Broadcast Products
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TTU250F

SOLID STATE
250W UHF TRANSMITTER

MDS • MMDS • ITFS • LPTV
North America • South America • Europe • Asia • Australia • Africa
Since 1960

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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SECTION I

THE TTU250F TRANSMITTER

1.1 – Introduction:

The EMCEE TTU250F Transmitter is rated to provide 250W peak visual and 12.5W average aural power on any FCC specified channel extending from 470 to 860MHz. The TTU250F is completely solid-state providing maximum performance and reliability. Comprised of a modulator, a 20 Watt UHF Exciter, one 300W Final Amplifier, and a panel for power distribution and metering, the TTU250F is easy to service and maintain while RF alignment is practically nonexistent. A number of front panel indicators are included which display the results of the transmitter's diagnostic/control circuitry.

The TTU250F is designed for the express purpose of broadcasting as authorized by the U.S. Federal Communications Commission under Part 74, Subpart G, of the FCC Rules and Regulations.

1.2 Specifications:

Output Power	250W peak visual 12.5W average aural
Emissions	5M75C3F visual 250KF3E aural
Color Transmission	NTSC, PAL, or SECAM
Output Frequency Range	470-860MHz (FCC - Ch.14-69) (CCIR - Ch.21-68)
Frequency Stability	Visual Carrier ±1kHz Aural Carrier ±200Hz
Visual Output Power Stability	±0.5dB
Spurious Products	-60dB below peak sync
Harmonics	-60dB below peak sync
In-band Intermodulation (IM_3)	-52dB below peak sync
Differential Gain	5%
Differential Phase	±3°
Visual Frequency Response	±0.5dB
Visual Sideband Response	Better than FCC 73.687(a)(1)

Envelope Delay	Better than FCC 73.687(a)(3)
Output Impedance	50 ohms (7/8" EIA flange connector)
Video Input Level	1 volt peak-to-peak nominal
Video Input Impedance	75 ohms unbalanced (SO239 UHF connector)
Video Signal to Noise	-55dB
Audio Input Level	0dBm nominal
Audio Input Impedance	600 ohms balanced (3-pin Cannon connector)
Audio Distortion	<1%
Aural FM Noise	<-55dB
Ambient Temperature	-30°C to +50°C
Power Requirements	230Vac ± 15% @ 50/60Hz, 1.25kW
Mechanical Dimensions	69"H x 23"W x 29"D
Weight	225 lb.

1.3 Installation:

Except where otherwise noted, the connectors mentioned in the following instructions are located on the rear of the transmitter.

1. After unpacking the transmitter, 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 transmitter in a clean, weatherproof environment providing adequate ventilation for the exhaust fans at the top of the transmitter. It is important to maintain the transmitter's ambient temperature within the -30°C and +50°C limits. Cooler ambient temperatures will provide increased reliability.

3. Place the transmitter in its permanent location near a single-phase receptacle that supplies 230Vac at 50/60Hz. The ac source should have a minimum power capacity of 1.9kW.

IMPORTANT

Do not apply ac power to the transmitter 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 ac line breaker, to the OFF position. Place an appropriate ac power line protector (surge suppressor) across the ac line that supplies the transmitter.

5. Connect the video and audio cables (customer supplied) to the transmitter's VIDEO IN and AUDIO IN connectors.

6. Connect the transmitting antenna cable to the 7/8" EIA flange connector marked RF OUTPUT located at the top, rear, right-hand corner of the cabinet.

7. Verify that the power cords of the Modulator and the Exciter drawer are plugged into the receptacle at the bottom of the transmitter cabinet inside the rear door.

8. Using the 4-prong, twist lock, female plug supplied with the transmitter, fabricate an ac power cord and plug it into the transmitter's AC MAINS connector at the top left rear (as seen facing the front of the cabinet) of the transmitter's cabinet. Connect the other end of the power cord into an appropriate electrical outlet.

1.4 Operation:

Assuming the installation instructions of Section 1.3 have been completed and the transmitter is receiving baseband video and audio signals, proceed with the following steps to place the transmitter in operation. Except where otherwise noted, the controls, switches, and indicators mentioned in these steps are located on the front of the transmitter.

1. Place the modulator's power switch to ON and verify that it provides 87.5% video modulation. If necessary, adjust the modulator for 87.5% video modulation as described in its instruction manual.

2. Turn the Exciter's POWER ADJUST controls fully counterclockwise and place its OPERATE/STANDBY switch to STANDBY, its OPERATE/ALIGN switch to OPERATE, and its POWER circuit breaker to off. Place the Control/Metering Panel's AC POWER circuit breaker and the UHF Exciter POWER ON breaker both to the on/up position. Then verify the following responses of the transmitter.

   a. The fans of the transmitter should be operating. The Exciter exhausts air out the rear of the drawer while the Power Amplifier drawer exhausts air through the cabinet top with the aid of cabinet-mounted exhaust fans.

   b. The Exciter's OPERATE, SYNTH LOCK, and DRIVER AMP indicators should be illuminated green.

c. The Exciter's TEMP EXCITER, ON, FINAL BIAS and VSWR OVLD indicators should be extinguished.

d. The TEMPERATURE, VSWR OVLD and COLLECTOR BIAS indicator of the Power Amplifier should be extinguished.

3. Place the Exciter's OPERATE/STANDBY switch to OPERATE. Then verify the following responses of the transmitter.

   a. The Exciter's OPERATE, SYNTH LOCK and DRIVER AMP indicators should remain illuminated green.

   b. The Exciter's ON and FINAL BIAS indicators should be illuminated green while the VSWR OVLD and TEMP indicators remain extinguished.

   c. The TEMPERATURE indicator of each Power Amplifier drawer should remain extinguished while the COLLECTOR BIAS indicator should be illuminated green.

4. Place the Control/Metering Panel's meter switch to FWD and turn the Exciter's POWER ADJUST control clockwise until a 100% indication appears on the Control/Metering Panel's RF POWER meter. Set the Exciter's % meter to display FWD power. Note that the meter may not show 100%. This is OK.

5. Place the Control/Metering Panel's meter switch to REFLD and verify that its RF POWER meter indicates no more than 10% returned power. If the reflected power is more than 10%, shut down the transmitter and check the VSWR of the transmitting antenna and its associated cable.

6. Place the Control/Metering Panel's meter switch to FWD for constant monitoring of the transmitter's final output power.

The transmitter is now in operation. Check its 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 subsection 3.5) 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 Parts Lists subsection of this manual.
   If a module is required, give the part number (PN) and Schematic Diagram designator (e.g., 10331209).
   Designate the mode of shipping desired (e.g., Air Freight, UPS, Fed Ex, etc.).
   Shipping and billing addresses.

Spare and Replacement Parts – The Spare Modules and Components section of this manual provides a detailed listing of the modules and some discrete components contained within the transmitter. The listing contains those modules or components considered to be essential bench-stock items and should be available to the 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 – The transmitter consists of a modulator, a number of modules and components mounted in eight drawers, a number of components mounted to two panels, and several cabinet-mounted components and modules. Components mounted in a module which is included in a drawer take the drawer number and the module number in addition to a component number. Thus the reference designator A2A1Q1 means transistor Q1 in module A1 of drawer A2. Components mounted in a drawer take only the drawer number and a component number (e.g., A2M1 designates meter M1 of drawer A2). Components mounted directly to a panel take only the panel number and a component number. Components and modules mounted directly to the cabinet take only a component or module number.

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

SECTION II

CIRCUIT DESCRIPTION

SECTION II

CIRCUIT DESCRIPTION

2.1 - Modulator:

EM1, Catel ATM-1600 or Scientific Atlanta 6340 ★ A1

Composite IF OUT	≈-8dBm peak visual

The modulator processes baseband video and audio signals to provide a composite IF output composed of a visual carrier at 45.75MHz with 5M75C3F modulation, and an aural carrier at 41.25MHz with 250KF3E modulation. An EM1, ATM-1600 or SA6340 modulator can be used to drive the Upconverter/Power Amplifier drawer (A2). The optional video sense circuit provides an indication of whether the modulator is receiving a baseband video signal. The output of the video sense is either a logic high (≈+5Vdc), when video is present, or a logic low (≈0Vdc) when video is not present. This logic signal is used by the Exciter Drawer's Control Board (A2PC1) to take the transmitter off the air if the video signal is lost.

2.2 Exciter Drawer:

Interconnection Diagram 40383113/Rev 51 ★ A2 TTU20F

Composite IF IN (J1)	≈-8dBm peak visual
RF OUT (J2)	+43dBm peak visual +33dBm average aural
LO SAMPLE (J3)	+9dBm ± 2dBm

The Exciter drawer converts the composite IF signal from the modulator to the desired UHF channel, then amplifies the RF signal to the desired output level. This drawer is used to drive the 300W Final Amplifier Drawer (A3). The Linearizer provides precorrection to the composite IF signal. Upconversion is performed by the IF Upconverter (A1) along with the UHF Synthesizer (A4). The UHF Synthesizer provides a programmable LO to the Upconverter where the LO and IF signal from the modulator are mixed to create the desired UHF frequency. The Upconverter also provides AGC and precorrector functions. The UHF signal from the Upconverter module is passed through a UHF Bandpass Filter (FL1) to remove the unwanted products from the conversion process while passing the desired signal with a minimal loss. The RF is then amplified approximately 50dB by a 2W driver amplifier (A2) and then amplified another 12dB by a 20W driver amplifier (A3). The output signal is passed through the Metering Coupler (DC1). The Metering Coupler provides samples for the Metering Detector (A5) while passing the signal to the output of the drawer.

Metering and Control functions are provided by the Metering Detector, the Metering Switch (PC2), and the Control Board (PC1). The Control Board also has several status and diagnostic LED indicators. Power is supplied to the drawer by two power supplies, a ±15V/+5V linear supply (PS2) and a +28V switching supply (PS1).

2.2a Linearizer:

Schematic Diagram 30367078/Rev 60 ⋆ A2A6

Gain with S1 OFF (J1-J2)	3dB min./6dB max.
Gain with S1 ON (J1-J2)	6dB min./12dB max.
Emitter of Q1/Q2	+4.8Vdc @ 13mAdc/+13Vdc @ 30mAdc
Emitter of Q3/Q4	+3.3Vdc @ 11mAdc/+15Vdc @ 45mAdc
Emitter of Q5	+8.7Vdc @ 22mAdc

The Linearizer is a five-stage circuit which compensates for linearity distortions generated by the transmitter's Class AB power amplifiers. Transistors Q1 through Q5 are all amplifier stages with the Q1/Q2 combination providing approximately 20dB of gain. 8dB of gain is provided by transistors Q3/Q4. Q2, Q4, and Q5 are used as low impedance emitter followers. Variable gain expansion networks which provide linearity correction are centered around diodes CR1 through CR8, slope potentiometers SL1 through SL4 (i.e., R10, R11, R21, R22), unity gain inverting amplifiers U1 and U2, threshold potentiometers TH1 through TH4 (i.e., R37, R38, R39, R40), and switch S1. When S1 is in the OFF position, each diode pair is continuously reverse biased throughout the positive and negative cycles of the visual IF carrier. Due to the high reverse resistance provided by CR1 through CR8, each network essentially represents a resistive L-pad with the composite IF signal attenuated by a fixed amount. As a result, no linearity correction is provided. However, when S1 is in the ON position and the Linearizer is properly adjusted, the four diode pairs form a nonlinear circuit where each diode pair is biased to turn on at different points of the positive and negative cycles of the visual IF carrier envelope. Each diode pair is initially reverse biased by equal but opposite polarity dc voltages established by U1 and U2. L1 through L8, shunted by R29 through R36, isolate the visual IF carrier from the diode biasing circuitry. When the positive and negative peaks of the visual IF carrier are sufficient to forward bias a diode pair, the diode pair turns on placing the resistance of its respective slope potentiometer either in parallel or in shunt to ground with its respective series arm resistance. As a result of switching additional resistance in parallel or shunt with the series arm of the L-pad, the attenuation of the visual IF carrier is reduced. Threshold potentiometers TH1 through TH4 determine the turn-on point of each diode pair while slope potentiometers SL1 through SL4 vary the amount of gain expansion achieved during the turn-on period of each diode pair. Threshold controls TH1, TH2, and TH3 are used to adjust the differential gain of the white to black region while TH4 adjusts the sync amplitude. When properly adjusted, the Linearizer provides sync amplitude, differential gain, and intermodulation correction to the RF output signal.

2.2b IF/Upconverter:

Schematic Diagram 30383013/Rev 55 ⋆ A2A1

IF INPUT (J1)	-8dBm peak visual
RF OUTPUT (J2)	-13.5dBm minimum
LO SAMPLE (J3)	+9dBm ± 2dB
LO INPUT (J4)	+13dBm minimum

The IF/Upconverter performs three tasks in this transmitter. It provides signal precorrection, AGC level control, and it upconverts the IF signal to the desired UHF channel. This module also provides a sample of the LO signal.

The IF input at J1 is attenuated by AT1, an adjustable attenuator which can be tuned to compensate for different input levels. A monolithic amplifier (U1) provides approximately 12dB of gain to the signal passed through the attenuator. U1 is biased by R1 with L1 providing impedance matching and isolation. C2 is an RF bypass capacitor, while C1 and C3 are coupling capacitors. T1 steps up the signal's voltage to drive the precorrector circuit. The precorrector circuit is made up of CR1, C4 to C6, C8 to C12, R2 through R10, L4, L5, U2, and S1. This circuit compensates for small linearity distortions generated by the wideband power amplifiers or created by the modulator. When switch S1 is in the off position (open), this circuit reduces to a simple attenuator formed by R2 and R3; therefore, no precorrection is provided. When S1 is on, the precorrector becomes a nonlinear circuit that provides less attenuation for the positive and negative peaks of the IF signal, thereby stretching the waveform. CR1 is biased by U2 A and B, with each op amp biasing one half of CR1. The amount of bias provided by U2 is determined by R7 through R10. R9 allows the bias level to be adjusted. This adjustment determines at which point on the waveform precorrection begins. R5, R6, C8 through C11, L4, and L5 provide isolation between CR1 and U2. C4 to C6 are dc blocking capacitors. The precorrector operates by placing R4 in parallel with R2 when the IF signal is positive or negative enough to forward bias half of CR1. Adjusting R4 determines the amount of precorrection provided. At the output of the precorrector, a second monolithic amplifier provides +12dB of gain to the IF signal. C7 and C14 are coupling capacitors while C13 acts as an RF bypass. L2 is an RF choke and R11 provides the correct bias voltage for U3.

The next circuit in the Upconverter is the AGC circuit. Three PIN diodes, CR2, CR3, and CR4, form a voltage controlled attenuator along with R14 and C17. C14, C16, and C18 serve as dc blocking capacitors. Bias is provided to this attenuator by R12, VR1, and R13, as well as R15, L3, and the three operational amplifiers U4(A), U5(A), and U5(B). C15, C32, and C19 are bypasses. The control voltage for the AGC is generated by U5(B). A dc voltage proportional to the output power is connected to pin 6 of U5 by R26. A reference voltage from the Control Board's Power Adjust circuit is supplied to pin 5 of U5 by R22. U5(B) compares these two voltages and provides a control voltage at pin 7 of U5. R27 sets the gain of U5(B) to unity. U5(A) is an integrator that provides a smooth transition for the changing control voltage. Input to U5(A) is provided by R20, with C22 as the integration capacitor. A reference voltage is provided to pin 3 of U5 by R21 and CR5 through CR7. The output of U5(A) is passed through an attenuator formed by R18 and R19 before driving the unity gain buffer amplifier formed by U4(A) R16 and R17. When the OPERATE/ ALIGN switch is in the ALIGN position, pin 3 of U4A is grounded. This defeats the AGC circuit and allows minimum attenuation of the IF signal. Q1, R35-R37 and C33 make up a soft start circuit that retards the spike in output power that normally would occur when the transmitter is turned ON and the OPERATE/STANDBY switch is placed in the OPERATE position. The circuit places approximately +13Vdc on pin 3 of U4A, putting the AGC circuit into a condition of maximum attenuation. As C33 charges, this imposed voltage on pin 3 decreases giving the AGC circuit time to stabilize before Q1 turns off and the output of U5A takes control of the AGC. Whenever +28V switched is removed from the drawer (OFF or STANDBY), CR8 forward biases and C33 discharges through it and R38 to ground. The output of U4(A) is the AGC control voltage.

