INSTALLATION

OPERATION

MAINTENANCE

MELLTRONICS DRIVES

2600RG

Single Phase Regenerative DC Drives
¼ HP TO 7½ HP

Melltronics Industrial, Inc.

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INDIAN TRAIL, NC 28079-2368
SHIPPING: 3479 GRIBBLE ROAD
MATTHEWS, NC 28104-8114

PHONE: 704-821-6651
www.melltronics.com

SAFETY WARNINGS
Improper installation or operation of this drive control may cause serious injury to personnel or equipment. Before you begin installation or operation of this equipment you should thoroughly read this instruction manual and any supplementary operating instructions provided. The drive must be installed and grounded in accordance with local and national electrical codes. To reduce potential of electric shock, disconnect all power sources before initiating any maintenance or repairs. Keep fingers and foreign objects away from ventilation and other openings. Keep air passages clear. Potentially lethal voltages exist within the control unit and connections. Use extreme caution during installation and start-up.

BRANCH CIRCUIT PROTECTION
Branch circuit protection is to be provided by end user.

OVERLOAD PROTECTION
Overload protection must be provided per national electric code article 430, Section C.

INITIAL CHECKS
Before installing the drive control, check the unit for physical damage sustained during shipment. Remove all shipping restraints and padding.

INSTALLATION LOCATION OF CONTROL
Controls are suitable for most factory areas where industrial equipment is installed. The control and operator's control station should be installed in a well-ventilated area. Locations subject to steam vapors or excessive moisture, oil vapors, flammable or combustible vapors, chemical fumes, corrosive gases or liquids, excessive dirt, dust or lint should be avoided unless an appropriate enclosure has been supplied or a clean air supply is provided to the enclosure. The location should be dry and the ambient temperature should not exceed 104°F. If the mounting location is subject to vibration, the enclosure should be shock-mounted.
If the enclosure has a ventilating fan, avoid, wherever possible, and environment having a high foreign-matter content otherwise the filters will have to be changed more frequently or micron-filters installed. Should a control enclosure require cleaning on the inside, a low pressure vacuum cleaner is recommended, not an air hose, because of the possible oil vapor in the compressed air and its high pressure.

2600RG– RECEIVING AND STORAGE INFORMATION

Please record information below before installing the unit and use these numbers when communicating with the factory.

MODEL NAME ____________________

PART NO. ____________________

SERIAL NO. ____________________

REVISION ____________________

MODIFICATIONS ____________________

ACCEPTANCE
Carefully inspect shipment upon arrival and check items with packing list. Shortage or damage should be reported promptly to your carrier and your distributor.

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SECTION 1
GENERAL INFORMATION

1.1 INFORMATION

This instruction manual contains installation information, operating instructions and troubleshooting procedures for the MELLTRONICS 2600RG Adjustable Speed DC Motor Control. A comprehensive description of the MELLTRONICS 2600RG control with detailed product specifications and a complete description of all customer selectable functions and customer installable option kits is included.

The information in this instruction manual will describe the drive system set-up and operating procedure for most drive applications. Also provided is the information required by the customer to install and maintain a MELLTRONICS 2600RG control. Additional drive system set-up and operating information may be required in some applications. This information will normally be supplied in the form of a system schematic and system interconnection diagrams.

Before beginning installing and before performing any start-up or maintenance on the drive system read this instruction manual in its entirety .

1.2 GENERAL DESCRIPTION

The MELLTRONICS 2600RG is a high performance, regenerative DC motor control. Accessibility to all important internal regulator points is provided by terminals on the control. This permits the MELLTRONICS 2600RG to be used in custom engineered applications, as well as in standard speed regulated applications.

The MELLTRONICS 2600RG controls a DC motor's speed or torque by varying the DC voltage applied to the motor's armature. Being regenerative it can provide power to the load or absorb power from the load and return that power to the AC power line. Rectilinear phase control assures stable operation at low speeds and smooth transitions between motoring and regenerative modes (zero dead-band).

The MELLTRONICS 2600RG control converts single phase AC input power to variable voltage DC output power. The DC output is applied directly to the DC motor armature. DC output voltage varies as a function of an input reference voltage in speed regulated applications. (Typically, this input reference voltage is provided by an operator adjustable potentiometer). Changing the speed reference (potentiometer setting) results in a motor speed change.

DC output current varies as a function of an input reference voltage in torque regulated applications. Changing the torque reference (potentiometer setting) results in a change in motor torque output.

The MELLTRONICS 2600RG control is designed for use with either shunt wound or permanent magnet DC motors. A fixed voltage unregulated DC source is provided for connection of the motor field in wound field applications.

The MELLTRONICS 2600RG is a versatile control. Simple jumpered programming allows the MELLTRONICS 2600RG to operate from either 115 or 230 volt AC input power at 50 or 60 Hz. Additional jumpers program the control to operate as either a speed regulator with armature voltage or DC tachometer feedback or as a torque regulator with armature current feedback. The entire 1/4 to 5HP range of applications is covered by two control models. (See Table 1). Drive current limit and inverse time overload protective circuits for ratings within this range are calibrated by means of a jumper change on the main printed circuit board.

Motor field economy and separately adjustable rates of acceleration and deceleration are included on all units. If desired, the built-in Accel-Decel control ramps can be by-passed completely by a jumper change on the control. Current compounding can be added to the speed regulator by changing another jumper position. Current limit is normally set by a potentiometer located on the main printed circuit board, but if desired, it can be adjusted using a remote mounted potentiometer or a customer supplied voltage signal. An output signal is available for use with one of the MELLTRONICS 2600RG ammeter kits to provide an indication of drive output current without the addition of an ammeter shunt.

1.3 TYPICAL PACKAGING

The normal MELLTRONICS 2600RG control is chassis mounted non-enclosed control suitable for subpanel mounting inside a customer furnished control enclosure. (See Figure 1).

Typically MELLTRONICS 2600RG controls are furnished without operator's devices. Terminals are provided on the basic MELLTRONICS 2600RG control for connection of one or more of the following operator's devices:

- Forward/Reverse Selector Switch
- Jog Push-button
- Remote Current Limit Potentiometer
- Speed Adjust Potentiometer
- Start Push-button
- Stop Push-button

Customer requirements may dictate that the operator's devices be mounted on the door of the enclosure enclosed in a remote operator's station. Consult the schematic and interconnection diagrams furnished with your control for specific variations in packaging.

1.4 EQUIPMENT IDENTIFICATION

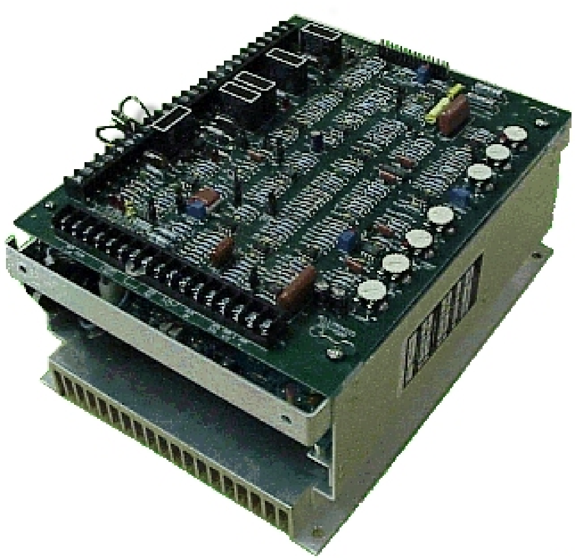


Figure 1: Typical Melltronics 2600RG Chassis Mount Control

Identification of your drive control completely and accurately is necessary when you contact Melltronics Industrial to order spare parts or request assistance in service.

Every MELLTRONICS 2600RG includes a product nameplate located on the right side of the chassis.

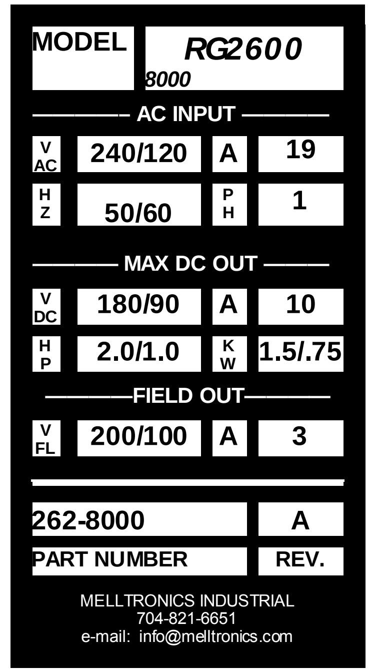


Figure 2: Typical Melltronics 2600RG Nameplate

Figure 3: Product Nameplate Location

Record both the part number and serial number for your future reference.

SECTION 2
CONTROL SPECIFICATIONS AND FEATURES

2.1 EQUIPMENT RATINGS

The MELLTRONICS 2600RG was designed to handle most drive applications without the addition of external hardware and without the need for costly, time consuming engineering. Four MELLTRONICS 2600RG control models cover the 1/4 through 10 HP range of DC drive applications.

Drive current limit and inverse time overload protective circuits are calibrated for the application by jumper.

Table 1, lists the AC input and DC output current ratings by control part number and motor horsepower for all possible combinations.

Table 1: Armature Circuit Rating Table

Armature Circuit Rating Table

Control Part No.	Horsepower 120 VAC	Horsepower 240 VAC	AC Input Amps @Full Load	DC Armature Amps @ Full Load
262-8000	1/4	1/2	4.2	3
	1/3	—	5.6	4
	—	3/4	5.6	4
	1/2	1	8.5	6
	3/4	1 1/2	11	8
	1	2	14	10
262-8001	1 1/2	3	21	15
	2	—	28	20
	—	5	35	25
	—	—	—	—
262-8075	—	7 1/2	42	30
262-8175	10HP @277VAC		52.5	37.5

A fixed voltage, unregulated DC motor supply is provided on all MELLTRONICS 2600RG controls. The DC voltage output level is a function of the AC voltage input level. Field data for the MELLTRONICS 2600RG control is tabulated in Table 2.

Table 2: Melltronics 2600RG Field Data

***MELLTRONICS 2600RG* Field Data**

Voltage:	100 VDC with 120 VAC input 200 VDC with 240 VAC input 240 VDC with 277 VAC input
Current:	3 amperes maximum

2.2 PERFORMANCE FEATURES

- **Current (Torque) Regulator** - One percent accuracy armature current regulator allows the operator to control motor torque instead of speed.
- **Field Economy** - Promotes longer life for wound field DC motors. Easily by-passed to meet specific application requirements.
- **Full Four Quadrant Operation** - Allows operation of the drive motor in both the forward and reverse directions while producing torque in either the clockwise or counterclockwise direction.
- **Inner Current Loop Regulator** - Inherent high band width capability for fast response.
- **Circuit Board Indicators** - Light emitting diodes (LEDs) on the main printed circuit board indicate:
- DC Overload
- Field Loss
- Instantaneous Over-current Trip
- Jog Mode
- Run Mode
- In addition to the indicators listed above, four separate LEDs located on the lower (firing) PC board provide a positive indication that each SCR firing circuit is receiving gate pulses.
- **Ammeter Output** - Motor current can be indicated with the simple addition of a remote meter.
- **Isolated Control Circuitry** - Provides complete isolation of the control and regulator circuitry from the AC power bus for protection in the event of a ground fault. The speed potentiometer, ammeter and tachometer are not at line potential. Complete system compatibilitity is also possible without additional isolation accessories.
- **Dual Frequency Operation** - Controls may be operated from 50 or 60Hz power supplies by simple jumper change.
- **Exclusive Static Adjustable Current Limit** - Permits static setting of the desired current limit value without applying DC power and without a connected output load when the optional test meter is connected.
- **Jog Set at Preset Speed** - Separately adjustable from zero to plus or minus 30% of base speed.
- **Negative IR Compensation** - or current compounding, enables this drive to operate in load sharing applications. This feature becomes available by jumper connection.
- **Rectilinear Phase Control** - Provides significantly improved performance at low speeds and near zero load.
- Separately Adjustable Linear Accel/Decel Control - Two ranges; 0.2-4 seconds and 2-30 seconds.
- **Solid State Full Wave Power Bridge** - Provides generously rated power semiconductors for maximum reliability and long life.
- **Remote Current Limit** - Available by the simple addition of a potentiometer of DC voltage input.

- **SCR Trigger Circuits** - Pulse transformer isolated, hard firing, high frequency "burst" type pulse train output from individually gated oscillators insures SCR conduction regardless of the effects of line notching on the incoming AC power line.
- **Quadrant Lockout** - Able to be selected by jumper programming to prevent forward or reverse motoring in certain applications.
- **AC Line Filter** - Eliminates interaction between other drives or AC equipment.

2.3 PROTECTIVE FEATURES

- **DC Overload (Armature) -** Senses over-current conditions with inverse time shutdown.
- **Fault Trip Circuit -** Visual indication of the fault condition is provided when a DC overload, field loss, or instantaneous over-current condition occurs. Protective circuits are designed to quickly shut the drive down whenever a drive fault condition occurs. A fault trip circuit prevents unintended drive restart after a fault has occurred and must be reset before the drive can run again.
- **Field Loss Protection -** Protects against runaway due to loss of motor field by shutting down the drive.
- **Current Limit** - By limiting the level of current to a user preset value (adjustable from 0 to 150% of rated armature current) protects the DC motor armature from excessive current.
- **Double Break DC Armature Loop Contactor** - Full rated and fully sequenced contactor assures positive disconnect of DC motor when the stop push-button is pushed or whenever an under-voltage condition occurs.
- **High Speed Current Limiting SCR Semiconductor Fuses -** Gives the ultimate in fuse coordination and protection of the SCRs and motor with positive circuit clearing on both AC and DC faults.
- **Instantaneous Over-current Protection -** Senses armature fault currents fast to protect both semiconductors and motors against damaging current levels.
- **Reactors, Snubber Networks -** Prevents interaction and SCR DV/DT failures, due to line spikes and transients. Provides DI/DT protection during SCR turn-on and aids in SCR turn-off during SCR commutation, therefore minimizing the effects of AC power-line notching.

NOTE: ADDITIONAL ELECTRICAL EQUIPMENT TO INSURE PROPER CONTROL OPERATION MAY BE REQUIRED FOR SEVERE SYSTEM APPLICATIONS. FOR FURTHER INFORMATION, CONTACT MELLTRONICS INDUSTRIAL.

2.4 PERFORMANCE SPECIFICATIONS

Controlled Speed Range:	20:1 basic control. May be extended to 200:1 by modification
Speed Regulation:	
For a 95% Load Change:	
Voltage Regulated:	2-5% of maximum speed
Speed Regulated:	1% of maximum speed with any DC tachometer.
For All Other Variables:	
Voltage Regulated:	Changes up to 15% of top speed can result from temperature variations, voltage and frequency variations, and drift.
Speed Regulated:	1% of maximum speed with any DC tachometer

NOTE: SPEED REGULATION MAY BE MODIFIED TO ACHIEVE 0.1% DUE TO A 95% LOAD CHANGE AND 0.15% DUE TO ALL OTHER VARIABLES.

Overload Capacity:	150% of related current for 1 minute
Service Factor:	1.0

2.5 OPERATING CONDITIONS

◆Rated Line Voltage:	120 or 240 VAC , Single-Phase
◆Line voltage Variations:	± 10%
◆Rated Line Frequency:	50 or 60Hz
◆Line Frequency Variations:	± 2Hz

2.6 ENVIRONMENTAL CONDITIONS

◆ Storage Temperature:	-30^0 C to 65^0 C (-20^0 F to 150^0 F)
◆ Ambient Temperature (Enclosed Control):	0^0 C to 40^0 C (32^0 F to 105^0 F)*
Ambient Temperature (Chassis Mount Control):	0^0 C to 55^0 C (32^0 F to 131^0 F)*
◆ Altitude:	Sea level to 3300 feet (1000 meters)*
◆ Relative Humidity:	0 to 95%

*Operation at elevated temperature and higher altitudes requires derating of the control.

2.7 ADJUSTMENTS

The ***MELLTRONICS 2600RG*** control includes a number of potentiometers that may require adjustment during drive installation and start-up. These adjustment potentiometers are located on the main (regulator) PC board.

- **Stability** User adjusted for best results
- **Deceleration Time** User adjustable from 0.2-4 sec. or 2-30 sec. (selectable)
- **Acceleration Time** User adjustable from 0.2-4 sec. or 2-30 sec. (selectable)
- **Maximum Speed** User adjustable from 70-130% of rated speed.
- **Jog Speed** User adjustable from 0-30% of rated speed
- **Current Limit** User adjustable from 0-150% of selected current range.
- **Speed Rate** User adjustable for best results.
- **I R Compensation** User adjustable from 0-10% of rated voltage.

Included on the MELLTRONICS 2600RG are several additional adjustment potentiometers. These potentiometers are all factory set and normally do not require further adjustment.

CAUTION

ANY ALTERNATION TO FACTORY-ADJUSTED POTENTIOMETERS MAY CAUSE EQUIPMENT DAMAGE AND/OR MACHINERY PROCESS PROBLEMS. FOR FURTHER ADJUSTMENTS, CONTACT:

MELLTRONICS INDUSTRIAL, INC.

2.8 CONTROL DIMENSIONS AND WEIGHTS

Table 3 gives the approximate weight and dimensions for various MELLTRONICS 2600RG controls. Figure 31 shows the outline and mounting dimensions for these MELLTRONICS 2600RG controls.

Table 3: Melltronics 2600RG Weights and Dimensions

Control Type	Approximate Weight (lbs)	Approximate Dimensions
Chassis Mount	17	13.0 x 9.5 x 6.7
Chassis Mount with Test Meter	17	13.0 x 9.5 x 9.0
Chassis Mount with Dead-Front	17	13.0 x 9.5 x 9.0

SECTION 3
DETAILED FUNCTIONAL DISCRIPTION

It is important to understand how, in general terms, the MELLTRONICS 2600RG control functions, before looking at specific circuits within the controller.

3.1 GENERAL DESCRIPTION

The MELLTRONICS 2600RG is a fully regenerative DC motor control which consists of two basic functional blocks: a power conversion assembly and a regulator assembly.

The power conversion assembly consists of 8 silicon controlled rectifiers (SCRs) connected in a bi-directional full wave bridge configuration. This bi-directional full wave bridge can convert AC power (from the AC power lines) into DC power and deliver it to the DC motor. It can also convert DC power from the DC motor when the motor is acting as a generator into AC power and return this “regenerative” power to the three-phase AC power lines.

The regulator assembly includes all of the electronic circuitry used to control (provide gating signals to) the power conversion assembly. The regulator used in the MELLTRONICS 2600RG employs two control loops, an outer velocity loop and an inner current loop. There are several advantages inherent in a DC motor control that employs this dual control loop concept. First of all, the inner current loop can easily and effectively be used to limit DC motor armature current. This protects the motor, the power bridge and the fuses during abnormal (transient) loading conditions. It also helps to maintain stable drive operation under varying load conditions. Another advantage of a DC motor control that employs an inner current loop is the ease with which it can be converted from a speed regulated drive to a torque regulated drive. This provides application flexibility which would not otherwise be available.

3.2 BLOCK DIAGRAM DESCRIPTION

In this section, the MELLTRONICS 2600RG control will be analyzed and described using the functional block diagram shown in Figure 4.

Incoming AC power is applied to the MELLTRONICS 2600RG control at Terminals L1 and L2. Two current limiting type fuses (1FU and 2FU) provide AC line short circuit protection and serve to protect the SCRs from DC fault currents. AC line power is distributed within the MELLTRONICS 2600RG control to three major functional blocks: the power conversion assembly, the DC motor field regulator and the control power supply.

The power conversion assembly consists of two-phase controlled, full wave rectified, SCR power conversion circuits connected in a “back to back” configuration. This power conversion assembly directly converts and AC line voltage into adjustable voltage DC power of either positive or negative polarity.

The power conversion assembly can also function as a line-commutated inverter and convert DC power flowing in the motor armature circuit into a chopped AC wave-form. This allows DC power generated by an overhauling load to be returned to the AC power line (regeneration). The output of the power conversion assembly is connected to the DC motor armature through a DC loop contactor (M). The DC loop contactor provides a positive means of disconnecting the DC motor armature from the power conversion assembly in the event of a drive fault.

The DC motor field supply rectifies AC line voltage to produce a fixed DC voltage which may be connected to the field windings of a wound field DC motor. The field power supply produces and output of 200VDC with 240VAC input or 100VDC with a 120VAC input. An auxiliary contact (AUX) “half waves” the field power supply anytime the DC loop contactor is opened. This reduces the field voltage applied to the DC motor (field economy) and helps to increase motor life in those applications where the motor field remains energized while the motor is stopped.

The control power supply assembly steps down the incoming AC line voltage, and then rectifies, filters and regulates it to provide four DC power sources (±15VDC, ±24VDC) which are used internally by the MELLTRONICS 2600RG regulator assembly.

A ±10VDC output is also produced which may be used in conjunction with an external potentiometer to generate a drive reference signal.

The control power supply assembly includes an isolated 115 VAC power source which is used to operate the control logic relays and DC loop contactor. A fused 115VAC output is also available for customer use.

All of the remaining functional blocks shown in Figure 4 are associated with the MELLTRONICS 2600RG regulator assembly.

The MELLTRONICS 2600RG control works off a zero to ±10VDC reference signal. This input reference signal can represent either a DC motor speed reference or a DC motor torque reference depending on the placement of a terminal board jumper. The input reference signal is usually introduced into the control at TB1, Terminal 21 on the main control board.

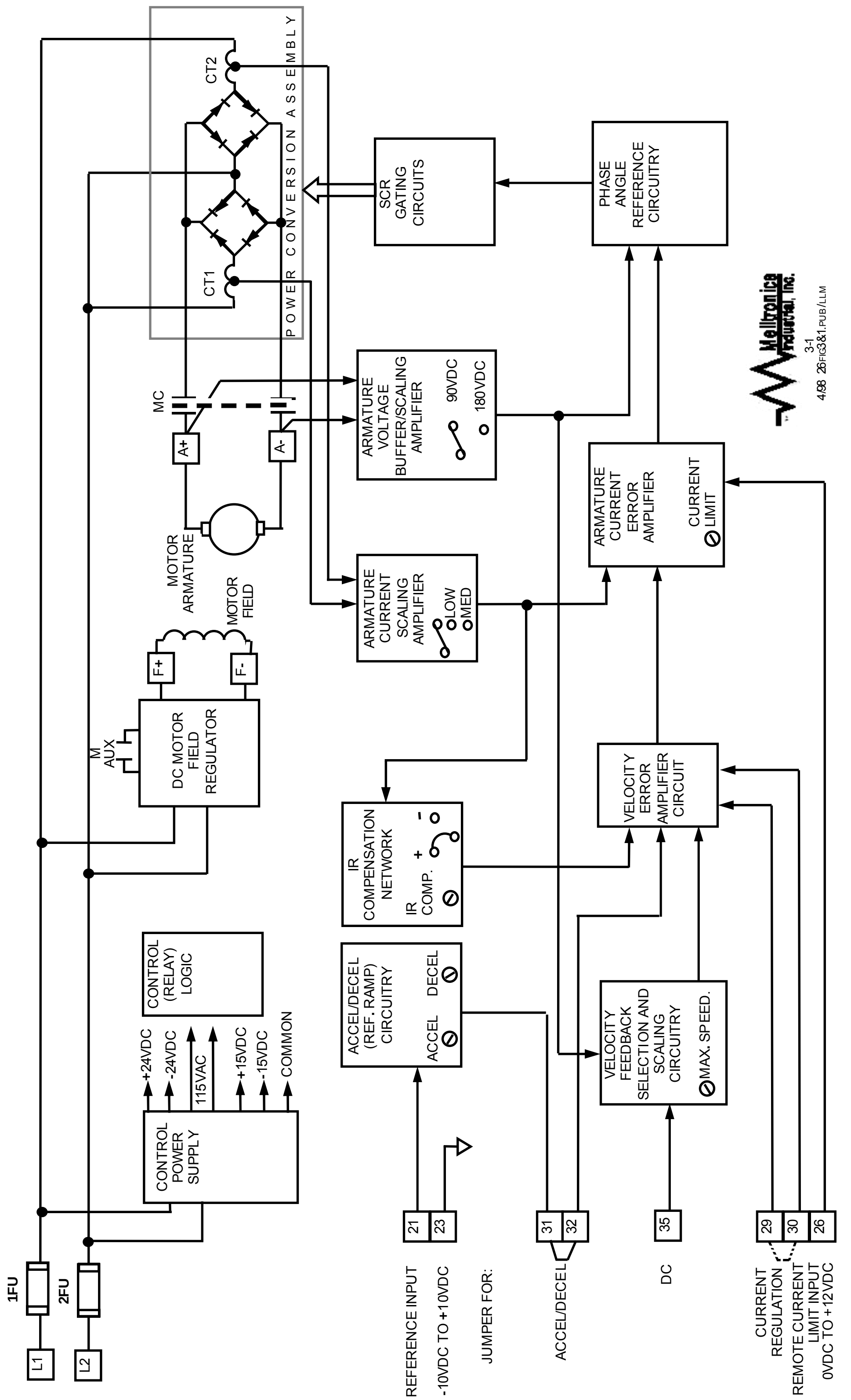


Figure 4: Melltronics 2600RG Block Diagram

Terminal 21 is connected to the input of the MELLTRONICS 2600RG's accel/decel circuit. This circuit controls the rate at which the drive reference can change. When a reference signal is applied to the input of the accel/decel circuit, the output of the
can change. When a reference signal is applied to the input of the accel/decel circuit, the output of the
accel/decel circuit changes at a linear rate with respect to time until the output of the accel/decel circuit (Terminal 31) is equal to its input (Terminal 21). The rate of change is adjustable and separate adjustments are provided for positive going and negative going reference changes. The accel/decel circuit is most commonly used in speed regulated drive applications. If the operator rapidly changes the speed reference to the drive, the accel/decel circuit will limit the acceleration or deceleration rate to a rate that will not cause machine or process problems. The accel/decel circuit can also be used in torque regulated applications to limit the rate at which the torque reference to the drive can change.

