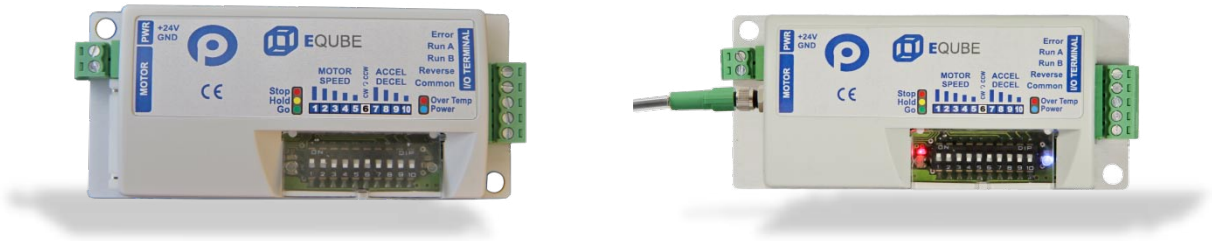
PULSEROLLER

EQUBE

Reference Manual

Version 1.6

June 2015



Reference for Part Numbers:

EQube-P
EQube-N
EQube-AI-P
EQube-AI-N

Publication EQ-1000

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GLOSSARY OF TERMS

Brushless DC Motor	A D.C. motor with a permanent magnet rotor and coils in the stator. The stator coil currents are sequenced by an external brushless D.C. motor controller. In such motors, current and torque, voltage and rpm are linearly related. The main advantage to this type of motor is the elimination of EMI caused by the arcing brushes and improved motor life.
Hall Effect Sensor	Special sensor embedded within the brushless DC motor of an **MDR** used to provide motor rotor position feedback to the motor controller
JST	This is the name of a particular connector manufacturer that produces a specific plug/socket arrangement for **MDR** connection to control cards. This name is accepted within the conveyor and **MDR** industry as a simple description of the particular socket style used on standard ***EQube*** hardware.
LED	**L**ight **E**mitting **D**iode – In the context of this document, **LED's** are used on ***EQube* controllers** to provide visual indication of module status
M8	Refers to standard metric style industrial connectors that utilize mating pin/socket pairs arranged in a circular pattern. *EQube-Ai* utilizes 8mm M style receptacle (M8) for the motor roller port to accommodate Senergy-Ai motor roller.
MDR	**M**otorized **D**rive **R**oller or **M**otor **D**riven **R**oller - Brushless DC motor and gearbox assembly integrated into a single conveyor roller.
NPN / PNP	Electronics term that indicates the type of transistor circuit used for a logical input or output for controllers. **NPN** devices will provide a common or ground connection when activated and a **PNP** device will provide a logic voltage connection when activated.
PLC	**P**rogrammable **L**ogic **C**ontroller – A wide variety of industrial computing devices that control automatic equipment
PWM	**P**ulse **W**idth **M**odulation – a control scheme that utilizes high speed switching transistors to efficiently deliver power in a controlled fashion from ***EQube*** controllers to **MDR**.
Senergy ECO & Senergy-Ai	***EQube*** controllers control only **Senergy** brand MDRs and only provide **ECO** mode performance. **Senergy AI** MDR is a specific version of the Senergy MDR mechanics where the **Hall Effect sensors** are encoded on a single conductor so that the **Senergy AI** MDR only utilizes 4 wires. These 4 wires are accessed with a standard **M8** style connector. ***EQube*** modules compatible with **Senergy AI** utilize the mating **M8** style receptacle.

SYMBOL CONVENTIONS

This symbol indicates that special attention should be paid in order to ensure correct use as well as to avoid danger, incorrect application of product, or potential for unexpected results

This symbol indicates important directions, notes, or other useful information for the proper use of the products and software described herein.

IMPORTANT USER INFORMATION

The device must be used exactly as recommended by the manufacturer. Failure to do so, may interfere with the safety mechanisms incorporated in the device.

To ensure proper device operation, the other system components must be designed to operate in the same environmental conditions as EQube. In addition, all other components must meet EMC requirements. The manufacturer will not be responsible and the warranty is voided if the device is used outside the stated operating conditions, or if inappropriate devices are used with this device.

Because of the variety of uses for the products described in this publication, those responsible for the application and use of this control equipment must satisfy themselves that all necessary steps have been taken to assure that each application and use meets all performance and safety requirements, including any applicable laws, regulations, codes, and standards

The illustrations, charts, sample programs and layout examples shown in this guide are intended solely for purposes of example. Since there are many variables and requirements associated with any particular installation, Insight Automation Inc. does not assume responsibility or liability (to include intellectual property liability) for actual use based on the examples shown in this publication

SUMMARY OF CHANGES

The following table summarizes the changes and updates made to this document since the last revision

Revision	Date	Change / Update
1.0	May 2014	Initial Release
1.1	October 2014	Updated instructions on using REVERSE signal on pages 17 & 20
1.2	January 2015	Updated Electrical Specifications, installation instructions, and power supply requirements
1.4	May 2015	Updated Figure 8 to show 0VDC connections
1.5	May 2015	Updated Figures 8, 9, 12, and 13 to show proper COMMON connections
1.6	June 2015	Updated Motor Roller Speed section to include gear ratios table

GLOBAL CONTACT INFORMATION

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TABLE OF CONTENTS

EQUBE MODULE FEATURES

- ✓ Over-voltage protection with transient voltage suppressor
- ✓ Internal SMD fast 8 Amp fuse
- ✓ Protection from over-voltage produced by over-speeding of MDR
- ✓ Thermal and Over-Current Protection for module and MDR
- ✓ Reverse polarity protection against incorrect wiring of the power terminals
- ✓ Sensing and indication of over voltage from power supply and/or MDR (32 Volts)
- ✓ Sensing and indication of under voltage from power supply (18 Volts)
- ✓ PID speed regulation mode with 32 fixed speed settings
- ✓ Adjustable acceleration and deceleration with 16 fixed settings
- ✓ Dynamic brake control mode
- ✓ Automatic error recovery
- ✓ Five status LEDs
- ✓ Removable power and control signal terminal blocks
- ✓ Motor reversing capability while motor is running.
- ✓ Error Output signal and LED indication for module and MDR diagnosis
- ✓ Build-in communication (UART) with PC for diagnostic and easy configuration
- ✓ Thermal and Over-Current Protection for Error Output – (PNP version only)
- ✓ Selectable default rotation direction
- ✓ Hinged clear protective cover for DIP Switch and LEDs
- ✓ Options for PNP or NPN control signal wiring accommodation
- ✓ Options for Senergy and Senergy-Ai motor rollers

EQUBE PART NUMBERS

Part Number	*Description*
EQUBE-P	PNP version with standard JST connector, sinking input (+24V signal to energize) and sourcing ERROR output (+24V signal output)
EQUBE-N	NPN version with standard JST connector, sourcing inputs (0V signal to energize inputs) and sinking ERROR output (0V signal output)
EQUBE-AI-P	PNP version with standard 4-Pin M8 connector, sinking input (+24V signal to energize) and sourcing ERROR output (+24V signal output)
EQUBE-AI-N	NPN version with standard 4-Pin M8 connector, sourcing inputs (0V signal to energize inputs) and sinking ERROR output (0V signal output)

EQUBE-P AND EQUBE-N (SENERGY WITH JST CONNECTOR)

Figure 1 shows an example *EQube* module for part numbers EQUBE-P and EQUBE-N both of which accommodates the standard Senergy motor roller with 9-pin JST style connector. Figure 2 shows a Senergy motor roller with JST connector.

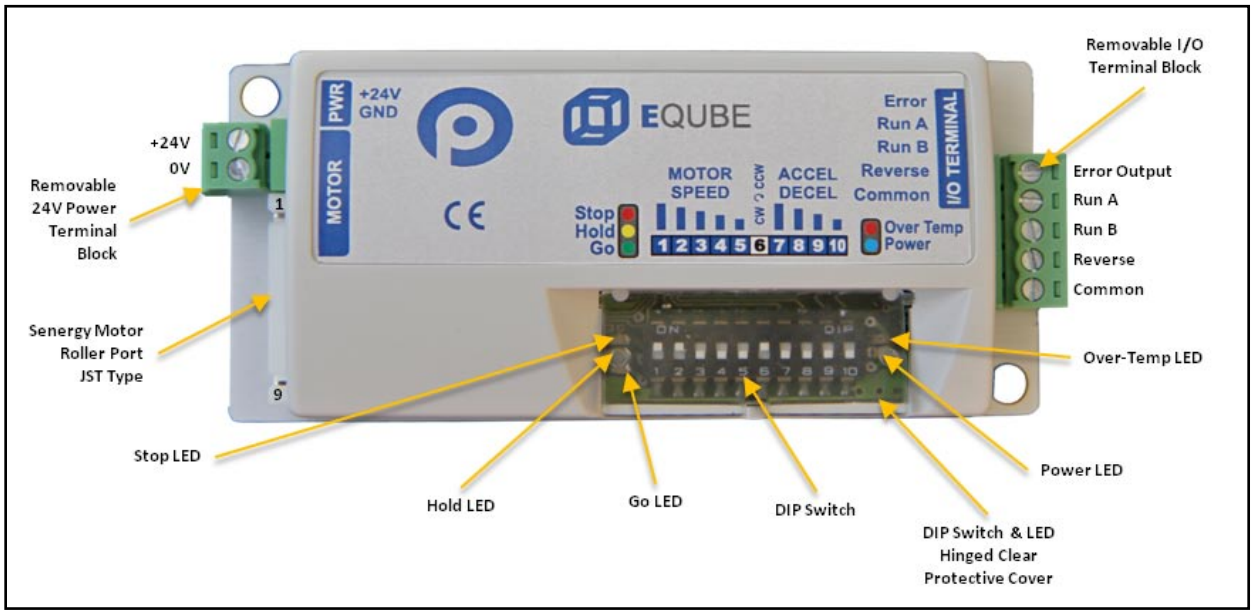


FIGURE 1 EQUBE-P OR EQUBE-N MODULE LAYOUT

FIGURE 2 - SENERGY MOTOR ROLLER WITH JST CONNECTOR

EQUBE-AI-P AND EQUBE-AI-N

For the *EQube-Ai* versions, all functionality, power/control connections, DIP Switch, and LED's are the same as *EQube*. The only difference is that the *EQube-Ai* versions accommodate a Senergy-Ai type motor roller with 4-Pin M8 style connector. Figure 3 identifies the M8 connector location. Figure 4 shows a Senergy-Ai motor roller with 4-pin M8 style connector.

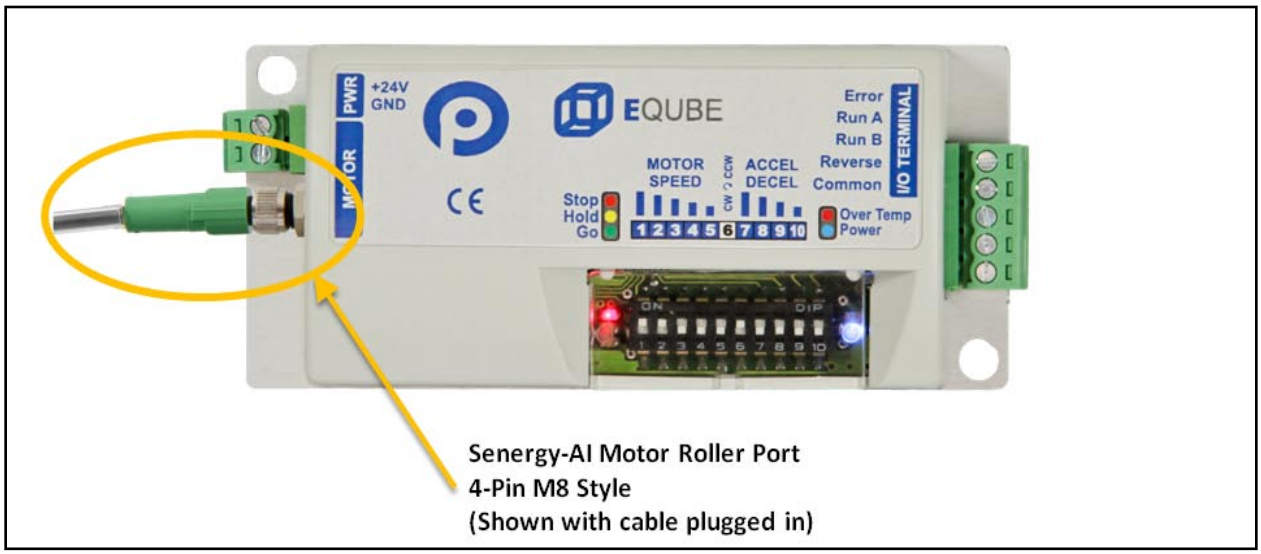


FIGURE 3 - EQUBE-AI VERSION

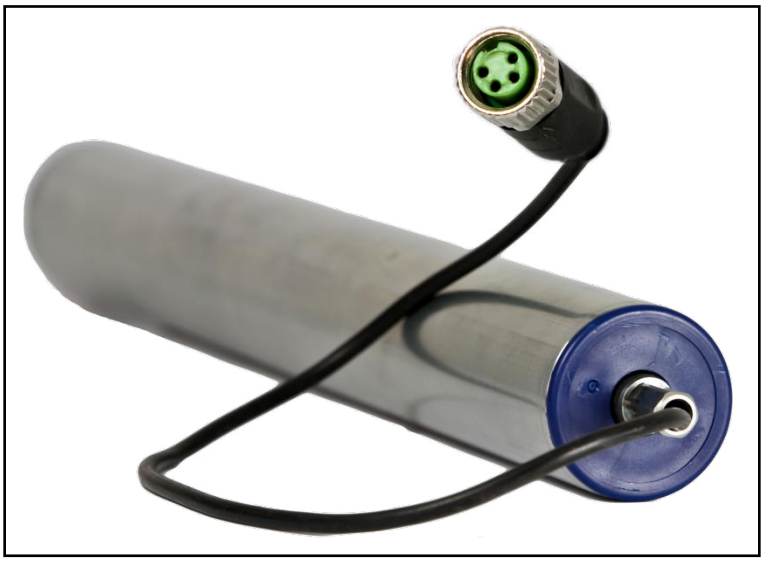


FIGURE 4 - SENERGY-AI MOTOR ROLLER WITH 4-PIN M8 CONNECTOR

TERMINAL CONNECTIONS

REMOVABLE POWER TERMINAL

This is a removable 2 pin plug with screw terminal connections. Wire size range is 28AWG to 16 AWG (0.4 mm^2 to 1.5 mm^2). Refer to Figure 1 for +24V and 0V terminal designation.

