Table of Contents

Thank You!

Electromotive Systems, Inc. appreciates your purchase of this IMPULSE•Si adjustable frequency drive. When properly installed, operated and maintained, the IMPULSE•Si will provide a lifetime of reliable operation. It is MANDATORY that the person who operates, inspects, and maintains this equipment thoroughly read and understand this manual.

This instruction manual has been designed to serve as a self-supporting guide for the proper installation, operation, and maintenance of the IMPULSE•Si adjustable frequency drive. If you require additional assistance, please feel free to contact either your local supplier or Electromotive Systems by phone at **414/783-3500** or by fax at **414/783-3510.**

Note:

Throughout this instruction manual IMPULSE•Si will be referred to as an adjustable frequency drive, drive or inverter. All references should be considered as one in the same.

Danger!

Do NOT touch any circuit components while AC main power is on or immediately after the main AC power is disconnected from the unit. You must first wait until the red "CHARGE" lamp on the main circuit board (TM2) is extinguished. It may take as long as 10 minutes for the charge on the main DC bus capacitors to drop to a safe level. Failure to adhere to this warning could result in serious injury.

Section 1: Introduction

1.1 General

IMPULSE•S represents a new age in adjustable frequency motor controls using microprocessor-based digital control of all functions and settings. Modifications and adjustments are easily performed using on-board switches.

IMPULSE•S incorporates a high performance Pulse Width Modulated (PWM) design generating a variable voltage - variable frequency output that closely approximates a sinusoidal current waveform to allow variable speed control of any conventional squirrel cage, three-phase induction motor.

IMPULSE•S is a unique hardware and software configuration specifically designed for application to crane, hoist and monorail systems. This product is the direct result of years of experience in applying adjustable frequency drives to satisfy the demanding requirements of this market.

1.2 Receiving

This unit has been put through demanding tests at the factory prior to shipment. Before unpacking please check the following:

- Read the specifications sticker on outside of box. Compare the description on that sticker with the description of the product on your purchase order.
- Inspect for damage sustained in transit. Damage to carton may be indicative of unit damage.

After unpacking, please check the following:

- Check to see that the specifications sticker (shipped loose) with the unit matches your application requirement (i.e. current and voltage).
- Check to see that all electrical connections and screws are secure.
- Verify that there is no visible damage to any of the components.

If any part of the IMPULSE•S is damaged or lost, immediately notify both the carrier and Electromotive Systems.

Section 2: Installation

Special Note: If you purchased this IMPULSE•S as part of an Electromotive Systems pre-engineered, *TCONTROLS®* motor control panel, you should skip Sections 2 and 3 and proceed directly to Section 4.

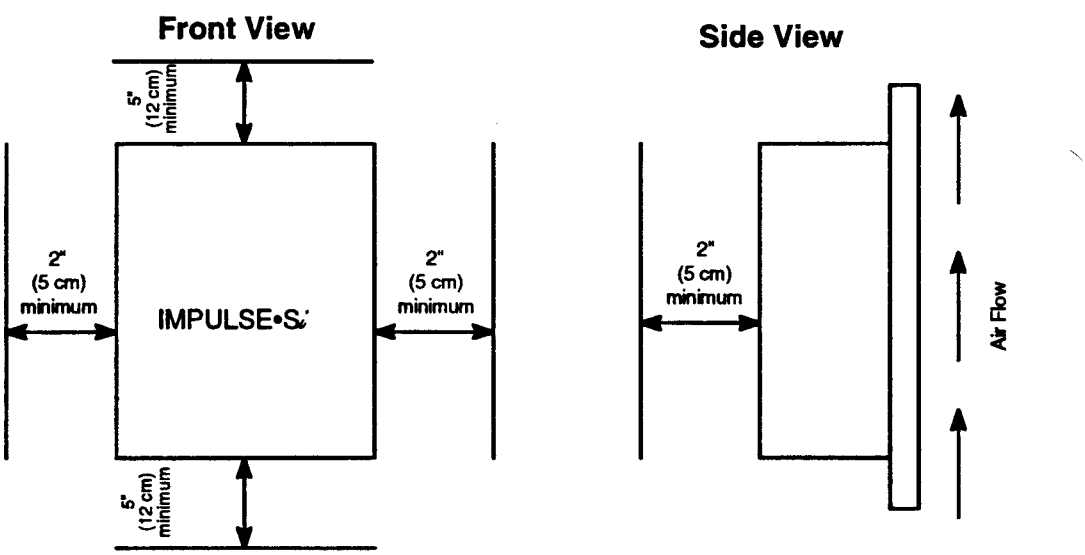
2.1 Location

Proper location of the IMPULSE•S is imperative to achieve optimum performance and a normal operating life. These units should always be installed in areas where the following conditions exist:

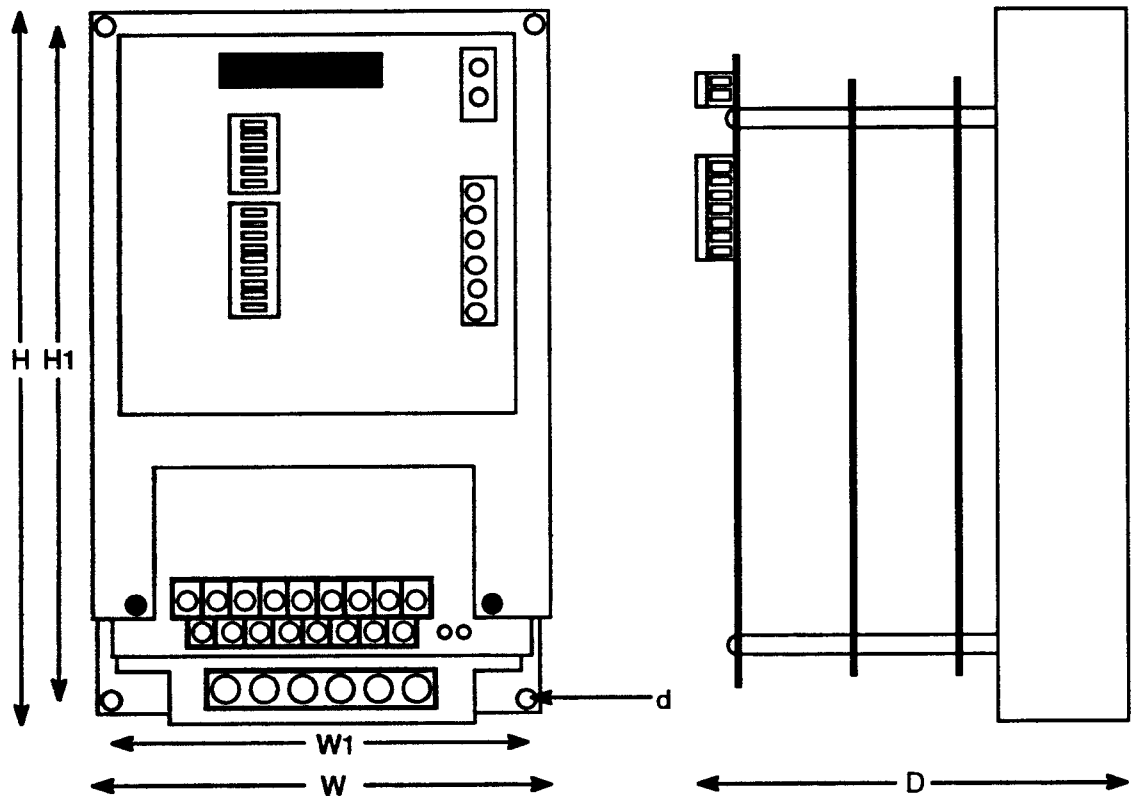
- Ambient operating temperature is between+14 ~ +104° F (-10 ~ +40° C).
- Protected from rain and moisture.
- Protected from corrosive gases or liquids.
- Sheltered from direct sunlight.
- Free from metallic particles or excessive airborne dust.
- Free from excessive vibration (see specifications).

2.2 Positioning

For cooling and maintenance purposes, make sure that there is sufficient clearance around the IMPULSE•S whether it is enclosed in a cabinet or not, as shown below. To maintain effective air flow/cooling, IMPULSE•S must be installed with heatsink ribs oriented vertically.



2.3 Mounting Dimensions (in inches)



Model Number	H	H1	W	W1	D	d	Wt. in lbs. (kg.)
230AFD1-Si	7.00 (178)	6.50 (165)	4.47 (113)	4.13 (105)	5.34 (136)	0.19 (4.8)	2.60 (1.18)
230AFD2-Si	7.60 (193)	7.10 (180)	5.12 (130)	4.72 (120)			3.15 (1.43)
230AFD3-Si	8.01 (203)	7.32 (186)	5.62 (143)	5.03 (128)	6.45 (164)	0.22 (5.5)	5.65 (2.57)
230AFD5-Si	8.32 (211)	7.92 (201)	5.93 (151)	5.63 (143)	6.93 (176)		8.51 (3.86)
460AFD1-Si	7.10 (180)	6.41(163)	5.05 (128)	4.25 (108)	5.53 (140)	0.19 (4.8)	3.35 (1.52)
460AFD2-Si	7.48 (190)	7.01 (178)			6.62 (159)		4.50 (2.04)
460AFD3-Si							4.60 (2.09)
460AFD5-Si	9.02 (230)	8.50 (216)	5.72 (145)	4.95 (126)	7.30 (185)	0.21 (5.3)	7.20 (3.27)
460AFD7.5-Si	12.67 (322)	11.90 (302)	7.23 (184)	6.63 (170)	8.95 (227)	0.24 (6.1)	17.05 (7.74)
460AFD10-Si							17.55 (7.97)

Weight and dimensions do not include standard dynamic braking resistor. For more information about these dynamic braking resistors, please see Appendix I of this manual.

2.4 Specifications

Output Characteristics	Input Voltage 200 to 230V				Input Voltage 380 to 480V					
Model Number	230AFD (Hp) - Si				460AFD (Hp) - Si					
Horsepower* (Hp)	1	2	3	5	1	2	3	5	7.5	10
kW	0.75	1.5	2.2	3.7	0.75	1.5	2.2	3.7	5.5	7.5
Max. allowable FLA for traverse and hoisting motions	4.2	7.5	9.7	17.5	2.3	4.0	5.5	9.0	11.0	17.5
Max. allowable FLA for worm gear hoists	3.4	6.0	7.7	14.0	1.8	3.2	4.4	7.2	8.8	14.0
Max. output voltage	3-Phase 200/208/220/230V (Proportional to input voltage)				3-Phase 380/400/415/440/460V (Proportional to input voltage)					
Output frequency range	2 to 120 Hz (Maximum frequency for V/f pattern is adjustable between 60 and 120 Hz)									

* Horsepower is based on standard NEMA B 4-pole squirrel cage motor. Size and mass of crane should always be considered when sizing drive.

Power Supply	Input Voltage 200 to 230V	Input Voltage 380 to 480V
Model Number	230AFD (Hp) - Si	460AFD (Hp) - Si
Rated input voltage and frequency	3-Phase 200/208/220V, 50/60 Hz	3-Phase 380/400/415/440/460V, 50/60 Hz
Allowable voltage fluctuation	± 10%	
Allowable frequency fluctuation	± 5%	

Control Characteristics	All IMPULSE•Si models
Control method	Sine wave PWM
Control commands	Commanded by a 16-bit microprocessor through a fully programmable proprietary EPROM
Frequency control range	30 to 1 (frequency range that allows for a minimum 150% torque)
Frequency accuracy	± 0.5% (+14 to +104 °F, -10 to +40 °C)
Frequency setting signal	Digital (dry circuit contact closure) Analog [0 to 10 VDC (20 kΩ), 4-20mA (250Ω)]
Accel/decel time	2.5 to 20 sec (accel/decel set independently)
Braking torque	Approx. 20% (up to approx. 150% with dynamic braking resistor package)
V/f patterns	Adjustable

Protective Functions	Input Voltage 200 to 230V	Input Voltage 380 to 480V
Model Number	230AFD (Hp) - Si	460AFD (Hp) - Si
Instantaneous overcurrent	Inverter output is shut off at 300% rated current	
Overload	150% of horizontal motion continuous output current rating for one minute	
Overvoltage	If DC bus voltage exceeds 410V	If DC bus voltage exceeds 800V
Undervoltage	If DC bus voltage drops to 210V or below	If DC bus voltage drops to 420V or below
Ground fault	Provided by electronic circuit	
Power charge indication	Charge lamp stays ON until DC bus drops to 50V	

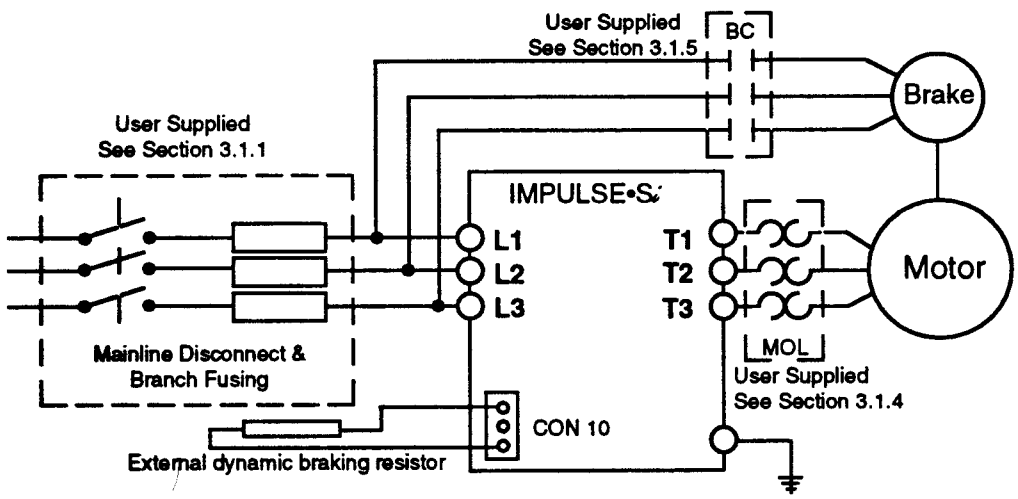
Environmental Conditions	All IMPULSE•Si models
Location	Indoor (protected from corrosive gases and dust)
Ambient temperature	+14 to +104 °F (-10 to +40 °C)
Humidity	90% RH (no condensation)
Vibration	1G less than 20 Hz, up to 0.2 G at 20 to 50 Hz

Section 3: Wiring

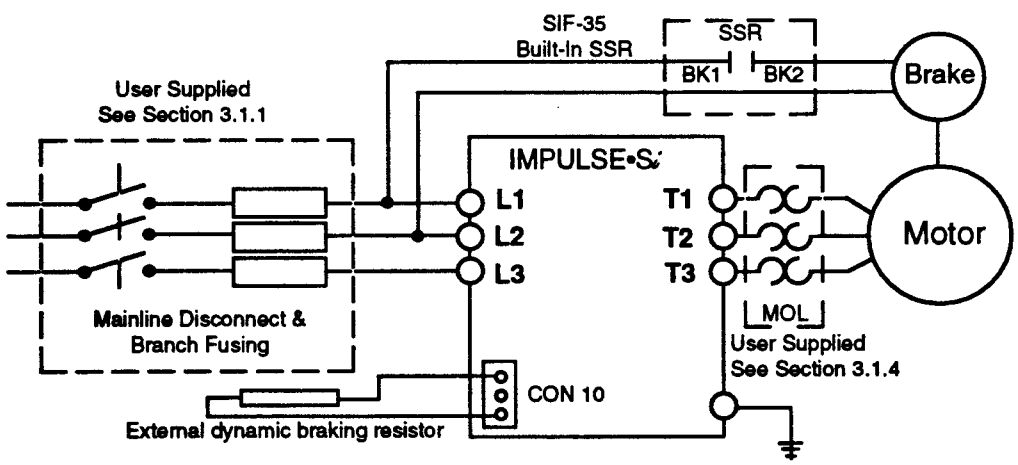
Special Note: If you purchased this IMPULSE•S; as part of an Electromotive Systems pre-engineered, *TCONTROLS* motor control panel you should skip Section 3 and proceed directly to Section 4.

Section 3 provides Electromotive Systems' recommendations regarding the power and control circuit wiring of the IMPULSE•S; unit. However, these are only suggestions. **You must follow the NEC and your local applicable codes whenever making any of the interconnections to this unit.**

3.1 Main AC Power Interconnections



IMPULSE•S; used with three-phase motor brake



IMPULSE•S; used with single-phase brake coils

3.1.1 Input Fuse or Circuit Breaker Selection

You should have some disconnecting means and branch circuit protection between the incoming three-phase power supply and the IMPULSE•S. This branch circuit protection can either be in the form of a thermal magnetic, Molded Case Circuit Breaker (MCCB) or dual element "slow blow" type fuses. The table below provides the suggested ratings for each of the IMPULSE•S models.

Model Number	230 AFD (Hp) - Si				460 AFD (Hp) - Si					
Horsepower	1	2	3	5	1	2	3	5	7.5	10
Rated output current (A)	4.2	7.5	9.7	17.5	2.3	4	5.5	9	13.5	17.5
Molded case circuit breaker (MCCB) rating (A)	10	15	20	35	10	10	15	20	25	35
Input fuses (A) *	7	12	15	25	4	6	8	12	15	25

* Use rejection type fuses, class J or class CC, with time delay. Bussman-LPJ, LPCC, Gould-ATDR, AJT, or Littelfuse-CCMR

3.1.2 Wire Size

The wiring used in the main power circuit should be sized according to the table below.

Model Number	230 AFD (Hp) - Si				460 AFD (Hp) - Si					
Horsepower	1	2	3	5	1	2	3	5	7.5	10
Rated output current (A)	4.2	7.5	9.7	17.5	2.3	4	5.5	9	13.5	17.5
Power circuit wiring (L1, L2, L3 and T1, T2, T3) minimum AWG	12 AWG	12 AWG	12 AWG	12 AWG	12 AWG	12 AWG	12 AWG	12 AWG	12 AWG	12 AWG

3.1.3 Grounding

Connect a positive ground using terminal E.

- Wire size should be at least 14 AWG. The lead length should be kept as short as possible.
- Ground resistance should be 100 ohm or less.
- Never ground the IMPULSE•S along with welding machines, large current machines, etc. Run the ground for the IMPULSE•S in separate conduit.

3.1.3 Grounding (Continued)

- Where several IMPULSE•S; units are used together all of them should be directly grounded to a common ground pole. Connecting all of the IMPULSE•S; earth (E) ground terminals together and running a single wire to the ground pole is also acceptable. Be careful to ensure that you do not form a loop with the ground wires.

3.1.4 Motor Thermal Overload Relay

To prevent the motor from overheating, a thermal overload relay (MOL) should be installed between the IMPULSE•S; output terminals T1, T2, T3 and the motor (see Section 3.1).

A thermal overload relay is not required when using motors with thermal detectors embedded in the windings of the motor. Because operating fan-cooled motors at low speeds may overheat the motor (even at rated current), the use of thermal detectors in the motor is recommended when using IMPULSE•S; with fan-cooled motors. Although this is not the case with non-ventilated type motors, thermal detectors will always provide a level of protection not available with conventional thermal overload relays.

- The thermal overload relay should be adjusted to match the motor's full load amp rating.

- When multiple motors are being operated in parallel using a single IMPULSE•S;, a separate thermal overload relay should be provided for each motor.

A normally closed contact of the thermal overload relay should be wired in series with the (X2) signal lead to stop operation in the event of a motor thermal overload condition. (See Section 3.2.)

- When multiple thermal overload relays are being used, the relay contacts should be wired in series with the (X2) signal lead.

- When motors with thermal detectors are used, the overload contact should be wired in series with the (X2) signal lead.

- When only a single direction is to be interrupted by a motor overload condition, the overload relay contact should be placed in series with the appropriate directional input.

3.1.5 Motor Brake Magnetic Contactor

IMPULSE•S; generates a variable voltage output (dependent on output frequency). For this reason, when using a motor brake in conjunction with IMPULSE•S;, the brake power supply must be from the commercial supply, not derived from the IMPULSE•S; output terminals.

Section 3.1 shows typical wiring schemes for both a three phase motor brake, and single phase brake coils.

- A **three phase** motor brake requires the use of a magnetic brake contactor as so detailed. We strongly recommend the use of a suitable surge absorber across the brake coil(s) to prevent excessive voltage when the coil is de-energized. For AC coil brakes you should use an R-C type (not MOV type) suppressor. For DC coil brakes you should use a diode type suppressor. See Section 3.2.6.1 for surge suppressor standards.

- When using **single phase** brake coils (120 VAC or 240 VAC or 460 VAC), note that SIF-35 terminals BK1 and BK2 can be wired directly to the motor brake coil. This eliminates the need for the motor brake magnetic contactor (BC). Applying the built-in solid state relay also eliminates the requirement for a surge suppressor for the brake coil.

3.1.6 Magnetic Mainline Contactor

Caution: **NEVER connect a magnetic contactor between the motor and the IMPULSE•S; output terminals (T1, T2, T3). Opening of such a contactor while the unit is driving a motor will result in a large transient voltage that could result in power device failure. Closing of such a contactor after the unit is running will result in a large locked rotor inrush current that could eventually weaken the power devices.**

If a mainline, input magnetic contactor is used, it should be wired to provide line power to the input terminals of the IMPULSE•S; (or multiple units in separate branch circuits) when the contactor coil is energized via a typical momentary/maintained on/off control circuit.

