIPTION

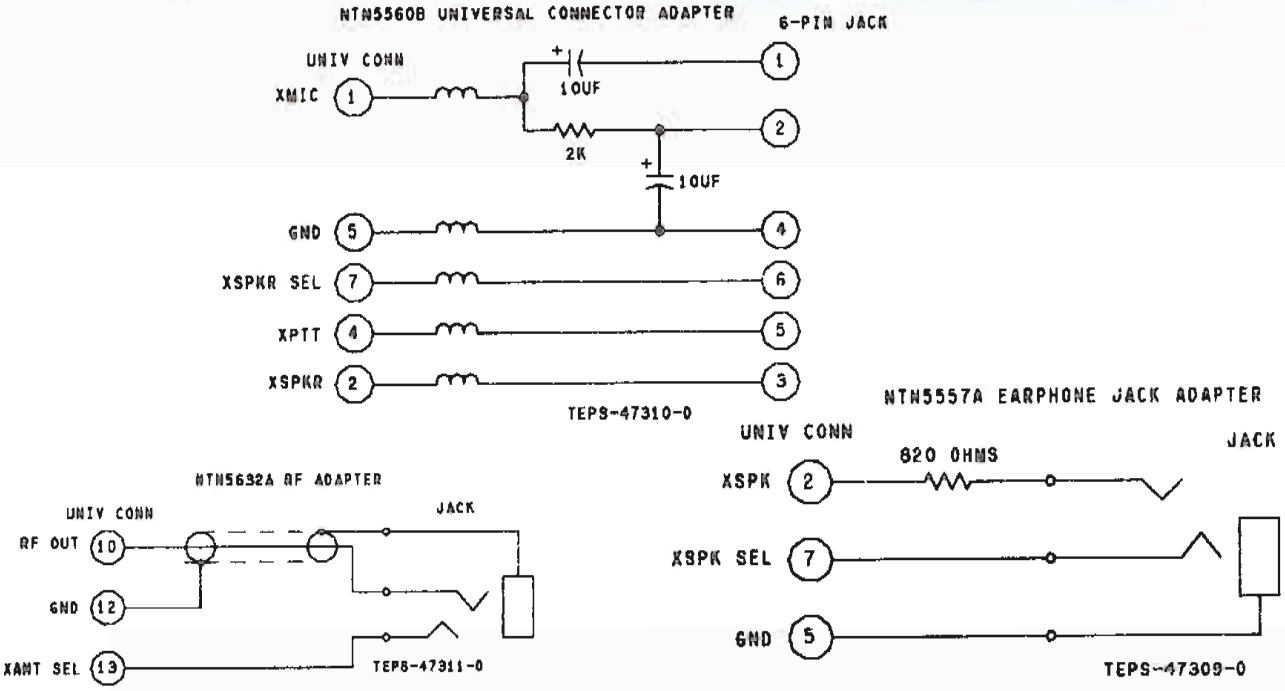
The following adapters provide a convenient method of connecting remote accessories to many Motorola series *Handie-Talkie* portable radios. Each adapter has a connector or connector jack for connecting to the remote accessory, and spring loaded pins, which make positive contact with corresponding mating pins of the universal connector on the radio.

Attaching any of the three adapters to the radio does not disable or alter the radio's operation in any way. But, when the adapter is attached to the radio and terminated at the other end with a remote accessory, the radio's corresponding function of that remote accessory is disabled. For example, if the NTN5632A RF Adapter is attached to the radio and connected to a remote antenna, the radio's antenna becomes nonfunctional.

- The NTN5557A Adapter provides an earphone jack that connects the radio to audio accessories using a 3.5mm phone plug.
- The NTN5560B Adapter provides a six-pin jack to connect the radio to two piece audio accessories.
- The NTN5632A Adapter provides an rf port that connects the radio to a remote antenna. This adapter requires an NKN6419A Cable Kit.

The NTN5557A Earphone Adapter and the NTN5632A RF Adapter look alike. The NTN5632A RF Adapter is marked with an antenna symbol on the top surface of the housing near the antenna jack. Be careful not to mistake one adapter for the other.

WARNING
DO NOT plug an audio accessory into the NTN5632A RF Adapter and transmit.



Radius Products Division
1411 E. Washington St., Mt. Pleasant, IA 52641

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9/20/89-UP

MOTOROLA INC.
Communications Sector

NTN5540A AND NTN5541A
SINGLE-UNIT COMPACT BATTERY CHARGERS FOR *P200* SERIES *HANDIE-TALKIE* PORTABLE RADIOS

1. INTRODUCTION

The NTN5540A (117 V ac) and the NTN5541A (220 V ac) Compact Battery Chargers are accessory items for charging rechargeable nickel-cadmium batteries. The chargers are approved for use with the following standard-charge and rapid-charge batteries:

Battery Number	Capacity	Charge Type
NTN5531A	Medium	Rapid
NTN5521A, NTN5545A	High	Rapid

2. SPECIFICATIONS

Input Power	117 V ac, 220 V ac, 50/60 Hz
Size	4.28 × 3.43 × 2.28 in. (108.6 × 87 × 57.3mm)
Weight	0.71 lbs (322.3g) with Power Supply 0.32 lbs (145 g) without Power Supply
Charge Rate	Approximately 16 hours
Operating Temperature Range	0°C to 50°C

3. DESCRIPTION

These single-unit compact chargers are current sensing, voltage sensing, current regulating devices which provide a 16-hour charge rate. The batteries can be left in the charger indefinitely without any resultant harm.

The NTN5540A charger operates from a 117 V ac, 60 Hz power source and the NTN5541A operates from a 220 V ac, 50 Hz power source. A red light-emitting diode (LED) indicates a charging condition when a battery is inserted into the charger.

4. SAFETY INSTRUCTIONS

This manual contains important safety and operating instructions. Before using battery charger, read all instructions and cautionary markings on (1) battery charger, (2) battery, and (3) radio using battery.

WARNING

- To reduce risk of injury, charge only Motorola nickel-cadmium type rechargeable batteries listed. Other types of batteries may burst, causing personal injury and damage.
- Do not expose charger to rain or snow.
- Use of an attachment not recommended or sold by Motorola may result in a risk of fire, electric shock, or injury to persons.
- To reduce risk of damage to electric plug and cord, pull by plug rather than cord when disconnecting charger.
- Make sure cord is located so that it will not be stepped on, tripped over, or otherwise subjected to damage or stress.
- An extension cord should not be used unless absolutely necessary. Use of improper extension cord could result in a risk of fire and electric shock. If extension cord must be used, make sure:

  1. That pins on plug of extension cord are same number, size, and shape as those on plug on charger:

WARNING (Cont'd.)

2. That extension cord is properly wired and in good electrical condition; and

3. The cord size is 18AWG for lengths up to 100 ft., and 16AWG for lengths up to 150 ft.

- Do not operate charger with damaged cord or plug — replace them immediately.

- Do not operate charger if it has received a sharp blow, been dropped, or otherwise damaged in any way; take it to a qualified serviceman.

- Do not disassemble charger; take it to a qualified serviceman when service or repair is required. Incorrect reassembly may result in a risk of electric shock or fire.

- To reduce risk of electric shock, unplug charger from outlet before attempting any maintenance or cleaning. Turning off controls will not reduce this risk.

5. OPERATION

Normal battery operation is eight hours of use followed by approximately 16 hours of charge. Place the charger in operation as follows:

a. Visually check the battery and charger charging contacts for dirt, grease or other material which may prevent good conduction, and clean if necessary.

b. Connect the charger's transformer power supply to the appropriate ac power source.

c. Insert the battery, with or without radio, into the charger pocket. When the battery contacts mate with the charger's charging contacts, charging begins and the red LED indicator will light.

