FP3314R2
7/2/97

CX2500/S/13.56MHz
RF GENERATOR

Table of Contents

NOTE: Before installing equipment, carefully read and familiarize yourself with the entire operations manual. Observe and obey all WARNING and CAUTION notes provided.

I. Safety Information

Warning Label and Safety Marking Explanations:

The following symbols and terms may be found on an instrument or used in this manual.

The CE mark indicates compliance with all currently applicable directives and standards.

This label indicates a general warning or caution condition.

This symbol indicates the presence of high voltages in or around the unit.

This symbol indicates that the component or circuit is short circuit protected.

This symbol indicates the presence of RF energy in or around the unit.

This symbol indicates a protective earth ground connecting point.

This label indicates a presence of high voltage in or around the equipment, which may cause sever injury or death. All appropriate precautions should be observed when installing, operating or servicing this equipment.

This label indicates the presence of Radio Frequency energy in and around the equipment, which may cause burns or other injuries. All appropriate precautions should be followed when installing, operating or servicing this equipment.

The **WARNING** heading used in this manual explains dangers that might result in personal injury or death. **Always read the associated information** very carefully before performing the indicated procedure.

The **CAUTION** heading used in this manual explains hazards that could damage the unit. Such damage may invalidate the warranty.

MUST – This word is understood to indicate a mandatory condition.

HIGH VOLTAGE – Voltages greater than 50 volts DC or 25volts AC and known to cause death or serious injury if contacted.

SERVICE – Any operation of maintenance, repair, calibration or similar activity other than the normal operation of the unit.

QUALIFIED SERVICE TECHNICIAN, QUALIFIED ELECTRICIAN, QUALIFIED PERSONELL – These terms indicate persons specifically trained to install, service or other wise handle electronic equipment of the character and hazard potential of this unit.

End User Labeling

The system installer should obtain and apply all appropriate safety and warning labels required by the end user's local fire department jurisdiction and Occupational Health and Safety Administration over and above those supplied by the generator manufacturer.

Read And Understand This Section Fully Before Installing or Operating This Equipment.

WARNING: This equipment must be installed, operated and serviced only by trained, qualified persons.

General Safety Requirements

- **WARNING:** Hazardous Voltages and RF voltages are present inside this unit, which may cause injury or death. To prevent electrical shock and or RF burns, never operate this equipment with the covers removed. Never operate without an appropriate cable connected between the RF output connector on the rear panel and the load.

- **CAUTION: There are no user or operator serviceable parts inside this equipment. Refer all service to a qualified service technician.**

- This equipment must be bonded to Protective Earth (safety ground) prior to operating the unit. Safety ground connection must be made at the unit's rear panel designated 1/4"- 20 threaded ground stud. The ground wire should be a #14 awg or equivalent (minimum) green/yellow lead.

- Replace fuses only with identical type and rating parts. Installation and connection of this equipment must only be performed by a qualified electrician.

- **HEAVY OBJECT CAUTION:** A heavy object caution exists for equipment weighing more that 51 lbs or 23 kg. Use lifting aids to install unit, such as chain lifts or hooks and straps, attached to the four handles at the sides and front of unit. Guide unit into final location using care to keep hands and body parts clear of unit.

Interlock System

- The low voltage (24 V) safety interlock circuit is designed to disable the unit in the event of an interlock fault condition. At a minimum, interlock protection is located at the removable top cover, bottom cover and RF output connector safety cover.

- End user's system should provide indication to the operator of the interlock fault condition.

- Low voltage power for the interlock circuit is supplied by a step down transformer located inside the unit. This transformer is designed to provide safe low voltage operation and provide isolation from the main AC line.

Lockout/Tagout

Prior to performing system maintenance, repair or other service operations the generator must be locked out and tagged out to prevent accidentally energizing the system.

The following steps should be performed only by a qualified service technician:

- Disconnect AC input power to the generator.

- Mount a suitable "Clamshell" type lockout device to the AC input plug such as a Hubbell # HLD2 or equivalent. Follow all manufacturers' directions for the lockout device.

- Secure the lockout device with an appropriate padlock or safety lock.

- Apply a lockout warning tag to the lock out device.

The Lockout / Tagout device should not be removed until system service is completed and it has been determined appropriate to reconnect and operate the generator.

II. Description / Specification

The CX2500/13.56 RF amplifier operates at a frequency of 13.56 MHz. The power source produces maximum transfer of power into a 50 ohm resistive load and is designed to withstand large deviations in load impedance without failure. The primary features of the CX2500 series are its solid-state design, small physical size and reliability.