3.1.7 Special Warnings for Power Semi-Conductors

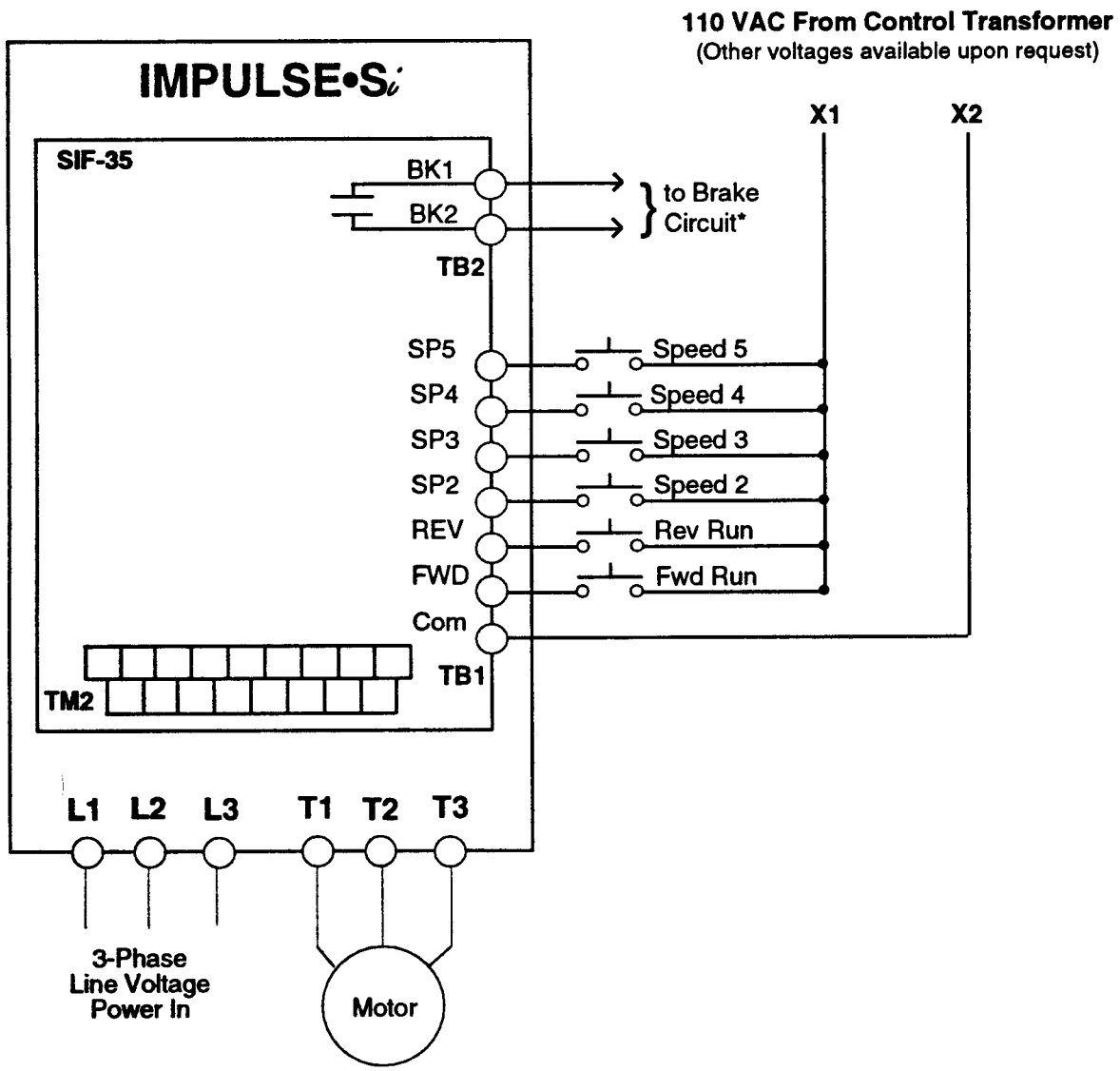
- **Never wire the incoming AC power (230 Volt or 460 Volt) to the output terminals (T1, T2, T3). Applying this voltage to the IMPULSE•S; output will destroy the unit.**

- Never connect power factor correction capacitors across the output terminals (T1, T2, T3) of the unit.

- Ensure there are no short circuits on the IMPULSE•S; output terminals.

- Never megger the motor leads while the IMPULSE•S; is connected. The power semi-conductors are vulnerable to such high, transient voltages.

3.2 Control Circuit Interconnections



* Brake Circuit: See Sections 3.1 and 3.1.5.

Note: Fault output terminals (1, 2 and 3 of TM2) do not connect to terminals 1, 2 and 3 of SIF-35. If detection of fault conditions are required, connect directly to the fault output terminals.

3.2.1 Wire Size

All of the control wiring used with the IMPULSE•S unit should be at least 16 AWG.

3.2.2 Direction and Speed Selection Input Commands

The IMPULSE•S has been specifically designed to be directly compatible with 120 VAC input signals. There is no need to add interface relays or isolation circuitry. The IMPULSE•S control inputs are all optically isolated to provide superior immunity from electrical noise common in the industrial environment.

The control inputs for crane, hoist and monorail applications are typically provided by means of a remote operator's station or pendant control (i.e. pushbutton station). Section 3.2 shows a common control scheme utilizing a cumulative-type, five-step pushbutton control.

IMPORTANT NOTE: The number of input steps required (one-, two-, three-, four- or five-step) depends on the number of speed steps required. Section 7 of this manual outlines the various capabilities of the IMPULSE•S and lists the number of input steps required to achieve that particular method of speed control. Once the speed control method is known, the actual control circuit interconnection requirements are also known. In fact, the power and flexibility of the IMPULSE•S allows the user to change from one speed control method to another without changing any input wires, as long as each method utilizes the same number of input steps. (See Section 7 for more details.)

3.2.3 Motor Brake Interlock Output Command

The IMPULSE•S in combination with the SIF-35 interface card has been specifically designed to provide an output signal that is used to energize the brake coil (or brake contactor coil (BC)) and release the motor brake at the same time the unit receives a forward/reverse command. This output is often referred to as a run contact output. (See Section 3.2)

IMPORTANT NOTE: The state of the brake interlock output signal when the IMPULSE•S receives a STOP command depends on the chosen method of braking. Section 5.2 of this manual outlines the two different methods of braking that are available with the IMPULSE•S. Regardless of the braking method, the control wiring does not change. In fact, the power and flexibility of the IMPULSE•S allows the user to change from one braking method to another without changing any wires. (See Section 5 for more details.)

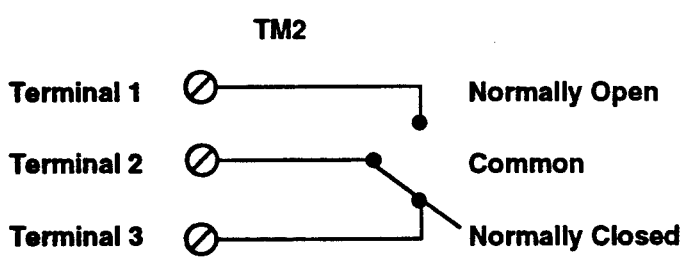
3.2.4 Interface Options and Specifications

Various interface cards are available for IMPULSE•S. These interface options are made available at no additional cost, and include capabilities for various input voltages and brake (SSR) output rated voltages:

Interface Card Model Number	Rated Input Voltage (AC)	Rated Input Voltage (DC)	Rated Brake SSR Output Voltage	Rated Brake SSR Output Min. Current	Rated Brake SSR Output Max. Current	Comments
SIF-35-2	110V	110V	20~250V	100mA	4.0A	Standard interface card for all 230V drives
SIF-35-4			380~480V			Specified by customer
SIF-35-2.1	220V	220V	20~250V			
SIF-35-4.1			380~480V			
SIF-35-2.2	24V	24V	20~250V			
SIF-35-4.2			380~480V			
Other configurations available upon request and Electromotive Systems' Engineering approval						

3.2.5 Fault Relay Output Contacts

A fault relay Form C contact (normally open/normally closed) output is provided on the TM2 circuit board (terminals 1, 2 and 3). This can be used in a specific control scheme to signal an IMPULSE•S protective fault condition. (See Section 3.2.)



Contact rating
250 VAC, 1A, Resistive Load
30 VDC, 1A, Resistive Load

3.2.6 Additional Wiring Precautions

An R-C type (not MOV type) surge absorber must be used across the coil of all contactors and relays contained within the same electrical enclosure as the IMPULSE•S. Failure to do so will result in noise related nuisance fault conditions. (See Section 3.2.6.1 for applicable surge absorbers.)

R-C type (not MOV type) surge absorbers are sometimes required to suppress the coils of AC electro-mechanical brakes. Be certain to test all functions of the IMPULSE•S. system if 3Ø AC brakes are applied. (See Section 3.2.6.1 for applicable surge absorbers.) Failure to adhere to this precaution may lead to nuisance noise related fault conditions.

Source KVA MUST BE limited to ≤ 500 KVA to protect against premature rectifier assembly failure. If Source KVA exceeds 500 KVA, then installation of appropriate reactor is required. If multiple inverters are used, installation of individual reactors is not required. One reactor capable of combined amperage is acceptable. (See Section 3.2.6.2 for details.)

3.2.6.1 R-C Surge Absorber Specifications

Applied VAC/ General Application	Capacitor	Resistor	Part Number
120 VAC (1Ø) for contactor coil/magnetic brake coils	0.47μF	100Ω, 0.5W	RCS1G6
	0.47μF	150Ω, 0.5W	RCS1H6
	0.47μF*	220Ω, 0.5W*	RCS1A6 *
240 VAC (1Ø) for contactor coil/magnetic brake coils	0.47μF	100Ω, 0.5W	RCS2G6
	0.47μF	150Ω, 0.5W	RCS2H6
	0.47μF	220Ω, 0.5W	RCS2A6
480 VAC (3Ø) for 3Ø brake coils	0.47μF	100Ω, 7W	RCY6G-30
	0.47μF	220Ω, 7W	RCY6A-30

*Electromotive Systems standard. Part numbers are those of R-K Electronics. These parts are available from Electromotive Systems or R-K, at 513/860-4474. (If A-B brand contactor (IEC type) is used, then part number is A-B 199-FSMA1.)

3.2.6.2 AC Reactors Specifications

Model Number	Max. Cont. Amps	230V Part Number	230V Max. Hp	460V Part Number	460V Max. Hp
230AFD1-Si	4	REA230-1	1		
230AFD2-Si	8	REA230-2	2		
230AFD3-Si	12	REA230-3	3		
230AFD5-Si	18	REA230-5	5		
460AFD1-Si	2			REA460-1	1
460AFD2-Si	4			REA460-2	2
460AFD3-Si	4			REA460-3	3
460AFD5-Si	8			REA460-5	5
460AFD7.5-Si	12			REA460-7.5	7.5
460AFD10-Si	18			REA460-10	10
These sizes are for combinations of multiple low capacity inverters.	25	REA230-7.5	7.5	REA460-15	15
	35	REA230-10	10	REA460-25	25
	45	REA230-15	15	REA460-30	30
	55	REA230-20	20	REA460-40	40
	80	REA230-25	25	REA460-60	60
	100	REA230-40	40	REA460-75	75
	130	REA230-50	50	REA460-100	100

Reactors are 3% impedance type.

Section 4: Quick Programming

This section outlines the fastest way to get your IMPULSE•Si up and running. This section is divided into three parts: multi-step, two-step infinitely variable and three-step infinitely variable speed control.

4.1 Quick Programming: Multi-Step Speed Control

To set IMPULSE•Si for multi-step speed control, begin with DS1, which is located on the TM2 board.

(DS1-1 through DS1-10)

Set your speed control method.

Sets IMPULSE•Si to multi-step speed control	DS1-1 = off DS1-2 = off *(initial setting)*

For more information, please see Sections 4.1.1 and 6.1.

Select your stopping method. Traverse or hoisting?

Do you have a traverse (horizontal) motion? Choose decelerate at STOP command	DS1-3 = off
Do you have a hoisting (vertical) motion? Choose immediate stop at STOP command	DS1-3 = on *(initial setting)*

For more information, please see Section 4.2.

Choose your minimum speed.

Speed	Setting
2 Hz	DS1-4 = on DS1-5 = off DS1-6 = off
3 Hz	DS1-4 = on DS1-5 = off DS1-6 = on
5 Hz	DS1-4 = on DS1-5 = on DS1-6 = off *(initial setting)*
10 Hz	DS1-4 = on DS1-5 = on DS1-6 = on
15 Hz	DS1-4 = off DS1-5 = off DS1-6 = off
20 Hz	DS1-4 = off DS1-5 = off DS1-6 = on
25 Hz	DS1-4 = off DS1-5 = on DS1-6 = off
30 Hz	DS1-4 = off DS1-5 = on DS1-6 = on

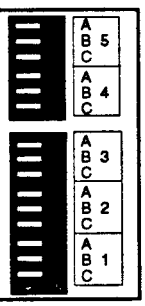
For more information, please see Section 6.1.4.1.

Choose the speed group that is best for your application.

	Speeds							Setting
Speed Group 1	10 Hz	15 Hz	20 Hz	30 Hz	40 Hz	50 Hz	60 Hz	DS1-7 = off DS1-8 = off *(initial setting)*
Speed Group 2	10 Hz	20 Hz	30 Hz	40 Hz	50 Hz	60 Hz	75 Hz	DS1-7 = off DS1-8 = on
Speed Group 3	15 Hz	20Hz	30 Hz	45 Hz	60 Hz	75 Hz	90 Hz	DS1-7 = on DS1-8 = off
Speed Group 4	20 Hz	30 Hz	40 Hz	60 Hz	80 Hz	100 Hz	120 Hz	DS1-7 = on DS1-8 = on

For more information, please see Sections 4.1.1, 5.3.4.1 and 6.1.

Continue by setting SW1 and SW2, which are located on the SIF-35 interface card.



Choose your five speeds (steps).

Each CBA group (on SW1 and SW2) sets one speed. Working only with the speed group you selected, set the CBA switches as indicated to obtain the desired speed. Note: To access the minimum speed you set via DS1-4, DS1-5 and DS1-6, you must set your first group to C=off, B=off, A=off.

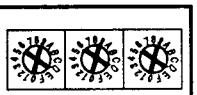
Speed Group 1	Minimum	10 Hz	15 Hz	20 Hz	30 Hz	40 Hz	50 Hz	60 Hz
	C = off B = off A = off *(initial setting)*	C = off B = off A = on *(initial setting)*	C = off B = on A = off	C = off B = on A = on *(initial setting)*	C = on B = off A = off	C = on B = off A = on *(initial setting)*	C = on B = on A = off	C = on B = on A = on *(initial setting)*

Speed Group 2	Minimum	10 Hz	20 Hz	30 Hz	40 Hz	50 Hz	60 Hz	75 Hz
	C = off B = off A = off	C = off B = off A = on	C = off B = on A = off	C = off B = on A = on	C = on B = off A = off	C = on B = off A = on	C = on B = on A = off	C = on B = on A = on

Speed Group 3	Minimum	15 Hz	20Hz	30 Hz	45 Hz	60 Hz	75 Hz	90 Hz
	C = off B = off A = off	C = off B = off A = on	C = off B = on A = off	C = off B = on A = on	C = on B = off A = off	C = on B = off A = on	C = on B = on A = off	C = on B = on A = on

Speed Group 4	Minimum	20 Hz	30 Hz	40 Hz	60 Hz	80 Hz	100 Hz	120 Hz
	C = off B = off A = off	C = off B = off A = on	C = off B = on A = off	C = off B = on A = on	C = on B = off A = off	C = on B = off A = on	C = on B = on A = off	C = on B = on A = on

For more information, please see Sections 4.1.1, 5.3.4.1 and 6.1.

Continue by setting RDS1 and RDS2, located on the TM2 board. 

Set your acceleration and deceleration times.

Use RDS1 to set your acceleration time. Use RDS2 to set your deceleration time.

Notch	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
Time (sec.)	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	8.0	9.0	10.0	12.0	15.0	20.0

For more information, please see Section 5.3.1.

Do you need any special features?

For more information about voltage/frequency patterns, see Section 6.3.2

For more information about Reverse Plug Simulation, see Section 6.3.5.1

For more information about Quick Stop, see Section 6.3.5.2

Your IMPULSE•S; is now set up for multi-step operation.

DS1-9 and DS1-10 are used for an analog input. Their settings will not affect normal operation. For more information, see Sections 6.3.4 and 6.3.4.2.

4.2 Quick Programming: Two-Step Infinitely Variable Speed Control

To set IMPULSE•Si for two-step speed control, begin with DS1, which is located on the TM2 board.

(DS1-1 through DS1-10)

Set your speed control method.

Sets IMPULSE•Si to two-step infinitely variable speed control	DS1-1 = on DS1-2 = off

For more information, please see Sections 5.1.2 and 7.2.

Select your stopping method. Traverse or hoisting?

Do you have a traverse (horizontal) motion? Choose decelerate at STOP command	DS1-3 = off
Do you have a hoisting (vertical) motion? Choose immediate stop at STOP command	DS1-3 = on *(initial setting)*

For more information, please see Section 5.2.

Choose your minimum speed.

Speed	Setting
2 Hz	DS1-4 = on DS1-5 = off DS1-6 = off
3 Hz	DS1-4 = on DS1-5 = off DS1-6 = on
5 Hz	DS1-4 = on DS1-5 = on DS1-6 = off *(initial setting)*
10 Hz	DS1-4 = on DS1-5 = on DS1-6 = on
15 Hz	DS1-4 = off DS1-5 = off DS1-6 = off
20 Hz	DS1-4 = off DS1-5 = off DS1-6 = on
25 Hz	DS1-4 = off DS1-5 = on DS1-6 = off
30 Hz	DS1-4 = off DS1-5 = on DS1-6 = on

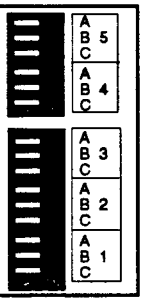
For more information, please see Section 7.2.4.1.

Choose your maximum speed.

Speed	Setting
45 Hz	DS1-7 = off DS1-8 = off
50 Hz	DS1-7 = off DS1-8 = on
55 Hz	DS1-7 = on DS1-8 = off
60 Hz	DS1-7 = on DS1-8 = on

For more information, please see Sections 7.2.4.1.

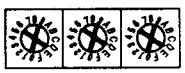
Continue by setting SW1 and SW2, which are located on the SIF-35 interface card.



Enable your minimum and maximum speeds.

SW1 Group 1	SW1 Group 2	SW1 Group 3	SW2 Group 4	SW2 Group 5
C = off B = off A = off	C = on B = off A = off	No function in this mode		

For more information, please see Sections 7.2.2.

Continue by setting RDS1 and RDS2, located on the TM2 board. 

Set your acceleration and deceleration times.

Use RDS1 to set your acceleration time. Use RDS2 to set your deceleration time.

Notch	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
Time (sec.)	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	8.0	9.0	10.0	12.0	15.0	20.0

For more information, please see Section 6.3.1.

Do you need any special features?

For more information about voltage/frequency patterns, see Section 6.3.2

For more information about Reverse Plug Simulation, see Section 6.3.5.1

For more information about Quick Stop, see Section 6.3.5.2

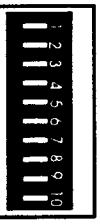
Your IMPULSE•S5 is now set up for two-step infinitely variable operation.

DS1-9 and DS1-10 are used for an analog input. Their settings will not affect normal operation. For more information, see Sections 6.3.4 and 6.3.4.2.

4.3 Quick Programming: Three-Step Infinitely Variable Speed Control

To set IMPULSE•Si for three-step infinitely variable speed control, begin with DS1, which is located on the TM2 board.

(DS1-1 through DS1-10)



Set your speed control method.

Sets IMPULSE•Si to three-step infinitely variable speed control	DS1-1 = on DS1-2 = on

For more information, please see Sections 5.1.3 and 7.3.

Select your stopping method. Traverse or hoisting?

Do you have a traverse (horizontal) motion? Choose decelerate at STOP command	DS1-3 = off
Do you have a hoisting (vertical) motion? Choose immediate stop at STOP command	DS1-3 = on *(initial setting)*

For more information, please see Section 5.2.

Choose your minimum speed.

Speed	Setting
2 Hz	DS1-4 = on DS1-5 = off DS1-6 = off
3 Hz	DS1-4 = on DS1-5 = off DS1-6 = on
5 Hz	DS1-4 = on DS1-5 = on DS1-6 = off *(initial setting)*

Speed	Setting
10 Hz	DS1-4 = on DS1-5 = on DS1-6 = on
15 Hz	DS1-4 = off DS1-5 = off DS1-6 = off
20 Hz	DS1-4 = off DS1-5 = off DS1-6 = on

Speed	Setting
25 Hz	DS1-4 = off DS1-5 = on DS1-6 = off
30 Hz	DS1-4 = off DS1-5 = on DS1-6 = on

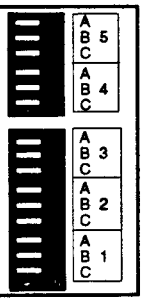
For more information, please see Section 7.3.4.1.

Choose your maximum speed.

Speed	Setting
45 Hz	DS1-7 = off DS1-8 = off
50 Hz	DS1-7 = off DS1-8 = on
55 Hz	DS1-7 = on DS1-8 = off
60 Hz	DS1-7 = on DS1-8 = on

For more information, please see Sections 7.2.4.1.

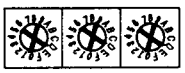
Continue by setting SW1 and SW2, which are located on the SIF-35 interface card.



Enable your minimum and maximum speeds.

SW1 Group 1	SW1 Group 2	SW1 Group 3	SW2 Group 4	SW2 Group 5
C = off B = off A = off	C = on B = off A = off	C = on B = on A = off	No function in this mode	

For more information, please see Sections 7.3.2.

Continue by setting RDS1 and RDS2, located on the TM2 board. 

Set your acceleration and deceleration times.

Use RDS1 to set your acceleration time. Use RDS2 to set your deceleration time.																
Notch	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
Time (sec.)	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	8.0	9.0	10.0	12.0	15.0	20.0

For more information, please see Section 6.3.1.

Do you need any special features?

For more information about voltage/frequency patterns, see Section 6.3.2
For more information about Reverse Plu Simulation, see Section 6.3.5.1
For more information about Quick Stop, see Section 6.3.5.2

Your IMPULSE•S⁄ is now set up for three-step infinitely variable operation.

DS1-9 and DS1-10 are used for an analog input. Their settings will not affect normal operation. For more information, see Sections 6.3.4 and 6.3.4.2.

