SAFTRONICS

SOLID STATE MOTOR CONTROLS

DC12

DC MOTOR DRIVES

Installation & Operating Instructions

Solid State Motor Controls

TABLE OF CONTENTS

1. DESCRIPTION

1.1 GENERAL

Saftronics DC12 thyristor converters are intended to power DC motors from 5 HP to 1000 HP in all four quadrants of speed control.

The basic converter unit consists of: (Refer to *Fig. 1*)

a) Two 6 SCR fully-controlled thyristor bridges connected in "Back-to-back." (Refer to drawing *DC12-100* to *1250*)

b) A single control card, type AA1200, mounted on the power stack assembly. The entire control circuit is accommodated on this card. (Refer to drawing AA1200).

c) Synchronizing transformer, upon which is mounted a power supply relay logic PC board. This Board which is connected to the control card via a flat ribbon cable, also has all the START/STOP control function relays. (Refer to drawing AA1200-MB).

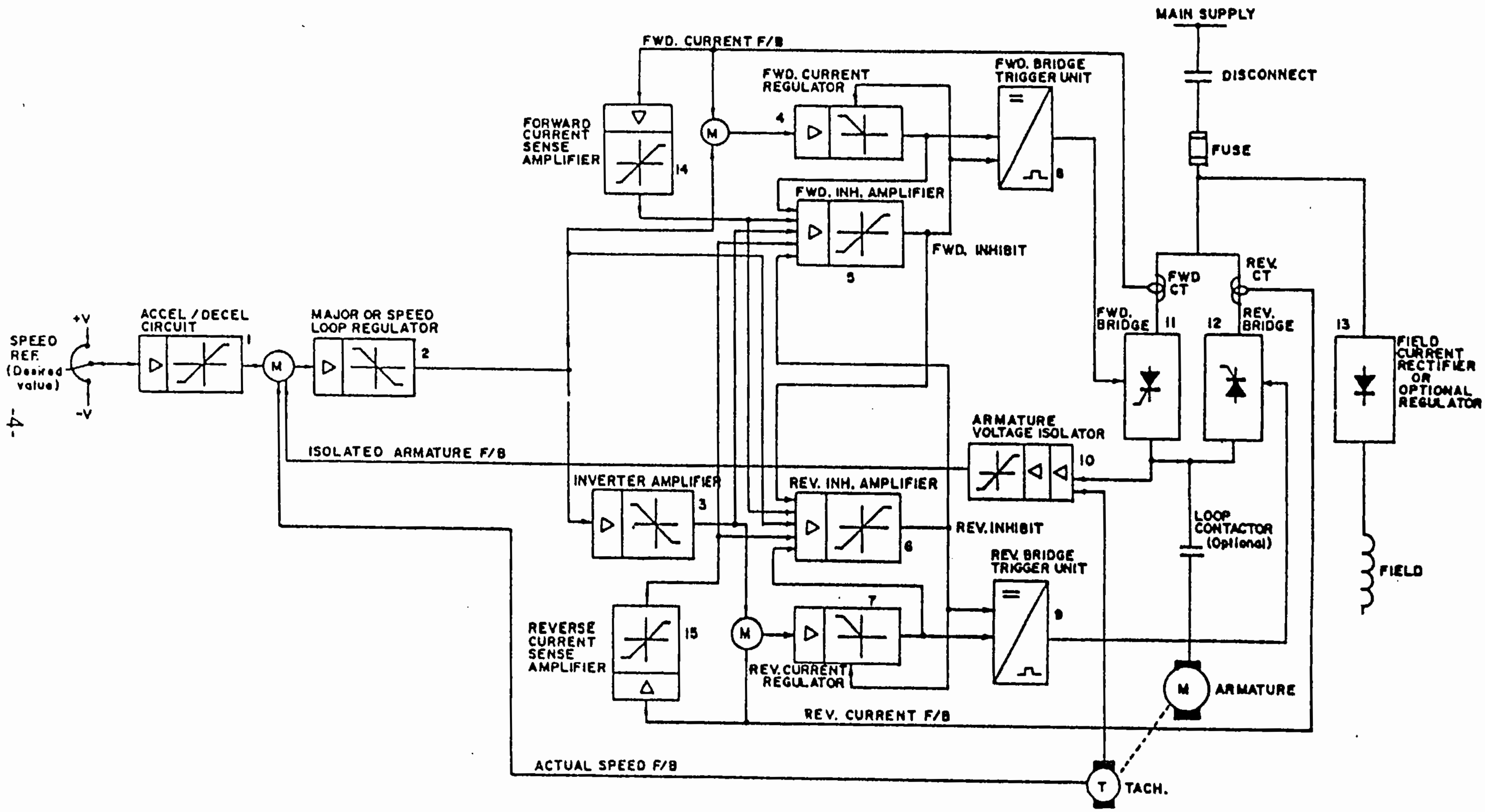
The standard converter unit is usually supplied complete in a floor-standing cabinet. The customer is required to connect all incoming/outgoing cables as per diagrams supplied with the converter.

1.2 STANDARD CONTROL FEATURES OF THE DC12 CONVERTOR

- Four quadrant operation, i.e. fully regenerative operation.
- Regenerative braking from any set speed or direction to stand-still when stopping, using tach feedback.
- Impedance-isolated armature feedback, for speed regulation of better than 5%.
- Isolated current feedback using current transformers.
- Single control card for quick replacement when faulty.
- Visual indication of all important control points within the single control card (Light emitting diodes).
- Adjustable maximum speed with tach feedback.
- Adjustable maximum speed with impedance-isolated armature voltage feedback.
- Adjustable acceleration.
- Adjustable deceleration.
- Adjustable forward current limit.
- Adjustable reverse current limit.
- Adjustable major and minor loop stabilities.
- Adjustable low voltage trip point (LVT).
- Phase failure protection interlocked with LED indication.
- Phase rotation protection interlocked with LED indication.
- Low supply voltage protection interlocked with LED indication.
- Low control voltage protection interlocking.
- Instantaneous protection against excessive current overload, (ICT current fault trip).
- Automatic resetting of low voltage/current overload trip conditions when operating the operator's *Stop/Start* circuit.

1.3 OPTIONAL CONTROL FEATURES OF THE DC12 CONVERTOR

- Tachometer feedback for speed regulation of better than 1%.
- Jog forward operation.
- Jog reverse operation.
- Parallel 12-pulse operation.
- Multi-drive systems with load sharing.
- 0 - 5 mA, 1 - 10 mA, 4 - 20 mA or 10 - 50 mA input programming for follower drive applications.
- Remote control station(s).
- Constant HP operation incorporating a field current regulator.
- Motor overspeed protection.
- Digital control for better than 0.1% speed regulation.



DC12 Block Diagram

FIGURE 1

1.4 POWER STACK TECHNICAL DATA AND TABLES

1.4.1 Standard Protective features of the Converter

- Fast-acting HRC fuses.
- Instantaneous protection against excessive current overload, (electronic protection — ICT)
- Thyristor protection against excessive dv/dt and overvoltage by means of individual RC* circuitry.
- Power stack over temperature protection interlocking (above 85 C) for stacks rated above 60A.
- Blower motor for cooling DC motor supplied via a contactor with thermal overload and fusing protection interlocked with the run control circuitry (optional).

**RC Resistor/Capacitor networks.*

1.4.2 Power Stack Rating Data

The *DC12* series covers the power range of 5 HP to 1000 HP with 10 different power stack assemblies. The control circuit, however, remains the same for the full range.
For power requirements above 1000 HP, power stack assemblies are connected in parallel, and are normally phase displaced by 30° with respect to each other for 12-pulse operation.

The different stack assemblies are listed in *Table 1* below:

— TABLE 1 —

Model*	Max. HP			Maximum DC Current
	240V	480V	600V	
DC 12-61	5	10	—	20A
DC 12-61	7.5	15	—	30A
DC 12-61	15	30	—	60A
DC 12-126	30	60	—	125A
DC 12-251	50	100	—	175A
DC 12-350	100	200	250	350A
DC 12-500	150	300	400	500A
DC 12-800	—	500	700	800A
DC 12-1000	—	600	800	1000A
DC 12-1250	—	800	1100	1250A

**Add suffixes as follows for different voltage ratings: -2 (240V) -4 (480V) -6 (600V)*

TABLE 2 lists the required supply voltages against maximum allowable DC output voltage.

— TABLE 2 —

NOMINAL LINE VOLTAGE	240	480	600
Maximum armature voltage for 4-quadrant operation line fluctuation ± 10%	240	460	550
Maximum armature voltage for 4-quadrant operation line fluctuation ± 5%	240	500	600

1.4.3 Derating Data

TABLE 1 lists the maximum continuous DC output current at 40°C ambient, for a height of 2000 meters above sea level, for the 10 different power stack assemblies.

For ambient temperatures in excess of this value, all power stack assemblies must be derated by 1.5% per °C.

For altitudes in excess of 2000 meters above sea level, all power stack assemblies must be derated by 1% for every 100 meters.

1.4.4 Field Excitation Supply

1.4.4.1 Constant Field Excitation (Standard)

Constant field excitation is supplied form a bridge rectifier having the voltage and current ratings listed in *Table 3*.

— *TABLE 3* —

STANDARD AC SUPPLY VOLTAGE	DC FIELD SUPPLY VOLTAGE	MAXIMUM DC CURRENT
240	150 Volts	10 Amps
480	300 Volts	10 Amps
600	200 - 300 Volts	10 Amps

1.4.5 SYNCHRONIZING TRANSFORMER

The standard transformer has a 240/480 volt, 3-phase input, and would therefore require an auxiliary supply transformer for supplies greater or lower than 10% of the nominal 480 volt value. (for example 600V input)

2. INSTALLATION OF DC12 CONVERTERS

2.1 GENERAL

The *DC12* drive unit is usually contained in a floor-standing cabinet which should be positioned directly above a cable channel. In most cases, all cable entry is from the top of the cabinet and cable exit is from the bottom of the cabinet.

Unless the unit has been specifically designed for poor environmental conditions, it must be installed in an area where the following conditions exist:

a) Ambient temperature does not exceed 40°C.
b) Altitude above sea level in excess of 2000 meters must be taken into account as in *Derating Data*, section 1.4.3.
c) Ambient air is reasonably clean and dry, and free of flammable, or combustible vapor, steam, etc.
d) The clearance around the cabinet must be sufficiently large enough to:

i) Provide full accessibility to the front and rear.
ii) Provide a non-restricted air flow from the intake and exhaust ventilation louvres.

2.2 CONSIDERATIONS FOR EXTERNAL CABLING TO THE CONVERTOR

It is most important to establish that the available input AC supply is of the correct voltage and current rating.

All external connections must be made according to the engineering drawings supplied in this manual.

All power cabling and control cabling ratings should be referred to *Cable Current Rating Table 4,* next page.

2.2.1 Cable Current Ratings

TABLE 4 lists required cable sizes for the various currents.

— TABLE 4 —

ARMATURE CURRENT	CABLE RATING VOLTAGE INSULATION	3-PHASE SUPPLY CURRENT (RMS)
20A	600	25A
30A	600	40A
60A	600	80A
125A	600	150A
175A	600	225A
350A	600	450A
500A	600	600A
800A	600	1000A
1000A	600	1250A
1250A	600	1500A

2.2.1.1 Field Cable Current Ratings

Field cable current ratings are determined by the motor being used. This can normally be ascertained by referring to the motor nameplate. A cable rating of 20A would be adequate for the full range up to 500 HP.

It can safely be stated however, that a cable rating in excess of 20 amps would be adequate for the full range up to 1000 HP.

The cable insulation rating should not be less than 600 volts.

2.2.1.2 Control Signal Cable Consideration

All control signal cables must have a current rating of at least 5 amps, and the voltage insulation rating should be 600 volts.

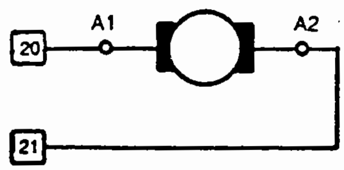
Tachometer and speed control signals should be inter-connected by means of shielded twisted conductor cable and should be run completely in separate steel conduit.

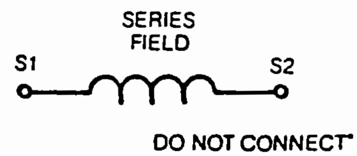
The shields should then be terminated together at one point in the control cabinet, at the ground lug provided.

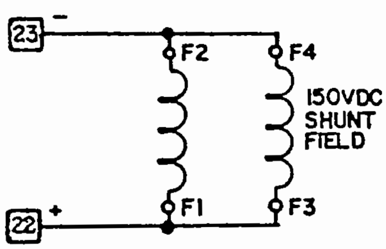
It should be noted that the screens must be grounded at one point only, to avoid unwanted ground current loops, and that the screens must be continuous, with no breaks in the shield.

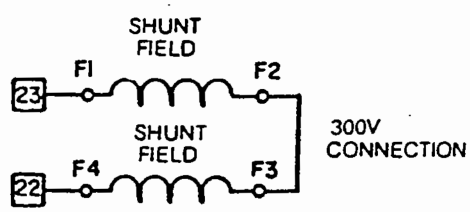
Signal cable must be run in separate steel conduits, away from power and AC control cabling.

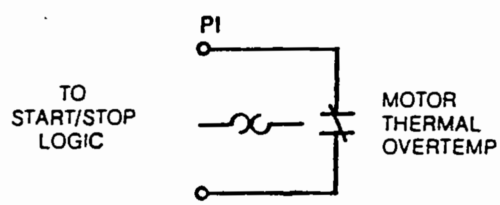
2.2.2 MOTOR CONNECTIONS TO DC12



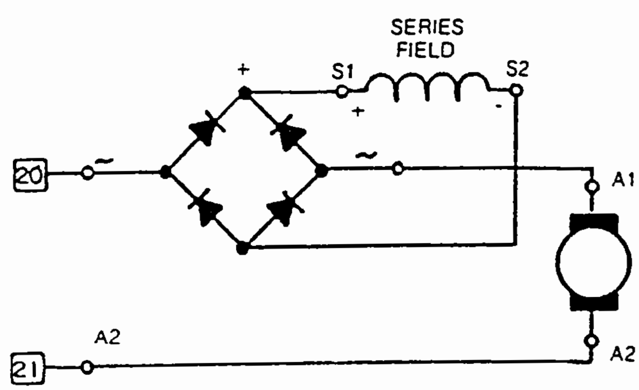








***NOTE:** *For extra starting torque duty connect series field via a full wave bridge rectifier: (Consult Factory)*



2.3 START-UP PROCEDURE

2.3.1 Adjustments to be made prior to Operation

When all external cable connections have been thoroughly checked out according to the engineering drawing supplied, power may be applied to the drive unit, but the START circuit must not be operated at this point.

The following adjustments should be made on the AA1200 control card:

MAXIMUM SPEED (Tach feedback)	— Fully counterclockwise
RATE I (Acceleration Rate)	— Fully counterclockwise
RATE II (Deceleration Rate)	— Fully counterclockwise
STABILITY (Speed)	— Mid position
FWD. TORQUE LIMIT	— Fully counter clockwise
REV. TORQUE LIMIT	— Fully counter clockwise
LVT (Low voltage trip adjustment)	— Fully counter-clockwise
FS (Forward Current Stability)	— Mid position
RS (Reverse Current Stability)	— Mid position
AV (Max. Armature Voltage) (RV3)	— Fully counter clockwise
BI SWITCH (Fwd. Inhibit Lock)	— Out
BII SWITCH (Rev. Inhibit Lock)	— Out

The state of the LED's on the A1200-R control card should be as follows:

-V (-12 Volt Supply)	— Glowing brightly
R (Run Indication)	— Off
+D (Positive Reference Indication)	— Off
-D (Negative Reference Indication)	— Off
TF (Tach Fail Indication)	— Off
TR (LVT, ICT Trip Indication)	— Not important initially
OS (Zero speed/Zero Current Indication)	— Off
LV (Low Supply Voltage Indication)	— Glowing brightly
Ø (Phase Rotation/Loss Indication)	— Glowing brightly
+V (+12 Volt Supply)	— Glowing brightly
BI (Top or Bridge I Inhibit Indication)	— Off
BII (Bottom or Bridge II Inhibit Indication)	— Off
Ø1 to Ø6 (Comparator Output Indication)	— Glowing dimly

NOTE: *If any of the lights do not conform to the pre-start list shown, do not immediately suspect the AA1200 card of being faulty.*

First check out all external connections for short circuits and cross connections, etc.
The AA1200 card has been thoroughly tested out at our factory and it will be unlikely that this card would be at fault.

2.3.2 Phase Rotation Correct Indication

If the phase rotation/phase loss LED "0" is not glowing, the supply should be disconnected and any two phases of the supply reversed.

When power is restored, this LED should glow brightly. If this LED remains in the "OFF" condition, the supply to the drive should be checked for the correct phase to phase voltage.

2.3.3 LVT (Low Supply Voltage) Adjustment

Slowly rotate the *LVT* adjustment clockwise until the LV LED begins to decrease in intensity. Back off the adjustment until the light glows brightly once again.

Bearing in mind that the AC supply voltage can fluctuate by 10%, the *LVT* control should be backed off a little further to accommodate this fluctuation.

This step will prevent the low voltage sensing circuit from locking out the drive unit prematurely.

It is important that the supply voltage does not fall below 10% of the nominal value, to prevent faulty operation during regeneration.

The *LVT* circuit ensures that the drive unit will automatically be locked out under such conditions, and this would be indicated by the *LV* light.

2.3.3.1 +12 Volt Failure Protection

A further feature of the LVT circuit is that it will automatically lock out the drive unit should the +12 volt supply fall to a value less than 80%.

2.3.3.2 -12 Volt Failure Protection

A further feature of the ICT trip circuit is that it will automatically lock out the drive unit should the -12 volt supply fall to a value less than 80%.

2.3.4 Checks Before Starting the Drive

Prior to running the DC motor, make sure that the motor is free to rotate at maximum speed in both directions without damage to the machine to which it is coupled.
It is preferable to de-couple the motor from the machine during this test

Where compound motors are used for applications requiring maximum speed and torque in both directions of operation, remove the series field connection from the armature circuit. (But consult factory for a series field bridge to allow high torque starting). See 2.2.2.

2.3.5 Initial Operation of the Converter

Before operating the drive, it will be necessary to carry out the following:

a) Set operator's speed control to a mid-position

b) Set the "BI" switch on the control card to the *In* position.

c) Where tachometer feedback is used, it will initially not be certain whether the signal is of the correct polarity. It is therefore suggested that the tachometer be temporarily disconnected. The drive will automatically revert to the correct polarity armature feedback signal, and the drive can be set up initially on this feedback signal.

d) Ensure that the shunt field voltage is as its maximum value.

Depress the *Start* pushbutton and slowly adjust the *Fwd Torque* control in a clockwise direction until the *BI* light switches on and the motor starts to turn. The motor will then accelerate under current limit to the *Set* speed on the operator's control.

Check that the motor is turning in the right direction. If the motor is not turning in the correct direction, switch off the power and reverse the field connections to the motor.

Restore power to the drive again, and run once more. The motor should be turning in the correct direction.

While the motor is running, check the polarity of the voltage generated by the *Tachometer*. When this polarity has been determined, switch off the drive and reconnect the *Tachometer* to the drive with the polarity indicated in the Wiring Diagram.

NOTE: Unlike most other SCR drives, the polarity of the *Tachometer* signal must be the same as that of the *Reference*, i.e. for a positive reference, the tachometer signal must be positive, and vice-versa.

Restore power to the drive and run once more. The drive should be running under the influence of the tach, and the tach fail LED *TF* should be glowing brightly.

Set the *Speed Control* to maximum, and check the motor speed by holding a *Hand Tachometer* to the motor shaft, or by checking the actual tach voltage.

