Amalgen

Models 6978-0.6kW to 6978-3.0kW

Solid State Reversing Motor Starter

Manual Revision 3

Model 6978

1 Scope

This manual applies to Model 6978 Solid State Motor Starter. The manual covers application, installation, operation, repair and bench test of the motor starter. The 6978 is designed for 415VAC line-line.

2 Applicable documents

Schematic	6978logic_rev 4	attachment 1
	6978scr_rev 2	attachment 2
	6978pwr_rev 3	attachment 3

3 Specification

Model range	6978-0.6	0.6kW Half-19" rack
	6978-1.1	1.1kW Half-19"rack
	6978-1.5	1.5kW Full-19" rack
	6978-2.2	2.2kW Full-19" rack
	6978-3.0	3.0kW Full-19" rack
Design type	All 3 phases switched in forward & reverse	
	Close (rwb->uvw)	Phases go straight through
	Open	2 phases swapped
Electrical connection	Mains voltage	415VAC +10% -15% 3-wire
	Mains frequency	47-63Hz
	Output Current	Load/ fault 10msec
	0.06-0.55kW	1.5A/ 94A (limited by 2.2ohm)
	1.1kW	2.5A/ 180A (limited by 1.1ohm)
	1.5kW	3.8A/ 180A (limited by 1.1ohm)
	2.2kW	5.5A/ 400A (limited by 0.5 ohm)
	3kW	7A/ 400A (limited by 0.5 ohm)
	I^2t rating of fuse	**Must fit external fuses**
		Use high speed HRC type
	0.06-0.55kW	200 A^2sec 15A rating
	1.1kW	400 A^2sec 20A rating
	1.5-3.0kW	8kA^2sec 35A rating
	Thermistor	<750Ω motor OK (reset)
		>1600Ω tripped
	Thermistor trip resistances as per AS1023.1-1971	
Ambient temperature	Inside rack	10C to 55C air flow must not be restricted
Mechanical	0.06-1.1kW	Half 19" rack 3U high, 5kg
	1.5, 2.2 3.0kW	Full 19" rack 3U high, 9kg
Control	Inputs	16-24VDC for ON Open-circuit for OFF
	Open/close, local/remote, limit-switch, torque-switch	
	Outputs	Open collector, 28V max supply
	Field input status, Static switch OK, available, temp.l	
Static switch functions	Brake	Adjustable DC injection brake
	Interlock	Prevents incorrect operation
	Torque latch	Travel must be reversed after a torque switch has operated.

4 Product description

4.1 Application

Model 6978 is designed to control valve actuators where a 3-phase motor is used to open and close valves or dampers in flow control applications. The unit improves on previous Amalgen designs with the inclusion of latched torque switch inputs, remote monitoring of field switches and power supply, adjustable DC brake and easier connection method for AC and control wiring. The design is conservative, using well-proven SCR AC switches.
Control connects to the front via a DB37 and all power connects to the rear via a 15-way DIN connector. Installation or replacement takes only seconds.

4.2 Functional description

Model 6978 is a solid state reversing 3-phase motor starter, with a static switch and control unit. It connects a 3-phase motor to AC mains directly, as shown in Figure 1, with forward or reverse phase rotation depending on the control signals from the controller. The controller interface is optically isolated and accepts 24VDC signals from relays or open collector logic. See section 4.3 for connections.

