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Mini-Series Amplifiers
for Brush Type motors

Instruction Manual for Models
DC-35L and DC-45L

Electro-Craft®

Rockwell Automation/Electro-Craft
6950 Washington Avenue South
Eden Prairie, MN 55344

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Mini-Series amplifiers are used to drive brush type DC motors. They can also interface with digital controllers or can be used as stand-alone amplifiers. A single red / green LED indicates the operating status (red or green). All models are fully protected against overvoltage, overcurrent, overheating and against short circuits across motor, ground and power leads. The DC-35L and DC-45L amplifiers operate directly from 120 VAC power.

Potentiometer (pot) controls allow you to adjust Loop Gain, Current Limit, VCS Gain and IR Compensation (Test / Offset). The Test / Offset pot can also be used as an on-board input signal for test purposes.

Typical Applications

- Medical Equipment
- Packaging Machinery
- Material Handling
- Textile Machinery
- Robotics

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CHAPTER 1:

Product Information

Electro-Craft Amplifiers

Standard Features

- Small size, low cost, ease of use
- Surface-mount board technology
- DIP switches that configure different modes of operation
- Four quadrant regenerative operation
- Short Circuit protection
- AC Power Cord for off-line operation

WARNING



Mini-Series Amplifiers are not capable of sourcing optical encoder power.

Adjustment Controls

- I Limit adjusts both continuous and peak hand picked current limits by maintaining their ratio (50%).
- Offset / Test adjusts the zero velocity offset on board signal generator.
- VCS Gain adjusts ratio between input signal and output variables (voltage, current, and velocity).
- Loop Gain adjusts the system response.



Output current must be derated when the heat sink and cooling fan are not used.

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Design Elements

TABLE 1.1 **Amplifier Parameters**

Item	Value
Part number	See Table 1.7 or Table 1.9
Temperature (ambient) operating storage	 32° to 122° F (0° to 50° C) -40° to 176° F (-40° to 80° C)
Relative humidity	5% to 95% non-condensing
Current foldback	50% automatic
Switching frequency	22 kHz
Load inductance	200 mH minimum
Input signal range	±10V (±15 VDC maximum)
Current output monitor (MCO)	Amps to Volts

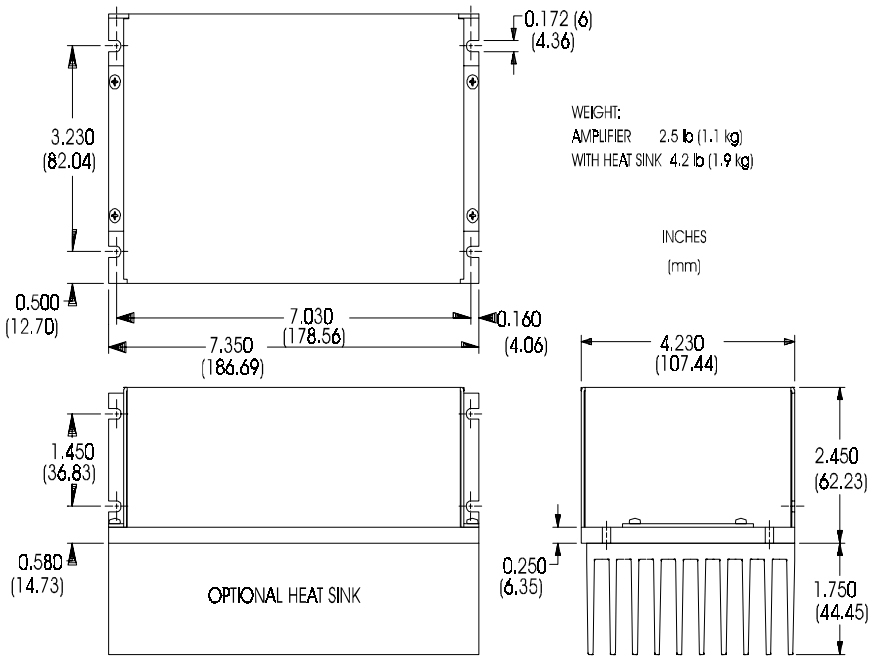


FIGURE 1.1 **Amplifier Schematic** (M743)