The IF output of the AGC circuit connects to mixer MX1 where it is mixed with the LO signal from the synthesizer to produce the desired UHF channel frequency at the RF output port, J2. The LO is provided to the mixer by R29 and R30 (which provide isolation) and U7, an amplifier that provides about 12dB of gain to the signal. U7 is biased by R28. A sample of the LO is also supplied to J3 by U6. The input to U6 is provided by the attenuator formed by R31 to R33. U6, biased by R34, provides 12dB of gain. C24 to C27 are coupling capacitors, while all remaining capacitors are RF bypasses.

2.2c UHF Synthesizer:

Schematic Diagram 30367094/Rev A ★ A2A4A1

10MHz REF. IN (J1)	3.5V P/P square wave
LO OUT (J2)	+15.25dBm min. (see Table 2–1 for freq.)
SYNTH. LOCK (Pin A of J4)	logic high (locked) logic low (unlocked)

The UHF Synthesizer is a phase-lock loop type and uses one of the 10MHz reference signals from the Reference Oscillator (A4A2) and develops a programmable LO signal for the Mixer (MX1) in the IF Upconverter (A1). The frequency of the LO signal is calculated as the sum of the visual IF carrier and the visual UHF carrier of the specified output channel. The LO signal's frequency is programmed by the setting of switches S1 through S4 which are accessible through the module's cover via access holes on the right lower side wall of the transmitter drawer. The relationship between the setting of these switches and the resulting LO frequency is provided in Table 2–1 for each UHF channel.

A 10MHz reference signal is brought in from the Reference Oscillator (A2A4A2) through J1, 10MHz IN. Both sections of U4 perform binary divide-by-5 counting to provide a 400kHz signal to the OSC_{in} input of U1, pin 27. To create U1's internal 50kHz reference signal, U1 performs a binary divide-by-8 operation on the OSC_{in} signal.

Controlling the VCO, G1, is the output of op-amp U3. U3 compares and integrates the $\emptyset_V$ and $\emptyset_R$ phase detector outputs of U1. The output of U3 is filtered to create the dc control voltage for the VCO. The output of G1, RF OUT, is amplified by U5 and available as the transmitter's LO at J2, OUT.

The output of G1 is also amplified by U6 and then fed to a ÷64/÷65 prescaler, U2. After prescaling, the signal is connected to U1 pin 1, F_{in}, from U2 pin 4, OUT, completing the loop. The prescaling factor of U2 is selected by the MOD CONTROL, pin 9, of U1. Switches S1 to S4 set two divide-by-ratios, counters A and N, within U1. When divide-by-A is being performed on the signal at F_{in}, MOD CONTROL is set high, selecting ÷64 in the prescaler, U2. MOD CONTROL goes low for divide-by-N selecting ÷65 in U2.

The A and N counters form a binary number from A0 to N9 with A0 being the LSB and N9 being the MSB. The decimal equivalent of this number, when multiplied by the internal reference frequency 50kHz, gives the synthesizer's output frequency. Hence, for NTSC operation, A0 and A1, pins 21 and 23 on U1, are grounded. For PAL operation, A0 and A1 are made high by cutting the traces from pins 21 and 23 to ground thereby adding the 150kHz to the LO that is characteristic of the PAL system.

When the synthesizer is locked onto a frequency, LD is high. This saturates Q1 and puts a low on SYNTH LOCK. C28 provides a time delay to ensure that the synthesizer has successfully locked before indicating so on the SYNTH LOCK line. For an unlocked condition, LD pulses low preventing C28 from charging and saturating Q1. +5V is therefore present on the SYNTH LOCK line for the unlocked condition.

2.2d Reference Oscillator:

Schematic Diagram 10368219/Rev A ⋆ A2A4A2

10MHz REF. OUT (J1, J2)	3.5V P/P square wave

The Reference Oscillator provides a 10MHz reference signal for the UHF Synthesizer (A4A1). This module is centered around a 10MHz temperature-compensated crystal oscillator (G1). The output from G1 is applied to two exclusive-OR gates used as inverting buffers. The output signal from each gate is a 10MHz low-level square wave with a frequency stability of 0.3 parts per million (PPM).

2.2e UHF Bandpass Filter:

Schematic Diagram 10331209/Rev 53 ⋆ A2FL1

1dB Bandwidth (J1-J2)	7MHz
Insertion Loss (J1-J2)	3dB

The UHF Bandpass Filter (FL1) consists of three tunable resonant cavities, with the three tuning capacitors of the filter adjusted to provide the frequency response, shown in Figure 3–5, selecting the appropriate UHF channel. FL1 is tuned to select the desired UHF mixer products from the lower sideband or difference signal found at the RF OUTput (J2) of the IF/Upconverter (A1) module.

2.2f 2W UHF Amplifier:

Schematic Diagram 30367002/Rev A ⋆ A2A2

Gain (J1-J2)	50dB
Power Output	≈+33dBm peak visual
	≈+23dBm average aural
Flatness (J1-J2)	±1dB from 470-860MHz
U1, PIN 3	+3.9Vdc @ 29mA
U2, PIN 3	+5.3Vdc @ 58mA
U3, PIN 4	+20Vdc @ 100mA
Q1, Collector	+25Vdc @ 600mA

The 2W UHF Amplifier (A2) provides amplification to the selected UHF channel. The Amplifier is a four-stage, class A, microstrip design. The first three stages are centered around broadband monolithic amplifiers U1 through U3 which provide a combined gain of 40dB. The fourth stage is an RF transistor amplifier Q1 which provides a gain of approximately 10dB. Q1 is biased by a dc current regulator consisting of Q2, R4, R5, R6, R7, and R9. This circuit continuously maintains the collector voltage and current of Q1 over a wide variation of load and temperature. The required collector voltage and current of Q1 is established by potentiometer R5. Input matching for Q1 is provided by C9, C10, C11, C12, and C24 while output matching is accomplished by C13, C14 and C30. Capacitor C10 is tuned for maximum gain with a flat frequency response from 470 to 860MHz. C1, C3, C5, C8, and C14 provide signal coupling while all other capacitors are used for bypassing. Coils L1 through L4 function as RF chokes while R1 through R3 are used as biasing resistors.

2.2g 20W UHF Amplifier:

Schematic Diagram 40383053/Rev 52 ★ A2A3

Gain (J1-J2)	12dB min.
Power Output	≈+44.5dBm peak visual/ ≈+34.5dBm average aural
Flatness (J1-J2)	±1dB from 470-860MHz
Collector of Q1 & Q2	+26.8Vdc @ 1.2Adc (each side)

The 20W amplifier is a class A, broadband, microstrip design consisting of two RF transistor stages centered around push-pull devices Q1 and Q2. These two stages are connected in parallel via splitter CP1 and combiner CP2. Q1 and Q2 are biased by separate dc current regulators which continuously maintain each collector voltage and current, over a wide variation of temperature and signal level. Each current regulator is made up of PNP transistors Q3 and Q4 working with potentiometers R4 and R11 to provide the required collector voltage and current for each side of Q1 and Q2. CP1 and CP2 are Wireline quadrature 3dB,90° hybrid couplers which split and combine power equally with resistors R5/R12 used to terminate the isolated port of each. The function of R5/R12 is to absorb any imbalance that develops in either hybrid as well as to establish a 50 ohm input/output impedance. Baluns Z1/Z3 transform the unbalanced signal into a balanced input to drive the push-pull transistor pair of Q1/Q2. Baluns Z2/Z4 act in the opposite manner to transform the balanced output from Q1/Q2 into an unbalanced output. Input matching for transistors Q1/Q2 is provided by capacitors C1-3, C32, C65, C76/C18-C21, C66, C77, C80 while output matching is accomplished by capacitors C43, C68-C70, C72, C81/C48, C53-C55, C74, C82. Variable capacitors C79, C32, C80, and C18 are tuned for maximum gain with a flat frequency response. Coils L1 through L8 function as RF chokes while capacitors C1, C2, C20, C21, C68, C69, C54 and C55 are used for signal coupling. All other capacitors are used for bypassing.

Fault Circuit:

The Fault Circuit board (PC3) detects the presence of either an open or shorted RF device in the 20W Driver Amplifier. Under normal operation, the collector voltage on both sides of each push-pull transistor in the 20W Driver Amplifier is typically +26.8Vdc. Under this condition, Q1 through Q3 of the fault circuit are turned on, the diodes identified by pins 1 and 3 in CR2 and CR3 are turned on, the diodes identified by pins 2 and 3 are turned off, and the diodes identified by pins 1/14 and 7/8 of CR1 are turned on while those identified by pins 2/13 and 3/12 are turned off. Hence, for normal operation of each push-pull RF transistor, the FAULT line (pin C of connector J3) is set at a logic low (approximately 0Vdc) by the pull-down resistor (R10) or the Control Board (A2PC1). However, if either side of one of the push-pull transistors opens, its collector voltage rises from +26.8Vdc to about +27.4Vdc. This action results in turning off Q3 and Q2 as well as the diode identified by pins 7 and 8 of CR1. With these components turned off, the diode identified by pins 3 and 12 of CR1 turns on applying a logic high (approximately +4.7Vdc) to the FAULT line. On the other hand, if either side of one of the push-pull transistors shorts, the shorted transistor collector falls from +26.8Vdc to about +0.2Vdc causing the diode identified by pins 2 and 3 of either CR2 or CR3 to turn on. This action results in turning off Q1 and the diode identified by pins 1 and 14 of CR1. With these components turned off, the diode identified by pins 2 and 13 of CR1 turns on applying a logic high to the FAULT line. The information on the FAULT line is processed by the fault monitoring/display section of the Control board (A2PC1).

2.2h Metering Coupler:

Schematic Diagram 10199178/Rev 51 ★ A2DC1

Insertion Loss (J1-J2)	<0.5dB
FWD Coupling (J1-J3)	30dB
REFL Coupling (J1-J4)	30dB

The Metering Coupler is a four-port device designed to provide forward and reflected RF samples to the Metering Detector (A2A5) with minimal loss to the output signal. The RF signal is applied to the coupler's input port (J1) and exits the coupler with a maximum of 0.5dB of loss at J2. A -30dB sample of the signal's forward power is provided at J3, and a -30dB sample of the reflected power is provided at J4. These two signals are connected to the metering detector which then provides DC signals, proportional to the output signal, to the Control Board, AGC circuit, and Metering Switch.

2.2i Metering Detector:

Schematic Diagram 30368024/Rev M ★ A2A5

The Metering Detector contains three circuits for monitoring signal levels. Each of these circuits can take an RF signal at its input and provide a DC voltage at its output proportional to the input signal's strength. Only two of the detector circuits are used in this application. A sample of the output signal is supplied to the Visual port of the detector, and a sample of the reflected power is provided at the Reflected input of the detector. These signals are provided by the Metering Coupler. The front end or detector portion of each circuit is basically the same. Diodes CR2 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 and C11 form the RF ground of the visual power detector. Detection of the sampled reflected signal is the same except for a faster time constant, R22/C6 forms a time constant of 1 millisecond. The positive dc voltages from the visual 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 and the detectors. The settings of potentiometers R9 and R27 determine the voltage level applied to the % POWER meter when the meter switch (A2PC2) is in its FWD or REFL positions, respectively. The aural detector circuit is not used in this transmitter.

A dc voltage proportional to the exciter's output power is available at pin 5 of connector J4, designated VISUAL POWER REFERENCE.

2.2j Control Board:

Schematic Diagram 40383016/Rev 58 ★ A2PC1

The Exciter's Control Board (PC1) is mounted to the inside of the transmitter's front panel. It provides various monitoring and control functions for the transmitter while displaying the results on front panel indicators and the metering display. The circuitry can be divided into three sections:

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

The Interlock section monitors the VIDEO SENSE from the modulator (optional), SYNTH LOCK, 20 WATT TEMP SENSOR, VSWR OVLD, and +28V FINAL AMPL PS TTL level signals and OPERATE/STANDBY switch. When these signals are of the appropriate levels, the OPERATE/STANDBY switch, S1, is set to OPERATE and the POWER circuit breaker is set to ON, the contactor (K1) closes putting the transmitter on line. The FINAL BIAS, ON and SYNTH LOCK indicators are illuminated green and the TEMP EXCITER and VSWR OVLD indicators are unlit when the interlock is closed.

The optional VIDEO SENSE line, J1-3, from the modulator is high when baseband video is present. The SYNTH LOCK line, J1-8, is low when the synthesizer is locked on frequency. This makes the outputs of U1D and U1F high. U1F saturates Q9, illuminating the SYNTH LOCK LED (DS5) green. If video is lost, the VIDEO SENSE line will go low. An unlocked synthesizer puts a high on the SYNTH LOCK line causing the outputs of U1D and U1F to go low and Q9 to cut off, extinguishing DS5. Should either of these situations occur, the output of U3A, which is normally high, will be driven low. Note that the VIDEO SENSE line can be left unconnected and R30 will hold it high so that the transmitter will operate.

The 20 WATT TEMP SENSOR line, J1-7, connects to ground through the thermostat, S1, mounted to the heat sink of the 20 WATT UHF AMPLIFIER, A3. When the temperature of the thermostat is below 150°F, the thermostat is closed. This pulls the 20 WATT TEMP SENSOR line low, driving inverter U1H high and buffer U2H low. Temperatures in excess of 150°F cause the thermostat to open and the 20 WATT TEMP SENSOR lines goes high. This high drives U1H low and U2H high. U2H controls transistor switch Q8. When the output of U2H is low, Q8 is off and the TEMP EXCITER LED, DS4, is unlit. DS4 is illuminated yellow when U2H is high, turning on Q8.

The FINAL AMPL TEMP SENSOR line (J1-24) monitors the temporary (10 second) VSWR OVLD signal from the Main Control Board (PC1). This line is normally low, driving U1B high and reverse biasing CR1. When a VSWR OVLD occurs, a high is present at J1-24 driving U1B low. A low at the output of U1H or U1B forward biases CR1 or CR4, respectively, and places a low on pin 5 of U3B which is normally high.

The VSWR OVLD signal, from the Main Control Board (PC1), is applied to pin J1-5. Under normal operation, with the forward and reflected powers correctly set, this line is low. This turns Q1 off and Q2 on. U4A is set to have a high at $\overline{Q}$, pin 6, and a low at Q, pin 5. The low at pin 5 turns off Q5 and the red VSWR OVLD indicator (DS7). If the reflected power exceeds the reference level set in the Metering Detector (A5), the VSWR OVLD line goes high, turning on Q1 and providing a discharge path for C11. C11, R22, and CR2 provide a quick on/slow off circuit so that a transient does not trigger the VSWR OVLD circuit. When C11 has discharged sufficiently, Q2 will shut off. This causes the CLK input, pin 3, of U4A to go from low to high triggering the flip-flop action of U4A. Q is now high turning on Q5 and the red section of DS7. $\overline{Q}$ is now low and places a low at pin 4 of U3B. The VSWR OVLD line returns to approximately -0.6Vdc when this happens. The momentary VSWR RESET switch (S2) resets U4A by grounding the CLR input, pin 1, when depressed. J1-21, REMOTE VSWR OVLD RESET allows the VSWR overload circuit to be reset from a remote location through the REMOTE MONITOR jack J4.

The output of U3B is normally high. If a low appears at either input of U3B, its output will be driven low.

The output of U3B connects to one input of U3D. The output of U3A connects to the other input of U3D through the OPERATE/STANDBY switch. Under normal operating conditions, the output of U3D is high. If U3A goes low while S1 is in the OPERATE (closed) position, S1 is in the STANDBY (open) position or U3B goes low, the output of U3D will be pulled low. When U3D is high, Q6 and the green section of the FINAL BIAS indicator (DS6) are on, Q3 is off and the FINAL PS INHIBIT line at J1-4 is floating. If U3D goes low, Q6 and DS6 turn off and Q3 turns on, grounding the FINAL PS INHIBIT line.