CX2500 series power amplifiers can be supplied with internal frequency sources or may be driven from external frequency sources having a 50 ohm output and a digital drive level of 0-5 V.

The CX2500 series amplifier is constructed with three main sections DC power supply, RF power stage and control and interface. This section includes all of the filter capacitors, rectifiers and regulators as well as the three-phase 208 VAC power transformer. The bridge rectifiers are mounted on a water-cooled heatsink. These components are operated at about half of their rated outputs to insure the high reliability of this section. The RF section of the amplifier is mounted around the DC section. This section consists of the internal/external oscillator frequency control board (OCB), driver, two PA1250 power amplifiers on one water-cooled block, an RF combiner, and an output matching network/harmonic filter. The driver, power amplifier and combiner modules are mounted on water-cooled heatsinks. All components are used well below their dissipation ratings for long life and low maintenance operation. The control and interface section is mounted to the front panel assembly. On this assembly there is a 20 x 2 character florescent display, CX microprossesor PCB, softkey input interface PCB and a CX interface PCB. The CX interface PCB consists of a remote interface, amplifier interface, local interface and low voltage dc power supplies.

A. Electrical Specifications

1. AC Input Voltage: 188-228VAC; no neutral; three phase with ground.

2. AC Line Frequency: 50/60Hz nominal; 49 to 61 Hz range.

3. AC Input Current: 15 amps maximum.

4. Output Characteristics:

    4.1 0 to 2500W continuous forward power at the unit's rear bulkhead RF connector into a 50ohm load.

    4.2 The forward power out is to track the command setpoint for any load conditions where the reflected power is less than: 375W.

    4.3 Accuracy/Regulation: +/- 3.0% of setpoint, from 10% to 100% max. output, as measured by either the actual output power and/or the forward analog read back signal

    4.4 Linearity: +/- 2.0% deviation from a straight line for successive requested setpoint power increment changes, from 10% to 100% max. output, as measured by either the actual output power and/or the forward analog read back signal.

    4.5 Short Term Stability: +/- 1.0% for any given output power setpoint during one continuous hour of output.

    4.6 Long Term Stability: +/- 5.0% for any given output power setpoint during 3 years of continuous output.

    4.7 Rise Time: less than 100ms; from leading edge of enable signal to 90% of power level requested.

4.8 Zero Setpoint: less than 1.0W actual output power and less than 1.0W read back power when setpoint signal is at zero or at a negative voltage.

4.9 Frequency stability: 13.56 MHz +/- 0.005%

4.10 Output Filtering: (for full power into 50 ohms)

Harmonic Signals: less than -30dBc
Spurious Signals: less than -40dBc
AM & FM Noise: less than -40dBc
(@ 50 KHz offset)

5. Protection Features:

5.1 Mismatch Protection: Continuous operation into any impedance mismatch condition without damage or malfunction; forward power foldback shall occur within 500us if reflected power exceeds 375W.

5.2 AC Line Protection: A manually resettable circuit breaker on the rear panel opens upon overcurrent conditions.

5.3 RF Output Power Connection Interlock: A Hard-wired interlock that disables the input AC power contactor upon removal of either of the RF output cables.

5.4 Safety Interlock: Disables the input AC power contactor via either of the control I/O connection signals; open between Pins 10 & 23.

5.5 Over Temperature Fault: Output disabled on high internal temperature.

5.6 Control Signal Protection: Unit not to be damaged if a short circuit or up to 30 volts AC or DC is placed between any input signal, return signal, and ground.

6. Control Signals

6.1 Signal Input Impedance: 10K ohms, minimum.

6.2 Signal Input Isolation: 1000VAC minimum to the A/C supply line.

7. Rear Panel Electrical Connections

7.1 Input Power Connection: TBD

7.2 Output Power Connector: Type "N" female coaxial bulkhead connector.

7.3 Control I/O Connector: 25 pin sub miniature ”D" type (female) receptacle.

8. Control I/O Pinout & Signals (Refer to Figure CX INTERFACE).

Pins 1 & 14: DO, Max. RF power, Active = 2500 Watts forward.

Pins 2 & 15: AO, Ref Power Output: 0 to +10VDC = 0 to 2500W linear.

Pins 3 & 16: AO, Fwd Power Output: 0 to +10VDC = 0 to 2500W linear.

Pins 4 & 17: DI, RF Power Enable, Activated Enables RF output.

Pins 5 & 18: AI, Remote Setpoint Input: 0 to +10VDC = 0 to 2500W linear.

Pins 6 & 19: Unregulated DC output: 15 - 30 VDC.

Pins 7 & 20: DO, RF Power On Output, Active = RF ON.