NOTE

To insure proper charging, make certain that the battery is pushed fully into the charger pocket.

d. Allow sufficient time for the battery to fully charge (approximately 16 hours). After this time the battery will reach 100% full charge. The battery can be removed from the charger or remain in the charger indefinitely.

6. CIRCUIT DESCRIPTION

(Refer to the schematic diagram)

a. General

Operating voltage (B+) is developed from a remote ac to dc converter power supply (T1). The B+ voltage (approximately 30 V dc — no load, to 20 V dc — full load) is applied to transistor Q1 and resistor R1.

Initially, when the charger is plugged in (without a battery inserted), Q1 conducts and Q4 turns on, which provides a turn-on voltage for Q3. The conduction of Q3 effectively shorts out resistor R8, and a quiescent drive current is established for Q1, by components R1, VR1 and R9. Transistors Q3 and Q4 are components of the charger's short-circuit protection circuitry and are active during both the quiescent and charging states.

When a battery is placed in the charger pocket, a current path is established through the battery. This allows current to flow through diode CR2 and the base-emitter junction of transistor Q5, which turns on Q5 and diode CR1 (the red LED). Charging current for the battery is provided by the current regulator circuitry consisting of transistors Q1 and Q2. Base current for Q1 is controlled by transistor Q2, resistors R2, R7, and R9, and the internal battery resistor RC. The value of RC determines the charge rate for a particular battery capacity. RC is electrically placed across the base-emitter junction of Q2. The RC value, combined with the resistance of R7 and R9, determines the amount of conduction of Q2, which limits the amount of base drive for Q1, thus regulating the charge current. The following chart lists the three different capacity batteries and their respective RC and trickle charge currents.

Battery Capacity	RC	Charge Current
Medium	5.6k	50 mA
High	3.3k	80 mA

b. Over-Voltage Protection

Battery over-voltage protection is achieved by Zener diode VR1 during the charging mode. If the voltage between the base of Q1 and the battery ground terminal approaches 16 volts, VR1 conducts. This conduction removes the base drive from Q1, thus maintaining a safe battery voltage of approximately 14.5 volts. Also, if Q1 should fail (e.g. collector to emitter short), the diode combination of CR3 and VR1 will hold the battery terminal voltage to a safe level.

c. Short-Circuit Protection

Transistor Q4 and resistors R3, R4, and R5, together with transistor Q3 and resistor R8 help to protect the charger if the charging contacts are shorted. During normal operation, transistor Q4 is biased "on" to insure

that transistor Q3 is always saturated, thus bypassing resistor R8. However, if B+ is shorted to ground (e.g. charging contacts are shorted together), Q4 is cut off, which removes the base drive of transistor Q3. Consequently, R8 (a high resistance component), is placed in the charging path, which limits the current to a value of less than 1 mA.

7. MAINTENANCE

a. General

There are no user serviceable parts in the compact charger. If the charger fails to operate properly, contact a local Motorola Service Shop (MSS) for repairs.

b. Radio Contacts

If the red LED does not turn on when a battery is inserted into the pocket, check the contacts of the radio for dirt, grease, or other foreign material. Clean the contacts if necessary.

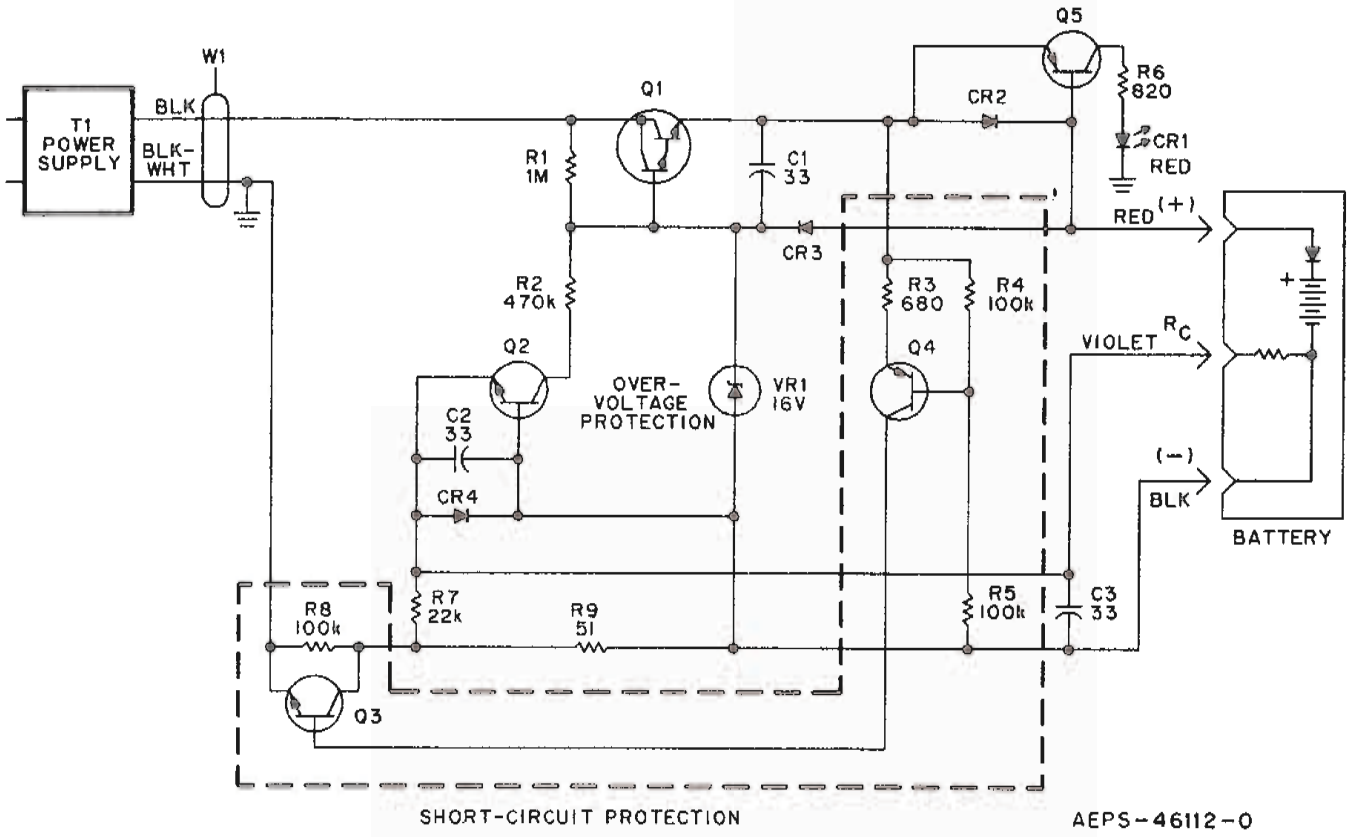
c. DC Voltage Measurements Charts

In the following DC Voltage Measurements chart,

- Measurements were taken with a Fluke 8010A digital multimeter at 25°C room temperature.
- All voltage readings are dc and referenced to charger ground.
- The dc voltages are typical readings and will vary with conditions of the battery.