The output of the accel/decel circuit (Terminal 31) is usually connected to the velocity error amplifier input (Terminal 32) via a jumper connection at the customer terminal strip (TB1). It is possible to by-pass the accel/decel circuit completely by removing this jumper and connecting the drive input reference signal to Terminal 32 instead of Terminal 21. The accel/decel circuit is often by-passed in custom engineered drive applications.

The velocity error amplifier circuit is used in speed regulated drive applications. It compares a velocity reference signal with a velocity feedback signal to determine whether the DC motor is operating faster or slower than its commanded velocity. The output of the velocity error amplifier circuit is used as a reference signal to the MELLTRONICS 2600RG's "inner current loop". The inner current loop directly controls DC motor armature current.

The feedback signal to the velocity error amplifier can be a signal proportional to DC motor armature voltage or it can be a signal from a DC tachometer generator. Armature voltage feedback is used in those applications where the speed regulation and drift characteristics of the drive are not extremely critical. Tachometer feedback provides improved speed regulation and drift characteristics. The velocity feedback section and scaling circuitry allows the control to be programmed for armature voltage feedback or tachometer feedback. It allows the control to be used with 90VDC or 180VDC motors (voltage regulated applications) or with a variety of tachometer voltage output levels (speed regulated applications).

The velocity error amplifier circuit has one additional input, IR compensation.

The IR compensation network introduces an increase (or decrease) in the velocity reference proportional to motor armature current. The magnitude of the increase (or decrease) can be adjusted using the IR compensation potentiometer. On the MELLTRONICS 2600RG, the IR compensation signal can be either positive or negative. Positive IR compensation increases the motor velocity reference as the motor armature current increases. Positive IR compensation is used in armature voltage regulated control applications to offset the natural tendency for the speed of a motor to decrease as the load on the motor increases. Positive IR compensation is generally not used in applications which employ tachometer feedback. Negative IR compensations are just the opposite of positive IR compensation. It causes the motor velocity reference to decrease as motor armature current increases. When negative IR compensation is employed, the DC drive motor will function much like a compound wound DC motor would function in the same application. Negative IR compensation is used in "helper drive" applications where the speed of the drive must conform to the speed of the process it drives. Negative IR compensation may be used with both armature voltage and tachometer feedback regulated controls.

The armature current error amplifier compares an armature current reference signal (the output of the velocity error amplifier) with an armature current feedback signal (the output of the armature current scaling amplifier). The output of the armature current error amplifier is one of two reference signals applied to the phase angle reference circuitry. The phase angle reference circuitry determines the correct SCR firing angle for the SCR power conversion assembly. Actual SCR firing is controlled by the SCR gating circuit.

A pair of current sensing transformers measures the AC line current flowing in the power conversion assembly. One CT senses forward current flow while the other CT senses reverse current flow. Each CT output waveform is rectified and normalized by the armature current scaling amplifier to provide a bi-directional signal that is directly proportional to the current flowing in the DC motor. This signal is utilized as the feedback signal to the armature current error amplifier and it is also used as an input to the IR compensation circuit.

The armature voltage buffer/scaling amplifier is used to isolate and scale DC motor armature voltage for use by the phase angle reference circuit. The output of the armature voltage buffer/scaling amplifier is also used as 'velocity' feedback in some applications.

The velocity error amplifier circuit is designed to normally function as a very high gain error amplifying circuit. It can also be configured to function as a low gain, input reference buffer amplifier. This configuration is normally used in current regulated drive applications. By jumpering terminals 29 and 30 at the user terminal block (TB1) and eliminating both the armature voltage and tachometer feedback signals, it is possible to re-configure the MELLTRONICS 2600RG to function as a current (torque) regulated DC drive control. When configured in this manner, the input reference signal applied to Terminal 21 (or Terminal 32) will control the DC motor current (torque) instead of DC motor speed.

Drive current limit is typically set using a potentiometer located on the MELLTRONICS 2600RG control. In many applications, it is desirable to adjust drive current limit using either a remote mounted potentiometer or a customer supplied voltage signal. A 0 to +10VDC signal applied to Terminal 26 (TB1) adjusts drive current limit between 0 and 200% of the selected current range.

3.3 DETAILED CIRCUIT DESCRIPTIONS

Functional blocks will be examined in detail.

3.3.1 POWER CONVERSION ASSEMBLY

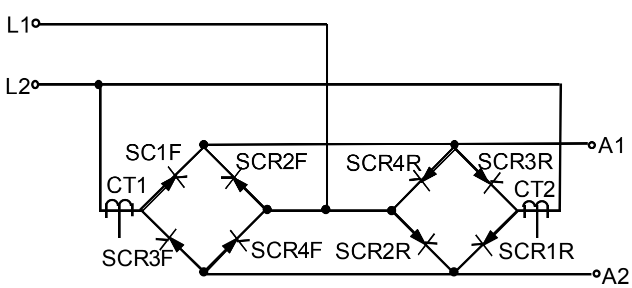


Figure 5: SCR Power Conversion Assembly

The MELLTRONICS 2600RG's power conversion assembly consists of eight silicon controlled rectifiers (SCRs). These eight SCRs form a bi-directional, full-wave power conversion bridge.

The DC output voltage of a bi-directional full-wave power conversion bridge can be either positive or negative, and electrical energy can flow from the AC power lines (designated L1 and L2 in Figure 5) to the DC motor (designated A1 and A2 in Figure 5) or power can also flow from the DC motor (now functioning as a DC generator) back into the AC power lines. The direction of power flow and the DC output polarity of the power conversion assembly are a function of the load connected to the DC motor and the phase angle reference signal applied to the SCR gating circuitry.

Two current transformers (CT-1 and CT-2) are included in the power conversion assembly to measure the current flow in both the forward power conversion bridge and the reverse power conversion bridge.

In order to understand how the MELLTRONICS 2600RG's power conversion assembly works, it is first necessary to understand how an SCR works. An SCR is a three terminal semiconductor power conversion device. The three terminals are called the anode, the cathode and the gate. The schematic symbol for an SCR is shown in Figure 6.

The working of an SCR is best understood by first looking at how a diode works. Diodes are two terminal semiconductor power conversion devices. The two terminals are called the anode and the cathode. When the voltage of a diode's anode is positive with respect to its cathode, the diode is said to be forward biased. A forward biased diode will conduct current. It looks like a short circuit (low resistance to current flow). When the voltage of a diode's cathode is positive with respect to its anode, the diode is said to be reverse biased. A reverse biased diode will block all current flow. A reverse biased diode can be thought of as an open circuit (a very high resistance to current flow).

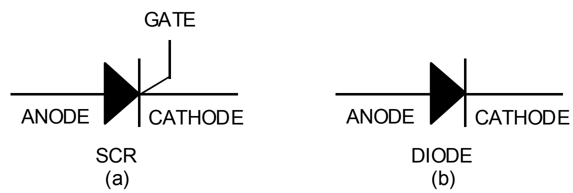


Figure 6: Semiconductor Devices

To summarize, a diode functions like a one way switch. The switch is closed when the anode voltage is positive with respect to the cathode, and is open whenever the cathode voltage is positive with respect to the anode voltage. Diodes are commonly used to convert fixed voltage AC power into fixed voltage DC power.

An SCR is similar to a diode. It must be forward biased (anode positive with respect to cathode) before it will conduct current. In addition to being forward biased, and SCR must also be "gated on" before it can conduct current. SCRs are "gated on" by applying a positive voltage between the gate lead and the cathode of the SCR during a time when the SCR is forward biased. Once a SCR has been "gated on", it functions exactly like a diode would function. It conducts current (and will continue to conduct current) in the forward direction as long as it remains forward biased. Removing the gate signal from an SCR will not stop the SCR from conducting after it has been "gated on". The SCR must become reverse biased to stop the flow of current through it.

After an SCR stops conducting current, it must once again be forward biased and “gated on’ before it can conduct current.

The average DC output voltage of an SCR rectifying circuit can be adjusted quite easily by time delaying the application of the SCR gating signal with respect to the zero crossing of the AC power line. As the gate signal is further delayed relative to the zero crossing of the AC power line, the SCR conducts for a shorter and shorter period of time during each AC cycle. The average DC output voltage is reduced further and further as the gate signal is delayed more and more. If the gate signal is delayed a full 180 degrees, the SCR never turns on and the SCR’s average output voltage is zero. SCRs are commonly used to convert fixed voltage AC power into adjustable voltage DC power.

The SCR power conversion bridge used in the MELLTRONICS 2600RG functions exactly as outlined above except for the fact that a DC motor is not a pure resistive load. DC motors convert electrical energy into mechanical motion. They require direct current input (current that flows in one direction) in order to make them rotate. A DC motor normally absorbs electrical energy from some type of energy source (a battery or a DC power supply) and converts that energy into mechanical energy.

Every DC motor is also capable of functioning as DC generator. When a DC motor functions as a DC generator, the motor absorbs mechanical energy from the mechanical system to which it is connected, and it converts that mechanical energy into a direct current. The electrical energy produced by a DC generator can be used to power other DC motors, or the energy can be converted to some other form.

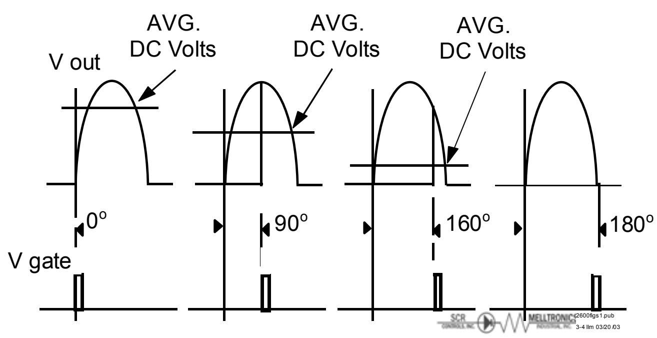


Figure 7: Typical SCR Voltage Waveforms

When a DC machine (motor or generator) rotates, it produces a DC voltage that is directly proportional to its rotational speed. This DC voltage is called the DC motor counter voltage or counter EMF (CEMF). It does not make any difference whether the DC machine is functioning as a DC motor or a DC generator.

It still generates a voltage (CEMF) proportional to its rotational speed. The CEMF will be either positive or negative depending on the direction of machine rotation. Clockwise (CW) rotation will produce an output voltage of one polarity while counterclockwise (CCW) rotation will produce an output voltage of the opposite polarity.

It is possible to control the speed of a DC motor by adjusting the magnitude of the DC voltage applied to the motor’s armature. If the DC voltage source that is used to control the DC motor is a bi-directional voltage source (like the MELLTRONICS 2600RG), the operating speed of the DC motor may be controlled anywhere between maximum motor speed in the forward direction and maximum motor speed in the reverse direction without the use of reversing contactors.

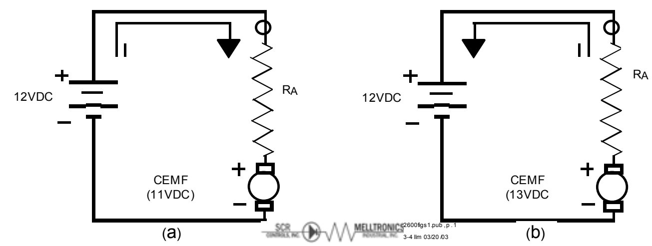


Figure 8: Motoring vs. Regenerative Operation

The direction of current flow and the polarity of the CEMF determine whether the DC machine is functioning as a DC motor (converting electrical energy into mechanical energy) or whether it is functioning as a DC generator (converting mechanical energy into electrical energy).

Figure 8 shows two DC motors. Each DC motor is connected to a fixed voltage DC power supply (a 12VDC battery). The DC motor-(a) is operating in a motoring condition while the DC motor-(b) is operating in a regenerative condition. Each of the DC motors is represented by its equivalent circuit which consists of a voltage source (the CEMF) in series with a resistor (R_A). The resistor (R_A) represents the motor armature winding resistance.

In DC motor-(a), the motor is rotating at a speed that produces a CEMF of 11VDC. DC current flows through the circuit in a clockwise direction because the battery voltage (12VDC) is greater than the DC Motor CEMF (11VDC). When a clockwise current flows in this circuit, electrical energy is flowing from the battery to the DC motor. The DC motor is absorbing electrical energy and converting that electrical energy into mechanical motion. This is called motoring.

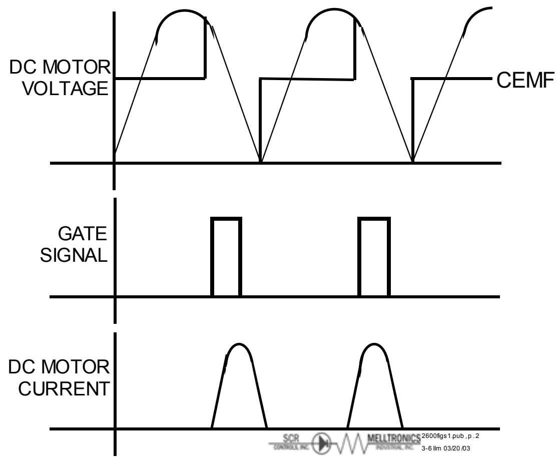


Figure 9: Voltage Current Waveforms – Motoring Operation

When we want 'motoring' current to flow in a motor that has a negative CEMF, we gate the SCRs on when the AC line voltage is more negative than the negative DC motor CEMF. If we want 'regenerative' current to flow in a motor that has a negative CEMF, we gate the SCRs on when the AC line voltage is less negative than the negative DC motor CEMF.

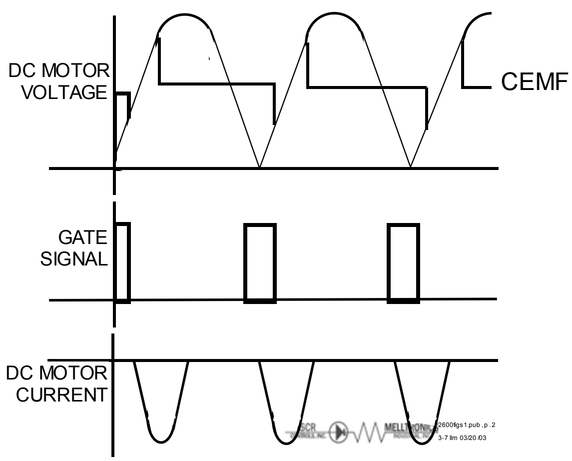
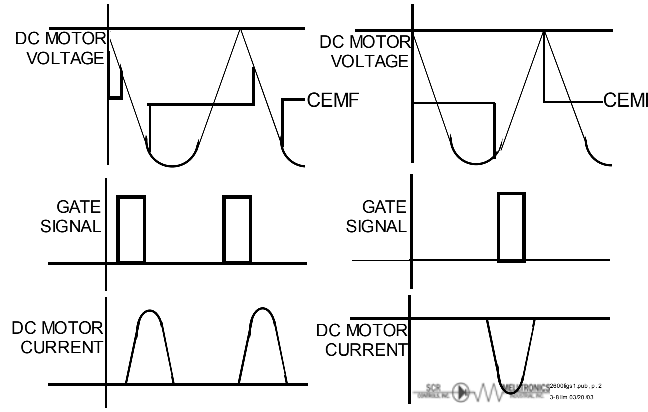


Figure 10: Voltage and Current Waveforms - Motoring Operation

In the 'motoring' mode, the DC motor consumes electrical energy and converts it to mechanical motion. In the "motoring" mode, we gate the SCRs one at a time when the AC line voltage is slightly higher than the DC motor CEMF. This allows current (power) to flow from the AC line to the DC motor. (This situation is exactly like the situation depicted in Figure 8- current flows from the power source to the motor because the voltage of the power source is higher than the CEMF voltage of the motor.)

Current will only flow from the AC line to the DC motor for a short period of time. The flow of current ceases as soon as the AC line voltage drops below the DC motor CEMF (the SCRs become reverse biased and shut off). If we repeat the process (gate the SCRs on repeatedly at approximately the same point in the AC cycle), current will flow from the AC line to the DC motor.

In the 'regenerative' mode, the DC motor 'absorbs' mechanical energy from the machine or process it is connected to and converts that mechanical energy into electrical energy. In the 'regenerative' mode, we gate the SCRs on at a time when the DC motor CEMF is slightly higher than the AC line voltage. This allows current to flow from the DC motor to the AC line. (This situation is just like the situation depicted in Figure 8 current flows from the motor to the power source because the motor CEMF voltage is higher that the voltage of the source.) Current will only flow from the DC motor to the AC line for a short period of time. The flow of current ceases as soon as the AC line voltage rises above the DC motor CEMF (the SCRs become back biased and shut off). If we repeat the process (gate the SCRs on repeatedly at approximately the same point in the AC cycle), current will flow from he DC motor to the AC line.



Reverse Regeneration (a)

Reverse Motoring (b)

Figure 11: Voltage and Current Waveforms - Reverse Operation

The DC motor counter voltages shown in Figure 9 and Figure 10 were shown as positive voltages. They could have and would have been negative voltages if the DC motor has been rotating in the opposite direction. If we want motoring current to flow in a motor that has a negative CEMF we gate the SCRs on when the AC line voltage is more negative than the negative DC motor CEMF (Figure 11 (a)), If we want regenerative current to flow in a motor that has a negative CEMF we gate the SCRs on when the AC line voltage is less negative than the negative DC motor CEMF (Figure 11 (b)).

It should be noted that we gate on a different group of SCRs for motoring operation than we do for regenerative operation. The SCRs in the forward bridge are gated on to produce motoring current flow with positive CEMF. The SCRs in the reverse bridge are gated on to produce regenerative current flow with positive CEMF. If the CEMF is negative, the opposite sets of SCRs must be gated on.

3.3.2 SCR GATING CIRCUITRY

Figure 12 shows the MELLTRONICS 2600RG SCR gate pulse circuitry. This circuitry controls the output of the power conversion assembly by controlling which SCRs are gated on and by controlling when these SCRs are gated on. All of the circuitry shown in Figure 12 is located on the lower printed circuit board.

Four separate gating circuits are provided to control the eight SCRs in the power conversion assembly. Each of the four gating circuits controls a pair of SCRs (i.e. SCR1F and SCR4F). Each gating circuit includes pulse transformers, a driver FET (Q1 through Q4), and indicating LED (1 LED through 4 LED), and a 4-input and gate (LA, L7B, L8A, and L8B). The 4-input AND gate functions as the gate circuit control element while the FET and pulse transformer create the isolated gate signals that are applied to each SCR.

Each of the 4-input AND gates (L7A, L7B, L8A, and L8B) receives a gate sync signal, a gate enable signal, a bridge lockout signal and a gate pulse generator signal. Before a pair of SCRs can be gated on, the gate sync signal, the gate enable signal, and the bridge lockout signal must all be high. If these three signals are high and the gate oscillator is enabled, a burst of SCR gating pulses is produced at the output terminals of the SCR gate pulse transformer.

An additional lockout circuit is provided on the lower printed circuit board. A contactor sequenced lockout circuit locks out all gating circuits until after the DC loop contactor picks up and relocks out all gating circuits approximately 20 msec after the DC loop contactor opens. This circuit is not the ‘M’ contactor sequencing circuit that insures contactor pickup and drop out at zero current levels.

The information that follows will describe how the input signals to each 4-input AND gate are generated. It also describes how these four input signals control which SCR is gated on an how they control when each SCR is gated on.

Figure 13 shows the MELLTRONICS 2600RG’s SCR gate control circuitry. All of the circuitry shown in Figure 13 is located on the lower printed circuit board. SCR gating in the MELLTRONICS 2600RG is controlled by a phase angle reference signal generated on the upper printed circuit board. This signal is transferred to the lower printed circuit board through a wire harness and plug assembly (P3-Pin 3). The phase angle reference signal controls the voltage level on capacitors C18 and C19.

The MELLTRONICS 2600RG includes two timing ramp circuits. These two timing ramp circuits determine when each SCR is gated on. One timing ramp circuit controls the forward power bridge and the second timing ramp circuit controls the reverse power bridge. Since the two timing ramp circuits are identical, only the forward timing ramp will be described here.

Transistor Q7 is a constant current source that charges capacitor C17 at the constant rate. The voltage across C17 increases at a constant rate and forms a linear voltage ramp with respect to time. Once every 8.3 msec (every 10 msec for 50 Hz power sources) the voltage level on capacitor C17 is reset to zero by Q3 which functions as a floating solid state switch. The periodic reset of capacitor C17 synchronizes the linear voltage ramp with respect to the AC power line. Q3 (our floating switch) is controlled by a timing ramp reset signal that will be described later.

The line synchronized linear voltage ramp created by Q7, C17, and Q3 “floats” on the voltage level of C18 which as previously explained is controlled by the phase angle reference signal. This “floating” linear voltage ramp is compared to a fixed voltage level 7.5 volts) by comparator L3-A. When the value of the “floating” linear voltage ramp exceeds +7.5 volts, comparator L3-A toggles to a “high” (+15 volt) state and an SCR gating sequence is initiated for the forward power bridge. Comparator L3-A is reset to its “low” state once every 8.3 msec (every 10msec for 50 Hz power sources) by the same sync signal that resets the linear timing ramp.

The reverse timing ramp circuit consists of current source Q8, capacitor C20 and floating switch Q4 plus comparator L3-B. It functions exactly the same as the forward timing ramp circuit. A negative phase reference signal (at P3-Pin 3) will cause the forward power bridge capacitor (L3-A) to be toggled during each half cycle of the AC line, while a positive phase reference signal will cause the reverse power bridge comparator (L3-B) to be toggled during each half cycle of the AC power line.