Pins 9 & 22: DO, Indicates status of heatsink temperature, Active = HOT.

Pins 10 & 23: AC Interlock loop, Jump to enable AC power to unit.

B. Mechanical Specifications

1. Size: 19"W x 7"H x 21.5"D (483mm x 178mm x 546mm) maximum chassis dimension

2. Weight: 132 lbs. (60 kg)

3. Mounting: Standard 19" EIA rack mounting adapters with 7" front panel.

4. Color and Finish: All surfaces shall painted or have a coated finish such as gold zinc chromate, gold alodyne, or equivalent.

5. Water Connections: 1/4" NPT male, one inlet and one outlet for water cooling of amplifier sections.

6. Handles:

    6.1 Front Panel: Two handles (left & right) to be mounted on the front panel exterior, evenly spaced on center.

7. Front Panel and Indicators and Actuators:

    7.1 All front panel indicators will be displayed on a 20 X 2 character alpha-numeric display.

    7.2 All settings (in local control mode) will be made from a single rotary encoder or four soft key actuators.

8. Warning Labels:

    8.1 Safety Labels for hazardous voltages, Heavy Object, and Caution for lifting by water fittings are to be provided on operator visible areas of the generator. IEC standard symbols in user visible areas for start, stop, enable and cautionary conditions, PE ground, high temperatures and RF energy present.

    8.2 Special marking available at customers specifications

C. Environmental Specifications

1. Operating range: +10 to +40° C (50 to 104° F) ambient, 5-85% R.H. (non-condensing, no formation of ice), 86-106 kPa. Temperature, humidity and air pressure operating range class 3K3 per prEN50178.

2. Inlet Water Cooling Requirements: 5.68 Liters l/m (1.5 GPM) @ 690 kPa (100 psi) max, 35° C max.

3. Coolant type: Water

4. Inlet Air Requirements: 5-30° C max (41-95° F).

5. Storage: Temp, pressure & humidity per prEN50178. –25 to +70° C (class 1K4) @ up to 95% R.H. non-condensing (class 1K3), 70 to 106 kPa (class 1K4).

6. Transportation: Temp, humidity and pressure class 2K3 per prEN50178. –25 to +70° C @ up to 95% R.H. non-condensing, 70-106 kPa.

7. This equipment has been designed to be compliant with FCC Part 18 emission standards for EMI/RFI radiation. Radiated emissions shall also not exceed maximum levels permitted by ANSI C95.1-1982 standards on safety levels with respect to human exposure to RF and electromagnetic fields from 300KHz to 100GHz.

D. Testing Specifications

1. Production Acceptance Test: Each unit will be required to "pass" production acceptance testing and a "Final Test Report" will be generated to document results.

    1.1 Production Acceptance Testing process shall include as a minimum: Complete Parametric/Functional Tests covering: line regulation, calibration, linearity, burn-in, over-temp test, open circuit test, MAX power test, harmonic distortion, AC ripple, and remote interface tests. Data sheet for each generator to be shipped with unit.

E. Packaging & Shipping Specifications

1. Accessories Supplied

    1.1 Final test results
    1.2 Operating manual

2. Shipping

    NOTE: If there is a conflict between this document and customer Purchase Order then the latter supersedes.

    NOTE FOR REPAIRS: Unless repairs have accessories included with them and have them listed on the Return Material Authorization (RMA) Tag, returned materials will not have to fulfill procedural requirements for accessories.

III. Unpacking and Inspection

1. Carefully unpack the unit and inspect for any obvious signs of physical damage that might have occurred during shipment. Notify the shipping agent of any damage immediately.

2. Check the outside of the unit for missing or loose mounting screws or broken parts.

3. If there is shipping damage or the unit fails to operate properly upon receipt, report damage to the carrier and Comdel immediately.

CAUTION: Breaking the seal or removing the warranty decal from this unit will void the warranty. If internal damage is suspected, contact factory for assistance.

IV. Maintenance

The CX2500 is designed to run unattended for long periods of time. Should service be required, the system is designed for quick repair. The whole RF section could be replaced in under thirty minutes.

After a time, scale may build up on the inside of the cooling tubes. This could greatly reduce the cooling capacity of the system. It is recommended that the system be flushed with a descaling agent. A cleaning agent that does not damage copper, stainless-steel, nickel or nylon tubing should be chosen.

V. Preparation for Use

A. Line Requirements

The CX2500 is designed to operate from a 208 VAC three phase line. The system will still function within specifications when the line voltage fluctuates between 190 volts and 225 volts. Voltages over the recommended 208 VAC, however, reduce the safety margins designed into the system and should be avoided. The system draws a maximum of 13 amps per phase when used to drive a load of 50 ohms. Under conditions of mismatch the amplifier could draw slightly more current.

