SAF Drives Inc.

Installation & Operating Procedures

DD306/312 Series

THREE PHASE DIGITAL DC DRIVE

FOR DC MOTORS FROM 5-1000HP

SAF Drives Inc.

DD306/312 SERIES

DD312 ANALOG FOUR QUADRANT REGENERATIVE
DD306 TWO QUADRANT NON-REGENERATIVE

THREE PHASE DIGITAL DC DRIVE

FOR DC MOTORS FROM 5 - 1000HP

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FOR YOUR SAFETY

Only qualified personnel should install this equipment, after first reading and understanding all the information in this manual. All instructions should be strictly adhered to. The user should consult SAF Drives Inc. or a SAF supplier for clarification of the contents of this manual should any doubt or questions arise.

The installation of this equipment must be conducted in accordance with all national, regional and local electrical codes.

All drawings and technical representations included in this manual are for typical installations and should not in any way be considered for specific applications or modifications. Consult SAF Drives for supplemental instructions.

SAF Drives Inc. accepts no liability for any consequences resulting from inappropriate, negligent or incorrect installation, application or adjustment of this equipment.

The contents of this manual are believed to be correct at the time of printing. In following with our commitment to the ongoing development and improvement of our products SAF Drives Inc. reserves the right to change the specification of this product and/or the content of this instruction manual without notice.

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1.0 DD312 GENERAL DESCRIPTION

The DD312 is a hybrid analog-digital drive, which can operate in either 2 quadrant or 4 quadrant configuration. The control card on the DD312 (CA384) consists of an analog current loop, digital gate pulse firing, 120VAC control sequencing, fault annunciation, and interface circuitry for the SAFphire PLnC.

Replacement cards can be used for any size drive, at any voltage (200VAC to 480VAC, 50Hz/60Hz), and in any quadrant configuration (2Q or 4Q).

The horsepower rating of the drive affects the stack only, not the cards. The voltage rating of the drive is determined by the links for the control transformer on the CA384 card, and the version of CA525 cell state card used. The choice of 2 or 4 quadrant operation is simply selected by a Molex jumper on the CA384 card, not a change of cards.

Armature feedback is fully (galvanically) isolated from the rest of the drive. Since there are voltage and current buffers on board, voltmeters and ammeters operate at low voltage and therefore pose no safety hazards from having full armature voltage on the meters.

2.0 SPECIFICATIONS

2.1 POWER RATINGS

DRIVE MODEL	INCOMING VOLTAGE (all voltages are ± 10%)	INCOMING CURRENT	OUTPUT CURRENT	RATED HP
DD312-55-2	200-380VAC, 3ø, 50/60 Hz	45 AMPS	55 AMPS	15 HP
DD312-90-2	200-380VAC, 3ø, 50/60 Hz	73 AMPS	90 AMPS	25 HP
DD312-130-2	200-380VAC, 3ø, 50/60 Hz	106 AMPS	130 AMPS	40 HP
DD312-180-2	200-380VAC, 3ø, 50/60 Hz	146 AMPS	180 AMPS	55 HP
DD312-260-2	200-380VAC, 3ø, 50/60 Hz	211 AMPS	260 AMPS	80 HP
DD312-350-2	200-380VAC, 3ø, 50/60 Hz	284 AMPS	350 AMPS	110 HP
DD312-500-2	200-380VAC, 3ø, 50/60 Hz	405 AMPS	500 AMPS	160 HP
DD312-800-2	200-380VAC, 3ø, 50/60 Hz	648 AMPS	800 AMPS	250 HP
DD312-1000-2	200-380VAC, 3ø, 50/60 Hz	810 AMPS	1000 AMPS	320 HP
DD312-1250-2	200-380VAC, 3ø, 50/60 Hz	1013 AMPS	1250 AMPS	400 HP
DD312-55-4	380-500VAC, 3ø, 50/60 Hz	45 AMPS	55 AMPS	30 HP
DD312-90-4	380-500VAC, 3ø, 50/60 Hz	73 AMPS	90 AMPS	50 HP
DD312-130-4	380-500VAC, 3ø, 50/60 Hz	106 AMPS	130 AMPS	80 HP
DD312-180-4	380-500VAC, 3ø, 50/60 Hz	146 AMPS	180 AMPS	110 HP
DD312-260-4	380-500VAC, 3ø, 50/60 Hz	211 AMPS	260 AMPS	160 HP
DD312-350-4	380-500VAC, 3ø, 50/60 Hz	284 AMPS	350 AMPS	220 HP
DD312-500-4	380-500VAC, 3ø, 50/60 Hz	405 AMPS	500 AMPS	320 HP
DD312-800-4	380-500VAC, 3ø, 50/60 Hz	648 AMPS	800 AMPS	500 HP
DD312-1000-4	380-500VAC, 3ø, 50/60 Hz	810 AMPS	1000 AMPS	640 HP
DD312-1250-4	380-500VAC, 3ø, 50/60 Hz	1013 AMPS	1250 AMPS	800 HP

* For recommended fuse size and type, refer to the spare parts section.

** When the voltage used is other than 240 or 480 VAC, a 50 VA transformer must be used to convert the voltage to 240 VAC for a DD312-x-2 or 480 VAC for a DD312-xx-4. The phase relationship between line R and S must remain the same on both sides of the transformer being installed.

2.1 SERVICE CONDITION

ELEVATION	For altitudes in excess of 2000 meters / 6600 feet above sea level, all assemblies must be derated 1% for every 100 meters / 330 feet above
AMBIENT TEMPERATURE	Do not install in areas where ambient temperature falls below 0°C / 32°F or exceeds 40 °C / 104°F

2.3 CONTROL LOGIC POWER

The voltage used for the control logical inputs (terminals 18 to 30 on the CA384 card) must be 120VAC, ± 10%, 50/60 Hz.

2.4 DIMENSIONS

DRIVE MODEL	DIMENSIONS (Imperial)	DIMENSIONS (Metric)
	(Length X Width X Height)	
DD306-55-2/4	17" x 12" x 10"	42.5cm x 30cm x 25cm
DD306-90-2/4	17" x 12" x 10"	42.5cm x 30cm x 25cm
DD306-130-2/4	23" x 12" x 10"	57.5cm x 30cm x 25cm
DD306-180-2/4	23" x 12" x 10"	57.5cm x 30cm x 25cm
DD306-260-2/4	23" x 12" x 12"	57.5cm x 30cm x 30cm
DD306-350-2/4	16.25" x 15.5" x 11"	40.5cm x 39cm x 27.5cm
DD306-500-2/4	24.75" x 20" x 12.5"	62cm x 50cm x 31.5cm
DD306-800-2/4	30.5" x 20" x 12.5"	76.5cm x 50cm x 31.5cm
DD306-1000-2/4	30.5" x 20" x 12.5"	76.5cm x 50cm x 31.5cm
DD306-1250-2/4	30.5" x 24" x 21.5"	76.5cm x 60cm x 54cm
DD312-55-2/4	17" x 12" x 10"	42.5cm x 30cm x 25cm
DD312-90-2/4	17" x 12" x 10"	42.5cm x 30cm x 25cm
DD312-130-2/4	23" x 12" x 10"	57.5cm x 30cm x 25cm
DD312-180-2/4	23" x 12" x 12"	57.5cm x 30cm x 25cm
DD312-260-2/4	23" x 12" x 12"	57.5cm x 30cm x 30cm
DD312-350-2/4	30.5" x 15.5" x 11"	76.5cm x 39cm x 27.5cm
DD312-500-2/4	46" x 20" x 12.5"	115cm x 50cm x 31.5cm
DD312-800-2/4	46" x 20" x 12.5"	115cm x 50cm x 31.5cm
DD312-1000-2/4	52.75" x 20" x 12.5"	132cm x 50cm x 31.5cm
DD312-1250-2/4	57.75" x 24" x 21.5"	144.5cm x 60cm x 54cm

* With the use of a CA366 card, drives up to 260A have an additional 3" or 7.5cm in height and drives above 260A have an additional 2" or 5cm in the height of the unit.
** The dimensions of stacks above 260A do not include incoming AC fuses or an output DC fuse (DC fuse only applies to DD312 converters).

3.0 STANDARD FEATURES

Features which are particularly useful include:

3.1 ADAPTIVE GAIN

A gain change occurs over the range between continuous and non-continuous conduction. Digital circuitry modifies the operation of the current loop to keep the gain high at low current, thereby providing excellent control across the entire torque range.

3.2 ELECTRONIC INVERSE TIME MOTOR OVERLOAD

Motor thermal overload is performed electronically on the CA384 card. As a result, no external thermal overloads are required. The time delay before a fault occurs depends on how far in excess of 100% the motor current is allowed to rise. ie. 150% for one minute.

3.3 FAULT ANNUNCIATION

Nine faults are annunciated on a scrolling LED bar display. If a fault occurs, the first fault is latched and the drive stops until it is reset. Holding or taping the reset button down after a fault will not re-start the drive. The button has to come back up. Activating the drive reset during normal operation has no effect.

3.4 SEQUENCE LOGIC

Logic for basic sequencing such as start, stop, fwd/rev, jog, and E-stop is implemented in the logic of the CA384 with no external relays required. However, external logic for such functions is permissible.

3.5 TRANSFER FUNCTION

The algorithm controlling the current loop is normalized to "per unit" functions. This means that the same cards are used for any current, voltage or HP range

3.6 OPERATING MODES

The DD312 with a CA384 card, is a current amplifier, which regulates motor armature current. The DD312 requires some sort of outer control loop, such as speed, tension, or position. The two most common types of interfaces are as follows.

First is an analog speed loop card (CA366) which is connected by a 60 pin ribbon cable to the CA384 and used in stand alone single drive applications (for more information refer to the CA366 Manual).

The second interface is the SAFphire PLnC which is connected via a 25 pin cable to a CA407, tach interface card in a SAFphire rack. This is used for system oriented drive applications.

4.0 CA355 GATE PULSE TRANSFORMER CARD DESCRIPTION

4.1 CA355 GATE PULSE TRANSFORMER CARD

CA355 is connected to the CA384 with a 10-conductor ribbon cable. The ribbon cable tracer must be connected to Pin 1 of either connector P1 or P2. Pin 1 of either connector P1 or P2 is located at the top of each connector when facing the component side of CA355, viewing the silk screen characters in an upright position. The purpose of the CA355 card is to provide isolation between the low voltage digital electronics, and the high voltage which is present on the gate and cathode of the SCR's, as well as to provide enough gate current to trigger the SCR's.

5.0 CA525 CELL STATE DETECTOR CARD DESCRIPTION

5.1 VOLTAGE RATING

There are two versions of the CA525 card: a 240VAC version used for incoming voltages between 200VAC and 380VAC, and a 480VAC version used for incoming voltages between 400VAC and 500VAC. If you have any other incoming voltage, please contact SAF DRIVES.

5.2 INTERCONNECTION

The CA525 card is connected to CA384 card through a 14-conductor ribbon cable. The ribbon cable tracer must be connected to Pin 1 of connector P1. Pin 1 is located at the top of connector P1 when viewing CA525 from the component side and with the silk screen characters upright.

5.3 ISOLATION

The CA525 card is used to galvanically isolate the high voltage AC mains and DC motor armature connections from the low voltage circuits on the CA384 card. All cell state and phase voltage signals are optically isolated.

5.4 PHASE ROTATION

Two optic isolators are used to determine the presence of AC mains voltages and 3-phase AC mains rotation. The two isolated signals are RSO and STO. These two signals are used by the CA384 to determine phase rotation and the presence of correct AC mains phase voltages. An open delta configuration is used.

5.5 CELL STATE

Six optic isolators are used to determine the thyristor cell state. Cell state is defined as "Conducting" or "Not Conducting".

The cell state detectors sense the voltage drop from cathode to anode of each thyristor cell. When the voltage drop exceeds approximately 50 volts, the optic isolator is ON.

