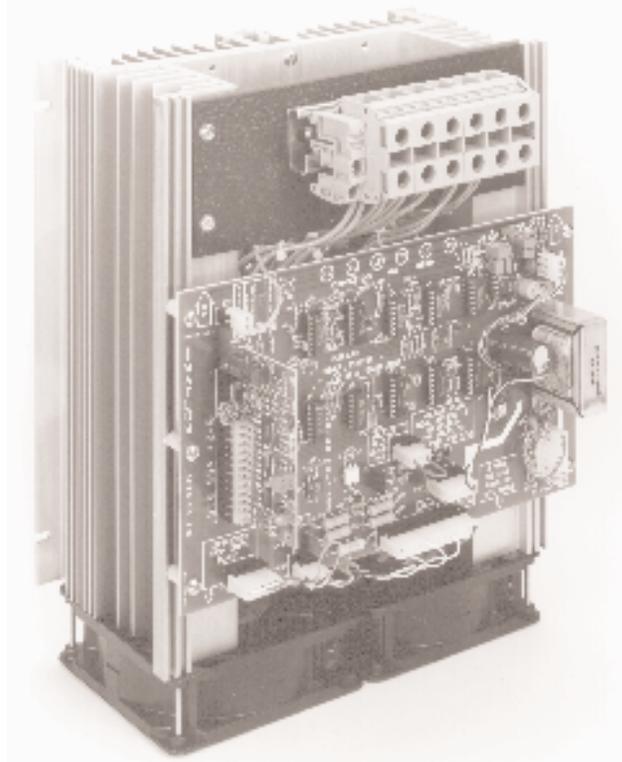




QPAC



Modular SCR Power Control

Service Manual



1241 Bundy Blvd., P.O. Box 5580, Winona, MN 55987-5580, Phone: 507/454-5300, Fax: 507/452-4507

QPAC-SA10-9403
April, 1994

\$10.00

Made in the U.S.A.

 Printed on Recycled Paper

Use The Manual

- Chapter 1, Page 4
- Chapter 2, Page 8
- Chapter 3, Page 9
- Chapter 4, Page 15
- Chapter 5, Page 17
- Appendix, Page 31

How to Use the Manual

- General Description
- Cleaning Fans, Fins, Filter
- Base & Firing Cards
- Test Procedures
- Troubleshooting
- Waveforms and Schematics
- Indication of Malfunction
- Tightening Connections
- Operation Theory
- Bench Testing
- Specifications
- Periodic Test Runs
- SCRs

Notes

The user's manual contains informational notes to alert you to important details. When you see a note icon, look for an explanation in the margin.



NOTE:
Details of a "Note" appear here in the narrow box on the outside of each page.



Safety Information

This user's manual also has boldface safety information notes to protect both you and your equipment. Please be attentive to them. Here are explanations:



CAUTION:
Details of a "Caution" appear here in the narrow box on the outside of each page.



The Caution symbol (exclamation point) in the wide text column alerts you to a "CAUTION", a safety or functional hazard which could affect your equipment or its performance. A full explanation is in the narrow column on the outside of the page.



WARNING:
Details of a "Warning" appear here in the narrow box on the outside of each page.



The Warning symbol (lightning bolt) in the wide text column alerts you to a "WARNING", a safety hazard which could affect you and the equipment. A full explanation is in the narrow column on the outside of the page.

Technical Assistance

If you encounter a problem with your Watlow control, review all of your configuration information to verify that your selections are consistent with your application... Inputs, Outputs, Alarms, Limits, etc. If the problem persists after checking the above, you can get technical assistance by dialing: 1-507-454-5300

An Applications Engineer will discuss your problem with you.

Please have the following information available when calling:

- Complete model number
- Bar Code Number
- All configuration information
- User's Manual

Your Feedback

Your comments or suggestions on this manual are welcome, please send them to: Technical Writer, Watlow Controls, 1241 Bundy Blvd., Box 5580, Winona, MN 55987-5580, Phone: 507/454-5300, Fax: 507/452-4507. The QPAC Service Manual is copyrighted by Watlow Winona, Inc., © 1994, with all rights reserved.

blr 0693

Table of Contents

Chapter 1	QPAC Modular SCR Power Control	Page
	General Description	4
	Overview	5
	Replacement Parts	5
	Indication of Malfunction	5
	QPAC Specifications	6
Chapter 2	Preventative Maintenance	
	Cleaning Cooling Fans, Fins and Filter	8
	Tightening Connections	8
	Periodic Test Runs	8
Chapter 3	Operation Theory of Base and Firing Cards	
	Single Phase Model - Q01	9
	Power Base Operation	9
	Three Phase, Two Leg - Q32	10
	Power Base Operation	10
	Three Phase, Three Leg - Q33	11
	Power Base Operation	11
	Zero Cross Control Cards	13
Chapter 4	Test Procedures	
	Q01 and Q32	15
	Q33 Zero Cross Adjustment	15
	Bias and/or Gain Adjustments	16
	Current Limit Adjustments	16
Chapter 5	Troubleshooting	
	Indications of Malfunction	17
	Troubleshooting Guidelines	17
	Q01 Troubleshooting	18
	Q32 Troubleshooting	21
	Q33 Troubleshooting	24
	Bench Testing	27
	Testing SCRs in the Unit	28
	Installing an SCR Package	28
	Troubleshooting the Base and Control Cards	28
Appendix		
	Waveforms and Schematics	31

Chapter 1

QPAC Modular SCR Power Control

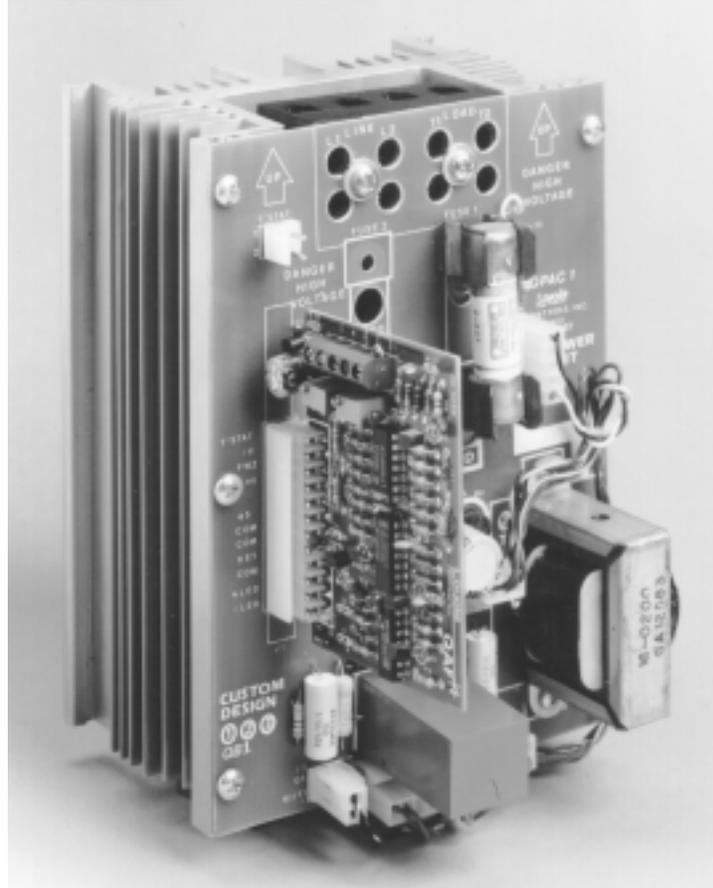


Figure 1 -
The QPAC-01
SCR Power Control

General Description

The QPAC Power Controls are a family of solid state controls used for electric heating applications. A solid state power control provides output power that is proportional to the input command signal from a temperature control. This proportional output power helps to produce a closely controlled heater temperature, which saves energy and prolongs heater life by holding heater elements at a nearly constant temperature.

The QPAC has a modular construction with plug-in features for flexibility. The three modules of the QPAC are the *power base*, *transformer*, and *control card*. See Figure 2. Power bases are available in 30 to 300 Ω ratings in single phase, three phase-two leg and three phase-three leg configurations. A transformer plugged into the power base allows the QPAC to operate on any voltage from 120 to 480VAC. The plug in control card sets the QPACs firing mode. Control cards are available in solid state contactor, burst firing (zero cross), or phase angle modes with a wide variety of input options. This modular approach, using a standard power base with plug-in transformers and control cards, allows power control users, distributors and OEMs to maintain minimum inventories while still providing rapid service.

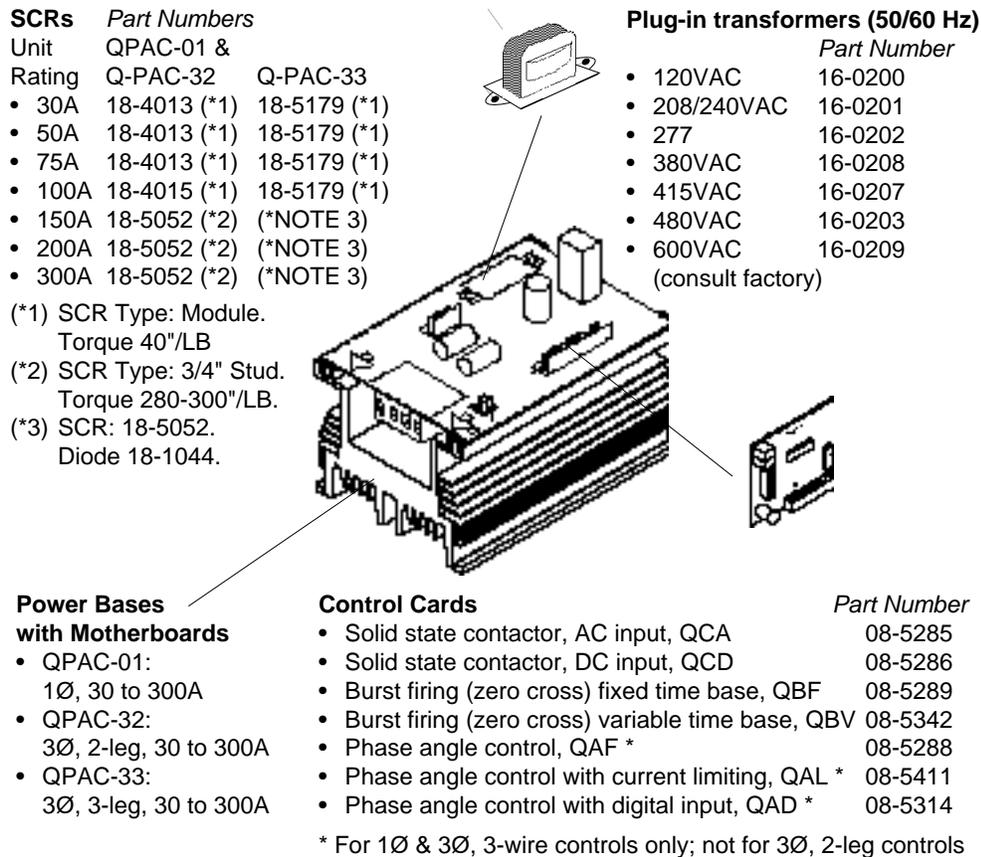


Figure 2 - QPAC Modularity Overview

Q01 is a single phase power control that operates with any type of firing method such as burst fired, phase angle, variable time base, and AC. It uses a pair of back-to-back SCRs ("package" or individual) depending on amperage ratio.

Q32 is a 3-phase, 2-leg power control that can operate on most types of firing methods, except phase angle, and controls two of the three legs. The QPAC-32 was designed for zero cross applications only. It uses two pairs of SCRs, individual or SCR package, depending on amperage ratio.

Q33 is a 3-phase, 3-wire hybrid (SCR and diode) power control that operates with any type of firing method. It features a series of jumpers for fast AC input changes after changing transformers, and a jumper for changing from burst fired to phase angle firing. It also has LEDs to indicate "Power On," "Phase Lock Loop," "Phase Rotation," and "Phase Loss." For fast malfunction diagnostics, and for bench troubleshooting, complete data is on the board at a series of test points. Integrated circuits are easy to change by simply plugging and unplugging for replacement or testing.

Indications of Malfunction

1. No output under any circumstances.
2. Full ON output at all times and the load is uncontrollable.
3. Output is not proportional to the command signal (unbalanced output).
4. Operating erratic and inconsistent.
5. Half output.
6. One or more LEDs not lit on the Q33 base

Operation

- Modular control base with plug-in card and transformer
- **Plug-in control cards**
 - Solid state contactor, AC or DC input
 - Burst firing (zero cross) control, fixed or variable time base
 - Phase angle control with soft start and current limiting, or digital input
- **Plug-in transformers (50/60Hz)**
 - 120 VAC operation
 - 208/240 VAC operation
 - 380 VAC operation
 - 415 VAC operation
 - 480 VAC operation
 - 600 VAC operation, consult factory
- **Power bases**
 - Single phase (Q01), 1 pair of SCRs
 - Three phase (Q32), 2 leg control, 2 pair SCRs.
Resistive load only, balanced or unbalanced, burst firing (zero cross) only
 - Three phase (Q33), 3 pair hybrid SCRs/diodes
Recommended for phase angle only with balanced load.

Control Cards

- **(QCA)** Solid state contactor, AC Input (08-5285)
 - 120 VAC @ 30mA minimum
 - AC signal input sources (ie., Triacs or mechanical relay outputs with noise suppression) require customer supplied resistors across the power control AC command signal input terminals to prevent false firing.
 - 24 VAC input, 200 Ω /10 watts typical
 - 120 VAC input, 1K Ω /25 watts typical
 - 240VAC input, two 1K Ω /25 watts in series typical
- **(QCD)** Solid state contactor, DC Input (08-5286)
 - ON, 4 to 10VDC; OFF, 0VDC
 - Built-in noise reduction network
- **(QBF)** Burst firing (zero cross) control Fixed Time Base (08-5289)
 - Process input factory set @ 4-20mA
 - Input impedance 250 Ω (clip resistor for 5K Ω voltage input)
 - Time Base 4 seconds (clip resistor for 1 sec)
- **(QBV)** Burst firing (zero cross) control , Variable Time Base (08-5342)
 - Process input factory set @ 4-20mA
 - Input impedance 250 Ω (clip resistor for 5K Ω voltage input)
 - Bias and Gain card optional
- **(QAF)** Phase angle control (08-5288)
 - Process input factory set @ 4-20mA
 - Input impedance 250 Ω (clip resistor for 5K Ω voltage input)
 - Soft start 10 sec (approximately)
- **(QAL)** Phase angle control with current limit: (08-5411)

Some heater elements change resistance during their operation, (i.e., silicon carbide). In order to control at a slow ramp, it is often advantageous to limit the current. Sensing the current is via a current transformer. This is NOT a means of protecting the SCR.

 - Process input factory set @ 4-20mA
 - Input impedance 250 Ω (move jumper for 5K Ω voltage input)
 - Soft start 10 sec (approximately)
 - Current transformer included
 - Current Limiting.
- **(QAD)** Phase angle control with digital input (08-5314)
 - Remote digital phase control
 - Interface, Centronics® parallel, 8 lines
 - Power steps, 256

Output

- 120VAC through 480VAC (600VAC, consult factory)
- 1, 2, or 3 pole
- 30 through 300 amps per pole

Power

- Frequency 50/60 Hz
- Voltage +/- 10%, 120/208/240/277/380/415/480VAC (600VAC, consult factory)

Power Dissipation (Watts)

- 1.5 watts/amps per controlled leg

Line Voltage Compensation

- 10% Δ in line, 2%Δ in load in the 30% to 70% power region (QAF, QAL & QBV)

Isolation

- Command signal to load 1250VAC minimum

Linearity

- 2%, 30% to 70% power region (All units except QAD, QCA & QCD)

Off State Leakage Current

- 20mA @ 480VAC

SCR Protection

- I2t fuses provided, dv/dt 200V/ μsec minimum.
I2t are fast acting fuses designed to protect SCRs and capable of opening (blowing) inside 1/2 cycle (2.3 msec). They are not designed for protection of other parts of the heater system and should not be used in place of circuit breakers or fusible disconnects.
- Q33 units equipped with MOV and snubber. Q01 & Q32 units, snubber only.
- **(Q32)** 3rd leg fuse kit may be used, but not required, with 3 phase- 2 leg models

Cooling

- Fans provided in 75A to 100A units must be supplied with 120VAC (or 240VAC), 20 watts fan power each
- All fans wired by the customer, Q01: 75A through 300A units, 1 fan; Q32: 30A through 100A units, 1 fan; 150A, 200A, 300A units, 2 fans; Q33: 30A through 100A units, 2 fans; 150A, 200A, 300A units, 3 fans
- Natural convection only: Q01: 30A and 50A units
Heat Sink Thermostat. SCRs that incorporate a fan for forced air cooling can reach unsafe temperatures if the fan fails. All Loyola SCRs with fan cooling incorporate a heat sink thermostat to remove power from the SCR in case of fan failure, filter blockage, or excess heat in the enclosure.