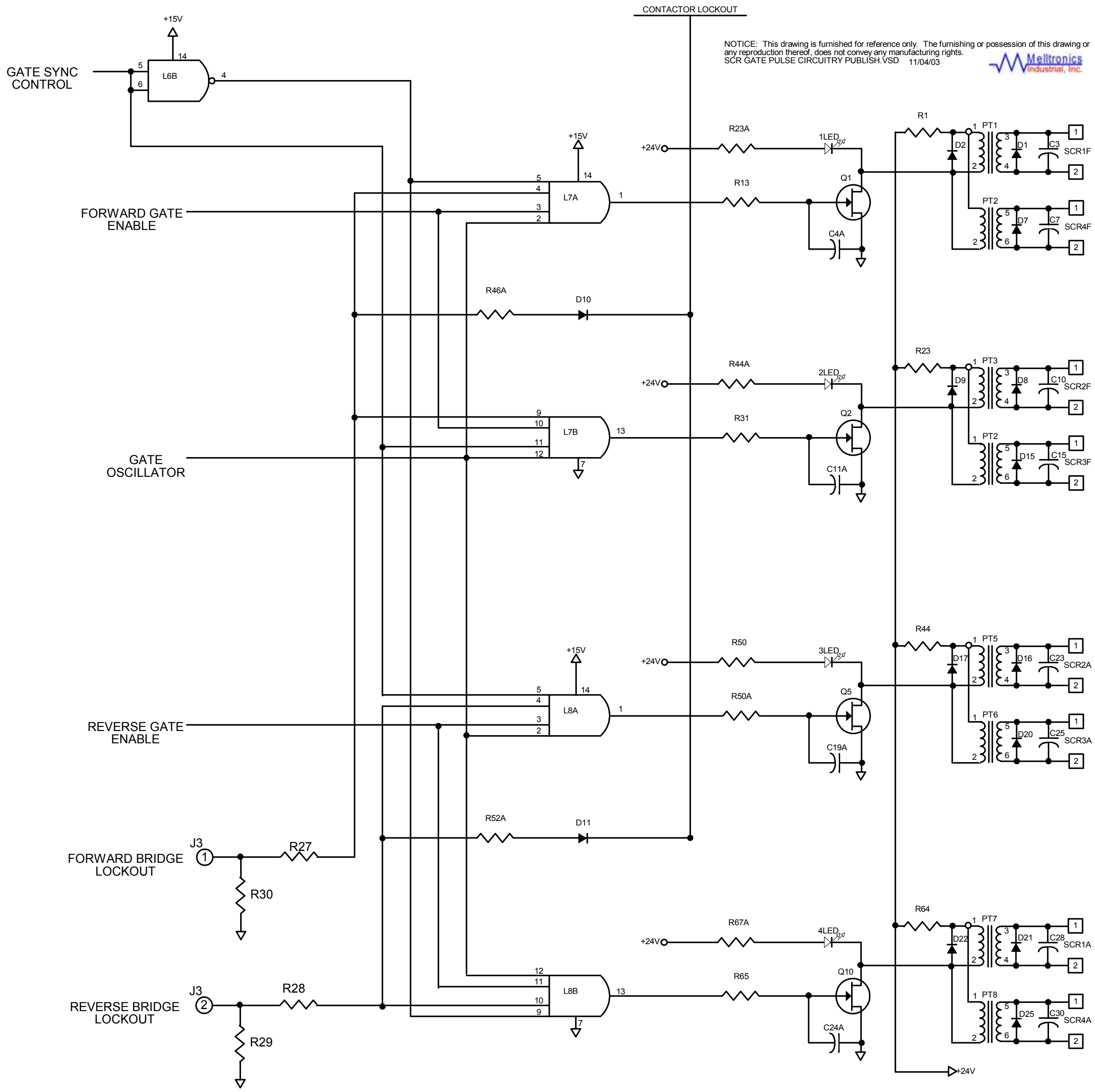


Figure 12: SCR Gate Pulse Circuitry

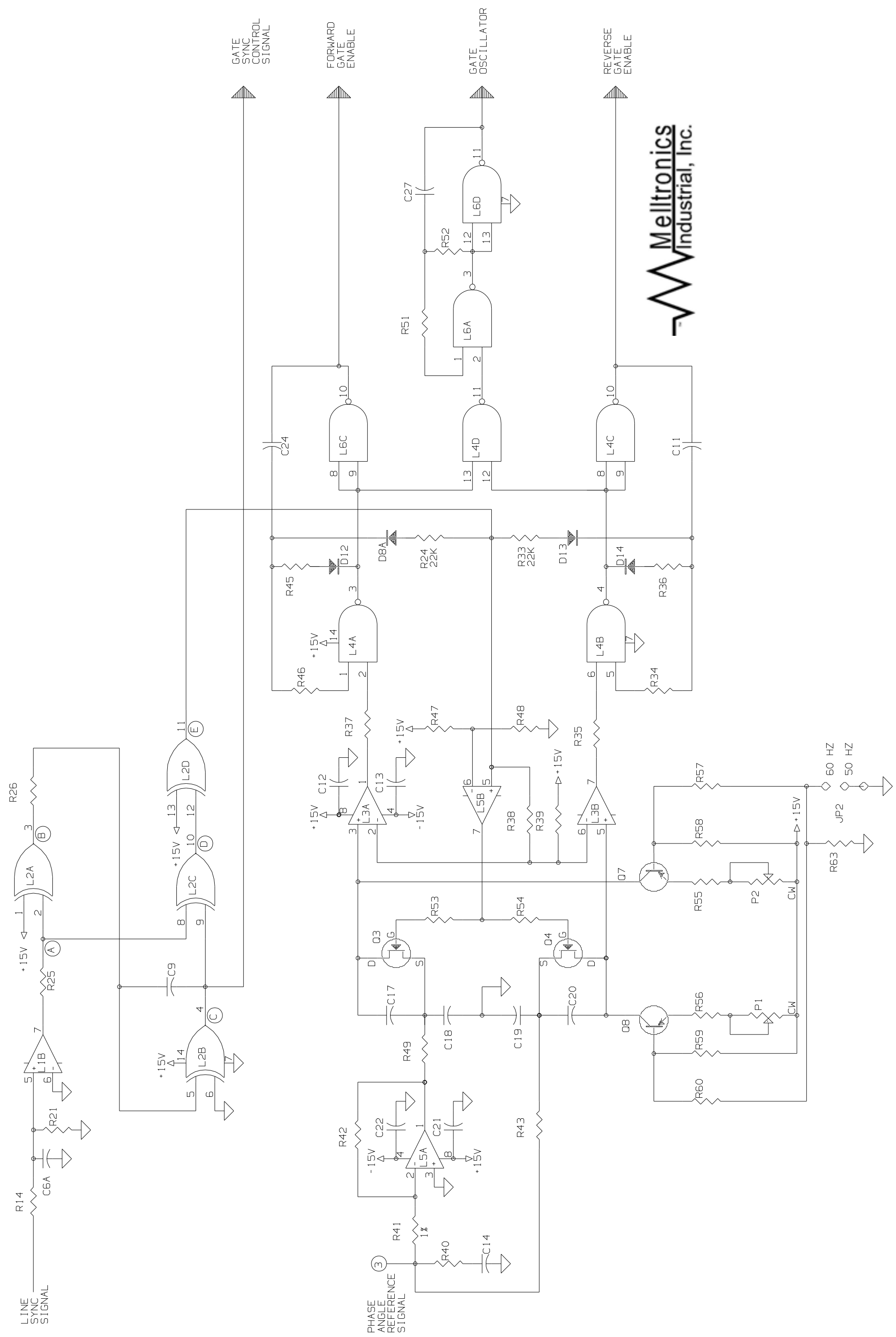


Figure 13: SCR Gate Control Circuitry

Two balance pots (P1 and P2) are included to adjust the two timing ramp circuits. P1 controls the reverse timing ramp while P2 controls the forward timing ramp. These potentiometers are factory set for the proper ramp rate and should not require further adjustment. A jumper (JP2) is provided to recalibrate the timing ramp circuits for operation on 50 Hz power.

When the forward bridge comparator (L3-A) is toggled high, a forward bridge gating sequence is initiated. As the reverse power bridge comparator (L3-B) is toggled high, a reverse power bridge gating sequence is initiated. Since these two sequences are identical, only the forward power bridge gating sequence will be described here.

A forward gate enable signal (high output on L6-C, Pin 10) and a gate oscillator enable signal (high output on L4-D, Pin 11) are both generated whenever a forward power bridge gating sequence is initiated. Both of these outputs (L6-C, Pin 10 and L4-D, Pin 11) are driven high by L3-A and both outputs remain high for approximately 1 msec after L3-A changes state. When the gate oscillator enable signal (L4-D, Pin 11) is “high”, the output of L6-D (the gate oscillator) oscillates between its “low” state (zero volts) and it “high” state (+15 volts). Since the forward gate enable signal (L6-C, Pin 10) is also high, a 1 msec wide burst of gate pulses will be generated by one of the two forward gate pulse transformers (assuming the forward lockout signal is not low). The gate sync control signal determines which one of the two forward gate pulse transformers actually produces gate pulses.

For a number of reasons, it is desirable to only apply gate pulses to those SCRs in the power bridge that are forward biased. The purpose of the gate sync signal is to prevent SCR gate pulses from being applied to those SCRs in the power bridge that cannot possibly be in a forward biased condition. The gate sync control signal is a 1 to 15VDC square wave that is used to synchronize the application of SCR gate pulses with respect to the AC power line. When L1 is positive with respect to L2, SCR-1F and SCR-4F of the forward bridge plus SCR -1R and SCR-4R of the reverse bridge are forward biased by the AC power line. The gate sync signal for these SCRs (the signal applied to L7-A, Pin 5 and L8-B, Pin 9 (See Figure 12) is also high during this time period allowing gate pulses to be generated if all other conditions (gate enable high, bridge lockout high, and gate oscillator enabled) are met. When L2 is positive with respect to L1, the above mentioned SCRs are reverse biased and the gate sync signal goes low to prevent the application of gate pulses to these reverse biased SCRs. In similar fashion, when L2 is positive with respect to L1, SCR-2F and SCR-3F of the forward bridge plus SCR-2R and SCR-3R of the reverse bridge are forward biased by the AC power line. The gate sync signal for these SCRs (the signal applied to L7-B. Pin 11 and L8-A, Pin 5) will be high and gate pulses can be generated if the other conditions(gate enable high, bridge lockout high and gate oscillator enabled) are met. When L1 is positive with respect to L2 these SCRs are reverse biased and the gate sync signal prevents the application of gate pulses to these SCRs that are now reverse biased.

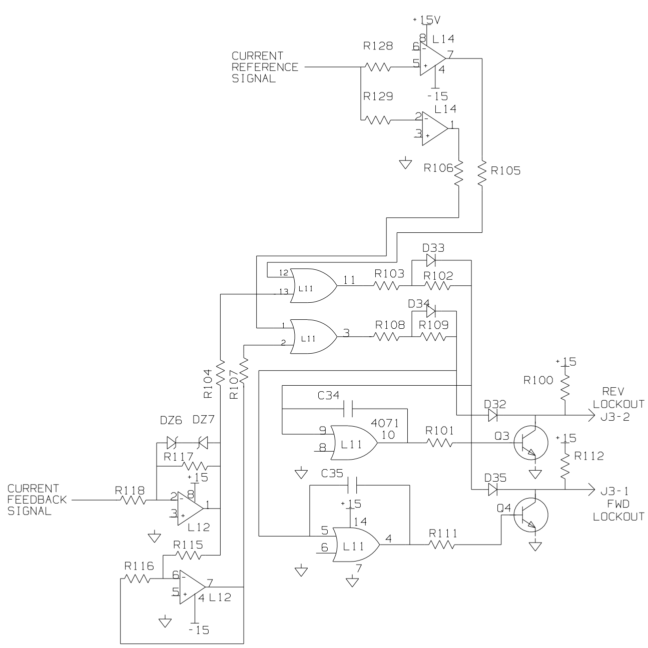


Figure 14: Power Bridge Lockout Circuits

The gate sync control signal (L2-B, Pin 4) and the timing ramp reset signal (L2-D, Pin 11) are generated by an operational amplifier (L1-B) and four logic gates (L2-A, L2-B, L2-C, and L2-D). The gate sync control signal (used to synchronize the application of SCR gate pulses with respect to the AC power line) is phase shifted approximately 35 degrees relative to the AC power line. The timing ramp reset signal (used to reset the SCR gate timing ramp circuits) is also phase shifted approximately 35 degrees relative to the AC power line. By phase shifting the timing ramp reset signal and gate sync control signal approximately 35 degrees (slightly less when the control is operated off a 50Hz power source) it is possible to control the current in either the forward power bridge or the reverse power bridge at any value between zero and full load assuming a DC motor load.

Figure 14 shows the forward and reverse power bridge lockout circuits. The forward and reverse lockout circuits are located on the upper printed circuit board. These two circuits generate a pair of lockout signals that are used to prevent the incorrect power bridge from being gated on. These two signals are transferred from the upper printed circuit board to the lower printed circuit board through a wire harness and plug assembly (P3-Pins 1 and 2) Each lockout circuit monitors both the current reference signal (L9-B, Pin 7) and the current feedback signal (L12-A, Pin-1 or L12-B, Pin-7). When a positive current reference exists, the reverse power bridge is locked out by the output of Q3 which is driven low. When a negative current reference exists, the forward power bridge is locked out by the output of Q4. In similar fashion, when the current feedback signal indicates that a positive armature current is flowing, the reverse power bridge is locked out by Q3. Whenever negative armature current is flowing, the forward power bridge is locked out by Q4. The current reference signal and the current feedback signal are “OR’d” together by logic gates L11-A and L11-C. To prevent both bridges from being locked out at the same time L11-B and L11-D have been added. These logic gates provide a 1 msec off delay in each lockout signal when the current reference reverses polarity.

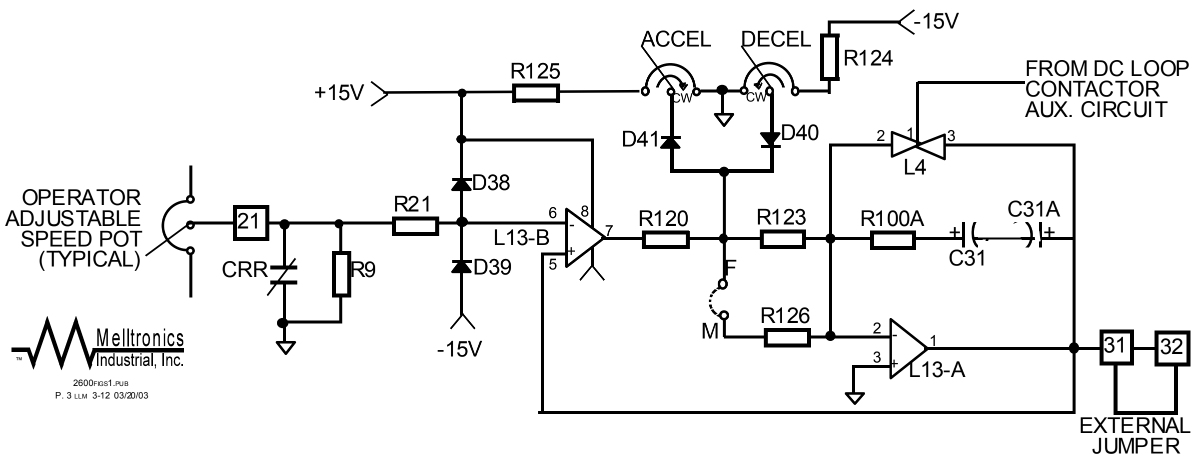


Figure 15: Accel/Decel (Reference Ramp) Circuitry

3.3.3 ACCEL/DECEL (REFERENCE RAMP) CIRCUIT

When drive run is initiated, relay CRR is picked up and the input reference signal (from an operator adjusted potentiometer or master reference) is applied to Pin 6 on L13-B. This causes the output of L13-B (Pin 7) to be driven either positive or negative until the output of L13-A (Pin 1) is equal to the input reference signal. Whenever the output of L13-B is not equal to zero, the output voltage of L13-A will change at a linear rate determined by the setting of either the acceleration or deceleration rate adjustment potentiometer.

When the reference input swings more negative (less positive), the output of the accel/decel circuit (L13-B) goes positive and the rate of change of L13-A’s output is controlled by the acceleration rate adjustment potentiometer. When the input reference swings more positive (or less negative), the output of L13-B goes negative and the rate of change of L13-A’s output is controlled by the deceleration rate adjustment potentiometer. The output of the accel/decel circuit (TB1, Terminal 31) is usually jumpered to the input of the velocity error amplifier (TB1, Terminal 32). Clockwise rotation of the ‘accel’ and ‘decel’ potentiometers will increase the acceleration and deceleration time. Accel/decel time is adjustable from approximately .2 to 4 seconds when JP10 is set to F-H and is 2 to 30 seconds when the jumper is set to H-I. The solid state switch (L4) is controlled by an auxiliary contact located on the DC loop contactor. This switch clamps and holds the output of the accel/decel circuit to zero until the loop contactor has closed.

It should be noted that when a bi-directional speed reference signal is used, the acceleration rate potentiometer controls the acceleration rate in the 'forward' direction but it controls the deceleration rate in the 'reverse' direction. The deceleration rate potentiometer controls the deceleration rate in the 'forward' direction but it controls the acceleration rate in the 'reverse' direction. When a bi-directional speed reference signal is used, a negative signal with respect to common must be used for the forward direction and a positive signal with respect to common must be used for the reverse direction.

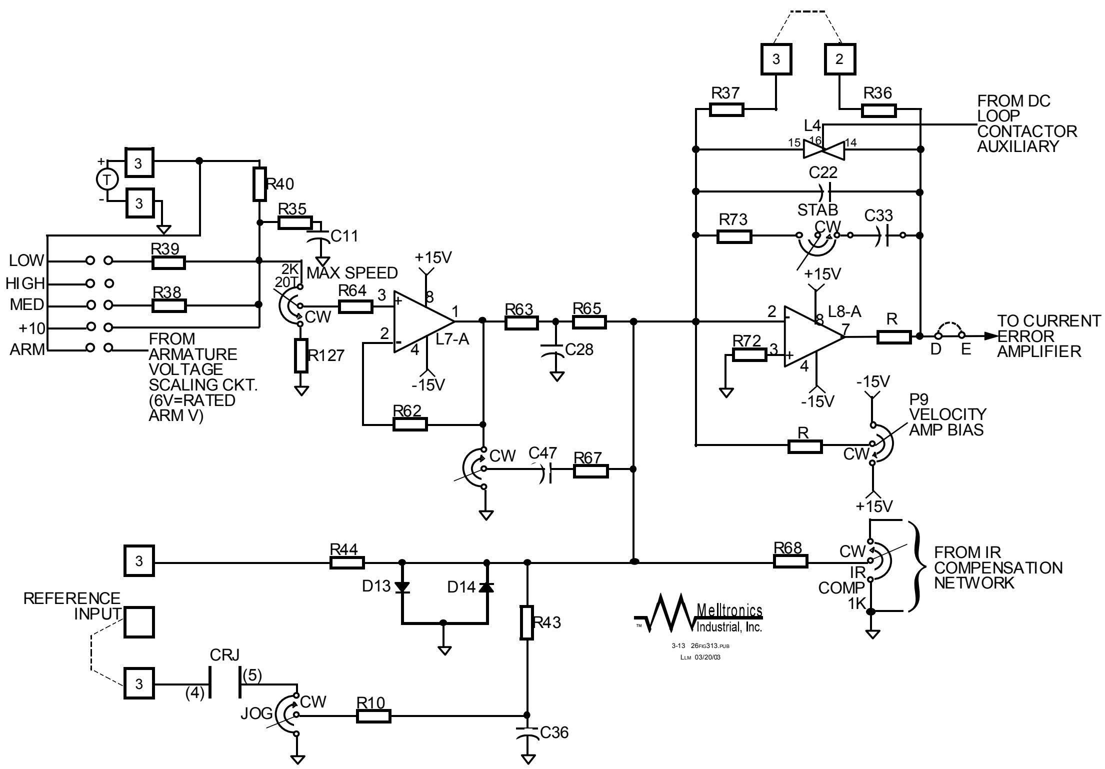


Figure 16: Velocity Error Amplifier and Velocity Feedback Selection and Scaling Circuits

3.3.4 VELOCITY ERROR AMPLIFIER AND FEEDBACK CIRCUITRY

The velocity error amplifier is a high gain operational amplifier that algebraically sums a velocity reference signal with a velocity feedback signal and amplifies the result. The output of L3-A (Pin 1) is a velocity error signal and it becomes the reference signal for the current error amplifier. The velocity error amplifier has been scaled so that a 4VDC feedback signal exactly offsets a 10VDC input reference signal (TB1, Terminal 32).

The velocity reference signal enters the MELLTRONICS 2600RG control at Terminal 32 (TB1). In most applications, the velocity reference signal will come directly from the output of the accel/decel (reference ramp) circuit (TB1, Terminal 31). The accel/decel circuit, described earlier, may be bypassed by removing the jumper normally connected between Terminals 31 and 32 (TB1) and introducing the input reference signal directly at Terminal 32.

When the jog relay (CRJ) is energized, a jog reference is applied to the input of the velocity error amplifier. The polarity and magnitude of the jog reference signal are determined by the voltage applied to Terminal 33 (TB1) and the setting of the JOG reference potentiometer. A voltage of +10VDC or -10VDC (available at Terminal 20 or Terminal 22 on TB1) is usually applied to Terminal 33 (TB1). If a negative voltage is applied to Terminal 33 (TB1), the drive will jog in the forward direction. If a positive voltage is applied to Terminal 33(TB1), the drive will jog in the reverse direction. The jog reference circuit is scaled so that jog speed is adjustable from 0 to 30% of rated maximum speed when 10VDC is applied at Terminal 33(TB1). It should be noted that the jog reference input is a step input and does not go through the accel/decel circuit.

The velocity feedback signal may be an armature voltage feedback signal or it may be a signal from a motor mounted DC tachometer. JP11 is used to select the desired feedback.

If armature voltage feedback is used, JP 11 should be ARM. When connected for armature voltage feedback the MAX SPEED potentiometer provides an adjustment range of gated armature voltage (90VDC or 180VDC) ±30% (assuming a 10VDC reference voltage). Standard MELLTRONICS 2600RG controls are shipped from the factory programmed for armature voltage feedback.

If tachometer feedback is used, the motor mounted DC tachometer should be connected as shown between Terminals 34 and 35 (TB1). Tachometer feedback scaling is set by jumper JP11. The placement of the tachometer feedback scaling jumper depends on the output voltage of the DC tachometer at maximum motor speed. The following table gives the range of tachometer output voltages (at maximum motor speed) that can be accommodated in each feedback range.

JP11 SETTING	TACHOMETER VOLTAGE OUTPUT AT MAXIMUM SPEED
LOW	65VDC - 130VDC
MEDIUM	94VDC - 188VDC
HIGH	131VDC - 262VDC

When connected for tachometer feedback, the 'max speed' potentiometer scales the tachometer feedback signal so that the tach feedback signal exactly offsets a 10VDC reference signal when the motor reaches the desired maximum RPM.

The velocity control loop includes two potentiometer adjustments which affect the dynamic response of the drive. These two adjustments are the velocity stability potentiometer (labeled 'STAB') and the speed rate potentiometer. Together, these two potentiometers can be used to match the dynamic characteristics of the velocity control loop to the dynamic characteristics of the DC motor and the load it is driving.

The velocity error amplifier includes an adjustable lead circuit to compensate for the electrical and mechanical lags that exist in both the DC motor and the driven mechanical system. The STAB potentiometer adjusts the time constant of this lead circuit. Since this lead circuit is located in the drive velocity feedback network, it tends to reduce the responsiveness of the drive to step function increases in velocity by increasing the magnitude of the velocity feedback signal as a function of its rate of change.

The speed rate potentiometer controls the relative magnitude of this lead component in the velocity feedback signal.

