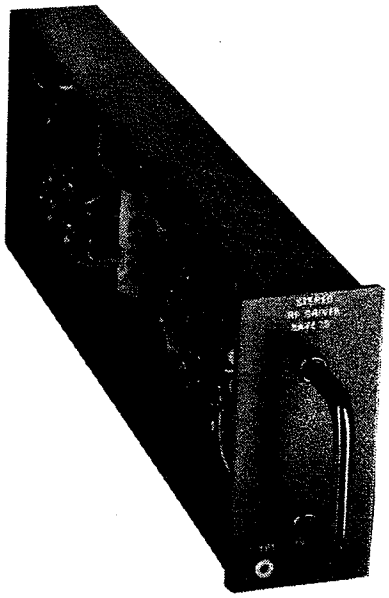
INSTRUCTION

# NAPE20 & NAPE20/1

## STEREO RF DRIVER MODULE

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## LIST OF EFFECTIVE PAGES

The list of effective pages lists the status of all pages in this manual. Pages of the original issue are identified by a zero in the Change No. column. Pages subsequently changed are identified by the date of the change number. On a changed page, the text affected by the latest change is indicated by a vertical bar in the margin opposite the changed material.

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## INTRODUCTION

1. The NAPE20 stereo rf driver module contains the rf amplifier/rf drive stage for Nautel's AMPFET series of transmitters. There are minor variations of the stereo rf driver module to accommodate the different power levels of their associated transmitters. The variation that is applicable to a specific transmitter is identified in the instruction manual for that transmitter. The variations are identified by a (/#) after the NAPE20 identifier. Trouble shooting and repair of the module is performed on a work bench independent of its associated transmitter. This document provides the information required for a competent technician to understand the operation of the electrical circuits and the procedures to restore defective modules to a serviceable status; using tools and test equipment normally available at an AM radio station workshop. An alternative to procedures provided in this document is to utilize Nautel's module exchange/repair service facilities.

## FACTORY EXCHANGE/REPAIR SERVICE

2. Nautel provides a factory, module exchange/repair service for users of Nautel's AMPFET series of transmitters. Users who do not have repair facilities or who are not able to repair a module may utilize this service for a nominal fee.

## MECHANICAL CONFIGURATION (refer to figure 4 for assembly detail)

3. The NAPE20 stereo rf driver utilizes a formed, metal box as the module chassis. Two electrical connectors and a guide pin are installed on the rear of the module. A stamped panel, containing a handle and three test points, is installed on the front. The remaining electrical components are installed on removeable assemblies. The rf amplifier components are mounted on a printed circuit board (A2) and are interconnected by the circuit board's printed pattern. Extenal wiring is connected by soldering to standoff terminals on the circuit board. The rf drive components are mounted on standoff terminals on a metal plate (A1). Electrical interconnection of the rf drive components, where applicable, and between the assemblies is by wiring which is soldered to the standoff terminals.

## THEORY OF OPERATION (refer to figure 3 for electrical schematic)

4. The NAPE20 rf driver module amplifies a phase modulated or fixed frequency rf carrier signal from an external source and provides the rf drive for its associated transmitter. The amplitude of the external rf carrier signal must be greater than 1.0 volts ac rms and less than 3.0 volts ac rms. Its frequency must be within the AM broadcast frequency band of 550 kHz to 1750 kHz.

4.1 RF CARRIER AMPLIFIER: The external 'rf input' is applied to the primary of voltage transformer A2T1 thru P2-2. The transformed rf signal is superimposed on a 7.5 volt dc voltage, which is provided from the junction of voltage divider A2R2/R3, and is applied thru A2R4 to OR gate A2U1A-1. The signal to A2U1A-1 will be switching from a logic '1' level to a logic '0' level during alternate half cycles, at the rf input frequency rate. Diode A2CR1 prevents the positive going peaks from exceeding 15 volts and diode A2CR2 prevents the negative going peaks from going negative. When a logic '0' (ground) is applied to P1-1 as the 'rf drive enable' command, the logic '0' will be applied thru A2CR3 to one input of OR gates A2U1A(2) and A2U1D(13). OR gates A2U1A and A2U1D will be enabled and the rf signal applied to A2U1A-1 will be passed thru A2U1A/U1D and applied to the base of transistors A2Q1/A2Q2. Transistors A2Q1 and A2Q2 form a complementary emitter-follower that provides a 15 volt peak-to-peak square-wave output at the rf input frequency. When a logic '0' (ground) is not applied to P1-1 as the 'rf drive enable' command, a logic '1' (15 volts dc) will be applied thru A2R5 to OR gates A2U1A(2) and A2U1D(13). The outputs of A2U1A and A2U1D will be maintained at a logic '0' level and the rf signal applied to A2U1A-1 will be inhibited.