The standard *5PY* tachometer used by *SAFTRONICS* is rated at 50 volts per 1000 RPM. (87.5 volts at 1750 RPM)

It will be noticed that the positive reference light "*+D*" will be glowing brightly on the control card at the maximum setting of the *Speed* control.

2.3.6 Maximum Speed Adjustment with Tach Feedback *(Optional)*

Adjust the *Maximum Speed* control on the control card for the required maximum speed, with the *Speed* control set to maximum. Note the armature voltage. This should not be in excess of that given in *Table 2.*

Caution: *Armature voltage must be less than RMS Line Voltage plus 20 volts. Example: for 460V line, set to 480V Max.*

If the armature voltage is in excess of the value given in *Table 2*, the field supply voltage will have to be trimmed such that the correct armature voltage is obtained.

NOTE: *Adjustment of the supply to the SHUNT FIELD should only be carried out once the motor has warmed up, as the armature voltage will automatically decrease as the motor warms up, i.e. the SHUNT FIELD current decreases as the field windings warm up.*

2.3.7 Maximum Speed Adjustment with Armature Voltage Feedback

When step 2.3.6 is complete, the maximum speed of the drive can now be adjusted.

With the drive ready to run, disconnect one end of the DC tachometer if a tach is to be used in this application.

Start the drive and set the speed reference to maximum, first in the forward direction and then reverse.

Note: *To run the drive in both directions, be sure both switches BI and BII are enabled.*

Adjust AV (RV3) on the control card AA1200 for the maximum armature voltage given in table 2. Ensure the armature voltage in the forward direction is within 10 volts of that in the reverse direction.

Caution: *Armature voltage must be less than the RMS line voltage plus 20 volts. Example: for 460V line, set 480V Max.*

Restore the *Tach* connection, and the drive should automatically revert to tachometer feedback. This will be indicated by LED TF glowing brightly. When the tachometer is removed, the drive will automatically revert back to tachometer feedback.

Removal of the *Tach* signal will automatically cause the drive to revert to impedance isolated armature voltage feedback.

2.3.8 Speed Stability Adjustment

When in operation, the drive unit regulator may be unstable and the Stability control on the control card should be adjusted if necessary.

2.4 Forward Torque Limit Adjustment

With the motor running at maximum speed, adjust the FWD torque control to minimum until the motor speed starts to drop and eventually stalls.

Stop the drive and switch off the AC power. Disconnect the motor field supply and jumper the field loss relay (FLR) in the AC control logic. Lock the motor shaft to prevent rotation.

Note: Make sure that switches BI and BII are out.

Note: Compound wound motors generate considerable torque even without the shunt field connected. It is advisable to leave the series field winding disconnected from the armature circuit until all adjustments have been made see section 2.2.2.

Set the operators speed reference to zero, apply AC power to drive, and press the start push button. While monitoring the armature current increase the speed reference slowly to maximum. Slowly increase the FWD torque potentiometer to rated armature current. Once the forward armature current has been set, decrease the speed reference to zero and stop the drive.

2.4.1 Reverse Torque Limit Adjustment

For reverse motor rotation, it will be necessary to operate the drive from a negative speed reference.

Remove AC power from the drive, and confirm that the speed reference is negative. Make sure that switch **BI is out**, **BII is in** and the speed reference is at zero.

Apply AC power to the drive and press the start pushbutton. While monitoring the armature amps increase the speed reference slowly to maximum. Slowly increase the REV torque potentiometer to rate armature amps. Once reverse armature current is set, decrease the speed reference to zero and stop the drive.

Remove AC power from the drive, switches BI and BII should be in the ***"IN"*** position, reconnect all motor connections, speed reference polarity, and remove jumper across the field loss relay FLR.

The drive and motor current have now been set.

CAUTION!!

BI and BII SWITCHES MUST NOT BE OPERATED WHILE DRIVE UNIT IS IN OPERATION

2.4.2 Acceleration/Deceleration Adjustments

Controls *Rate I* and *Rate II* can be adjusted for the required acceleration and deceleration rates to suit the application.

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3. DESCRIPTION OF OPERATION

3.1 GENERAL

As was mentioned in section 1.1, the *SAFTRONICS DC12* converter consists basically of:

a) Two fully controlled 3-phase, 6 SCR bridges connected in anti-parallel at their DC outputs, i.e. there are 12 SCR's mounted on a common heatsink power assembly.

b) A single *AA1200* control card mounted directly on the heatsink assembly. This card performs all the speed-current and SCR trigger functions.

c) A synchronizing and control transformer upon which is mounted the *AA1200-MB* run function card.

A flat ribbon cable connects this card to the *AA1200* control card.

3.2 GENERAL SYSTEM OPERATION

Figure 1 is a simple block schematic of the *DC12 4-quadrant controller.*

The 0-12V speed reference which can be either positive or negative is fed to the acceleration deceleration function *(Circuit 1).*

The output of *Circuit 1* is rate controlled. (adjustable 1 - 60 seconds) so that for a step reference input. the output of *1* rises linearly at a certain rate to a value equal to this reference. For a step reference decrease, the output of 1 decreases at a set rate to this new value.

The circuit is included as standard for applications requiring slow acceleration and/or deceleration.

The reference voltage derived from *1* is fed to the input of speed error amplifier *2*. An opposing speed signal. derived either from the motor armature voltage or tachometer coupled to the motor. is fed in opposition to the reference voltage at the input of *2*.

The resulting error voltage between these two signals is amplified by *2*, and used for the following:

a) Negative current reference for the forward current regulator *4*.

b) Positive unlocking signal for reverse inhibit amplifier *6*.

The output of inverter amplifier 3 is used for:

a) Negative current reference for the reverse current regulator *7*.

b) Positive unlocking signal for forward inhibit amplifier *5*.

The forward and reverse inhibit amplifiers must not operate simultaneously as this would cause both bridges *11* and *12* to operate together via trigger circuits *8* and *9*.

The forward and reverse inhibit amplifiers are therefore cross-interlocked so that they cannot operate simultaneously.

For a positive speed reference signal, the forward inhibit amplifier *5* will unlock both the forward current regulator *4* and the forward trigger *8*, as well as lock-out the reverse inhibit amplifier *6*.

The current reference fed to the input of the forward current regulator *4* is opposed by a forward positive current signal derived from the forward current transformer. The resulting error signal is amplified by *4*, the output of which is used to control the forward trigger circuit *8*.

For forward operation. the forward current sense amplifier *14* locks the forward inhibit amplifier *5* in the *On* condition and futher locks the reverse inhibit amplifier *6* in the *Off* condition. This locking action persists until the motor current falls to zero. Therefore, with speed and/or directional changes, the motor current must first fall to zero before bridge change-over can take place.

A further delay of 4 milliseconds is added to this change-over action, i.e. forward and reverse inhibit amplifiers have a built-in 4 millisecond switch-on-delay.

For a negative speed reference signal, the reverse inhibit amplifier *6* will unlock both the reverse current regulator *7* and reverse trigger *9*, as well as lock-out the forward inhibit amplifier *5*.

The current reference fed to the input of the reverse current regulator *7* is opposed by a positive reverse current signal derived from the reverse current transformer. The resulting error signal is amplified by *7*, the output of which is used to control the reverse trigger circuit *9*.

For reverse operation, the reverse current sense amplifier *15* locks the reverse inhibit amplifier *6* in the ***On*** condition and further locks the forward inhibit amplifier in the ***Off*** condition. This locking action also persists until the motor current falls to zero. Here again, with speed and/or directional changes, the motor current must first fall to zero before bridge change-over can take place. The further 4 millisecond delay also applies here.

The impedance-isolated armature voltage derived from circuit block *10* is automatically used as a feedback speed signal in the absence of a tachometer speed signal.

Where tachometer feedback is used, the impedance isolated armature feedback signal is automatically locked out, and should the tach signal fail, the control will automatically revert back to this armature feedback signal.

The shunt field of the motor normally has a constant excitation voltage supplied by a diode bridge, or for applications requiring constant kW/HP, a field regulator is included. This is depicted by Block *13.*

3.3 POWER STACK OPERATION

The *DC12* power stack consists of 12 SCR's mounted on a common vertical heatsink assembly.

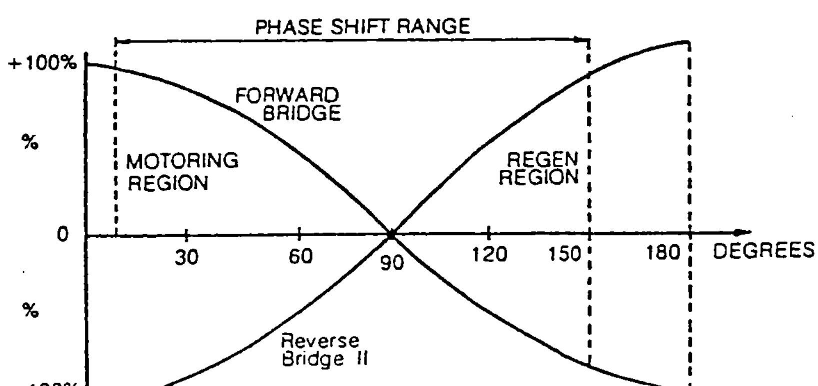
The SCR's peak inverse voltages (PIV) are:

All rated 1600 volt.

Each SCR is protected against high voltage changes (dv/dt) and high voltage spikes by means of resistor-capacitor networks.

The output voltage of both the forward and reverse bridges are illustrated in *Figure 2*, as the trigger angles of the SCR's for each bridge are advanced from 180° to 0°.

FIGURE 2

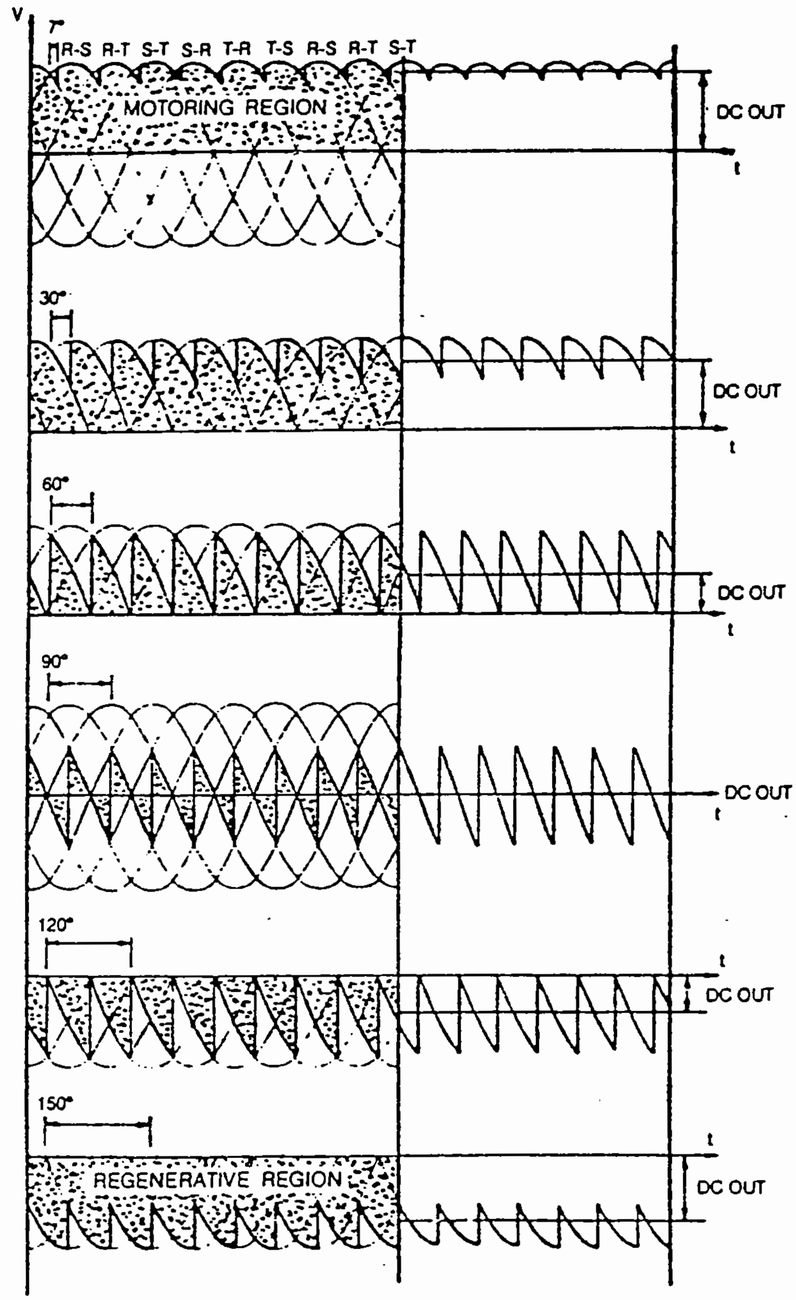


BRIDGE OUTPUT VS. DELAY ANGLE

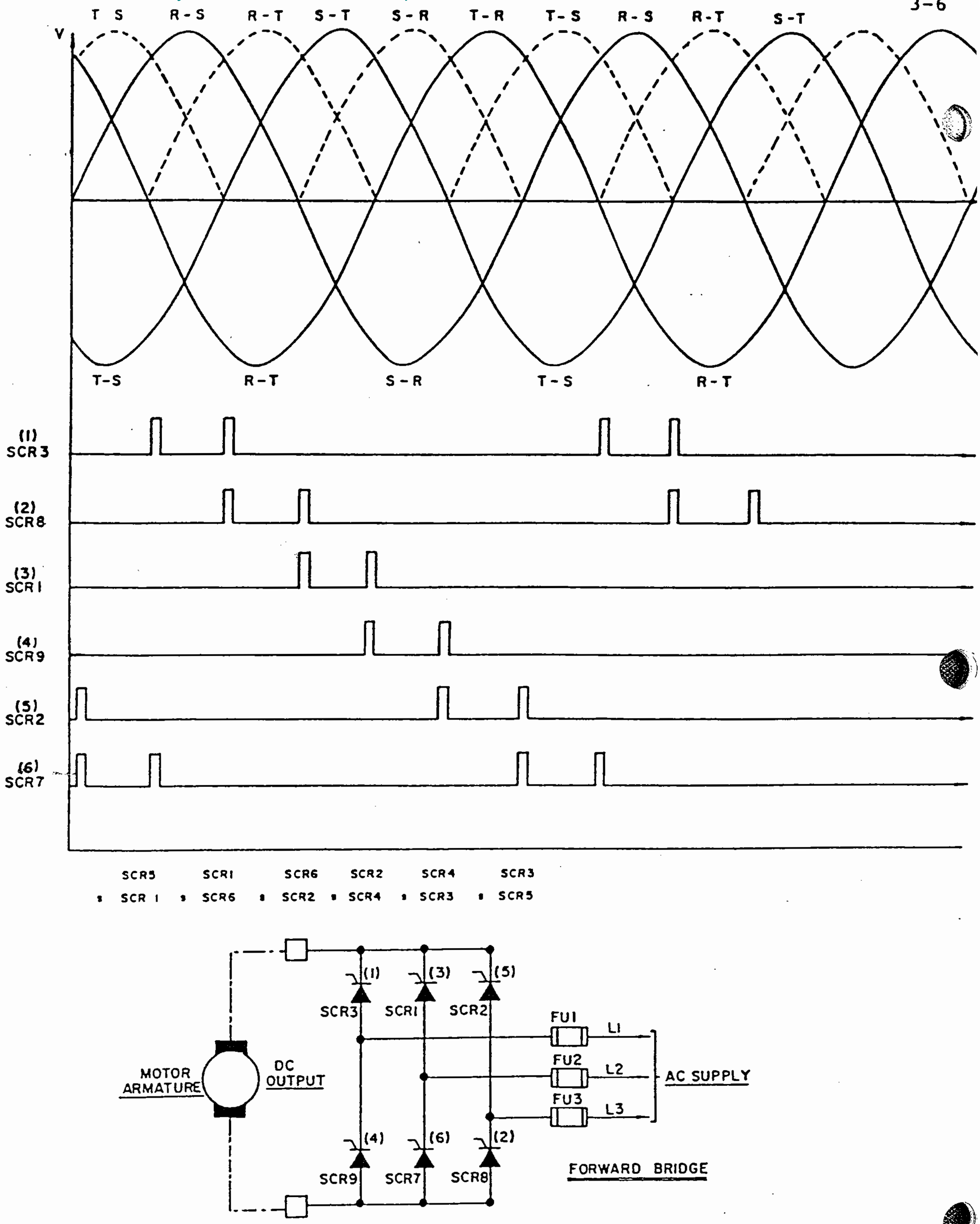
Figure 4 illustrates the trigger pulse timing requirements for each SCR of both the forward and reverse bridges. As can be seen from ***Figure 4***, each SCR receives a second trigger pulse 60°(electrical) after the first, thus ensuring conduction when the power converter operates in the discontinuous conduction mode.

Figure 3 illustrates the percentage of output DC volts versus the delay angle with continuous conduction. As can be seen, the DC output at 90° delay angle is zero, and will become negative for delay angles greater than 90°, i.e. regenerative region.

For delay angles less than 90°, the DC output becomes positive, (motoring operation).



— **Figure 3** —



NUMBERS IN PARENTHESIS INDICATE FIRING ORDER
PULSES ARE SHOWN AT POINT WHERE SCR JUST BEGINS TO CONDUCT (RESISTIVE LOAD)

— *Figure 4* —

3.4 DETAILED CIRCUIT DESCRIPTION OF AA1200 CONTROL CARD

For convenience, the *AA1200* control card circuit detail has been split in two sections: the speed regulator and logic section given by drawing *AA1200* (Sheet 1), and the trigger section given by drawing *AA1200* (Sheet 2).

We will now first consider the speed regulator and logic section.

3.4.1 Positive and Negative Power Supplies

The entire control card is powered by a dual +12 volt and -12 volt regulated supply.

3.4.2 Positive Power Supply

The positive +12 volt supply is generated by the series regulator consisting of amplifier *OA30*, and the Darlington transistor pair of *AT24* and *AT26*.

An unregulated voltage of approximately 22 volts, which is filtered by *C45*, is fed into the positive regulator via pins *21* and *22* with respect to *OV* on pins *7* and *20*.

Resistors *R157* and *R158* have been selected so that the output voltage of 12 volts will balance out the internal reference of *OA30*, such that this 12 volt value will be maintained.

Resistor *R179* is inserted in series with the +12 volt output for linear current limit protection. This resistor, which has a value of 1 ohm, will limit the maximum output current to approximately 500 mA, by overriding the regulating action of *OA30*.

Further filtering of the +12 volt output is added by means of capacitors *C9* to *C14*.

Monitoring of the positive 12 volt output is given by LED *L13*, denoted by +V on the control card.

Diode *D72* couples the unregulated +22 volts to the primary circuits of *all* the trigger pulse transformers.

3.4.3 Negative Power Supply

The negative 12 volt supply is generated by the Constant Current Source Regulator, consisting of amplifier *OA19* and the Darlington transistor pair *AT23* and *AT25*.

An unregulated voltage of approximately 22 volts, which is filtered by *C44*, is fed into the negative regulator via pins *17* and *18* with respect to *OV* on pins *7* and *20*.

Resistors *R120* and *R122* are selected such that the negative regulator output voltage will track almost exactly with that of the positive regulator.

Resistor *R178* is inserted in series with the negative regulator input for linear current limit protection. Here again, the 1 ohm value of the resistor will limit the maximum output current to approximately 500 mA by the overriding action of transistor *AT13*, which responds to the voltage drop across *R178* at a 500 mA load.

Further filtering of the -12 volt output is added by means of capacitors *C15* to *C20*.