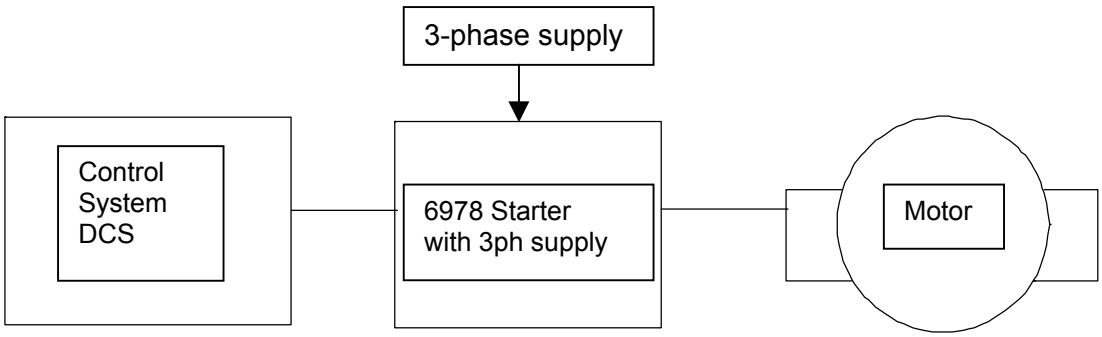


Figure 1
General application of 6978 Motor Starter

The motor starter is constructed using 2 or 3 PCBs depending on power rating. The higher power units use 2 PCBs (SCR and Power PCB are combined).
The Logic PCB (front of unit) has the control interface, functional logic and indicators.
The Power PCB has the power supply, thermistor circuit and power resistors.
The SCR PCB has the power connector, gate drive circuits and SCRs.

Function of the Logic PCB is described in section 4.2.1
Function of the Power PCB is described in section 4.2.2.
Function of the SCR PCB is described in section 4.2.3.

4.2.1 Logic PCB Description

The Logic PCB provides several functions for the motor starter: DCS input isolation and interlock, torque latch, restart holdoff, brake, DCS outputs, and SCR drive.
DCS input isolation is done with optocouplers with Schmitt trigger outputs, thus cleaning slow risetime inputs to the 6978. Interlocks block other inputs for safety.
Torque latch remembers the last direction so that the next operation must be in the opposite direction.

Brake is applied for a fixed time but with variable voltage. The phase is determined from a ramp and pedestal circuit (U17C) which results in a variable length pulse applied to forward and reverse SCRs alternatively. A short holdoff time is created by C32 and the overall brake time is created by C33 and associated circuits. The result of the brake timing circuits can be seen at test point J4 (near F4).
Restart holdoff comes from U8, which prevents operation for 150msec after a falling edge of Open/Close is detected.
DCS outputs come from optocouplers and signals on the Power PCB.
SCR drive is done by MOSFETS F7-10. Oscillator U16C produces 25usec pulses to drive the SCRs, once the correct Open/Close/Brake condition is present.
Due to the method of construction (surface mount technology), fault-finding and repair of this PCB is best done at Amalgen. Testing requires a test jig.

4.2.2 Power PCB Description

The power PCB provides internal power for logic and has the 3 power resistors, which limit fault current through the unit. 415VAC is taken into the PCB via a terminal block, and passes back to the SCR PCB via the power-resistors. Red and white phases supply power for the isolated thermistor sense circuit. White and blue phases supply power for the logic and SCR drive.

4.2.3 SCR PCB Description

The SCR PCB has the power connector, mains filter, and the SCRs and their drives. The user connects power and motor using a 15-way DIN41612 connector.

4.3 User connections

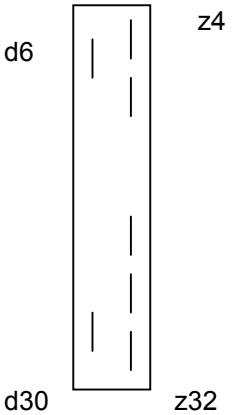
To use the 6978 Motor Starter, connection is made to AC mains and motor, with logic connected via a DB37 connector. Additionally, a thermistor may be connected. AC wiring and thermistor connect using a 15-way removable plug to the rear of the unit. Connections are summarised below (see Figure 2 for pinout).

SOLID STATE STARTER USER CONNECTIONS

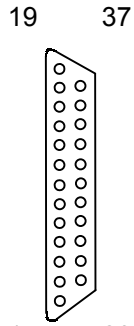
Connection	Method of connection	Comment
General	15-way DIN41612 style “H” Connector plugs into rear panel	plug into DIN connector
AC input 3-wire	6mm quick connect lugs	Wiring 415V, 2.5mm
Motor 3-wire	6mm quick connect lugs	Wiring 415V, 2.5mm
Thermistor 2-wire	6mm quick connect lugs	2.5mm wires from motor
Logic for control/monitoring	DB37 connector assembly	See table for details.