Agency Approval

- UL recognition to 300 Amps, UL873, File # E43684. Listed under UL508, File #E73741

Mounting

- Orientation: Heat sink fins must be vertical

Operating Environment

- 32 °F to 122 °F/0 °C to 50 °C
- 0 to 90% RH, non-condensing

Weight

Amps	Phase		
	1Ø/Q01	3Ø,2 leg/Q32	3Ø,3 wire/Q33
30	6 (2.7)	8 (3.6)	20 (9.1)
50	6 (2.7)	8 (3.6)	20 (9.1)
75	10 (4.5)	15 (6.8)	50 (22.7)
100	10 (4.5)	15 (6.8)	50 (22.7)
150	15 (6.8)	36 (16.3)	50 (22.7)
200	15 (6.8)	36 (16.3)	50 (22.7)
300	15 (6.8)	36 (16.3)	50 (22.7)

Options

- Manual Control Kit (1KΩ potentiometer) #08-5362
- 240VAC fans in place of 120VAC fans
- 600VAC operation, consult factory

Chapter 2

Preventive Maintenance

Cleaning Cooling Fans, Fins and Filter

Cooling a power control is critical to its reliable operation. Your unit should be inspected and cleaned every six months (more frequently in dirty environments). To achieve this, follow this simple procedure.

1. Remove power from the control. There may be more than one disconnect since the fan power is separate from the main power.
2. Inspect and clean the cooling fans and heat sink fins. In most cases an air hose is sufficient to remove lint or dirt which may block air flow.
3. Once again, inspect and clean any fans and/or filters which may bring air into or out of the enclosure. If the filters are not cleanable replace them.

Tightening Connections

Loose (arcing) connections can and will destroy SCRs. Stranded wire has a tendency to "cold flow" when clamped in a screw down compression connector.

After installation and every six months:

1. Remove power from the control.
2. Inspect and tighten all connections from the circuit breaker to the heaters.

Periodic Test Runs

If the system has been idle for a period of time, it is necessary to perform regular maintenance and periodically test the equipment. If the system has been idle for a period of time, follow this procedure before further use.

1. Make sure the power is turned OFF.
2. Check for moisture, dirt or foreign materials in the enclosure.
3. Check all connections making sure they are tight.

Certain heater types take on moisture when not in use.

1. Disconnect the heaters from the power control.
2. Test the heaters for resistance to ground using a high-pot tester or a "megger." Check with the heater manufacturer for the resistance or proper high pot tester. It may be necessary to dry the heater out before running it with the QPAC.

To test the system:

1. When calling for full heat, measure the output voltage and current for each phase.
2. Make sure the system removes all current from the load when the temperature control is not calling for heat. (Voltage may still be measured from phase to ground.)
3. Check any safety or limit controls in the system.

Chapter 3

Operation Theory of Base and Firing Cards

Single Phase Model - Q01

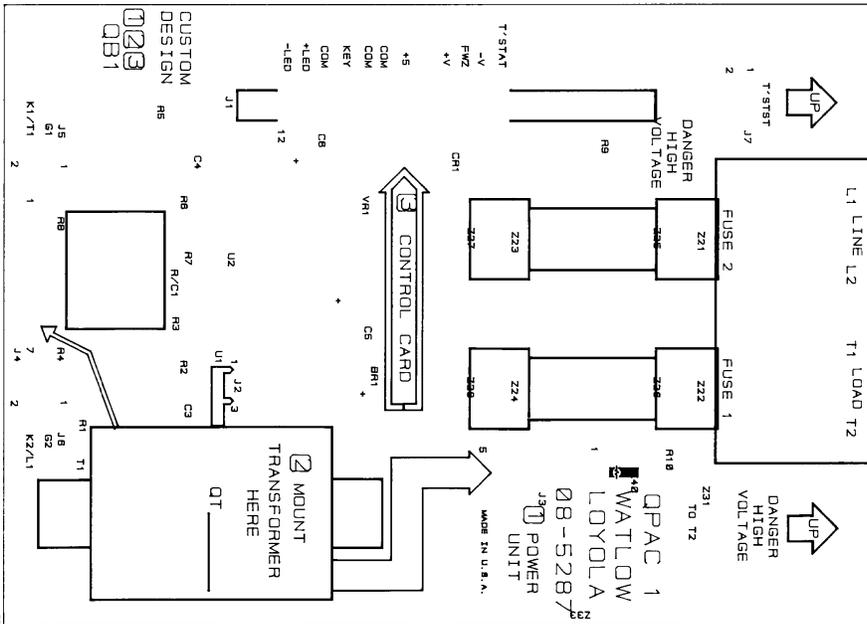


Figure 3 - Q01 Board Layout

Power Base Operation

The Q01 uses one pair of SCRs connected in inverse parallel to control a resistive or inductive load. The main board contains the power supply, output drivers, and connections for the transformer, and the control card. The Q01 accepts all control cards. The standard Q01 power base takes any transformer from 120VAC to 480VAC. 600VAC requires a special base.

The Q01 main board provides power and FWZ (full wave zero cross) to detect zero crossover to the control board. The control board then outputs a pulse for each half cycle to turn ON the instrument SCRs which in turn fire the power SCRs. Two windings of the power transformer provide power for the instrument SCRs. See schematic 02-0655 on Page 33.

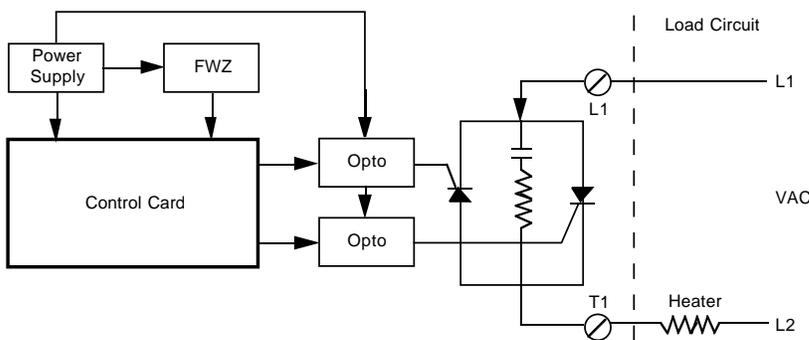
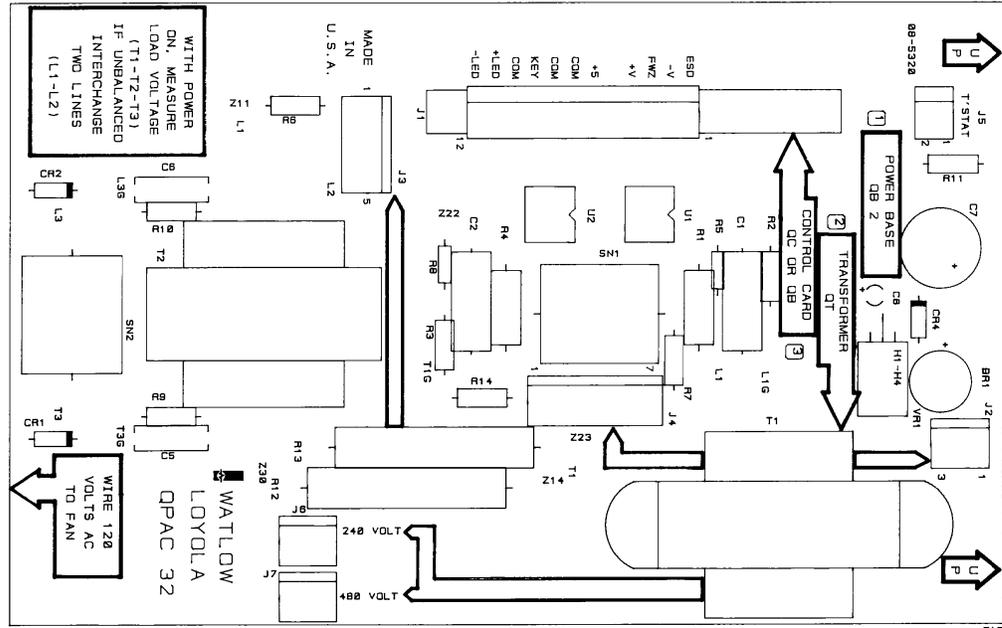


Figure 4 - Q01 Block Diagram and Typical Load Circuit

Three Phase, Two Leg - Q32

Figure 5 - Q32 Board Layout

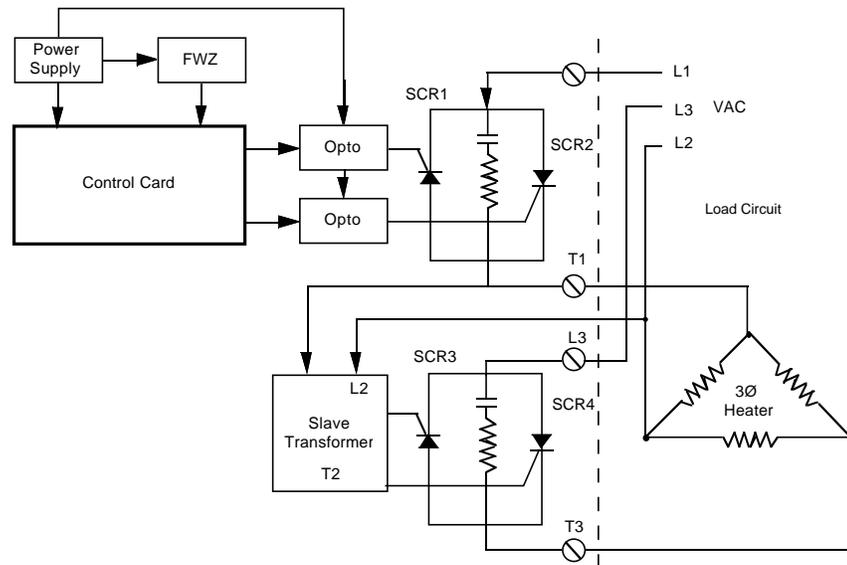


Power Base Operation

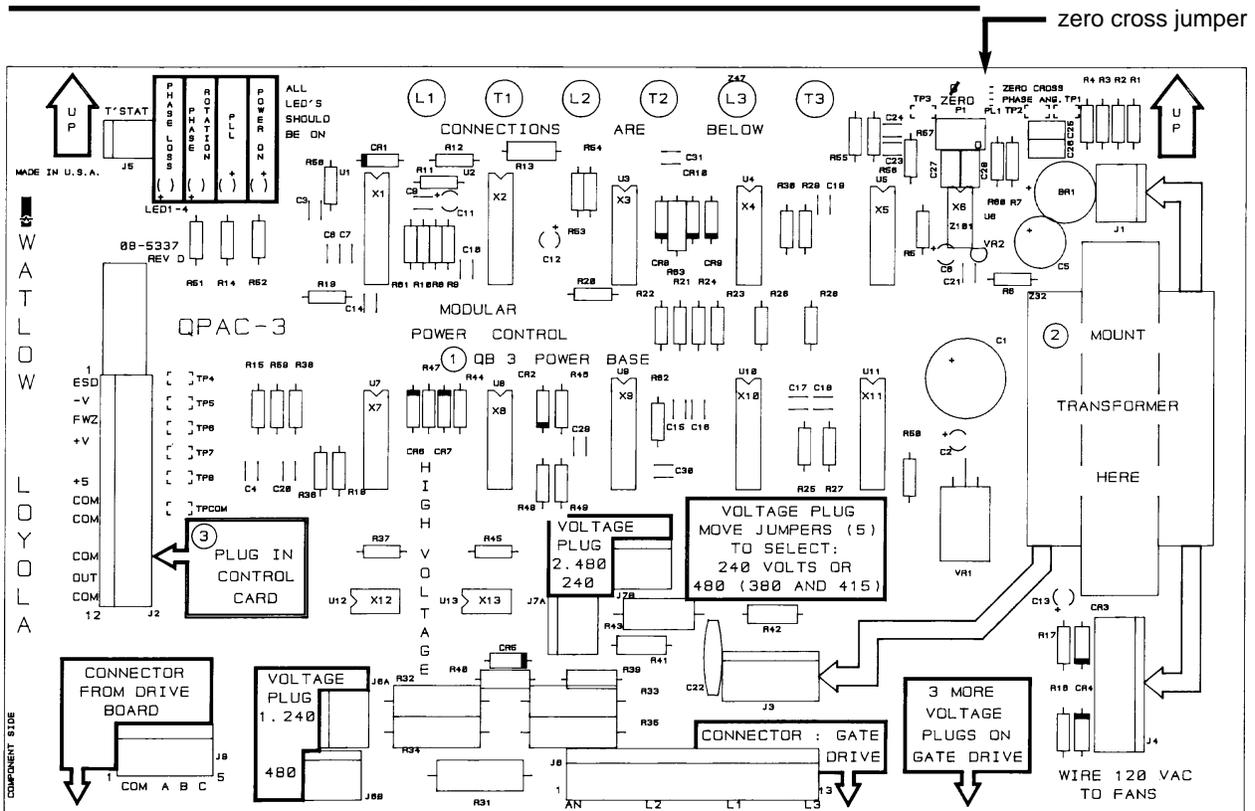
The Q32 uses two pair of SCRs connected in inverse parallel to control two lines of a three phase ungrounded, resistive load. The main board contains the power supply, the output drivers, connections for the transformer and any of the zero cross control cards. It is interlocked so that it will not allow any output if a phase angle card is installed. Q32's will accept 208 to 480 volt transformers as standard. 600 volt units need to be special ordered.

The master portion of the Q32 operates the same as the Q01. Once SCR #2 fires, transformer T2 receives load voltage and T2B then turns on SCR #4 approximately 60 degrees before zero crossing on L3 phase. As soon as L3 goes negative, SCR #4 is ON. The next half cycle, SCR #1 is fired, and T2C turns on SCR #3. See schematic 02-0682 on Page 34.

Figure 6 - Q32 Block Diagram and Typical Load Circuit



Three Phase, Three Leg - Q33



Power Base Operation

The Q33 uses three SCR/diode pairs (hybrid) in inverse parallel to control a resistive or inductive ungrounded load. The Q33 has two boards. The main board contains the power supply, phase locked loop (PLL), phase counters, zero cross filter/detector, phase loss, and phase rotation circuitry. The output board contains the SCR protection, artificial neutral, and output drivers. The Q33 accepts 208 to 480 volt transformers as standard. 600VAC must be special ordered.

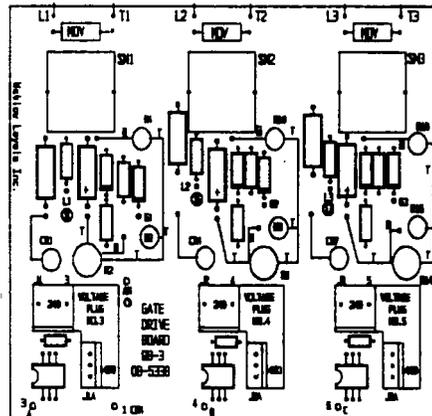


Figure 7 - Q33 Board Layout and Power Board

The Q33 is intended for use on phase control although it can be used on zero cross (with some loss of output), by moving one jumper to shift the zero cross notch.

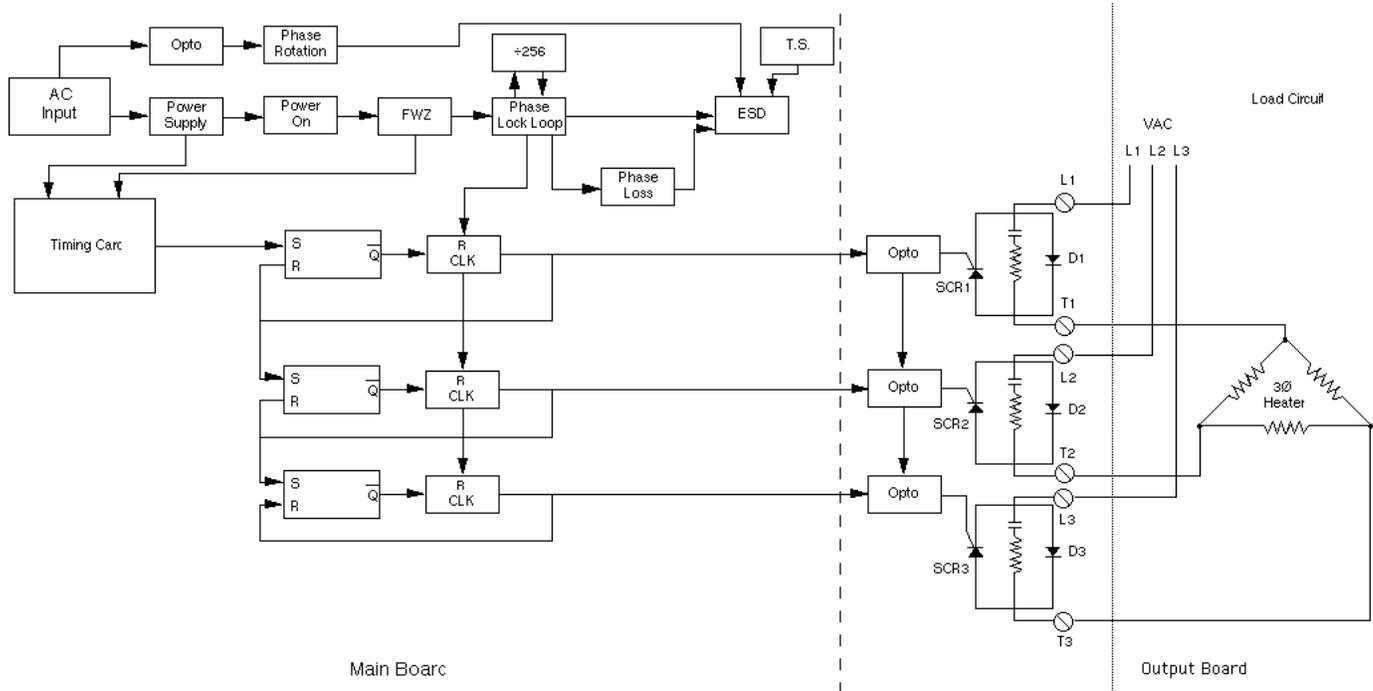
The Q33 is much more complicated than the Q32, since it controls all three leg's and can be used for zero cross, or phase control. U6, U3A, and U3B make up a noise filter and the zero cross detector (FWZ). This produces a negative pulse at each zero crossing for phase angle, and slightly after zero for zero cross firing. U1 and U2 make up a phase locked loop (PLL) which runs at 256 times the full wave frequency. (30.72KH at 60 Hz or 25.6KH at 50Hz). This divides each half cycle

Q33 Block

into 256 parts. When the control card sends out a pulse, U7A picks the correct half cycle, and sends the pulse to U3D which starts counter #1 (U9) and counts to 1 for a short delay. When U1 counts down, it sends a pulse to the output board to fire SCR #1, and resets U3C, and sets U4A. See schematic 02-0798 on Page 35. This starts counter #2 (U10) which counts to 85 (to give a 2.77ms delay). It sends an output pulse to fire SCR #2, resets U4B, sets U4D, and starts counter #3. Counter #3 (U11) counts to 85, sends an output pulse to fire SCR #3, (U11) counts to 85, sends an output pulse to fire SCR #3, and resets U4C to finish the cycle.