The setting of the IR COMP potentiometer determines the magnitude of the IR compensation signal. The IR compensation signal is a signal directly proportional to DC motor armature current which is added to the drive input reference. The output of the velocity error amplifier is clamped to zero by a solid state switch when the DC loop contactor is open. This switch, L4, is controlled by a relay located on the main control board. A velocity amplifier bias potentiometer is provided to zero the output of the velocity error amplifier with zero reference and zero feedback. This potentiometer is factory set and should not require adjustment.

It is desirable to control motor current (torque) rather than motor velocity in many applications. In these applications, the velocity error amplifier must be bypassed and the input reference signal must be applied directly to the current error amplifier. Terminals 29 and 30 on the TB1 provide access to the velocity error amplifier. By jumpering these two terminals together, the gain of the velocity error amplifier is reduced to a value of one and the velocity error amplifier ceases to function as an error amplifier. With a jumper between Terminals 29 and 30 the velocity reference signal can still be introduced at either Terminal 32 (TB1) or Terminal 21 (TB1). Any reference signal introduced at Terminal 21 will have its rate of rise or fall controlled by the reference ramp circuit described earlier.

3.3.5 ARMATURE CURRENT ERROR AMPLIFIER AND PHASE ANGLE REFERENCE CIRCUITRY

See Figure 18.

The armature current error amplifier is a high gain operational amplifier that algebraically sums a current reference signal with a current feedback signal and amplifies the result. The output of L8-B Pin 7 is a current error signal and this signal is used by the rectilinearity amplifier and armature tracking amplifier to generate a phase angle reference signal for the SCR gating circuits.

The reference signal applied to the armature current error amplifier comes directly form the output of the velocity error amplifier. The feedback signal to the armature current error amplifier comes from the armature current scaling amplifier. The inputs to the armature current error amplifier have been scaled so that a 4VDC reference signal at the input to R76 will produce 100% rated armature current.

A tailfire signal is also applied to the input of the armature current error amplifier. The tailfire input prevents the non-conducting power bridge from being gated on until the armature current has stopped flowing in the conducting power bridge.

The dynamics of most SCR drives change drastically as the average motor current increases. The rectilinearity amplifier is added to compensate for this problem and improve the dynamic performance of the drive.

The armature tracking amplifier sums the current phase reference (the output of the rectilinearity amplifier) with the armature voltage phase reference. The armature voltage phase reference causes the gating circuits to generate gate pulses at a phase angle where the armature voltage (CEMF) just crosses the AC power line. The addition of the current phase reference advances the firing (or gating) angle to provide the motor current level demanded by the current error/rectilinearity amplifier circuits. The armature voltage phase reference also phases back the reverse power bridge to the point where the gating pulses just produce zero regenerative current with a zero current reference.

The current limit in the MELLTRONICS 2600RG consists of a group of operational amplifiers that tactically limit the maximum output of the velocity error amplifier. The current limit level is normally set by adjusting the CURRENT LIMIT potentiometer located on the upper PC board. The current limit potentiometer provides an adjustment range of 0 to 150% of rated armature current. Current limit can also be controlled by an external voltage signal applied to Terminal 26 (TB1). The current limit circuit is scaled such that a 0 to +10VDC external signal will limit the armature current total value between 0 and 150% of rated current (assuming the current limit potentiometer is set fully counter clockwise).

In some applications, true four quadrant operation is not desirable. A circuit has been included in the MELLTRONICS 2600RG to prevent either forward motoring operation or reverse motoring operation in these applications. This quadrant lockout function is selectable by jumper programming JP1. An operational amplifier monitors both the DC motor armature voltage and the output of the velocity error amplifier. If jumper JP1 is connected to the ‘FWD’ jumper post, the output of the operational amplifier will clamp the output of the velocity error amplifier to zero when a reverse motoring condition is called for. If jumper JP3 is connected to the ‘B’ jumper post, the output of the operational amplifier will clamp the output of the velocity error amplifier to zero whenever a reverse motoring condition is called for. If jumper JP3 is connected to the ‘C’ jumper post, the motor can rotate in the locked out direction but its speed is limited to no more than 10% of rated motor speed. If jumper JP1 is connected to jumper post ‘A’, both forward and reverse motoring are enabled and jumper JP3 has no effect on operation.

The current error amplifier includes an adjustable lead circuit to compensate for the electrical and mechanical lags that exist in the DC motor and the driven mechanical system. The current loop stability potentiometer (labeled CURRENT STAB) adjusts the time constant of their lead circuit. This potentiometer is factory set and should not require adjustment. The output of the current error amplifier is clamped to zero by a solid state switch (L4) when the DC loop contactor is open. This switch is controlled by an auxiliary contact located on the DC loop contactor.

3.4 POWER COMPONENT IDENTIFICATION

See Figure 17.

All power connections are located on the extruded aluminum heat sink which also serves as the mounting plate on the MELLTRONICS 2600RG control. All major power components are located on the extruded aluminum heat sink below the interconnect PC board on the MELLTRONICS 2600RG control.

3.5 CONTROL BOARD COMPONENT IDENTIFICATION

All MELLTRONICS 2600RG controls utilize two printed circuit boards. All normal functions and all SCR firing circuits are contained on these two boards. The lower printed circuit board on the MELLTRONICS 2600RG is secured to the chassis assembly by four metal standoffs. The upper printed circuit board is attached to the chassis assembly using hinged standoffs and quick lock connectors. The upper printed circuit board swings open to reveal the lower printed circuit board and most of the major power components.

Shown in Figure 23 is the lower printed circuit board. This PC board contains all of the SCR gating circuits, the control power supply, the DC motor field supply and parts of the armature voltage and armature current scaling and buffering circuits. The location of all the important jumpers, fuses, terminal blocks and indicators located on the lower PC board is shown on Figure 28.

The upper printed circuit board is shown in Figure 22. The upper circuit board contains all of the drive regulator circuitry and all of the drive logic circuitry. It also includes all customer adjustment potentiometers and all fault indicators. All customer connections — except for power connections— are made to terminals located on the upper printed circuit board. Figure 26 shows the location of all the important fault indicators, jumpers, potentiometer adjustments and other devices.

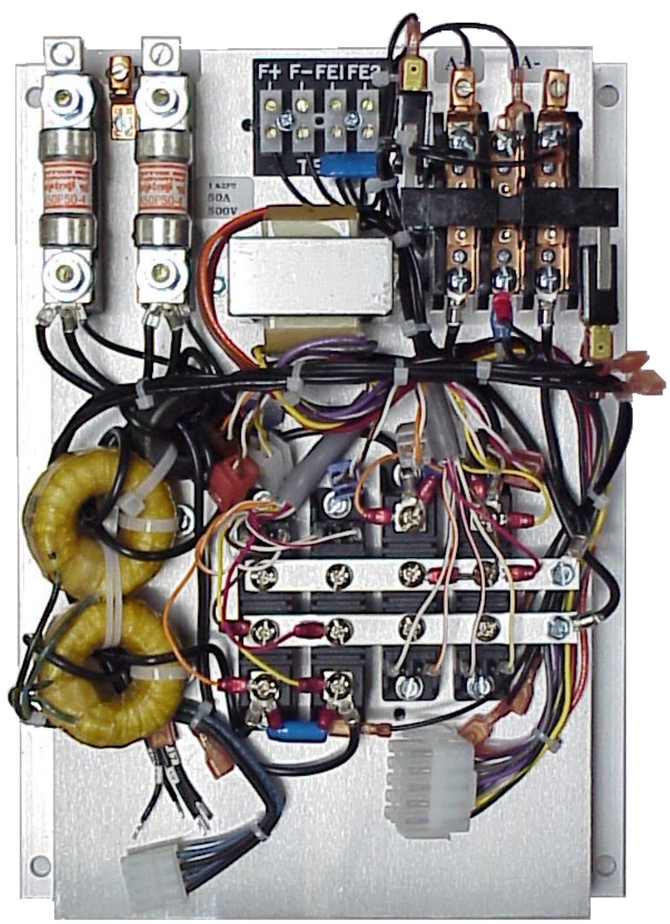


Figure 17: Power Components

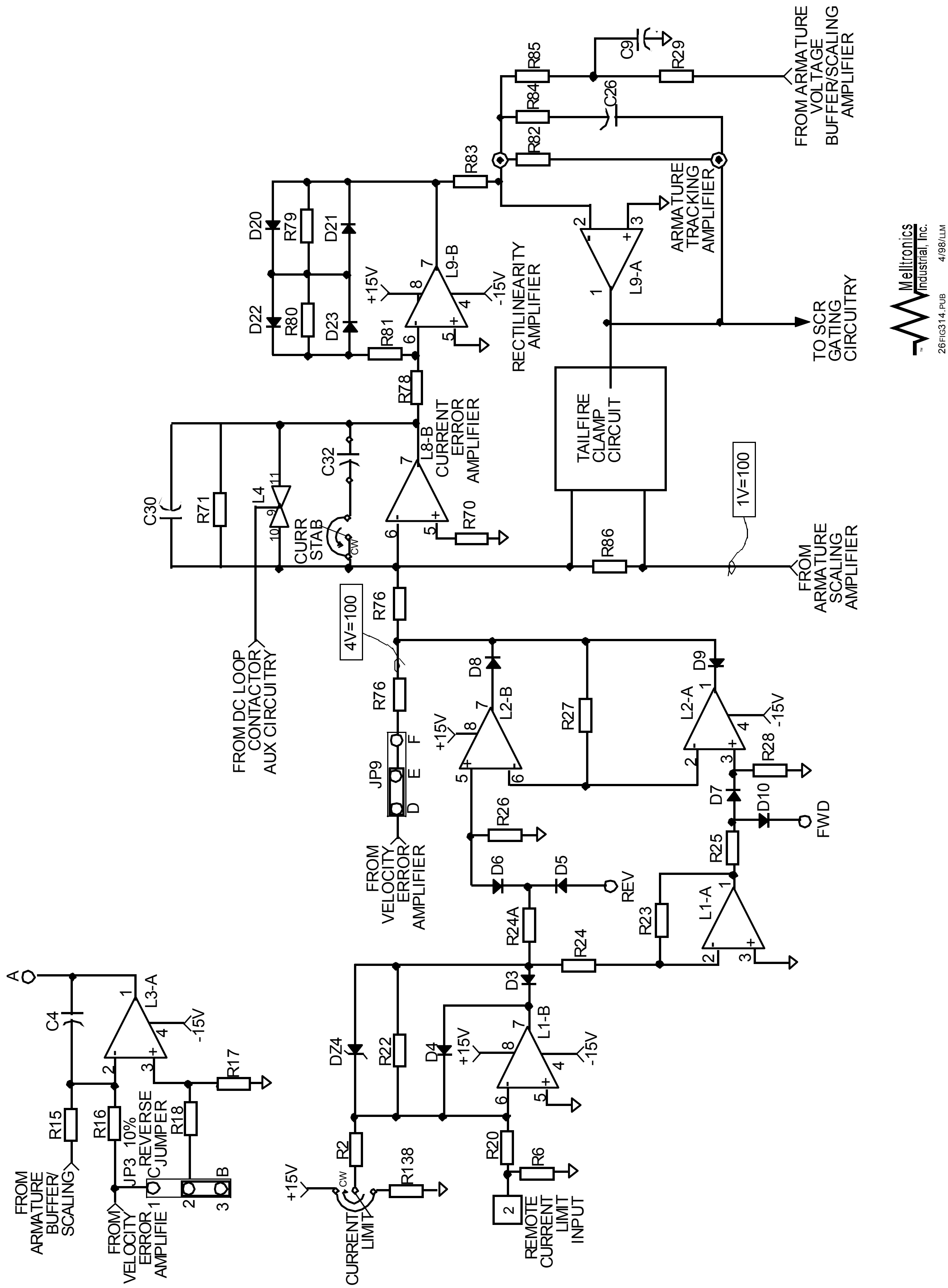


Figure 18: Armature Current Error Amplifier and Phase Angle Reference Circuitry

3.6 DC MOTOR FIELD SUPPLY

The MELLTRONICS 2600RG field supply is shown in Figure 19. It is an unregulated, fixed voltage, DC power supply that full wave rectifies the incoming AC power line. A 200VDC output is produced when connected to a 240VAC power line, a 100VDC output when connected to a 120VAC power line and a 240VDC output when connected to a 280VAC power line (10HP model only). The field supply is comprised of four diodes connected in a full wave bridge configuration plus one additional diode that provides a means of half waving the field supply for field economy purposes. Contact 'M' (AUX) is an auxiliary contact on the DC motor loop contactor. When it opens, the DC motor field supply voltage is automatically reduced by 50%. Two more diodes and an optical isolator are used to detect the presence of DC motor field current.

3.7 TORQUE REGULATION THEORY

The MELLTRONICS 2600RG can be configured as an armature current regulator. Since motor torque is directly proportional to armature current, a DC drive set up as an armature current regulator will enable the unit to regulate torque. Torque regulators are sometimes used in helper drive situations and in various load sharing applications. To properly apply a torque regulator it is important that one understands the theory of operation and the variables that affect the control system.

The torque produced by a motor can be described as shown:

Equation 1

$T = K_a Ø_p I_a$ Torque
K_a = Armature Torque Constant
$Ø_p$ = Field Excitation Flux
I_a = Armature Current

It can be seen in Equation 1 that torque is based on field excitation flux and armature current. It is obvious that if the DC drive were configured to regulate armature current that torque is also regulated, assuming that the field flux is constant. Therefore, it would be best to regulate the field excitation current to maintain a constant field flux.

The rotational speed of a DC motor can be approximated by the following equation:

Equation 2

$$W_m = \frac{Vt}{K_a Ø_p}$$

W_m = Motor Speed
K_a = Armature Torque Constant
$Ø_p$ = Field Excitation Flux
I_a = Armature Current

Pure current regulated drives demand that the motor shaft is loaded to some degree, at all times. Should the current set point or reference be set to a high value and the shaft load diminish or be removed, a current regulated drive is compelled to increase voltage output to achieve the current requested. Equation 2 illustrates that if the applied voltage increases and the field flux remains constant, the speed is subject to increase.

The increase in speed can result in a safety concern since motor speeds can rise beyond their intended speed rating very quickly should shaft loading be suddenly removed.

Therefore, a system designer must be cognizant of the control system relationships and provide external safety mechanisms, such as an over-speed detector shutdown circuit, to prevent motor runaway conditions.

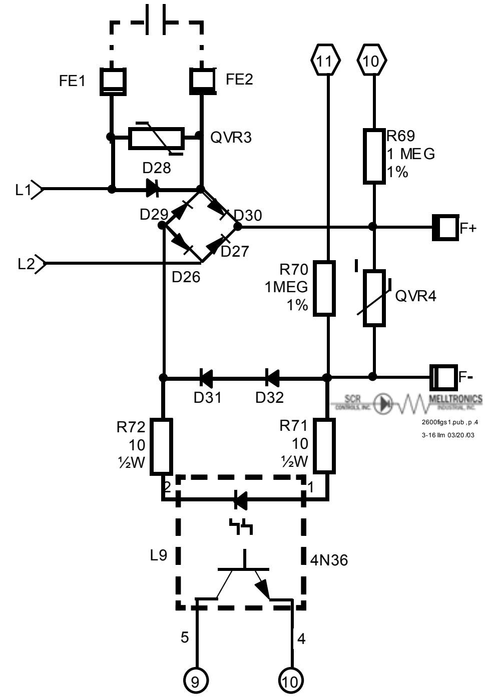


Figure 19: Field Supply

SECTION 4
INSTALLATION

4.1 SAFETY WARNINGS

4.1.1 GENERAL

Injury to personnel or equipment may be caused by improper installation or operation of this control. Read the operating instructions. The control and its associated motors and operator control devices must be installed and grounded in accordance with all local codes and the National Electrical Code. To reduce the potential for electric shock, disconnect all power sources before initiating any maintenance or repairs. Potentially lethal voltages exist within the control unit and connections. Use extreme caution during installation and start-up.

4.2 INITIAL CHECKS

Check the unit for physical damage sustained during shipment before installing the control. If damaged, file claim with shipper and return for repair following procedures outlined on the back cover. Remove all shipping restraints and padding. Check nameplate data for conformance with the AC power source and motor.

4.3 LOCATION

The MELLTRONICS 2600RG is suitable for most well-ventilated factory areas where industrial equipment is installed. Locations subject to steam vapors or excessive moisture, oil vapors, flammable or combustible vapors, chemical fumes, corrosive gases or liquids, excessive dirt, dust or lint should be avoided unless an appropriate enclosure has been supplied or a clean air supply is provided to the enclosure. The location should be dry and the ambient temperature should not exceed 40°C (104°F). If the mounting location is subject to vibration, the unit should be shock mounted.

If the enclosure is force ventilated, avoid, wherever possible, an environment having a high foreign matter content as this requires frequent filter changes or the installation of micron-filters. Should a control enclosure require cleaning on the inside, a low pressure vacuum cleaner is recommended. Do not use an air hose because of the possibility of oil vapor in the compressed air and the high air pressure.

4.4 INSTALLING CHASSIS MOUNT CONTROLS

The chassis mount MELLTRONICS 2600RG control is suitable for mounting in a user's enclosure where internal temperature will not exceed 55°C (131°F). The following procedure is recommended. Mount the control so that there is access to the front panel. See Figure 31 for dimensions.

4.5 INSTALLING ENCLOSED CONTROL

Enclosed MELLTRONICS 2600RG controls are suitable for wall mounting in an ambient atmosphere between 0°C(32°F) and 40°C (104°F). Mount the control so that there is access to the front panel. See Figure 31 for dimensions.

CAUTION

NEVER OPERATE THE CONTROL ON ITS BACK.

CAUTION

THE TOP, BOTTOM AND TWO SIDE SURFACES OF THE CONTROL CHASSIS MUST BE A MINIMUM OF NINE INCHES FROM ANY OTHER SOLID SURFACE WHEN INSTALLED. FAILURE TO OBSERVE THIS PRECAUTION COULD CAUSE THE CONTROLLER TO OVERHEAT.

4.6 POWER WIRING

The MELLTRONICS 2600RG will operate from the AC power lines. The line should be monitored with an oscilloscope to insure that transients so not exceed limitations as listed:

Repetitive line spikes of less than 10 microseconds must not exceed the following magnitude:

120V drives	200V peak
240V drives	400V peak

Non-repetitive transients must not exceed 25 watt seconds of energy. Transients of excessive magnitude or time duration can damage DV/DT networks or surge suppressors.

Line notches must not exceed 300 microseconds in duration.

An abnormal line condition can reflect itself as an intermittent power unit fault. High amplitude spikes or excessive notch conditions in the applied power could result in a power unit failure.

Refer to Figure 20 for power wiring connections. The 2600RG is insensitive to AC line phase sequencing. Designation of inputs L1 and L2 is arbitrary.

CAUTION

A SEPARATE FUSED DISCONNECT OR CIRCUIT BREAKER MUST BE INSTALLED IN THE INCOMING AC POWER LINE TO THE CONTROL, AS PER THE NATIONAL ELECTRIC CODE (NEC).

Use the AC line current specified on the nameplate of the control being installed to size the AC input wiring.

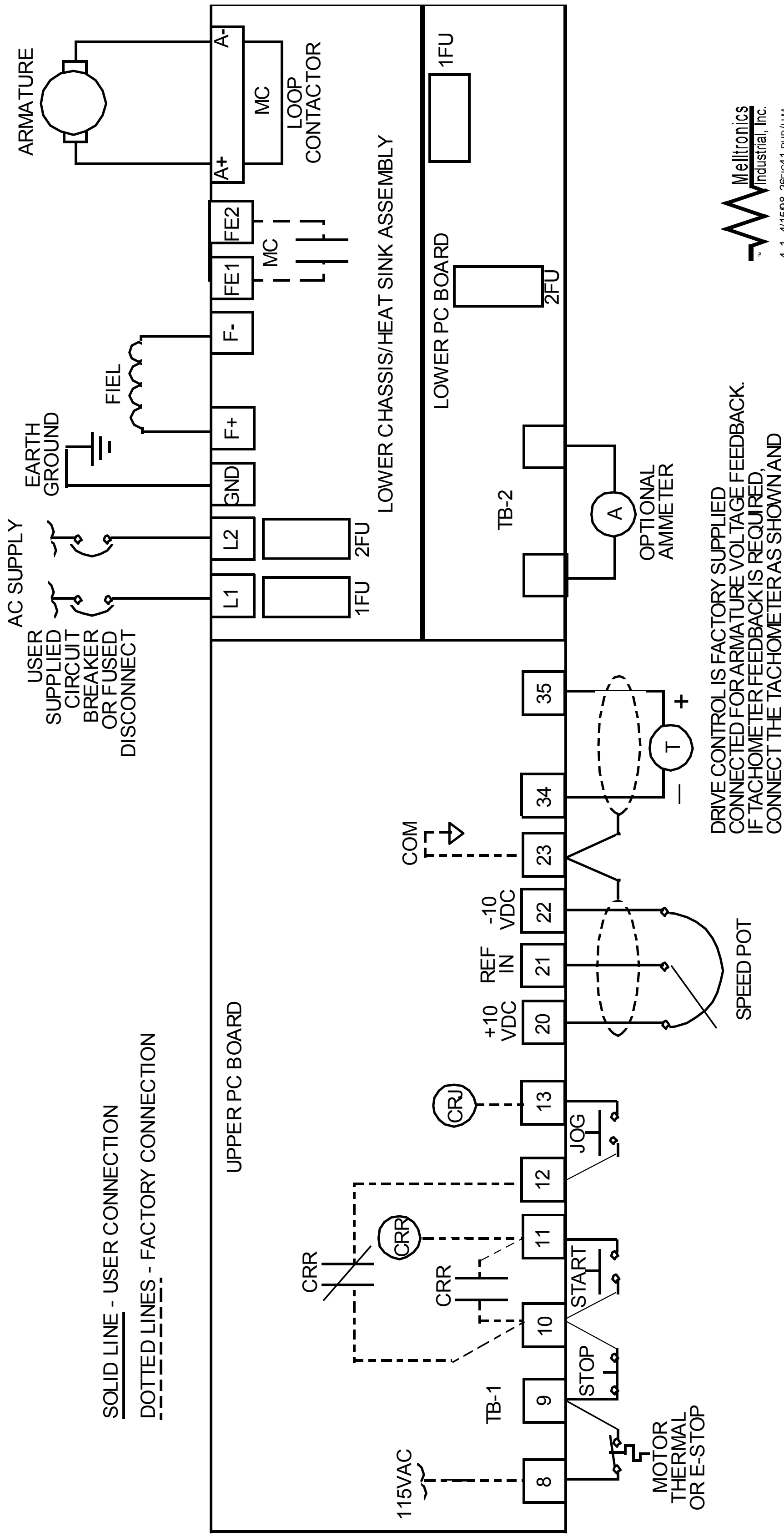


Figure 20: User Connection Diagram

Size the motor leads according to the motor nameplate current ratings following NEC requirements.

Connect the armature leads to the terminal lugs marked A+ and A- on contactor MC located above the upper right corner of the control chassis. Consult the motor connection diagram supplied with the motor for proper polarity. Connections to the motor field should be made with due consideration to proper polarity. Consult the motor connection diagram. The MELLTRONICS 2600RG field supply provides 100VDC when the control is wired to a 120VAC line, and 200VDC when wired to a 240VAC line. The field supply provides 50VDC or 100VDC, respectively, when the field economy feature is wired in, AC power is applied to the control and the loop contactor is open.

NOTE: THE MELLTRONICS 2600RG IS SHIPPED WITH THE FIELD ECONOMY FEATURE WIRED FOR OPERATION. THIS FEATURE SHOULD NOT BE BYPASSED. IT REDUCES THE VOLTAGE TO THE MOTOR FIELD WHEN THE CONTROL IS STOPPED BUT NOT REMOVED FROM THE AC INPUT LINE.