REMOVABLE I/O TERMINAL BLOCK

This is a removable 5 pin plug with screw terminal connections. Wire size range is 28AWG to 16 AWG (0.4 mm^2 to 1.5 mm^2). The following chart lists each signal and its usage. Refer to Figure 1 for Removable I/O Terminal Block designations.

EQUBE-P AND EQUBE-AI-P

Signal Name	*Description*
ERROR Output	Provides +24V output when Error condition is active
Run A	Accepts +24V input for run at speed control (see section *Run A and Run B Inputs*)
Run B	Accepts +24V input for run at speed control (see section *Run A and Run B Inputs*)
Reverse	Accepts +24V input to run motor in opposite direction that is set on DIP Switch 6
Common	Provides 0V module power common connection

EQUBE-N AND EQUBE-AI-N

Signal Name	*Description*
ERROR Output	Provides 0V output when Error condition is active
Run A	Accepts 0V input for run at speed control (see section *Run A and Run B Inputs*)
Run B	Accepts 0V input for run at speed control (see section *Run A and Run B Inputs*)
Reverse	Accepts 0V input to run motor in opposite direction that is set on DIP Switch 6
Common	Provides 0V module power common connection

RUN A AND RUN B INPUTS

The combination of signals on the Run A and Run B terminals allows you to dynamically set the speed with your run signals to the *EQube* module. The following chart lists the signal states and their respective speed control:

Run A	*Run-B*	*Description*
ON	OFF	Start motor roller and run at 100% of speed selected on DIP Switches 1 thru 5
OFF	ON	Start motor roller and run at 50% of speed selected on DIP Switches 1 thru 5
ON	ON	Start motor roller and run 75% of speed selected on DIP Switches 1 thru 5
OFF	OFF	Stop motor roller

Proper Motor Roller & Module Grounding

MDR drive-end shaft and/or fixing bracket must be bonded or otherwise electrically connected to grounded conveyor frame.

Improper grounding of MDR and/or Power Supply Common will result in pre-mature MDR and/or *EQUBE* module failure. Proper grounding techniques MUST be observed for all applications.

Inspection and Cleaning

When inspecting the device, the operator or maintenance personnel should visually inspect all mechanical parts and connections. The inspection should be performed on a monthly basis unless the device is not functioning as expected.

In case of damage or if specific maintenance is required, it should be handled only by the manufacturer or buy a technician authorized by the manufacturer to perform such maintenance.

For cleaning, use dry or slightly damp piece of cloth to wipe off the exterior of the module. Do not use solvents or abrasives.

Do not allow any liquids to penetrate inside the module cover. Any liquids inside the cover will result in damage.

Power Supply Requirements

The power supply for any and all EQube modules must meet the following requirements:

- Supplying 24 Volts DC and a minimum of 4 Amperes per module
- Certified as NEC Class II device
- Capable of detecting and properly handling short circuit and overload of its DC power output

DIP Switch Settings

Figure 5 shows ON / OFF positions for DIP switches. The following table defines each of the 10 separate switches for the DIP SW:

Switch	Function	OFF	ON
1	Speed Selection	Refer to section *DIP Switch Positions 1 thru 5 – Motor Roller* Speed on page 16	
2			
3			
4			
5			
6	Rotation Direction	CW	CCW
7	Accel / Decel Selection	Refer to section DIP Switch positions 7 thru 10 – Motor Roller Acceleration/Deceleration on page 17	
8			
9			
10			

The DIP Switch and LED area on the *EQube* module utilizes a hinged clear plastic protective cover. Simply lift the cover from the bottom edge of the module to open the cover to gain access to the DIP Switch. Be sure to snap the cover back closed when done making and changes to the DIP Switch settings.

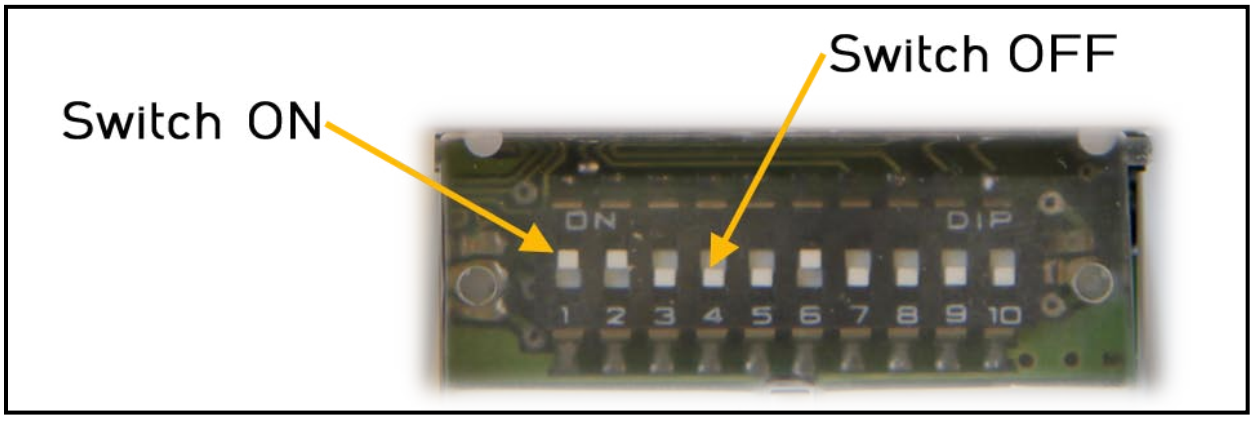


FIGURE 5 - DIP SWITCH ON-OFF EXAMPLE

DIP Switch Positions 1 thru 5 – Motor Roller Speed

SW 1	SW 2	SW 3	SW 4	SW 5	Frequency	Motor RPM
OFF	OFF	OFF	OFF	OFF	49	580
OFF	OFF	OFF	OFF	ON	67	800
OFF	OFF	OFF	ON	OFF	84	1000
OFF	OFF	OFF	ON	ON	100	1200
OFF	OFF	ON	OFF	OFF	117	1400
OFF	OFF	ON	OFF	ON	134	1600
OFF	OFF	ON	ON	OFF	150	1800
OFF	OFF	ON	ON	ON	167	2000
OFF	ON	OFF	OFF	OFF	184	2200
OFF	ON	OFF	OFF	ON	200	2400
OFF	ON	OFF	ON	OFF	217	2600
OFF	ON	OFF	ON	ON	234	2800
OFF	ON	ON	OFF	OFF	250	3000
OFF	ON	ON	OFF	ON	267	3200
OFF	ON	ON	ON	OFF	284	3400
OFF	ON	ON	ON	ON	300	3600
ON	OFF	OFF	OFF	OFF	317	3800
ON	OFF	OFF	OFF	ON	334	4000
ON	OFF	OFF	ON	OFF	350	4200
ON	OFF	OFF	ON	ON	367	4400
ON	OFF	ON	OFF	OFF	384	4600
ON	OFF	ON	OFF	ON	400	4800
ON	OFF	ON	ON	OFF	409	4900
ON	OFF	ON	ON	ON	417	5000
ON	ON	OFF	OFF	OFF	425	5100
ON	ON	OFF	OFF	ON	434	5200
ON	ON	OFF	ON	OFF	442	5300
ON	ON	OFF	ON	ON	450	5400
ON	ON	ON	OFF	OFF	459	5500
ON	ON	ON	OFF	ON	467	5600
ON	ON	ON	ON	OFF	475	5700
ON	ON	ON	ON	ON	484	5800

To determine the speed of the roller, you must know the diameter of your roller tube and the gear reduction ratio of the motor roller in order to calculate the speed based upon the Motor RPM you have selected with DIP Switch Positions 1 thru 5.

The following charts list the Senergy roller speed codes and their corresponding gear ratios

Speed Code	Gear Reduction Ratio
10M	66.978 : 1
15M	45 : 1
20M	32.94 : 1
25M	27 : 1
35M	18.3 : 1
45M	15 : 1

Speed Code	Gear Reduction Ratio
60M	10.98 : 1
75M	9 : 1
95M	6.818 : 1
125M	5 : 1
175M	3.66 : 1
215M	3 : 1

The formula for calculating the roller tube speed in meters per second is:

$$\text{Speed (in meters/mecond)} = \left[\frac{\boldsymbol{Motor\ RPM}}{\boldsymbol{Gear\ Reduction}}\right] \times \boldsymbol{\pi} \times \left[\frac{\boldsymbol{Tube\ Diameter\ (in\ meters)}}{\boldsymbol{60}}\right]$$

For example, for a 75M speed code roller with a 50 mm tube diameter running at 5000 RPM the calculation is:

$$\frac{5000}{9} \times \pi \times \frac{0.05}{60} = 1.45\ Meters/sec$$

DIP Switch positions 7 thru 10 – Motor Roller Acceleration/Deceleration

SW 7	SW 8	SW 9	SW 10	Accel / Decel Time (sec)
OFF	OFF	OFF	OFF	0.050
OFF	OFF	OFF	ON	0.100
OFF	OFF	ON	OFF	0.200
OFF	OFF	ON	ON	0.300
OFF	ON	OFF	OFF	0.400
OFF	ON	OFF	ON	0.500
OFF	ON	ON	OFF	0.600
OFF	ON	ON	ON	0.700
ON	OFF	OFF	OFF	0.800
ON	OFF	OFF	ON	1.000
ON	OFF	ON	OFF	1.200
ON	OFF	ON	ON	1.400
ON	ON	OFF	OFF	1.600
ON	ON	OFF	ON	1.800
ON	ON	ON	OFF	2.000
ON	ON	ON	ON	2.500

Please note that the time values shown are the same for both acceleration and deceleration

TYPICAL WIRING DIAGRAMS

EQUBE-P AND EQUBE-AI-P

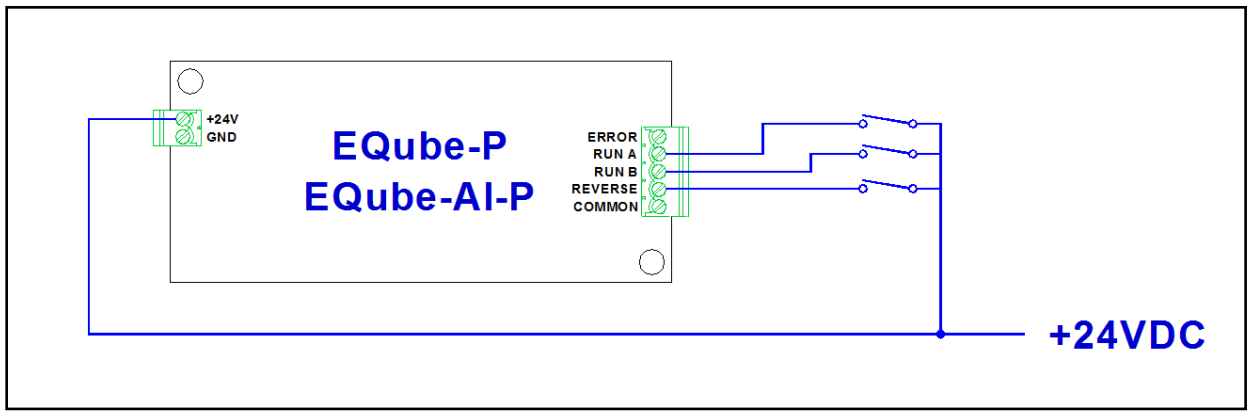


FIGURE 6 - SINGLE PNP MODULE RUN/REVERSE WIRING

To use the *REVERSE* input, either *RUN* A or *RUN* B must also be energized. Please note that you DO NOT have to de-energize both *RUN A* and *RUN B signals* in order to change MDR direction with the *REVERSE* input.