TABLE 1.2 **Potentiometer Function**

Potentiometer	Function	Turning CW
Loop Gain	Loop gain, adjustment in voltage and velocity modes. Voltage-to-current scaling factor adjustment in current mode.	Increases Loop Gain
Current Limit	Current limit. Adjusts both continuous and peak current limit by maintaining their ratio (I cont = 1/2 I peak).	Increases Current Limit
VCS Gain	VCS gain. Adjusts the ratio between input signal and output variables (voltage, current and velocity).	Increases VCS Input Gain
Test/Offset	Test/offset. Used to adjust any imbalance in the input signal or in the amplifier. When SW4 (DIP switch) is ON, the sensitivity of this pot is greatly increased, so it can be used as an on-board signal source for test purposes.	Not applicable

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TABLE 1.3 **DIP Switch**

Switch	Block Number	Mode
Test/Offset	10	OFF/ON
Loop Compensation	9	OFF/ON
Loop Integrator	8	OFF/ON
Current Integrator	7	OFF/ON
Continuous Current Limit	6	OFF/ON
Current Limit	5	OFF/ON
Current Loop Integrator	4	OFF/ON
Current Loop Gain	3	OFF/ON
IR Compensation	2	OFF/ON
Volt Feedback	1	OFF/ON

TABLE 1.4 **Pin Function**

Pin	Function	Description	I/O
1	+10V @ 5mA	For customer use.	O
2	SIGNAL GND	Reference ground only.	GND
3	-10V @ 5mA	For customer use.	O
4	VCS+	Differential Analog Reference Input.	I
5	VCS-	Negative voltage at VCS+ with respect to VCS- will cause clockwise rotation when facing motor shaft.	I
6	-TACH	Tachometer input.	I
7	+TACH (GND)		
8	CURRENT MONITOR	Signal is proportional to the actual current in the motor leads. Scaling is approximately 4A/V (2A/V when SW5=OFF) for the DC-35L; and 8A/V (4 A/V when SW5=OFF) for the DC-45L.	0
9	CURRENT REF. (Volts)	Command signal to the internal current loop. The maximum peak current rating of the amplifier equals approximately 7.5V at this point.	O
10	NC	Not connected.	NA
11	ENABLE	Enables the amplifier when connected to SIGNAL GND.	I
12	FORWARD AMPLIFIER CLAMP	Disables CW rotation of the motor. To activate this input, remove connection to SIGNAL GND.	I
13	REVERSE AMPLIFIER CLAMP	Disables CCW rotation of the motor. To activate this input, remove connection to SIGNAL GND.	I
14	FAULT (Red LED)	TTL compatible output becomes high if output short-circuit, overvoltage, overheating, amplifier/disabled, or during power-up reset. Fault condition indicated by red LED. NOTE: Fault conditions are not latched. When a fault condition is removed, the amplifier will be enabled and can resume motion unexpectedly.	O
15	NC	Not Connected	NA
16	NON-ISO GND	Connected to power ground and can be used as ground with P1-8, 9.	

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Amplifier Fan

TABLE 1.5 **Fan Parameters**

Item	Value
Part number	9090-0237
Air flow	35.9 CFM @ 120 VAC, 60 Hz
Speed	3150 RPM
Operating temperature	-10°C to +70°C
Power input	10.5 Watts
Voltage	115V, 50/60 Hz
Housing	metal
Impeller	metal
Rotation	clockwise, looking at rotor

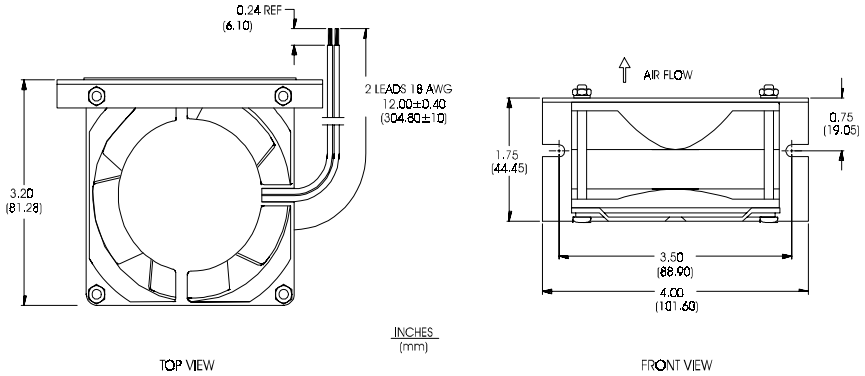


FIGURE 1.2 **Fan Schematic** (730A)