1.2 RF DRIVE: The rf drive input, which is a square wave at the rf input frequency, is applied to transformer A1T1. Transformer A1T1 is a 1:1 coupling transformer that has two sets of identical secondary windings. One end of each secondary winding is connected to the gate and the other end to the source of a power MOSFET (A1Q1 and A1Q2). Power MOSFET's A1Q1 and A1Q2 are connected in a push-pull configuration with the phasing of their inputs determining which one is turned on. When the gate of A1Q2 goes positive, the gate of A1Q1 will go negative. A1Q2 will turn on and A1Q1 will turn off. When A1Q2 is turned on, -72 volts dc is applied thru fuse A1F2, resistor A1R1, inductor A1L2, resistor A1R3, the source/drain junction of power MOSFET A1Q2, to the 'rf drive' output at P1-3. During the next half cycle, the gate of A1Q1 will go positive and the gate of A1Q2 will go negative, causing A1Q1 to turn on and A1Q2 to turn off. A ground will be applied to P1-3 thru the drain/souce junction of A1Q1. The resultant 'rf drive' output on P1-3 will be a 72 volt peak-to-peak square wave at the rf carrier frequency. Transient suppression and decoupling of the -72 volts dc is provided by capacitors C1, C2, C3, C4, C5; diodes CR1, CR2; inductor L1; resistors R1 and R3.

## TROUBLESHOOTING

5. Troubleshooting of stereo rf driver modules that are defective or are suspected of being defective consists of performing a visual inspection and then conducting a functional test to isolate the defective components.

5.1 TEST EQUIPMENT AND SPECIAL TOOLS: The test equipment required is listed in table 1. There are no special tools required.

5.2 VISUAL INSPECTION: It is recommended that a visual inspection be performed on the stereo rf driver module prior to applying power. Inspect the module for the following:

(a) Inspect all electrical components for evidence of overheating or physical damage.

(b) Verify fuses A1F1 and A1F2 are the correct value and are not defective.

(c) Inspect all solder connections for good mechanical bond and adequate solder.

(d) Verify connectors P1 and P2 do not contain damaged or loose pins and that they are securely fastened to the bracket.

(e) Verify the guide pin is present and that it is securely fastened.

(f) Verify all wiring insulation is not pinched, frayed, broken or otherwise damaged.

(g) Verify wire strands of wiring conductors are not broken or otherwise damaged.

(h) Verify the leads of power MOSFET A1Q1 which protrude thru the metal plate are not shorting to the plate and the protective plastic sleeve over the gate and source leads is present and is not damaged.

(i) Verify the chassis is free from solder slivers and other conductive foreign objects; paying particular attention to areas under the leads of components mounted on insulated standoff terminals on assembly A2's metal plate.

(j) Verify all fastening hardware is securely tightened.

5.3 FUNCTIONAL TEST: Functional testing of the stereo rf driver module is the recommended first step in troubleshooting a defective module and also verifies the module is operating within design limits after corrective action has been taken. Modules that meet the requirements of the functional test may be considered to be operating satisfactorily and returned to service.

NOTE

Final testing of the stereo rf driver module is performed with the module installed in the transmitter it will be used in. Instructions are provided in the associated transmitter's instruction manual.

(a) Verify the visual inspection has been completed.

(b) Connect the NAPE20 stereo rf driver module to the test setup depicted in figure 1.

NOTE

If a -24 volt dc power supply is not available, it may be replaced with a dc power supply which provides any voltage from -10 volts dc to -70 volts dc. If a voltage other than -24 volts dc is used, the amplitude of the 'rf drive' waveform on P1-3 will require correcting to correspond to the voltage of the power supply.

(c) Set the rf signal generator to the desired frequency that is between 550 kHz and 1750 kHz at an output of 2.0 volts ac rms.

(d) Connect the oscilloscope test leads between test point TP1 and terminal 2 (ground) of printed circuit board assembly A2. Observe waveform on oscilloscope and adjust oscilloscope time base for approximately six cycles and gain for an amplitude of 5.0 volts/division.