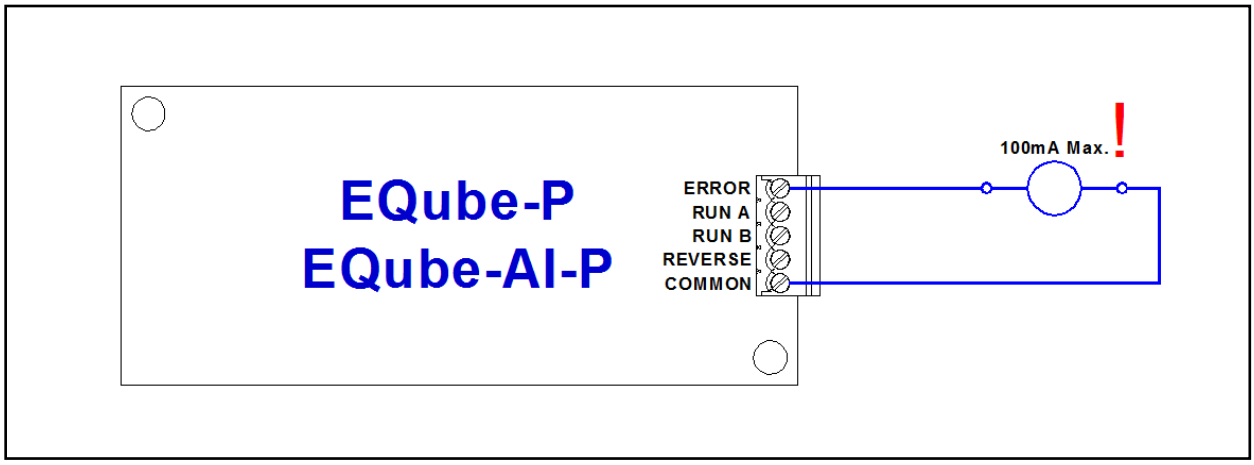


FIGURE 7 - SINGLE PNP MODULE ERROR OUTPUT WIRING

Please note that the *ERROR* output current for either PNP EQube models is limited to 100 mA. If the device connected to the *ERROR* output requires a higher current, then you must utilize an interface relay into the circuit.

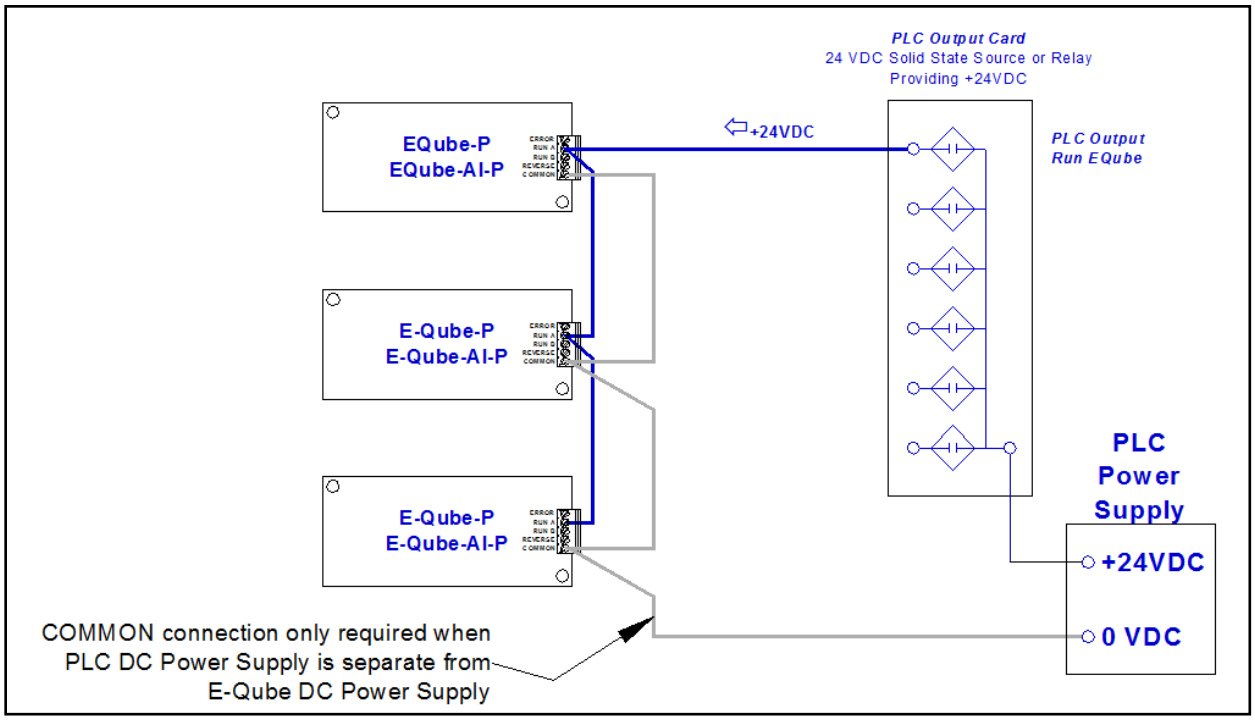


FIGURE 8 - MULTIPLE PNP MODULES GETTING RUN SIGNAL FROM SINGLE PLC OUTPUT

Figure 8 shows a single PLC output connected to multiple modules for the *RUN* A signal only for clarity. PLC outputs can also be connected to *RUN* B and *REVERSE* inputs as well. Please note that COMMON terminal is ONLY connected if the PLC's DC power supply is separate from the E-Qube's DC power supply.

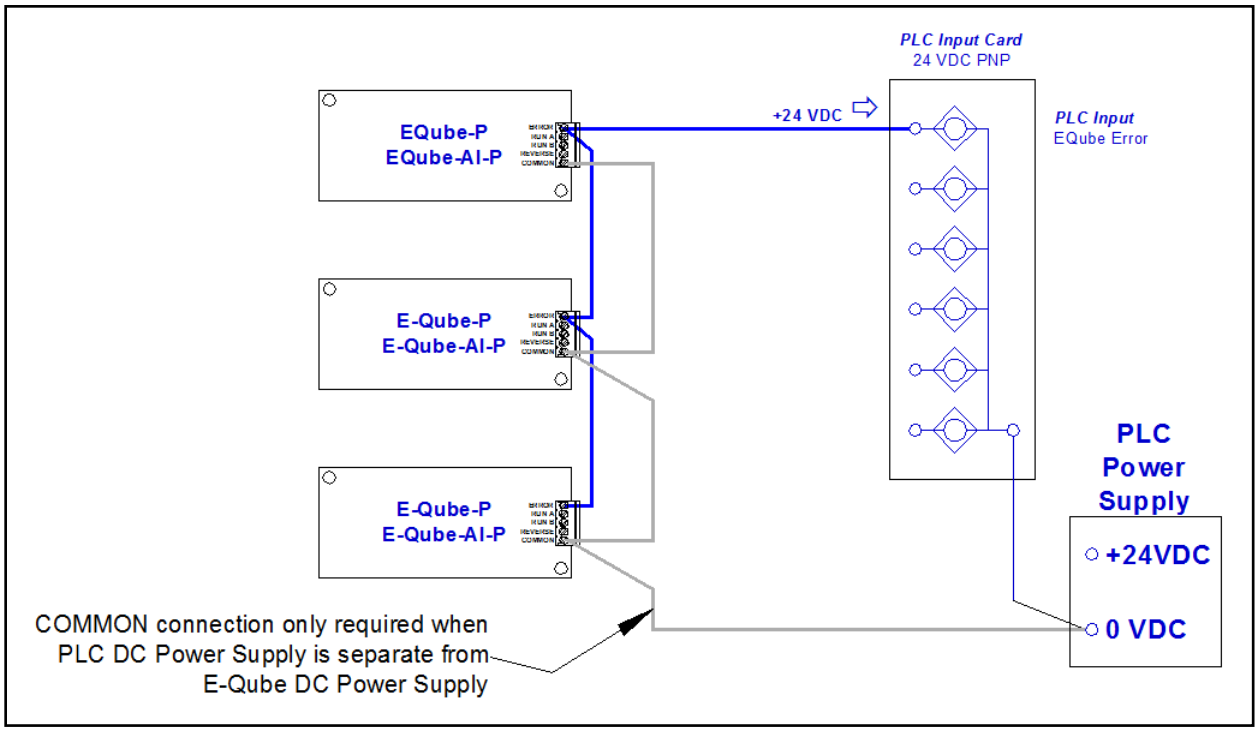


FIGURE 9 - MULTIPLE PNP MODULES PROVIDING SINGLE ERROR INPUT TO PLC

In Figure 9, if any of the connected module's *ERROR* signals energizes, then the PLC input will energize. Please note that COMMON connection is only required when PLC DC poer supply is separate from E-Qube DC power supply.

EQUBE-N AND EQUBE-AI-N

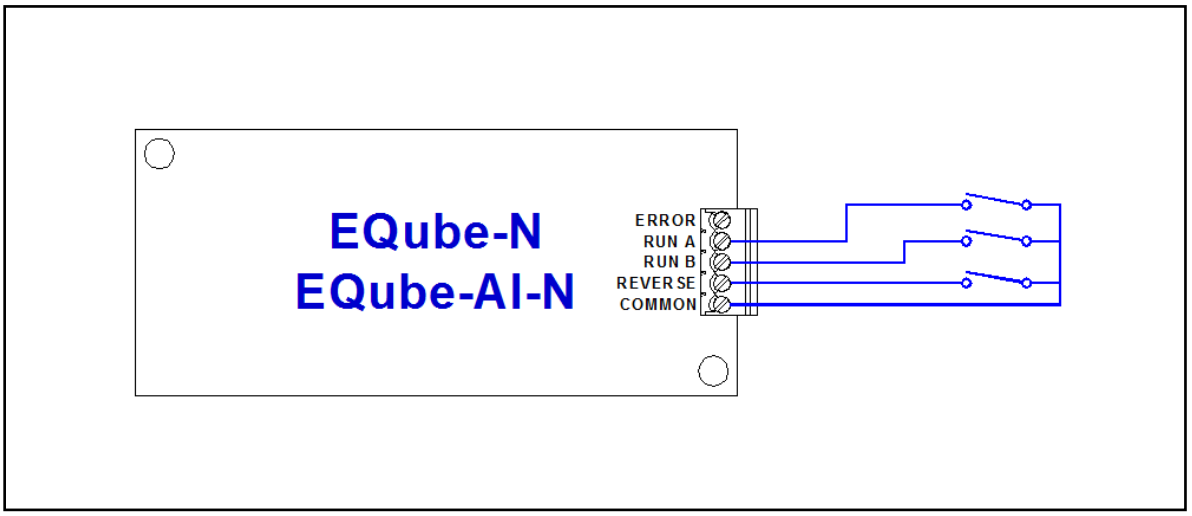


FIGURE 10 - SINGLE NPN MODULE RUN/REVERSE WIRING

To use the *REVERSE* input, either *RUN* A or *RUN* B must also be energized. Please note that you MUST STOP the MDR (de-energize both *RUN A* and *RUN B*) in order to change MDR direction with the *REVERSE* input. Failure to stop before changing directions could damage the MDR.

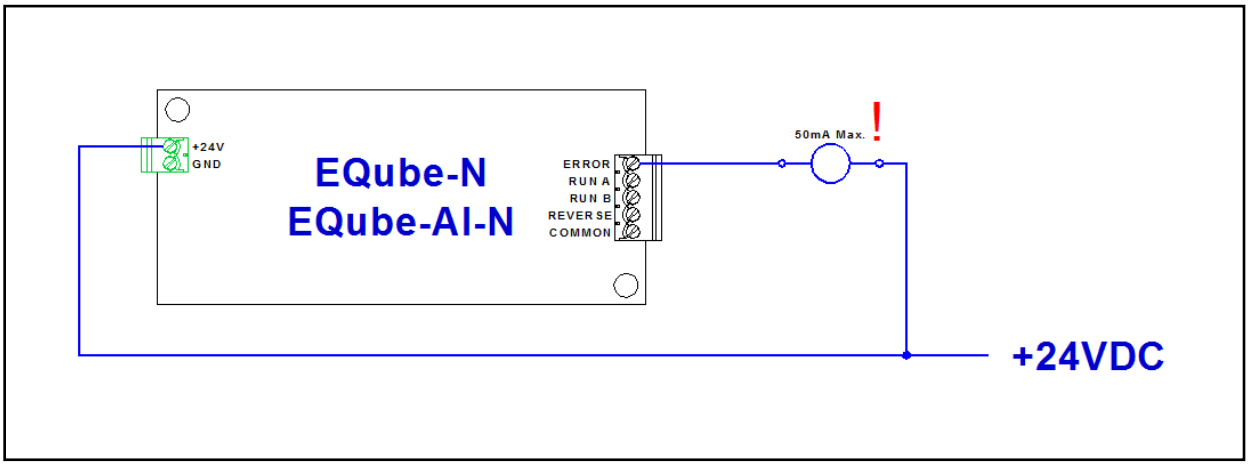


FIGURE 11 - SINGLE NPN MODULE ERROR OUTPUT WIRING

Please note that the *ERROR* output current for either NPN EQube models is limited to 50 mA. If the device connected to the *ERROR* output requires a higher current, then you must utilize an interface relay into the circuit.

