CLF5000/PLL, FP1541RD
4-28-01 Corrected Cooling requirements (Changed 3GPM to 2GPM)
7/27/97 Added heat load requirements to Specification sections II.C.1.2 & II. C.1.5, PR
8-26-97 Addition of details to Safety section for S2-93
2-7-98 Removed FA0907RA Schematic & changed FA0600RF to RG per RA-RB ECO

CLF5000/PLL
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 bums, 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.

- This equipment must be powered only from a service capable of supplying 3 phase, 208VAC (3 wire plus ground), 50/60 Hz power. No neutral wire is used on this system. The power source must be able to sustain a 25A RMS per phase draw. The source must be protected by an appropriately sized circuit protection device having a 10,000 symetrical Amp Interrupt Current (AIC) rating.

- 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.

- When installed as intended and secured by the eight front panel mounting screws, the unit can withstand shocks and accelerations. Unit must be installed such that it is supported fully along both bottom side edges of the chassis, at least 2 inches in, by a suitable angle bracket on shelf.

CE Mark Specific Safety Requirements

- This equipment meets all applicable safety directives (as specified in prEN50178) required to qualify for the application of the CE marking.

- This equipment must be installed in accordance with the applicable requirements, or prEN50178 and EN60204-1 / IEC-204-1.

- This equipment is qualified to operate at Pollution Degree II and Insulation Category II.

- This equipment is intended to be powered only from a 208 VAC, 3 Phase (3 wire plus ground) service with no neutral connection used. For use at other voltages, a safety isolation transformer must be used to power this equipment in accordance with the requirements of EN60742 / IEC-742.

- The installation of this equipment must assure that the AC power input connector (UL/CSA) is not accessible to the user/operator. Access may be gained only by a qualified service technician. AC Mains connector installation must be in accordance with local requirements.

- This unit provides appropriate separation between all interface, mains and output circuits in accordance with 5.2.18 of prEN50178.

AC Interlock System

- The low voltage (24 VAC) 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 CLF5000/PLL RF amplifier operates at a center frequency of 400 kHz. 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.

A. Electrical Specifications

1. Output Frequency

    1.1 Center Frequency: 400 KHz

    1.2 Frequency Range: +/- 50 KHz

    1.3 Frequency Stability: Frequency deviation due to PLL loop dithering less than 50 Hz

    1.4 Frequency Tuning Mechanism: VCO driven by phase detector at RF output

2. Output Power

    2.1 Rated Output Power: 5000 Watts into 50 ohm load over frequency range

    2.2 Output Impedance: 50 ohms

    2.3 RF Power Margin: 6000 Watts min., open loop

    2.4 Mismatch Power: 1000 watts Minimum Forward Power into any load

    2.5 Spurious Output: all spurious output to be more than 30 dB below fundamental

    2.6 Noise, Hum and Ripple: Less than 1% at any power level

    2.7 Harmonic Output: Less than 20 dB below fundamental

    2.8 AC to RF Efficiency: Better than 70%

3. Control

    3.1 Control Range: 0 -10 V range for 0-5000W RF output

    3.2 Power leveling Control on Delivered power to be measured by direct four-quadrant multiplication of RF output voltage and current.

    3.3 Command to actual output power repeatability for same generator: < .5%

    3.4 Generator-to-generator command to actual output variation: +/- 3% of reading

    3.5 RF Output turn - on time: Approx. 1-2 second ramp time from RF Enable signal to rated output power.

    3.6 Power response to set point change time: Approx. 10ms

    3.7 Warm-up delay Time: Less than 100ms

4. Power Amplifier

4.1 Output device protection by means of active device current limitation, active voltage limitation, output power limitation, active reflected power limitation, over-temperature limitation, and passive device snubber circuits. These features enable the generator to encounter any load condition without failure.

4.2 5000 Watts output power is attained through the summed output currents of four 1250 Watt RF power amplifiers. Each power amplifier is comprised of eight FETs capable of 340 Watts dissipation each, arranged in a push pull configuration with four FETs per side in parallel. Each device runs at about 50 watts dissipation under normal operating conditions. Each device can withstand 300 volts from drain to source with the active voltage limit circuitry set for 175 volts MAX. Each power amplifier is current - limited to 40 Amps.

4.3 Each 1250 Watt power amplifier is built upon a solid copper heatsink block that is naturally corrosion resistant. Four 4" fans reduce any possibility of condensation developing internally in the unit.

4.4 Two different manufacturer's FET devices to be qualified in specified unit.

5. Input Power Requirements

5.1 Electrical input requirements:
208 VAC, 3 phase
50/60 Hz
20 A

5.2 Manufacturers input specification:

5.2.1 Nominal Input: 208VAC, 3 phase, 50/60 Hz, 4 wire (3 wire with protective earth ground).

5.2.2 Voltage AC Input Range 195-225VAC

5.2.3 Input Fusing: 25 Amps Max.

5.2.4 Power Consumption: Approx. 7.5KVA

5.2.5 Power Consumption by RF Generator at rated output: Less than 1.5KW to be dissipated via water cooling. Less than 500 watts to be dissipated by internal fan air cooling.

5.2.6 Grounding: AC grounded via AC Line Connector. PE/Safety 1/4" ground stud provided at back panel.

6. Front Panel Controls & Indicators

6.1 AC On Indicator: Green LED indicates AC power on.

6.2 RF On Indicator: Green LED indicates RF power is enabled.

6.3 Remote/Local Indicators: Yellow LED indicates control status.

6.4 Fault Indicators: Yellow LED's indicate fault conditions of over-temp, over-voltage, over-current, and over-power.

6.5 Local RF enable toggle switch.

6.6 Local power control pot.

6.7 Monitor meter with select switch: Digital panel meter measures 4-way switch selectable - delivered RF power, reflected power, output frequency, Local or Remote setpoint.

7. Remote Analog Interface

Pins 25(+) & 12(-), FWD OUT: Linear 0-10 differential analog out representing 0-5KW RF output forward power. 1K output impedance.

Pins 24(+) & 11(-), RFL OUT: Linear 0-10 differential analog out representing 0-5KW RF output reflected power. 1K output impedance.

Pins 23(+) & 10(-), DEL PWR OUT: Linear 0-10 VDC differential analog out representing 0-5KW RF output delivered power. 1K output impedance.

Pins 22(+) & 9(-), SETPOINT IN: 0 - 10 VDC volt differential analog input giving linear response to 0-5KW delivered output power. 10 K input impedance.

Pins 21(collector) & 8(emitter), MAX POWER LIMIT: Opto isolated digital output representing an output delivered power condition over 5.1KW.

Pins 20(collector) & 7(emitter), OVERTEMP: Opto isolated digital output representing a latched over-temp condition. RF must be disabled via RF ENABLE IN to reset overtemp latch.

Pins 19(collector) & 6(emitter), RF ENABLED OUT: Opto isolated digital output representing RF has been enabled via RF ENABLE IN.

Pins 18(cathode) & 5(anode), RF ENABLE IN: Opto isolated digital input that enables RF output. Activate input to enable. 2K input impedance.

Pins 17(anode) & 4(cathode), REMOTE SELECT: Opto isolated digital input to enable remote operation. Activate for remote. 2K input impedance.

Pins 16(anode) & 3(cathode), FWD/DEL SELECT: Opto isolated digital input to select power control loop from delivered to forward. Activate for forward control. 2K input impedance.

Pins 15(+) & 2(RET), Aux 15VDC output, 50 mA available MAX.

Pins 14 & 1, INTERLOCK LOOP: For External control of generator AC contactor. Pull-in current at 24VAC is 350mA continuous (2A peak).

B. Mechanical Specifications

1. Size: nominal, standard 19" rack mount 16.75"W x 10.5"H x 24.125"D
(425 mm W x 267 mm H x 613 mm D)

2. Weight: 200lbs (91 kg)

3. Connectors:

    3.1 AC input connector: 4 Wire Hubbell male twist lock plug, Comdel P/N JH5005 (Hubbell CS6365) with 6 feet of power cord (UL/CSA/VDE rated).