The cell state isolators pull down the inputs to Schmitt Triggers (located on the CA384). All cell state isolators must be ON to produce a "Not Conducting" signal on the CA384. If any of the cell state isolators fail, the corresponding output transistor cannot pull down the Schmitt Trigger input, inhibiting thyristor firing.

5.6 THYRISTOR FIRING

Shorted thyristors produce the same effect as the "Conducting" state. The CA384 does not produce a "START ENABLE" signal unless all thyristors are not conducting and/or there is no "Zero-Crossing"

5.7 DV/DT PROTECTION

The CA525 provides a RC network across each SCR to limit the rise in voltage, thus preventing the SCR's from being damaged by voltage spikes.

6.0 CA384 CONTROL CARD

6.1 LOW VOLTAGE POWER SUPPLY

The low voltages needed for the CA384 are supplied by three voltage regulators: +5VDC, +15VDC, and -15VDC. Unregulated +24VDC is used for gate pulse transformer primaries and relays.

The AC input voltage to the CA384 is 240/480VAC, 50/60 Hz on terminals R and S. R and S are located on the lower right of the CA384. Terminal R must be connected in phase with the converter phase "R", and Terminal S must be connected in phase with converter phase "S". The CA384 cannot be synchronized to any phase except R-S.

Input voltages to terminals R and S, other than 240/480VAC are not permissible. For voltages other than 240/480 VAC, an interposing single-phase two-winding transformer must be used (minimum 50VA, 240V/480V output).

A power ON reset function, (PURST), delays all logic and operation for 5 seconds. PURST resets all logic, including residual faults, sequencing logic, and delays the +24VDC power to the gate pulse transformers.

6.2 PHASE LOCKED LOOP

The phase locked loop (PLL), operates with 45 to 65 Hz mains without any necessary frequency adjustments. Phase Lock is internally monitored. The internal R-S phase, is compared to the external AC mains R-S phase. If the two signals differ by several electrical degrees, PLL FLT is latched and annunciated. Phase lock is annunciated on the CA384 by LD5, located at the top of the CA384. LD5 is illuminated when lock is achieved.

LD3, adjacent to LD5, annunciates correct R-S connections to Terminals R and S. LD3 is illuminated when Terminals R and S are in phase with the AC mains phase R-S.

NOTE:

IF LD3 (SYNCH OK) IS NOT ILLUMINATED, DO NOT RUN THE DRIVE. CHECK MAINS CONNECTIONS, OR CONSULT FACTORY SERVICE DEPARTMENT.

The phase angle reference PHAL, is input either on Terminal 5 or internally from the current loop. Full 180° phase control is 0 to 7.5 VDC (0.042 volts per degree). Molex jumper JP6 EXTERNAL PHASE on position ENA enables the signal from Terminal 5, while position DISA connects the output of the current loop to PHAL . The analog PHAL signal is converted to a digital signal which is then used to produce "picket fence" gate pulses for the SCR's. Gate pulse transformers are located on the CA355. The CA355 assemblies are connected to the CA384 with 10-conductor band cables (Ribbon Cable tracer is Pin 1). Two CA355 cards are used for 4-quadrant dual converters. The 10-conductor band cables connect to the top left side of CA384 at positions marked CONVERTER 1 (CN1) and CONVERTER 2 (CN2). Reversed connections result in loss of motor control (i.e. Converter 1 connected to Converter 2). Be certain that the correct converter is connected to the proper 10-pin connector.

6.3 CONVERTER COMMAND SWITCHING LOGIC

The converter command switching logic controls when either one of two converters receive thyristor gate pulses. Command logic is controlled by IA (Continuous Conduction), CREQ (Converter Request), RENB (Regulator Enable), and CA525 Cell State Detector Card.

The CA525 Cell State Detector Card is connected to the CA384 with a 14-conductor ribbon cable to connector CS1. CS1 is located midway along the left side of the CA384. The CA525 detects thyristor cell conduction. All of the thyristor cell signals are monitored and are ANDed on the CA384. If all cells are in a non-conducting state, the command logic is set ON. (The command logic must have a RENB signal to accept the cell state ON signal).

Cell states can be interconnected to another CA384 by removing link LK1 and interconnecting the drives. Terminals 1, 2, 3, and 4 are used for interconnection. Terminal 1 is connected to Terminal 3 on the remote CA384, Terminal 1 of the remote CA384 is connected to Terminal 3 on the CA384, and Terminals 2 and 4 (Zero common) of both CA384 cards are connected together. Use a twisted 4-conductor cable. When a remote CA384 is not used, a link must be inserted to LK1 and terminals 1, 2, 3, and 4 are left unconnected CA384. This is the factory default.

6.4 PHASE SEQUENCE/LOSS PROTECTION

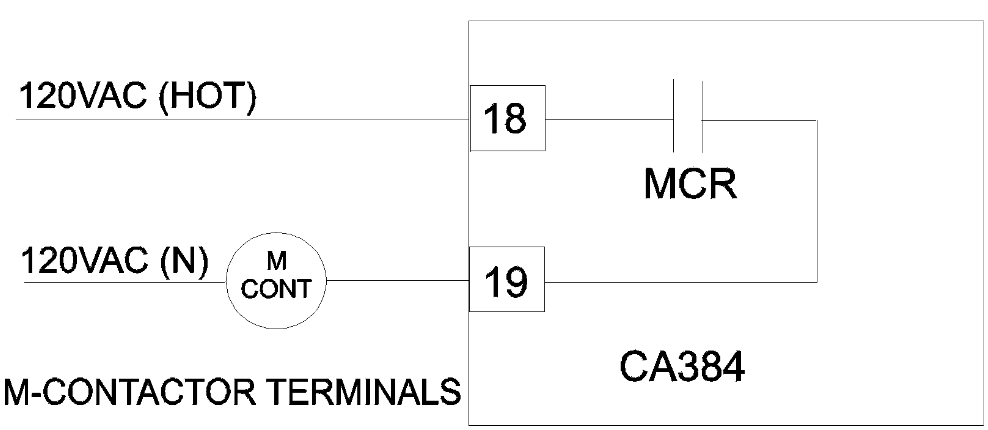
All three AC mains phases are continually monitored. Phase Sequence/Loss signals are generated from the CA525 (Cell State Detector Card). If a phase is lost, a fault is latched, and the fault is annunciated on the CA384.

6.5 DRIVE CONTROL LOGIC

Terminals 18 through 30 (inclusive) are used as 120VAC input or outputs. The neutral for the 120VAC supply must be earth grounded in order for the CA384 to comply with various electrical codes. (See CSA, NEC, etc).

6.5.1 Terminals 18 and 19

These terminals are used to energize a DC motor armature circuit contactor (M-Contactor). No other devices may be connected in this circuit. This includes any type of protection, E-Stop, Thermal, Overload, etc. MCR contacts (Terminals 18 and 19) are rated 6.5 amperes @ 120 VAC. If M-Contactor coils rated at more than 8 amperes, an interposing relay must be added externally.



6.5.2 Terminals 20, 21 and 22

Terminals 20,21,and 22 provide a Form-C contact from the FLT relay (Fault Relay). Contact rating is 0.5 amperes @ 120 VAC, resistive pilot duty only.
The FLT relay annunciates a global fault. It will not energize immediately when power is switched ON, but energizes after the CA384 Power Up Reset is complete. LD15 (READY) annunciates that power is applied to the FLT relay coil (24 VDC). The FLT relay de-energizes for the following conditions:

1. Power supply failure or power OFF.
2. FLT relay coil failure.
3. Heat sink over-temperature (if connected).
4. Feedback loss .
5. Instantaneous converter over-current.
6. Inverse time motor overload (Class 1 operation)
7. Phase locked-loop lock loss.
8. Incorrect mains phase sequence and/or mains phase loss.
9. Loss of Watch dog (SAFphire interface only)
10. Armature overvoltage
11. External fault (SAFphire interface only)

6.5.3 Terminal 23

Terminal 23 is the 120VAC neutral connection point.

6.5.4 Terminal 24

Terminal 24 is a 120 VAC input used to reset the CA384 global faults through a normally-open contact. This type of fault reset is not "TRIP-FREE". If the external fault reset push button is continually depressed, fault resets occur at the mains frequency (50/60 Hz). Global faults produce drive shut down. However, the annunciator on CA384 is cleared by every reset signal and diagnostic information is lost. External fault reset is optional and need not be connected.
A fault can also be reset locally on the CA384 with the RESET pushbutton, located at the lower left of the CA384. The local fault RESET is "TRIP-FREE", i.e. holding the RESET depressed does not prevent a fault trip.

6.5.5 Terminal 25

Terminal 25 is a 120 VAC input used to confirm DC armature circuit loop contactor closure. This input must be connected through a normally-open auxiliary contact on the main armature loop contactor. The auxiliary contact must close after the main power contacts close and open before the main power contacts open. This input must be energized to enable the current loop. LD6 annunciates that the main armature loop contactor has closed its auxiliary normally-open contact.

6.5.6 Terminal 26

Terminal 26 is a 120 VAC input used to confirm emergency stop logic. Terminal 26 is held energized for "SAFE" operation. All emergency stop logic must be connected to this input. When properly connected, Terminal 26 provides a "hard-wired" emergency stop in the event of internal logic failure. This input must be energized for the drive to run or jog. If this input is de-energized while the drive is running or jogging the drive will inhibit the firing of SCR's, open the contactor and the motor will coast to a stop.

6.5.7 Terminal 27

Terminal 27 is a 120 VAC input used to confirm "NORMAL" stop logic. This input is connected to external control which energizes Terminal 27 unless a "NORMAL" stop is requested. When "NORMAL" stops are not required, Terminal 26 and 27 are connected in parallel so that all stops are defined as emergency stops. If using the "software run" signal from the SAFphire, this terminal must be left unconnected. The CA384 may also receive a zero speed signal from either the SAFphire or a CA366, this signal being high if the motor is above the zero speed setting. When "STOP" is de-energized the drive will continue to regulate as long as the zero speed signal is high.

6.5.8 Terminal 28

Terminal 28 is a 120 VAC input used to detect a "RUN" request. External logic may energize Terminal 28 either momentarily or continuously. Terminal 28 is internally interlocked through "JOG", "NORMAL STOP" and "ESTOP" logic. When either Terminals 26 or 27 are not energized, inputs to Terminal 28 are not serviced. When Terminal 29 is energized (JOG), inputs to Terminal 28 are not serviced.

6.5.9 Terminal 29

Terminal 29 is a 120 VAC input used to detect a "JOG" request. External logic must energize Terminal 29 for the duration of time that "JOG" is necessary. "JOG" is not a maintained function. Terminal 29 is internally interlocked through "RUN", "NORMAL STOP" and "ESTOP". When either Terminals 26 or 27 are not energized, inputs to Terminal 29 are not serviced. When Terminal 28 (RUN) is energized, inputs to Terminal 29 are not serviced.

6.5.10 Terminal 30

Terminal 30 is a 120 VAC input used to request FORWARD or REVERSE references.

NOTE:
THE 120 VAC SUPPLY FOR THE ABOVE SEQUENCING CONTROL MUST COME FROM ONE SINGLE 120 VAC SOURCE.

6.6 FAULT ANNUNCIATION

The fault annunciator is a 10 position LED display located on the bottom left of the CA384. Nine positions are used. The display is OFF during power up reset. The position that is illuminated determines which fault has occurred. A moving light bar results if power reset has been successful and no faults exist. The moving light bar is produced by the internal phase lock loop clock and sequences at 1/4 of the mains frequency (50/60 Hz). Nine faults are detected & latched to the display:

6.6.1 Phase Lock Loss - PLL FLT

PLL FLT compares the internally generated R-S phase to AC mains phase R-S. If the two R-S phases differ by several degrees, a fault results. This fault cannot be disabled.