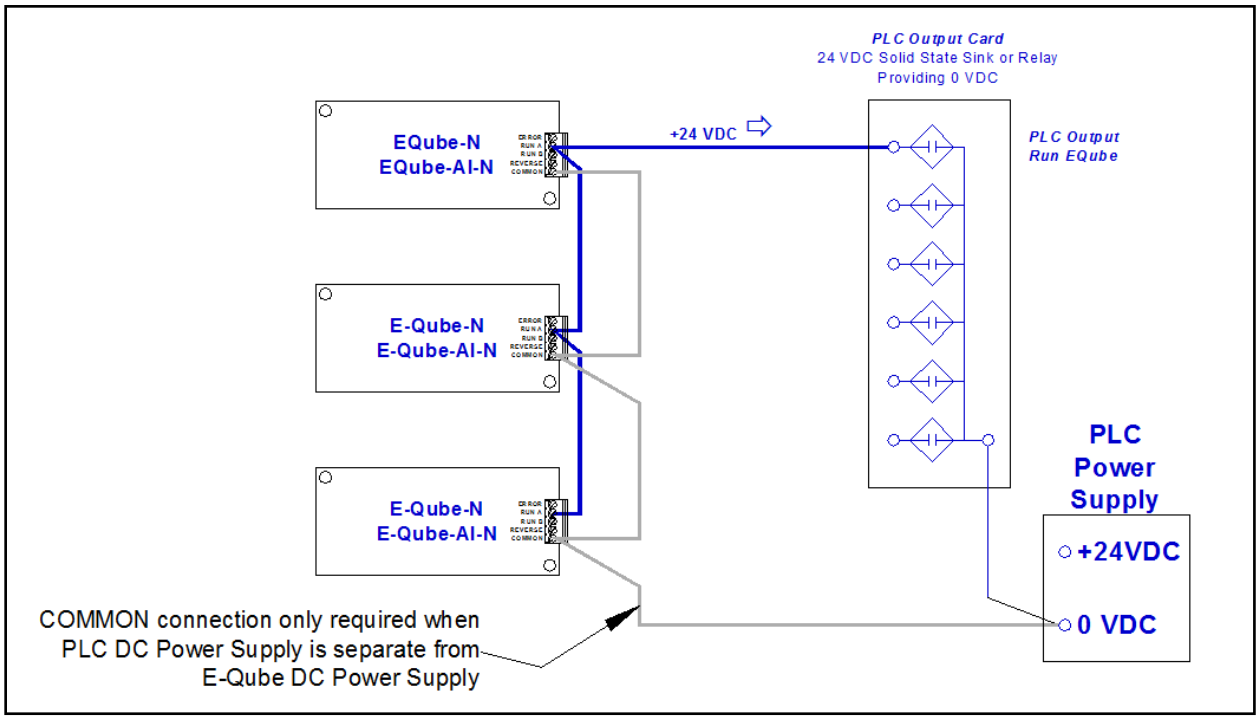


FIGURE 12 - MULTIPLE NPN MODULES GETTING RUN SIGNAL FROM SINGLE PLC OUTPUT

Figure 12 shows a single PLC output connected to multiple modules for the *RUN* A signal only for clarity. PLC outputs can also be connected to *RUN* B and *REVERSE* inputs as well. Please note that the COMMON connection is only required if the PLC DC power supply is separate from the E-Qube DC power supply.

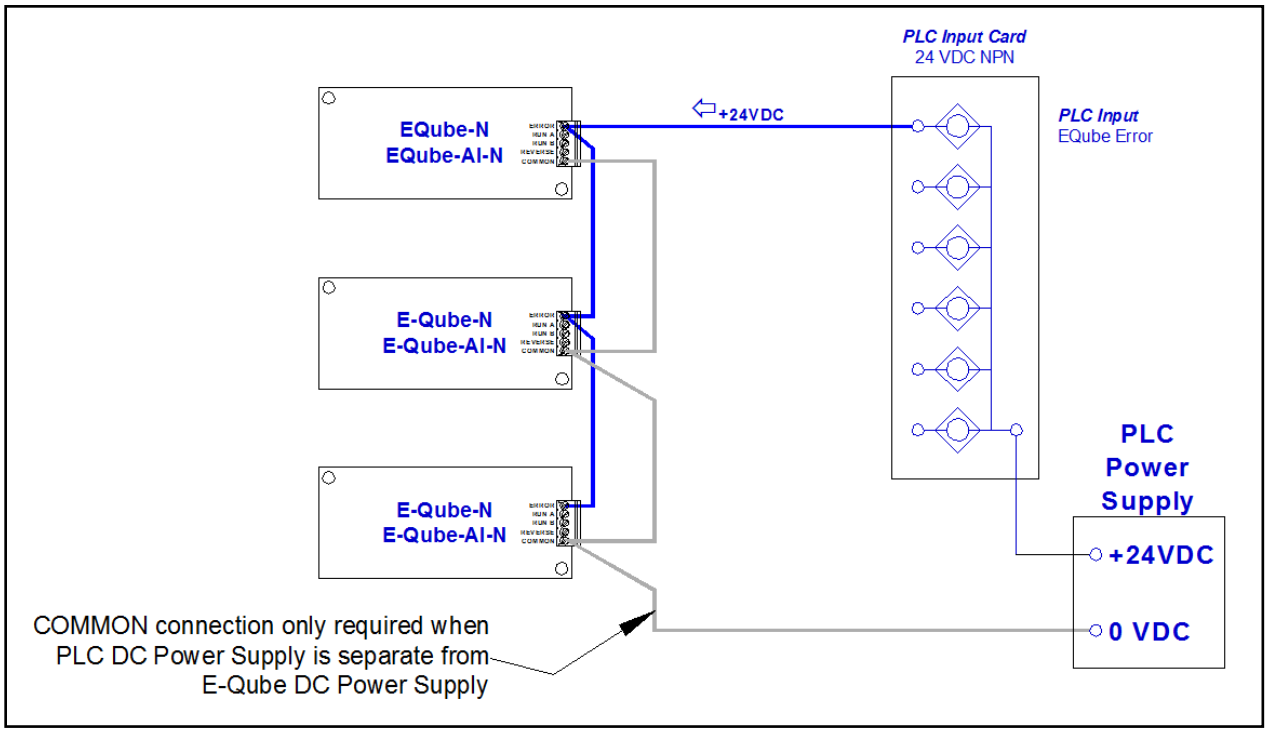


FIGURE 13 - MULTIPLE NPN MODULES PROVIDING SINGLE ERROR INPUT TO PLC

In Figure 13, if any of the connected module's *ERROR* signals energizes, then the PLC input will energize. Please note that the COMMON connection is only required if the PLC DC power supply is separate from the E-Qube DC power supply.

STATUS AND ERROR CONDITIONS WITH TIMING DIAGRAMS

Figure 1 on page 11 depicts the location of each *EQube* LED indicator. The following chart lists each and their primary functions.

LED	*LED State*	*Description*
Power	ON at normal brightness	Input power is between 18V and 31V
	FLASH at 0.1s interval	Input power is below 18V
	ON at high brightness	Input voltage is greater than 31V
Go	Flashing	RUN signal(s) are on and flash rate is proportional to motor speed
Over-Temp	ON	Calculated motor temperature is above 107˚C
Hold	ON	Current is being limited to motor
	Flash & Blink	See Timing Diagrams
Stop	0.2s Flash at 0.4 sec interval	Motor roller is disconnected
	Flash at 1.0 s interval	Controller has stopped the motor due to error condition
	Other flash rates	See Timing Diagrams

These LED's can also display brief indications of normal events. The following pages show timing diagrams that illustrate normal status and each error condition along with the visual LED behaviour used to indicate these conditions.