Monitoring of the Negative 12 volt output is given by *L4*, denoted by *-V* on the control card.

3.4.4 Acceleration/Deceleration Circuit

This circuit consists of amplifiers *OA20*, *OA21* and associated circuitry.

The 0 to 12 volt reference which can be either positive or negative, and which is derived from pins *23* and/or *19*, is fed in at pin *8*.

Resistors *R123* and *R124* divide this 12 volt reference down to a value of 10 volts, which is fed in at the inverting output *2* of *OA20*.

Diodes *D77* and *D97* clamp the input reference to a maximum of ± 12.5 volts, should the reference exceed this value.

Capacitor *C41* provides decoupling of any unwanted noise at the input of this circuit.

Amplifier *OA20* is a comparator, where the reference signal at pin *2* is compared with the output reference signal at pin *3*.

Amplifier *OA21* is an integrator, with integrating action provided by capacitors *C30* and *C31* connected from the output at pin *6* to the inverting input pin *2*.

Since *C30* and *C31* are of the polarized tantalum type, they cannot be subjected to reverse voltages. They are therefore series connected with diodes *D61* and *D62*, so connected as to divert the negative charging currents passing through alternative capacitors. The capacitive value will therefore also not be affected by the series connection of *C30* and *C31*.

Transistor *AT7* acts as a clamp across integrator amplifier *OA21*. This will ensure that the output of *OA21* will always be zero at start-up.

Upon start-up, the clamping action of *AT17* will be removed from integrator *OA21*.

Since the speed reference voltage at pin *2* of *OA20* could be of any value between 0 and ±12 volts, and the output of *OA21* initially at zero, there could be an error voltage at the input of *OA20*.

If, for example, this reference were positive, *OA20* would saturate negatively. This negative voltage would be impressed upon the input of integrator *OA21* via diode *D99*, *RV6* and *R163*. Resistor *R164* will divide this voltage down in value, thus increasing the integrating time of *OA21*.

The negative bias voltage will cause the output of *OA21* to rise positively at a rate dependant on the setting of *RV6* and *C30*.

When the output of *OA21* equals the reference value, the output of *OA20* will fall to zero, thus removing the integrating bias from *OA21*. The output of *OA21* will therefore remain at this value.

If the reference voltage is decreased from an already established value, the output of *OA20* will saturate positively. This positive voltage would be impressed upon the input of *OA21* via diode D98, *RV7* and *R163*.

The positive bias will cause the output of *OA21* to decrease at a rate dependant on the setting of *RV7* and *C31*.

When the output of *OA21* equals the reference voltage once more, the output of *OA20* returns to zero, thus removing the bias from *OA21*.

This new setting is then maintained until further adjustment.

For negative reference values, the action is reversed, but the same explanation applies.

When the drive is stopped, *AT17* will automatically reset the output of *OA21* to zero in preparation for the next start cycle, regardless of actual input voltage value.

The output of the ACC/DECEL circuit which is monitored by LED's *L6* (+D) for a positive reference, and *L7* (-D) for a negative reference, is fed to the input of the Speed Error Amplifier *OA22*, via resistor *R127*.

3.4.5 Speed Error Amplifier

As mentioned in 3.3.4 the speed reference is fed via the acceleration circuit and *R127* to the input *2* of the Speed Error Amplifier *OA22*.

An actual speed signal is also fed in at pin *2* of *OA22* in opposition to the reference signal.

The method of obtaining this actual speed signal will be discussed in Section 3.5.

The error voltage that exists between the speed reference signal and the actual speed signal is amplified by *OA22*, the output of which is used to drive the emitter-follower pair *AT14* and *AT15* via *R132*.

The output of the emitter-follower pair can be limited from +0.5 to +8 volts and -0.5 volts to -8 volts by diode clamp circuits *D94* and *D93* respectively, as determined by *RV12* and *RV11*.

Clamp controls *RV11* and *RV12* ensure that maximum current reference to the current error amplifiers is never exceeded.

The output of the emitter-follower pair *AT15* and *AT14* is fed out on pin *15* as a Current Reference. Pin *15* is normally linked via pin *12* to the Current Error Amplifiers, to be discussed in Section 3.4.6.

Stability of the Speed Error Amplifier is provided by components *C36*, *R135*, *R165* and *RV8*. *R169* is included to improve the DC drift characteristic of this amplifier.

Transistor *AT16* acts as a clamp across the output and input of the speed error amplifier so that the output of this stage will always be at zero before operation. This will prevent any jerking of the motor upon starting.

Diodes *D85* and *D88* prevent any voltage overloading at the input of *OA22*.

3.4.6 Current Reference Input Circuit

As discussed in section 3.3.5, the output of the Speed Error Amplifier circuit is used as a Current Reference Signal.

For *Forward* operation this reference signal fed in at pin *12*, would be of the correct polarity for the *Forward Current Error* amplifier *OA7*.

However, for *Reverse* operation, this reference would be of the incorrect polarity for the *Reverse Current Error* amplifier *OA8*.

The *Current Reference Inverter* amplifier *OA23* is therefore included. This amplifier which has a gain of unity by virtue of *R171* and *R99*, ensures that the Reverse Current error amplifier *OA8* receives the correct polarity reference signal for reverse operation.

The function of the CURRENT REFERENCE INPUT therefore is to:

a) Provide a Current Reference for the *Forward Current* amplifier *OA7* via *R92*.

b) Unlock the *Reverse Inhibit* amplifier *OA10* via *R110*, *R73* at input *2* for reverse operation.

c) Drive inverter amplifier *OA23* via *R171*

The function of the CURRENT REFERENCE INVERTER is:

a) Provide a Current Reference for the *Reverse Current* amplifier *OA8* via *R98*.
b) Unlock the *Forward Inhibit* amplifier *OA9* via *R101* and *R67* for forward operation.

3.4.7 Forward/Reverse Inhibit Amplifier Operation

The *Forward* and *Reverse* inhibit amplifiers *OA9* and *OA10* respectively, ensure the correct changeover action of the Forward and Reverse Trigger Circuits, while also resetting the *Forward* and *Reverse* current amplifiers to zero when in the "Locked" condition.

Prior to operation, a strong positive 12 volt bias is fed via *R172* to both inputs of the *Forward* and *Reverse Inhibit* amplifiers via *D71-R75* and *D70-R74* respectively. This bias will ensure that the outputs of both inhibit amplifiers will be "Locked" at a positive output potential of 10 volts.

The monitoring lights *L2* and *L3*, denoted by *BI and BII* on the control card will both be off under this condition.

The positive output potential of both the INHIBIT amplifiers will ensure that:

a) Both Trigger Circuits will be locked out via switches *BI* and *BII*.
b) Both Current Amplifiers *OA7* and *OA8* will be clamped at zero volts because of the positive bias that clamping transistors *AT11* and *AT12* receive via *R69* and *R71* respectively.

***NOTE:** If the BI and BII switches are in the "OUT" position, the Trigger Circuits are automatically locked through R54 and R55.*

The Trigger Circuits will therefore not be under the controlling influence of the INHIBIT amplifiers.

This feature is required for the initial checking out of the correct control function of the control card without actually running the motor concerned.

Upon Start-up, the INHIBIT LINE is clamped to the -12 volt rail via relay contact RL3-1 on the A1200-MB mother board (see Drawing No. A1200-MB-2).

This action will automatically remove the positive bias from:

a) The clamp transistor ***AT17***, allowing the ***Acceleration*** circuit to function normally.
b) The clamp transistor ***AT16***, allowing the ***Speed Error Amplifier*** circuit to function normally.
c) Both the ***Inhibit Amplifiers***.

At start-up, the ***Speed Error Amplifier*** output can rise to a positive or negative value, dependent on the polarity and value of the speed reference.

For a positive output from the ***Speed Error Amplifier***, the ***Reverse Inhibit*** amplifier ***OA10*** will unlock, whereas for a negative output, the ***Forward Inhibit*** amplifier ***OA9*** will unlock because of the action of ***Inverter*** amplifier ***OA23***.

If we consider the case where a positive speed reference is used, the output of the ***Speed Error*** amplifier goes negative, and the ***Forward Inhibit*** amplifier is unlocked i.e. the output of ***OA9*** switches from a +10 volt value to a -10 volt value.

The clamping across the ***Forward Current*** amplifier ***OA7*** is therefore removed, and the ***Forward Trigger*** circuit is "Unlocked".

Where a negative speed reference is used, the output of the ***Speed Error*** amplifier goes positive, and the ***Reverse Inhibit*** amplifier is unlocked, i.e. the output of ***OA10*** switches from a +10 volt value to a -10 volt value.

The clamping across the ***Reverse Current*** amplifier ***OA8*** is therefore removed and the ***Reverse Trigger*** circuit is "Unlocked".

As was mentioned previously, it is absolutely essential that the ***Forward*** and ***Reverse Inhibit*** amplifiers do not "Unlock" at the same time.

To ensure that this cannot happen, amplifiers ***OA9*** and ***OA10*** are cross-interlocked.

Consider the case where the ***Forward Inhibit*** amplifier ***OA9*** is unlocked, i.e. it has switched from +10 volts to -10 volts.

This -10 volts is impressed upon input *2* of the ***Reverse Inhibit*** amplifier ***OA10*** via ***R49*** and ***D44***.

This -10 volt bias ensures that ***OA10*** cannot be unlocked by other associated input signals.

Where the ***Reverse Inhibit*** amplifier ***OA10*** is unlocked, i.e. it has switched from +10 volts to -10 volts, the ***Forward Inhibit*** amplifier ***OA9*** will be kept in the locked condition by the -10 volt signal being impressed on input *2* of ***OA9*** via ***R47*** and ***D43***.

Capacitors ***C32*** and ***C33*** ensure a 4 millisecond delay before either ***Inhibit*** amplifier will unlock.

Resistors ***R44*** and ***R48*** are included to add a limited amount of hysteresis to the ***Inhibit*** amplifiers, thus ensuring a more stable operation from these circuits.

3.4.8 Forward/Reverse Current Sensor Circuit Operation

When the drive unit is in operation, a voltage signal derived from either the ***Forward*** or ***Reverse AC CT's*** will be fed in at pins *9* and *10* respectively.

For forward operation the current signal fed in at pin *9* will operate ***Forward Current Sense*** amplifier ***OA11*** via ***R113*** and ***R88***. The output of ***OA11*** will switch from -10 volts to +10 volts. This +10 volt signal will be impressed on input *2* of the *Forward Inhibit* amplifier *OA9* via *D56* and *R72*, thus keeping it in the "unlocked" condition until the motor current becomes discontinuous or disappears completely.

This feature will allow the motor current to commutate to zero before bridge switch-over can take place.

A further protective feature of this action is that *OA10* is kept well in the locked condition by the action of the output of *OA11* via *D46* in input *3* of *OA10*.

For reverse operation, the current signal fed in at pin *10* will operate *Reverse Current Sense* amplifier *OA12* via *R114* and *R87*. The output of *OA12* will switch from -10 volts to +10 volts. This +10 volt signal will be impressed on input *2* of the *Reverse Inhibit* amplifier *OA10* via *D55* and *R76*, thus keeping *OA10* in the "unlocked" condition until the motor current becomes discontinuous or disappears completely.

Here again, the motor current must commutate to zero before bridge switch-over can take place.

The action of *OA10* on the *Forward Inhibit* amplifier *OA9* input *3* via *D45* will ensure further locking of this amplifier.

Resistors *R50* and *R51* ensure a small bias at the inputs of both *Current Sense* amplifiers *OA11* and *OA12* to exclude any noise switching of these amplifiers.

It is interesting to note that if the fault condition occurred where there were current signals at pins *9* and *10* at the same time, both *Inhibit* amplifiers will be kept in the "locked" condition by the action of *OA11* and *OA12*.

3.4.9 Forward/Reverse Current Amplifier Operation

As was mentioned previously, the *Forward Current* amplifier *OA7* receives a current reference signal via *R92*.

With forward operation, *OA9* will be in the "unlocked" condition, removing the clamping from *Forward Current* amplifier *OA7*, and allowing the trigger circuit to function normally.

The positive forward current signal at pin *9* is fed to the input of the *Forward Current* amplifier *OA7* via *R113*, *RV4* and *R83*.

The current signal opposes the reference signal, and the error that exists between these signals is amplified by *OA7*, the output of which controls the forward trigger circuit such that a balance of the two signals is maintained.

Stability of this circuit is provided by *C21* and *RV1*.

Zener diode *D41* clamps the output of *OA7* to a minimum of -0.5 volts.

With reverse operation, the *Reverse Current* amplifier *OA8* receives a current reference signal via *R98*.

Reverse Inhibit amplifier *OA10* will be in the "unlocked" condition, thus removing the clamping from *OA8*, and allowing the reverse trigger circuit to function normally.

The positive reverse current signal at pin *10* is fed to the input of the *Reverse Current* amplifier *OA8* via *R114*, *RV5* and *R82*.

The current signal opposes the reference signal, and the error that exists between these signals is amplified by *OA8*, the output of which controls the reverse trigger circuit such that a balance of the two signals is maintained.

Stability of this circuit is provided by *C22* and *RV2*.

Zener diode *D42* clamps the output of *OA8* to a minimum of -0.5 volts.

Diodes *D50* - *D51* and *D53* - *D54* provide input protection to *OA7* and *OA8* respectively.

3.5 LOW VOLTAGE TRIP (LVT) CIRCUIT OPERATION

The Low Voltage Trip (LVT) circuit has been included in the AA1200 control to guard against malfunction during regeneration with low AC supply voltage. It is important that the AC supply voltage does not decrease by more than 10% of the nominal value since with regeneration, ***Shoot-Through*** could occur when braking from maximum speed, i.e. an excessive fault current can be fed back into the AC supply as a direct result of poor AC supply regulation.

The Low Voltage Trip circuit consists basically of *OA29* together with *OA28*.

The stable reference voltage fed in at pin *2* of *OA29* via *R155*, ***RV13***, and *R181*, is compared with the unregulated 22 volt supply, which is a direct reflection of the actual AC supply value.

With the correct setting of *RV13* the output of *OA29* will be at -10 volts and *L11*, denoted by *LV* on the control card, will be glowing brightly.

However, with an input supply voltage decrease of -10%, the output of *OA29* will suddenly swing up to +10 volts because the 22 volt input will decrease proportionally.

The positive output voltage will be impressed on the gate input of thyristor *AT22* through *R154* and *R151*.

Thyristor *AT22* then switches on, and removes the strong positive bias at input *2* of comparator *OA28* via *R150* and *R149*. The potential at input *3* of *OA28* via *R109* and *D62* is now greater, and the output *6* swings from a normally negative 10 volt value to positive 10 volts.

This +10 volts in impressed on inputs *3* of both *Inhibit* amplifiers, through diodes *D68* and *D69*.

The *Inhibit* amplifiers are immediately *Locked* by this signal, and will not respond to any other controlling signals, and all triggering will cease.

This is called the *Trip* condition, and will be indicated by the fact that *L9*, denoted, *TR* on the control card, will be switched off from a normally *On* condition.

For "Resetting" this Trip-Condition, the *Stop* circuit must first be operated, and then the *Start* circuit operated again.

This action will generate a strong negative pulse at the base input of Reset Transistor *AT21* via *R148* and *C43*. Transistor *AT21* then saturates, and shortcircuits thyristor *AT22*, which then becomes "cut-off" once again, and the TRIP circuit is reset for operation.

3.5.1 Instantaneous Current Overload Trip (ICT) Circuit Operation

Under normal conditions, the output of *OA29* is at a -10 volt value. This -10 volts is limited to a -5 volt value through *R154* and *D81* - *D82*. The -5 volts is impressed on the gate of *AT22* through *R151*.

The gate of thyristor *AT22* is therefore negatively biased at -5 volts, and held strongly in the "Cut-off" condition.

The positive current signals for both *Forward* and *Reverse* operations are also impressed on the gate of *AT72* through diodes *D95-D96* and *R173*.

Therefore, with excessive current in either the *Forward* or *Reverse* bridge, the -5 volt bias is overcome by the current signal, and thyristor *AT22* switches on.

For normal operation, the voltage signal at *9* and *10* for maximum normal current is calculated by engineering for a value of approximately +2.5 volts. Therefore, above 200% overload, (i.e. +5 volts) the trip circuit will come into operation.

3.5.2 +12 Volt and -12 Volt Loss Protection

It is most important with regenerative control that both the +12 volt and -12 volt control supply voltages do not decrease by a value of more than 20% because of regulator malfunction or excessive loading either externally or internally, due to faulty amplifiers, etc.

The AA1200 is provided with circuitry to prevent operation as far as is possible with control supply fluctuations of greater than 15%.

3.5.3 +12 Volt Loss Protection Circuit Operation

The +12 volt loss protection circuit also comprises the LVT amplifier *OA29*.

The normally stable +12 volt reference is fed to input *3* of *OA29* via *D83* and *R118*.

With *RV13* correctly adjusted as in Section 3.5, the voltage at input *2* of *OA29* will be marginally higher than at input *3*.

The output of *OA29* is therefore saturated at -10 volts, ensuring a negative cut-off bias at the gate of *AT22*.

Should the +12 volt control supply voltage drop by 15% for example, input *3* of *OA29* will now be at a higher potential than *2*. The output of *OA29* now switches to +10 volts, and triggers thyristor *AT22*.

As described in section 3.4, the output of *OA28* switches from -10 volts to +10 volts, and locks both inhibit amplifiers *OA9* and *OA10*.

This locked condition will persist until the +12 volt control supply is restored to the normal value.

3.5.4 -12 Volt Loss Protection Circuit Operation

The -12 volt loss protection circuit centres around *OA28*.

Under normal conditions, input *2* of *OA28* is at +4.7 volts because of the zener regulator *D80* supplied through *R150* and *R149*. Input *3* of *OA28* is at +3 volts because of the zener regulator supplied through *R109*.

Clearly, input *2* is at a higher potential than input *3*, and the output of *OA28* remains saturated at -10 volts. Should the -12 volt control supply drop by 15% however, input *3* will now be at the higher potential, and the output of *OA28* switches from -10 volts to +10 volts, thus locking out both the inhibit amplifiers *OA9* and *OA10*.

NOTE: ***If both the control supply voltages drop together, it will not effect the protective feature of this circuit.***
This locked condition will also persist until the -12 volt control supply is restored to the normal value.

3.6 GENERAL SPEED FEEDBACK OPERATION

As discussed in Section 3.3.5, the *Set* or *Desired* speed from the acceleration/deceleration circuit is opposed at the input of the *Speed Error* amplifier *OA22* by an "Actual" speed signal. The error between these two signals is amplified by *OA22*, and the output used such that the motor speed is maintained within close limits.

The two standard methods of obtaining an actual speed signal are:

a) Armature voltage feedback, giving a speed holding capability of 5% of maximum speed.
b) Tachometer voltage feedback giving a speed holding capability of better than 1% of maximum speed.

The two methods used in the AA1200 card will now be discussed in detail.

3.6.1 Armature Voltage Feedback Operation

With standard DC motors operating from a converter supplied from the 480V AC supply, the maximum armature voltage is taken as 500 volts DC.

This high voltage obviously cannot be fed directly onto the control card, as this would make it "LIVE". The "LIVE" condition would make the card extremely hazardous to handle, and where more than one controller is to operate the same speed signal, isolation units would have to be used between controllers. Furthermore, accidental grounding of the control card would have disastrous results.

With the* AA1200' *control, these problems are overcome as follows:

a) The high armature voltage is first divided down to a maximum of 100 volts directly on the power stack assembly. This is accomplished by three high-wattage resistors connected in series across the DC output of the power stack. The voltage across the center resistor is used for the actual armature feedback signal.