The output of U3C is normally high. U3D is connected to one input of U3C. J1-9, RF DRIVE CONTROL is a TTL level signal. Provided at least one Triple Output +28V Power Supply (A5PS1, A6PS1, A7PS1, A8PS1) is on and functioning properly, this line will be high. If not, or if U3D goes low, U3C will go low turning off Q7, Q4 and the ON indicator (DS8). When Q4 turns off, ground is removed from the CONTACTOR CONTROL line, pin J1-11, and it is left floating. This deenergizes the contactor and removes +28V from the IF Upconverter (A1), the 2 Watt UHF Amplifier (A2) and the 20 Watt UHF Amplifier (A3). During normal operation, U3C is high, turning on Q7, Q4 and the green section of DS8, and the CONTACTOR CONTROL line is pulled to ground through Q4. Note, J1-9 cannot be left unconnected or else U3C will never go high.

Once the output of U3C goes low, it will remain in that state until the condition that caused the low at either of U3C's inputs is corrected.

The Amplifier Fault Monitoring/Display section monitors the 20W AMPL FAULT line (J1-13), which is low when the 20 WATT UHF AMPLIFIER (A3) is functioning properly. A fault is represented by a high on the line. For normal operation of the 20 WATT UHF AMPLIFIER, U1E is high, illuminating the green section of the DRIVER AMP indicator (DS1), and U2E is low, bypassing the red section of DS1. For a fault, the opposite occurs. U1E goes low extinguishing the green section of DS1 and U2E goes high illuminating the red section of DS1.

There are three Miscellaneous Control/Display circuits. The POWER ADJUST potentiometer, accessible through the front panel, sends a DC voltage to the AGC circuit in the IF Upconverter (A1) to control the output level. The OPERATE/ALIGN switch switches in and out the AGC circuit. In the ALIGN position, J1-23 is grounded and the OPERATE indicator (DS9) is unlit. DS9 is illuminated green and the OP/ALIGN line is an open circuit on the Control Board when the OPERATE/ALIGN switch is in the OPERATE position. The voltage on the METER line (J1-15) is selected by the METERING SWITCH (PC2) which is mounted below the 30-segment LED bar graph metering display on the front panel. Forward power (FWD), reflected power (REFL), +28V or +5V can be chosen. The voltage level is decoded by three voltage level-indicator drivers (U5-U7) and the appropriate number of LEDs are lit on the metering bar graph display (DS10-DS12).

2.2k Power Supplies:

Schematic Diagrams N/A ★ A2PS1, A2PS2

±15V/+5V Power Supply Outputs	±15Vdc @ 400mA maximum +5Vdc @ 2A maximum
+28V Power Supply Output	+28Vdc @ 9A maximum

Two DC power supplies are used in this drawer to provide power to the modules. A +28V supply is used to power the 2 Watt UHF Amplifier (A2) and the 20 Watt UHF Amplifier (A3) while all other modules are powered by a ±15V/+5V supply. The ±15V/+5V unit is a fully regulated, multiple output, linear power supply. The +28V supply is a high efficiency, single output, switching power supply.

2.2l Digital Code ID Unit: (OPTIONAL)

Schematic 20258029 ★ A2PC3

According to FCC Rules and Regulations, Section 74.783, each television broadcast transmitter in the United States of over 1 watt peak visual power must transmit its call sign in International Morse Code every sixty minutes or arrange for the primary station to visually or aurally identify the transmitter and its location. The Digital Code Identification Unit is available for the customer who wishes to identify a transmitter station with Morse Code. The ID unit is a sixteen word by eight bit sequencer which generates a series of pulses used to shift the frequency of the transmitted carriers by frequency shift keying (FSK) the transmitter's Upconverter Oscillator.

The Digital Code ID Unit is composed of four integrated circuits: a Dual Timer (U4), a Dual 4 Bit Counter (U3), a Programmable Read Only Memory (U2) and an 8 to 1 Line Multiplex (U1). The Dual Timer or master clock contains two sections which control the operation of the ID unit by dictating when and at what rate pulses will be fed to the Upconverter oscillator. The first section of the timer is a gated astable oscillator or bit clock which produces square-wave pulses at a rate of approximately 20Hz. The bit rate is controlled by U4 resistors R11, R12 and capacitor C2. The second section of U4 is a 20 minute timer controlled by resistors R9, R10 and capacitor C1. When C1 charges to 63% of its capacity (after 20 minutes), pin 9 of U4 will go low, reverse biasing transistor Q3 which presents a high (4Vdc) at pin 4. This high gates on the bit generator which feeds the 20Hz pulses to pin 1 of the Dual 4 Bit Counter (U3).

As each clock pulse reaches pin 1 of U3, the 4 Bit Counter "counts" the number of pulses entering the chip and displays that count in binary code at its own pins 3, 4 and 5. For example, as the first pulse is fed to U3, pin 3 goes high representing the decimal number 1 in binary code (001). With the second clock pulse, U3 pin 4 goes high and pin 3 goes low representing the binary number 2 (010). This counting process will continue up to the number 7 (111) and, as the eighth pulse is fed to the counter, pins 3, 4, and 5 will all go low (000) to begin the sequence over again. During this time integrated circuit U2, the Programmable Read Only Memory (PROM), has a series of high and low voltages present at its pins 1 through 9 (excluding pin 8 which is ground). These voltages are bits which make up the first word (Morse code letters or numbers) of the transmitter's call sign. (The transmitter's call sign is programmed into the PROM by the EMCEE test department.) In order for this information to be delivered to the Upconverter oscillator, it must be converted from parallel form to serial form by the 8 Line to 1 Line Multiplexer (U1). The binary numbers developed by the Dual 4 Bit Counter are fed to pins 9, 10, and 11 of the 8 to 1 Line Multiplexer. Each binary number (or voltage fluctuation) presented to U1 signals the multiplexer circuit to individually read (take) the parallel bits presented by the PROM and deliver them serially to the oscillator via transistor Q4. Therefore, as the Dual 4 Bit Counter (U3) feeds the binary numbers 1 (001) to pins 9, 10 and 11 of the Line Multiplexer (bit address), the Multiplexer reads the bit at pin 1 of the PROM (U2) and delivers it to the base of transistor Q4. With each subsequent binary number (010, 011, 100, 101, 110, 111, 000) provided by the Dual Counter, the Line Multiplexer will read each individual PROM bit present at U2 pins 2 through 9 (exclude pin 8) until the Dual Counter reaches 111. The next pulse then resets the count to 0 (000). The transition from high to low (1 to 0) at pin 5 of the counter is seen by pin 13, causing pin 11 of U3 to go high. This binary number 1 (0001) seen by pins 10, 11, 12 and 13 (word address) of U2 causes the PROM to present the second set (word) of eight bits to the Line Multiplexer. The Dual Counter (U3 - pins 3, 4, 5) presents another binary eight count to the Line Multiplexer (U1 - pins 9, 10, 11) which individually reads the eight new PROM bits (U2 - pins 1 through 9) and delivers them to transistor Q4. At the end of the second eight count, pin 13 of U3 again sees a high to low transition which causes pin 10 of U3 to go high while pin 11 goes low (binary number 2 = 0010). With U2 pins 10 through 13 receiving a binary number 2, a third word is presented to the Line Multiplexer by the PROM. This entire process occurs so that the PROM delivers sixteen, eight bit words to the Upconverter oscillator via the Line Multiplexer. After word 16, pins 8 through 10 of U3, which were all high (binary number 16 = 1111), drop to zero. The negative going transition at pin 8 of U3 is coupled to transistor Q1 via C3. This action forward biases transistor Q2 which discharges capacitor C1. As the voltage at pin 12 of the Dual Timer drops, pin 9 goes high causing pin 4 of U4 to go low. The Dual Timer's bit clock is gated off, disabling the Digital Code Identification Unit for 20 minutes until capacitor C1 recharges.

2.3 <u>Power Amplifier Drawer</u>:

Interconnection Diagram 30386091/Rev 51 ⋆ A3

VISUAL RF IN (J1)	≈+36.7dBm peak visual
VISUAL RF OUT (J2,)	≈+55.0dBm peak visual
Visual Gain (J1-J2)	16dB min.

The Power Amplifier drawer (A3) is capable of providing approximately 300 watts of peak visual power. The amplifier unit includes a 60W UHF Amplifier pallet (A1), a two-way Splitter (CP1), two 200W UHF Amplifier pallets (A2, A3), and a two-way Combiner (CP2). The Diagnostic/Control circuitry consists of a Current Monitor board (A1PC1) and a 150°F thermostat (A1S1). Power is supplied to each amplifier pallet by a Single Output +28V, 750W Power Supply (PS1). The drawer contains a Status Display board (PC1), which is mounted on the drawer's front panel.

2.3a 300W UHF Amplifier:

Schematic Diagram 30386091/Rev 51 ⋆ A3A1

Gain (J1-J2)	16dB min.
Flatness (J1-J2)	±1dB from 470-860MHz

The 300W UHF Amplifier consists of a 60W UHF Amplifier (A1), a Splitter (CP1), two 200W UHF Amplifiers (A2, A3), a Combiner (CP2), a Circulator (HY1), and a 150°F thermostat (S1). The <u>60W UHF Amplifier</u> and the <u>two 200W UHF Amplifiers</u> are class AB, microstrip designs that provide at least 8dB and 7.5dB of gain, respectively. Each amplifier's gain variation from 470 to 860MHz is typically ±0.75dB. The Splitter and Combiner are both two-section Wilkinson couplers which separately contribute about 0.1dB of insertion loss. The Splitter divides the signal from the 60W UHF Amplifier into two signals of equal amplitude and phase. These two in-phase signals are used to separately drive the two 200W UHF Amplifiers. The Combiner joins the amplified signals to form the output of the drawer. The thermostat monitors the temperature of the 300W UHF Amplifier's heat sink by grounding pin B of A1PC1J2. If the temperature rises above 175°F, the thermostat opens, putting +5V on pin J3-10, which causes the Control Board (PC1) to respond by placing 5V on J3-9, disabling the 28V power supply (PS1). As a result, +28Vdc is removed from the 60W UHF Amplifier and the two 200W UHF Amplifiers while the TEMPERATURE indicator of the Status Display (PC1DS4) illuminates yellow and the COLLECTOR BIAS indicator extinguishes.

2.3b Status Display:

Schematic Diagram 30386093/Rev 51 ⋆ A3PC1

On the Power Amplifier drawer the Status Display board monitors the +28Vdc voltage from the Power Supply (PS1) as well as the status of the thermostat (A1S1). The results are displayed on the COLLECTOR BIAS (DS1) and TEMPERATURE (DS4) indicators. When the transmitter's interlock circuit and the thermostats are closed, the Single Output Power Supply provides +28Vdc to the 300W UHF Amplifier assembly while the DS1 indicator is illuminated green and DS4 is extinguished. When the interlock circuit is opened, the Power Supply is disabled, +28Vdc is removed from each module of the 300W UHF Amplifier, and the DS1 indicator is extinguished while DS4 remains out. However, if the circuit breaker on the Control/Metering panel is in the ON position and the circuit breaker on the Front Panel of the Exciter drawer (A2) is in the OFF position, indicator DS1 will illuminate green. If the thermostat is opened due to high ambient temperature or an amplifier problem, the Power Supply is again disabled. This is indicated by the DS1 indicator being extinguished, and DS4 illuminating yellow. The unused circuitry is for a second 300W UHF Amplifier.

2.3c Single Output +28V Power Supply:

Schematic Diagram N/A ⋆ A3PS1

The Single Output +28V Power Supply provides +28Vdc at up to 750W or 27A for the three amplifier pallets when the transmitter's interlock circuit is closed. The power supply is a high efficiency, switching type, with power factor correction and a remote inhibit line. The supply is energized from the Control Board (PC1), which provides a +5Vdc level to J1-2 of the supply via J3-9 of the amplifier drawers. This occurs only when the transmitter's interlock circuits are closed.

The +28V power supply is not field repairable. If defective, it should be returned to EMCEE for repair or replacement.

2.4 Metering Coupler:

Schematic Diagram N/A ★ DC1

Insertion Loss (J1-J2)	<0.5dB
FWD Coupling (J1-J3)	-45dB
REFLD Coupling (J2-J4)	-45dB

The Directional Coupler is a four-port circuit. The coupler provides samples of the two RF signals which are used by the Metering Detector (A7). These RF signals are a sample of the forward and reflected output power.

2.5 Control/Metering Panel:

Interconnection Diagram N/A ★ A5

Located in the top rack position, the Control/Metering Panel holds the AC POWER circuit breaker, the Metering Detector (A7) and Main Control Board (PC1).

2.5a Metering Detector:

Schematic Diagram 30368024/Rev M ★ A5A7

The Metering Detector contains separate but similar circuitry for monitoring the average forward power and average reflected power at the output of the transmitter. Samples of these two RF signals are supplied by the Directional Coupler mentioned above.

The front end or detector portion of each circuit is basically the same. Diodes CR2 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 and C11 form the RF ground of the visual power detector. Detection of the sampled reflected signal is the same except for a faster time constant, R22/C6 form a time constant of 1 millisecond. The positive dc voltages from the visual 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 meters (A10M1, A10M2) and the detectors. The settings of potentiometers R9 and R27 determine the voltage level applied to the visual % POWER meter when the VISUAL meter switch (A10S1) is in its VISUAL or REFL positions, respectively. The aural power detector is not used in this transmitter.

A dc voltage proportional to the transmitter's visual output power is applied to pin 5 of connector J4, designated VIS PWR REF. This voltage is fed back to the Exciter drawer's Control Board (A2PC1). When the OUTPUT AGC switch (A2S2) is in its ON position, this voltage ultimately controls the attenuation of the visual IF signal so that the transmitter's visual output power is automatically maintained at 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 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 the VSWR OVLD line. This voltage instructs the Control Board (PC1) that a VSWR overload condition has been detected. 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 Control Board that no VSWR overload condition exists.

2.5b Control Board:

Schematic Diagram 40386094/Rev 51 ★ A5PC1

The Control Board provides various monitoring, control and display functions and provides an interface for remote monitoring. The circuitry of this board can be divided into three sections:

(1) VSWR OVLD Monitoring/Interlock Control
(2) 300 Watt UHF Power Amplifier Temperature Fault Monitoring/DC Control
(3) Metering Display

The VSWR OVLD Monitoring/Interlock Control section monitors VSWR OVLD. This circuit is centered around two one-shot multivibrator circuits, U1A and U1B, and a two-bit binary counter formed by flip-flops U2A and U2B. Under normal operating conditions, the VSWR OVLD line (J2-14) is low and Q1 is off, with +5V at its collector. The OUTput of U1A is low, which gets inverted by U10D and buffered by U4A. The high output of U4A is inverted by U10E, placing a low on J1-1, which provides an input to the Control Board of the Exciter (A2PC1). U4D ANDs together the normally low Q outputs, pins 5 and 9, of U2A and U2B producing a low at its output. When the POWER circuit breaker on the Exciter drawer is set to ON, the outputs of U2A and U2B are cleared by turning on Q2 to provide a ground to the active low CLR inputs, pins 1 and 13. Q2 is turned on because the +15V supply rises to +5Vdc before the +5V supply does, producing a negative voltage at the output of U7A. After the +5V supply reaches +5Vdc, +0.3V higher than the inverting input is clamped to, the output of U7A goes high, turning off Q2. The output of U4D is ANDed with the normally low OUTput of U1B. Going to the Exciter drawer on pin J1-19, EXCITER VSWR OVLD, is the normally low output of U4C.

When REFLected power exceeds 10% of the FWD power (or whatever ratio the trip point was set for), J2-14, the VSWR OVLD line from the Metering Detector, is pulled high. This action turns on Q1, grounding the TRIG inputs of U1A and U1B and the CLR input of U2A. The OUTput of U1A goes high for 10 seconds, placing a high on J1-1 and shutting down the transmitter. For 4 1/2 minutes, the OUTput of U1B will be high also. When the transmitter is shut down, there is no output power; therefore, the VSWR OVLD line goes low and turns off Q1. The resulting low to high transition at the collector of Q1 triggers the clock input of U2A, flip-flopping its outputs so that Q is now high. If the reflected power exceeds 10% a second time within four minutes of the first, U1A will again shut the transmitter down for 10 seconds and then bring it back up; U1B will continue to be high and the Q outputs of U2A and U2B will count up one. A third occurrence of a VSWR overload within approximately four minutes of the first will have the same results as the previous occurrence except that, when U1A brings the system back on line, the flip-flop counter will reach binary three; the Q outputs of U2A and U2B will both be high. This causes the output of U4D to go high which, together with the high OUTput of U1B, drives U4C high placing 5V on J1-19.

