Golden Ding Series Analog Servo Drives

AMC

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OFFSET 16
VEL MONITOR OUT/TACH IN 15
ENCODER-A IN 14
ENCODER-B IN 13
FAULT OUT 12
CURRENT REFERENCE 11
HALL C 10
HALL B 9
HALL A 8
SIGNAL GND 7
+V HALL OUT 6
INHIBIT IN 5
CURRENT MONITOR 4
-REF IN 3
SIGNAL GND 2
+REF IN 1

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GND HV MC MB MA

Hardware Installation Manual

Attention Symbols

The following symbols are used throughout this document to draw attention to important operating information, special instructions, and cautionary warnings. The section below outlines the overall directive of each symbol and what type of information the accompanying text is relaying.

Note - Pertinent information that clarifies a process, operation, or ease-of-use preparations regarding the product.

Notice - Required instruction necessary to ensure successful completion of a task or procedure.

Caution - Instructs and directs you to avoid damaging equipment.

Warning - Instructs and directs you to avoid harming yourself.

Danger - Presents information you must heed to avoid serious injury or death.

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1. Products Safety Overview

This section discusses characteristics of your Golden Ding Drive to raise your awareness of potential risks and hazards. The severity of consequences ranges from frustration of performance, through damage to equipment, injury or death. These consequences, of course, can be avoided by good design and proper installation into your mechanism.

In order to install an Golden Ding drive into a servo system, you must have a thorough knowledge and understanding of basic electronics, computers and mechanics as well as safety precautions and practices required when dealing with the possibility of high voltages or heavy, strong equipment.

Observe your facility's lock-out/tag-out procedures so that work can proceed without residual power stored in the system or unexpected movements by the machine.

Notice

You must install and operate motion control equipment so that you meet all applicable safety requirements. Ensure that you identify the relevant standards and comply with them. Failure to do so may result in damage to equipment and personal injury.

Read this entire manual prior to attempting to install or operate the drive. Become familiar with practices and procedures that allow you to operate these drives safely and effectively. You are responsible for determining the suitability of this product for the intended application. The manufacturer is neither responsible nor liable for indirect or consequential damages resulting from the inappropriate use of this product.

Caution

Over current protective devices recognized by an international safety agency must be installed in line before the servo drive. These devices shall be installed and rated in accordance with the device installation instructions and the specifications of the servo drive (taking into consideration inrush currents, etc.). Servo drives that incorporate their own primary fuses do not need to incorporate over current protection in the end user's equipment.

High-performance motion control equipment can move rapidly with very high forces. Unexpected motion may occur especially during product commissioning. Keep clear of any operational machinery and never touch them while they are working.

Notice

Keep clear of all exposed power terminals when power is applied to the equipment. Follow these safety guidelines:

➢ Always turn off the main power and allow sufficient time for complete discharge before making any connections to the drive.

➢ Do not rotate the motor shaft without power. The motor acts as a generator and will charge up the power supply capacitors through the drive. Excessive speeds may cause over-voltage breakdown in the power output stage. Note that a drive having an internal power converter that operates from the high voltage supply will become operative.

➢ Do not short the motor leads at high motor speeds. When the motor is shorted, its own generated voltage may produce a current flow as high as 10 times the drive current. The short itself may not damage the drive but may damage the motor. If the connection arcs or opens while the motor is spinning rapidly, this high voltage pulse flows back into the drive (due to stored energy in the motor inductance) and may damage the drive.

➢ Do not make any connections to any internal circuitry. Only connections to designated connectors are allowed.

➢ Do not make any connections to the drive while power is applied.

Warning

➢ Do not reverse the power supply leads! Severe damage will result!

➢ If using relays or other means to disconnect the motor leads, be sure the drive is disabled before reconnecting the motor leads to the drive. Connecting the motor leads to the drive while it is enabled can generate extremely high voltage spikes which will damage the drive.

Caution

➢ Over current protective devices recognized by an international safety agency must be installed in line before the servo drive.

➢ These devices shall be installed and rated in accordance with the installation instructions of the device and the power specifications of the servo drive.

➢ Servo drives that incorporate their own primary fuses do not need to incorporate over current protection in the end user's equipment.

Caution

Use sufficient capacitance!

Pulse Width Modulation (PWM) drives require a capacitor on the high voltage supply to store energy during the PWM switching process. Insufficient power supply capacitance causes problems particularly with high inductance motors. During braking much of the stored mechanical energy is fed back into the power supply and charges its output capacitor to a higher voltage. If the charge reaches the drive's over-voltage shutdown point, output current and braking will cease. At that time energy stored in the motor inductance continues to flow through diodes in the drive to further charge the power supply capacitance. The voltage rise depends upon the power supply capacitance, motor speed, and inductance.

Make sure minimum inductance requirements are met!

Pulse Width modulation (PWM) servo drives deliver a pulsed output that requires a minimum amount of load inductance to ensure that the DC motor current is properly filtered. The minimum inductance values for different drive types are shown in the individual data sheet specifications. If the drive is operated below its maximum rated voltage, the minimum load inductance requirement may be reduced. Most servo-motors have enough winding inductance. Some types of motors (e.g. "basket-wound", "pancake", etc.) do not have a conventional iron core rotor, so the winding inductance is usually less than 50 μH.

If the motor inductance value is less than the minimum required for the selected drive, use an external filter card.

2. Products And System Requirements

2.1 Drive Family Overview

The family of Golden Ding analog drives are designed to offer the same high performance and accuracy of larger drives, but in a space-saving mount architecture. By utilizing high density power devices, dual sided PCB boards, and creative design these drives are ideal for applications with limited size and weight constraints.

The Golden Ding drive family contains drives that power both Single Phase (brushed) and Three Phase (brushless) motors. Golden Ding drives are powered off a single unregulated DC power supply, and provide a variety of control and feedback options. The drives accept either a ±10V analog signal or a PWM and Direction signal as input. A digital controller can be used to command and interact with these drives, and a number of input/output pins are available for parameter observation and drive configuration.

TABLE 2.1 Standard Golden Ding Analong Servo Drive Family Part Numbers

	Voltage	10-36V	20-80V		10-80V			40-175V	
	Peak Current	**10A**	**6A**	**12A**	**20A**	**40A**	**60A**	**10A**	**25A**
Three Phase (Brushless) and Single Phase (Brushed	**Current Mode** Analog ±10V Command	CAB10A36	CAB6A80	CAB12A80	CAB20A80	CAB40A80	CAB60A80	CAB10A175	CAB25A175
	Current Mode PWM / Dir Command	CABDC10A36	CABDC6A80	CABDC12A80	CABDC20A80	CABDC40A80	CABDC60A80	CABDC10A175	CABDC25A175
	Hall Velocity Analog ±10V Command	CABH10A36[1]	CABH6A80	CABH12A80	CABH20A80	CABH40A80	CABH60A80	CABH10A175	CABH25A175
	Encoder Velocity Analog ±10V Command	CABE10A36	CABE6A80	CABE12A80	CABE20A80	CABE40A80	CABE60A80	CABE10A175	CABE25A175
	Duty Cycle Mode Analog ±10V Command	-	-	-	-	-	-	-	-

1. Three phase (brushless) motors only.

Special Environment Golden Ding Analog Servo Drive Family Part Numbers

Voltage	10-80V				
Peak Current	**8A**	**15A**	**25A**	**40A**	**16A**
Analog ±10V Command	CAB8A80X	CAB15A80X	-	-	-
PWM / Dir Command	CABDC8A80X	CABDC15A80X	CABDC25A80X	CABDC40A80X	-
Hall Velocity, Analog ±10V Command	CABH8A80X	CABH15A80X	CABH25A80X	CABH40A80X	CABH16A175X
Encoder Velocity, Analog ±10V Command	CABE8A80X	CABE15A80X	CABE25A80X	CABE40A80X	-

2.1.1 Drive Datasheet

Each drive has a separate datasheet that contains important information on the modes and product-specific features available with that particular drive. The datasheet is to be used in conjunction with this manual for system design and installation.

2.2 Drives Model Numbering

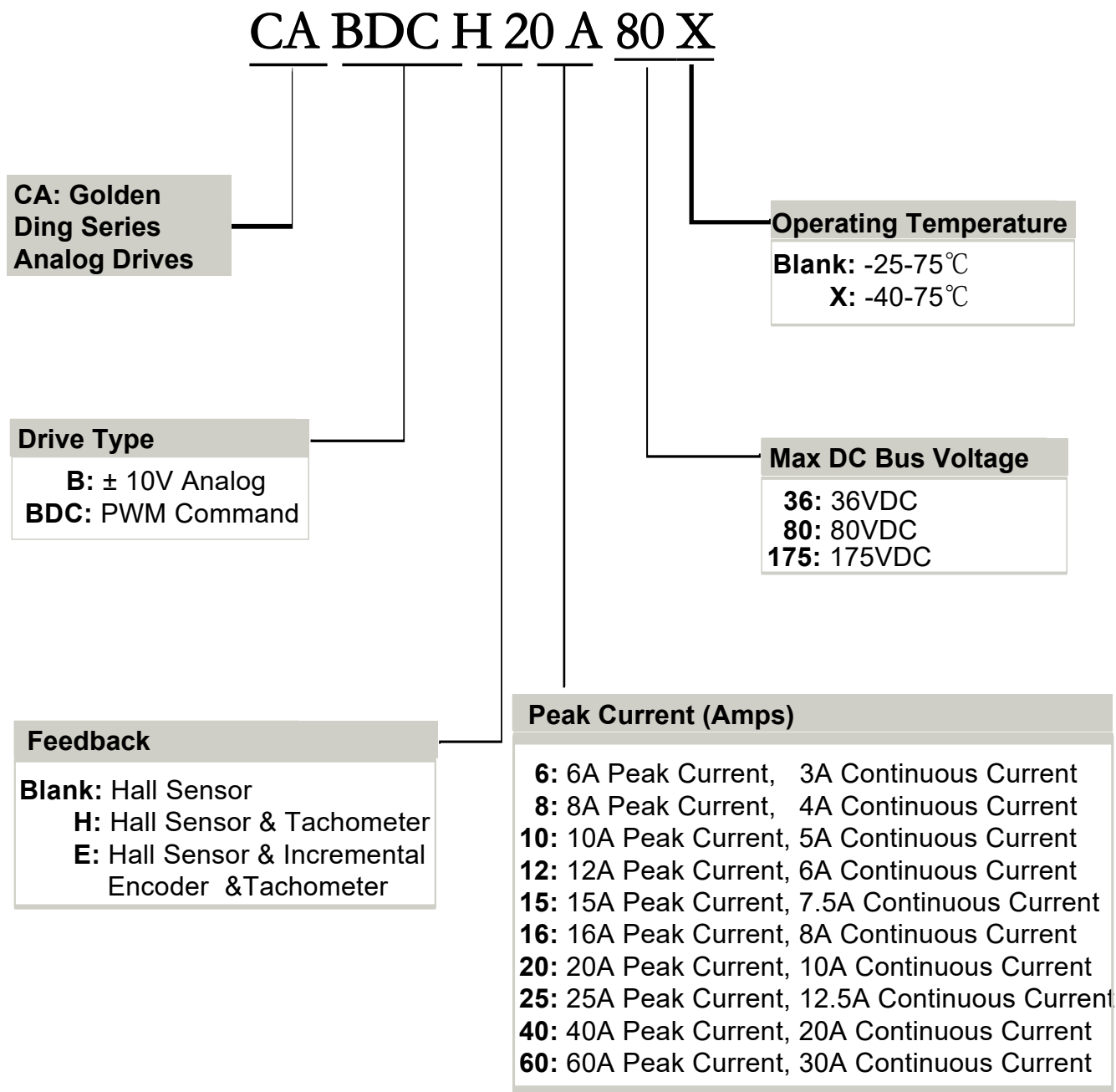**FIGURE 2.1 Golde Ding Analog Servo Drives Model Numbering**