DIAGRAM #1 - POWER SUPPLY ON WITH MOTOR ROLLER CONNECTED

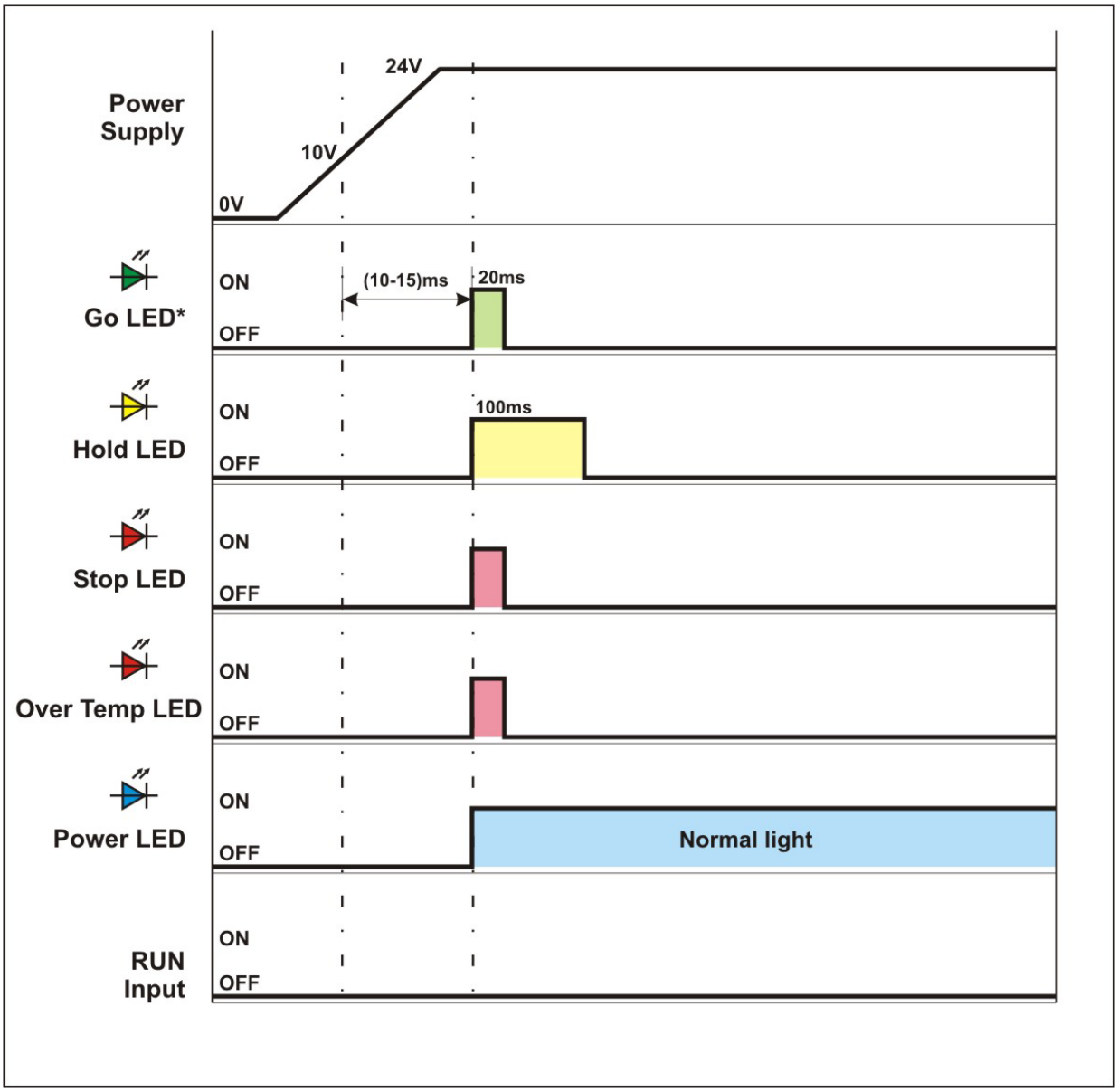


DIAGRAM #2 - POWER ON WITH MDR NOT CONNECTED

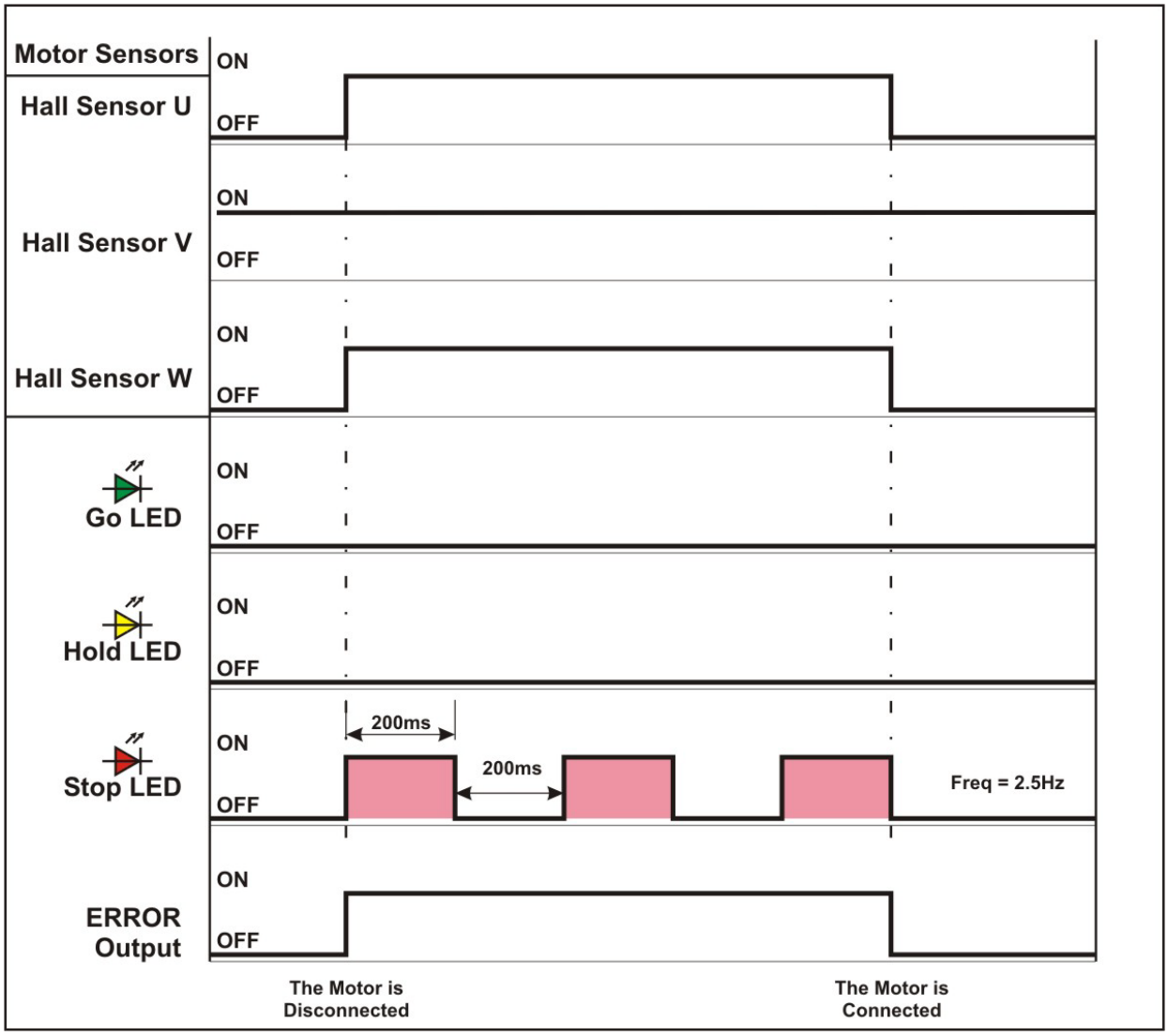
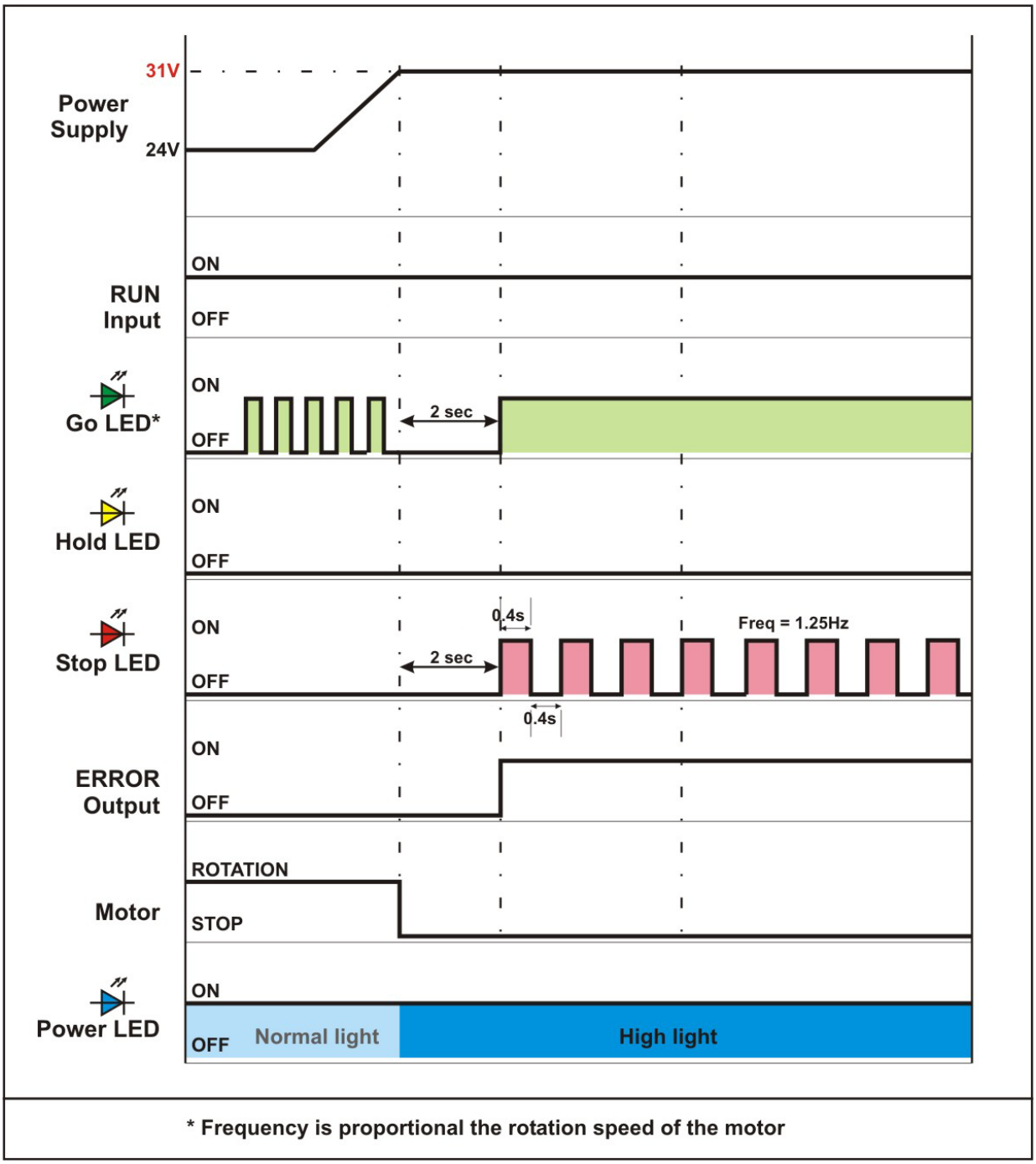


DIAGRAM #3 - POWER SUPPLY VOLTAGE EXCEEDS 31V



* Frequency is proportional the rotation speed of the motor

DIAGRAM # 4 – VOLTAGE DROP BELOW 18V AND VOLTAGE DROP BELOW 13V

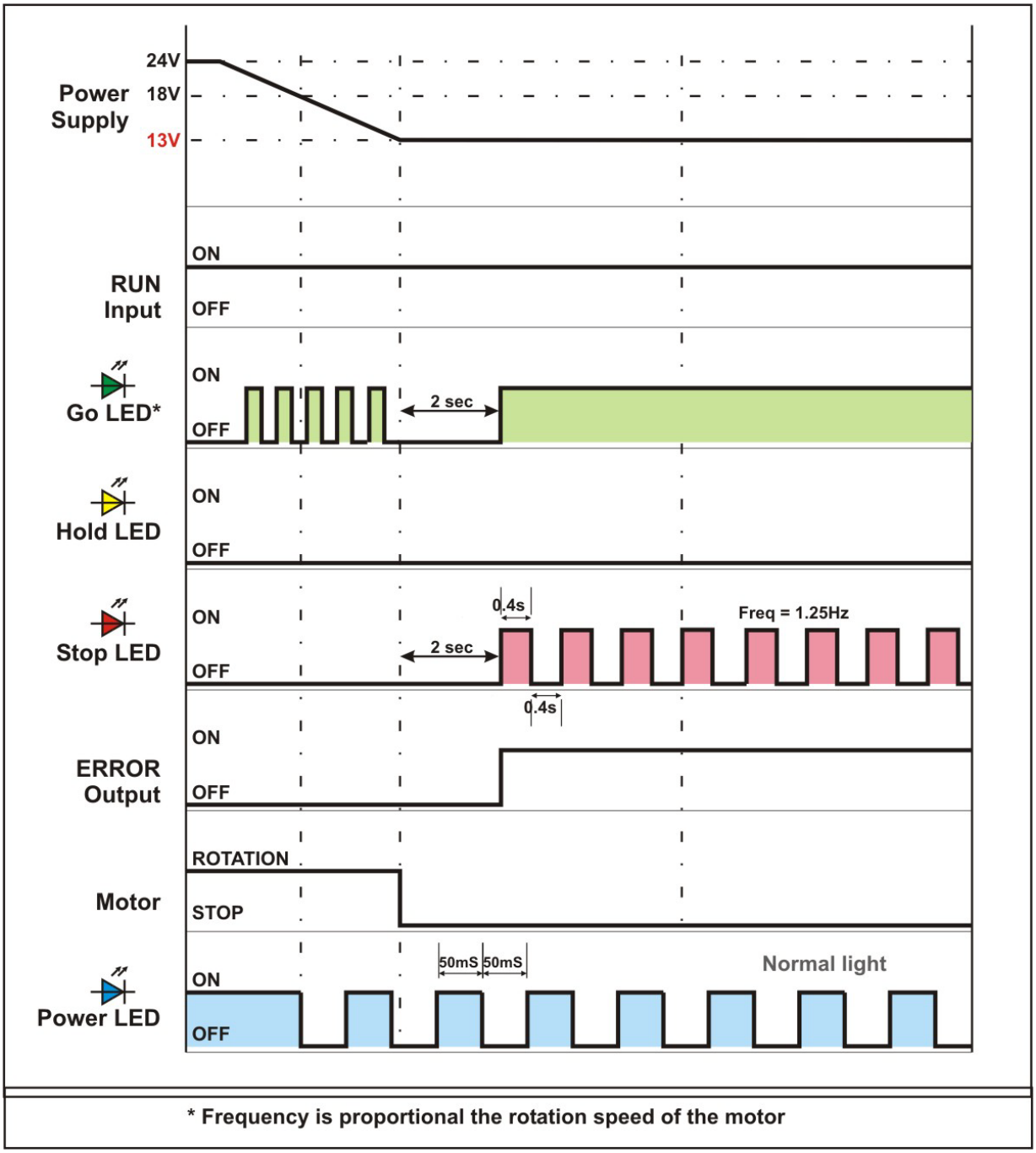
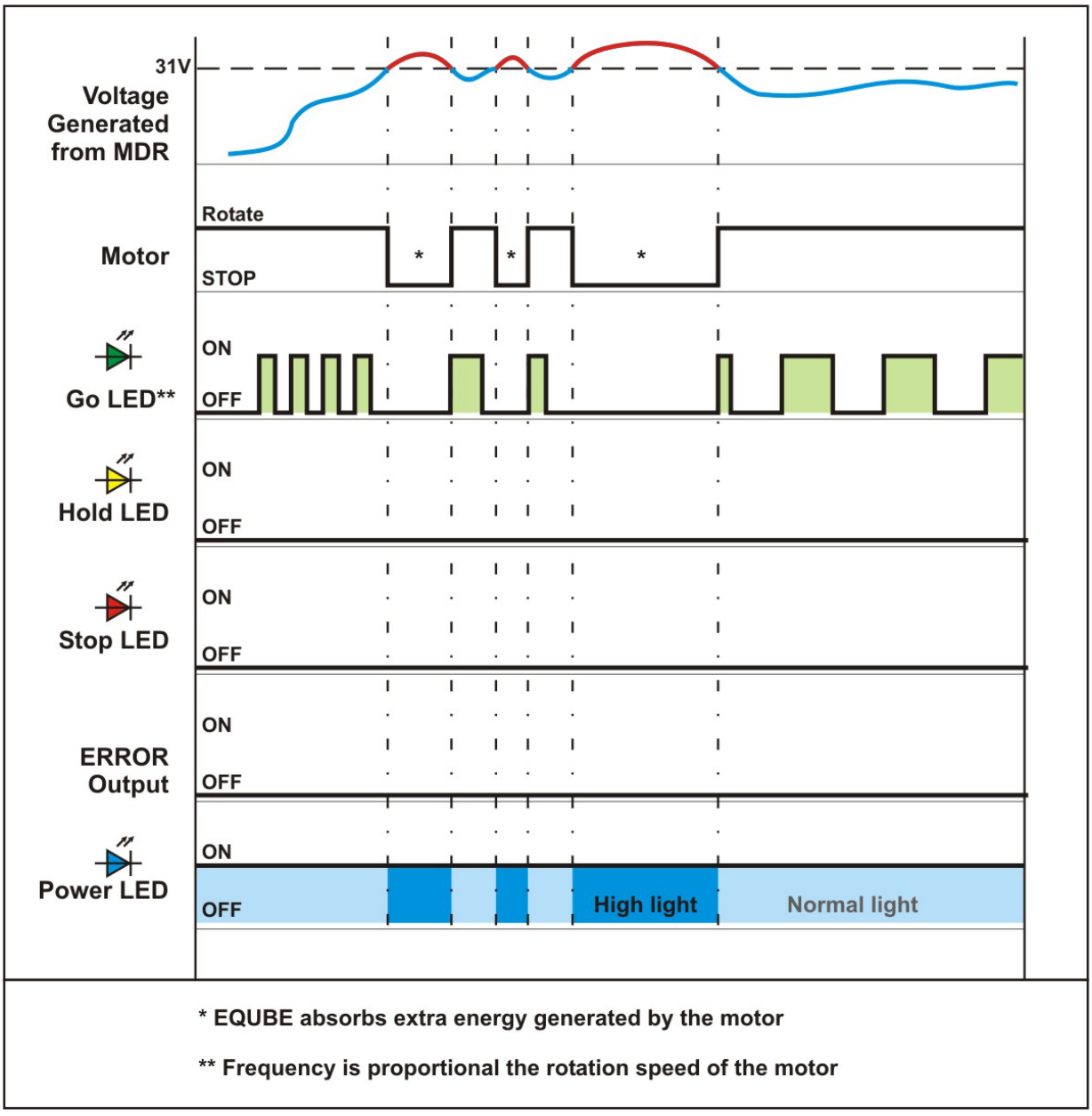