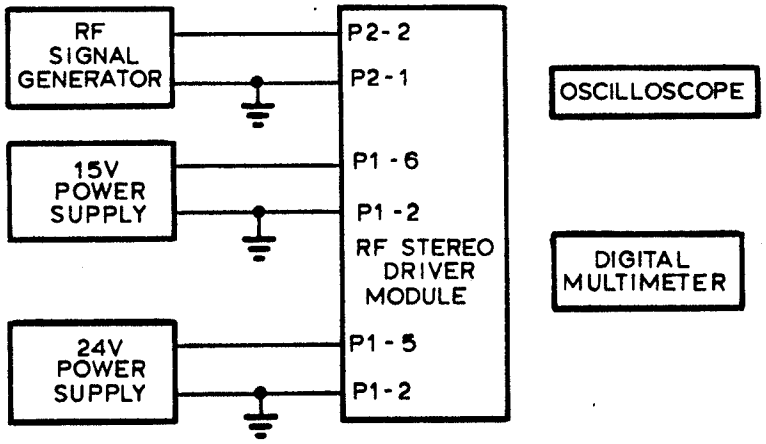



Figure 1 Test Setup for NAPE20 Stereo RF Driver Module

(e) If waveform in step (d) does not correspond to example A in figure 2, rf amplifier on printed circuit board A2 is defective. Isolate and replace defective component and then repeat step (d).

(f) Connect oscilloscope test leads between the anode of diode A1CR1 (rf drive on P1-3) and ground lug of output coaxial cable shield. Observe waveform on oscilloscope leaving oscilloscope time base at the setting established in step (d) and setting the gain as appropriate for the negative dc voltage applied to P1-5.

(g) If waveform in step (f) does not correspond to example B in figure 2, a component in the rf drive stage is defective. Isolate and replace defective component using procedures described in paragraph 5.4 for power MOSFET's A1Q1/A1Q2 and then repeat step (f).

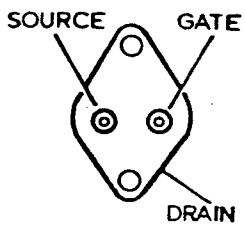
(h) Set rf signal generator's output to 1.0 volts ac rms and then repeat steps (d) thru (g).

(i) Set rf signal generator's output to 3.0 volts ac rms and then repeat steps (d) thru (g).

5.4 RESISTANCE MEASUREMENT OF POWER MOSFETS: Isolate defective power MOSFET's by performing a resistance measurement of each device as follows:

NOTE

The power MOSFET's can be checked while still mechanically mounted, provided their source and gate leads have been electrically isolated.




(a) Electrically isolate a power MOSFET by disconnecting the wiring and component leads from its source and gate leads.

(b) Measure the resistance between gate and source using an ohmmeter. Resistance reading should be infinity.

(c) Ensure power MOSFET is turned off by momentarily shorting source and gate leads.

(d) Measure forward source/drain resistance ensuring the ohmmeter's negative lead is on the drain. Resistance reading should be the same as the forward resistance of a diode.

(e) Measure reverse source/drain resistance ensuring the ohmmeter's positive lead is on the drain. Resistance reading should be infinity.

(f) Turn power MOSFET on by forward biasing gate/source junction (connect ohmmeter's positive lead to gate and negative lead to source).

(g) Measure source/drain resistance. Resistance reading should be less than one ohm.

(h) Power MOSFET's that meet the requirements of steps (a) thru (g) are acceptable.

(i) Reconnect the wiring to the source and gate leads of each power MOSFET.

REPAIR

6. Replace any component or wiring which does not meet the requirements of the visual inspection, ensuring leads of replacement wiring and passive components, are kept to the shortest length possible without causing mechanical stress to component or lead. Replace power MOSFET's as follows:

NOTE

Refer to table 2 for interconnecting wiring information and to figure 4 for additional wiring information and assembly detail of the stereo rf driver module.

(a) Gain access to the underside of rf drive assembly A1 by removing four screws and four lock washers, one of each from each corner, and then carefully turning the assembly upside down, ensuring interconnecting wiring is not damaged.

(b) Disconnect wiring and component leads from the gate and source leads of the power MOSFET(s) to be removed.

(c) Remove and retain power MOSFET fastening hardware and then extract the power MOSFET.

(d) If power MOSFET A1Q1 is to be replaced, remove insulating tubing from its gate and source leads and install them on the gate and source leads of the replacement power MOSFET.

(e) If power MOSFET A1Q2 is to be replaced, verify the insulator between the power MOSFET and the metal plate is in place, is free from damage and is coated with thermal compound. If necessary, apply a thin coat of thermal compound to both sides of insulator under replacement power MOSFET A1Q2, ensuring the thermal compound is free of foreign objects.

