Broadcast Products
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TSA50HSS

SOLID STATE
50W S-BAND POWER AMPLIFIER

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TSA50HSS

SOLID STATE
50W S-BAND POWER AMPLIFIER

EMCEE

05/98

WARNING

Amplifier Cooling

In order to gain access to the various circuits in the TSA50HSS Amplifier, it is necessary to remove the drawer cover. Please be advised that this cover is an integral part of the drawer cooling and may not be removed for more than five minutes while the amplifier is in operation. Any period longer than this could cause overheating and catastrophic damage to the final amplifier.

IMPORTANT

Transient Overvoltage Protection

Transient overvoltage of micro- and nano-seconds durations are a continuous threat to all solid-state circuitry. The resulting costs of both equipment repairs and system downtime make preventative protection the best insurance against these sudden surges. Types of protection range from isolation transformers and uninterruptible power supplies to the more cost effective AC power line protectors. As transient culprits are most often lightning induction and switching surges, AC power line protectors are the most practical solution. An effective AC power line protector is one capable of dissipating impulse energy at a low enough voltage to ensure the safety of the electronic components it is protecting. The protection unit should be across the AC line at all times even during periods of total blackout. It should also reset immediately and automatically to be 100% ready for repeated transients.

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THE TSA50HSS POWER AMPLIFIER

SECTION I

THE TSA50HSS POWER AMPLIFIER

1.1 Introduction:

The EMCEE TSA50HSS Power Amplifier is rated to provide 50W peak visual and 1.25W average aural power on any FCC specified channel extending from 2.15 to 2.7GHz when driven by an appropriate driver with a separate visual/aural output capable of providing 5W peak visual and 13W average aural (e.g., the EMCEE TTS10HSX, TTS10HSB or TTS10EB Transmitters). The TSA50HSS is completely solid-state utilizing GaAsFET devices and microwave circuit technology to achieve maximum performance and reliability. Consisting of a single Power Amplifier drawer which requires no RF alignment, the TSA50HSS is easy to service and maintain. Several front panel indicators are included which display the results of the amplifier's diagnostic/control circuitry.

The TSA50HSS is designed for the express purpose of broadcasting as authorized by the Federal Communications Commission under Part 21, Subpart K; Part 74, Subpart I; and Part 94 of the FCC Rules and Regulations.

1.2 Specifications:

Output Power	50W peak visual 1.25W average aural
Emissions	5M75C3F visual 250KF3E aural
Color Transmission	Compatible with NTSC, PAL, or SECAM
Output Frequency Range	2.15-2.162GHz (MDS Ch 1, 2, 2A) 2.5-2.7GHz (MMDS Ch. A-1 to G-4)
Gain	11dB minimum
Frequency Response	±1dB from 2.5-2.7GHz/2.1-2.2GHz
Aural Attenuation	10dB
Spurious Products	>60dB below peak sync
Harmonics	>65dB below peak sync
Intermodulation Products (IM_3)	Unmeasurable
Differential Gain	±3%
Differential Phase	±3°
Low Frequency Linearity	3%

Output Impedance	50 ohms (type N connector)
Input Level	5W peak visual 13W average aural
Input Impedance	50 ohms (type N connector)
Ambient Temperature	-30°C to +50°C
Power Requirements	115Vac ± 15% @ 50/60Hz, 450W 230Vac ± 15% @ 50/60Hz (OPTIONAL)
Mechanical Dimensions	5.25"H x 19"W x 23.25"D
Weight	33 lb.

1.3 Installation:

NOTE: The connectors mentioned in the following instructions are located on the rear of the equipment.

1. After unpacking the TSA50HSS, a thorough inspection should be conducted to reveal any damage which may have occurred during shipment. If damage is found, immediately notify the shipping agency and advise EMCEE Broadcast Products (Customer Service) or its field representative. Also check to see that any connectors, cables or miscellaneous equipment, which may have been ordered separately, are included.

2. Place the TSA50HSS in a clean, weatherproof environment providing adequate ventilation for the exhaust fans at the rear of the drawer. It is important to maintain the amplifier's ambient temperature within the -30°C and +50°C limits.

3. Place the TSA50HSS in its permanent location near a receptacle that supplies 115Vac at 50/60Hz. Unless the customer has specifically requested a power requirement of 230Vac at 50/60Hz, the TSA50HSS will operate only from a 115Vac source. The ac source should have a minimum power capacity of 600W plus the power requirements of any other drawers operating from that source.

IMPORTANT

Do not apply ac power to the amplifier at this time since its RF output must be properly loaded before being placed in operation.

4. Set all circuit breakers and switches, including the customer's incoming line breaker, to the OFF position. Place an appropriate ac power line protector (surge suppressor) across the ac line that supplies the amplifier.

5. Connect the transmitting antenna/channel combiner cable to the TSA50HSS RF OUT connector (J3).

NOTE: If the TSA50HSS is packaged in a cabinet with an appropriate EMCEE driver (e.g., a TTS10HSX with a split output), proceed to step #9; otherwise, continue with step #6.

6. Fasten a low-loss N to N cable to the driver's VISUAL RF OUT connector (J3 on the TTS10HSX with a split output) and the TSA50HSS VISUAL RF IN connector (J1). Fasten another low-loss N to N cable to the driver's AURAL RF OUT connector (J5 on the TTS10HSX with a split output) and the TSA50HSS AURAL RF IN connector (J2).

7. Locate the small-wire harness with the two 9-pin female connectors supplied by EMCEE (accessories box). Fasten one end of this harness to the driver's CONTROL connector (J4 on the TTS10HSX) and fasten the other end to the TSA50HSS CONTROL connector (J4).

NOTE: If a driver other than the TTS10HSX/TTS10HSB/TTS10EB is used, pin 1 of the TSA50HSS CONTROL connector (J4) must be provided +15Vdc to activate the amplifier. When the TSA50HSS interlock circuit is closed, +12Vdc switched is applied to the amplifier module as well as to pin 2 of its CONTROL connector (see Figure 2–1). This voltage should be used to initiate RF drive from the driver, eliminating the possibility of damage caused by prematurely driving the TSA50HSS before bias voltage is applied to its amplifier modules.

8. Plug the power cord of the TSA50HSS into an appropriate electrical outlet.

9. Verify that the wire harness and RF cables are connected properly. Verify that the power cords of the TSA50HSS and its driver are plugged into the receptacle at the bottom of the system's cabinet.

10. Plug the power cord of the system's cabinet receptacle into an appropriate electrical outlet.

1.4 Operation:

1.4a 50 Watt Transmitter (TTS10HSX / TTS10HSB / TTS10EB with Split Output and TSA50HSS):

Assuming the installation instructions of Section 1.3 have been completed and the transmitter/driver is receiving baseband video and audio signals, proceed with the following steps to place the system in operation. The controls, switches, and indicators mentioned in these steps are located on the front of the equipment. It is assumed that an EMCEE TTS10HSX Transmitter with a split output is being used to drive the TSA50HSS Power Amplifier.

1. For the TTS10HSX Transmitter, place its modulator's power switch to ON (if applicable) and verify that it is providing 87.5% video modulation. If necessary, adjust the modulator for 87.5% video modulation as described in its instruction manual.

2. Turn the transmitter's VISUAL POWER ADJ and AURAL POWER ADJ controls fully counterclockwise and place its OPERATE/STANDBY switch to STANDBY, its AGC switch to OFF, and its AC POWER circuit breaker to ON. For the TSA50HSS, place its OPERATE/

STANDBY switch to STANDBY and its AC POWER circuit breaker to ON. Then verify the following responses of the system.

a. The fans at the rear of the TTS10HSX and TSA50HSS should be operating.

b. The OPERATE/STANDBY indicators of the TTS10HSX and TSA50HSS should be illuminated orange.

c. The VSWR OVLD indicators of the TTS10HSX and TSA50HSS should be extinguished.

d. The SYNTH LOCK indicator of the TTS10HSX should be illuminated green.

3. For the TTS10HSX and TSA50HSS, place their corresponding OPERATE/STANDBY switches to OPERATE. Then verify the following responses of the system. (NOTE: The TTS10HSX % POWER meter will not read 100% when the TSA50HSS is at 100%. Typically the transmitter's % POWER meter will be approximately 60%.)

   a. The OPERATE/STANDBY indicators of the TTS10HSX and TSA50HSS should be illuminated green.

   b. The VSWR OVLD indicators of the TTS10HSX and TSA50HSS should remain extinguished.

   c. The SYNTH LOCK indicator of the TTS10HSX should remain illuminated green.

   d. The AURAL DRIVER, AURAL FINAL, VISUAL DRIVER, and VISUAL FINAL indicators of the TTS10HSX should be illuminated green as well as the AMPL A1 indicator of the TSA50HSS.

4. Place the TSA50HSS meter switch to VIS and turn the TTS10HSX VISUAL POWER ADJ control clockwise until a 100% indication appears on the TSA50HSS % POWER meter.

5. Place the TTS10HSX AGC switch to ON.

   a. Verify that the TSA50HSS % POWER meter still reads 100%. If necessary, vary the TTS10HSX AGC ADJ control for a 100% indication.

   b. Verify that the TTS10HSX AGC indicator is illuminated green.

6. Place the TTS10HSX meter switch to AURAL and turn its AURAL POWER ADJ control clockwise until a 100% indication appears on its % POWER meter.

7. Place the TSA50HSS meter switch to REFLECTED and verify that its % POWER meter indicates no more than 10% returned power. If the reflected power is more than 10%, shut down the system and check the VSWR of the transmitting antenna and its associated cable.

8. Place the TSA50HSS meter switch to VISUAL for constant monitoring of the system's visual output power.

The TSA50HSS Power Amplifier driven by the TTS10HSX Transmitter is now in operation. Check the system's coverage area for clean, sharp television reception. If the reception or picture quality is unsatisfactory, examine the amount of power delivered to the transmitting antenna (see section 3.4) and, if necessary, examine the antenna orientation, antenna VSWR, and transmission line VSWR to insure maximum radiation in the proper direction.

1.5 Warranty and Parts Ordering:

Warranty – EMCEE warrants its equipment to be free from defects in material and workmanship for a period of one year after delivery to the customer. Equipment or components returned as defective (prepaid) will be, at our option, repaired or replaced at no charge as long as the equipment or component part in question has not been improperly used or damaged by external causes (e.g., water, ac line transients, or lightning). Semiconductors are excepted from this warranty and shall be warranted for a period of not more than ninety (90) days from date of shipment. Equipment or component parts sold or used by EMCEE, but manufactured by others, shall carry the same warranty as extended to EMCEE by the original manufacturer.

Equipment Returns – If the customer desires to return a unit, drawer, or module to EMCEE for repair, follow the procedure described below:

1. Contact EMCEE Customer Service Department by phone or fax for a Return Authorization Number.

2. Provide Customer Service with the following information:

   Equipment model and serial numbers.
   Date of purchase.
   Unit input and output frequencies.
   Part number (PN) and Schematic Diagram designator if a module is being sent.
   Detailed information concerning the nature of the malfunction.

The customer shall designate the mode of shipping desired (e.g., Air Freight, UPS, Fed Ex, etc.). EMCEE will not be responsible for damage to the material while in transit. Therefore, it is of utmost importance that the customer insure the returned item is properly packed.

Parts Ordering – If the customer desires to purchase parts or modules, utilize the following procedure:

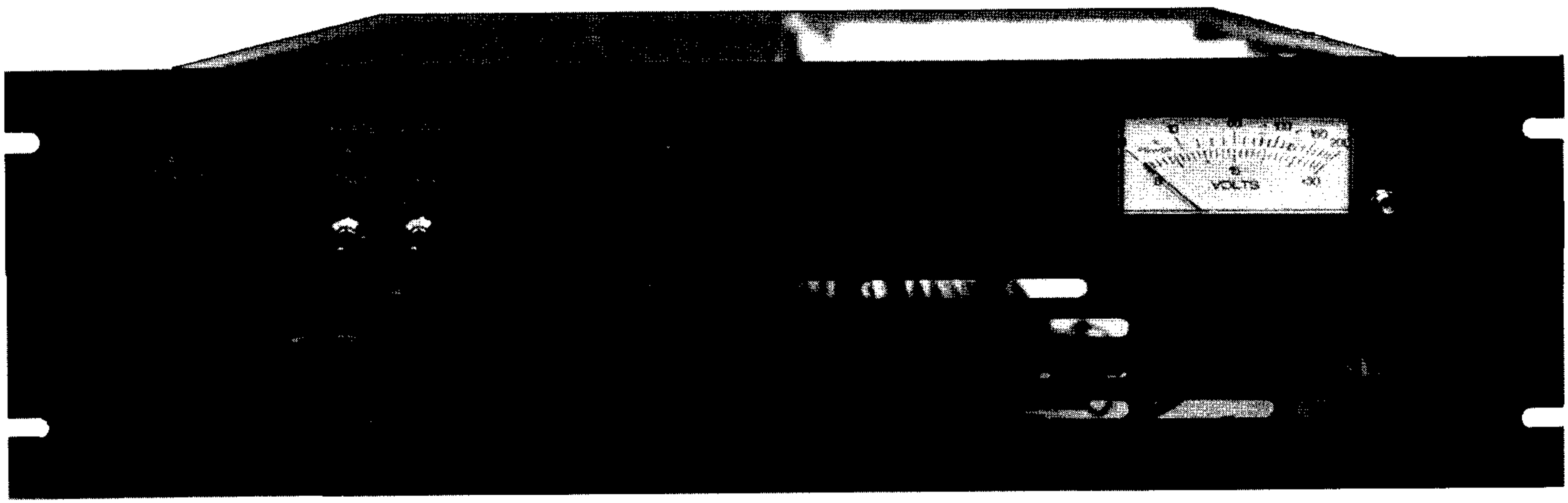
1. Contact EMCEE Customer Service by phone or fax indicating the customer's purchase order number. If the purchase order number is provided by phone, written confirmation of the order is required.