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Model DC-35L

TABLE 1.6 **DC-35L Parameters**

Item	Value
Part number	See Table 1.7
Weight	4 lbs, 2.5 oz. (1.9 Kg)
Power input auxiliary	 25-130 VAC ±10 VDC (2) 5 mAmps max
Output current, 1Ø continuous peak	 ±8A ±16A

Standard Unit	•	•	•	•
With added heat sink		•	•	
With 30 cfm airflow fan			•	
With chassis = < 65° C				•
Peak output current	±16A	±16A	±16A	±16A
Amplifier output curve	A	B	C	C

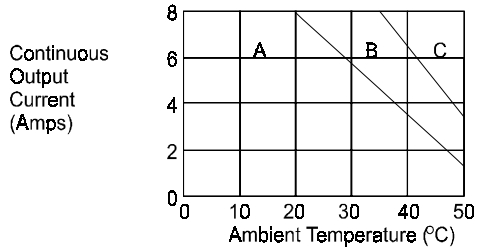


FIGURE 1.3 **DC-35L Amplifier Output Current Derating Curve** (OP1)

TABLE 1.7 **DC-35L Accessories**

Part Number	Description	Stall Torque (lb-in)	Max Speed (RPM)	Power Supply (VAC)
9077-0647	Amplifier, with heat sink	Not applicable		
9077-0646	Amplifier, without heat sink			
9106-0063	Connector kit, included with amplifier			
0721-34-001	Motor, recommended for DC-35L	10	2750	120
0721-32-010	Motor, recommended for DC-35L	17	2750	120
0721-31-041	Motor, recommended for DC-35L	23	2750	120
0642-31-001	Motor, recommended for DC-35L	6	4800	120
0643-33-004	Motor, recommended for DC-35L	8	4800	120
0644-36-012	Motor, recommended for DC-35L	12	1850	120

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Model DC-45L

TABLE 1.8 **DC-45L Parameters**

Item	Value
Part number	See Table 1.9
Weight	4 lbs, 5.0 oz. (2.0 Kg)
Power input shunt	 25-130 VAC up to 30 W continuous (fused)
Output current, 1Ø continuous peak	 ±15A ±30A

Standard Unit	•	•	•	•
With added heat sink		•	•	
With 30 cfm airflow fan			•	
With chassis = < 65° C				•
Peak output current	±30A	±30A	±30A	±30A
Amplifier output curve	A	B	C	C

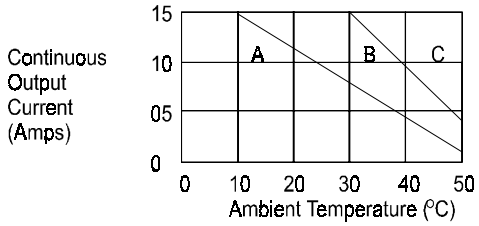


FIGURE 1.4 **DC-45L Amplifier Output Current Derating Curve** (OP2)

TABLE 1.9 **DC-45L Accessories / Repair Parts**

Part Number	Description	Stall Torque (lb-in)	Max Speed (RPM)	Power Supply (VAC)
9077-0649	Amplifier, with heat sink	Not applicable		
9077-0648	Amplifier, without heat sink			
9106-0063	Connector kit, included with amplifier			
0721-34-001	Motor, recommended for DC-45L	10	2750	120
0721-32-010	Motor, recommended for DC-45L	17	2750	120
0721-31-041	Motor, recommended for DC-45L	23	2750	120
0727-32-010	Motor, recommended for DC-45L	28	2750	120
0728-39-003	Motor, recommended for DC-45L	35	2750	120
0642-31-011	Motor, recommended for DC-45L	6	4800	120

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TABLE 1.9 **DC-45L Accessories / Repair Parts** (continued)

Part Number	Description	Stall Torque (lb-in)	Max Speed (RPM)	Power Supply (VAC)
0643-33-004	Motor, recommended for DC-45L	8	4800	120
0644-36-012	Motor, recommended for DC-45L	12	1850	120
Bussman P/N MDL3	Shunt Fuse, 3 A motor delay	Not applicable		

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CHAPTER 2:

Installation

Mounting

The amplifier must be mounted in the vertical position away from other heat producing devices. In multiple axis applications, a minimum of 1.0" separation between each chassis is recommended.

