SIEMENS

30 kW/20 A
L-828 Constant Current Regulator

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Manufactured per FAA Specification
FAA-E-2689A

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RECORD OF CHANGES

Page	Rev.	Description	Chkd	App'd
3-1 thru 3-9, 8-2, 8-3, 10-7, 10-8	D	EC 3314: Revised theory of operation. EC 3461: Added Fuse F5 to text and Figures 7 and 8.	TN	VP
Title page	E	ECO 00822. Converted title page to conform to Siemens standards for manuals. Changed company name from ADB to Siemens Airfield Solutions.	JY	WT

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SAFETY NOTICES

The operating and maintenance personnel should refer to FAA Advisory Circular AC 150/5340-26, "Maintenance of Airport Visual Aids Facilities" for instructions on safety precautions. Personnel must observe the safety regulations at all times. All operations on this unit shall be carried out by personnel qualified to work on high voltage equipment. While every practicable safety precaution has been incorporated in this equipment, the following rules must be strictly observed:

KEEP AWAY FROM LIVE CIRCUITS

Operating and maintenance personnel must at all times observe all safety regulations. Do not change plug-in components or make adjustments inside equipment with high voltage supply on. To avoid casualties, always remove power, then discharge and ground by use of a grounding rod, prior to touching any parts. See FAA Advisory Circular AC 150/5340-26 concerning safety.

RESUSCITATION

Operating and maintenance personnel should familiarize themselves with the technique for resuscitation found in the First Aid Instruction Manual.

WARRANTY

Siemens Airfield Solutions, Inc. warrants that the 30 kW L-828 Constant Current Regulators described herein, when sold by Siemens Airfield Solutions, Inc. or its approved representatives, will perform in accordance with FAA specification FAA-E-2689A, and that any defect in design, materials or workmanship which may occur during proper and normal use during a period of one (1) year from date of installation or a maximum of two (2) years from date of shipment will be corrected by repair or replacement by Siemens Airfield Solutions, Inc., f.o.b. factory. Damage resulting from improper installation does not constitute proper and normal use and is not covered by the warranty. Such corrections shall constitute the limit of all Siemens Airfield Solutions, Inc. liabilities for the L-828 Constant Current Regulators.

1. GENERAL INFORMATION AND REQUIREMENTS

1.1 INTRODUCTION

The Siemens Airfield Solutions, Inc. 30 kW air-cooled L-828 Constant Current Regulators (CCRs) are designed to supply five precision output current levels (20 amp maximum) for series lighting circuits on airport runways and taxiways. The output of the L-828 CCR is accurately regulated within ±1% of the adjustable nominal current levels (see Table 1-1) from no load (short circuit) to full load and with input voltage variations of -10% to +10% of nominal. Output current levels are maintained even if 30 percent of the isolation transformers in the series lighting circuit supplied by the regulator have open secondaries.

1.1.1 Purpose

This manual describes procedures for the installation, operation, maintenance and troubleshooting of Siemens Airfield Solutions, Inc. manufactured 30 kW L-828 Constant Current Regulators.

1.1.2 Scope

This L-828 CCR described in this manual are manufactured to FAA specification FAA-E-2689A Operation outside the design limitations of this specification may result in degradation of performance, damage or failure of regulator components or hazardous conditions.

1.2 CONSTRUCTION

A painted steel-frame cabinet houses the power components (transformer and capacitors) and the control logic necessary to monitor and regulate the output current level. The control logic is contained in plug-in modules in the card rack and is divided into separate modules: the Input Module PCB, the Current Controller PCB, and Monitoring Module PCB.

1.3 MODULES

1.3.1 Input Module PCB

The Input Module printed circuit board (PCB) receives:

- Remote control signals
- Output current
- 240 Vac signals.

The Input Module PCB outputs the following signals to the Current Controller PCB, Monitoring Module PCB and Remote Monitoring System (RMS):

- Supply voltage for the input control logic
- A signal proportional to the output current
- DC power to all circuit cards
- Signal to prevent overcurrent from occurring in case of OFF switching
- A signal to set the output current according to the brightness setting
- Required and fault isolation RMS circuitry for remote trouble shooting

1.3.2 Current Controller PCB

The Current Controller PCB receives signals from the Input Module PCB and performs the following functions:

- Produces SCR-drive signals in accordance with the signals from the Input Module PCB
- Detects an overcurrent, open circuit, and switches the CCR off
- Provides a signal to the Monitoring Module if overcurrent is detected and a DC signal proportional to the output current
- Required and fault isolation RMS circuitry for remote trouble shooting

1.3.3 Monitoring Module

- The Monitoring Module provides status signals (24 V high logic) indicating the actual status of the regulator and what commands have been activated. These signals are available on the "STATUS" terminal block with terminals labeled: COMMON, ON, B1, B2, B3, B4, B5 and REMOTE.
- Required and fault isolation RMS circuitry for remote trouble shooting.

1.4 Protective Devices

The following protective devices are provided on each regulator:

- Output open-circuit protection
- Output overcurrent protection
- Fuse protection of : regulator control supply on primary and secondary, the 240 Vac supplies of the Input Module, and status indication power supply.
- Lightning protection for input power and output to series circuit.

1.5 REGULATION

See Table 1-1 for output current limits. Current regulator is obtained under the following conditions:

- Load variations of zero (short-circuit) to full load with input voltage variations of -10% to +10%, at -10°C up to +50°C ambient temperature.
- With up to 30% of the series-load isolation transformers open-circuited (burned-out lamps).

Table 1-1. Output Current Levels

5-STEP CCR BRIGHTNESS CONTROL SWITCH POSITION	NOMINAL RMS OUTPUT CURRENT (amperes)	OUTPUT CURRENT LIMITS (amperes)
5	20	19.6 - 20.0
4	15.8	15.4 - 16.2
3	12.4	12.1 - 12.7
2	10..3	10.0 - 10.6
1	8.5	8.3 - 8.7

1.6 PANEL AMMETER

A true rms-reading ammeter mounted on the front of the Input Module indicates the output current. The screw on the face of the ammeter is for zeroing adjustment of the indicator needle.

1.7 INPUT POWER

The power transformer for L-828 CCRs is designed for an input voltage of 240/480 Vac, 60Hz, single phase. The input voltage must be accurately determined prior to ordering the regulators as no alternate input voltage taps are available.

Table 1-2. Equipment Data

FAA Type: L-828 (air-cooled) Constant Current Regulator (CCR)

Siemens Airfield Solutions Part Number: 44D2519-0000

Rating: 30 kW with taps for 25, 20 and 15 kW.

Input Voltage: 240/480 Vac, 60Hz, single phase.

Class 2 (20 A maximum output current)

Style 2—5 step (8.5, 10.3, 12.4, 15.8, & 20 A)

Power Factor: not less than 95%

Efficiency: Greater than 93%

Reactive Loading: The CCRs maintain the current within the limits of Table 1-1 for all brightness steps when the load is connected via isolating transformers, and secondaries of 30% of these transformers become open-circuited. The load before opening the isolation transformer secondaries may be any value from half to full load

Resistive Loading: The CCRs maintain the output current within the limits of Table 1-1 while powering any load between no load (short circuit) and full load. The regulation is maintained over the full range of environmental conditions specified below and for the input voltages specified above.

Environmental Operating Conditions: Designed for indoor use only in an area with adequate ventilation for cooling the constant current regulator.

Temperature Range: -10°C to +55°C

Relative Humidity: 0 to 100%

Altitude: Sea level to 10,000 feet

Table 1-3. Equipment and Accessories Supplied

Quantity	Description
1	30 kW Constant Current Regulator

Table 1-4. Recommended Input Power Supply Wire

(Recommended Input Wire: 90°C, 600V or 5000V maximum)

kW Rating	480 V Input
30 kW	AWG 4, 600V

☑ **Note**: It is recommended that the circuit breaker on the input power supply lines have a rating of 125% of the CCR's input current, as given in Table 1-5, unless local codes require a different rating technique. See the CCR's nameplate for the kW rating and input voltage to determine the input current from Table 1-5. If no standard size circuit breaker exists at the 125% value, use the next larger standard size circuit breaker.

Table 1-5. Input Current for L-828 Constant Current Regulators

kW Rating	480 V Input
30 kW	95 amp

2. INSTALLATION

2.1 INTRODUCTION

This section provides instructions for the installation of the L-828 Constant Current Regulators. Refer to the airport project plans and specifications for the specific installation instructions.

2.2 UNPACKING

Unpack crate upon receipt and examine regulator to insure that no damage has occurred during shipment. Note any exterior damage to crate which might lead to detection of equipment damage. When handling the regulator, care should be taken to maintain the unit in an upright position.

2.2.1 Damage

If damage to any equipment is noted, a claim form should be filed with the carrier immediately. Inspection of equipment by the carrier may be necessary.

2.3 INSTALLATION

The regulator can be lifted using a forklift (remove the two lower vent screens on the bottom of the regulator) or with a portable hoist (using the four 3/8- inch I.D. eyebolts on top of cabinet). Place regulator inside a well ventilated room with sufficient clearance for personnel to inspect and maintain the unit.

☑ **Note**: Remove internal shipping strap from power transformer prior to installation.

2.3.1 Shipping Strap Removal

A metal shipping strap has been installed inside the regulator cabinet on top of the power transformer to restrain the transformer from movement during shipping. The strap is clearly marked with a label SHIPPING STRAP and must be removed prior to the connection of the input power supply lines. Since the rear panel of the regulator cabinet must be opened to gain access to the shipping strap, it is best removed prior to the placement of the regulator in its final operating location. If the shipping strap is not removed, the regulator will not operate properly, since the transformer must be free to vibrate. After removal of the strap, visually inspect the interior of the cabinet to make sure no parts are loose or damaged.

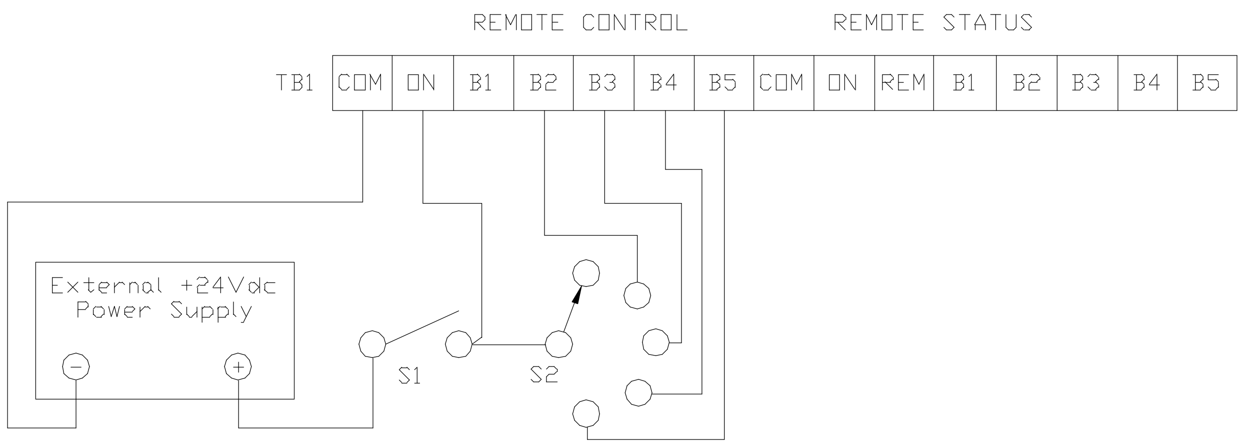
2.4 WIRING CONNECTIONS AND STARTUP (SEE CCR ASSEMBLY AND SCHEMATIC)

WARNING

Installation and operation of the CCR should be performed by personnel qualified to work on high voltage equipment. The high voltage involved with the unit makes it potentially dangerous and may be lethal if contacted by operating personnel.

1. Verify the input supply voltage corresponds to the voltage rating on the nameplate of the regulator.
2. Make sure the rotary switch S2 on the front panel is set to the OFF position. Also, insure that the card rack switch S8 is set to OFF.
3. Ground the regulator by making an adequate ground wire (AWG 6 or larger) connection to the external ground lug on the regulator.
4. An appropriate disconnect-type cutout or circuit breaker shall be provided for the input power supply lines.
5. Short-circuit the output lightning arrestors (E1, E2) using AWG #10 (minimum) wire to avoid lamp destruction in case of excessive current output.
6. Connect the power supply lines (see Table 1-4 for recommended input wire) from the disconnect switch or main circuit breaker to the CCR's input terminal block TB2. Tighten all connections.
7. Install PCBs into card rack see Fig.6 for location.
8. Energize regulator (engage main circuit breaker or disconnect switch). Turn switch S8 on the card rack to the ON position, and turn rotary selector switch S2 (on the front panel) to all brightness steps. Verify current values on panel ammeter correspond to those in Table 1-1 for each brightness step.
9. Deenergize regulator (disengage main circuit breaker or disconnect switch), and turn rotary selector switch S2 and switch S8 to OFF.
10. Connect remote control lines, if required, to the remote control terminal block TB1 (use AWG 19, 300 V wire (minimum)) as indicated in Table 9-1. See diagram on next page for remote control and external alarm connections.

Table 2-1. Remote Control Connections	
Terminal Block TB1 Label	Function
COM	Remote Control Common
CCI	Remote Control Power
ON	On-Command Voltage (from remote control)
B2, B3, B4, B5	Brightness Control



☑ **Notes**:

a) Table 9-1 gives the necessary connections for remote control. Terminal B1 does not need to be wired. Brightness step B1 occurs when the regulator is switched on.

b) In situations where the remote control lines are extremely long or in cases when there is the potential of noise voltage being generated on inactive control lines, an L-841 relay cabinet should be used to clean up the lines.

c) Do not use an L-847 circuit selector switch with an L-828 regulator. If an L-847 must be used to switch loads, use an L-828 regulator with an L-827 monitor on each of the L-847's output load lines. Each L-827 monitor must be calibrated to the particular load line.

d) When CCR is energized the remote status terminals will be high (+24Vdc) correspond to the correct output. Example: CCR is operated in remote and in step 5. Terminals B5, REM, and ON will be high with respect to COM terminal.

11. Make sure wiring connections are tight and no wires are shorting across each other.

CAUTION

Incorrect wiring can damage regulator. Double check all connections.

12. With regulator turned off, energize remote control lines using remote control panel, and check for proper voltages on input of remote control terminal block TB1. Insure that the voltage on the lines not energized is less than 5 Vdc.
13. Energize regulator and set rotary selector switch of the REM position. Operate the CCR by remote control, and verify correct current levels are obtained on all brightness steps.
14. Turn rotary selector switch S2 to OFF and deenergize regulator (disengage disconnect switch or main circuit breaker). Remove short-circuit link from output lightning arrestors.
15. Connect the 20 A series lighting circuit to the output lightning arrestors and tighten all connections.
16. Check if the *input current x input voltage x CCR efficiency = 0.90 or 0.92* (for 30 kW CCR) is larger than the kW rating given on the CCR's nameplate. If it is, either reduce the load or replace regulator with one having a larger kW rating.

3. THEORY OF OPERATION

3.1 SIGNAL DESCRIPTION

The following are the functional description of the printed circuit boards on the constant current regulator. The printed circuit boards consist of the Input Module Assembly (IMA), Current Controller Assembly (CCA), and Monitor Module Assembly (MMA).