All power connections (ie., armature, line voltage) are made to lower PC board through faston connections. In cases where polarity of phasing of a signal is critical, two different size fastons are used to insure proper polarity.

Jumper JP2 (on the firing circuit board) is the frequency programming jumper. Verify that they are correct for your application. The MELLTRONICS 2600RG control is shipped programmed for:

60Hz
240VAC
High armature voltage feedback

NOTE: A FUNCTIONAL DESCRIPTION OF ALL JUMPERS IS CONTAINED IN SECTION 5, OPERATION AND START-UP PROCEDURE. CHECK THAT ALL PROGRAM JUMPERS ARE CORRECT FOR YOUR APPLICATION.

CAUTION

NO POINTS IN THE CONTROL CIRCUITRY, INCLUDING COMMON, SHOULD BE CONNECTED TO EARTH GROUND UNLESS SPECIFICALLY SHOWN ON MELLTRONICS SYSTEM DIAGRAMS.

CONNECT EARTH GROUND TO THE GROUND LUG BESIDE 1FU AND 2FU ON THE HEAT SINK CHASSIS ASSEMBLY.

When ready to apply power to the MELLTRONICS 2600RG, connect the 120VAC or 240VAC supply lines to Terminals L1and L2 on fuse blocks 1FU and 2FU on the chassis assembly.

WARNING

NEVER ATTEMPT TO CONVERT A DRIVE UNIT TO ANY INPUT VOLTAGE OTHER THAN ITS LABEL RATING. THIS CAN CAUSE EQUIPMENT DAMAGE AND POSSIBLE PERSONAL INJURY.

4.7 CONTROL LOGIC WIRING

Terminal strip TB1 Contains two sections of terminal block. Terminals 1 through 24 are located along the left edge of the main control board. Terminals 1 through 19 are used for control logic. A detailed description of control logic functions is contained in SECTION 5, OPERATION AND START-UP PROCEDURE. The wiring of the upper PC board is shown in Figure 34 and Figure 33.

4.8 SIGNAL WIRING

Terminals 20 through 41 on TB1 are used for connecting drive reference and feedback signals to the MELLTRONICS 2600RG. Terminals 25 through 41 are located along the bottom edge of the upper control board. See Table 7 and Figure 20 and Figure 34 for terminal strip connections. Terminals 20 though 30 and 41 are discussed in SECTION 5.

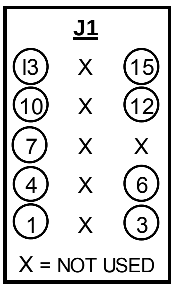
NOTE: IT IS RECOMMENDED THAT SHIELDED WIRE BE USED FOR REFERENCE, TACHOMETER, OPTIONAL AMMETER AND OTHER SIGNAL WIRE CONNECTIONS. BELDEN #83394 (2 CONDUCTOR) AND BELDEN #83395 (3 CONDUCTOR) SHIELDED WIRE (OR EQUIVALENT) IS RECOMMENDED. THE SHIELDS SHOULD BE TAPED OFF AT THE REMOTE END. AT THE DRIVE CONTROL THE SHIELDS SHOULD BE CONNECTED TO CIRCUIT COMMON, TB1 TERMINAL 23. ADDITIONAL CONSIDERATION IS RECOMMENDED TO ROUTE THIS WIRING AWAY FORM HIGH CURRENT LINES.

4.9 CIRCUIT BOARD INTERCONNECTIONS

Most of the connections between the various circuit boards are made with wire-harness and mating connectors. The half of the mating connector attached to the end of the wire-harness is denoted as a plug (with a P) and the other half, which is board-mounted, is denoted as a jack (with a J). The other end of the wire-harness is usually soldered into the control board. This prevents the harness from being mislaid during assembly of the control.

There are five (5) multi-pin connectors used in the control to supply power and transmit control signals for the upper and lower PC boards.

J1 is a 15 pin connector which attaches to the upper right side of the lower PC board. Power is supplied to the board from the AC inputs L1 and L2 and in turn feeds the primary of the control transformer. It also supplies AC power form the control transformer secondary to the DC power supplies and the 120VAC control logic. See Figure 21 for pin assignments. The wiring of the lower PC board is shown in Figure 36.



Pin#		Input to Control Transformer from:
3		AC Line L1
6	JB	Input Voltage
12	JA	Program Jumpers (to center tap)
15		Fused AC Line L2

Pin#	From Output of Control Transformer to:
1	120VAC control power
4	Fused 120VAC control power
7	Rectifier for DC
13	power supplies
10	common

Figure 21: Connector J1 Pin Assignments

CAUTION

TO AVOID WRONG CONECTIONS AND DAMAGE TO THE CONTROL, CARE MUST BE TAKEN TO ALIGN THE PINS AND JACKS ON THE FOLLOWING CONNECTORS.

J2 is an 11 pin connector which supplies AC and DC power and field voltage to the upper PC board. It is located on the back of the upper PC board in the top right corner. See Figure 34.

J3 is a 11 pin connector located on the back of the upper PC board in the bottom right corner. It provides feedback and control signals from the the lower PC board. See Figure 35.

J4 is a 15 pin connector located in the the center of the top edge of the upper PC board. It provides a quick means of connecting the optional test meter kit to the MELLTRONICS 2600RG (see Figure 34)

J5 is a 4 pin connector located on the the bottom left corner of the lower PC board. It supplies the current feedback signals from the current transformers to the lower PC board. These signals are then rectified and passed to the upper PC board through J3. J5 Pins 1 and 2 provide reverse current feedback from CT2 and Pins 3 and 4 provide forward current feedback from CT1. See Figure 32.

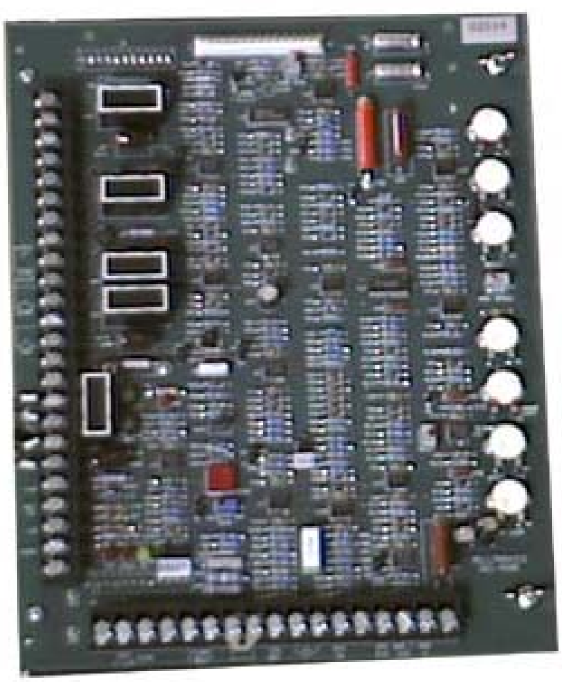


Figure 22: Upper PC Board

Figure 23: Lower PC Board

4.10 INSTALLING MODIFICATIONS

4.10.1 TEST METER

There are two test meter kits available for use in starting up and troubleshooting the MELLTRONICS 2600RG control.

One meter screws down on the the upper PC board of the control while the other is part of a dead front cover that snaps over the control chassis. Both units are easily connected by installing the connector wired to the test meter PC board into connector J4 on the upper PC board of the MELLTRONICS 2600RG control.

The test meter can be used to monitor the following signals:

- Armature Voltage
- Armature Current (%) Reference
- Control Voltage Reference
- Current Limit (%)
- Field Voltage
- Line Voltage
- Negative 15VDC
- Positive 15VDC
- Trigger Signal

The test meter schematic diagram is shown in Figure 37.

4.10.2 AMMETER

The MELLTRONICS 2600RG has the circuitry to drive an external ammeter without addition of an armature shunt. This external meter can be calibrated in either percent load or in amperes. From the factory, the MELLTRONICS 2600RG control has a minimum 100% current output rating of 6 amps. For applications below 1HP at 240VAC (1/2HP at 120VAC input) the built in DC overload protection will be scaled for too much output current and will not function. To provide overload protection and properly calibrate the ammeter kit, a scaling resistor change is required. The appropriate resistor values and current range jumper settings are given in Table 6.

Terminal strip TB-2, located at the bottom of the lower PC board (Figure 20) is for connecting the optional external ammeter. This meter should be a zero center type with a 100μA-0-100μA movement, 640 Ω coil resistance and read 150% current full scale. A 200% full scale ammeter can be used when jumper JP-1 is removed from the lower PC board. A complete line of ammeters for the MELLTRONICS 2600RG controls are available from Melltronics Industrial. Consult the factory for assistance in ordering a meter.

4.10.3 REMOTE CURRENT LIMIT

A potentiometer to modify the current limit setting of the MELLTRONICS 2600RG control from a remote location may be installed. The voltage signal from the wiper of the potentiometer is wired to TB1, Terminal 26. A +12V signal at that terminal yields 150% current limit. The +10VDC power supply, TB1 Terminal 20 and TB1 Terminal 23 (common) may be used to supply voltage for the remote current limit potentiometer. The equivalent resistance of the remote current limit potentiometer, in parallel with the speed reference potentiometer, should not go below 5K ohms as this would excessively load the ±10VDC power supply.

NOTE: THE REMOTE CURRENT LIMIT POTENTIOMETER VOLTAGE SIGNAL IS SUMMED WITH THE SIGNAL FROM THE CURRENT LIMIT POTENTIOMETER MOUNTED ON THE UPPER PC BOARD. IF REMOTE CURRENT LIMIT IS USED THE CURRENT LIMIT POTENTIOMETER ON THE UPPER BOARD SHOULD BE ADJUSTED TO PROVIDE 0VDC

4.11 CONTACT SUPPRESSION

All relays or electrical solenoids with wiring in close proximity to the MELLTRONICS 2600RG control wiring should be properly suppressed. This reduces the possibility of electrical noise interference. Note, however, that it is generally not necessary to suppress non-inductive loads such as resistive heater elements.

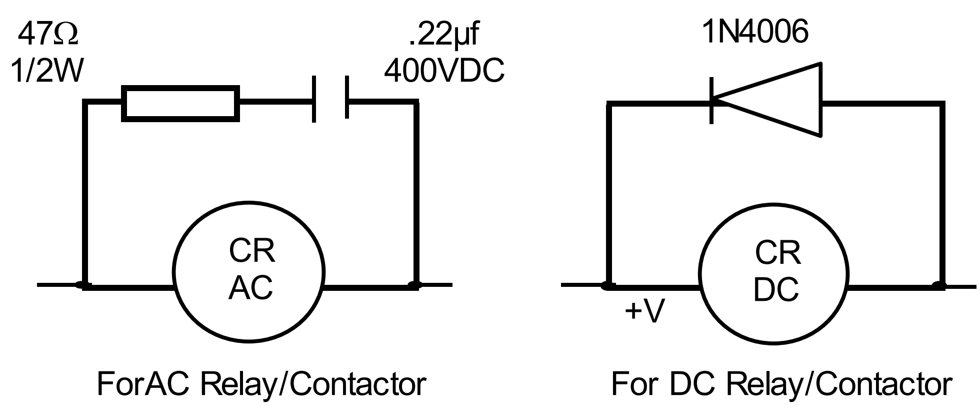


Figure 24: Suppression Techniques

SECTION 5
OPERATION AND START-UP PROCEDURE

5.1 INTRODUCTION

This section describes the operator controls and their functions, and initial start-up procedure and applications adjustments of potentiometers and jumpers for the MELLTRONICS 2600RG control.

It is recommended that you read this section thoroughly to develop an understanding of the operation and logic incorporated in the MELLTRONICS 2600RG control.

5.2 OPERATOR CONTROLS

Refer to Figure 32, Figure 33 and Figure 34 for operator control locations.

5.2.1 CONTROL VOLTAGE

Terminals TB1, 1 and 2 provide 115VAC control power for customer use. A total of 5VA of power is available for user supplied devices.

5.2.2 FAULT TRIP RELAY (CRFT)

This relay is energized when AC power is applied to the MELLTRONICS 2600RG control. When energized, CRFT enables the operator control devices by closing the contact that provides control voltage to these devices at TB1 terminal 8.

There are three causes for a fault trip which drops out CRFT:

5.2.2.1 Field Loss (FL)

The field loss circuit monitors the presence of field current. If field current is absent after the start push-button is depressed, the FL LED lights and the CRFT drops out. The field loss LED may flash when AC power is first applied and the DC power supplies are coming up to their proper voltages. No fault trip will occur until the start push-button is depressed.

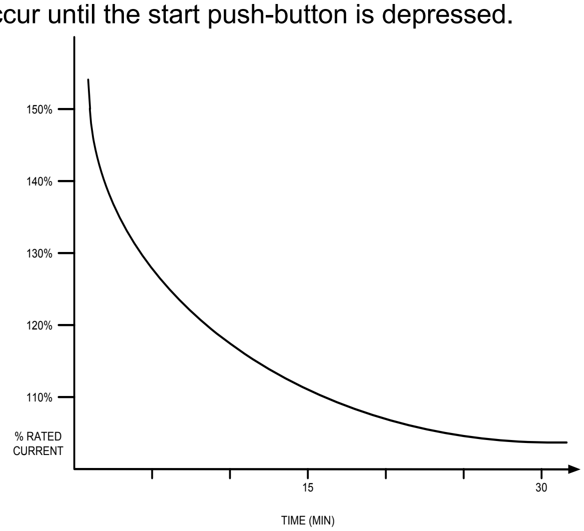


Figure 25: Inverse Time Trip Overload Characteristics

5.2.2.2 Instantaneous Over-current (IOC)

A fault trip occurs dropping out CRFT and lighting the IOC LED when an armature current 300% of the rated current is detected.

5.2.2.3 Inverse Time DC Overload (DCOL)

The DC overload circuit drops out CRFT and lights the yellow DCOL LED when the drive has run at 150% current limit for approximately one minute. Less severe over-loading will take longer to trip out. See Figure 25.

5.2.3 MOTOR THERMAL SWITCH/E-STOP

Motors with built-in fans may overheat when they are run for extended periods at low speed. A thermal sensing switch inside the motor will open before overheating occurs. When wired to Terminals TB1 8 and 9, the open switch will stop the drive control to protect the motor. A user supplied, normally closed switch may be wired in series with the thermal switch or in place of it to provide an E-stop function. If neither the thermal switch nor the E-stop is used, TB1-8 and 9 must be jumpered. The shut-down sequence is the same as the stop function sequence.

5.2.4 STOP

When pressed, the STOP button switch interrupts the path that supplies the current to keep the run relay (CRR) energized. This opens the by-pass that locks in the relay (CRR), closes the contacts that permit the jog button to function, removes the supply voltage that keeps the motor contactor energized, opens the reference circuit from the speed potentiometer and clamps the accel/decel, velocity error and current error amplifiers.

5.2.5 START

When permitted by the fault trip relay (CRFT), this switch momentarily closes the circuit that energizes relay CRR. As CRR is energized, contacts close that lock this relay on, providing a path to energize the motor contactor, connect the reference voltage from the speed pot to the accel/decel circuit, and disables the jog switch form energizing the jog relay (CRJ). A set of normally open contacts of CRR is available between Terminals TB1 6 and 7. The run LED lights when CRR is energized.

5.2.6 JOG

When permitted by the run relay (CRR) and fault trip relay (CRFT), the jog switch completes the circuit to energize the jog relay (CRJ). The jog relay then provides a path to energize the motor contactor and connect the jog reference signal to the jog circuitry.

CRJ does not lock in so that when the jog push-button is released, the motor contactor drops out and the control is in a stop condition. The jog LED lights when CRJ is energized. A latch-in jog function can be achieved by jumpering Terminals 14 to 15 at TB1.
A normally open (NO) contact, MB, is available to the user at Terminals TB1-18 and 19. This contact closes when either CRR or CRJ is energized.

5.2.7 MOTOR CONTACTOR

The motor contactor is factory wired to Terminals TB1-16 and 17. When energized the contactor closes the DC loop that energizes the motor armature, and the N.O. 'A' auxiliary contacts disable the field economy circuit so that the motor receives full field voltage.
The N.O. 'B' auxiliary contacts are accessible to the user at Terminals TB1-18 and 19.

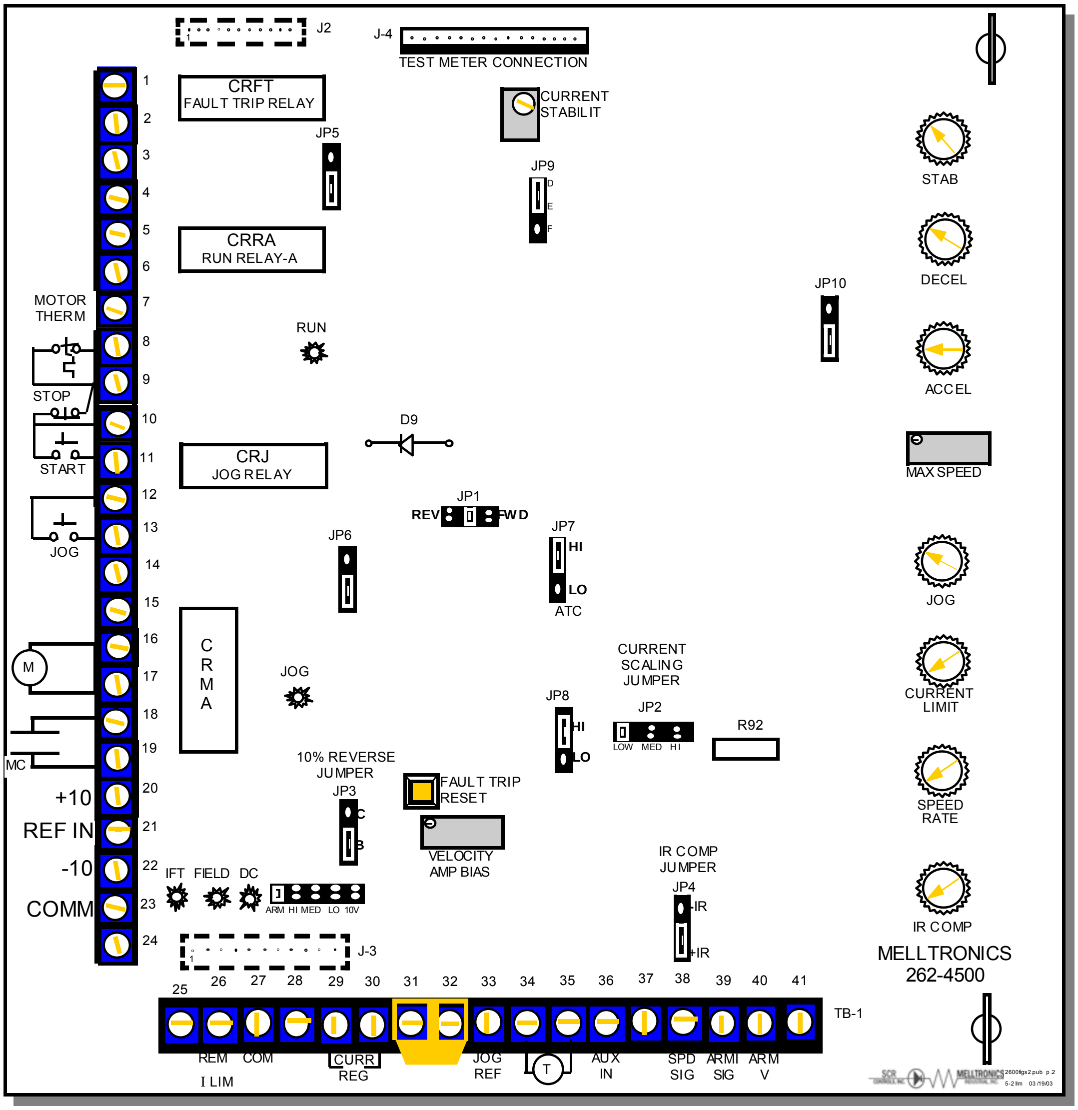


Figure 26: Upper Control Board Operating Features

5.2.8 SPEED REFERENCE POTENTIOMETER

These potentiometers are connected to the TB1 Terminal 21 as follows: A negative voltage reference signal corresponds to positive armature voltage while a positive voltage reference produces negative armature voltage. Both a positive and negative 10VDC are available for the speed reference at Terminals TB1-20 and 22 respectively.

A bi-directional speed potentiometer may be used with the zero speed position occurring when the wiper is centered. This is the configuration shown in Figure 20. If only one direction of rotation is desired the potentiometer may be connected to supply only the required polarity of reference voltage, or the direction may be selected using jumper JP1 which will be explained later in this section.

5.2.9 MISCELLANEOUS USER CONNECTIONS

Terminal TB1-23 is control common.
Terminal TB1-24 and 25 are not for customer use.
TB1-26 is the connection for the remote current limit signal.
Field loss detection is disabled when terminals TB1-27 and 28 are jumpered together. This is generally not recommended as severe motor and machine damage may result if over-speed occurs due to field loss.
Operation as a current regulated drive using Terminals TB1-29, 30 and 32.
Terminal TB1-41 is an armature current signal for factory assembled custom applications and is not calibrated for customer use. A calibrated armature current signal is available at terminal strip TB2.

5.3 ADJUSTMENTS

There are nine (9) adjustment potentiometers located on the main control board. Refer to Figure 26.

NOTE: EXERCISE CAUTION WHEN MAKING ADJUSTMENTS. WITH THE CONTROL DRIVING A MOTOR, DO NOT EXCEED TEN (10) DEGREES OF POT ROTATION PER SECOND.

WARNING

DO NOT ALLOW THE ADJUSTING SCREW DRIVER TO TOUCH ANYTHING OTHER THAN THE POTENTIOMETER WHILE THE DRIVE IS OPERATIVE.

AN INSULATED SCREW DRIVER IS RECOMMENDED.

5.3.1 DECEL TIME

The decel time potentiometer adjusts the amount of time the drive takes to decelerate. This rate of change of speed (ramp) is linear (constant) throughout the speed range but may be limited by the current limit setting. Set to mid-position by the factory, CW adjustment of this potentiometer causes the drive to ramp down in speed more slowly.

NOTE: THE ROLES OF THE ACCEL AND DECEL POTENTIOMETERS ARE REVERSED WHEN REVERSE ROTATION (POSITIVE SPEED REFERENCE) IS APPLIED TO THE MOTOR.

5.3.2 ACCEL TIME

The accel time potentiometer adjusts the amount of time the drive takes to accelerate to the speed set by the speed reference potentiometer. This rate of change of speed (ramp) is linear (constant) throughout the speed range but may be limited by the current limit setting. Set to the mid-position by the factory, clockwise rotation of the accel time potentiometer increases the time required to accelerate to set speed.

5.3.3 MAX SPEED

When using armature voltage feedback, the max speed potentiometer scales the armature voltage feedback signal so that it exactly offsets a 10VDC reference signal when the motor reaches the desired maximum RPM. The speed reference potentiometer must be set for maximum (10VDC) reference voltage and the motor must be running at constant speed before adjusting the max speed potentiometer.
Determine the maximum motor speed required for your machine or processs; do not exceed the rated speed of the motor. Using a tachometer or strobe light to measure the motor or machine speed, adjust the max speed potentiometer until the desired maximum speed is obtained. CW rotation of this potentiometer increases the armature voltage and motor speed. The range of adjustment is 70 to 130% of rated armature voltage.
For applications using tachometer feedback, the max speed potentiometer scales the tachometer feedback signal to offset the 10VDC reference signal at the chosen maximum motor speed. Calculate the tachometer output voltage corresponding to the desired maximum motor speed and adjust the max speed potentiometer until this voltage is read at the output of the tachometer.

5.3.4 CURR STAB (CURRENT STABILITY)

This potentiometer performs the same function in the current error circuit as the VEL STAB potentiometer performs in the velocity error circuit, however, since the current loop responds to current changes much faster than the velocity loop does to speed changes, the CURR STAB adjustment is much more sensitive and harder to adjust properly. CW rotation increases response but the factory shipped setting of 4.5 turn from full counterclockwise is adequate for most applications.