Section 5: Control Flexibility

IMPULSE•S; is a unique combination of hardware and software that provides the user with unparalleled sophistication and flexibility for selection of specific crane and hoist operation modes. These include:

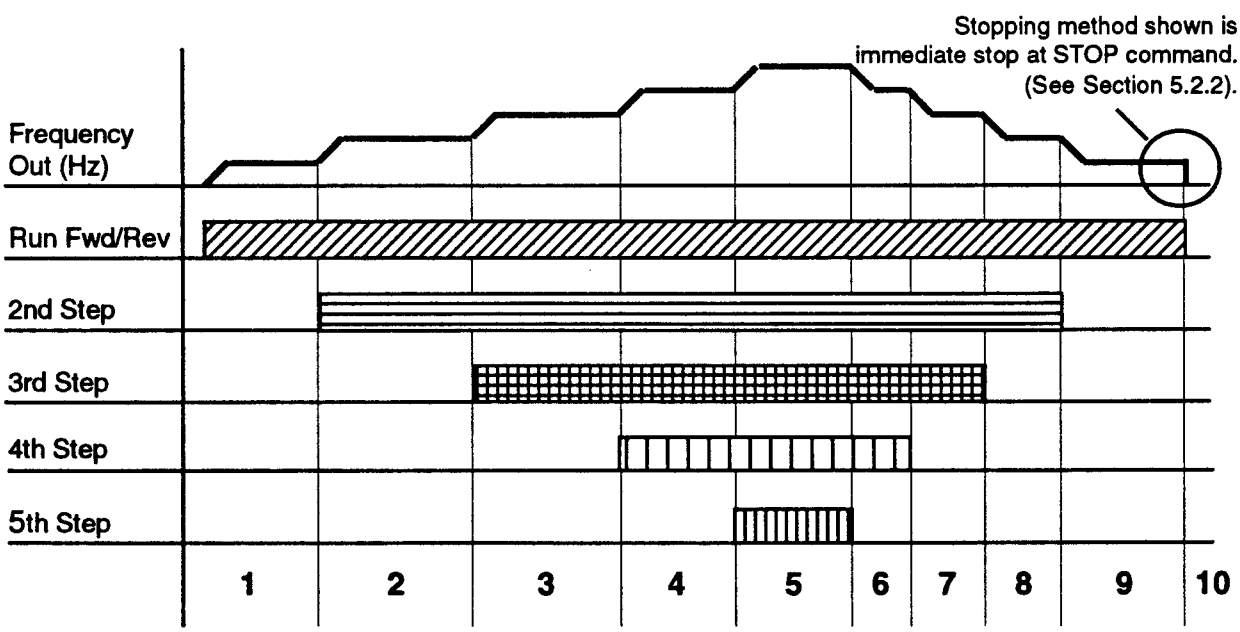
Speed control method selection:
- Multi-step mode (1, 2, 3, 4, or 5 step).
- Two-step infinitely variable mode.
- Three-step infinitely variable mode.

Stopping method selection:
- Immediate stop at STOP command.
- Decelerate at STOP command.

5.1 Speed Control Method Definitions (Set by DS1-1 and DS1-2)

5.1.1 Multi-Step Speed Control Method (VR3 Enabled at Upper Limit) (DS1-1 = Off, DS1-2 = Off)

IMPULSE•S; provides for up to five speeds in the multi-step speed control mode. Note that IMPULSE•S; allows for any number of speed steps up to a maximum of five. Frequency output at the various steps is set by the dip switch groups found on the SIF-35 interface card. A sample timing chart for multi-step speed control is below:



5.1.1 Multi-Step Speed Control Method (Continued)

Time Frame Descriptions

Time 1 Run Forward/Reverse Command (First Speed). Frequency output increases to hertz of Group 1 (SW1-1C, SW1-1B and SW1-1A), or minimum speed set by DS1-4, DS1-5 and DS1-6. Operation continues at this frequency.

2 Second Detent/Second Speed Command. Frequency output increases to hertz of Group 2 (SW1-2C, SW1-2B and SW1-2A.) Operation continues at this frequency.

3 Third Detent/Third Speed Command. Frequency output increases to hertz of Group 3 (SW1-3C, SW1-3B and SW1-3A.) Operation continues at this frequency.

4 Fourth Detent/Fourth Speed Command. Frequency output increases to hertz of Group 4 (SW2-4C, SW2-4B and SW2-4A.) Operation continues at this frequency.

5 Fifth Detent/Fifth Speed Command. Frequency output increases to hertz of Group 5 (SW2-5C, SW2-5B and SW2-5A.) Operation continues at this frequency.

6 Removal of Fifth Detent/Fifth Speed Command. Frequency output decreases to hertz of Group 4 (SW2-4C, SW2-4B and SW2-4A.) Operation continues at this frequency.

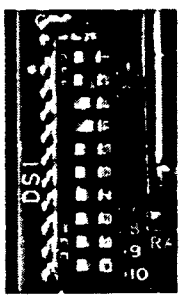
7 Removal of Fourth Detent/Fourth Speed Command. Frequency output decreases to hertz of Group 3 (SW1-3C, SW1-3B and SW1-3A.) Operation continues at this frequency.

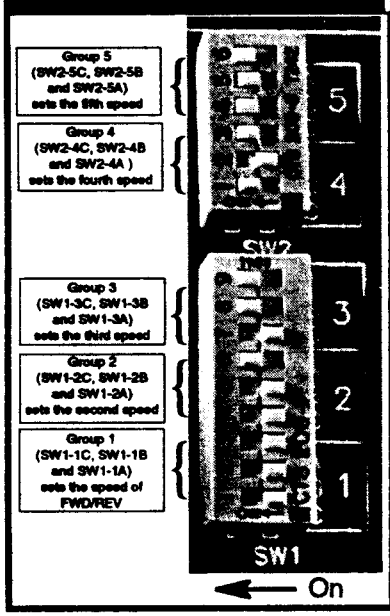
8 Removal of Third Detent/Third Speed Command. Frequency output decreases to hertz of Group 2 (SW1-2C, SW1-2B and SW1-2A.) Operation continues at this frequency.

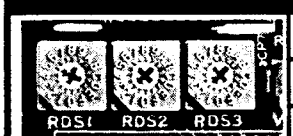
9 Removal of Second Detent/Second Speed Command. Frequency output decreases to hertz of Group 1 (SW1-1C, SW1-1B and SW1-1A), or minimum speed set by DS1-4, DS1-5 and DS1-6. Operation continues at this frequency.

10 Absence of Commands. Removal of RUN Forward/Reverse = STOP. Operation at STOP depends upon the setting of DS1-3. (Immediate STOP = ON or Deceleration to STOP = OFF.)

5.1.1.1 Suggested Settings for Multi-Step Speed Control (Standard Initial Setting)

DS1	Setting	For More Information
 Default stopping method is **immediate stop.** Extreme caution should be used when changing to deceleration at STOP command. A long deceleration time will cause driven equipment to require a greater stopping distance.	DS1-1 = Off	Section 5.1.1
	DS1-2 = Off	
	DS1-3 = On	Section 5.2.1/5.2.2
	DS1-4 = On	Section 6.3.4
	DS1-5 = On	
	DS1-6 = Off	
	DS1-7 = Off	Section 6.3.4.1
	DS1-8 = Off	
	DS1-9 = Off	n/a
	DS1-10 = Off	

SW1 and SW2	Output	Setting	For More Information
	Higher of 60 Hz or Hz set by VR3*	SW2-5A = On	Section 6.3.4.1
		SW2-5B = On	
		SW2-5C = On	
	40 Hz	SW2-4A = On	
		SW2-4B = Off	
		SW2-4C = On	
	20 Hz	SW1-3A = On	
		SW1-3B = On	
		SW1-3C = Off	
	10 Hz	SW1-2A = On	
		SW1-2B = Off	
		SW1-2C = Off	
	5 Hz (Set by DS1-4, DS1-5 and DS1-6)	SW1-1A = Off	
		SW1-1B = Off	
		SW1-1C = Off	

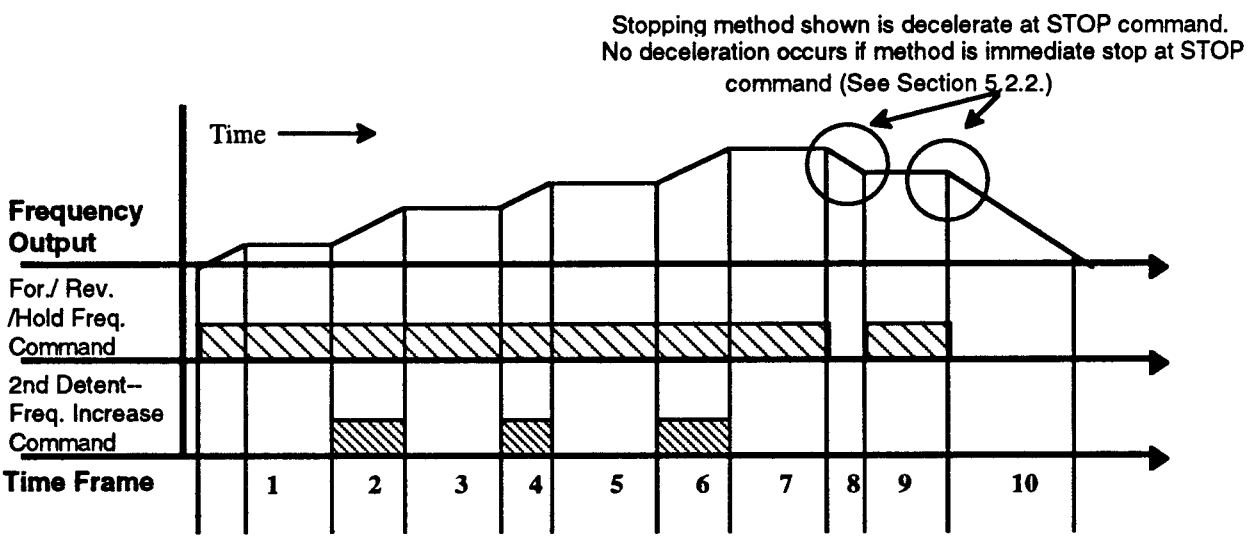
RDS1, RDS2, RDS3		Name	Setting	For More Information
	RDS1	Acceleration Time	5 (5.0 seconds)	Section 6.3.1
	RDS2	Deceleration Time	2 (3.5 seconds)	Section 6.3.1
	RDS3	V/f Pattern	2 (Traverse) 8 (Hoisting)	Section 6.3.2

VR1, VR2, VR3		Name	Setting	For More Information
	VR1	Reverse Plug Simulation	Full counterclockwise	Section 6.3.5.1
	VR2	Quick Stop Gain	Full counterclockwise	Section 6.3.5.2
	VR3	Stepless Speed Adjustment	Full counterclockwise	Section 6.3.5.3

*DS1-1 and DS1-2 must be off in order for VR3 to set maximum speed

5.1.2 Two-Step Infinitely Variable Speed Control DS1-1 = On, DS1-2 = Off

IMPULSE•S: provides for true infinitely variable speed control with just two simple 120 VAC inputs. This unique software function allows the use of inexpensive two-speed pushbuttons. Two-step infinitely variable is most often used on horizontal travel motions where it is acceptable to decelerate the motor when a STOP command is applied. (The control device is returned to the off position.) Two-step infinitely variable speed control is described by the following timing chart:



Time Frame Descriptions

Time 1 Run Forward/Reverse Command. Frequency output increases to hertz set by DS1-4 ~ DS1-6. Operation continues at this frequency.

2 Second Detent/Frequency Increase Command. Frequency output increases. The longer this contact is closed, the higher the frequency output becomes. Limited only by the adjustable maximum speed (DS1-7 and DS1-8 or VR3).

3 First Detent/Frequency Hold Command. Frequency output remains constant.

4 Second Detent/Frequency Increase Command. Frequency output increases. The longer this contact is closed, the higher the frequency output becomes. Limited only by the adjustable upper limit (the higher of DS1-7 and DS1-8 or VR3).

5 First Detent/Frequency Hold Command. Frequency output remains constant.

5.1.2 Two-Step Infinitely Variable Speed Control DS1-1 = On, DS1-2 = Off (Continued)

6 Second Detent/Frequency Increase Command. Frequency output increases. The longer this contact is closed, the higher the frequency output becomes. Limited only by the adjustable upper limit (the higher of DS1-7 and DS1-8 or VR3).

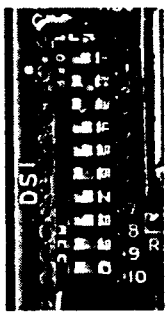
7 First Detent/Frequency Hold Command. Frequency output remains constant.

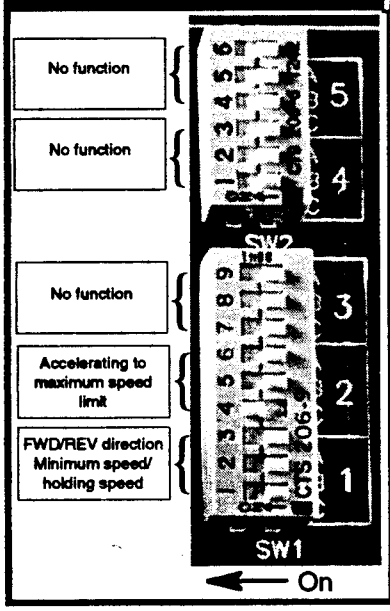
8 Absence of Commands = STOP Command. Output frequency decreases. The longer this input signal condition exists, the lower the output frequency becomes. Output frequency will go to zero, and the brake will set. Braking method shown is decelerate at STOP command only! (DS1-3 = Off).

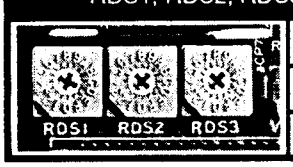
9 First Detent/Frequency Hold Command. Frequency output remains constant.

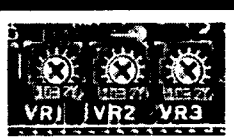
10 Absence of Commands = STOP Command. Output frequency decreases. The longer this input signal condition exists, the lower the output frequency becomes. Output frequency will go to zero, and the brake will set automatically. STOP by DS1-3 = Off.

5.1.2.1 Suggested Settings for Two-Step Infinitely Variable Speed Control

DS1	Setting	For More Information
 Default stopping method is **immediate stop**. Extreme caution should be used when changing to deceleration at stop command. A long deceleration time will cause driven equipment to require a greater stopping distance.	DS1-1 = On	Section 5.1.3
	DS1-2 = Off	
	DS1-3 = Off	Section 5.2.1/5.2.2
	DS1-4 = On	Section 6.3.4
	DS1-5 = On	
	DS1-6 = Off	
	DS1-7 = On	
	DS1-8 = On	
	DS1-9 = Off	n/a
	DS1-10 = Off	

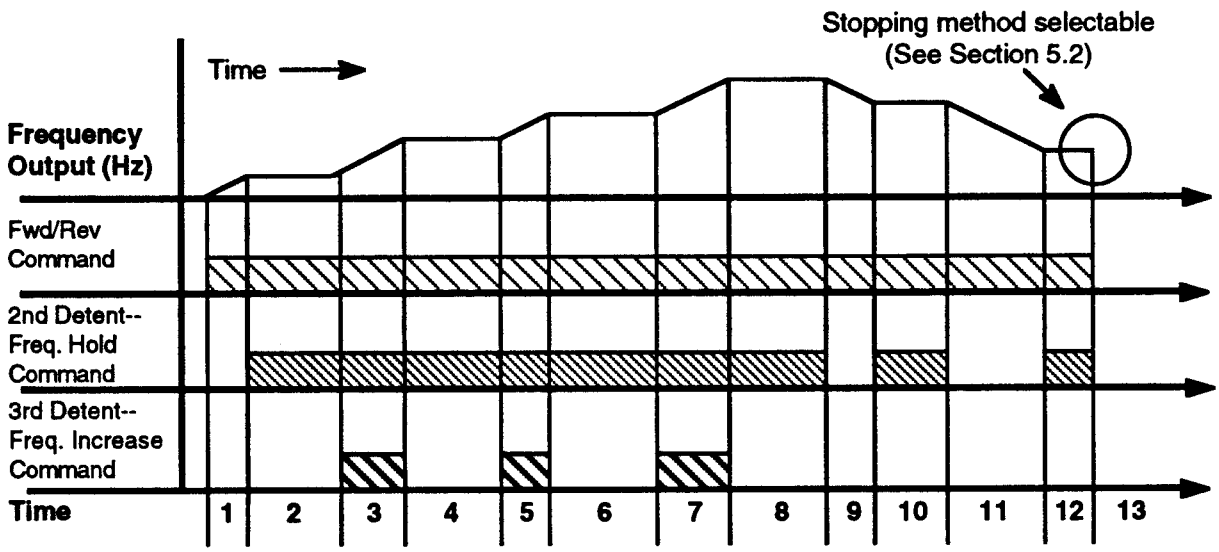
SW1 and SW2	Output	Setting	For More Information
	n/a	SW1-3C through SW2-5A have no function in this mode	Section 6.3.4
	Up to maximum speed 60 Hz or VR3	SW1-2A = Off	
		SW1-2B = Off	
		SW1-2C = On	
	5 Hz (Set by DS1-4, DS1-5 and DS1-6)	SW1-1A = Off	
		SW1-1B = Off	
		SW1-1C = Off	

RDS1, RDS2, RDS3	Name	Setting	For More Information
			
RDS1	Acceleration Time	5 (5.0 seconds)	Section 6.3.1
RDS2	Deceleration TIme	2 (3.5 seconds)	Section 6.3.1
RDS3	V/f Pattern	2 (Traverse) 8 (Hoisting)	Section 6.3.2

VR1, VR2, VR3	Name	Setting	For More Information
			
VR1	Reverse Plug Simulation	Full counterclockwise	Section 6.3.5.1
VR2	Quick Stop Gain	Full counterclockwise	Section 6.3.5.2
VR3	Stepless Speed Adjustment	Full counterclockwise	Section 6.3.5.3

5.1.3 Three-Step Infinitely Variable Speed Control Method DS1-1 = On, DS1-2 = On

IMPULSE•S; provides true infinitely variable speed control with three simple 120 VAC inputs. Three-step infinitely variable speed control is most often used on hoist motions where it is not acceptable to decelerate the motor when a STOP command is applied. (The control device is returned to the off position.) Three-step infinitely variable speed control is described below.



Time Frame Descriptions

Time **1** Run Forward/Reverse Command. **Frequency output increases to hertz set by** DS1-4 ~ DS1-6. Operation continues at this frequency.

2 **Second Detent/Frequency Hold Command.** Frequency output remains constant.

3 **Third Detent/Frequency Increase Command.** Frequency output increases. The longer this contact is closed, the higher the output frequency becomes. Limited only by the adjustable maximum speed (DS1-7 and DS1-8 or VR3).

4 **Second Detent/Frequency Hold Command.** Frequency output remains constant.

5 **Third Detent/Frequency Increase Command**. Frequency output increases. The longer this contact is closed, the higher the output frequency becomes. Limited only by the adjustable maximum speed (DS1-7 and DS1-8 or VR3).

6 **Second Detent/Frequency Hold Command.** Frequency output remains constant.

7 **Third Detent/Frequency Increase Command.** Frequency output increases. The longer this contact is closed, the higher the output frequency becomes. Limited only by the adjustable maximum speed (DS1-7 and DS1-8 or VR3).

5.1.3 Three-Step Infinitely Variable Speed Control Method DS1-1 = On, DS1-2 = On (Continued)

8 **Second Detent/Frequency Hold Command**. Frequency output remains constant.

9 **Run Forward/Reverse at Lower Limit Command.** Frequency output decreases. The longer this input signal condition exists, the lower the output frequency becomes. Limited only by DS1-4 ~ DS1-6.

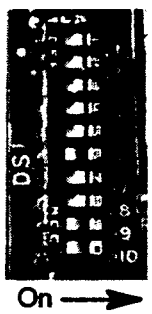
10 **Second Detent/Frequency Hold Command.** Frequency output remains constant.

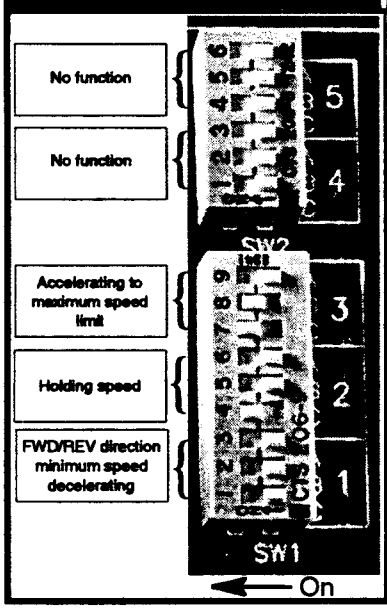
11 **Run Forward/Reverse Command.** Frequency output decreases. The longer this input signal condition exists, the lower the output frequency becomes. Limited only by DS1-4 ~ DS1-6.

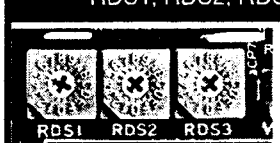
12 **Second Detent/Frequency Hold Command**. Frequency output remains constant.

13 **Absence of Commands = STOP Command.** Stopping method is selectable. (See Section 5.2).