2. Also provide:
   The equipment model and serial number.
   The unit input and output frequencies.
   The quantity, description, vendor, number, and designation of the parts needed as found in the Spare Modules and Components Lists section of this manual.
   If a module is required, give the part number (PN) and Schematic Diagram designator (e.g., A329-80).
   Designate the mode of shipping desired (e.g., Air Freight, UPS, Fed Ex, etc.).
   Shipping and billing addresses.

Spare and Replacement Modules and Components – The Spare Modules and Components section of this manual provides a listing of the modules and some discrete components contained within the amplifier. This list contains those modules or components considered to be essential bench-stock items and should be available to the maintenance technician at all times. The Schematic or Interconnection Diagram is the governing document of this manual. Should there be a discrepancy between a modules or components list and a diagram, the diagram takes precedence. Such a discrepancy is possible since manufacturing changes cannot always be incorporated immediately into the instruction manual.

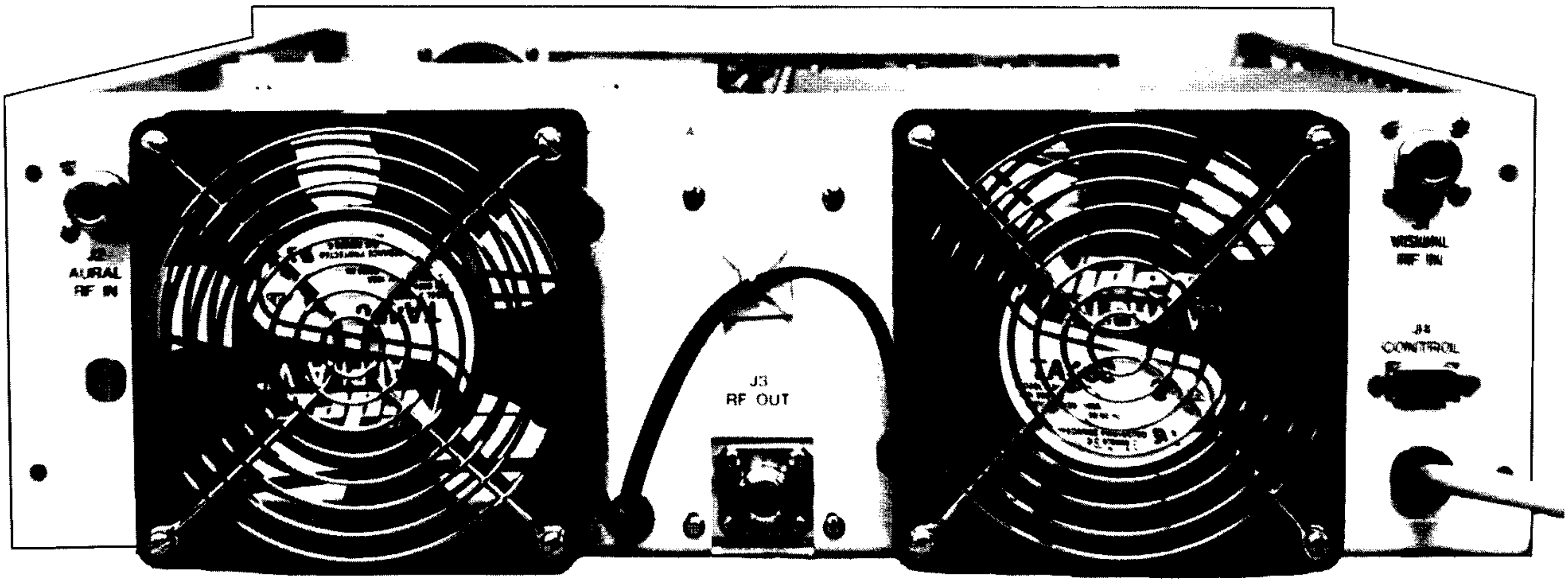
Component Referencing – EMCEE transmitters and amplifiers consist of a number of modules and components mounted in a drawer. Components mounted in a module take the drawer number and the module number in addition to a component number. Thus the reference designator A1A2Q1 means transistor Q1 in module A2 of drawer A1. Components mounted in a drawer take only the drawer number and a component number (e.g., A1M1 designates meter M1 of drawer A1).

> For EMERGENCY technical assistance, EMCEE offers a toll free, 24-hour, 7-day-a-week customer service hot line: 1-800-233-6193.



TSA50HSS Front Panel View

Figure 1-1



<u>**TSA50HSS Rear View**</u>

Figure 1-2

SECTION II

CIRCUIT DESCRIPTION

SECTION II

CIRCUIT DESCRIPTION

2.1 Power Amplifier Drawer:

Interconnection Diagram 40390005/Rev 51 ⋆ A1

RF OUT (J2)	50W (+47dBm) peak visual 1.25W (+31dBm) average aural
RF SAMPLE (J5)	≈-40dB; Composite Output Sample
Visual Gain (J1-J2)	11dB Min.
Visual Flatness (J1-J2)	±1dB from 2.5-2.7GHz and 2.1-2.2GHz
Aural Attenuation (J3-J2)	10dB

The Power Amplifier drawer provides 11dB of visual gain and 10dB of aural attenuation to a transmitter's visual and aural carriers. The 10dB of aural attenuation results when the amplified visual carrier and external aural carrier are diplexed internally. The Power Amplifier drawer is comprised of an RF amplifier chain, power detection/metering circuitry, diagnostic/control circuitry, and various power supplies. The RF amplifier chain consists of one 50W S-Band Power Amplifier (A1) and a Combiner/Coupler (A3). The power detection/metering circuitry includes three 10dB attenuators (AT1, AT2, AT3), a Metering Detector (A2), a Metering Switch board (PC2), and a % POWER meter (M1). Diagnostic/control circuitry is centered around the Monitor/Control board (PC1) and 175°F thermostat (A1S1). Power supply components consist of a +12V Power Supply (PS1), a ±15V/+5V Power Supply (PS2), a contactor (K1), and an AC POWER circuit breaker (CB1).

The Power Amplifier front panel provides various controls, indicators, and signals. The controls include the AC POWER circuit breaker as well as the meter switch (PC2S1) and the Monitor/Control OPERATE/STANDBY switch and VSWR OVLD RESET switch. The indicators include the Monitor/Control OPERATE/STANDBY, VSWR OVLD, and AMPL A1 indicators in conjunction with the % POWER Meter. A sample of the Power Amplifier's composite output signal is provided at the RF SAMPLE port.

2.1a 50W S-Band Power Amplifier:

Schematic Diagram 40390039/Rev 54 ⋆ A1A1

Flatness (J1-J2)	±1dB, 2.5-2.7GHz and 2.1-2.2GHz
Gain (J1-J2)	+7dB
Current	24A @ 12V

The 50W Power Amplifier module (A1) provides a final +10dB of gain to the visual signal. The module utilizes two class A power GaAsFET pairs (Q1/Q2, Q3/Q4) and microstrip circuitry. The module's circuitry resides on two separate PC boards or pallets (A1PC1, A1PC2) which provide input and output matching structures for the FETs.

On PC1 the 3dB, 90° hybrids (HY1, HY2, HY3) split the input signal into two pairs of out of phase signals to drive the FET pairs. Individual gate-source bias voltages for each transistor are generated using -15V to forward bias a cathode grounded zener diode (VR1, VR2, VR3, VR4). Potentiometers (R5, R10, R15, R20) provide individual bias adjustment for each transistor. On PC2, the 3dB, 90° hybrids (HY4, HY5, HY6) properly combine the out of phase signals from the FETs to form the output signal. The FETs are supplied with +10Vdc via dropping power resistors R24 through R27.

Transistor faults are detected by monitoring the drain voltage of each FET with diodes CR1 through CR4. Normally, approximately +10Vdc is present on pin 3 of each diode. As a result, Q5, Q6, and Q7 are conducting and the FAULT line has 0V on it. If a GaAsFET opens, pin 3 on the respective diode package will go to +12Vdc, turning off Q7 and Q6 resulting in approximately +4.3Vdc being placed on the FAULT line. Likewise, the FAULT line will go high if a FET shorts. The voltage at pin 3 of the respective diode package will be approximately 0.2Vdc. This causes the voltage at pin 2 of CR1 through CR4 to drop to approximately 1V turning off Q5 forcing its collector to go high.

2.1b Combiner Coupler:

Schematic Diagram A329-90/Rev D ⋆ A1A3

VISUAL Insertion Loss (J1-J2)	<1dB
AURAL Insertion Loss (J7-J2)	10dB
RF SAMPLE Coupling (J1&J7-J3)	40dB
FWD VISUAL Coupling (J1-J5)	30dB
REFLD POWER Coupling (J2-J4)	30dB
AURAL SAMPLE Coupling (J7-J6)	30dB

The Combiner Coupler (A3) is a seven-port module which performs two functions. The first function is to combine the amplified visual and aural S-Band carriers applied to ports J1 and J7, respectively. The combined carriers result in a composite signal at port J2 where the aural carrier is attenuated by 10dB. This signal is applied to the amplifier's rear panel VIS/AUR RF OUT connector. A sample of the composite signal is coupled to port J3 where it is then applied to the amplifier's front panel RF SAMPLE connector. The second function is to provide a sample of three RF signals which are used by the Metering Detector (A2). These RF signals include a sample of the forward visual carrier at port J5, a sample of the forward aural carrier at port J6, and a sample of the reflected visual signal at port J4.

2.1c Metering Detector:

Schematic Diagram 30368024/Rev P ⋆ A1A2

The Metering Detector (A2) contains separate but similar circuitry for monitoring the peak visual, average aural, and average reflected power at the output of the amplifier. Samples of these three RF signals are supplied via the Combiner Coupler.

The front end or detector portion of each circuit is basically the same. Diodes CR2, CR3, and CR4, together with their surrounding components, convert the sampled on-channel RF signals to positive dc voltages proportional to the detected RF power. Detection of the sampled visual output carrier is accomplished by CR2 in conjunction with R4 and C2 which form a time constant of 1 second. R4 is the dc load while C1, C11 and C17 form the RF ground of the visual power detector. Detection of the other two sampled RF signals is the same except for a faster time constant (R22/C6) in the reflected power detector. The positive dc voltages from the visual, aural, and reflected power detectors are processed by buffer amplifiers U1 and U2 which provide voltage gains of 1V/V and 2V/V, respectively. These buffer amplifiers also provide isolation between the % POWER meter (M1) and the detectors. The setting of potentiometers R9, R18, and R27 determines the voltage level applied to the % POWER meter when the meter switch (PC3S1) is in its VIS, AUR, and REFL positions.

A dc voltage proportional to the amplifier's visual output power is applied to pin 5 of connector J4, designated VISUAL POWER REFERENCE. When using an EMCEE HS series transmitter as a driver, this voltage is fed back to the IF/Upconverter (A8) of the transmitter. When the AGC switch (PC2S3) is in its ON position, this voltage ultimately controls the attenuation of the visual IF carrier so that the amplifier's visual output power is automatically maintained close to its rated value.

A dc voltage proportional to the transmitter's reflected output power is fed to pin 10 of comparator U2. This voltage is compared to a reference voltage at pin 9 whose magnitude is determined by the setting of potentiometer R30. With R30 properly set (see paragraph 3.5b), the voltage on pin 10 will be greater than the reference voltage whenever the transmitter's reflected power is at least 50% of its rated forward power. As a result, the output of the comparator saturates in the positive mode applying approximately +4Vdc to pin 7 of connector J4, designated VSWR OVLD. This voltage instructs the Monitor/Control (PC1) that a VSWR overload condition has been detected. However, when the transmitter's reflected power is less than 50% of its rated forward power, the voltage on pin 10 of comparator U2 will be less than the reference voltage. As a result, the comparator saturates in the negative mode, diode CR1 is forward biased, and approximately -0.7Vdc is applied to pin 7 of connector J4. This voltage instructs the Monitor/Control that no VSWR overload condition exists.

2.1d Monitor/Control:

Schematic Diagram 30390070/Rev 52 ⋆ A1PC1

The Monitor/Control board (PC1) provides various monitoring and control functions for the amplifier while displaying the results on several front panel diagnostic indicators. The circuitry of this board can be divided into three sections:

(1) Interlock Monitoring/Display Section
(2) Fault Monitoring/Display Section
(3) Miscellaneous Control/Display Section

The <u>interlock monitoring/display section</u> monitors several key voltages and displays the results on the OPERATE/STANDBY (DS1) and VSWR OVLD (DS3) indicators. The voltages monitored include the Metering Detector's VSWR OVLD voltage, the ±15V/+5V Power Supply's -15Vdc and +5Vdc voltages, and the INTLK RETURN voltage. When these voltages are at their normal levels and the OPERATE/STANDBY switch (S1) is in its OPERATE position, the amplifier's interlock circuit is closed and in the operate mode. In this mode, the VSWR OVLD indicator is extinguished while the OPERATE/STANDBY indicator is illuminated green. However, if one or more of these voltages significantly deviate from their normal levels, the interlock circuit is automatically opened placing the unit in the standby mode with the OPERATE/STANDBY indicator illuminated orange.

The Metering Detector's VSWR OVLD voltage is normally -0.7Vdc. On the Control/Monitor board this voltage is buffered by exclusive-OR U5 and applied to the clock input (pin 11) of flip-flop U2 whose Q output (pin 9) is normally high. U2's Q output changes state whenever its clock input goes positive. Therefore, when a VSWR overload condition is sensed by the Metering Detector (A8), the VSWR OVLD voltage switches from -0.7Vdc to about +4Vdc causing U2's Q output to toggle low. This low is sensed by pin 5 of AND gate U1 placing the transmitter in its standby mode. This low is also sensed by the base of Q4 which causes Q4 to turn off and the VSWR OVLD indicator to illuminate red. U2's Q output can be reset high by activating the VSWR OVLD RESET momentary switch (S2).