CA: Golden Ding Series Analog Drives

Operating Temperature

Blank: -25-75℃	
X: -40-75℃	

Drive Type

B: ± 10V Analog
BDC: PWM Command

Max DC Bus Voltage

36: 36VDC
80: 80VDC
175: 175VDC

Feedback

Blank: Hall Sensor
H: Hall Sensor & Tachometer
E: Hall Sensor & Incremental
      Encoder &Tachometer

Peak Current (Amps)

6: 6A Peak Current,   3A Continuous Current
8: 8A Peak Current,   4A Continuous Current
10: 10A Peak Current, 5A Continuous Current
12: 12A Peak Current, 6A Continuous Current
15: 15A Peak Current, 7.5A Continuous Current
16: 16A Peak Current, 8A Continuous Current
20: 20A Peak Current, 10A Continuous Current
25: 25A Peak Current, 12.5A Continuous Current
40: 40A Peak Current, 20A Continuous Current
60: 60A Peak Current, 30A Continuous Current

TABLE 2.2 Power Specifications

Description	Units	CA_10A36	CA_6A80	CA_12A80	CA_20A80	CA_40A80	CA_60A80	CA_10A175	CA_25A175
DC Supply Voltage Range	VDC	10-36	20-80		10-80			40-175	
DC Bus Over Voltage Limit	VDC	40	88					195	193
DC Bus Under Voltage Limit	VDC	8	18		9			36	
Maximum Peak Output Current	A	10	6	12	20	40	60	10	25
Maximum Continuous Output Current	A	5	3	6	12	20	30	6	12.5
Maximum Power Dissipation at Continuous Current	W	9	12	24	48	80	120	53	110
Minimum Load Inductance	μH	100	100					250	
Switching Frequency[1]	kHz	40	31					20.7	

1. Switching frequency for CABE/CABH_40A80 and CABE/CABH_60A80 drive models is 33 kHz. Switching frequency for CABE/CABH_10A175 and CABE/CABH_25A175 is 22 kHz.

Description	Units	CA_8A80X	CA_15A80X	CA_25A80X	CA_40A80X	CA_16A175X
DC Supply Voltage Range	VDC	10-80				40-175
DC Bus Over Voltage Limit	VDC	88				195
DC Bus Under Voltage Limit	VDC	9				32
Maximum Peak Output Current	A	8	15	25	40	16
Maximum Continuous Output Current	A	4	7.5	12.5	20	8
Maximum Power Dissipation at Continuous Current	W	16	30	50	80	70
Minimum Load Inductance	μH	100				

TABLE 2.3 Control Specifications

| Description	CAB(X)	CABDC(X)	CABE(X)[1]	CABH(X)[2]
Command Sources	± 10V Analog	PWM and Direction	± 10V Analog	± 10V Analog
Commutation Methods	Trapezoidal	Trapezoidal	Trapezoidal	Trapezoidal
Control Modes	Current	Current	Current, Duty Cycle, Encoder Velocity, Tachometer Velocity	Current, Duty Cycle, Hall Velocity, Tachometer Velocity
Motors Supported	Three Phase Single Phase	Three Phase Single Phase	Three Phase Single Phase	Three Phase Single Phase

1. CABE10A36 models operate solely in Encoder Velocity mode.

2. CABH10A36 models operate solely in Hall Velocity mode, and support only three phase (brushless) motors.

2.3 Analog PWM Servo Drive Basics and Theory

Analog servo drives are used extensively in motion control systems where precise control of position and/or velocity is required. The drive transmits the low-energy reference signals from the controller into high-energy signals (motor voltage and current). The reference signals can be either analog or digital, with a ±10 VDC signal being the most common. The signal can represent either a motor torque or velocity demand.

Figure 2.1 shows the components typically used in a servo system (i.e. a feedback system used to control position, velocity, and/or acceleration). The controller contains the algorithms to close the desired servo loops and also handles machine interfacing (inputs/outputs, terminals, etc.). The drive represents the electronic power converter that drives the motor according to the controller reference signals. The motor (which can be of the brushed or brushless type, rotary, or linear) is the actual electromagnetic actuator, which generates the forces required to move the load. Feedback elements are mounted on the motor and/or load in order to close the servo loop.

FIGURE 2.2 Typical Motion Control System
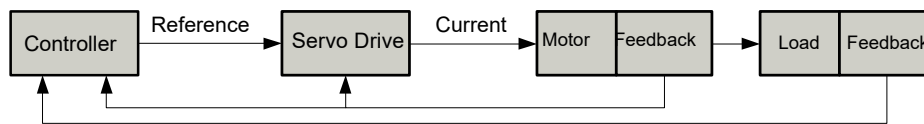
Although there exist many ways to "amplify" electrical signals, pulse width modulation (PWM) is by far the most efficient and cost-effective approach. At the basis of a PWM servo drive is a current control circuit that controls the output current by varying the duty cycle of the output power stage (fixed frequency, variable duty cycle). Figure 2.2 shows a typical setup for a single phase load.

FIGURE 2.3 PWM Current Control Circuit
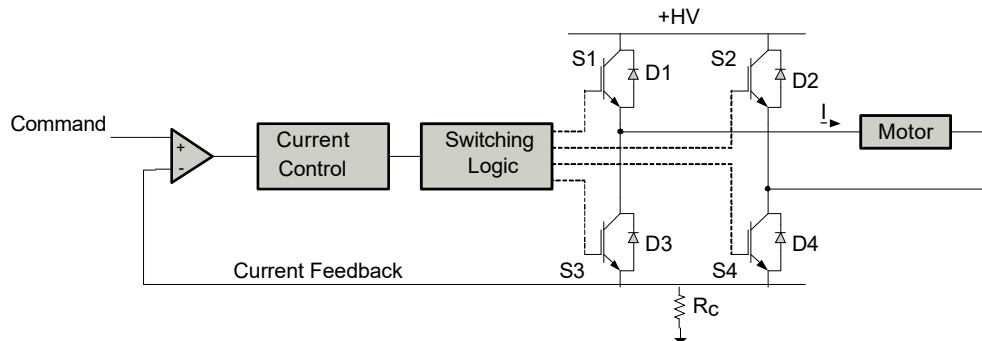
S1, S2, S3, and S4 are power devices (MOSFET or IGBT) that can be switched on or off. D1, D2, D3, and D4 are diodes that guarantee current continuity. The bus voltage is depicted by +HV.

The resistor R_C is used to measure the actual output current. For electric motors, the load is typically inductive due to the windings used to generate electromagnetic fields. The current can be regulated in both directions by activating the appropriate switches. When switch S1 and S4 (or S2 and S3) are activated, current will flow in the positive (or negative) direction and increase. When switch S1 is off and switch S4 is on (or S2 off and S3 on) current will flow in the positive (or negative) direction and decrease (via one of the diodes).

The switch "ON" time is determined by the difference between the current demand and the actual current. The current control circuit will compare both signals every time interval (typically 50 sec or less) and activate the switches accordingly (this is done by the switching logic circuit, which also performs basic protection functions). Figure 2.3 shows the relationship between the pulse width (ON time) and the current pattern. The current rise time will depend on the bus voltage(+HV) and the load inductance. Therefore, certain minimum load inductance requirements are necessary depending on the bus voltage.

FIGURE 2.4 Output Current and Duty Cycle Relationship
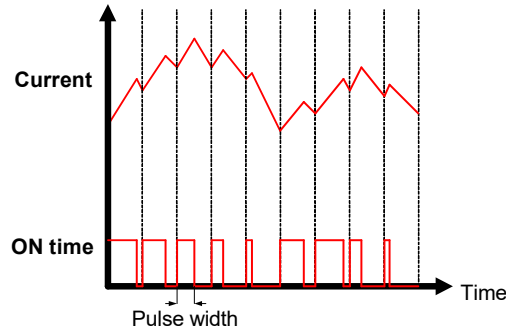
## 2.3.1 Single Phase (Brushed) Motors

Golden Ding Analog Servo Drives can be used with permanent magnet brushed DC motors (PMDC motors). PMDC motors have a single winding (armature) on the rotor, and permanent magnets on the stator (no field winding). Brushes and commutators maintain the optimum torque angle. The torque generated by a PMDC motor is proportional to the current, giving it excellent dynamic control capabilities in motion control systems.

Golden Ding Analog Servo Drives can also be used to control current in other inductive loads such as voice coil actuators, magnetic bearings, etc.

2.3.2 Three Phase (Brushless Motors

Golden Ding Analog Servo Drives are designed for use with brushless servo motors. These motors typically have a three-phase winding on the stator and permanent magnets on the rotor. Brushless motors require commutation feedback for proper operation (the commutators and brushes perform this function on brush type motors). This feedback consists of rotor magnetic field orientation information, supplied either by magnetic field sensors (Hall Effect sensors) or position sensors (encoder or resolver). Brushless motors have better power density ratings than brushed motors because heat is generated in the stator, resulting in a shorter thermal path to the outside environment. Figure 2.4 shows a typical system configuration.