DC Voltage Measurements Chart

		Q1			Q2			Q3			Q4			Q5			CR1
Battery Type	Charge Current mA	E	B	C	E	B	C	E	B	C	E	B	C	E	B	C	
No Battery	0	15.1	16.2	29.1	.01	.02	15.4	0	0.79	.01	9.6	8.9	0.79	15.1	14.7	0	0
500 mAh	50	15.5	16.6	25.0	2.2	2.7	12.9	0	0.84	.08	10.9	10.2	0.84	15.5	14.8	15.4	2.0
900 mAh	80	16.7	17.7	23.6	3.6	4.1	15.3	0	0.86	0.12	12.1	11.4	0.86	16.7	15.9	16.6	2.03



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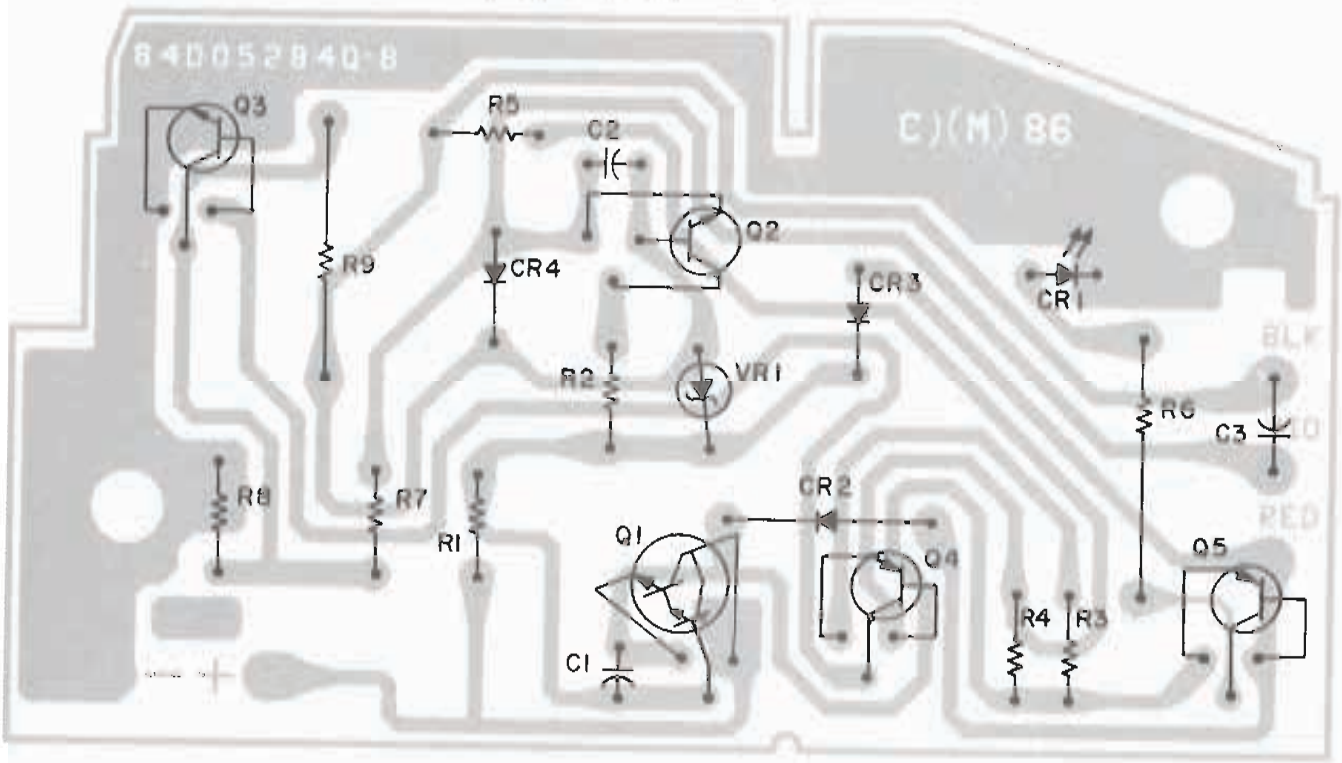

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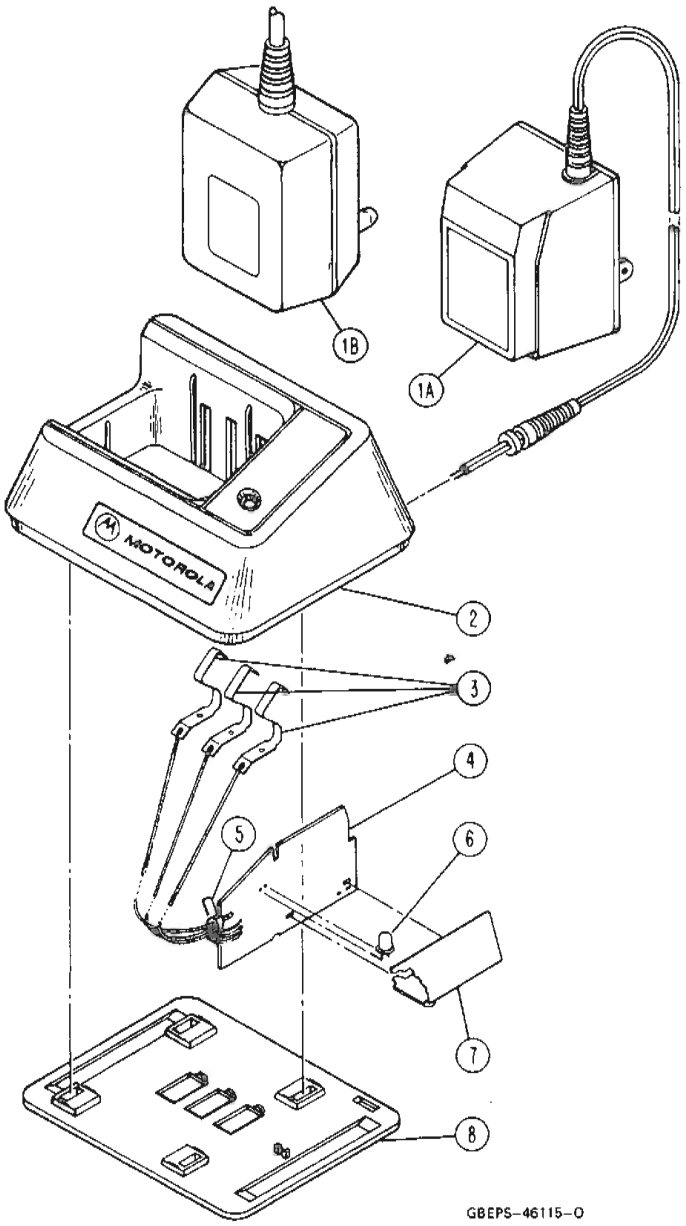


GBEPS-46115-O

parts list

Electrical Parts List PL-11092-O

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
		capacitor, fixed:
C1, 2, 3	2105455G09	33 pF ±5%; 63 V
		diode: (see note)
CR1	4805729G07	LED, RED
CR2	4805746G10	silicon
CR3, 4	4805746G13	silicon
		transistor: (see note)
Q1	4805474G40	NPN, Darlington
Q2, 3	4805474G42	NPN
Q4, 5	4805474G41	PNP
		resistor, fixed: ohms ±5%; 1/8 W; unless otherwise stated
R1	0660075B22	1 meg
R2	0660075B14	470k
R3	0660075A45	680
R4, 5	0660075A97	100k
R6	0660075L47	820; 3/4 W
R7	0660075M57	22k; 2%
R8	0660075A97	100k
R9	0660075L18	51; 3/4 W
		transformer:
T1	2505225Q01	power supply; ac to dc converter (NTN4666A)
	or 2505533R01	power supply; ac to dc converter (NTN4667A)
		diode, Zener: (see note)
VR1	4805249R14	16 V
		cable:
W1	— —	2-wire; part of T1

note: For optimum performance, diodes, transistors, and integrated circuits must be ordered by Motorola part numbers.

Exploded View Parts List PL-11091-O

ITEM NO.	MOTOROLA PART NO.	DESCRIPTION
1A	see note	POWER SUPPLY, 117 V ac (T1)
1B	see note	POWER SUPPLY, 220 V ac (T1)
2	0105952Q87	ASSEMBLY, housing; includes HOUSING and CONTACTS
3	— —	CONTACTS, part of item 2
4	0105950N69	ASSEMBLY, PC board; includes electrical components
5	4210217A26	TIE WRAP
6	see note	LED (CR1)
7	2605171Q01	HEAT SINK
8	0105950N70	ASSEMBLY, baseplate (NTN4666A); includes BASEPLATE, RUBBER FEET, and LABEL
	or 0105950N72	ASSEMBLY, baseplate (NTN4667A); includes BASEPLATE, RUBBER FEET, and LABEL

note: refer to electrical parts list for part number and description.