    3.2 RF output connector: HN female

    3.3 Remote Interface Connector: 25 pin D-sub male on generator.

4. Warning Labels:

    4.1 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.

    4.2 Special marking available at customers specifications

C. Environmental Specifications

1. Operating Temperature & Humidity

    1.1 Operating ambient temperature/humidity/air pressure: 10 to 40° C, 5 - 85% humidity (non-condensing, no formation of ice), 86-106 kPa. Class 3k3 per prEN50178.

    1.2 Inlet Water Cooling Requirements: 7.6 l/m (2 GPM) @ 690 kPa (100 psi) max, 35° C Max. Heat load: 2KW = 114 BTU/MIN = 6840 BTU/HR

    1.3 Coolant type: Water

    1.4 Coolant Fittings: Swagelok, 3/8" tube fitting. Tighten per Swagelok specifications using Swagelok Inspection gauge part# MS-IG-600.

    1.5 Inlet Air Requirements: 5-35° C max (40-95° F). Heat Load: 500W = 29 BTU/MIN = 1750 BTU/HR

2. Storage and Transportation

    1.1 Storage Temperature/Humidity/air pressure: -25 to 70° C (class 1k4 per prEN50178), 5 - 95% humidity (non-condensing, no formation of ice, class 1k3), 70-106 kPa (class 1k4).

    1.2 Transport Temperature/Humidity/air pressure: -25 to 70° C, 5 - 95% humidity, 70-106 kPa (class 2k3).

3. 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 CLF5000/PLL 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 sixty 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.

A. RF Output Calibration Check

The CLF5000/PLL comes pre-calibrated from the factory and does not require any further adjustment. If you must check the calibration of the CLF5000/PLL, use the following procedure:

WARNING: Qualified personnel only should perform Calibration. Improper procedures could damage the unit or cause serious injury. There are no user adjustments inside the generator. Never operate this unit with the covers removed. Any calibration discrepancies should be reported immediately to Comdel customer service. **Trained Comdel technicians may only make corrective adjustments to this unit.**

1. Equipment required:

    1.1 Wattmeter

    1.2 2. 50 ohm dummy load capable of handling 5000 Watts.

    1.3 Two 50 ohm coaxial cables capable of handling 5000 Watts, one less than 10 feet long, and the other any length.

2. Setup:

    2.1 Disconnect AC Power to generator.

    2.2 Connect Wattmeter to output of Unit Under Test (UUT) with a 50 ohm coaxial cable no longer than 10 feet long.

    2.3 Connect dummy load to Wattmeter with a 50 ohm coaxial cable of any length.

    2.4 Disconnect any connector attached to the 25 pin ‘D’ Remote I/O connector at the rear of the unit and jump AC interlock pins 1-14.

    2.5 Connect AC power and cooling water.

3. Procedure:

    3.1 Flip ‘CALIBRATE’ toggle switch on right side of front panel up to ‘CALIBRATE’ or ‘450KHz’ position.

    3.2 Turn AC power on and enable RF with the front panel RF enable toggle switch.

    3.3 Turn power setpoint knob to 4000 Watts as indicated by the front panel meter with the meter switch in the ‘SETPOINT’ position.

    3.4 Verify actual output power as indicated on external Wattmeter to be 4000 Watts +/- 3% or +/- 120 Watts.

    3.5 Disable RF output and AC power.

    3.6 Return ‘CALIBRATE’ toggle switch down to the ‘AUTOTUNE’ position.

V. Preparation For Use

A. Line Requirements

The CLF5000/PLL is designed to operate from a 208 VAC, three phase line. The system will still function within specifications when the line voltage fluctuates between 195 volts and 225 volts. Voltages over the recommended 208 VAC, however, reduce the safe performance margins designed into the system and should be avoided. The system draws a maximum of 22 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 40^{o} 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^{0} C, and should not fall below a temperature where excess condensation could develop within the unit. Water volume should be at least 7.6 l/m (2 GPM) and pressure kept below 414 kPa (60 PSI).

C. Installation Requirements

Prior to energizing the RF output perform the following safety checks:

1. Confirm that an appropriate RF output cable is connected from the RF output connector of the generator to the system head or load. The RF interlock cover must be securely in place to allow operation of the unit.

2. Check all cooling system piping and fittings for possible leaks. The preferred method is to pressurize the entire cooling system with air and observe any loss of pressure prior to exposing the system to liquid flow. The minimum air pressure used for testing should be at least equal to the maximum rated pressure of the system.

3. Confirm that the remote control cable attached to J1 on the rear of the unit is securely in place. This cable completes the interlock circuit as well as supplies RF enable commands to the generator.

4. Assure that the AC power connection is securely in place.

5. Test the interlock circuit to confirm that it is functioning properly. The interlock may be interrupted via the interlock switch (CB2) on the front panel of the generator. Confirm that the RF enable signal is disabled at the remote interface to the generator when an interlock fault condition occurs. Confirm that AC power in the generator is dropped when the interlock fault occurs. Confirm that the RF enable signal is held disabled by the host system after the interlock fault is cleared until it is intentionally reset by the operator.

6. Confirm that all applicable safety labeling is in place as required by the end user's local fire department jurisdiction and Occupational Health and Safety Administration (OSHA).

VI. Operating Instructions

The CLF5000/PLL may be operated either locally at the front panel, or remotely through the 25 pin sub-miniature D connector (J1) on the rear panel.

A. Local Operation

NOTE: AC interlock Pins 1-14 must be jumped for the unit to be operated.

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. Assure that RF interlock cover is installed and secured.

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

3. Turn on interlock circuit breaker on front panel and verify that red AC ON LED and the yellow LOCAL LED light are on. If the yellow REMOTE LED is lit instead of the yellow LOCAL LED, remove any connection to the REMOTE/LOCAL control lines, Pins 17 & 4 of the rear panel analog remote 25 pin 'D' connector.

4. RF ENABLE should activate, and the red LED should illuminate when RF Enable toggle switch is pulled out, then up.

5. RF is disabled by pulling out and toggling down the front panel RF ENABLE toggle switch, or by interrupting the AC mains via the AC interlock loop (Pins 1 & 14 of rear panel 'D' connector), the front panel interlock circuit breaker, or the circuit breaker located on the rear panel.

6. The CLF5000/PLL regulates delivered power based upon the setpoint selected by the front panel power control knob.

7. The front panel digital meter and selector switch shows power level setpoint, actual delivered power, output frequency, and reflected power.

8. An overtemp condition due to lack of coolant flow or high coolant temperature will automatically disable RF output of the CLF5000/PLL. The front panel OVERTEMP LED will light. The remote overtemp indicator at J1 will respond. RF will be disabled until proper coolant flow/temperature is established, and either the AC power or RF enable signal is recycled.

B. Remote Control Operation

Refer to above "Electrical Specification," Section II.A.7 for electrical interface specification. For remote control operation follow the first two procedures for local control as listed above.

1. Turn on interlock circuit breaker on the front panel and verify that the red AC POWER LED lights.

2. Energize Pins 17 & 4 of rear panel I/O connector as outlined in Section II.A.7. The red RF ENABLE LED should illuminate, and readings of delivered and reflected power and frequency should be appropriate.

3. The power setpoint voltage on Pin 22(+) and 9(-) of the rear panel connector will determine the output power level. A voltage of 0 to 10 volts DC across Pins 22 and 9 will linearly correspond to a RF output of 0 to 5000 watts.

4. Reflected, delivered, and forward power can be monitored remotely through Pins 24(+) & 11(-), 23(+) & 10(-), and 25(+), 12(-) respectively. All of these balanced analog outputs are 0 to 10 VDC linearly corresponding to 0 to 5000 watts of RF power.

5. An overtemp condition as stated in #8 above in LOCAL will also result in the 'closure' of the OVERTEMP DIGITAL OUTPUT, Pins 20(collector) and 7(emitter) of the rear panel connector. The digital output opto-isolator will be turned on.