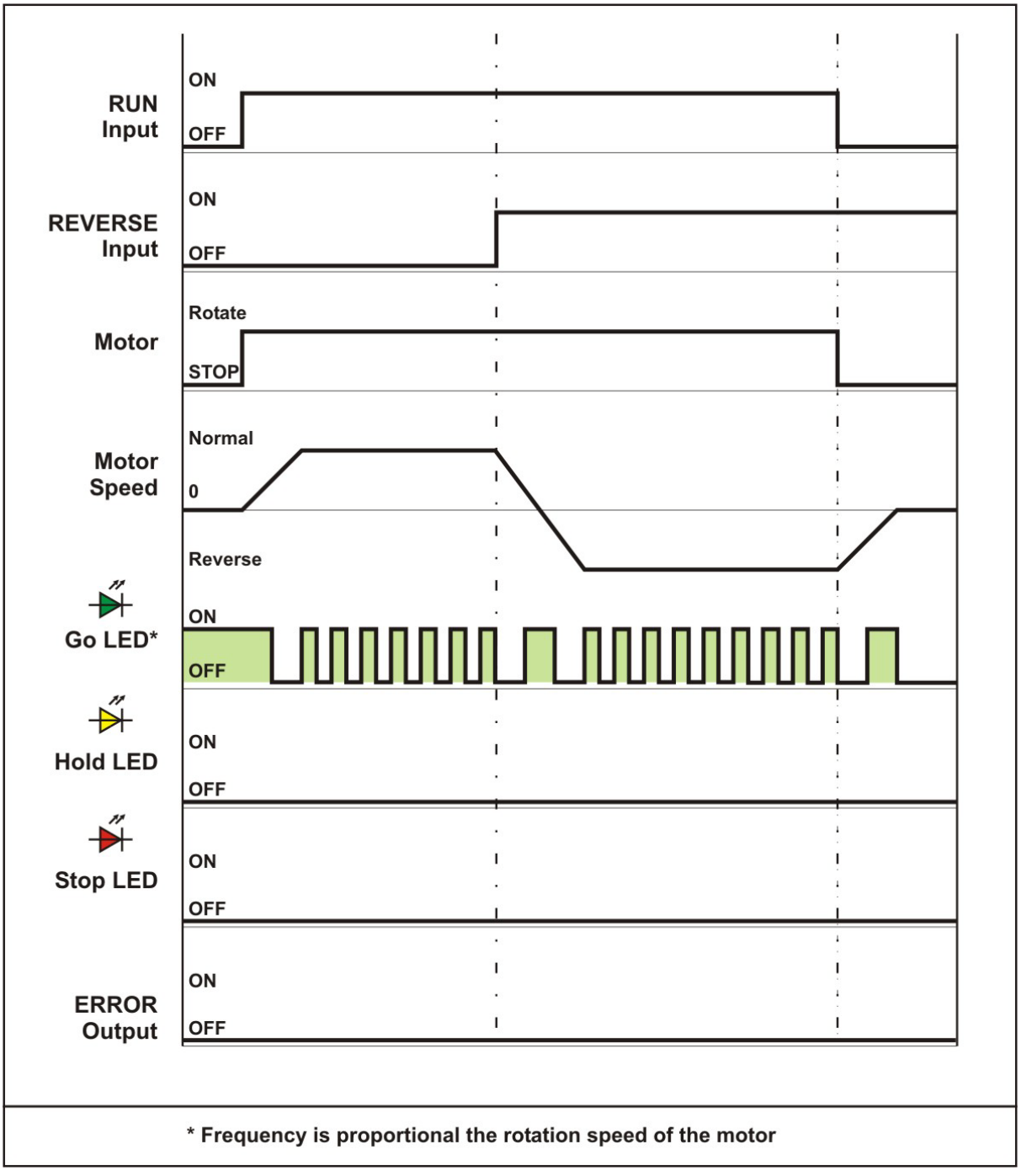
DIAGRAM #5 - VOLTAGE OVER 31V DUE TO OVER SPEEDING