6.6.2 Instantaneous Over Current - IOC

The IOC level is set by the current transformer and burden resistor. Assuming correct burden resistance, IOC faults occur at 200% of maximum converter current. The importance of correct burden resistors cannot be over emphasized especially if the converter operates at, or near, maximum current for the converter being used. This fault cannot be disabled.

6.6.3 Inverse Time Motor Overload - MOTOR OVERLOAD

This fault cannot be calibrated properly if the burden resistor is not installed or calculated correctly. If the burden resistor is calculated for 150% of the motor name plate and the OLCB pot is set for 100% motor nameplate, the drive will trip after one minute at 150% of motor nameplate. This fault can be disabled by turning the OLCB pot to 100% (fully clockwise).

6.6.4 Phase Sequence/Loss - PHASE LOSS

PHASE LOSS detects the voltage level of each AC mains phase and the internal R-S phase relationship to AC mains R-S phase. Incorrect AC mains voltage levels produce a PHASE LOSS fault.

6.6.5 Heat Sink Over Temperature - OVER TEMP

OVER TEMP is an option located on CA384. A heat sink temperature detector (mounted on the heat sink) and/or detectors buried in the thyristor assemblies may be used. The fault is detected by an open circuit between Terminals 7 and 8 located on the CA384. Circuit voltage is +24 VDC. HSOT can be disabled by installing a wire jumper from Terminals 7 and 8 on the CA384. The detected temperature is dependent upon the heat sensing device(s) used.

6.6.6 Feedback Loss - FEEDBACK LOSS

FEEDBACK LOSS is an option on the CA366, which produces a fault when 35% motor armature voltage exists and no tach feedback is detected. Molex jumper JP8 (CA366) position PQ enables FBLS and position QR disables FBLS. (See CA366 instructions). Standard position is PQ. The SAFphire can also send a FEEDBACK LOSS fault to the CA384.

6.6.7 Fault External - EXTERNAL FLT

EXTERNAL FLT is an external fault for the CA384. EXTERNAL FLT is driven by the SAFphire Interface.

6.6.8 Armature Over Voltage - ARM OVER VOLTS

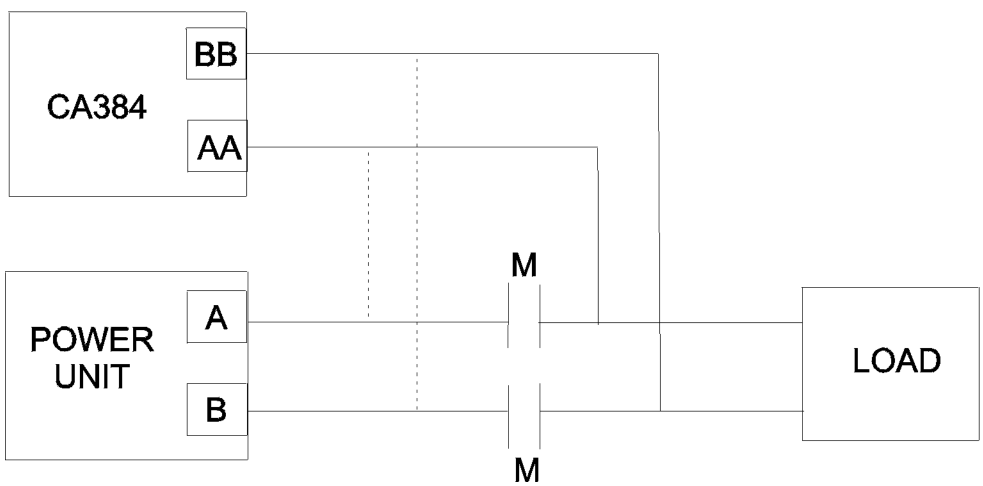
ARM OVER VOLTS is a fault that detects the armature voltage rising above the level set by the armature overvoltage pot RV3.

6.6.9 Watch Dog Fault - WATCH DOG FLT

WATCH DOG FLT is enabled only when the drive is interfaced with the SAFphire PLnC. The drive will trip if it loses communication with the drive for 200msec.

6.7 MOTOR ARMATURE VOLTAGE ISOLATION

All signal and logic circuits are galvanically isolated from high voltage armature circuits . Input terminals are marked AA and BB.
Two connection schemes are shown above. Solid lines are the preferred connection for sensing motor armature voltage, while solid line connections MUST be used when a shunt field regulator operates in armature CEMF mode.

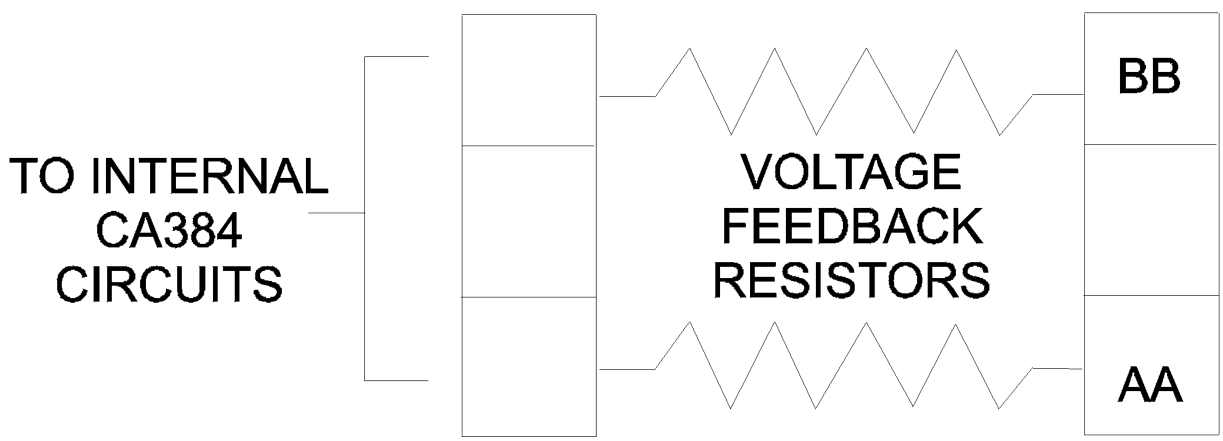


Dotted line connections may be used when the shunt field is fixed. Fixed shunt fields may be supplied either from constant potential rectifiers or shunt field regulators used as constant current regulators. (Shunt Field Temperature Compensation).

The isolator input impedance (Terminals AA and BB) is 1000 ohms. The impedance must be increased for input voltages greater than +1VDC by changing two resistors mounted between two terminal strips. The resistors are calculated by:
(Max. Armature Volts - 1) = Total resistance (Kilohms)

The total resistance is divided into two resistors as equal as possible. Equal resistors divide the common-mode voltage into the isolator input. Use 1%, metal film, 0.6 watt resistors. There is sufficient mounting space for parallel devices if calculated values cannot be met with available resistors.

Input current to Terminals AA and BB is 1 milliampere at maximum armature voltage. The isolator should not be summed for higher than 1 milliampere or for isolator output voltages greater + VDC at maximum armature voltage. Voltage regulators operate on average values. Voltage waveforms from thyristor powered armature supplies contain voltage peaks nearly twice average values. Attempts to derive isolator outputs in excess of +5 VDC result in peak distortion. Non-linear operation results with this practice and the subsequent feedback limiting causes feedback loss.
Isolator outputs are Terminals 13 and 14. Terminal 13 output is bipolar, 0 to +5 VDC. Terminal 14 is the negative absolute value of Terminal 13, 0 to -5 VDC.



Isolator outputs can be used to drive low voltage indicators. There is a basic safety factor obtained when high voltage armature circuits do not exist in enclosures that are accessible to non-qualified personnel such as machine operators.

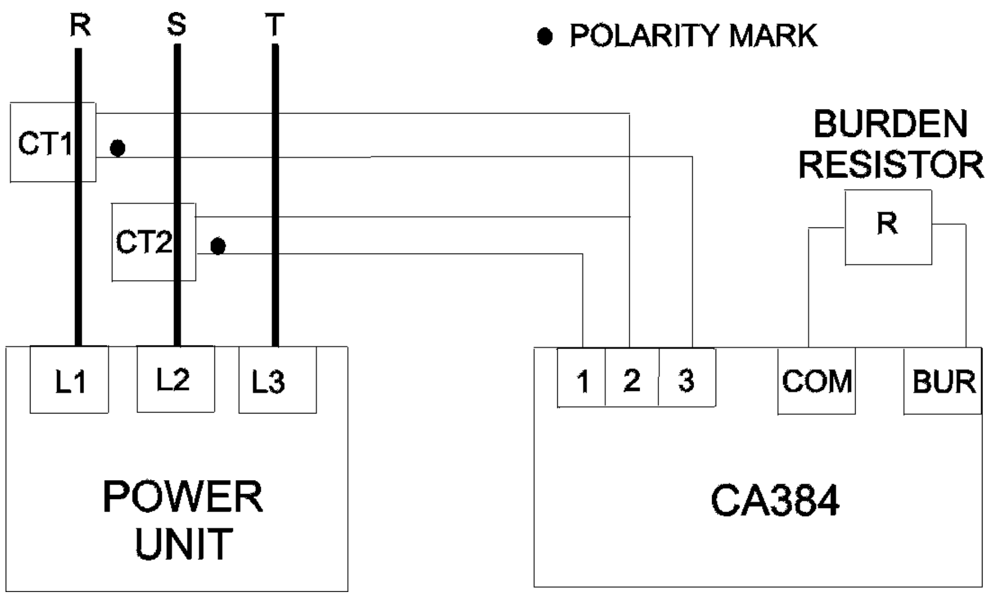
The isolator has a zero set, 20-turn trim potentiometer located at the top of the CA384, VFZR(RV4). Terminal 13 is monitored when the motor armature voltage is zero (Drive stopped) and VFZR is adjusted for zero volts on Terminal 13.

6.8 CURRENT LOOP REGULATOR

6.8.1 Current Feedback

Armature circuit current feedback is taken from the 3-phase AC converter input by two current transformers. The two current transformer secondary signals are rectified by a 6 diode fullwave bridge. Three of the six diodes are 15 V zeners which provide input transient protection for the current comparator and current amplifier.

Figure 4 shows the current transformer connections. Of the three incoming phases, any two can be monitored. However, the current transformer polarity marks, primary turn(s) direction, and terminal connections are mandatory. The current transformers are connected to the 3-pole terminal strip marked "CURRENT XFMRS" (J3) along the top left edge of the CA384.



An external burden resistor (RBUR) is mounted on a 2-pole terminal strip at the top left on the
CA384. The position is marked "BURDEN RESISTOR". Viewed from the component side of the CA384, the left terminal is zero common and the right terminal is the burden signal. A fixed internal burden is installed on the CA384. If no external resistor is installed, the current will be limited to a value less the 3% of the stack rating for +10.0VDC current reference into Terminal 11.

For higher converter currents, resistance values for the external burden resistor are calculated by:

$$\text{RBUR} = \frac{3.11 \ * \text{CT RATIO}}{0.9 * \text{MAX DC AMPS}}$$

MAX DC AMPS = MOTOR NAMEPLATE CURRENT * 150%
Note: The 150% is a typical value but can be adjusted to fit a specific application.

For example, consider a motor, rated at 55.6 amperes (Nameplate Armature Current). Current limit is specified as 150%. Maximum motor current = 150% of 55.6 = 83.4 amperes. The current transformers on a 90 Amp stack are 1500 to 1, but have 3 primary turns. The current transformer ratio = 500 to 1. Then:

$$\frac{3.11 * 500}{0.9 * 83.4} = 20.72 \text{ ohms, use 18 ohms}$$

The burden resistor power dissipation must be calculated. The average voltage is 3.11 VDC at current limit.

$$\frac{3.11 * 3.11}{18} = 0.53 \text{ watts}$$

Use one 1%, metal film, 1 watt resistor. Each current transformer operates at 0.54 volt-ampere at current limit.