NTN5538B AND NTN5539B
SINGLE-UNIT RAPID-CHARGE BATTERY CHARGERS

1. INTRODUCTION

The NTN5538B (117 V ac) and NTN5539B (220 V ac) Single-Unit Rapid-Charge Battery Chargers are accessory items for charging rechargeable nickel-cadmium batteries. The chargers are approved for use with the following standard-charge and rapid-charge batteries:

Battery Number	Capacity	Charge Type
NTN5531A	Medium	Rapid
NTN5521A, NTN5545A	High	Rapid

2. SPECIFICATIONS

Input Power	117 V ac, 220 V ac, 240 V ac; 50/60 Hz
Size	7.72 × 5.12 × 3.14 in. (193 × 128 × 78.5mm)
Weight	2.43 Lbs. (1.1 kg.)
Rapid Charge Rate	Approximately 1 hour
Operating Temperature Range	0°C to 50°C
Rapid-Charge Temperature Window	8°C to 41° C

3. DESCRIPTION

These single-unit rapid chargers are current sensing, voltage sensing, current regulating devices which provide two different charger rates; a one-hour rate and a 16-hour rate. A rapid-charge nickel-cadmium battery is charged initially at a one-hour charge rate, after which the charging rate is automatically reduced to the 16-hour rate. A standard-charge nickel-cadmium battery is charged only at the 16-hour rate. Either of the batteries (rapid or standard) can be left in the charger indefinitely without any resultant harm.

The NTN5538B Charger operates from a 117 V ac, 60 Hz power source and the NTN5539B Charger operates from a 220 V ac, 50 Hz power source. Two light-emitting diode (LED) indicators display charging conditions and battery fault indications, such as open or shorted battery cells.

4. SAFETY INSTRUCTIONS

This manual contains important safety and operating instructions. Before using battery charger, read all instructions and cautionary markings on (1) battery charger, (2) battery, and (3) radio using battery.

WARNING

- To reduce risk of injury, charge only Motorola nickel-cadmium type rechargeable batteries listed. Other types of batteries may burst, causing personal injury and damage.
- Do not expose charger to rain or snow.
- Use of an attachment not recommended or sold by Motorola may result in a risk of fire, electric shock, or injury to persons.
- To reduce risk of damage to electric plug and cord, pull by plug rather than cord when disconnecting charger.
- Make sure cord is located so that it will not be stepped on, tripped over, or otherwise subjected to damage or stress.
- An extension cord should not be used unless absolutely necessary. Use of improper extension cord could result in a risk of fire and electric shock. If extension cord must be used, make sure:

  1. That pins on plug of extension cord are same number, size, and shape as those on plug on charger:
  2. That extension cord is properly wired and in good electrical condition; and

WARNING, (Cont'd.)

3. The cord size is 18AWG for lengths up to 100 ft., and 16AWG for lengths up to 150 ft.

- Do not operate charger with damaged cord or plug — replace them immediately.
- Do not operate charger if it has received a sharp blow, been dropped, or otherwise damaged in any way; take it to a qualified serviceman.
- Do not disassemble charger; take it to a qualified serviceman when service or repair is required. Incorrect reassembly may result in a risk of electric shock or fire.
- To reduce risk of electric shock, unplug charger from outlet before attempting any maintenance or cleaning. Turning off controls will not reduce this risk.

5. OPERATION

Normal battery operation is eight hours of use followed by approximately one hour of rapid charge. Place the charger in operation as follows:

a. Visually check the battery and charger charging contacts for dirt, grease or other material which may prevent good conduction, and clean if necessary.

b. Connect the charger to the appropriate ac power source. Both LED's will light momentarily.

c. Insert the battery, with or without radio, into the charger pocket. When the battery contacts mate with the charger's charging contacts, charging begins. If the battery is within the proper temperature range (+8 to +41°C), the red (CHARGING) LED will light to indicate that the battery is rapid-charging.

NOTE

To insure proper charging, make certain that the battery is pushed fully into the charger pocket.

d. Allow sufficient time for the battery to fully charge (approximately one hour). When rapid-charging is complete, trickle-charging begins. The red (CHARGING) LED will turn off and the green (charge COMPLETE) LED will turn on.

At this time, the battery has reached approximately 90% full charge and can be used. If the battery is left in the charger, it will reach 100% full charge after approximately two hours of trickle-charging. The battery can be removed from the charger and used or remain in the charger indefinitely.

If a battery which is outside the +8 to +41°C temperature range is inserted into the charger, it will be trickle-charged. The green LED will light if the battery temperature is above 41°C, or the red LED will light if the battery temperature is below 8°C. Once the battery moves inside the temperature window, the charger automatically switches to the rapid-charge rate and charging continues as described in the steps above.

6. CIRCUIT DESCRIPTION

(Refer to the Schematic Diagram)

a. General

Operating voltage (B+) is developed from a step-down transformer (T1) with a fused primary, driving a conventional full-wave bridge rectifier (CR1-CR4). The B+ (approximately 30 V dc) output is applied to a number of transistor stages and to a precision 12-volt regulator circuit (U4). The regulated 12 V dc (A) is applied to various transistor stages and to most of the logic circuits. A reduced B+ voltage (approximately 27 V dc) is applied to the Vcc input at U1 pin 4.

Charging current for the battery is provided by a constant-current source. The charging current is controlled by a current regulator with negative feedback. The current regulator is comprised of transistor circuits (Q1-Q6), a differential amplifier (U1C), and a single-input amplifier (U1D). Under normal charging conditions, transistors Q2 and Q6 are turned on, R10 is effectively shorted (rapid charge condition). For a momentary increase in charging current, the voltage across R14 will increase. The input to U1C pin 10 increases, which produces an increased output at U1C pin 8. The higher potential at U1C pin 8 is fed through CR8, R21, and R22 to U1D pin 13. This higher input at pin 13 reduces the output at U1D pin 14, which is passed through R15, CR7, and VR2 to reduce the drive of Q3, then Q1. The reduced drive of Q1 results in a reduction of charging current, returning back to normal.

Diodes CR5, CR6, transistor Q4, and resistor R73 provide for a constant current input of transistor Q2, ensuring Q2 to be turned on, independent of battery terminal voltage and charge rate. Together with Q5, this constant current source can be switched off for trickle-charging, by switching off Q5, consequently Q4, and Q2. With Q2 turned off, resistor R10 is added in the charging path.

Rapid-charge charging current for a high-capacity rapid-charge battery is approximately 800 mA. Trickle-charge current for the same battery is approximately 72 mA. The following chart lists the two different capacity

batteries and the battery's respective RC, rapid charging current, and trickle charging current.