5.3.5 SPEED RATE

A lead compensation network is used to supply some additional feedback to compensate for the lag when the drive experiences a step change in velocity and the velocity feedback signal lags behind this change. This also reduces the overshoot in the speed response of the drive. The amount of feedback compensation is proportional to the rate of change of the feedback signal and is adjusted using the speed rate potentiometer. CW (clockwise) rotation of this potentiometer causes a greater reduction in the rate of change of drive velocity and less overshoot. Normally used in tachometer feedback applications, the speed rate potentiometer is factory adjusted to its CCW (counterclockwise) position.

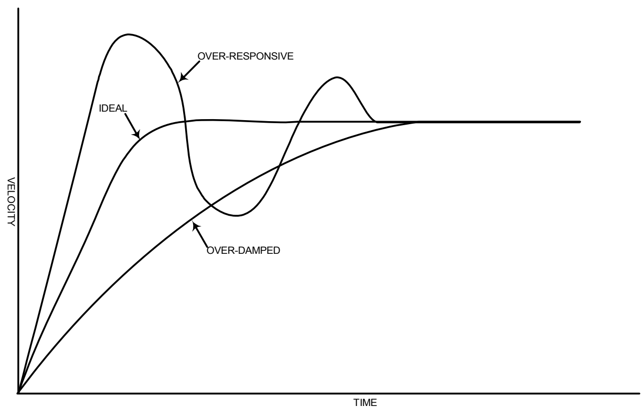


Figure 27: Stability Effects on the Velocity Profile

5.3.6 JOG

When a jog push-button is wired in and 10VDC (from TB1-20) is applied to the jog reference input, TB1-33, the jog potentiometer will adjust the speed at which the motor will run when in jog. Jog speed may be set from 0 to 30% of maximum speed. Set full CCW by the factory, CW rotation of the jog potentiometer increases the jog speed.

5.3.7 IR COMP

The IR compensation circuit increases the drive speed reference signal as armature current increases. The effect of the increase in current is an increased voltage drop due to the impedance of the motor and also distortion of the field flux. The result is a reduction in counter EMF produced by the motor and a reduction in speed (droop). CW rotation of the IR Comp potentiometer increases the amount of droop correction added to the speed reference signal.

5.3.8 ARMATURE CURRENT LIMIT

The armature current limit (I limit) potentiometer adjusts the maximum armature current that the controller will supply to the motor. The range of adjustment is 0 to 150% of the rated current selected with jumper JP2 (JP2 will be described later in this section). CW rotation of this potentiometer increases the allowed armature current.

5.3.9 VELOCITY STABILITY

This potentiometer adjusts the electrical lead of the compensating network in the velocity error circuit to correct for mechanical lags in the motor and driven system. CW rotation causes the drive to respond more quickly to speed reference or speed feedback changes but increases the overshoot experienced by the drive. CCW adjustment of this potentiometer dampens the drive response. The factory shipped setting is at the 11 o'clock position.

5.4 JUMPER PROGRAMMING

In addition to the potentiometers, the MELLTRONICS 2600RG can be programmed for specific applications. The functions of the jumpers and their positioning to achieve these functions follows. Jumpers are listed according to the board on which they are located.

WARNING

IF ANY JUMPER PROGRAMMING IS ATTEMPTED WHILE THE CONTROL IS OPERATIONAL, EQUIPMENT DAMAGE AND/OR PERSONAL INJURY MAY RESULT.

LOCK OUT POWER AT THE DISCONNECT BEFORE CHANGING ANY JUMPER POSITIONS.

5.4.1 UPPER PC BOARD

5.4.1.1 JP1 Quadrant Lockout Selection

Refer to Figure 26.

FWD motoring lockout
REV motoring lockout
Center position No lockout
Defult position--Center

The 2600RG is a four (4) quadrant control meaning that it can control the drive in either the forward or reverse direction as either a motor or a generator. The polarity of the armature voltage coincides with the direction of the drive rotation. Positive armature voltage is forward rotation and negative armature voltage is reverse rotation. Whether the drive is acting as a motor or generator is determined by comparing the polarity of the armature voltage with the armature current polarity. The polarity of the armature current coincides with the direction of torque production. Positive armature current is forward torque produced by the drive while negative armature current is reverse torque produced by the drive.

When the armature voltage polarity (direction of rotation) is the same as the armature current polarity (direction of torque produced) the drive is motoring. When the armature voltage polarity is the opposite of the armature current polarity the drive is regenerating. See Table 4.

Table 4: Four Quadrants of Operation

	$+I_A$ FORWARD TORQUE		
$-V_A$ REVERSE ROTATION	QUADRANT II REVERSE GENERATING	QUADRANT I FORWARD MOTORING	$+V_A$ FORWARD ROTATION
	QUADRANT III REVERSE MOTORING	QUADRANT IV FORWARD GENERATING	
	$-I_A$ FORWARD TORQUE		

Table 5: Four Quadrants of Operation Summarized

	FORWARD		REVERSE	
	Motoring1	Regenerating4	Motoring3	Regenerating2
Forward Torque	◆			◆
Reverse Torque		◆	◆	
Positive ArmatureVolts	◆	◆		
Negative ArmatureVolts			◆	◆
Positive Armature Current	◆			◆
Negative Armature Current		◆	◆	

In some applications it is desirable to keep the machine or process from operating in a given direction while still maintaining regenerative braking capabilities in the desired direction. This is called two quadrant operation.

The function of jumper JP1 is to select in which quadrants the motor will be allowed to operate.

- JP1 to REV: The reverse rotation quadrants 2 and 3 are locked out. Operation is in quadrants 1 and 4
- JP1 to BOTH (A): Four quadrant operation.
- JP1 to FWD: The forward rotation quadrants 1 and 4 are locked out. Operation is in quadrants 2 and 3. If the load causes the drive to back up or creep forward slightly at zero speed the drive will compensate in either direction to maintain zero speed. Some slight motion may be detectable due to the dead band of the velocity error amplifier.

See the description of jumper JP3, 10% Reverse Sector, as this jumper affects two quadrant operation.

5.4.1.2 JP2 HP Rated Current Selection

HP/Rated Current Selection
Low/Med/High
Same as original board (2600-4000)
Defalt position--Low
This jumper selects the value of armature current that the drive will see as 100% rated current. This sets the horsepower rating of the control by scaling the value of armature current at which current limit will occur. Table 6. gives the jumper settings along with the 100% current values and subsequent horsepower ratings.

Table 6: Armature Current Overload Scaling

CONTROL	Horsepower		Input Amps@ Full Load	DC Armature Amps @Full Load*	JP2 Current Range Jumper	100% Current	AMMETER SCALING		Scaling Resistor Value
	120VAC	240VAC					150%	200%	
262-8000	¼	½	4.2	3	LOW	3A*	—	6A*	133KΩ
	1/3	—	5.6	4	LOW	4A*	6A*	—	100KΩ
	—	¾	5.6	4	LOW	4A*	6A*	—	100KΩ
	1/2	1	8.5	6	LOW	6A	—	12A	—
	¾	1½	11	8	MED	8A	12A	—	—
	1	2	14	10	HIGH	10A	—	20A	—
262-8001	1½	3	21	15	LOW	15A	—	30A	—
	2	—	28	20	MED	20A	30A	40A	—
	—	5	35	25	HIGH	25A	—	50A	—
262-8075	——	—	—	—	—	—	—	—	—
		7½	42	30	MED	30A	—	60A	—
262-8175	10HP @ 277VAC		52.5	37.5	HIGH	37.5A	—	75	—

*This MELLTRONICS 2600RG Control is shipped with 100% current rating of 6 amps. For applications below 1HP at 240VAC input (1/2HP at 120 input) the built in DC overload protection will not be functional For applications where overload protection is required, or when the ammeter kit is used, a scaling resistor change is required. Resistor R92 on the upper PC board must be removed and a new resistor (see table) installed in its place. Use a precision 1% resistor.

**To use the 150% ammeter scale, jumper JP1 on the lower PC board needs to be in place.
For a 200% full scale ammeter scale, remove JP1.

5.4.1.3 JP3 10% Reverse Selector

C (pos 1-2) 10% enable
B (pos 2-3) 0% enable
Same as original board (2600-4000)
Defalt position--B

If JP1 has been set for two quadrant operation, the drive will operate in only one direction. It may also be desirable to permit the drive to back up slowly for threading or loading operations where two quadrant operation is required or to supply extra holding torque at zero speed in some applications The 10% reverse feature allows the drive to operate up to 10% of maximum speed in the locked out direction.

5.4.1.4 JP4 IR Comp Selection

+IR (pos 2-3)
-IR (pos 1-2)
Same as original board (2600-4000)
Defalt position--+IR

Jumper JP4 selects either positive (pos 2-3) or negative (pos 1-2) IR compensation to be adjusted by the IR Comp potentiometer. Positive IR compensation is an increase in the speed reference when increasing armature current and speed droop occur. Negative IR compensation is a subtraction from the speed reference signal when armature current increases. This causes a greater droop in speed to occur. Negative IR compensation is useful when the 2600RG control is used in a follower or helper type application to keep the follower drive from taking too much load on itself or over-running the lead drive. The IR Comp potentiometer increases the amount of droop in speed when it is turned CW and JP4 is set for negative IR compensation.

5.4.1.5 JP5 Run Relay Burden Select

Pos 1-2 - burden selected
Pos 2-3 - no burden
Default position —2-3

5.4.1.6 JP6 Jog Relay Burden Select

Same as JP5

5.4.1.7 JP7 ACT — Armature Tracking

Hi (pos 1-2), (Default position)
Low (pos 2-3)
Low position NOT used

5.4.1.8 JP8 Armature Voltage Selection

HI (pos 1-2) 180VDC Armature, (Default position)
LO (pos 2-3) 90 VDC Armature

5.4.1.9 JP9 Systems Jumper

D-E (pos 1-2), (Default position)
E-F (pos 2-3)

5.4.1.10 JP10 Accel/Decel Time Select

selects the range of adjustment for the accel and decel potentiometers:
F-H→0.2-4 second range
H-I→2-30 second range (Default position)
Jumper JP9 must be in the D-E position It is for factory use in customized system applications.

5.4.1.11 JP11 Arm/Tachometer Select

ARM V - arm volt feedback, (Default position)
HIGH (131-262VDC) tachometer
MED (94-180VDC) tachometer
LOW (65-130VDC) tachometer
10V (7.5-15VDC)tachometer

5.4.2 Lower PC Board

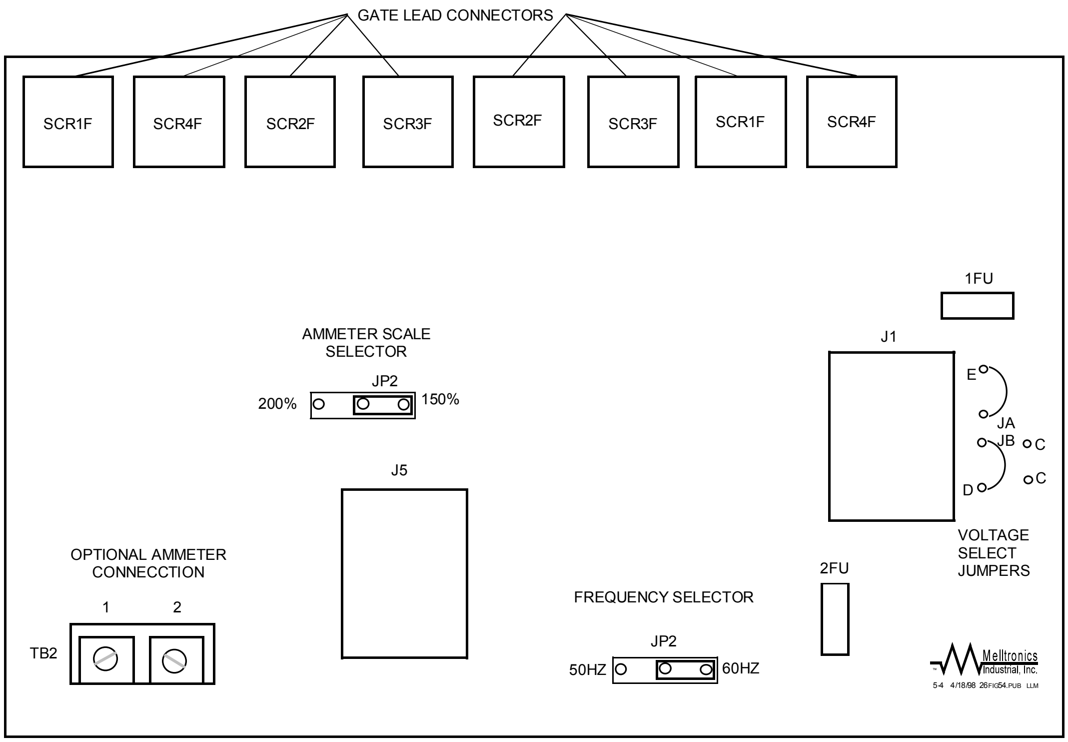


Figure 28: Lower PC Board

5.4.3 JA/JB Line Voltage Selectors

This pair of jumpers connects the incoming AC line to the control transformer and must be set to match the user supplied AC voltage.

- 120VAC input: JA to E - JB to D
- 240VAC Input: JA to C - JB to CX

5.4.1.12 JP1 Ammeter Scale Selector

The operational ammeter which is wired to TB-2 can be scaled to read 150% rated current full scale or 200% rated current full scale.

- JP1 In - 150% rated current full scale
- JP2 Removed - 200% rated current full scale

5.4.1.13 JP2 Frequency Selector

The 2600RG controller will operate on either 50Hz or 60Hz AC power.

- JP2 In - 60Hz AC power supply
- JP2 In - 50Hz AC power supply

CAUTION

THE FOLLOWING START-UP INSTRUCTIONS ARE INTENDED ONLY AS A GUIDE, AND SHOULD BE CLEARLY UNDERSTOOD BY THE RESPONSIBLE INSTALLATION PERSONNEL BEFORE PROCEEDING.

5.5 START UP PROCEDURE

5.5.1 POWER OFF CHECKS

- Check that the motor armature, motor field, AC input power and operator devices are connected in accordance with these instructions and existing system diagrams.
- On the upper PC board make the following jumper connections.
  JP4 to +IR   JP3 to B
  JP1 to A   JP2 according to Table 5-3.
- On the lower PC board set the jumpers:
  120VAC operation - JA to E and JB to D
  240VAC operation - JA to C and JB to C
  244VAC operation - JA to E and JB to D (10HP only)

- Set the potentiometers on the upper PC board:

Accel/Decel -	Fully CCW
Current Limit -	25% CW
Current Stability - position	4.5 Turns from Full CCW
IR Comp -	Fully CCW
Jog Speed -	Fully CCW
Maximum Speed -	Fully CCW
Speed Rate -	Fully CW
Velocity Stability -	40% CW

- Visually do a detailed inspection of the system, checking for:
  - Correct jumper programming
  - Incorrect power transformer connections
  - Loose electrical connections
  - Loose mechanical connections, especially the tachometer coupling
  - Mechanical binding
  - Metallic chips within the drive caused by drilling into the enclosure
  - Pinched wires at the control, motor or operator's station
- Measure the resistance between the following points using a Simpson 260 or equivalent disconnect test meter plug P4 from connector J4

TEST LEAD (+)	TEST LEAD (-)	METER READING
L1	L2	GREATER THAN 10 OHM
L1	CHASSIS	INFINITE
L2	CHASSIS	INFINITE
L1	A+	INFINITE
L1	A-	GREATER THAN 1 MEG
L2	A+	GREATER THAN 1 MEG
L2	A-	GREATER THAN 1 MEG
L1	SIGNAL COMM	GREATER THAN 1 MEG
L2	SIGNAL COMM	GREATER THAN 1 MEG
A+	SIGNAL COMM	GREATER THAN 1 MEG
A-	SIGNAL COMM	GREATER THAN 1 MEG
A+*	CHASSIS	GREATER THAN 1 MEG
A-*	CHASSIS	GREATER THAN 1 MEG
F+	CHASSIS	GREATER THAN 1 MEG
F-	CHASSIS	GREATER THAN 1 MEG
A+	CHASSIS	GREATER THAN 1 MEG
A-	CHASSIS	GREATER THAN 1 MEG
*Refer to motor side of contactor.		

NOTE: SIGNAL COMMON IS TB1 TERMINAL 23. A+ AND A- CONNECTIONS ARE ON THE DRIVE SIDE OF THE ARMATURE CONTACTOR.

5.5.2 POWER ON CHECKS

- Remove the eight (8) color-coded 2 pin connectors from the top edge of the lower PC board. These are the gate lead connections to the SCRs.
- Apply AC power.
- With a voltmeter, check the power supply voltages using the following table:

(+) Lead	(-) Lead	Reading
TB1-1	TB1-2	115VAC
TB1-20	TB1-23	+10VDC
TB1-22	TB1-23	-10VDC
J2-7	J2-9	+15VDC
J2-8	J2-9	-15VDC
J2-5	J2-9	+24VDC
J2-6	J2-9	-24VDC

NOTE: MAKE READINGS ON CONNECTOR J2 AT THE FRONT OF THE UPPER PC BOARD IN THE TOP LEFT CORNER. PIN #1 IS ON THE LEFT, PIN #11 IS ON THE RIGHT.

- If the optional test meter was reconnected after the power off, remove AC power and disconnect J4. Apply AC power and check the following voltages on J4:

(+) Lead	(-) Lead	Reading	Parameter
Pin 12	Pin 9	0 VDC	Armature volts
Pin 13	Pin 9	0 VDC	Armature amps
Pin 15	Pin 9	±0.1 VDC	Trigger signal

- Check the field voltage at Terminals F+ and F-. With the field economy feature operational the following approximate readings should be observed:

  120VDC for a 277VAC input (10HP only)

  100VDC for a 240VAC input

  50VDC for a 120VAC input
- Set the speed reference potentiometer to +10VDC and depress the start push-button. Note the reverse gate firing indicators (LEDs 3 and 4 on the upper right side of the lower PC board) are lit.
- Set the speed reference potentiometer to -10VDC. The forward gate firing indicators (LEDs 1 and 2) are now lit.
- Press the stop push-button. The forward and reverse gate firing indicators are now dark.

5.5.3 DYNAMIC CHECKS

- Remove AC power. Connect the eight (8) SCR gate lead connectors to the interconnect board according to their color coding. Apply AC power.
- Set the current limit potentiometer to approximately 10% current (9 o'clock position).
- Set the speed reference potentiometer to +10VDC.
- Start the drive and slowly adjust the current limit potentiometer to the mid-position. When the motor no longer accelerates, adjust the maximum speed pot so that the voltage at the armature terminals is 240VDC for a 277 VAC input (10HP only), 180VDC for a 240VAC input or 90VDC for a 120VAC input. Adjust max speed to suit your application.

CAUTION

THESE STABILITY ADJUSTMENTS MUST BE PERFORMED WITH CARE. MOTOR INSTABILITY WILL RESULT IF THESE POTENTIOMETERS ARE ADJUSTED TOO QUICKLY OR SET TOO HIGH. THESE POTENTIOMETER SHOULD BE TURNED CLOCKWISE JUST ENOUGH TO PREVENT VELOCITY OVERSHOOT.

- Adjust the velocity stability (STAB) and speed rate potentiometers to achieve the desired motor response to speed changes.
- Adjust the current limit potentiometer for 100% current by turning it CW until +4VDC is measured at the anode of D9 located on the upper board.
- Check the accel/decel circuit for the 0.2-4 second range.
  - Stop the drive and remove AC power.
  - Jumper pins F and H on the upper board.
  - Set the accel and decel potentiometers fully CW.
  - Apply AC power and start the drive. Note that the motor ramps to full speed in about 4 seconds.
  - Reduce the speed reference to zero. Note that the motor ramps to zero speed in about 4 seconds.
  - Set each of the accel and decel potentiometers for the required ramping rate in the desired time range using the above procedure. CW rotation of these potentiometers increases the ramp time.
- Check the drive for two quadrant operation if required.

NOTE: ALWAYS STOP THE DRIVE AND REMOVE AC POWER BEFORE CHANGING A JUMPER SETTING.

  - Set JP1 to the REV position. Note that only positive armature voltage is attainable when adjusting the speed reverence.
  - Set JP1 to the FWD position and note that only negative armature voltage is attainable.
  - Set JP3 to the C position and note that only negative and a small (10%) positive armature voltage is attainable.
  - Stop the drive and remove AC power. Set JP1 and JP3 to their desired positions.
- Check the jog Circuit.
  - Set the jog potentiometer fully CW.
  - Supply voltage to the jog reference by placing a jumper between TB1-20 (+10VDC) and TB1-33 (jog reference).
  - While depressing the jog push-button, the armature voltage should read approximately 60VDC for a 180VDC armature. (75VDC for a 240VDC armature).
  - Set the jog potentiometer for the desired jog speed.
- Set the IR compensation. Use only if armature feedback is used (set fully CCW for tachometer feedback).
  - Run the motor at maximum speed with no load.
  - With a hand tachometer, record the motor RPM.
  - Load the motor.
  - Again measure the motor RPM. Match this loaded speed to the unloaded speed of Step 1 using the IR Comp potentiometer.
  - Repeat steps 1 through 4.

NOTE: EXCESSIVE IR COMPENSATION CAN CAUSE THE DRIVE CONTROL TO BECOME UNSTABLE

SECTION 6
MAINTENANCE AND TROUBLESHOOTING

IMPORTANT SAFEGUARDS

Before performing any maintenance or troubleshooting, read the instructions and consult the system designs. All work on the drive should be performed by personnel familiar with it and its application.

WARNING

LETHAL VOLTAGES EXIST INSIDE THE CONTROL ANYTIME INPUT POWER IS APPLIED, EVEN IF THE DRIVE IS IN A STOP MODE. MAKE SURE THAT ALL POWER SOURCES HAVE BEEN DISCONNECTED BEFORE MAKING CONNECTIONS OR TOUCHING INTERNAL PARTS. EXERCISE CAUTION WHEN MAKING ADJUSTMENTS. WITH THE CONTROL DRIVING A MOTOR, DO NOT EXCEED TEN (10) DEGREES OF POT ROTATION PER SECOND. NEVER INSTALL OR REMOVE THE CONTROL BOARD WITH POWER APPLIED TO THE CONTROLLER.

6.1 NORMAL MAINTENANCE

Only minor adjustments should be necessary on initial start-up of the ***MELLTRONICS 2300RG***, dependant on the application. Standard maintenance procedures need to be followed.

♦ Keep It Clean

The control should be kept relatively free of dust, dirt, oil caustic atmosphere, and excessive moisture. External cabinet filters should be checked and cleaned periodically. Do not use high pressure air to blow the control or cabinet clean--use a small brush and vacuum cleaner to limit dust being stirred up during cleaning.

♦ Keep Connections Tight

Keep the equipment away from high vibration areas that could loosen connections or cause chafing of wires. Also, all interconnections should be re-tightened at the time of initial start-up and at least every six months.

♦ Follow Motor Maintenance Instructions

The brushes and commutator should be inspected for excessive wear or arcing. Motor wiring should be inspected for wear and the connections should be checked for tightness. For more detail, consult the instructions supplied with the motor for more detail.

♦ Keep It Cool

Locate the control away form machines having a high ambient temperature. Air flow across heat-sinks on chassis models must not be restricted by other equipment within the enclosure.

WARNING

MOTOR MAY BE AT LINE VOLTAGE EVEN WHEN IT IS NOT IN OPERATION, NEVER ATTEMPT TO INSPECT, TOUCH OR REMOVE ANY INTERNAL PART OF THE DC MOTOR WITHOUT FIRST MAKING SURE THAT ALL AC POWER TO THE CONTROL AND THE MOTOR HAS BEEN COMPLETELY DISCONNECTED!