6. When RF is present at the RF output connector, the POWER DELIVERED DIGITAL OUTPUT, Pins 19(collector) and 6(emitter), will also be turned on.

7. When Maximum RF output power (over 5100 watts) is present at the RF output connector, the MAX POWER DIGITAL OUTPUT, Pins 21(collector) and 8(emitter), will also be turned on.

VII. Theory of Operation

The CLF5000/PLL is a low frequency power amplifier for use in OEM applications. The power source consists of DC power supplies, a pulse width modulating - voltage controlled oscillator, four - 1250 Watt push-pull power amplifiers running in parallel, and associated control systems and monitoring circuits. The main power DC supply and current monitor reside in a separate compartment in the bottom half of the unit with all other components in the top half.

The radio frequency signal is generated locally on the front panel CLF controller. From this assembly, the signal is split four ways and goes to four LF1250 power amplifiers (PAs). The output of these four power amplifiers are combined in parallel and matched to 50 ohms through a 6 pole low-pass filter. Control signals are obtained from the output signal as it passes through the power monitor board to the RF output connector. The front panel CLF 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 sensors, PA current monitor, and PA overtemp switch. Refer to FP1541RX, CLF5000/PLL BLOCK DIAGRAM to see how the individual modules are connected together.

A. Interlock System

Refer to the “Safety Information” section of this manual for a detailed description of the interlocks.

B. DC Power Supplies

There are four DC supplies in the CLF5000/PLL RF generator. The primary RF power DC supply consists of a 3-phase transformer T2, 3-phase full-wave bridge rectifiers BR1 & BR2 and a low-pass filter C1, C2, & C3. Low voltage control power is produced by three single-phase bridge rectifiers BR1, BR2, & BR3 (see Fig. FA0302RX), filters C1, C3, & C5, and regulators VR2, VR3. This provides positive 15 volt, negative 15 volt (respectively) sources for the front panel control assembly (FA0600RX) and a 12 volt source (VR1 & VR4) for the RF power amplifier (FA0003RX) gate drive circuits.

The outputs of the DC supplies are:

1	44 VDC Unregulated	Unloaded
	37 VDC Unregulated	200 amps (@5000W RF output)
1	+15 VDC Regulated	250 mA max
1	-15 VDC Regulated	250 mA max
1	+12 VDC Regulated	1A max

The high current required by the RF power amplifiers (PAs) is monitored by the HALL EFFECT CURRENT MONITOR PCB (Figure FA0509) mounted in the bottom half of the unit. This PCB uses four

Hall effect devices (HE1-HE4) to separately monitor the DC currents feeding each 1250 watt RF power amplifier.

C. Front Panel Control Board

The front panel control board (Figure FA0600RX) has six parts, a frequency controlled, pulse-width modulator, circuitry for output power control, monitoring circuitry for protection, frequency measuring circuitry, metering circuitry, and remote interface circuitry.

The frequency controlled pulse-width modulator U1 provides the digital drive signals that run the four 1250 Watt power amplifiers. This circuit determines the RF output frequency and RF output power. This IC also provides a soft-start function that slowly (1 second) ramps the power up to the setpoint when RF is enabled. R35, R36, and C11 and the voltage applied to varactor diodes D54 & D64 determine the output frequency. Voltage to the non-inverting input Pin 2 of U1 determines the PA drive pulse-width (output power).

The power control circuitry smoothes output power and stabilizes it against line and load variations. Control is achieved through U3D, the OP400 operational amplifier. This op-amp compares the delivered power signal (from the power monitor board, FA0132RX) to that of the DC reference level (setpoint) at the summation point of R24 & R32. The setpoint is from either the front panel potentiometer or from Pin 22(+) & 9(-) of the rear panel 'D' connector as determined by LOCAL/REMOTE relay K2.

Monitoring circuitry for power amplifier protection is composed of five parts: RF output transistor over-voltage control, over-current control, reflected power control, peak power control, and over-temperature control. These separate functions are controlled respectively by U5D, U5A&B, U5D, U5C, and K3. In each circuit, RF output is limited by reducing setpoint at summing junction R24 & R32 The over-temperature circuit also disables RF output and stays latched until the RF enable signal from either front panel toggle or rear panel Pins 17 and 4 is turned off.

The output frequency of the pulse-width modulator U1 is monitored by a frequency to voltage converter, U8. The circuit is calibrated by pot R95.

Four-way meter switch S2C enables the user to monitor delivered power, reflected power, output frequency, and setpoint. Op-amp U4B serves as a high input impedance buffer amplifier for the front panel meter. Meter calibration is provided by R45.

Remote control analog interfaces are provided by op-amps U3B, U2C, U2A, & U2B. These op-amps provide differential inputs (setpoint in) and outputs (delivered power, forward, & reflected power) respectively. Opto-isolators ISO1D, ISO1C, ISO1B provide digital inputs (RF ENABLE, REMOTE/LOCAL SELECT, DELIVERED/FORWARD POWER CONTROL) and ISO2B, ISO2A, & ISO1A provide digital outputs (OVERTEMP, MAX POWER, RF OUTPUT ENABLED) respectively.

D. LF1250 Power Amplifier

There are four LF1250 power amplifiers (FA0003RX) in the CLF5000/PLL. This amplifier is an eight device push-pull Class 'D' amplifier, with all devices mounted on a water-cooled copper heatsink. Each device (transistor) is rated to produce over 300 Watts of power, giving a total potential output power of 2500 watts per amplifier. Four of these amplifiers are used in the CLF5000/PLL to give a large margin of reliability and immunity to large load impedance fluctuations and gives the CLF5000/PLL the ability to deliver large amounts of power into less than ideal load conditions. The output devices are FETs with paralleled gates. The gate drive consists of two FET gate drive ICs U1 & U2. Peak voltage detector diodes D9 & D10 are used by the front panel monitoring circuitry to limit peak voltages seen by the devices. The output impedance of the LF1250 amplifier is about 15 ohms.