Battery Capacity	RC	Charging Current	
		Rapid	Trickle
Medium	5.6k	500 mA	50 mA
High	3.3k	800 mA	72 mA

b. Maximum Current Limiter

The maximum current limiter is a protective circuit for the charger. If the charge rate exceeds a predetermined threshold, set by resistors R30 and R31, the output at U2A pin 1 goes high. This high turns on Q7, which turns off Q6. With Q6 turned off, the charging rate is no longer a function of RC, but a function of resistor R23. The charging current is limited to approximately 850 mA.

c. Battery Sense Detect

With no battery in the charger, the voltage at U1B pin 6 is approximately 9.6 V, which holds the output at U1B pin 7 low. When battery is placed in the charger, via the conduction of transistor Q6, the voltage at U1B pin 6 drops to approximately 2.2 V (during normal charging) or lower (if either the dynamic voltage clamp circuit or the open cell detect circuit is activated). The voltage drop at pin 6 of U1B, results in a high output at U1B pin 7, which turns on transistor Q8 and the red CHARGING LED, CR18.

d. Temperature Window and Bistable Multivibrator

Comparators U2C and U2D sense the RT line and set the cold and hot sides of the temperature window respectively. The cold side temperature is 8 degrees C. The hot side temperature is 41 degress C. In a normal rapid-charge condition, a voltage level which represents the battery's temperature is felt at U2C pin 10 and U2D pin 9. As the battery charges and the battery's temperature rises, the voltage at U2D pin 9 decreases. At 41 degrees C, the low level input at U2D pin 9 reaches a point that triggers the output at U2D pin 14 to go low. The low output of U2D is applied through CR12, CR13, and R13 to the base of Q5 and the following sequence occurs. Transistor Q5 turns off, Q4 turns off, Q2 turns off, resistor R10 is placed in the charging circuit, and the battery trickle charges. The low output at U2D is also applied through coupling capacitor C15 to U3A pin 7, which triggers the output of U3A at pin 1 to switch from high to low. This low output at U3A pin 1 is applied to the LED display circuitry via Q8, turning off the red (CHARGING) LED, and via Q10/Q9, turning on the green (charge COMPLETE) LED. When the battery's temperature cools down below 41 degrees C, the outputs of U2D and U3A are latched low via a feedback through diode CR14. This feedback latching prevents a fully charged battery from being rapid-charged again.

When a battery outside the cold temperature window is placed in the charger, the battery sense detect circuit, via U1B, turns on the red (CHARGING) LED. The temperature window circuit, via an increased voltage level at U2C pin 10, triggers a low from U2C pin 13 to initiate trickle charging. The output of U2C is isolated from the output of U2D by diode CR13. Thus, the green LED remains off and the red LED remains on. When the battery's temperature rises and enters the temperature window, the output at U2C goes high, Q5, Q4 and Q2 turn on, and the battery begins rapid charging.

e. Oscillator

The oscillator circuit turns the green and red LEDs on and off (flashing) to indicate that a problem (shorted or open cells or shorted contacts) is detected with the battery or battery contacts. Whenever the potential at the cathode is lower than the anode of diode CR26 (a low from U2B pin 2 or a low from U3D pin 14), the oscillator becomes activated. The oscillator output at U3B pin 2 flips back and forth (high to low), and is sent to the LED display circuit. On the low cycle, both transistors (Q8 and Q9) are turned off and both LEDs are turned off. On the high cycle, both transistors are turned on and both LEDs are turned on. If a problem occurs during the charge complete cycle, only the green LED will flash.

f. Battery Open Circuit (O/C) Detect

During normal charging conditions (good battery) or when a battery is not in the charger, the voltage at the cathode of CR16 is somewhat higher than the anode voltage. The output of U2B at pin 2 is high. When an open-circuited battery is detected (RC present but no charging current), the low impedance path of RC (compared to R53) causes the voltage at the anode to drop to a very low level. This low-level input (2.2 V to 1.2 V) at U2B pin 5 flips the output (U2B pin 2) high to low. The U2B low is passed to the LED display circuit, turning on the green LED (CR21). The U2B low is also passed to the oscillator circuit, which triggers both LEDs to flash.

g. Shorted Cells and Short Circuit Detect

This circuit detects shorted battery cells and shorted contacts by monitoring the battery's terminal voltage (BATT B+). Low battery voltage at U3D pin 8 triggers the comparator (for rapid-charge battery or standard-charge battery) to produce a low output at U3D pin 14. A low from the comparator keys the oscillator to flash the LEDs and to trickle-charge the battery.

h. Dynamic Voltage Clamp

During normal charging conditions, a low voltage level at U1A pin 2 holds the output at U1A pin 1 high. As the battery voltage (BATT B+) increases, the input voltage level at U1A pin 2 increases. If the BATT B+ voltage

increases to a predetermined threshold level (approximately 15.5 volts), the higher potential at U1A pin 2 triggers the output at U1A pin 1 low. This low output from U1A pin 1 overrides the output at U1D pin 14, and reduces the base drive current of transistor Q3, hence that of Q1. This negative feedback action to reduce the charging current results in maintaining a constant battery terminal voltage (15.5 volts). This circuit prevents overvoltage conditions that could damage the radios' electronics if the radio is attached to the battery when charging.

7. MAINTENANCE

a. Fuse

The fuse (F1) in the primary circuit of transformer T1 is the only user serviceable part in the charger. If necessary, replace this fuse with one the same size and rating as marked, or refer to the electrical parts list for the proper electrical specifications. After replacing the fuse, if the charger still fails to operate properly, contact a local Motorola Service Shop (MSS) for repairs.

b. Radio Contacts

If the red CHARGING LED does not turn on when a battery is inserted into the pocket, check the contacts of the radio for dirt, grease, or other foreign material. Clean the contacts if necessary.

c. DC Voltage Measurements Charts

In the following charts,

- Measurements were taken with a FLUKE 8010A Digital Multimeter at 25°C room temperature.
- All voltage readings are dc and referenced to charger ground
- DC voltages designated with an "*" will vary with the temperature of the battery.

MOTOROLA INC.
Communications Sector

MULTI-UNIT RAPID-CHARGE BATTERY CHARGERS

MODELS NTN5536A AND NTN5537A

IMPORTANT SAFETY INSTRUCTIONS
SAVE THESE INSTRUCTIONS

- This manual contains important safety and operating instructions.
- Before using battery charger, read all instructions and cautionary markings on (1) battery charger, (2) battery, and (3) radio using battery.
- **WARNING** — To reduce risk of injury, charge only Motorola nickel-cadmium type rechargeable batteries listed. Other types of batteries may burst, causing personal injury and damage.
- Do not expose charger to rain or snow.
- Use of an attachment not recommended or sold by Motorola may result in a risk of fire, electric shock, or injury to persons.
- To reduce risk of damage to electric plug and cord, pull by plug rather than cord when disconnecting charger.
- Make sure cord is located so that it will not be stepped on, tripped over, or otherwise subjected to damage or stress.
- An extension cord should not be used unless absolutely necessary. Use of improper extension cord could result in a risk of fire and electric shock. If extension cord must be used, make sure:
  (1) That pins on plug of extension cord are same number, size, and shape as those on plug on charger;
  (2) That extension cord is properly wired and in good electrical condition; and
  (3) The cord size is 18AWG for lengths up to 100 ft., and 16AWG for lengths up to 150 ft.
- Do not operate charger with damaged cord or plug — replace them immediately.
- Do not operate charger if it has received a sharp blow, been dropped, or otherwise damaged in any way; take it to a qualified serviceman.
- Do not disassemble charger; take it to a qualified serviceman when service or repair is required. Incorrect reassembly may result in a risk of electric shock or fire.
- To reduce risk of electric shock, unplug charger from outlet before attempting any maintenance or cleaning. Turning off controls will not reduce this risk.

1. INTRODUCTION

WARNING
Do not discard batteries in fire; they may explode.

The NTN5536A (117 V ac) and NTN5537A (220-240 V ac) Multi-Unit Rapid Charge Battery Chargers are accessory items for *Handie-Talkie* Portable Radios using rechargeable nickel-cadmium batteries. These chargers are approved for use with the following rapid- and standard-charge batteries.

Battery Number	Charge Type	Capacity
NTN5531A	Rapid	Medium
NTN5521A, NTN5545A	Rapid	High

2. SPECIFICATIONS

Input Voltage	110 V ac, 220-240 V ac, 50/60 Hz
Size	17.6" × 12.0" × 5.5" (45cm × 31cm × 14cm)
Weight	8 lbs. 14 oz. (4 kg)
Rapid Charge Rate	Approximately 1 hour
Operating Temperature Range	0°C to 50°C
Rapid-Charge Temperature Window	10°C to 40°C

3. DESCRIPTION

The multi-unit rapid chargers are constant-current devices which can charge up to six nickel-cadmium batteries simultaneously. Each charging pocket provides two different charge rates: a one-hour rate, and a 16-hour rate. A rapid-charge nickel-cadmium battery is

charged initially at the one-hour rate, after which the charging rate is automatically reduced to the 16-hour rate; a standard-charge battery charges only at the 16-hour rate. The battery may be left in the battery charger indefinitely without any resultant harm.