The voltage across RBUR is delayed 0.0022 seconds and buffered at a gain of +1. The buffer output is the current feedback signal, IFB. IFB is 0 to +3.11 VDC. IFB is summed into the current loop, the IOC comparator, inverse time motor overload circuit, and a buffer amplifier used for current monitoring (Terminal 12).

The current loop may produce appreciable armature current with no current reference applied. If appreciable armature current results, OFFSET (RV1) on CA384 is used as a zero set adjustment for the current loop.

6.8.2 Current Reference (IREF)

The current reference input is Terminal 11 . When the CA366 (Major Loop Regulator) is used, IREF is connected to the major loop regulator through a 60-conductor ribbon cable. When a SAFphire is used the IREF is connected through the 25 pin interface cable.

IREF is defined as 0 to +-10 VDC. A +10 VDC level represents +LIM(pu), -10VDC level represents -LIM(pu).

NOTE:

THE BURDEN RESISTOR, (RBUR), MUST BE CALCULATED, AND INSTALLED, FOR 3.11 VOLTS AT LIM(pu). THE CURRENT REGULATOR TRANSFER FUNCTION IS CALCULATED TO OPERATE CORRECTLY WITH A 3.11 VOLT CURRENT FEEDBACK AT LIM (pu).

Negative IREF inputs request Converter 1 (Converter 1 makes Power Terminal A positive with respect to Terminal B). Positive IREF inputs request Converter 2 (Converter 2 makes the Power Terminal A negative with respect to Terminal B).

Three possible converter modes are selectable using JP11.

1. JP11 on position AC, both converters active.
2. JP11 on position CD, Converter 1 active.
3. JP11 on position AB or BD, Converter 2 active.

CREQ hysteresis is adjusted on HYS, RV2. The hysteresis level is adjustable from +0.025 volt to +0.25 volt. HYS is used to prevent needless converter changes when operating at low values of armature current. The effect of HYS is lost when IREF is greater than the hysteresis level.

IREF is input to a current reference rate limiter. The rate limiter is a ramp generator which converts IREF to a signal that has a linear change with respect to time. The rate limiter output is IRRF. IRRF may be adjusted from 0.002 to 0.05 seconds with RATE (RV8). IRRF is 0.002 seconds with RATE fully clockwise. The current loop regulator is capable of generating extremely high rates of armature current change. These rates should be limited to avoid a motor armature commutation problem. With respect to motor commutation problems, NEMA publication MG1-1963, paragraph MG1-23.48 puts the commutation problem in a quantitative form.

"Direct current motors can be expected to operate successfully with repetitive changes in load current such as those which occur during a regular duty cycle provided that, for each change in current, the K factor, as defined in the following formula does not exceed 15."

$$\frac{\left[\dfrac{\text{Change In Current}}{\text{Rated Current}}\right]^2}{\text{Equivalent time in seconds for current change to occur}} = K$$

Assuming a current change equal to 150% of rated current, the formula states that the minimum time in which this current change can take place is:

$$\text{Delta T (seconds)} = \frac{(1.5)^2}{15} = 0.15 \text{ seconds}$$

6.8.3 Current Loop Regulator

IRRF is the current reference to the current loop regulator. The current regulator sums IRRF and IFB in a P-I loop. GAIN (RV7), is used to compensate the current loop gain for the motor armature electrical time constant. GAIN may be preset fully counter-clockwise (0%) for use with any motor, however, this produces a highly overdamped response.

GAIN is adjusted during a stalled rotor test, at current limit. Gain should be adjusted for a current reference step input from 0 to +10 volts. When observe the current signal on Terminal 12 with an oscilloscope, the signal should comenserate with the best rate of current rise without any "overshoot". After the major loop, speed or voltage, is optimized; the current signal on Terminal 12 should be verified to confirm that there is no "Overshoot" when operating in the regenerating mode at current limit.

The current regulator also uses adaptive gain. The two signals IA and (Not)IA are used to switch the current loop summing level. These two signals, form a type of pulse-width modulation during operation in the discontinuous armature current region. Current loop gain is increased for discontinuous mode operation.

Two phase "End-Stops" are also provided. ADVL (RV6) adjusts the phase advance limit. RTDL (RV5), adjusts the phase retard limit. Both adjustments are factory set and should not need re-adjustment. The optimum adjustment for RTDL is 30°, and ADVL is 150°.

6.9 ELECTRONIC INVERSE TIME MOTOR OVERLOAD

6.9.1 Current Buffer

The current feedback signal IFB is buffered. The buffer output is Terminal 12. This signal is proportional to IFB and changes polarity dependent on the polarity of the armature current. Terminal 12 signal is +3.11 VDC when operating at LIM(pu).

6.9.2 IOC - Instantaneous Overcurrent

If IFB exceeds +6.8 VDC (peak) the IOC comparator senses an IOC fault. IOC faults are latched and annunciated on the CA384. IOC faults operate in 2 milliseconds or less. The IOC fault level is set at 200% of maximum converter current. The importance of correct calculations for RBUR cannot be over-emphasized. IOC cannot protect the converters if RBUR is not correct. This situation is extremely important when the converters are operating at, or near, the maximum ratings.

6.9.3 Motor Overload - Inverse Time Motor Overload

Motor overload monitors motor armature current and must be calibrated for proper operation. To calibrate motor overload (RV13) is adjusted so that LD8 illuminates at 102% of rated armature current. When properly adjusted, motor overload trips in 60 seconds at 150% of rated motor armature current. Since motor overload is an inverse time function, trips can occur in shorter or longer times dependent on the time the motor spends at greater than 100% of rated armature current. Motor overload cannot be reset immediately as some cool-down time is necessary, which simulates the cooling of the motor. Turning OFF the main AC power defeats the overload memory function. The motor overload fault is annunciated on the CA384. Motor overload cannot be properly calibrated if burden resistors are not calculated and installed properly.

NOTE:
SAF DRIVES IS NOT RESPONSIBLE FOR MOTOR FAILURE DUE TO DEFEATED INVERSE TIME OVERLOAD FUNCTIONS!

The motor overload function can drive an external relay (24 VDC coil Type KHU). The relay coil is connected to Terminal 15 and +24 VDC. The external relay is energized during normal operation and is de-energized for a fault. It is not necessary to supply a commutating diode for the 24 VDC relay. The commutating diode is provided on CA384.

A second relay driver is provided to externally annunciate motor overloads warnings. Use a relay with a 24 VDC coil (Type KHU). The relay coil is connected to Terminal 16 and +24 VDC. The external relay is energized during normal operation and is de-energized during overload. The external relay operates in conjunction with LD8. This function can be used to annunciate, to a machine operator, that the motor is operating in overload. If the overload is permitted to persist, an overload fault will result. This type of annunciation can be used by a machine operator to reduce the motor load before the fault occurs.

7.0 CA384 CONNECTIONS

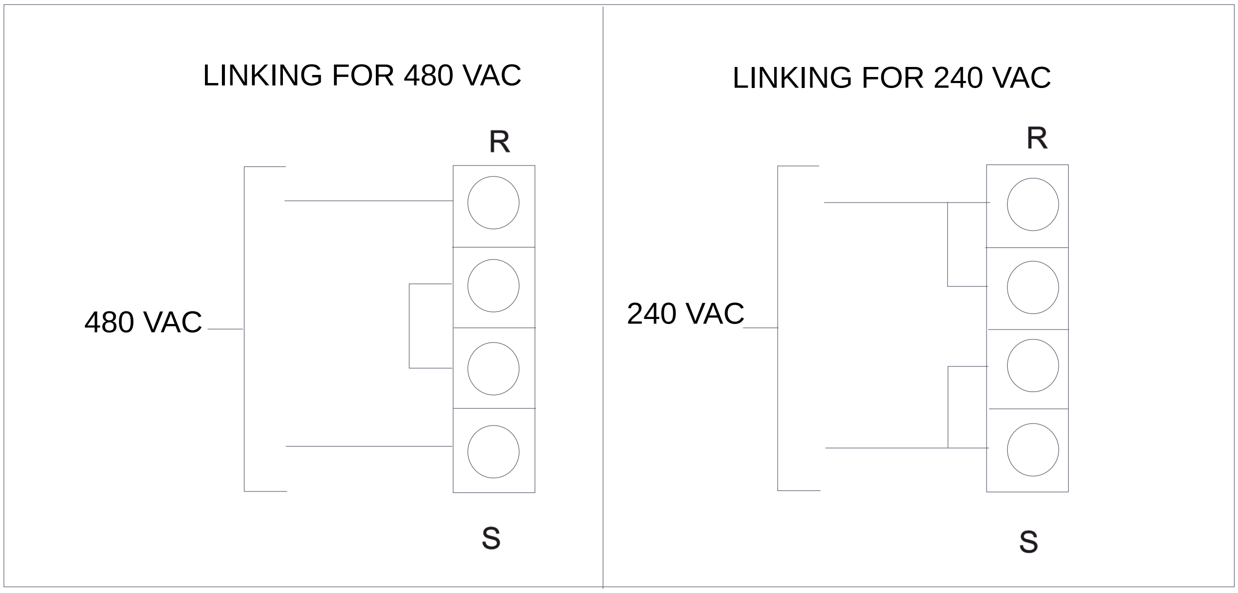
7.1.TERMINAL CONNECTIONS

TERMINAL	NO.	NAME	DESCRIPTION
J1	1	CELL OUT	A +24Vdc signal which is high when all of the cells are in a none conducting state. If this signal is low, switching of bridges will not be permitted. This signal prevents firing of opposite bridges simultaneously in a parallel stack configuration.
	3	CELL IN 1	A +24Vdc input which is monitored for permission to switch bridges. In the most common case of a single drive, the CELL INPUT and CELL OUTPUT are connected internally. When using parallel stacks, LK1 must be removed and the CELL INPUT of one drive must be connected to CELL OUTPUT of the other drive.
	5	EXTERNAL PHASE	This input is a 0 to +7.5Vdc analog input used to directly control the firing angle of the SCR's. 0Vdc represents 0 degrees while +7.5Vdc represents 180 degrees. When using this input, all the control loops are disabled. Therefore there is no attempt to limit armature current or armature voltage.
	7	HSOT IN	This input senses a heat sink over temperature. An open thermal switch will result in 0V and a fault while normal conditions will be +24Vdc at this terminal.
	8	HSOT OUT	This terminal is a 24Vdc supply for the normally closed thermal switch
	2, 4, 6	COMMON	Common for the signals on J1
J2	9	+24V	This terminal is the +24Vdc control power supply and should be used for diagnostics only.
	11	CURRENT REF.	This input is a reference to the current loop, ±10Vdc is equal to ± maximum current which is determined by the burden resistor. If an internal current reference is used from either a SAFphire or a CA366 card, it can be monitored at this terminal.
	12	CURRENT BUFFER	This is an analog output which represents the current feedback, ±3.1Vdc is equal to ± maximum current which is determined by the burden resistor.

TERMINAL	NO.	NAME	DESCRIPTION
J2	13	BI_VFBK	This is a bipolar analog output which represents the armature voltage feedback. Full armature voltage is represented by ±5Vdc as scaled by the armature voltage feedback resistors.
	14	UNI_VFBK	This is a unipolar analog output which represents the armature voltage feedback. The output is equal to 0 to -5Vdc, with -5Vdc being maximum armature voltage as determined by the armature voltage feedback resistors.
	15	IT_MOL	This is an open collector output which when inactive signals that the drive has tripped on an inverse time motor overload fault. During normal operation this output is active.(+24VDC, 50mA max)
	16	INST_MOL	This is an open collector output which when inactive signals that the drive is in an overload condition and if it persists, the drive will trip on an overload fault. During normal operation this output is active.
	10, 17	COMMON	This is a common which can be used for any of the above signals.
J9	18, 19	---	Normally open contact rated at 6.5A, 120VAC used to energize the DC contactor on the load side.
	20	---	Normally open of form C Fault contact.
	21	---	Normally closed of form C Fault contact.
	22	---	Toggle of form C Fault contact. During normal operation the fault relay is energized. It will de-energize on a fault or power loss. The contacts are rated for 0.5 Amp at 120VAC.
J10	23	N	This is the neutral connection for the 120VAC control inputs.
	24	RESET	This is a 120VAC input which when active will reset the drive after a fault has been cleared. If the drive is already in run mode this input will have no affect.
	25	MX	This is a 120VAC input which should be connected through the auxiliary normally open contact of the DC contactor to verify that the contactor has been closed.
	26	ESTOP	This is a 120VAC input which has to be activated for the drive to operate. When de-activated the drive inhibits the firing of the SCR's, de-energizes the DC contactor, and the motor will coast to a stop.