B. Cooling Requirements

The ambient air temperature should not exceed 35° C. There should be enough room over the top of the amplifier and along the sides to permit an unobstructed airflow through the unit. Water temperature should not exceed 35° C. and should not fall below a temperature where excess condensation could develop within the unit. Water volume should be at least 1.5 GPM and pressure kept below 60 PSI.

C. Installation Requirements

1. Connect a 50 ohm load to the RF output of the amplifier.

   NOTE: Load and coaxial cable should have a minimum 2500 watt power handling capacity.

2. With circuit breaker "OFF" connect the power line to the unit.

VI. Operating Instructions

The CX2500 may be operated either locally at the front panel or remotely through the 25 pin subminiature D connector (J1) on the rear panel.

A. Local Operation

NOTE: AC interlock Pins 10-23 must be jumpered and RF ENABLE Pins 4-17 must be energized for the unit to be operated. RF ENABLE can be energized by supplying > 5 volts to Pin 4(+) and 17(-). Pins 6(+) and 19(-) are a 15V or 24V source that can be used for this purpose. See CX INTERFACE DEFINITION Figure.

1. Check to see that coolant is running through the unit and that a proper RF load is connected to the RF output connector at rear of unit.

2. Connect unit to 208VAC nominal, 3 phase and turn on main power breaker at rear of unit.

3. Verify that LED at red push-button (AC OFF) marked 'O' LED is on. If LED is off, then check AC line power. If LED is flashing then check RF output connector interlock switch, top cover interlock switch, or interlock loop, Pins 10 and 23 of rear panel connector.

4. Push AC ON green push-button marked '|'. The AC ON LED should be illuminated after the mains contactor closes.

5. The front panel display should show the model/frequency of the unit and the software version number for the first two seconds. The front panel display should show 'REM' for remote control. Push the mode select key (>>) on the front panel to select LOCAL control.

6. Enable RF by pushing the blue RF button on the left side of the front panel. The RF button should illuminate, the display flash 'RF ON', and readings of forward and reflected power should appear. If the display shows 'CHECK RF INTERLOCK', this means that the RF enable Pins 4 and 17 of rear panel connector is not energized. This can be done by connecting Pin 4 to Pin 6 (+15/24V) and 17 to 19 (RET).

7. RF is disabled by pushing the RF button again, by removing RF interlock by disconnecting Pin 4 or 17 of rear panel connector, or by interrupting the AC mains via the AC interlock loop, the stop softkey, or the circuit breaker located on the rear panel.

8. The CX2500 regulates forward power based upon the setpoint selected by the large data encoder knob on the front panel.

9. The CX2500 can be programmed to linearly ramp up and down the RF output power when RF is enabled or disabled. This is done by pushing the function select softkey (>) once to adjust the upramp time, and once more (>) to adjust the down ramp time. The times are programmable from .1 to 10 seconds, in .1 second increments through turning the data encoder knob on the front panel. Pushing the function select softkey a third time (>) brings the data encoder knob adjustment back to forward power setpoint.

10. An overtemp condition due to lack of coolant flow or high coolant temperature will automatically disable RF the CX2500. The front panel display will show 'OVERTEMP' for about 2 seconds if the RF ENABLE softkey is pushed. RF will not be able to be turned on until proper coolant flow/temperature is established.

B. Remote Control Operation

1-4. Refer to Figure CX REMOTE INTERFACE DEFINITION for the electrical interface specifications. For remote control operation follow the first four procedures for local control as listed above.

5. Remote operation is the power-up default mode. If the current mode of operation is LOCAL, then push the mode select key (>>) until the display shows 'REM' in the upper left corner OR restart the unit by turning AC off then back on.

6. Enable RF by energizing the RF ENABLE Pins 4(+) and 17(-) of the rear panel connector. The RF button should illuminate, the display flash 'RF ON', and readings of forward and reflected power should appear.

7. The voltage on Pin 5(+) and 18(-) of the J1 connector will determine the output power level. A voltage of 0 to 10 volts DC across Pins 5 and 18 will linearly correspond to an RF output of 0 to 2500 watts.

8. Reflected and forward power can be monitored remotely through Pins 2(+), 15(-) and 3(+), 16(-) respectively. Both of these balanced analog outputs are 0 to 10 VDC linearly corresponding to 0 to 2500 watts of RF output.

9. An overtemp condition as stated in #10 above in LOCAL will also result in the 'closure' of the OVERTEMP DIGITAL OUTPUT, Pins 9 and 22 of the rear panel connector. The digital output opto-isolator will be turned on.