E. Output Filter

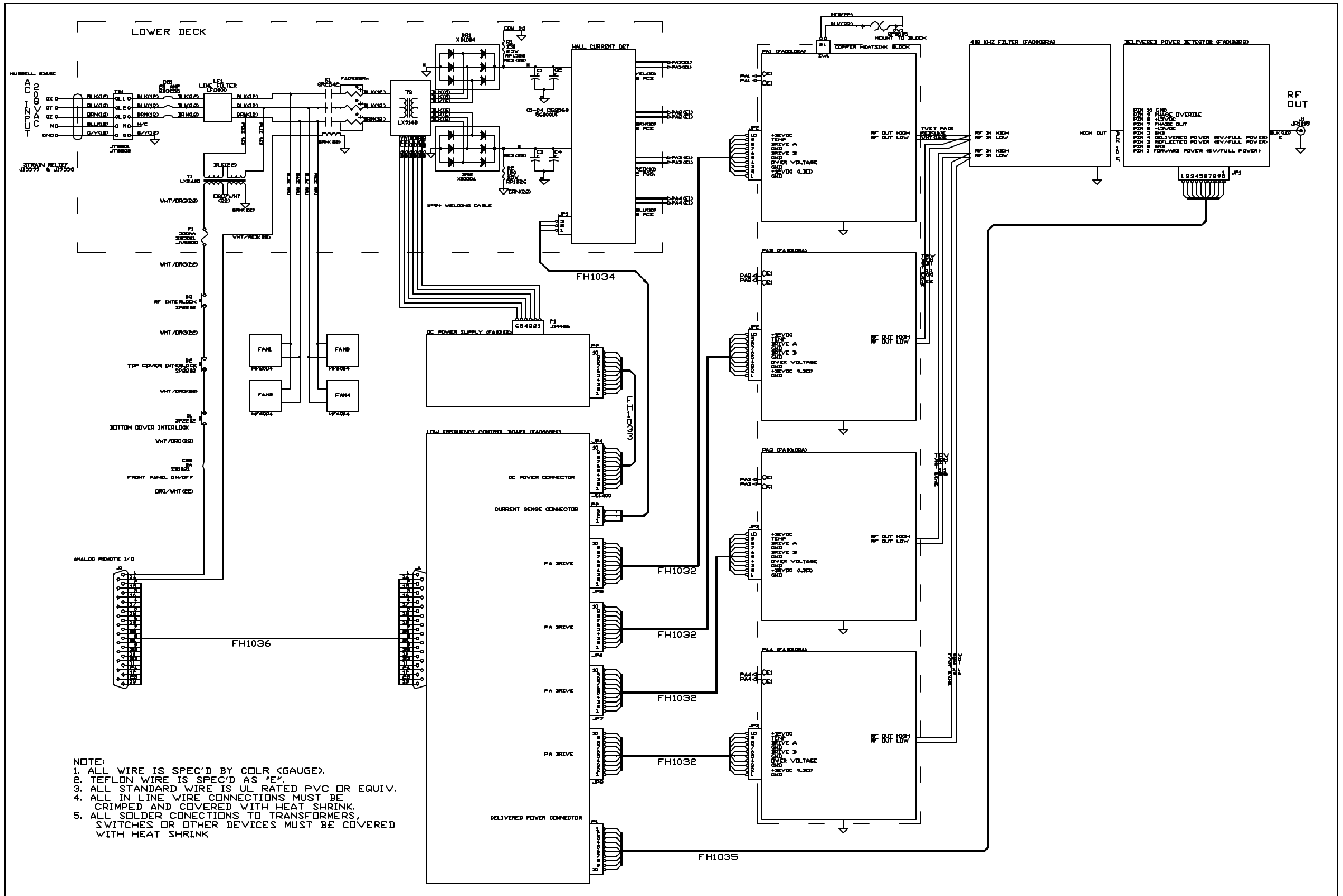
The output filter of the CLF5000/PLL performs two functions. The first is to provide low pass filtering to the square-wave outputs of the power amplifiers to provide RF power with low harmonic components. The second is to provide an effective 1/4 wave-length line section to effect a real-part impedance reversal to provide a maximum output voltage when the load impedance is high. The input impedance to the filter is about 4 ohms and the output is impedance is 50 ohms. The filter is made of 3 'L' networks in series.

F. Power Monitor Board

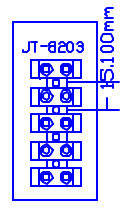
The power monitor board (Figure FA0132RX) is a detector that produces voltages which are proportional to actual delivered RF power, forward power, and reflected power. In addition, there is an output which provides a relative indication of the phase relationship of the RF output voltage and current. The signal from the delivered power detector is produced from current and voltage taps off the output line which are multiplied with a four quadrant multiplier, U1 and buffered with U3A. Reflected power is derived by summing a voltage tap with a current tap which is 180 degrees out of phase with the voltage tap. This summed voltage is then squared with four-quadrant multiplier U2 and buffered with U3B. Forward power is derived by summing the delivered and reflected output signals via U3C. The phase detector is obtained by driving a center-tapped current transformer with a voltage tap 90 degrees from the actual RF output voltage and rectifying the 0 degree and 180 degree outputs of the current transformer. One side of the current transformer is rectified to a positive polarity and the other side to a negative polarity. When these two rectified signals are summed, the resulting output represents (bipolar) the phase relationship of the actual RF output voltage and current. This summed signal is amplified and buffered with U3D.

VIII. Certification

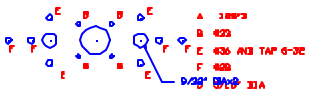
This unit is designed and labeled in compliance with CE mark certification requirements. The manufacturer will supply a Declaration of Conformity as required.

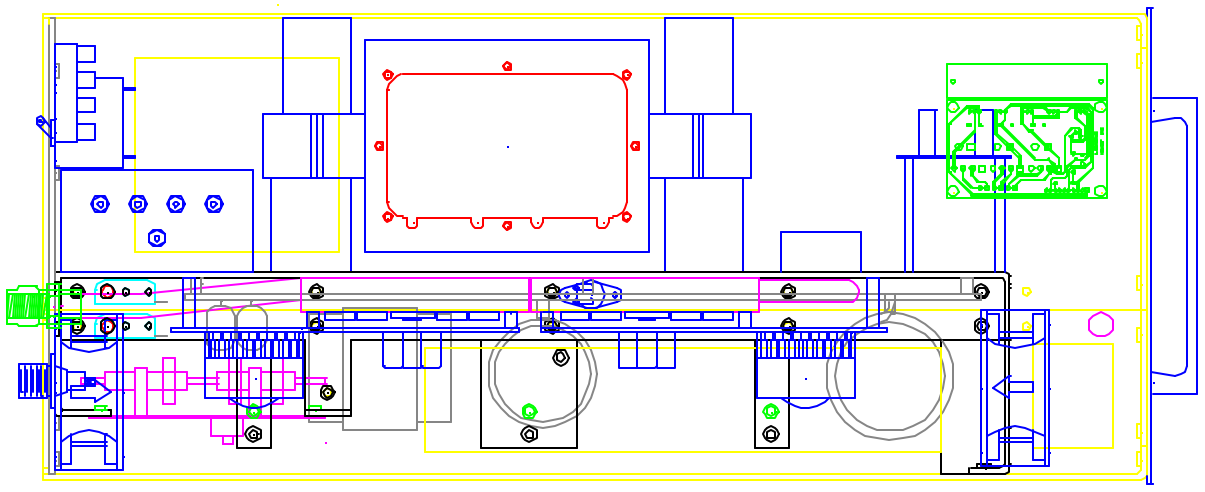


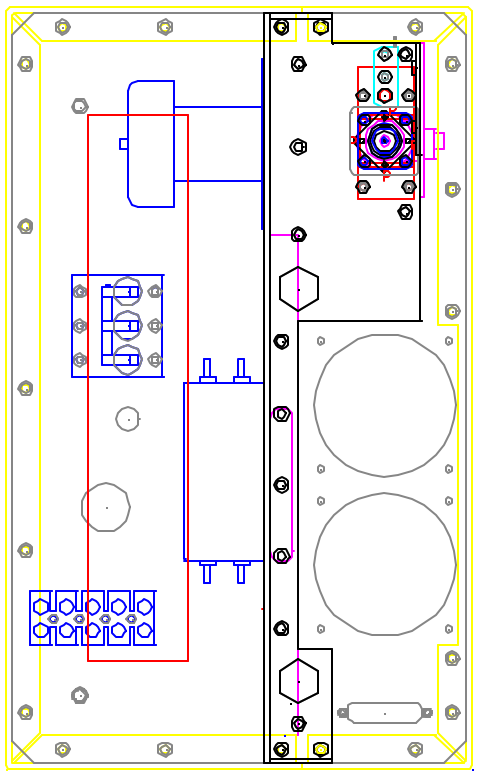
COMTEL INC		
34 NORELIN ROAD		
BLAUVELT, NY 10913		
Title: 6LP 6KV BLOCK DIAGRAM W/FRAME LOCK		
SIZE: D	DOCUMENT NUMBER: FP13GRD	REV: D
Date: FEBRUARY 24, 2010	Sheet: 2 OF 2	