TERMINAL	NO.	NAME	DESCRIPTION
J10	28	RUN	This is a 120VAC input, which when momentarily activated, will put the drive into run mode as long as the estop and stop commands are active and there are no faults. It is usually a momentary normally open push button. This input is ignored if the JOG input is active.
	29	JOG	This is a 120VAC input which when active will put the drive into jog mode as long as the estop and stop commands are active. If the drive is already in run mode this input will have no affect.
	30	FWD/REV	This is a 120VAC input which when active will put the drive into the reverse mode when using a CA366 analog speed loop card.
J3	---	CURRENT XFMRS	Each drive has two Current Transformers on the incoming AC power lines which are connected to this 3-pole terminal. Any two of the three lines are acceptable, however the polarity must be the same. See Section 15 for wiring.
J8	---	BURDEN RESISTOR	This 2-pole terminal is for mounting of the burden resistor to scale the current feedback from the CT's. R = 3.1 × CT Ratio ÷ maximum current
J13	---	VOLTAGE FEEDBACK	Terminals AA and BB are used to connect the armature voltage feedback from the motor side of the DC contactor and install scaling resistors. R (in kilo-ohms) = maximum armature volts - 1 The resistance is a combination of two resistors as close to equal as possible.
J15	---	R	Connection from 240 or 480 VAC "R" phase for the power supply and synchronizing of the CA384.
	---	S	Connection from 240 or 480 VAC "S" phase for the power supply and synchronizing of the CA384.
	---	---	Two other terminals of the 4-pole terminal strip for linking the transformer for 240 or 480 VAC. See following figure.

7.1.1 TRANSFORMER LINKING



7.2 RIBBON CABLE CONNECTIONS

RIBBON	NAME	DESCRIPTION
CN1	CONVERTER 1	This 10 pin ribbon cable sends the firing pulses to the CA355 firing card for bridge #1.
CN2	CONVERTER 2	This 10 pin ribbon cable sends the firing pulses to the CA355 firing card for bridge #2.
CS1	CELL STATE	This 14 pin ribbon cable passes the cell information, the state of each of the 3 phases, as well as the phase rotation from the CA525 cell state and snubber card to the CA384 card.
JP1	CONTROL SIGNALS	This ribbon cable is used to connect the CA366 analog speedloop card to the CA384. This is used in place of a SAFphire controller or any other type of external speedloop.

7.3 DB25 CONNECTORS

DB25	NAME	DESCRIPTION
DB201	SAFPHIRE COMMUNICATIONS PORT	This is a 25 conductor cable which connects the drive to a CA407 interface card which is mounted in a SAFphire controller.
DB202	DIAGNOSTICS PORT	This connector is reserved for future development.

8. 0 JUMPER SETTINGS

JUMPER	NAME	DESCRIPTION
J4	SAFPHIRE CONTROL	This jumper is used to enable (ENA) or disable (DISA) SAFphire control. With SAFphire control signals such as start, stop, reset, and zero speed signals are passed via the DB25 cable. When the SAFphire is being used the jumper should be in the enable position.
J5	SAFPHIRE CURRENT REF	When in the enable (ENA) position this jumper will connect the current reference from the SAFphire. In the disable (DISA) position the current reference either comes from a CA366 card or terminal 11.
J6	EXTERNAL PHASE	With this jumper in the disable (DISA) position the phase angle reference will come from the CA384 current loop. In the enable (ENA) position it will use the phase angle reference form terminal 5. *Note if the jumper is in the enable position there is no attempt to limit armature current or armature voltage.
J11	---	This jumper determines what converters are enabled. Jumper position: *AC = regenerative both converters enabled *AB = non-regenerative converter #2 enabled *CD = non-regenerative converter #1 enabled If the jumper is removed the drive will be non-regenerative with converter #2 enabled.

9. 0 POTENTIOMETER FUNCTIONS

POT	NAME	DESCRIPTION
RV1	OFFSET	This allows the user to add a slight offset to the current feedback signal. Normally used to prevent current from being drawn with a current reference of 0 Vdc. Normal position is 50%.
RV2	HYSTER	Adjustment for hysterisis on the bridge switching circuit. No hysteresis is achieved at 0% and 100% gives 50mV of hysterisis.
RV3	OVR VOLTAGE ADJ	Controls the set point at which the drive will trip on an armature over voltage fault. With correct VFBK resistors the setting should be approximately 50%.
RV4	VFBK ZERO	Controls offset adjustment for the output of the armature voltage feedback isolator. ***This pot is factory set and should not be adjusted.***
RV5	RETARD	Controls the lower limit on the phase angle reference. ***This pot is factory set to 30° and should not have to be adjusted.***
RV6	ADVANCE	Controls the upper limit on the phase angle reference. ***This pot is factory set to 159° and should not have to be adjusted.***
RV7	GAIN	Stability adjustment for the current regulator. This should be set as high as possible without causing the current loop to go unstable. Normally settings are between 50% and 80%.
RV8	CURRENT RATE	Controls slew rate limit for current reference, 0% is a 50msec ramp and 100% is a 3.5msec ramp. Normal position is 100%.
RV9	IFBK GAIN	Controls the gain setting for the analog armature current feedback signal which goes back to the SAFphire via the 25 pin connector. ***This pot is factory set and should not be adjusted.***
RV10	VFBK GAIN	Controls the gain setting for the analog armature voltage feedback signal which goes back to the SAFphire via the 25 pin connector. ***This pot is factory set and should not be adjusted.***
RV13	MOTOR OVRLD CAL	This pot sets up the point at which the overload begins to charge as illuminated by LD8, OLCB. See Section 11.4 for setup.

10.0 LED INDICATORS

LED	NAME	COLOUR	DESCRIPTION
LD1	---	RED	This is a ten segment light bar which will scroll continuously as long as the drive is healthy (no faults). See Section 6.6 for fault details.
LD2	ESR	GRN	This LED indicates that the 120VAC E-STOP input is active and the drive is permitted to run.
LD3	SYNCH OK	RED	This LED indicates that the control power coming into the CA384 is synchronized with lines R and S of the 3ø power section.
LD4	JOG	GRN	This LED indicates that the drive is in the jog mode. (only active when using 120VAC control)
LD5	PLL OK	RED	This LED indicates that the phase lock loop is operating properly.
LD6	CONTACTOR	GRN	This LED indicates that the 120VAC MX input is active.
LD7	RUN	GRN	This LED indicates that the drive is in the run mode.
LD8	OLCB	RED	This LED will turn on when the drive is in an overload condition. Usually setup to illuminate when drawing more than motor nameplate armature current. Calibration is via RV13, MOTOR OVRLD CAL pot.
LD9	CELL STATE	RED	This LED will be on when none of the SCR's are conducting.
LD10	CONV 2	GRN	This LED indicates that Converter #2 is active.
LD11	CONV 1	GRN	This LED indicates that Converter #1 is active.
LD12	VRA	GRN	This voltage relay LED is a signal from either the SAFphire or the CA366 card indicating, when illuminated, that the motor is not at zero speed.
LD13	PRUN	GRN	This LED being on indicates that the run signal from the SAFphire is active.
LD14	WDOG	GRN	When J4 is in the ENA position, this LED will flash once per second if communication between the SAFphire and the drive is okay.
LD15	READY	GRN	This LED indicates that the fault relay is energized and there are no faults.

11.0 STARTUP PROCEDURE

NOTE:
THIS SECTION SHOULD BE READ IN ITS ENTIRETY BEFORE APPLYING POWER TO THE DRIVE! THIS STARTUP PROCEDURE APPLIES TO DD312/306'S BEING CONTROLLED BY A SAFPHIRE PLnC. IF YOU HAVE A STAND ALONE DD312/306 WITH A CA366 TOP CARD YOU SHOULD REFER TO THE CA366 MANUAL FOR THE STARTUP PROCEDURE!

11.1 PRELIMINARY CHECKS

11.1.1 ADJUSTMENTS (To Be Made Prior to Operation)

POT	NAME	SETTING
RV1	OFFSET	50%
RV2	HYSTER	0%
RV3	OVR VOLTAGE ADJ	70%
RV4	VFBK ZERO	factory set
RV5	RETARD	factory set
RV6	ADVANCE	factory set
RV7	GAIN	60%
RV8	CURRENT RATE	100%
RV9	IFBK GAIN	factory set
RV10	VFBK GAIN	factory set
RV13	MOTOR OVRLD CAL	100%

11.1.2 Jumper Positions To Be Checked

JUMPER	REFERENCE	POSITION
J4	SAFPHIRE CONTROL	ENA
J5	SAFPHIRE CURRENT REF	ENA
J6	EXTERNAL PHASE	DISA
J11	---	AC = regenerative both converters enabled AB = non-regenerative converter #2 enabled CD = non-regenerative converter #1 enabled

11.1.3 Wire Checks

Use ohmmeter and check all power and control wiring to ground. Check for proper resistance readings on the armature and field of the motor. (see motor manufacture's specifications for proper readings). Make sure that power and signal cables are run in separate conduits.

11.2 CALIBRATION RESISTORS

Check that the burden resistor has been calibrated properly (section 6.8.1).
Check that the armature voltage feedback resistors have been calibrated properly (section 6.7).

11.3 INITIAL DRIVE OPERATION

It is recommended that the motor be mechanically disconnected from the load during the initial drive operation.

Make sure the ESTOP circuit is disabled and apply power to the drive.

Check the incoming 3 phase power, make sure all 3 phases are balanced and the proper voltage.

Check that the field voltage and current are correct for the motor. Add external series trimming resistors, or adjust field regulator if necessary.

Check that the bar graph fault annunciator is scrolling at the bottom left of the CA384 card. If it is stopped, check the fault and refer to section 6.6.

Adjust the FWD and REV current limits to ZERO in the SAFphire program. Set speed or voltage reference to 10% of full reference. Enable the ESTOP circuit and give the drive a run command either using the external 120VAC control logic or the software run command from the SAFphire. At this point the motor should not be turning or drawing any current because the current limits are set at 0%. Use the hand terminal or the annunciator to monitor the reference and feedback going into your control loop in SAFphire. SLOWLY increase the FWD current limit until the motor starts to rotate. The reference and the feedback should be the same polarity. If they are not the motor will try to run away. BE READY TO HIT THE ESTOP. If the motor runs away the feedback signal is backwards. If you are running a voltage loop double check the voltage feedback connections (section 7.7). If you are running a speedloop, change the polarity of the encoder feedback.

Once you have control of the motor check the direction of rotation is correct. If it is wrong and you are running a voltage loop, reverse the field connections and the rotation will be opposite. If you are running a speedloop you will have to reverse the field connections as well as the encoder polarity.
NOTE: To reverse the polarity of a quadrature differential encoder, interchange "A" and "A NOT" or "B" and "B NOT". To reverse the polarity of a quadrature single ended encoder, interchange "A" and "B".

11.4 CURRENT REGULATOR SETUP AND OVERLOAD CALIBRATION

Remove AC power and disconnect the field leads. The motor shaft should be mechanically locked to prevent it from moving. The following procedure will require a full load test on the motor. A stalled motor should not be subjected to high armature current for prolonged periods of time. If possible let the motor cool down and turn the shaft in between periods of high current.
Make sure the current limit settings in the SAFphire are set to 0%. Adjust the GAIN pot RV7 on the CA384 card to 30%. Connect a scope across the burden resistor set for 1VDC/div and a time base of 5msec to monitor the current feedback.