3.1.1 Input Module Assembly (IMA)

3.1.1.1 Signal Description

- **RMSHI, RMSLO:** This signal is generated from a 20 to 6.6-amp current transformer (T3) located in high voltage compartment and is sent to the Input Module.
- **RMSA, RMSB:** This signal is generated from RMSHI and RMSLO and current transformer T1 on the Input Module. The transformer T1 on IMA steps the 6.6 amp current down to 55 mA and is input into the Current Controller.
- **240ON, 240HI, 240LO:** These signals are generated from the 480Vac input used for generating DC power, a phase reference, and also the input voltage monitoring circuits.
- **ON,B2, B3, B4, B5:** 24 Vdc logic remote control input signals.
- **RON:** This signal turns the regulator off when the switch S2 on the front panel of the Input Module is set to off or if CCR is controlled remotely when CC is low.
- **VCON:** DC signal generated on the Input Module — used to set a reference voltage for each step level used on the Current Controller.
- **P24Vdc:** 24 Vdc power for powering IMA, CCA, and MMA.
- **P24RTN:** DC ground for 24 Vdc power supply.
- **P12Vdc:** +12 Vdc power for powering IMA, CCA, and MMA.
- **P12RTN:** DC ground for + 12 Vdc power supply.
- **N12Vdc:** –12 Vdc Power for powering IMA, CCA, and MMA.
- **N12RTN:** DC ground for –12 Vdc power supply.
- **P12V:** +12 Vdc power supply voltage monitor for the RMS.
- **P12A:** +12 Vdc power supply current monitor for the RMS.
- **N12V:** –12 Vdc power supply voltage monitor for the RMS.
- **N12A:** –12 Vdc power supply current monitor for the RMS.
- **P24V:** +24 Vdc power supply voltage monitor for the RMS.
- **P24A:** +24 Vdc power supply current monitor for the RMS.

- **IVCON:** Signal used to monitor VCON circuitry on the Input Module.

3.1.1.2 DC POWER SUPPLIES

a) Bridge rectifier D26-29 rectifies the AC voltage from T2 (on Input Module PCB), charges C9-12 to +12 Vdc and –12 Vdc, respectively. The ±12Vdc power is used to drive the regulator control and RMS circuits.

b) If S8 is switch to on (rotary switch S2 in position 1, 2, ..., 5 or in position REM with remote control switch set to ON) all the circuitry of the CCR is supplied with DC voltage

c) Bridge rectifier D12-15 rectifies the AC voltage from T2 (on Input Module PCB), charges C8 to +24 Vdc. This +24 Vdc is used for step selection in local, monitoring output, and RMS circuits.

3.1.1.3 Brightness Control Adjustment

The output current of the constant current regulator is determined by the current required via VCON. The signal VREF produces a stable reference voltage, which supplies voltage to the potentiometers R11 through R15. The adjustments of these potentiometers corresponds to the different brightness steps. Brightness step selection occurs through the transistor stage of the opto-coupler (IS01, IS02, IS03, IS04). Brightness step selection can be accomplish by the rotary switch or by remote control. For example, if brightness B1 is selected by setting the rotary switch to B1 or by remote control, then the output U3A/12 adjustable by R11 will determine the output current. Brightness B2-B5 operate the same manner as B1.

3.1.1.4 REGULATOR ON

When the rotary switch is in any position other than OFF, the 24Vdc is applied to the connector JP31-1 which turns on the opto-isolator ISO5. The RON signal is now low and sends to the Current Controller Assembly.

3.1.1.5 CURRENT FEEDBACK

The current transformer located inside the high voltage compartment steps down the current 20A to 6.6A and sends to transformer T1. The transformer T1 steps down the current 6.6A to .055A and sends to the Current Controller Assembly.

3.1.1.6 RMS MONITOR SIGNALS

The remaining circuitry is used to monitor the power supplies voltage and current, and control voltage. This monitor circuitry uses operational amplifier to sense and amplify the signals and send it to the 37-pins connector on the component plate.

3.1.2 CURRENT CONTROLLER ASSEMBLY (CCA)

3.1.2.1 Signal Description

- **OVCUR:** Indicates an overcurrent condition on the series circuit.
- **DCRMS:** DC signal proportional to the loop current.
- **OPCIR:** Indicates an open circuit on the series circuit.
- **SCR1, SCR2:** SCR drive signals generated on the Current Controller.
- **ARON1, ARON2:** This signal is used to disable the relay K1 in low voltage compartment when an open circuit occurs on the series loop.
- **PHREF:** Phase reference signal — used by Current Controller for generating timing waveforms to control the SCRs.
- **ILOOPST:** This signal indicates the status (OK, overcurrent or open circuit) of the CCR current loop.

3.1.2.2 SCR Inhibit Signals

a) The Current Controller generates an AC voltage of about 24 Vac (signal PHREF) in phase with the supply voltage of the power transformer T2 on the IMA.

b) Integrator U4A outputs an AC voltage shifted in phase, filtered and lowered in level in comparison to signal PHREF.

c) Comparators U4B and U4D transform the output voltage of U4A into square waves such that:

   1. The output of U4B is HIGH (about +10.5 V) as long as the output voltage of U4A is higher than –0.94 V.
   2. The output of U4D is HIGH as long as the output voltage of U4A is lower than +0.94V.

3.1.2.3 Sawtooth Generator

Capacitor C8 is slowly charged through resistor R20 and is short-circuited if Q6 is switched on. Q6 is switched on during the short period of time that both U4B and U4D are HIGH. This provides a sawtooth voltage across C8 synchronized with the AC voltage at the output of U4A.

3.1.2.4 SCR Ignition Circuit

a) If there is no SCR-inhibit signal, then trigger transformer T1 or T2 on the Current Controller has an input square wave generated by a push-pull transistor stage (one for each trigger transformer).

b) The voltage across resistor R112 depends on the current through the trigger transformer. As soon as this current exceeds a certain value, the Schmitt-trigger U1 commutates the push-pull stage. This means that the frequency of oscillation is determined by the saturation point of the trigger transformers.

c) To drive the gates of SCR1 and SCR2 (on SCR block):

    1. The output current of either transformer T1 or T2 is rectified.
    2. The gate current is limited by R110 or R111, respectively.

d) The SCR's ignition circuit is controlled by three signals:

    1. If the output of U4B is HIGH (about +10.5 V), circuitry for SCR1 is inhibited from oscillation.
    2. If output of U4D is HIGH, circuitry for SCR2 is inhibited from oscillation.
    3. If output of U2C is HIGH, U1 is forced HIGH, and Q13 and Q3 are shut off by Q14 and Q4. Therefore, the two SCRs and U1 are inhibited.

3.1.2.5 Output Current Regulation

a) A voltage of −6.2 V ±5% provided by reference Zener diode D25 (high stability and low-temperature-coefficient type Zener diode) on the IMA. This stabilized voltage produces signal VREF (adjustable by potentiometer R18) which determines all the brightness levels. Signal VREF is used to adjust the maximum output current.

b) The secondary current of transformer T1 (on IMA) is rectified by diode D11-14 (on CCA) produces a voltage across R35 proportional to the output current.

c) A squarer composed of R9,R34,R30,R32,R31,R33,D8,D9,D10 produces a DC feedback voltage across capacitor C9 proportional to the rms value of the output current of the CCR.

d) The difference between the current through R29 (produced by the voltage across C9) and the current through R36 (derived from VREF on the Input Module PCB) produces a charge (+ or –) on capacitor C7, which causes a correction of the output voltage of integrator U2D.

e) The sawtooth voltage present across capacitor C8 and the output voltage of integrator U2D are compared by U2C. The output of U2C swings to LOW when the sawtooth voltage becomes higher than the output voltage of U2D, and stays LOW as long as sawtooth voltage is higher than the voltage U2D. This determines the conduction time of the SCRs and adjusts the CCR's output current until the difference between the current through R29 and R36 are equal.

f) To speed up regulation response time:

   1. When output current is higher than demanded, the output of U2D is held to –0.6 V minimum by diode D5.
   2. When the output current is lower than that which is demanded, the output U2D is held to a level slightly higher than the maximum sawtooth voltage by U2B (valid as long as the output current is higher than about 16.1 A when a current of 20 A is demanded.
   3. Diode D7 makes sure the SCRs are always conducting when switched on. This prevents overvoltage spikes from occurring across the SCRs in case the CCR is switched on when an open circuit is present on the output.

3.1.2.6 Switching On

a) The DC voltage produced by resistor-capacitor network R79, R80, R82, R81, C15, C16 is compared with the voltage generated by Zener diode D30 through resistor-divider network R93, R87. The minimum supply voltage for on/off switching can be adjusted with potentiometer R81. R81 should be turned fully counter-clockwise.

b) When the supply voltage is too low, the output of U4C will be LOW and transistor Q9 will be off. This causes integrated circuits IS01, U3, Zener diode D20, and relay K1 to not be supplied with –12 Vdc.

c) When the supply voltage reaches a threshold (adjusted with R81), U4C goes HIGH causing Q9 to conduct. This causes Q10 to conduct as long as C14 is charging (less than 1 second). Q7 turns on Q8 causing relay K1 to switch on. If no open circuit or overcurrent exists, Q9 will conduct and Q8 will energized a normally open contact relay K1.

d) By means of connecting signal RON to 0V-level the Input Module PCB is able to create an under voltage condition. This is useful to prevent over current when switching Off.

3.1.2.7 Failure Protection

a) The voltage across resistor R35 (proportional to the output current) is also used for the squarer R44, R47, R45, R48, R46, R49, D15, D16, D17 which produces a voltage across capacitor C11 proportional to the rms value of the CCR's output current. The voltage across C11 is used for the overcurrent and open-circuit protection.

b) Zener diode D20 (high stability and low-temperature-coefficient Zener diode) produces –6.2 Vdc ±5% voltage which is used for the overcurrent and open-circuit protection.

3.1.2.8 Overcurrent Protection

The voltage across C11 is proportional to the rms value of the output current. If the current through R57 becomes higher than the current through R53 (adjustable by R57), the integrator U3A will swing to -12V causing solid state relay K1 (on MMA) to turn off. This causes normally open contact K1 in the low voltage compartment to turn off. K1 in the low voltage compartment turns off, causing the contactor K2 in the low voltage compartment to turn off. This de-energizes the regulator. The CCR can only be re-energized by interrupting the supply to PCB (such as turning the rotary switch S2 on the Input Module or S8 to off).

3.1.2.9 Open-Circuit Protection

In normal conditions the current through R59 is higher than the current through R58. With an open circuit the output current will become lower, and the current through R59 will decrease. The moment that pin 6 of U3B becomes less than 0 V, the output of U3B will go to –12 Vdc causing C13 to discharge through D22, R65 until Q10 turns off which causes Q7 and Q8 to turn off. When Q8 turns off, relay K1 in the low voltage compartment switches off—de-energizing the regulator. The CCR can only be re-energized by interrupting the supply to the PCB (such as turning the rotary switch S2 on the Input Module or S8 to off).

3.1.2.10 Output Status Monitor

The ILOOPST signal is used to monitor the status of the output of the CCR. If there is a condition occurring either by open-circuit or overcurrent, then the corresponding operation amplifier will turn on the correct opto-isolator ISO2/ISO3 and switch the ILOOPST signal to 24Vdc and send it to the 37-pins connector on the component plate.

3.1.3 MONITOR MODULE ASSEMBLY (MMA)

3.1.3.1 Signal Description

- **MBREM, MBON, MB1, MB2, MB3, MB4, MB5:** 24 Vdc logic remote monitoring signals output to the remote status terminal block.
- **ARC3, ARC2:** This signal is used to disable the relay K1 in low voltage compartment when an overcurrent condition occurs on the series loop.
- **HILOOPV, LOLOOPV:** Output of the 5000V/50V high-voltage step-down transformer used to measure the loop voltage.
- **240ON, 240LO:** These signals are generated from the 480Vac input — used for generating DC power, a phase reference, and also the input voltage monitoring circuits.
- **LOOPA:** DC signal proportional to the current delivered to the loop circuit.
- **LOOPV:** AC signal proportional to the loop voltage.
- **IN480V:** AC signal proportional to the 480 Vac input voltage.
- **IN480A:** AC signal proportional to the 480Vac input current.
- **IKSTAT:** Signal shows the state of the relays (OK).
- **DCRMS:** DC signal proportional to the loop current.

3.1.3.2 Overcurrent Memory

Normal operation signal OVCUR is always higher than -6 Vdc which causes the output U1A/12 (wired as integrator) to be approximately -12 Vdc.

Detection of overcurrent by the Current Controller causes the signal OVCUR (JP12/A28) to swing to approximately -12 Vdc which causes the output pin 12 of the operational amplifier U1A to slowly rise (integrator action of R1 and C1). The output pin 10 of U1B is a result of the comparison of the voltage on pin 12 with the positive voltage on U1 pin 7. This means that,

a) Normally the voltage at U1 pin 10 is about -12 Vdc causing transistor Q1 to conduct and energize the solid state relay K1.

b) As soon as the voltage level at U1 pin 6 exceeds the level at U1 pin 7, the output pin 10 will swing to about +12 Vdc. Diode D2 clamps U1 pin 6 at +12 Vdc as long as power is supplied to the Monitoring PCB. If the output U1 pin 10 is at about +12 Vdc, transistor Q1 will cease to conduct and solid state relay K1 will no longer be energized.

3.1.3.3 Status of the Constant Current Regulator

3.1.3.4 24 Vdc Logic Levels

a) Logic HIGH corresponds to higher than 15 Vdc, but not greater than 28 Vdc.

b) Logic LOW corresponds to higher than -0.5 Vdc, but not greater than 5 Vdc.

The status signals from the Monitoring Module PCB are connected to terminal block TB1 in the control cabinet. The current level required by the equipment connected to TB1 may not be higher than 2 mA (each output line has a series resistor equal to 1 kiloohm). Logic HIGH signals are produced between terminal COM and,

- Terminal REMOTE if the rotary switch S2 on the Input Module is in position REMOTE and if the +24 Vdc power supply on the Input Module is operational.
- Terminal ON if the +24 Vdc power supply on the Input Module is operational.
- One of the terminals B1, B2, B3, B4 or B5 if the actual output current of the constant current regulator corresponds to the same brightness level and if the +24 Vdc power supply on the Input Module is operational.

The status and control signals are completely isolated from the logic circuitry by means of opto-couplers on the Input and Monitoring Modules.

3.1.3.5 Determining Actual Brightness Level

See MMA and CCA Schematic.

The Current Controller delivers a dc voltage DCRMS which is proportional to the rms value of the output current. This voltage is filtered by C2 and C3 and amplified by operational amplifier U4. Operational amplifier U3A outputs a temperature compensated zener diode D4 and is adjustable between about -2.5 and -4.2 Vdc.

Between U4B and U3A there is a resistor divider network. Each section of this network corresponds to a brightness step and is connected to the input of an operational amplifier (U3B, U2A, U2B, U5A and U5B). These operational amplifiers give an output voltage of about:

⇒ +12 Vdc, as long as the voltage on the voltage divider network input remains lower than 0.05 Vdc.

⇒ -12 Vdc, as soon as the voltage on the voltage divider network input exceeds 0.05 Vdc and as long as the voltage stays higher than -0.05 Vdc.

This means that for brightness step B1, only the output U5B will be near -12 Vdc; for brightness step B5, all the outputs U5B, U5A, U2B, U2A and U3B will be near -12 Vdc.

The opto-couplers are wired so that only the highest detected brightness step is indicated. For example, this means for brightness step B3 that U5B, U5A and U2B are near -12 Vdc and U2A, U3B are at about +12 Vdc. Therefore, current will only flow through the LED in opto-coupler AR3 though the following path: U2A → D14→ R50 → D8→AR3 pin 5 → AR3 pin 7 → U2B

The output transistors of the opto-couplers will switch on the corresponding output transistor Q5 through Q9 when current is flowing through the LED in the corresponding opto-coupler.

3.1.3.6 OVERCURRENT SHUTDOWN

In the event overcurrent condition occurs, the signal is sent from the CCA and fed to the integrator operational amplifier. The output of this amplifier turns on the transistor. This boosts the current to drive the solid state relay and turn the CCR off.