(f) If power MOSFET A1Q2 is to be replaced, verify the insulator on the component side of rf drive assembly A1 is free from damage, paying particular attention to the raised shoulders which extend into the mounting holes in the metal plate.

(g) Position the insulators referred to in steps (e) and (f) on the appropriate side of the metal plate, where power MOSFET A1Q2 will be installed, ensuring lead and mounting holes are properly aligned.

(h) Install the power MOSFET and secure using fastening hardware removed in step (c), ensuring the terminal lugs which were originally secured by the fastening hardware have been reinstalled correctly.

(i) Connect wiring and component leads, which were removed in step (b), to gate and source leads of power MOSFET.

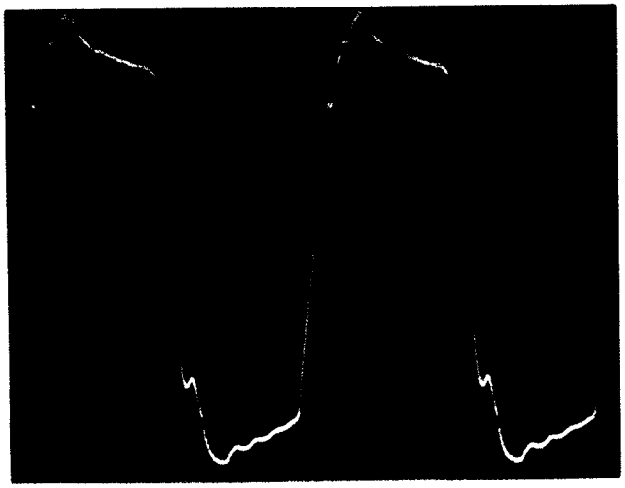
(j) Install rf drive assembly A1 in the module using four screws and lock washers removed in step (a), ensuring rf output coaxial cable shield ground lug and the ground lug on the wire from P1-2 are reinstalled and that interconnecting wiring is not pinched or strained.

Table 1 - Test Equipment

| NOMENCLATURE | PART, MODEL, OR TYPE NUMBER (EQUIVALENTS MAY BE USED) |
|---|---|
| Digital Multimeter | 3 1/2 digit, ac and dc volts, ohms and amps, ±0.5% accuracy. Beckman 3010 |
| Oscilloscope | 15 MHz. Tektronics Model T922 |
| 15 Vdc Power Supply | 15 Volts 1 Amp |
| 24 Vdc Power Supply | 24 Volts 1 Amp |
| RF signal Generator | Hewlett Packard Model 606A |

Table 2 Wiring List - NAPE20 Stereo RF Driver Module

| SOURCE | DESTINATION | CODE | | SIZE | FUNCTION |
|---|---|---|---|---|---|
| P1-1 | A2-5 | 1 | White | 22 | |
| P1-3 | A1-Q1 Base | 2 | White | 16 | (WF22) |
| P1-4 | Ground | - | Shield | | |
| P1-5 | F2-1 | 3 | Blue | 22 | |
| P1-6 | F1-1 | 4 | Red | 22 | |
| P1-2 | A2-2 | 5 | Black | 22 | |
| TP1 | A2-3 | 6 | White | 22 | |
| TP2 | A1-R2 | 7 | Blue | 22 | |
| TP3 | A2-8 | 8 | White | 22 | |
| Junction L1/C2 | A2-4 | 9 | Red | 22 | |
| P2-2 | A2-7 | 10 | Core | RG188A/U | WE38 |
| P2-1 | A2-6 | - | Shield | | |
| T1-1 | A2-1 | - | - | - | T1 lead |
| T1-2 | A2-2 | - | - | - | T1 lead |
| P1-2 | Gnd lug near F1 | - | - | | |

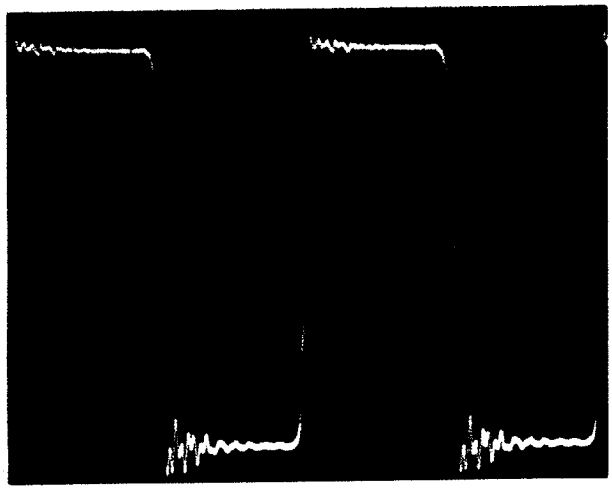


RF AMPLIFIER OUTPUT

Carrier Frequency

Test Point TP1

2 volts/division
Scale centered at 0 Vdc



RF DRIVE OUTPUT

Carrier frequency
switching between
negative voltage and ground

P1-3

Scale centered at 0 Vdc
Amplitude dependent on
negative voltage level applied
to P1-5.