Accidental grounding of either feedback connections will not result in damage to the power stack or control card as the resulting fault currents are limited by the two outer divider resistors.

b) The armature voltage signal obtained as in *a)* is fed in at pins *25* and *24* on the control card.

Further isolation is accomplished by virtue of the high ohmage resistors *R183* and *R182* each of which have a value of 1 megohm.

The resulting signals after resistors *R182* and *R183* are fed into the Common-Mode Rejection Circuit consisting of amplifiers *OA17* and *OA18*.

Provided that the voltage signal at inputs *24* and *25* is increasing in value, the output of *OA17* will increase in direct proportion.

However, inputs *24* and *25* are "FLOATING" with respect to zero volts. This floating voltage could adversely affect the output of *OA17*. Inverter amplifier *OA18* is included, the function of which is to add an opposing signal to the input of *OA17* such that the *Floating* signal is completely cancelled.

The output of *OA17* will therefore be a true reflection of the actual armature voltage. Smoothing or integration of this signal is provided by capacitor *C26*, such that the armature ripple voltage is reduced to a minimum at the input of *OA22*, without affecting the response time adversely.

The Impedance-Isolated Armature Voltage signal is fed from the output of *OA17* to the input of the *Speed Error Amplifier* via *R139*, diodes *D103 - D104*.

In the absence of a tach signal, transistor *AT18* will be *Cut Off*, and thus not affect the armature signal in any way.

With armature feedback control, the maximum motor speed is set by control *RV3* located on the control card, i.e. the gain of *OA17* is altered such that speed error amplifier receives more or less feedback signal for the same speed.

Diodes *D103* and *D104* are added in series with output of *OA17* to block any voltage reflected back into the input of *OA22*.

Where tach feedback is used, *AT18* will be saturated thus short-circuiting the normal armature signal.

However, a residual bias signal can still remain across *AT18*, which is blocked by *D103* and *D104*.

Since diodes *D103* and *D104* are added, the output of *OA17* has to rise to either +0.5 volts or -0.5 volts before any signal actually reaches the input of *OA22*. *Diodes D101* and *D102* are added in the feedback circuit across *OA17* to eliminate this ±0.5 volt *Deadband* effect, as well as offset the *Drifting* effects of diodes *D103* and *D104*.

3.6.2 Tachometer Feedback Operation

Tachometer feedback control is essential for applications requiring very close speed holding, i.e. better than 1% or where field *Spill-Over* control is required for constant kW/HP applications.

For regenerative control, the tachometer must of necessity be of the DC type for the correct operation of the control.

The tachometer signal is fed in at pin *14* of the AA1200 control card. The standard tachometer used by *SAFTRONICS* is the type *5PY* which delivers 50 volts DC at the speed of 1000 RPM.

It should also be noted that the polarity of the tach signal ***must*** be the same as that of the desired speed reference. This is exclusive to the ***A1200-R*** control unit, i.e. where a positive speed reference is used, the tacho signal must be positive and vice versa.

The tach signal passes from pin *14* to the input *2* of the inverter amplifier *OA24* via *RV9 R166, R136* and *R102*.

The output of inverter amplifier *OA24* is completely proportional to that of the tachometer signal but of opposite sign. This proportional signal is fed to input *2* of the speed error amplifier *OA22* via *R142* and *R138*. It can be assumed at this point that transistor *AT19* is cut-off. The operation of *AT19* will be discussed at a later stage.

The proportional tachometer signal from *OA24* therefore opposes the normal reference signal and the motor speed is kept within very close tolerances.

Capacitor *C35* affords filtering of the tach signal to exclude any unwanted noise or ripple. Diodes *D73* and *D74* provide voltage overload protection to the input of inverter *OA24*.

The ***Maximum Speed*** control *RV9* determines the maximum speed at which the motor will run, i.e. the effect of the feedback signal will increase or decrease with adjustment of *RV9* for the same set speed.

3.6.3 Tachometer Signal Loss

An exclusive protective feature of the AA1200 control is the tachometer loss feature. Where tach feedback is used, the possibility exists that this signal can be lost due to actual damage to the tach unit or the control cable inter-connecting it to the control unit.

The effect of losing this signal is the rapid acceleration of the motor to maximum speed regardless of speed setting. In many applications, this could prove disastrous, and even more so in applications using the *Field-Spill* control features since the motor would over-speed under low field conditions.

This danger is guarded against in the AA1200 control in that the *Isolated Armature* feedback signal automatically replaces the lost feedback signal.

The detailed operation of this feature is explained in Section 3.6.4.

3.6.4 Tachometer Signal Loss Protection Circuit Operation

With tach feedback, both the tach and impedance-isolated armature feedback signals are present at inputs *14* and *24-25* respectively.

Amplifier pair *OA14* and *OA13*, together with associated circuitry, form an absolute rectifier circuit to the tach signal inverter *OA24* via *R80* and *R77*.

The tach signal is essentially bi-polar, and the absolute rectifier circuit is included to derive a single polarity signal.

Amplifier pair *OA16* and *OA15* together with associated circuitry form a second absolute rectifier circuit.

The second absolute rectifier circuit is included since the armature feedback signal is also essentially bi-polar.

The positive outputs of both absolute rectifier circuits, i.e. output of *OA13* and *OA15* are compared in comparator *OA25* via divider networks *R78 - R103* and *R85 - R104*.

The absolute rectifier circuit of *OA14* and *OA13* has a sensitivity of approximately 10 times greater than that of *OA16 - OA15* by virtue of *R184* being 10 times greater than *R60*.

Therefore, the positive output of absolute rectifier *OA13* will always be greater than that of *OA15*. This greater signal level at input *2* of comparator *OA25* will ensure a negative -10 volts level at its output.

Light *L8* denoted by *TF* on the control card will glow brightly with this situation, and transistor *AT18* will be completely saturated, thus short circuiting any armature signal at the input to speed error amplifier *OA22*.

However, with failure of the tach signal, the situation is reversed, i.e. the output of *OA15* is now greater than that of *OA13*, and the output of comparator *OA25* switches from -10 volts to +10 volts, and *L8* switches off, indicating a tach loss condition.

This positive output level of *OA25* "cuts-off" transistor *AT18*, thus restoring the armature signal to the input of the speed error amplifier *OA22*, while saturating transistor *AT19* to ensure the exclusion of any unwanted tach signal at the input of *OA22*.

3.6.5 Zero Speed Sensing Circuit Operation

With regenerative control, it is normally desirable to have the motor brake regeneratively down to standstill when depressing the STOP pushbutton, i.e. the motor comes to rest in a minimum of time, before power is actually removed from it.

The function of the *Zero Speed Sensing* circuit is to provide this feature, i.e. it will hold the run circuit until zero speed is reached.

The zero speed sensing circuit consists of amplifiers *OA26 - OA27* together with associated circuitry.

The bi-polar tachometer voltage signal at input *14* is fed to the sensing circuit via *R167 - R146*. Diodes *D91 - D92* provide limiting to this signal of approximately 5 volts for both polarities. Capacitor *C42* provides filtering of this signal.

For positive tach voltage signal, the output of amplifier *OA26* switches from a normal -10 volts to +10 volts. This positive voltage provides a forward bias for transistor *AT20* via *D75* and divider network *R145 - R144*.

Transistor *AT20* saturates, providing a switched output at pin *13* for the zero speed relay *RL1* accommodated on the AA1200-MB motherboard.

The zero speed relay *RL1* will remain energized throughout the operation of the drive unit, and will de-energize when the motor speed has reached zero, i.e. the output of *OA26* has switched negative again.

For negative tach voltage signals, the output of amplifier *OA27* switches from a normal -10 volt value to +10 volts. This positive voltage also provides a forward bias for transistor *AT20* via *D76* and *R145 - R144*.

Here again, relay *RL1* will remain operated throughout the operation of the drive unit, and de-energize when the motor speed has reached zero.

A small bias provided by *R105* and *R106* at input *2* of *OA26*, and *R107* and *R108* at input *3* of *OA27* ensures that their outputs will be at -10 volts for zero signal input.

3.6.6 Auxiliary Speed Amplifier Input Operation

Access to the speed error amplifier, OA22 input is provided from pin 16 via R160.

This input can be used for an auxiliary input when required.

3.7 DESCRIPTION OF THE TRIGGER CIRCUIT

3.7.1 Synchronizing Circuit

The *Synchronizing Circuit* produces a sharp narrow positive pulse when the applied AC cycle passes through zero, as indicated by *Figure 5.*

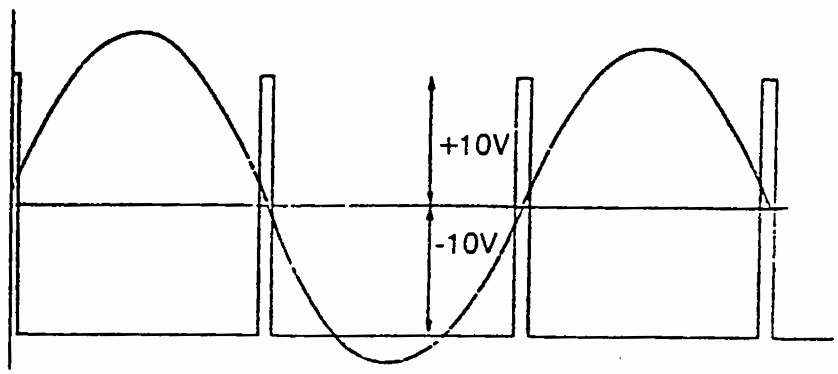


Fig. 5 Output Signal of Synchronizing Circuit

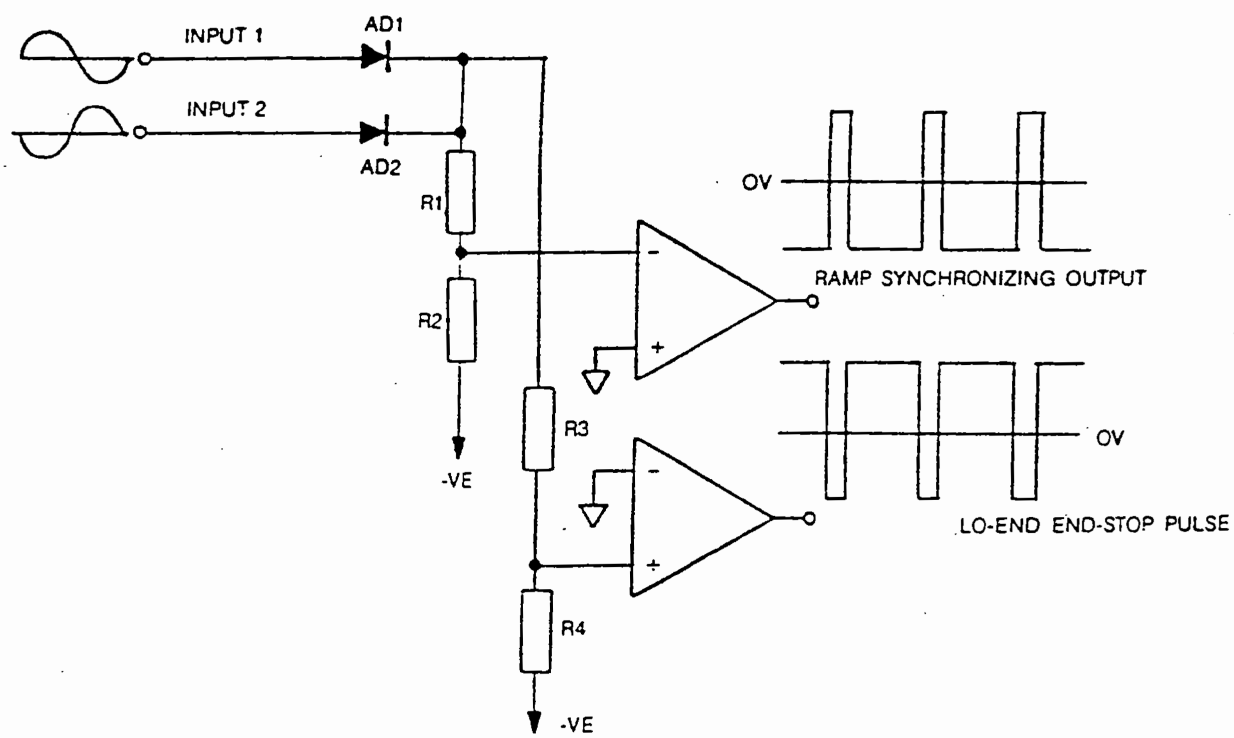


Fig 6 Simplified Diagram of Synchronizing and End-Stop Circuit

3.7.2 Ramp Generator Circuit

The *Ramp Generator* circuit produces a linear saw-tooth ramp when driven by the *Synchronizing* output as shown in *Figure 7*.

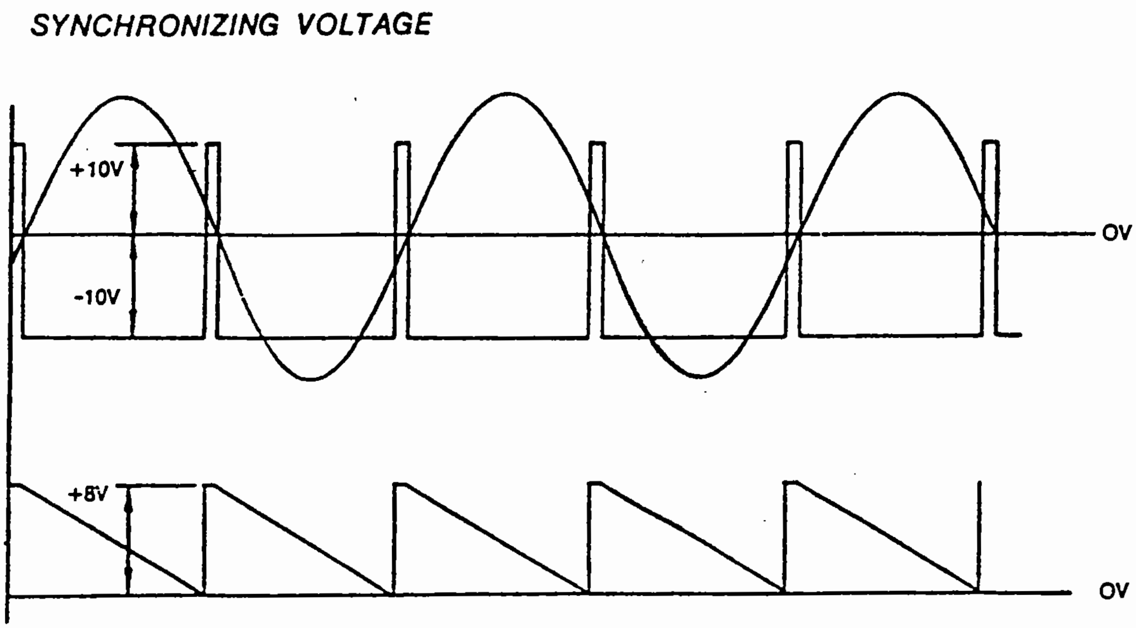


Fig. 7 Output Waveform of Ramp Generator Circuit

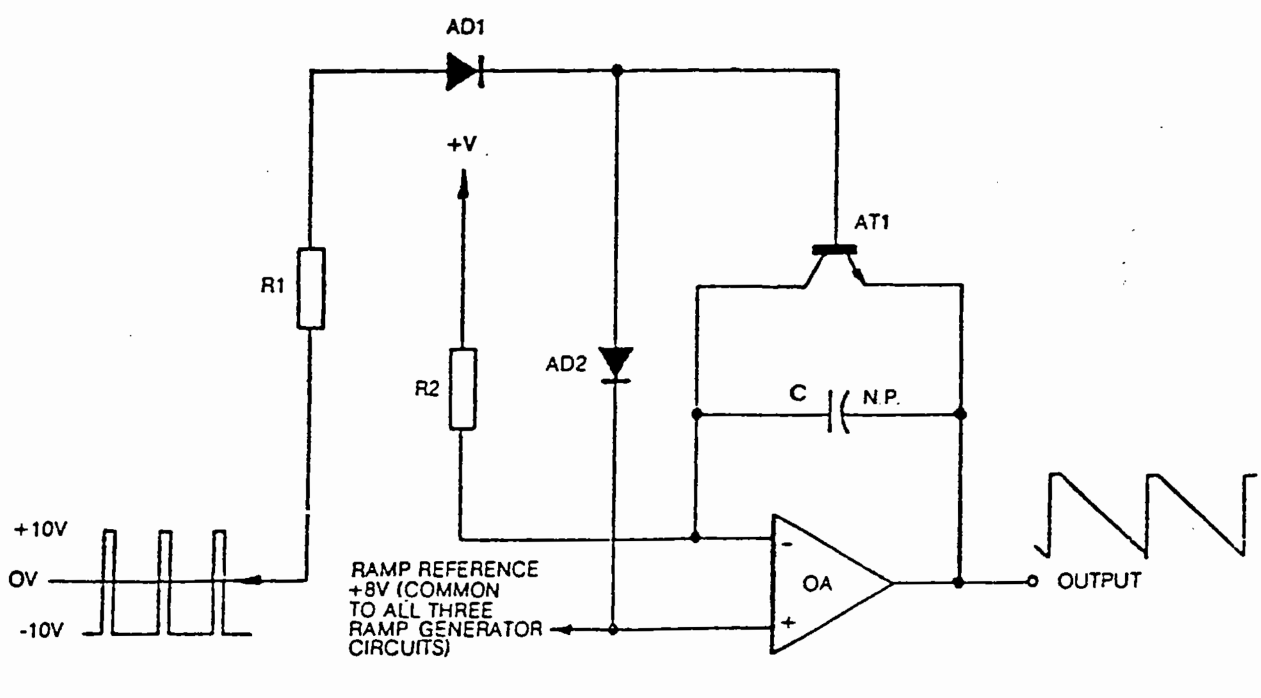


Fig. 8 Simplified Diagram of Ramp Generator Circuits

3.7.3 Comparator Circuit

In the *Comparator Circuit*, the *Ramp* signal is compared with the output control signal from the *Current Amplifier*.

When the two signals are equal in level, the output of the *Comparator* rises sharply from a negative to a positive value, as shown in *Figure 9*

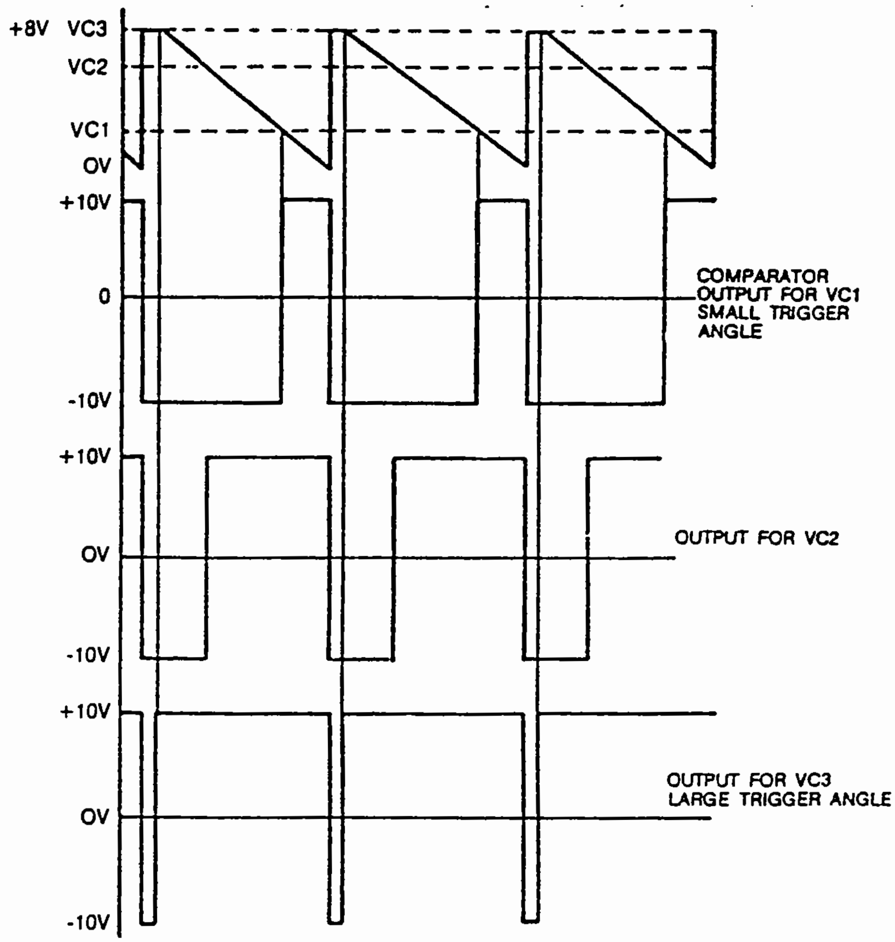


Fig. 9 Output Wave Form of Comparator Circuit

As can be seen from *Figure 9* , the output waveform of the comparator circuit adances to the left as the control signal VC increase from zero to 10 volts.