3.1.3.7 RMS MONITOR SIGNALS

The remaining circuitry is used to monitor the output voltage, output current, input voltage, input current, and contactor K1 located on the component plate. These signals are accomplished by operational amplifiers and the signals are send to the 37-pins connector on the component plate.

4. REMOTE MAINTENANCE SYSTEM

4.1 INTRODUCTION

The Siemens Airfield Solutions, Inc. 30 kW air-cooled L-828 Constant Current Regulators (CCRs) are designed to supply five precision output current levels (20 amp maximum) for series lighting circuits on airport runways and taxiways. The output of the L-828 CCR is accurately regulated within ±1% of the adjustable nominal current levels from no load (short circuit) to full load and with input voltage variations of ±10% of nominal. Output current levels are maintained even if 30 percent of the isolation transformers in the series lighting circuit supplied by the regulator have open secondaries.

4.1.1 Purpose

This manual describes the Remote Maintenance System (RMS) of Siemens Airfield Solutions, Inc. manufactured 30 kW L-828 Constant Current Regulators.

4.1.2 Scope

This L-828 CCR RMS described in this manual are manufactured to FAA specification FAA-E-2689A Operation outside the design limitations of this specification may result in degradation of performance, damage or failure of regulator components or hazardous conditions.

The RMS signals are defined below. Theory of operation, calculation of test limits and its use are discuss in detail.

- **LOOPA:** DC signal proportional to the current delivered to the series circuit. LOOPA is a function of the commanded step setting.
- **LOOPV:** DC signal proportional to the series voltage. LOOPV is a function of the commanded step setting and CCR load.
- **IN480V:** DC signal proportional to the 480 V ac input voltage. IN480V is a function of the input voltage.
- **IN480A:** DC signal proportional to the 480V ac input current. IN480A is a function of the input voltage, load being driven by the CCR, Commanded Step, and Power efficiency of the power core.
- **P12V:** +12 V dc power supply voltage monitor for the RMS. P12V is a function of the input voltage and commanded Step because the DC power supplies are unregulated.
- **P12A:** +12 V dc power supply current monitor for the RMS. The power delivered should be relative because it is a function of the input voltage and commanded Step.
- **N12V:** −12 V dc power supply voltage monitor for the RMS. N12V is a function of the input voltage because the DC power supplies are unregulated.
- **N12A:** −12 V dc power supply current monitor for the RMS. The power delivered should be relative because it is a function of the input voltage and commanded Step.

- **P24V:** +24 V dc power supply voltage monitor for the RMS. P24V is a function of the input voltage because the DC power supplies are unregulated.
- **P24A:** +24 V dc power supply current monitor for the RMS. The power delivered should be relative because it is a function of the input voltage and commanded Step.
- **ILOOPST:** This signal indicates the status (OK, overcurrent, or open circuit) of the CCR current loop.
- **IKSTAT:** Signal shows the state of relays (OK, stuck open, or closed).
- **IVCON:** Isolation signal used to test VCON circuitry on the input module. This signal is also useful in determining if the remote input lines are being responded to. VCON is a function of the commanded step setting.

4.2 RMS INTRODUCTION

The ALSF-2/SSALR RMS includes voltage and current sensors, cabling, connectors, and the mounting hardware necessary to route the required signals and control functions to the monitoring units of the ALSF-2/SSALR RMS, and includes all circuitry necessary to buffer, condition data into the engineering units, and preprocess the sampled signals.

The RMS provides the capability for diagnosing ALSF-2/SSALR equipment faults to the LRU (lowest replaceable unit) level. These diagnostics provide the identity of the failed LRU. The diagnostics isolate faults to a single LRU in 95% of diagnostic attempts. Faults shall be isolated to two or more LRUs in 98% of diagnostic attempts. Faulty LRUs shall be listed in order of most likely to least likely.

A diagnostic attempt is a snapshot of the state of the CCR and contains all the information necessary for fault isolation. A diagnostic attempt is recorded measurement of each RMS. signal defined.

4.3 LRUS ON THE CCR

The LRU is defined in FAA-E-2689a as the lowest replaceable unit to be replaced within the system during site maintenance. It is a separate, installable, physical package performing a single function or group of related functions.

The RMS signals from the CCR fault isolate down to the correct LRU or provide information on non-LRU components.

4.3.1 The CCR contains the following LRUs (three total):

1. Input Module Assembly (IMA)
2. Current Controller Assembly (CCA)
3. Monitoring Module Assembly (MMA)

4.3.2 Information is provided for the following non-LRU items:

1. Contactor K2 and Relay K1 in low-voltage compartment to 240Vac step-down Transformer T2
2. The Power Core (power transformer T1, current transformer T3), Capacitor Bank (C1-C36)

3. SCR Block and Snubber Network
4. Current Sensor CS1
5. Loop Voltage 5000V/50V step-down Transformer T4
6. Input fuses F1 and F2
7. Input lightning arrestor RV1 and RV2
8. Output lightning arrestor E1 and E2

4.4 RMS METHODOLOGY

The following are assumptions made on the design:

- Calibration at the factory and/or in the field are independent of the RMS signals. Adjustments made to potentiometers do not influence the operation of the RMS circuits.
- In the calculation of fault isolation percentages it is assumed every component has an equal probability of failure. Each faulty LRU identified when a failure occurs is weighted according to the number of components exclusively used to generate the signal and the LRU location. Fault isolation percentage estimates are based on this criteria. Non-LRU components are not counted in fault isolation percentage calculations.
- Remote brightness signals, Remote/Local, and On/Off input and output signals are not required at the RMS connector, but are required for fault isolation of stuck bits or failure to respond to remote commands. It is assumed that the RMS can find out the logic state of these signals where appropriate.
- All RMS analog signals are required to be differential and isolated from the regulation circuitry. Isolation is defined as circuitry required to prevent a fault in the RMS circuits from causing a CCR failure. However, if a fault occurs in a particular RMS circuit, then the appropriate LRU will be flagged for removal and replacement.
- All digital RMS signals are 24V logic and require signal and return for both input and output.
- This analysis assumes the regulator is either operating correctly, no overcurrent /open circuit protection mode or a failure has occurred. Protection mode occurs when relay K1 and contractor K2 in low voltage compartment is disabled because of a problem detected with the input power signal (PWRLO, .78Vnom = 374.4 V ac) , an open circuit (OPCIR) on series circuit, or an overcurrent condition (OVCUR), (step current = 1.05 times rated current).
- It is assumed that NBP can detect a power failure, i.e., 480 V ac input = 0 V or using generator power.

4.5 TEST TOLERANCE ANALYSIS METHODS AND CONE OF TOLERANCE.

Tolerances are derived using therorectical methods and then combined by Root-Sum-Square (RSS) errors together to provide the overall test point tolerance. The purpose of this section is to provide guidelines for incorporating tolerance concepts and conning into documentation that controls the testing of LRUs used on the CCRs tested by the RMS and at the depot maintenance level. The RMS test limits are set tight enough to satisfy the designer that the LRU is operating as expected and required. Initial tolerance of elements such as operational amplifiers and its associated summing and feedback resistors will be RSS with measurement error to provide the RMS Test Tolerances.

The approach of RSS tolerances comes from the Central Limit Theorem which states that errors are continuous and independent, the statistical estimate for total effect of all variables is the square root of the sums of the squares of the deviations.

5. RMS DESCRIPTION

5.1 RMS TEST POINTS IN480V AND IN480A

Input Voltage and Current Tests. The RMS is required to monitor the input voltage and current. RMS signals "IN480V and IN480A".

5.1.1.1 Theory of Operation

IN480V Calculations:

Tolerances Input voltage = 20%
Power Transformer = 5%

$\Delta IN480 := 20$ %

$\Delta TX := 10$ %

$\Delta R := 1.562$ %

The input voltage is scaled by two transformers, a resistors divider network, and a precision fullwave rectifier circuit. This circuit is located on the MMA.

$R127 := 10 \cdot K$ $R138 := 15 \cdot K$ $R128 := 3.3 \cdot K$
$R130 := 10 \cdot K$ $R134 := 10 \cdot K$ $R129 := 4.75 \cdot K$
$R132 := 10 \cdot K$ $R133 := 10 \cdot K$ $R131 := 4.75 \cdot K$

$Vin := 480$ VAC

$$R1 := \frac{(R132 + R134) \cdot R131}{(R131 + R132 + R134)} \qquad R1 = 3.838 \cdot 10^{3}$$

$$Av := \left(\frac{1}{2}\right) \cdot \left(\frac{10}{240}\right) \cdot \left[\frac{R1}{(R133 + R1)}\right] \cdot \left(\frac{R138}{R127}\right) \cdot \left(\frac{2}{3.1416}\right) \cdot (1.4142) \qquad Av = 0.0078$$

$$Vin480v := Vin \cdot Av \qquad Vin480v = 3.746$$

$$\Delta Vin480v := \sqrt{\left(\Delta TX^{2} \cdot 2 + \Delta IN480^{2} + 9 \cdot \Delta R^{2}\right)} \qquad \Delta Vin480v = 24.939 \ \%$$

$UL(Vin480v, \Delta Vin480v) = 4.68$ VDC

$LL(Vin480v, \Delta Vin480v) = 2.81$ VDC

IN480A Calculations:

The input voltage current monitor is based on the F.W. Bell BB-150 Current sensor. The BB-150 is a Hall Effect sensor that outputs a signal that is proportional to the input current (40mV/Amp +/-2%) this circuit is located on the MMA.

Tolerances:

$\Delta R := 1.562$ %

$R135 := 10 \cdot K$ $R144 := 10 \cdot K$ $R139 := 15 \cdot K$
$R126 := 10 \cdot K$ $R121 := 10 \cdot K$ $R122 := 3.3 \cdot K$
$R143 := 10 \cdot K$ $R123 := 4.75 \cdot K$ $R125 := 4.75 \cdot K$

$$Av := \left(\frac{R143}{R126} + 1\right) \cdot \left(\frac{R139}{R121}\right) \cdot \left(\frac{2}{3.1416}\right) \cdot (1.414) \qquad Av = 2.701$$

$$Vin480a(I) := I \cdot (.04) \cdot (Av) \qquad \Delta Vin480a := \sqrt{\left[\left(\Delta R^2\right) \cdot 9 + 2^2\right]} \qquad \Delta Vin480a = 5.095 \quad \%$$

Therefore, IN480A for 25, 47 and 75 Amps is

$Vin480a(25) = 2.701$ VDC $Vin480a(47) = 5.077$ VDC $Vin480a(75) = 8.102$ VDC

5.1.1.2 IN480V and IN480A Test Points

IN480V and IN480A are defined as follows. If IN480V is out of tolerance then one or more of the following actions are taken.

1. RMS should set an input voltage out-of-tolerance flag. Reset flag if IN480V is in tolerance. When IN480V is out of tolerance then, P12V, N12V, IVCON, and P24V analog RMS signals are invalid until the voltage is corrected.
2. If P12V/P12A, N12V/N12A, and P24V/P24A are not delivering power to circuit cards and IN480A ≈ 0 amps (i.e. main power fuse blown), maintenance personnel should check fuse F1 and F2 and remove and replace if blown, else remove and replace 480 to 240V transformer T2 (VERY UNLIKELY EVENT).
3. If IN480V ≈ 0 Vdc and (no power failure) remove and replace LRU MMA, and check 480 to 240V transformer T2 located in the low-power compartment. Remove and replace if broken. (IN480V RMS circuit failure)
4. Maintenance personnel should contact the local utility company to check the voltage and correct the problem.

Table 2: IN480V and IN480A Test Points

Signal	Signal Type	Units	Typ or (Max)	UL	LL	Scale Factor	RMS Typical Vdc	UL	LL
IN480V	AC	V ac	480 (528)	24.94%	–24.94%	0.0078 V/V	3.75	4.68	2.81
IN480A	AC	A ac	69 (90)	5.10%	-5.10%	0.108V/A	NA	10.22	1.02

If IN480A is ≈ 0 Vdc and CCR is operational (LOOPA > = 8.3 amps, step 1 or higher) then following action is taken. (IN480A RMS circuit or current sensor CS1 has failed)

Remove and replace LRU MMA, after replaced LRU MMA and IN480A is still ≈ 0 Vdc then remove and replace current sensor CS1.

5.2 RMS DIGITAL TESTS

The RMS digital tests consist of tests used to find out if there is a stuck bits, either high or low. The digital tests are broken into two parts. first there are the remote input tests. secondly, there are the monitoring output tests.

5.2.1.1 Theory of Operation

The theory of operation is basic; Given a certain set of remote control line inputs you must get a predicable response. The given truth table highlights the responses.

5.2.1.2 Digital Control and Monitor Tests

These tests are composed of digital input and output signals sent to and from the Control and Monitor cabinet (REMOTE only). They also involve a comparison of the delivered current (LOOPA) and the monitored step setting (MBX).

Table 3: Digital Control And Monitor tests

	HIGH	1
	LOW	0
	DON'T CARE	X

LOCAL ON/OFF	B1	B2	B3	B4	B5	LOOP CURRENT	MB1	MB2	MB3	MB4	MB5	MBREM	MBON
1	1	0	0	0	0	≈ 8.5 amps	1	0	0	0	0	0	1
1	0	1	0	0	0	≈10.3 amps	0	1	0	0	0	0	1
1	0	0	1	0	0	≈12.4 amps	0	0	1	0	0	0	1
1	0	0	0	1	0	≈15.8 amps	0	0	0	1	0	0	1
1	0	0	0	0	1	≈20.0 amps	0	0	0	0	1	0	1
0	X	X	X	X	X	X	X	X	X	X	X	X	X

REMOTE REM	CC	B2	B3	B4	B5		MB1	MB2	MB3	MB4	MB5	MBREM	MBON
1	1	0	0	0	0	≈ 8.5 amps	1	0	0	0	0	1	1
1	1	1	0	0	0	≈10.3 amps	0	1	0	0	0	1	1
1	1	X	1	0	0	≈12.4 amps	0	0	1	0	0	1	1
1	1	X	X	1	0	≈15.8 amps	0	0	0	1	0	1	1
1	1	X	X	X	1	≈20.0 amps	0	0	0	0	1	1	1
1	0	X	X	X	X	X	X	X	X	X	X	X	X

If a monitor signal is stuck high or low, then the following actions should be taken.

1. Signal Mxxxx is a stuck bit then call out LRU as defined below.

Table 4: LRU Call Outs for Stuck Bits

Stuck Bit	LRU
MB1	MMA
MB2	MMA
MB3	MMA
MB4	MMA
MB5	MMA
MBREM	MMA
MBON	MMA

If the CCR does not respond to step level commanded, e.g., CCR operates at step 4 and 5, but will not accept step 1 or 2, the remote input signal is stuck bit —call out IMA LRU, and check cabling from CCR terminal block 1 to control and monitor cabinet. Check for this fault by comparing the commanded step setting with the monitored outputs MB1, MB2, MB3, MB4, and MB5 and the delivered loop current (LOOPA).

5.3 RMS P12V AND P12A TEST POINTS

The P12V and P12A RMS signals are required. These signal sample the +12VDC power supply voltage and current being delivered. If either of these two signals is out of tolerance, The +12VDC power supply has failed.

5.3.1.1 Theory of Operation

The + 12VDC Power Supply:

Calculate the Ripple Voltage. Assume that caps discharge for 1/4th of period of rectified waveform.