Figure 2 Waveforms - NAPE20 Stereo RF Driver Module

Table 3 Reference Designation Index - NAPE20 Stereo RF Driver Module

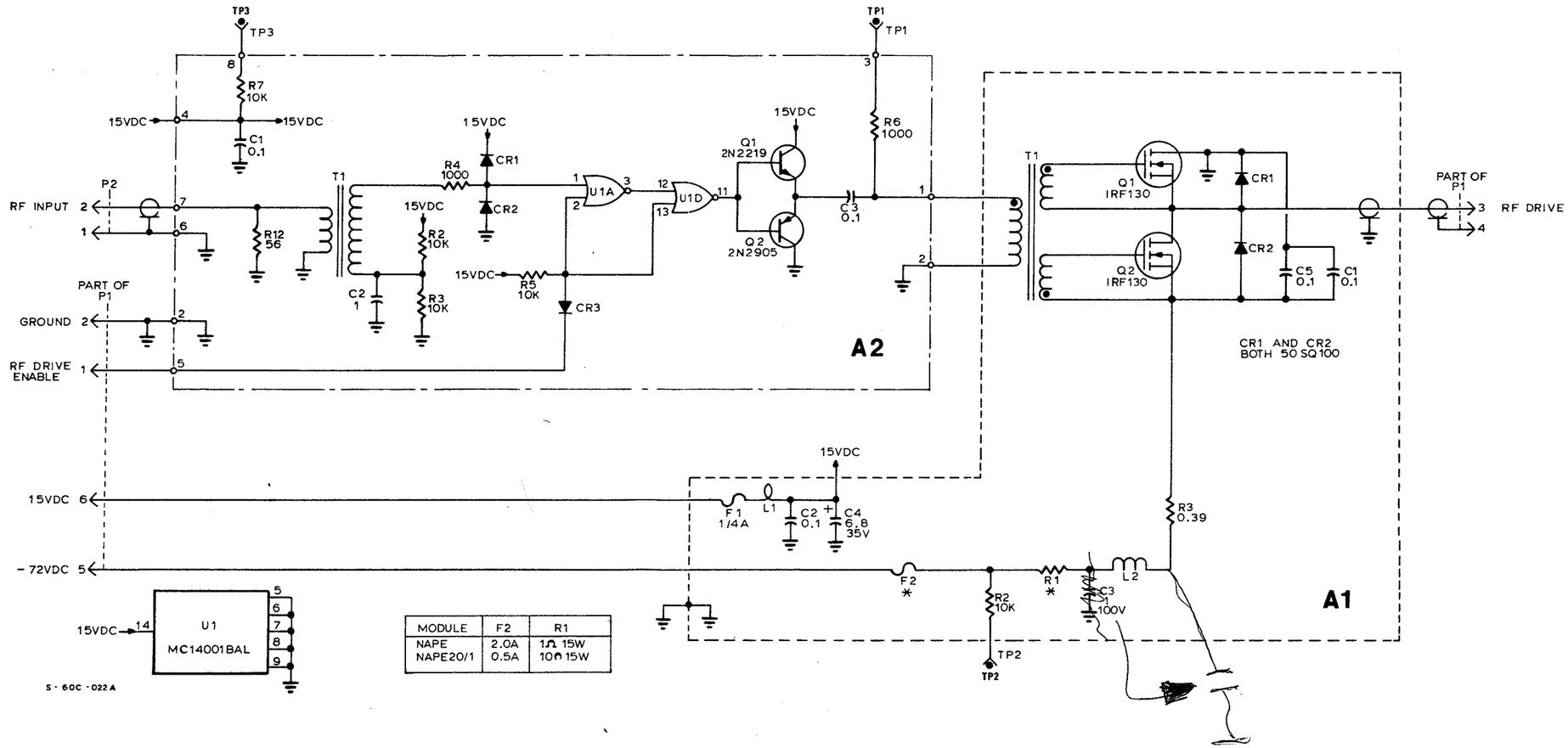
| REF DES | NAME OF PART AND DESCRIPTION | NAUTEL'S PART NO. | JAN, MIL OR MFR PART NO. | (OEM) MFR CODE |
|---|---|---|---|---|
| A - | Stereo RF Driver Module | NAPE20 | 139-3092 | 37338 |
| B - | Stereo RF Driver Module | NAPE20/1 | 139-3092-1 | 37338 |
| A A1 | RF Drive Assembly | 139-3008 | 139-3008 | 37338 |
| B A1 | RF Drive Assembly | 139-3008-1 | 139-3008-1 | 37338 |
| A1C1 | Capacitor, Ceramic, 0.1uF 10%, 100V | CCG07 | CKR06BX104KL | 56289 |
| A1C2 | Capacitor, Ceramic, 0.1uF 10%, 100V | CCG07 | CKR06BX104KL | 56289 |
| A1C3 | Capacitor, Plastic, 1.0uF 10%, 100V | CNP11 | MFP1W1-10 | 14655 |
| A1C4 | Capacitor, Tantalum, 6.8uF 10%, 35V | CCP19 | CSR13F685KM | 56289 |
| A1C5 | Capacitor, Ceramic, 0.1uF 10%, 100V | CCG07 | CKR06BX104KL | 56289 |
| A1CR1 | Diode, Schottky Rectifier, 4.5A | QL10 | 50 SQ 100 | 81483 |
| A1CR2 | Diode, Schottky Rectifier, 4.5A | QL10 | 50 SQ 100 | 81483 |
| A1F1 | Fuse, 1/4 Amp, Slow Blow | FB11 | 323.250 | 75915 |
| A A1F2 | Fuse, 2 Amp, Slow Blow | FB25 | MDL-250V-2A | 71400 |
| B A1F2 | Fuse, 1/2 Amp, Slow Blow | FB13 | 323.500 | 75915 |
| A1L1 | Ferrite Bead | LX16 | 11-622-B | 33062 |
| A1L2 | Inductor | 139-3036 | 139-3036 | 37338 |
| A1Q1 | Transistor, Field Effect, N Channel | QA04 | IRF130 | 81483 |
| A1Q2 | Transistor, Field Effect, N Channel | QA04 | IRF130 | 81483 |
| A A1R1 | Resistor, Wirewound, 1.0 ohms, 5% 15W | RS05 | HLM15-1.0 Ohms-5% | 35005 |
| B A1R1 | Resistor, Wirewound, 10 ohms, 5% 15W | RS18 | NHLM15-10 Ohms-5% | 35005 |