FIGURE 2.5 Brushless Servo System
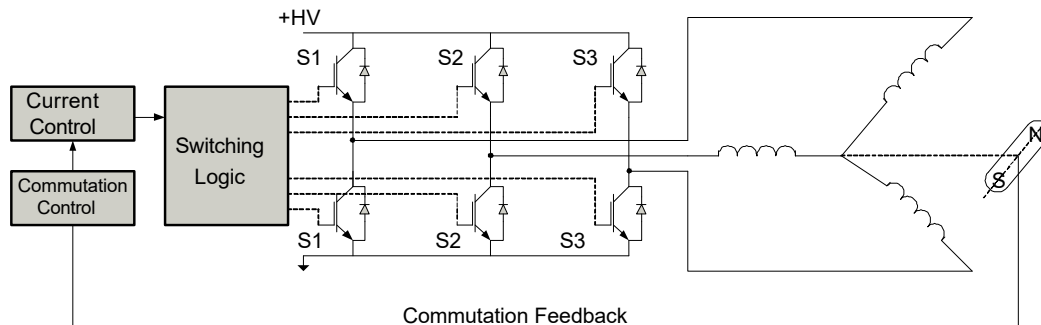
2.4 Control Modes

The Golden Ding Analog family of drives offers a variety of different control methods. While some drives in the series are designed to operate solely in one mode, on other drives it is possible to select the control method by DIP switch settings. Consult the datasheet for the drive in use to see which modes are available for use.

The name of the mode refers to which servo loop is being closed in the drive, not the end-result of the application. For instance, a drive operating in Current (Torque) Mode may be used for a positioning application if the external controller is closing the position loop. Oftentimes, mode selection will be dependent on the requirements and capabilities of the controller being used with the drive as well as the end-result application.

2.4.1 Current (Torque)

In Current (Torque) Mode, the input command voltage controls the output current. The drive will adjust the output duty cycle to maintain the commanded output current. This mode is used to control torque for rotary motors (force for linear motors), but the motor speed is not controlled. The output current can be monitored through an analog current monitor output pin. The voltage value read at the "Current Monitor Output" can be multiplied by a scaling factor found on the drive datasheet to determine the actual output current. All Golden Ding series analog drives are able to operate in Current (Torque) Mode.

> **i**
> Note
>
> While in Current (Torque) Mode, the drive will maintain a commanded torque output to the motor based on the input reference command. Sudden changes in the motor load may cause the drive to be outputting a high torque command with little load resistance, causing the motor to spin rapidly. Therefore, Current (Torque) Mode is recommended for applications using a digital position controller to maintain system stability.

2.4.2 Duty Cycle (Open Loop)

In Duty Cycle Mode, the input command voltage controls the output PWM duty cycle of the drive, indirectly controlling the output voltage. However, any fluctuations of the DC power supply voltage will affect the voltage output to the motor. This mode is available as a DIP switch selectable mode on CABE(X) and CABH(X) drives, and is the sole mode of operation on the CABD10A36 model.

> **i**
> Note
>
> This mode is recommended as a method of controlling the motor velocity when precise velocity control is not critical to the application, and when actual velocity feedback is unavailable.

2.4.3 Hall Velocity

The Hall Sensor frequency closing the velocity loop. An analog velocity monitor output allows observation of the actual motor speed through a Hz/V scaling factor found on the drive datasheet. The voltage value read at the velocity monitor output can be used to determine the motor RPM through the scaling factor. See "Velocity Monitor Output" for the motor RPM equation. This mode is available as a DIP switch selectable mode on CABH(X) drives, and is the sole mode of operation on the CABH10A36 model.

> **i**
> **Note**
>
> Due to the inherent low resolution of motor mounted Hall Sensors, Hall Velocity Mode is not recommended for low-speed applications below 300 rpm for a 6-pole motor, 600 rpm for a 4-pole motor, or 900 rpm for a 2-pole motor. Hall Velocity Mode is better suited for velocity control applications where the motor will be spinning at higher speeds.

2.4.4 Encoder Velocity

In Encoder Velocity Mode, the input command controls the motor velocity, with the frequency of the encoder pulses closing the velocity loop. An analog velocity monitor output allows observation of the actual motor speed through a kHz/V scaling factor found on the drive datasheet. The voltage value read at the velocity monitor output can be used to determine the motor RPM through the scaling factor. See "Velocity Monitor Output" for the motor RPM equation. This mode is available as a DIP switch selectable mode on CABE(X) drives.

> **i**
> **Note**
>
> The high resolution of motor mounted encoders allows for excellent velocity control and smooth motion at all speeds. Encoder Velocity mode should be used for applications requiring precise and accurate velocity control, and is especially useful in applications where low-speed smoothness is the objective.

2.4.5 Tachometer Velocity

In Tachometer Velocity Mode, the input command voltage controls the motor velocity. This mode uses an external DC tachometer to close the velocity loop. The drive translates the DC voltage from the tachometer into motor speed and direction information. This mode is available as a DIP switch selectable mode on certain CABE and CABH drives.

> **i**
> **Note**
>
> DC Tachometers have infinite resolution, allowing for extremely accurate velocity control. However, they also may be susceptible to electrical noise, most notably at low speeds.

2.5 Feedback Supported

There are a number of different feedback options available in the Golden Ding analog family of drives. The feedback element can be any device capable of generating a voltage signal proportional to current, velocity, position, or any parameter of interest. Such signals can be provided directly by a potentiometer or indirectly by other feedback devices such as Hall Sensors or Encoders. These latter devices must have their signals converted to a DC voltage, a task performed by the drive circuitry.

TABLE 2.4 Feedback Supported

Description	Feedback Supported			
	CAB(X)	CABDC(X)	CABE(X)	CABH(X)
Hall Sensors for Commutation	✔	✔	✔	✔
Hall Sensors for Velocity Control				✔
Single- Ended Incremental Encoder			✔	
Tachometer			✔	✔

2.5.1 Feedback Polarity

The feedback element must be connected for negative feedback. This will cause a difference between the command signal and the feedback signal, called the *error signal*. The drive compares the feedback signal to the command signal to produce the required output to the load by continually reducing the error signal to zero. For Golden Ding analog series drives, this becomes important when using "Encoder Feedback" and "Hall Sensors", as connecting these feedback elements for positive feedback will lead to a motor "run-away" condition. In a case where the feedback lines are connected to the drive with the wrong polarity in either Hall Velocity or Encoder Velocity Mode, the drive will attempt to correct the "error signal" by applying more command to the motor. With the wrong feedback polarity, this will result in a positive feedback run-away condition. To correct this, either change the order that the feedback lines are connected to the drive, or change the DIP switch settings to reverse the internal feedback velocity polarity. See the drive datasheet for more information on DIP switch settings. Some drives may feature a removable jumper to reverse the velocity polarity.

2.5.2 Hall Sensors

Golden Ding analog series drives use single-ended Hall Sensors for commutation feedback, and in the special case of the CABH drives, for velocity control. The Hall Sensors (typically three) are built into the motor to detect the position of the rotor magnetic field. These sensors are mounted such that they each generate a square wave with 120-degree phase difference over one electrical cycle of the motor. Depending on the motor pole count, there may be more than one electrical cycle for every motor revolution. For every actual mechanical motor revolution, the number of electrical cycles will be the number of motor poles divided by two. For example:

➢ a 6-pole motor contains 3 electrical cycles per motor revolution
➢ a 4-pole motor contains 2 electrical cycles per motor revolution
➢ a 2-pole motor contains 1 electrical cycle per motor revolution

The drive powers two of the three motor phases with DC current during each specific Hall Sensor state as shown in Figure 2.6.

FIGURE 2.6 Hall Sensor Commutation and Motor Phase Current for 120-Degree Phasing
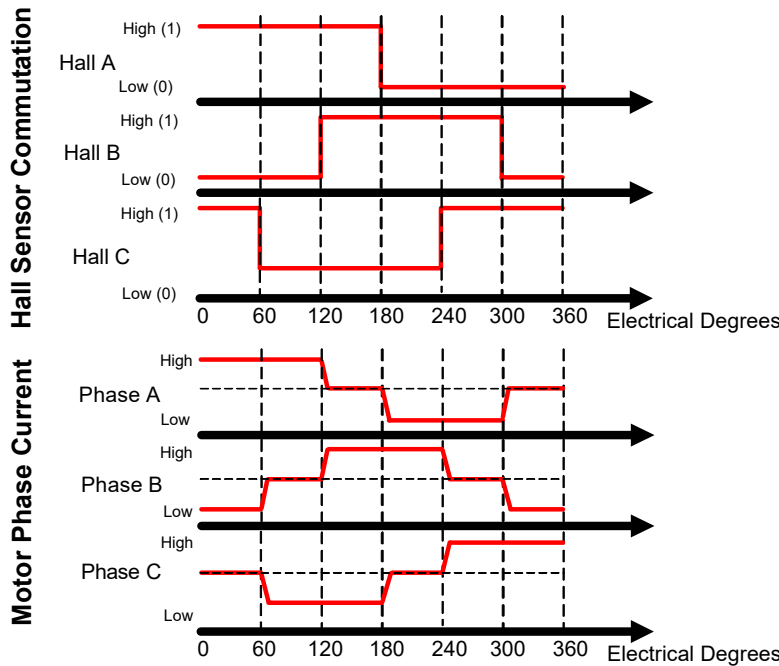
Note: Not all AMC China's servo drive series use the same commutation logic. The commutation diagrams provided here should be used only with drives covered within this manual.

The table below shows the valid commutation states for both 120-degree and 60-degree phasing.

TABLE 2.5 Commutation Sequence Table

	60 Degree			120 Degree			Motor		
	Hall 1	Hall 2	Hall 3	Hall 1	Hall 2	Hall 3	Phase A	Phase B	Phase C
Valid	1	0	0	1	0	0	HIGH	-	LOW
	1	1	0	1	1	0	-	HIGH	LOW
	1	1	1	0	1	0	LOW	HIGH	-
	0	1	1	0	1	1	LOW	-	HIGH
	0	0	1	0	0	1	-	LOW	HIGH
	0	0	0	1	0	1	HIGH	LOW	-
Invalid	1	0	1	1	1	1	-	-	-
	0	1	0	0	0	0	-	-	-

By default, Golden Ding series analog drives are always set to 120-degree phasing. However, certain drives feature either a surface-mount jumper (JE2) on the drive PCB that can be removed to manually set the drive to 60-degree phasing, or a DIP Switch that can configure the drive for 60-degree phasing. If necessary, please contact AMC China to make factory settings.