The 300 Watt UHF Power Amplifier Temperature Monitoring/DC Control section takes the THERMAL MONITOR line from the Power Amplifier as its input. Normally this line (J1-15) is low. The circuit containing U7D and Q3 is identical to the U7A/Q2 circuit in the VSWR OVLD section. When the transmitter is turned on, Q3 turns on, clearing the flip-flop U12A. This sets the output to its normal state, Q is low and $\bar{Q}$ is high. The Q output drives the THERMAL OVLD INDICATOR line. The $\bar{Q}$ output connects to NAND gate U14D. Being normally low, the output of the NAND gate holds its connected transistor (Q4) on so that the DC CONTROL lines are high.

If the Interlock circuit opens, FINAL PS INHIBIT, pin J1-29, will go low, driving U14D high. This will turn off transistor Q4 thereby grounding the DC CONTROL line and shutting off the 300 Watt UHF Power Amplifier's Single Output +28V power supply. The FINAL PS INHIBIT line is normally high and originates on the Exciter's Control Board (A2PC1).

When the power amplifier's heat sink temperature exceeds 150°C, its THERMAL MONITOR line goes high. This triggers the flip-flop (U12A), driving the THERMAL OVLD INDICATOR line high and the NAND gate U14D high, which turns the PNP transistor (Q4) supplying +5V to the amplifier's DC CONTROL line off. 0V on the DC CONTROL line shuts off the amplifier's +28V Power Supply. If the Power Amplifier is shut off in this manner, it will remain off until the MOMENTARY TEMP RESET push-button switch is depressed, which triggers the CLR input on the flip-flop. Also, shutting the entire transmitter down and then turning AC POWER back on will clear the flip-flop.

The Metering Display section consists of three 10-segment LED bar graphs (DS1, DS2 and DS3) and their drivers (U1, J2 and U3). Switch S1 selects whether FORWARD or REFLected RF POWER will be displayed.

2.6 Output Filter:

Schematic Diagram N/A ⋆ FL1

Insertion Loss (J1-J2) <0.5dB

The Output Filter, located in the bottom of the cabinet, is a bandpass, resonant cavity type. This filter is set by the EMCEE test department and is not field serviceable. If it becomes necessary to have the filter tuned, contact the EMCEE Customer Service Department for a return authorization.

UHF SYNTHESIZER PROGRAMMING CHART (NTSC)

Channel	Visual Frequency (MHz)	LO Freq (MHz)	S4	S3	S2	S1
14	471.25	517	0	A	1	9
15	477.25	523	0	A	3	7
16	483.25	529	0	A	5	5
17	489.25	535	0	A	7	3
18	495.25	541	0	A	9	1
19	501.25	547	0	A	A	F
20	507.25	553	0	A	C	D
21	513.25	559	0	A	E	B
22	519.25	565	0	B	0	9
23	525.25	571	0	B	2	7
24	531.25	577	0	B	4	5
25	537.25	583	0	B	6	3
26	543.25	589	0	B	8	1
27	549.25	595	0	B	9	F
28	555.25	601	0	B	B	D
29	561.25	607	0	B	D	B
30	567.25	613	0	B	F	9
31	573.25	619	0	C	1	7
32	579.25	625	0	C	3	5
33	585.25	631	0	C	5	3
34	591.25	637	0	C	7	1
35	597.25	643	0	C	8	F
36	603.25	649	0	C	A	D

Table 2–1

UHF SYNTHESIZER PROGRAMMING CHART (NTSC)

Channel	Visual Frequency (MHz)	LO Freq (MHz)	S4	S3	S2	S1
37	609.25	655	0	C	C	B
38	615.25	661	0	C	E	9
39	621.25	667	0	D	0	7
40	627.25	673	0	D	2	5
41	633.25	679	0	D	4	3
42	639.25	685	0	D	6	1
43	645.25	691	0	D	7	F
44	651.25	697	0	D	9	D
45	657.25	703	0	D	B	B
46	663.25	709	0	D	D	9
47	669.25	715	0	D	F	7
48	675.25	721	0	E	1	5
49	681.25	727	0	E	3	3
50	687.25	733	0	E	5	1
51	693.25	739	0	E	6	F
52	699.25	745	0	E	8	D
53	705.25	751	0	E	A	B
54	711.25	757	0	E	C	9
55	717.25	763	0	E	E	7
56	723.25	769	0	F	0	5
57	729.25	775	0	F	2	3
58	735.25	781	0	F	4	1
59	741.25	787	0	F	5	F

Table 2–1

UHF SYNTHESIZER PROGRAMMING CHART (NTSC)

Channel	Visual Frequency (MHz)	LO Freq (MHz)	S4	S3	S2	S1
60	747.25	793	0	F	7	D
61	753.25	799	0	F	9	B
62	759.25	805	0	F	B	9
63	765.25	811	0	F	D	7
64	771.25	817	0	F	F	5
65	777.25	823	1	0	1	3
66	783.25	829	1	0	3	1
67	789.25	835	1	0	4	F
68	795.25	841	1	0	6	D
69	801.25	847	1	0	8	B

Table 2–1

UHF SYNTHESIZER PROGRAMMING CHART (PAL)

Channel	Visual Frequency (MHz)	LO Freq (MHz)	S4	S3	S2	S1
21	471.25	510.15	0	9	F	6
22	479.25	518.15	0	A	1	E
23	487.25	526.15	0	A	4	6
24	495.25	534.15	0	A	6	E
25	503.25	542.15	0	A	9	6
26	511.25	550.15	0	A	B	E
27	519.25	558.15	0	A	E	6
28	527.25	566.15	0	B	0	E
29	535.25	574.15	0	B	3	6
30	543.25	582.15	0	B	5	E
31	551.25	590.15	0	B	8	6
32	559.25	598.15	0	B	A	E
33	567.25	606.15	0	B	D	6
34	575.25	614.15	0	B	F	E
35	583.25	622.15	0	C	2	6
36	591.25	630.15	0	C	4	E
37	599.25	638.15	0	C	7	6
38	607.25	646.15	0	C	9	E
39	615.25	654.15	0	C	C	6
40	623.25	662.15	0	C	E	E
41	631.25	670.15	0	D	1	6
42	639.25	678.15	0	D	3	E
43	647.25	686.15	0	D	6	6
44	655.25	694.15	0	D	8	E

For PAL operation the grounds to Pins 21 and 23 of U1 (MC145152) must be removed.

Table 2–1

UHF SYNTHESIZER PROGRAMMING CHART (PAL)

Channel	Visual Frequency (MHz)	LO Freq (MHz)	S4	S3	S2	S1
45	663.25	702.15	0	D	B	6
46	671.25	710.15	0	D	D	E
47	679.25	718.15	0	E	0	6
48	687.25	726.15	0	E	2	E
49	695.25	734.15	0	E	5	6
50	703.25	742.15	0	E	7	E
51	711.25	750.15	0	E	A	6
52	719.25	758.15	0	E	C	E
53	727.25	766.15	0	E	F	6
54	735.25	774.15	0	F	1	E
55	743.25	782.15	0	F	4	6
56	751.25	790.15	0	F	6	E
57	759.25	798.15	0	F	9	6
58	767.25	806.15	0	F	B	E
59	775.25	814.15	0	F	E	6
60	783.25	822.15	1	0	0	E
61	791.25	830.15	1	0	3	6
62	799.25	838.15	1	0	5	E
63	807.25	846.15	1	0	8	6
64	815.25	854.15	1	0	A	E
65	823.25	862.15	1	0	D	6
66	831.25	870.15	1	0	F	E
67	839.25	878.15	1	1	2	6
68	847.25	886.15	1	1	4	E

For PAL operation the grounds to Pins 21 and 23 of U1 (MC145152) must be removed.

Table 2–1

SECTION III

MAINTENANCE

SECTION III

MAINTENANCE

3.1 Periodic Maintenance Schedule:

OPERATION	RECOMMENDATION
ALIGNMENT	Upon installation and at one-year intervals thereafter (see subsection 3.4).
OUTPUT POWER CALIBRATION	Same as above (see subsection 3.5).
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	HEWLETT PACKARD	E2378A
Oscilloscope	TEKTRONIX	2232
VHF Sweep Generator	WAVETEK	2001
50 Ohm RF Detector	TELONIC BERKELEY	8553
30dB Attenuator, 20W	NARDA	766-30
10dB Attenuator, 150W	NARDA	769-10
Power Meter	HEWLETT PACKARD	435B
Step Attenuator	KAY	1/432
Frequency Counter	HEWLETT PACKARD	5386A
Spectrum Analyzer	HEWLETT PACKARD	8594E
NTSC Video Generator	TEKTRONIX	TSG100

3.3 Troubleshooting:

If the visual and/or aural output signals from the transmitter appear distorted, noisy or nonexistent, consider the following procedure as a troubleshooting aid. This procedure assumes the transmitter wiring as well as the cabling and connectors are trouble free. It also assumes the modulator is receiving baseband video and audio signals while providing the required visual and aural IF carriers at appropriate levels of -8dBm peak and -21dBm average, respectively. The general problem area will be indicated by simply checking the front panel diagnostic lights as well as the FINAL and EXCITER % POWER meters. The diagnostic indicators are located on the front panels of the UHF Exciter, Control/Metering Panel and Final Amplifier Drawer.

3.3a Final Amplifier Drawer Indicators:

The COLLECTOR BIAS 1 indicator monitors the voltage applied to the 60 watt driver and two 200 watt final amplifier modules within the 300W amplifier unit. If the power supply malfunctions, this normally green indicator will turn off.

The TEMPERATURE indicator monitors the thermostat fixed to the heat sink of the drawer's amplifier portion. If the heat sink temperature exceeds 150°F due to high ambient temperature or because of an amplifier malfunction, the thermostat will open, shutting off the amplifier's power supply and illuminating the yellow TEMPERATURE indicator. Since the 28Vdc power supply is now off, the COLLECTOR BIAS 1 LED has turned off. If any of the above malfunctions occur, the Final Amplifier drawer should be substituted or, depending on the problem's location, the drawer's power supply or amplifier section should be replaced.

3.3b UHF Exciter Drawer Indicators:

Under normal "on the air" operating conditions, the OPERATE/ALIGN and STBY/OPERATE operate switches will be in the OPERATE position, the FINAL BIAS, ON, OPERATE, SYNTH LOCK and DRIVER AMP indicators should be illuminated green and the VSWR OVLD and TEMP EXCITER LEDs should be extinguished.

If the DRIVER AMP LED is lit red, the 20 watt amplifier has failed. Replace the 20 watt amplifier.

The green SYNTH LOCK indicator turns off when the Exciter's frequency synthesizer is not properly locked. Also, the green FINAL BIAS and ON LEDs will turn off. If the problem persists, the synthesizer should be replaced.

The ON LED turning off, and all other LEDs remaining in their normal states, indicates a fault in the +28V power supply, A2PS1. Replace the power supply.

The TEMP EXCITER indicator monitors the thermostat fixed to the heat sink of the drawer's amplifier portion. If the heat sink temperature exceeds 150°F due to high ambient temperature or because of an amplifier malfunction, the thermostat will open, illuminating the yellow TEMP EXCITER indicator. This will also cause the FINAL BIAS and ON LEDs to turn off indicating that the power amplifier has been turned off and +28V has been removed from the Exciter's 2 watt and 20 watt amplifiers, respectively. Replace any faulty modules, ensure that fans are operational and have adequate room to ventilate drawer.

If the FINAL BIAS and ON LEDs are extinguished for 10 seconds and then come back on and all other LEDs remained in their normal states, the system was in a state of temporary VSWR overload. If this happens two more times within a 4 1/2 minute period, the VSWR OVLD indicator will illuminate and the transmitter is placed in a permanent standby mode. This condition is accompanied by FINAL BIAS and ON indicators remaining off, indicating that the power amplifier has been turned off and +28V has been removed from the Exciter's 2 watt and 20 watt amplifiers, respectively. Under this condition, the cause of the VSWR problem at the transmitter's output must be cleared before lifting the VSWR OVLD RESET switch to reactivate the transmitter. If the FINAL BIAS and ON LEDs are extinguished and do not come back on and all other LEDs remained in their normal states, this indicates that video is not being detected at the input of the modulator. Check cabling and ensure that video is being applied. If the problem persists, replace modulator.

The OPERATE indicator will be green if the position of the OPERATE/ALIGN switch is up. This is the appropriate position when the transmitter is on the air. The OPERATE/ALIGN switch should only be in the ALIGN position (down) while performing sweep alignment of the Exciter and 20 watt Driver Amplifier drawer. This switch position sets the AGC for minimum signal attenuation.

3.3c TTU250F Troubleshooting Chart:

The following chart is meant as an aid to uncovering faults that have developed in this transmitter. 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 transmitter, note the state of the indicator LEDs and compare this to the chart.

TTU250F TROUBLESHOOTING CHART

PROBLEM	INDICATORS	CAUSE	SOLUTION
NO OUTPUT POWER	ALL EXCITER DRAWER INDICATORS UNLIT	+5VDC Power Supply faulty or shorted feedthru	Check Meter reading for 5V. Replace power supply if necessary.
	SYNTH LOCK UNLIT ON UNLIT FINAL BIAS UNLIT	Defective Synthesizer	Check synthesizer for correct output level and frequency. Replace if faulty.
	FINAL BIAS UNLIT ON UNLIT	Operate/Standby switch on Standby No video detected at input of modulator Temporary VSWR overload	Place switch to Operate. Check cabling. Replace modulator if faulty. Will come back on after 10 seconds.
	ON UNLIT	+28V Exciter Supply faulty	Replace module.
	DRIVER AMP RED	20 Watt Amplifier faulty	Replace module.
	TEMP EXCITER YELLOW FINAL BIAS UNLIT ON UNLIT	High ambient temperature	Ensure fans are operational and have adequate room to ventilate drawer. If problem persists, check for faulty operation of amplifier and replace if necessary.

TTU250F TROUBLESHOOTING CHART

PROBLEM	INDICATORS	CAUSE	SOLUTION
NO OUTPUT POWER	VSWR OVLD RED	VSWR overload	Check the combiner, transmission line, and antenna for high VSWR. Repair or replace any component with a high VSWR.
	VSWR OVLD RED ON UNLIT FINAL BIAS UNLIT	VSWR overload has occurred.	Clear problem at transmitter's output, then lift the VSWR OVLD RESET switch.
	No fault indicated	Modulator failure Bad cable	Replace modulator. Check cabling between the modulator and transmitter.
NO VISUAL OUTPUT (AURAL OK)	No Fault indicated	Modulator failure Bad cable	Replace modulator. Check all cables along the Visual RF chain. (See Interconnect Diagram and Signal Flow Diagram [Figure 3–2].)
NO AURAL OUTPUT (VISUAL OK)	No Fault indicated	Modulator failure Bad cable	Replace modulator. Check all cables along the Aural RF chain. (See Interconnect Diagram or Signal Flow Diagram [Figure 3–2].)
LOW OUTPUT POWER OR DISTORTED OUTPUT	No Fault indicated	Output Power Calibration is incorrect Modulator malfunction High loss in one of the modules	See Section 3.5. Replace modulator. Test each module for correct gain/loss. See Signal Flow Diagram (Fig. 3–2) for gains/ losses.

TTU250F TROUBLESHOOTING CHART

PROBLEM	INDICATORS	CAUSE	SOLUTION
LOW OUTPUT POWER OR DISTORTED OUTPUT	No Fault indicated.	Precorrector improperly adjusted or not turned on	See Section 3.6.
	TEMPERATURE YELLOW COLLECTOR BIAS UNLIT	Heat sink temperature too high due to high ambient temperature	Ensure fans are operational and have adequate room to ventilate drawer.
		Heat sink temperature too high due to amplifier malfunction	Replace faulty amplifier assembly.
	COLLECTOR BIAS UNLIT	Faulty +28V Power Supply	Replace power supply.
		Power supply exceeded current limit due to malfunctioning Final Amplifier	Replace amplifier assembly.
CONTACTOR CYCLES	28VDC settings on % Meter will cycle	Internal Short (Feedthru or GaAsFET)	Unplug each module and check for a short. Replace module(s) or amplifier assembly as needed.
		Power Supply no good when under a load	Replace Power Supply.