U12 is used to detect the loss of L2 phase, (phase loss) and U13 is used to detect the proper phase rotation. U7B, U7C, and U7D combine phase loss, phase rotation, PLL, and the thermostat for emergency shut down (ESD).

**Figure 8 -
Q33 Block Diagram
and Typical Load
Circuit**



AF - Phase Angle Fired (08-5288)

The AF card provides a delayed SCR turn ON, providing an infinitely variable voltage and current from full OFF to full ON. The AF card can be used on resistive, inductive, or Tungsten lamp loads. It includes a 10 second soft start, and a missing half cycle detector to put it into emergency shut down (ESD), and retrigger the soft start. A low signal on the ESD terminals puts the QPAC in ESD. The input is factory set for 4 - 20mA into 250Ω. It can be converted to a voltage input by removing R3 and readjusting the bias and gain potentiometers for any voltage fan 0 - 3VDC to 0 - 15VDC.

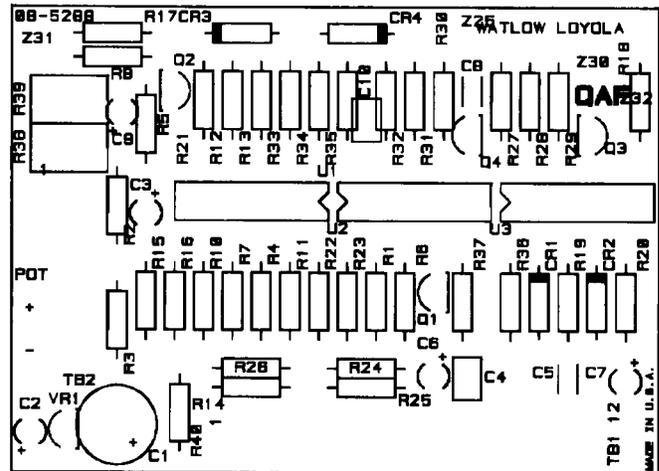


Figure 9 - QAF Board Layout

AL - Phase Angle Fired with Current Limit (08-5411)

The AL card incorporates all of the features of the AF card with the addition of a two mode controller to hold the output current at a pre-set maximum level. The load current is monitored by a CT (current transformer) and the maximum output can be set by a potentiometer on the card.

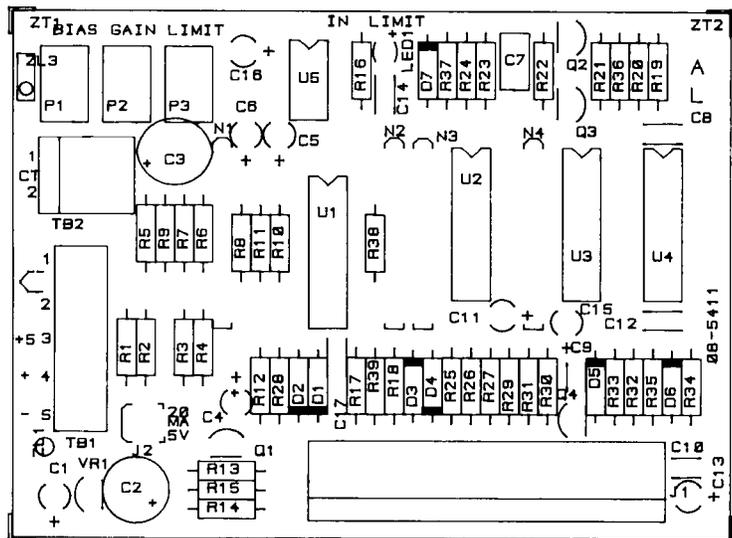


Figure 10 - QAL Board Layout

Zero Cross Control Cards (work on all bases)

BF - Burst Fired with a Four Second Time Base (08-5289)

The BF card is designed for time proportioning with a 4 second time base. It can be field changed to a 1 second time base by removing R17. A 4 - 20mA input is standard, and can easily be changed to accept a voltage input by removing R8 and readjusting the bias and gain pots for any voltage input from 0 - 3VDC to 0-15VDC. The output of the card is disabled if the emergency shut down goes low.

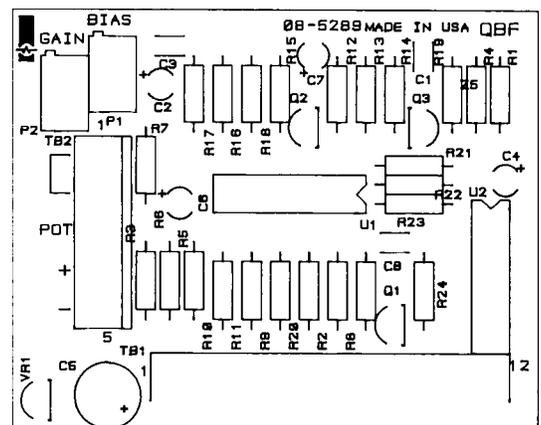


Figure 11 - QBF Board Layout

Cards

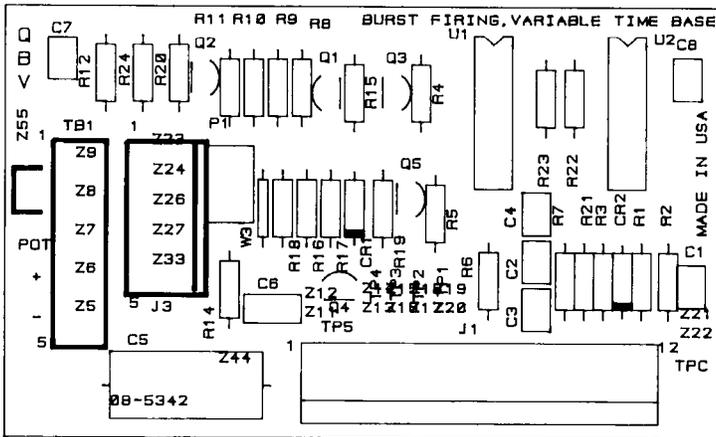


Figure 12 -
QBV Board Layout

BV - Burst fired with a Variable Time Base (08-5342)

The BV card is time proportioning with a variable (very fast) time base. At 50% power, one full cycle is ON, and one full cycle is OFF. At 25% power, it is ON one cycle and OFF for three. At 90%, it is ON nine cycles and OFF for one. As the command signal gets farther from 50% power, the time base gets longer. The maximum cycle time is 1 of 360 cycles. The BV card is standard, setup for 4 - 20mA into 250Ω. It can be changed to 1 - 5 VDC by removing the resistor on the plug located on the back of the card, adding a small circuit board (08-7210) containing bias and gain pots allow the card to be adjusted for any voltage from 0 - 3VDC to 0 - 15VDC or current between 0 and 25mA. The card output is removed if the emergency shut down signal is low.

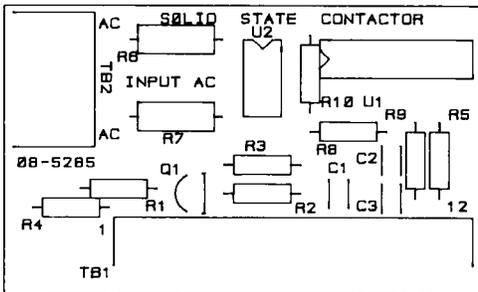


Figure 13 -
QCA Board Layout

CA - Contactor with an AC Input Signal (08-5285)

The CA control card operates the same as the CD card except it requires a 120VAC input command signal. The CA can be special ordered for 24VAC or 240VAC if required. The QPAC can be kept OFF if the emergency shut down signal is held low.

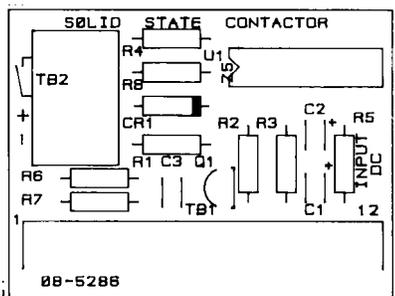


Figure 14 -
QCD Board Layout

CD - Contactor with a DC Input Signal (08-5286)

The CD control card operates the QPAC power control as a zero cross solid state contactor. A 3 - 30VDC input signal is required to switch ON the QPAC and a 0 - 1VDC is required to switch it OFF. The QPAC can be kept OFF if the emergency shut down signal is held low.

Chapter 4

Test Procedures

Q01 and Q32

No power base adjustments are required on the Q01 and Q32 models. See the bias and gain control card procedures.

Q33 Zero Cross Adjustment

Follow this step by step procedure to test the Q33 zero cross adjustment.

Equipment Needed:

- Dual trace oscilloscope

Procedure:

1. Set Channel A on the scope to 5 volts per division.
2. Set Channel B to 2 volts per division.
3. Center both channels vertically.
4. Place the zero cross jumper in the phase angle position. See Page 11 for the board layout.
5. Unplug the control card.
6. Connect the scope common to test point COM on the mother board (next to the control card plug).
7. Connect the Channel A probe to Test Point 1 (TP1), located on the upper right corner of the mother board. The card is unplugged.
8. Connect the Channel B probe to Test Point 6 (TP6) FWZ.
9. Turn power ON.
10. Adjust potentiometer P1 until the FWZ notch (Channel B) is centered on the sine wave (Channel A). Refer to the scope picture below.

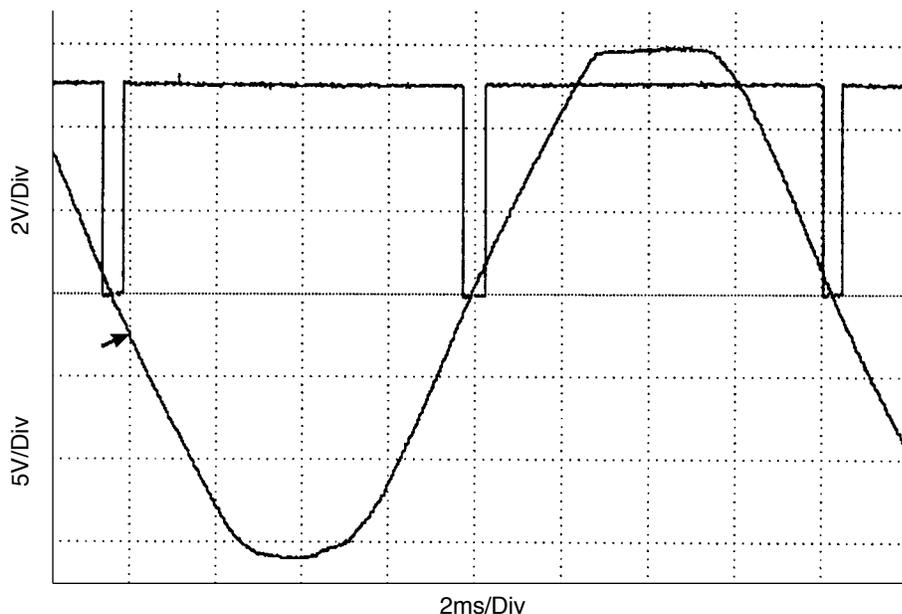


Figure 15 -
Q33 Scope Output

Bias & Gain

These adjustments are necessary for the following control cards:

QBF - Bias and Gain adjustments

QBV - Gain adjustment

QAL - Bias, Gain and Current Limit adjustments

QAF - Bias and Gain adjustments

* NOTE:

Any adjustments or troubleshooting of this unit should be done by a qualified technician.

Bias and/or Gain Adjustments

The bias and gain are factory set for a command signal of 4 - 20mA. However, if minor or major adjustments are required, follow this adjustment procedure.

1. Set the temperature control for zero output (4mA or 0VDC) by adjusting the set point below the ambient temperature, or put the control in manual mode at 0% power.
 - a. **If there is an output**, turn the bias potentiometer clockwise until the output just disappears.
 - b. **If there is no output**, turn the bias potentiometer counterclockwise until the output is noted, then turn it back to until it is just OFF.
2. Set the temperature control for full output (20mA or 5VDC) by turning the set point above the ambient temperature, or put the control in manual mode at 100% power.
 - a. **If the output of the SCR is full ON**, turn the gain potentiometer counter clockwise until a drop in the output is noted. Next, turn the pot back to until the output is just full ON.
 - b. **If there is no SCR output**, or the output is not full ON, turn the gain potentiometer pot clockwise until the output is just full ON.
3. Repeat Steps 1 and 2 until no further adjustments are necessary.

Current Limit Adjustments

The QAL control card is a phase angle control with the capability to limit the maximum current to the load. A potentiometer on the QAL card adjusts the current limit setting. Use the following procedure to adjust the current limit on initial setup. The purpose of the procedure is to bring the load power up slowly so the maximum current to the load is not exceeded before the current limit is adjusted.

***Note: If the input signal from the temperature control is abruptly increased, a short overcurrent through the load may occur as the QAL card circuitry detects the higher current.**

1. Attach a clamp-on ammeter to the load line.
2. Adjust the QAL card current limit potentiometer fully counterclockwise (for minimum current flow).
3. Turn the temperature control ON, and adjust the input signal to the control card for 0% power.
4. Turn the power to the QPAC ON.
5. Gradually increase the input signal.
6. Adjust the current limit potentiometer clockwise until current to the load is measurable.
7. Gradually increase the input signal to 100% power, then adjust the current limit potentiometer to obtain the desired maximum current to the load.

Chapter 5

Troubleshooting

Indications of Malfunction

1. No output under any circumstances.
2. Full ON output at all times and the load is uncontrollable.
3. Output is not proportional to the command signal (unbalanced output).
4. Operating erratic and inconsistent.
5. Half output.
6. One or more LEDs not lit on the Q33 base

Troubleshooting Guidelines

Troubleshooting the QPAC should be limited to changing fuses, transformers, SCRs and printed circuit boards. Any other troubleshooting should be done on a test bench and by a qualified electronic technician capable of working on high voltage.



WARNING:

When working on a power control, *caution must be used as high voltage is present when power is applied.*

On power bases of 100 amps or less, the heat sinks should be at ground potential. Units above 100 amps are electrically hot.

Before troubleshooting, make sure you have isolated the problem to the QPAC. Make sure all connectors and load terminations are tight and the control card is seated properly. Next, verify that there is AC power present at L1 and L2. For three phase units check at L3 by measuring phase to phase. Phase to ground is meaningless on ungrounded three-phase loads. Verify that there is a good command signal (i.e. 4-20mA) from the temperature control, and that the temperature control is operating properly.

Troubleshooting the QPAC can be narrowed down to three distinct problems.

- Unit has no heat
- Unit has partial heat
- Full or partial uncontrollable heat

Once you have determined the category that best describes your situation, read through the appropriate section on the following pages. Follow the procedure which applies to you.

Problem: No Heat**Blown Fuse**

This can be done one of two ways. Measure voltage across the fuse. If there is voltage present the fuse is bad. You can also check the fuse for continuity using an ohmmeter. Replace the fuse if necessary. Prior to changing fuses, check the heaters and wiring for a possible short or loose connections.

Open Heater

Check all the connections from the circuit breaker to the heaters. Measure the heater current. Next, measure the voltage across the heater. If voltage is present and no current is flowing, there is a bad connection or heater. Disconnect the heater from the power control. Check the resistance of each element. The resistance should correspond with the heater KW rating. If not, replace the heater.