Using a Single Phase Motor

Golden Ding series analog drives are also compatible with Single Phase (Brushed) motors (CABH10A36 excepted). However, because there are no Hall Sensors on a brushed motor, one of the following course of actions must be taken to properly commutate the drive:

➢ Remove the JE2 jumper to set the drive for 60-degree phasing . Leave all the Hall Sensor inputs on the drive open. These inputs are internally pulled high to +5V, creating a "1-1-1" commutation state (see Table 2.5 above) which is a valid state

> Remove the JE2 jumper to set the drive for 60-degree phasing . Leave all the Hall Sensor inputs on the drive open. These inputs are internally pulled high to +5V, creating a "1-1-1" commutation state (see Table 2.5 above) which is a valid state in 60-degree phasing. Connect only two of the motor output wires, Motor A and Motor B.
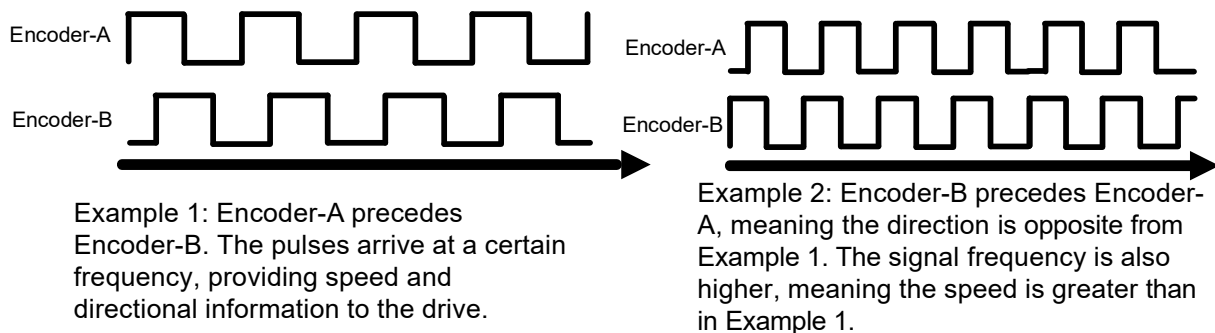
or:

> Tie one of the Hall Sensor inputs on the drive to signal ground. Since the Hall Sensor inputs are by default internally brought high to +5V, this will put the drive in a commutation state where two Hall inputs are high, and one is low (as shown in Table 2.5, having all three Hall inputs pulled high is an invalid commutation state in 120-degree phasing). Depending on which Hall Sensor input is tied to ground, consult Table 2.5 above to determine which two motor output wires will be conducting current for that specific commutation state.

2.5.3 Encoder Feedback

CABE(X) drives utilize two single-ended incremental encoder inputs for velocity control. The encoder provides incremental position feedback that can be extrapolated into very precise velocity information. The encoder signals are read as "pulses" that the drive uses to essentially keep track of the motor's position and direction of rotation. Based on the speed and order in which these pulses are received from the two encoder signals, the drive can interpret the motor velocity. The diagram below represents encoder "pulse" signals, showing how dependent on which signal is read first and at what frequency the "pulses" arrive, the speed and direction of the motor shaft can be extrapolated.

FIGURE 2.7 Encoder Feedback Signals

Example 1: Encoder-A precedes Encoder-B. The pulses arrive at a certain frequency, providing speed and directional information to the drive.

Example 2: Encoder-B precedes Encoder-A, meaning the direction is opposite from Example 1. The signal frequency is also higher, meaning the speed is greater than in Example 1.

2.5.4 Tachometer Feedback

CABE(X) and most CABH(X) drives offer the option of using a DC Tachometer for velocity control. The tachometer provides an analog DC voltage feedback signal that is related to the actual motor speed and direction. The drive subsequently adjusts the output current based on the error between the tachometer feedback and the input command voltage. The maximum range of the tachometer feedback signal is ±60 VDC.

2.6 Features and Control Specifications

2.6.1 CAB(X)

➢ Designed to drive brushless/brushed motors with a ±10 V analog input
➢ Current (Torque) Mode
➢ Hall Sensor trapezoidal Commutation

2.6.2 CABDC(X)

➢ Designed to drive brushless/brushed motors with a PWM input command
➢ Current (Torque) Mode
➢ Hall Sensor trapezoidal Commutation

2.6.3 CABE(X)

➢ Designed to drive brushless/brushed motors with a ±10 V analog input
➢ DIP Switch selectable modes - Current (Torque), Duty Cycle, Encoder Velocity, Tachometer Velocity
➢ Hall Sensor trapezoidal commutation
➢ Single-ended incremental encoder feedback for velocity control
➢ External potentiometer input pin for command offset adjustment

2.6.4 CABH(X)

➢ Designed to drive brushless/brushed motors with a ±10 V analog input
➢ DIP Switch selectable modes - Current (Torque), Duty Cycle, Hall Velocity, Tachometer Velocity
➢ Hall Sensor trapezoidal commutation
➢ Single-ended Hall Sensor feedback for velocity control
➢ External potentiometer input pin for command offset adjustment

2.6.5 Block Diagrams

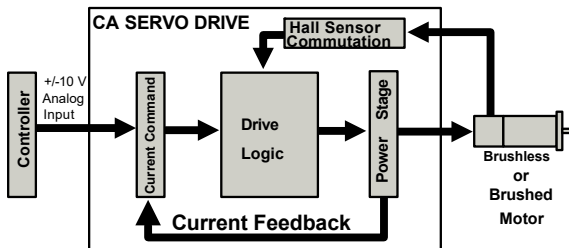**FIGURE 2.9 CAB & CAB_A80X Drive Structure**

FIGURE 2.10 CABDC & CABDC_A80X Drive Structure
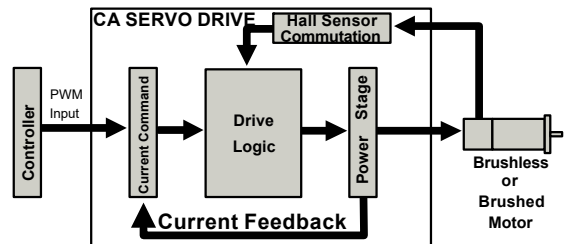

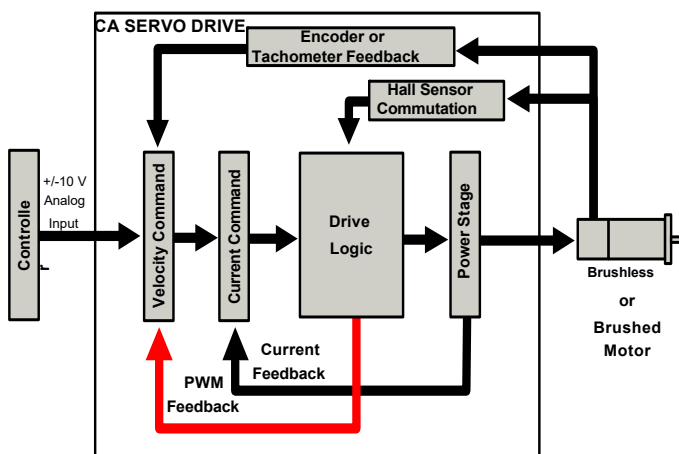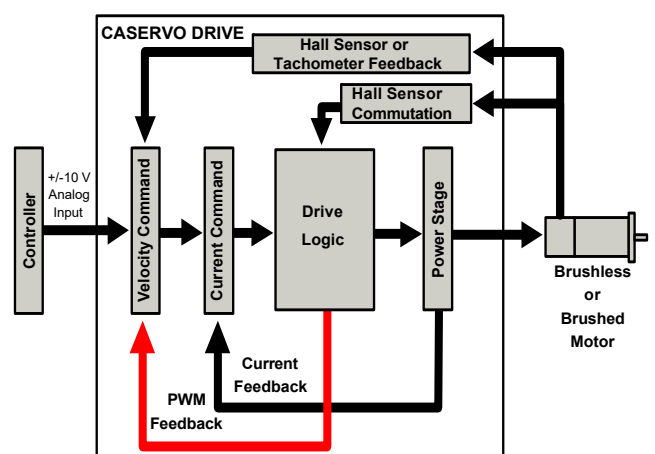**FIGURE 2.11 CABE &CABE_A80X Drive Structure**

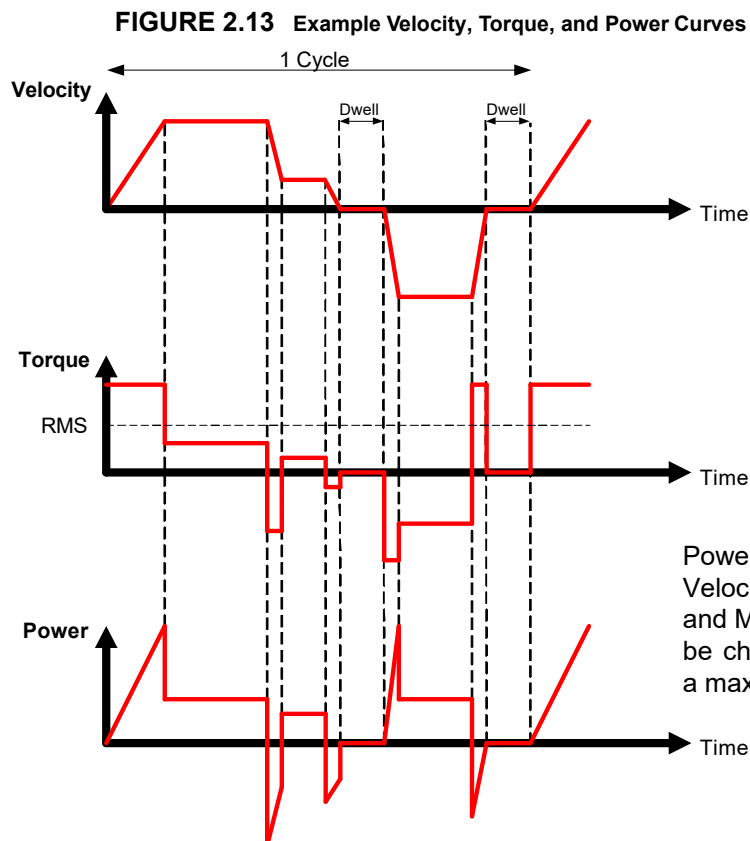**FIGURE 2.12 CABH & CABH_A80X Drive Structure**

2.7 System Requirements

To successfully incorporate a Golden Ding analog servo drive into your system, you must be sure it will operate properly based on electrical, mechanical, and environmental specifications, follow some simple wiring guidelines, and perhaps make use of some accessories in anticipating impacts on performance. Before selecting a servo drive, a user should consider the requirements of their system. This involves calculating the required voltage, current, torque, and power requirements of the system, as well as considering the operating environment and any other equipment the drive will be interfacing with.

2.7.1 Analog Servo Drive Selection and Sizing

Golden Ding series analog servo drives have a given current and voltage rating unique to each drive. Based on the necessary application requirements and the information from the datasheet of the motor being used, a drive may be selected that will best suit the motor capabilities. A drive should be selected that will meet the peak and continuous current requirements of the application, and operate within the voltage requirements of the system.