3.4 Alignment:

3.4a Exciter UHF Bandpass Filter:

1. If the transmitter is operating, place the OPERATE/STANDBY switch to STANDBY and place the OPERATE/ALIGN switch to ALIGN. Remove the four screws on the front panel of the Exciter drawer (A2), carefully pull out the drawer, and remove its top cover. Leave the Power Adjust control as it would be for normal operation.

2. Remove the modulator cable attached to the IF INPUT connector (J1) and the RF cable attached to the RF OUT connector (J2). Set up the test equipment as shown in Figure 3–4. Set the VHF sweep generator to sweep from 36 to 50MHz. (Use 45.75MHz and 41.25MHz markers if available.)

3. Place the OPERATE/STANDBY switch to OPERATE. Adjust C1, C2, and C3 on the UHF Bandpass Filter to obtain the frequency response shown in Figure 3–5.

4. If the transmitter's channel is being changed to one that is 40MHz or more from the factory preset, connect a spectrum analyzer to the 20dB attenuator in Figure 3–4 to ensure that the sweep appears on the low side of the LO. Tune the spectrum analyzer to the UHF Synthesizer's LO frequency as shown in Table 2–1, UHF Synthesizer Programming Chart. Program the synthesizer for the new channel and look for the LO carrier on the analyzer. Tune the analyzer 45.75MHz (38.9MHz for PAL B/G) below the LO frequency and tune C1, C2 and C3 of the UHF Bandpass Filter for maximum amplitude of the sweep generator signal on the spectrum analyzer. Replace the analyzer with the sweeper diode detector and adjust the UHF Bandpass Filter for the response of Figure 3–5 as shown on the oscilloscope.

3.4b Notch Filter (Optional in 20 Watt Exciter):

5. Place the Exciter to STANDBY. Disconnect the input cable from the notch filter and connect it directly to the sweep generator's RF output.

6. Place the RF Detector directly on the RF OUTPUT connector (J2) of the transmitter.

7. Tune the sweep generator to the center frequency of the transmitter's output channel employing a 20MHz sweep width display on the oscilloscope.

8. The (flathead) adjustment screws are located in the cavities in the short side of the filter. If they are not marked, slowly adjust one and observe which notch moves on the scope and set accordingly.

   Set the lower notch to (Visual Carrier Frequency - 4.5MHz).
   Set the upper notch to (Aural Carrier Frequency + 4.5MHz).
   The visual carrier frequency for the appropriate UHF channel can be found in Section 4, the Data Pak, or in Table 2–1.

9. Remove the sweeper cable from the filter input and the RF Detector from the drawer output. Replace the Notch Filter input cable, reconnect the modulator cable to the drawer's IF INPUT, and reconnect the RF cable to the Exciter's RF OUTput.

3.5 Output Power Calibration:

To ensure proper transmission, the output power level and % Power Meter calibration should be checked once every year. With the meter switch in the FWD position, the % Power Meter has been factory calibrated for 100% with the transmitter providing 250 watts peak visual and 12.5 watts average aural. The following calibration procedure assumes that the composite signal from the transmitter has the aural carrier 13dB down from the visual with the visual carrier having 87.5% video modulation and 50% average picture level (APL). It is also assumed that the directional coupler has been calibrated.

NOTE: In the following steps, the power levels stated are those expected at the output of the transmitter. Therefore, when measuring these power levels as shown in Figure 3–6, be sure to take into account the 40dB attenuation factor provided by the 10dB and 30dB attenuators.

3.5a Forward Power:

1. With the OPERATE/STANDBY switch on STANDBY, set up the test equipment as shown in Figure 3–6.

2. Verify that the modulator is on and providing 87.5% video modulation and the aural carrier is 13dB down from the visual carrier. With the transmitter POWER ON breaker up, make sure the OPERATE/ALIGN switch is on OPERATE and the Meter Switch is on FWD. Place the OPERATE/STANDBY switch to OPERATE.

3. To set the output power, adjust the POWER ADJUST control for an external power meter reading of 107.5W. Note that 250W peak visual at 50% APL and 87.5% modulation plus 12.5W average aural for a 13:1 peak visual to average aural ratio equals 107.5W.

4. To check or adjust visual to aural ratio, replace the power meter in Figure 3–6 with a spectrum analyzer. Adjust the aural carrier level on the modulator for the desired ratio. Remove the spectrum analyzer and return the power meter to the setup to reset the output power. Set the POWER ADJUST again for an external power meter reading of 95W visual plus the average aural carrier level for the set ratio. Modulators are preset by EMCEE test department.

5. With the external power meter reading correctly, place the meter switch to FWD and check the transmitter's front panel % Power Meter for a 100% indication. If this reading is not obtained, adjust potentiometer R9 of the Metering Detector located behind the Control/ Metering Panel (A5) and accessible through the METER ADJUST hole marked FWD.

3.5b Reflected Power:

6. Through the METER ADJUST access hole marked VSWR OVLD, adjust potentiometer R30 of the Metering Detector fully clockwise to disable the VSWR overload detection circuit. Place the meter switch to REFL.

7. Place the OPERATE/STANDBY switch to STANDBY and the OPERATE/ALIGN switch to ALIGN. Switch the FWD (J3) and REFLD (J4) coupling port cables on the Metering Coupler (DC1). J3 (REFLD) of the Metering Detector (A5A7) should now be connected to J3 (FWD) of the Metering Coupler (DC1). This simulates an open circuit at the transmitter's RF OUTput (J2) delivering maximum returned power to the reflected power detector. Insert a 1dB step attenuator between the modulator and the transmitter's IF INput connector and set the attenuator for 10dB attenuation.

8. Place the OPERATE/STANDBY switch to OPERATE. Remove attenuation from the step attenuator until an external power meter reading of 107.5W is reached. Check the front panel % POWER meter for a 100% reading. If the meter is incorrect, adjust it using potentiometer R27 of the Metering Detector found behind the METER ADJUST hole marked REFL.

9. Decrease the transmitter's power to 10% using the step attenuator (a power meter reading of 10.8W). This power level is used for setting the trip point of the VSWR overload detection circuit. Adjust R30 of the Metering Detector, found through the METER ADJUST access hole marked VSWR OVLD, <u>slowly</u> counterclockwise until the front panel VSWR OVLD indicator illuminates red.

10. Check the VSWR OVLD trip point by adding an additional 1dB of attenuation in the step attenuator. Press the momentary VSWR RESET switch to reactivate the transmitter and remove an additional 1or 2dB of attenuation from the step attenuator. The VSWR OVLD circuit should again trip. If it does not, repeat this section beginning at step #6.

11. Place the OPERATE/STANDBY switch to STANDBY. Return the metering cables, W16 and W17 on the Interconnect Diagram, to their original coupler ports. Place the OPERATE/ ALIGN switch to OPERATE, properly load the transmitter and place the OPERATE/ STANDBY switch to OPERATE.

3.6 <u>Precorrection Adjustment</u>:

Adjustment of the precorrection is accomplished with two potentiometers in the IF Upconverter and eight potentiometers in the Linearizer which <u>should not be realigned unless absolutely necessary</u>. (The IF Upconverter and Linearizer can produce unwanted distortion if adjusted incorrectly.) The test equipment which should be available for readjustment of the precorrector is a spectrum analyzer which provides demodulated video for measurement of sync and intermodulation or a waveform monitor and television demodulator for sync and differential gain measurements. Acquire as much of this test equipment as possible since the precorrection accuracy will depend on equipment versatility. It is assumed that the transmitter's overall frequency response is correct, allowing the unit to operate with maximum efficiency.

1. To the output of the transmitter, connect the test equipment available for monitoring intermodulation, sync amplitude and differential gain.

2. Remove the four screws on the front panel of the 20W Exciter drawer, pull out the drawer, and remove its top cover. Insure switch S1 of the IF Upconverter is in the ON (right) position and S1 of the Linearizer is in the ON position.

3. Place the transmitter in operation with the system providing its rated output. After demodulating video, slowly adjust R9 and R4 of the IF Upconverter and/or R37, R38, R39, R40, R10, R11, R21 and R22 of the Linearizer for 100% horizontal sync.

4. While looking at the spectral waveform, adjust R4 and R9 of the IF Upconverter and/or R10, R11, R21, R22, R37, R38, R39, and R40 of the Linearizer for minimum in-band intermodulation products. This can be accomplished using a modulated ramp video signal and 100kHz resolution bandwidth on the spectrum analyzer.

5. Check and, if necessary, correct the transmitter's output power with the front panel POWER ADJUST.

6. Repeat steps #3 through #5 to find the appropriate trade-off for 100% horizontal sync and minimum in-band intermodulation products.

7. Reinstall the top cover to the 20W Exciter drawer, slide the drawer back into the cabinet, secure it, remove the test equipment, and properly load the transmitter output before reactivation.

3.7 Spare Modules and Components:

The following contains the description, vendor, part number, and designator of each module found in the TTU250F Transmitter which EMCEE considers to be essential bench-stock items. These modules should be available to the technician at all times.

TTU250F
INTERCONNECTION DIAGRAM 40386005 (REV 51)

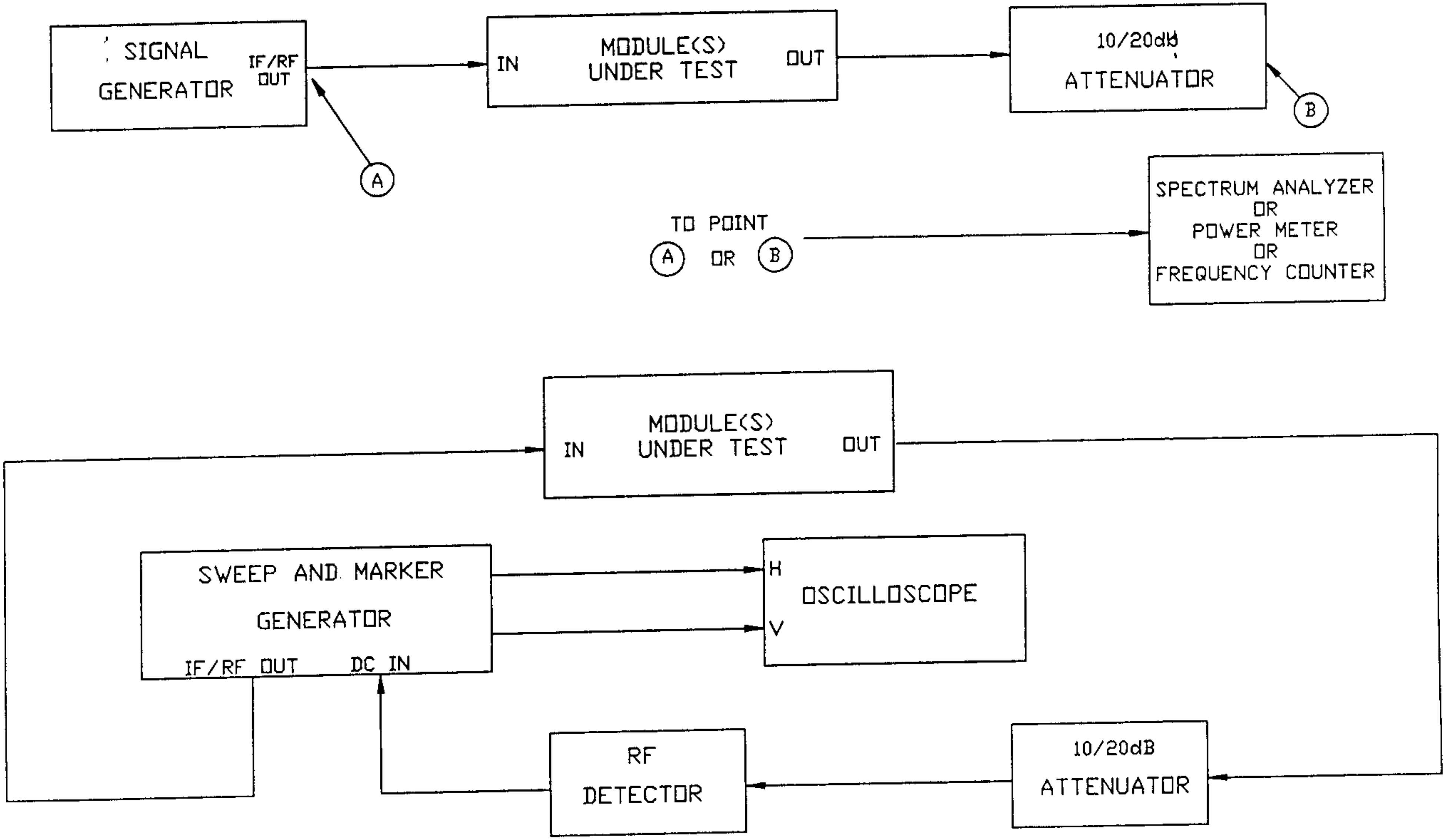
DESCRIPTION	VENDOR/PART #	DESIGNATOR
Fans 10" 560CFM 220Vac	EMCEE/4C829	B1, B2
Control Board	EMCEE/40386095-1	PC1
Metering Detector	EMCEE/60386050-1	A4

300W UHF AMPLIFIER
INTERCONNECTION DIAGRAM 30386091

DESCRIPTION	VENDOR/PART #	DESIGNATOR
Fans 4.5" 106CFM 220Vac	EMCEE/A30135-10	A3B1, A3B2
300W UHF Amplifier	EMCEE/40386007-1	A3A1
Status Display	EMCEE/20386037-2	A3PC1
Single Output +28V Power Supply	TODD/SPF-750-28	A3PS1

TTU20F
INTERCONNECTION DIAGRAM 40383113

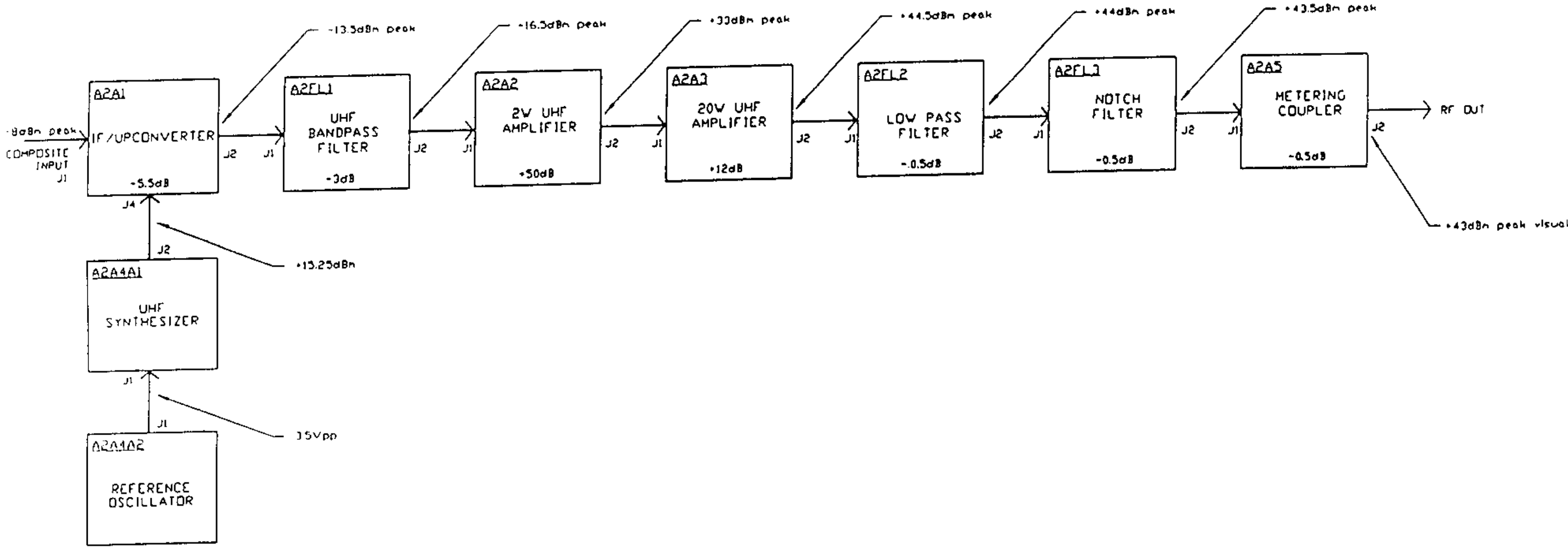
DESCRIPTION	VENDOR/PART #	DESIGNATOR
Linearizer	EMCEE/60367083-1	A2A6
IF Upconverter	EMCEE/70383030-1	A2A1
2 Watt UHF Amplifier	EMCEE/70367080-1	A2A2
20 Watt UHF Amplifier	EMCEE/80383011-1	A2A3
UHF Synthesizer	EMCEE/60367103-1	A2A4A1
Reference Oscillator	EMCEE/60386216-1	A2A4A2
Metering Detector	EMCEE/60386050-1	A2A5
+28V Power Supply	TODD/SC28-9	A2PS1
±15V/+5V Power Supply	Deltron/W300A	A2PS2
Control Board	EMCEE/80383018-1	A2PC1
Contactor	Telemecanique/LP1-EC03	A2K1
Voltage Regulator	Motorola/MC7812CT	A2U1
Fans 4.5" 106CFM 220Vac	EMCEE/A30135-10	A2B1, A2B2