AC Input

The amplifier may be powered with a 25-130 VAC source, or directly off the 120 VAC power line. To avoid shock hazard, connect the power cord to a power receptacle with earth ground.

WARNING

A shock hazard potentially exists from improper or unguarded electrical equipment. Install a #16 or #18 green ground wire from the amplifier and motor cases to earth ground. Cable shield termination should also be grounded as shown in Figure 2.1.

Multiple Axis Power Wiring

The AC or line power can be common to more than one amplifier. Power leads from each amplifier should terminate at the power supply source.

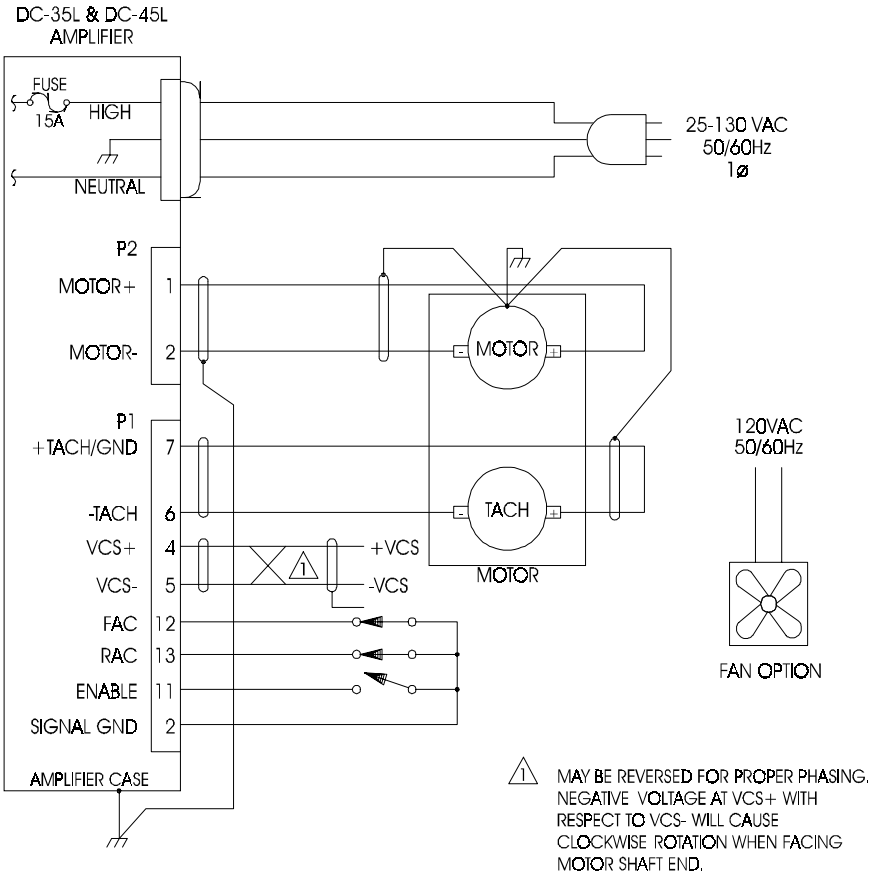


FIGURE 2.1 **Typical Power/Motor Wiring** (M692E)

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Tachometer Wiring

Use of twisted shielded pair wires for the tachometer is recommended. Ground the shield termination at only one end to the amplifiers P1 (+TACH / GND 7) input.

Analog Command Signal (VCS)

Use twisted shielded pair wires for the VCS input. If the VCS source can float (remain ungrounded), connect the cable shield to both the VCS source common and the amplifier signal ground. It is recommended that the input be connected directly to the amplifier differential input (if applicable). Connect the VCS source (+) to VCS+ and the VCS source(-) or common to VCS-. If the VCS source and amplifier power ground are grounded to the master chassis ground, leave the source end of the shield unconnected. The servo amplifiers input circuit will attenuate the common mode voltage between signal source and amplifier power grounds.