Motor Current and Voltage Motor voltage and current requirements are determined based on the maximum required torque and velocity. These requirements can be derived from the application move profiles (Figure 2.13).

FIGURE 2.13 Example Velocity, Torque, and Power Curves

Power is equal to Torque x Velocity. Motor Voltage (V_m) and Motor Current (I_m) should be chosen where power is at a maximum.

The **motor current I_M** is the required motor current in amps DC, and is related to the torque needed to move the load by the following equation:

$$I_M = \frac{Torque}{K_T}$$

Where:

K_T — motor torque constant

The motor current will need to be calculated for both continuous and peak operation. The peak torque will be during the acceleration portion of the move profile.

The continuous torque is the average torque required by the system during the move profile, including dwell times. Both peak torque and continuous, or RMS (root mean square) torque need to be calculated. RMS torque can be calculated by plotting torque versus time for one move cycle.

$$T_{RMS} = \sqrt{\frac{\sum_i T_i^2 t_i}{\sum_i t_i}}$$

Here T_i is the torque and t_i is the time during segment i. In the case of a vertical application make sure to include the torque required to overcome gravity.

The system voltage requirement is based on the motor properties and how fast and hard the
motor is driven. The system voltage requirement is equal to the **motor voltage**, **V_M**, required to achieve the move profile. In general, the motor voltage is proportional to the motor speed and the motor current is proportional to the motor shaft torque. Linear motors exhibit the same behavior except that in their case force is proportional to current. These relationships are described by the following equations:

$$V_m = I_m R_m + E$$

$$E = K_e S_m$$

for rotary motors $\qquad T = K_t I_m$

for linear motors $\qquad F = K_f I_m$

Where:

    V_m -motor voltage

    I_m -motor current (use the maximum current expected for the application)

    R_m -motor line-to-line resistance

    E   -motor back-EMF voltage

    T   -motor torque

    F   -motor force

    K_t -motor torque constant

    K_f -motor force constant

    K_e -voltage constant

    S_m -motor speed (use the maximum speed expected for the application)

The motor manufacturer's data sheet contain K_t (or K_f) and K_e constants. Pay special attention to the units used (metric vs. English) and the amplitude specifications (peak-to-peak vs. RMS, phase-to-
phase vs. phase-to-neutral).

The maximum motor terminal voltage and current can be calculated from the above equations. For example, a motor with a K_e = 10V/Krpm and required speed of 3000 RPM would require 30V to operate. In this calculation the IR term (voltage drop across motor
winding resistance) is disregarded. Maximum current is maximum torque divided by K_t. For example, a motor with K_t = 0.5 Nm/A and maximum torque of 5 Nm would require 10 amps of current. Continuous current is RMS torque divided by K_t.

Motor Inductance

The motor inductance is vital to the operation of servo drives, as it ensures that the DC motor current is properly filtered.

Caution

A motor that does not meet the rated minimum inductance value of the drive may damage the drive! If the motor inductance value is less than the minimum required for the selected drive, use of an external filter card is necessary. See "Inductive Filter Cards" for more information.

A minimum motor inductance rating for each specific drive can be found in the drive datasheet. If the drive is operated below the maximum rated voltage, the minimum load inductance requirement may be reduced.

In the above equations the motor inductance is neglected. In brushless systems the voltage drop caused by the motor inductance can be significant. This is the case in high-speed applications if motors with high inductance and high pole count are used. Please use the following equation to determine motor terminal voltage (must be interpreted as a vector).

$$V_m = (R_m + j\omega L)I_m + E$$

    Where:

        L   -phase-to-phase motor inductance

        ω -maximum motor current frequency

2.7.2 Power Supply Selection and Sizing

There are several factors to consider when selecting a power supply for a Golden Ding series analog servo drive.

➢ Power Requirements
➢ Isolation
➢ Regeneration
➢ Voltage Ripple

Power Requirements refers to how much voltage and current will be required by the drive in the system. Isolation refers to whether the power supply needs an isolation transformer. Regeneration is the energy the power supply needs to absorb during deceleration. Voltage Ripple is the voltage fluctuation inherent in unregulated supplies.

Power Supply Current and Voltage

The power supply current rating is based on the maximum current that will be required by the system. If the power supply powers more than one drive, then the current requirements for each drive should be added together. Due to the nature of servo drives, the current into the drive does not always equal the current out of the drive. However, the power in is equal to the power out. Use the following equation to
calculate the power supply output current, I_{PS}, based on the motor voltage and current requirements.

$$I_{PS} = \frac{V_M \cdot I_M}{V_{PS} \cdot (0.98)}$$

Where:

V_{PS}	-nominal power supply voltage
I_M	-motor current
V_M	-motor voltage

Use values of V_m and I_m at the point of maximum power in the move profile, Figure 2.13 (when $V_M I_M$ = max). This will usually be at the end of a hard acceleration when both the torque and speed of the motor is high.
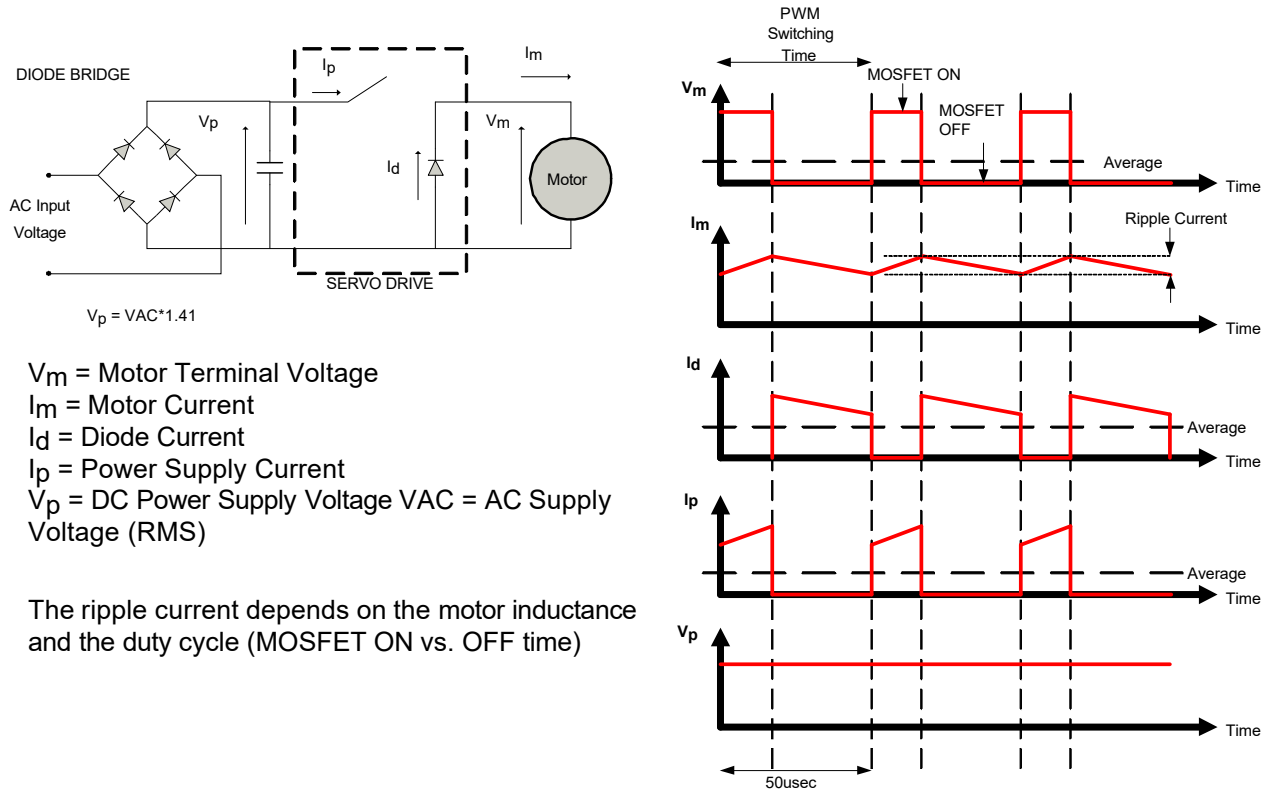
The power supply current is a pulsed DC current (Figure 2.14): when the MOSFET switch is on, it equals the motor current; when the MOSFET is off it is zero. Therefore, the power supply current is a function of the PWM duty cycle and the motor current (e.g. 30% duty cycle and 12 amps motor current will result in 4 amps power supply current). 30% duty cycle also means that the average motor voltage is 30% of the DC bus voltage. Power supply power is approximately equal to drive output power plus 3 to 5%.

⚠ The only time the power supply current needs to be as high as the drive output current is if the move profile requires maximum current at maximum velocity. In many cases however, maximum current is only required at start up and lower currents are required at higher speeds.

Caution

FIGURE 2.14 Unregulated DC Power Supply Current

V_p = VAC*1.41

V_m = Motor Terminal Voltage
I_m = Motor Current
I_d = Diode Current
I_p = Power Supply Current
V_p = DC Power Supply Voltage VAC = AC Supply
Voltage (RMS)

The ripple current depends on the motor inductance
and the duty cycle (MOSFET ON vs. OFF time)

A system will need a certain amount of voltage and current to operate properly. If the power supply has too little voltage/current the system will not perform adequately. If the power supply has too much voltage the drive may shut down due to over voltage, or the drive may be damaged.

To avoid nuisance over- or under-voltage errors caused by fluctuations in the power supply, the ideal system power supply voltage should be at least 10% above the entire system voltage requirement, and at least 10% below the lowest value of the following:

— Drive over voltage
— External shunt regulator turn-on voltage (see "Regeneration and Shunt Regulators")

These percentages also account for the variances in K_t and K_e, and losses in the system external to the drive. The selected margin depends on the system parameter variations.

Do not select a supply voltage that could cause a mechanical over-speed in the event of a drive malfunction or a runaway condition.

Brushed Motors may have voltage limitations due to the mechanical commutators. Consult the manufacturer's data sheets.

Caution

Golden Ding series analog servo drives operate off an isolated unregulated DC Power Supply (see Table 2.2 for drive model power supply ranges and over-voltage shutdown values). Figure 2.15 provides one possible example of an appropriate system power supply voltage for an CA_20A80 drive using an external shunt regulator. The shunt regulator turn-on voltage was chosen at an appropriate level to clamp the power supply voltage so it will not exceed the drive over voltage limit during regeneration. The system power supply requirement is based on the motor properties and how much voltage is needed to achieve the application move profile (see "Motor Current and Voltage"). Keep in mind that the calculated value for V_m is the minimum voltage required to complete moves at the desired speed and torque. There should be at least 10% headroom between the calculated value and the actual power supply voltage to allow for machine changes such as increased friction due to wear, change in load, increased operating speed, etc.