The monostable circuit comprising transistor *AT1* and associated circuitry, limits the output pulse width of the comparator after *R7* to 450 uSec.

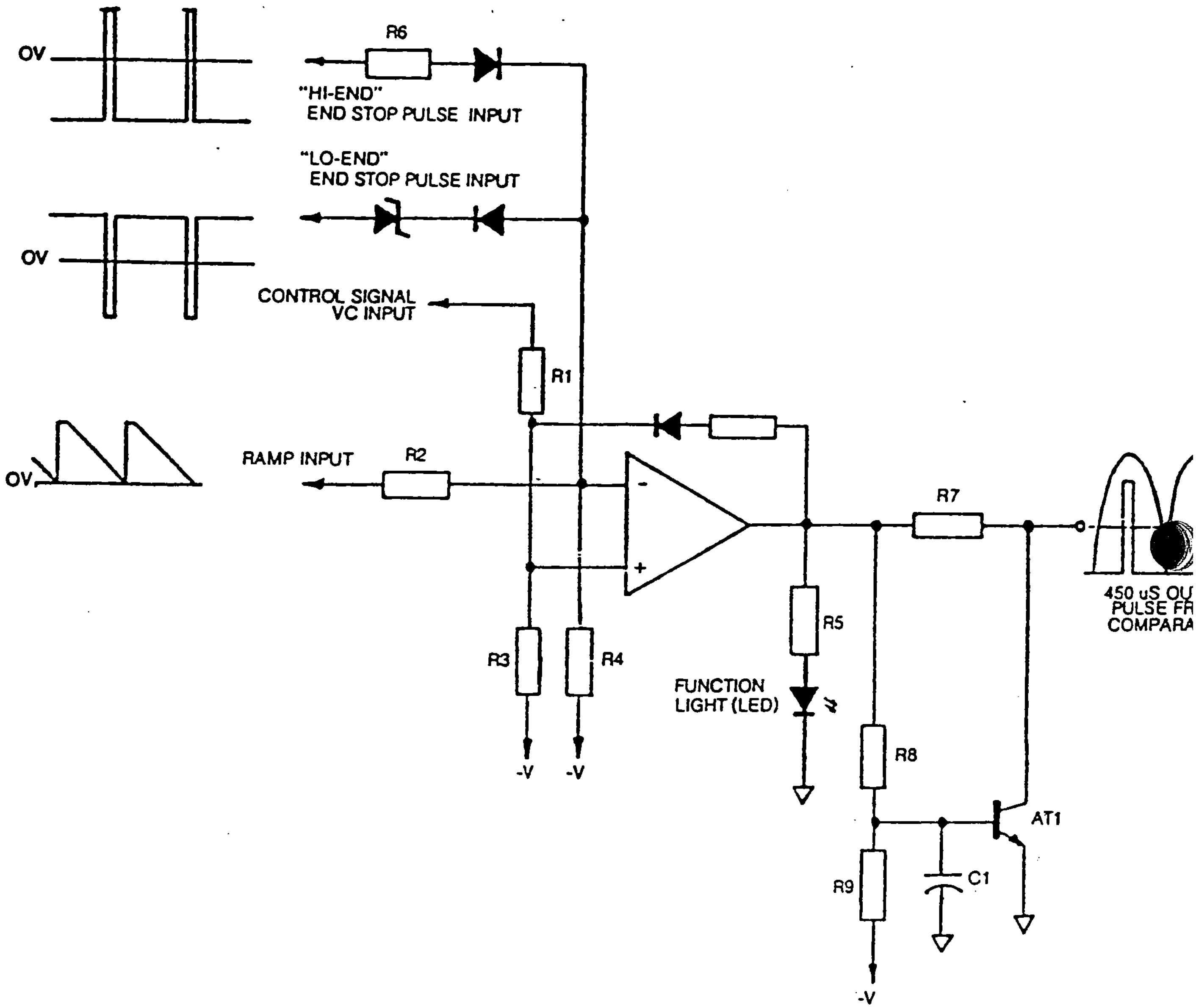


Fig. 10 Simplified Diagram of Comparator Circuit

3.7.4 Pulse Amplifier Circuit

The *Pulse Amplifier* is driven by the output of the *Comparator* circuit.

Together with associated circuitry, the pulse amplifier forms a monostable circuit, having a fixed pulse width regardless of duration of the input signal.

Provision is made for *Cross-Coupling* of one amplifier to another by means of diode logic. This is essential for *Full-Bridge* power control.

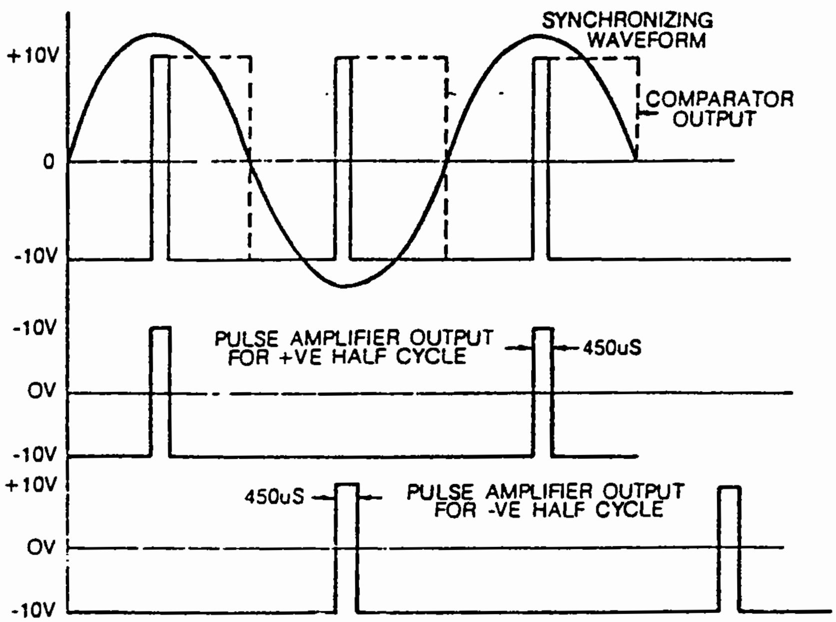


Fig. 11 Illustrates the Waveforms from the Pulse Amplifier

As can be seen from the above diagrams, each PULSE AMPLIFIER is "Gated" so that it will function for one half cycle only.

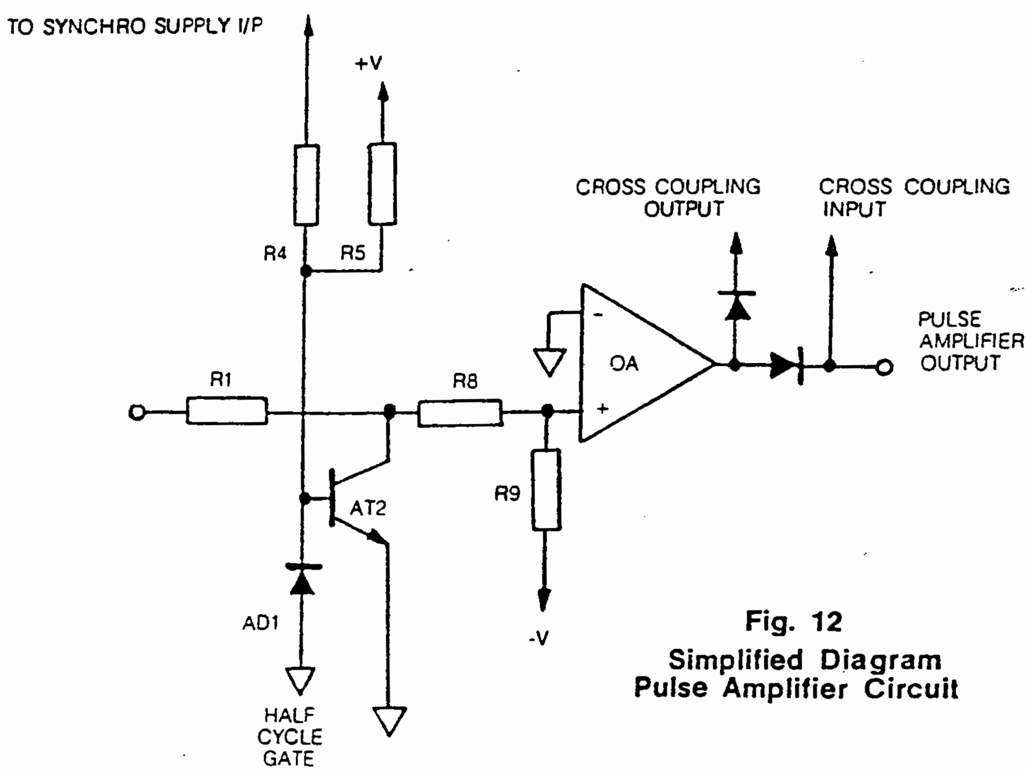


Fig. 12
Simplified Diagram
Pulse Amplifier Circuit

3.7.5 Pulse Transformer Output Circuits

The output from the *Pulse Amplifier* is fed into the *Pulse Transformer* circuit, together with a cross-coupled pulse from one of the pre-arranged *Pulse Amplifiers*.

The output pulse waveforms are shown in *Figure 13* below.

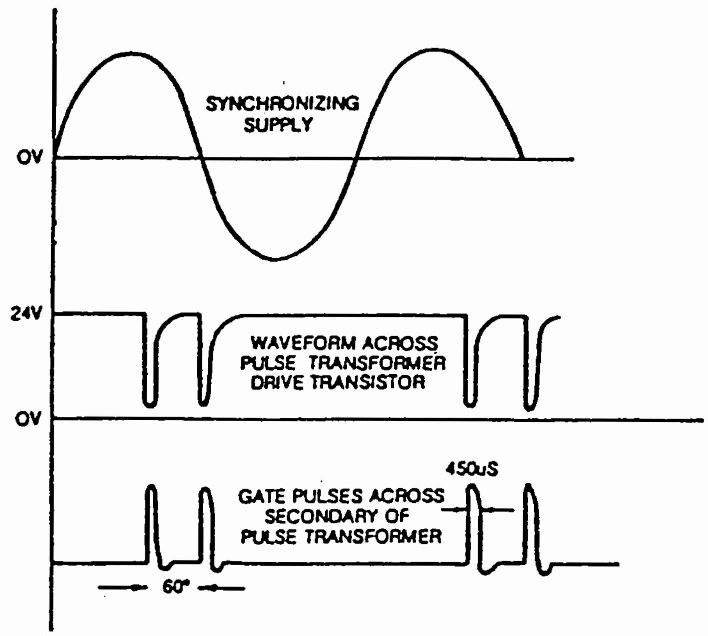


Fig. 13 Output Waveforms of Pulse Transformer Circuit

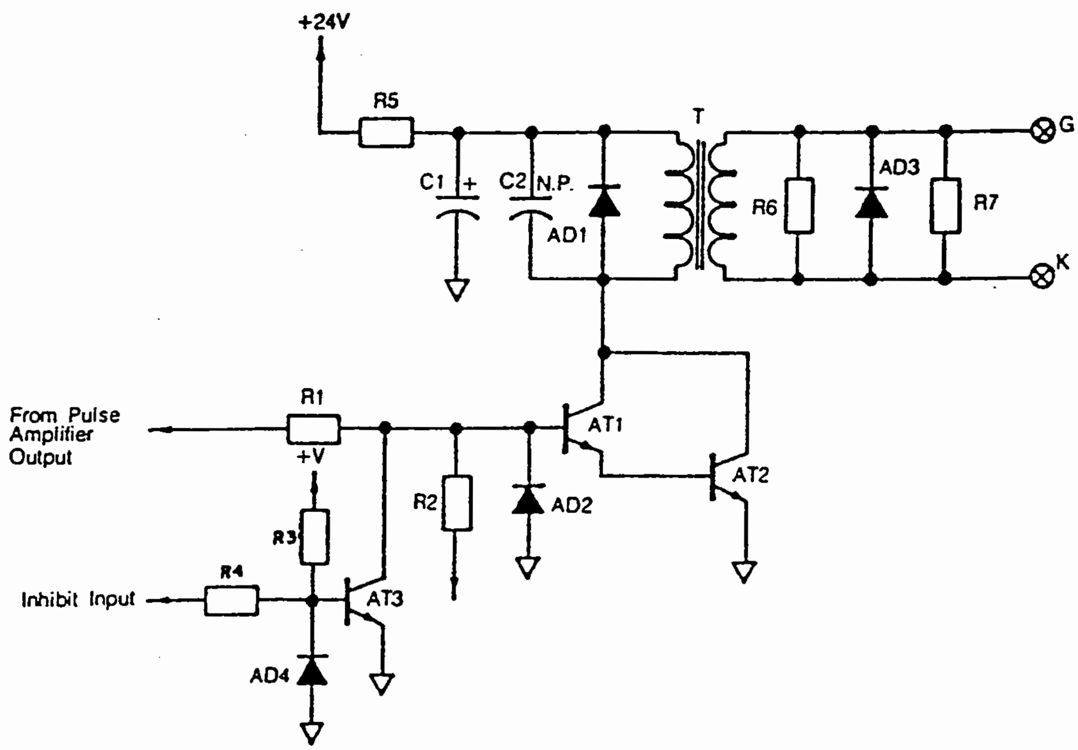


Fig. 14 Simplified Diagram of Pulse Transformer Circuit

The *Pulse Transformer* circuit consists of pulse transformer *T* driven by the Darlington transistor pair *AT1* and *AT2*.

The 450u sec pulse from the pulse amplifier is fed via *R1* to the base of *AT1*, which saturates the Darlington pair, and the resulting pulse is transferred via *T* to the gate-cathode outputs *G* & *K*.

The *Inhibit* input to transistor *AT3* ensures the correct pulse function to the Darlington Transistor pair *AT1* - *AT2*.

4. TROUBLESHOOTING

4.1 COMMON CAUSES OF DRIVE MALFUNCTION

The three most frequent causes of a drive system or major components malfunctioning are:

a) Fuse failure.

b) Discontinuity in a circuit, caused by a broken or loose connection in the wiring.

c) Circuit grounding, caused by faulty or damaged insulation on wiring or a loose component coming in contact with ground.

If a drive or major component, that has been operating properly, suddenly malfunctions, DO NOT make any adjustments or replace any components without first checking:

a) For blown fuses.

b) All wiring for breaks.

c) All wires for faulty or damaged insulation.

d) For any loose connections.

If, after making the above checks, trouble is still encountered, refer to the following test procedures.

4.2 METERING

Generally, a multi-meter and oscilloscope are the only instruments required to make tests. The multi-meters commonly used for electrical maintenance, having a sensitivity of 100 ohms per volt on AC or 10,000 ohms per volt on DC, or more, are satisfactory for all tests given.

WARNING

Do not use the ohmmeter section of the multi-meter to check transistors or associated circuitry unless called for by instructions in this manual or any other instructions supplied with the drive or component. Never use a megger to check control circuitry or any of its associated components.

Table 5 lists possible malfunctions and their probable cause. This table may be used to determine which of the major components of the drive is most likely defective.

TROUBLESHOOTING . . .

Symptom	Probable Cause
Contactor will not energize when start button is depressed.	1. Overload relay tripped. 2. No control power. Check for 120 VAC 3. Faulty or improper wiring between drive cabinet and operator's control station. 4. Faulty relay. 5. Open contactor coil. 6. Blown fuse. 7. Field Loss relay (FLR).
Output voltage does not increase as speed pot is turned up.	1. Improper or defective wiring between drive cabinet and speed pot. 2. Defective speed pot. 3. Defective controller *AA1200 or AA1200 MB*
Drive unstable.	1. Speed/Current stability pots incorrectly set. 2. Motor series field connected backward. 3. Defective control card *AA1200 or AA1200 MB*
Speed drift or poor regulation.	1. Current limit setting too low. 2. Motor overloaded. 3. Defective control card *AA1200 or AA1200 MB*
Low maximum speed.	1. Current limit set too low. 2. Motor overloaded. 3. Max. speed pot not adjusted. 4. Defective cable between *AA1200 or AA1200 MB* 5. Bad SCR.
Circuit breaker trip (If CB is supplied).	1. Current limit set too high. 2. Feedback resistor *R1* or *R2* incorrect. 3. Ground in motor armature or field. 4. Defective SCR.
AC Line fuse/fuses blown.	1. Shorted or grounded DC output wiring. 2. Grounded motor armature or field. 3. Shorted motor field.
Control circuit fuse blows.	1. Defective wiring or component contacting ground or other circuits. 2. Shorted relay or contactor coil.

4.3 POWER MODULE TESTING

Disconnect the motor armature and field leads from the drive.

Connect four 100 watt, 115V light bulbs in series across the SCR bridge DC bus.

Apply power to the drive.

A) If fuses blow immediately, the problem is one of the following:

a) Shorted or grounded wiring between the fuses and SCR bridge.
b) Shorted or grounded wiring of components within the SCR bridge.

B) If the fuses do not blow, but the light bulbs glow, the problem is a shorted thyristor (controlled rectifier) or one or more thyristors acting as diode rectifiers (Refer to Section 4.4, on Rectifier Testing).

C) If items *A* or *B* do not occur, do the following:

Measure the DC voltage between the SCR bridge DC buses. This voltage should be less than 5V. If it is greater than 5V there is a thyristor with a high leakage current or defective suppression component.
The defective component can be located by disconnecting components within the SCR bridge, (with power off), until the voltage across the DC bus falls below 5V, (with power on).

D) Apply power to the drive. If more than 5V is measured across the SCR bridge DC buses, the control card *AA1200* or AA1200-MB is most likely faulty.

4.4 RECTIFIER TESTING

4.4.1 Silicon Rectifiers

Diodes (uncontrolled rectifiers) and thyristors (controlled rectifiers) are the two types of silicon rectifiers used in the solid state power conversion section of this drive.
When abused, these devices usually fail completely open or completely shorted. A shorted rectifier is evidenced by the operation of protective devices (circuit breaker or fuses). An open rectifier will cause a reduction in the maximum DC output voltage.