6.2 DC MOTOR

- The motor should be inspected at regular intervals and the following checks must be made:
- See that both the inside and outside of the motor are not excessively dirty. This can cause added motor heating and shorten motor life.
- If a motor blower is used, make sure that the air passages are clean and the impeller is free to rotate. If air filters are used, they should be cleaned at regular intervals or replaced if they are disposable. Any reduction in cooling air will increase motor heating.
- Inspect the commutator and brushes. Replace the brushes if needed. Make sure that the proper brush grade is used.
- The motor bearing should be greased per the manufacture's instructions as to type of grease and frequency. Over greasing can cause excessive bearing heating and failure. Consult the instructions supplied with the motor for more details.

6.3 TROUBLESHOOTING OVERVIEW

Effective and timely troubleshooting requires capable electronic technicians who have received training in the control operation and who are familiar with the application. Well-trained personnel are qualified to service this equipment. They need to be supplied with the necessary test instruments as well as a sufficient stock of recommended spare parts.

6.3.1 TRAINING

- Study the system instruction manual and control drawings.
- Obtain practical experience during the system installation and in future servicing.
- Train in the use of test instruments.
- For additional help, contact the Melltronics factory.

6.3.2 MAINTENANCE RECORDS

The user should keep records of down time, symptoms, results of various check, meter readings, etc. Such records will often help a service engineer locate the problem in the minimum time, should such services be required.

6.4 GENERAL TROUBLESHOOTING

Before troubleshooting the drive system read the warning section and notes on the use of test instruments.

WARNING

CARE MUST BE TAKEN WHEN TEST INSTRUMENTS ARE BEING USED, TO INSURE THAT ITS CHASSIS IS NOT GROUNDED EITHER BY A GROUNDING PLUG CONNECTION OR BY ITS CASE BEING IN CONTACT WITH A GROUNDED SURFACE. EXTREME CARE MUST BE TAKEN WHEN USING THE OSCILLOSCOPE SINCE ITS CHASSIS WILL BE ELECTRICALLY HOT TO GROUND WHEN CONNECTED TO THE CONTROL SYSTEM.

The most frequent causes of drive failure are:

- A broken wire or loose connection.
- Circuit grounding within the interconnections or the power wiring.
- Mechanical failure at the motor, or tachometer.

Do **NOT** make adjustments or replace components before checking all wiring. Check all indicator lights before proceeding with troubleshooting checks. Also check for blown fuses.
It should be noted that modern solid state electronic circuitry is highly reliable. Often problems which appear to be electrical are actually mechanical. It is advised that the motor be checked in the event of any drive problems. Refer to the motor owner's manual for maintenance and repair procedures.

6.4.1 TROUBLESHOOTING NOTES

- A minimum knowledge of system operation is required, but it is necessary to be able to read the system schematics and connection diagrams.
- An oscilloscope may be needed to locate problem areas and to make adjustments. The majority of the problems can be solved by using a multi-meter and by parts substitution.
- Multimeters having a sensitivity of 1000 ohms per volt on DC or more, is recommended.
- Technician should keep records of downtime, systems, results of various checks, meter readings, etc.. Such records will often help a service engineer to quickly locate a problem and verifying the service required.
- Check for blown fuses and monitor all indicator lights before proceeding with more complex troubleshooting checks.

WARNING

DO NOT USE THE OHMMETER PORTION OF A MULTIMETER TO CHECK TRANSISTORS, EXCEPT WHERE ADVISED TO DO SO IN THIS MANUAL. NEVER USE A MEGGER TO CHECK ANY PORTION OF THE CONTROL CIRCUITRY. BEFORE TROUBLESHOOTING THE DRIVE SYSTEM, READ THE WARNING SECTION AND NOTES ON THE THE USE OF TEST INSTRUMENTS.

6.5 BASIC TROUBLESHOOTING

Included in this section are a basic list of symptoms of an improperly functioning control along with possible causes and corrective measures for each symptom described. if you do not find the source and solution of your specific problem, call the Melltronics factory. Before calling, obtain the system part number and serial number. This information can be obtained from the nameplate on the control.

NOTE: BE SURE TO CHECK JUMPER PROGRAMMING WHEN REPLACING A PC BOARD. IT MAY BE NECESSARY TO READJUST POTENTIOMETERS.

6.5.1 LINE FUSES BLOWN OR MAIN CIRCUIT BREAKER TRIPS WHEN APPLYING AC POWER:

1. External short in AC wiring - locate and remove short.
2. AC input shorted at control - locate and remove short.
3. Control wired to AC voltage exceeding control rating - rewire control to proper AC voltage or use step-down transformer.
4. Lower board is improperly wired or is damaged - check wiring to power section or replace lower board.
5. Damaged(shorted) power blocks - replace bad power blocks.

6.5.2 CONTROL MOMENTARILY COMES ON WITH AC POWER BUT THEN DIES (FUSES ON INTERCONNECT BOARD BLOW):

1. Voltage input jumpers improperly connected - reprogram voltage input jumpers (located on lower board).
2. External short in motor field connections - locate and remove .
3. Field connections shortened at field regulator board - locate and remove short.
4. Field diodes or SCR shorted - replace bad power device.
5. Fans or power supply transformer shorted - replace bad fans or power supply transformer.

6.5.3 DRIVE IS UNSTABLE:

1. If drive utilizes armature voltage feedback see that IR compensation has not been set too high.
2. If drive utilizes tachometer feedback see that the IR compensation pot is fully CCW.
3. If the frequency of oscillation is a function of speed, this would indicate that there is a mechanical problem with the load.
4. Check that the AC supply voltage is constant with load changes.
5. Check that the brushes are not worn, seated improperly or sticking in the brush-holders.

6.5.4 MOTOR WILL NOT REACH RATED SPEED:

1. Motor is overloaded - corrected overload condition.
2. Control is improperly shunted for desired horsepower - reshunt control.
3. Incorrect control jumper programming - reprogram jumpers
4. Max speed power is set too low - adjust max speed pot CW.
5. Curr limit pot is set too low - adjust Curr limit pot clockwise.
6. Low AC line voltage (more than 10% below nominal) - check AC line voltage and correct.
7. Incorrect adjustment.
8. Check that the motor brushes are not worn, seated improperly or sticking in the brush holders.
9. Check for defective SCR(s).

6.5.5 MOTOR RUNS TOO FAST:

1. DC tachometer wires reversed, loose or damaged - check tachometer wires.
2. Armature feedback jumper is missing - install armature feedback jumper.
3. Incorrect control jumper programming - reprogram jumpers

6.5.6 DRIVE RUNS TO TOP SPEED AT ALL SPEED POT SETTINGS

1. Check for a false reference signal to operational amplifier. Check for loss of the +10VDC and -10CVDC power supplies.
2. Check to see if the reference pot is open, for center-tapped pot applications.
3. If drive is armature voltage regulated ensure that there is a jumper between terminals 39 and 40 on TB1.
4. If drive is tach regulated check for the presence of the tach signal and the proper polarity.
5. IR comp (if used) is set too high.
6. Shorted SCR(s).
7. Max speed pot is turned too far in the CW direction. Turn the max speed pot fully CCW and readjust the maximum drive speed per the start-up instructions.

6.5.7 DRIVE IS INTERMITTENT:

1. Keep an accurate log of the type of intermittent malfunction and the operating conditions at the time of malfunction.
2. Check for loose connections, worn relay contacts, excessive environmental vibration or control, worn brushes, etc.
3. Monitor with test instruments the circuits that are believed to be causing the problem, i.e., if the drive intermittently speeds up or slows down, the feedback circuit or reference circuit, etc.

6.5.8 DRIVE TRIPS OUT:

1. If IFT light is lit, refer to ‘IFT light is on’.
2. If the IFT light is not lit, refer to ‘Magnetic sequencing’ and from a knowledge of the permissive circuitry involved, track down the cause of the trip-out.

6.5.9 NO SCR MODULE OUTPUT:

1. No AC voltage input, No Power Light
2. Loss of reference, see ‘No reference’.
3. Incomplete magnetic relay sequencing, see ‘IFT light is on’.

6.5.10 MAGNETIC SEQUENCING:

Consult the description of operation for control relay sequencing and functions.

6.5.11 MOTOR DOES NOT COME TO FULL STOP:

1. Vel bias pot out of adjustment - readjust vel bias pot.
2. Faulty speed pot - replace speed pot
3. External generated speed reference does not go to zero. - examine circuitry used to generate speed reference.
4. Incorrect adjustment.
5. Low line voltage
6. Motor is overloaded. (ie. control is in current limit)
7. Check that the motor brushes are not worn, seated improperly or sticking in the brush-holders.
8. Check for defective SCR(s).

6.5.12 IFT LIGHT IS ON:

This is an indication of an excessive armature current which has shut the drive off.

1. Depress the reset push-button momentarily and the IFT light should go out.
2. By opening the armature loop and actuating the magnetic sequencing, determine if the IFT trip is due to electrical noise or actual over-current. If IFT trips due to an actual over-current, check:
   Balance wave-form
   Are there transients on the AC line at the time of the IFT
   DC short -shorted armature.
   Presence of SCR module voltage output before application to motor armature .
   Rapid load change such as the application of a brake
3. Unbalanced armature waveform:

NOTE: DO NOT TURN AC POWER ON UNTIL THE FOLLOWING CHECKS HAVE BEEN MADE.

4. Check the condition of each of the power semiconductors using an ohmmeter making sure the polarity is correct The plus lead will have a positive polarity from the battery in the multimeter.
5. Test the SCR modules.

6.5.13 SCR TEST:

1. Connect the positive lead from the ohmmeter to the anode of the SCR and the negative lead from the ohmmeter to the cathode of the SCR. The ohmmeter should read a value of resistance greater than 200,000 ohms.
2. Reverse the two ohmmeter leads, and the resistance should read approximately the same. (ie., T.R. greater than 200,000 ohms). Connect the positive lead from the the ohmmeter to the gate lead of the SCR and the negative lead to the cathode. The resistance should read less than 100 ohms but greater than 2 ohms.
3. Reverse the leads, the resistance should remain approximately the same.
4. Replace any defective SCRs
5. Turn on AC power after replacing fuses.
6. Check line voltage.
7. Check control voltage. Indication should be 120VAC, +10 to -5%.
8. Make all other adjustments as shown in the adjustment procedures.

6.5.14 MOTOR JUMPS UPON STARTING:

Machine has high break away torque. Reduce if possible.

6.5.15 MOTOR OVERHEATS:

1. Ambient temperature above 40^o C (104^o F).
2. Check that the motor is properly rated to run at the speed set with load applied.
3. Defective motor.
4. If supplied, check the blower motor rotation for proper direction.
5. Motor ventilation restricted.

6.5.16 EXCESSIVE MOTOR NOISE:

1. Damaged bearing.
2. Defective or maladjusted control
3. Loose motor mounting or load connecting coupling.

6.5.17 EXCESSIVE MOTOR SPARKING:

1. Brushes are worn, or the wrong grade of brushes is being used.
2. Brush rigging is improperly adjusted.
3. Commutating poles are not properly shimmed.
4. Defective or maladjusted control.
5. Motor is overloaded.
6. Rough commutator.

6.6 SCR REPLACEMENT

Refer to Figure 29 and Figure 30 for component identification.

1. Remove and lockout AC power to the controller.
2. Remove the leads from Terminals 16, 17, 18 and 19 on the terminal strip TB1.
3. Open the upper PC board and pull the leads back through the whole in the upper board.

NOTE: DO NOT ALLOW LOOSE HARDWARE TO FALL INTO HEAT SINK ASSEMBLY.

4. Remove the connectors from J2 and J3 on the back of the upper PC board.
5. Label the following leads and remove them from the lower PC board:
   - A+ and A-
   - F+ and F-
   - FE1 and FE2
   - J1
   - J5
   - L1 and L2
   - SCR gate leads
   - TB2-1 and 2
6. Remove the fast-on connectors from the auxiliary switch on the right side of the motor contactor.
7. Remove the four mounting screws and carefully lift out the lower PC board so as not to damage any component on the board.
8. Label and remove all leads connected to AC1 and AC2 on each of the SCR power blocks to be tested.

NOTE: POWER BLOCKS USE METRIC (10MM) SCREW TERMINALS. WHEN TESTING, REMOVE THE GATE LEADS (G1 AND G2) ONE AT A TIME, PERFORM THE TEST AND REPLACE TO AVOID CONNECTION ERRORS.

6.6.1 SCR POWER BLOCK REPLACEMENT - 1/4 TO 2HP CONTROL

1. Remove the 2 hold down bolts and slide the power block to the side.
2. Sparingly apply silicon thermal compound to the bottom of the new power block.
3. Bolt the new power block in place. Torque the hold down bolts to 19 inch-pounds.
4. Transfer electrical connections from the used power block to the new power block one at a time to avoid connection errors.

6.6.2 SCR POWER BLOCK REPLACEMENT - 3 TO 10HP CONTROL

1. Label and remove the gate leads form from the defective SCR.
2. Loosen the screws connecting the DC+ and DC- buss bars to the SCRs on each power block.
3. Remove the 2 hold down bolts and the DC+ and DC- buss bar connecting screws from the defective power block and slide it out form beneath the buss bars.
4. Apply silicon thermal compound sparingly to the bottom of the new power block and slide it into place beneath the buss bars.
5. Bolt the new power block into place. Torque the hold down bolt to 19 inch-pounds
6. Replace the screws connecting the buss bars to the new power block and tighten the buss bar connecting screws on each power block.
7. Connect the gate leads to the new power block.
8. Connect the leads AC1 and AC2 to the appropriate power blocks.
9. Reassemble the control in the reverse order.

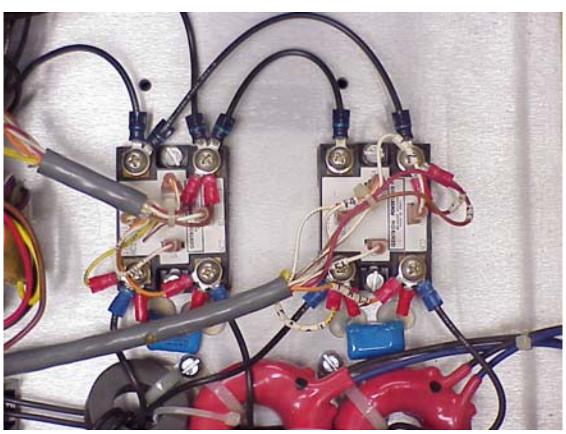


Figure 29: Low HP SCRs

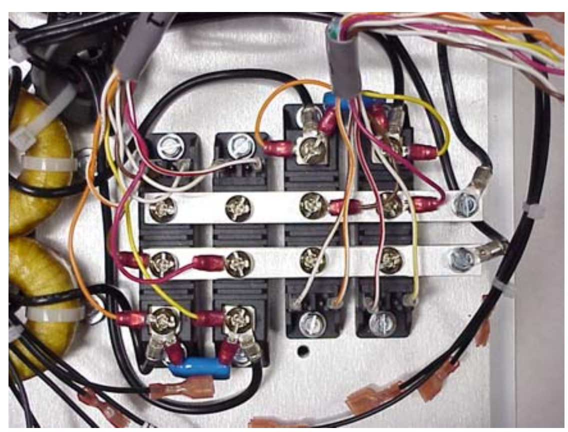


Figure 30: High HP SCRs

SECTION 7
ADDENDUM

CONTROL POWER FUSES (10HP ONLY)			
Designation	Rating	Type	Part Number
1FU	3/8A, 250V	3AG	3704-110
2FU	1/4A, 250V	3AG	3704-120

PC BOARDS		
Control	Upper Board	Lower Board
262-8000	262-4500	262-4005
262-8001	262-4500	262-4005
262-8075	262-4575	262-4005

POWER BLOCK (SCRs)			
Control	Quantity	Rating	Part Number
262-8000	2	25A, 240V	3720-016
262-8001	4	40A, 600V	55C120
262-8075	4	90A, 1200V	91C120

LINE FUSES (QTY. 2)		
Control	Rating	Part Number
262-8000	25A, 600V	3707-602500
262-8001	50A, 500V	3701-505000
262-8075	60A, 500V	3701-506000

Table 7: Terminal Strip TB1 Connections

1	120 VAC CONTROL POWER (5VA MAX)
2	120 VAC CONTROL POWER (5VA MAX) FUSE SIDE
3	N.C.
4	FORM C FAULT TRIP RELAY CONTACT (ARM)
5	N.O.
6	RUN CONTACT N.O.
7	RUN CONTACT N.O.
8	120 VAC SWITCHED THROUGH 8FT CONTACT FOR OPERATOR DEVICES
9	MOTOR THERMAL CONNECTION/ E-STOP
10	N.C. STOP PUSHBUTTON`
11	N.O. RUN PUSHBUTTON
12	N.O. JOG PUSHBUTTON
13	N.O. JOG PUSHBUTTON
14	120 VAC SWITCHED THROUGH IFT RUN/JOG CONTACT
15	120 VAC SWITCHED THROUGH IFT CONTACT
16	M-CONTACTOR (100VDC)
17	M-CONTACTOR (100VDC)
18	M-CONTACTOR AUX
19	M-CONTACTOR AUX
20	+10 VDC FOR REFERENCE IN ONLY
21	REF IN (THROUGH ACCEL/DECEL
22	-10 VDC FOR REFERENCE IN ONLY
23	COMMON
24	CONNECTION TO TURRET
25	CONNECTION TO TURRET
26	REMOTE CURRENT LIMIT 0-12 VDC (0-150%) 22K INPUT
27	FIELD LOSS DEFEAT
28	FIELD LOSS DEFEAT
29	JUMPER FOR CURRENT REGULATOR
30	JUMPER FOR CURRENT REGULATOR (8V=100% CURRENT)
31	OUTPUT ACCEL/DECEL CIRCUIT
32	INPUT TO VELOCITY AMP
33	JOG REFERENCE INPUT
34	TACH INPUT (-)
35	TACH INPUT (+)
36	AUX IN
37	LOW TACH VOLTAGE SELECTION
38	MED TACH VOLTAGE SELECTION
39	HIGH TACH VOLTAGE SELECTION
40	OUTPUT ARMATURE VOLTAGE ISOLATOR AMPLIFIER 6 VOLTS= RATED VOLTAGE (POS FOR POS ARM)
41	CURRENT SCALING AMPLIFIER OUTPUT (THROUGH 10K RESISTOR, (2 VOLTS = 100%) POLARITY DEPENDS UPON JP4 POSITION JP4 – IR NEGATIVE FOR POS ARM CURRENT JP4 – (-) IR POSITIVE FOR POS ARM CURRENT

SECTION 8
SCHEMATICS AND DIAGRAMS

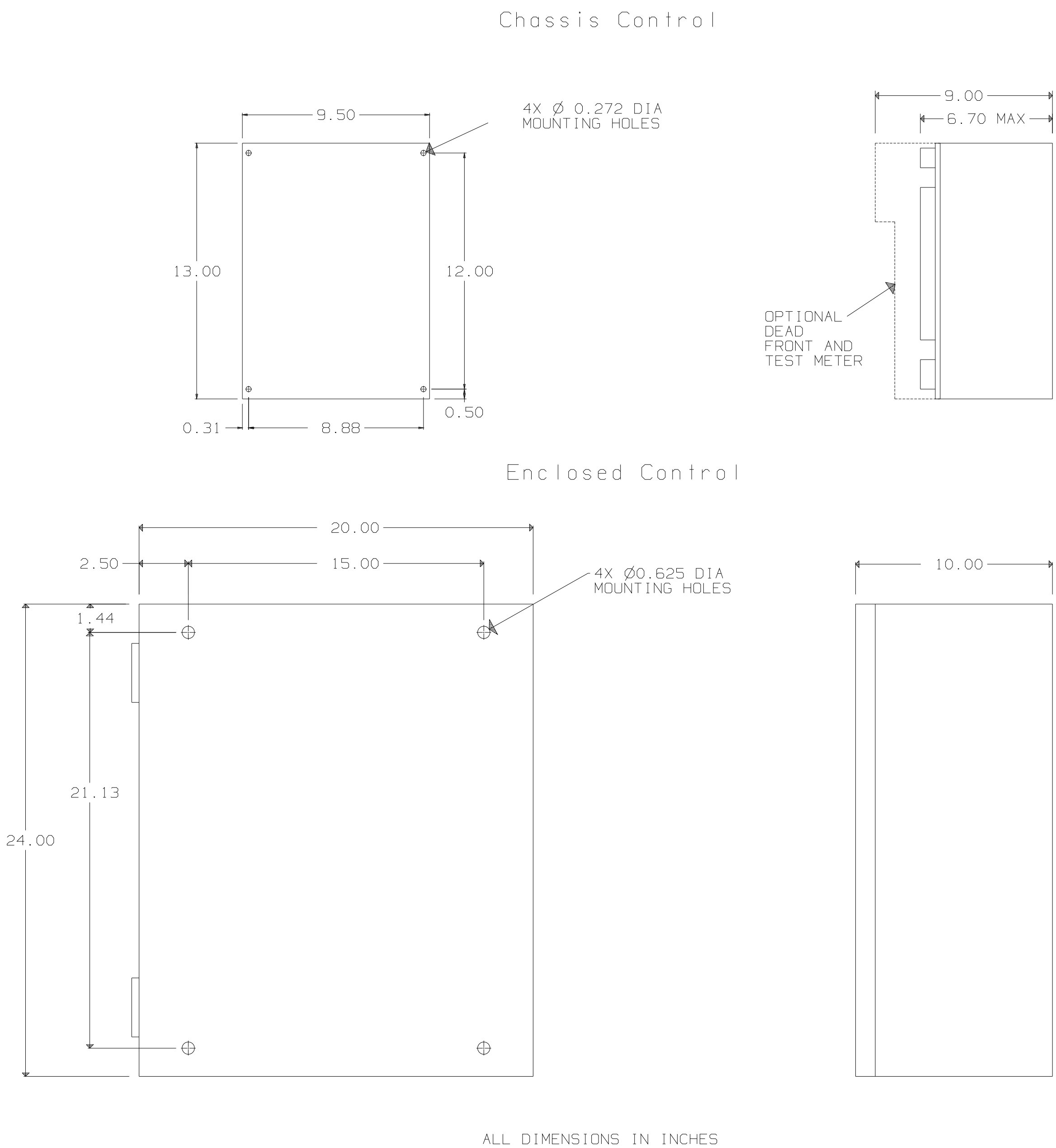


Figure 31: Outline and Mounting Dimensions

Note: The dimensions shown on this page are only applicable to non-modified 2600RG controls. Modifications to the controller may increase the size of the control enclosure (enclosed units) or may require the addition of a drive subpanel (chassis units). Consult the factory for dimensions of the modified controls.