The NTN5536A charger requires a 117 V ac, 50/60 Hz power source, whereas the NTN5537A charger utilizes a 220-240 V ac, 50/60 Hz power source. A line voltage selector switch at the bottom of the charger selects which power source voltage will be used. The appropriate ac power cord is provided with the charger.

4. OPERATION

After a period of use, a battery normally requires approximately one hour of rapid charging. The radio should be turned off while attached to a battery being recharged. Place the charger in operation as follows:

a. Connect the ac power cord to the battery charger.

b. Plug the ac line cord into the proper ac receptacle. The battery charger performs a self test: pocket 1's three LEDs are simultaneously turned on, then off, followed, in numerical order, by the LEDs of pockets 2 through 6.

NOTE

Make certain that the ac power cord's plug is completely inserted into the charger socket and a good electrical connection is made.

IMPORTANT NOTE

DO NOT press the PTT switch on the radio while the radio is in a charger pocket.

c. Insert the battery, with or without radio attached, into a vacant charger pocket and seat it firmly to ensure that proper contact has been made. The pocket's three LEDs turn on and off, then the red **CHARGING** LED turns on to indicate that the battery is being rapid-charged.

NOTE

1. If the yellow **STAND-BY** LED lights instead of the red LED, the battery is either too hot or too cold to be rapid-charged. Refer to "Circuit Description" for details.

2. If both the red **CHARGING** LED and the yellow **STAND-BY** LED light at the same time, the battery is being trickle-charged. Refer to "Circuit Description" for details.

d. Allow approximately one hour for batteries to charge.

NOTE

When a rapid charge battery reaches full charge, the red **CHARGING** LED turns off, and the green **COMPLETE** LED turns on.

5. IN CASE OF TROUBLE

Before requesting service, refer to the following table for possible remedies.

WARNING

USE ONLY MOTOROLA NICKEL-CADMIUM (NI-CD) BATTERIES WITH THIS CHARGER.

Condition	Remedy
Red **CHARGING** LED does not light when battery is inserted in pocket.	◦ Check battery contacts for dirt, grease, or foreign material. Wipe with a soft cloth.
Red **CHARGING** LED flashes.	◦ Try reseating the battery. ◦ Check battery contacts for dirt, grease, or foreign material. Wipe with a soft cloth. ◦ Try another battery. If problem goes away, the problem is with the first battery.
Yellow **STAND-BY** LED lights.	◦ Battery is either too hot or too cold to be rapid-charged.
No LEDs light.	◦ Make sure charger is plugged in. ◦ Check to see if charger has a fuse. ◦ Check to see if fuse is blown.

6. CIRCUIT DESCRIPTION

(Refer to the schematic diagram.)

a. Power Supply

The position of the line voltage selector switch on the bottom of the power supply determines the input source voltage (110 V ac or 220-240 V ac). An operating B+ (12.5 V dc) is developed within the power supply and fed to the main circuit board via plug P1. The power supply's output voltage (B+) is determined by the position of a jumper on the side of the power supply. On the main circuit board, B+ is distributed to LED boards 1 and 2, to charging circuit transistors Q5, Q7, Q9, Q11, Q13, and Q15, to ICs U18 and U23, and to 5-volt regulator U13. The 5-volt regulator provides regulated +5 V dc to the microcomputer (U15) and all other ICs.

b. Microcomputer and Display Circuits

All of the timing, monitoring, and sensing of the circuits is performed by the microcomputer (U15). Upon power-up, with no battery inserted, the microcomputer performs a self-check of its erasable program-

mable read-only memory (EPROM), random-access memory (RAM), and internal timer.

Next, the microcomputer tests the display circuitry by turning all three LEDs for each pocket on and off in numerical order, starting with pocket 1. To control the display, the microcomputer sends pocket display data via the PA0 through PA5, and PA7 lines (U15, pins 33 through 38, and 40) to hex D flip-flop ICs U4 through U6 as follows:

Pocket	Data Lines	IC	Pins In	Pins Out	LEDs
1	PA0-2,7	U4	1,3,4,6	2,5,7	1-3
2	PA3-5,7	U4	1,11,13,14	10,12,15	4-6
3	PA0-2,7	U5	1,3,4,6	2,5,7	7-9
4	PA3-5,7	U5	1,11,13,14	10,12,15	10-12
5	PA0-2,7	U6	1,3,4,6	2,5,7	13-15
6	PA3-5,7	U6	1,11,13,14	10,12,15	16-18

At the same time, the microcomputer selects the pocket displays to be changed by sending positive-going clock pulses via the PB5 through PB7 lines (U15, pins 30 through 32) to the clock inputs (pin 9) of ICs U4 through U6. These ICs multiplex and latch the display data from the microcomputer, and send control signals to the appropriate LEDs via lamp drivers in ICs U1 through U3. A logic high output from one of the flip-flops will turn a LED on; a logic low will turn the LED off.

If the microcomputer fails its self-check, all LEDs will light simultaneously and will remain lit until the charger is reset by removing ac power. If the self-check is completed without any problems being encountered, the microcomputer turns all LEDs off; the LEDs will remain off until a battery is inserted into one of the pockets.

c. Monitoring and Sensing Circuits

Before any batteries can be charged, the microcomputer (U15) must first determine the charger type (NTN5536A or NTN5537A) by checking the value of B+. This is accomplished by applying B+ across voltage divider network R142 and R143, and feeding the network's output to the pin 4 input of multiplexer U22. The microcomputer selects this input by sending its binary address, via control lines PB0 through PB2, to pins 9 through 11 of U22. U22 outputs this voltage, via the PD2 line (U22, pin 3), to the AN2 input (pin 22) of U15. This voltage (see Table 3) is then used by the microcomputer to set up its internal charging parameters.

Following charging parameter setup, the microcomputer monitors the PD0 through PD3 lines (U15, pins 21 through 24) from multiplexers U21 through U24 to monitor battery type, temperature, voltage, and current. Using these four multiplexers, the PD0 through PD3 lines are able to report the battery parameters of all six pockets.

The microcomputer searches for the presence of a battery in any of the pockets by continually monitoring their battery type and temperature values, cycling through the pockets in ascending order. The microcomputer selects the pocket to be sensed by sending the desired pocket's binary address (0 through 5), via control lines PB0 through PB2, to pins 9 through 11 of all four multiplexers.

When the presence of a battery in a pocket is indicated by a valid capacity resistor (RC) value (see Table 1), and a thermistor (RT) value between 10° (3.33 V dc on the RT contact) and 40° Celsius (1.87 V dc on the RT contact) is detected, the pocket's charge cycle will begin.

Table 1. Normal RC Values

Battery Type	RC Value
NTN5521A, NTN5545A	3.3k-ohm
NTN5531A	5.6k-ohm

If the RC value is not valid, the red **CHARGING** LED will flash. *If the thermistor is neither shorted nor open but its value is not within the rapid-charging window,* the yellow **STAND-BY** LED will light and no charging will occur. When the battery temperature is within the prescribed window, the yellow LED will turn off and the red LED will light, and the normal charging cycle will begin. If the thermistor is shorted, the red LED will flash, if the thermistor is open, the battery will first be pre-charged as described under "Charging Circuit," then it will be trickle-charged, and both red and yellow LEDs will light.

d. Charging Circuits

Following the power-up, microcomputer self check, battery installation, and normal battery RC, RT, and voltage checks, rapid charging begins. There are several different rapid-charge rates as determined by the battery RC (see Table 2).