To insure proper bias is applied to the amplifier transistors, the Monitor/Control board also examines the -15Vdc portion of power supply PS2. When the -15Vdc voltage is present, zener diode VR1 is biased in its breakdown region while diode CR1 is forward biased clamping the base of Q3 at -0.7Vdc. With Q3 normally turned off, a high is applied to pin 4 of U1. However, when -15Vdc is no longer available, VR1 and CR1 are turned off while Q3 is turned on applying a low to pin 4 of U1. This low results in placing the amplifier in its standby mode.

Another condition necessary to allow the transmitter to operate is that the INTLK RETURN voltage is present and the OPERATE/STANDBY switch is in its OPERATE position. In this configuration a high is normally applied to pin 12 of U1. However, when the INTLK RETURN voltage is no longer available, a low is applied to pin 12 of U1 placing the amplifier in standby. The INTLK RETURN voltage will be the +15Vdc supplied by the transmitter driving the amplifier to pin 1 of CONTROL plug J4 on the amplifier's rear panel. This is accomplished using the appropriate wire harness connected between CONTROL jack J4 of the TSA50HSS amplifier and CONTROL jack J4 of the HS series transmitter/driver. Also, the thermostat attached to amplifier A1 must remain closed below temperatures of 175°F.

Under normal operation, the above conditions will be met and output pin 3 of AND gate U1 will be high, forward biasing transistors Q5 and Q6. The ground provided by Q6 via J1-22 activates contactor K1 which in turn supplies 12Vdc to the 50W S-Band Power Amplifier Module placing the transmitter in operation. The high placed on J1-12 from the activated contactor forward biases transistor Q1, extinguishing the red portion of OPERATE/STANDBY LED DS1 turning it green.

Conversely, if one of the monitored voltages mentioned above changes state, pin 3 of U1 will switch low turning off transistors Q5 and Q6. This will result in the removal of the switched 12Vdc from the 50W S-Band amplifier due to the deactivation of contactor K1. Also, with loss of the switched 12Vdc, transistor Q1 will be reverse biased via J1-12 turning the OPERATE/STANDBY LED to orange.

The fault monitoring/display section monitors the detection of a failure associated with the four transistors in the 50W S-Band Amplifier (A1) and displays the result on the AMPL A1 front panel indicator. Under normal operation, the voltage level on the amplifier FAULT line is low (0.4Vdc). If a fault is detected in the 50W S-Band Amplifier, the corresponding FAULT line becomes high (+4Vdc). This high is applied to transistor Q8. The corresponding low at its collector results in forward biasing series diode CR4 which extinguishes the green LED of the associated indicator DS9. Meanwhile, the low on the collector of Q8 results in reverse biasing transistor Q7, illuminating the red LED of the fault indicator.

2.1e +12V Power Supply:

Schematic Diagram N/A ⋆ A1PS1

The +12V Power Supply (PS1) is a single output, high efficiency, switching power supply with a rated output current of 33Adc. The primary purpose of this supply is to provide the drain voltage and current for each GaAsFET contained in the 50W Amplifier module. When energized, the contactor (K1) provides +12Vdc switched to this module as well as to transistor Q1 in the Monitor/Control (PC1).

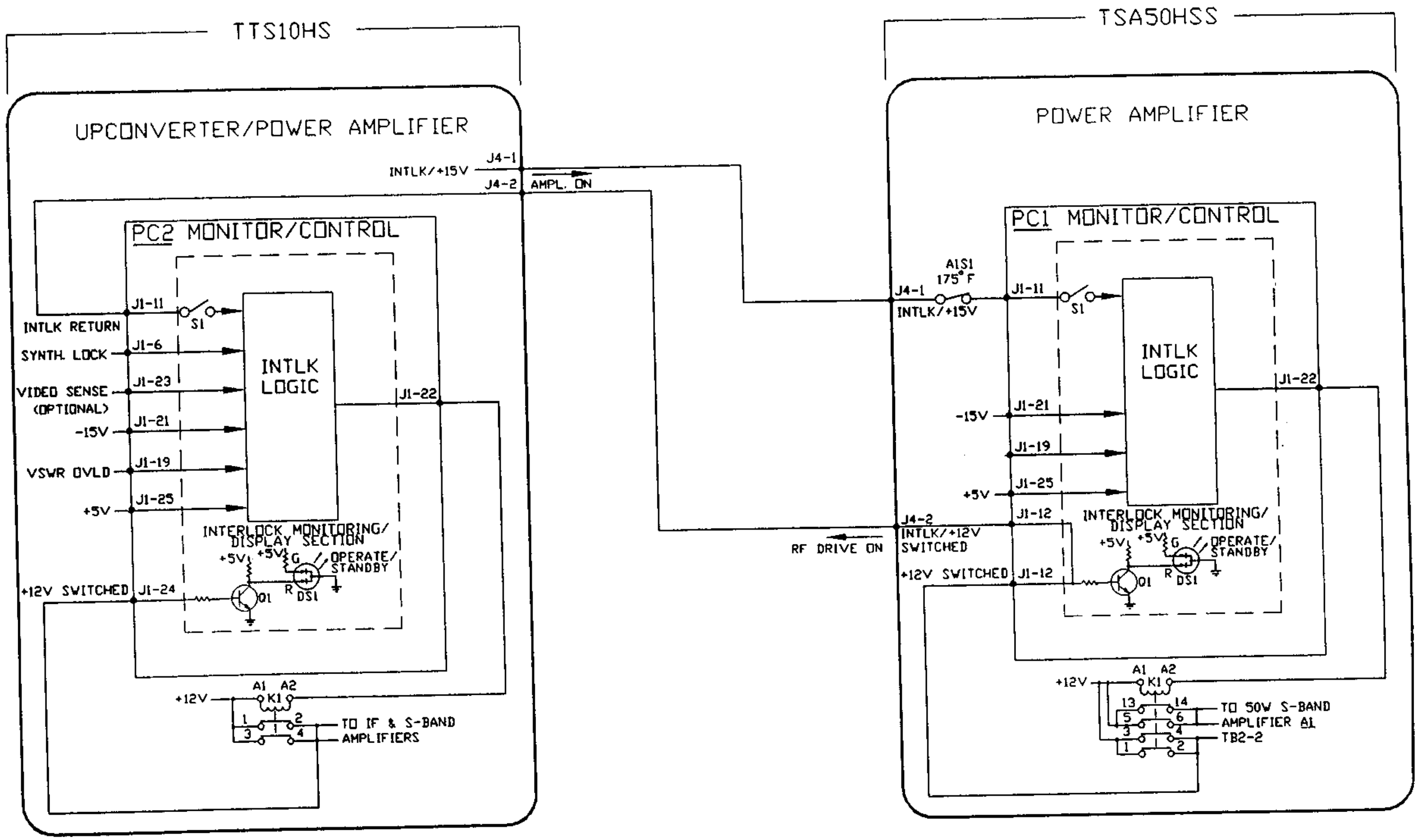
The +12V Power Supply is nonfield repairable. If defective, it should be returned to EMCEE for repair or replacement.

2.1f ±15V/+5V Power Supply:

Schematic Diagram N/A ⋆ A1PS2

The ±15V/+5V Power Supply (PS2) is a multiple output, linear power supply. This supply provides ±15Vdc and +5Vdc to circuitry on the Monitor/Control PC board. -15Vdc is also provided as bias for each GaAsFET in the 50W S-Band Power Amplifier module.

The ±15V/+5V Power Supply is nonfield repairable. If defective, it should be returned to EMCEE for repair or replacement.



SYSTEM INTERLOCK FOR THE TSA50HSS AMPLIFIER WITH TRANSMITTER DRIVER

FIGURE 2-1

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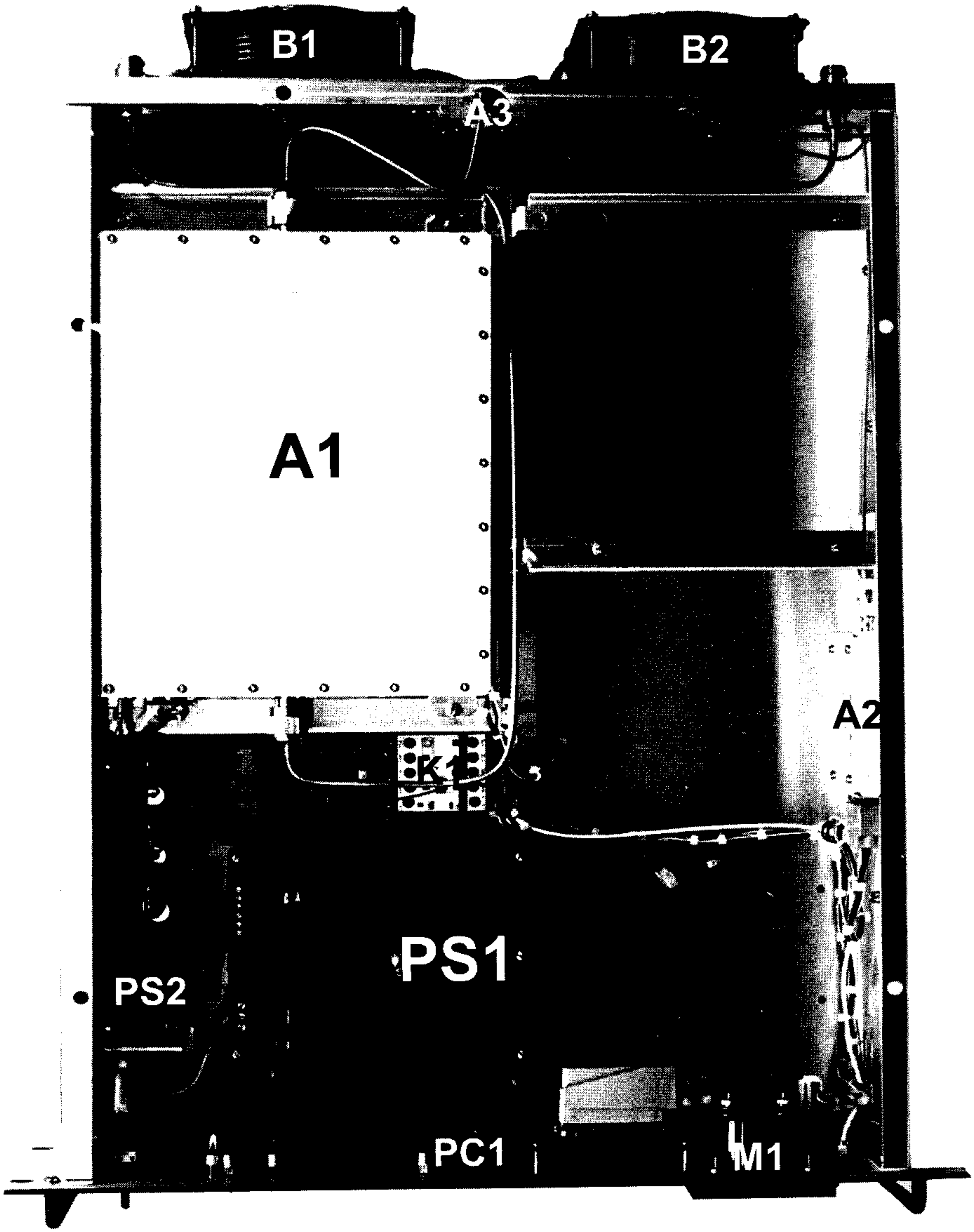


TSA50HSS Internal View

Figure 2-2

SECTION III

MAINTENANCE

SECTION III

MAINTENANCE

3.1 Periodic Maintenance Schedule:

OPERATION	RECOMMENDATION
ALIGNMENT	No alignment required.
OUTPUT POWER CALIBRATION	Upon installation and at one-year intervals thereafter (see subsection 3.4).
FANS	Inspect as often as possible (at least monthly) and clean when necessary. No lubrication needed.

3.2 Recommended Test Equipment:

EQUIPMENT	MANUFACTURER	MODEL #
Digital Multimeter	FLUKE	8050A
Oscilloscope	TEKTRONIX	2232
50 Ohm RF Detector	TELONIC BERKELEY	553
30dB, 150W Attenuator	NARDA	769-30
Power Meter	HEWLETT PACKARD	435B
Frequency Counter	HEWLETT PACKARD	5386A
Spectrum Analyzer	HEWLETT PACKARD	8594E
Driver	EMCEE	TTS10HSX with Split Output
NTSC Video Generator	TEKTRONIX	TSG100

3.3 Troubleshooting:

If the visual and/or aural output signals from the TSA50HSS appear distorted, noisy or nonexistent, consider the following procedure as a troubleshooting aid. (NOTE: This procedure assumes the cabling and connectors are trouble free. It also assumes the TSA50HSS is driven by a proper input signal.)

1. The general problem area may be pointed to by simply checking the TSA50HSS front panel diagnostic indicators as well as the % POWER meter and the signal seen at the RF SAMPLE port. The diagnostic indicators are located on the amplifier's front panel.

   a. The OPERATE/STANDBY indicator illuminates green when the following conditions are satisfied. The AC POWER circuit breaker is closed, the driver's INTLK/+15V voltage is available, the 175°F thermostat is closed, the OPERATE/STANDBY switch is in its OPERATE position, a VSWR overload condition does not exist, the ±15V/+5V Power Supply's -15Vdc and +5Vdc voltages are available, and the contactor is energized supplying +12Vdc switched. However, if one or more of these conditions are not satisfied, the OPERATE/STANDBY indicator illuminates orange indicating the TSA50HSS is in its standby or nonradiating mode with its interlock circuit open (see Figure 2–1).

   b. The VSWR OVLD indicator is normally extinguished. However, this indicator illuminates red when a VSWR overload condition exists.

   c. Assuming +12Vdc switched and -15Vdc are available, the AMPL A1 indicator illuminates green when the RF transistors of the amplifier module are operating correctly. However, if one of these transistors fails, the corresponding indicator will illuminate red.

   d. The % POWER meter, in conjunction with the meter switch, provides an indication of the voltage from the +12V Power Supply as well as an indication of the peak visual, average aural and average reflected power at the output of the TSA50HSS.

   e. The RF SAMPLE port provides convenient monitoring of the TSA50HSS sampled composite output signal. The signal applied to the RF SAMPLE port is approximately 40dB less than the power level of the signal that is sampled.