10. When RF is present at the RF output connector, the POWER DELIVERED DIGITAL OUTPUT, Pins 7 and 20, will also be turned on.

11. When the SETPOINT IN analog input has 10V or above meaning full power is requested, the MAX. POWER LIMIT DIGITAL OUTPUT, Pins 1 and 14, will be turned on.

C. Serial Operation

The following is a description of the RS-232 ASCII instruction set to operate the CX series of RF generators. The baud rate is selectable via a DIP switch on the uP control PCB behind the front panel and is factory set to 9600 baud, N, 8, 1, with echo.

1. All incoming instructions need to be terminated with a carriage return (HEX 'D') except for the ATTENTION (!) and EXIT (#) commands.

2. The CX interface does not normally require handshaking for it's input because it is interrupt driven with a 1K buffer. Handshake control of it's output is optional.

3. The (PROMPT) response is defined as: <CR><LF> > or HEX D, A, & 3E

Instruction	Function	Response
! (NO <CR>)	ATTENTION	(PROMPT)
SPxxxx	SET RF POWER	(PROMPT)
ER	ENABLE RF	(PROMPT)
DR	DISABLE RF	(PROMPT)
P+xx.x	SET POWER UPRAMP TIME	(PROMPT)
P-xx.x	SET POWER DOWNRAMP TIME	(PROMPT)
RF	READ FORWARD POWER	xxxx (PROMPT)
RR	READ REFLECTED POWER	xxxx (PROMPT)
EE	ENABLE ECHO	(PROMPT)
DE	DISABLE ECHO	(PROMPT)
# (NO <CR>)	EXIT	<CR><LF>BYE

4. Function descriptions:

! - ATTENTION

The '!' command redirects control of the RF generator from either local (front panel) or analog remote (15 pin 'D' connector) to the serial port (9 pin 'D' connector). There will be no response from the CX from any other ASCII codes sent while in local or analog remote modes. Upon receipt of the ASCII '!', the CX will disable RF, set power setpoint to 0 watts, disable echoing of ASCII characters, and issue a PROMPT. The CX is now ready to receive ASCII commands via the serial port and will not respond to local or analog remote commands. This command does not require a carriage return <CR>.

SPxxxx - SET RF POWER

This command provides for forward power setpoint (in watts). The syntax allows up to four digits (xxxx) with leading zeroes OK.

This command only adjusts the setpoint for the CX and does not enable or disable the RF power.

ER - ENABLE RF

This command enables RF power at the preprogrammed setpoint SPxxxx (SET RF POWER). The power out will start at 0 watts and increase linearly to the setpoint over the period of time as set by P+xx (UPRAMP TIME).

If the external RF interlock connection is interrupted (25 pin rear panel analog remote interface connector), the RF output will not be enabled, and the CX2500 will respond with the message: "CHECK RF INTERLOCK". If RF output is already turned on when the RF interlock is interrupted, the CX2500 will respond with the same message and disable RF output.

If at any time the CX2500 overheats, the unit will disable RF and respond with the message: "OVERTEMP".

DR - DISABLE RF

This command disables RF power without affecting the setpoint. The power out will decrease from setpoint to 0 watts linearly over the period of time as set by P-xx.x (DOWNRAMP TIME).

P+xx.x - UPRAMP TIME

This command allows up to three digits with an optional decimal point (xx.x) to set the RF power upramp time as described above in the ER (ENABLE RF) command.

The units of time is in seconds and is adjustable from .1 to 10 seconds. The default time is .1 second unless previously set from either the serial port or local control (front panel).

P-xx.x - DOWNRAMP TIME

This command allow up to three digits with an optional decimal point (xx.x) to set the RF power downramp time as described above in the DR (DISABLE RF) command.

The units of time is in seconds and is adjustable from .1 to 10 seconds. The default time is .1 second unless previously set from either the serial port or local control (front panel).

RF - READ FORWARD POWER

This command returns the forward power of the CX.

The returned value can be from one to four digits and the units will be watts. The PROMPT as described above will follow the value returned.

RR - READ REFLECTED POWER

This command returns the reflected power of the CX.

The returned value can be from one to four digits and the units will be watts. The PROMPT as described above will follow the value returned.

EE - ENABLE ECHO

This command enables the serial port to echo all ASCII characters sent. The start default for the echo function is programmable by the serial port configuration switch on the microcontroller PCB mounted on the back of the front panel, switch #1.

DE - DISABLE ECHO

This command disables echoing of characters.