* EQUBE absorbs extra energy generated by the motor

** Frequency is proportional the rotation speed of the motor

DIAGRAM #6 - NORMAL OPERATION WITH MDR ROTATING THEN REVERSE SIGNAL



* Frequency is proportional the rotation speed of the motor

DIAGRAM #7 - MDR CURRENT EXCEEDING PEAK LIMIT

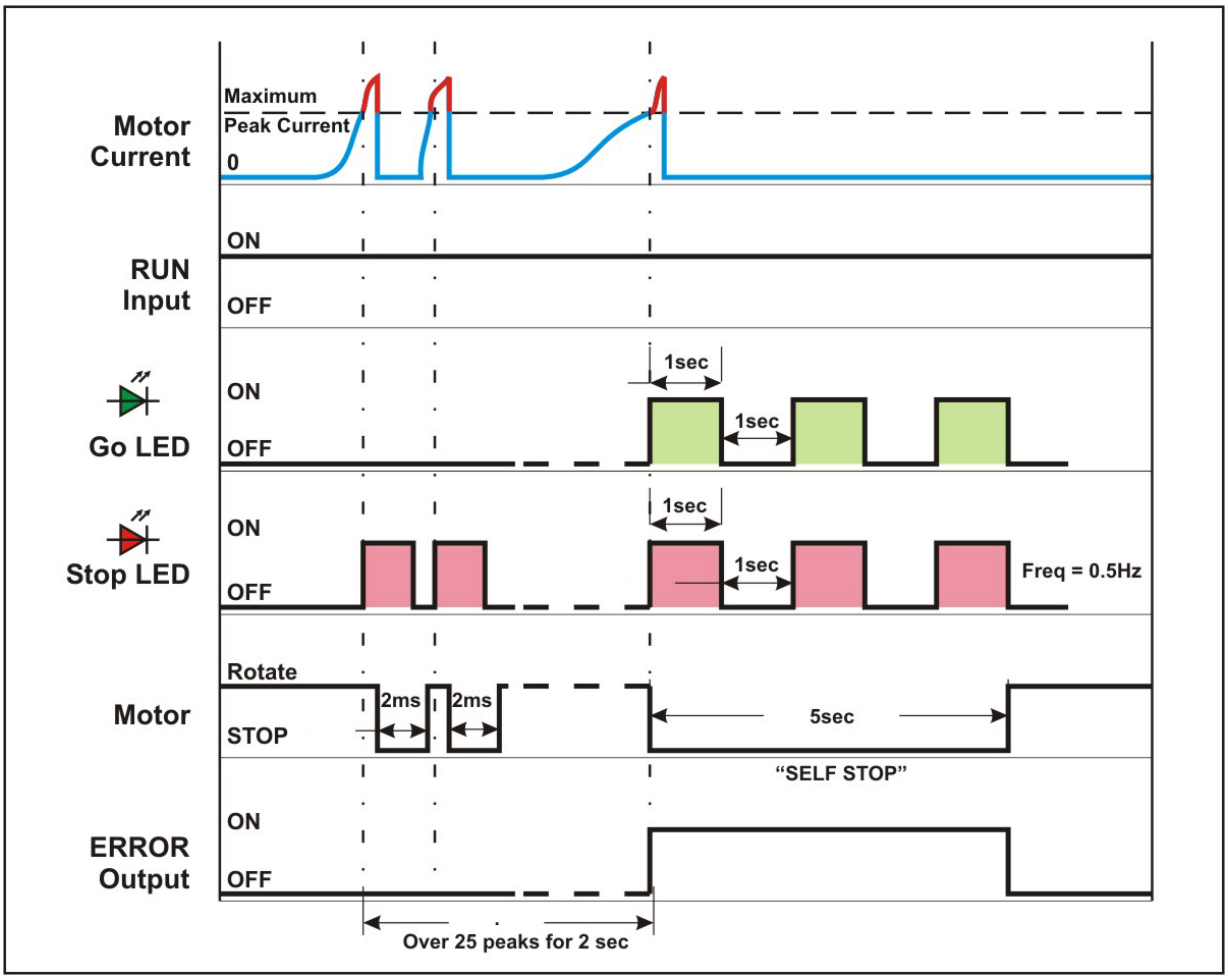


DIAGRAM #8 - OVER CURRENT WITH PWM LIMITING

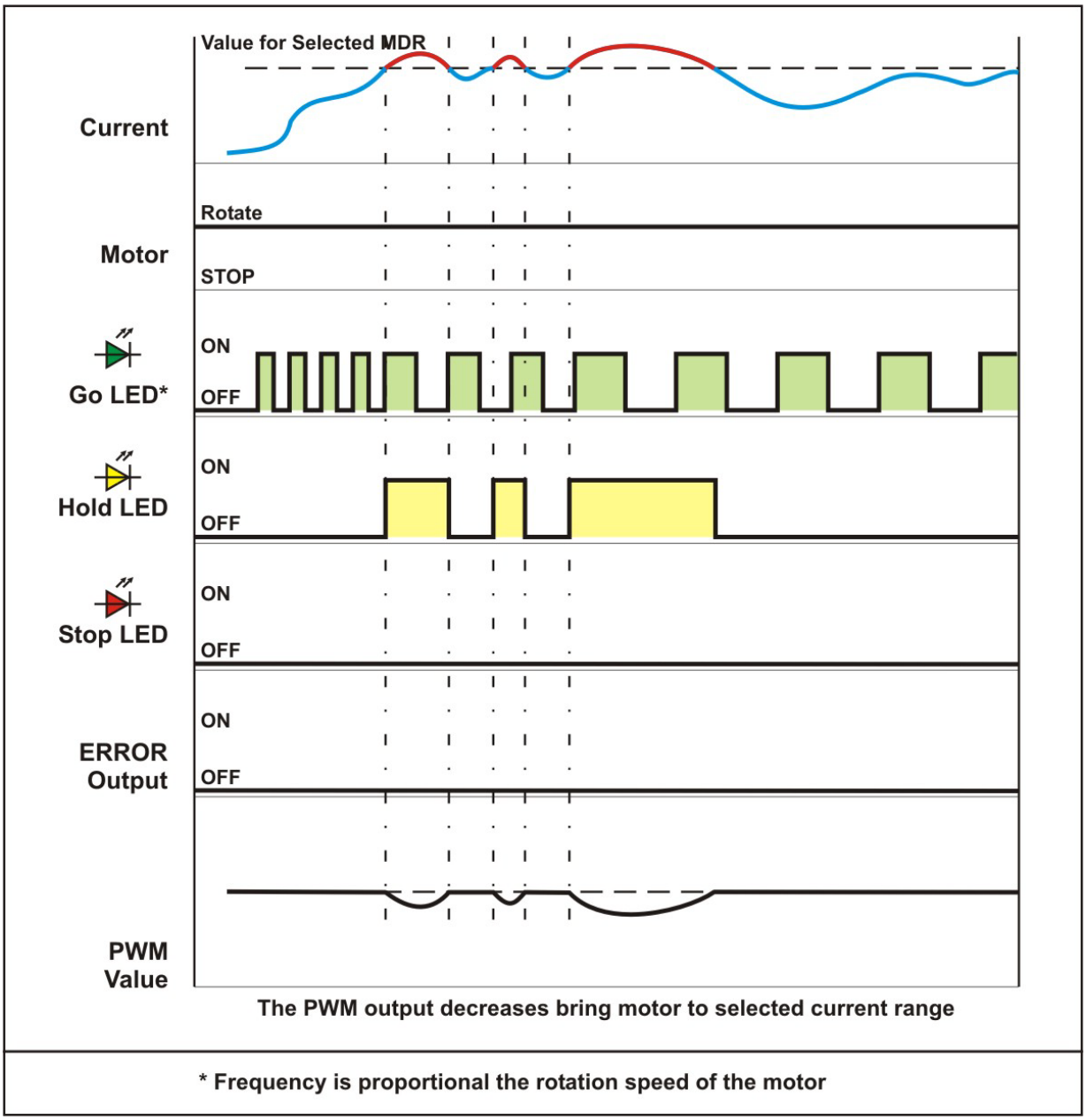


DIAGRAM #9 - MDR STALLED CONDITION WITH SELF STOP

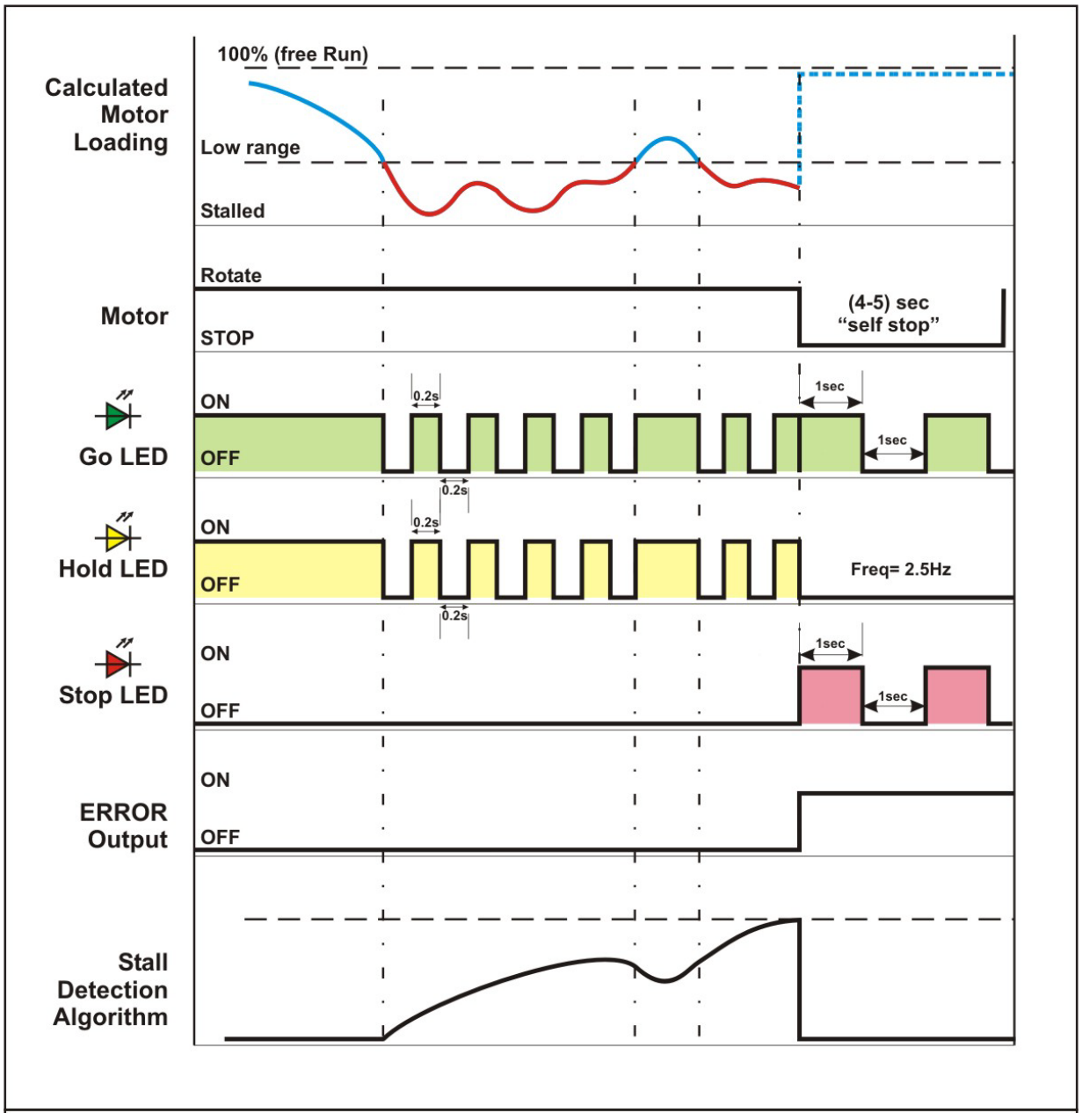


DIAGRAM #10 – MOTOR ROLLER OVERLOAD WITH SELF STOP

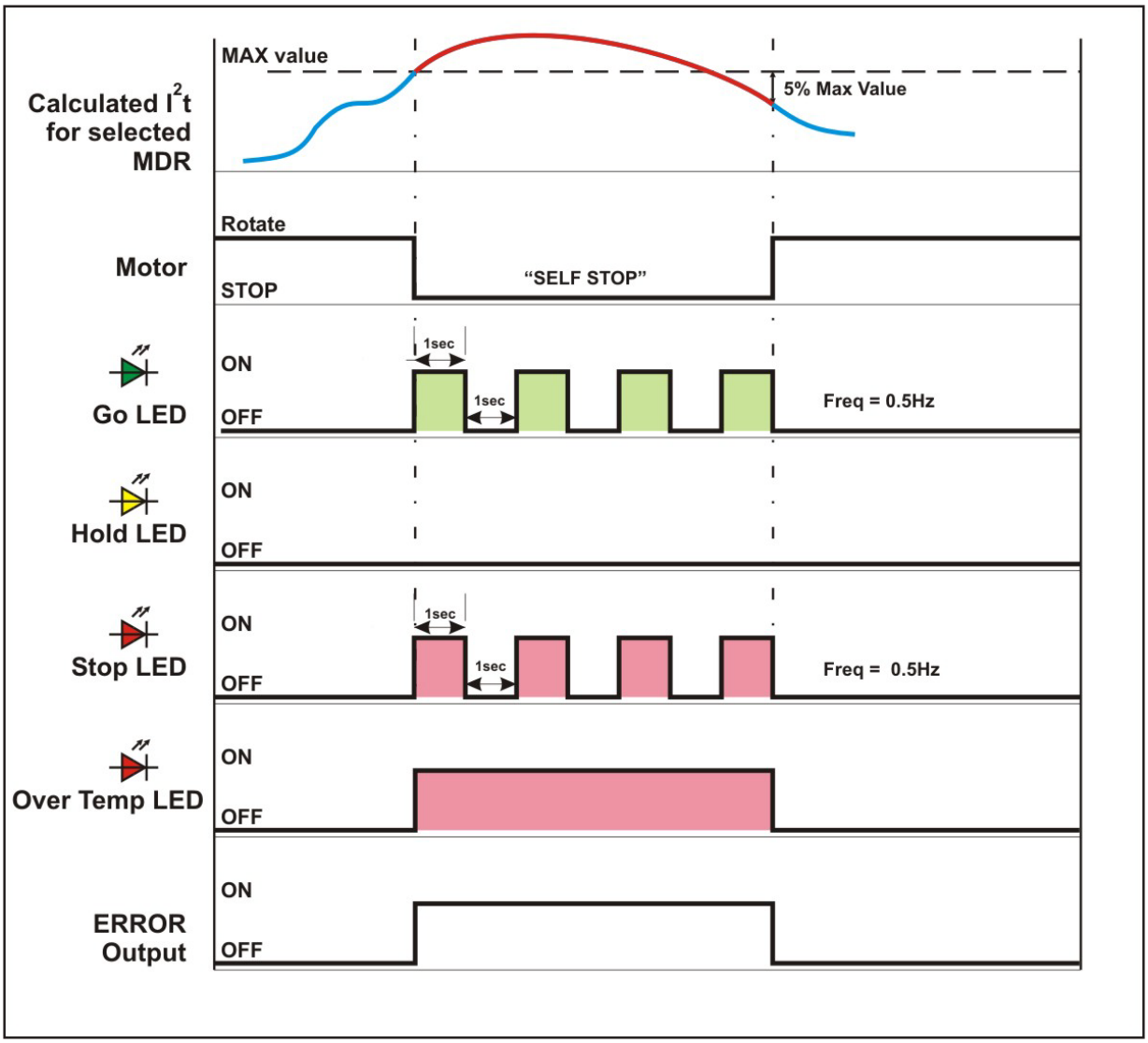


DIAGRAM #11 – MOTOR NOT ROTATING WHEN RUN IS ON

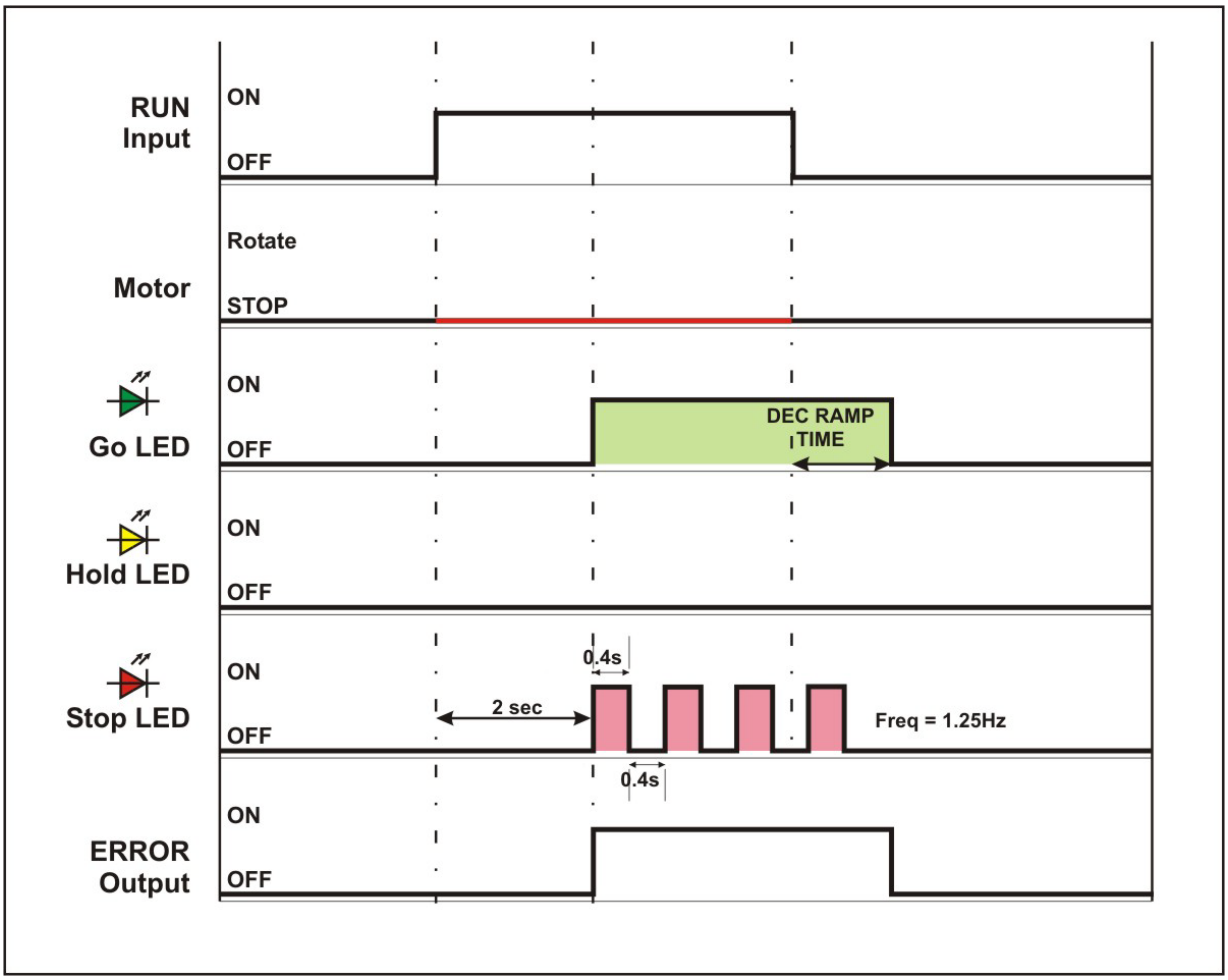
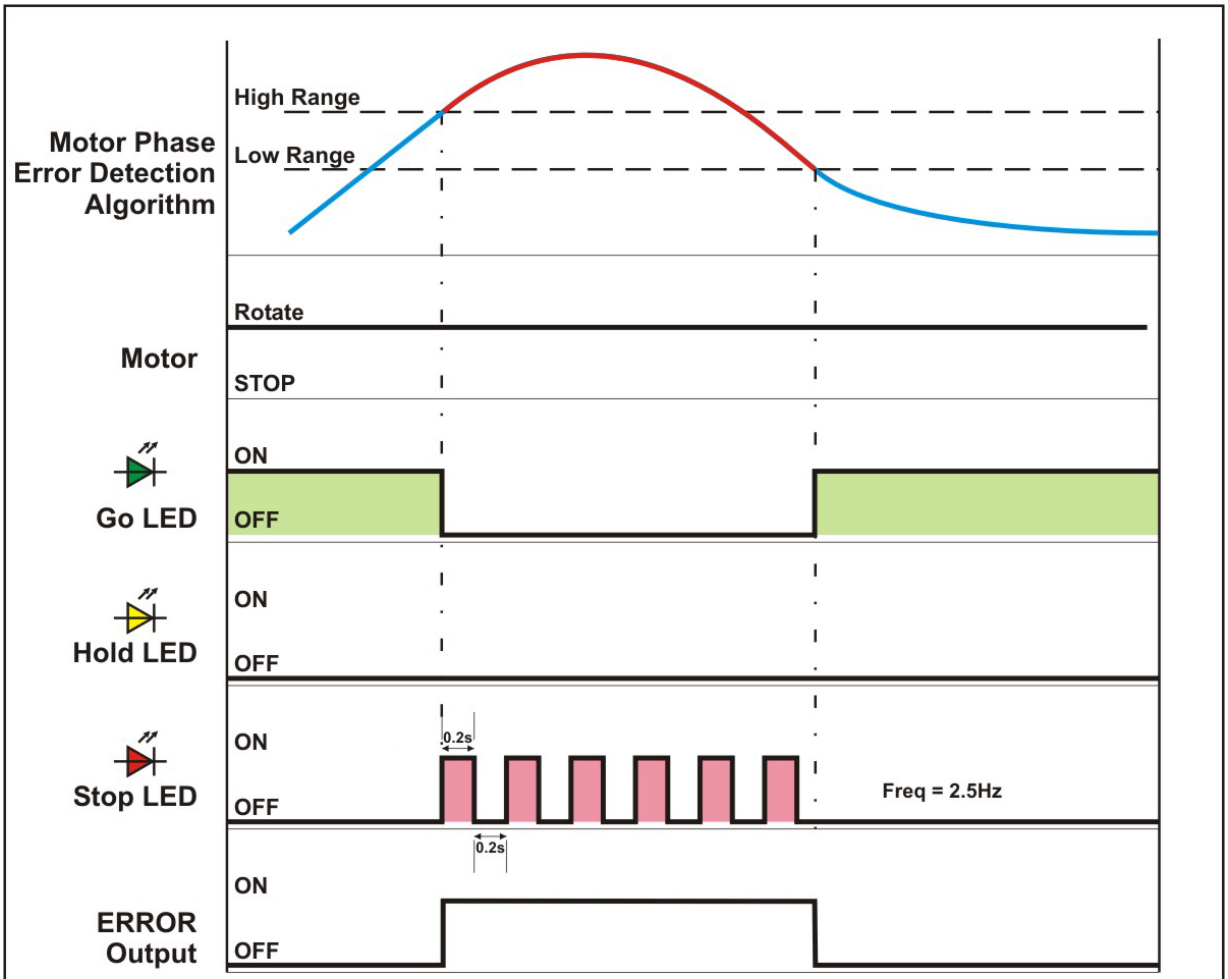