Tolerances Input voltage = 20%
Power Transformer = 5%

$Irmax := 1.5 \cdot 10^{-3}$ A — From 1N5420 diode data sheets

$Cap := 2200 \cdot 10^{-6}$ F — Total caps (-10%)

$f := 60$ Hz — Frequency (+/-3%)

$$Vripple := \frac{Irmax}{(4 \cdot Cap \cdot .9 \cdot f)} \qquad Vripple = 0.003 \quad Vp-p$$

Negilible

$$\Delta Vripple := RSS(20, 5) \qquad \Delta Vripple = 20.616 \quad \%$$

Calculate the DC voltage

$Vrms := 11$ Volts — The AC input voltage from the Power transformer

$Vdiode := 1.1$ Volts

$$\Delta Vdc := RSS(20, 5) \qquad \Delta Vdc = 20.616 \quad \%$$

$$Vdc := \left(\sqrt{2}\right) \cdot Vrms - Vdiode - \frac{Vripple}{2} \qquad Vdc = 14.455 \quad Volts$$

$UL(Vdc, \Delta Vdc) = 17.435$ Volts

$LL(Vdc, \Delta Vdc) = 11.475$ Volts

The P12V RMS Signal:

$\Delta R := RSS(1, 12 \cdot .1)$

$\Delta R = 1.562$ % $\Delta Vp12V := RSS(\Delta Vdc, \Delta R)$ $\Delta Vp12V = 20.675$

$R62 := 4.75 \cdot K$ Ω $R65 := 10 \cdot K$ Ω

$R63 := 15 \cdot K$ Ω

$R64 := 15 \cdot K$ Ω

$$Vp12V := Vdc \cdot \left(\frac{R62}{R62 + R64}\right) \cdot \left(\frac{R65}{R63} + 1\right) \qquad Vp12V = 5.794$$

$$\Delta Vp12V := \sqrt{\Delta Vdc^2 + 4 \cdot \Delta R^2} \qquad \Delta Vp12V = 20.851 \ \%$$

$UL(Vp12V, \Delta Vp12V) = 7.002$ VDC

$LL(Vp12V, \Delta Vp12V) = 4.586$ VDC

The P12A RMS Signal:

$R68 := 0.22$ Ω $R69 := 4.75 \cdot K$ Ω

$R70 := 4.75 \cdot K$ Ω $R86 := 150 \cdot K$ Ω

$R71 := 4.75 \cdot K$ Ω $R87 := 150 \cdot K$ Ω

$R72 := 4.75 \cdot K$ Ω

The circuit converts delivered current from amps to volts as shown below

$$Vp12a(i) := i \cdot (R68) \cdot \left(\frac{R87}{R72}\right)$$

$$\Delta Vp12a := \sqrt{7 \cdot \Delta R^2} \qquad \Delta Vp12a = 4.133 \ \%$$

So the Voltage for 1 amp is

$Vp12a(i) := 6.95$ VDC per amp

5.3.1.1.1 + 12 VDC Power Supply Tests.

The RMS is required to monitor DC power supply voltage and current. The RMS signals P12V and P12A are defined below.

Table 5: P12V and P12A Test Points

Signal	Signal Type	Units	Typ or (Max)	UL	LL	Scale Factor	RMS Typical Vdc	UL	LL
P12V	DC	V dc	12 (17.44)	20.85%	–20.85%	0.40 V/V	5.79	7.00	4.59
P12A	DC	A dc	0.55 (1.0)	4.13%	-4.13%	6.95 V/A	3.82	7.24	1.67

If P12V is out of tolerance and IN480V in tolerance, then +12 V dc power supply has failed. Maintenance personnel should take the following actions:

1. If fuse F2 on IMA blown then remove and replace fuse F2, else go to step 2.
2. Remove and replace LRU IMA.

If P12A RMS circuit is reading less than 1.6 Vdc, then the +12V dc power supply RMS current monitor has failed. Maintenance personnel should remove and replace LRU IMA.

For example, If the +12Vdc Power supply is 15Vdc the P12V is 6.0Vdc, or the +12Vdc Power supply is 12 Vdc the P12V is 4.8 Vdc.

For example, If the +12Vdc power supply is delivering 750 ma then P12A is 5.21 Vdc, or the +12Vdc power supply is delivering 1000 ma then P12A is 6.95 Vdc.

5.4 RMS N12V AND N12A TEST POINTS

The N12V and N12A RMS signals are required. These signal sample the -12VDC power supply voltage and current being delivered. If either of these two signals is out of tolerance, The -12VDC power supply has failed.

5.4.1.1 Theory of Operation

The - 12VDC Power Supply:

$Irmax := 1.5 \cdot 10^{-3}$ A

$Cap := 2200 \cdot 10^{-6}$ F

$f := 60$ Hz

$Vripple := \frac{Irmax}{(4 \cdot Cap \cdot .9 \cdot f)}$ $Vripple = 0.003$ Vp – p

$\Delta Vripple := RSS(20, 5)$ $\Delta Vripple = 20.616$

Calculate the DC voltage

$Vrms := 11$ Volts

$Vdiode := 1.1$ Volts

$\Delta Vdc := RSS(20, 5)$ $\Delta Vdc = 20.616$ %

$Vdc := \left(\sqrt{2}\right) \cdot Vrms - Vdiode - \frac{Vripple}{2}$ $-Vdc = -14.455$ Volts

$UL(-Vdc, -\Delta Vdc) = -11.475$ Volts

$LL(-Vdc, -\Delta Vdc) = -17.435$ Volts

The N12V RMS Signal:

$\Delta R := RSS(1, 12 \cdot .1)$

$\Delta R = 1.562$ % $\Delta Vn12V := RSS(\Delta Vdc, \Delta R)$ $\Delta Vn12V = 20.675$

$R51 := 15 \cdot K$ Ω $R52 := 10 \cdot K$ Ω $R53 := 1 \cdot K$ Ω

$R54 := 4.75 \cdot K$ Ω $R56 := 1 \cdot K$ Ω

$R57 := 15 \cdot K$ Ω $R55 := 1 \cdot K$ Ω

$$Vp12V := Vdc \cdot \left(\frac{R54}{R54 + R57} \right) \cdot \left(\frac{R52}{R51} + 1 \right)$$ $Vp12V = 5.79$

$$\Delta Vp12V := \sqrt{\Delta Vdc^2 + 7 \cdot \Delta R^2}$$ $\Delta Vp12V = 21.026$ %

$UL(Vp12V, \Delta Vp12V) = 7.012$ VDC

$LL(Vp12V, \Delta Vp12V) = 4.576$ VDC

The N12A RMS Signal:

$R76 := 0.22$ Ω $R95 := 4.75 \cdot K$ Ω

$R92 := 4.75 \cdot K$ Ω $R96 := 150 \cdot K$ Ω

$R93 := 4.75 \cdot K$ Ω $R97 := 150 \cdot K$ Ω

$R94 := 4.75 \cdot K$ Ω

The circuit converts delivered current from amps to volts as shown below

$$Vn12a(i) := i \cdot (R76) \cdot \left(\frac{R97}{R94} \right)$$

$$\Delta Vn12a := \sqrt{7 \cdot \Delta R^2}$$ $\Delta Vn12a = 4.133$ %

So the Voltage for 1 amp is

$Vn12a(i) := 6.95$ VDC per amp

5.4.1.1.1 VDC Power Supply Tests.

The RMS is required to monitor DC power supply voltage and current. The RMS signals N12V and N12A are defined below.

Table 6: N12V and N12A Test Points

Signal	Signal Type	Units	Typ or (Max)	UL	LL	Scale Factor	RMS Typical Vdc	UL	LL
N12V	DC	V dc	-12 (-17.44)	21.03%	–21.03%	0.40 V/V	5.79	7.00	4.57
N12A	DC	A dc	0.55 (1.0)	4.13%	-4.13%	6.95 V/A	3.82	7.24	1.67

If N12V is out of tolerance and IN480V in tolerance, then –12V dc power supply has failed. Maintenance personnel should take the following actions.

1. If fuse F2 on IMA blown, then remove and replace fuse F2, else go to step 2.
2. Remove and replace LRU IMA.

If N12A RMS circuit reading is less than 1.6 Vdc, then –12 V dc power supply RMS current monitor has failed. Maintenance personnel should remove and replace LRU IMA.

For example, If the -12Vdc Power supply is -15Vdc the N12V is 6.0 Vdc, or the -12Vdc Power supply is -12 Vdc the N12V is 4.8 Vdc.

For example, If the -12Vdc power supply is delivering 750 ma then N12A is 5.21 Vdc, or the -12Vdc power supply is delivering 1000 ma then N12A is 6.95 Vdc.

5.5 RMS P24V AND P24A TEST POINTS

The P24V and P24A RMS signals are required. These signal sample the +24VDC power supply voltage and current being delivered. If either of these two signals is out of tolerance, The +24VDC power supply has failed.

5.5.1.1 Theory of Operation

The +24VDC Power Supply :

Calculate the Ripple Voltage. Assume that caps discharge for 1/4th of period of rectified waveform.

Tolerances Input voltage = 20%
Power Transformer = 5%

$Irmax := 1.5 \cdot 10^{-3}$ A — From 1N5420 diode data sheets

$Cap := 2200 \cdot 10^{-6}$ F — Total caps (-10%)

$f := 60$ Hz — Frequency (+/-3%)

$Vripple := \frac{Irmax}{(4 \cdot Cap \cdot .9 \cdot f)}$ $Vripple = 0.003$ Vp – p Negilible

$\Delta Vripple := RSS(20, 5)$ $\Delta Vripple = 20.616$ %

Calculate the DC voltage

$Vrms := 16.00$ Volts — The AC input voltage from the Power transformer

$Vdiode := 1.1$ Volts

$\Delta Vdc := RSS(20, 5)$ $\Delta Vdc = 20.616$ %

$Vdc := \left(\sqrt{2}\right) \cdot Vrms - Vdiode - \frac{Vripple}{2}$ $Vdc = 21.526$ Volts

$UL(Vdc, \Delta Vdc) = 25.964$ Volts

$LL(Vdc, \Delta Vdc) = 17.088$ Volts

The P24V RMS Signal

$R48 := 36 \cdot K \quad \Omega \qquad R49 := 10 \cdot K \quad \Omega \qquad \Delta R := RSS(1, 12 \cdot .1)$

$\Delta R = 1.562 \quad \% \qquad \Delta Vp24V := RSS(\Delta Vdc, \Delta R) \qquad \Delta Vp24V = 20.675 \quad \%$

Calculating the P24V we get:

$Vdc := 24 \quad Vdc$

$Vp24V := Vdc \cdot \left(\frac{R49}{R48 + R49} \right) \qquad Vp24V = 5.217 \quad Volts$

$\Delta Vp24V := \sqrt{\Delta Vdc^2 + 2 \cdot \Delta R^2} \qquad \Delta Vp24V = 20.734 \quad \%$

$UL(Vp24V, \Delta Vp24V) = 6.299 \quad VDC$

$LL(Vp24V, \Delta Vp24V) = 4.136 \quad VDC$

The P24A RMS Signal:

$R46 := 1.0 \quad \Omega \qquad R88 := 4.75 \cdot K \quad \Omega \qquad R91 := 4.75 \cdot K \quad \Omega \qquad R47 := 4.75 \cdot K \quad \Omega$

$R50 := 4.75 \cdot K \quad \Omega \qquad R90 := 150 \cdot K \quad \Omega \qquad R89 := 150 \cdot K$

The circuit converts delivered current from amps to volts as shown below.

$Vp24a(i) := i \cdot (R46) \cdot \left(\frac{R89}{R91} \right)$

$\Delta Vp24A := \sqrt{7 \cdot \Delta R^2} \qquad \Delta Vp24A = 4.133 \quad \%$

So the Voltage for 150 mamp is

$Vp24a(.15) = 4.74 \quad VDC \quad per \quad 150 \ mamp$

5.5.1.1.1 VDC Power Supply Tests.

The RMS is required to monitor the DC power supply voltage and current. The RMS signals P24V and P24A are defined below.

Table 7: P24V and P24A Test Points

Signal	Signal Type	Units	Typ or (Max)	UL	LL	Scale Factor	RMS Typical Vdc	UL	LL
P24V	DC	V dc	24 (26)	20.73%	–20.73%	0.22 V/V	5.22	6.30	4.14
P24A	DC	A dc	0.15 (0.30)	4.13%	-4.13%	31.58 V/A	2.37	9.87	1.50

If P24V is out of tolerance and IN480V in tolerance, then P24V dc power supply has failed. Maintenance personnel should take the following actions.

1. If fuse F1 on IMA blown then replace Fuse F1, else go to step 2.
2. Remove and replace LRU IMA.

If P24A RMS circuit reading less than 1.5 Vdc then +24 V dc power supply RMS current monitor has failed. Maintenance personnel should remove and replace LRU IMA.

For example, If the +24Vdc Power supply is 24Vdc the P24V is 5.22 Vdc, or the +24Vdc Power supply is 26Vdc the P12V is 5.72 Vdc.

For example, If the +24Vdc power supply is delivering 300 ma then P24A is 9.47 Vdc, or the +24Vdc power supply is delivering 100 ma then P24A is 3.16 Vdc.

5.6 RMS LOOPA TEST POINT

The LOOPA signal is required. This signal samples the current being delivered by the CCR. The signal is dependent on the step level commanded.

5.6.1.1 Theory of Operation

The RMS is required to monitor the series circuit current. The RMS signal "LOOPA" is defined below. It is generated from DCRMS and also is used for fault isolation between the CCA and the MMA. DCRMS is generated from two current transformers that step the current from 20 to 6.6 amps and 6.6 amps to 55 mA and a squarer network that converts the current into a DC signal proportional to the loop current.

The LOOPA RMS Signal:

$R141 := 1 \cdot K \quad \Omega$

$R142 := 1 \cdot K \quad \Omega$

$R140 := 2.2 \cdot K \quad \Omega$

The circuit converts delivered current from amps to volts as shown below as an example for step B1.

$DCRMS := .678$

$$Vloopa := DCRMS \cdot \left(\frac{R140}{R142} + 1 \right) \qquad Vloopa = 2.17$$

$$\Delta Vloopa := \sqrt{3 \cdot \Delta R^2} \qquad \Delta Vloopa = 2.706 \quad \%$$

Table 8: LOOPA Test Points

Step	CCR Output Current	DCRMS Vdc	DCRMS UL	DCRMS LL	Scale Factor	LOOPA Vdc	LOOPA UL	LOOPA LL
1	8.5	0.678	5.41%	-5.41%	3.2V/V	2.19	2.71%	-2.71%
2	10.3	0.804	5.41%	-5.41%	3.2V/V	2.57	2.71%	-2.71%
3	12.4	0.969	5.41%	-5.41%	3.2V/V	3.10	2.71%	-2.71%
4	15.8	1.230	5.41%	-5.41%	3.2V/V	3.94	2.71%	-2.71%
5	20	1.530	5.41%	-5.41%	3.2V/V	4.90	2.71%	-2.71%

If LOOPA is out of tolerance per table above, then take the following actions:

1. Make sure protection circuit is enabled (LOOPA ≈ 0 amps) and IN480V < 374.4 V ac (PWRLO). Then go to input voltage tests, else go to Step 2.
2. Check to see if protection circuit is enabled (LOOPA ≈ 0 amps) and ILOOPST = HIGH. Then go to Step 3 (open circuit or overcurrent), else go to Step 4 (still delivering current).
3. Protection circuit worked (no failure)—check loop circuit for open.
4. If (LOOPA > 1.05 times rated current for step setting), then (overcurrent with protection circuit failure) — remove and replace LRU CCA and check SCR block and power core.
5. Isolate fault. Run IVCON test and return if OK.
6. Can not isolate fault further. Remove and replace LRU CCA and check SCR block and power core.

5.7 RMS LOOPV TEST POINT

The LOOPV signal is required. This signal samples the voltage across the series circuit. The signal is dependent on the step level commanded and output load.

5.7.1.1 Theory of Operation

The RMS is required to monitor the series circuit voltage. The RMS signal “LOOPV” is defined below. It is generated from the loop voltage. This signal is then input into the high voltage transformer 100:1 ratio, a resistive divider network, and the precision full wave rectifier circuits.