Apply power to the drive and give the drive a run command. Set the speed reference to 20%. Nothing should be happening yet because the current limits in SAFphire are still set to 0%. Increase the current to full load (usually 150% of the motor nameplate) in a couple of steps and then increase the GAIN pot RV7 as high as possible without the current feedback going unstable. Set the current back to 0%. Again increase the current limit to the motor nameplate current and decrease the MOTOR OVRLD CAL pot RV13 until LD9 starts to flicker. Disable the drive. This sets up the inverse timed overload to trip in 1 minute if the drive is drawing 150% of the motor nameplate current. Change the speed reference to 20% in the opposite direction and repeat the above procedure verifying the settings of the GAIN pot and the MOTOR OVRLD CAL pot.

Remove the AC power from the drive, reconnect the field leads and unlock the motor shaft.

NOTE: SAF DRIVES will not be held responsible for damage to equipment or personal injury caused by improper calibration of the current limit or the motor overload settings.

11.5 FINAL SETUP

Connect the motor to the machine and tune the speedloop accordingly either by using the autotune function in SAFphire, or by manually tuning the integrating time and proportional gain of the control loop in SAFphire.

12.0 TROUBLESHOOTING

12.1 PROBLEM: Drive is being told to start, but contactor doesn't pick-up

Possible Cause:

Drive has faulted.

Solution:

Check LED bar graph fault annunicator on the CA384. If it has stopped on a fault, try resetting the drive. If it won't reset, consult the appropriate section of this troubleshooting guide.

Possible Cause:

No external 120V control supply.

Solution:

Check that there is 120VAC between terminals 18 and 23 of the CA384 card. Check external fuses etc.

Possible Cause:

E-STOP circuit is not energized.

Solution:

Check that there is 120VAC between terminals 27 and 23 on the CA384 card.

Possible Cause:

Software enable is not activated. This is a feature which is meant to be used in conjunction with the SAFphire intelligent front end.

Solution:

Check that jumper JP4 on the CA384 is in the "ENA" position.

Possible Cause:

External supply does not have sufficient power to pick up the contactor.

Solution:

Check for voltage at the coil of the contactor. Check transformer ratings etc

12.2 PROBLEM: Motor contactor energizes, but motor doesn't move

Possible Cause:

The drive cannot produce current in the motor.

Solution:

Check burden resistor calibration. Check that the CA355 card(s) are properly connected to the CONVERTER1 and CONVERTER2 ports on the CA384 card. Check that gate leads are connected to the CA355 card(s). Check that the motor armature is properly connected. Check appropriate current limits. Check that the DC armature fuse (optional) is not blown.

Possible Cause:

The current regulator is in current limit but there is no shunt field, and therefore no torque to turn the motor.

Motor is stalled.

Solution:

Correct the problem with the motor shunt field.

Possible Cause:

The Cell State card is not permitting the SCR's to be fired.

Solution:

Check that LD9 on the CA384 card is on. Check for shorted SCR's by measuring the AC voltages between each supply line and each DC output, if you measure zero volts across an SCR it is shorted. Check that the CA525 card is connected to the CA384 card. (This would normally show up as a PHASE LOSS fault).

Possible Cause:

The drive has zero reference.

Solution:

Check external circuitry.

Possible Cause:

In the case of a DD312 the DC output fuse could be blown.

Solution:

Check DC output fuse and replace if necessary.

12.3 PROBLEM: Drive trips on Instantaneous Over-Current (IOC).

Possible Cause:

Current loop is unstable.

Solution:

Turn current loop gain pot (labeled "GAIN" on the CA384 card) counter clockwise until problem is eliminated.

Possible Cause:

Current transformers are backwards.

Solution:

Change polarity of one of the CT's. This is checked at the factory and should not be a problem, unless CT's have been rewired on site.

12.4 PROBLEM: Drive trips on heatsink over-temperature (HSOT)

Possible Cause:

Heatsink over temperature contact has opened. Check for DC voltage across terminals 7 and 8 of the CA384 card, 24 volts indicates that the contact has opened.

Solution:

Let the heatsink cool down, then check the loading on the drive to see that it's rating is not being exceeded. Double check to make sure all cooling fans are functional and all air filters are clean

Possible Cause:

The heatsink over temperature leads are not connected.

Solution:

Connect heatsink over-temperature leads to terminals 7 and 8 on the CA384 card.

12.5 PROBLEM: Drive trips on feedback loss trip.

Check polarity of the encoder feedback to SAFphire, the tach feedback to CA366 card if used, or the polarity to the voltage feedback to the CA384 if a voltage loop is being used.

CA366

Possible Cause:

Tachometer has been improperly calibrated.

Solution:

Consult the Startup Instructions and run the drive using armature voltage feedback. Monitor the tachometer feedback and recalibrate the feedback if necessary.

Possible Cause:

The current regulator is being enabled, but the drive is unable to fire SCR's or the motor circuit is open. This will cause the current regulator to increase the phase angle but there will be no feedback because the motor is not moving.

Solution:

Check motor armature connections for an open circuit. Check CT connections going into the CA384 card and make sure that the burden resistor on the CA384 card is not shorted. Check that the CA355 firing card(s) are connected properly to the CONVERTER1 and CONVERTER2 ports on the CA384 card. Check that the gate leads are connected to the CA355 card(s).

Possible Cause:

The current loop is unstable. If the current loop gain is turned too far clockwise, the phase angle can increase more quickly than the tachometer feedback, during acceleration.

Solution:

Try decreasing the current loop gain by turning the pot labeled "GAIN" on the CA384 card, counter-clockwise. Do this gradually, resetting any trips, to see if the problem goes away

SAFphire
If using a differential encoder reverse wires "B" and "BNOT", this will change the polarity of the encoder. If using a single ended encoder reverse wire "A" and "B".Double check to make sure that the "max rpm" and "tach ppr" settings in the SBL program are correct

12.6 PROBLEM: Phase loss trip (Phase Loss on Annunciator)

Possible Cause:

The synchronization at R and S terminals on the CA384 card is incorrect. If this is true, the red LED labeled LD3 at the top of the CA384 card will be OFF.

Solution:

If these points were wired at our factory, it is doubtful that this is the problem. If these points have been wired elsewhere, make sure that the AC input at the R and S terminals of the CA384 card are in phase with R and S of the AC supply. If they are, and LD3 on the CA384 card is OFF, swap the wires on the R and S terminals of the CA384

Possible Cause:

The drive is not manufactured for the correct voltage. Check the voltage rating for the drive on the assembly.

Solution:

If the drive has been manufactured for the wrong voltage, contact SAF DRIVES.

Possible Cause:

The AC supply is not balanced, or is too low. The supply should be within 10% of nominal.

Solution:

Check transformer taps etc.

Possible Cause:

Blown line fuse on the DD312 or at supply. With power on, carefully check for AC voltage across each fuse. This method is generally more reliable than using an ohm-meter with power removed.

Solution:

Replace fuse(s).

Possible Cause:

CA525 Cell State card is faulty or not connected.

Solution:

Check the ribbon cable which joins the CA525 to the CA384 card. If it is not connected, reconnect it. If the "PhaseLoss" fault will not reset, the CA525 may have failed. Try replacing it.

12.7 PROBLEM: Drive blows fuses

Possible Cause:

No current feedback.

Solution:

Check that CT's are connected to the three terminals of the CA384. Check that the burden resistor is not shorted.

Possible Cause:

Incorrect wiring of gate leads to the SCR's and/or incorrect ribbon cables connecting CA355 pulse amplifier card(s) to the CA384 card.

Solution:

Check connections

Possible Cause:

Armature of the motor is shorted to ground.

Solution:

Disconnect the armature wires and check for ground faults on the motor leads. If you have a short circuit it must be fixed before proceeding.

Possible Cause:

There may be a shorted SCR.

Solution:

To check for a shorted SCR, first remove AC incoming power. Using an ohmeter measure the resistance between each armature output lug and the three AC lines. A shorted SCR will read as 0 ohms.

Possible Cause:

There may be missing gate pulses, which would mean certain SCR's will not fire.

Solution:

Check to make sure all the gate connections are secure on the CA355 card and also on the SCR's

Possible Cause:

Inversion fault. This is caused by trying to regenerate when the armature voltage is too high compared to the incoming AC lines.

Solution:

Increase the voltage of the incoming AC lines or decrease armature voltage.

13.0 FIELD BRIDGE CONNECTIONS

All DD312 stack sizes 180A and below have a built in field supply. There is four terminals on the stack to connect the field. The connection points are labeled "F+", "F-", "C", and "T". "F+" should be connected to the positive field wire and "F-" should be connected to the negative field wire. A normally open auxiliary contact from the "M" contactor should be connected between "C" and "T". When "C" and "T" are shorted on a 240VAC drive, the field voltage will be 160VDC, if there is no connection between "C" and "T" the field voltage will be 110VDC. On a 480VAC drive the respective voltages are 220VDC and 320VDC. The reason for the auxiliary contact between "C" and "T" is to prevent the field windings form over heating during times when the drive is powered up but sitting idle.

14.0 SPARE PARTS

14.1 FUSING FOR DD312 240VAC/480VAC

DRIVE MODEL	AC INPUT FUSES	DC OUTPUT FUSE (DD312 only, Not Used on DD306)
DD312-55-2/4	100Amps, 500V	150Amps, 700V
DD312-90-2/4	100Amps, 500V	150Amps, 700V
DD312-130-2/4	300Amps, 500V	400Amps, 700V
DD312-180-2/4	300Amps, 500V	400Amps, 700V
DD312-260-2/4	400Amps, 500V	400Amps, 700V
DD312-350-2/4	400Amps, 500V	600Amps, 700V
DD312-500-2/4	600Amps, 500V	800Amps, 700V
DD312-800-2/4	1000Amps, 500V	1200Amps, 700V
DD312-1000-2/4	1200Amps, 500V	1600Amps, 700V
DD312-1250-2/4	1000Amps, 500V ONE FUSE PER SCR (there must be an indicator fuse in parallel with each large fuse)	Not Used

*All of the above are semi-conductor fuses.
**Fuses must be replaced with fuses that have identical characteristics as those supplied by the factory

SAF DRIVES IS NOT RESPONSIBLE FOR ANY DAMAGE OR PERSONAL INJURY CAUSED BY IMPROPER FUSING.