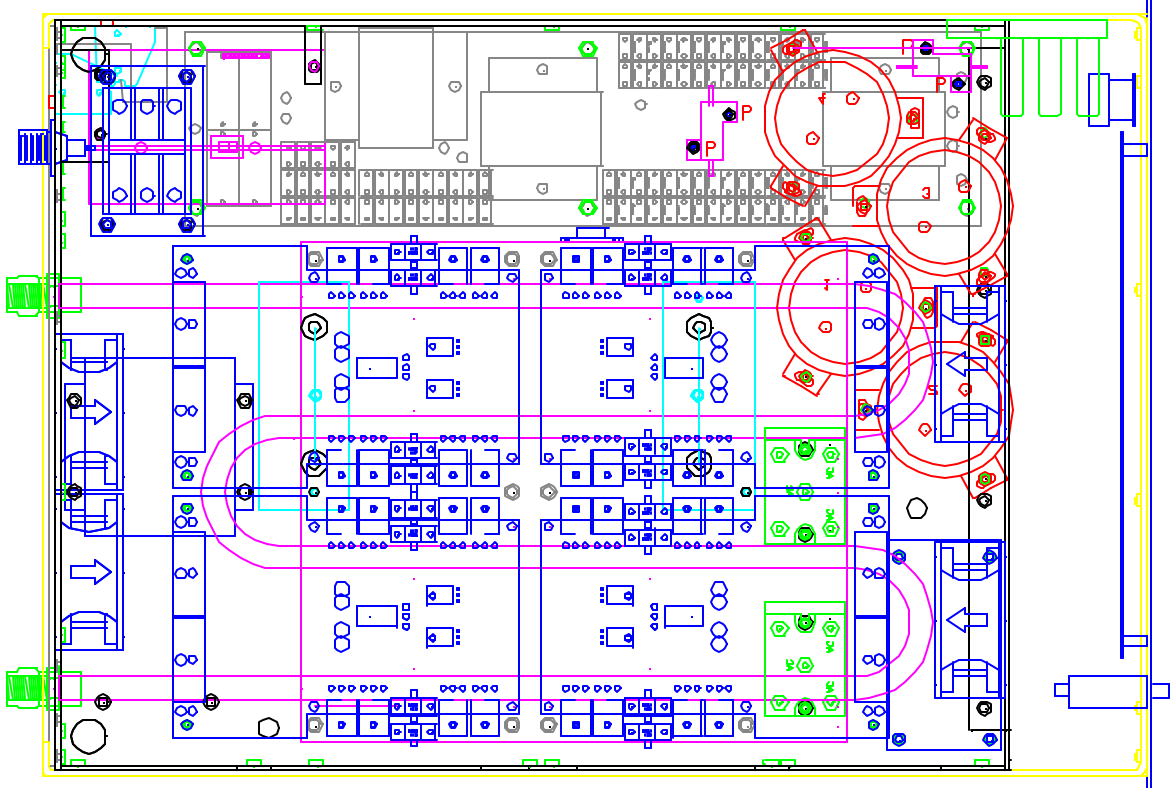


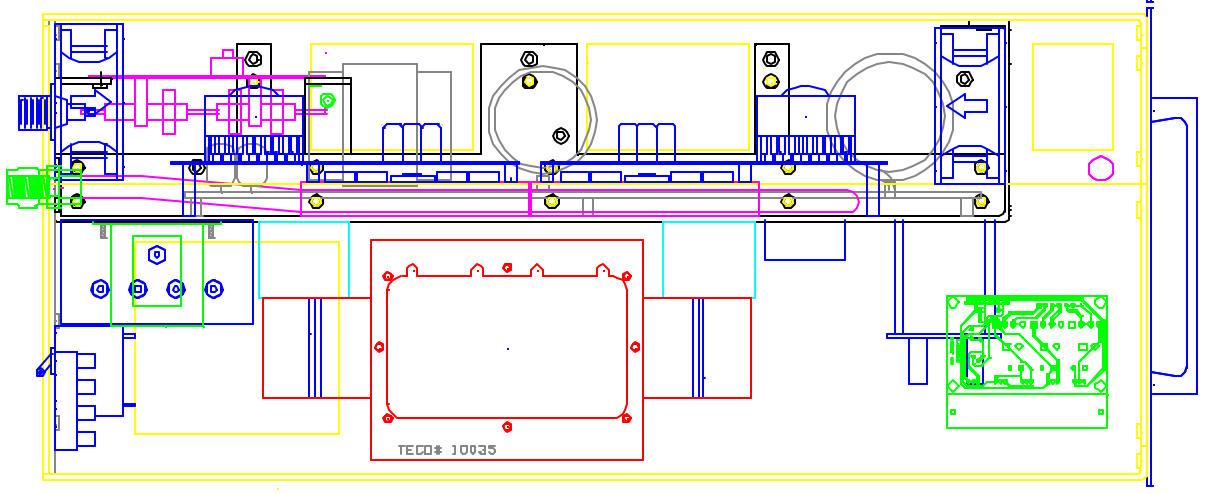
HEYCO L5MM
CANDEN 14 5MM

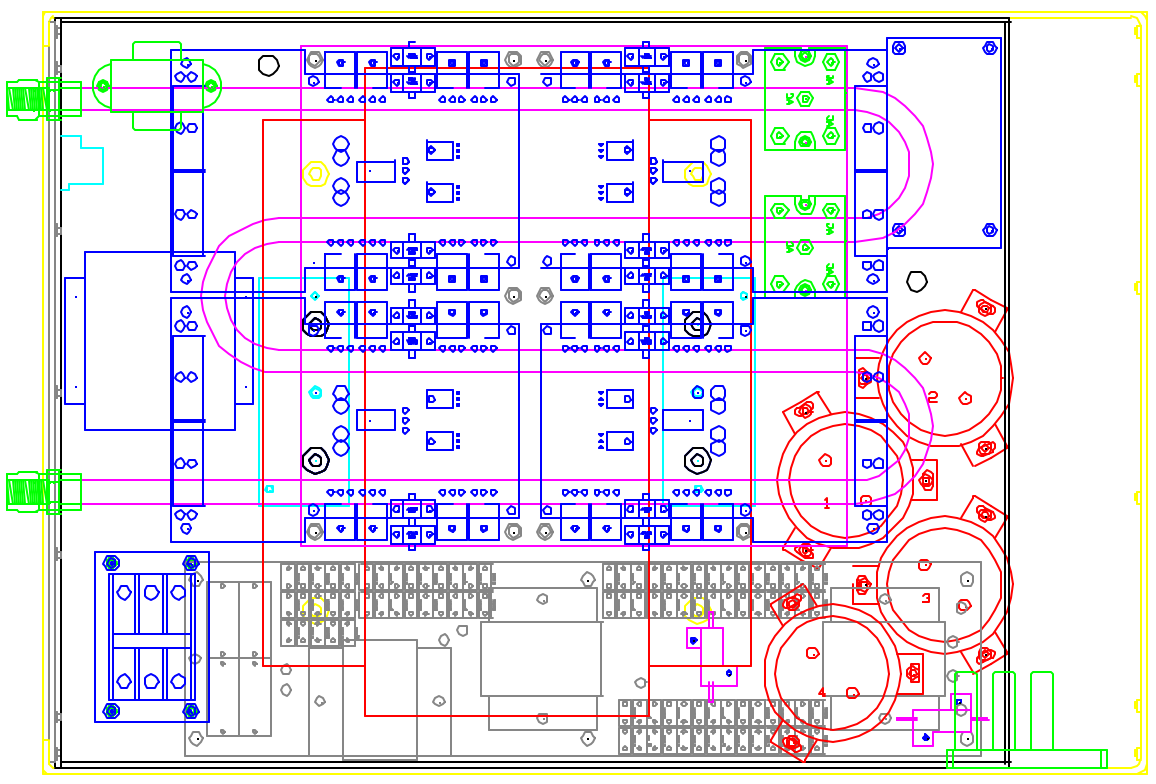