4.3.1 Wiring for 15way Connector

Pin number	Description	Comment
d6 (left side)	Red in	from AC supply
d10	White in	from AC supply
d14	Blue in	from AC supply
d18	Red out (motor phase U)	to motor
d22	White out (motor phase V)	to motor
d26	Blue out (motor phase W)	to motor
d30	Earth	frame ground
z4 (right side)	Thermistor	from motor
z8	Thermistor	from motor
z12	Earth	protective earth
z16	Earth	protective earth
z20	Not used	
z24	Not used	
z28	Not used	
z32	Not used	



DIN41612 pinout looking at rear



DB37 pinout looking at front of unit

Figure 2
Connector Pin Locations

4.3.2 Wiring for DB37 Connector

Outputs are optically isolated. Cable type is Multicomp 36 core (7/0.2mm). 28 used.

Pin No/Cable colour	Description	Designation/cable marking
1 red	Field input return for 24V supply	F0V
2	TOL not operated	Not used
3 green	OPEN L/S not operated	FLSO
4 yellow	OPEN TORQUE sw not operated	FTSO
5 white	CLOSE L/S not operated	FLSC
6 black	CLOSE TORQUE sw not operated	FTSC
7 brown	REMOTE selected	FAVL
8 violet	+24V field supply from DCS	F24+
9 orange	+24V limit switches	FSW+
10 pink	+24V remote supply	FRE+
11	Not used	
12	Not used	
13 red/blue	MOTOR TEMP NORMAL+	THT+
14 green/red	STATIC SWITCH FAULT +	NFL+
15 yellow/red	AVAILABLE +	AVL+
16 white/red	CLOSE L/S monitor +	LSC+
17 red/black	OPEN L/S monitor +	LSO+
18 red/brown	CLOSE TORQUE LATCH +	CTL+
19 yellow/blue	OPEN TORQUE LATCH +	OTL+
20 white/blue	Field input return for 24V supply	F0V
21 blue/black	LOCAL OPEN from test box	LO
22 orange/blue	LOCAL CLOSE from test box	LC
23 green/blue	DCS OPEN	O
24 grey/blue	OVERRIDE OPEN	OPO
25 yellow/green	DCS CLOSE	C
26 white/green	OVERRIDE CLOSE	CLO
27	Not used	
28	Not used	
29	Not used	
30	Not used	
31 white/brown	MOTOR TEMP NORMAL-	THT-
32 brown/black	STATIC SWITCH FAULT -	NFL-
33 grey/brown	AVAILABLE -	AVL-
34 yellow/violet	CLOSE L/S monitor -	LSC-
35 violet/black	OPEN L/S monitor -	LSO-
36 white/violet	CLOSE TORQUE LATCH -	CTL-
37 grey/green	OPEN TORQUE LATCH -	OTL-

4.4 Safety

There is no fusing inside Model 6978. Short circuit current is internally limited. **Fuses or circuit breakers must be provided in the AC supply**. See Specification for types. Due to the method of power connection, model 6978 Motor Starter should be installed in limited access locations where personnel are instructed in electrical safety.

The unit must be earthed using the earth point provided.

For protection of operator and connected control equipment, the 6978 Motor Starter uses optically isolated control inputs/outputs. All isolated signals connect via the DB37 connector on the front panel.

The control logic has interlocks on all inputs to prevent simultaneous Open and Close operation. This prevents an effective short circuit from phase to phase.

Design is conservative with regards to component rating and heatsinking.

4.5 Voltage Input

The 6978 Motor Starter can operate over a range of +20% to –20% of rated mains voltage. Note that the DC brake and/or low AC voltage operation may lead to increased temperature in motors.

4.6 Installation

Mounting of Model 6978 uses a standard 19" rack. Two 2kW units can be mounted side-by-side. The 3kW unit is full width. Height is 3U. Air circulation must be adequate (100mm free space above/below units). Use 4 bolts for mounting.

Power connection for Model 6978 is via the 15-way connector at the rear of the unit. Wiring size and type should have appropriate rating.

Fusing is not provided in the unit, so therefore the installation must include a suitable circuit breaker or fuse (see specifications).