14.2 REPLACEMENT CURRENT TRANSFORMERS

STACK SIZE	CURRENT TRANSFORMER	CURRENT TRANSFORMER RATIO
DD312-55-2/4, DD312-90-2/4	T261123	1500 : 1 (3 turns = 500 : 1)
DD312-130-2/4, DD312-180-2/4	T261320	1000 : 1
DD312-260-2/4, DD312-350-2/4, DD312-500-2/4	T262320	2500 : 1
DD312-800-2/4	T265320	5000 : 1
DD312-1000-2/4, DD312-1250-2/4	T268320	8500 : 1

14.3 REPLACEMENT SCR'S

STACK SIZE	SCR'S	RATINGS
DD312-55-2/4, DD312-90-2/4	N10SP06	90 Amps, 1600V
DD312-130-2/4, DD312-180-2/4	N10SP16	140 Amps, 1600V
DD312-260-2/4	N20SP06	250 Amps, 1600V
DD312-350-2/4	N728452	580 Amps, 1600V
DD312-500-2/4	N718602	720 Amps, 1600V
DD312-800-2/4, DD312-1000-2/4, DD312-1250-2/4	N718133	1100 Amps, 1600V

14.4 SCR TIGHTENING PROCEDURE

14.4.1 Clean both heat sink and SCR surfaces.

14.4.2 Apply a thin layer of joint compound (Noalox) to both SCR surfaces.

14.4.3 Observe correct SCR polarity.

14.4.4 Install SCR so that roll pins engage dimples on both sides of the SCR.

14.4.5 Tighten clamp bolts evenly until finger-tight.

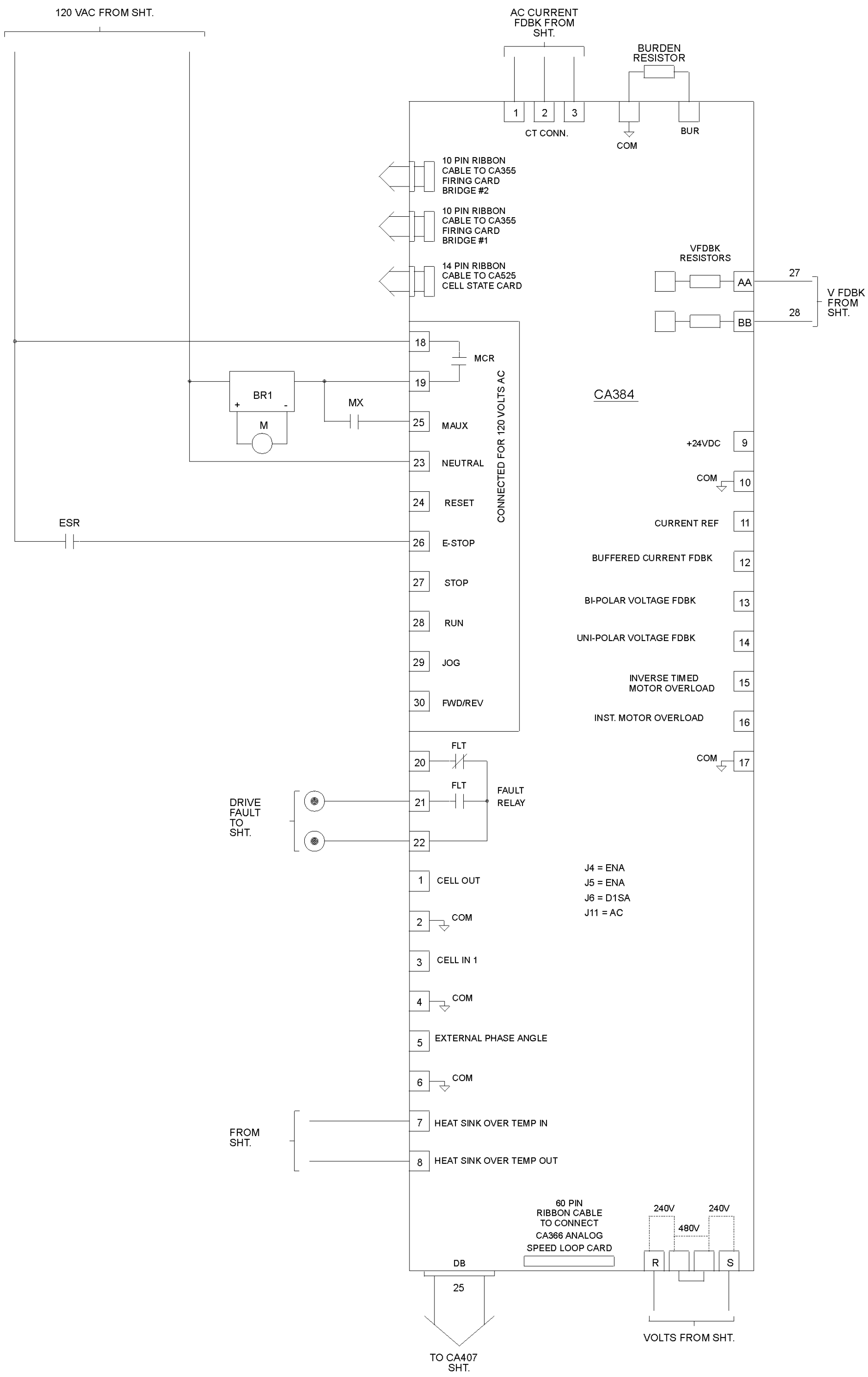
14.4.6 Tighten each bolt according to table below (based on number of spring bars and size of bars).

* NOTE: SMALL clamps are 4.25 inches / 10.5 cm and LARGE clamps are 5 inches / 12.5 cm

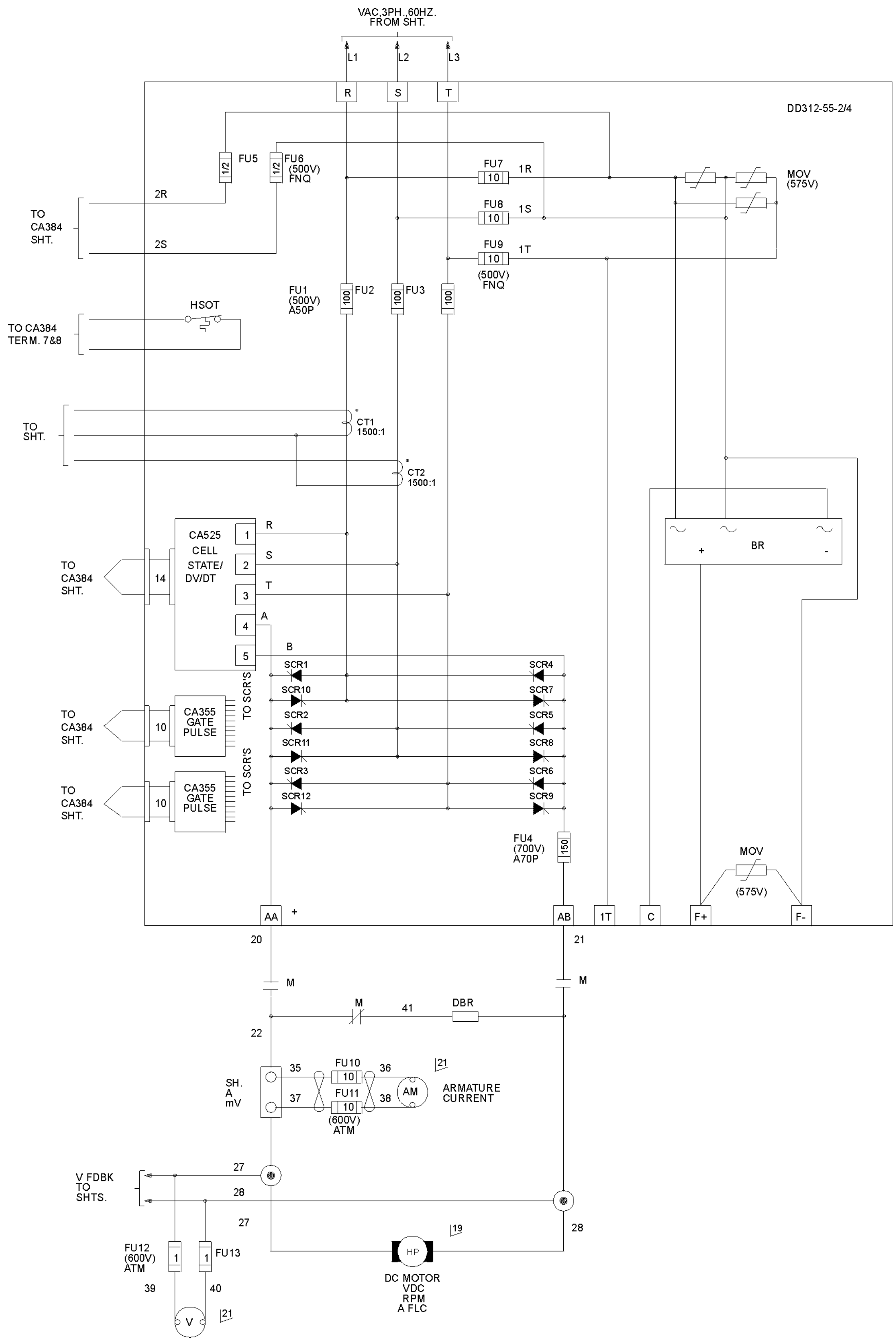
CLAMP SIZE	# OF SPRING BARS	BOLT TURNS PAST FINGER TIGHT
SMALL	1	0.8
SMALL	2	1
LARGE	3	1.8
LARGE	4	1.8