Bad Connection

Check all the connections from the circuit breaker to the heaters. Measure the current and output voltage from the heater. If voltage is present and no current is flowing, there is a bad connection or heater. Repair or replace.

Open Limit or Safety Contactor Within the Thermal System

The overtemperature limit contactor may have tripped. Check the limit or safety contactor. Locate the cause for the limit tripping, correct and reset.

Command Signal Polarity is Backwards

Verify that the mA or VDC signal from the temperature control is wired correctly. Make sure Terminal 5 is (-) and Terminal 4 is (+) on the control card.

The SCR Switch Will Not Turn ON

With the command signal full ON (20mA for a 4-20mA signal), check the VAC voltage drop across the L1 and T1 terminals. They should read approximately 1.5VAC. If you are reading the line voltage potential, the SCR is not turning on. The mother board or control card may be bad. Try another control card or contact the factory.

The Interlock Connection on the QPAC Control Card is Open

Measure voltage from Terminal 5 (-) to Terminal 1, then from Terminal 5 to 2 on the control card. Voltage must be present at both Terminal 1 and 2. If not, place a jumper between these terminals. If you are using the interlock feature, check the interrupt switch or the interlock.

The Unit is in Emergency Shut Down (ESD) - For Fan-Cooled Units ONLY

If the heat sink temperature exceeded 187°F (86°C) the on-board thermostat will close and the QPAC will enter Emergency Shut Down. More than likely a clogged or non-operational fan is the cause. Check the fan and clean if necessary. If the problem still exists, check for a shorted heat sink thermostat, unclog the fan, check for fan power or replace the fan.

The Control Card is Bad

First, try to re-seat the control card. Make sure there is a good connection between the control card and the mother board. If there is still a problem, replace the control card with another card. Also, check the troubleshooting section on Page 29 or 30. See Page 5 for ordering a replacement card.

The QPAC Transformer or Resistor Fuse (R10) is Bad

Check for AC voltage present at the transformer (T1), see Page 33 for transformer wiring. Be extremely careful! High voltage is present on the transformer connections. If no voltage is present, verify that the resistor fuse is good by measuring across R10. You should be able to visually determine whether or not the fuse is

bad. The resistor will usually be black or dark brown if open. It should read a minimal voltage of < 1V. If it reads line voltage R10 is bad. See Page 5 for ordering a replacement transformer.

The QPAC Mother Board is Bad

Check the DC voltages at the J1 connector. Place the voltmeter common on pin 7 or 8. They should read as follows:

J1 Connector Test Point	Label	Without Card	With BF, AF or AL Card Installed
1	T STAT	Not Used	3 to 5V
2	-V	-11 to -14VDC	-15 to -22VDC
3	FWZ*	11 to 14VDC	11 to 14VDC*
4	+V	15 to 18VDC	15 to 18VDC
5	Q32, connected to Pin 1 Q01 or Q33	Not Used	Not Used
6	+5V	5V ±0.1V	5V ±0.1V
7	COM		
8	COM (meter common)		
9	KEY		
10	COM		
11	+LED	Not Used	Pulses possible
12	COM		

*See scope pictures on Page 31.

Problem: Full or Partial Uncontrollable Heat

The SCR Switch is Shorted

Remove the control card and power up the QPAC. The output should be OFF. If the unit is still full ON, remove power and disconnect the load wires and measure across L1 and T1 with an ohmmeter. If resistance is low (5Ω or less), the SCR is shorted and must be replaced. See Page 5 for ordering a replacement SCR.

A Heater is Partially Shorted or Shorted to Earth Ground

Disconnect the control card; the output should be OFF. If not, disconnect the power and heater, and measure the heater resistance. It should match the heater KW rating.

The Control Card has the Wrong Bias Adjustment

The bias adjustment is set too high and needs to be readjusted. See the Bias and Gain Adjustment procedure with the appropriate control card on Page16.

The Control Card is Bad

First, try to re-seat the control card. Make sure there is a good connection between the control card and the mother board. Power down the control and remove the control card. Power up without the control card installed. If there is no heat, the control card is bad. Replace the control card. See Page 5 for ordering.

An Excessive Input Signal from the Temperature Control

Check the input signal for proper calibration (i.e. 4-20mA at 4mA). The output should be full OFF. At 20mA the output should be full ON.

The QPAC Mother Board is Bad

Refer to the mother board troubleshooting procedure on Page 28.

Problem: Partial Heat

This problem can be broken down into two categories:

Uncontrollable Heat

One of Two SCRs has Shorted (Half Waving is Continuous)

This condition exists when one of two SCRs is shorted, allowing half of the AC sinewave to pass through the heater uncontrolled. See Page 19 to test for shorted or open SCRs.

The Bias Adjustment is Too High

Recalibrate the bias and gain adjustments by following the procedure on Page 16.

Insufficient Heat

One of Two SCRs Won't Turn ON (Half Waving)

This is most likely a problem with the mother board. A gate signal may be missing. **Refer to the mother board troubleshooting procedure on Page 28.**

The Gain Adjustment is Too Low

Recalibrate the bias and gain adjustments by following the procedure on Page 16.

There is an Insufficient Control Signal

Verify that the signal from the temperature control is correct (i.e. 4-20mA, 1-5VDC, etc.) Refer to the control card section, or the control user's manual.

A Partially Open Heater(s)

Check all the connections from the circuit breaker to the heater. Measure the heater current. Next, measure the voltage across the heater. If voltage is present and no current is flowing, there is a bad connection or heater. Disconnect the heater from the power control. Check the resistance of each element. The resistance should correspond with the heater KW rating. If not, replace the heater.

Problem: No Heat

Blown Fuse

This can be done one of two ways. Measure voltage across the fuse. If there is voltage present the fuse is bad. You can also check the fuse for continuity using an ohmmeter. Replace the fuse if necessary.

Open Heater

Check all the connections from the circuit breaker to the heaters. Measure the heater current. Next, measure the voltage across the heater. If voltage is present and no current is flowing, there is a bad connection or heater. Disconnect the heater from the power control. Check the resistance of each element. The resistance should correspond with the heater KW rating. If not, replace the heater.

Bad Connection

Check all the connections from the circuit breaker to the heaters. Measure the current and output voltage from the heater. If voltage is present and no current is flowing, there is a bad connection or heater. Repair or replace.

Open Limit or Safety Contactor Within the Thermal System

The overtemperature limit contactor may have tripped. Check the limit or safety contactor. Locate the cause for the limit tripping, correct and reset.

Command Signal Polarity is Backwards

Verify that the mA or VDC control signal from the temperature control is wired correctly. Make sure Terminal 5 is (-) and Terminal 4 is (+) on the control card.

The SCR Switch Will Not Turn ON

With the command signal full ON, check the VAC voltage across the L1 and T1 terminals, and the L3 and T3 terminals. They should read approximately 1.5VAC. If you are reading the line voltage potential, the SCR is not gating on. The mother board or control card may be bad. Try another control card or contact the factory.

The Interlock Connection on the QPAC Control Card is Open

Measure voltage from Terminal 5 (-) to Terminal 1, then from Terminal 5 to 2 on the control card. Voltage must be present at both Terminal 1 and 2. If not, place a jumper between these terminals. If you are using the interlock feature, check the interrupt switch or the interlock.

The Unit is in Emergency Shut Down (ESD) - For Fan-Cooled Units ONLY

If the heat sink temperature exceeded 187°F (86°C) the on-board thermostat will close and the QPAC will enter Emergency Shut Down. More than likely a clogged or non-operational fan is the cause. Check the fan and clean if necessary. If the problem still exists, check for a shorted heat sink thermostat, unclog the fan, check for fan power or replace the fan.

The Control Card is Bad

First, try to re-seat the control card. Make sure there is a good connection between the control card and the mother board. If there is still a problem, replace the control card with another card. Also, check the troubleshooting section on Page 29 or 30. See Page 5 for ordering a replacement card.

The Phase Angle Card is Installed

The QPAC-32 is interlocked, and cannot operate with a phase control card.

The QPAC Transformer or Resistor Fuse (R10) is Bad

Check for AC voltage present at the transformer (T1), see Page 34 for transformer wiring. Be extremely careful! High voltage is present on the transformer connections. If no voltage is present, verify that the resistor fuse is good by measuring across R10. You should be able to visually determine whether or not the fuse is bad. The resistor will usually be black or dark brown if open. It should read a minimal voltage of < 1V. If it reads open circuit line voltage, R10 is bad. See Page 5 for ordering a replacement transformer.

The QPAC Mother Board is Bad

Check the DC voltages at the J1 connector. Place the voltmeter common on pin 7 or 8. They should read as follows:

J1 Connector Test Point	Label	Without Card	With BF Card Installed
1	T STAT	Not Used	3 to 5V
2	-V	-11 to -14VDC	-15 to -22VDC
3	FWZ*	11 to 14VDC	11 to 14VDC*
4	+V	15 to 18VDC	15 to 18VDC
5	Q32, connected to Pin 1 Q01 or Q33	Not Used	Not Used
6	+5V	5V ±0.1V	5V ±0.1V
7	COM		
8	COM (meter common)		
9	KEY		
10	COM		
11	+LED	Not Used	Pulses possible
12	COM		

*See scope pictures on Page 31.

Problem: Full or Partial Uncontrollable Heat

The SCR Switch is Shorted

Remove the control card and power up the QPAC. The output should be OFF. If the unit is still full ON, remove power and disconnect the load wires and measure across L1 and T1, and L3 and T3 with an ohmmeter. If resistance is low (5Ω or less), the SCR is shorted and must be replaced. See Page 5 for ordering a replacement SCR.

A Heater is Partially Shorted

Disconnect the control card; the output should be OFF. If not, disconnect the power and heater, and measure the heater resistance. It should match the heater KW rating.

The Control Card has the Wrong Bias Adjustment

The bias adjustment is set too low and needs to be readjusted. See the Bias and Gain Adjustment procedure with the appropriate control card on Page 18.

The Control Card is Bad

First, try to re-seat the control card. Make sure there is a good connection between the control card and the mother board. Power down the control and remove the control card. Power up without the control card installed. If there is no heat, the control card is bad. Replace the control card. See Page 5 for ordering.

An Excessive Input Signal from the Temperature Control

Check the input signal for proper calibration (i.e. 4-20mA at 4mA). The output should be full OFF. At 20mA the output should be full ON.

The QPAC Mother Board is Bad

Refer to the mother board troubleshooting procedure on Page 28.

The T1 Load Connection is Open

If T1 is open at the heater, the leads will occasionally couple AC back, and turn on L3 and T3 SCRs. Check the load with an ohmmeter at Q32.

Problem: Partial Heat**Incorrect Phase Rotation**

The phase rotation must be "A-B-C". Measure voltage T1 to T2, T2 to T3, and T3 to T1. If it is not within 2 to 5%, reverse any two "L" leads and try again.

One of Two SCRs Won't Turn ON (Half Waving)

This is most likely a problem with the mother board. A gate signal may be missing. Refer to the mother board troubleshooting procedure on Page 28.

The Gain Adjustment is Too Low

Recalibrate the bias and gain adjustments by following the procedure on Page 16.

There is an Insufficient Control Signal

Verify that the signal from the temperature control is correct (i.e. 4-20mA, 1-5VDC, etc.) Refer to the control card section, or the control user's manual.

A Partially Open Heater(s)

Check all the connections from the circuit breaker to the heater. Measure the heater current. Next, measure the voltage across the heater. If voltage is present and no current is flowing, there is a bad connection or heater. Disconnect the heater from the power control. Check the resistance of each element. The resistance should correspond with the heater KW rating. If not, replace the heater.

Problem: No Heat**Blown Fuse**

This can be done one of two ways. Measure voltage across the fuse. If there is voltage present the fuse is bad. You can also check the fuse for continuity using an ohmmeter. Replace the fuse if necessary.

Open Heater

Check all the connections from the circuit breaker to the heaters. Measure the heater current. Next, measure the voltage across the heater. If voltage is present and no current is flowing, there is a bad connection or heater. Disconnect the heater from the power control. Check the resistance of each element. The resistance should correspond with the heater KW rating. If not, replace the heater.

Bad Connection

Check all the connections from the circuit breaker to the heaters. Measure the current and output voltage from the heater. If voltage is present and no current is flowing, there is a bad connection or heater. Repair or replace.

Open Limit or Safety Contactor Within the Thermal System

The overtemperature limit contactor may have tripped. Check the limit or safety contactor. Locate the cause for the limit tripping, correct and reset.

Command Signal Polarity is Backwards

Verify that the 4-20mA control signal from the temperature control is wired correctly. Make sure Terminal 5 is (-) and Terminal 4 is (+) on the control card.

The SCR Switch Will Not Turn ON

With the command signal full ON, check the VAC voltage across the L1 and T1 terminals. They should read approximately 1.5VAC. If you are reading the line voltage potential, the SCR is not gating on. The mother board or control card may be bad. Try another control card or contact the factory.

The Interlock Connection on the QPAC Control Card is Open

Measure voltage from Terminal 5 (-) to Terminal 1 or 2 on the control card. Voltage must be present at both Terminal 1 and 2. If not, place a jumper between these terminals. If you are using the interlock feature, check the interrupt switch or the interlock.

The Unit is in Emergency Shut Down (ESD) - For Fan-Cooled Units ONLY

If the heat sink temperature exceeded 187°F (86°C) the on-board thermostat will close and the QPAC will enter Emergency Shut Down. More than likely a clogged or non-operational fan is the cause. Check the fan and clean if necessary. If the problem still exists, check for a shorted heat sink thermostat. Measure from the thermostat, unplug the fan, check for fan power, or replace the fan.

The Control Card is Bad

First, try to re-seat the control card. Make sure there is a good connection between the control card and the mother board. If there is still a problem, replace the control card with another card. Also, check the troubleshooting section on Page 29 or 30. See Page 5 for ordering a replacement card.

The QPAC Transformer or Resistor Fuse (R10) is Bad

Check for AC voltage present at the transformer (T1), see Page 35 for transformer wiring. Be extremely careful! High voltage is present on the transformer connections. If no voltage is present, verify that the resistor fuse is good by measuring across R10. You should be able to visually determine whether or not the fuse is bad. It should read a minimal voltage of < 1V. If it reads open circuit line voltage, R10 is bad. See Page 5 for ordering a replacement transformer.

The QPAC Mother Board is Bad

Check the DC voltages at the J1 connector. Place the voltmeter common on pin 7 or 8. They should read as follows:

J1 Connector Test Point	Label	Without Card	With BF, AF or AL Card Installed
1	T STAT	Not Used	3 to 5V
2	-V	-11 to -14VDC	-15 to -22VDC
3	FWZ*	+5VDC Pulses	+5VDC Pulses*
4	+V	15 to 18VDC	15 to 18VDC
5	Q32, connected to Pin 1 Q01 or Q33	Not Used	Not Used
6	+5V	5V ±0.1V	5V ±0.1V
7	COM		
8	COM (meter common)		
9	KEY		
10	COM		
11	+LED	Not Used	Pulses possible
12	COM		

*See scope picture on Page 15.

The Phase Loss LED is Not ON

Any one or a combination of phases are low (20% or greater). Measure the incoming voltage on L1 and L2, L2 and L3, and L3 and L1.

Incorrect Phase Rotation (Phase Rotation LED is Not ON)

The phase rotation must be L1 - L2 - L3. Reverse any two “L” leads and try again.

The Phase Lock Loop (PLL) is not synchronized with the AC Line (PLL LED is Not ON)

There is probably noise on the AC line. Check the incoming power with a scope and try a different power source.

The Zero Cross or Phase Angle Jumper is in the Wrong Location

Move the jumper. See the Zero Cross Calibration procedure on Page 15.

The Unit is Calibrated for the Wrong Frequency

The Zero Cross Calibration procedure must be performed at the operating frequency (50 or 60Hz). See this procedure on Page 15.

Problem: Full or Partial Uncontrollable Heat**The SCR Switch is Shorted**

Remove the control card and power up the QPAC. The output should be OFF. If the unit is still full ON, remove power and disconnect the load wires and measure across L1 and T1 with an ohmmeter. If resistance is low (5Ω or less), the SCR is shorted and must be replaced. See Page 5 for ordering a replacement SCR.

A Heater is Partially Shorted

Disconnect the control card; the output should be OFF. If not, disconnect the power and heater, and measure the heater resistance. It should match the heater KW rating.

Card has the Wrong Bias Adjustment

The bias adjustment is set too low and needs to be readjusted. See the Bias and Gain Adjustment procedure with the appropriate control card on Page 16.

The Control Card is Bad

First, try to re-seat the control card. Make sure there is a good connection between the control card and the mother board. Power down the control and remove the control card. Power up without the control card installed. If there is no heat, the control card is bad. Replace the control card. See Page 5 for ordering.

An Excessive Input Signal

Check the input signal for proper calibration (i.e. 4-20mA at 4mA). The output should be full OFF. At 20mA the output should be full ON.

The QPAC Mother Board is Bad

Refer to the mother board troubleshooting procedure.