Data connection is via a 37-way D-connector. Data wiring does not need to be shielded, and can be up to 6 metre in length.

Thermistor connection is made at the rear of the unit. Thermistors complying with AS1023.1-1971 are suitable. See section 4.3.1for pin numbers.

4.6.1 Connecting power after installation

The 6978 is connected to 415VAC mains via a 15-way DIN connector. It is not recommended to connect/disconnect the cable with the power applied. Connect the 15-way cable with the power switched off.

4.6.2 Connecting the 37-way cable, or maintenance test box

The 6978 includes latches on Open and Close Torque. The logic is designed to be "fail-safe" where loss of signal (+24VDC) means a switch has operated. Because of this, either Open or Close Latch will definitely operate, when the 37-way cable or Test Box is plugged into or removed from a 6978 with the AC power applied.

To clear the latched condition (after plugging-in the 37-way cable or test box to the actuator), manually set the actuator in mid-travel (neither limit switch operated), then send once, an Open then a Close command. The latched condition will clear and normal operation will resume.

It is recommended that the Test Box be plugged into the system when the actuator is in mid-travel position. This allows use of Local Open and Close commands to clear the Torque Switch Latch.

4.7 Operation

Local mode gives the operator access to Local Open and Close. Movement ceases when limit switch or torque switch is activated.

Remote mode is the normal mode of operation. The controller can open or close the valve, with the option of DCS overriding the command.

Brake occurs after each open or close operation. The brake applies DC to the motor for a short time. The amount of braking is adjustable and can be defeated through change of links on the control PCB.

Torque stop and Limit stop. These stop the motor when a pre-determined limit is reached. The next operation after torque switch operation must be in the opposite direction. Close limit switch can be defeated so that torque-switch only stops the motor. Limit switch status is output to the DCS to verify valve position.

4.7.1 Settings for control PCB

The Table below shows settings for the control PCB.

Brake Operation	**Function**	**Comment**
JP1, JP2, JP4	ON selects brake function	Adjust with VR1
	OFF selects NO BRAKE only	Setting ex factory
Close Function	**Function**	**Comment**
JP3	ON selects Close L/S & T/S	
	OFF selects Close T/S only	Setting ex factory

4.8 Maintenance and Repair

Testing the unit.

It is assumed that normal electronic workshop equipment is available.

Testing should be done using the Amalgen 6978 Test Jig and AC cable. The test jig has manual inputs for all DCS inputs, for checking logic and power circuits.

Set the field sensors so that +24VDC is present at L/S and T/S inputs. The 6978 needs +24VDC applied as if a real actuator was connected and it was sitting in a mid-travel position for control section to operate.
Three grouped switches on the Logic PCB select the brake function. One switch selects the close-on-torque-only function

Connect the starter via the 37-way and 15-way connectors. Connect a 415V motor to the AC cable. Connect switched 415V mains to AC cable and operate switches as described below. Turn the Test Jig ON but do not switch the motor starter power on.

Apply AC to the starter. In Remote mode, the Available LED and Static Switch OK are ON. Ensure the Test Jig has limit switches ON.Test Jig indicators for L/S & T/S Open/Close Available and Static Switch Fault should all be ON. Thermal Fault indicator is ON if front panel Therm Fault LED is OFF.

Operating Open/Close in remote mode. Operate Test Jig DCS Open/Close inputs apply.

In Remote mode, Open input causes Open CMD and Close causes Close CMD to light, with motor running each time.

In Local mode, Local LED is lit and Local Open/Close inputs result in Open CMD and Close CMD as before.

Completion of the command may come from a limit switch, torque switch or removing the Open or Close input. Torque switch operation is indicated by the appropriate LED and requires the next start in the opposite direction. When a command is complete, and if the Brake function is selected, a number of brake pulses will be applied to the motor. The severity of braking is adjustable via Brake Adjust control.

Check the brake current using a current transformer and oscilloscope. Correct operation shows a series of alternate current pulses on the blue or white phases after the command has stopped. (about 70msec pulse at J4)

The minimum time between repeated commands of open and close is around 150msec (measure at J5).