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

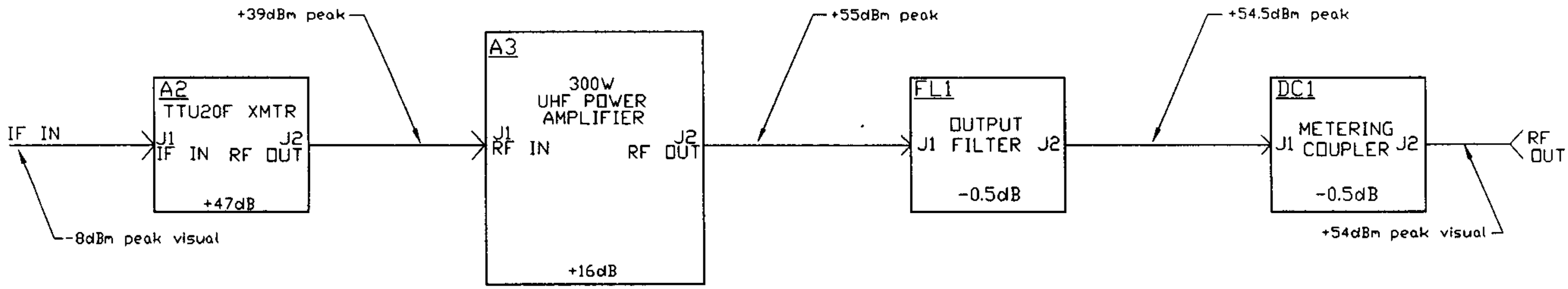
FIGURE 3-1

10129783



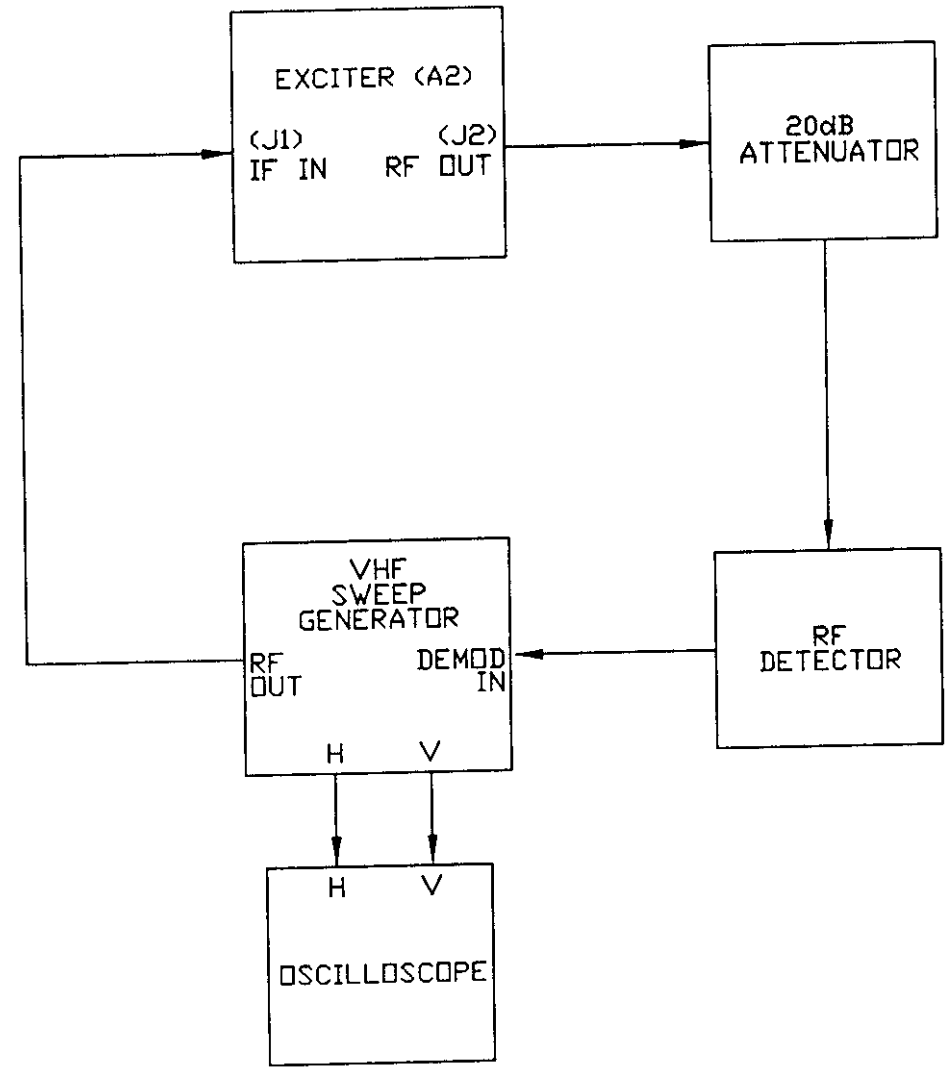
SIGNAL FLOW DIAGRAM OF THE TTU20F UPCONVERTER/POWER AMPLIFIER DRAWER
FIGURE 3-2

00207
6/14/96
D.ESTOCK



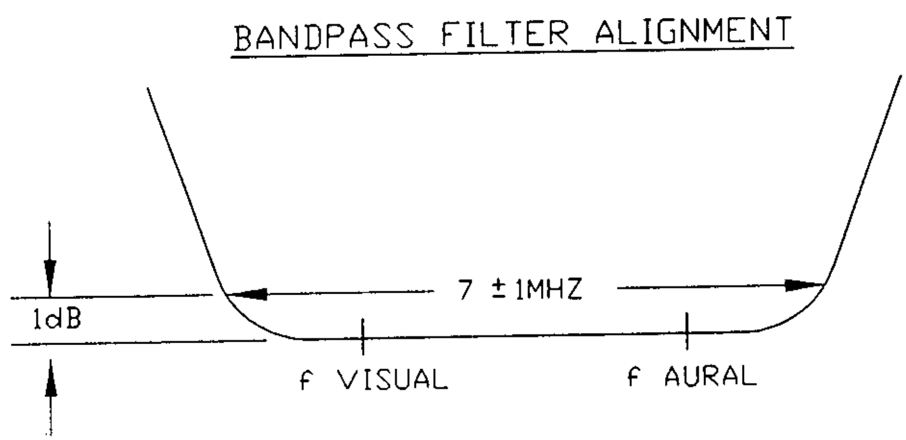
SIGNAL FLOW DIAGRAM OF THE TTU250F TRANSMITTER
FIGURE 3-3

00265

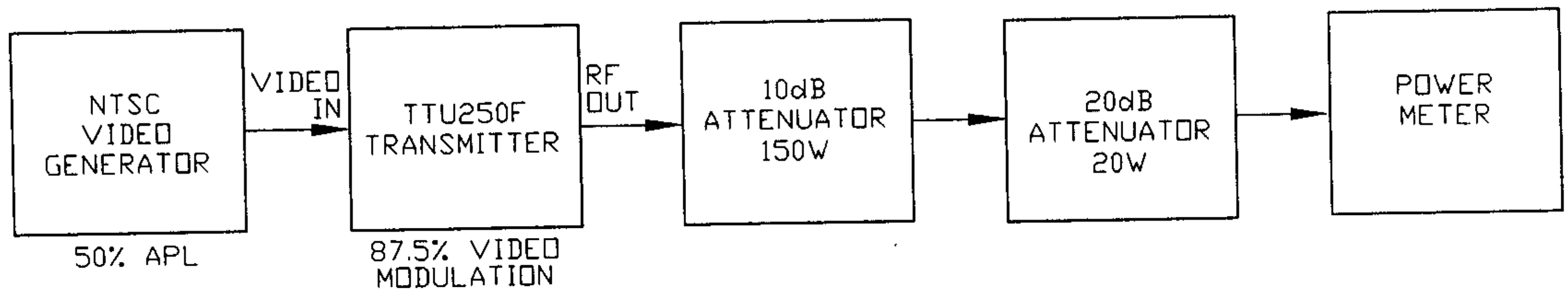


ALIGNMENT OF RF AMPLIFIER CHAIN
FIGURE 3-4

00234



FREQUENCY RESPONSE OF RF AMPLIFIER CHAIN
FIGURE 3-5



OUTPUT POWER CALIBRATION
FIGURE 3-6

00264

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

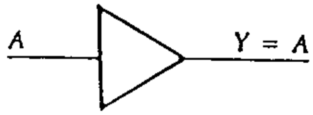
TV Channel Frequencies (MHz)

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

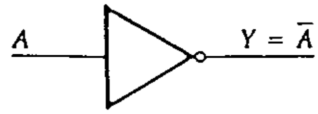
TV Channel Frequencies (MHz)

Channel Labeling Schemes			Headend Type					
			Standard		HRC		IRC/ICC	
NCTA	Standard	Your 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



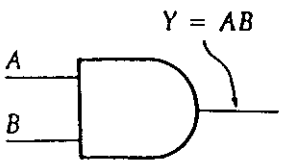
A	Y
0	0
1	1

(a) Buffer



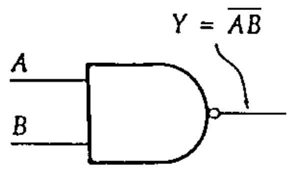
A	Y
0	1
1	0

(b) Inverter



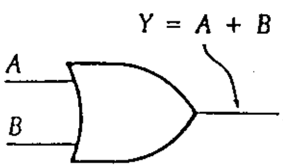
A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

(c) AND



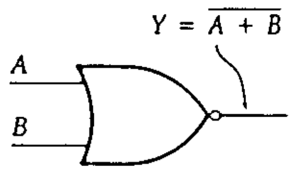
A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

(d) NAND



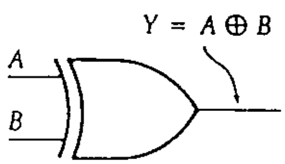
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

(e) OR



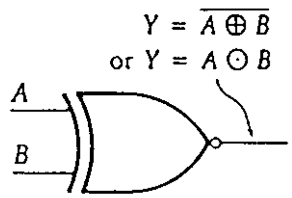
A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

(f) NOR



A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

(g) XOR



A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

(h) XNOR (or equivalence)

		BUFFER	INVERTER	AND	NAND
TTL	—	7417	7404	7408	7400
ECL	—	MC10188	MC10189	MC10104	MC10121
CMOS	—	MM74HC125	MM74HC04	MM74HC08	MM74HC00

		OR	NOR	XOR	XNOR
TTL	—	7432	7402	7486	74266
ELL	—	MC10103	MC10102	MC10113	MC10107
CMOS	—	MM74HC32	MM74HC02	MM74HC86	MM74HC266

Note: This summary is based on positive logic.

CONIFER®

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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

CONIFER CORP • P.O. BOX 1025 • 1400 N. ROOSEVELT • BURLINGTON, IOWA 52601 • (319) 752-3607 (IOWA) • 800-843-5419 • FAX 319-753-5508

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 x 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.

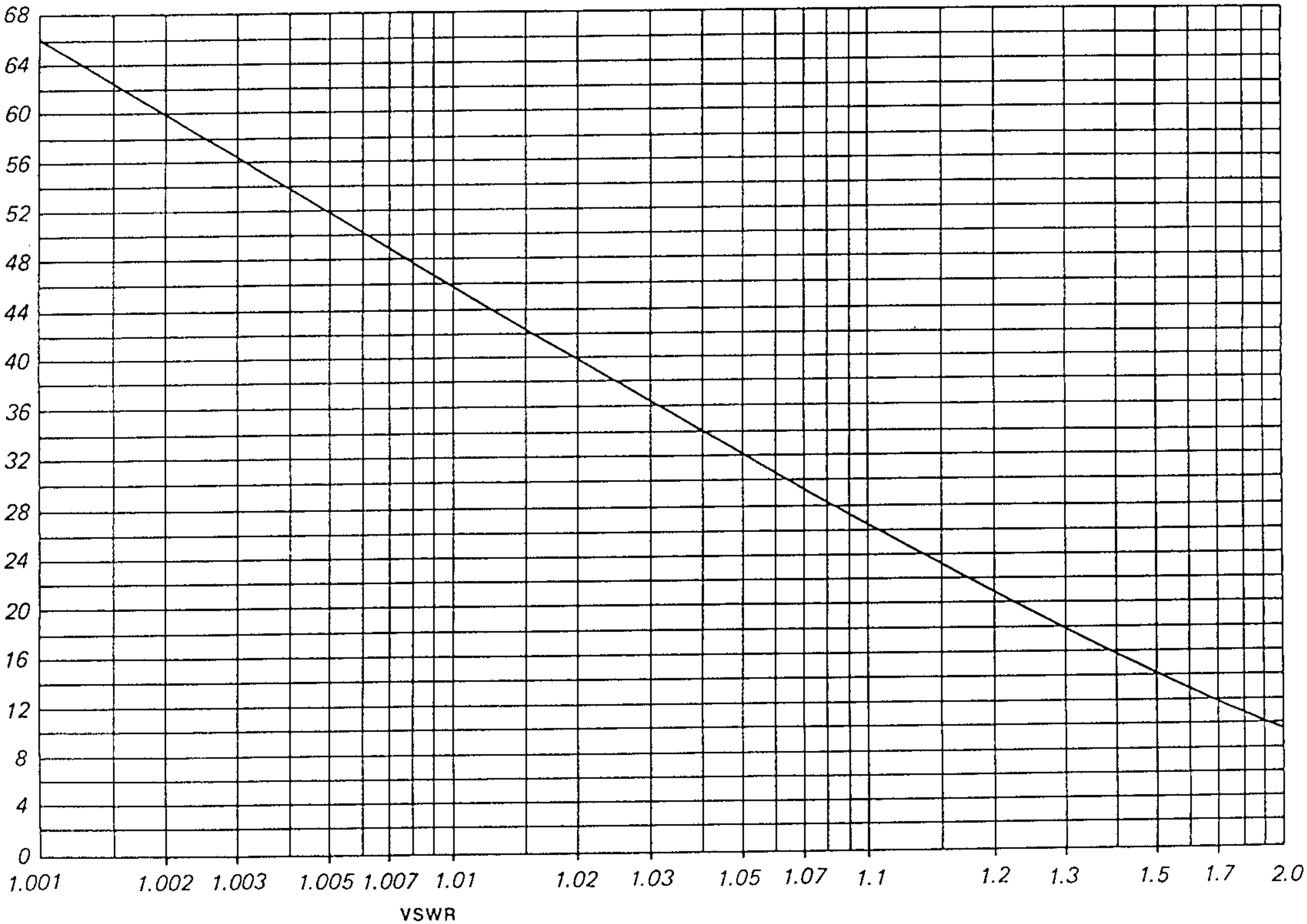
Voltage Ratio	Power Ratio	-dB+	Voltage Ratio	Power Ratio
1.000	1.000	0	1.000	1.000
.989	.977	0.1	1.012	1.023
.977	.955	0.2	1.023	1.047
.966	.933	0.3	1.035	1.072
.955	.912	0.4	1.047	1.096
.944	.891	0.5	1.059	1.122
.933	.871	0.6	1.072	1.148
.923	.851	0.7	1.084	1.175
.912	.832	0.8	1.096	1.202
.902	.813	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