- EXIT

Upon receipt of this ASCII character the CX will disable RF power, set the power setpoint to zero, issue a "<CR><LF>BYE" response, then redirect control of the CX to the mode the unit was previously in when the attention command (!) was given. Local control can now be commanded from the front panel mode select button.

This command only functions after a PROMPT and does not require a carriage return. The '#' will not be recognized buried in or tagged at the end of another command.

The CX will no longer recognize serial port ASCII characters EXCEPT for the attention '!' character.

VII. Theory of Operation

The CX2500/13.56 is a high frequency power amplifier for use in OEM applications. The power sources consist of an AC Interlock/Softstart system, DC power supply, five stages of gain with associated control systems and monitoring circuits.

The radio frequency signal is generated locally in the Oscillator Control Module. From this module the signal goes to the driver. The driver further amplifies and splits the signal into two channels of equal phase and magnitude. These two signals are then amplified in two PA1250 power amplifiers. The signals are then added together in a two- way hybrid combiner. From the combiner module the signal is matched to 50 ohms through a low-pass filter. Control signals are obtained from the output signal as it passes through the power monitor board to the output RF connector. The front panel CX Controller monitors the user input from either the front panel or rear connector, and monitors the control signals from the RF output power monitor, PA voltage monitor, PA current monitor, and PA overtemp switch. Refer to Fig. FP3314RX, CX2500 BLOCK DIAGRAM to see how the individual modules are connected together.

A. AC Interlock System

The AC mains to the TECO 8978 power transformer is switched via contactor K1, controlled by the AC INTERLOCK PCB (Figure FA0900RX) mounted on the front panel behind the ON/OFF softkeys. AC power to this interlock system is supplied by 24VAC transformer which is energized when circuit breaker CB1 on the back panel is thrown. There are three fuses in the interlock circuitry: two mounted on top of T2 (208VAC input side) inside the CX2500 and one mounted on the AC INTERLOCK PCB itself (24VAC output side).

The AC INTERLOCK PCB supplies the logic to the AC mains control contactor to start and stop the CX2500 via the front panel softkeys. The PCB's start/stop circuitry is done with relay logic for safety. The active circuitry (U1A) causes the OFF softkey lamp to flash if the interlock loop is broken.

The interlock 'loop' for the CX2500 includes the rear panel I/O 25 pin 'D' connector, the top cover, and the RF output connector cover.

B. DC Power Supply

The DC supply consists of a three-phase transformer, three-phase, full-wave, bridge rectifier and a low-pass filter for the main power voltages. There are two single-phase bridge rectifiers and filters feeding both a positive 15 volt, negative 5 volt, and positive 5 volt regulators. These voltages are used in the control circuitry.

The outputs of this stage are:

1	44 VDC	Unloaded
	37 VDC	85 amps (2000W RF output)
1	+15 VDC Regulated	250 mA max
1	-5 VDC Regulated	250 mA max
1	+5 VDC Regulated	1A max

The high current required by the RF power amplifiers (PAs) is monitored by the HALL EFFECT CURRENT MONITOR PCB (Figure FA0503) mounted on the driver/bridge rectifier heatsink block, which is mounted between the front panel and the RF POWER AMPLIFIER heatsink block. This PCB uses two Hall effect devices to separately monitor the DC current feeding the two 1250 watt RF power amplifiers.

C. Oscillator Control Board (OCB)

The oscillator control board (Figure FA0403RX) has six parts, oscillator clock, three stages of gain, circuitry for output power control and monitoring circuitry. The oscillator clock is a TTL compatible output device that determines the frequency of operation. This square signal is amplified by three tuned stages of gain, producing a relatively clean sinusoidal 1 watt output. The DC voltage that powers the last gain stage is adjustable through control transistor Q5 to control the RF output level of the OCB.

The gain control circuitry smoothes output control and stabilizes output power against line and load variations and limits output power during high VSWR conditions. Control is achieved through the LM 356 operational amplifier, IC1. This op-amp compares the forward power signal (from the power monitor board) to that of the DC reference level applied to the non-inverting input. The reference level is set either from the front panel potentiometer or from Pin 5 of the J1 connector.

The LM 356 drives the gain control transistor, Q5, until enough signal from the forward power detector in the directional coupler is applied to the inverting input to the op-amp. When the inverting signal equals the reference voltage on the non-inverting input the drive level holds constant.

The non-inverting input is also the point to which some of the protection circuits connect. The CX controller pulls this point down when load conditions bring the amplifiers near their over-voltage, or over-current limits. This limits the drive to the amplifiers until the match between the generator and the load is corrected.