Check the thermistor using a 2K variable resistor. LED is ON above 1600 ohms (hot condition) and is OFF when the value is 750 ohms or less.

Likely faults:

Motor is OK in one direction, growls in other: loss of ½ static switch (drive or device) Motor growls in both directions: loss of static switch pair. (drive or device) The gate drive for each SCR pair comes from the Logic PCB. “Static Switch OK” not lit: Check either power supply for correct voltage output. Optocouplers may fail due to fault conditions, and will show on the test jig.

Repairs

Replacement of SCRs: Replacing the SCRs requires careful removal of the old parts. Mounting of SCRs requires care to ensure both mounting surfaces are aligned. It is important that the PCB is washed with isopropyl alcohol after fitting new parts to ensure that dirt does not affect voltage isolation.

Repairing the Logic PCB: Because the logic is not complex, fault finding is fairly easy. However, the repair of the PCB requires careful removal of surface mount parts such as integrated circuits. Best tool for removal of parts is a SMD hot air tool. For this reason, Logic PCBs should be returned to Amalgen for repair.

Mechanical details: The modular construction of the motor starter allows quick replacement of the whole unit (it is better not to hot swap), and quick replacement of PCBs.

Replacing PCBs. Remove Front panel. Remove 4 nuts at rear, remove 2 bolts holding the SCRs to the heat sink. Withdraw the electronic subassembly from the front of the unit. Individual PCBs may then be removed as needed. The SCR and Power PCBs are most likely to fail due to being part of the power circuit for the starter.

The table below explains input and output conditions for the motor starter. Optocouplers are used for outputs to control system

INPUTS				**OUTPUTS to DCS and LEDs for local indication**			
				Optocoupler outputs have BOTH collector & emitter taken to DCS connection			
Signal name	**Signal type/source**	**Condition**		**Signal name**	**Normal Condition**	**Activated Condition**	**Motor Starter Power Fail**
Thermistor	Thermistor	24V at input		THT +/- Monitor output	Contact “closed” for OK TEMP FAULT is OFF locally	Contact “open” for fault TEMP FAULT is ON	Contact “open”
Open L/S	Limit switch not operated	24V at input		LSO +/- Monitor output	Contact “closed” for L/S closed Field Input LED off in mid-travel	Contact “open” at limit OPEN LS ON at limit or if 37-way plug removed	Contact same as DCS input “Contact” powered by DCS
Close L/S	Limit switch not operated	24V at input		LSC +/- Monitor output	Contact “closed” for L/S closed Field Input LED off in mid-travel	Contact “open” at limit CLOSE LS ON at limit or if 37-way plug removed	Contact same as DCS input “Contact” powered by DCS
Open Torque	Torque switch not operated	24V at input		OTL +/- Monitor output	Contact “closed” for not latched Field Input LED off when not latched	Contact “open” if latched OPEN LATCH ON	Contact “open”
Close Torque	Torque switch not operated	24V at input		CTL +/- Monitor output	Contact “closed” for not latched Field Input LED off when not latched	Contact “open” if latched CLOSE LATCH ON	Contact “open”
Static Switch OK	Input phases. Checked as R-W and W-B	Internal supplies OK		NFL +/- Monitor output	Contact “closed’ for phases OK LED is ON when phases OK	Contact “open’ for fail STATIC SW OK OFF	Contact “open”
Open local	Local open command Signal from Test Box	24V at input			LED OFF	LED ON for local OPEN	LED OFF
Close local	Local close command Signal from Test Box	24V at input			LED OFF	LED ON for loc CLOSE	LED OFF
Remote (actuator available)	24V from DCS sets mode Connection is broken when test box is used.	24V at input		AVL +/-	Contact “closed’ for Available AVAILABLE ON for Remote mode LOCAL ON for Local	Contact “open’ for local, or 37-way plug removed	Contact “open”
Open ICMS		24V at input			LED is ON for DCS OPEN		LED OFF
Close ICMS		24V at input			LED is ON for DCS CLOSE		LED OFF
Return	Common connection to negative side of all control inputs	Maximum return current is 70mA		F0V	Separate returns for each open collector output		
Starter input impedance 4k7 ohm. Outputs to DCS 7mA max load							