WARNING



During deceleration of the motor, the capacitor can be charged to potentially dangerous voltages. Electro-Craft uses a Shunt Power resistor (50 Watts) connected to the power supply to absorb the energy surge. Avoid touching connections to the Amplifier until the capacitor has drained to at least 30 Volts.

Operational Modes

Switch Functions

Front panel DIP switches are used to set up different operational modes

Switch	Function
1	Supplies back EMF voltage feedback when ON.
2	Supplies current feedback for IR compensation when ON.
3	Reduces current loop gain when ON
4	Increases the value of the current loop integrator capacitor when ON.
5	Reduces both peak and continuous current limit by 50% when OFF.
6	Reduces continuous current limit by 50% when ON.
7	Shorts out (disables) the current loop integrator capacitor when ON.
8	Shorts out (disables) the velocity loop integrator capacitor when ON.
9	Increases the value of the velocity loop integrator capacitor when ON.
10	Function on Pot 4 – test input when ON, offset adjustment when OFF.

Voltage Mode

In voltage mode, the VCS input voltage commands a proportional motor voltage regardless of power supply voltage variations. This mode is recommended for velocity control when velocity feedback is unavailable.

S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
ON	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF

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IR Compensation Mode

If there is a load torque variation when running in voltage mode, the motor current will vary, since torque is proportional to motor current. Since the motor windings have resistance, the actual motor voltage is reduced by the product of motor current and resistance. Therefore, motor speed which is proportional to motor voltage (terminal voltage minus IR drop) varies with the load torque.

S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
ON	ON	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF

To compensate for the internal motor voltage drop, a voltage proportional to motor current can be added to the IR compensation level. If the feed back voltage is high enough to cause a rise in motor voltage with increased motor current, instability occurs. This is due to the fact increased voltage increases motor speed and load current which in turn, increases motor voltage. If a great deal of motor torque change is anticipated, it may be necessary to add a tachometer to the motor.

To adjust IR feedback, start with a very high (or open) IR feedback resistor (R8) with an unloaded motor shaft. Command a low motor speed (about 20-200 RPM). Note that the motor shaft can be stalled easily without any IR feedback. Decreasing the IR feedback resistor increases motor torque at lower speeds. Too much IR feedback, for examples, too low of a resistor value, will cause motor run-away when torque is applied to the motor shaft.

Current (Torque) Loop Mode

Current mode produces a torque output from the motor proportional to the VCS voltage input. Motor output torque is proportional to the motor current. Current mode is particularly important if the servo amplifier is used with a digital position controller. Under this condition, a movement of the motor shaft from the desired position causes a large correcting torque, or “stiffness”. Therefore, this mode may produce a “run away” condition if operated without a controller.

S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
OFF	OFF	ON	OFF	ON	OFF	OFF	ON	OFF	OFF

Velocity Mode

The addition of a tachometer to the motor shaft produces a voltage proportional to speed. The tachometer output voltage replaces the motor terminal voltage as the controlled variable. Since this voltage is proportional to the motor speed, the operating mode is velocity mode.

S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
OFF	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF

Note that the speed is dependent on terminal voltage and motor current. The motor current is, in turn, dependent on the load torque which includes both constant friction torque and the torque to accelerate or decelerate the load. Velocity mode is more complex than voltage mode, but also results in the best performance among all the operating modes.

Performance in the velocity mode is dependent on the load inertia and characteristics, and should be verified with the motor connected to the actual load.

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Startup Procedures

Current (Torque) Loop Mode

Motor Leads

1. Connect the motor leads to P2. Pin 1 is MOTOR+ and Pin 2 is MOTOR-. To reduce the effect of radiated electrical noise, the motor leads and the supply leads should be run as twisted pairs or as shielded cable. Keep the motor and power leads away from the signal leads. Do not connect any tachometer leads.

Interface Connections

2. Install the required interface connections to P1 as outlined in Table 1.4.

Initial Potentiometer Setting

3. Rotate loop gain potentiometer full CW (15 turns maximum). Rotate all other potentiometers to full CCW position.

Apply Power

4. Apply power; verify that the LED indicator is red. Once the amplifier is enabled and no fault conditions are present, the LED will turn green.

Current Limit

5. Set the current limit potentiometer to a suitable current level for the motor being used.

Turns CW	Percent of Rated Current
5	33%
10	66%
15	100%

The current limit potentiometer adjusts both peak and continuous current at the same time. The amplifier will output peak current for 2 seconds before gradually reducing the current limit to 50% of the peak current setting.