5.1.3.1 Suggested Settings for Three-Step Infinitely Variable Speed Control Mode

DS1	Setting	For More Information
 Default stopping method is **immediate stop.** Extreme caution should be used when changing to deceleration at STOP command. A long deceleration time will cause driven equipment to require a greater stopping distance.	DS1-1 = On	Section 5.1.3
	DS1-2 = On	
	DS1-3 = On	Section 5.2.1/5.2.2
	DS1-4 = On	Section 6.3.4
	DS1-5 = On	
	DS1-6 = Off	
	DS1-7 = On	
	DS1-8 = On	
	DS1-9 = Off	n/a
	DS1-10 = Off	

SW1 and SW2	Output	Setting	For More Information
	n/a	SW2-5A through SW2-4C have no function in this mode	Section 6.3.4
	Accelerating to maximum speed limit 60 Hz or VR3	SW1-3A = Off	
		SW1-3B = On	
		SW1-3C = On	
	Frequency hold/increase command	SW1-2A = Off	
		SW1-2B = Off	
		SW1-2C = On	
	Minimum speed (set by DS1-4, DS1-5 and DS1-6)	SW1-1A = Off	
		SW1-1B = Off	
		SW1-1C = Off	

RDS1, RDS2, RDS3	Name	Setting	For More Information
			
RDS1	Acceleration Time	5 (5.0 seconds)	Section 6.3.1
RDS2	Deceleration Time	2 (3.5 seconds)	Section 6.3.1
RDS3	V/f Pattern	2 (Traverse) 8 (Hoisting)	Section 6.3.2

VR1, VR2, VR3	Name	Setting	For More Information
			
VR1	Reverse Plug Simulation	Full counterclockwise	Section 6.3.5.1
VR2	Quick Stop Gain	Full counterclockwise	Section 6.3.5.2
VR3	Stepless Speed Adjustment	Full counterclockwise	Section 6.3.5.3

5.2 Stopping Method Definitions (DS1-3 Function)

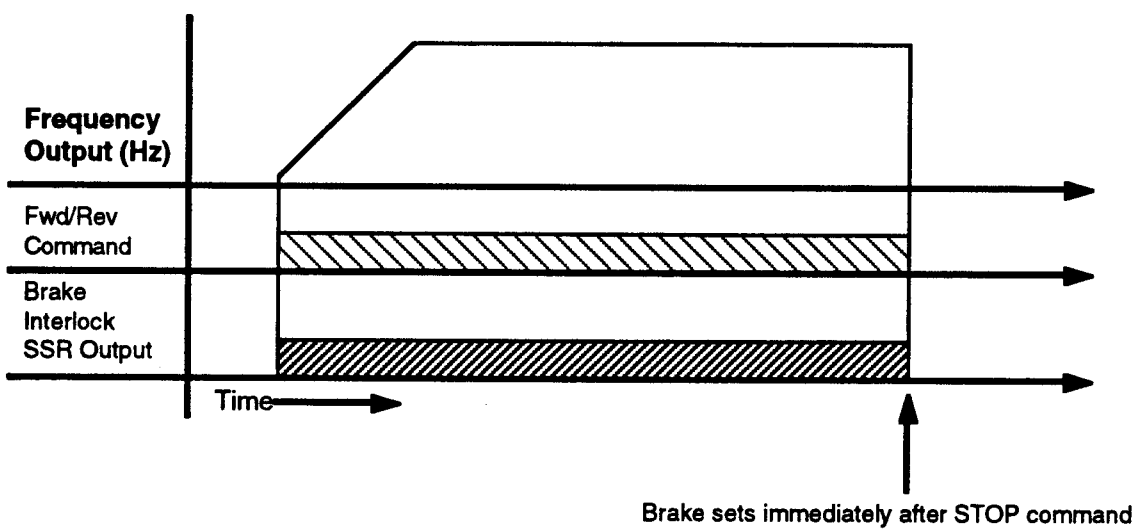
IMPULSE•S; provides for both types of commonly accepted braking methods.

- Immediate stop at STOP command (DS1-3 = On).
- Decelerate at STOP command (DS1-3 = Off).

Initial stopping method is **immediate stop.** Extreme caution should be used when changing to deceleration at STOP command. Operation should not begin until the user has reviewed the deceleration time set by Rotary Switch RDS2. A long deceleration time will cause driven equipment to require a greater stopping distance.

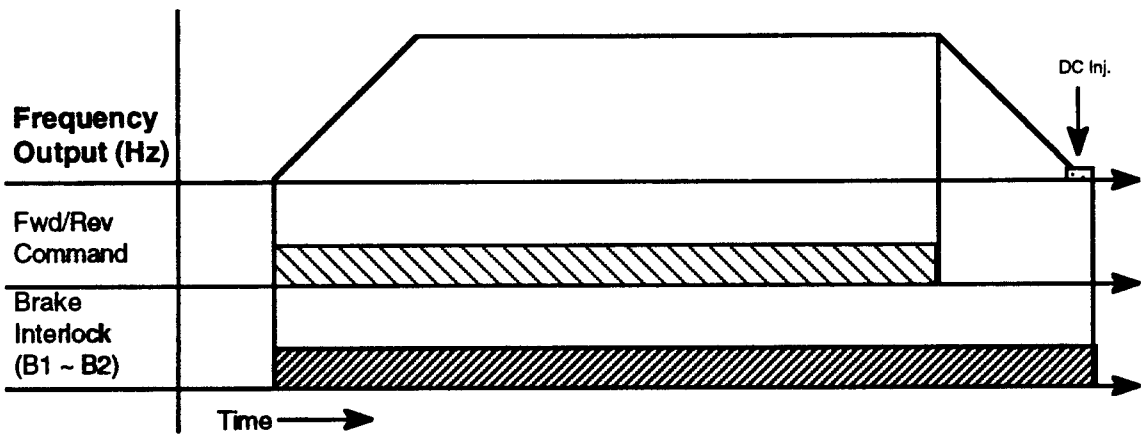
5.2.1 Immediate Stop at STOP Command

Upon STOP command, IMPULSE•S; base blocks main output transistors (i.e. the motor is electrically disconnected from the drive). The brake interlock solid state relay (terminals BK1 and BK2) sets the motor brake. See below for operation characteristics.



5.2.2 Decelerate at STOP Command

Upon STOP command, IMPULSE•S; output frequency decreases to near zero, DC injects for a few milliseconds, then the brake interlock relay (terminals BK1 and BK2) sets the motor brake. (See below for operation characteristics.)



Section 6: Settings and Adjustments

Special Note: If you purchased this IMPULSE•S; as part of an Electromotive Systems, Inc. pre-engineered, *TCONTROLS* motor control panel, actual settings will be those specified by the order and may be different than those listed in Section 6 as initial values.

6.1 General Description of Settings and Adjustments

IMPULSE•S; offers many specific adjustments and setting capabilities. These adjustments are accessed on both the interface card (SIF-35) and the logic card (TM2) of the IMPULSE•S;.

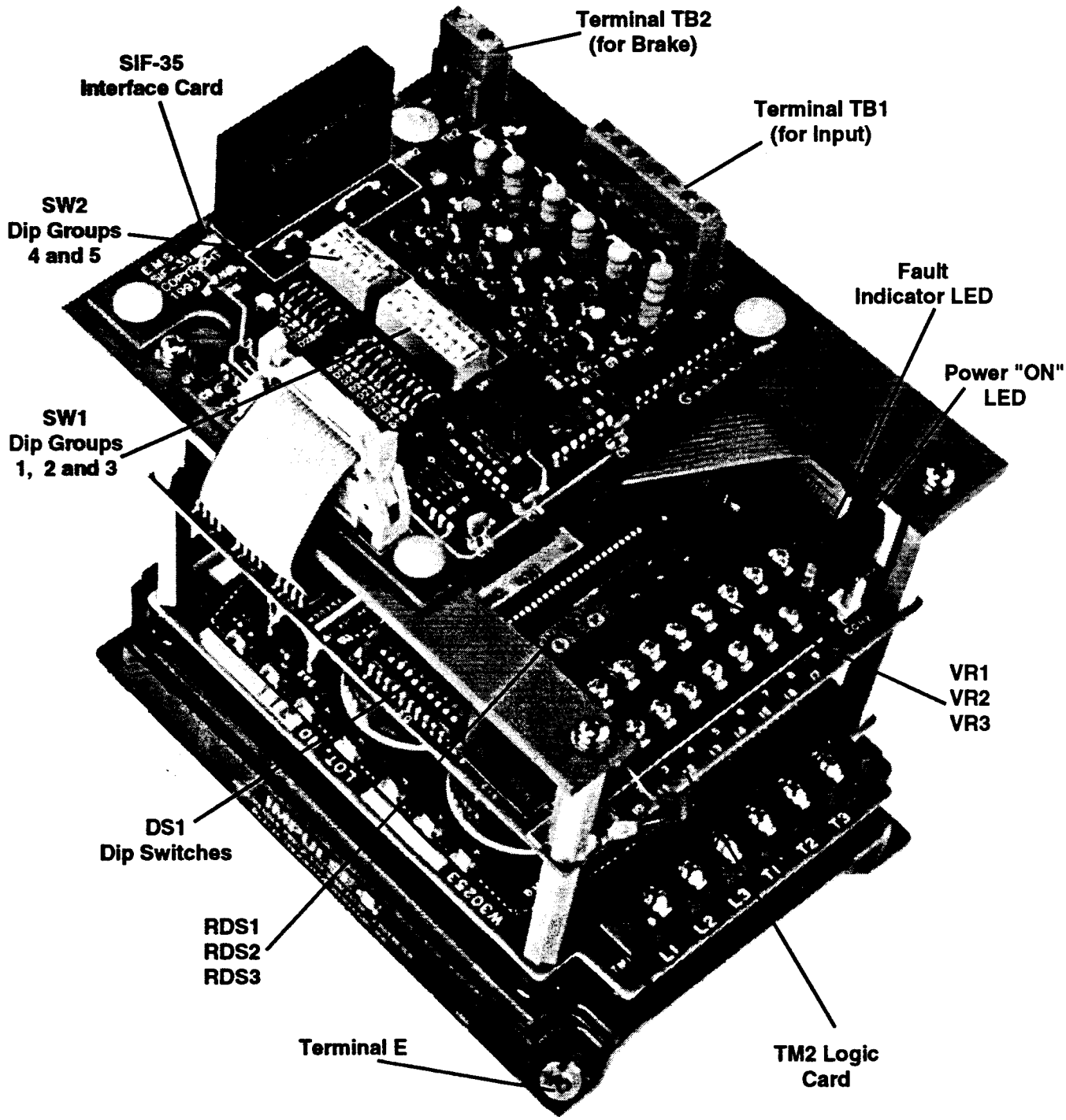
TM2 Adjustments and Settings

- RDS1 function:
  acceleration time
- RDS2 function:
  deceleration time
- RDS3 function:
  voltage/frequency output pattern selection
- DS1 functions:
  speed control method selection/braking method selection/frequency upper and lower limit (minimum and maximum speed), f-out speed selection for multi-step mode.
- VR1, VR2, VR3 functions:
  special functions

Interface (SIF-35) Settings:

- SW1 dip switches
  - Group 1 (SW1-1C, SW1-1B and SW1-1A):
    Sets the frequency output of run forward/reverse command
  - Group 2 (SW1-2C, SW1-2B and SW1-2A):
    Sets the frequency output of the second speed command (multi-step)/maximum frequency output command (two-step infinitely variable)/hold frequency command (three-step infinitely variable)
  - Group 3 (SW1-3C, SW1-3B and SW1-3A):
    Sets the frequency output of the third speed command (multi-step)/maximum frequency output command (three-step infinitely variable)
- SW2 Dip Switches
  - Group 4 (SW2-4C, SW2-4B and SW2-4A):
    Sets the frequency output of the fourth speed command (multi-step)
  - Group 5 (SW2-5C, SW2-5B and SW2-5A):
    Sets the frequency output of the fifth speed command (multi-step)

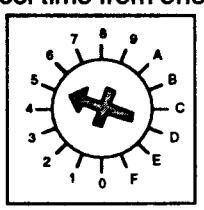
6.2 Location of Adjusting Devices



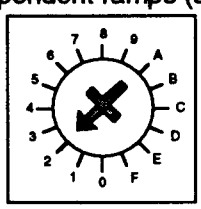
6.3 TM2 Settings and Adjustments

6.3.1 RDS1-Acceleration Time/RDS2-Deceleration Time Adjustments

The acceleration time and the deceleration time can be independently set by rotary selector switches RDS1 and RDS2 (shown below) located on the TM2 circuit card. IMPULSE•S allows the user to select a specific accel/decel time from one of sixteen preset independent ramps (see table below.)



RDS1 - Acceleration Time

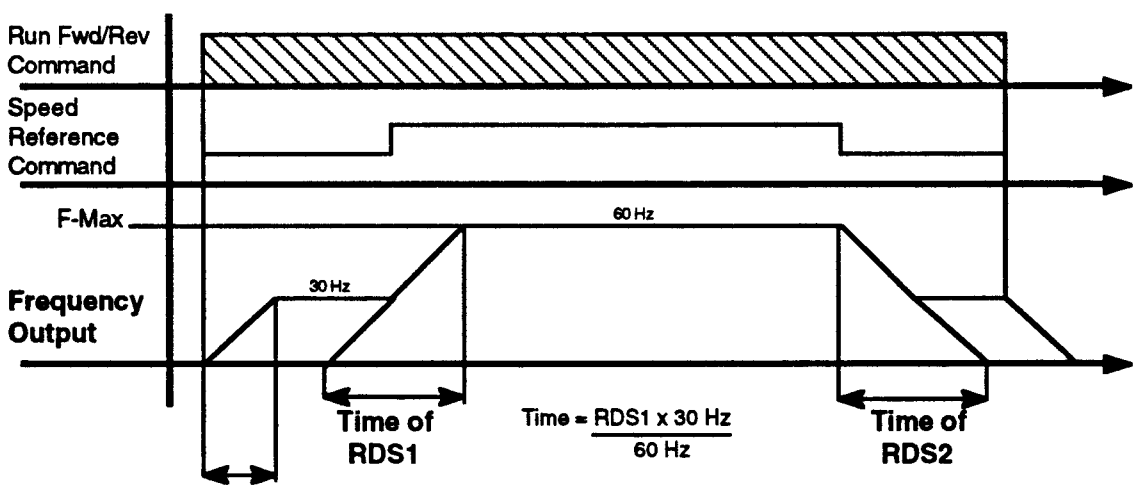


RDS2 - Deceleration Time

(Both are shown in the initial setting position)

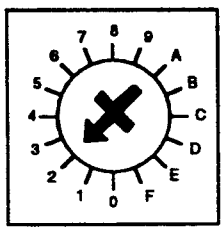
RDS1/ RDS2 Notch	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
Accel/ Decel Time (seconds)	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	8.00	9.00	10.0	12.0	15.0	20.0
DC Inj. Time	0.20	0.20	0.20	0.20	0.20	0.20	0.25	0.25	0.30	0.30	0.40	0.50	0.50	0.75	1.00	1.00

The time indicated by each notch setting in the table above is the time to accelerate (decelerate) from zero frequency to maximum frequency (f-max). To determine acceleration to any intermediate frequency, follow the example below.

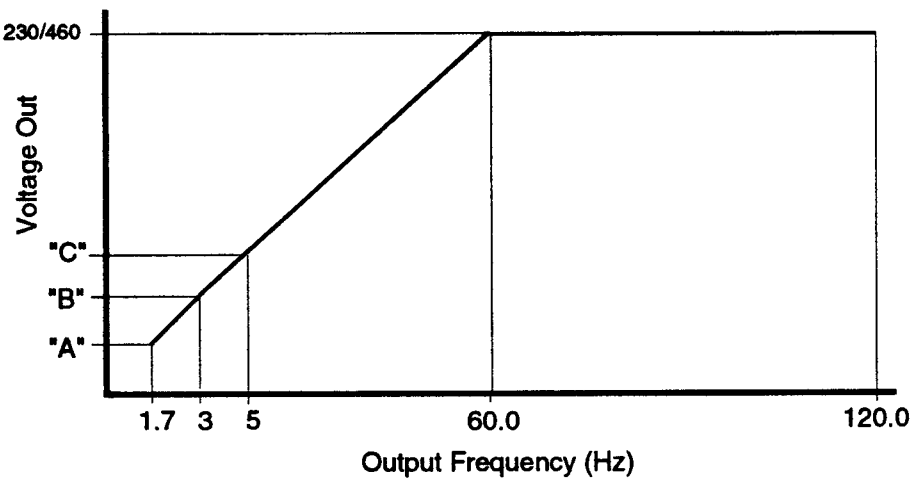


6.3.2 RDS3-Voltage/Frequency Pattern Selection

IMPULSE•S; offers sixteen V/f patterns specially tailored for crane and hoist applications. Rotary selector switch RDS3 determines which pattern is applied. RDS3 serves to adjust low speed "torque boost".



RDS3 - V/f Pattern
Initial setting for traverse motions is 2.
Initial setting for hoisting motions is 8.



230 Volts																
RDS3 Notch	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
"A" Volts	9.5	11.0	11.5	13.5	14.5	16.0	17.0	13.5	15.0	16.0	17.5	18.5	20.0	21.0	22.0	22.0
"B" Volts	13.5	15.0	16.0	18.0	19.0	19.5	21.0	18.0	20.0	22.0	23.5	26.0	28.0	29.5	33.0	33.0
"C" Volts	22.0	23.5	24.5	26.5	28.0	29.0	31.0	27.5	31.0	35.0	37.5	42.5	46.0	48.5	53.5	53.5

460 Volts																
RDS3 Notch	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
"A" Volts	25.0	27.5	29.5	33.5	36.0	38	41.5	34.0	36.5	39.0	41.5	44.0	46.5	49.0	51.5	51.5
"B" Volts	34.0	37.0	38.5	42.0	45.0	47.0	50.0	43.0	47.5	51.0	54.5	59.5	63.5	67.0	72.0	72.0
"C" Volts	51.0	54.0	56.0	59.0	62.0	64.0	67.5	61.0	68.5	76.5	81.5	91.5	99.0	104.5	114.0	114.0

Note: Actual output voltage depends on actual input voltage. Actual output voltage may be calculated as percentage of above numbers. All relationships will be linear.

6.3.3 Voltage/Frequency Pattern Selection Procedure

Application notes for choosing optimum V/f pattern:

1) As a general rule, notch 2 is considered the horizontal V/f pattern.
2) As a general rule, notches 5 to 8 are considered hoisting V/f patterns.
3) As a general rule, notches 9 to F are for extremely high torque applications (not for general use).

Procedure:

a) Set lowest notch appropriate for your application (horizontal or hoisting).
b) Run motor under "worst-case" condition (fully loaded hoist, etc.)
   - If 125% load test is required, then load for this condition.
c) If operation is successful, then setting is acceptable.
d) If operation is not successful, then try again at next higher notch value.

Continue this procedure until operation is successful.

6.3.4 DS1-1 to DS1-10, Speed Mode Selection, Braking Mode Selection/Speed (Frequency) Point Selection

DS1 series of dip switches control inverter output functions as described below:

DS1	Description	Switch Settings and Output Description		
DS1-1 and DS1-2	Speed Control Method Selection	DS1-1 = off	DS1-2 = off	Multi-Step Speed Control - VR3 enabled for maximum speed when Group 5 (SW2-5C, SW2-5B and SW2-5A) = on
		DS1-1 = off	DS1-2 = on	Multi-Step Speed Control - VR3 enabled for minimum speed when Group 1 (SW1-1C, SW1-1B and SW1-1A) = off
		DS1-1 = on	DS1-2 = off	Two-Step Infinitely Variable Speed Control Mode
		DS1-1 = on	DS1-2 = on	Three-Step Infinitely Variable Speed Control Mode

DS1-3	Stopping Method Selection	DS1-3 = on	Immediate Stop at STOP Command
		DS1-3 = off	Deceleration to Stop at STOP Command (Time of RDS2)

DS1-4 DS1-5 and DS1-6	Minimum Speed (frequency output lower limit) Effective when Group 1 (SW1-1C, SW1-1B, SW1-1A) set to off. (Determined by the combination of DS1-4, DS1-5 and DS1-6.)	DS1-4 = on	DS1-5 = off	DS1-6 = off	2 Hz	output
		DS1-4 = on	DS1-5 = off	DS1-6 = on	3 Hz	
		DS1-4 = on	DS1-5 = on	DS1-6 = off	5 Hz	
		DS1-4 = on	DS1-5 = on	DS1-6 = on	10 Hz	
		DS1-4 = off	DS1-5 = off	DS1-6 = off	15 Hz	
		DS1-4 = off	DS1-5 = off	DS1-6 = on	20 Hz	
		DS1-4 = off	DS1-5 = on	DS1-6 = off	25 Hz	
		DS1-4 = off	DS1-5 = on	DS1-6 = on	30 Hz	

DS1-7 and DS1-8	Infinitely Variable Mode Only				
	Maximum Speed (frequency output upper limit) for infinitely variable mode only	DS1-7 = off	DS1-8 = off	45 Hz	output
		DS1-7 = off	DS1-8 = on	50 Hz	
		DS1-7 = on	DS1-8 = off	55 Hz	
		DS1-7 = on	DS1-8 = on	60 Hz	
	Multi-Step Mode Only				
	For multi-step operation, settings of DS1-7 and DS1-8 determine possible frequency output combinations. (Please see Section 6.3.4.1 for details.)	DS1-7 = off	DS1-8 = off	See Section 6.3.4.1	output
		DS1-7 = off	DS1-8 = on		
		DS1-7 = on	DS1-8 = off		
		DS1-7 = on	DS1-8 = on		

DS1-9 and DS1-10	Analog Frequency Reference Selection	DS1-9 = off	DS1-10 = off	Freq. set by Freq. setting potentiometer or 0 ~ 10 VDC signal
		DS1-9 = off	DS1-10 = on	Freq. set by 1 ~ 5 VDC signal
		DS1-9 = on	DS1-10 = off	Freq. set by 4 ~ 20 mA signal
		DS1-9 = on	DS1-10 = on	Analog freq. setting is not used

6.3.4.1 Multi-Step Frequency Selection

When operating in the multi-step speed control mode, there are a variety of speed settings from which you can choose. The possible speeds (frequency outputs) are determined by how you set up DS1-7 and DS1-8.

To set up IMPULSE•S; first choose the speed group (below) which offers the speed settings most appropriate for your application. You can only choose values from one of the speed groups. To access those values, DS1-7 and DS1-8 must be set corresponding to that particular speed group.

Once you have selected a speed group by adjusting DS1-7 and DS1-8, set your individual speeds. These speeds are set by the five groups of CBA switches (SW1 and SW2). In the multi-step mode, Group 1 (SW1-1C, SW1-1B and SW1-1A) sets the minimum speed; Group 2 (SW1-2C, SW1-2B and SW1-2A) sets the second speed; Group 3 (SW1-3C, SW1-3B and SW1-3A) sets the third speed; Group 4 (SW2-4C, SW2-4B and SW2-4A) sets the fourth speed; and Group 5 (SW2-4C, SW2-4B and SW2-4A) sets the maximum speed.