| A1R2 | Resistor, Film, 10K ohms, 2% 1/2W | RAP13 | RL20S103G | 36002 |
| A1R3 | Resistor, Film, 0.39 ohms, 5% 1/2W | RP17 | A31.0.39 Ohms-5% | 36002 |
| A1T1 | Transformer | 139-3013 | 139-3013 | 37338 |
| A1XF1 | Fuse Block, 2-pole | FA25 | 357002 | 75915 |
| A2 | Stereo RF Driver PCB Assembly | 139-3070 | 139-3070 | 37338 |
| A2C1 | Capacitor, Ceramic, 0.1uF 10%, 100V | CCG07 | CKR06BX104KL | 56289 |
| A2C2 | Capacitor, Ceramic, 1.0uF 10%, 50V | CCG10 | CKR06BX105KL | 56289 |
| A2C3 | Capacitor, Ceramic, 0.1uF 10%, 100V | CCG07 | CKR06BX104KL | 56289 |
| A2CR1 | Diode | QAP29 | 1N4938 | 01295 |
| A2CR2 | Diode | QAP29 | 1N4938 | 01295 |
| A2CR3 | Diode | QAP29 | 1N4938 | 01295 |
| A2Q1 | Transistor, NPN | QAP05 | 2N2219 | 04713 |
| A2Q2 | Transistor, PNP | QAP08 | 2N2905 | 04713 |
| A2R1 | Resistor, Film, 56 ohms, 2% 1/2W | RAP04 | RL20S560G | 36002 |
| A2R2 | Resistor, Film, 10K ohms, 2% 1/2W | RAP13 | RL20S103G | 36002 |
| A2R3 | Resistor, Film, 10K ohms, 2% 1/2W | RAP13 | RL20S103G | 36002 |
| A2R4 | Resistor, Film, 1000 ohms, 2% 1/2W | RAP09 | RL20S102G | 36002 |
| A2R5 | Resistor, Film, 10K ohms, 2% 1/2W | RAP13 | RL20S103G | 36002 |
| A2R6 | Resistor, Film, 1000 ohms, 2% 1/2W | RAP09 | RL20S102G | 36002 |
| A2R7 | Resistor, Film, 10K ohms, 2% 1/2W | RAP13 | RL20S103G | 36002 |
| A2T1 | Transformer | 139-3072 | 139-3072 | 37338 |
| A2U1 | IC, CMOS, Quad, 2-input NOR Gates | UB01 | MC14001BAL | 04713 |
| P1 | Connectpr, Plug, 6-pin | JD09 | P-3306-AB | 13150 |
| P2 | Connector, Plug, 2-pin | JD01 | P-3002-AB | 13150 |
| TP1 | Jack, Tip, White | J021 | 450-4355-1-0319 | 71279 |
| TP2 | Jack, Tip, Violet | J020 | 450-4355-1-0317 | 71279 |
| TP3 | Jack, Tip, Red | J019 | 450-4355-1-0312 | 71279 |