DIAGRAM #12 - MDR PHASE ERROR DETECTED



Fault phases may occur due to:
- Failed sensor
- short circuit between connecting cables
- short circuit between sensor and ground

SPECIFICATIONS

TECHNICAL SPECIFICATIONS

Input Power Supply Requirements	24VDC +15% / -25% NEC Class II Certified	
Control Input Voltage Range	(14 – 30) VDC	
Current Consumption	~ 30 mA without Motor Roller	
Built –in Current Limits	Max Peak Current	16A
	Max Start Current	4A
	Max. Rated Current	3A
	Input Power Fuse	8A
	Max. Current ERROR Output	100mA (-P versions only)
		50mA (-N versions only)
	ERROR Output Short circuit protection	150mA (-P versions only)
Supported Motor Rollers	Senergy Standard (JST Version) – ECO Mode only	
	Senergy-Ai (4-Pin Ai Version) – ECO Mode only	
PWM frequency	20kHz	
Time delay initial setting	< = 20 msec from power ON.	
Time to start motor rotation	< = 5 msec	
Ambient Operating Temperature	0˚ C to 50˚ C	
Storage Temperature	-40˚ C to 85˚ C	
Environmental Rating	IP20 For Indoor Use Only Altitude up to 2000m Maximum Relative Humidity: 70% for temperatures up to 30°C and decreasing linearly to 50% at 50°C Environmental Pollution Class 2	
Weight	Approximately 60g	

MOUNTING DIMENSIONS AND INSTRUCTIONS

DIMENSIONS

All dimensions in mm. Mounting dimensions as shown in Figure 14 are the same for all versions of *EQube*.

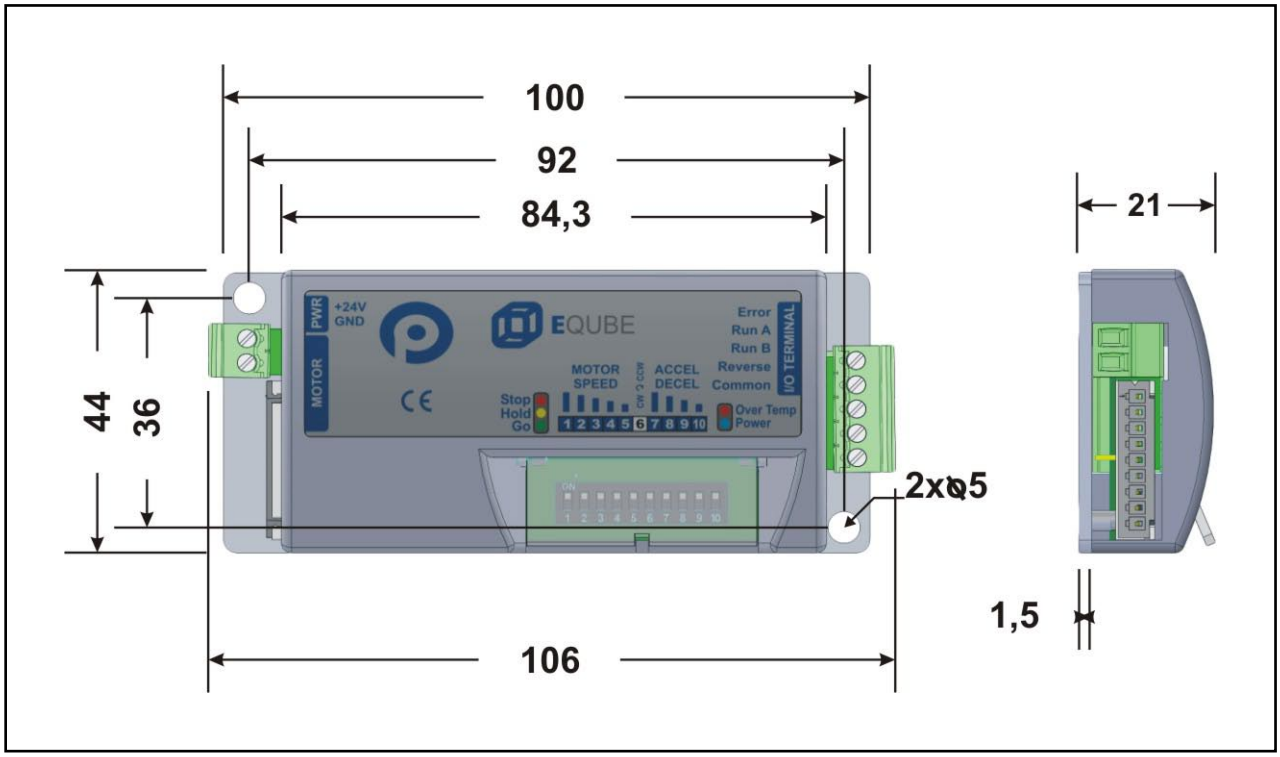


FIGURE 14 - EQUBE DIMENSIONS

MOUNTING

EQube module must be mounted with its long side parallel to the conveyor frame and with its heat sink plate in contact with the conveyor frame. Attach module to frame using fasteners through the 2 mounting holes on the module through matching holes drilled into conveyor frame as shown in Figure 15 and Figure 16 .

Other mounting and installation requirements:

- Metal Heat Sink surface must face the conveyor frame and Heat Sink must not be accessible by any personnel without removing the module from the frame
- **Module must be mounted on electrically grounded metal surface or provided with a conductor wire connecting the module's metal heat sink plate to electrical ground.**
- Module must be mounted in such a way such that there are no interferences with an operator's ability to remove or unplug the power, motor, and control signal connectors.
- Module should be mounted in such a way and location such that any personnel can easily retreat away from the module in the event of a device failure
- Module must be mounted such that it can be accessed by personnel of any height.

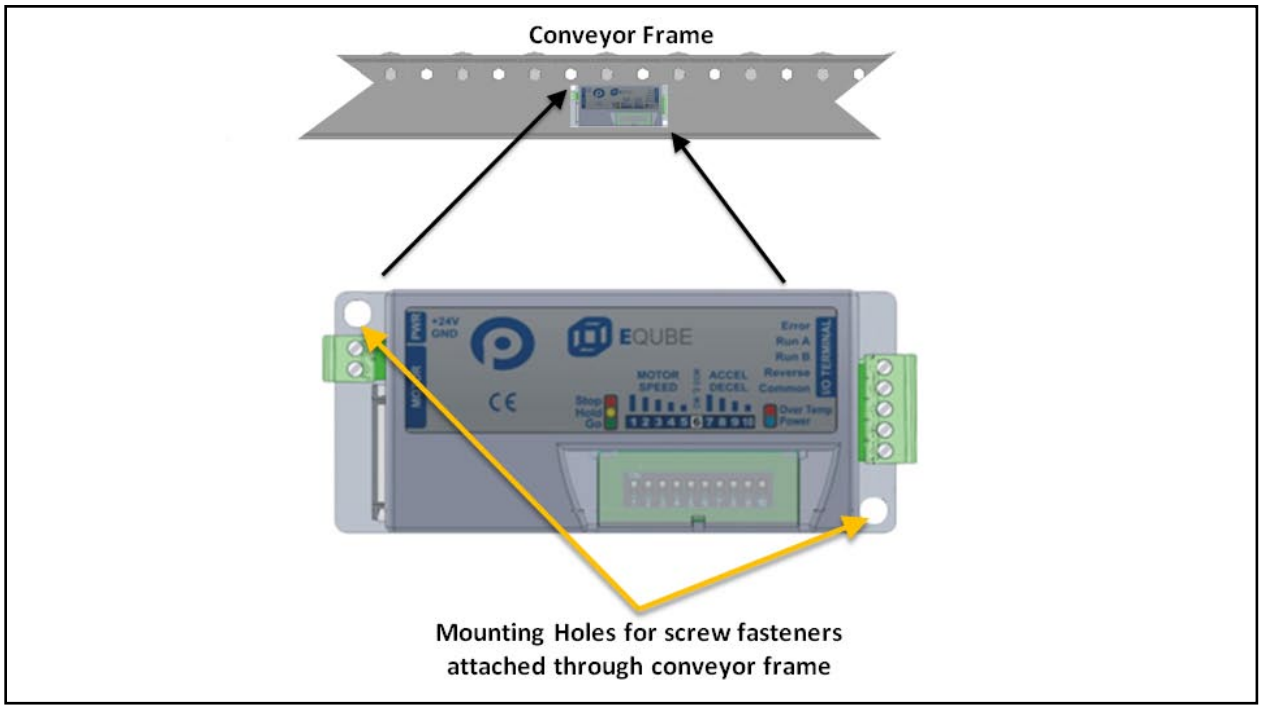


FIGURE 15 - EQUBE ATTACHMENT TO CONVEYOR FRAME

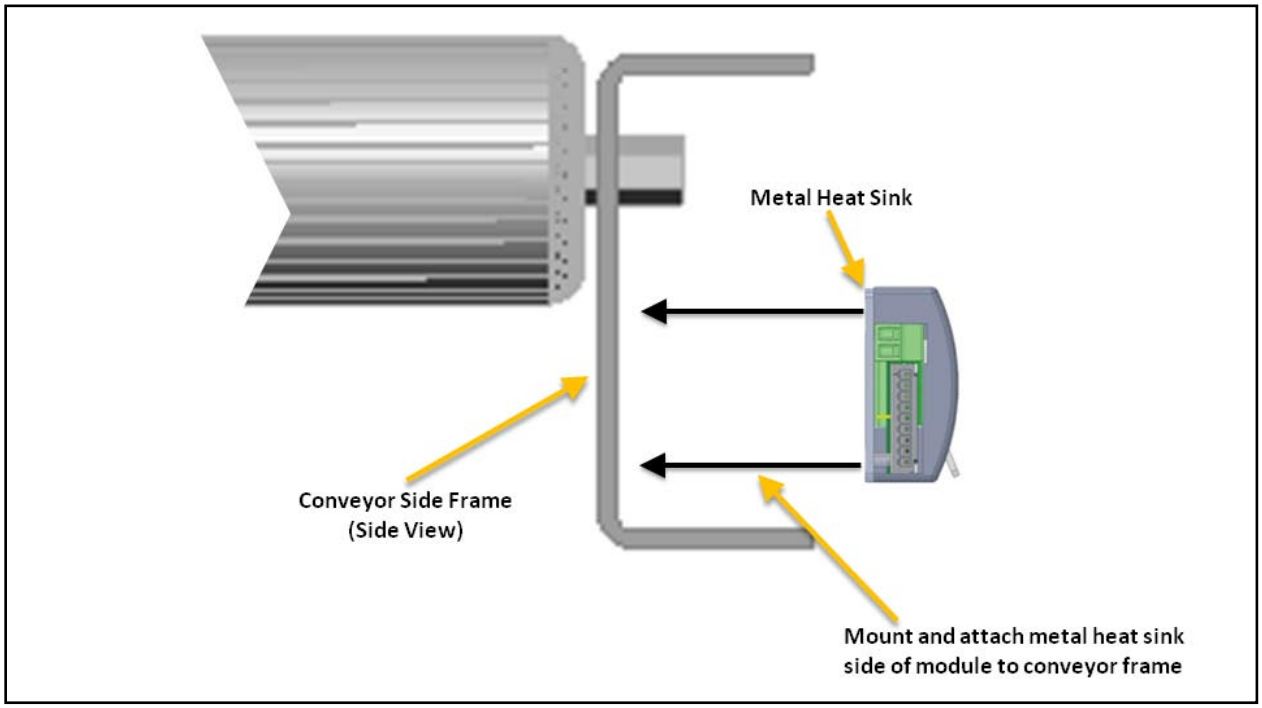


FIGURE 16 - HEAT SINK ATTACHMENT TO FRAME

NOTES:

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