Test / Offset

6. Adjust the test / offset potentiometer until the motor shaft remains stationary.

VCS Gain

7. Adjust the VCS gain potentiometer for the desired scaling of VCS Volts to motor torque. After adjusting, bring the VCS input to zero and readjust the test / offset potentiometer if necessary.

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Velocity Mode

Motor Leads

1. Connect the motor leads to P2. Pin 1 is MOTOR+ and Pin 2 is MOTOR-. To reduce the effect of radiated electrical noise, the motor leads and the supply leads should be run as twisted pairs or as shielded cable. Keep the motor and power leads away from the signal leads.

Tachometer Leads

2. Connect the tachometer leads to P1. Pin 7 is +TACH and Pin 6 is -TACH.

Interface Connections

3. Install the required interface connections to P1 as outlined in Table 1.4.

Initial Potentiometer Setting

4. Rotate all potentiometers at least 15 turns CCW (to full CCW position).

Apply Power

5. Apply power; verify that the LED indicator is red. Once the amplifier is enabled and no fault conditions are present, the LED will turn green.

Current Limit

6. Slowly turn the current limit potentiometer CW until the motor starts to rotate. If it accelerates toward full speed, remove power and reverse the tachometer leads. Apply power again and the motor should rotate slowly.

Test / Offset Control

7. Adjust the test / offset potentiometer until the motor shaft remains stationary.

Current Limit Control

8. Set the current limit potentiometer to a suitable current level for the motor being used.

Turns CW	Percent of Rated Current
5	33%
10	66%
15	100%

The current limit potentiometer adjusts both peak and continuous current at the same time. The amplifier will output peak current for 2 seconds before gradually reducing the current limit to 50% of the peak current setting.

Loop Gain Control

9. Turn the loop gain potentiometer CW until the motor shaft starts to oscillate, then turn back sufficiently to stop the oscillation.

VCS Gain

10. After the desired system response is obtained by appropriate adjustment of the loop gain potentiometer, adjust the VCS gain potentiometer for the desired scaling of VCS Volts to motor RPM. After adjusting, bring the VCS input to zero and readjust the test / offset potentiometer if necessary.

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Cautionary Notes

Do Not Reverse the Power Supply Leads



Damage can result from reversing current flow through the amplifier. Always check the polarity of wire leads before connecting.

Use Sufficient Power Supply Capacitance



Insufficient power supply capacitance problems occur particularly with high inductance motors. During braking much of the stored mechanical energy is fed back into the power supply which charges the output capacitor to a higher voltage. If the charge reaches the amplifier's overvoltage shutdown point, output current and braking will cease. At that time the energy stored due to the motor inductance continues to flow through diodes in the amplifier to further charge the power supply capacitor. The actual voltage rise depends upon the power supply capacitance, motor speed, and inductance. For example, a 2mH motor at 20 amperes can charge a 2000µF capacitor up to 30V.

Do Not Spin The Motor Without Power



The motor acts as a generator and will charge the power supply capacitors through the amplifier. Too high a speed may cause overvoltage breakdown in the power MOSFETs. An amplifier with an internal power converter operating from a high voltage supply will become operative.

Do Not Short The Motor



When the motor is shorted, its own generated voltage may produce a current flow as high as 10 times the amplifier peak current. The short itself should not damage the amplifier but may damage the motor. If the connection arcs or opens while the motor is spinning rapidly, this high current flows back into the amplifier (due to stored energy from the motor inductance) and may damage the amplifier.

Protect Against Electrical Noise



The main source of amplifier noise is the high DV/DT (typically about 1V/nanosecond) of the amplifier's output power MOSFETs. Unfiltered motor outputs can introduce noise in digital encoder signal wires if they are routed in the same cable harness without shielding.

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CHAPTER 3:

Warranty

The following product warranty and returned goods information summarizes the product warranty and return policy of Electro-Craft. A copy of the formal “Returned Goods and Field Service Policy” is available upon request.

Defective Equipment

If you are unable to correct a problem, and the product is defective, you may return the unit to your Electro-Craft distributor for repair or replacement.