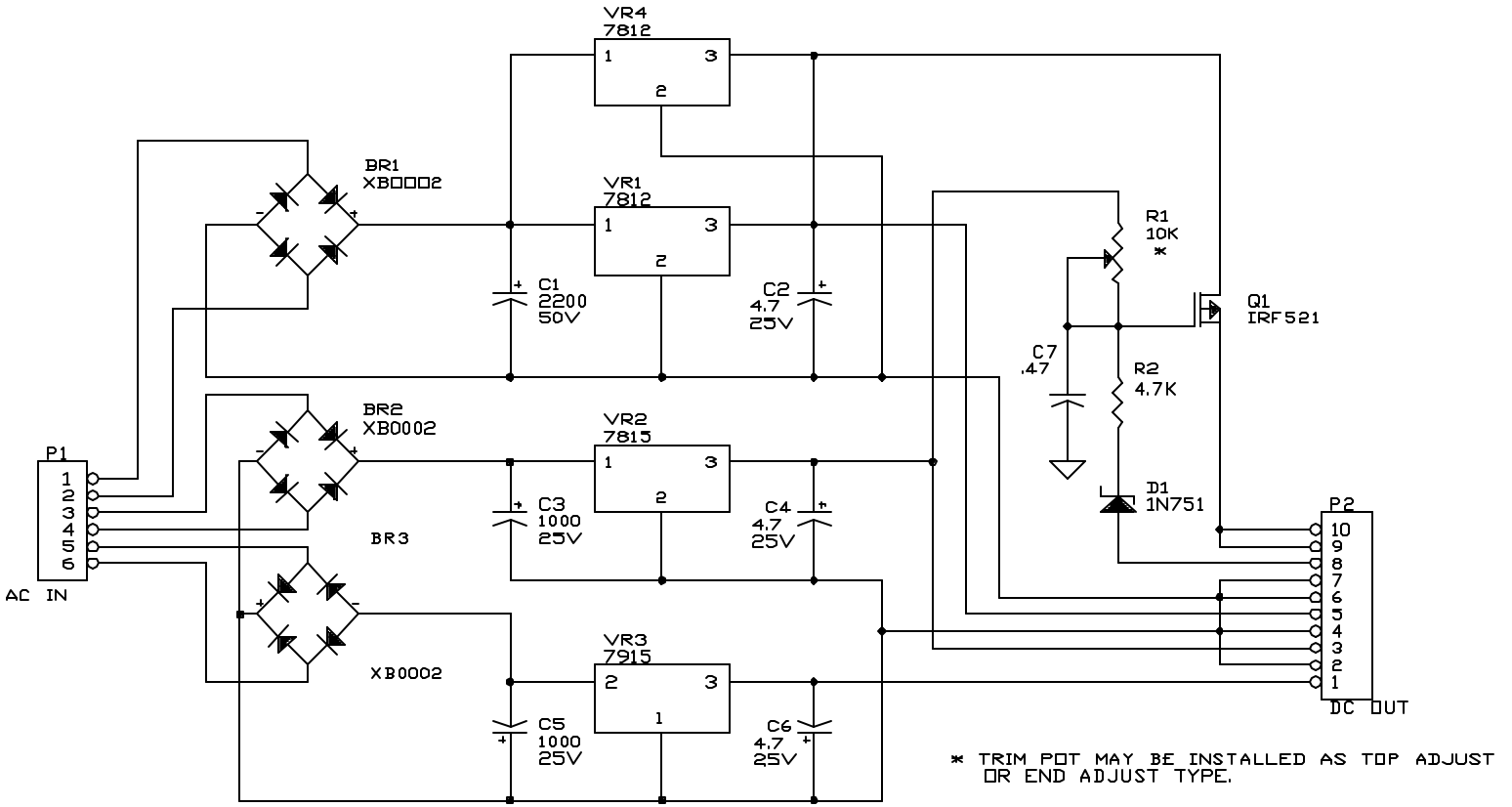




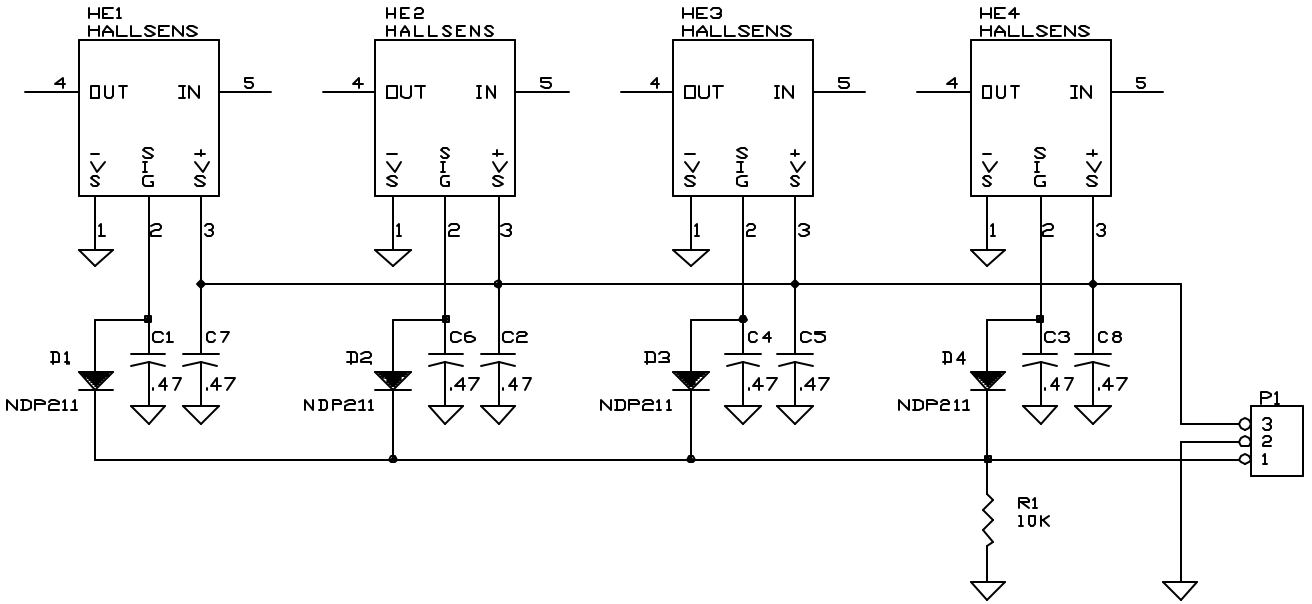




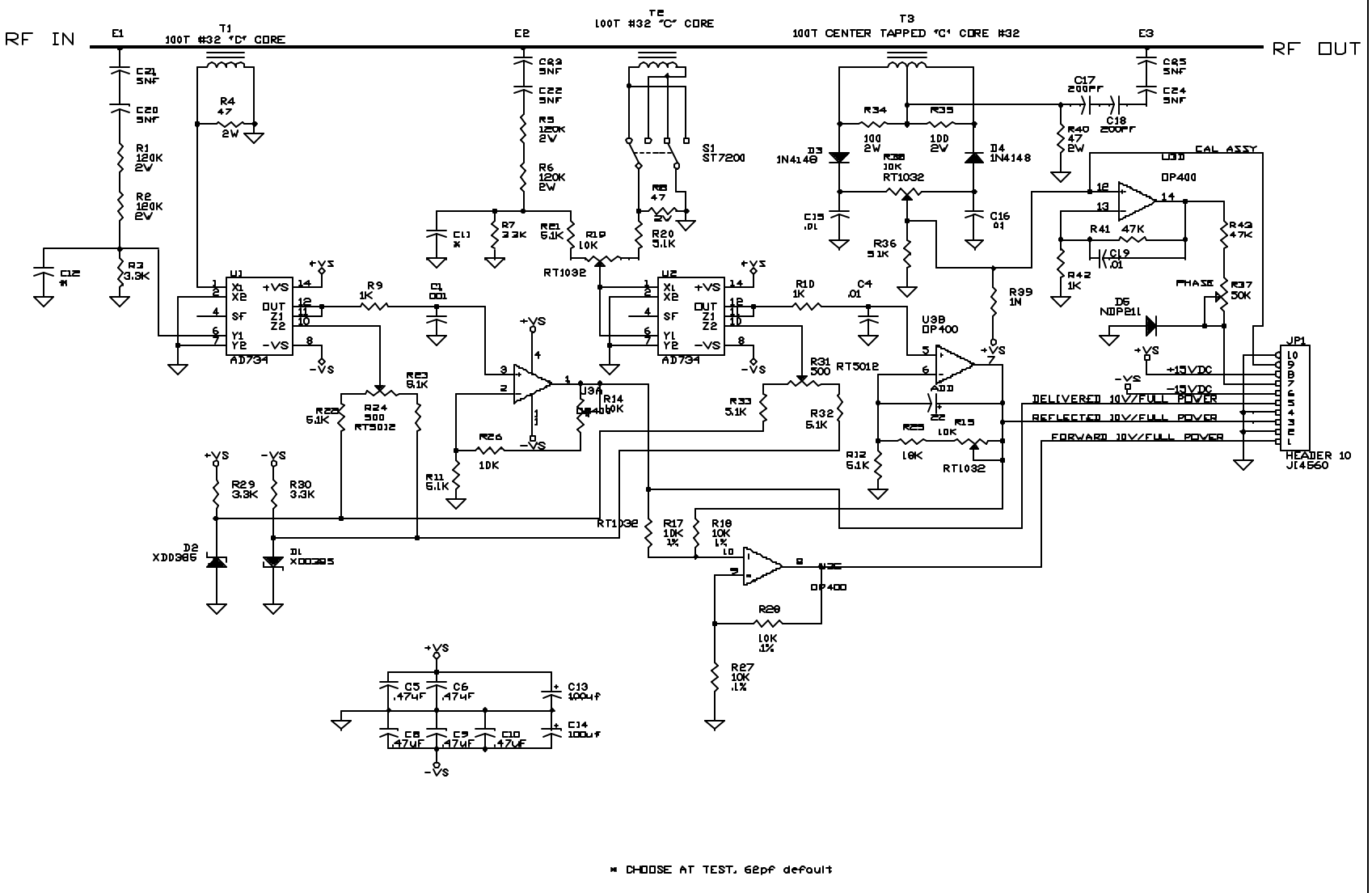


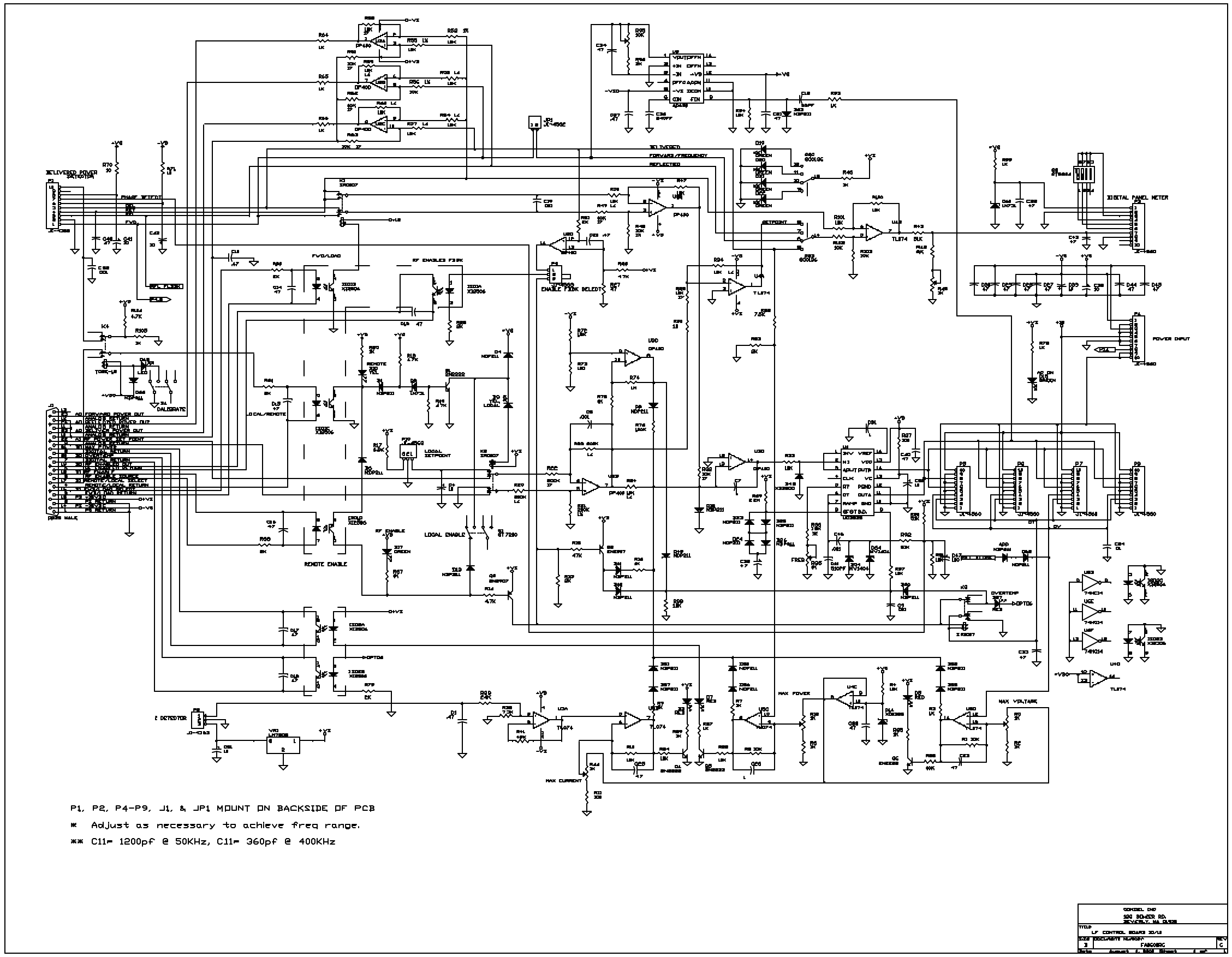