2. The problem area can be specifically determined by systematically troubleshooting the circuitry comprising the various sections of the TSA50HSS.

   a. The TSA50HSS can be subdivided into four sections:

      (1) Power Supply/Circuitry (CB1, E1, PS1, PS2, K1)
      (2) RF Amplifier Chain (A1, A3)
      (3) Power Detection/Metering Circuitry (AT1, AT2, AT3, A2, PC2, M1)
      (4) Diagnostic/Control Circuitry (PC1, A1S1)

   b. Verify that the power supply/circuitry is not at fault.

   c. Verify the specified gain or loss of each module comprising the RF amplifier chain. With the TSA50HSS RF OUT port terminated in 50 ohms, set up the test equipment as shown in Figure 3–1 and use the signal flow diagram provided in Figure 3–2.

d. Verify that the power detection/metering circuitry and the diagnostic/control circuitry are not at fault.

TSA50HSS TROUBLESHOOTING CHART

The following chart is meant as an aid to uncovering faults that have developed in this amplifier. During normal operation, all indicator LEDs are green, except the VSWR OVLD LED which is normally extinguished. This chart lists the LEDs that are indicating a fault (i.e., are not in their normal state). If a problem develops with the amplifier, note the state of the indicator LEDs and compare this to the chart.

TSA50HSS TROUBLESHOOTING CHART

PROBLEM	INDICATORS	CAUSE	SOLUTION
NO VISUAL OUTPUT POWER	OPERATE/STANDBY ORANGE	Operate/Standby Switch on Standby	Place switch to Operate.
		+12VDC Power Supply faulty	Check Meter reading for 12V. Replace power supply if determined to be faulty.
		+12Vdc or Multioutput Power Supply shorted	Unplug each module or PCB and check for a short. Replace module(s) as needed.
		Multioutput Power Supply defective	Check the power supply with an appropriate load connected. Replace supply if necessary.
		Monitor/Control board malfunction	Replace board.
		No Interlock Voltage from driver	Make sure the intercon-nect cable between the driver and the TSA50HSS is correctly connected and make sure the driver is turned on or place +12V or +15V on pin 1 of J4.

TSA50HSS TROUBLESHOOTING CHART

PROBLEM	INDICATORS	CAUSE	SOLUTION
NO VISUAL OUTPUT POWER	OPERATE/STANDBY ORANGE VSWR OVLD RED	VSWR Overload	Check the Output Combiner, transmission line, and antenna for high VSWR. Repair or replace any component with a high VSWR.
	AMPL A1 RED	Power Amplifier module has failed	Replace amplifier module.
	No fault indicated	Driver not connected or not providing required output	Make sure the driver is connected and providing a signal with sufficient level.
NO AURAL OUTPUT POWER	No Fault indicated	Driver not connected or not providing required output Combiner/Coupler has excessive loss	Make sure driver is connected correctly and is providing an aural signal with sufficient level. Check through loss of combiner. Combiner loss should be 10dB ± 1dB.
LOW OUTPUT POWER OR DISTORTED OUTPUT	AMPL A1 RED	Failed Amplifier module	Replace amplifier module.
	No Fault indicated	Transmitter/Driver drawer is not set up correctly	Refer to the owner's manual for the transmitter/driver to make sure it is set up correctly.

3.4 Output Power Calibration:

> **WARNING**
> **Amplifier Cooling**
>
> In order to gain access to the various circuits in the TSA50HSS Amplifier, it is necessary to remove the drawer cover. Please be advised that this cover is an integral part of the drawer cooling and may not be removed for more than five minutes while the amplifier is in operation. Any period longer than this could cause overheating and catastrophic damage to the amplifier module.

3.4a 50 Watt Transmitter (TTS10HSX with Split Output and TSA50HSS):

To insure correct transmission parameters, the output power level and % POWER meter calibration of the TSA50HSS driven by the TTS10HSX should be checked at least once every year. With the TSA50HSS meter switch in the VISUAL position, its % POWER meter has been factory calibrated for 100% with the TSA50HSS providing 50W peak visual power. With the meter switch in the AURAL position, its % POWER meter has been factory calibrated for 100% with the TSA50HSS providing 1.25W average aural. The following calibration procedure assumes that the composite signal from the transmitter has a visual/aural carrier power ratio of 40:1 with the visual carrier consisting of 87.5% video modulation and 0% average picture level (APL). When measuring these power levels as shown in Figure 3–3, be sure to take into account the 30dB attenuation factor provided by the attenuator. Power levels at 50% APL are included in brackets following the power levels at 0% APL.

1. Place the TSA50HSS OPERATE/STANDBY switch to STANDBY and set up the test equipment as shown in Figure 3–3.

2. For the TTS10HSX modulator, place its power switch to ON (if applicable) and verify that it provides 87.5% video modulation. For the TTS10HSX Upconverter/Power Amplifier drawer, place its AC POWER circuit breaker to ON, its AGC switch to OFF, its OPERATE/STANDBY switch to OPERATE, and turn its AURAL POWER ADJ control fully counterclockwise to disable the aural carrier. For the TSA50HSS, place its AC POWER circuit breaker to ON and its OPERATE/STANDBY switch to OPERATE.

3. To set the TSA50HSS visual output power, adjust the TTS10HSX VISUAL POWER ADJ control for a power meter reading of 29.8W [17.0W]. (Note that 50W peak visual with 0% APL and 87.5% video modulation is equal to 29.8W average visual.)

4. After a 15-minute warm-up, place the TSA50HSS meter switch to VISUAL and check its % POWER meter for a 100% indication. (Note that the TTS10HSX visual % POWER meter will not read 100%. It typically will read approximately 60%.) If this reading is not obtained, adjust potentiometer R9 of the TSA50HSS Metering Detector for a 100% indication. The Metering Detector is mounted to the right-hand inside wall of the TSA50HSS Power Amplifier drawer.

5. Place the TTS10HSX AGC switch to ON and verify that the TSA50HSS % POWER meter still reads 100%. If necessary, vary the TTS10HSX AGC ADJ control for a 100% indication.

6. To set the TSA50HSS aural output power, adjust the TTS10HSX AURAL POWER ADJ control for a power meter reading of 31.1W [18.25W]. (Note that -16dB aural power is equal to 1.25W average aural; therefore, 29.8W average visual plus 2.5% aural power is equal to 31.1W average.)

7. Place the TSA50HSS meter switch to AURAL and check its % POWER meter for a 100% indication. If this reading is not obtained, adjust potentiometer R18 of the TSA50HSS Metering Detector for a 100% indication. The Metering Detector is mounted to the right-hand inside wall of the amplifier drawer.

3.4b Reflected Power Calibration:

8. Place the TTS10HSX AGC switch to OFF and then adjust potentiometer R30 of the TSA50HSS Metering Detector fully clockwise to disable the VSWR overload detection circuit. Remove and reverse the coaxial cables connected to the two 10dB attenuators which in turn are connected to the VIS sample (J1) and REFL sample (J3) ports of the TSA50HSS Metering Detector. The reflected power circuit of the TSA50HSS Metering Detector will now monitor the system's forward power, simulating an open circuit (total returned power) at the system's output.

9. Place the TSA50HSS meter switch to REFL and check its % POWER meter for a 100% indication (70% for 50% APL). If this reading is not obtained, adjust potentiometer R27 of the TSA50HSS Metering Detector for the correct indication.

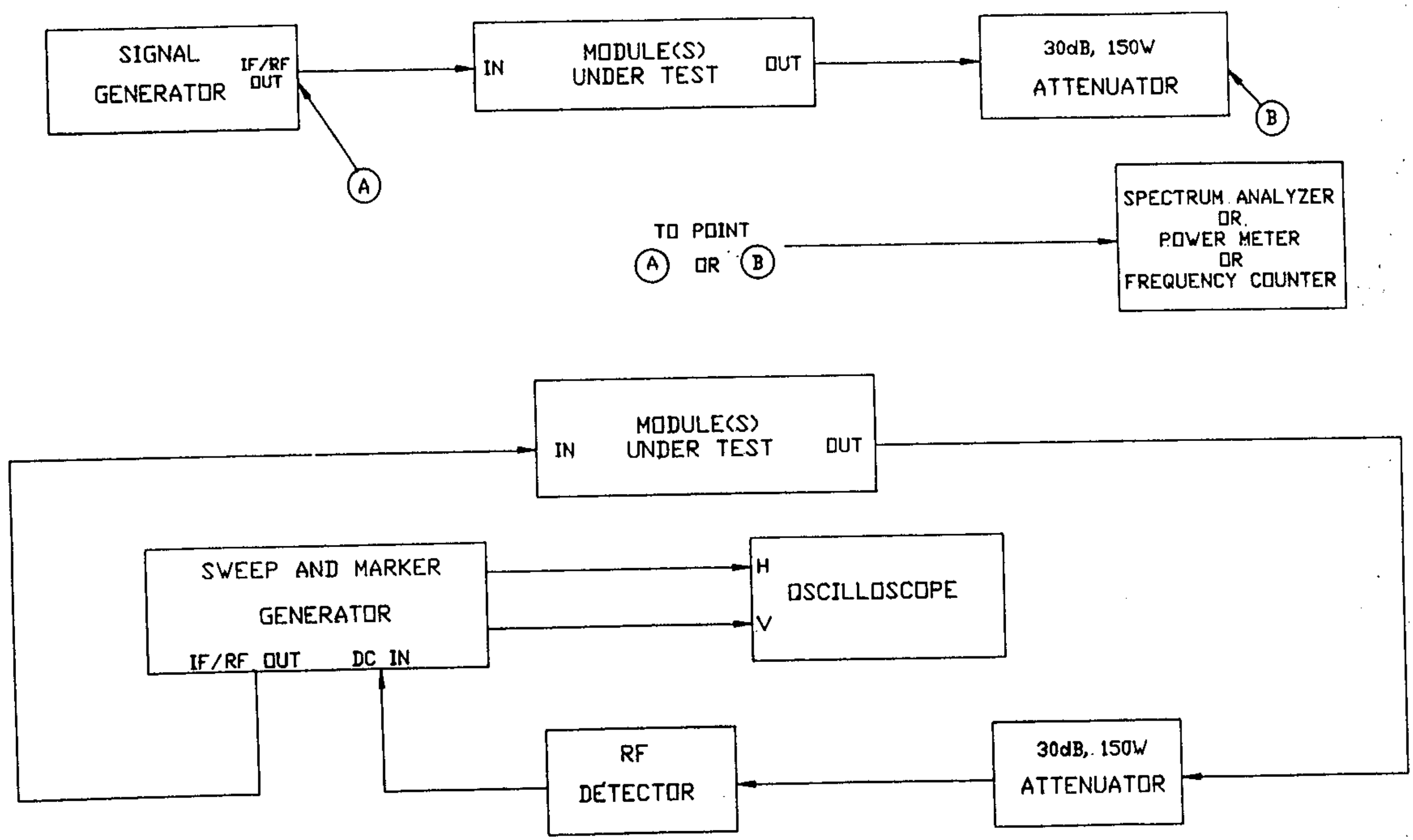
10. Decrease by 50% the TSA50HSS output power by setting the TTS10HSX VISUAL POWER ADJ for a power meter reading of 15.6W [9.1W]. This average power level is used for setting the "trip point" of the TSA50HSS VSWR overload detection circuit. Adjust potentiometer R30 of the TSA50HSS Metering Detector <u>slowly</u> counterclockwise until its VSWR OVLD indicator illuminates red. Leave the potentiometer at this setting.

11. Remove the coaxial cables connected to the two 10dB attenuators and connect them to their original positions. Since 50% reflected power is no longer present, reset the TSA50HSS VSWR overload detection circuit by activating its VSWR OVLD RESET momentary switch. Verify that the TSA50HSS VSWR OVLD indicator extinguishes.

12. Increase the TSA50HSS output power from 50% back to 100% by resetting the TTS10HSX VISUAL POWER ADJ. Keep the TSA50HSS meter switch to VIS for constant monitoring of the system's visual output power. Place the TTS10HSX AGC switch to ON and, if necessary, set the AGC ADJ for a 100% indication on the TSA50HSS % POWER meter.

13. Place the TSA50HSS OPERATE/STANDBY switch to STANDBY. Reinstall the top covers to the TTS10HSX Upconverter/Power Amplifier drawer and the TSA50HSS Power Amplifier drawer, slide the drawers back into the cabinet, and secure them properly. Disconnect the test equipment from the system. Reconnect the transmitting antenna cable to the TSA50HSS RF OUT connector (J2).