FIGURE 2.15 **CA_20A80(X) Power Supply Selection**
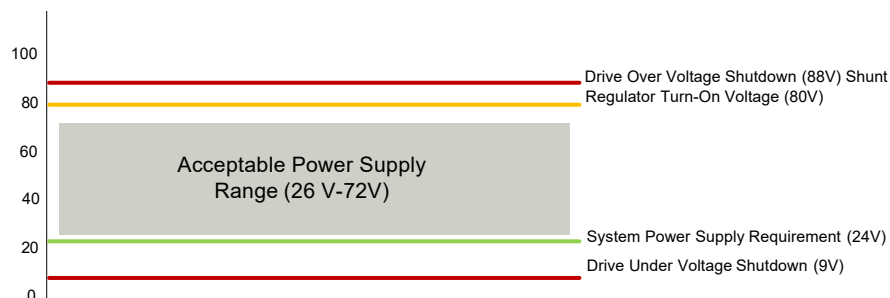
Isolation

In systems where an AC line is involved, isolation is required between theAC line andthe signal pins on the drive. This applies to all systems except those that use a battery as a power supply. There are two options for isolation:

1. The drive can have built in electrical isolation.
2. The power supply can provide isolation (e.g. a battery or an isolation transformer).

The system must have at least one of these options to operate safely.
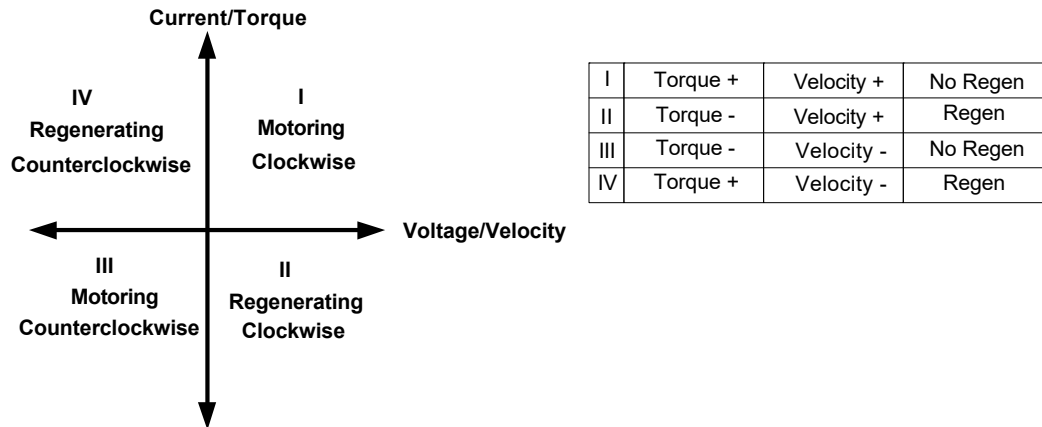
Power Supply with Isolation

An isolated power supply is either a battery or a power supply that uses an isolation transformer to isolate the AC line voltage from the power supply ground. This allows both the power ground on an isolated power supply and the signal ground on a non-isolated drive to be safely pulled to earth ground. Always use an isolated power supply if there is no isolation in the drive.

Regeneration and Shunt Regulators

Use of a shunt regulator is necessary in systemswhere motor deceleration or a downward motion of the motor load will cause the system's mechanical energy to be regenerated via the drive back onto the power supply.

FIGURE 2.16 Four Quadrant Operation - Regeneration occurs when Torque and Velocity polarity are opposite

I	Torque +	Velocity +	No Regen
II	Torque -	Velocity +	Regen
III	Torque -	Velocity -	No Regen
IV	Torque +	Velocity -	Regen

This regenerated energy can charge the power supply capacitors to levels above that of the drive over-voltage shutdown level. If the power supply capacitance is unable to handle this excess energy, or if it is impractical to supply enough capacitance, then an external shunt regulator must be used to dissipate the regenerated energy. Shunt regulators are essentially a resistor placed in parallel with the DC bus. The shunt regulator will "turn-on" at a certain voltage level (set below the drive over-voltage shutdown level) and discharge the regenerated electric energy in the form of heat.

The voltage rise on the power supply capacitors without a shunt regulator, can be calculated according to a simple energy balance equation. The amount of energy transferred to the power supply can be determined through:

$$E_i = E_f$$

Where:

E_i	-initial energy
E_f	-final energy

These energy terms can be broken down into the approximate mechanical and electrical terms - capacitive, kinetic, and potential energy. The energy equations for these individual components are as follows:

$$E_c = \frac{1}{2}CV_{nom}^2$$

Where:

E_c	-energy stored in a capacitor (joules)
C	-capacitance
V_{nom}	-nominal bus voltage of the system

$$E_r = \frac{1}{2}J\omega^2$$

Where:

E_r -kinetic (mechanical) energy of the load (joules)

J -inertia of the load (kg-m^2)

ω -angular velocity of the load (rads/s)

$$E_p = mgh$$

Where:

E_p -potential mechanical energy (joules)

m -mass of the load (kg)

g -gravitational acceleration (9.81 m/s^2)

h -vertical height of the load (meters)

During regeneration the kinetic and potential energy will be stored in the power supply's capacitor. To determine the final power supply voltage following a regenerative event, the following equation may be used for most requirements:

$$(E_c \cdot E_r \cdot E_p)_i = (E_c \cdot E_r \cdot E_p)_f$$

$$\frac{1}{2}CV_{nom}^2 + \frac{1}{2}J\omega_i^2 + mgh_i = \frac{1}{2}CV_f^2 + \frac{1}{2}J\omega_f^2 + mgh_f$$

Which simplifies to:

$$V_f = \sqrt{V_{nom}^2 + \frac{J}{C}(\omega_i - \omega_f^2) + \frac{2mg(h_i - h_f)}{C}}$$

The V_f calculated must be below the power supply capacitance voltage rating and the drive over voltage limit. If this is not the case, a shunt regulator is necessary. A shunt regulator is sized in the same way as a motor or drive, i.e. continuous and RMS power dissipation must be determined. The power dissipation requirements can be determined from the application move profile (see Figure 2.13).

AMC China offers a variety of shunt regulators for servo drives. When choosing a shunt regulator, select one with a shunt voltage that is greater than the DC bus voltage of the application but less than the over voltage shutdown of the drive. Verify the need for a shunt regulator by operating the servo drive under the worst-case braking and deceleration conditions. If the drive shuts off due to over-voltage, a shunt regulator is necessary. Golden Ding series analog servo drives have integrated regenerative and shunt regulators.

Continuous Regeneration

In the special case where an application requires continuous regeneration (more than a few seconds) then a shunt regulator may not be sufficient to dissipate the regenerative energy. Please contact AMC China for possible solutions to solve this kind of application. Some examples:

> ➢ Web tensioning device
> ➢ Electric vehicle rolling down a long hill
> ➢ Spinning mass with a very large inertia (grinding wheel, flywheel, centrifuge)
> ➢ Heavy lift gantry

Voltage Ripple

For the most part, AMC China Golden Ding series analog servo drives are unaffected by voltage ripple from the power supply. The current loop is fast enough to compensate for 60 Hz fluctuations in the bus voltage, and the components in the drive are robust enough to withstand all but the most extreme cases. Peak to peak voltage ripple as high as 25 V is acceptable.

There are some applications where the voltage ripple can cause unacceptable performance. This can become apparent where constant torque or force is critical or when the bus voltage is pulled low during high speed and high current applications. If necessary, the voltage ripple from the power supply can be reduced, either by switching from single phase AC to three phase AC, or by increasing the capacitance of the power supply.

The voltage ripple for a system can be estimated using the equation:

$$V_R = \frac{I_{PS}}{C_{PS}} F_f$$

Where:

V_R -voltage ripple
C_{PS} -power supply capacitance
I_{PS} -power supply output current
F_f -frequency factor (1/hertz)

The power supply capacitance can be estimated by rearranging the above equation to solve for the capacitance as:

$$C_{PS} = \frac{I_{PS}}{V_R} F_f$$

The frequency factor can determined from:

$$F_f = \frac{0.42}{f}$$

where f is the AC line frequency in hertz. Note that for half wave rectified power supplies, f = f/2.

The power supply output current, if unknown, can be estimated by using information from the output side of the servo drive as given below:

$$I_{PS} = \frac{V_M \cdot I_M}{V_{PS} \cdot (0.98)}$$

Where:

I_M	-current through the motor
V_{PS}	-nominal power supply voltage
V_M	-motor voltage (see "Motor Current and Voltage" on page 14)

2.7.3 Environment

To ensure proper operation of a Golden Ding series analog servo drive, it is important to evaluate the operating environment prior to installing the drive.

TABLE 2.7 Environmental Specifications

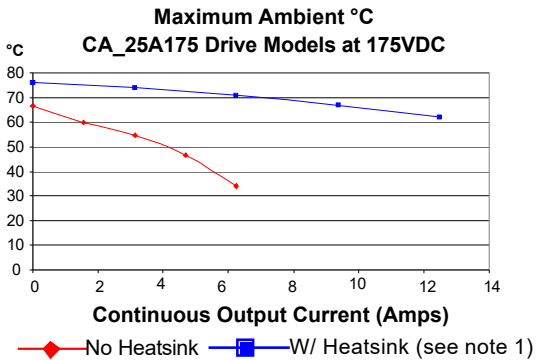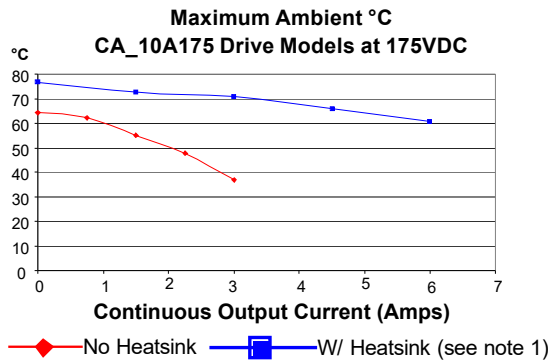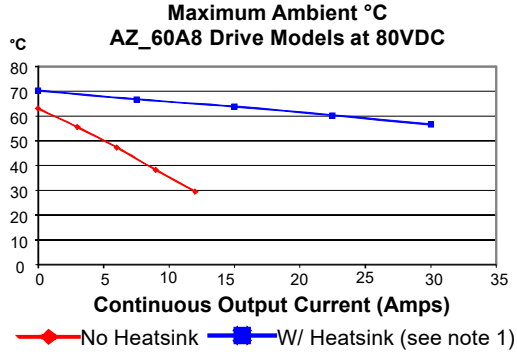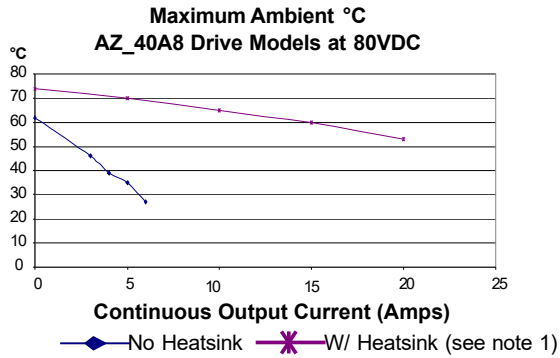| Standard Golden Ding Analong Servo Drive Family Environmental Specifications (CAB, CABDC, CABE,CABH)	
Parameter	**Description**
Baseplate Temperature Range	See drive datasheet
Humidity	90%, non-condensing
Mechanical Shock	10g, 11ms, Half-sine
Vibration	2 - 2000 Hz @ 2.5g
Altitude	0-3000m