Problem: Partial Heat**One of Three SCRs Won't Turn ON (Half Waving)**

This is most likely a problem with the mother board. A gate signal may be missing. Refer to the mother board troubleshooting procedure on Page 28 - 29.

The Gain Adjustment is Too Low

Recalibrate the bias and gain adjustments by following the procedure on Page 16.

There is an Insufficient Control Signal

Verify that the signal from the temperature control is correct (i.e. 4-20mA, 1-5VDC, etc.) Refer to the control card section, or the control user's manual.

A Partially Open Heater(s)

Check all the connections from the circuit breaker to the heater. Measure the heater current. Next, measure the voltage across the heater. If voltage is present and no current is flowing, there is a bad connection or heater. Disconnect the heater from the power control. Check the resistance of each element. The resistance should correspond with the heater KW rating. If not, replace the heater.

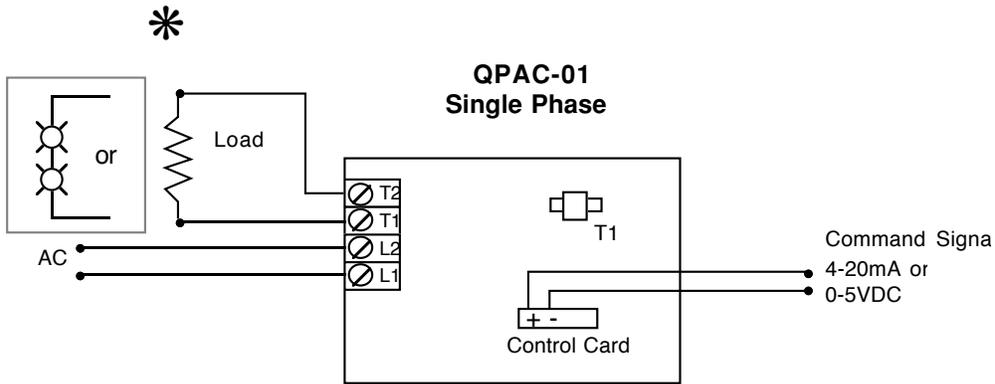
The Zero Cross or Phase Angle Jumper is in the Wrong Location

Move the jumper. See the Zero Cross Calibration procedure on Page 15.

Bench Testing Hookups

Equipment Required

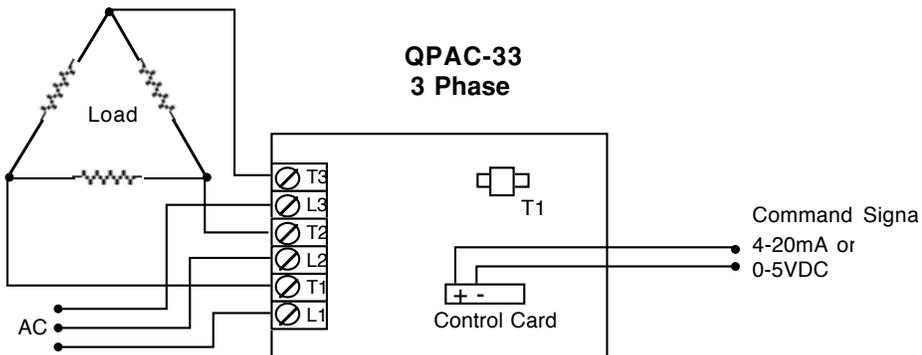
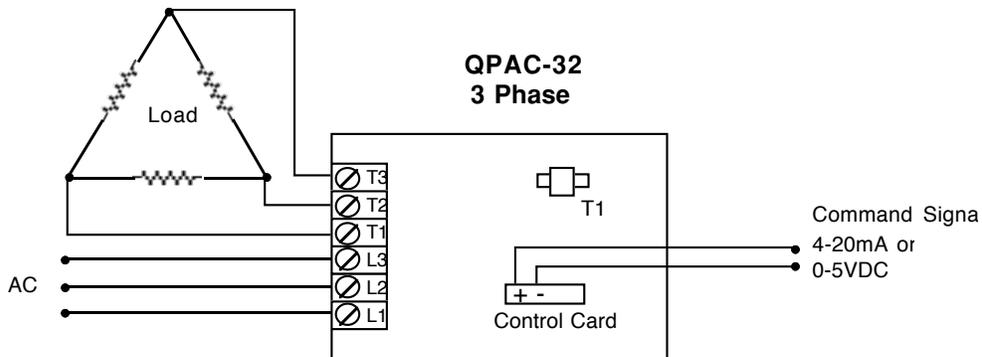
- Dummy Load, min. 1A
- 0-15VDC Command (signal)



* **NOTE:**

Dummy loads can be made up using 100 watt light bulbs. Bulbs can be put in series to obtain the proper voltage rating. (4each, 100 watt, 120V bulbs per phase for 480V)

An SCR will not latch without a load.



Testing SCRs in the Unit

A shorted SCR will show full uncontrollable line voltage at the T terminals. To test, turn main power OFF, remove the L and T wires. On a QPAC-01, measure resistance from L1 to T1. On a QPAC-32, measure resistance between L1 to T1 and L3 to T3. On a QPAC-33, measure resistance between L1 to T1, L2 to T2, and L3 to T3. A reading of 5 ohms resistance or less indicates that the SCR is shorted. A high resistance reading indicates that the SCR is good.

On a Q33 unit, a low reading will occur in one direction and a high reading in the other direction. This is normal.

Installing an SCR Package

After removing the old SCR package, thoroughly clean the heat sink and the base of the new SCR package to be installed. Add a thin coat of DOW-DC-4 thermal joint compound, or equivalent, to the base of the heat sink or bottom of SCR package. Put in screws and tighten. See Chapter 1, page 5, for replacement parts and torque settings.

Troubleshooting the Base and Control Cards

QPAC-01

The QPAC-01 main board provides power and FWZ (to detect zero crossover) to the control board. The control board then outputs a pulse for each half cycle to turn ON the instrument SCRs which in turn fire the power SCRs. Two windings of the power transformer provide power for the instrument SCRs. See schematic 02-0655 on Page 33.

QPAC-32

The master portion of the QPAC-32 operates the same as the QPAC-01. Once SCR #2 fires, transformer T2 receives load voltage and T2B then turns on SCR #4 approximately 60° before zero crossing on the L3 phase. As soon as L3 goes negative, SCR #4 is ON. The next half cycle, SCR #1 is fired, and T2C turns on SCR #3. Pin 5 on the Q32 base is connected to Pin 1. All phase angle cards have Pin 5 grounded, therefore if a phase angle card is used on a Q32 base, it will stay in permanent emergency shut down. See schematic 02-0682 on Page 34.

QPAC-33

The QPAC-33 is a lot more complicated since it controls all three legs and can be used for zero cross, or phase control. U6, U3A, and U3B make up a noise filter and the zero cross detector (FWZ). This produces a negative going pulse at each zero crossing for phase angle, and slightly after zero for zero cross firing. U1 and U2 make up a phase locked loop (PLL) which runs at 256 times the full wave frequency (30.72KH at 60 Hz or 25.6KH at 50 Hz). This divides each half cycle into 256 parts. When the control card sends out a pulse, U7A picks the correct half cycle, and sends the pulse to U3D which starts counter #1 (U9) and counts to one for a short delay. When U1 counts down, it sends a pulse to the output board to fire SCR 1, and resets U3C, and sets U4A. This starts counter #2 (U10) which counts to 85 (to give a 2.77 millisecond delay), and sends an output pulse to fire SCR #2, resets U4B, sets U4D, and starts counter #3. Counter #3 (U11) counts to 85, sends an output pulse to fire SCR #3, and resets U4C to finish the cycle.

U12 is used to detect the loss of L2 phase, (phase loss) and U13 is used to detect the proper phase rotation. U7B, U7C, and U7D combined phase loss, phase rotation, PLL, and the thermostat for ESD.

Scope picture 2 shows the AC input (L1 to L3) at TP1 and TP6 (FWZ) after zero cross calibration. Scope picture 3 is the high frequency clock TP9 (MCK). Scope picture 4 shows the sequence of operation at approximately 50% power. From top to bottom:

1. FWZ (zero cross reference)
2. Timing output A phase (U8, Pin 12)
3. Timing output B phase (U8, Pin 8)
4. Timing output C phase (U5, Pin 8)
5. Load Current T1
6. Load current T2
7. Load current T3

The output board contains the SCR protection, the output drivers, and power resistors to form the artificial neutral. See schematic 02-0798 on Page 35.

QCD and CA Cards (08-5286 and 08-5285)

FWZ at Pin 3 is shaped by Q1 to form a window around the zero cross point. See Scope Picture 5. This is summed with the command signal by U1A and with the ESD line by U1B to provide a high output at Pin 11 if the input signal is high, the ESD signal is high, and it is at zero cross. The CA card accepts an AC signal and U2 gives a high for each half cycle. See schematic 02-0672 (QCD) and 02-0673 (QCA) on Page 36 - 37.

QBF Card (08-5289)

Q1 and U2B make up the zero cross notch providing that the ESD signal is high. Q2, and Q3 make up a linear ramp with a 4 second time base and approximately 2 volts high U1C is the input amplifier with the Bias and Gain amplifiers, and U1D is used as a comparator to give a high output any time the ramp exceeds the input signal. U2A adds the output of the comparator and the FWZ signal to give output pulses only during the zero cross notch. See scope picture 5 (TP1, FWZ), scope picture 6 (TP2 & 3, ramp top and comparator output bottom, scope picture 7, (TP2 & 4 ramp top and output pulses bottom). See schematic 02-0657 on Page 38.

QBV Card (08-5342)

U2A is used to make up the FWZ signal. U1A is a flip-flop clocked by the FWZ to provide a square wave of one full cycle duration. U2B provides a delayed pulse, slightly after the end of each full cycle. The input signal, goes into Q2 (emitter follower) which produces a collector current proportional to the voltage across the emitter resistor. Q1 is used as a zener to linearize the output. Q3 is an emitter follower used to discharge C5 every other half cycle (Q5 prevents C5 from being discharged when ON). Once C5 voltage reaches the program point of Q4 (R14, R16) it charges C5 through R19 and sets U1B. Since C5 can only reach its peak when Q5 is OFF, (TP2 low) U1B will always stay on for one full cycle. With U1B output high, U2D will allow two output pulses insuring one full cycle output minimum. If ESD is low, U2D is inhibited from allowing FWZ pulses. See Scope Picture 8 for TP1 & TP2 FWZ top and TP2 bottom, Scope Picture 9 for TP1 FWZ top and count clear bottom, Scope Picture 10 for TP1 & TP4 FWZ top and output on the bottom, Scope Picture 11 for TP1, 2, 4, 5 showing FWZ, SQ wave, output and the staircase waveform on C5. See schematic 02-0729 on Page 39.

QAF Card (08-5288)

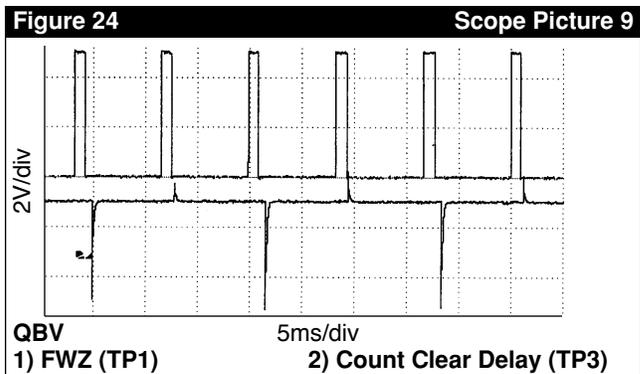
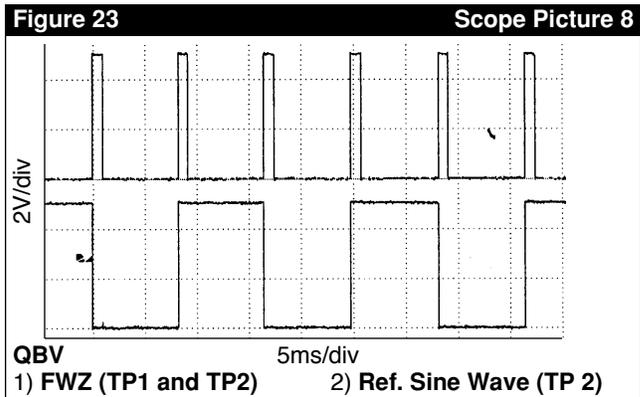
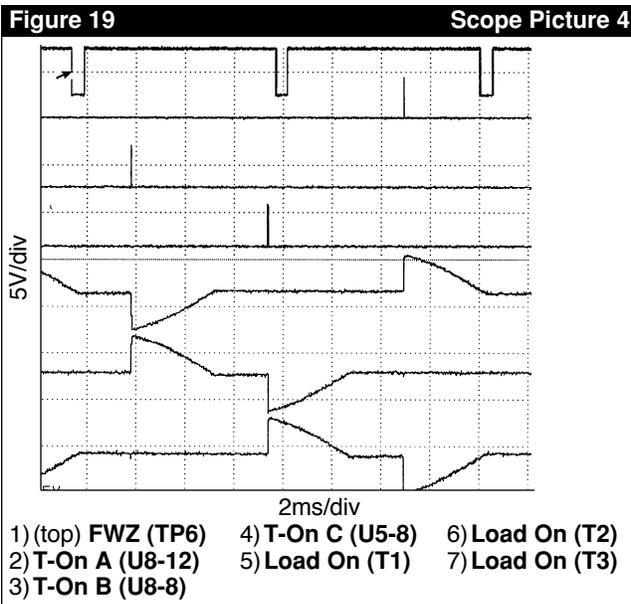
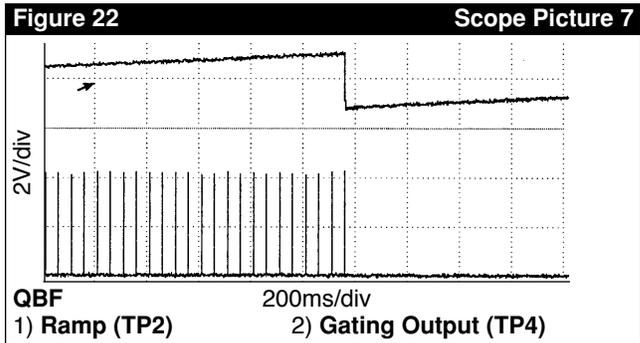
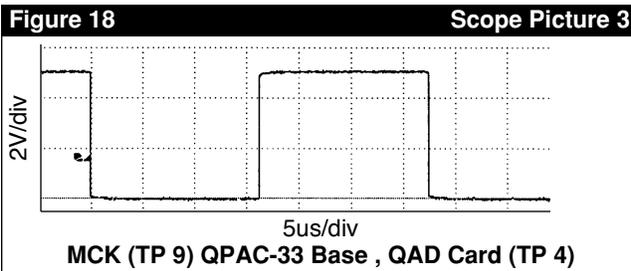
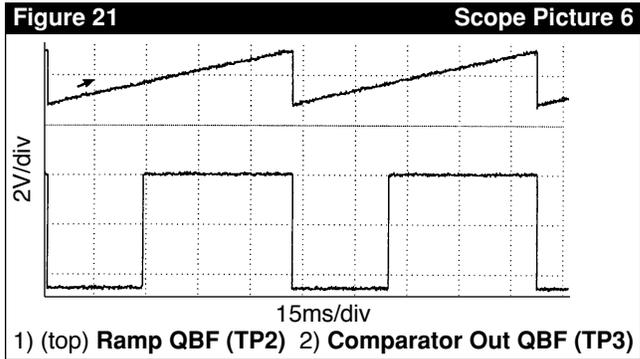
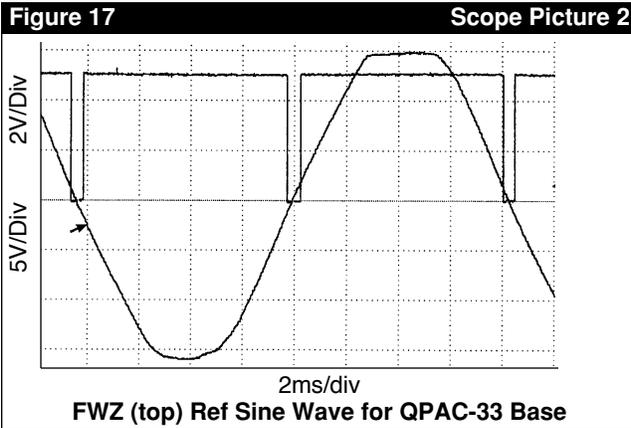
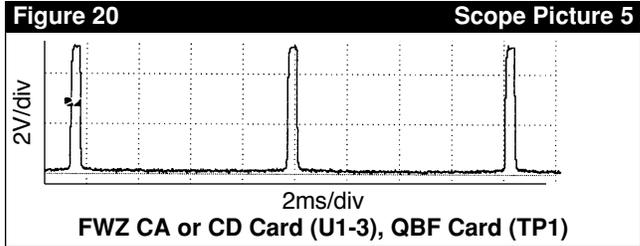
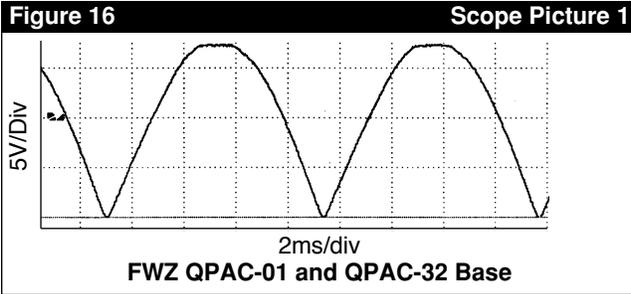
Q1 makes up the FWZ signal which is inverted by U3A to give a high signal for all of the half cycle but the zero cross notch. U3B, CR1, R19, and C5 detect missing half cycles which then pulls C7 low with CR2. When C7 is low, the AF card is in ESD. Q4 and Q3 make a linear ramp which is reset at the end of each half cycle by the output of U3A. U1C accepts the input signal and performs the bias and gain function. U1B adds the soft start from C9/R40, and U1D adds the line voltage compensation. The output of U1D is then compared to the ramp by U1A to output a square wave from U2B, providing ESD is high and it is during the high output period of U3A. See Scope picture 12 (TP1 top inverted FWZ, TP2 ramp, TP3 comparator output, and the load current waveform (measured by a CT), scope picture 13 (TP4 top ESD, TP5 soft start dump, and TP6 bottom soft start ramp). See schematic 02-0656 on Page 40.