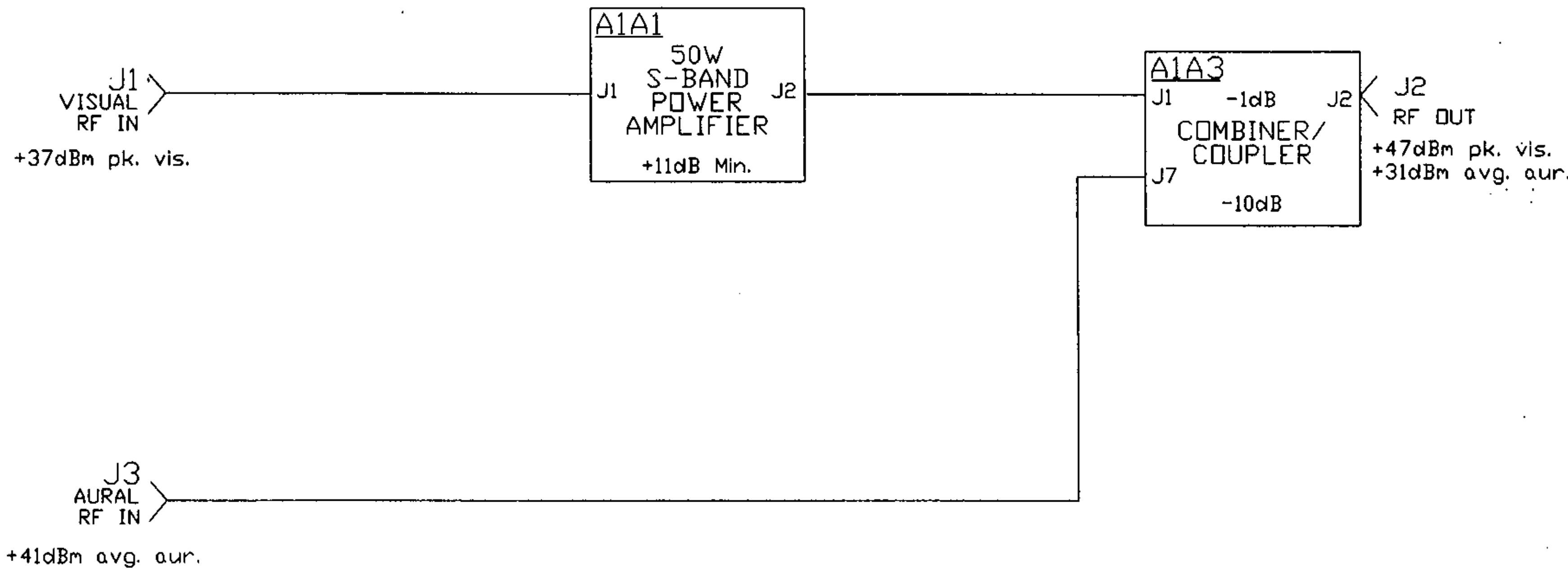
14. Place the TSA50HSS OPERATE/STANDBY switch to OPERATE to place the system on the air.



TEST EQUIPMENT SETUPS FOR MEASURING THE GAIN OR LOSS OF THE MODULES COMPRISING THE RF AMPLIFIER CHAIN

FIGURE 3-1

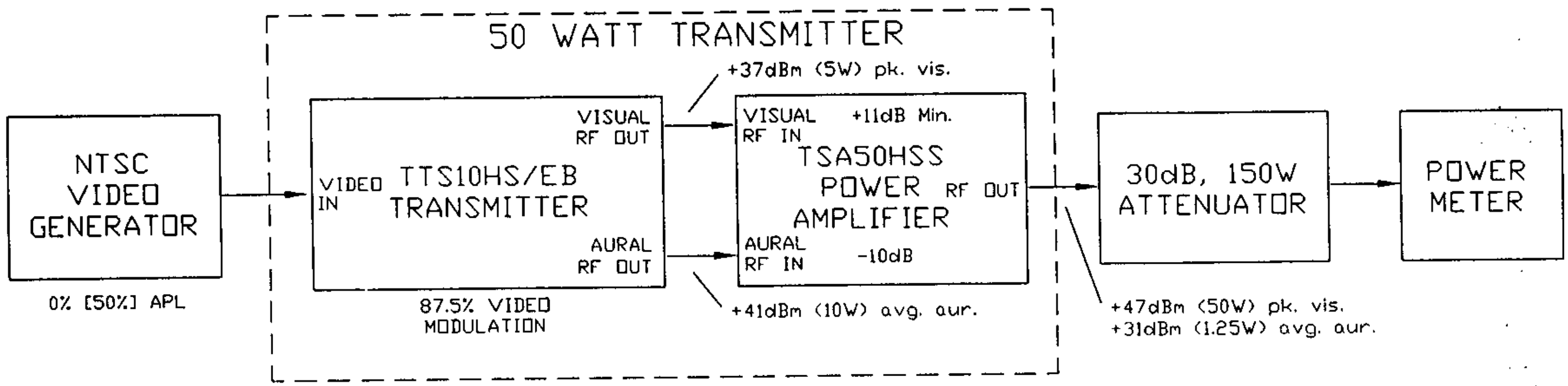
10129783-2



SIGNAL FLOW OF THE TSA50HSS POWER AMPLIFIER

FIGURE 3-2

00270



TRANSMITTER OUTPUT POWER CALIBRATION
FIGURE 3-3

00271

3.5 Spare Modules and Components Lists:

The following pages contain the description, vendor, part number, and designator of each module found in the TSA50HSS Power Amplifier which EMCEE considers to be essential bench-stock items. These modules should be available to the technician at all times.

TSA50HSS 50 WATT AMPLIFIER SPARE MODULES
INTERCONNECTION DIAGRAM 40390005 (REV 51)

DESCRIPTION	VENDOR/PART #	DESIGNATOR
S-Band Power Amplifier	EMCEE/40390030-2	A1
Monitor/Control	EMCEE/30390023-3	PC1
+12V Power Supply	VI-MAI-EQ	PS1
±15V/+5V Power Supply	Deltron/W300A	PS2
Contactor, 12Vdc	Telemecanique/LP1-K0610JD	K1
Surge Suppressor	GE/V150LA10A	E1
Fan 4.5" (110Vac)	NIDEC/A2000-5	B1, B2
Thermostat	Selco/SO-175-A	A1S1
Interlock Plug	EMCEE/50319216	P7

NOTE: The thermostat assembly, attached to the Final Amplifier module, is a separate part from the amplifier module. When replacing A1, remove the thermostat assembly from the old module so that it may be mounted on the new amplifier.

SECTION IV

DATA PAK

ITFS/INSTRUCTIONAL TELEVISION FIXED SERVICE MMDS/MULTICHANNEL MULTIPOINT DISTRIBUTION SERVICE OFS/OPERATIONAL FIXED SERVICE				
GROUP	CHANNEL	BAND LIMIT MHz	VISUAL CARRIER FREQUENCY (MHz)	AURAL CARRIER FREQUENCY (MHz)
A	A-1	2500-2506	2501.25	2505.75
	A-2	2512-2518	2513.25	2517.75
	A-3	2524-2530	2525.25	2529.75
	A-4	2536-2542	2537.25	2541.75
B	B-1	2506-2512	2507.25	2511.75
	B-2	2518-2524	2519.25	2523.75
	B-3	2530-2536	2531.25	2535.75
	B-4	2542-2548	2543.25	2547.75
C	C-1	2548-2554	2549.25	2553.75
	C-2	2560-2566	2561.25	2565.75
	C-3	2572-2578	2573.25	2577.75
	C-4	2584-2590	2585.25	2589.75
D	D-1	2554-2560	2555.25	2559.75
	D-2	2566-2572	2567.25	2571.75
	D-3	2578-2584	2579.25	2583.75
	D-4	2590-2596	2591.25	2595.75
E	E-1	2596-2602	2597.25	2601.75
	E-2	2608-2614	2609.25	2613.75
	E-3	2620-2626	2621.25	2625.75
	E-4	2632-2638	2633.25	2637.75
F	F-1	2602-2608	2603.25	2607.75
	F-2	2614-2620	2615.25	2619.75
	F-3	2626-2632	2627.25	2631.75
	F-4	2638-2644	2639.25	2643.75
G	G-1	2644-2650	2645.25	2649.75
	G-2	2656-2662	2657.25	2661.75
	G-3	2668-2674	2669.25	2673.75
	G-4	2680-2686	2681.25	2685.75
H	H-1	2650-2656	2651.25	2655.75
	H-2	2662-2668	2663.25	2667.75
	H-3	2674-2680	2675.25	2679.75
	H-4 Not Assigned	------	-----	-----
MDS	CH 1	2150-2156	2154.75	2150.25
	CH 2	2156-2162	2160.75	2156.25
	CH 2A	2156-2160	2158.75	-----

TV CHANNEL FREQUENCIES AND WAVELENGTH

Band	Channel Number	FREQUENCY BAND MHz	PICTURE CARRIER MHz	½ Wave Length, Inches — Type of Dielectric: Air	Foam	Solid
	MDS-1	2150-2156	2154.75	2.74	2.19	1.81
	MDS-2	2156-2162	2160.75	2.73	2.18	1.80
Low Band	2	54-60	55.25	106.8	85.50	70.50
Low Band	3	60-66	61.25	96.39	77.11	63.61
Low Band	4	66.72	67.25	87.79	70.23	57.94
Low Band	5	76-82	77.25	76.42	61.14	50.44
Low Band	6	82-88	83.25	70.91	56.73	46.80
	FM	88-108	(100.00)	59.04	47.23	38.96
Mid Band	A	120-126	121.25	48.69	38.95	32.13
Mid Band	B	126-132	127.25	46.39	37.11	30.62
Mid Band	C	132-128	133.25	44.30	35.44	29.24
Mid Band	D	138-144	139.25	42.39	33.91	27.98
Mid Band	E	144-150	145.25	40.64	32.51	26.82
Mid Band	F	150-156	151.25	39.03	31.22	25.76
Mid Band	G	156-162	157.25	37.54	30.03	24.77
Mid Band	H	162-168	163.25	36.16	28.93	23.86
Mid Band	I	168-174	169.25	34.88	27.90	23.02
High Band	7	174-180	175.25	33.68	26.95	22.23
High Band	8	180-186	181.25	32.57	26.05	21.49
High Band	9	186-192	187.25	31.53	25.22	20.80
High Band	10	192-198	193.25	30.55	24.44	20.16
High Band	11	198-204	199.25	29.63	23.70	19.55
High Band	12	204-210	205.25	28.76	23.01	18.98
High Band	13	210-216	211.25	27.94	22.35	18.44
Super Band	J	216-222	217.25	27.17	21.74	17.93
Super Band	K	222-228	223.25	26.44	21.15	17.45
Super Band	L	228-234	229.25	25.75	20.60	16.99
Super Band	M	234-240	235.25	25.09	20.07	16.56
Super Band	N	240-246	241.25	24.47	19.57	16.15
Super Band	O	246-252	247.25	23.87	19.10	15.75
Super Band	P	252-258	253.25	23.31	18.65	15.38
Super Band	Q	258-264	259.25	22.77	18.21	15.03
Super Band	R	264-270	265.25	22.25	17.80	14.69
Super Band	S	270-276	271.25	21.76	17.41	14.36
Super Band	T	276-282	277.25	21.29	17.03	14.05
Super Band	U	282-288	283.25	20.84	16.67	13.75
Super Band	V	288-294	289.25	20.41	16.32	13.47
Super Band	W	294-300	295.25	19.99	15.99	13.19
UHF	14	470-476	471.25	12.52	10.02	8.26
UHF	15	476-482	477.25	12.37	9.89	8.16
UHF	16	482-488	483.25	12.21	9.77	8.06
UHF	17	488-494	489.25	12.06	9.65	7.96
UHF	18	494-500	495.25	11.92	9.53	7.86
UHF	19	500-506	501.25	11.77	9.42	7.77
UHF	20	506-512	507.25	11.63	9.31	7.68
UHF	21	512-518	513.25	11.50	9.20	7.59
UHF	22	518-524	519.25	11.37	9.09	7.50
UHF	23	524-530	525.25	11.24	8.99	7.41
UHF	24	530-536	531.25	11.11	8.89	7.33
UHF	25	536-542	537.25	10.98	8.79	7.25
UHF	26	542-548	543.25	10.86	8.69	7.17
UHF	27	548-554	549.25	10.74	8.59	7.09
UHF	28	554-560	555.25	10.63	8.50	7.01
UHF	29	560-566	561.25	10.51	8.41	6.94

Band	Channel Number	FREQUENCY BAND MHz	PICTURE CARRIER MHz	½ Wave Length, Inches — Type of Dielectric: Air	Foam	Solid
U.H.F.	30	566-572	567.25	10.40	8.32	6.86
U.H.F.	31	572-578	573.25	10.29	8.23	6.79
U.H.F.	32	578-584	579.25	10.19	8.15	6.72
U.H.F.	33	584-590	585.25	10.08	8.07	6.65
U.H.F.	34	590-596	591.25	9.98	7.98	6.59
U.H.F.	35	596-602	597.25	9.88	7.90	6.92
U.H.F.	36	602-608	603.25	9.78	7.82	6.45
U.H.F.	37	608-614	609.25	9.69	7.75	6.39
U.H.F.	38	614-620	615.25	9.59	7.67	6.33
U.H.F.	39	620-626	621.25	9.50	7.60	6.27
U.H.F.	40	626-632	627.25	9.41	7.52	6.21
U.H.F.	41	632-638	633.25	9.32	7.45	6.15
U.H.F.	42	638-644	639.25	9.23	7.38	6.09
U.H.F.	43	644-650	645.25	9.14	7.31	6.03
U.H.F.	44	650-656	651.25	9.06	7.25	5.98
U.H.F.	45	656-662	657.25	8.98	7.18	5.92
U.H.F.	46	662-668	663.25	8.90	7.12	5.87
U.H.F.	47	668-674	669.25	8.82	7.05	5.82
U.H.F.	48	674-680	675.25	8.74	6.99	5.77
U.H.F.	49	680-686	681.25	8.66	6.93	5.71
U.H.F.	50	686-692	687.25	8.59	6.87	5.66
U.H.F.	51	692-698	693.25	8.51	6.81	5.62
U.H.F.	52	698-704	699.25	8.44	6.75	5.57
U.H.F.	53	704-710	705.25	8.37	6.69	5.52
U.H.F.	54	710-716	711.25	8.30	6.64	5.47
U.H.F.	55	716-722	717.25	8.23	6.58	5.43
U.H.F.	56	722-728	723.25	8.16	6.53	5.30
U.H.F.	57	728-734	729.25	8.09	6.47	5.34
U.H.F.	58	734-740	735.25	8.02	6.42	5.29
U.H.F.	59	740-746	741.25	7.96	6.36	5.25
U.H.F.	60	746-752	747.25	7.90	6.32	5.21
U.H.F.	61	752-758	753.25	7.83	6.27	5.17
U.H.F.	62	758-764	759.25	7.77	6.22	5.13
U.H.F.	63	764-770	765.25	7.71	6.17	5.09
U.H.F.	64	770-776	771.25	7.65	6.12	5.05
U.H.F.	65	776-782	777.25	7.59	6.07	5.01
U.H.F.	66	782-788	783.25	7.53	6.03	4.97
U.H.F.	67	788-794	789.25	7.48	5.98	4.93
U.H.F.	68	794-800	795.25	7.42	5.93	4.89
U.H.F.	69	800-806	801.25	7.36	5.89	4.86

TV Channel Frequencies (MHz)

Color carrier appears at a frequency 3.58 MHz above the video carrier.