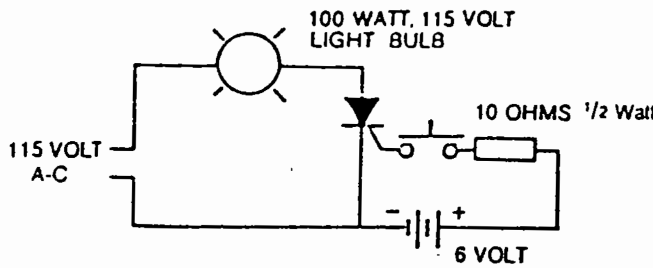
4.4.2 Silicon Diodes

These can be tested in the circuit by disconnecting one lead or unplugging the diode assembly and checking with an ohmmeter set on the high ohms scale (R x 1000 or more). The test is performed by readings taken with the ohmmeter leads connected across the diode in the forward and reverse direction. This means that the positive lead of the ohmmeter will be connected to first one side of the diode, and then to the opposite side. Comparison of the readings will indicate the condition of the diode. That is, with the leads connected in one direction, the reading should be very low. With the leads in the other direction, the readings should be high. If both readings are low, the diode is shorted. If both readings are high, the diode is open.

4.4.3 Thyristors (SCR's)

Controlled rectifiers should measure high resistance in both the forward and reverse directions. (100K ohms or more). Conected in the circuit may measure 30K or more.

The circuit below can be used to test the gating ability of the thyristor.



If the lamp is out with power applied, but lights when the pushbutton is depressed, the thyristor is good.

4.5 COMPONENT TESTING

The following gives recommended procedures for testing individual quick change type components and quick change circuits. Quick change components or circuits are defined as those which are readily removed (plug-in, clipped-in, or use screw-on or plug-in type terminals), as opposed to those which are soldered in the circuit.

NOTE: *Test procedures for such items as transistors are not given, since testing these devices requires test instruments and techniques not available to most users.*

Unless stated otherwise, the drive should be disconnected from all input power (all power off) when performing the following component tests.

4.5.1 Resistors *(Fixed, adjustable, rheostats and potentiometers)*

Fixed resistors can be checked for continuity (burn-out and ohmic value) without removing from the circuit by disconnecting one of its leads and checking across it with an ohmmeter. To check adjustable resistors without removing from the circuit, disconnect the leads to one side and to the slider or tap and check it with an ohmmeter. Rheostats and potentiometers can be checked by continuity and ohmic value by disconnecting all but one lead to its terminals and checking it with an ohmmeter.

4.5.2 Transformers can be checked for continuity or short circuits *(Input Power must be "ON")* by observing the voltage across each of their windings.

4.5.3 Switches and Circuit Breakers can best be checked for mechanical operation by visual inspection. The contacts in the switches and circuit breakers can also be checked for continuity.

4.5.4 Relays, Magnetic Contactors, etc. can be checked for proper operation by visual inspection. Two methods of checking the coils in relays and other magnetic contactors for shorts or opens are:

a) Ohmmeter test: Disconnect one of the leads to the coil and check across the coil terminals with an ohmmeter.

NOTE: *This method is generally limited to coils for which the ohmic value is known.*

b) Voltage test: **Warning:** This test must be made with the *Power On.* Check the voltage at the terminals of the relay coil. If the voltage is correct and the relay is inoperative, the relay coil has probably failed. The contacts in relays and magnetic contactors can also be checked for continuity.

4.5.5 Capacitors can be checked with an ohmmeter. First, remove one lead of the capacitor from the circuit. Next, discharge the capacitor by shorting its terminals. Set the ohmmeter to 10,000 ohms (or more) scale and connect it across the capacitor under test. A good capacitor will cause the ohmmeter needle to momentarily move toward zero when the leads are first connected. Then the needle should move toward the maximum end of the scale. An open capacitor will cause the needle to remain at maximum. A shorted capacitor will give a fixed resistance reading. Although this test is not 100% accurate, it will detect most defective capacitors.

4.5.6 A1200R Card Testing

Refer to page 43 and 44 for LED function to locate faults on the *AA1200* card. Because of the complexity of this card, repairing is not recommended.

AA1200 CONTROL CARD
Light Emitting Diode (LED) Diagnostic Identification

State of LED's when power applied

0 LED Off
◐ LED Dim
● LED Bright

Ø 1 GN ◐
Ø 2 GN ◐ FWD Bridge (BR 1)
Ø 3 GN ◐

Ø 4 Red ◐
Ø 5 Red ◐ REV Bridge (BR II)
Ø 6 Red ◐

B I 0 ● B II (1)

↓May be ON or OFF

-V	R	+D	-D	TF
●	0	0	0	0

TR	OS	LV	Ø	+V
●	0	●	●	●

Sate of LED's when
Start PB Activated
and Control is in Forward Direction (2)

(No tach Feedback)

Ø 1 ●
Ø 2 ●
Ø 3 ●
0 4 ◐
0 5 ◐
Ø 6 ◐

B I ● 0 B II

-V	R	+D	-D	TF
●	●	◐	0	0

TR	OS	LV	Ø	+V
●	0	●	●	●

1. Either BI or B II, but not both will be on.
2. When in Reverse Mode LED's will be as follows:

01, 02, 03	DIM	B II	ON
03, 04, 05	HALF BRIGHT	+D	OFF
B I	OFF	-D	ON

With tach feedback:

-V	R	+D	-D	TF
●	●	○	0	●

Control Forward (B I is on)

TR	OS	LV	0	+V
●	●	●	●	●

5. DC12 SPARES

These parts listed below are common for all drives.

PART NUMBER	DESCRIPTION	RECOMMENDED QUANTITY
AA1200	Control Card	1
A340003	240V AA1200MB Mother Board	1
A340004	480V AA1200MB Mother Board	1
K340003	24V DC Relays on Mother Board	3
W2600-48	26-way Ribbon Cable	1
T5005-03	Pulse Transformer	1
AA1094-2	SCR Suppression Board	1
	DC12-61	
F60200309	AC Line Fusing	3
N10Sp06A	SCR Module	3
T5004-01	Current Transformer	2
	DC12-126	
F602003-11	AC Line Fusing	3
N10SP06A	SCR Module	3
T5004-01	Current Transformer	2
	DC12-251	
F602003-20	AC Line Fusing	3
N20SP10	SCR Module	3
T5004-01	Current Transformer	2
	DC12-350	
F602003-20	AC Line Fusing	3
NF28452	SCR Module	6
T5003-02	Current Transformer	2
	DC12-500	
F602003-=23	AC Line Fusing	3
NF16452	SCR Module	6
T5003-03	Current Transformer	2
	DC12-800	
F602003-25	AC Linew Fusing	3
NF19122	SCR Module	6
T5003-04	Current Transformer	2

NOTE: *For 600 Volt input drives consult factory.*

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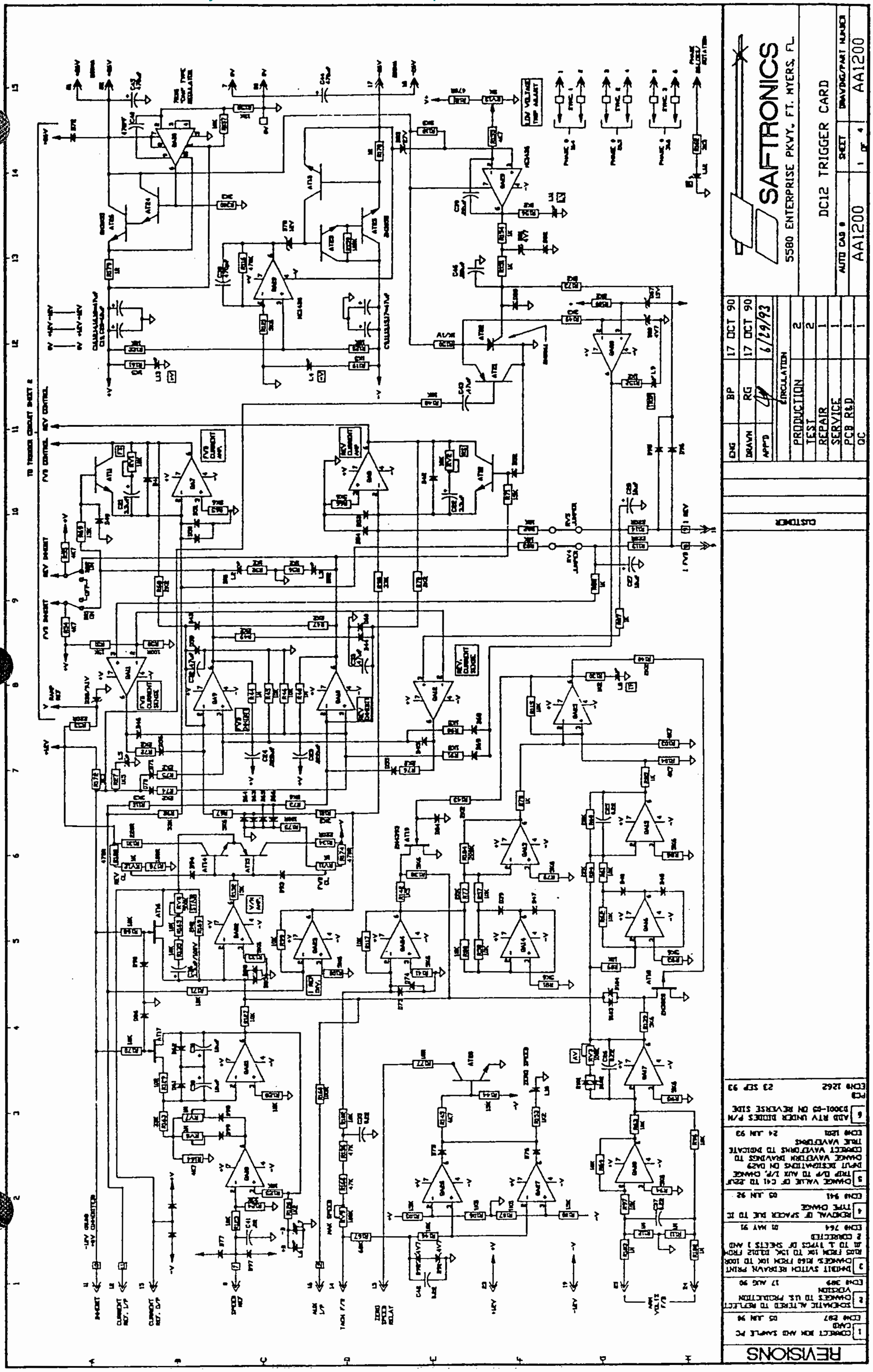
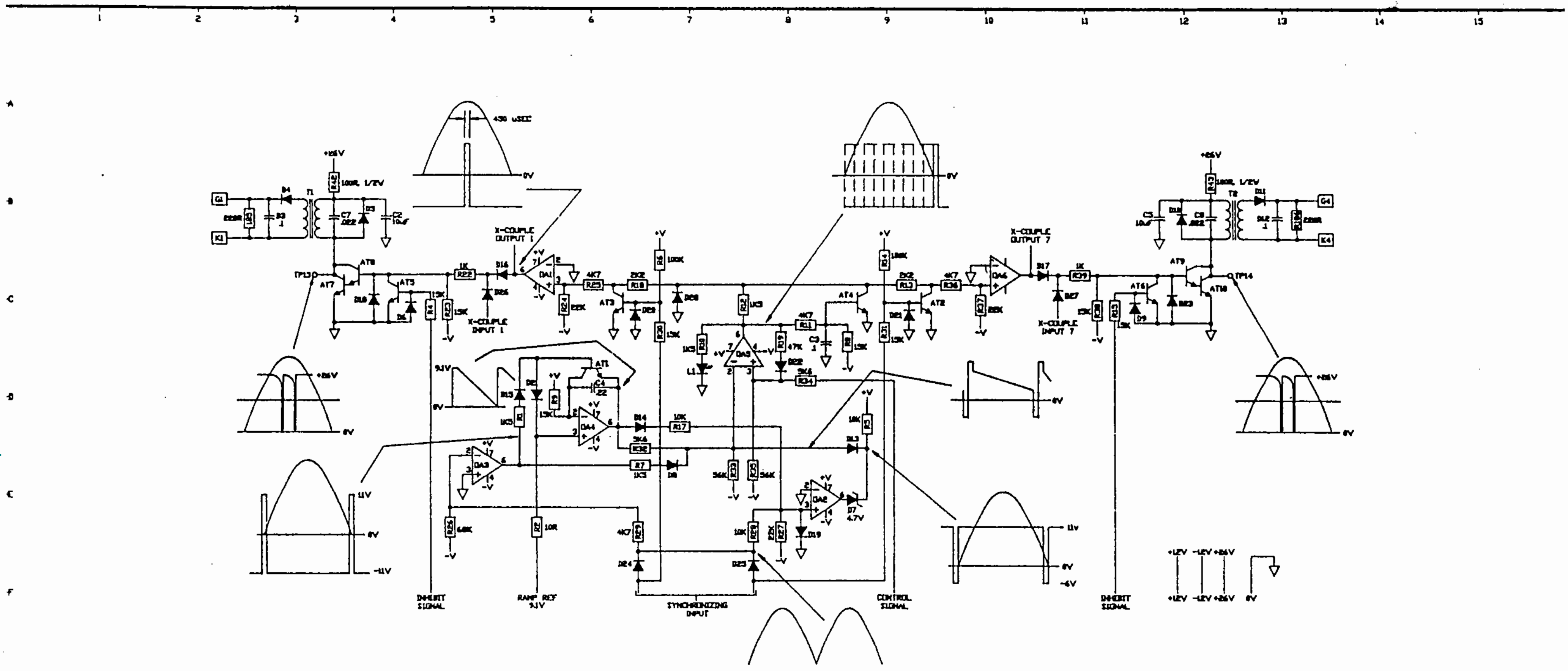
6. INDEX OF DRAWINGS


SAFTRONICS
5580 ENTERPRISE PKWY. FT. MYERS, FL
DC12 TRIGGER CARD
AA1200
SHEET 1 OF 4
REVISIONS
CUSTOMER
CIRCULATION
PRODUCTION
TEST
REPAIR
SERVICE
PCB R&D
QC



TRIGGER CIRCUITS A,B,C,D,E,F AS ABOVE

REVISIONS

CUSTOMER

ENG	BP	17 OCT 90
DRAWN	RG	17 OCT 90
APP'D		6/29/93
CIRCULATION		
PRODUCTION		2
TEST		2
REPAIR		2
SERVICE		1
PCB R&D		1
QC		1

SAFTRONICS
5580 ENTERPRISE PKWY. FT. MYERS, FL.

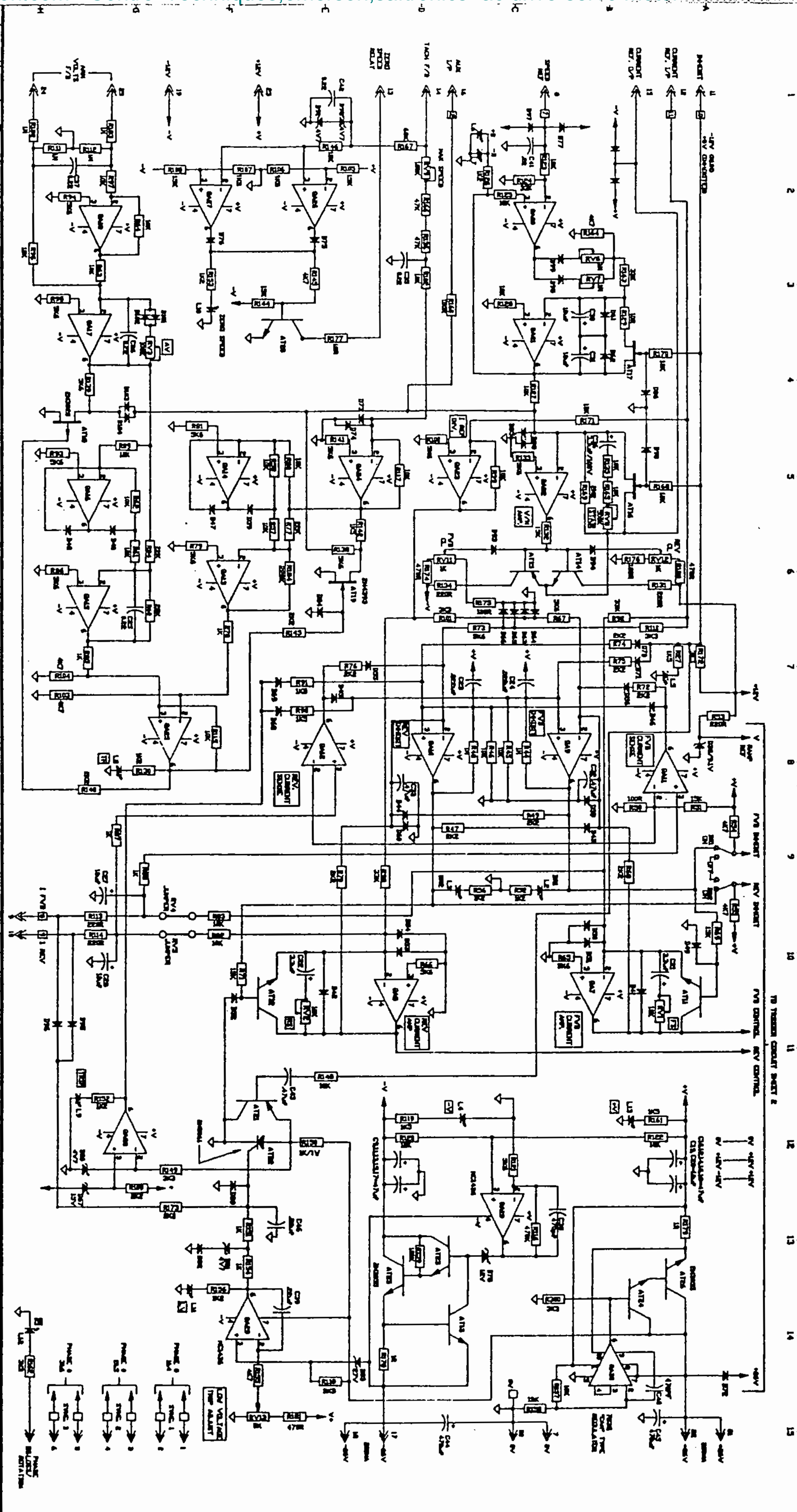
DC12 TRIGGER CARD

AUTO CAD #	SHEET	DRAWING/PART NUMBER
AA12002	2	AA1200

REVISIONS

1	CORRECT BOX AND SAMPLE PC CARD ECN# 297	05 JUN 90
2	SCHEMATIC ALTERED TO REFLECT CHANGES TO U.S. PRODUCTION VERSION ECN# 309	17 AUG 90
3	INHIBIT SWITCH REDRAWN, PRINT CHANGES: R160 FROM 10K TO 100R, R105 FROM 10K TO 15K, D3,D12 FROM ⊥ TO ⊥ TYPES OF SHEETS 1 AND 2 CORRECTED ECN# 764	01 MAY 91
4	REMOVAL OF SPACER DUE TO IC TYPE CHANGE ECN# 941	05 JUN 92
5	CHANGE VALUE OF C41 TO .22UF TRIP O/P TO AUX I/P, CHANGE INPUT DESIGNATIONS ON DA29 CHANGE WAVEFORM DRAWINGS TO CORRECT WAVEFORMS TO INDICATE TRUE WAVEFORMS ECN# 1251	24 JUN 93
6	ADD RTV UNDER DIODES P/N D3001-05 ON REVERSE SIDE PCB ECN# 1262	23 SEP 93