CCR Loop Voltages Assuming a 30KW load:

$Istep1 := 8.5$ $\Delta Istep1 := 0.2$ All values in amps

$Istep2 := 10.3$ $\Delta Istep2 := 0.3$

$Istep3 := 12.4$ $\Delta Istep3 := 0.3$

$Istep4 := 15.8$ $\Delta Istep4 := 0.4$

$Istep5 := 20.0$ $\Delta Istep5 := 0.2$

$Pdelivered := 30000$ Watts

$$Rload := \frac{Pdelivered}{20^2} \qquad Rload = 75 \quad \Omega$$

$$Vloop(i) := i \cdot Rload$$

Nominal	Upper Limit	LowerLimit
$Vloop(Istep1) = 637.5$	$Vloop(Istep1 + \Delta Istep1) = 652.5$	$Vloop(Istep1 - \Delta Istep1) = 622.5$
$Vloop(Istep2) = 772.5$	$Vloop(Istep2 + \Delta Istep2) = 795$	$Vloop(Istep2 - \Delta Istep2) = 750$
$Vloop(Istep3) = 930$	$Vloop(Istep3 + \Delta Istep3) = 952.5$	$Vloop(Istep3 - \Delta Istep3) = 907.5$
$Vloop(Istep4) = 1185$	$Vloop(Istep4 + \Delta Istep4) = 1215$	$Vloop(Istep4 - \Delta Istep4) = 1155$
$Vloop(Istep5) = 1500$	$Vloop(Istep5 + \Delta Istep5) = 1515$	$Vloop(Istep5 - \Delta Istep5) = 1485$

LOOPV Calculations:

Tolerances HV Transformer = 10%

$\Delta TX := 10$ %

$\Delta R := 1.562$ %

The output voltage is scaled by the hi voltage transformer, a resistors divider network, and a precision fullwave rectifier circuit. This circuit is located on the MMA.

$R120 := 10 \cdot K$	$R110 := 15 \cdot K$	$R115 := 4.75 \cdot K$
$R137 := 10 \cdot K$	$R117 := 10 \cdot K$	$R119 := 4.75 \cdot K$
$R118 := 10 \cdot K$	$R116 := 3.3 \cdot K$	$R136 := 4.75 \cdot K$

$LOOPV := 1500$

$$R1 := \frac{(R137 + R120) \cdot R119}{(R137 + R120 + R119)} \qquad R1 = 3.838 \cdot 10^{3}$$

$$Av := \left(\frac{R1}{R136 + R1}\right) \cdot \left(\frac{R110}{R117}\right) \cdot \left(\frac{2}{3.1416}\right) \cdot (1.414) \qquad Av = 0.603$$

$$LOOPV := \left(\frac{LOOPV}{100}\right) \cdot Av \qquad LOOPV = 9.052$$

$$\Delta LOOPV := \sqrt{\left(\Delta TX^{2} + 9 \cdot \Delta R^{2}\right)} \qquad \Delta LOOPV = 11.043 \ \%$$

Table 9: LOOPV Test Points

Step	LOOP VOLTAGE Volts RMS	HILOOPV Voltage AC	Scale factor	Vdc	LOOPV UL	LL
1	637.5	6.37	0.006 V/V	3.84	11%	-11%
2	772.5	7.72	0.006 V/V	4.66	11%	-11%
3	930	9.30	0.006 V/V	5.61	11%	-11%
4	1185	11.85	0.006 V/V	7.15	11%	-11%
5	1500	15.00	0.006 V/V	9.05	11%	-11%

Note: The table above is calculated for resistive load, not inductive load.

5.8 RMS IKSTAT TEST POINT

The IKSTAT signal is not required. This signal is a 24 VDC logic signal that shows the state of relay K1 and Contactor K2.

5.8.1.1 Theory of Operation

5.8.1.1.1 IKSTAT Test

The RMS signal "IKSTAT" is used to determine if relays K1 is stuck open or are short. IKSTAT is generated from K1 status signals. This signal is a 24V logic signal that is *high* for a "go" or *low* for a stuck relay.

1. If running IKSTAT test from LOOPA, then go to Step 2 below, else go to Step 4.
2. If (IKSTAT = HIGH), then return, else go to Step 3.
3. Remove and replace LRU CCA and LRU MMA , K1 in low voltage compartment. END
4. Run IKSTAT test alone (Steps 2 and 3).

5.9 RMS ILOOPST TEST POINT

The ILOOPST signal is not required. This signal is a 24V logic signal that tells the status of the (overcurrent/open circuit) protection circuitry.

5.9.1.1 Theory of Operation

5.9.1.1.1 Loop Status Test

The ILOOPST signal (24V logic) is generated from OPCIR and OVCUR and indicates whether or not an open circuit or overcurrent condition is present on the series loop. Logic LOW indicates the loop circuit is OK, but a HIGH signal indicates an open circuit or overcurrent condition.

Note: If this signal is HIGH, the protection mode is enabled (relay K1 and contactor K2 in low voltage compartment is disabled). This signal is used to determine if LOOPV and LOOPA are valid.

5.10 RMS IVCON TEST POINT

The IVCON signal is not required. This signal samples reference voltage generated on the Input Module and determines if the signal is correct by looking at the commanded step and LOOPA.

5.10.1.1 Theory of Operation

The IVCON signal is generated from the VCON signal on the Input Module. This signal is input into a resistive divider network, a buffer operational amplifier, and an inverting operational amplifier.

The IVCON RMS Signal:

The following example will calculate the IVCON signal for step B1.

$\Delta R := RSS(1, 12 \cdot .1)$

$\Delta R = 1.562$ % $\quad \Delta Vn12V := RSS(\Delta Vdc, \Delta R) \quad \Delta Vn12V = 20.675$

$\Delta VCON := 2$ %

$R98 := 1 \cdot K$ Ω $\quad R101 := 1 \cdot K$ Ω

$R99 := 1.21 \cdot K$ Ω $\quad R102 := 1 \cdot K$ Ω

$R100 := 1 \cdot K$ Ω

$VCON := 2.30$

$$Vivcon := VCON \cdot \left(\frac{R99}{R98 + R99} \right) \qquad Vivcon = 1.259$$

$$\Delta Vivcon := \sqrt{\Delta VCON^2 + 5 \cdot \Delta R^2} \qquad \Delta Vivcon = 4.025 \ \%$$

$UL(Vivcon, \Delta Vivcon) = 1.31$ VDC

$LL(Vivcon, \Delta Vivcon) = 1.209$ VDC

5.10.1.1.1 IVCON Test

The RMS signal IVCON is generated on the IMA and is used to fault isolate between the IMA and the CCA. It is valid as defined below

Table 10: IVCON Test Points

Step	VCON			Scale factor	IVCON		
	Vdc	UL	LL		Vdc	UL	LL
1	-2.24	3.83%	-3.83%	-(.548 V/V)	1.23	4.03%	-4.03%
2	-2.72	3.83%	-3.83%	-(.548 V/V)	1.49	4.03%	-4.03%
3	-3.28	3.83%	-3.83%	-(.548 V/V)	1.80	4.03%	-4.03%
4	-4.22	3.83%	-3.83%	-(.548 V/V)	2.31	4.03%	-4.03%
5	-5.33	3.83%	-3.83%	-(.548 V/V)	2.92	4.03%	-4.03%

If IVCON out of tolerance, remove and replace IMA and/or calibrate CCR, else return.

6. OPERATION

6.1 CONTROL

The rotary selector switch S2 on the front panel of the regulator is used for local control of the regulator. This control switch has seven positions labeled: REM (remote), OFF, and brightness steps 1, 2, 3, 4 and 5. For regulator operation by remote control signals, rotary selector switch S2 must be set to REM. Remote control is disengaged when switch S2 is set to any position other than REM.

6.1.1 Local Control

a) Rotary selector switch (S2) positions 1 through 5 are for local operation of the regulator. Positions 1, 2, 3, 4, and 5 provide an output current of 8.5, 10.3, 12.4, 15.8, and 20 amp, respectively. The regulator will automatically maintain the output current within ±1% of the nominal value for the brightness position selected.

b) When rotary selector switch S2 is set to the OFF position, the regulator is deenergized and can not be remotely turned on.

☑ **Note**: Before removing any modules (such as the Input Module, Current Controller, or Monitoring Module) from the card rack, turn rotary selector switch S2 to the OFF position, and then turn switch S8 on the card rack to OFF.

c) When switch S2 is set to REM, operation of the regulator is by remote control signals.

6.1.2 Remote Control

a) When the rotary selector switch S2 is set to the position REM and remote control wiring is connected to remote control terminal block TB1 on the regulator, the output current of the regulator will correspond to the brightness setting energized by remote control signals. Remote control signals generated from a remote location have no control over the regulator when switch S2 is set to OFF.

b) When there are no remote control connections on terminal block TB1, the position REM becomes an additional OFF position, i.e., the regulator is deenergized when S2 is set to REM.

6.2 STARTUP PROCEDURE

WARNING

Read safety precautions in Sections 5-1 before proceeding. The high voltage involved with the unit makes it potentially dangerous and may be lethal if contacted.

Put local control switch in OFF position. It is possible that during shipment some damage may have taken place. Therefore, before making adjustments,

1. Open the Input/Output compartment and inspect the terminal bushings.
2. Short-circuit the output lightning arrestors (E1, E2) using #10 AWG minimum wire (to avoid lamp destruction in case of an excessive current output).
3. Ground the regulator by making an adequate ground wire (AWG 6 minimum) connection to the ground lug located on the bottom part of the CCR.
4. Connect 480 Vac, single-phase, supply voltage lines to TB2 through a suitable disconnect switch (1 neutral, 2 phase).

5. Turn local control switch successively to all brightness steps and check the current values on the local ammeter.
6. Put the local control switch on REMOTE and check for proper operation from the remote station control panel.
7. Deenergize the regulator (turn off disconnect switch) and remove short-circuit link from the output lightning arrestor.
8. Connect load to the output lightning arrestor and energize regulator.

6.3 SHUTDOWN PROCEDURE

Set local control switch S2 to position OFF. The power to the output is now off and the regulator cannot be activated by remote control. Power is still present on the input terminals. Disengage disconnect switch to remove power to the input terminals.

☑ **Note**: Turn off toggle switch S8 if power to card cage needs to be turned off.

6.4 ADJUSTMENTS

The regulator has been adjusted at the factory to provide the nominal output current levels as given in Table 1-1. If the current level settings need to be adjusted, read the following warning statement before proceeding.

WARNING

Only personnel qualified to work on high voltage systems should attempt to make any adjustments on the constant current regulator.

Remove 480 Vac input power to regulator by turning off disconnect switch before opening access panel to service regulator. Turn off toggle switch S8 if power to card cage needs to be turned off.

If the regulator deenergizes suddenly, the output circuit could be interrupted by an overcurrent, open-circuit or undervoltage condition. Turn rotary selector switch S2 to position OFF and disconnect the input power (turn off main circuit breaker or disconnect switch) before inspecting the output circuit. Without this precaution, a dip in the power line may produce an on-cycling and reenergize the regulator, causing an output voltage of several hundreds or thousands of volts to be present. These high voltages can cause serious injury or death.

6.4.1 Output Current Adjustment (See Card Rack Schematic)

Potentiometers are provided on the Input Module PCB to permit adjustment of the output current levels if not within the limits defined in Table 1-1.

a) Connect a clamp-on true rms-reading instrument (such as a Beckman “Tech 360” multimeter with Model CT-231 current clamp or equivalent) around one of the output current leads.

☑ **Note**: Because the output current waveform is not a true sine wave, the ammeter must be of the true rms type. Field instruments such as clamp-on ammeters and Simpson voltmeters will give erroneously low readings.

b) Energize the regulator locally, and set the rotary selector switch S2 to the maximum brightness position 5.

c) Turn potentiometer R15 on the Input Module fully clockwise, then back up one full turn. See Table 5-1.

d) Adjust potentiometer R18 on the IMA to obtain an output current of 20 amps.

e) Adjust the potentiometers of the other brightness steps, if necessary, without touching R18 anymore.

Table 6-1. Output Current Adjustment Potentiometers

Rotary Switch S2 Position	Adjustment Potentiometer on Input Module PCB
1	R11
2	R12
3	R13
4	R14
5	R15

☑ **Note**: If the adjustment of R11 exceeds the adjustment of R12 or R13 or R14 or R15, then the output current of the CCR will correspond to the adjustment of R11 as long as this gives the highest output current. Also, R18 is the master potentiometer, adjusting this potentiometer will affect the output current on all steps.

6.4.2 Overcurrent Adjustment (See Card Rack Schematic)

Read safety precautions in paragraph 5.4 before proceeding.

6.4.2.1 Direct Method

☑ **Note**: It is a good rule to short-circuit the output terminals of the regulator with a minimum AWG 8 wire before making this adjustment.

a) Turn potentiometer R57 on Current Controller PCB fully counterclockwise.

b) Energize regulator by engaging disconnect switch or main circuit breaker.

c) Turn rotary selector switch S2 to maximum brightness position 5.

d) Adjust potentiometer R18 on IMA to obtain an output current of 20.3 amp measured with a precision true rms ammeter.

e) Turn potentiometer R57 slowly clockwise until the regulator deenergizes in 2 to 3 seconds or less after reaching the new R57 position. Use one of the following methods in order to set R57 to the proper position:

   1. *Oscilloscope Method*: Connect an oscilloscope across C13 on the Current Controller PCB. Short the test points E25 and E26 on Current Controller PCB. Rotate potentiometer R57 clockwise until the voltage waveform (voltage across C13) starts to fall on the oscilloscope screen. The voltage waveform falls when the overcurrent-detection circuitry starts to operate.

   2. *Timing Method*: Turn R57 clockwise until the regulator shuts down. Then turn R57 counterclockwise by 3 turns and reenergize regulator. Slowly turn R57 clockwise in short intervals, waiting approximately 2-3 seconds to determine if the R57 setting causes the regulator to shut off. Continue with this procedure until the R57 position is reached which causes the regulator to shut off.

   3. *Analog Voltmeter Method*: Using a voltmeter (1 MΩ minimum input) measure the voltage across C13. Short the test points E25 and E26 on the Current Controller PCB. Rotate potentiometer R57 clockwise while observing voltage across C13 on the voltmeter. The correct R57 position is reached when the voltage starts to drop. The overcurrent detection circuitry starts to become operational when the voltages starts to drop. Remove the short across E25 and E26.

f) To check the overcurrent detection, switch rotary selector switch S2 to OFF and then switch from brightness 4 to the maximum brightness position 5 (20.3A output) to verify the delay time between switching to overcurrent and regulator shutdown is below 2 seconds (by adjusting R57).

g) Verify that this R57 position corresponds to approximately 20.25-20.35 amps without external test points shorted (by readjusting R18 as described in paragraph 5.4.1).

h) Verify that the Monitoring Module memorizes the overcurrent after 2-4 seconds.

6.4.2.2 Indirect Method (Recommended by Siemens Airfield Solutions)

☑ **Note**: It is good rule to short-circuit the output terminals of the regulator with a minimum AWG 8 wire before making this adjustment.

a) Turn potentiometer R57 on the Current Controller PCB fully counterclockwise.

b) Short-circuit test points E25 and E26 on the Current Controller PCB.

c) Energize the CCR and turn rotary selector switch S2 to the maximum brightness position 5 and adjust R15 on IMA until the output current reads 19.75A.

d) Turn potentiometer R57 slowly clockwise until regulator deenergizes in 2 seconds or less.

e) Reenergize regulator to verify the delay-time between switching to 19.8A and turn-off of the regulator is 2 seconds or less.

f) Remove short-circuit between test points.