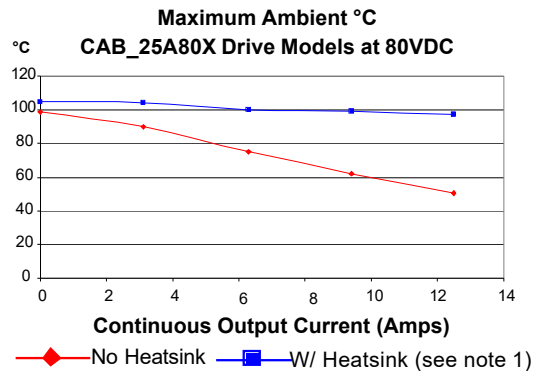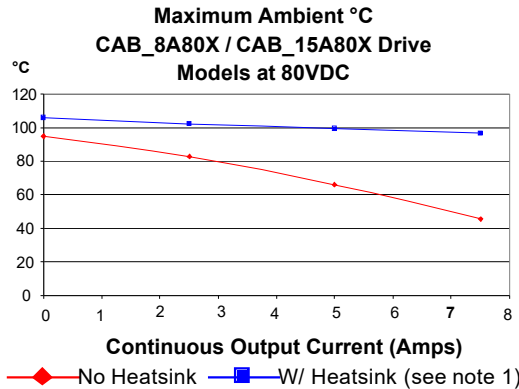| Special Environment Golden Ding Analog Servo Drive Family Environmental Specifications (CAB_X, CABDC_X, CABE_X, CABH_X)	
Parameter	**Description**
Baseplate Operating Temperature Range	-40 to 105 ºC (-40 to 221 ºF)
Storage Temperature Range	-50 to 100 ºC (-58 to 212 ºF)
Thermal Shock	-40 - 85 ºC (-40 to 185 ºF) in 2 minutes
Relative Humidity	0-95%, non-condensing
Mechanical Shock	15g, 11ms, Half-sine
Vibration	30 Grms for 5 minutes in 3 axes
Altitude	0-3000m

Ambient Temperature Range and Thermal Data

Golden Ding series analog drives contain a built-in over-temperature disabling feature if the baseplate temperature rises above a certain value. For a specific continuous output current, the graphs below specify an upper limit to the ambient temperature range Golden Ding Series Analog drives can operate within while keeping the baseplate temperature below the over-temperature value.

FIGURE 2.17 **Golden Ding series analog Servo Drives Ambient Temperature Ranges**

**Maximum Ambient °C
AZ_40A8 Drive Models at 80VDC**

Continuous Output Current (Amps)

◆ No Heatsink   ✳ W/ Heatsink (see note 1)

**Maximum Ambient °C
AZ_60A8 Drive Models at 80VDC**

Continuous Output Current (Amps)

◆ No Heatsink   ■ W/ Heatsink (see note 1)

**Maximum Ambient °C
CA_10A175 Drive Models at 175VDC**

Continuous Output Current (Amps)

◆ No Heatsink   ■ W/ Heatsink (see note 1)

**Maximum Ambient °C
CA_25A175 Drive Models at 175VDC**

Continuous Output Current (Amps)

◆ No Heatsink   ■ W/ Heatsink (see note 1)

1.   The heatsink used in the above tests is a 15" x 22" x 0.65" aluminum plate.

**Maximum Ambient °C
CAB_8A80X / CAB_15A80X Drive
Models at 80VDC**

Continuous Output Current (Amps)

◆ No Heatsink   ■ W/ Heatsink (see note 1)

**Maximum Ambient °C
CAB_25A80X Drive Models at 80VDC**

Continuous Output Current (Amps)

◆ No Heatsink   ■ W/ Heatsink (see note 1)

1.   The heatsink used in the above tests is a 15" x 22" x 0.65" aluminum plate.
2.   Contact AMC China for CAB_40A80X and CAB_16A175X thermal data.

Shock/Vibrations

While Golden Ding series analog drives are designed to withstand a high degree of mechanical shock and vibration, too much physical abuse can cause erratic behavior, or cause the drive to cease operation entirely. Be sure the drive is securely mounted in the system to reduce the shock and vibration the drive will be exposed to.

3. Installation

This chapter will provide various detailed information about installing the Golden Ding servo drive, such as the definition of the drive interface, how to properly ground the drive and the entire system, and how to correctly connect the motor line, power line, feedback line and drive input and so on

3.1 Low Voltage Directive Requirements(LVD)

The servo drives covered in the LVD Reference report were investigated as components intended to be installed in complete systems that meet the requirements of the Machinery Directive. In order for these units to be acceptable in the end users' equipment, the following conditions of acceptability must be met.

1. European approved overload and current protection must be provided for the motors as specified in section 7.2 and 7.3 of EN60204.1.

2. A disconnect switch shall be installed in the final system as specified in section 5.3 of EN60204.1.

3. All drives that do not have a grounding terminal must be installed in, and conductively connected to a grounded end use enclosure in order to comply with the accessibility requirements of section 6, and to establish grounding continuity for the system in accordance with section 8 of EN60204.1.

4. A disconnecting device that will prevent the unexpected start-up of a machine shall be provided if the machine could cause injury to persons. This device shall prevent the automatic restarting of the machine after any failure condition shuts the machine down.

5. European approved over current protective devices must be installed in line before the servo drive, these devices shall be installed and rated in accordance with the installation instructions (the installation instructions shall specify an over current rating value as low as possible, but taking into consideration inrush currents, etc.). Servo drives that incorporate their own primary fuses do not need to incorporate over protection in the end users' equipment.

3.2 CE-EMC Wiring Requirements

The following sections contain installation instructions necessary for meeting EMC requirements.

General

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

Analog Input Drives

4. A Fair Rite model 0443167251 round suppression core must be fitted to the low level signal interconnect cables to prevent pickup from external RF fields.

PWM Input Drives

5. A Fair Rite model 0443167251 round suppression core must be fitted to the PWM input cable to reduce electromagnetic emissions.

MOSFET Switching Drives

6. A Fair Rite model 0443167251 round suppression core must be fitted at the load cable connector to reduce electromagnetic emissions.
7. An appropriately rated Cosel TAC series AC power filter in combination with a Fair Rite model 5977002701 torroid (placed on the supply end of the filter) must be fitted to the AC supply to any MOSFET drive system in order to reduce conducted emissions fed back into the supply network.

IGBT Switching Drives

8. An appropriately rated Cosel TAC series AC power filter in combination with a Fair Rite model 0443167251 round suppression core (placed on the supply end of the filter) must be fitted to the AC supply to any IGBT drive system in order to reduce conducted emissions fed back into the supply network.
9. A Fair Rite model 0443164151 round suppression core and model 5977003801 torroid must be fitted at the load cable connector to reduce electromagnetic emissions.

Fitting of AC Power Filters

It is possible for noise generated by the machine to "leak" onto the main AC power, and then get distributed to nearby equipment. If this equipment is sensitive, it may be adversely affected by the noise. AC power filters can

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

3.2.1 Ferrite Suppression Core Set-up

If PWM switching noise couples onto the feedback signals or onto the signal ground, then a ferrite suppression core can be used to attenuate the noise. Take the motor leads and wrap them around the suppression core as many times as reasonable possible, usually 2-5 times. Make sure to strip back the cable shield and only wrap the motor wires. There will be two wires for single phased (brushed) motors and 3 wires for three phase (brushless) motors. Wrap the motor wires together as a group around the suppression core and leave the motor case ground wire out of the loop. The suppression core should be located as near to the drive as possible. TDK ZCAT series snap-on filters are recommended for reducing radiated emissions on all I/O cables.

3.2.2 Inductive Filter Cards

Inductive filter cards are added in series with the motor and are used to increase the load inductance in order to meet the minimum load inductance requirement of the drive. They also serve to counteract the effects of line capacitance found in long cable runs and in high voltage systems. These filter cards also have the added benefit of reducing the amount of PWM noise that couples onto the signal lines. Golden Ding series analog servo drives have reserved the position of the inductive filter card by default, and the inductive filter card can be added according to the customer's motor. If you need it, please contact ACM China.

3.3 Grounding

In most servo systems all the case grounds should be connected to a single Protective Earth (PE) ground point in a "star" configuration. Grounding the case grounds at a central PE ground point reduces the chance for ground loops and helps to minimize high frequency voltage differentials between components. All ground wires must be of a heavy gauge and be as short as possible. The following should be securely grounded at the central PE grounding point:

➢ Motor chassis
➢ Controller chassis
➢ Power supply chassis
➢ Golden Ding Analog Servo Drive

FIGURE 3.1 System Grounding
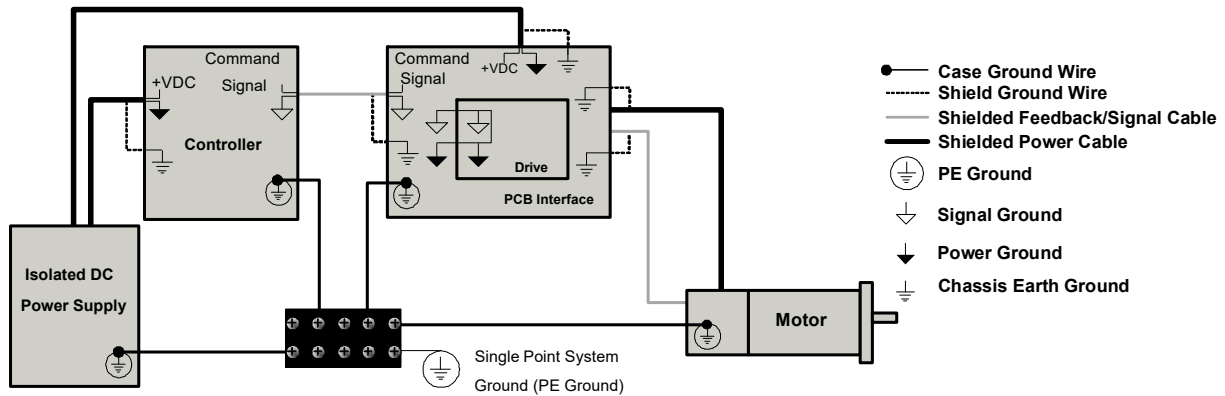
Ground cable shield wires at the mounting card or PCB interface side to a chassis earth ground point.