QAL Card (08-5411)

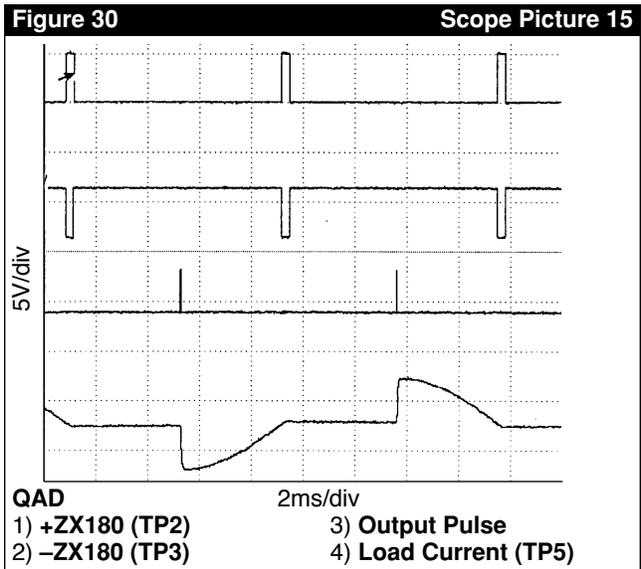
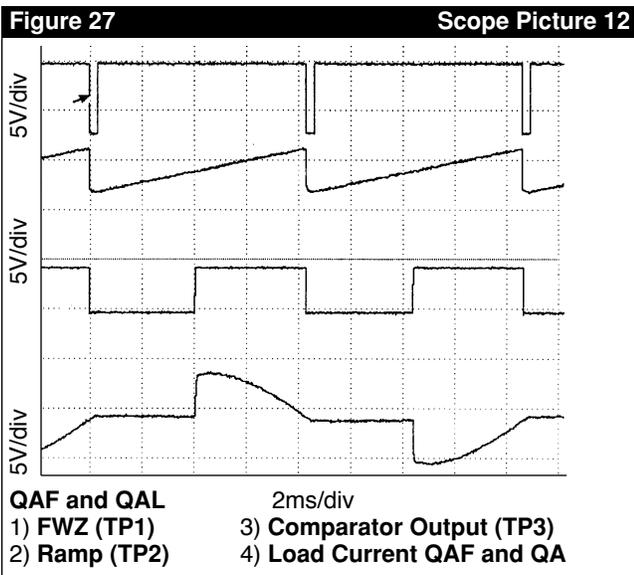
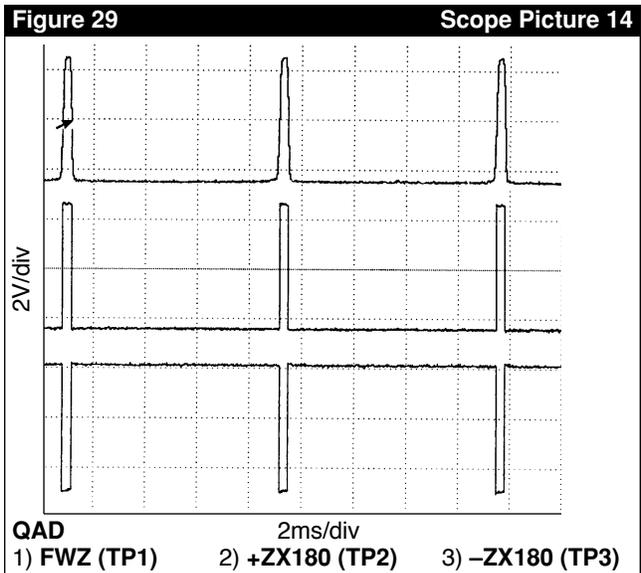
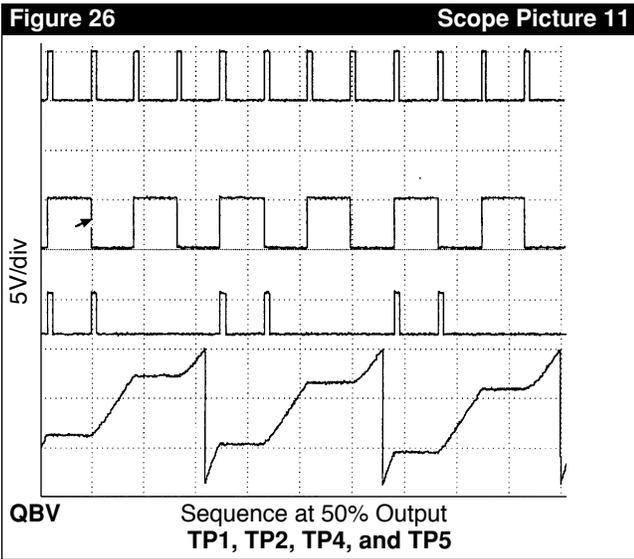
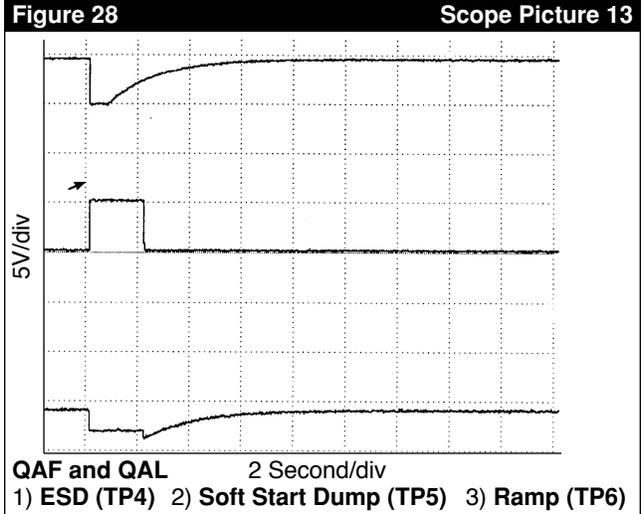
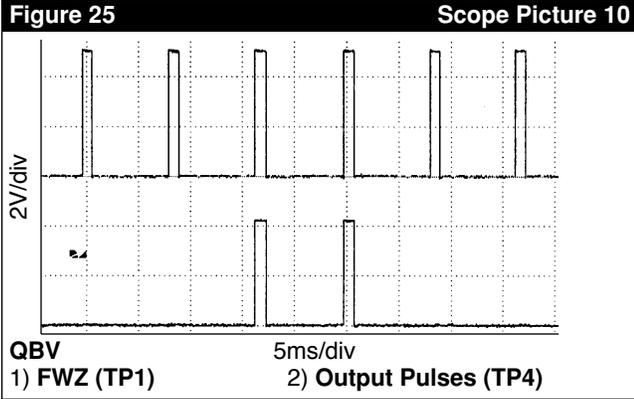
Q4 makes up the FWZ signal which is inverted by U3A to give a high signal for all of the half cycle but the zero cross notch. U3B, CR5, R33, and C12 detect missing half cycles which then pulls C13 low with CR2. When C13 is low, the AF card is in ESD. Q4 and Q3 make a linear ramp which is reset at the end of each half cycle by the output of U3A. U1A accepts the input signal and performs the bias and gain function. U1B adds the soft start from C4/R15, and U2B adds the signal from the current limit circuit. U2C adds the line voltage compensation the output of U2C is then compared to the ramp by U2D to output a square wave from U4C, providing ESD is high and it is during the high output period of U3A. A current transformer is used to monitor the output of the power control and provides an AC signal to TB3. Its input is then converted to a DC signal by U5 which provides a DC output equivalent to the true RMS value at the CT. U1D provides a gain of 4, and U2C is a two mode amplifier providing both proportional and integral feedback (for limiting the current) into U2B. U2A is a comparator to turn on the LED when in limit. See scope picture 12 (TP1 top inverted FWZ, TP2 ramp, TP3 comparator output, and the load current waveform, measured by a CT), scope picture 13 (TP4 top ESD, TP5 soft start dump, and TP6 bottom soft start ramp.) See schematic 02-0701 on Page 41.

QAD Card (08-5314)

U4 and U5 make up a phase locked loop (PLL) which is synchronized to the 50 or 60 Hz line. It produces an output 256 times the full wave frequency ($120 \times 256 = 30.72\text{KHz}$) for the U5 and ($100 \times 256 = 25.6\text{KHz}$) at 50 Hz. The input lines D0 to D7 are used to set the power level desired. When the input lines are programmed to give an output level, the address line is low (Pin 1), and the strobe line is pulsed low, the octal D latch (U1) will be updated. The output of the latch goes through the prom (U2) for inversion and to linearize the output curve. the output of the prom is then used to program U3 which counts down from zero cross to whatever power level is set in. See Scope Picture 14 (TP1 FWZ, TP2 +ZX180, and TP3 -ZX180. Scope 15 (TP2, TP3, and TP5 output. Picture 3 TP4 MCK (high frequency clock). See schematic 02-0671 on Page 42.



Appendix



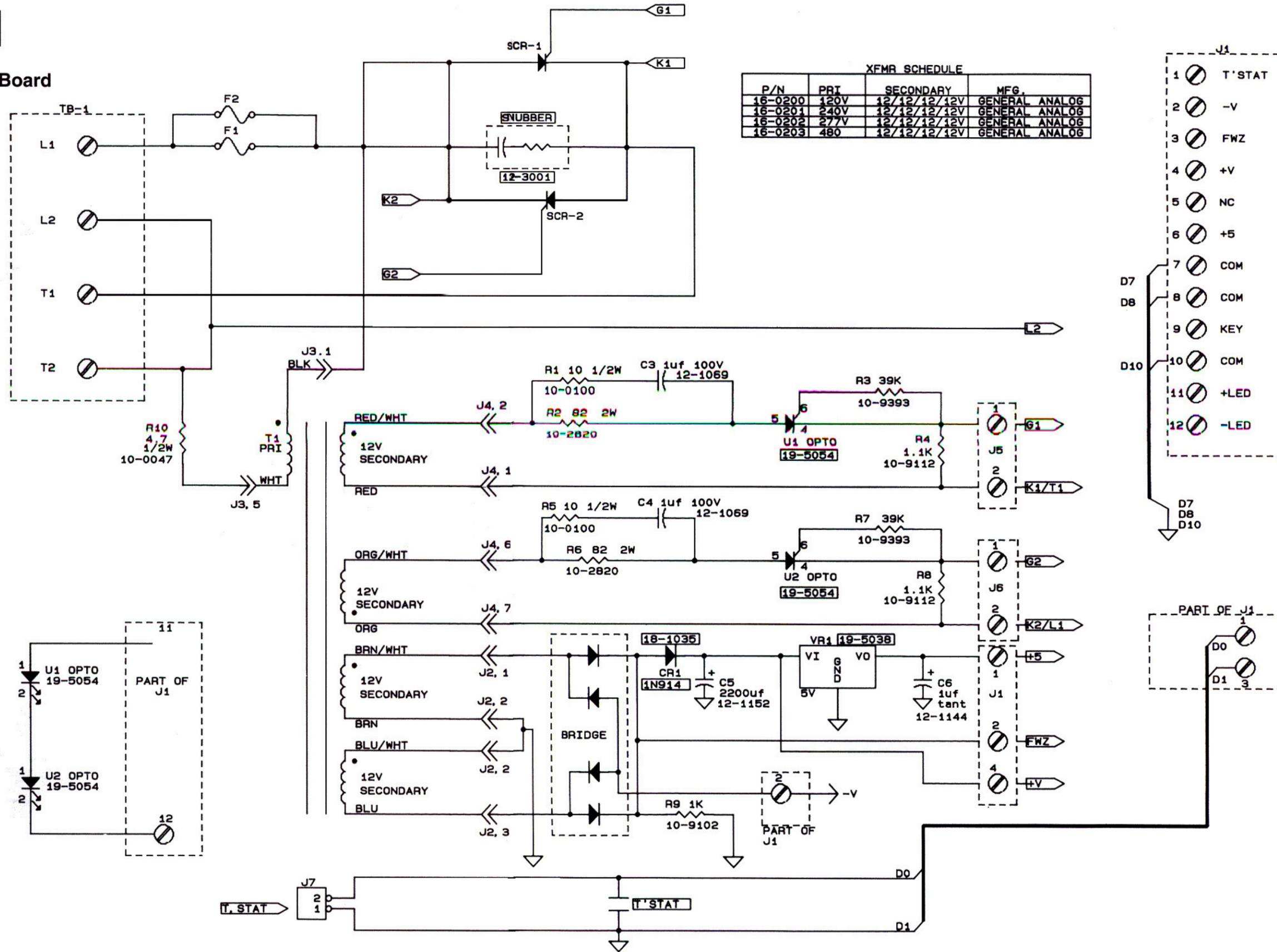
Appendix

Schematic 02-0655

QPAC-01 Mother Board

NOTES:

1. All resistors are 1/4 W 5% unless otherwise specified.
2. All capacitors are valued in microfarads unless noted.
3. Last Used: R-10, C-6, U-2.
4. Ref: PCB Bare: 35-0179.
5. Ref: Assy PCB 08-5287.
6. Fuse 2 (F2) used on single phase 30 & 50 amp units.
7. Fuse mounted by customer on single phase 75 and 100 amp units.



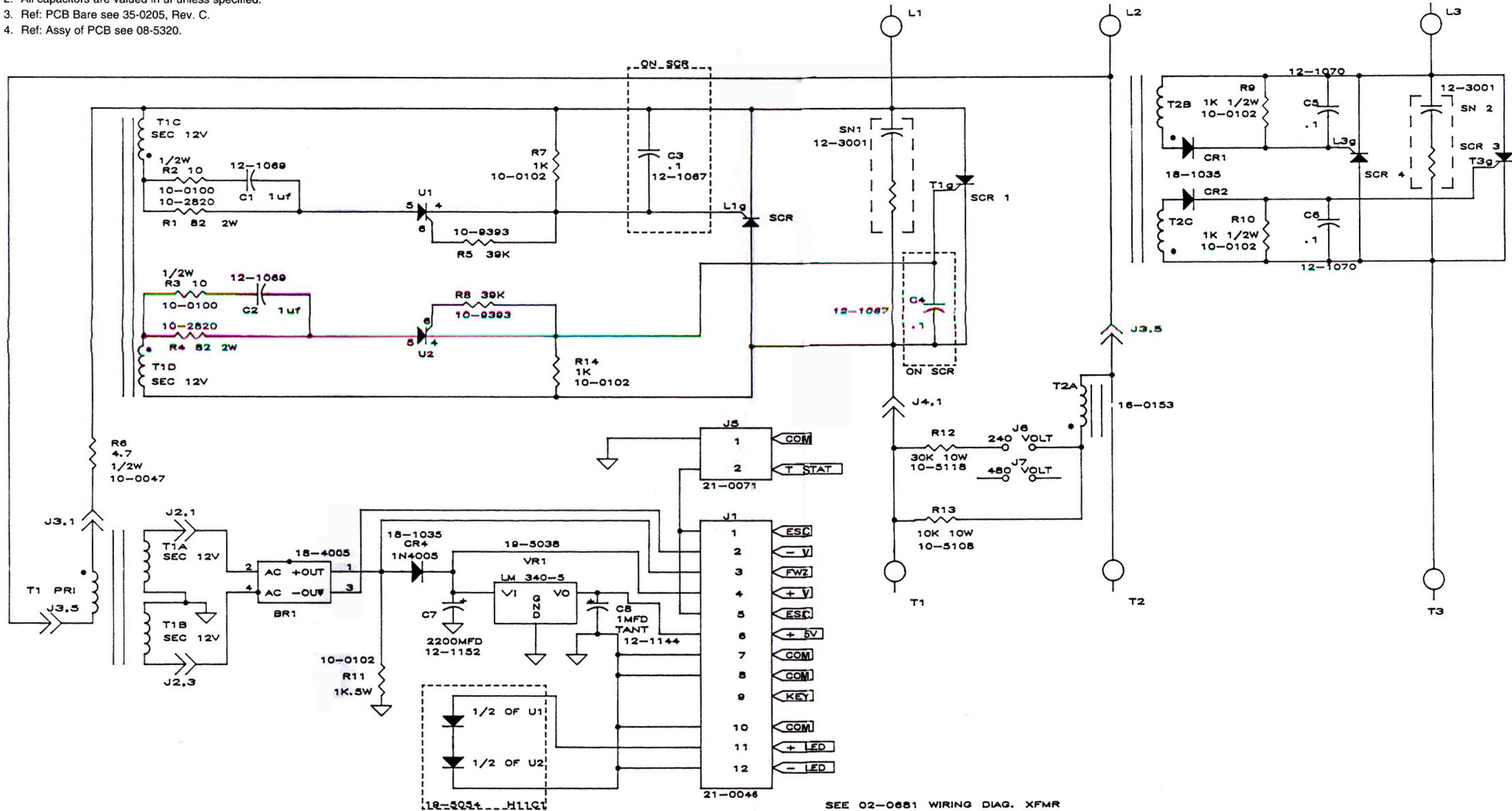
Appendix

Schematic 02-0682

QPAC-32 Mother Board

NOTES:

1. All resistors are 1/4 W unless otherwise specified.
2. All capacitors are valued in uf unless specified.
3. Ref: PCB Bare see 35-0205, Rev. C.
4. Ref: Assy of PCB see 08-5320.