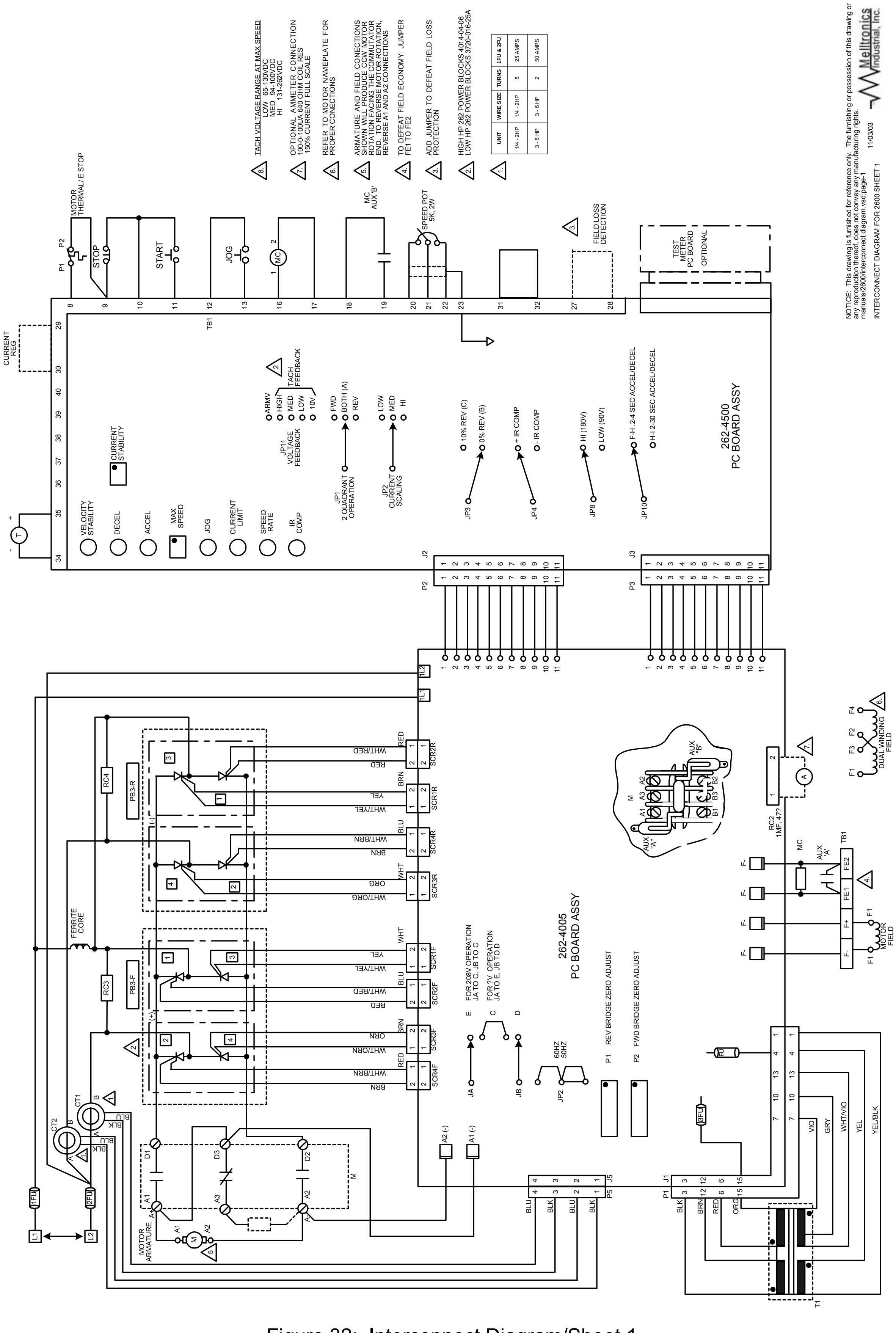


Figure 32: Interconnect Diagram/Sheet 1

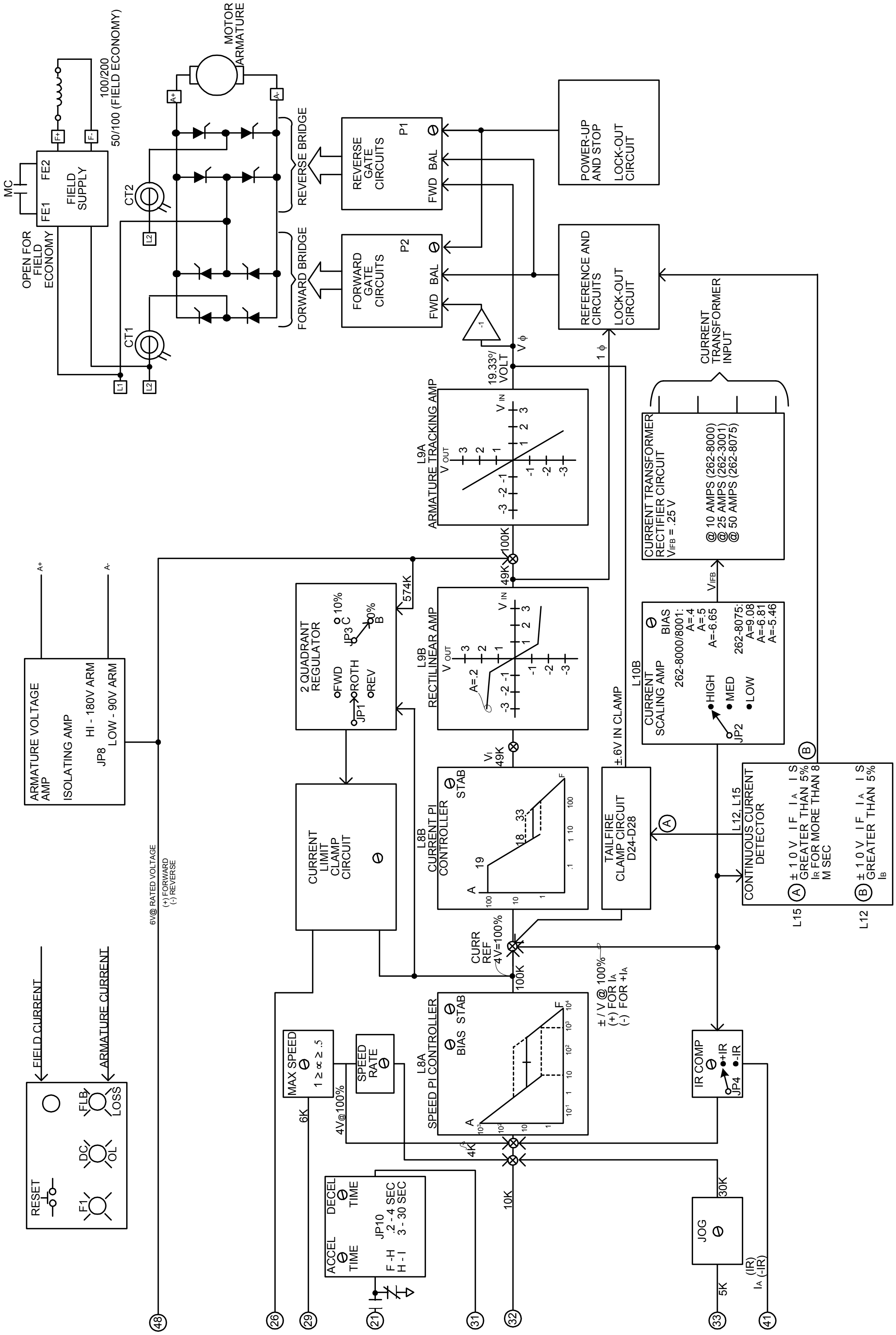


Figure 33: Interconnect Diagram/Sheet 2

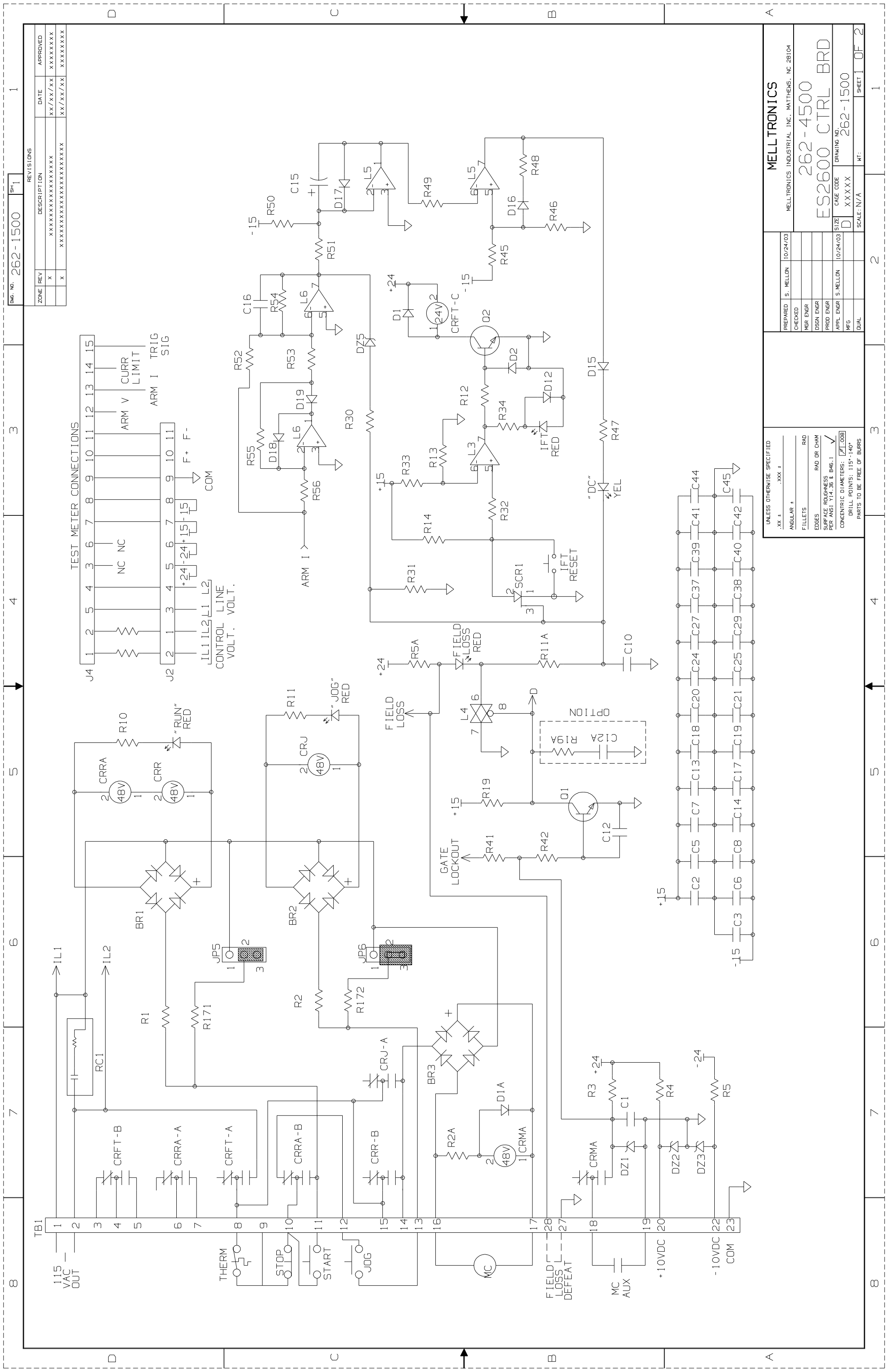


Figure 34: Top Board Schematic Diagram/Sheet 1

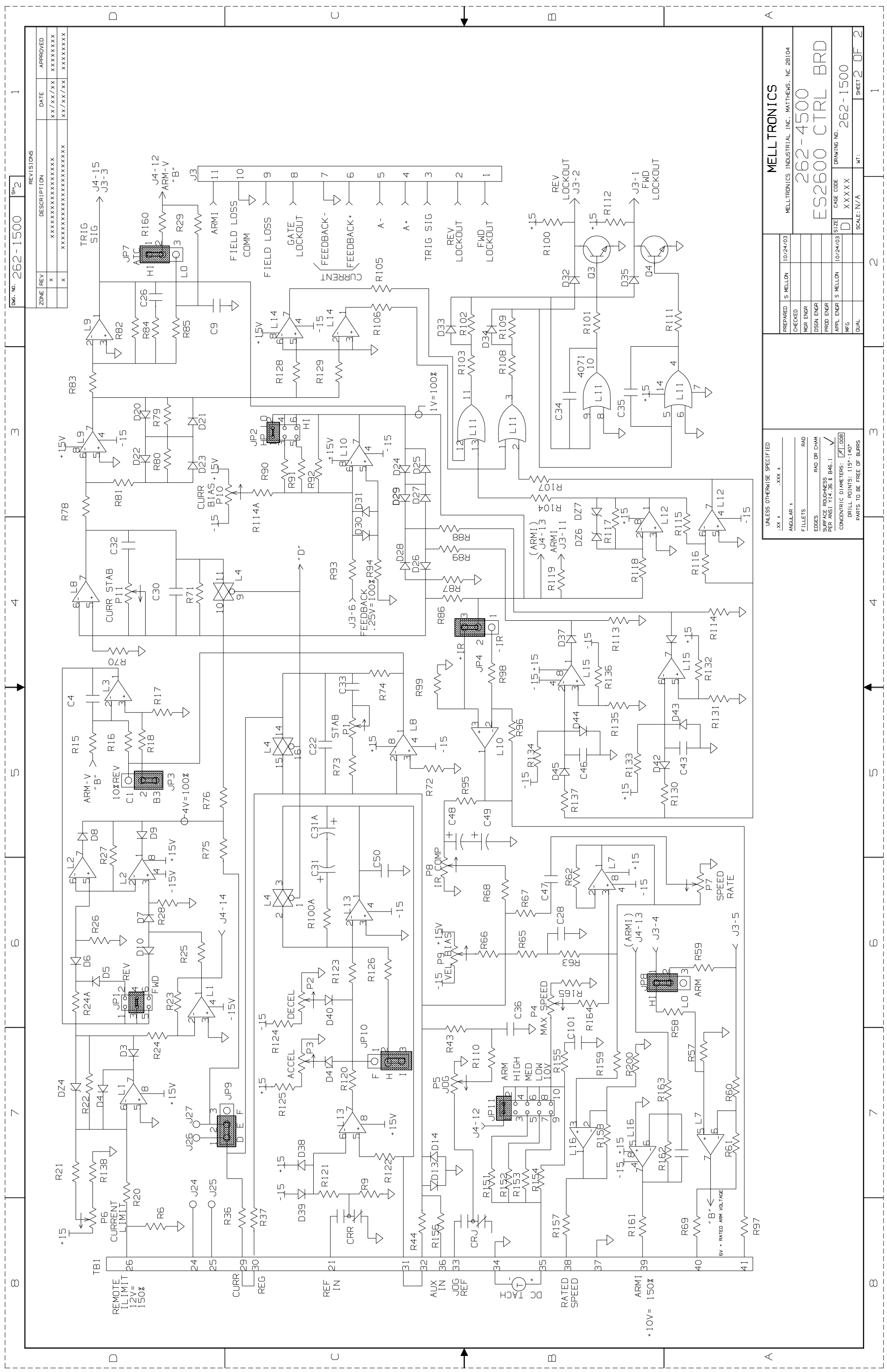


Figure 35: Top Board Schematic Diagram/Sheet 2

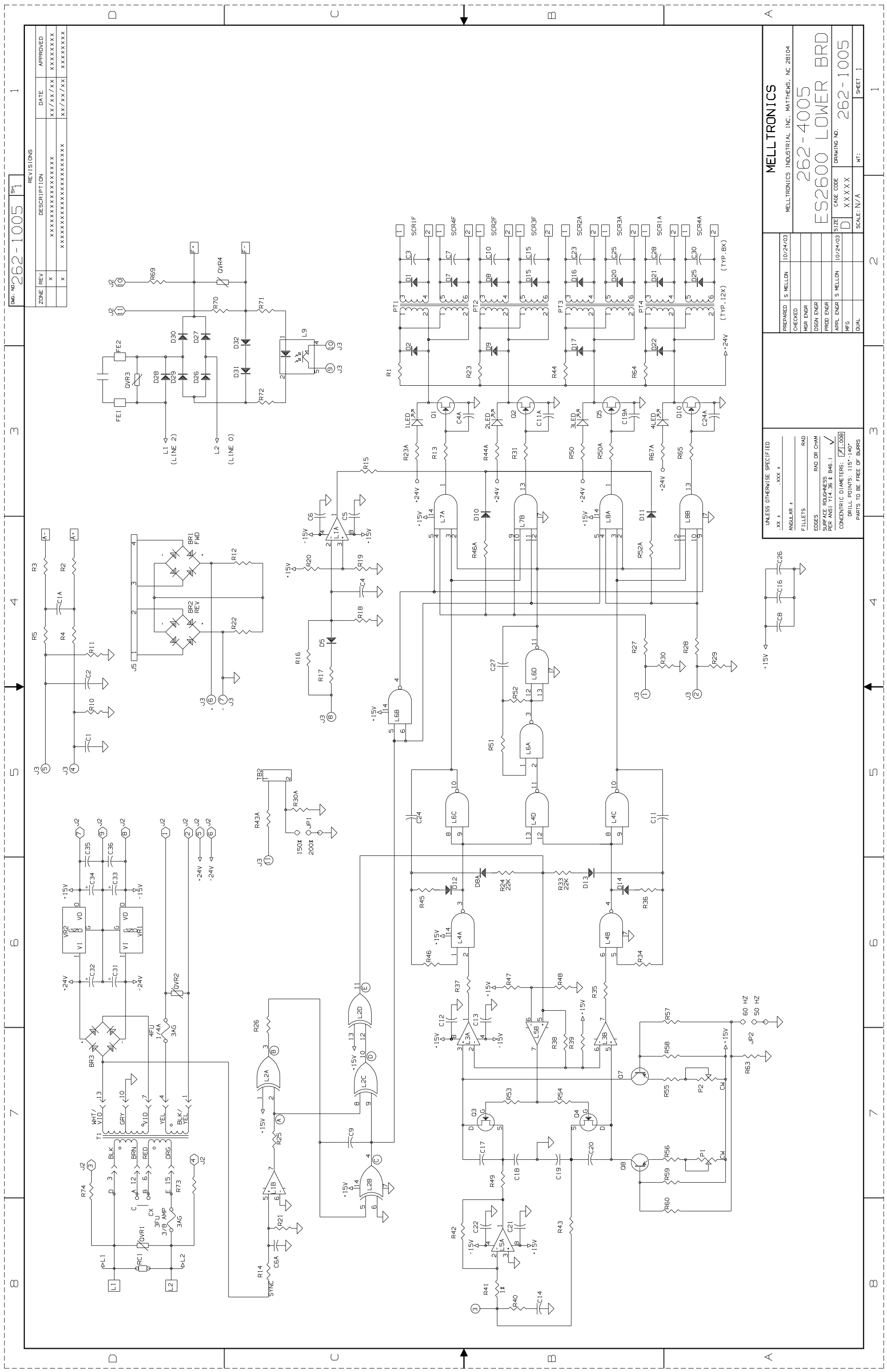


Figure 36: Lower Board Schematic Diagram

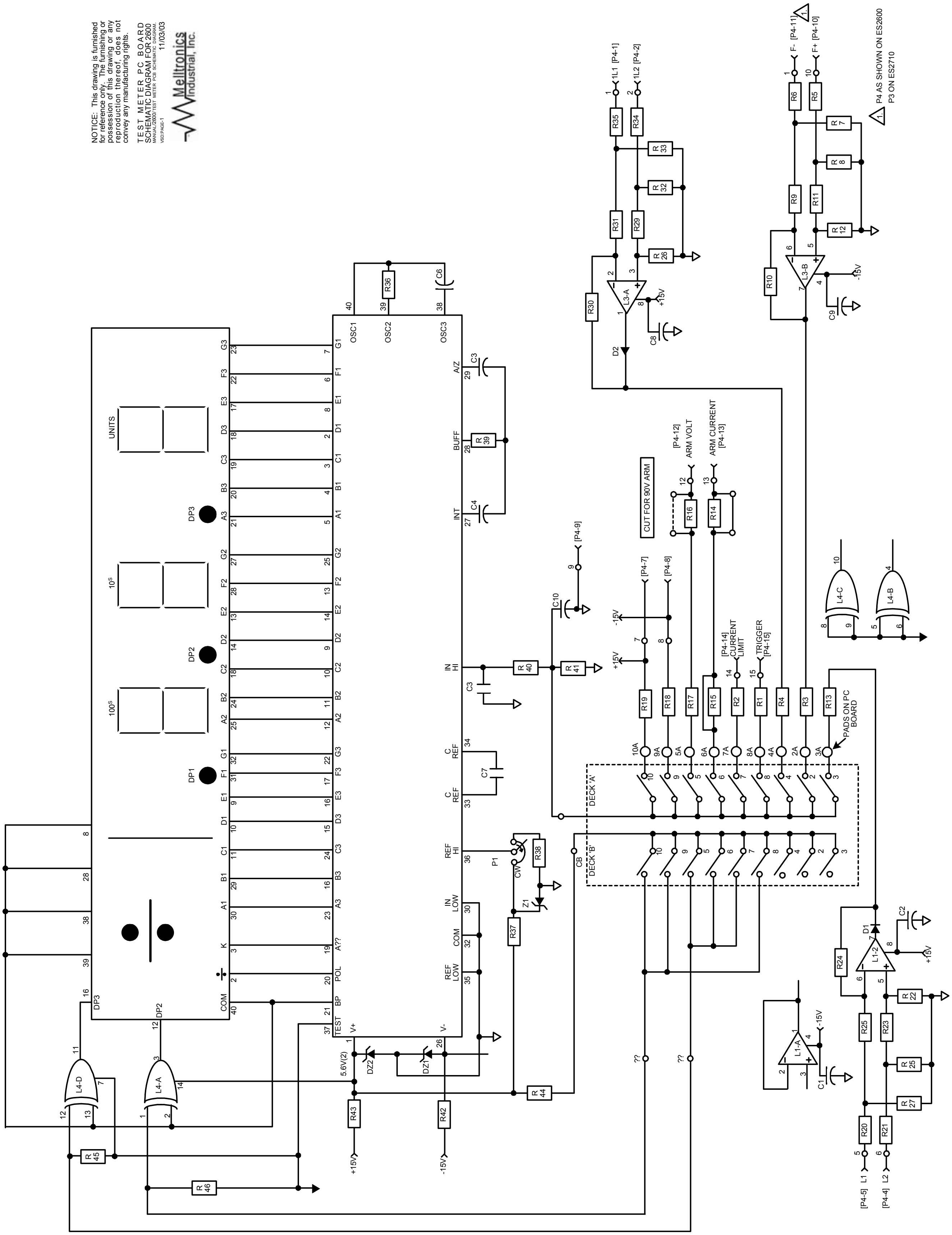


Figure 37: Test Meter PC Board Schematic Diagram

REVISION TABLE

REV	DATE	DESCRIPTION	REVISIONS
NONE	11/13/2003	1ST RELEASE BY MELLTRONICS	NONE
A	09/14/2006	2ND RELEASE BY MELLTRONICS	PGS: 7, 10, 30 TEXT ERRORS PGS: 55, 56 ADDED
B	07/01/2009	3RD RELEASE BY MELLTRONICS	PGS: 7,8,9,11,13,17,20,21,22, 23, 24, 27, 28, 30 TEXT ERRORS FIG: 13, 14 CHANGED NOTES DELETED. REVISION TABLE MOVED

SECTION 9
WARRANTY

Melltronics warrants to the Buyer whom purchases for use and not for resale that the equipment described in this instruction manual is sold in accordance with published specifications or the specifications agreed to in writing at the time of sale. Melltronics further warrants that such goods are free of defects in material and workmanship.

The warranty shall apply for a period of twelve months (12) from date of purchase, not to exceed eighteen months (18) from the date of manufacture.

If the goods fail to perform to Melltronics specifications as outlined in the warranty, then Buyer should contact Melltronics to obtain a "Material Return Authorization" (MRA), prepare the goods for shipment and return the goods to Melltronics for repair or replacement at Melltronics option. Buyer will bear all costs of transportation to and from Melltronics factory, risk of loss for goods not at Melltronics factory and any cost required to remove or prepare the goods for shipment to the repair facility, and to reinstall equipment subsequent to repair.

This warranty is effective only if written notification of any claim under this warranty is received by Melltronics at the address indicated below within thirty-days (30) from recognition of defect by Buyer.

The above indicates the full extent of Melltronics liability under this warranty. Melltronics specifically disclaims any liability for: (a) damage or failure due to improper use or installation; (b) damages in shipment; (c) damage or failure due to abnormal operation conditions of load, temperature, altitude or atmosphere whether intentional or unintentional; (d) non-authorized service, repair, modification, inspection, removal, transportation or installation; (e) misapplication or misuse, or; (f) consequential damages arising out of the use, operation or maintenance of the goods.

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