6.5 MONITORING MODULE BRIGHTNESS DETECTION ADJUSTMENT

To adjust the brightness detection on the Monitoring Module, proceed as follows:

1. Connect a DC voltmeter (30 Vdc full scale) to terminals COM and B5 on terminal block TB2.
2. Switch regulator on at brightness level B5.
3. Readjust R15 on Input Module to obtain an output current reading of 18.5 A on panel ammeter.
4. Adjust R38 on Monitoring Module to obtain a voltmeter reading of approximately 24 Vdc between COM and B5 on terminal block TB1.
5. Readjust R15 on Input Module so that the output current reading on the ammeter drops to 17.7 A and the status indication B5 disappears and status indication B4 appears.
6. Readjust R15 on Input Module to obtain the 20 A reading.

7. PERIODIC MAINTENANCE

7.1 GENERAL

This section establishes the maintenance procedures required for the L-828 constant current regulators. The maintenance tasks must be performed on a recurring basis to insure optimum performance, minimize service interruptions and avoid major breakdowns.

WARNING

Only personnel authorized to work on high-voltage equipment should perform maintenance on the regulator.

Operate regulator under local control (using rotary switch S2) when performing maintenance tasks on the regulator. This will prevent the regulator from accidentally being turned on and causing serious injury or death.

Deenergize regulator by turning rotary switch S2 to OFF, and remove input power to regulator by turning off disconnect switch or main circuit breaker before opening access door to service regulator.

7.2 PREVENTIVE MAINTENANCE

The preventive maintenance checks for the regulator are listed in Table 6-1.

7.3 SHORT-CIRCUIT TEST

WARNING

Since high open-circuit voltages may result by the opening of the primary of a series lighting circuit, only personnel authorized to work on high voltage equipment should be allowed to perform the short-circuit test.

1. Turn rotary switch S2 to OFF and turn switch S8 to OFF on the front panel. Remove 480 Vac input power to regulator (turn off disconnect switch or main circuit breaker).
2. Remove leads from output lightning arrestors, and short output lightning arrestors using AWG #10 or larger wire.
3. Make sure the panel ammeter on the regulator is zeroed. If not, adjust screw on face cover so the needle is set to 0 amps.

4. Energize regulator by turn switch S8 to ON and turn rotary selector switch S2 to the lowest brightness step “1” and then to the remaining brightness steps. Check the output current on the ammeter at each step. The output current should be within the tolerance given in Table 1-1.
5. If the output current is not within the limits specified in Table 1-1, check the input voltage to the regulator. The supply voltage should be within -10% to +10% of the 480 Vac nominal input voltage given on the regulator nameplate.
6. Turn CCR off and disconnect switch or main circuit breaker to remove input power to regulator.
7. Disconnect the shorting jumper and reconnect output cable.
8. Close input power disconnect switch or main circuit breaker.

7.4 OPEN-CIRCUIT TEST

WARNING

Since high open-circuit voltages may result by the opening of the primary of a series lighting circuit, only personnel authorized to work on high voltage equipment should be allowed to perform the open-circuit test.

1. Turn rotary switch S2 to OFF and turn switch S8 to OFF on the front panel. Remove 480 Vac input power to regulator (turn off disconnect switch or main circuit breaker).
2. Disconnect cables from output lightning arrestors.
3. Turn on input power to regulator.
4. Turn rotary selector switch S2 to lowest brightness step (1). The open-circuit protective device should automatically deenergize the regulator in less than 2 seconds.
5. Turn rotary selector switch S2 to OFF. The open-circuit protective device should reset.
6. Turn switch S8 to ON and rotary selector switch S2 to lowest brightness step (1). The regulator should turn on and then deenergize in less than 2 seconds.
7. If the regulator operation is satisfactory, turn CCR off, and disconnect switch or main circuit breaker to remove input power to regulator.
8. After the load has been reconnected, turn on input power to regulator.

TABLE 7-1. PREVENTIVE MAINTENANCE TASKS		
INTERVAL	MAINTENANCE TASK	ACTION
Daily	(1) Check all control equipment for proper operation	(1) Check local and remote control (if used) on each brightness step.
Monthly	(1) Check input voltage (2)Check and record output current on each brightness step	(1) If input voltage is not within −10% to +10% of the nominal value (480 Vac), notify power company to correct voltage. (2) Use a rms-reading instrument. Adjust current levels if out of tolerance (see Table 1-1 and Section 5.4.1).
Annually	(1) Check relays, wiring and insulation (2) Inspect housing for rust spots (3)Inspect lightning arrestor connections. (4) Perform a short-circuit test (5) Perform an open-circuit test	(1) Clean dirty or slightly pitted contactor contacts. Use a fine file for surface cleaning. Replace contacts that are excessively burned or pitted. Operate the local control switch S2 to check for proper operation of relays and contactors. Make sure input and output connections are tight and that there are no damaged wires or frayed or burnt insulation (2) Clean and touch-up rust spots with paint. (3) Tighten any loose connections. Replace charred or burnt wiring or broken arrestors. (4) See paragraph 6.3. (5) See paragraph 6.4.
Unscheduled	Check load on regulator	At installation and subsequent load changes make sure that the *output voltage times the output current does not exceed the rated load* of 30 kVA, 25kVA, 20kVA or 15kVA.

8. TROUBLESHOOTING

8.1 TROUBLESHOOTING TABLE

The troubleshooting guide for the L-828 constant current regulator is given in Table 7-1.

WARNING

Only personnel authorized to work on high-voltage equipment should perform maintenance on the regulator.

Deenergize regulator by turning rotary switch S2 to OFF, and remove input power to regulator by turning off disconnect switch or main circuit breaker. Discharge capacitors and ground input and output lightning arrestors by using a grounding rod prior to touching any parts.

If regulator deenergizes suddenly, the output circuit could be interrupted by an overcurrent or open-circuit. Before inspecting the output circuit. place rotary selector switch S2 in the OFF position and turn off disconnect switch or main circuit breaker. Without this precaution, a dip in the power line may produce an on-cycling and reenergize the regulator, resulting in an output voltage of several hundreds or thousands of volts which can cause serious injury or death.

8.2 PRELIMINARY TROUBLESHOOTING

It is essential for rapid troubleshooting of the CCR that at least one set of spare PCBs (Input Module, Current Controller, and Monitoring Module) be available.

The following is a check list of steps to perform:

1. Visually examine all areas of the CCR. Are there any burnt or loose connections/parts?
2. Is the input voltage present and within ±10% of nominal?
3. Check all fuses.
4. Are the PCBs fully pushed into the card rack?
5. Are the relays on the front panel fully seated?
6. Are there any bent pins on the rear of the Input Module, Current Controller, or Monitoring Module?

7. Are the wire harness connectors P3, P4 and P14 fully seated?
8. Have the PCBs been adjusted in accordance with the instruction manual?
9. Has the Input Module, Current Controller, and Monitoring Module PCB been replaced?
10. Replace SCR, if necessary.
11. Replace SCR Protective Network PCB, if necessary.
12. If CCR works in local but not in remote, check voltage on remote control lines.
13. Can the CCR be reenergized by turning rotary switch S2 from OFF to step 1? If it can be, problem is due to open circuit or overcurrent.
14. Does relay K1 on front panel energize? If it does but CCR does not come on, the problem is bad contactor wiring or bad contactor.
15. Does the CCR intermittently deenergize in both local and remote? If so, replace K1/check K1 socket and wiring or check overcurrent condition.
16. Short the output of the CCR with an AWG 8 wire, and turn CCR on. If the regulator operates normally, problem is load related.
17. If the CCR turns on and then shuts off after a few seconds and the ammeter on the Input Module indicates 0 amps, the problem is either an open circuit or current transformer T3 is open. T3 can be checked by comparing the primary and secondary current readings.
18. If the CCR turns on and then shuts off after a few seconds and there is a high current reading on the Input Module's ammeter, the problem is an overcurrent. Adjust the output current accordingly.

8.3 FUSES

1. Input Module Fuses:

   F1 (2A, 250 V) — Protects secondary of T2 on Input Module PCB which supplies AC voltage for ±12Vdc power supplies on Input Module.

   F2 (0.3A, 250 V) — Protects secondary of T2 on Input Module PCB which supplies AC voltage for +24Vdc power supplies on Input Module.

2. Input power fuses F1 and F2 rating in amps: 90 A, 600V

3. F3(4A, 250V), F4, and F5(3A, 600V)—Protects step down transformer T2 which supplies 240 Vac to card rack.

☑ **Note**: After replacement of any module, check the output current on all brightness steps and the overcurrent protection adjustment.

TABLE 8-1. TROUBLESHOOTING GUIDE

PROBLEM: REGULATOR DOES NOT TURN ON

POSSIBLE CAUSE	**SOLUTION**
Main power supply off	Verify presence of input voltage.
Switched off due to overcurrent	Switch regulator off in local, wait 2 seconds and check if regulator now operates correctly.
Incorrect external wiring	If regulator works correctly in local but not in remote, check the remote control signals. Replace the Input Module if necessary.
Blown fuse	Replace any blown fuse. Check input 480 Vac supply voltage and insure that it is between −10% and +10% of the nominal value listed on the CCR nameplate. Check fuse F3 on primary of 480/240 Vac transformer T2. Also check fuses F4 and F5 on secondary of T2.
Defective relay	Turn rotary selector switch S2 (on Input Module) to position 1. Check if relay K1 is energizing. Check coil of main contractor K2.

PROBLEM: OUTPUT CURRENT IS ALWAYS 20 A OR MORE

CAUTION

SHORT THE OUTPUT LIGHTNING ARRESTORS BEFORE SWITCHING THE REGULATOR ON. WIRE SHOULD BE AWG 8 OR LARGER.

POSSIBLE CAUSE	**SOLUTION**
Malfunction of output current control circuitry	• If problem exists only in remote mode, check remote control signals for +24 Vdc control signal on brightness control terminals. • Check the adjustment of R11 on Input Module. • If problem occurs in remote and local mode, replace Input Module and/or current controller PCB.
Overcurrent condition	See problem “Regulator turns on but deenergizes suddenly”.

TABLE 8-1. TROUBLESHOOTING GUIDE

PROBLEM: REGULATOR TURNS ON BUT DEENERGIZES SUDDENLY

POSSIBLE CAUSE	**SOLUTION**

CAUTION

SHORT THE OUTPUT LIGHTNING ARRESTORS BEFORE SWITCHING THE REGULATOR ON. WIRE SHOULD BE AWG 8 OR LARGER.

Output circuit interrupted	Turn CCR on. If CCR works correctly, repair lighting circuit taking safety precautions into account.
Defective printed circuit board	Check regulator output current on panel ammeter. Replace Input Module and/or Current Controller if defective.
Overcurrent condition	• If no overcurrent (output current higher than 21 A) condition exists on the maximum brightness setting, then readjust the overcurrent protection. See Section 5.4.2. Verify the current is within nominal range (defined in Table 1-1) at all other brightness steps. • Verify the presence of voltage across R35 of Current Controller. (JP34: 0 V reference; JP25 voltage across R35; this is a rectified AC signal with a peak value of about 36 V max. at 20 A output current). If no voltage is present, replace Input Module. • Verify SCR ignition by replacing the Current Controller. • Check SCRs and wiring. • Replace SCR Protective Network PCB.

PROBLEM: MORE THAN 2 SECONDS IS REQUIRED FOR CCR TO DEENERGIZE ON AN OPEN-CIRCUIT LOAD

POSSIBLE CAUSE	**SOLUTION**
Faulty open-circuit protection	Replace Current Controller.

PROBLEM: SHORT LAMP LIFE AND/OR HIGH OUTPUT CURRENT READING ON PANEL AMMETER

POSSIBLE CAUSE	**SOLUTION**
Incorrect output current adjustment	Proceed as in Section 5.4.1.
Faulty overcurrent protection	Readjust overcurrent protection as described in section 5.4.2, or replace Current Controller.

TABLE 8-1. TROUBLESHOOTING GUIDE

PROBLEM: OUTPUT CURRENT IS ALWAYS 8.5 A OR LESS.

POSSIBLE CAUSE	SOLUTION
Opto-couplers ISO1-ISO4 on Input Module fails to operate	• If problem exists only in remote mode, check remote control signals for +24 Vdc control signal on brightness control terminals.
Defective module	If problem exists in remote and local mode, replace Input Module to see if current transformer reacts correctly (low probable failure), or the brightness control signal on the opto-couplers ISO1, ISO2, ISO3, ISO4 are correct.
SCRs always conducting	Verify SCR ignition by replacing Current Controller. Check SCRs and wiring for shorts in SCR circuitry. Replace SCR Protective Network PCB and/or SCR block.
Defective resonant circuit (transformer or capacitor)	• Visually inspect capacitor for damaged housing or wire connections. • Visually inspect transformer for damaged coils, connections and/or wiring.

PROBLEM: REGULATOR DOES NOT INDICATE PROPER CURRENT

POSSIBLE CAUSE	SOLUTION
Incorrect output current adjustment	Proceed as in Section 5.4.1.
Defective module	Replace Input Module or Current Controller PCB.

TABLE 8-1. TROUBLESHOOTING GUIDE

PROBLEM: REGULATOR OPERATES BY LOCAL CONTROL SWITCH S2, BUT DOES NOT OPERATE BY REMOTE CONTROL	
POSSIBLE CAUSE	**SOLUTION**
Rotary switch S2 (on input module) not set to "REM"	Set switch S2 to "REM".
Loose or broken remote control wires	Check connections on remote terminal block TB1 for presence of +24 Vdc on TB1-COM and TB1-ON, B2, B3, B4, and B5.
Incorrect wire connections	See Section 9 and verify remote wiring connections are correct.

PROBLEM: AMMETER ON CCR OSCILLATES AND A LOUD "GROWLING" NOISE IS PRESENT	
POSSIBLE CAUSE	**SOLUTION**
Incorrect connections on transformer T2 (if T2 has been replaced in the field)	Reverse wires number 104 and 152 (See schematics in Section 10.)

PROBLEM: OUTPUT CURRENT CANNOT BE ADJUSTED UP TO 20 A	
POSSIBLE CAUSE	**SOLUTION**
Regulator load is too large	Check if the *input current x input voltage x CCR efficiency* [=0.90 (or 0.92 for 30 kW CCR)] is larger than the kW rating of CCR nameplate. If it is, either reduce the load or replace regulator with a larger kW CCR. This problem can also be verified by shorting the output of the CCR and verifying output current can be adjusted correctly in each step.

TABLE 8-1. TROUBLESHOOTING GUIDE

PROBLEM: NO STATUS INDICATION, BUT CORRECT OPERATION OF CCR

POSSIBLE CAUSE	**SOLUTION**
Defective Monitoring Module PCB	Replace Monitoring Module PCB.

PROBLEM: WRONG STATUS INDICATION

POSSIBLE CAUSE	**SOLUTION**
Incorrect adjustment	Readjust potentiometer R38 on the Monitoring Module. See par. 5.5
Defective Monitoring Module PCB	Replace Monitoring Module PCB.

9. PARTS LIST

9.1 PARTS LIST

Table 8-1 provides data on all replaceable parts for each repairable or replaceable component or assembly. Items in boldface are recommended spare parts.

NOTE

Substitution of electrical components can not be done except if substitution is the exact physical equivalent (body or case size) and equal, or better electrical characteristics with respect to tolerance, failure rate and/or reliability.