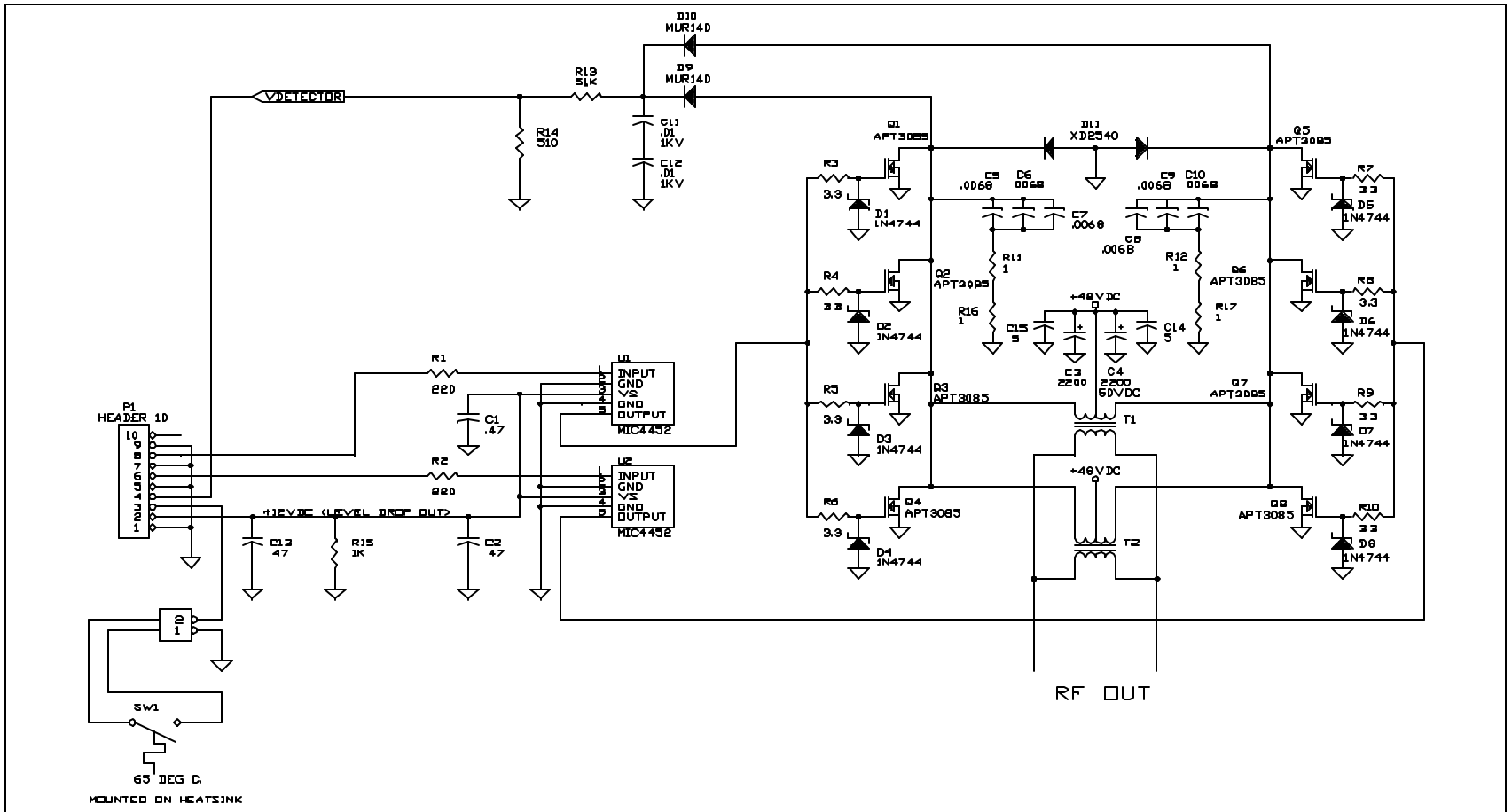
COMDEL INC 126 SOHIER RD. Beverly MA 01915		
Title: CLF DC POWER SUPPLY		
Size: A	Document Number: FA0302RB	REV: B
Date: May 15, 1997	Sheet 1 of 1	