The reflected power limiter performs in the same way when the signal from the reflected power detector in the directional coupler reaches a pre-set limit. The Q6 transistor does the pull-down function until SWR conditions are within safe limits. The OCB also includes linearizing circuitry allowing both forward and reflected analog power level signals to appear at connector J1 as linear presentations of the incident and

reflected RF output power. Two squaring ICs U2 and U4 are used to condition the square law signals from the directional couplers.

Typical Specifications
(OCB)

Output load impedance	50 ohms
Output RF power level	1 watt (max)
Input power Pin 10	+15 VDC at 170 mA max
Pin 8	-5 VDC at 24 mA max
Remote power control input impedance	
Pin 2 on J1	2 K ohm
Reflected power limit	Internally set to 300-400W

D. Driver

The CX2500 driver is a two-stage Class "C" amplifier with feedback. The first transistor amplifies a 1 watt (typical) input from the OCB to about 10 watts. The circuitry between the two stages include two wideband impedance matching transformers and a loss section. The loss section provides added stability to the system and isolation between stages. The second stage of the driver sends 70 watts (max) to the hybrid output splitter. This transformer splits the signal into two equal phase and magnitude outputs of 35 watts each. The balancing resistors on this transformer allow for any variances in input characteristics of the two amplifiers. There are no adjustments or tuning required for this module.

Typical Specifications
(Driver)

Gain	18 dB
Input power	1 watt (max)
Output power	35 watts x2
Input impedance	50 ohms
Output impedance	50 ohms
Collector voltage at full power *	40 VDC
Current at full power *	3 A

* 2500 watts into 50 ohm resistive load

E. PA2500 Power Amplifier

Each PA2500 uses sixteen power transistors arranged in eight pairs of push-pull Class "C" amplifiers. The input power from the driver is matched with a wideband transformer, T1. The driver input is then split into eight signals and fed into eight push-pull transformers, T2. Each of these transformers drives the bases of two power transistors, Q1-Q16. The transistors are operated common emitter with feedback.

The collector signals are coupled by a push-pull hybrid combiner, T3. The output of these combiners is once again added together in a four-way hybrid combiner. There are no adjustments on the PA2500.

The PA2500 also contains a peak collector voltage detect circuit that the CX controller monitors to limit forward power if the RF load is such that generates high voltages at the PA transistor collectors.

Typical Specifications
(PA2500)

Gain	15 dB
Input power	66 watts
Output power	2700 watts (min)
Input impedance	50 ohms
Output impedance	50 ohms
Collector voltage *	37 VDC
Current draw *	85 ADC

* At 2500 watt system output into 50 ohm resistive load

F. Combiner

The combiner block is an integral part of the PA2500 and adds the outputs from the two 1250 watt amplifiers in a two-way hybrid transformer. High power balancing resistors allow for any output differences between amplifier outputs.

Input impedance to the combiner is 50 ohms and the output is at 25 ohms. The signal passes through a low-pass impedance matching "Pi" network. This filter provides a signal of the correct impedance and low harmonic distortion to the Power Monitor Board.

G. Directional Coupler Board

The directional coupler board (Figure FA0109) is a detector which produces voltages which are proportional to the square of both forward and reflected power. The signals from the two detectors are produced from current and voltage taps off the output line. The forward and reflected signals are fed into the OCB where they are linearized. They are then fed to the CX controller where they are reproduced to the remote interface connector and displayed on the front panel. The reflected power signal is only present when the generator is driving a load that is not purely resistive, or not 50 ohms. This signal is also used to drive the OCB VSWR shutdown circuitry.

H. CX Controller

The CX controller is comprised of four PC boards mounted to the left side of the front panel:

1. CX INTERFACE PCB

   The function of the CX Interface PCB (Figure FA0606RF) is to condition all of the analog and digital inputs and outputs for the CX Microcontroller. This PCB board also provides the protection control circuitry to limit forward power in cases of high PA current or high PA RF voltage. This protection function is handled by U1.

2. CX MICROCONTROLLER PCB

   This PCB (Figure FA0604RC), mounted under the CX INTERFACE PCB, contains a 16 bit microprocessor, memory, digital I/O, and analog I/O to control and monitor all activities of the CX2500. If for any reason the program is terminated or gets lost, the watchdog timer U6 automatically restarts the system. U6 also monitors VCC for low voltage conditions. If VCC drops below 4.5V, the system is shut down via uP reset line, U1-71.

   If the optional RS-232 serial port is utilized, U7 and associated components supplies the interface.