15.0 SCHEMATICS

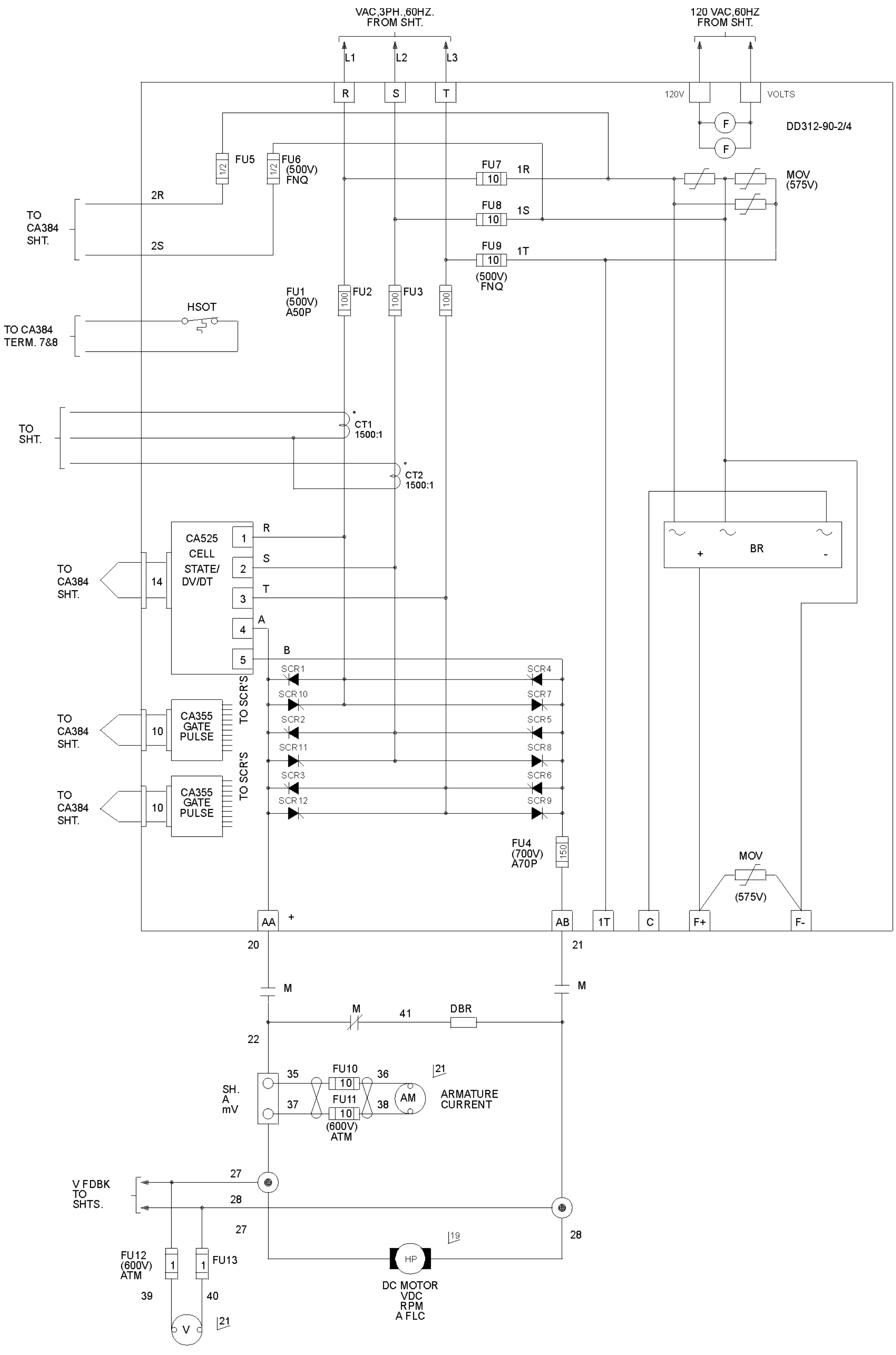
15.1 CA384 CONTROL CARD



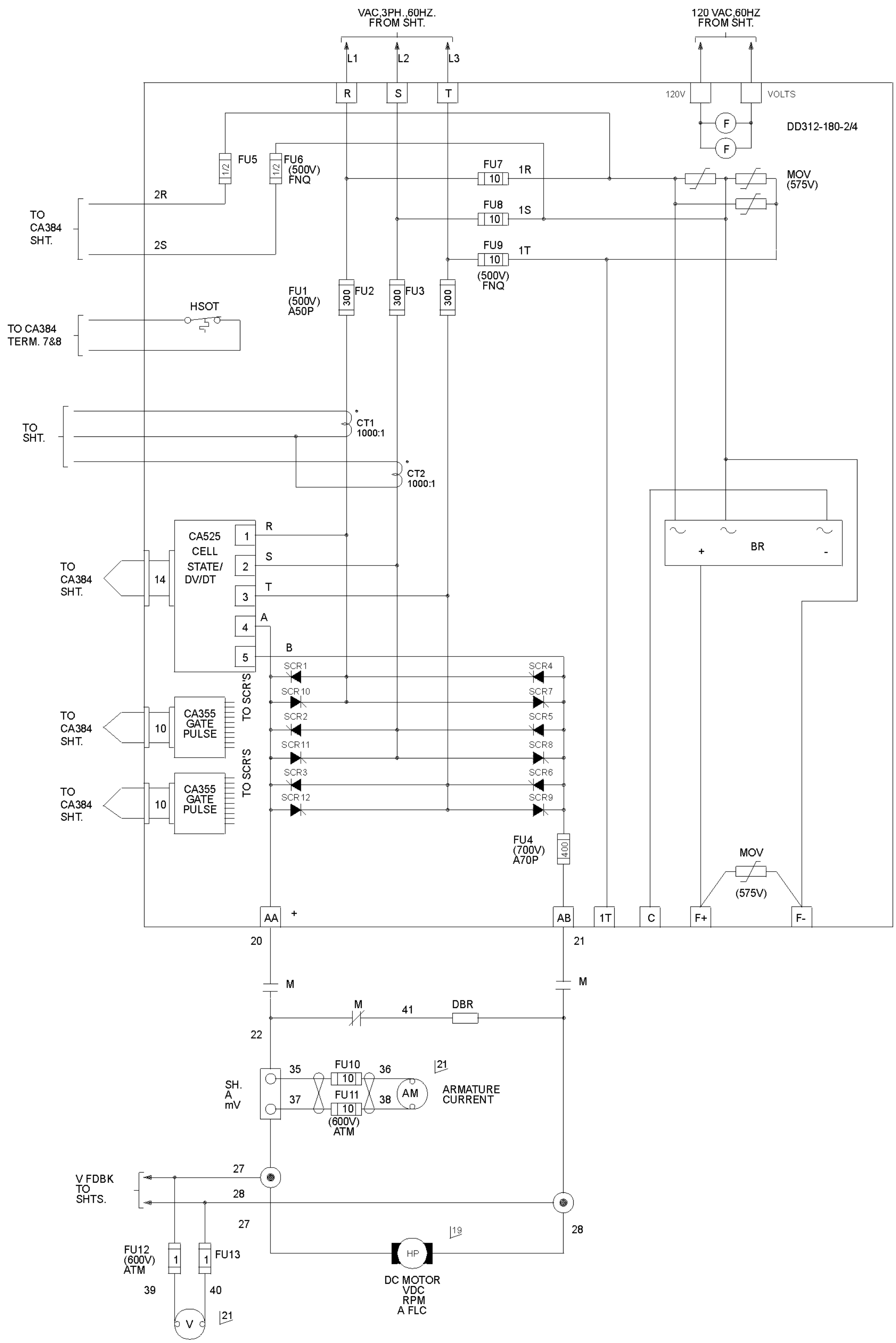
15.2 DD312-55-2/4



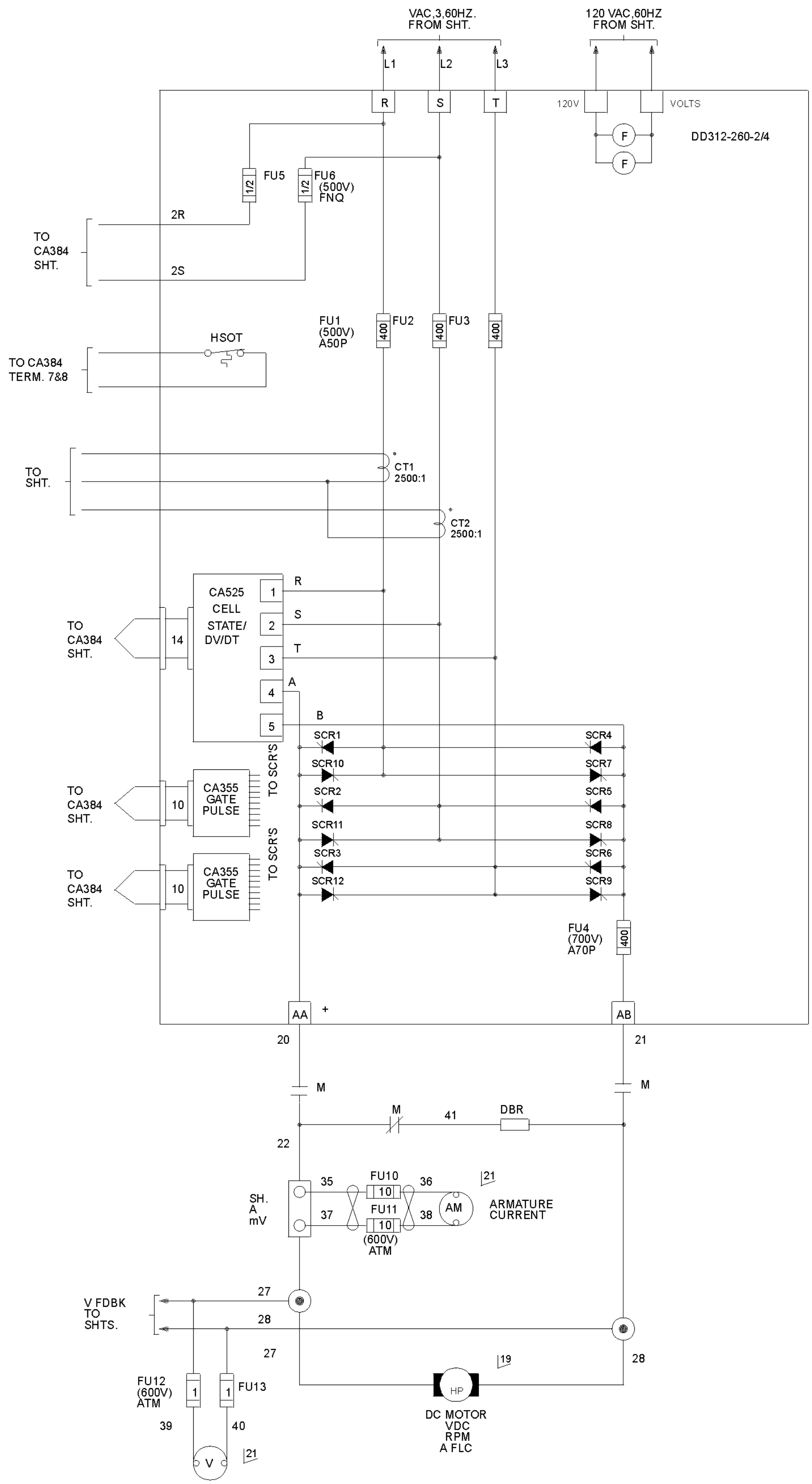
15.3 DD312-90-2/4



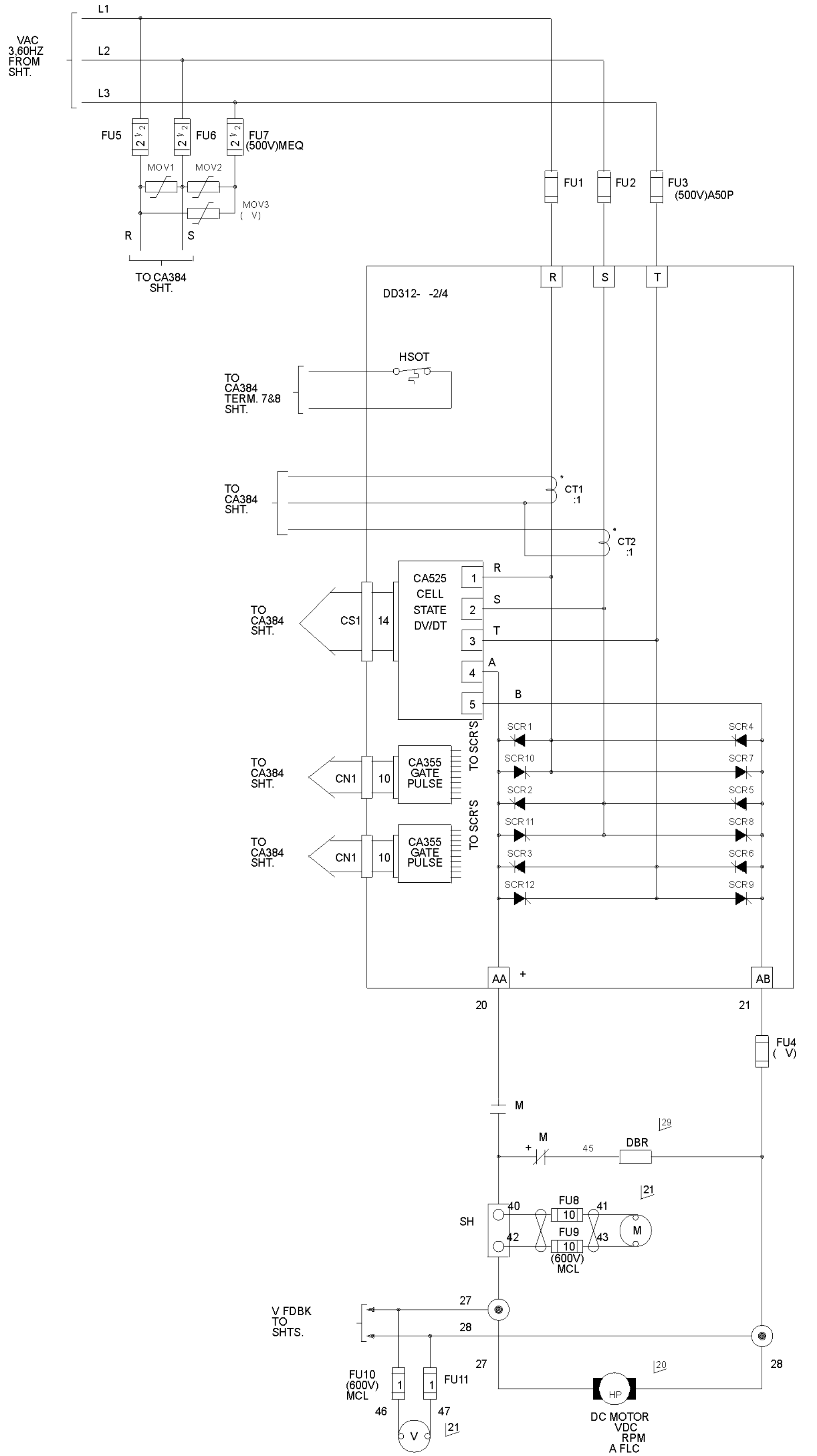
15.4 DD312-130-2/4, DD312-180-2/4



15.5 DD312-260-2/4



15.6 DD312-ABOVE 260-2/4



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