Table 9-1. Parts List

Item #	Description: 44D2519/0000	Manufacturer Part No.	SAS Part No.
1	Capacitor, 26 µF, 525 Vac, 6%		20A0019
2	**SCR Block**		**28A0012**
3	Surge Arrestor, 6 kV		32A0024-1
4	**Varistor, V571DA40**		**32A0028**
5	SD TX 480/240VAC		35A0150
6	**Contactor, 3P, 115A, 175A, 240Vac Coil**		**53A0387**
7	**Current Controller Assembly**		**44D4509**
8	**Fuse, 3A, 600V**		**47A0084**
9	**Fuse, 4A, 125V, Slow Blo**		**47A0073**
10	**Fuse, 90A, 600V**		**47A0097**
11	Current TX 20/6.6A		35A0308
12	SD TX 5000/50VAC		53A0346
13	**Input Module Assembly**		**44D4508**
14	**Monitoring Module Assembly**		**44D4510**
15	Power TX 30KW 480V 20A MIL		35C0186/1
16	**Relay, DPDT, 10A, 24Vdc, Coil**		**53A0173**
17	**SCR Protective Network**		**44B1171**
18	**Current Sensor 150A**		**53A0366**
19	EMI Filter 480V/90A		144D1409

Items in boldface are recommended spares.