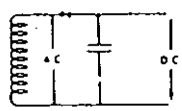
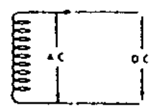
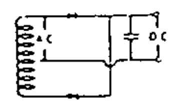
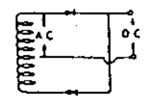
Fractions of an Inch to Decimal and Millimeter

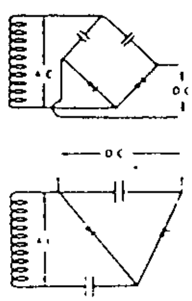
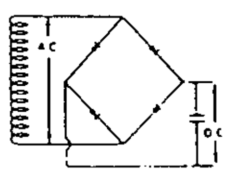
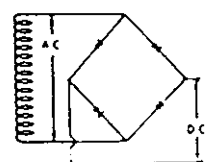
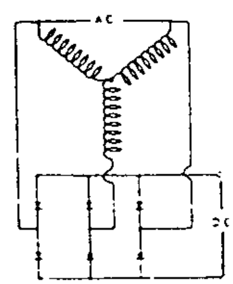
1 Inch = 25.4 mm

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

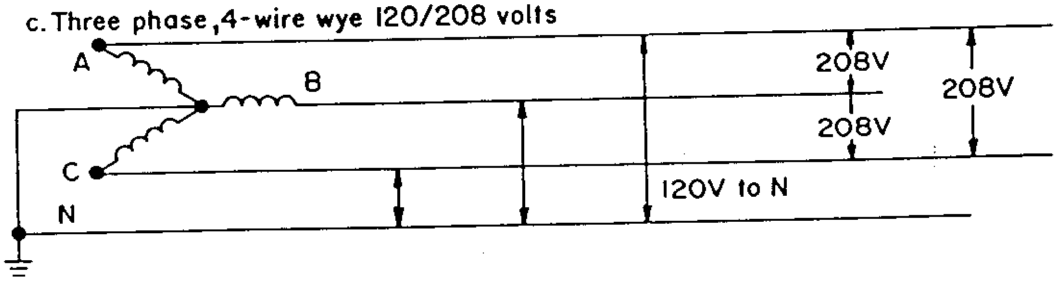
Inch and Millimeter

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

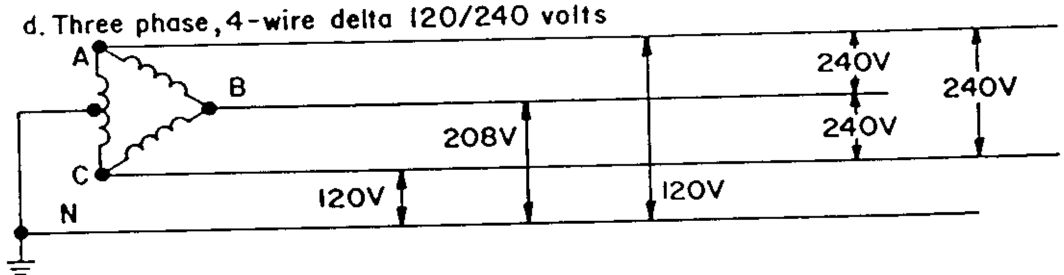
CIRCUIT		SINGLE PHASE HALF WAVE		SINGLE PHASE CENTER TAP	
SCHEMATIC		 CAPACITIVE LOAD	 RESISTIVE INDUCTIVE LOAD	 CAPACITIVE LOAD	 RESISTIVE INDUCTIVE LOAD
A.C. INPUT VOLTAGE	PEAK	1.0 x DC	3.14 x DC	1.0 x DC	1.57 x DC
	RMS	0.7 x DC	2.22 x DC	0.7 x DC	1.11 x DC
ACTUAL P.I.V.		2.0 x DC	3.14 x DC	2.0 x DC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

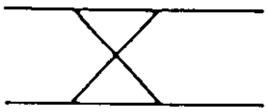


d. Three phase, 4-wire delta 120/240 volts

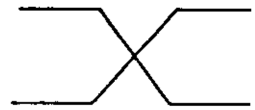


AC DISTRIBUTION - 600 VOLTS OR LESS

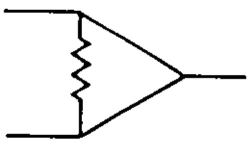
DIRECTIONAL COUPLER



90° HYBRID



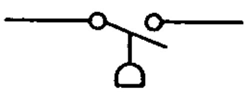
POWER DIVIDER



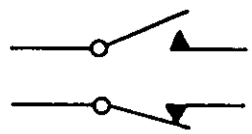
BALANCED STRIPLINE

UNBALANCED STRIPLINE

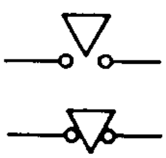
PRESSURE ACTUATED SWITCH



MOMENTARY TOGGLE SWITCH



SAFETY INTERLOCK SWITCH



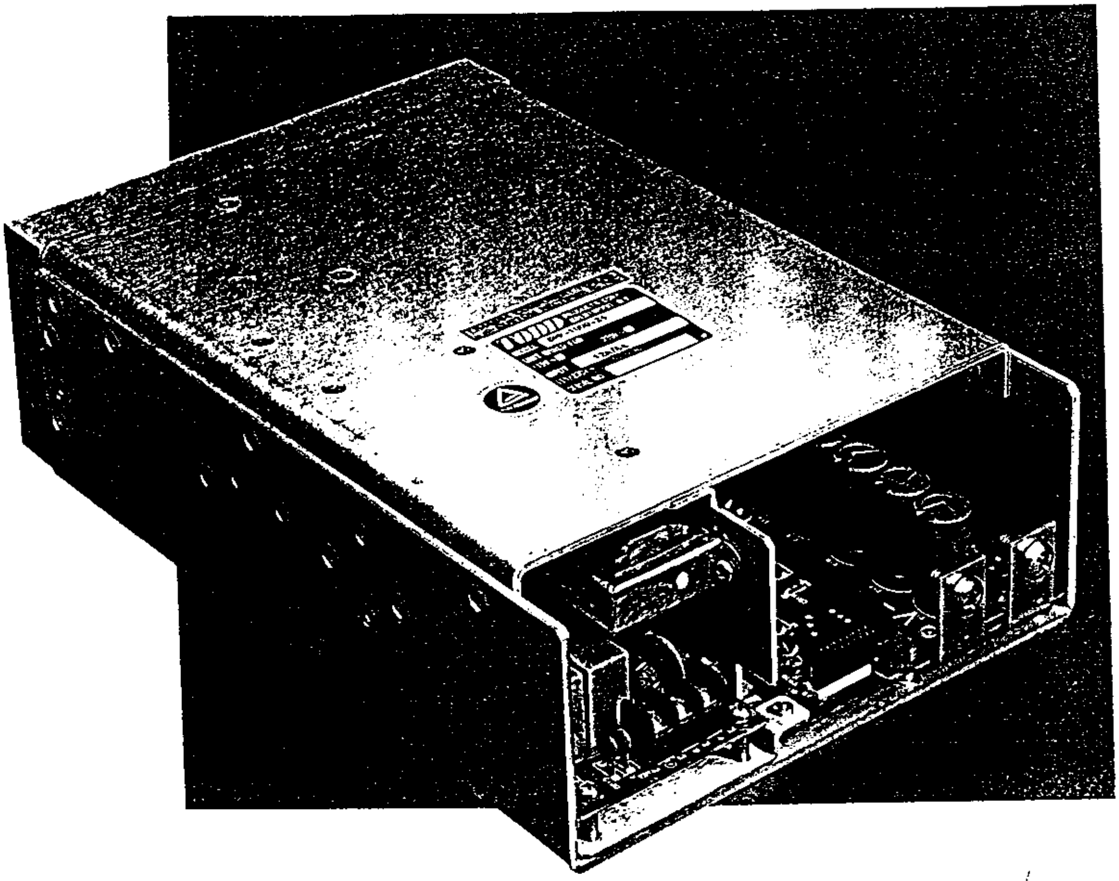
SURGE ARRESTER

THERMAL ELEMENT

TODD
POWER SUPPLIES

600 – 750 – 1000 – 1500 WATTS POWER FACTOR CORRECTED SINGLE OUTPUT, FORCED CURRENT SHARING

SPF-600
SPF-750
SPF-1000
SPF-1500



Featuring:

- Forced current sharing for N +1 redundancy
- Universal AC input (except SPF-1500)
- 0.99 typical power factor
- Low ripple and noise
- DC power good and AC power fail signals
- True remote inhibit
- Monotonic turn-on and turn-off

When you need a single-output power supply, but want all the proven industry-leading features of our NMX series, the SPF power supplies can't be beat. They incorporate TODD's high performance, power factor correction, low cost and reliable technology. The SPF series gives you all this and more in low-profile, compact packages which cost no more than common single output switchers without power factor correction.

600 and 750 WATTS
90-264 VAC INPUT–12.92" x 5" x 2.5"

MODEL	OUTPUT RATING	PWR OUT
SPF-600-05	+5V @ 120A	600
SPF-750-12	+12V @ 62A	750
SPF-750-15	+15V @ 50A	750
SPF-750-24	+24V @ 31A	750
SPF-750-28	+28V @ 27A	750
SPF-750-48	+48V @ 16A	750

1000 WATTS
90-264 VAC INPUT–12" x 8" x 3.38"

MODEL	OUTPUT RATING	PWR OUT
SPF-1000-05	+5V @ 200A	1000
SPF-1000-12	+12V @ 84A	1000
SPF-1000-15	+15V @ 67A	1000
SPF-1000-24	+24V @ 42A	1000
SPF-1000-28	+28V @ 36A	1000
SPF-1000-48	+48V @ 21A	1000

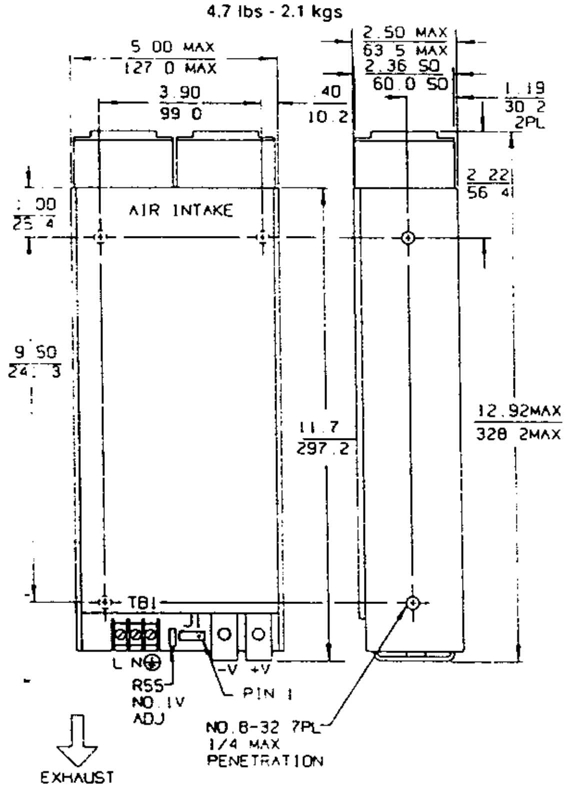
1500 WATTS
180-264 VAC INPUT–12" x 8" x 3.38"

MODEL	OUTPUT RATING	PWR OUT
SPF-1500-05	+5V @ 300A	1500
SPF-1500-12	+12V @ 125A	1500
SPF-1500-15	+15V @ 100A	1500
SPF-1500-24	+24V @ 63A	1500
SPF-1500-28	+28V @ 54A	1500
SPF-1500-48	+48V @ 32A	1500

600 – 750 – 1000 – 1500 WATTS
12.92" x 5" x 2.5" 12" x 8" x 3.38"
SPF-650, 750 SPF-1000, 1500

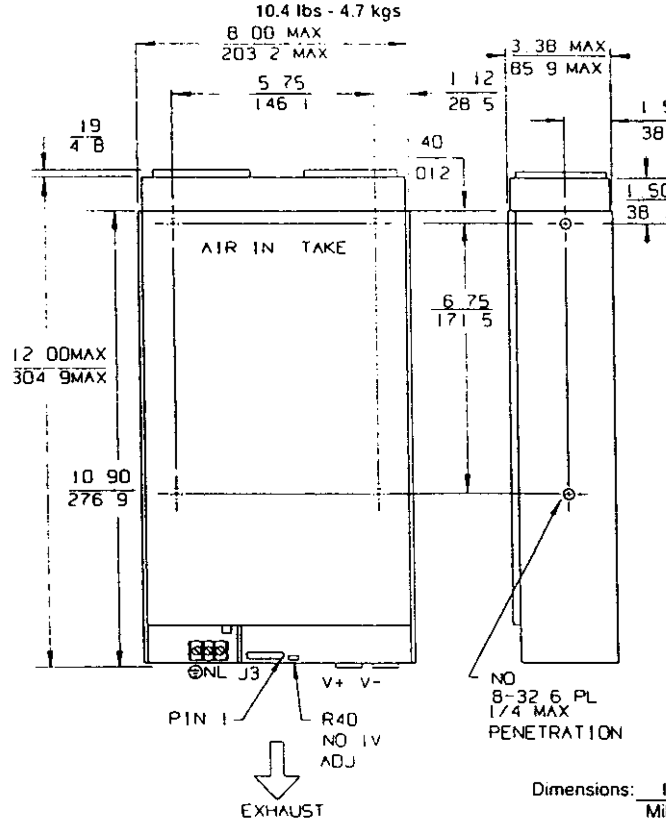
SPF-600, 750

4.7 lbs - 2.1 kgs



SPF-1000, 1500

10.4 lbs - 4.7 kgs



Dimensions: Inches / Millimeters

ALL MODELS

AC Input: 90-264 Vac continuous range, 47 to 63 Hz, except SPF-1500 series, 180-264 Vac, 47 to 63 Hz. 600 W and 750 W units fused for 15 A. 1000 W and 1500 W units fused for 20 A.
Power Factor: 0.99 typical at full load. Meets EN60555-2.
Adjustability: User adjustable ±5% minimum.
Line & Load Reg: ±1% over AC input range and 0 to 100% load change.
Ripple & Noise: Less than 0.2% rms, 1% p-p or 100 mV, whichever is greater.
Remote Sense: Compensates for 250 mV total line drop. Open sense lead protection. (See Redundancy, below.)
Temperature Coefficient: 0.02% per degree C
Stability: 0.1% over 8 hours after 30 minutes warm-up.
Transient Response: Output voltage returns to within 1% in less than 500 µs for a 50% load change. Peak transient does not exceed 5%.
Overload Protection: All outputs are protected against overload and short circuit. Automatic recovery upon removal of fault.
Overvoltage Protection: Protects load against power supply induced overvoltage. Trip point is factory set so that output voltage cannot exceed 136% of nominal.
Inrush: Cold start AC current is less than 50 A at 115 Vac and 100 A at 230 Vac for 600 W and 750 W models; 90 A at 115 Vac and 180 A at 230 Vac for 1000 W and 1500 W models. Limited by surgistor.
Brownout Protection: Continuous range units hold regulation to 85 Vac. SPF-1500 holds regulation to 170 Vac.
Thermal Protection: Shuts down power supply if overheated. Automatic recovery.
Holdup Time: 20 ms minimum after removal of power at full load.
Temperature Range: 0° to 50°C at full ratings.
Efficiency: 75% typical.
Safety Agencies: Most models are approved to UL1950; CSA 22.2 #234, IEC 950 and TUV EN60950, Class 1 SELV. Contact factory for status.
Conducted RFI: Meets FCC Part 15, Subpart B, Class A, EN55022 Class B, CISPR 22 Class B and German Decree VFG243.
Output Isolation: Isolated from ground 50 Vdc.
Reverse Voltage: Protected against reverse voltage up to supply current rating.
Cooling: Self cooled by internal ball-bearing fans.
Remote Inhibit: Contact closure to the negative sense line or a TTL level "0" turns off DC output.
AC Power Fail: Provides TTL "0" 5 ms before output voltage goes out of regulation band upon loss of power.
DC Power Good (5V Outputs): Provides a TTL "1" open collector when output is above 4.6 V nominal.
Redundancy: External OR-ing diodes and forced current sharing provide "N+1" capability. Remote sense (+S) compensates for additional 0.6 V diode voltage drop. When the current sharing terminal is connected between units, current sharing remains within 10% of the unit's full output current rating. (See page 42.)