A in 'Ref Des' column denotes used in NAPE20, B denotes used in NAPE20/1

Table 4 Quantities Per Unit Index - NAPE20 Stereo RF Driver Module

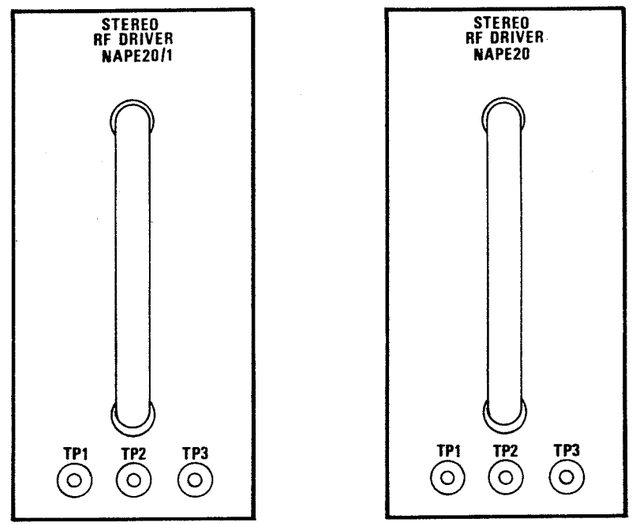
| NAUTEL'S PART NO. | NAME OF PART AND DESCRIPTION | JAN, MIL OR MFR PART NO. | (OEM) MFR CODE | TOTAL IDENT PARTS |
|---|---|---|---|---|
| NAPE20 | Stereo RF Driver Module | 139-3092 | 37338 | REF A |
| NAPE20/1 | Stereo RF Driver Module | 139-3092-1 | 37338 | REF B |
| 139-3008 | RF Drive Assembly | 139-3008 | 37338 | 1 A |
| 139-3008-1 | RF Drive Assembly | 139-3008-1 | 37338 | 1 B |
| 139-3013 | Transformer | 139-3013 | 37338 | 1 |
| 139-3036 | Inductor | 139-3036 | 37338 | 1 |
| 139-3070 | Stereo RF Driver PCB Assembly | 139-3070 | 37338 | 1 |
| 139-3072 | Transformer | 139-3072 | 37338 | 1 |
| CCG07 | Capacitor, Ceramic, 0.1uF 10%, 100V | CKR06BX104KL | 56289 | 5 |
| CCG10 | Capacitor, Ceramic, 1.0uF 10%, 50V | CKR06BX105KL | 56289 | 1 |
| CCP19 | Capacitor, Tantalum, 6.8uF 10%, 35V | CSR13F685KM | 56289 | 1 |
| CNP11 | Capacitor, Plastic, 1.0uF 10%, 100V | MFP1W1-10 | 14655 | 1 |
| FA25 | Fuse Block, 2-pole | 357002 | 75915 | 1 |
| FB11 | Fuse, 1/4 Amp, Slow Blow | 323.250 | 75915 | 1 |
| FB13 | Fuse, 1/2 Amp, Slow Blow | 323.500 | 75915 | 1 B |
| FB25 | Fuse, 2 Amp, Slow Blow | 323002 | 75915 | 1 A |
| JD01 | Connector, Plug, 2-pin | P-3002-AB | 13150 | 1 |
| JD09 | Connectpr, Plug, 6-pin | P-3306-AB | 13150 | 1 |
| J019 | Jack, Tip, Red | 450-4355-1-0312 | 71279 | 1 |
| J020 | Jack, Tip, Violet | 450-4355-1-0317 | 71279 | 1 |
| J021 | Jack, Tip, White | 450-4355-1-0319 | 71279 | 1 |
| LX16 | Ferrite Bead | 11-622-B | 33062 | 2 |
| QA04 | Transistor, Field Effect, N Channel | IRF130 | 81483 | 2 |
| QAP05 | Transistor, NPN | 2N2219 | 04713 | 1 |
| QAP08 | Transistor, PNP | 2N2905 | 04713 | 1 |
| QAP29 | Diode | 1N4938 | 01295 | 3 |
| QL10 | Diode, Schottky Rectifier, 4.5A | 50 SQ 100 | 81483 | 2 |
| RAP04 | Resistor, Film, 56 ohms, 2% 1/2W | RL20S560G | 36002 | 1 |
| RAP09 | Resistor, Film, 1000 ohms, 2% 1/2W | RL20S102G | 36002 | 2 |
| RAP13 | Resistor, Film, 10K ohms, 2% 1/2W | RL20S103G | 36002 | 5 |
| RP17 | Resistor, Film, 0.39 ohms, 5% 1/2W | A31.0.39 Ohms-5% | 36002 | 1 |
| RS05 | Resistor, Wirewound, 1.0 ohms, 5% 15W | HLM15-1.0 Ohms-5% | 35005 | 1 A |
| RS18 | Resistor, Wirewound, 10 ohms, 5% 15W | NHLM15-10 Ohms-5% | 35005 | 1 B |
| UB01 | IC, CMOS, Quad, 2-input NOR Gates | MC14001BAL | 04713 | 1 |