Table 2. Charge Rates

Battery Type	Charge Rate (mA)	
	Rapid	Trickle
NTN5531A	600	50
NTN5521A, NTN5545A	840	90

The microcomputer first precharges the battery at 600 mA for 30 seconds. The microcomputer selects the pocket to be charged by sending that pocket's address, via the PB0 through PB2 lines, to triple "AND" gates U17A through U17C. At the same time, a high pulse is sent over the PC7 line to U17 to enable the gates. The resulting address is fed over the A1 through A3 lines to binary-to-octal decoder U16. U16 then sends a clock

binary-to-octal decoder U16. U16 then sends a clock pulse, via one of the Q1 through Q6 lines, to the hex D flip-flop IC (U7 through U12) for the desired pocket.

Charging current is set and latched by sending a six-bit word from U15, pins 9 through 14, via the PC0 through PC5 lines, to pins 3, 4, 6, 11, 13, and 14 of hex D flip-flop ICs U7 through U12, and setting the PA7 line (U15, pin 40) high. The six-bit word is determined by the value of the battery's RC. At the flip-flop IC of the selected pocket, the clock pulse (Q1 through Q6) from U16 latches the six-bit word; the flip-flop ICs six output lines (Q0 through Q5) select a resistive network which determines the charge rate. If the charge current is not within specified limits (see Table 2), the microcomputer will stop charging current to the pocket, and will indicate a pocket fault condition by lighting all three of the pocket's LEDs.

At the end of the 30-second precharge, the battery voltage is read. If the voltage reading falls between 9 V dc and 15 V dc, the charger switches to the rapid-charge mode. If the voltage is outside of this range, the charger signals a battery problem by flashing the red **CHARGING** LED.

Every three minutes, the microcomputer stops the charging current and checks the temperature of the battery. As the battery reaches full charge in the rapid-charge mode, the battery temperature rises. When the battery temperature reaches 45°C, or the rate of increase within the three minutes exceeds 1.6°C (80 mV), the charger switches to the trickle-charge mode, turning off the red **CHARGING** LED, and turning on the green **COMPLETE** LED.

e. Reset Circuit

Integrated circuit U14 is a "watchdog" timer. At least once every second, a positive signal from U15, pin 28 (PB3 line), is received at U14, pin 2. This signal keeps Q1 from resetting the microcomputer. If a problem occurs in the microcomputer, such as the microcomputer's internal timer is ceasing to function correctly, the microcomputer stops sending the signal at U15, pin 28. As a result, the following sequence occurs: U14, pin 3, goes low, turning off Q2. This turns on Q1, which resets the microcomputer. When the microcomputer is reset, Q3 is turned on, pulling U14, pin 2, low, and resetting the U14 timer. Resetting the timer causes U14, pin 3, to go high, which turns on Q2, turns off Q1, and pulls the microcomputer out of reset via U15, pin 2.

f. Shutdown Circuit

The charger also contains a shutdown circuit which the microcomputer controls via the PA6 line (U15, pin 39). During normal operation, a logic high appears at pin 39 which keeps Q17 turned on. If the microcomputer senses current flow when current should not be flowing, it outputs a logic low on pin 39, turning off Q17, and pulling pin 1 of P1 high. This triggers an SCR within the power supply which ceases to send power to the main circuit board. AC power must be removed from the power supply to reset the unit.

7. MAINTENANCE

a. Fuse

If the charger does not operate, check the fuse, and replace if necessary. If the replaced fuse "blows", check for shorts in the power supply output, charger circuits, and 5-volt regulator U13.

b. Contacts

If the red **CHARGING** LED does not turn on with a radio or battery inserted into the pocket, check the contacts of the battery or charger for dirt, grease, or other foreign materials. Clean the contacts with a soft cloth, if necessary.

CAUTION

The following DC Voltage Measurements should only be performed by qualified service personnel.

c. DC Voltage Measurements

The following DC Voltage Measurements Table lists typical voltage levels that should be present with varying chargers, batteries, and operating conditions. Measurements shown are for pocket 1.

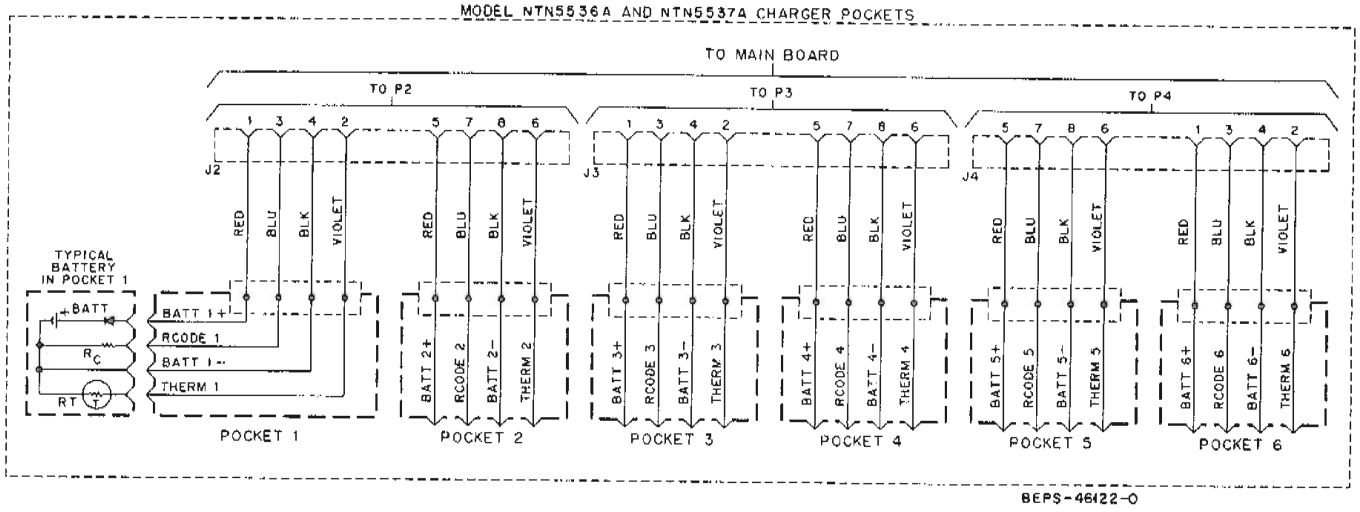
Table 3. NTN5536A and NTN5537A DC Voltages

Battery and Condition / Pin	B+	U22	Q7		Q8		U8						U10			U18						P1	U1			Charging Current (mA)
		4	B	C*	B	E	2	5	7	10	12	15	1	3	9	2	21	22*	23	24**	29	1	16	15	14	
No Battery	16.0	4.7	16.0	10.9	0	0	0	0	0	0	0	0	0	0	0	5.0	0	3.1	4.9	4.9	4.8	0	14.7	14.7	14.7	0
Rapid Charge NTN5531A	16.0	4.7	15.3	12.4	2.2	1.5	5.0	0	0	5.0	5.0	0	1.70	0.36	0.36	5.0	1.70	3.6	0.8	2.7	4.8	0	14.7	0.7	14.7	600
Rapid Charge NTN5521A	16.0	4.7	15.3	12.5	3.2	2.5	5.0	0	0	0	0	5.0	2.40	0.51	0.51	5.0	2.40	3.6	0.8	2.8	4.8	0	14.7	0.7	14.7	840
Charge Complete NTN5545A	16.0	4.7	15.3	12.0	1.0	0.3	5.0	0	5.0	0	0	0	0.27	0.06	0.06	5.0	0.27	3.4	0.4	0.5	4.8	0	14.7	14.7	0.7	90

NOTES:

1. All voltages referenced to charger ground.
2. Voltages designated * will vary with the voltage of the battery; battery voltage for this table is 12 V dc.
3. Voltages designated ** will vary with the temperature of the battery. For this table, rapid-chart RT = 10k-ohm and charge complete RT = 1 k-ohm.