Converter channel numbering schemes vary. We have provided space for you to record your own system's numbering scheme under "Your Converter."

Channel Labeling Schemes			Headend Type					
		Your	Standard		HRC		IRC/ICC	
NCTA	Standard	Converter	Video	Sound	Video	Sound	Video	Sound
			Sub Band					
T-7			7	11.5				
T-8			13	17.5				
T-9			19	23.5				
T-10			25	29.5				
T-11			31	35.5				
T-12			37	41.5				
T-13			43	47.5				
			VHF Low Band					
2	2		55.25	59.75	54	58.5	55.25	59.75
3	3		61.25	65.75	60	64.5	61.25	65.75
4	4		67.25	71.75	66	70.5	67.25	71.75
5	5		77.25	81.75				
6	6		83.25	87.75				
			FM Band					
					72	76.5	73.25	77.75
					78	82.5	79.25	83.75
					84	88.5	85.25	89.75
95	A-5		91.25	95.75	90	94.5	91.25	95.75
96	A-4		97.25	101.75	96	100.5	97.25	101.75
97	A-3		103.25	107.75	102	106.5	103.25	107.75
98	A-2		109.25	113.75	108	112.5	109.25	113.75
99	A-1		115.25	119.75	114	118.5	115.25	119.75
			VHF Mid-Band					
14	A		121.25	125.75	120	124.5	121.25	125.75
15	B		127.25	131.75	126	130.5	127.25	131.75
16	C		133.25	137.75	132	136.5	133.25	137.75
17	D		139.25	143.75	138	142.5	139.25	143.75
18	E		145.25	149.75	144	148.5	145.25	149.75
19	F		151.25	155.75	150	154.5	151.25	155.75
20	G		157.25	161.75	156	160.5	157.25	161.75
21	H		163.25	167.75	162	166.5	163.25	167.75
22	I		169.25	173.75	168	172.5	169.25	173.75

Continued

TV Channel Frequencies (MHz)

Channel Labeling Schemes			Headend Type					
		Your	Standard		HRC		IRC/ICC	
NCTA	Standard	Converter	Video	Sound	Video	Sound	Video	Sound
			VHF High Band					
7	7		175.25	179.75	174	178.5	175.25	179.75
8	8		181.25	185.75	180	184.5	181.25	181.75
9	9		187.25	191.75	186	190.5	187.25	191.75
10	10		193.25	197.75	192	196.5	193.25	197.75
11	11		199.25	203.75	198	202.5	199.25	203.75
12	12		205.25	209.75	204	208.5	205.25	209.75
13	13		211.25	215.75	210	214.5	211.25	215.75
			VHF Super Band					
23	J		217.25	221.75	216	220.5	217.25	221.75
24	K		223.25	227.75	222	226.5	223.25	227.75
25	L		229.25	233.75	228	232.5	229.25	233.75
26	M		235.25	239.75	234	238.5	235.25	239.75
27	N		241.25	245.75	240	244.5	241.25	245.75
28	O		247.25	251.75	246	250.5	247.25	251.75
29	P		253.25	257.75	252	256.5	253.25	257.75
30	Q		259.25	263.75	258	262.5	259.25	263.75
31	R		265.25	269.75	264	268.5	265.25	269.75
32	S		271.25	275.75	270	274.5	271.25	275.75
33	T		277.25	281.75	276	280.5	277.25	281.75
34	U		283.25	287.75	282	286.5	283.25	287.75
35	V		289.25	293.75	288	292.5	289.25	293.75
36	W		295.25	299.75	294	298.5	295.25	299.75
			Hyper Band					
37	AA		301.25	305.75	300	304.5	301.25	305.75
38	BB		307.25	311.75	306	310.5	307.25	311.75
39	CC		313.25	317.75	312	316.5	313.25	317.75
40	DD		319.25	323.75	318	322.5	319.25	323.75
41	EE		325.25	329.75	324	328.5	325.25	329.75
42	FF		331.25	335.75	330	334.5	331.25	335.75
43	GG		337.25	341.75	336	340.5	337.25	341.75
44	HH		343.25	347.75	342	346.5	343.25	347.75
45	II		349.25	353.75	348	352.5	349.25	353.75
46	JJ		355.25	359.75	354	358.5	355.25	359.75
47	KK		361.25	365.75	360	364.5	361.25	365.75
48	LL		367.25	371.75	366	370.5	367.25	371.75
49	MM		373.25	377.75	372	376.5	373.25	377.75
50	NN		379.25	383.75	378	382.5	379.25	383.75

Continued

TV Channel Frequencies (MHz)

Channel Labeling Schemes			Headend Type					
		Your	Standard		HRC		IRC/ICC	
NCTA	Standard	Converter	Video	Sound	Video	Sound	Video	Sound
Hyper Band (cont'd)								
51	OO		385.25	389.75	384	388.5	385.25	389.75
52	PP		391.25	395.75	390	394.5	391.25	395.75
53	QQ		397.25	401.75	396	400.5	397.25	401.75
54	RR		403.25	407.75	402	406.5	403.25	407.75
55	SS		409.25	413.75	408	412.5	409.25	413.75
56	TT		415.25	419.75	414	418.5	415.25	419.75
57	UU		421.25	425.75	420	424.5	421.25	425.75
58	VV		427.25	431.75	426	430.5	427.25	431.75
59	WW		433.25	437.75	432	436.5	433.25	437.75
60	XX		439.25	443.75	438	442.5	439.25	443.75
61	YY		445.25	449.75	444	448.5	445.25	449.75
62	ZZ		451.25	455.75	450	454.5	451.25	455.75
63			457.25	461.75	456	460.5	457.25	461.75
64			463.25	467.75	462	466.5	463.25	467.75
65			469.25	473.75	468	472.5	469.25	473.75
66			475.25	479.75	474	478.5	475.25	479.75
67			481.25	485.75	480	484.5	481.25	485.75
68			487.25	491.75	486	490.5	487.25	491.75
69			493.25	497.75	492	496.5	493.25	497.75
70			499.25	503.75	498	502.5	499.25	503.75
71			505.25	509.75	504	508.5	505.25	509.75
72			511.25	515.75	510	514.5	511.25	515.75
73			517.25	521.75	516	520.5	517.25	521.75
74			523.25	527.75	522	526.5	523.25	527.75
75			529.25	533.75	528	532.5	529.25	533.75
76			535.25	539.75	534	538.5	535.25	539.75
77			541.25	545.75	540	544.5	541.25	545.75
78			547.25	551.75	546	550.5	547.25	551.75
79			553.25	557.75	552	556.5	553.25	557.75
80			559.25	563.75	558	562.5	559.25	563.75
81			565.25	569.75	564	568.5	565.25	569.75
82			571.25	575.75	570	574.5	571.25	575.75
83			577.25	581.75	576	580.5	577.25	581.75
84			583.25	587.75	582	586.5	583.25	587.75
85			589.25	593.75	588	592.5	589.25	593.75
86			595.25	599.75	594	598.5	595.25	599.75
87			601.25	605.75	600	604.5	601.25	605.75

CONIFER®

Technical Bulletin #201

Power Conversion Chart

Frequently when working with several types of equipment it is necessary to convert from one form of power measurement to another. The accompanying chart will make these conversions easier.

Power dbm	Power Watts	Microvolts 50 Ohms	Microvolts 75 Ohms	Power dbmv
−108.75	13.33 fw	0.82	1.00	−60
−107.75	16.78 fw	0.92	1.12	−59
−106.75	21.13 fw	1.03	1.26	−58
−105.75	26.60 fw	1.15	1.41	−57
−104.75	33.49 fw	1.29	1.58	−56
−103.75	42.16 fw	1.45	1.78	−55
−102.75	53.08 fw	1.63	2.00	−54
−101.75	66.82 fw	1.83	2.24	−53
−100.75	84.12 fw	2.05	2.51	−52
−99.75	105.90 fw	2.30	2.82	−51
−98.75	133.32 fw	2.58	3.16	−50
−97.75	167.84 fw	2.90	3.55	−49
−96.75	211.30 fw	3.25	3.98	−48
−95.75	266.01 fw	3.65	4.47	−47
−94.75	334.89 fw	4.09	5.01	−46
−93.75	421.60 fw	4.59	5.62	−45
−92.75	530.76 fw	5.15	6.31	−44
−91.75	668.19 fw	5.78	7.08	−43
−90.75	841.20 fw	6.49	7.94	−42
−89.75	1.06 pw	7.28	8.91	−41
−88.75	1.33 pw	8.16	10.00	−40
−87.75	1.68 pw	9.16	11.22	−39
−86.75	2.11 pw	10.28	12.59	−38
−85.75	2.66 pw	11.53	14.13	−37
−84.75	3.35 pw	12.94	15.85	−36
−83.75	4.22 pw	14.52	17.78	−35
−82.75	5.31 pw	16.29	19.95	−34
−81.75	6.68 pw	18.28	22.39	−33
−80.75	8.41 pw	20.51	25.12	−32
−79.75	10.59 pw	23.01	28.18	−31
−78.75	13.33 pw	25.82	31.62	−30
−77.75	16.78 pw	28.97	35.48	−29
−76.75	21.13 pw	32.50	39.81	−28
−75.75	26.60 pw	36.47	44.67	−27
−74.75	33.49 pw	40.92	50.12	−26
−73.75	42.16 pw	45.91	56.23	−25
−72.75	53.08 pw	51.52	63.10	−24
−71.75	66.82 pw	57.80	70.79	−23
−70.75	84.12 pw	64.85	79.43	−22
−69.75	105.90 pw	72.77	89.13	−21
−68.75	133.32 pw	81.65	100.00	−20
−67.75	167.84 pw	91.61	112.20	−19
−66.75	211.30 pw	102.79	125.89	−18
−65.75	266.01 pw	115.33	141.25	−17
−64.75	334.89 pw	129.40	158.49	−16
−63.75	421.60 pw	145.19	177.83	−15
−62.75	530.76 pw	162.91	199.53	−14
−61.75	668.19 pw	182.78	223.87	−13
−60.75	841.20 pw	205.09	251.19	−12
−59.75	1.06 nw	230.11	281.84	−11
−58.75	1.33 nw	258.19	316.23	−10
−57.75	1.68 nw	289.69	354.81	−9
−56.75	2.11 nw	325.04	398.11	−8
−55.75	2.66 nw	364.70	446.68	−7
−54.75	3.35 nw	409.20	501.19	−6
−53.75	4.22 nw	459.13	562.34	−5
−52.75	5.31 nw	515.15	630.96	−4
−51.75	6.68 nw	578.01	707.95	−3
−50.75	8.41 nw	648.54	794.33	−2
−49.75	10.59 nw	727.67	891.25	−1
−48.75	13.33 nw	816.46	1000	0

Power dbm	Power Watts	Microvolts 50 Ohms	Microvolts 75 Ohms	Power dbmv
−48.75	13.33 nw	816.46	1000	0
−47.75	16.78 nw	916.08	1122	1
−46.75	21.13 nw	1028	1259	2
−45.75	26.60 nw	1153	1413	3
−44.75	33.49 nw	1294	1585	4
−43.75	42.16 nw	1452	1778	5
−42.75	53.08 nw	1629	1995	6
−41.75	66.82 nw	1828	2239	7
−40.75	84.12 nw	2051	2512	8
−39.75	105.90 nw	2301	2818	9
−38.75	133.32 nw	2582	3162	10
−37.75	167.84 nw	2897	3548	11
−36.75	211.30 nw	3250	3981	12
−35.75	266.01 nw	3647	4467	13
−34.75	334.89 nw	4092	5012	14
−33.75	421.60 nw	4591	5623	15
−32.75	530.76 nw	5152	6310	16
−31.75	668.19 nw	5780	7079	17
−30.75	841.20 nw	6485	7943	18
−29.75	1.06 uw	7277	8913	19
−28.75	1.33 uw	8165	10000	20
−27.75	1.68 uw	9161	11220	21
−26.75	2.11 uw	10279	12589	22
−25.75	2.66 uw	11533	14125	23
−24.75	3.35 uw	12940	15849	24
−23.75	4.22 uw	14519	17783	25
−22.75	5.31 uw	16291	19953	26
−21.75	6.68 uw	18278	22387	27
−20.75	8.41 uw	20509	25119	28
−19.75	10.59 uw	23011	28184	29
−18.75	13.33 uw	25819	31623	30
−17.75	16.78 uw	28969	35481	31
−16.75	21.13 uw	32504	39811	32
−15.75	26.60 uw	36470	44668	33
−14.75	33.49 uw	40920	50119	34
−13.75	42.16 uw	45913	56234	35
−12.75	53.08 uw	51515	63096	36
−11.75	66.82 uw	57801	70795	37
−10.75	84.12 uw	64854	79433	38
−9.75	105.90 uw	72767	89125	39
−8.75	133.32 uw	81646	100000	40
−7.75	167.84 uw	91608	112202	41
−6.75	211.30 uw	102786	125893	42
−5.75	266.01 uw	115328	141254	43
−4.75	334.89 uw	129400	158489	44
−3.75	421.60 uw	145189	177828	45
−2.75	530.76 uw	162905	199526	46
−1.75	668.19 uw	182783	223872	47
−0.75	841.20 uw	205086	251189	48
0.00	1.00 mw	223607	273873	48.75
0.25	1.06 mw	230110	281838	49
1.25	1.33 mw	258187	316228	50
2.25	1.68 mw	289691	354813	51
3.25	2.11 mw	325039	398107	52
4.25	2.66 mw	364699	446684	53
5.25	3.35 mw	409199	501187	54
6.25	4.22 mw	459129	562341	55
7.25	5.31 mw	515152	630957	56
8.25	6.68 mw	578010	707946	57
9.25	8.41 mw	648537	794328	58
10.25	10.59 mw	727671	891251	59
11.25	13.33 mw	816460	1000000	60