There are no field serviceable parts in the drive. If the drive fails, the unit should be returned to the factory for repair or replacement. To save unnecessary work and repair charges, please verify that the drive unit is defective before returning it for repair.

Limitations to warranty coverage are detailed in “Returned Goods and Field Service Policy.” Products that have been modified by the customer, physically mishandled, or otherwise abused through incorrect wiring, inappropriate settings, and so on, are exempt from the warranty plan.

Return Procedure

To ensure accurate processing and prompt return of any Rockwell Automation / Electro-Craft product, the following procedure must be followed:

1. Call your distributor to obtain a Return Material Authorization (RMA) number. Do *not* return the drive or any other equipment without a valid RMA number. Returns lacking a valid RMA number will *not* be accepted and will be returned to the sender.
2. Pack the drive in the original shipping carton. Rockwell Automation is not responsible or liable for damage resulting from improper packaging or shipment of returned products.
3. Include a detailed description of the problem and any relevant information.

Repaired units are shipped via UPS Ground delivery. If another method of shipping is desired, please indicate this when requesting the RMA number and include this information with the returned unit.

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Things to Check

Overload Fault

1. Verify that the motor shaft rotates freely with no power applied and while uncoupled from the load.
2. Verify that the minimum inductance requirement is met.

Heat Sink Temperature

1. Verify that the heat sink temperature is less than 65°C.

Overvoltage Shutdown

1. Check the input power voltage. If the voltage is greater than the value listed in the specifications, check the AC power line connected to the power supply for the proper value.
2. Check the regenerative energy absorbed during deceleration. Use a voltmeter or oscilloscope to monitor the power supply voltage. If the supply voltage increases above the specified values, additional power supply capacitance is necessary. Additional capacitors must be electrolytic type and located within one foot of the amplifier.

Undervoltage Shutdown

1. Verify that the power supply voltage is above the minimum listed in the specifications.

Short Circuit Fault

1. Check each motor lead for shorts with respect to motor housing and power ground.
2. Measure motor resistance between motor leads with the amplifier disconnected.

Status

1. Check ALL INHIBIT inputs for the proper levels.

Causes of Erratic Operation

1. Improper grounding.
2. Noisy command signal. Check for system ground loops.
3. Mechanical backlash, dead-band, slippage, etc.
4. Excessive tachometer noise.

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Although amplifiers are not considered “machinery” under directive 89/336/EEC, machine builders prefer to use components that can meet electromagnetic compatibility (EMC) standards when properly installed.

EMC Wiring Requirements

The DC-35L and DC-45L conform to the generic and basic standards of EN50081-1:1992 and EN50082-2:1995 when installed in accordance with the installation instructions below.

Considerations

General

1. Shielded cables must be used for all interconnect cables to the amplifier and the shield of the cable must be grounded at the closest ground point with the least amount of resistance.
2. The amplifiers metal enclosure must be grounded to the closest ground point with the least amount of resistance.
3. The amplifier must be mounted in such a manner that the connectors and exposed printed circuit board are not accessible to be touched by personnel when the product is in operation. If this is unavoidable there must be clear instructions that the amplifier is not to be touched during operation. This is to avoid possible malfunction due to electrostatic discharge from personnel.

Analog Input Amplifiers

4. A Fair Rite model 043167251 round suppression core must be fitted to the low level signal interconnect cables to prevent pickup from external RF fields.

PWM Input Amplifiers

5. A Fair Rite model 043167251 round suppression core must be fitted to the PWM input cable to electromagnetic emissions.

MOSFET Switching Amplifiers

6. A Fair Rite model 043167251 round suppression core must be fitted at the load cable connector to electromagnetic emissions.
7. An appropriately rated Schaffner 2080 series AC power filter in combination with a Fair Rite model 5977002701 torroid (placed on the supply end of the filter) must be fitted to the AC supply to any MOSFET amplifier system in order to reduce conducted emissions fed back into the supply network.

Fitting of AC Power Filters

8. The above mentioned AC power filters should be mounted flat against the enclosure of the product using the two mounting lugs provided on the filter. Paint should be removed from the enclosure where the filter is fitted to ensure good metal to metal contact. The filter should be mounted as close to the point where the AC power enters the enclosure as possible. Also the AC power cable on the load end of the filter should be routed as far from the AC power cable on the supply end of the filter and all other cables and circuitry to minimize RF coupling.

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