Your minimum speed can be set in either of the two following ways:

1) Set Group 1 (SW1-1C, SW1-1B and SW1-1A) to all off (see below). Your minimum speed will be the speed set by DS1-4, DS1-5 and DS1-6 (see Section 5.3.4.)

or

2) Set Group 1 according to one of the CBA combinations detailed below. Your minimum speed will be the corresponding frequency.

Remember, all other speeds are set by simply using the appropriate combination of CBA settings for each group.

Switch Position			Speed Group 1	Speed Group 2	Speed Group 3	Speed Group 4
C	B	A	Setup DS1-7 = Off DS1-8 = Off	Setup DS1-7 = Off DS1-8 = On	Setup DS1-7 = On DS1-8 = Off	Setup DS1-7 = On DS1-8 = On
off	off	off	Minimum Speed - Set by DS1-4, DS1-5 and DS1-6*			
off	off	on	10 Hz	10 Hz	15 Hz	20 Hz
off	on	off	15 Hz	20 Hz	20 Hz	30 Hz
off	on	on	20 Hz	30 Hz	30 Hz	40 Hz
on	off	off	30 Hz	40 Hz	45 Hz	60 Hz
on	off	on	40 Hz	50 Hz	60 Hz	80 Hz
on	on	off	50 Hz	60 Hz	75 Hz	100 Hz
on	on	on	60 Hz*	75 Hz*	90 Hz*	120 Hz

* VR3 and Analog Input T14 can offer additional flexibility for setting of minimum and maximum speeds. For more information about these functions, please see Section 6.3.4.2.

6.3.4.2 Additional Flexibility for Setting Minimum and Maximum Speeds

To attain speeds for special requirements, IMPULSE•S has two additional ways to adjust minimum and maximum speeds: VR3 or an Analog Input T14. Once again, accessing these adjustment devices depends on the combination of the DS1 switches and the SW1 and SW2 switch groups 1 and 5.

Minimum speed

To adjust your **minimum** speed using **VR3**:
DS1-1= Off
DS1-2 = On
Group 1 (SW1-1C, SW1-1B, SW1-1A) = Off

With this setup, your minimum speed will be the **higher** of DS1-4, DS1-5 and DS1-6, or VR3.

To adjust your **minimum** speed using **Analog Input T14**:
DS1-1= Off
DS1-2 = Off
Group 1 (SW1-1C, SW1-1B, SW1-1A) = Off

With this setup, your minimum speed will be the **higher** of DS1-4, DS1-5 and DS1-6, or Analog Input T14.

Maximum speed:

To adjust your **maximum** speed using **VR3**:
DS1-1= Off
DS1-2 = Off
Group 5 (SW2-5C, SW2-5B, SW2-5A) = On

With this setup, your maximum speed will be the **higher** of Group 5 (SW2-5C, SW2-5B, SW2-5A) or VR3.

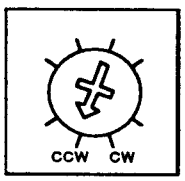
To adjust your **maximum** speed using **Analog Input T14**:
DS1-1= Off
DS1-2 = On
Group 5 (SW2-5C, SW2-5B, SW2-5A) = On

With this setup, your maximum speed will be the **higher** of Group 5 (SW2-5C, SW2-5B, SW2-5A) or Analog Input T14.

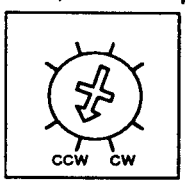
For more information about VR3, see Section 5.3.5.3.

6.3.5 Special Functions of VR1, VR2 and VR3

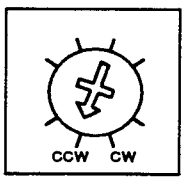
VR1, VR2 and VR3 are small potentiometers mounted on the main control card (TM2). Each of the potentiometers offers a unique function and adjusts special features exclusive to IMPULSE Adjustable Frequency Motor Controls, tailored specifically for the crane and hoist industry.



VR1
Reverse Plug Simulation
Adjustment (Gain)



VR2
Quick Stop
Adjustment (Gain)

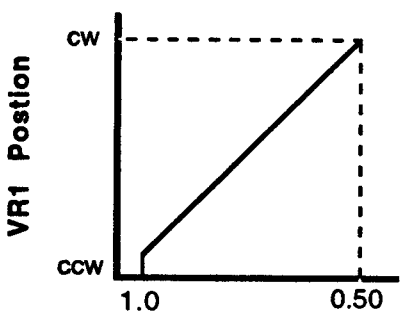


VR3
Minimum or Maximum
Stepless Speed Adjustment
(Frequency Upper Limit)
Enabled when Group 1
switches C, B and A = off, or
Group 5 switches
C, B and A = on

CW = clockwise; CCW = counterclockwise

6.3.5.1 Special Function of VR1: Reverse Plug Simulation Gain

Reverse Plug Simulation allows an operator to change direction of travel quickly. This function closely simulates the operation of systems using conventional reversing contactor type controls. Operators who are comfortable with the rapid deceleration achieved when plug reversing standard motors can smoothly and quickly stop in the direction of travel, then quickly accelerate in the opposite direction without setting the motor brake. This function is enabled during decel at STOP command operation only. To disable Reverse Plug Simulation, turn VR1 full counterclockwise. The farther VR1 is positioned clockwise, the faster the rate of acceleration/deceleration will be. VR1 adjusts Reverse Plug Simulation as below:



Acceleration/Deceleration
(Gain) of RDS1/RDS2

Explanation: If VR1 is full clockwise, then Gain = 0.50. Acceleration/deceleration time during Reverse Plug Simulation is equal to: Time of RDS1/RDS2 • VR1 Gain

Example 1: Given: RDS1 = 4.00 Seconds
RDS2 = 3.00 seconds
VR1 Position = Full clockwise (Gain of 0.50)

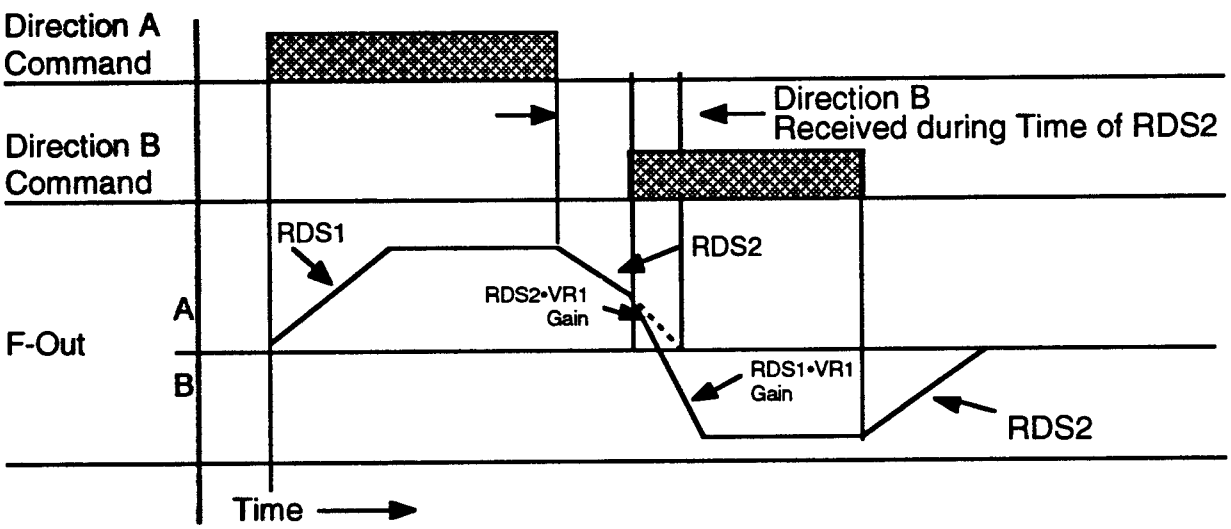
Then: Acceleration time during Reverse Plug Simulation
= 4.00 • 0.50
= 2.00 seconds

Then: Deceleration time during Reverse Plug Simulation
= 3.00 • 0.50
= 1.50 seconds

Example 2: Given: RDS1 = 4.00 Seconds
RDS2 = 3.00 seconds
VR1 Position = Full counterclockwise (Gain of 1.0)

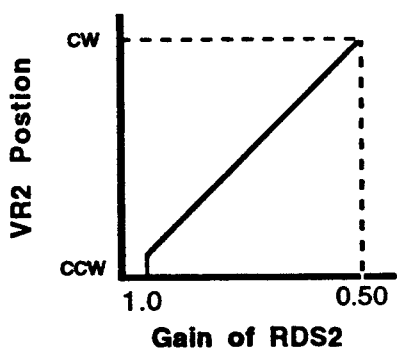
Then: No Change of Accel/Decel Time
("X" times 1 = "X")

6.3.5.1.1 Reverse Plug Simulation Gain Timing Chart



6.3.5.2 Special Function of VR2: Quick Stop Gain

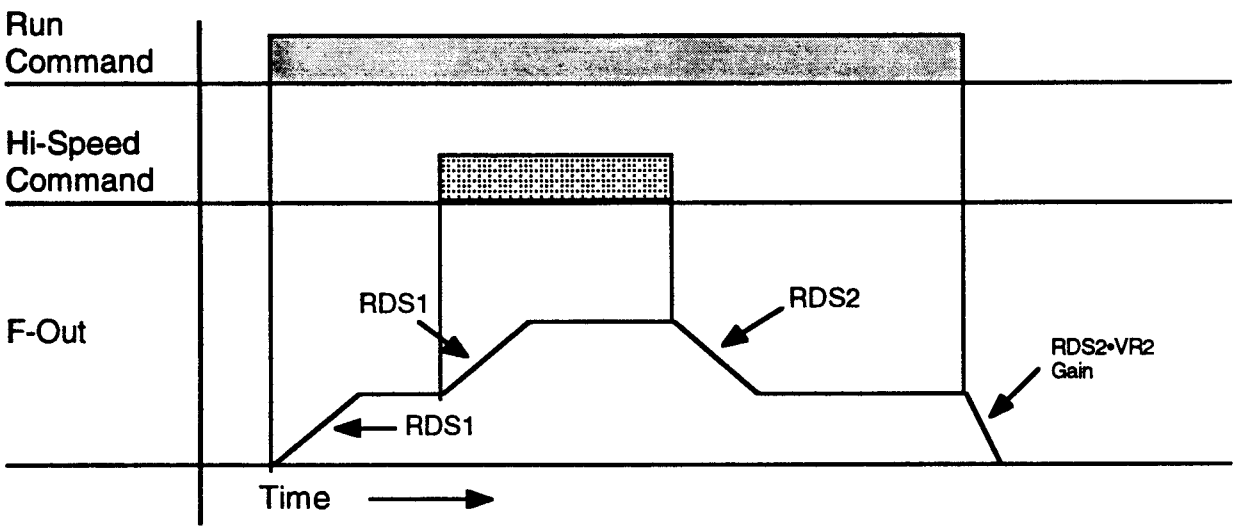
Quick Stop provides an automatic alternate decel time changeover at STOP command. This function provides for increased positioning accuracy by shortening the deceleration time at STOP command to within the safe operating limits of the equipment. Quick Stop ensures a rapid deceleration to stop once a drive RUN command is removed, and reduces the possibility of a crane collision. Quick Stop is enabled by VR2 as below:



Explanation: If VR2 is full clockwise, then Gain = 0.50.
Deceleration time during Quick Stop is equal to:
Time of RDS2 • VR1 Gain
Example 1:
Given: RDS2 = 3.00 seconds
VR2 Position = Full clockwise (Gain of 0.50)
Then: Deceleration time during Quick Stop
= 3.00 • 0.50
= 1.50 seconds
Example 2:
Given: RDS2 = 3.00 seconds
VR1 Position = Full counterclockwise (Gain of 1.0)
Then: No change of decel time
("X" times 1 = "X")

CW = clockwise; CCW = counterclockwise

6.3.5.2.1 Quick Stop Gain Timing Chart

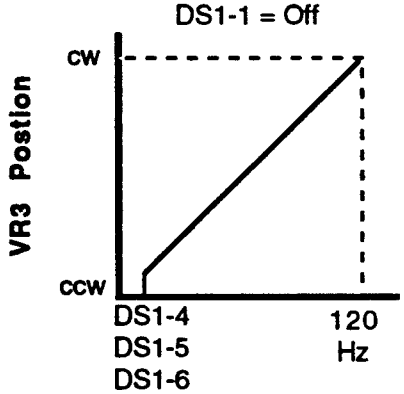


6.3.5.3 Special Function of VR3: Stepless Speed Adjustment

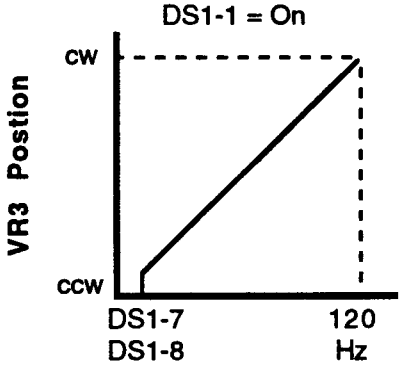
1. Multi-Step Mode: Certain applications of IMPULSE•S require unusual output speeds not provided by the tables selected by the DS1-7 and DS1-8 dip switches (see section 6.3.4.1). The function of VR3 is to provide for these speed selections. If the position of the Group 1 or Group 5 SW1 and SW2 Dip Groups (C, B and A) is either all on (Group 5) or all off (Group 1), the VR3 Analog Speed Reference is enabled.

2. Infinitely Variable Mode: When using the Infinitely Variable Speed Control Modes, the function of VR3 is to alter the Upper Limits provided by DS1-7 and DS1-8.

Multi-Step Mode
Function of VR3
(Analog Speed Reference)
DS1-1 = Off



Infinitely Variable Mode
Function of VR3
(Frequency Upper Limit)
DS1-1 = On



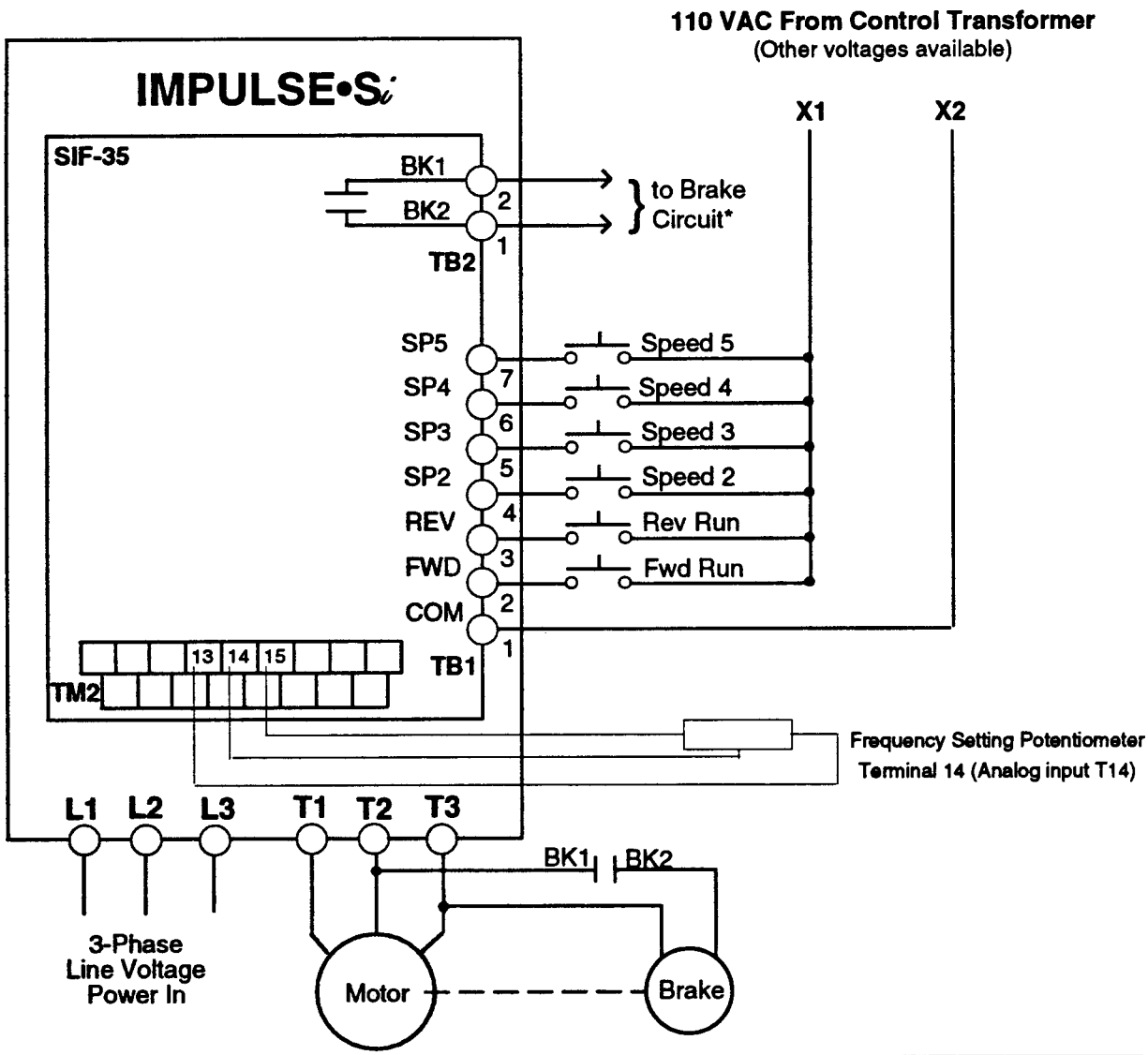
CW = clockwise; CCW = counterclockwise VR3 is disabled when it is full counterclockwise.

Section 7: Setting Recipes

7.1 Multi-Step Speed Control Method

Specific settings and connections are required to begin multi-step speed control mode operation. The "recipe" requires both control connections to the control voltage interface card (SIF-35) and setting adjustments to both the TM2 circuit board (DS1, RDS1, RDS2, RDS3, VR1, VR2, VR3) and the control voltage interface card (SW1, SW2).

7.1.1 Control Circuit Wiring Diagram (Multi-Step Speed Control Mode)



7.1.2 Suggested Settings for Groups 1 through 5 (SW1 and SW2) Multi-Step Speed Control

Suggested SW1 and SW2 Switch Group Settings - Multi-Step Mode				
Initial Settings	Switch Status			Frequency Reference by SW1 and SW2 Selection Pattern
	C	B	A	
Group 1	off	off	off	Hertz of DS1-4, DS1-5 and DS1-6*
Group 2	off	off	on	10 hertz
Group 3	off	on	on	20 hertz
Group 4	on	off	on	40 hertz
Group 5	on	on	on	Higher of 60 hertz or VR3**

* Initial setting is 5 Hz.
** See Section 5.3.5.1.

7.1.3 Suggested Settings to TM2 Board (Multi-Step Speed Control)

7.1.3.1 DS1 Dip Switch Settings (Multi-Step Speed Control)

DS1	Description	Switch Settings and Output Description		
DS1-1 and DS1-2	Speed Control Mode Selection	DS1-1 = off	DS1-2 = off	**Multi-Step Speed Control - VR3 enabled for maximum speed when Group 5 (SW2-5C, SW2-5B, SW2-5A) = on**
		DS1-1 = off	DS1-2 = on	**Multi-Step Speed Control - VR3 enabled for minimum speed when Group 1 (SW1-1C, SW1-1B and SW1-1A) = off**

DS1-3	Stopping Mode Selection	DS1-3 = on	**Immediate Stop at STOP Command**
		DS1-3 = off	**Deceleration to Stop at STOP Command Time of RDS2**

DS1-4 DS1-5 and DS1-6	Frequency Output Lower Limit. (Frequency is determined by the combination of DS1-4, DS1-5 and DS1-6.)	DS1-4 = on	DS1-5 = off	DS1-6 = off	**2 Hz**	output
		DS1-4 = on	DS1-5 = off	DS1-6 = on	**3 Hz**	
		DS1-4 = on	DS1-5 = on	DS1-6 = off	**5 Hz**	
		DS1-4 = on	DS1-5 = on	DS1-6 = on	**10 Hz**	
		DS1-4 = off	DS1-5 = off	DS1-6 = off	**15 Hz**	
		DS1-4 = off	DS1-5 = off	DS1-6 = on	**20 Hz**	
		DS1-4 = off	DS1-5 = on	DS1-6 = off	**25 Hz**	
		DS1-4 = off	DS1-5 = on	DS1-6 = on	**30 Hz**	

DS1-7 and DS1-8	Frequency Output Table Selection for Multi-Step Mode (Frequency is determined by the combination of DS1-7 and DS1-8, in conjunction with the speed control mode (set by DS1-1 and DS1-2))	DS1-7 = off	DS1-8 = off	**See Section 5.3.4.1**	output
		DS1-7 = off	DS1-8 = on		
		DS1-7 = on	DS1-8 = off		
		DS1-7 = on	DS1-8 = on		

DS1-9 and DS1-10	Analog Frequency Reference Selection	DS1-9 = off	DS1-10 = off	**Freq. set by Freq. setting potentiometer or 0 ~ 10 VDC signal**	output
		DS1-9 = off	DS1-10 = on	**Freq. set by 1 ~ 5 VDC signal**	
		DS1-9 = on	DS1-10 = off	**Freq. set by 4 ~ 20 mA signal**	
		DS1-9 = on	DS1-10 = on	**Analog freq. setting is not used**	

Default stopping method is **immediate stop.** Extreme caution should be used when changing to deceleration at STOP command. A long deceleration time will cause driven equipment to require a greater stopping distance.