CUSTOMER



ENG	BP	17 OCT 90
DRAWN	RG	17 OCT 90
APPD		6/29/93

CIRCULATION

PRODUCTION	2
TEST	2
REPAIR	1
SERVICE	1
PCB R&D	1
QC	1

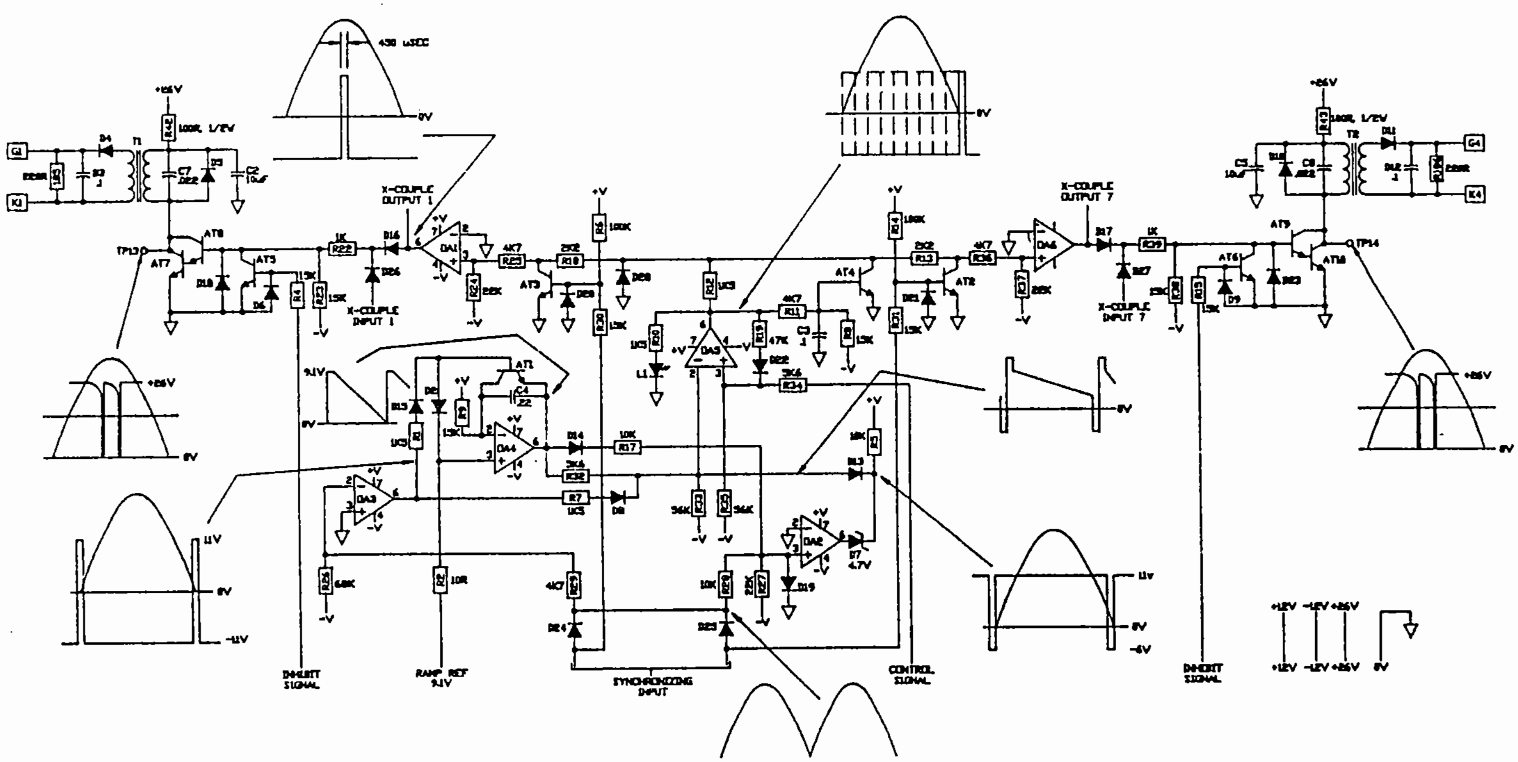
SAFTRONICS
5580 ENTERPRISE PKWY. FT. MYERS, FL.

DC12 TRIGGER CARD

AUTO CAD # AA1200

SHEET 1 OF 4

DRWG/PART NUMBER AA1200



TRIGGER CIRCUITS A,B,C,D,E,F AS ABOVE

REVISIONS

CUSTOMER

ENG	BP	17 OCT 90
DRAWN	RG	17 OCT 90
APP'D		6/29/93

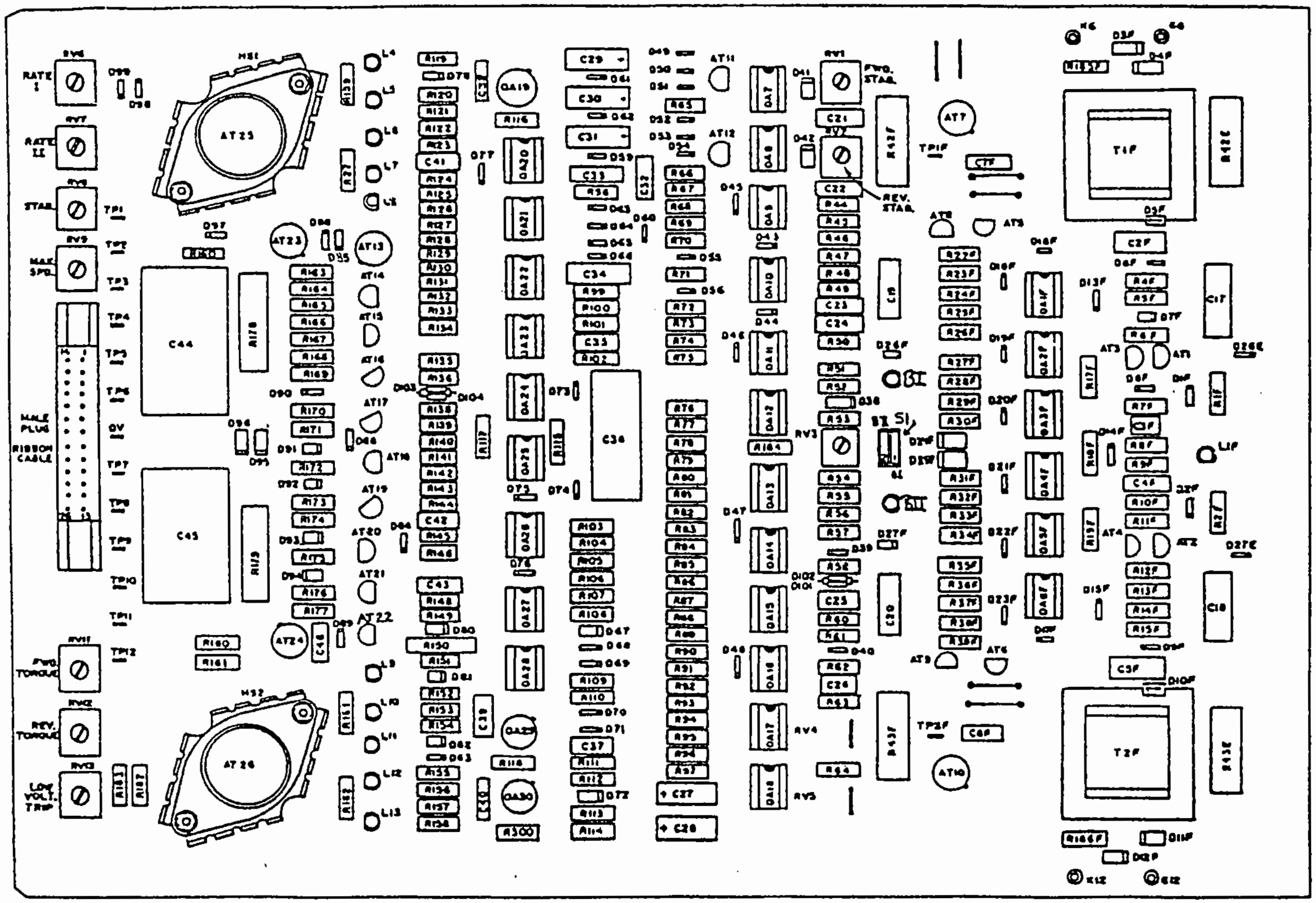
CIRCULATION	
PRODUCTION	2
TEST	2
REPAIR	2
SERVICE	1
PCB R&D	1
QC	1

SAFTRONICS

5580 ENTERPRISE PKWY, FT. MYERS, FL.

DC12 TRIGGER CARD

AUTO CAD #	SHEET	DRAWING/PART NUMBER
AA12002	2 OF 4	AA1200



ENG	BP	28 AUG 90
DRAWN	RG	28 AUG 90
APP'D		3 MAY 91

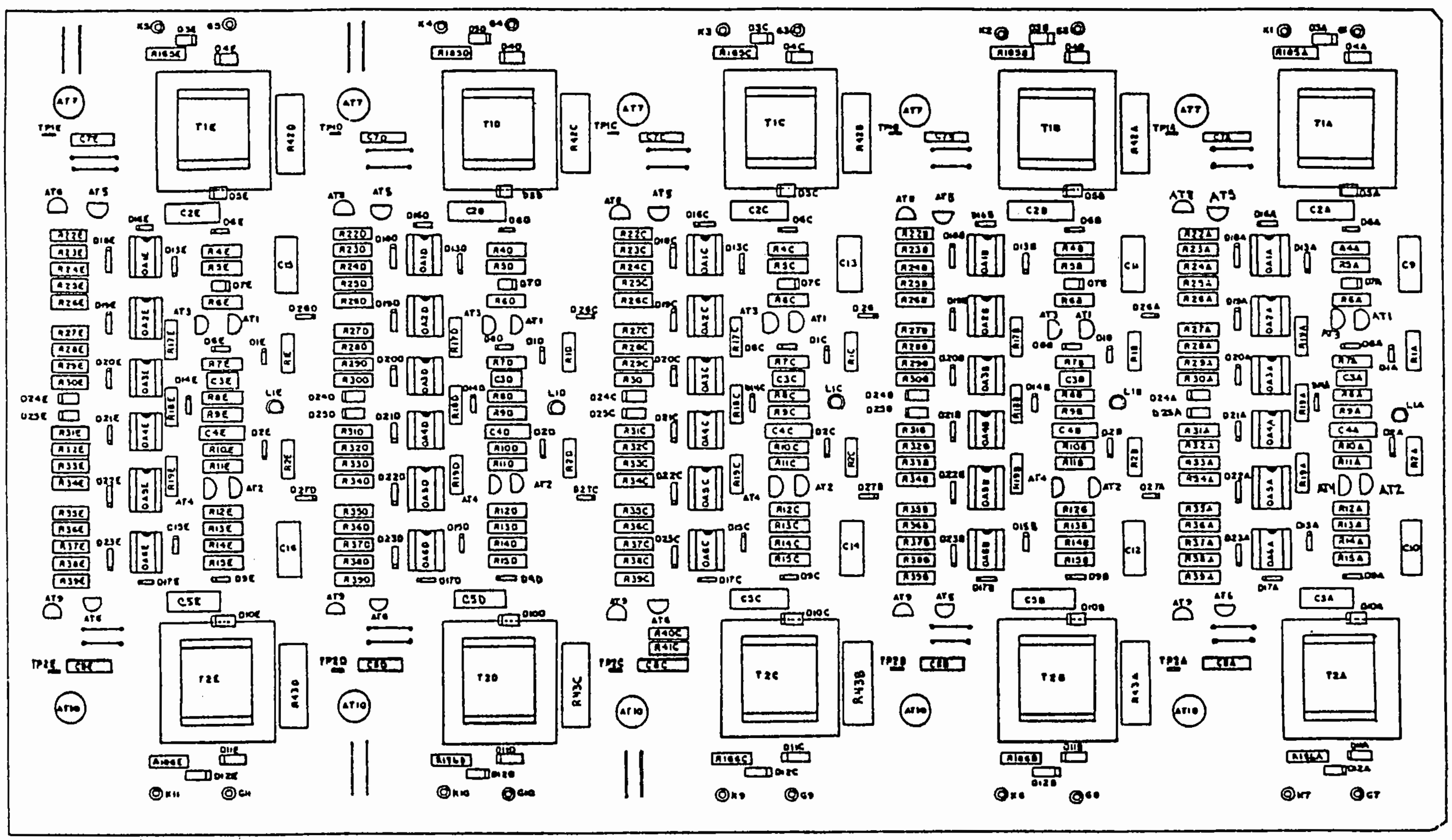
CIRCULATION

PRESIDENT	2
PRODUCTION	2
TEST	2
REPAIR	1
SERVICE	1
QC	1

SAFTRONICS
5580 ENTERPRISE PKWY. FT. MYERS, FL

DC12 TRIGGER CARD

SHEET	DRAWING/PART NUMBER
3 OF 4	AA1200



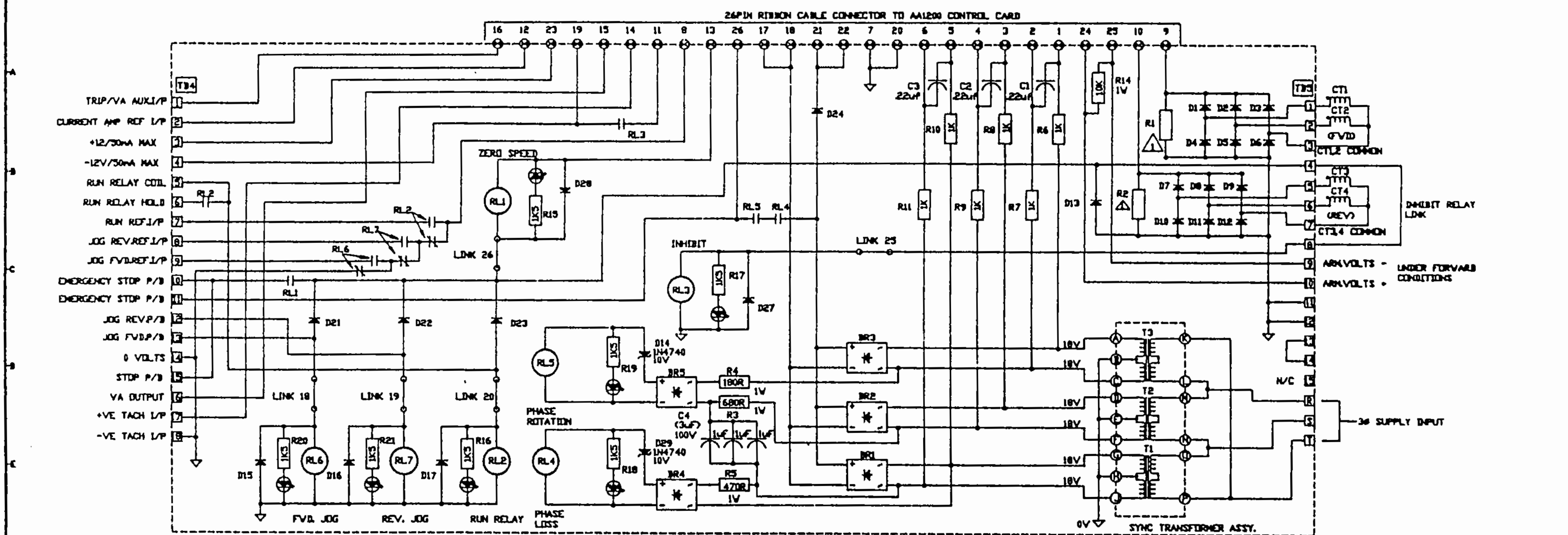
ENG	BP	28 AUG 90
DRAWN	RG	28 AUG 90
APP'D	[illegible]	3 MAY 91
CIRCULATION		
PRESIDENT		2
PRODUCTION		2
TEST		2
REPAIR		1
SERVICE		1
QC		1

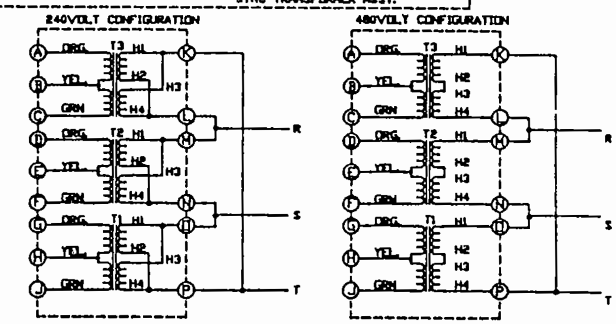
SAFTRONICS

5580 ENTERPRISE PKWY. FT. MYERS, FL

DC12 TRIGGER CARD

ACAD #	SHEET	DRAWING/PART NUMBER
AA1200H	4 OF 4	AA1200





HORSEPOWER	480VAC RL R2 OHM 3V	480VAC CT1-4	240VAC RL R2 OHM 3V	240VAC CT1-4
5	300	1500:1 T261122	150	1500:1 T261122
7.5	200		100	
10	150		68	
15	100		47	
20	75		35	
25	56		27	
30	50		25	
40	39		30	2500:1 T262320
50	30		25	
60	25		20	
75	20		15	
100	27	2500:1 T262320	12	
125	20		20	5000:1 T265320
150	18		15	
200	12			
250	22	5000:1 T265320		
300	18			
400	22	8500:1 T268320		
500	18			
600	15			
700	12			
800	12			

NOTE:

⚠ RL R2 (BURDEN RESISTORS) VALUE CAN BE DERIVED FROM HORSEPOWER CHART OR BY UTILIZING THE FOLLOWING FORMULA

$$\frac{2.6 \times \text{C/T RATIO}}{1.5 \times \text{FLA}} = \text{BURDEN RES.}$$

ALL DIODES ARE 1N4007 UNLESS OTHERWISE NOTED

REVISIONS

1	CHANGE QTY OF 1uF CAP P/N C5004-22 FROM 1 TO 3	ECN# 403	30 AUG 90
	SCHEMATIC REDRAWN. SHEETS 3 & 4 NOW INCLUDED ON 1		01 JUN 91
2	CHANGE RELAY USED FROM P/N K340004 TO K340003 VALUE SAME, DIFFERENT MANUF. REMOVE 1uF CAPS IN PARALLEL WITH RL4 & RL5 OHM VALUES FOR R1 & R2 ON DRAWING TABLE CORRECTED	ECN# 906	17 FEB 92
3	ADD BURDEN RES CAUTION LABEL P/N X6406-02 LOCATE IMMEDIATELY TO RIGHT OF BURDEN RESISTOR	ECN# 973	11 SEP 92
4	CHANGE D14 & D19 FROM 12V ZENER TO 10V ZENER	ECN# 1185	09 JUN 93
5	ADD HARDWIRE JUMPER FROM TERMINAL 14-TB4 TO THRU HOLE POINT ON COMMON RAILBY RIBBON HEADER. NO CHANGE TO DRAWING OR BOM.	ECN# 1197	22 JUN 93

CUSTOMER

ENG		
DRAWN	RG	01 JUN 91
APP'D		

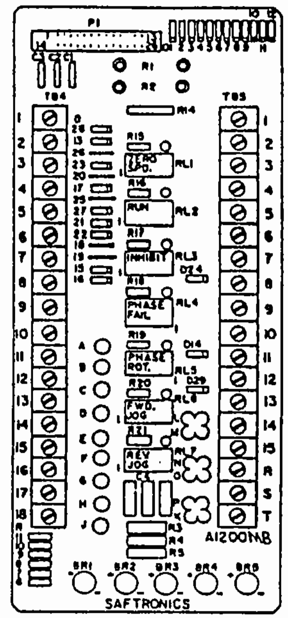
CIRCULATION	
PRODUCTION	2
TEST	2
REPAIR	2
SERVICE	1
PCB R&D	1
QC	1

SAFTRONICS
5580 ENTERPRISE PKWY, FT. MYERS, FL.