COMDEL INC 126 SOHIER RD. BEVERLY, MA 01915		
Title: HALL CURRENT SENSE		
Size: A	Document Number: FA0509	REV: 0
Date: January 19, 1996	Sheet 1 of 1	


RF IN
RF OUT
T1
100T #32 "C" CORE
T2
100T #32 "C" CORE
T3
100T CENTER TAPPED "C" CORE #32
E1
E2
E3
AD734
OP400
RT1032
RT5012
1N4148
HEADER 10
J14560
DELIVERED 10V/FULL POWER
REFLECTED 10V/FULL POWER
FORWARD 10V/FULL POWER
+15VDC
-15VDC
* CHOOSE AT TEST. 62pf default
COMPEL INC
11 KONDELIN RD
GLOUCESTER,MA 01930
LF POWER DETECTOR W/PHASE DETECT DE VER
Document Number
FA0139R5
March 8, 2001
Sheet 1 of 1


DELIVERED POWER DETECTOR
PHASE DETECDT
FWD
REFLECTED
FWD/LOAD
RF ENABLES F39K
ENABLE F39K SELECT
REMOTE
LOCAL/REMOTE
LOCAL SETPOINT
LOCAL ENABLE
REMOTE ENABLE
RF ENABLE
DELIVERED
FORWARD/FREQUENCY
REFLECTED
SETPOINT
3D DIGITAL PANEL METER
POWER INPUT
DIVERTEMP
OPTO6
MAX POWER
MAX VOLTAGE
MAX CURRENT
F DETECTOR
DALSGRATE
P1, P2, P4-P9, J1, & JP1 MOUNT ON BACKSIDE OF PCB
* Adjust as necessary to achieve freq range.
** C11= 1200pf @ 50KHz, C11= 360pf @ 400KHz
CENCOM, ENG
100 BOSTON RD.
BILLERICA, MA 01821
TITLE
LF CONTROL BOARD 30/10
SIZE
B
DOCUMENT NUMBER
FABCOMBC
REV
C



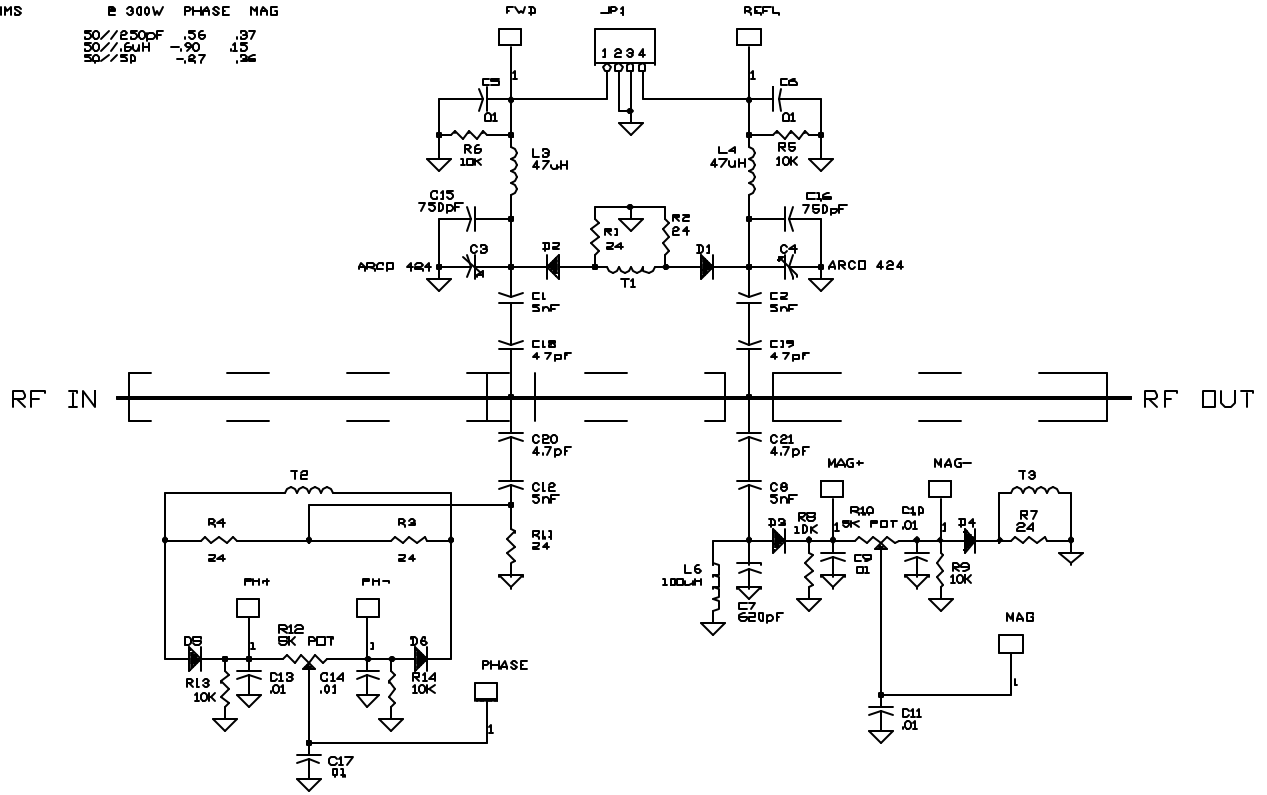
COMDEL INC 11 KONDELIN RD. GLOUCESTER, MA 01930		
Title LF1250 PA, WATER-COOLED		
Size B	Document Number FA0003RD	REV D
Date: April 25, 1997	Sheet 1 of 1	

@ 1000w INTO 50 OHMS

Vp	3.1
Vdc	1.7
Vn	-2.5
Vpp	8.1
Vpk	-1.46
f	155

@ 300W PHASE MAG

50//250pF	.56	.37
50//.6uH	-.90	.15
50//3p	-.97	.16



T1, T2 AND T3 50 TURNS ON 7/8" DIA H CORE

INSTALL D3, D4, D5 AND D6 OPPOSITE SILK SCREEN

ALL DIODES ARE MDP211

CONDEL INC 11 KONDELIN RD. GLOUCESTER, MA 01930		
Title: POWER MONITOR FOR CPM-5000		
Size: B	Document Number: FAP1PPR9	REV: R
Date: August 24, 1999	Sheet 1 of 1	