A in 'Total Ident Parts' column denotes used in NAPE20 only
B in 'Total Ident Parts' column denotes used in NAPE20/1 only




| MODULE | F2 | R1 |
|---|---|---|
| NAPE | 2.0A | 1Ω 15W |
| NAPE20/1 | 0.5A | 100Ω 15W |

Figure 3 Electrical Schematic - NAPE20 Stereo RF Driver Module







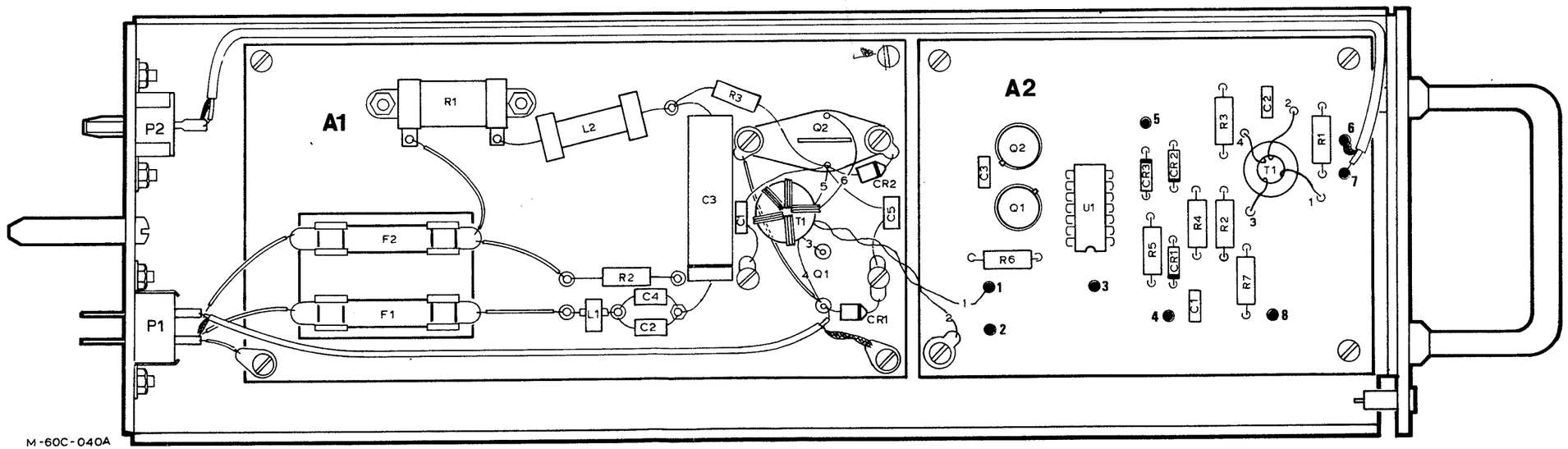



Figure 4 Assembly Detail - NAPE20 Stereo RF Driver Module