10. Figures

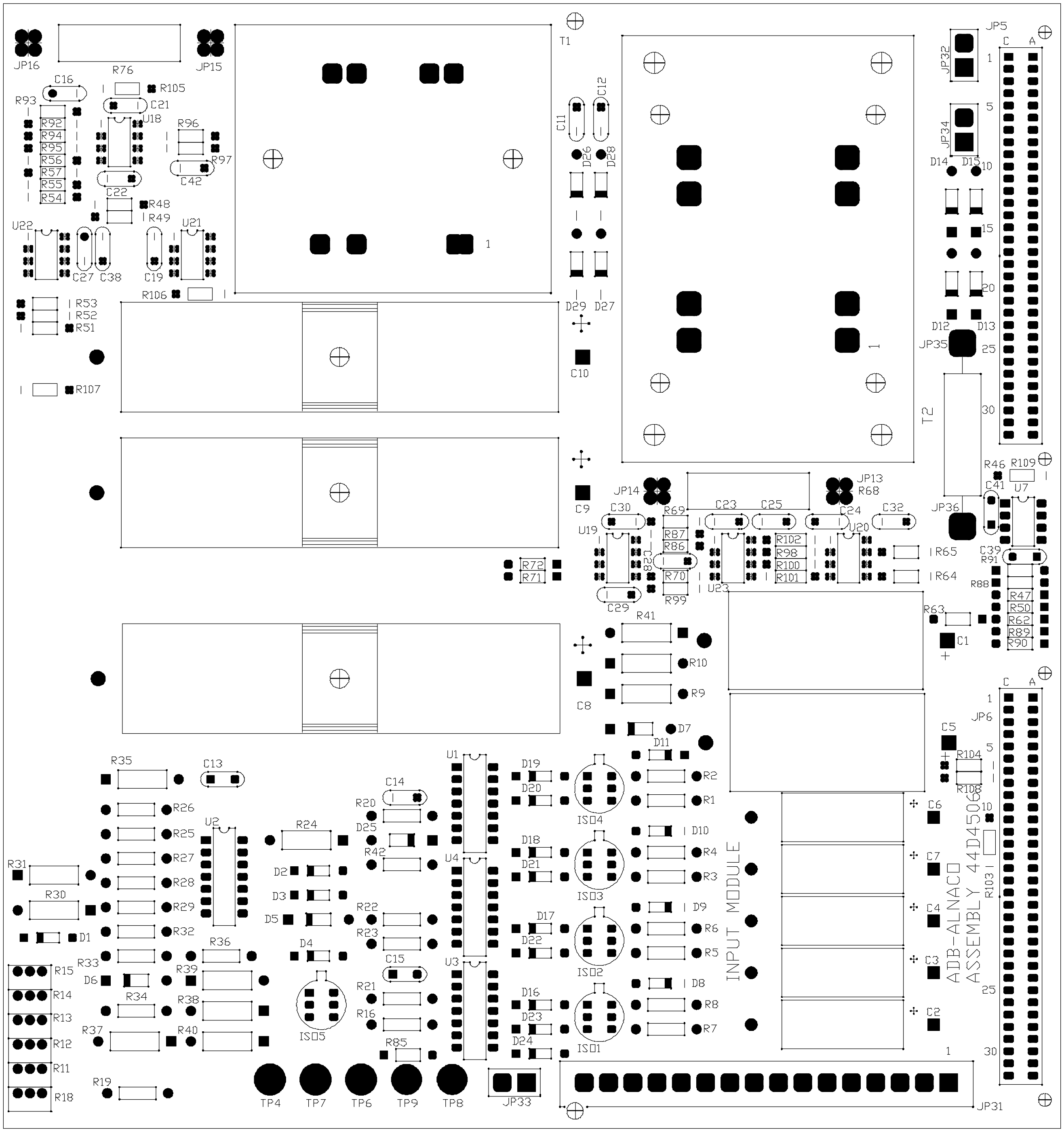


Figure 1. IMA PC Board

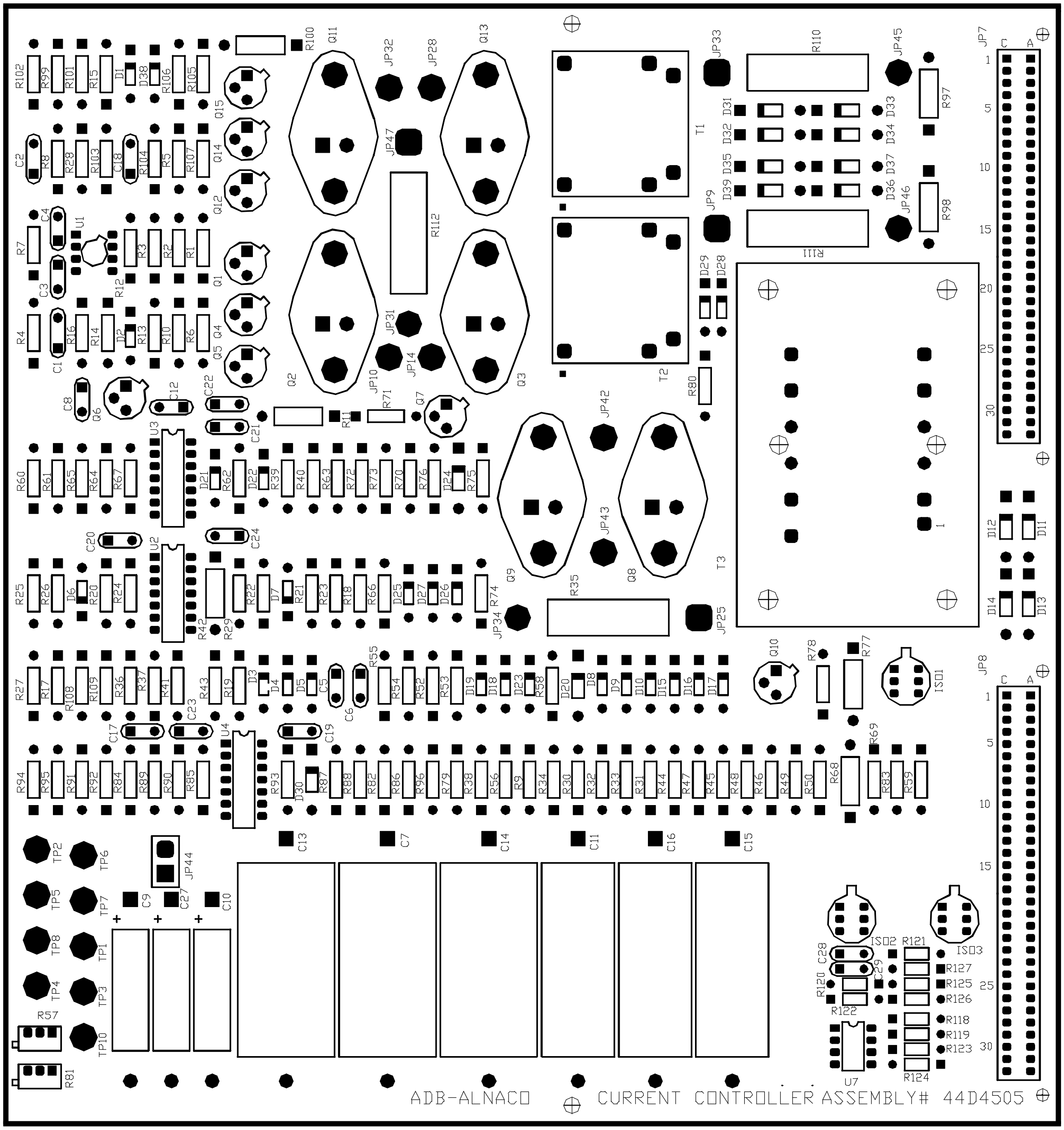


Figure 2. CCA PC Board

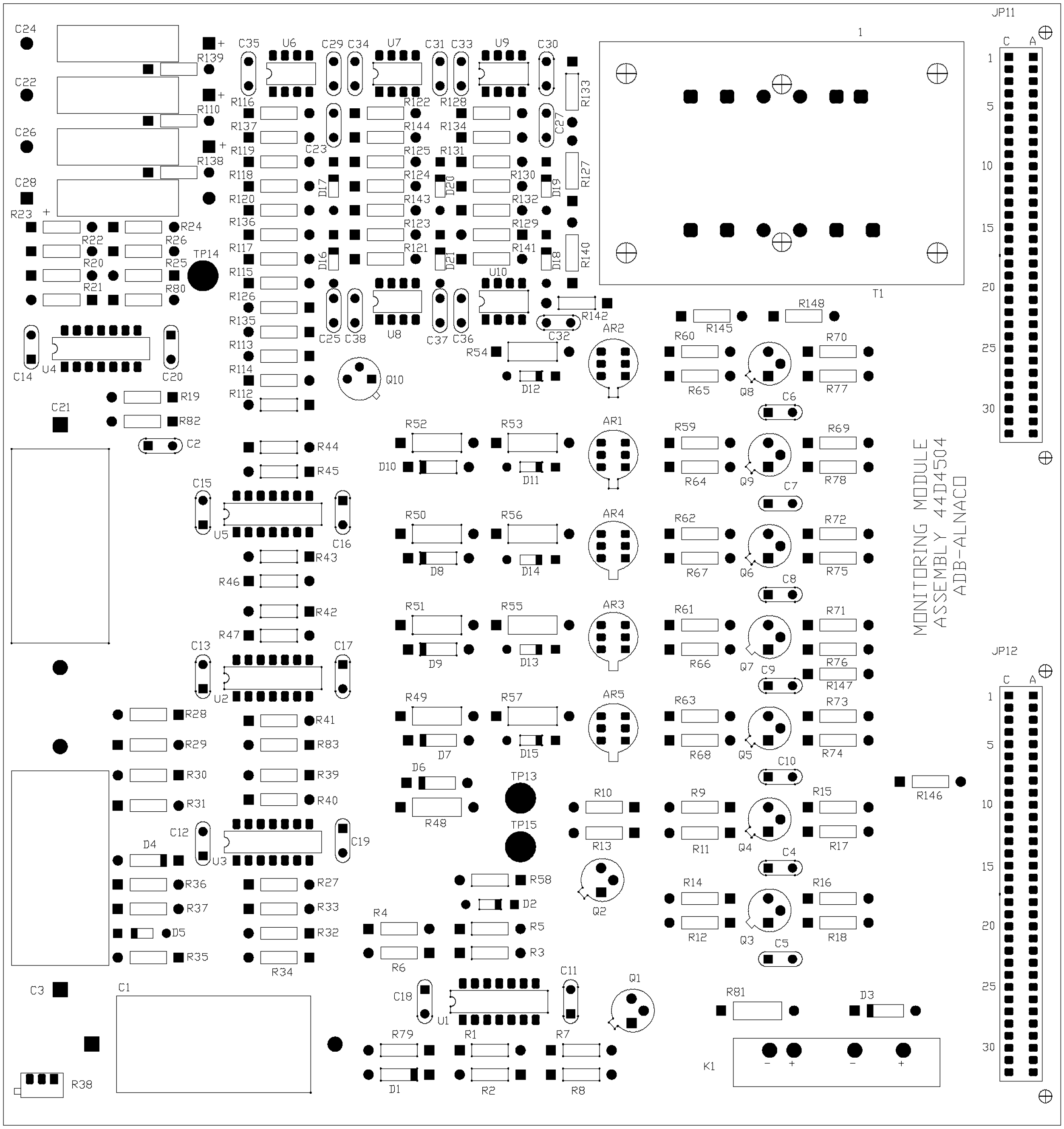


Figure 3. MMA PC Board

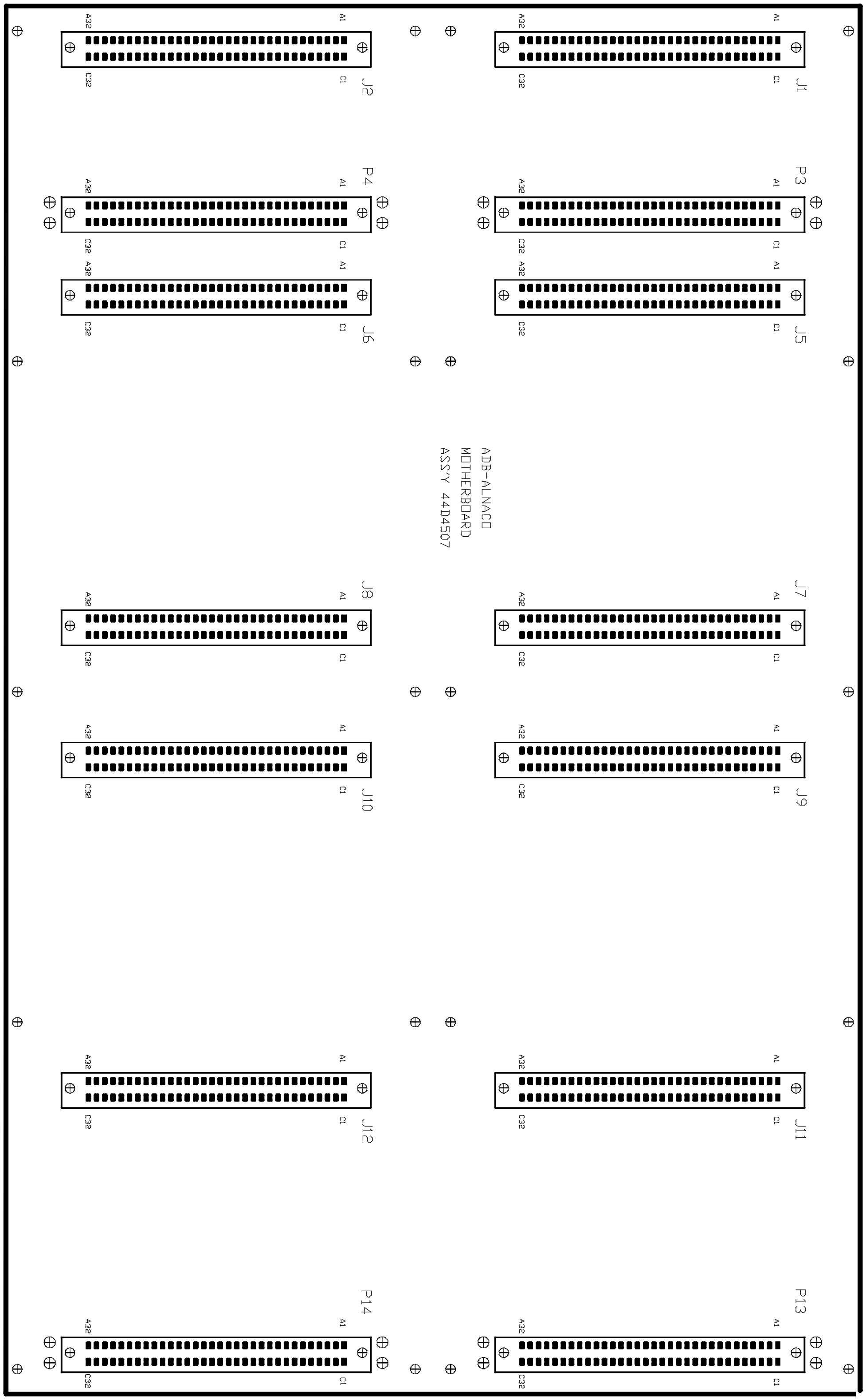


Figure 4. Mother Board

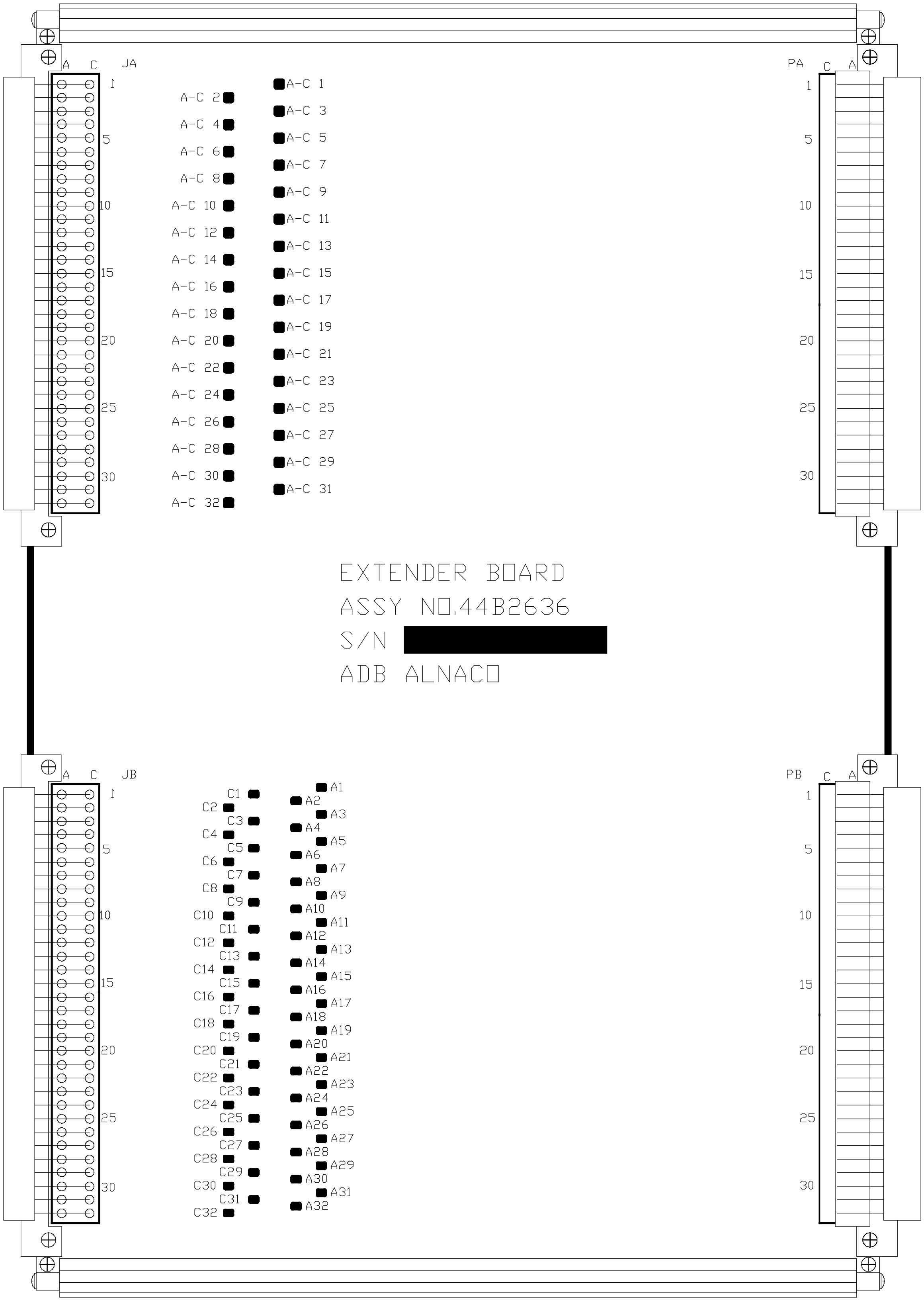


Figure 5. Extender PC Board

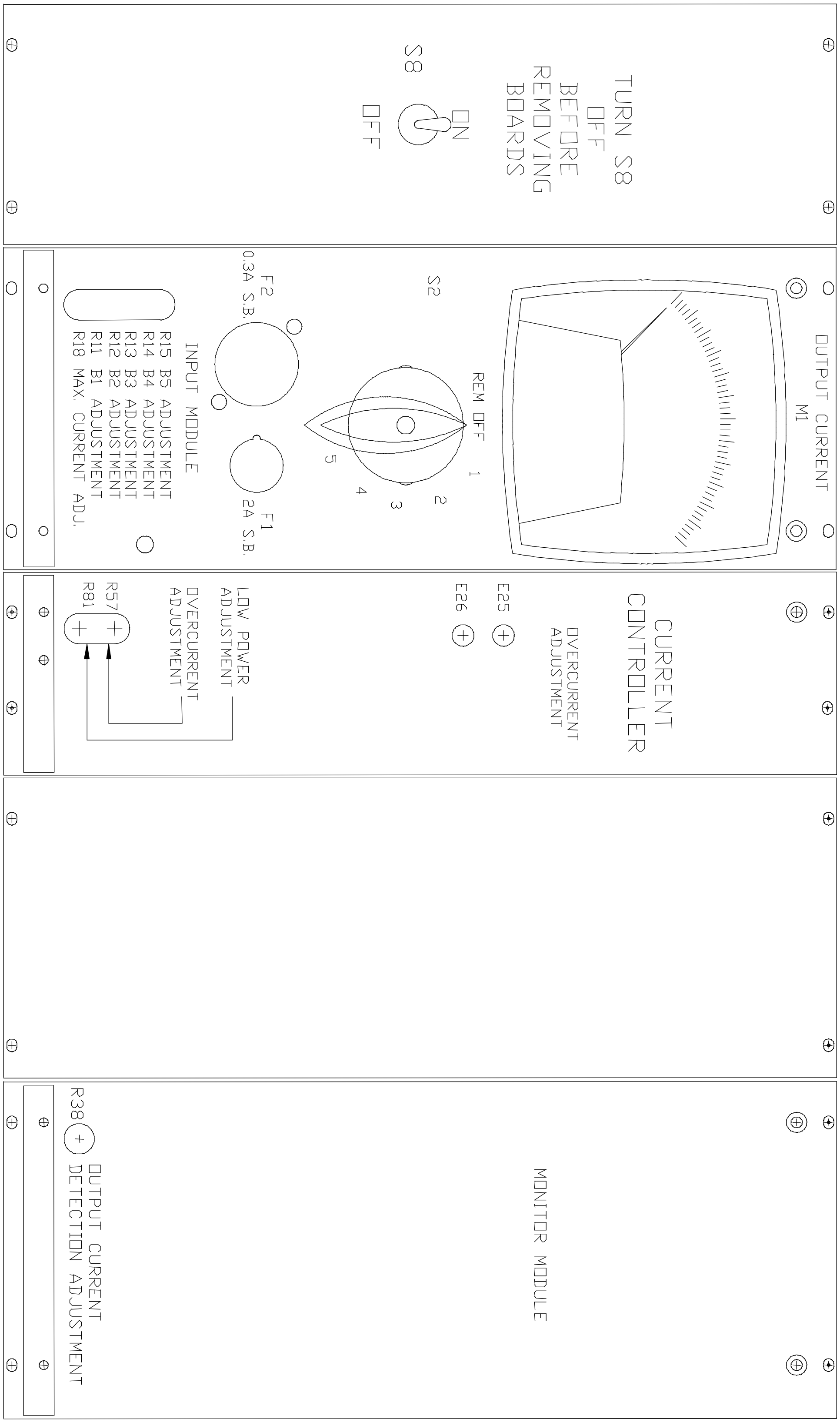


Figure 6. Card Rack

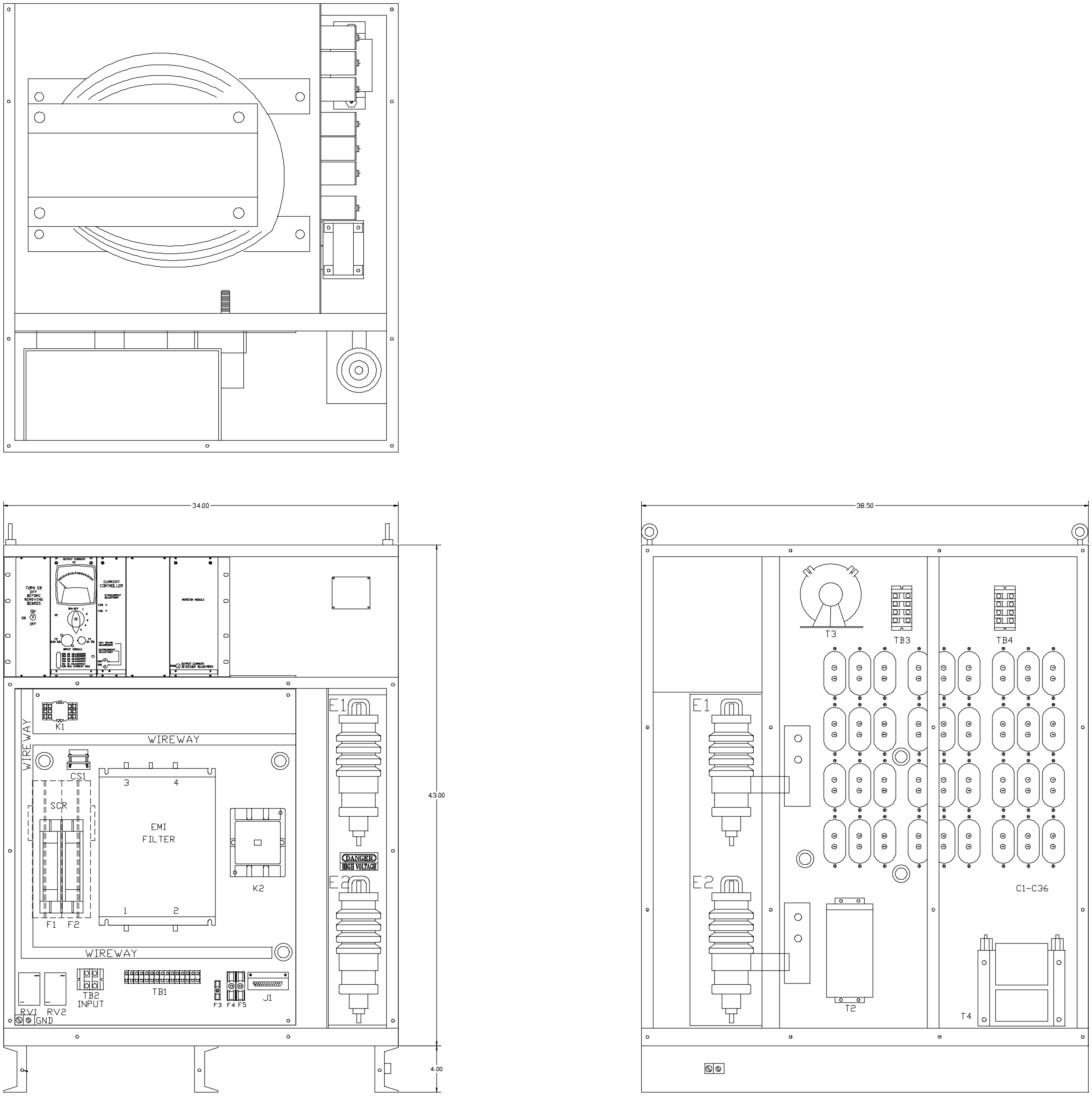


Figure 7. CCR Assembly

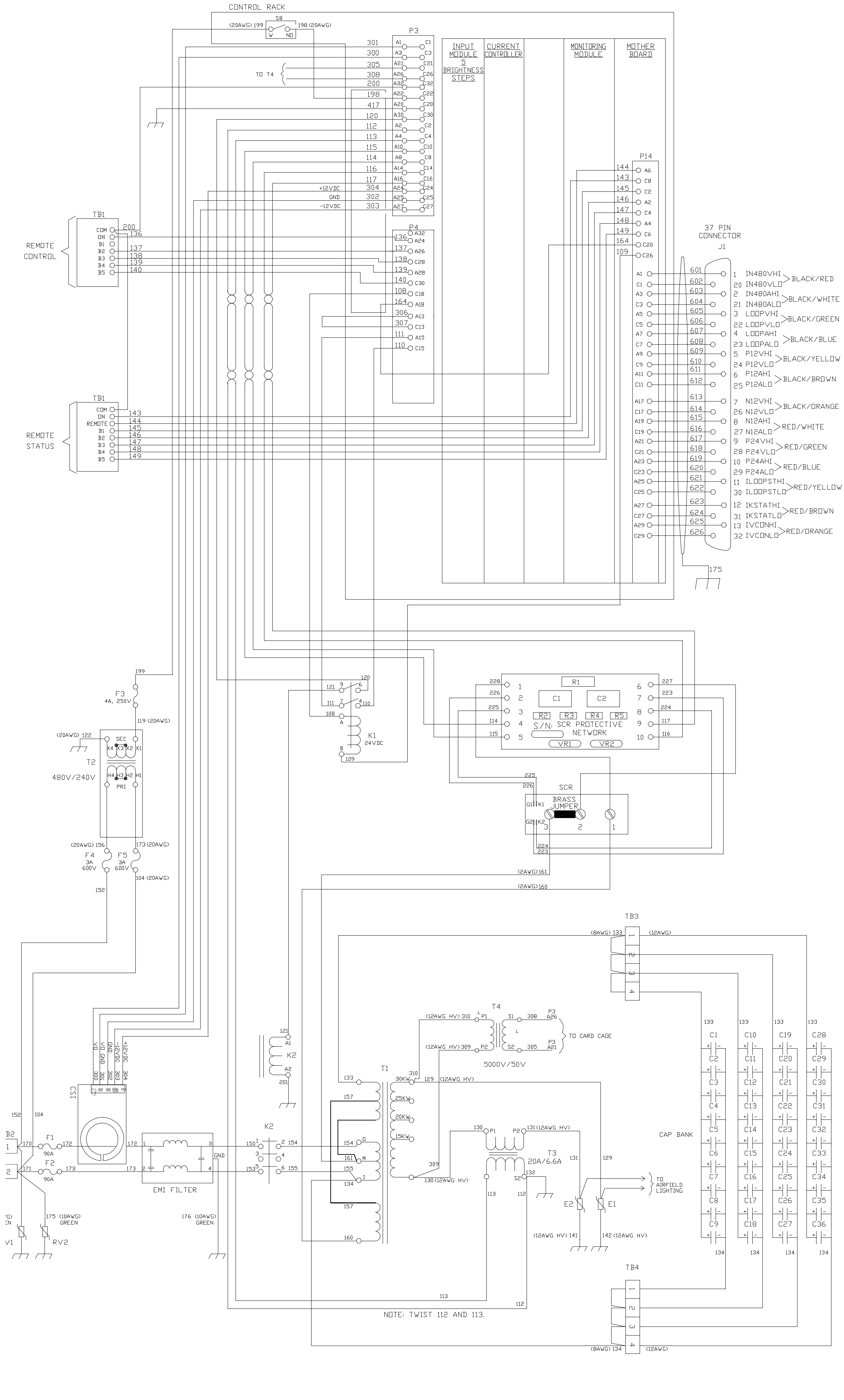


Figure 8. CCR Schematic