7.1.3.2 RDS1 (Accel Time), RDS2 (Decel Time), RDS3 (V/F Pattern) Selections

RDS1

Notch	Acceleration Time (Sec)
0	2.50
1	3.00
2	3.50
3	4.00
4	4.50
5	5.00
6	5.50
7	6.00
8	6.50
9	7.00
A	8.00
B	9.00
C	10.0
D	12.0
E	15.0
F	20.0

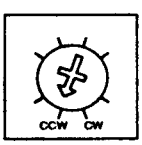
RDS2

Notch	Deceleration Time (Sec)	DC Injection Time (Sec)
0	2.5	0.20
1	3.0	0.20
2	3.5	0.20
3	4.0	0.20
4	4.5	0.20
5	5.0	0.20
6	5.5	0.25
7	6.0	0.25
8	6.5	0.30
9	7.0	0.30
A	8.0	0.40
B	9.0	0.50
C	10.0	0.50
D	12.0	0.75
E	15.0	1.00
F	20.0	1.00

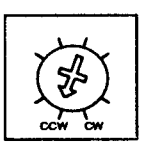
RDS3

Notch	Starting Torque
0	Lowest
1	
2	Horizontal
3	
4	
5	
6	
7	
8	Hoisting
9	
A	
B	
C	
D	
E	
F	Highest

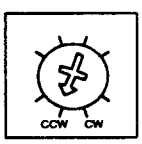
7.1.3.3 VR1 (Reverse Plug Simulation Gain), VR2 (Quick Stop Gain), VR3 (Analog Frequency Reference) Selections



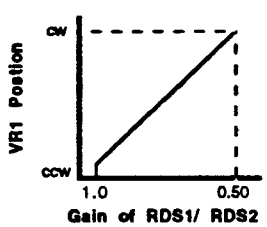
VR1
Reverse Plug Simulation (Gain)

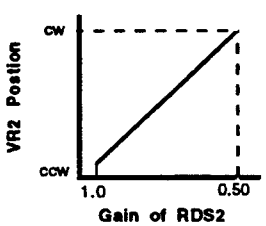


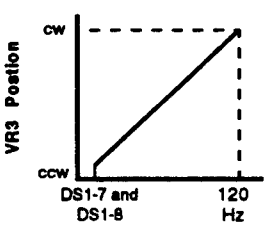
VR2
Quick Stop (Gain)



VR3
Stepless Speed Adjustment

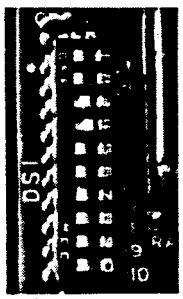


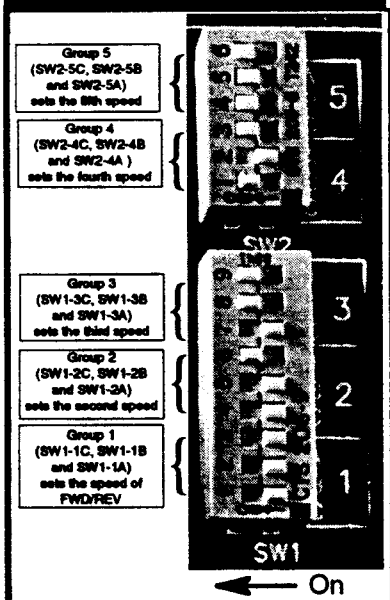


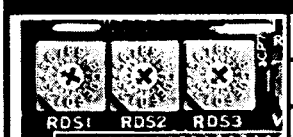


Initial Setting for VR1, VR2 and VR3 is full counterclockwise.
CW = clockwise; CCW = counterclockwise For more information please see Section 6.3.5.

7.1.4 Suggested Settings for Multi-Step Speed Control

DS1	Setting	For More Information
 Default stopping method is **immediate stop.** Extreme caution should be used when changing to deceleration at STOP command. A long deceleration time will cause driven equipment to require a greater stopping distance.	DS1-1 = Off	Section 5.1.1
	DS1-2 = Off	
	DS1-3 = On	Section 5.2.1/5.2.2
	DS1-4 = On	Section 6.3.4
	DS1-5 = On	
	DS1-6 = Off	
	DS1-7 = Off	Section 6.3.4.1
	DS1-8 = Off	
	DS1-9 = Off	n/a
	DS1-10 = Off	

SW1 and SW2	Output	Setting	For More Information
	Higher of 60 Hz or Hz set by VR3*	SW2-5A = On	Section 6.3.4.1
		SW2-5B = On	
		SW2-5C = On	
	40 Hz	SW2-4A = On	
		SW2-4B = Off	
		SW2-4C = On	
	20 Hz	SW1-3A = On	
		SW1-3B = On	
		SW1-3C = Off	
	10 Hz	SW1-2A = On	
		SW1-2B = Off	
		SW1-2C = Off	
	5 Hz (Set by DS1-4, DS1-5 and DS1-6)	SW1-1A = Off	
		SW1-1B = Off	
		SW1-1C = Off	

RDS1, RDS2, RDS3	Name	Setting	For More Information
			
RDS1	Acceleration Time	5 (5.0 seconds)	Section 6.3.1
RDS2	Deceleration TIme	2 (3.5 seconds)	Section 6.3.1
RDS3	V/f Pattern	2 (Traverse) 8 (Hoisting)	Section 6.3.2

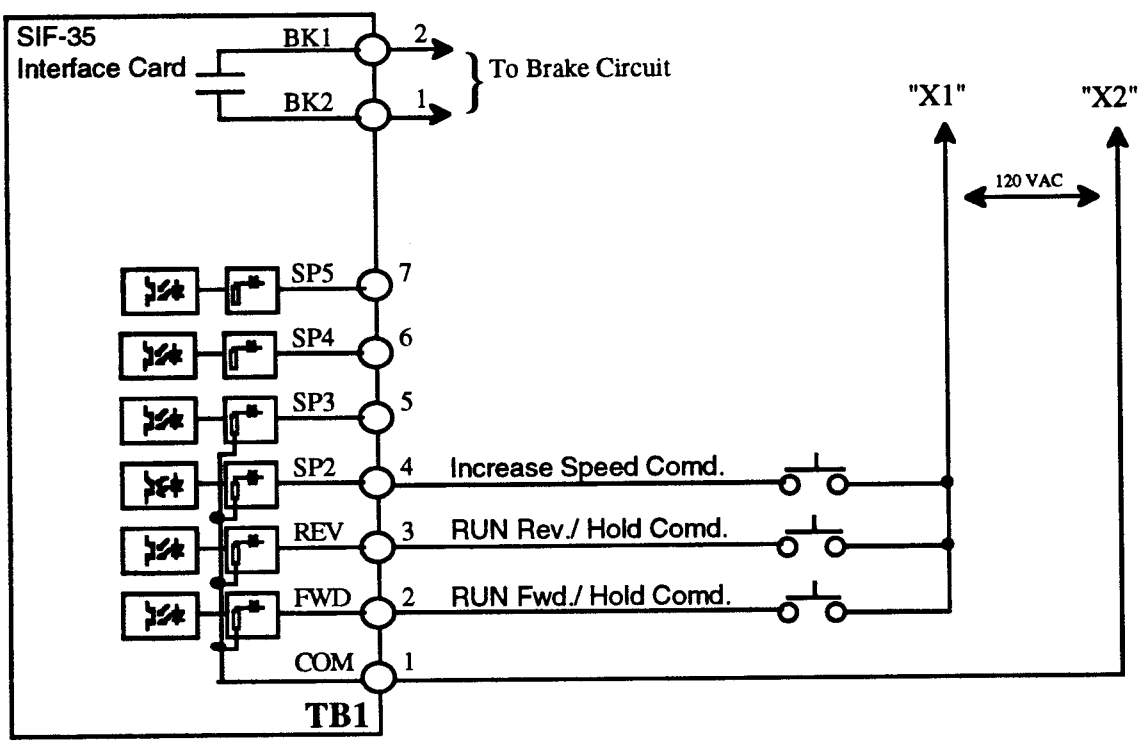
VR1, VR2, VR3	Name	Setting	For More Information
			
VR1	Reverse Plug Simulation	Full counterclockwise	Section 6.3.5.1
VR2	Quick Stop Gain	Full counterclockwise	Section 6.3.5.2
VR3	Stepless Speed Adjustment	Full counterclockwise	Section 6.3.5.3

* DS1-1 and DS1-2 must both be off in order for VR3 to set maximum speed

7.2 Two-Step Infinitely Variable Speed Control Method

Specific settings and connections are required to begin two-step speed control mode operation. The "recipe" requires both control connections to the control voltage interface card (SIF-35) and setting adjustments to both the TM2 circuit board (DS1, RDS1, RDS2, RDS3, VR1, VR2, VR3) and the control voltage interface card (SW1, SW2).

7.2.1 Control Circuit Wiring Diagram (Two-Step Infinitely Variable Speed Control)



7.2.2 Required Settings for Interface SW1 Dip Switch Groups 1 and 2: Two-Step Infinitely Variable

Required SW1 Switch Group Settings - Two-Step Infinitely Variable				
Initial Settings	Switch Status			Frequency Reference by SW1 Selection Pattern
	C	B	A	
Group 1	off	off	off	Minimum speed/holding speed Runs at hertz of DS1-4, DS1-5, DS1-6 Hold frequency steady
Group 2	on	off	off	Accelerating Frequency is increasing

7.2.3 Suggested Settings to TM2 Board (Two-Step Infinitely Variable Speed Control)

7.2.3.1 DS1 Dip Switch Settings (Two-Step Infinitely Variable)

DS1	Description	Switch Settings and Output Description		
DS1-1 and DS1-2	Speed Control Mode Selection	DS1-1 = on	DS1-2 = off	**2-Step Infinitely Variable Speed Control Mode**

DS1-3	Stopping Mode Selection	DS1-3 = on	**Immediate Stop at STOP Command**
		DS1-3 = off	**Deceleration to Stop at STOP Command Time of RDS2**

DS1-4 DS1-5 and DS1-6	Frequency Output Lower Limit. (Frequency is determined by the combination of DS1-4, DS1-5 and DS1-6.)	DS1-4 = on	DS1-5 = off	DS1-6 = off	**2 Hz**
		DS1-4 = on	DS1-5 = off	DS1-6 = on	**3 Hz**
		DS1-4 = on	DS1-5 = on	DS1-6 = off	**5 Hz**
		DS1-4 = on	DS1-5 = on	DS1-6 = on	**10 Hz**
		DS1-4 = off	DS1-5 = off	DS1-6 = off	**15 Hz**
		DS1-4 = off	DS1-5 = off	DS1-6 = on	**20 Hz**
		DS1-4 = off	DS1-5 = on	DS1-6 = off	**25 Hz**
		DS1-4 = off	DS1-5 = on	DS1-6 = on	**30 Hz**

DS1-7 and DS1-8	Infinitely Variable Mode Only			
	Frequency Output Upper Limit for Infinitely Variable Mode (Frequency is determined by the higher of DS1-7 and DS1-8 or VR3)	DS1-7 = off	DS1-8 = off	**45 Hz**
		DS1-7 = off	DS1-8 = on	**50 Hz**
		DS1-7 = on	DS1-8 = off	**55 Hz**
		DS1-7 = on	DS1-8 = on	**60 Hz**

DS1-9 and DS1-10	Analog Frequency Reference Selection	DS1-9 = off	DS1-10 = off	**Freq. set by Freq. setting potentiometer or 0 ~ 10 VDC signal**
		DS1-9 = off	DS1-10 = on	**Freq. set by 1 ~ 5 VDC signal**
		DS1-9 = on	DS1-10 = off	**Freq. set by 4 ~ 20 mA signal**
		DS1-9 = on	DS1-10 = on	**Analog freq. setting is not used**

Default stopping method is **immediate stop**. Extreme caution should be used when changing to deceleration at STOP command. A long deceleration time will cause driven equipment to require a greater stopping distance.

7.2.3.2 RDS1 (Accel Time), RDS2 (Decel Time), RDS3 (V/f Pattern) Selections

RDS1

Notch	Acceleration Time (Sec)
0	2.50
1	3.00
2	3.50
3	4.00
4	4.50
5	5.00
6	5.50
7	6.00
8	6.50
9	7.00
A	8.00
B	9.00
C	10.0
D	12.0
E	15.0
F	20.0

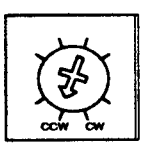
RDS2

Notch	Deceleration Time (Sec)	DC Injection Time (Sec)
0	2.5	0.20
1	3.0	0.20
2	3.5	0.20
3	4.0	0.20
4	4.5	0.20
5	5.0	0.20
6	5.5	0.25
7	6.0	0.25
8	6.5	0.30
9	7.0	0.30
A	8.0	0.40
B	9.0	0.50
C	10.0	0.50
D	12.0	0.75
E	15.0	1.00
F	20.0	1.00

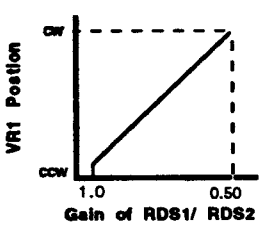
RDS3

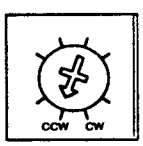
Notch	Starting Torque
0	Lowest
1	
2	Horizontal
3	
4	
5	
6	
7	
8	Hoisting
9	
A	
B	
C	
D	
E	
F	Highest

7.2.3.3 VR1 (Reverse Plug Simulation Gain), VR2 (Quick Stop Gain), VR3 (Stepless Speed Adjustment) Selections

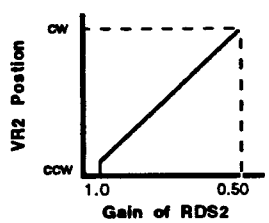


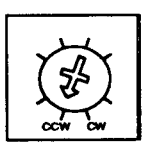
VR1
Reverse Plug
Simulation (Gain)



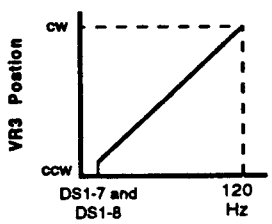


VR2
Quick Stop
(Gain)



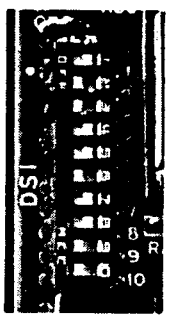


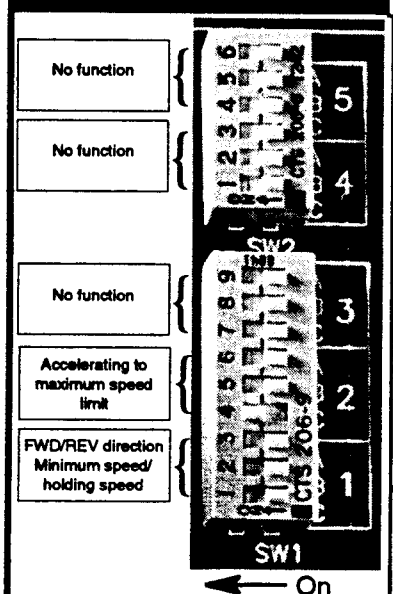
VR3
Stepless Speed
Adjustment

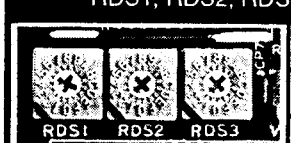


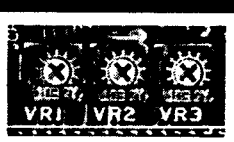
Initial Setting for VR1, VR2 and VR3 is full counterclockwise.
CW = clockwise; CCW = counterclockwise For more information please see Section 6.3.5.

7.2.4 Suggested Settings for Two-Step Infinitely Variable Speed Control

DS1	Setting	For More Information
 Default stopping method is **immediate stop**. Extreme caution should be used when changing to deceleration at stop command. A long deceleration time will cause driven equipment to require a greater stopping distance.	DS1-1 = On	Section 5.1.3
	DS1-2 = Off	
	DS1-3 = Off	Section 5.2.1/5.2.2
	DS1-4 = On	Section 6.3.4
	DS1-5 = On	
	DS1-6 = Off	
	DS1-7 = On	
	DS1-8 = On	
	DS1-9 = Off	n/a
	DS1-10 = Off	

SW1 and SW2	Output	Setting	For More Information
	n/a	SW1-3C through SW2-5A have no function in this mode	Section 6.3.4
	Up to maximum speed 60 Hz or VR3	SW1-2A = Off	
		SW1-2B = Off	
		SW1-2C = On	
	5 Hz (Set by DS1-4, DS1-5 and DS1-6)	SW1-1A = Off	
		SW1-1B = Off	
		SW1-1C = Off	

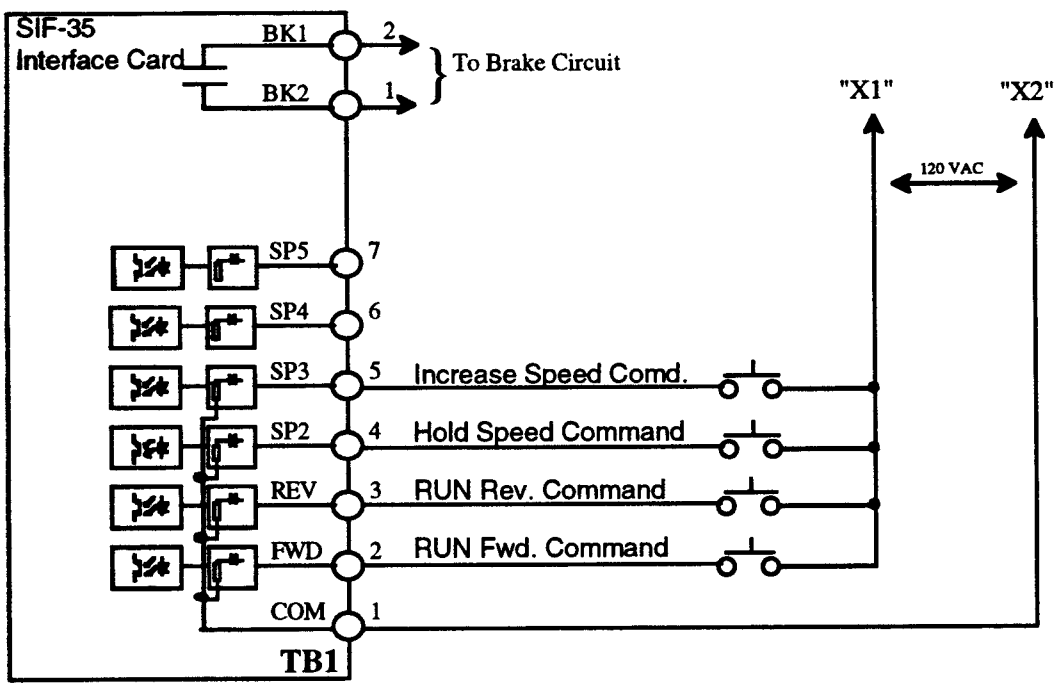
RDS1, RDS2, RDS3		Name	Setting	For More Information
	RDS1	Acceleration Time	5 (5.0 seconds)	Section 6.3.1
	RDS2	Deceleration TIme	2 (3.5 seconds)	Section 6.3.1
	RDS3	V/f Pattern	2 (Traverse) 8 (Hoisting)	Section 6.3.2

VR1, VR2, VR3		Name	Setting	For More Information
	VR1	Reverse Plug Simulation	Full counterclockwise	Section 6.3.5.1
	VR2	Quick Stop Gain	Full counterclockwise	Section 6.3.5.2
	VR3	Stepless Speed Adjustment	Full counterclockwise	Section 6.3.5.3

7.3 Three-Step Infinitely Variable Speed Control Method

Specific settings and connections are required to begin three-step speed control mode operation. The "recipe" requires both control connections to the control voltage interface card (SIF-35) and setting adjustments to both the TM2 circuit board (DS1, RDS1, RDS2, RDS3, VR1, VR2, VR3) and the control voltage interface card (SW1, SW2).

7.3.1 Control Circuit Wiring Diagram (Three-Step Infinitely Variable Speed Control Mode)



7.3.2 Required Settings for Interface SW1 Dip Switch Groups 1, 2 and 3: Three-Step Infinitely Variable Speed Control

Required SW1 Switch Group Settings - Three-Step Infinitely Variable				
Initial Settings	Switch Status			Frequency Reference by SW1 Selection Pattern
	C	B	A	
Group 1	off	off	off	Minimum speed/decelerating Runs at hertz of DS1-4, DS1-5, and DS1-6
Group 2	on	off	off	Holding speed Frequency hold command
Group 3	on	on	off	Accelerating Frequency is increasing

7.3.3 Suggested Settings to TM2 Board (Three-Step Infinitely Variable Speed Control)

7.3.3.1 DS1 Dip Switch Settings (Three-Step Infinitely Variable)

DS1	Description	Switch Settings and Output Description		
DS1-1 and DS1-2	Speed Control Mode Selection	DS1-1 = on	DS1-2 = on	**3-Step Infinitely Variable Speed Control Mode**

DS1-3	Stopping Mode Selection	DS1-3 = on	**Immediate Stop at STOP Command**
		DS1-3 = off	**Deceleration to Stop at STOP Command Time of RDS2**

DS1-4 DS1-5 and DS1-6	Frequency Output Lower Limit. (Frequency is determined by the combination of DS1-4, DS1-5 and DS1-6.)	DS1-4 = on	DS1-5 = off	DS1-6 = off	**2 Hz**
		DS1-4 = on	DS1-5 = off	DS1-6 = on	**3 Hz**
		DS1-4 = on	DS1-5 = on	DS1-6 = off	**5 Hz**
		DS1-4 = on	DS1-5 = on	DS1-6 = on	**10 Hz**
		DS1-4 = off	DS1-5 = off	DS1-6 = off	**15 Hz**
		DS1-4 = off	DS1-5 = off	DS1-6 = on	**20 Hz**
		DS1-4 = off	DS1-5 = on	DS1-6 = off	**25 Hz**
		DS1-4 = off	DS1-5 = on	DS1-6 = on	**30 Hz**

DS1-7 and DS1-8	Frequency Output Upper Limit for Infinitely Variable Mode (Frequency is determined by the higher of DS1-7 and DS1-8, or VR3)	DS1-7 = off	DS1-8 = off	**45 Hz**
		DS1-7 = off	DS1-8 = on	**50 Hz**
		DS1-7 = on	DS1-8 = off	**55 Hz**
		DS1-7 = on	DS1-8 = on	**60 Hz**

DS1-9 and DS1-10	Analog Frequency Reference Selection	DS1-9 = off	DS1-10 = off	**Freq. set by Freq. setting potentiometer or 0 ~ 10 VDC signal**
		DS1-9 = off	DS1-10 = on	**Freq. set by 1 ~ 5 VDC signal**
		DS1-9 = on	DS1-10 = off	**Freq. set by 4 ~ 20 mA signal**
		DS1-9 = on	DS1-10 = on	**Analog freq. setting is not used**

Extreme Caution:
Default stopping method is **immediate stop.** Extreme caution should be used when changing to deceleration at STOP Command. A long deceleration time will cause driven equipment to require a greater stopping distance.