DC12 MOTHERBOARD SCHEMATIC

AUTO CAD #	SHEET	DRAWING/PART NUMBER
AA1200MB	1 OF 2	AA1200MB

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16



REV

ENG	B.P	04'SEP'90	SAFTRONICS
DRAWN	R.G	04'SEP'90	5580 ENTERPRISE PKWY, FT. MYERS, FL
TEST		/ /	TITLE
QC		/ /	DC12 MOTHER BOARD
APP'D		/ /	
INPUT		/ /	

CUSTOMER	PO Nº	SIZE	JOB Nº	SHEET Nº	DRAWING/ASSEMBLY Nº
		B		2 of 2	AA1200MB

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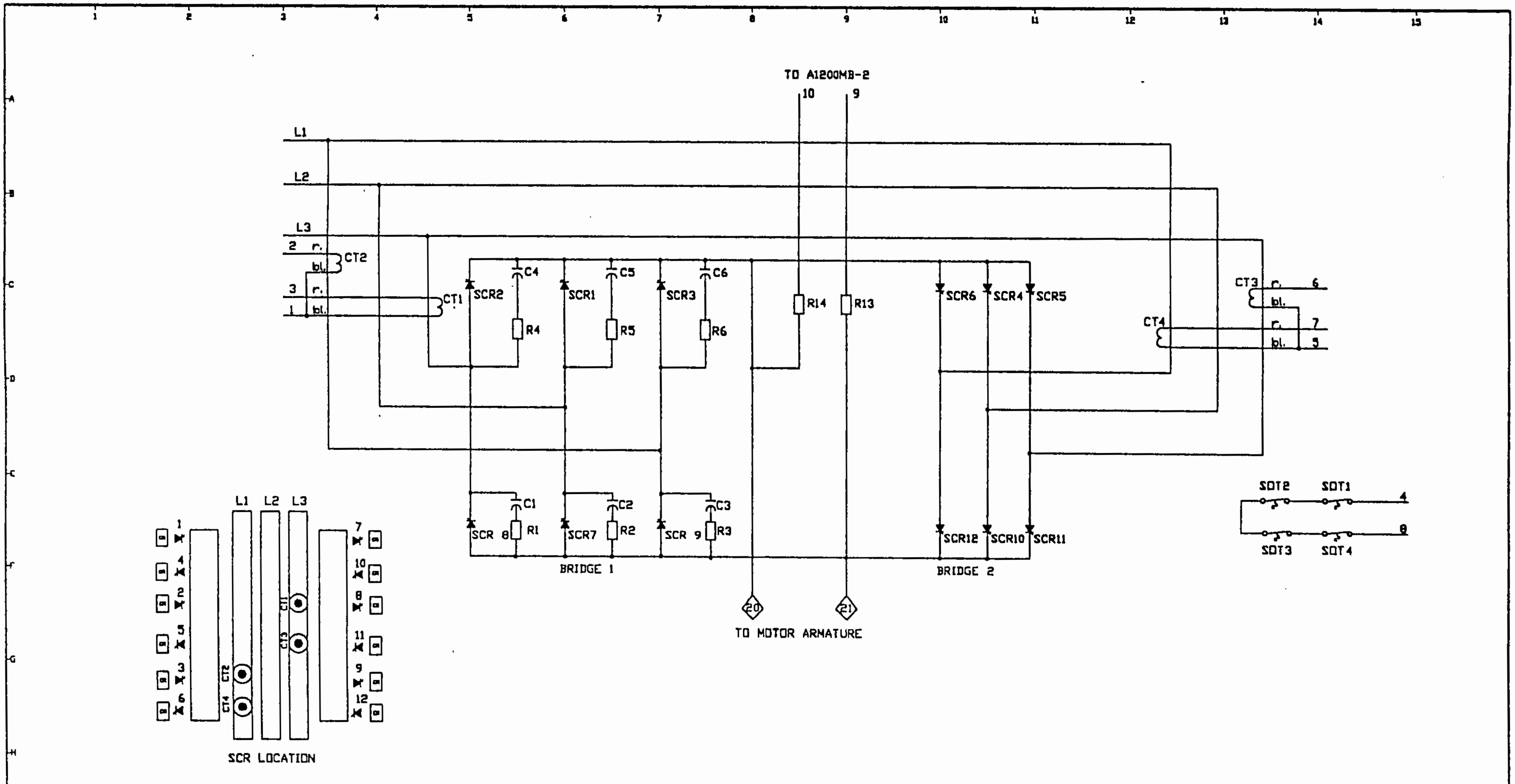


REVISIONS

ENG		
DRAWN		15 NOV 94
APP'D		

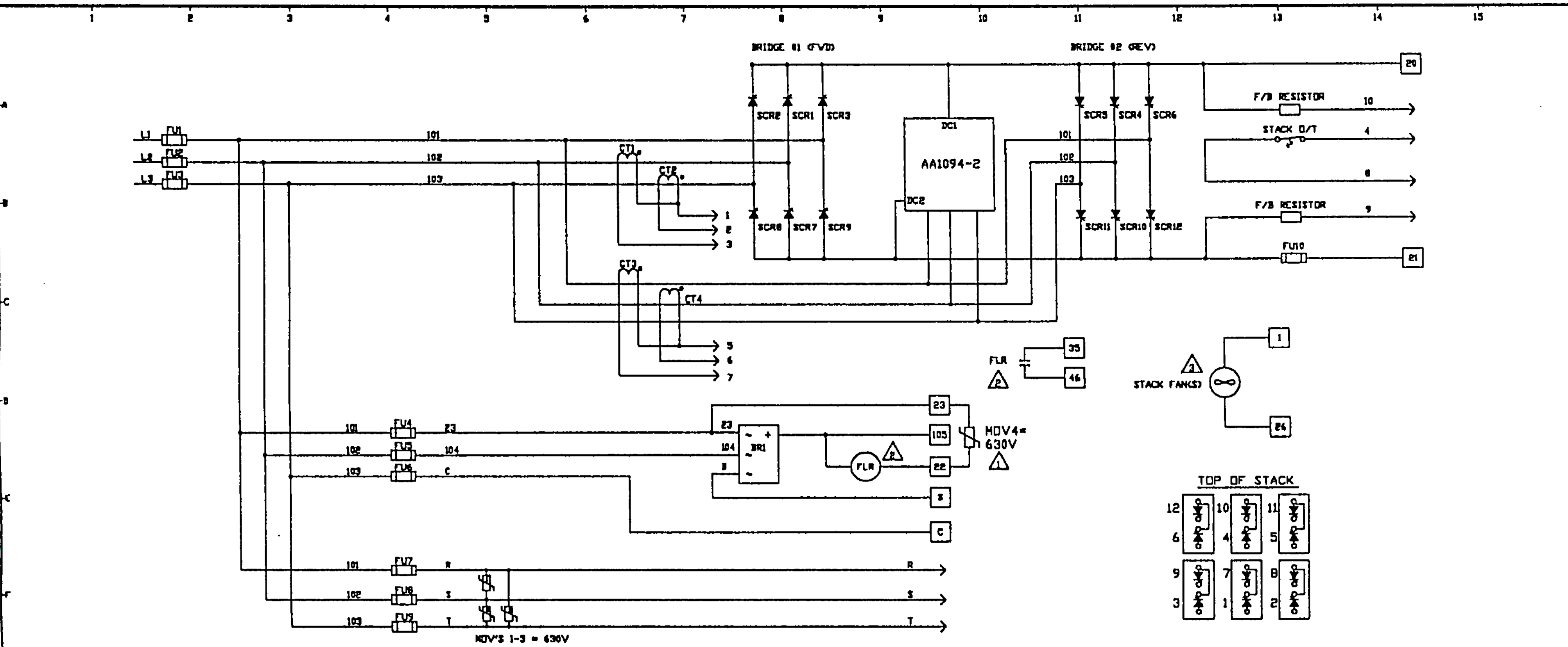
CUSTOMER

CIRCULATION

SAFTRONICS
SOLID STATE MOTOR CONTROLS

DC12-350/1500 STACKS
WIRING DIAGRAM

AUTO CAD #	SHEET	DRAWING/PART NUMBER
DC12-500.DWG	OF	



DC12 POWER STACK							
PART#	MODEL#	CT'S 1-4	SCR's1-6	FU1-3 & FU10	FU4-6	FU7-9	FDBK RES 5W
A120022	DC12-61-4	1500:1	N105P06	100A,500V	10A,500V	3A,500V	20K OHM
A120024	DC12-126-4	1500:1	N105P06	150A,500V	10A,500V	3A,500V	20K OHM
A120026	DC12-251-4	2500:1	N205P10	400A,500V	10A,500V	3A,500V	20K OHM
A120021	DC12-61-2	1500:1	N105P06	100A,500V	10A,250V	6A,250V	15K OHM
A120023	DC12-126-2	1500:1	N105P06	150A,500V	10A,250V	6A,250V	15K OHM
A120025	DC12-251-2	2500:1	N205P10	400A,500V	10A,250V	6A,250V	15K OHM

NOTE:

1. MOV4 LOCATED INSIDE STACK FOR CUSTOMER KIT ONLY.
2. FLR: *NOT SUPPLIED WITH KIT. *MUST BE SELECTED TO MATCH MOTOR SHUNT FIELD CURRENT.
3. FAN QTY. CHANGE WITH MODEL
   DC12-61 NO FAN
   DC12-126 1 FAN
   DC12-251 2 FANS

REVISIONS

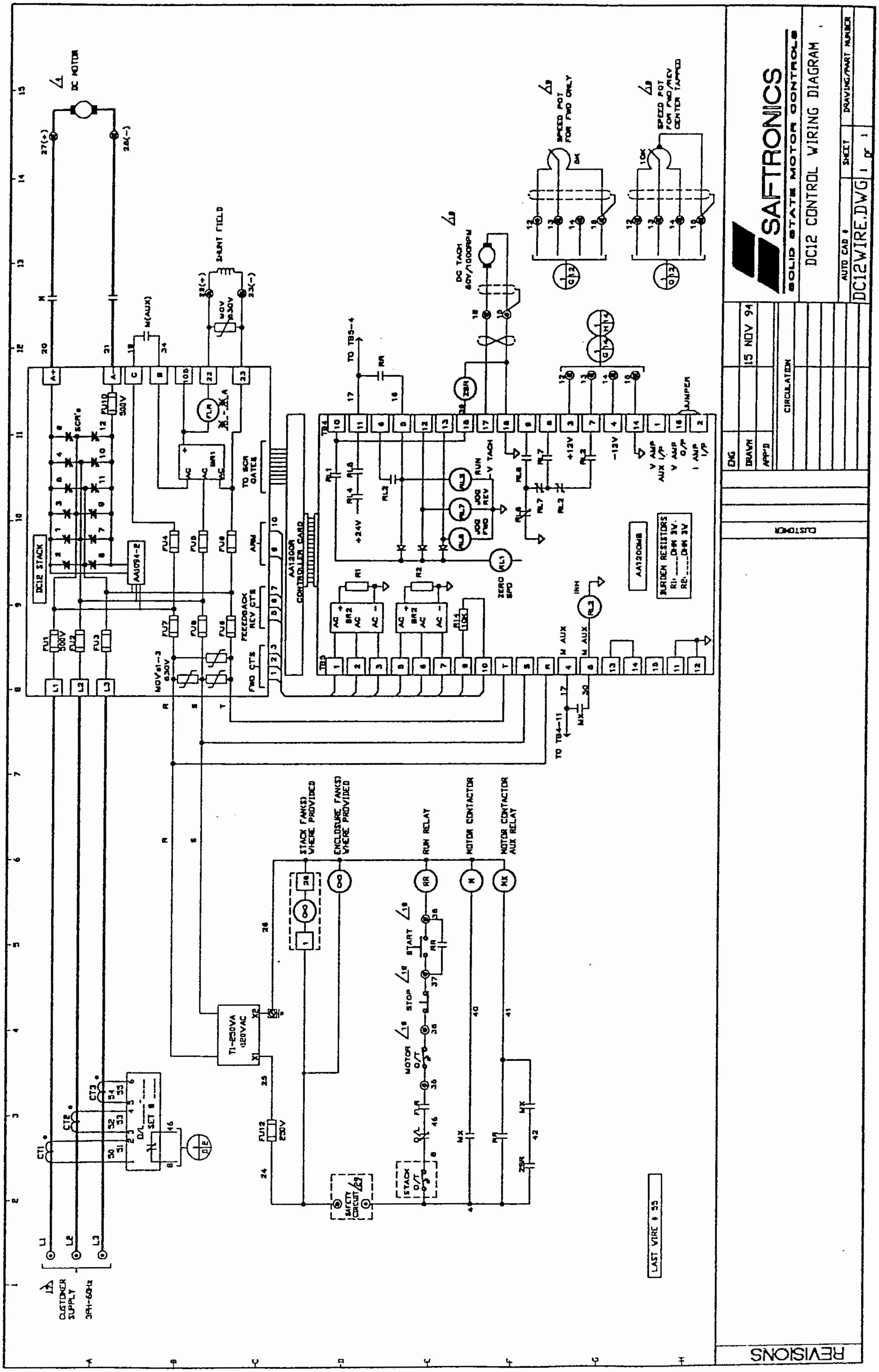
CUSTOMER

ENG		
DRAWN		15 NOV 94
APP'D		
CIRCULATION		

SAFTRONICS
SOLID STATE MOTOR CONTROLS

DC12-61/251 STACKS
WIRING DIAGRAM

AUTO CAD #	SHEET	DRAWING/PART NUMBER
DC12-251.DWG	OF	


SAFTRONICS
SOLID STATE MOTOR CONTROLS
DC12 CONTROL WIRING DIAGRAM
DC12WIRE.DWG
15 NOV 94
CIRCULATION
CUSTOMER
REVISIONS
DC MOTOR
SHUNT FIELD
DC TACH 60V/1000RPM
SPEED POT FOR FWD ONLY
SPEED POT FOR FWD/REV CENTER TAPPED
AA1200R CONTROLLER CARD
DC12 STACK
CUSTOMER SUPPLY 3PH-60Hz
T1-250VA 120VAC
STACK FAN(S) WHERE PROVIDED
ENCLOSURE FAN(S) WHERE PROVIDED
RUN RELAY
MOTOR CONTACTOR
MOTOR CONTACTOR AUX RELAY
LAST WIRE # 55

GROUND LUG
⊙ DENOTES TERMINAL BLOCK
□ DENOTES PC BOARD TERMINAL CONNECTION
⊗ DENOTES INTERNAL CONNECTION
S SOLDER CONNECTION
RIBBON CABLE CONNECTOR
COMMON. Do NOT ground unless fully isolated.
CHASSIS GROUND/EARTH
△ CAUTION. Directly connected to mains supply. DO NOT GROUND.
△ SAFE. Impedance isolated but DO NOT GROUND.
□ SAFE. Fully isolated. Goundable.

1. NOT SUPPLIED ON CHASSIS FORMAT
2. NOT SUPPLIED
3. SUPPLIED ON CHASSIS FORMAT
4. OPTIONAL
5. REPLACE WITH JUMPER
6. ADD APPROPIATE JUMPERS FOR 120VAC OR 240VAC.
7. MOUNTED ON FACE PLATE.

10. WARNING! THIS EQUIPMENT MAT BE AT LINE VOLTAGE EVEN WHEN NOT IN OPERATION. TO AVOID ELECTRIC SHOCK, DISCONNECT ALL AC INPUT POWER BEFORE TOUCHING INTERNAL PARTS.
11. CONNECT AC INPUT TO LINE L1,L2 AND L3 AS SHOWN. IF THE PHASE SEQUENCE INDICATOR DOES NOT LIGHT, INTERCHANGE L1 AND L3 CONNECTIONS.
12. SHUNT FIELD CONNECTIONS: LOW VOLTAGE = PARALLEL F1 & F3 WITH F2 & F4 HIGH VOLTAGE = SERIES F2 & F3
13. SERIES FIELD MUST BE AIDING SHUNT FIELD. ON REGENERATIVE APPLICATIONS, SERIES FIELD MAY BE DISCONNECTED.
15. USE TWISTED CONDUCTOR SHIELDED CABLE. THIS CABLE MUST BE IN A SEPERATE CONDUIT. IT CANNOT BE RUN WITH OTHER CONDUCTORS OR CABLES. SHIELDS MUST BE CONNECTED TO SIGNAL COMMON IN THE CONTROL CABINET ONLY. INTEGRITY OF THE INSULATION MUST BE MAINTAINED TO AVOID ACCIDENTAL SHIELD GROUNDING.
17. OPTIONAL COMPONENT. IF USED, REMOVE LEAD AND CONNECT COMPONENT PER DASHED LINES.
18. REFER TO TRANSFORMER NAME PLATE FOR CONNECTIONS.
19. CUSTOMER/USER SUPPLIED
20. SEPERATELY MOUNTED - SUPPLIED BY SAFTRONICS.
21. MOUNTED ON CABINET DOOR.
22. MOUNTED IN ENCLOSURE
23. MOUNTED ON REMOTE OPERATOR PANEL.

25. POLARITIES SHOWN MUST BE MAINTAINED.
26. USER'S FUSED SUPPLY
27. SHIPPED LOOSE.
28. ALL AC RELAY COILS SUPRESSED
29. USER SUPPLIED EMERGENCY STOP CIRCUIT.

LOCATION BUBBLE.

SHEET REFERENCE NUMBER.
GRID LOCATION COORDINATES.

COORDINATES:

(6-12E)
Y COORDINATE
X COORDINATE
SHEET REFERNCE NUMBER.

REVISIONS
1 RV	ADDED NOTE # 28	10 SEPT 91
2 RV	ADDED NOTE # 29	11 DEC 91

CUSTOMER

ENG	RV	9 AUG 91
DRAWN	RV	12 AUG 91
APP'D		

CIRCULATION

SAFTRONICS
5580 ENTERPRISE PKWY, FT. MYERS, FL.

DRAWING NOTES

AUTO CAD #	SHEET	DRAWING/PART NUMBER
	1 OF 1	DCN 113

DC12 BURDEN RESISTOR/OVERLOAD DATA CHART

	240 VAC				480 VAC			
HP	Current F/B CT	Burden resistor ohms	O/L CT	O/L Heater or Setting	Current F/B CT	Burden resistor ohms	O/L CT	O/L Heater or Setting
5	1500:1	150	-	FH46	1500:1	300	-	FH38
7.5	1500:1	100	-	FH50	1500:1	200	-	FH43
10	1500:1	68	-	FH54	1500:1	150	-	FH46
15	1500:1	47	-	FH83	1500:1	100	-	FH49
20	1500:1	35	-	FH86	1500:1	75	-	FH53
25	1500:1	27	-	FH89	1500:1	56	-	FH55
30	1500:1	25	-	FH90	1500:1	50	-	FH82
40	2500:1	30	250:5	2.3	1500:1	39	-	FH85
50	2500:1	25	250:5	2.9	1500:1	30	-	FH88
60	2500:1	20	250:5	3.3	1500:1	25	-	FH89
75	2500:1	15	250:5	4.2	1500:1	20	-	FH92
100	2500:1	12	500:5	2.8	2500:1	27	250:5	2.6
125	5000:1	20	500:5	3.5	2500:1	20	250:5	3.3
150	5000:1	15	500:5	4.1	2500:1	18	250:5	3.9
200	-	-	-	-	2500:1	12	500:5	2.6
250	-	-	-	-	5000:1	22	500:5	3.2
300	-	-	-	-	5000:1	18	500:5	3.9
400	-	-	-	-	8500:1	22	1000:5	2.6
500	-	-	-	-	8500:1	18	1000:5	3.3
600	-	-	-	-	8500:1	15	1000:5	4.0
700	-	-	-	-	8500:1	12	1000:5	4.7
800	-	-	-	-	8500:1	12	1500:5	3.6

Burden resistor calculation:
R=1.73 x CT / FLA
Where R = burden resistor in ohms,
CT = Current F/B ratio
FLA = Motor full load amps
Example: FLA = 100, CT = 1500:1, then
R= 1.73 X 1500 / 100 = 26 ohms, use 25 ohm, 3 watts.