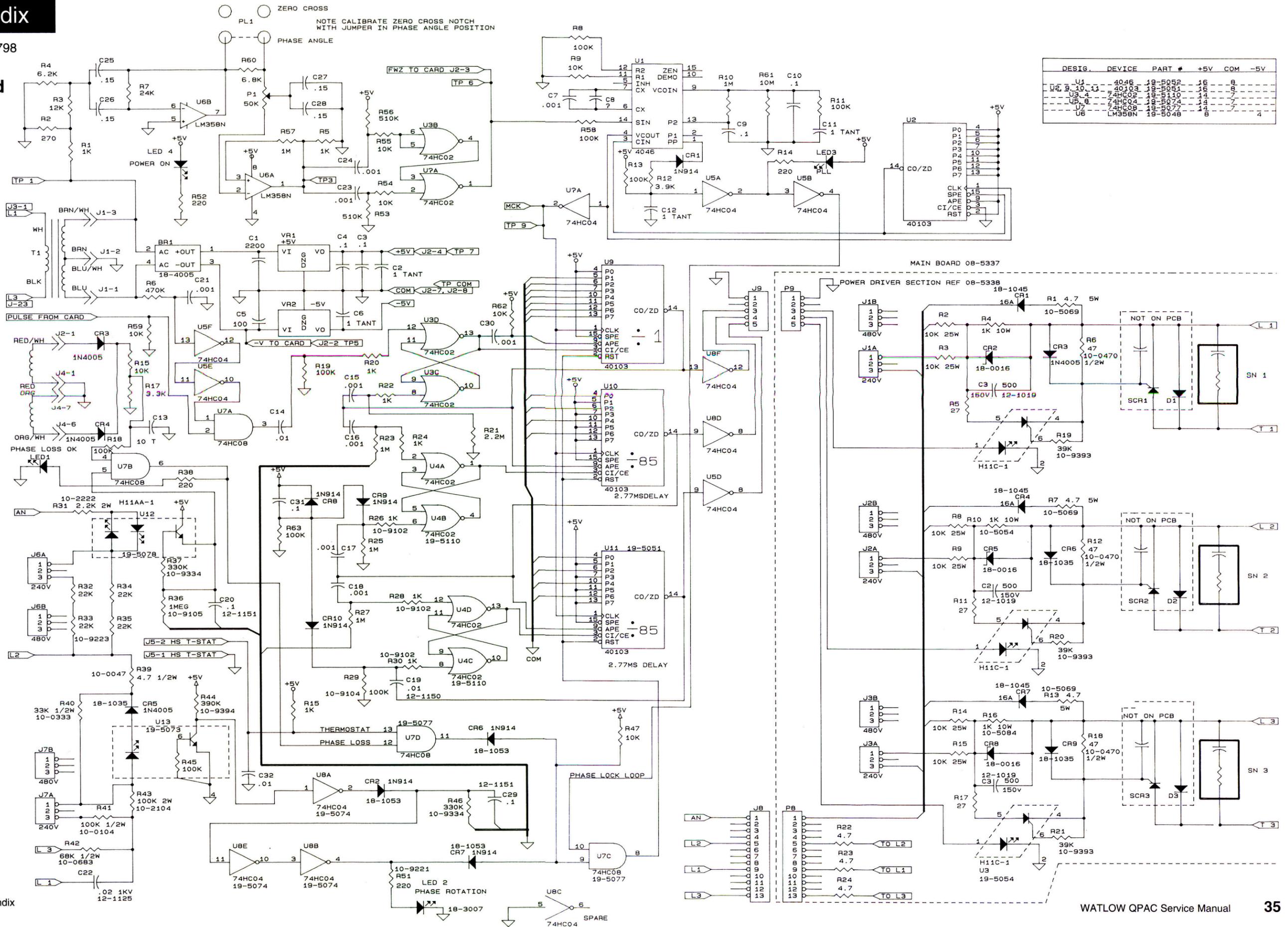
SEE 02-0681 WIRING DIAG. XFMR

IC SCHEDULE		
U1,2	19-5054	H11C1

NOTE: LAST USED: R-14, C-8, U2, CR4

Appendix

Schematic 02-0798 QPAC-33 Main Board and Power Section

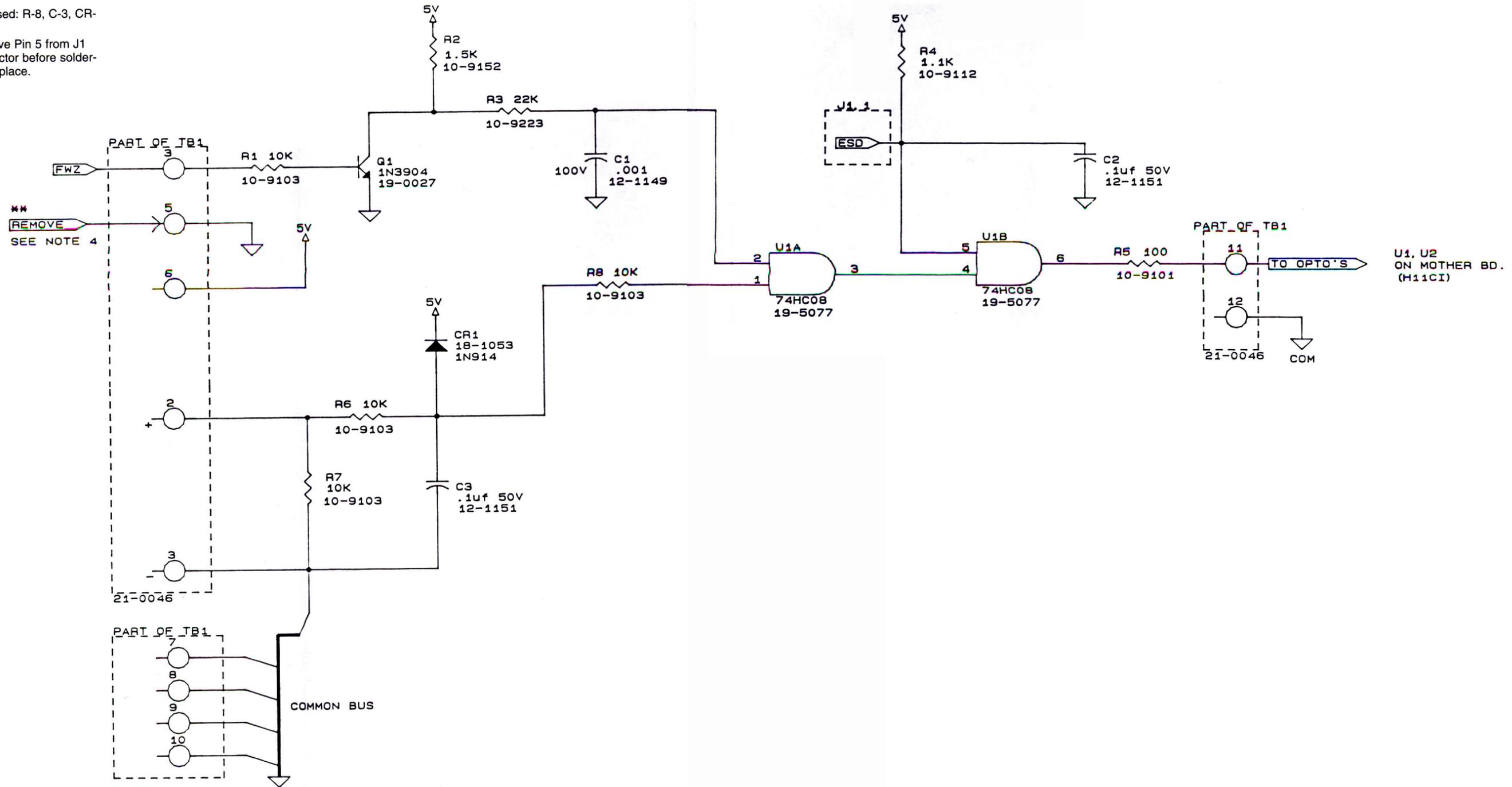


Appendix

Schematic 02-0672 DC Input QPAC Series

NOTES:

1. All resistors are 1/4 W 5% unless otherwise specified.
2. All capacitors are valued in microfarads unless noted.
3. Last Used: R-8, C-3, CR-1, U-1.
- **4. Remove Pin 5 from J1 connector before soldering in place.



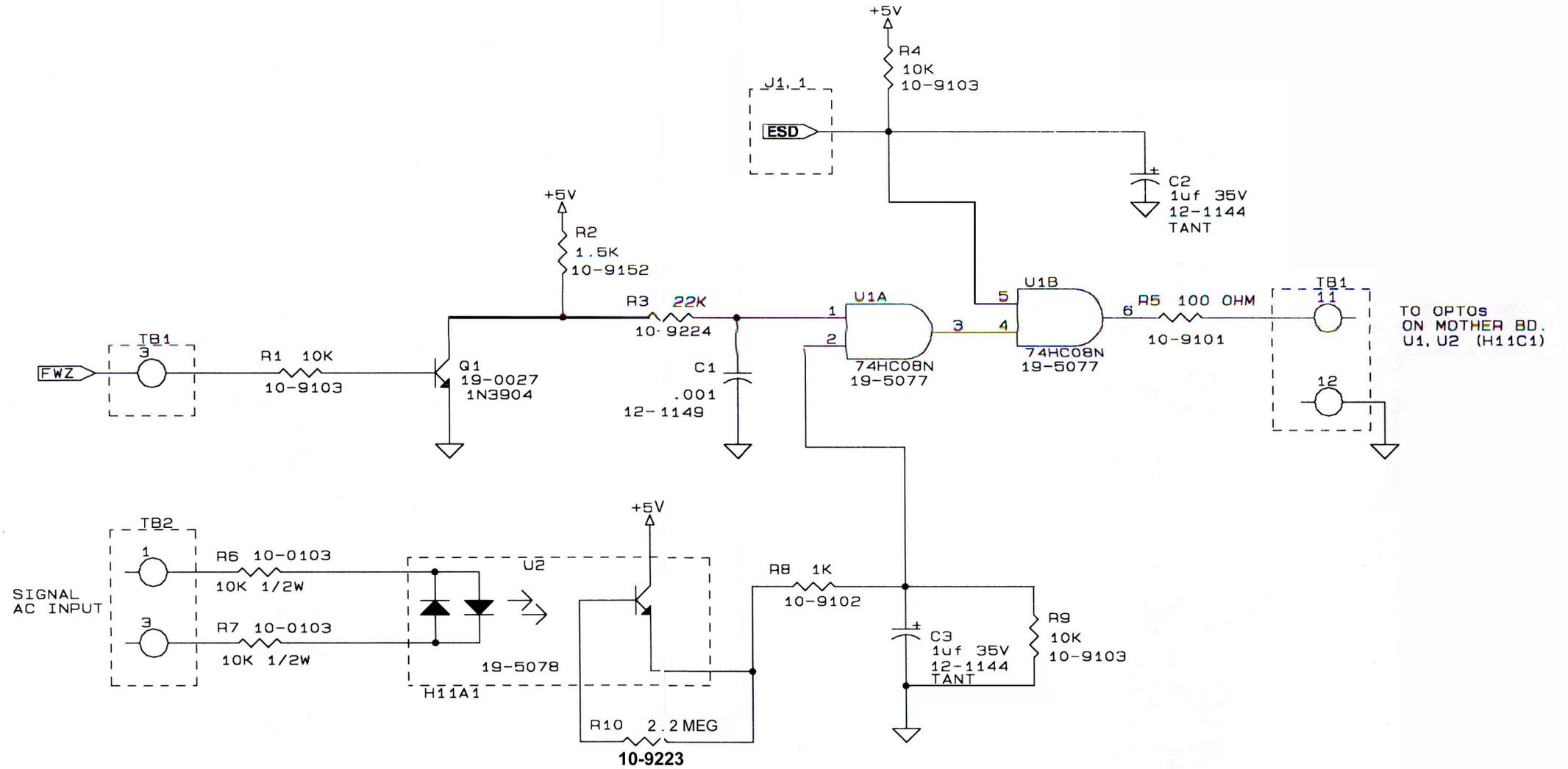
Appendix

Schematic 02-0673

AC Input QPAC Series

NOTES:

1. All resistors are 1/4 W unless otherwise specified.
2. All capacitors are valued in microfarads unless noted.
3. Ref: PC Board Bare: 35-0177.
4. Last used: R-10, C-3, U-2.
5. Last changes see ECN #2188 10/05/88



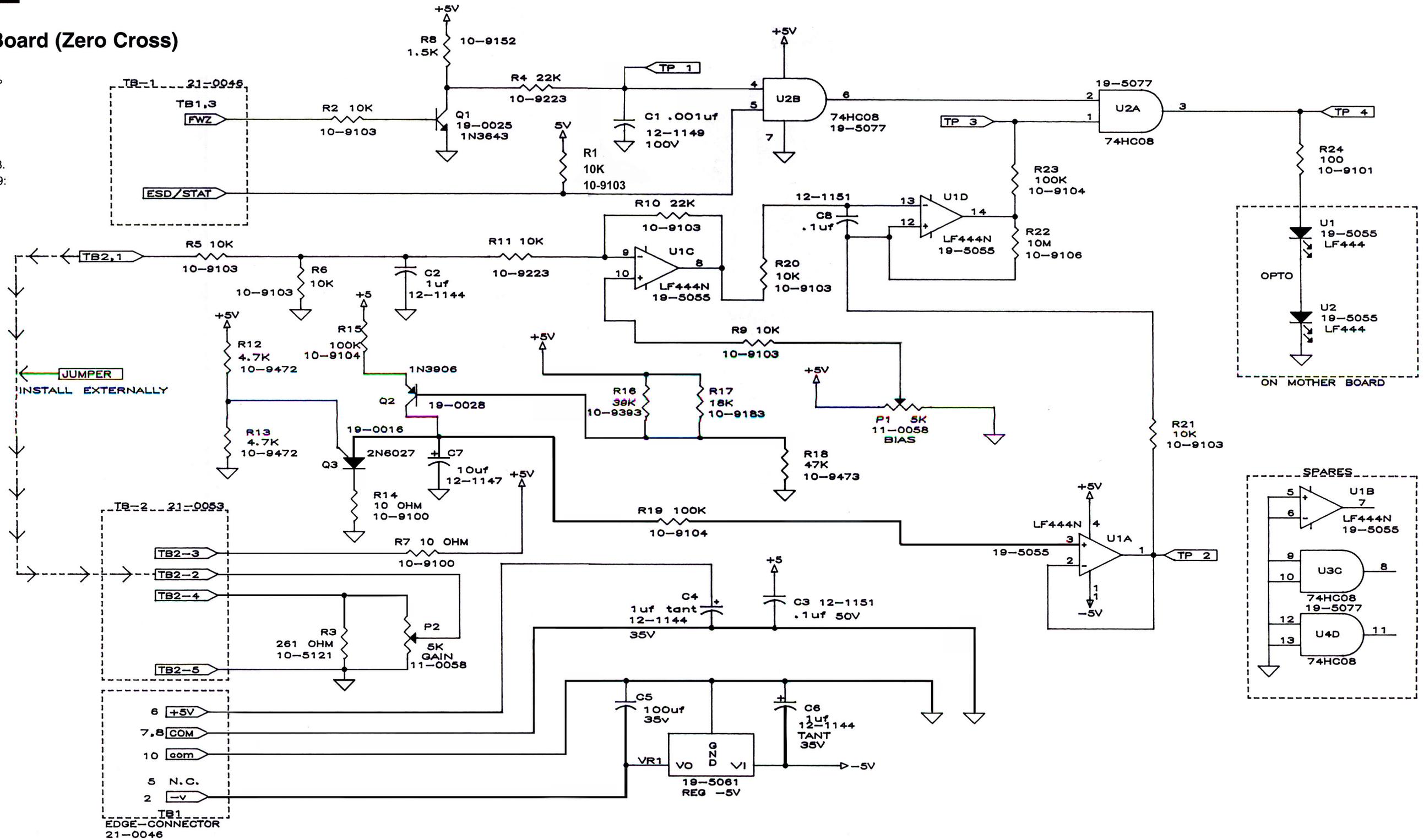
Appendix

Schematic 02-0657

QPAC-01 TPR Board (Zero Cross)

NOTES:

1. All resistors are 1/4 W 5% unless otherwise specified.
2. All capacitors are valued in microfarads unless noted.
3. Last used: R-26, C-8, Q-3.
4. Ref: AssY: PCB #08-5289: PCB Bare #35-0180.