0 dbm = 1 mw across 50 Ohms
0 dbmv = 1000 uv across 75 Ohms
1 femtowatt (fw) = 1 × 10^{-15} Watt
1 picowatt (pw) = 1 × 10^{-12} Watt

1 nanowatt (nw) = 1 × 10^{-9} Watt
1 microwatt (uw) = 1 × 10^{-6} Watt
1 milliwatt (mw) = 1 × 10^{-3} Watt

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Voltage and Power Ratios to Decibels

The basic chart below indicates the number of decibels (dB) corresponding to the listed ratios of voltage or power over the range of −20 to +20 dB. For voltage or power ratios greater than those included in the chart, the ratio can be broken down into a product of two numbers, the value in dB for each found separately, and the two results added. Example: 2,000:1 to dB, express 2,000 as 2×10^3; the number of dB corresponding to a power ratio of 2 is very nearly 3, and the number of dB for a power ratio of 10^3 is 30. Therefore, the power ratio of 2,000:2 is approximately 30 dB + 3 dB −33 dB. In the lower right-hand corner of the chart dB values for voltage and power ratios of integral powers of 10 are given.

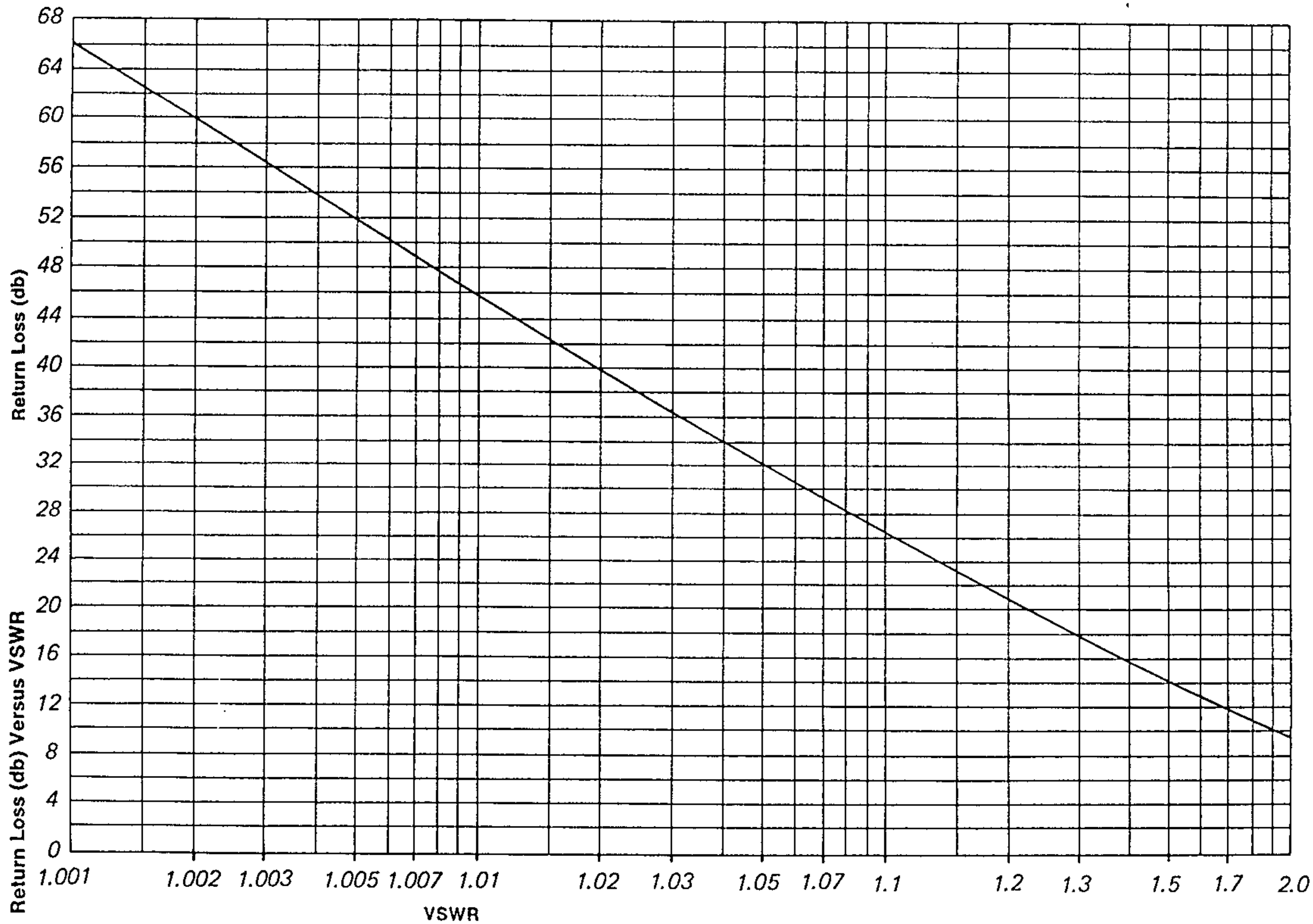
Voltage Ratio	Power Ratio	−dB+	Voltage Ratio	Power Ratio
1.000	1.000	0	1.000	1.000
.989	.977	0.1	1.012	1.023
.977	.955	0.2	1.023	1.047
.966	.933	0.3	1.035	1.072
.955	.912	0.4	1.047	1.096
.944	.891	0.5	1.059	1.122
.933	.871	0.6	1.072	1.148
.923	.851	0.7	1.084	1.175
.912	.832	0.8	1.096	1.202
.902	.813	0.9	1.109	1.230
.891	.794	1.0	1.122	1.259
.881	.776	1.1	1.135	1.288
.871	.759	1.2	1.148	1.318
.861	.741	1.3	1.161	1.349
.851	.724	1.4	1.175	1.380
.841	.708	1.5	1.189	1.413
.832	.692	1.6	1.202	1.445
.822	.676	1.7	1.216	1.479
.813	.661	1.8	1.230	1.514
.804	.646	1.9	1.245	1.549
.794	.631	2.0	1.259	1.585
.785	.617	2.1	1.274	1.622
.776	.603	2.2	1.288	1.660
.767	.589	2.3	1.303	1.698
.759	.575	2.4	1.318	1.738
.750	.562	2.5	1.334	1.778
.741	.550	2.6	1.349	1.820
.733	.537	2.7	1.365	1.862
.724	.525	2.8	1.380	1.905
.716	.513	2.9	1.396	1.950
.708	.501	3.0	1.413	1.995
.700	.490	3.1	1.429	2.042
.692	.479	3.2	1.445	2.089
.684	.468	3.3	1.462	2.138
.676	.457	3.4	1.479	2.188
.668	.447	3.5	1.496	2.239
.661	.437	3.6	1.514	2.291
.653	.427	3.7	1.531	2.344
.646	.417	3.8	1.549	2.399
.638	.407	3.9	1.567	2.455
.631	.398	4.0	1.585	2.512
.624	.389	4.1	1.603	2.570
.617	.380	4.2	1.622	2.630
.610	.372	4.3	1.641	2.692
.603	.363	4.4	1.660	2.754
.596	.355	4.5	1.679	2.818
.589	.347	4.6	1.698	2.884
.582	.339	4.7	1.718	2.951
.575	.331	4.8	1.738	3.020
.569	.324	4.9	1.758	3.090
.562	.316	5.0	1.778	3.162
.556	.309	5.1	1.799	3.236
.550	.302	5.2	1.820	3.311
.543	.295	5.3	1.841	3.388
.537	.288	5.4	1.862	3.467
.531	.282	5.5	1.884	3.548
.525	.275	5.6	1.905	3.631
.519	.269	5.7	1.928	3.715
.513	.263	5.8	1.950	3.802
.507	.257	5.9	1.972	3.890
.501	.251	6.0	1.995	3.981
.496	.246	6.1	2.018	4.074
.490	.240	6.2	2.042	4.169
.484	.234	6.3	2.065	4.266
.479	.229	6.4	2.089	4.365
.473	.224	6.5	2.113	4.467
.468	.219	6.6	2.138	4.571
.462	.214	6.7	2.163	4.677
.457	.209	6.8	2.188	4.786
.452	.204	6.9	2.213	4.898

Voltage Ratio	Power Ratio	dB+	Voltage Ratio	Power Ratio
.447	.200	7.0	2.239	5.012
.442	.195	7.1	2.265	5.129
.437	.191	7.2	2.291	5.248
.432	.186	7.3	2.317	5.370
.427	.182	7.4	2.344	5.495
.422	.178	7.5	2.371	5.623
.417	.174	7.6	2.399	5.754
.412	.170	7.7	2.427	5.888
.407	.166	7.8	2.455	6.026
.403	.162	7.9	2.483	6.166
.398	.159	8.0	2.512	6.310
.394	.155	8.1	2.541	6.457
.389	.151	8.2	2.570	6.607
.385	.148	8.3	2.600	6.761
.380	.145	8.4	2.630	6.918
.376	.141	8.5	2.661	7.079
.372	.138	8.6	2.692	7.244
.367	.135	8.7	2.723	7.413
.363	.132	8.8	2.754	7.586
.359	.129	8.9	2.786	7.762
.355	.126	9.0	2.818	7.943
.351	.123	9.1	2.851	8.128
.347	.120	9.2	2.884	8.318
.343	.118	9.3	2.917	8.511
.339	.115	9.4	2.951	8.710
.335	.112	9.5	2.985	8.913
.331	.110	9.6	3.020	9.120
.327	.107	9.7	3.055	9.333
.324	.105	9.8	3.090	9.550
.320	.102	9.9	3.126	9.772
.316	.100	10.0	3.162	10.00
.313	.0977	10.1	3.199	10.23
.309	.0955	10.2	3.236	10.47
.306	.0933	10.3	3.273	10.72
.302	.0912	10.4	3.311	10.96
.299	.0891	10.5	3.350	11.22
.295	.0871	10.6	3.388	11.48
.292	.0851	10.7	3.428	11.75
.288	.0832	10.8	3.467	12.02
.285	.0813	10.9	3.508	12.30
.282	.0794	11.0	3.548	12.59
.279	.0776	11.1	3.589	12.88
.275	.0759	11.2	3.631	13.18
.272	.0741	11.3	3.673	13.49
.269	.0724	11.4	3.715	13.80
.266	.0708	11.5	3.758	14.13
.263	.0692	11.6	3.802	14.45
.260	.0676	11.7	3.845	14.79
.257	.0661	11.8	3.890	15.14
.254	.0646	11.9	3.936	15.49
.251	.0631	12.0	3.981	15.85
.248	.0617	12.1	4.027	16.22
.246	.0603	12.2	4.074	16.60
.243	.0589	12.3	4.121	16.98
.240	.0575	12.4	4.169	17.38
.237	.0562	12.5	4.217	17.78
.234	.0550	12.6	4.266	18.20
.232	.0537	12.7	4.315	18.62
.229	.0525	12.8	4.365	19.05
.227	.0513	12.9	4.416	19.50
.224	.0501	13.0	4.467	19.95
.221	.0490	13.1	4.519	20.42
.219	.0479	13.2	4.571	20.89
.216	.0468	13.3	4.624	21.38
.214	.0457	13.4	4.677	21.88
.211	.0447	13.5	4.732	22.39
.209	.0437	13.6	4.786	22.91
.207	.0427	13.7	4.842	23.44
.204	.0417	13.8	4.898	23.99
.202	.0407	13.9	4.955	24.55