CHARGER POCKETS SCHEMATIC DIAGRAM



REPLACEMENT PARTS ORDERING

ORDERING INFORMATION

When ordering replacement parts or equipment information, the complete identification number should be included. This applies to all components, kits, and chassis. If the component part number is not known, the order should include the number of the chassis or kit of which it is a part, and sufficient description of the desired component to identify it.

Crystal and channel element orders should specify the crystal or channel element type number, crystal and carrier frequency, and the model number in which the part is used.

Orders for active filters, Vibrasender and Vibraspondder resonant reeds should specify type number and frequency, should identify the owner/operator of the communications system in which these items are to be used; and should include any serial numbers stamped on the components being replaced.

MAIL ORDERS

Send written orders to the following addresses:

Replacement Parts/Test Equipment/
Crystal Service Items:
Motorola, Inc.
Communications Parts Division
Attention: Order Processing
1313 E. Algonquin Road
Schaumburg, IL 60196

International Orders:

Motorola Inc.
Communications Parts Division
Attention: International Order Processing
1313 E. Algonquin Road
Schaumburg, IL 60196

Federal Government Orders:

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Communications Parts Division
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1701 McCormick Drive
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TELEPHONE ORDERS

Replacement Parts/Test Equipment:

Call: 1-800-422-4210
1-800-826-1913 (For Federal Government Orders)

Crystal Service Items:

Call: 1-800-323-1570
1-800-445-4564 (For Illinois Residents)

TELEX/FAX ORDERS

Replacement Parts/Test Equipment/
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Telex: 280127
FAX: 312-576-6285

Federal Government Orders:

FAX: 301-925-2473 or 301-925-2474

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NATIONAL DATA SERVICES

1711 West 17th Street, Tempe, AZ 85281
Call: 602-994-6472, TWX: 910-951-1334

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AVAILABLE BACKGROUND REFERENCE PUBLICATIONS

Seven reference publications are available to provide background information needed to service some of the newer Motorola products more effectively. The information in these publications is not duplicated in our instruction manuals. To obtain your free copy, check the ones you want and return this self-mailer to us.

Check item desired:

☐ **Basic Logic Circuit Guide** — 68P81105E88
Describes the basic logic circuits used in Motorola Communications digital equipment and the logic notational scheme used in our instruction manuals.

☐ **"Digital Private-Line" Binary-Coded Squelch** — 68P81106E83
Contains fundamentals of "Digital Private-Line" system operation, circuit operation and servicing techniques.

☐ **Safe Handling of CMOS Integrated Circuit Devices** — 68P81106E84
Describes special handling techniques needed to prevent irrepairable damage from static charges encountered with normal handling of CMOS devices.

☐ **Reducing Noise Interference in Mobile Two-Way Radio Installations** — 68P81109E33
Defines the major sources of noise encountered in a mobile radio installation and suggests methods of remedying them.

☐ **Anti-Skid Braking Precautions** — 68P81109E34
Provides installation suggestions and a detailed checkout procedure for installation of mobile radios in vehicles with anti-skid braking systems.

☐ **Removal and Replacement of Chip Components on Circuit Boards** — 68P81113E77
Contains general information and repair procedures relative to chip-type (leadless) components.

☐ **Lightning Protection Recommendations** — 68P81111E17
Provides general information concerning lightning protection for equipment sites. Also, provides a quick reference of available lightning protection kits.

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USER QUESTIONNAIRE

To the User of This Instruction Manual:

Motorola is engaged in a continuous program of improving its instruction literature. We believe that you can aid us in this program, so that we in turn can better help you service our equipment. To foster these aims, would you please answer the following questions:

SCHEMATIC DIAGRAMS AND CABLING DIAGRAMS

1. ☐ Are accurate and easy to follow
2. ☐ Contain minor errors
3. ☐ Contain major errors
4. ☐ Are difficult to follow

If you have checked any box except 1, please tell us what schematic diagrams, or portions thereof, were at fault, or enter other comments.*

_____

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TEXT

1. ☐ Easy to follow — helps to service equipment
2. ☐ Would like more information on*

_____

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3. ☐ Some instruction sections are too long or superfluous such as*

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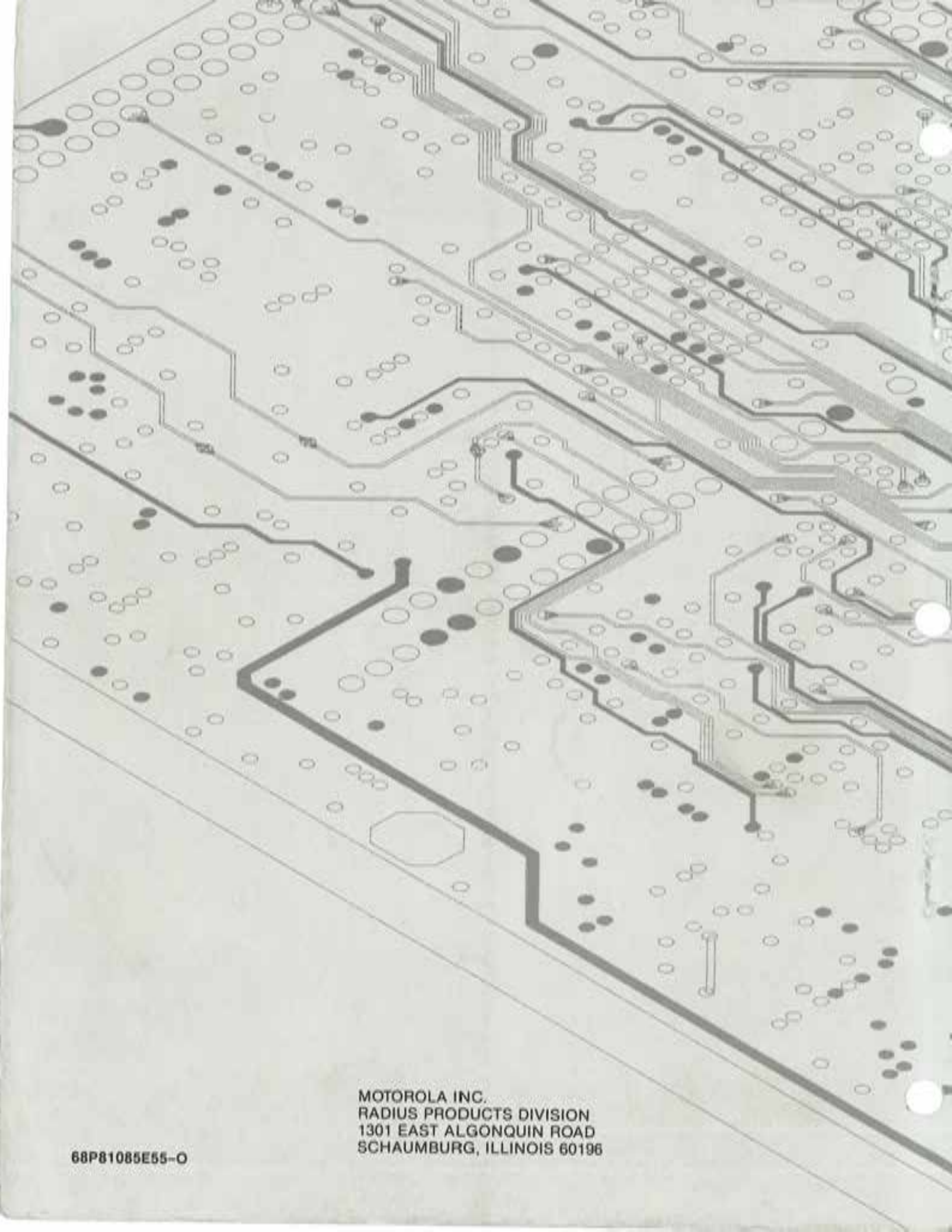

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