7.3.3.2 RDS1 (Accel Time), RDS2 (Decel Time), RDS3 (V/f Pattern) Selections

RDS1

Notch	Acceleration Time (Sec)
0	2.50
1	3.00
2	3.50
3	4.00
4	4.50
5	5.00
6	5.50
7	6.00
8	6.50
9	7.00
A	8.00
B	9.00
C	10.0
D	12.0
E	15.0
F	20.0

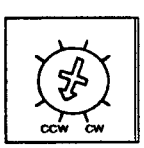
RDS2

Notch	Deceleration Time (Sec)	DC Injection Time (Sec)
0	2.5	0.20
1	3.0	0.20
2	3.5	0.20
3	4.0	0.20
4	4.5	0.20
5	5.0	0.20
6	5.5	0.25
7	6.0	0.25
8	6.5	0.30
9	7.0	0.30
A	8.0	0.40
B	9.0	0.50
C	10.0	0.50
D	12.0	0.75
E	15.0	1.00
F	20.0	1.00

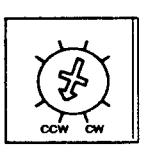
RDS3

Notch	Starting Torque
0	Lowest
1	
2	Horizontal
3	
4	
5	
6	
7	
8	Hoisting
9	
A	
B	
C	
D	
E	
F	Highest

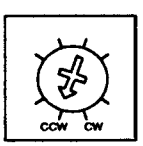
7.3.3.3 VR1 (Reverse Plug Simulation Gain), VR2 (Quick Stop Gain), VR3 (Frequency Upper Limit) Selections



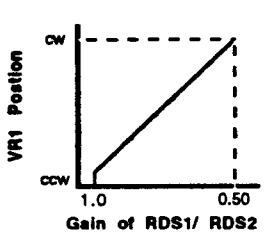
VR1
Reverse Plug
Simulation (Gain)

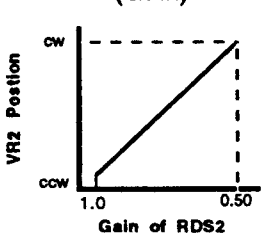


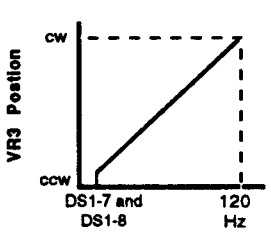
VR2
Quick Stop
(Gain)



VR3
Stepless Speed
Adjustment

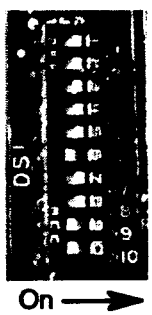


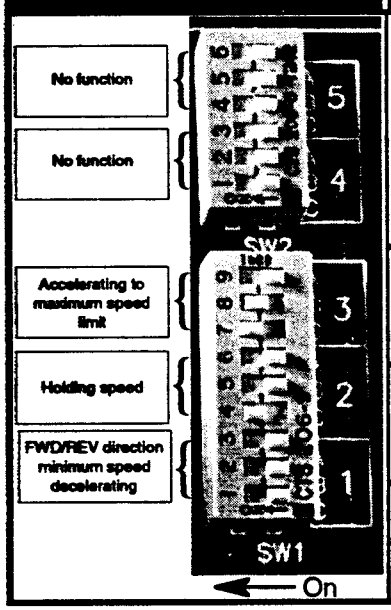


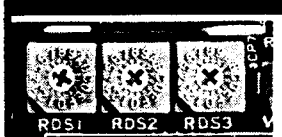


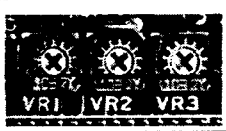
Initial Setting for VR1, VR2 and VR3 is full counterclockwise.
CW = clockwise; CCW = counterclockwise For more information please see Section 6.3.5.

7.3.4 Suggested Settings for Three-Step Infinitely Variable Speed Control Mode

DS1	Setting	For More Information
 On → Default stopping method is **immediate stop.** Extreme caution should be used when changing to deceleration at STOP command. A long deceleration time will cause driven equipment to require a greater stopping distance.	DS1-1 = On	Section 5.1.3
	DS1-2 = On	
	DS1-3 = On	Section 5.2.1/5.2.2
	DS1-4 = On	Section 6.3.4
	DS1-5 = On	
	DS1-6 = Off	
	DS1-7 = On	
	DS1-8 = On	
	DS1-9 = Off	n/a
	DS1-10 = Off	

SW1 and SW2	Output	Setting	For More Information
	n/a	SW2-5A through SW2-4C have no function in this mode	Section 6.3.4
	Accelerating to maximum speed limit 60 Hz or VR3	SW1-3A = Off	
		SW1-3B = On	
		SW1-3C = On	
	Frequency hold/increase command	SW1-2A = Off	
		SW1-2B = Off	
		SW1-2C = On	
	Minimum speed (set by DS1-4, DS1-5 and DS1-6)	SW1-1A = Off	
		SW1-1B = Off	
		SW1-1C = Off	

RDS1, RDS2, RDS3		Name	Setting	For More Information
	RDS1	Acceleration Time	5 (5.0 seconds)	Section 6.3.1
	RDS2	Deceleration Time	2 (3.5 seconds)	Section 6.3.1
	RDS3	V/f Pattern	2 (Traverse) 8 (Hoisting)	Section 6.3.2

VR1, VR2, VR3		Name	Setting	For More Information
	VR1	Reverse Plug Simulation	Full counterclockwise	Section 6.3.5.1
	VR2	Quick Stop Gain	Full counterclockwise	Section 6.3.5.2
	VR3	Stepless Speed Adjustment	Full counterclockwise	Section 6.3.5.3

Section 8: Checks Before Operation

After mounting and interconnections are completed, please check for:

- Correct connections.
- Correct input power supply. (No voltage drop or imbalance, source KVA ≤ 500.)
  Please note that 460V input to 230V series control will destroy power section of unit!
- No short circuit conditions.
- No loose screw terminals. (Check especially for loose wire clippings.)
- Proper load conditions.

Precautions:

- Only start the motor if motor shaft rotation is stopped.
- Even with small loading, never use a motor whose nameplate amperage exceeds the inverter rated current.
- When starting and stopping the motor, be sure to use the operation signals (fwd/rev), not the magnetic contactor on the power supply side.
- **Extreme Caution:**
  Braking method selection as shipped from Electromotive Systems is set for immediate stop at STOP command (DS1-3 = on). If changed to decelerate at STOP command (DS1-3 = off), then extreme caution should be used during deceleration. If deceleration time is too long, equipment can run into endstop device, causing damage to equipment or injury to personnel.

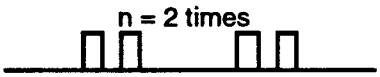
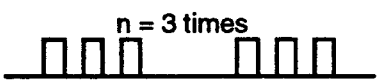
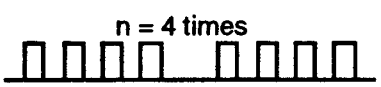
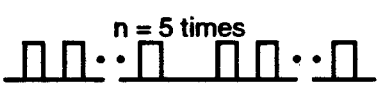
Section 9: Maintenance

IMPULSE•S requires almost no routine checks. It will function more efficiently and last longer if it is kept clean, cool and dry, observing precautions listed in Section 2.1. Check for tightness of electrical connections, discoloration or other signs of overheating. During service inspection, turn off AC main circuit power and wait at least ten minutes before touching any circuit components. The red charge lamp must be extinguished before touching any components. Failure to adhere to this warning could result in serious injury.

Section 10: Troubleshooting

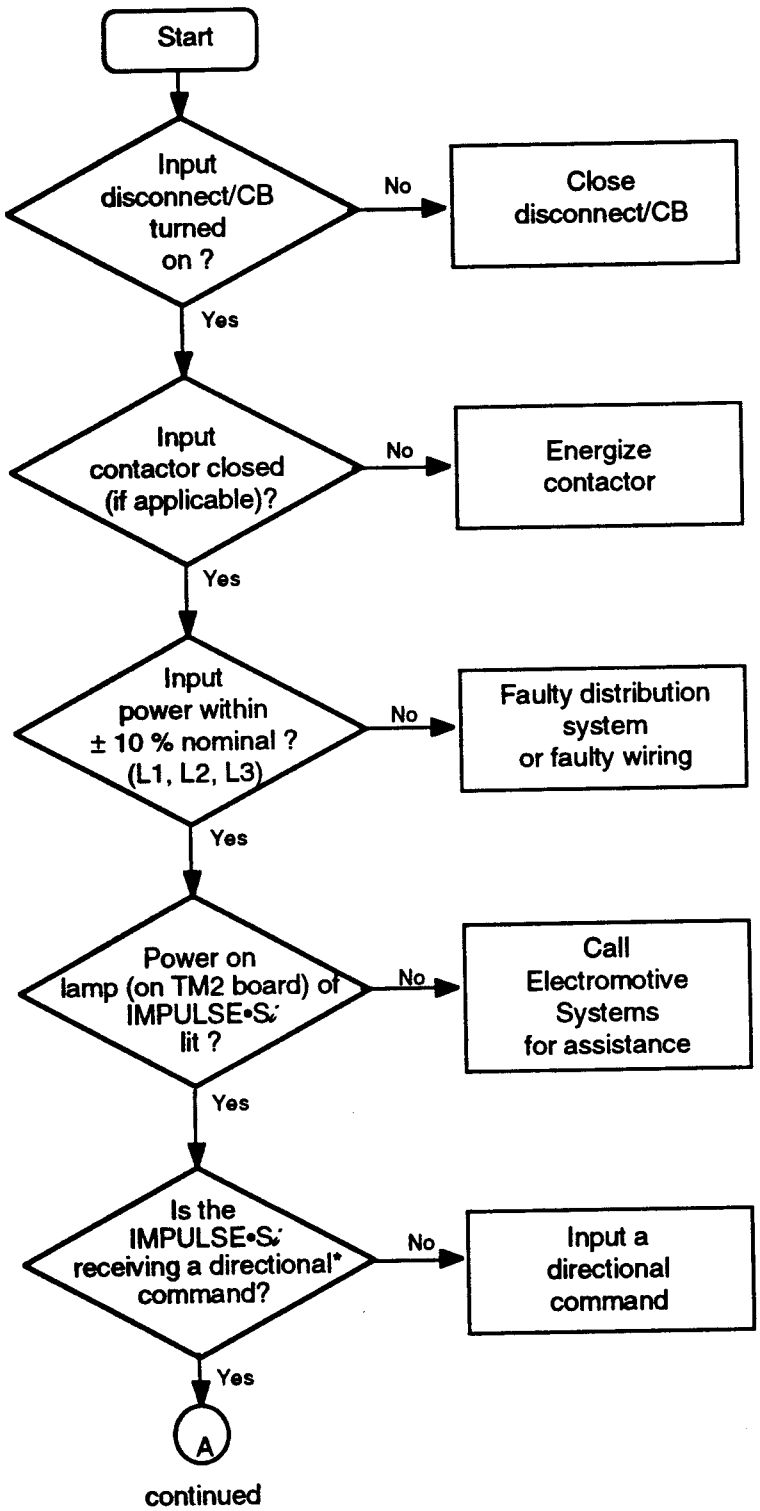
10.1 Failure Indications of IMPULSE•Si

If IMPULSE•Si malfunctions, the fault lamp (white LED, visible through plastic cover) blinks on and off. The blinking sequence tells the user the type of fault that has occurred.

Blinking Sequence	Probable Cause	What to Do
	**Instantaneous Overcurrent Protection** • Accel/decel time is set too short. • Load too heavy. • Power factor capacitor connected to IMPULSE•Si output. • Incorrect V/f pattern selection. • IMPULSE•Si output transistor is shorted or ground fault condition exists.	• Extend accel/decel time. • Run motor without load. Check load conditions. • Remove power factor capacitors. • Select the optimum V/f pattern via RDS-3. • IMPULSE•Si output transistor is shorted or motor is grounded. Call Electromotive Systems.
	**Overvoltage Protection** • Decel time too short. • Input power voltage > specification allows.	• Extend the decel time. • Correct input overvoltage problem.
	**Undervoltage Protection** • Supply voltage < specification allows. • Momentary power failure (> 15ms).	• Correct the input power supply problem. Check for single phase problem. • Inspect busbar system for collector bounce.
	**Ground Fault** • Transistor module damaged.	• Replace transistor module.
	**Microcomputer Fault** • Problem always due to high electrical noise environment.	• Install R-C type suppressors on all contactor/brake coils.

10.2 Troubleshooting Flow Chart

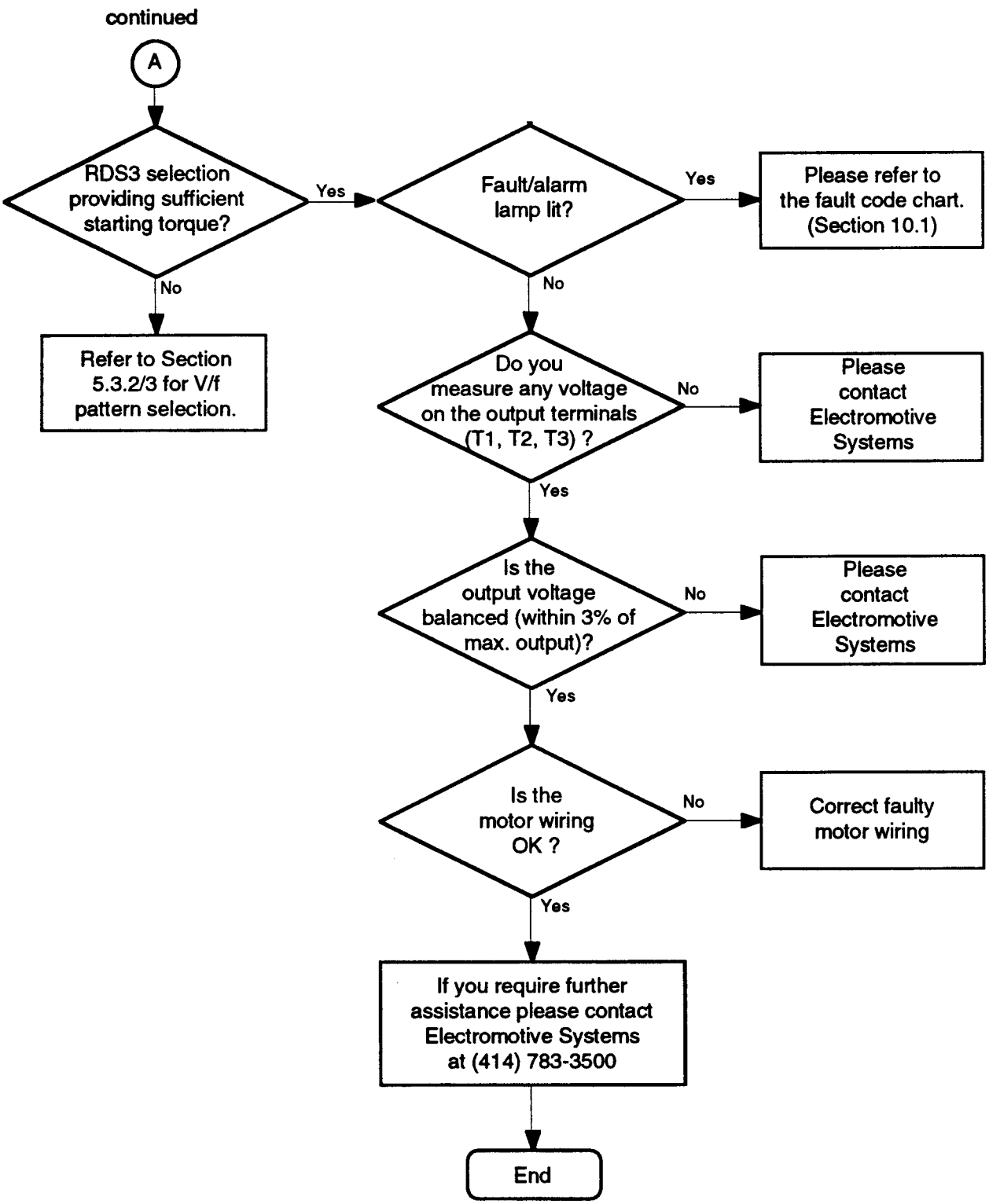
1) Motor will not run.



continued

* Confirm control voltage on proper terminals when RUN command is given

10.2 Troubleshooting Flow Chart (Continued)



10.3 Information Check List

IMPULSE•S; adjustable frequency controls and *TCONTROLS* motor control panels are designed to perform their tasks flawlessly. Should you encounter problems with Electromotive Systems control products, we invite you to call our customer service department for personal attention. Before calling, please complete the check list. The information will assist you in successful and expedient discussion with the Electromotive Systems Service Department.

Electromotive Systems, Inc. phone number: 414-783-3500
Electromotive Systems, Inc. fax number: 414-783-3510

10.3 Information Check List (Continued)

Control Information:

IMPULSE•S; Model Number: _____ TCONTROLS Serial Number: _____

Setting Values:

RDS1: _____

RDS2: _____

RDS3: _____

DS1-1 _____ **Group 1**

DS1-2 _____ SW1-1A _____

DS1-3 _____ SW1-1B _____

DS1-4 _____ SW1-1C _____

DS1-5 _____ **Group 2**

DS1-6 _____ SW1-2A _____

DS1-7 _____ SW1-2B _____

DS1-8 _____ SW1-2C _____

DS1-9 _____ **Group 3**

DS1-10 _____ SW1-3A _____

DS1-10 SW1-3B _____

SW1-3C _____

Fault alarm history: (if any)

#1 _____ (#Blinks/Pause)

#2 _____ (#Blinks/Pause)

#3 _____ (#Blinks/Pause)

VR1 _____

VR2 _____

VR3 _____

Group 4

SW2-4A _____

SW2-4B _____

SW2-4C _____

Group 5

SW2-5A _____

SW2-5B _____

SW2-5C _____

Application Information:

Hoist: _____ Manufacturer: _____

Trolley: _____

Bridge: _____

Hook Rotate: _____

Clamp Op.: _____

System Information:

Power Supply: _____ Motor(s) Data: _____

Voltage: L1-L2 _____ Hp: _____ Rated Amps: _____

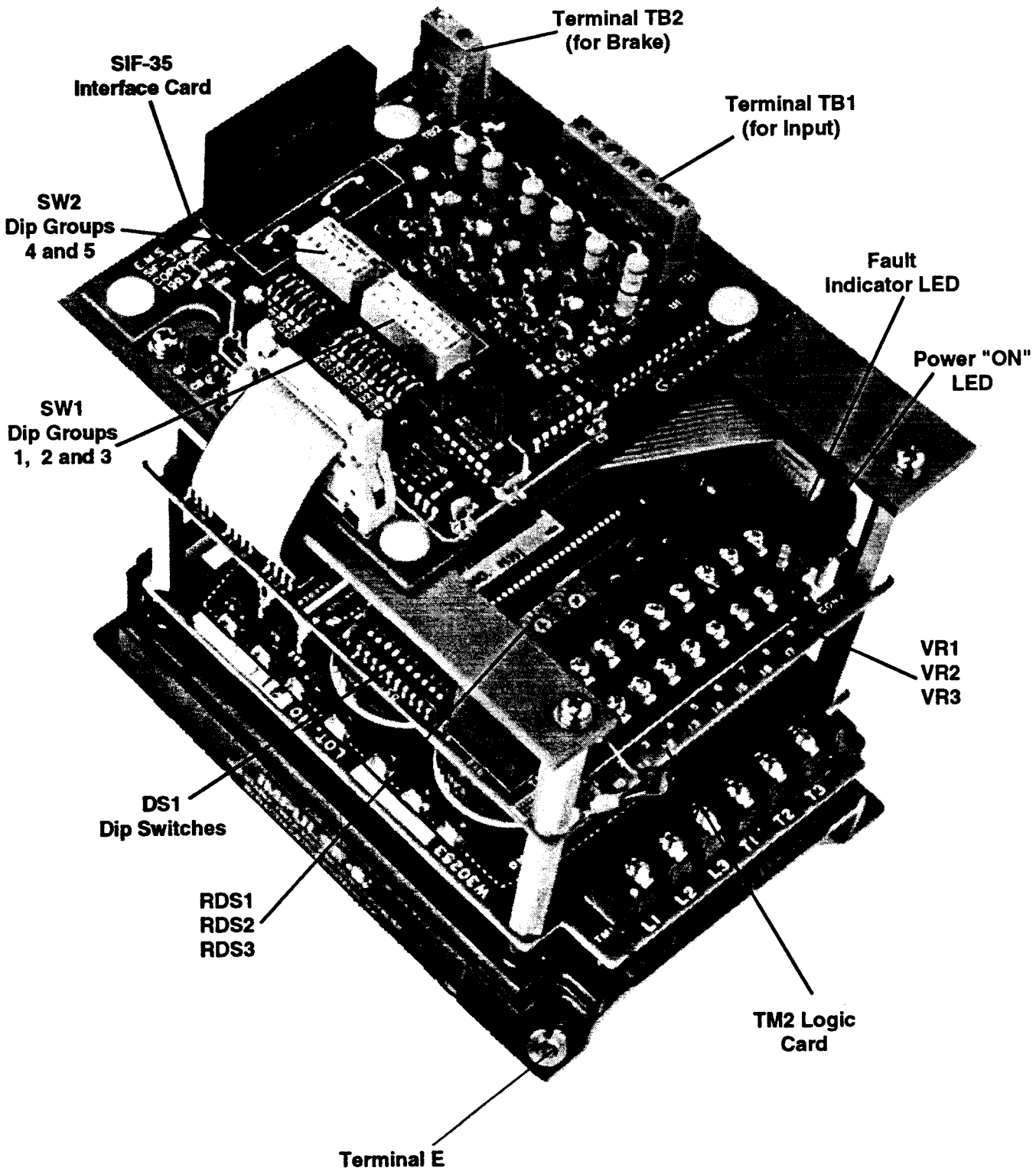
L2-L3 _____ RPM: _____ Aux. Equipment: _____