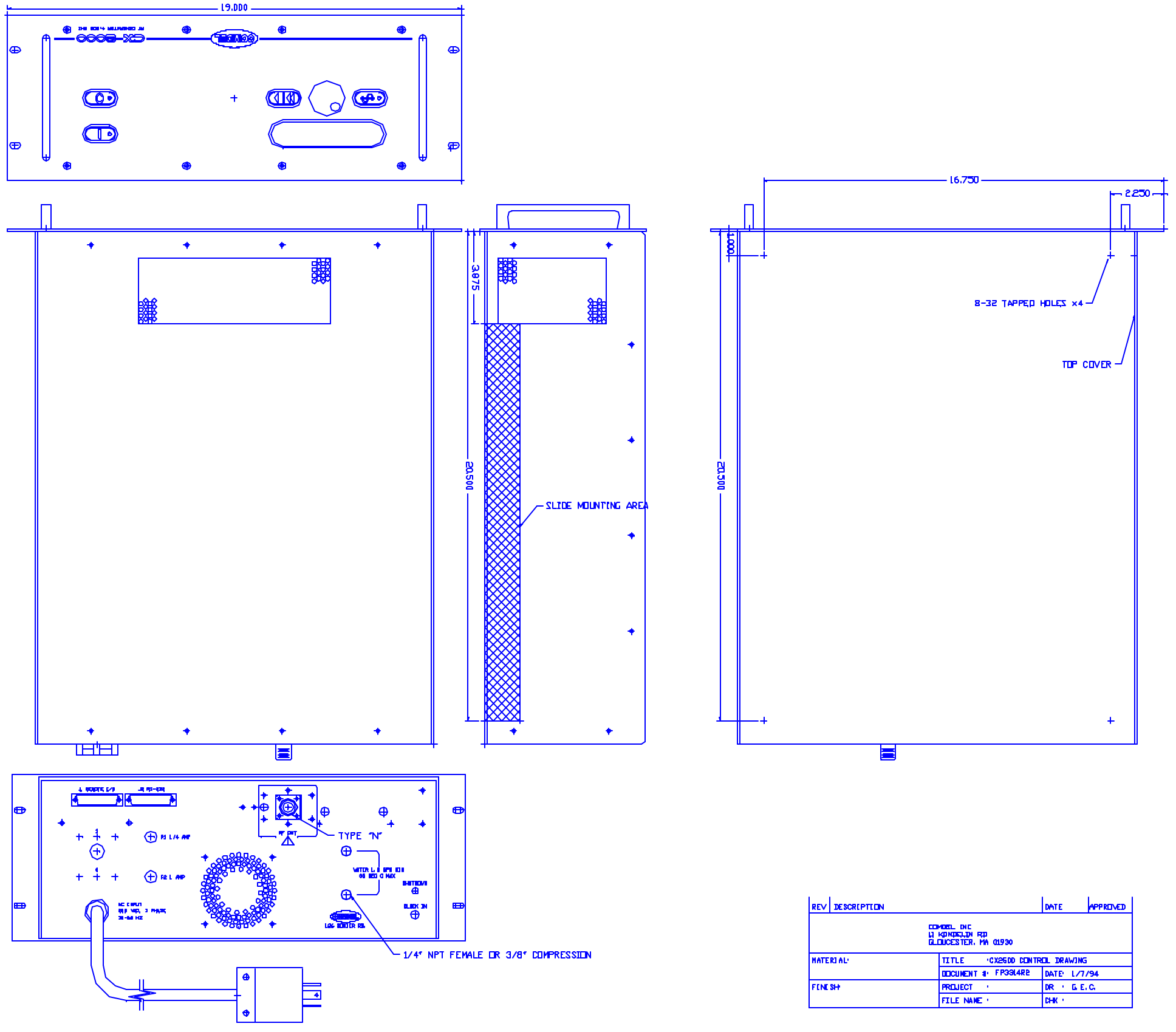
U14 provides the 5V or 10V reference for the A/D (U11) and D/A (U13) converters.

3. SOFTKEY INPUT INTERFACE PCB

This PCB (Figure FA0605RA) is mounted under the CX MICROCONTROLLER PCB and contains the softkey sense pads and buffer circuitry to interface all front panel user interface to the CX Microcontroller.

4. 20 x 2 CHARACTER ALPHA NUMERIC FLORESCENT DISPLAY PCB

This PCB, also mounted under the CX MICROCONTROLLER PCB, provides the display, high voltage power supply, drive circuitry, and microprocessor to interface the 20 x 2 character display to the CX Microcontroller data bus.



REV	DESCRIPTION	DATE	APPROVED
	COMBEL INC 41 KONDELIN RD GLOUCESTER, MA 01930		
MATERIAL:	TITLE: CX2500 CONTROL DRAWING		
	DOCUMENT #: FP3814RE	DATE: 1/7/94	
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