OPTIONS:

Consult factory for available options.

AC INPUT (90-264 VAC Continous Range)

FUNCTION	115 VAC*	230 VAC	CONNECTOR
TB1-(L)	Line	Line 1	Barrier strip #6-32 screws 3/8" centers
TB1-(N)	Neutral	Line 2	
TB1-(⊕)	Safety Ground	Safety Ground	

*SPF-1500 series rated for 230 VAC only

DC OUTPUT

FUNCTION	MODEL	LOCATION	CONNECTOR
Output Voltage	All SPF-750 models	Terminal +V	Bus bars #1/4-20 screws 2PL
		Terminal -V	
	SPF-1000-24, 28, and 48	Terminal +V	Bus bars #10-32 screws
	SPF-1500-24, 28, and 48	Terminal -V	
	SPF-1000-05, 12, and 15	Terminal +V	Bus bars #5/16-18 screws 3PL
	SPF-1500-05, 12, and 15	Terminal -V	

STATUS AND CONTROL

FUNCTION	SPF-750	SPF-1000 SPF-1500	CONNECTOR
Remote Sense	J1-5 (+S)	J3-7 (+S)	AMP MTA type #640456-6 (J1) or #640456-8 (J3) pin header (locking)
	J1-4 (-S)	J3-8 (-S)	
Power Good	J1-3	J3-5	
Inhibit	J1-2	J3-4	
Current Share	J1-6	J3-6	
AC Power Fail	J1-1	J3-3	
Aux. Fan Voltage		J3-1 (+12V)	
		J3-2 (Rtn)	

Deltron inc.

INSTRUCTION MANUAL
FOR
WORLD SERIES LINEAR POWER SUPPLIES

A17248-1

INSTALLATION

To comply with IEC 950 specifications, operate this supply in accordance with this Instruction Manual. Refer to the outline drawings for the dimensions of the three mounting surfaces. The power supply is to be mounted in a manner that the user shall be prevented from having access. Mount the unit allowing clearance for adequate air movement over the chassis surfaces. Power supply mounts in all orientations except with sides vertically down. Use spacers or cut outs to avoid contact with projecting components. A protective earthing conductor must be reliably connected to the power supply as per IEC 950 sub-clause 2.5.

Input Configurations are as follows:

	INPUT	SHORT OUT
100VAC +10%, -13%	0-4	1-2 & 3-4
120VAC +10%, -13%	1-4	1-2 & 3-4
220VAC +10%, -13%	0-4	2-3
230VAC +15%, -10%	1-4	2-3
240VAC +10%, -13%	1-4	2-3

50 HZ. OPERATION

If unit is intended for 50Hz. operation, derate output current by 10%.

MODEL NUMBERS
FUSING INFORMATION

	W100A W104A W108A W112A W116A W208A W214A W300A	W101B W105B W109B W113B W117B	W102C W106C W110C W114C W209B W205C W301D	W103D W107D W111D W115D	W120F W122F W124F W126F W118D W308E W304F W313F	W121G W123G W125G W127G	W210C W318D W302E W303E	W305G
FUSING								
100-120	MDL 1.0	MDL 1.5	MDL 2.0	MDL 2.5	MDL 4.0	MDX6.25	MDX 3.0	MDX 5.0
220-240	MDL 0.5	MDL .75	MDL 1.0	MDX1.25	MDX 2.0	MDA 3.0	MDX 1.5	MDA 2.5

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INSTRUCTION MANUAL
FOR
WORLD SERIES LINEAR POWER SUPPLIES

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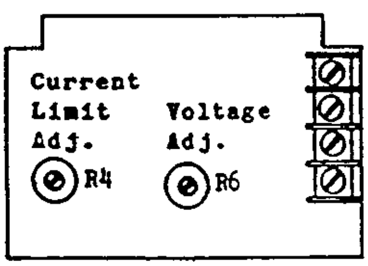
SENSE OPTIONS

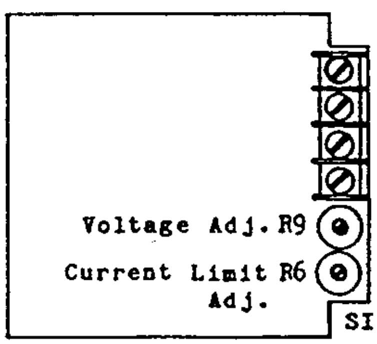
LOCAL SENSED:
Connect the load between the + and - terminations on the terminal block.

REMOTE SENSED:
To remote sense multiple output units, remove the screws from terminal block. Unsolder sense connecting straps from PC Board eyelets and solder 22 gauge sensing wires into the eyelets. For remote sensing of single output units, remove shorting jumpers from terminal block. Connect load wires to + and - terminations on the terminal block. Connect 22 gauge twisted pair to appropriate sense terminals. When the remote sense connections are used, some combinations of lead length and load impedance may cause the power supply to oscillate. This oscillation can frequently be eliminated by:
(1) adding approximately 200 uf at the load where the sense and power leads are connected or
(2) adding approximately 5 uf between + sense and + output and between - sense and - output terminations.

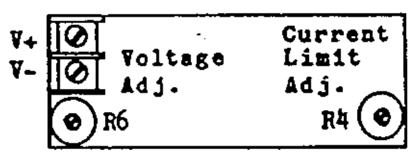
NOTE: Both the load wires and the remote sense wires must be connected to the same points at the load.



SINGLES - SIZES A thru D



SINGLES - SIZES F & G



MULTIPLES - ALL SIZES

Each output may be independently trimmed to its nominal output voltage with the voltage adjust pot. The current limit on each output is independent, and is preset at the factory. To insure safe operation of the unit it should not be adjusted.

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INSTRUCTION MANUAL
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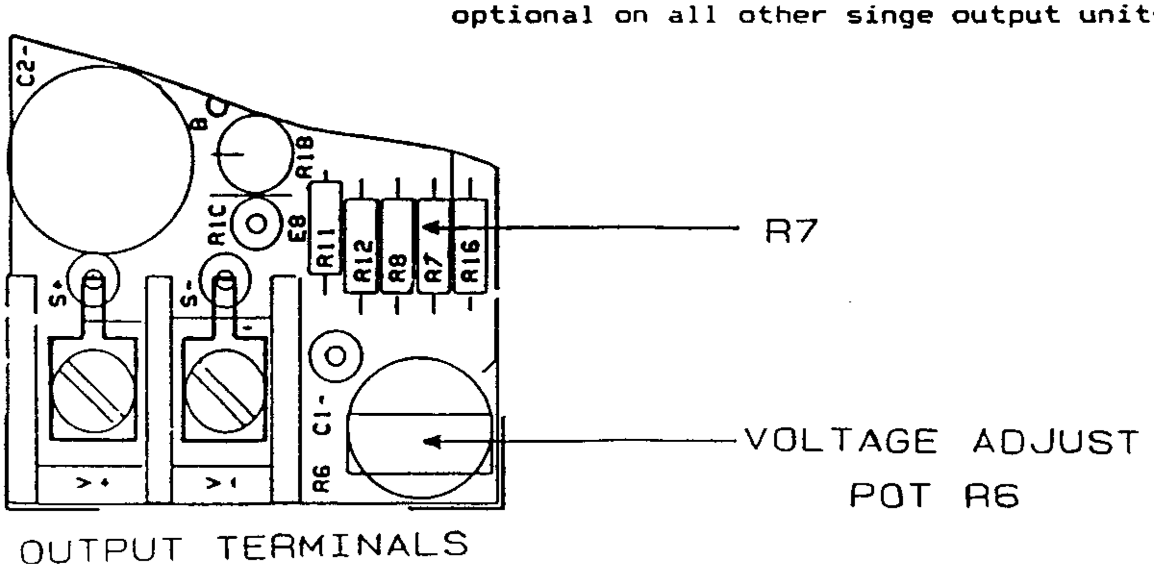
MULTIPLE RATED OUTPUTS

Models which have multiple voltage ratings can be adjusted with the voltage adjust pot to provide any of those output voltages except 5 volt. For 5 volt output, clip out R7 (5.6K, 0.25 watt resistor closest to the symbol E10 on the PC board) and connect the 220 ohm, 0.25 watt resistor supplied in the accessory envelope to the output terminals. Refer to diagram below.

SPECIFICATIONS

Line Regulation:	+0.05% for 10% line change
Load Regulation:	+0.05% for 50% load change
Ripple and Noise:	1mV rms, 5 mV p-p
Temp. Coefficient:	0.03%/deg.C.
Isolation input to output:	3750VAC
input to case:	3750VAC
output to case:	500VAC
Operating Temp:	0 deg.C.- 50 deg.C. UL, CSA 0 deg.C.- 40 deg.C. TUV/VDE derate linearly to 40% at 71 deg.C.
Storage Temp:	-20 deg.C. to 85 deg.C.
Recovery Time:	30 usec. typical
Short circuit protection:	Auto recovery
Over current protection:	Set at approx. 125% of full load rating.
Overvoltage protection:	Included on all 5 volt outputs and is optional on all other singe output units.



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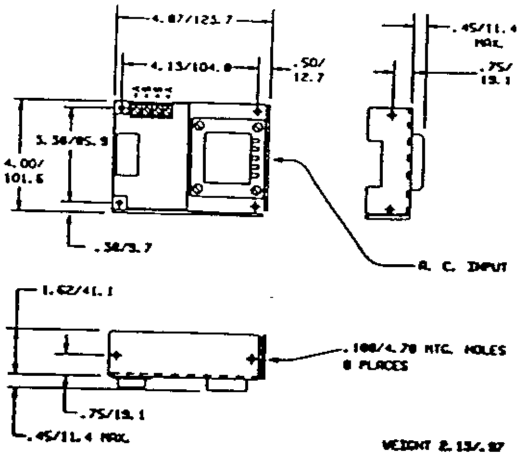
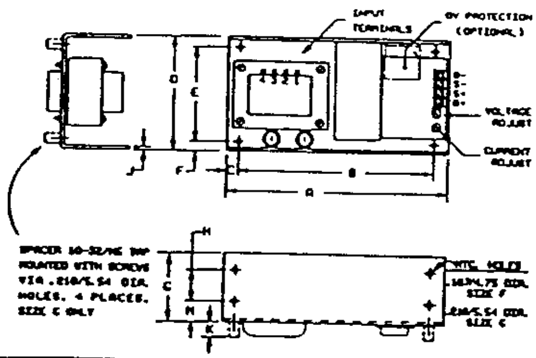
World Series Dimensions inches/mm

SIZE A SINGLE OUTPUT

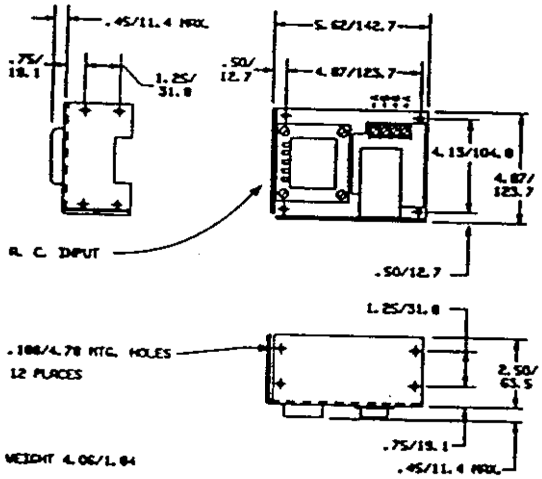


SIZES F & G SINGLE OUTPUT

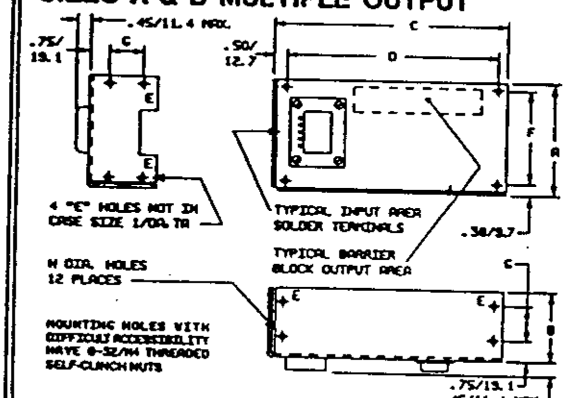


CASE SIZE	A	B	C	D	E	F	G	H	J	K	L	M	APPROX. WEIGHT
F	14.00/355.6	13.00/330.2	.50/12.7	4.87/123.7	4.13/104.9	.375/9.53	2.75/69.9	1.25/31.8	.13/3.2	.50/12.7	.75/19.1	14.00/6.35	
G	16.75/425.5	16.00/406.4	.50/12.7	4.87/123.7	4.13/104.9	.375/9.53	4.13/104.9	2.50/63.5	.13/3.2	.75/19.1	1.00/27.0	21.00/9.53	

SIZE B SINGLE OUTPUT

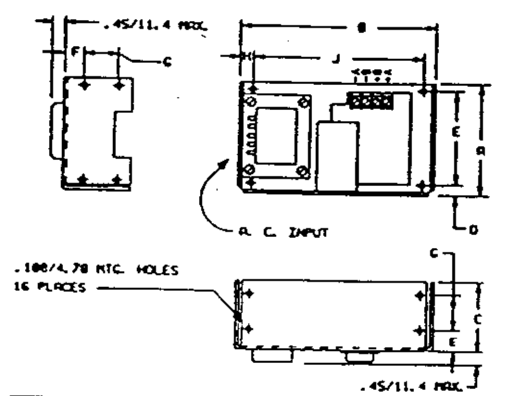


SIZES A & B MULTIPLE OUTPUT



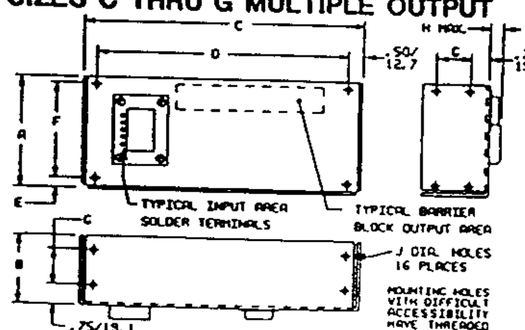
CASE SIZE	A	B	C	D	F	G	H	APPROX. WEIGHT
DA, TA	4.00/101.6	1.62/41.1	6.50/165.1	5.75/146.1	3.38/85.9	00	.213/5.41	2.00/.91
DB, TB	4.87/123.7	2.50/63.5	7.00/177.8	6.25/158.8	4.13/104.9	1.25/31.8	.213/5.41	4.00/1.81

SIZES C & D SINGLE OUTPUT



CASE SIZE	A	B	C	D	E	F	G	H	J	APPROX. WEIGHT
C	4.87/123.7	7.00/177.8	2.75/69.9	.50/12.7	4.13/104.9	.75/19.1	1.25/31.8	.38/9.7	6.25/158.8	6.13/2.78
D	4.87/123.7	8.00/203.2	2.75/69.9	.50/12.7	4.13/104.9	.75/19.1	1.25/31.8	.50/12.7	8.00/203.2	7.00/3.18

SIZES C THRU G MULTIPLE OUTPUT



CASE SIZE	A	B	C	D	E	F	G	H	J	K	APPROX. WEIGHT
DC, TC	4.87/123.7	2.75/69.9	9.38/238.3	8.38/212.9	.50/12.7	4.13/104.9	1.25/31.8	.45/11.4	.213/5.41	8-32/M4	7.50/3.40
TD	4.00/101.6	2.50/63.5	10.25/260.4	9.25/235.0	.38/9.7	3.38/85.9	1.25/31.8	.45/11.4	.213/5.41	8-32/M4	5.00/2.27
TE	4.87/123.7	2.75/69.9	11.00/279.4	7.00/177.8	.50/12.7	4.13/104.9	1.25/31.8	.45/11.4	.213/5.41	8-32/M4	9.00/4.08
TF	4.87/123.7	2.75/69.9	14.25/362.0	8.75/222.3	.50/12.7	4.13/104.9	1.25/31.8	.62/15.7	.250/6.35	10-32/M5	11.00/4.99
TG	4.87/123.7	3.75/95.3	15.00/381.0	14.00/355.6	.50/12.7	4.13/104.9	2.50/63.5	.62/15.7	.250/6.35	10-32/M5	12.00/5.44

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