L1-L3 _____ Rated VAC: _____ 1) Brake _____

Ø: _____ (1Ø, 2Ø, 3Ø?) _____ Model Number: _____ 2) Gearbox _____

Hz: _____ Manufacturer: _____ 3) Other _____

Source KVA: _____


Terminal TB2
(for Brake)
SIF-35
Interface Card
Terminal TB1
(for Input)
SW2
Dip Groups
4 and 5
Fault
Indicator LED
Power "ON"
LED
SW1
Dip Groups
1, 2 and 3
VR1
VR2
VR3
DS1
Dip Switches
RDS1
RDS2
RDS3
TM2 Logic
Card
Terminal E

10.4 Power Section Test for IMPULSE•Si

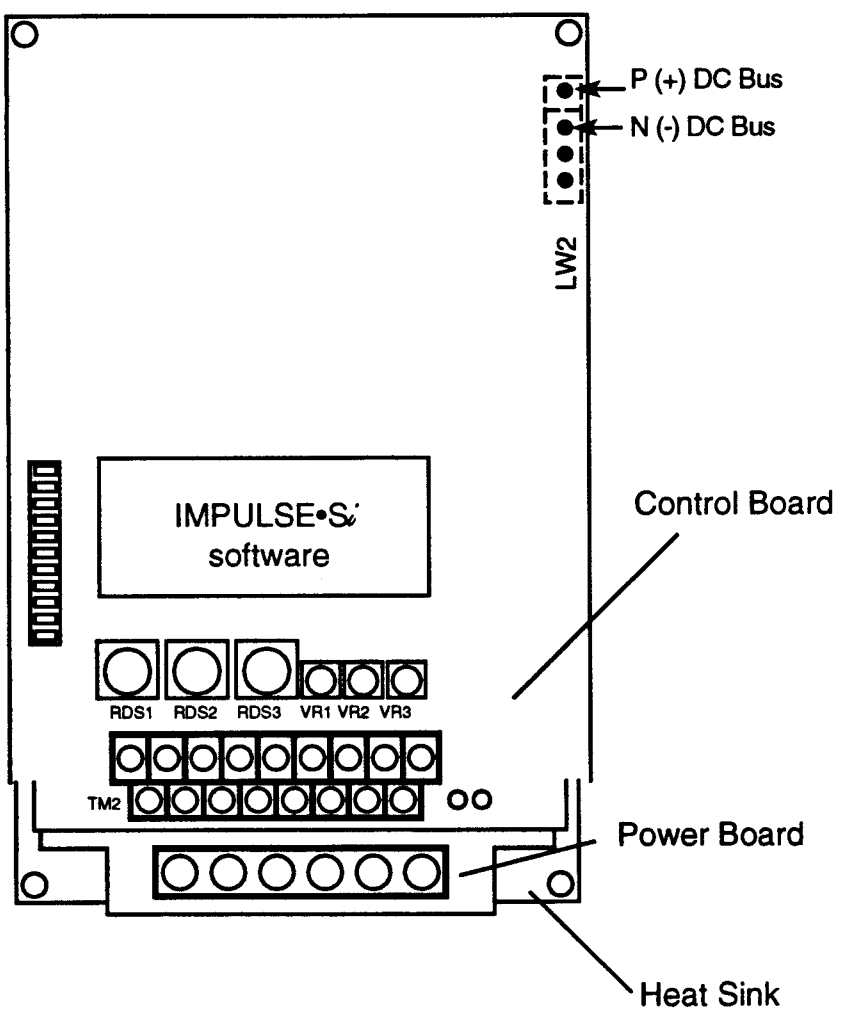
Warning: To avoid serious injury or death, the following tests should be made with power to the inverter off, the inverter disconnected and the charge lamp completely extinguished.

1) All tests should be done with an analog VOM

2) Set analog VOM on Rx1 scale and "zero" meter.

3) Locate DC bus on inverter. This can be found at location labeled LW2 (see below). LW2 is located on the top right edge of the control board. (TM2)

4) Take readings and compare with information included in sections 10.4.1 and 10.4.2.
Note:
L1, L2, L3 = inverter input terminals
T1, T2, T3 = inverter output terminals
P = positive (+) side of DC bus
N = negative (-) side of DC bus



10.4.1 Input Rectifier Check

VOM + probe	VOM - probe	Resistance	
		Normal	Abnormal
L1	P	5 - 80 Ω	0 or ∞
L2	P	5 - 80 Ω	0 or ∞
L3	P	5 - 80 Ω	0 or ∞
P	L1	∞	≠ ∞
P	L2	∞	≠ ∞
P	L3	∞	≠ ∞
L1	N	∞	≠ ∞
L2	N	∞	≠ ∞
L3	N	∞	≠ ∞
N	L1	5 - 80 Ω	0 or ∞ *
N	L2	5 - 80 Ω	0 or ∞ *
N	L3	5 - 80 Ω	0 or ∞ *

* A reading of ∞ indicates a pre-charge resistor is open.

10.4.2 Output Transistor Check

VOM + probe	VOM - probe	Resistance	
		Normal	Abnormal
T1	P	5 - 80 Ω	0 or ∞
T2	P	5 - 80 Ω	0 or ∞
T3	P	5 - 80 Ω	0 or ∞
P	T1	∞	≠ ∞
P	T2	∞	≠ ∞
P	T3	∞	≠ ∞
T1	N	∞	≠ ∞
T2	N	∞	≠ ∞
T3	N	∞	≠ ∞
N	T1	5 - 80 Ω	0 or ∞
N	T2	5 - 80 Ω	0 or ∞
N	T3	5 - 80 Ω	0 or ∞

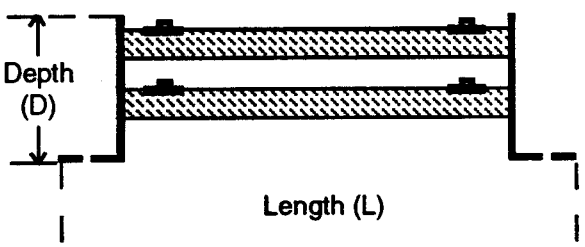
Application of the External Braking Resistor (via Con10)

This appendix is referenced in Section 2.3.

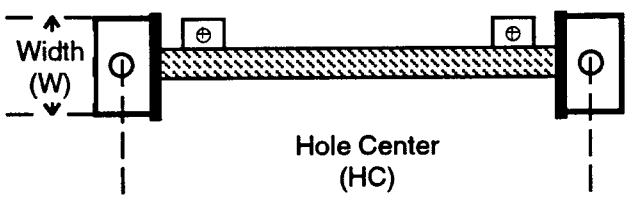
The IMPULSE•S: is shipped standard with an external dynamic braking resistor.

The part numbers, outline dimensions and mounting arrangement of the external braking resistor are given below:

Side View of Resistor Assembly



Top View of Resistor Assembly

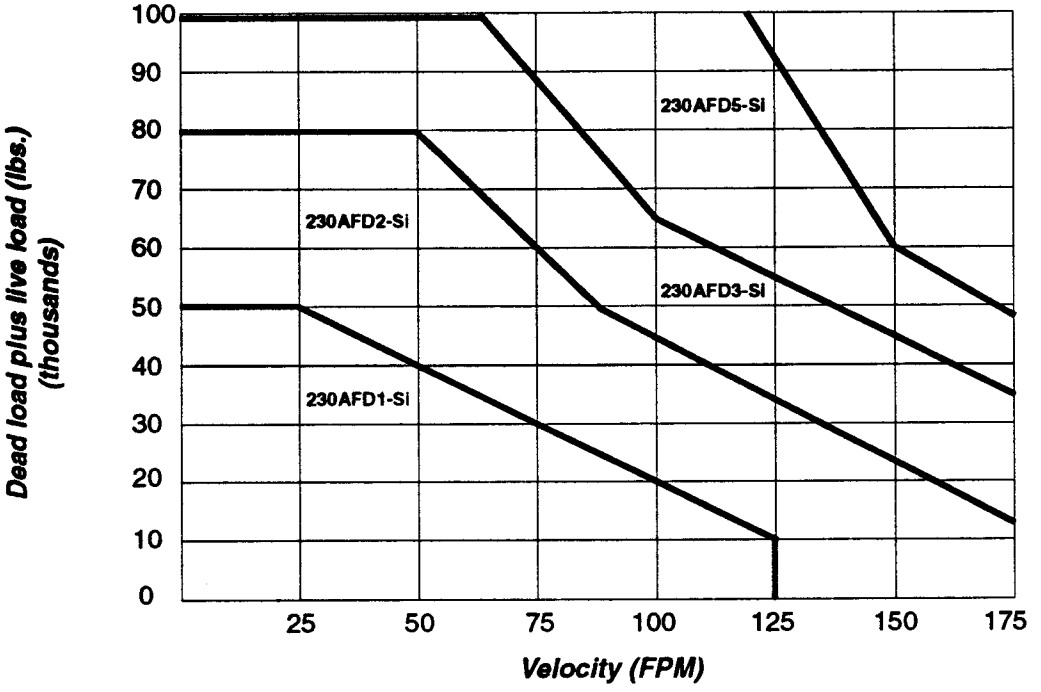


Model Number	External Resistor P/N	L	W	D	HC	Hole Diameter	Weight in lbs. (kg.)
230AFD1-Si	DB2-1	5.625 (143)	1.125 (29)	2.375 (60)	5.00 (127)	0.218 (5.5)	.35 (.16)
230AFD2-Si							
230AFD3-Si	DB2-2	8.125 (206)	1.375 (35)	3.44 (87)	7.50 (190)		.60 (.27)
230AFD5-Si	DB2-3						.64 (.29)
460AFD1-Si	DB4-1	5.625 (143)	1.125 (29)	2.375 (60)	5.0 (127)	0.218 (5.5)	.35 (.16)
460AFD2-Si	DB4-2	8.125 (206)	1.375 (35)	3.44 (87)	7.50 (190)		.65 (.30)
460AFD3-Si							
460AFD5-Si	DB4-3						
460AFD7.5-Si	DB4-5	10.375 (263)	1.875 (48)	4.375 (111)	9.50 (241)	0.278 (7)	1.65 (.75)
460AFD10-Si							

IMPULSE•Si Drive Selection

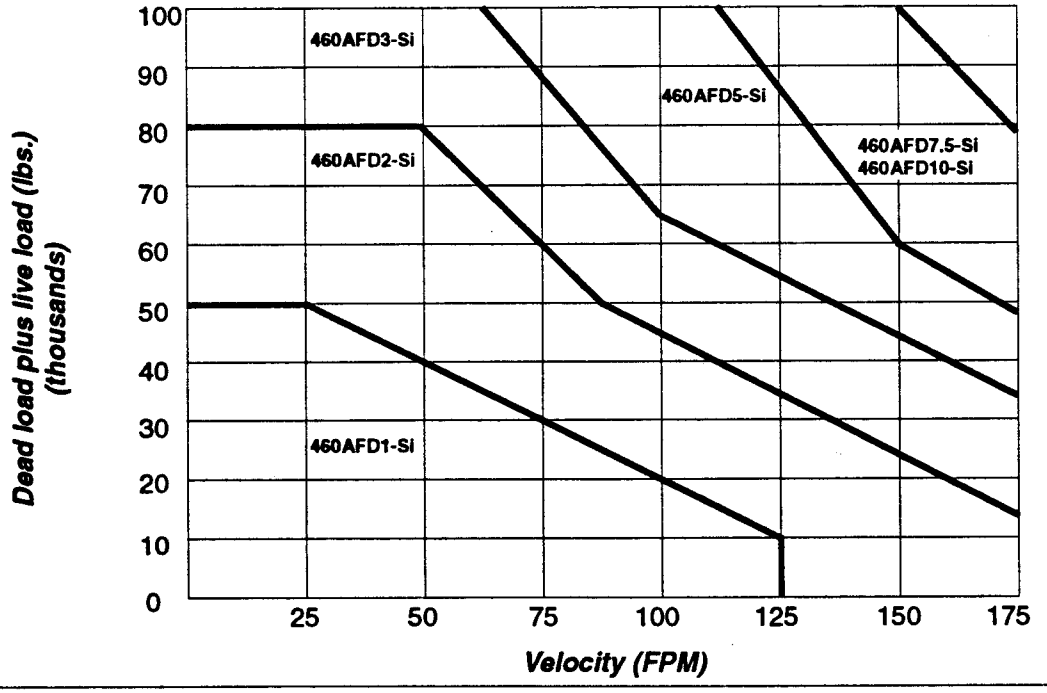
IMPULSE•Si - 230 Volt

Class C - 3.0 second decel time



IMPULSE•Si - 460 Volt

Class C - 3.0 second decel time



Velocity (FPM)	Acceleration			Deceleration		
	Time (Sec)	Rate (FPS)	Drive Notch Setting	Time (Sec)	Rate (FPS)	Drive Notch Setting
25	3.0	0.139	1	3.0	0.139	1
50	3.0	0.278	1	3.0	0.278	1
75	4.0	0.313	3	3.0	0.417	1
100	5.0	0.333	5	3.5	0.476	2
125	6.5	0.321	8	4.5	0.463	4
150	8.0	0.313	B	5.0	0.500	5
175	9.0	0.324	D	6.5	0.499	8

1) Use surge absorbers (R-C networks) on all relay and contactor coils.

2) Shielded cable shall be used for all low level D.C. speed reference signals (0-10VDC, 4-20 mA). Shield should be grounded only at the AF drive side.

3) Use a minimum of #16 AWG for control wiring, and #12 AWG (or larger) for power wiring. Size according to N.E.C. table 310-16.

4) The following is required for all dual motor bridge cranes and suggested for center driven cranes, trolleys and hoists. Upsize the wiring one size for every 25 feet of distance between AF drive and motor to account for voltage drop (which becomes significant at low frequencies).

5) Use time delay fuses for AF drive input protection. They shall be sized at approximately 150% of AF drive continuous rated amperage.

6) Control and power wiring (including dynamic braking resistor wiring) shall be kept separate on terminal block strip.

7) Keep control (directional and speed command inputs to the AF drive) and power wiring from running together in parallel paths on the panel or in conduit runs. Keep control and power festoon wiring in different cables and separated.

8) If control and power wiring do meet on a panel, cross them perpendicularly.

9) Before applying power to the AF drive, check the output circuit (T1, T2, T3) for possible short circuits or ground faults.

10) Always mount the AF drive in its proper (vertical) orientation with at least 3" of clearance on all four sides. AF drives should be housed in appropriate NEMA rated enclosures for the environment in which they will be used.

11) Keep AF drive heatsink clear of any obstructions (components on panel) to ensure proper cooling air flow.

12) If using externally mounted interface boards, or remotely mounted speed reference signals, use shielded cable from the interface output or remote speed reference to the AF drive control input terminals.

13) On external input devices (control), hard contact inputs are preferred rather than solid state inputs into the control voltage input boards (TC-GIF__, TC-SIF__, TC-SLC__).

14) If the input device is a PLC triac output, a 5K ohm, 10 watt resistor may have to be used between the signal and L2 (X2).

15) AF drives should always have the cover mounted on unit during normal operating conditions to protect the digital operator (Specific to Electromotive Systems IMPULSE•G Series, IMPULSE•VG Series and IMPULSE•P series).

16) All ground terminals or screws ("G" or "E") must be grounded back to earth ground.

17) If the power source is greater than 500 KVA, there should be at least 3% impedance in the line between the source and the input to the AF drive.

18) Incoming power supply voltage must be limited to 230 volts ± 10% or 460 volts ± 10%.

19) On existing wound rotor motor applications >25HP, a line reactor of 3% impedance shall be required on the load side of the AF drive. (Specific to Electromotive Systems IMPULSE•G Series, IMPULSE•VG Series, and IMPULSE•P series).

20) When using more than one transformer for control power, properly phase each transformer with respect to other(s).

21) All line and ground wiring should be disconnected when any welding is being done on or to the crane.

22) When using the Impulse•S Series AF drive on existing wound rotor motor applications oversizing the drive or installing a load reactor is suggested to avoid over-current conditions upon starting a motor.

23) When supplying single phase input to the AF drive, the amperage of the drive must be derated by approximately one-half. (Consult Electromotive Systems.)

24) All worm gear box hoist applications require dynamic braking resistors to avoid overvoltage conditions when lowering the hook.

25) Sliding collector bars are not to be used between the drive and the motor. It must be hard wired (i.e. festoon cable).

** If there are any questions, or a further explanation of the above recommendations is needed, please contact Electromotive Systems at 414/783-3500 before proceeding.

** The above recommendations, if followed, will help to ensure trouble-free start-up and successful operation of the adjustable frequency drive when applied to overhead material handling equipment.

Prices: Subject to Change Without Notice
Terms: Net 30 Days

F.O.B. Electromotive Systems, Inc.
Milwaukee, Wisconsin

Electromotive Systems, Inc., hereafter referred to as Company, guarantees all items manufactured by it against any defects of material and/or workmanship for a period of two years from the date of shipment. Company makes NO OTHER WARRANTY, EXPRESSED OR IMPLIED, AS TO THE MERCHANTABILITY OR FITNESS OF THE ITEMS FOR THEIR INTENDED USE OR AS TO THEIR PERFORMANCE. Any statement, description or specification in Company's literature is for the sole purpose of identification of items sold by the Company and imparts no guarantee, warranty or undertaking by company of any kind. Components and accessories not manufactured by Electromotive Systems are not included in this warranty and are warranted separately by their respective manufacturers

Company's sole liability shall be to repair at its factory, or replace any item returned to it within two years from date of shipment, which Company finds to contain defective material or workmanship. All items to be repaired or replaced shall be shipped to Company (Note: return authorization by Company is required) within said two year period, freight prepaid, as a condition to repair or replace defective material or workmanship. Company's herein assumed responsibility does not cover defects resulting from improper installation, maintenance, or improper use. Any corrective maintenance performed by anyone other than the Company during the warranty period shall void the warranty. Company shall not be liable for damages of any kind from any cause whatsoever beyond the price of the defective Company supplied items involved. Company shall not be liable for economic loss, property damage, or other consequential damages or physical injury sustained by the purchaser or by any third party as a result of the use of any Company supplied items or material.

Company neither assumes nor authorizes any other person to assume for Company any other liability in connection with the sale or use of items sold by Company.

List prices or discounts are subject to change without notice. Quoted prices will be honored for a period of 30 days from the date of the written quotation unless otherwise stated.

Orders of $25,000 or more, and orders for special control panels are subject to special terms and conditions of sale. Refer to those specific sections within this document.

Orders are not subject to alteration or cancellation except upon written consent of Company and payment of proper cancellation charges, when deemed applicable by Company.

Materials or items may not be returned for credit, without the prior written consent of the Company. Any authorized return of materials or items shall be subject to a restocking charge equal to 20% of the net invoiced amount therefor after Company determines that the material or item is in good condition and may be resold without alteration or service.

Terms of payment are NET 30 days. All materials and items are sold F.O.B. Company's shipping point. Company retains a security interest in all items sold by it so long as they remain in Company's possession to secure all obligations of purchaser to Company. A processing fee will be applied to all invoices for requested prepaid freight charges other than UPS. A service charge will be incurred on past due accounts extending beyond the terms of sale described above, at a rate of 1 1/2% per month of the net balance extending beyond 30 days.

Any claim for material or item shortages must be received by Company within 30 days of shipment and must be accompanied by copies of the bill of lading and packing slip.

Special Terms and Conditions: Orders of $25,000 or More

Electrification and Control Orders
Drawings and Drawing Approvals (if applicable)
In most cases, Electromotive Systems will submit drawings for customer approval within 30 days after receipt of purchase order.

Customer drawing approval and Electromotive Systems credit approval is required before Electromotive Systems will proceed with parts procurement or assembly work.

Progress payments
25% of total order is required prior to shipment.

75% balance to be paid Net 30 days upon shipment of order.

Customer Requested Changes
Customer shall pay for any additional charges that may be incurred due to customer change orders as incurred.

Cancellation Policy
Cancellation fee of 10% of order, plus all charges that may to incurred to-date of cancellation, will be applicable to all orders cancelled after receipt of order.

Credit Approval
All orders are subject credit approval by Electromotive Systems Inc.

All items manufactured and offered for sale by Electromotive Systems, Inc. are subject to limited warranty and terms of sale. These special terms and conditions are part of the limited warranty and terms, and only supersede to take exception to said warranty and terms section of this document for a complete description.

Special Terms and Conditions: Orders for Special Control Panels

Drawing and Drawing Approvals
In most cases, Electromotive Systems will submit drawings for customer approval within 30 days after receipt of purchase order.

Customer drawing approval and Electromotive Systems credit approval is required before Electromotive Systems will proceed with parts procurement or assembly work.

Special Terms and Conditions: Orders for Special Control Panels (Continued)

Progress Payments
25% of total net order is required upon drawing approval.

25% of total net order is required prior to shipment.

50% balance to be paid Net 30 days upon shipment of order.

Customer Requested Changes
Customer shall pay for any additional charges that may be incurred due to customer change orders as incurred.

Cancellation Policy
Cancellation fee of 10% of order, plus all charges that may be incurred to-date of cancellation, will be applicable to all orders cancelled after receipt of purchase order.

Credit Approval
All orders are subject to credit approval by Electromotive Systems, Inc.

All items manufactured and offered for sale by Electromotive Systems, Inc. are subject to limited warranty and terms of sale. These special terms and conditions are part of the limited warranty and terms, and only supersede to take exception to said warranty and terms as specifically outlined. Refer to limited warranty and terms section of this document for a complete description.