Voltage Ratio	Power Ratio	−dB+	Voltage Ratio	Power Ratio
.200	.0398	14.0	5.012	25.12
.197	.0389	14.1	5.070	25.70
.195	.0380	14.2	5.129	26.30
.193	.0372	14.3	5.188	26.92
.191	.0363	14.4	5.248	27.54
.188	.0355	14.5	5.309	28.18
.186	.0347	14.6	5.370	28.84
.184	.0339	14.7	5.433	29.51
.182	.0331	14.8	5.495	30.20
.180	.0324	14.9	5.559	30.90
.178	.0316	15.0	5.623	31.62
.176	.0309	15.1	5.689	32.36
.174	.0302	15.2	5.754	33.11
.172	.0295	15.3	5.821	33.88
.170	.0288	15.4	5.888	34.67
.168	.0282	15.5	5.957	35.48
.166	.0275	15.6	6.026	36.31
.164	.0269	15.7	6.095	37.15
.162	.0263	15.8	6.166	38.02
.160	.0257	15.9	6.237	38.90
.159	.0251	16.0	6.310	39.81
.157	.0246	16.1	6.383	40.74
.155	.0240	16.2	6.457	41.69
.153	.0234	16.3	6.531	42.66
.151	.0229	16.4	6.607	43.65
.150	.0224	16.5	6.683	44.67
.148	.0219	16.6	6.761	45.71
.146	.0214	16.7	6.839	46.77
.145	.0209	16.8	6.918	47.86
.143	.0204	16.9	6.998	48.98
.141	.0200	17.0	7.079	50.12
.140	.0195	17.1	7.151	51.29
.138	.0191	17.2	7.244	52.48
.137	.0186	17.3	7.328	53.70
.135	.0182	17.4	7.413	54.95
.133	.0178	17.5	7.499	56.23
.132	.0174	17.6	7.586	57.54
.130	.0170	17.7	7.674	58.88
.129	.0166	17.8	7.762	60.26
.127	.0162	17.9	7.852	61.66
.126	.0159	18.0	7.943	63.10
.125	.0155	18.1	8.035	64.57
.123	.0151	18.2	8.128	66.07
.122	.0148	18.3	8.222	67.61
.120	.0145	18.4	8.318	69.18
.119	.0141	18.5	8.414	70.79
.118	.0138	18.6	8.511	72.44
.116	.0135	18.7	8.610	74.13
.115	.0132	18.8	8.710	75.86
.114	.0129	18.9	8.811	77.62
.112	.0126	19.0	8.913	79.43
.111	.0123	19.1	9.016	81.28
.110	.0120	19.2	9.120	83.18
.108	.0118	19.3	9.226	85.11
.107	.0115	19.4	9.333	87.10
.106	.0112	19.5	9.441	89.13
.105	.0110	19.6	9.550	91.20
.104	.0107	19.7	9.661	93.33
.102	.0105	19.8	9.772	95.50
.101	.0102	19.9	9.886	97.72
.100	.0100	20.0	10.000	100.00
	10^{-3}	30		10^{3}
10^{-2}	10^{-4}	40	10^{2}	10^{4}
	10^{-5}	50		10^{5}
10^{-3}	10^{-6}	60	10^{3}	10^{6}
	10^{-7}	70		10^{7}
10^{-4}	10^{-8}	80	10^{4}	10^{8}
	10^{-9}	90		10^{9}
10^{-5}	10^{-10}	100	10^{5}	10^{10}
	10^{-11}	110		10^{11}
10^{-6}	10^{-12}	120	10^{6}	10^{12}

dBm—DBW—Powers of 10 and Prefixes Expressed in Watts

dBm	dBW	Watts Whole Number or Decimal Number	Multiple or Submultiple	Prefix
+150	+120	1,000,000,000,000	10^{12}	1 Terawatt
+140	+110	100,000,000,000	10^{11}	100 Gigawatts
+130	+100	10,000,000,000	10^{10}	10 Gigawatts
+120	+90	1,000,000,000	10^{9}	1 Gigawatt
+110	+80	100,000,000	10^{8}	100 Megawatts
+100	+70	10,000,000	10^{7}	10 Megawatts
+90	+60	1,000,000	10^{6}	1 Megawatt
+80	+50	100,000	10^{5}	100 Kilowatts
+70	+40	10,000	10^{4}	10 Kilowatts
+60	+30	1,000	10^{3}	1 Kilowatt
+50	+20	100	10^{2}	1 Hectrowatt (100 w)
+40	+10	10	10^{1}	1 Decawatt (10 w)
+30	0	1	10^{0}	1 Watt
+20	−10	0.1	10^{-1}	1 Deciwatt (100 mw)
+10	−20	0.01	10^{-2}	1 Centiwatt (10 mw)
0	−30	0.001	10^{-3}	1 Milliwatt
−10	−40	0.0,001	10^{-4}	100 Microwatts
−20	−50	0.00,001	10^{-5}	10 Microwatts
−30	−60	0.000,001	10^{-6}	1 Microwatt
−40	−70	0.0,000,001	10^{-7}	100 Nanowatts
−50	−80	0.00,000,001	10^{-8}	10 Nanowatts
−60	−90	0.000,000,001	10^{-9}	1 Nanowatt
−70	−100	0.0,000,000,001	10^{-10}	100 Picowatts
−80	−110	0.00,000,000,001	10^{-11}	10 Picowatts
−90	−120	0.000,000,000,001	10^{-12}	1 Picowatt



Return Loss (db) Versus VSWR

Temperature

$32 + \frac{9}{5}\,°C = °F$ $\qquad$ $\frac{5}{9}(°F - 32) = °C$

°C	°F	°C	°F
−50	−58	125	257
−45	−49	130	266
−40	−40	135	275
−35	−31	140	284
−30	−22	145	293
−25	−13	150	302
−20	−4	155	311
−15	5	160	320
−10	14	165	329
−5	23	170	338
0	32	175	347
5	41	180	356
10	50	185	365
15	59	190	374
20	68	195	383
25	77	200	392
30	86	205	401
35	95	210	410
40	104	215	419
45	113	220	428
50	122	225	437
55	131	230	446
60	140	235	455
65	149	240	464
70	158	245	473
75	167	250	482
80	176	255	491
85	185	260	500
90	194	265	509
95	203	270	518
100	212	275	527
105	221	280	536
110	230	285	545
115	239	290	554
120	248	295	563
		300	572

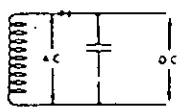
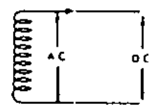
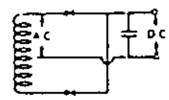
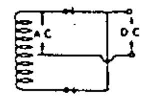
Fractions of an Inch to Decimal and Millimeter

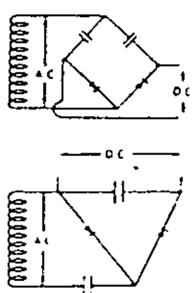
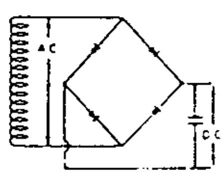
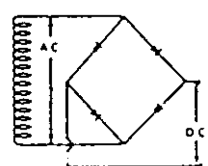
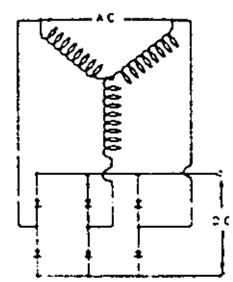
1 Inch = 25.4 mm

Inch	Decimal Inch	Millimeter	Inch	Decimal Inch	Millimeter
1/64	0.0156	0.397	33/64	0.5156	13.097
1/32	0.0313	0.794	17/32	0.5313	13.494
3/64	0.0469	1.191	35/64	0.5469	13.891
1/16	0.0625	1.588	9/16	0.5625	14.288
5/64	0.0781	1.984	37/64	0.5781	14.684
3/32	0.0938	2.381	19/32	0.5938	15.081
7/64	0.1094	2.778	39/64	0.6094	15.478
1/8	0.1250	3.175	5/8	0.6250	15.875
9/64	0.1406	3.572	41/64	0.6406	16.272
5/32	0.1563	3.969	21/32	0.6563	16.689
11/64	0.1719	4.366	43/64	0.6719	17.066
3/16	0.1875	4.763	11/16	0.6875	17.463
13/64	0.2031	5.159	45/64	0.7031	17.859
7/32	0.2188	5.556	23/32	0.7188	18.256
15/64	0.2344	5.953	47/64	0.7344	18.653
1/4	0.2500	6.350	3/4	0.7500	19.050
17/64	0.2656	6.747	49/64	0.7656	19.447
9/32	0.2813	7.144	25/32	0.7813	19.844
19/64	0.2969	7.541	51/64	0.7969	20.241
5/16	0.3125	7.938	13/16	0.8125	20.638
21/64	0.3281	8.334	53/64	0.8281	21.034
11/32	0.3438	8.731	27/32	0.8438	21.431
23/64	0.3594	9.128	55/64	0.8594	21.828
3/8	0.3750	9.525	7/8	0.8750	22.225
25/64	0.3906	9.922	57/64	0.8906	22.622
13/32	0.4063	10.319	29/32	0.9063	23.019
27/64	0.4219	10.716	59/64	0.9219	23.416
7/16	0.4375	11.113	15/16	0.9375	23.813
29/64	0.4531	11.509	61/64	0.9531	24.209
15/32	0.4688	11.906	31/32	0.9688	24.606
31/64	0.4844	12.303	63/64	0.9844	25.003
1/2	0.5000	12.700	1	1.0000	25.400

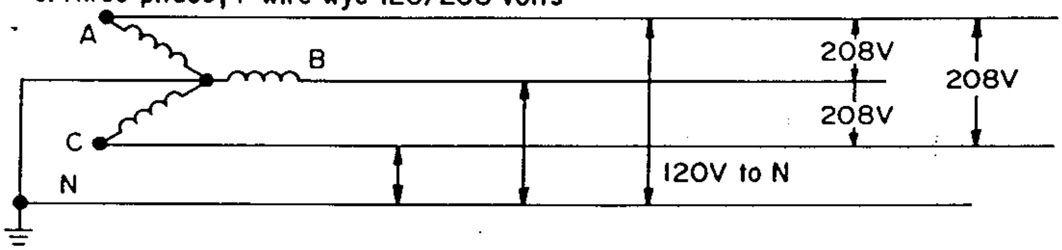
Inch and Millimeter

Inch	0	1/8	1/4	3/8	1/2	5/8	3/4	7/8	Inch
0	0.0	3.18	6.35	9.52	12.70	15.88	19.05	22.22	0
1	25.40	28.58	31.75	34.92	38.10	41.28	44.45	47.62	1
2	50.80	53.98	57.15	60.32	63.50	66.68	69.85	73.02	2
3	76.20	79.38	82.55	85.72	88.90	92.08	95.25	98.42	3
4	101.6	104.8	108.0	111.1	114.3	117.5	120.6	123.8	4
5	127.0	130.2	133.4	136.5	139.7	142.9	146.0	149.2	5
6	152.4	155.6	158.8	161.9	165.1	168.3	171.4	174.6	6
7	177.8	181.0	184.2	187.3	190.5	193.7	196.8	200.0	7
8	203.2	206.4	209.6	212.7	215.9	219.1	222.2	225.4	8
9	228.6	231.8	235.0	238.1	241.3	244.5	247.6	250.8	9
10	254.0	257.2	260.4	263.5	266.7	269.9	273.0	276.2	10
11	279	283	286	289	292	295	298	302	11
12	305	308	311	314	317	321	324	327	12
13	330	333	337	340	343	346	349	352	13
14	356	359	362	365	368	371	375	378	14
15	381	384	387	391	394	397	400	403	15
16	406	410	413	416	419	422	425	429	16
17	432	435	438	441	445	448	451	454	17
18	457	460	464	467	470	473	476	479	18
19	483	486	489	492	495	498	502	505	19
20	508	511	514	518	521	524	527	530	20
Inch	0	1/8	1/4	3/8	1/2	5/8	3/4	7/8	Inch

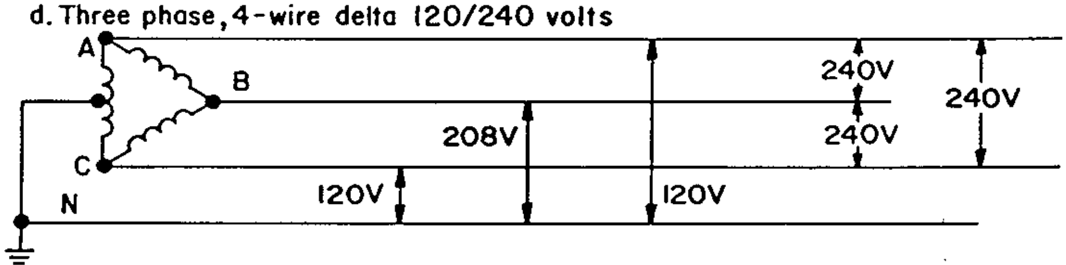
CIRCUIT		SINGLE PHASE HALF WAVE		SINGLE PHASE CENTER TAP	
SCHEMATIC		 CAPACITIVE LOAD	 RESISTIVE INDUCTIVE LOAD	 CAPACITIVE LOAD	 RESISTIVE INDUCTIVE LOAD
A.C. INPUT VOLTAGE	PEAK	1.0 x DC	3.14 x DC	1.0 x DC	1.57 x DC
	RMS	0.7 x DC	2.22 x DC	0.7 x DC	1.11 x DC
ACTUAL P.I.V.		2.0 x DC	3.14 x DC	2.0 x DC	3.14 x DC

CIRCUIT		SINGLE PHASE DOUBLER	SINGLE PHASE FULL WAVE BRIDGE		THREE PHASE FULL WAVE BRIDGE
SCHEMATIC			 CAPACITIVE LOAD	 RESISTIVE INDUCTIVE LOAD	
A.C. INPUT VOLTAGE	PEAK	0.5 x DC	1.0 x DC	1.57 x DC	1.05 x DC
	RMS	0.35 x DC	0.7 x DC	1.11 x DC	.735 x DC
ACTUAL P.I.V.		1.0 x DC	1.0 x DC	1.57 x DC	1.05 x DC

c. Three phase, 4-wire wye 120/208 volts

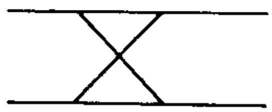


d. Three phase, 4-wire delta 120/240 volts

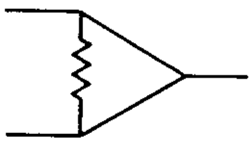


AC DISTRIBUTION - 600 VOLTS OR LESS

DIRECTIONAL COUPLER

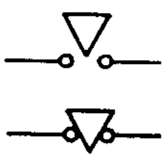


POWER DIVIDER



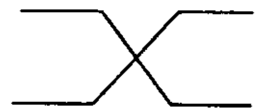
PRESSURE ACTUATED SWITCH

SAFETY INTERLOCK SWITCH



THERMAL ELEMENT

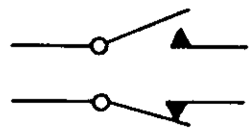
90° HYBRID



BALANCED STRIPLINE

UNBALANCED STRIPLINE

MOMENTARY TOGGLE SWITCH



SURGE ARRESTER