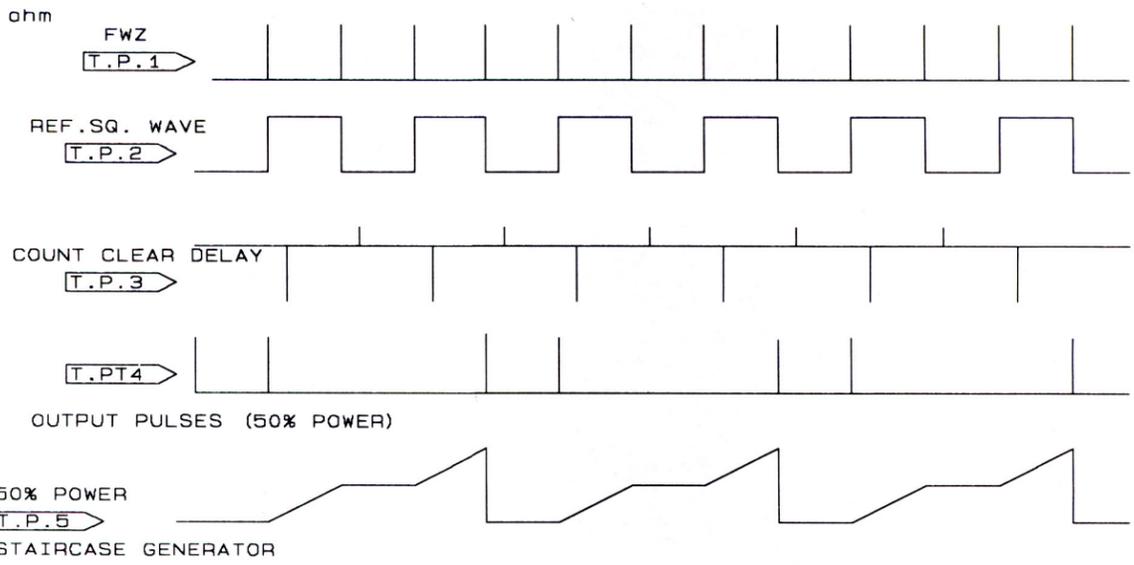
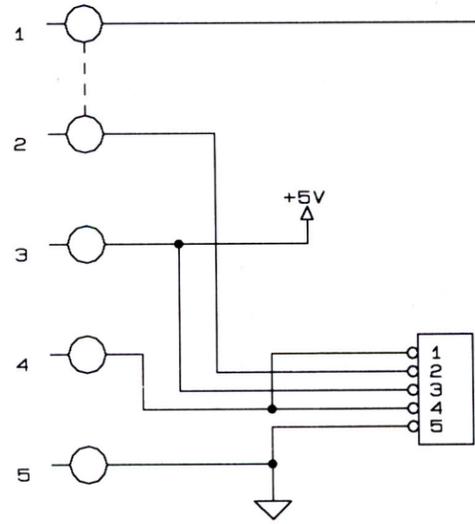
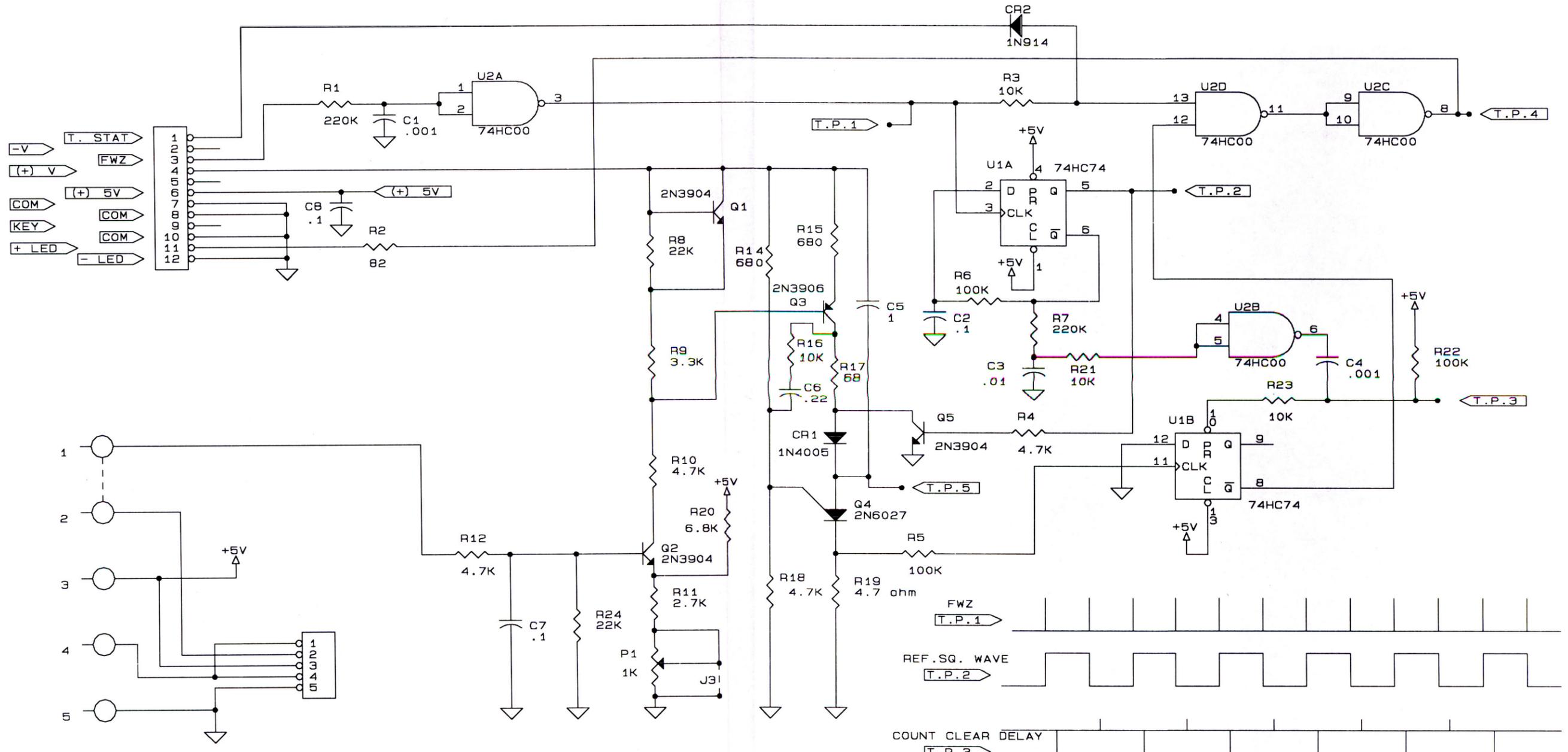


		IC SCHEDULE			
PART NO.	+5	-5	COM	GENERIC NUMBER	
U1	19-5055	5	11	9,10,12,13	LF444
U2	19-5077	14	—	7,9,10,12,13	MM74HC08

Appendix

Schematic 02-0729

QPAC Variable Time Base (Burst Fired)

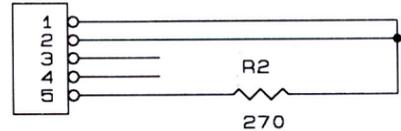


NOTE:
Control Type
Adjustable Bias and Gain

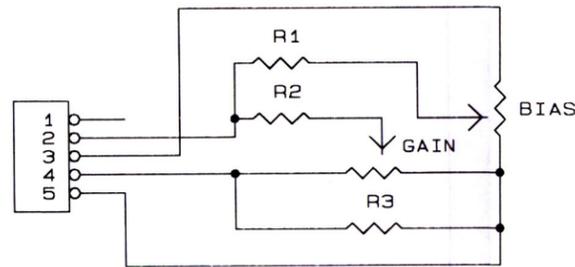
Potentiometer Input or Fixed Input

Use
R20, W3, Bias-Gain Range Card
Do not use P1

Fixed Input Connector
Do not use R20, W3



RANGE CARD
FIXED INPUT
4 TO 20 MA



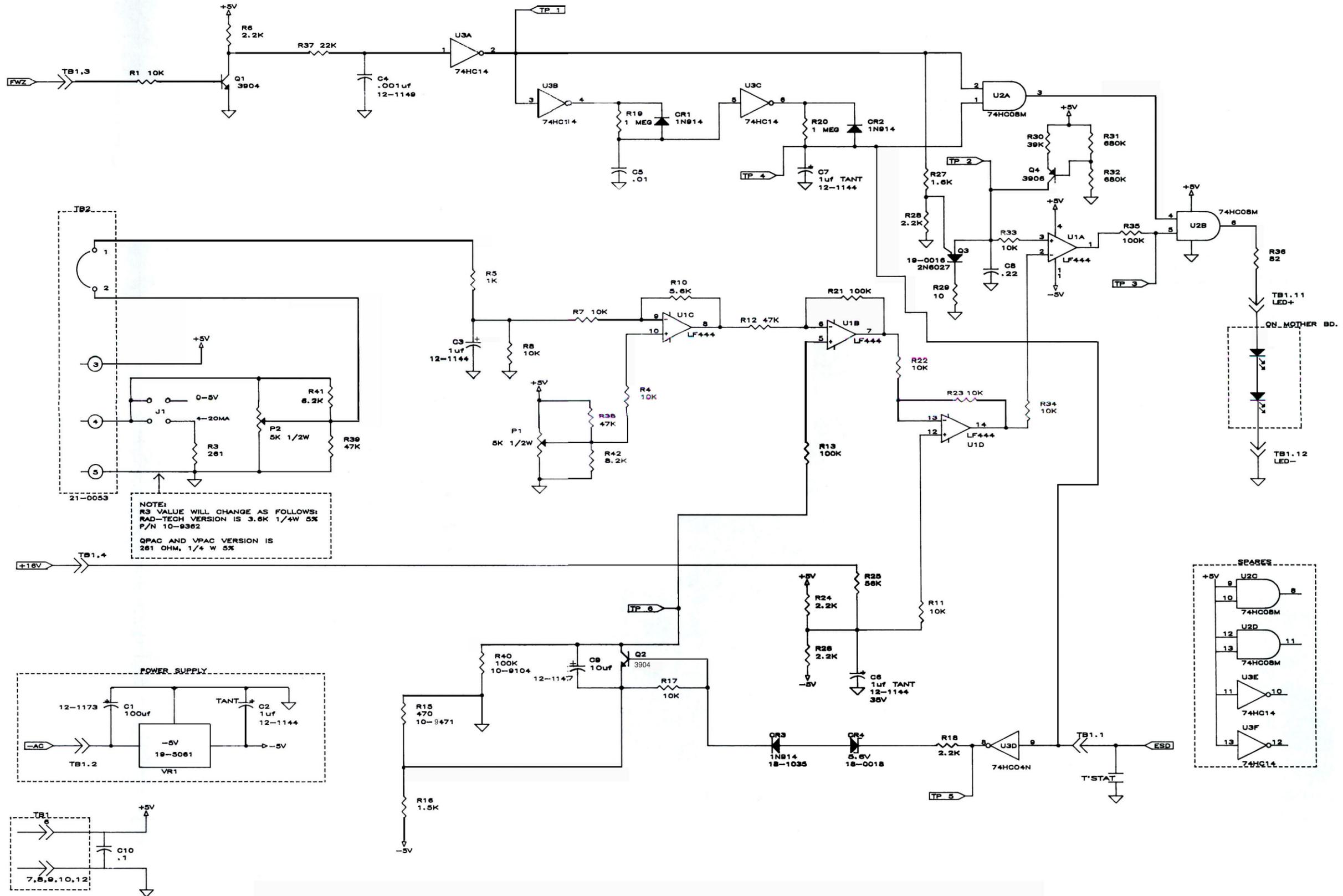
RANGE CARD
BIAS AND GAIN

Appendix

Schematic 02-0656 QPAC Phase Fired

NOTES:

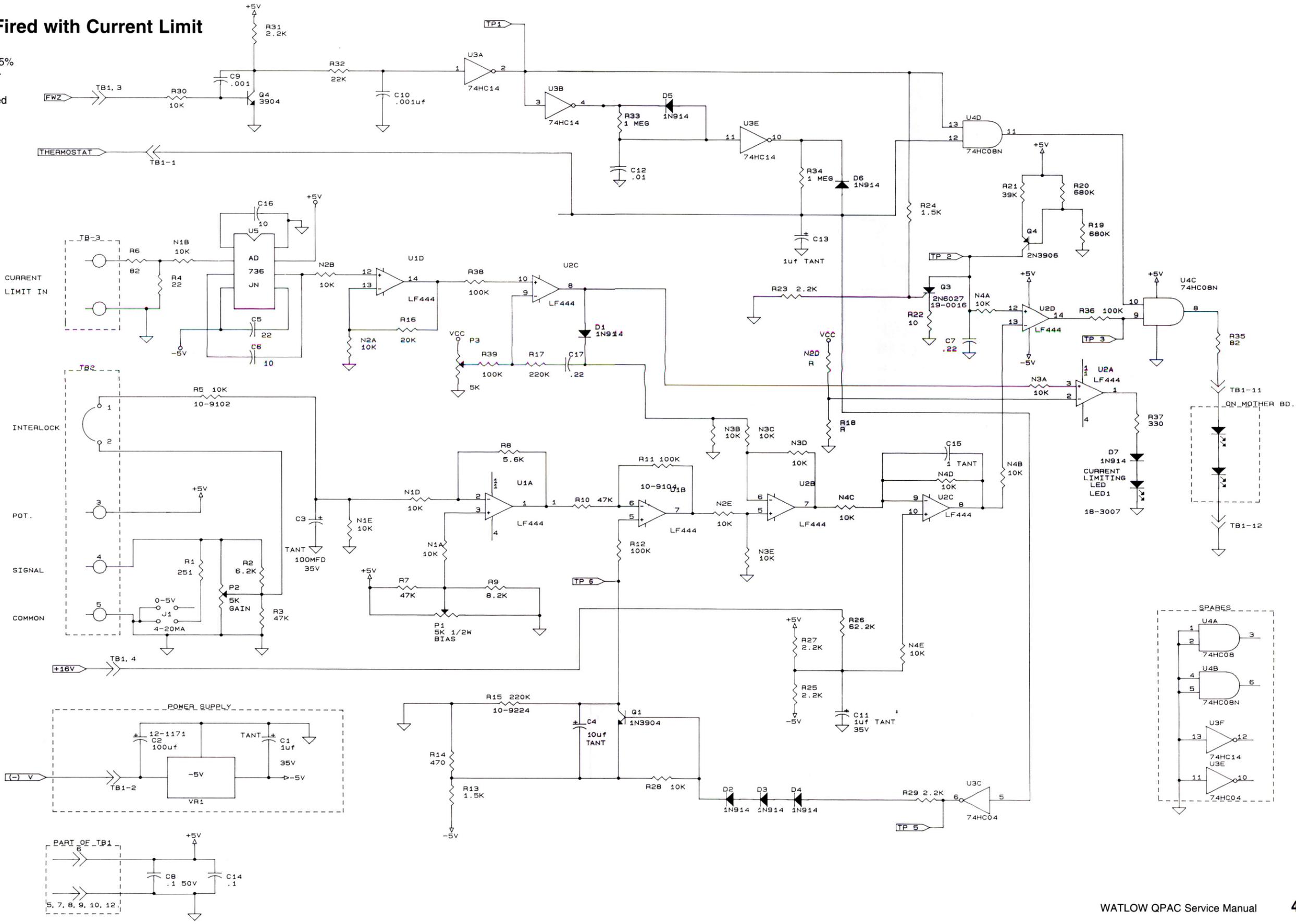
1. All resistors are 1/4 W 5% unless otherwise specified.
2. All capacitors are valued in microfarads unless noted.
3. Last used: R-42, C-10, CR-5, Q-4, U-3, P-2.



Appendix

Schematic 02-0701 QPAC Phase Fired with Current Limit

- NOTES:**
1. All resistors are 1/4 W 5% unless otherwise specified.
 2. All capacitors are valued in microfarads unless noted.



Watlow QPAC Service Manual

Watlow Controls, 1241 Bundy Blvd., P.O. Box 5580, Winona, MN 55987-5580, Phone: 507/454-5300, Fax: 507/452-4507