The DC power ground and the input reference command signal ground are oftentimes at a different potential than chassis/PE ground. The signal ground of the controller must be connected to the signal ground of the drive to avoid picking up noise due to the "floating" differential servo drive input. On all drives, the DC power ground and the input command signal ground are referenced to each other internally. In systems using an isolated DC power supply, signal ground and/or power ground can be referenced to chassis ground. First decide if this is both appropriate and safe. If this is the case, they can be grounded at the central grounding point.

> ⚠ **Warning**
>
> Grounding is important for safety. The grounding recommendations in this manual may not be appropriate for all applications and system machinery. It is the responsibility of the system designer to follow applicable regulations and guidelines as they apply to the specific servo system.

3.4 Wiring

Servo system wiring typically involves wiring a controller (digital or analog), a servo drive, a power supply, and a motor. Wiring these servo system components is fairly easy when a few simple rules are observed.

As with any high efficiency PWM servo drive, the possibility of noise and interference coupling through the cabling and wires can be harmful to overall system performance. Noise in the form of interfering signals can be coupled:

➢ Capacitively (electrostatic coupling) onto signal wires in the circuit (the effect is more serious for high impedance points).

➢ Magnetically to closed loops in the signal circuit (independent of impedance levels).

➢ Electromagnetically to signal wires acting as small antennas for electromagnetic radiation.

➢ From one part of the circuit to other parts through voltage drops on ground lines.

Experience shows that the main source of noise is the high DV/DT (typically about 1V/nanosecond) of the drive's output power stage. This PWM output can couple back to the signal lines through the output and input wires. The best methods to reduce this effect are to move signal and motor leads apart, add shielding, and use differential inputs at the drive. For extreme cases, use of an inductive filter card is recommended.

Unfortunately, low-frequency magnetic fields are not significantly reduced by metal enclosures. Typical sources are 50 or 60 Hz power transformers and low frequency current changes in the motor leads. Avoid large loop areas in signal, power-supply, and motor wires. Twisted pairs of wires are quite effective in reducing magnetic pick-up because the enclosed area is small, and the signals induced in successive twist cancel.

3.4.1 Wire Gauge

As the wire diameter decreases, the impedance increases. Higher impedance wire will broadcast more noise than lower impedance wire. Therefore, when selecting the wire gauge for the motor power wires, power supply wires, and ground wires, it is better to err on the side of being too thick rather than too thin. This recommendation becomes more critical as the cable length increases.

Current （A）	Wire Gauge （AWG）	mm^2	Current （A）	Wire Gauge （AWG）	mm^2
10	#20	0.518	60	#10	5.26
15	#18	0.823	80	#8	8.37
20	#16	1.31	120	#6	13.3
35	#14	2.08	150	#0	53.5
45	#12	3.31	200	#00	67.4

3.4.2 Motor Wires

The motor power wires supply power from the drive to the motor. Use of a twisted, shielded pair for the motor power cables is recommended to reduce the amount of noise coupling to sensitive components.

➢ For a brushed motor or voice coil, twist the two motor wires together as a group.

➢ For a brushless motor, twist all three motor wires together as a group.

Ground the motor power cable shield at one end only to the drives interface chassis ground. The motor power leads should be bundled and shielded in their own cable and kept separate from feedback signal wires.

DO NOT use wire shield to carry motor current or power!

C a u t i o n

3.4.3 Power Supply Wires

The PWM current spikes generated by the power output-stage are supplied by the internal power supply capacitors. In order to keep the current ripple on these capacitors to an acceptable level it is necessary to use heavy power supply leads and keep them as short as possible. Reduce the inductance of the power leads by twisting them. Ground the power supply cable shield at one end only to the mounting card or PCB interface chassis ground.

When multiple drives are installed in a single application, precaution regarding ground loops must be taken. Whenever there are two or more possible current paths to a ground connection, damage can occur or noise can be introduced in the system. The following rules apply to all multiple axis installations, regardless of the number of power supplies used:

1. Run separate power supply leads to each drive directly from the power supply filter capacitor.
2. Never "daisy-chain" any power or DC common connections. Use a "star"-connection instead.

3.4.4 Feedback Wires

Use of a twisted, shielded pair for the feedback wires is recommended. Ground the shield at one end only to the mounting card or PCB interface chassis ground. Route cables and/or wires to minimize their length and exposure to noise sources. The motor power wires are a major source of noise, and the motor feedback wires are susceptible to receiving noise. This is why it is never a good idea to route the motor power wires with the motor feedback wires, even if they are shielded. Although both of these cables originate at the drive and terminate at the motor, try to find separate paths that maintain distance between the two. A rule of thumb for the minimum distance between these wires is 10cm for every 10m of cable length.

FIGURE 3.2 Feedback Wiring
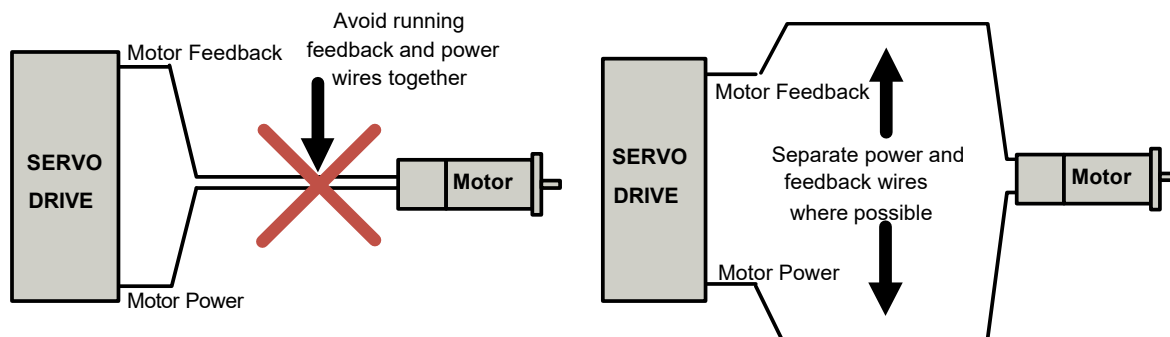
3.4.5 Input Reference Wires

Use of a twisted, shielded pair for the input reference wires is recommended. Connect the reference source "+" to "+REF IN", and the reference source "-" (or common) to "-REF IN". Connect the shield to the drive interface chassis ground. The servo drive's reference input circuit will attenuate the common mode voltage between signal source and drive power grounds. In case of a single-ended reference signal, connect the command signal to +REF IN and connect the command return and -REF IN to signal ground.

> In case of a single-ended reference signal, connect the command signal to "+ REF IN" and connect the command return and "- REF IN" to signal ground.
>
> Note
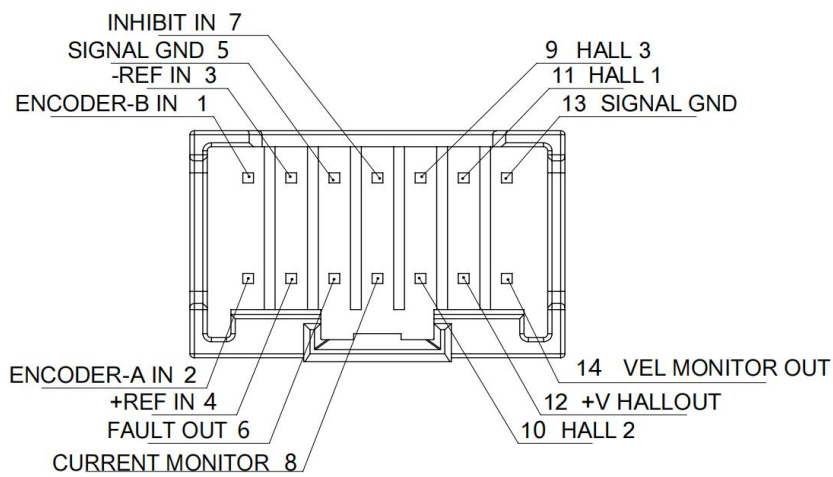
Long signal wires (10-15 feet and up) can also be a source of noise when driven from a typical OP-AMP output. Due to the inductance and capacitance of the wire the OP-AMP can oscillate.

It is always recommended to set a fixed voltage at the controller and then check the signal at the drive with an oscilloscope to make sure that the signal is noise free.

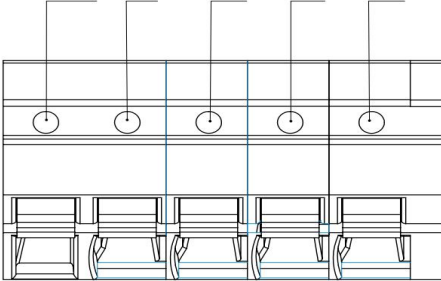## 3.5 Drive Interface

3.5.1 Connector Interface Definitions (CAB☐☐10A36)

P1 Signal Interface Definitions (CAB☐☐10A36)		
Connector information		14 Pin dual row, pitch 2 mm connector，vertical installation
Matching Connector	Part No.	MoleX: 051353-1400 (Housings); 056134-910(Socket)
	Remark	Connectors need to be ordered separately
Pin	Signal	Description
1	ENCODER-B IN [1]	Single-ended encoder channel inputs. +5 V logic level
2	ENCODER-A IN [1]	
3	-REF IN / DIRECTION [2]	Differential Reference Input (±10 V Operating Range, ±15 V Max. Input)
4	+REF IN / PWM IN [2]	Differential Reference Input (±10 V Operating Range, ±15 V Max. Input
5	SIGNAL GND	Signal Ground (Common With Power Ground).
6	FAULT OUT	TTL level (+5 V) output becomes high when power devices are disabled due to at least one of the following conditions: invalid Hall state, output short circuit, over voltage, over temperature, power-up reset.
7	INHIBIT IN	TTL level (+5 V) inhibit/enable input. Leave open to enable drive. Pull to ground to inhibit drive. Inhibit turns off all power devices.
8	CURRENT MONITOR	Current Monitor. Analog output signal proportional to the actual current output. Polarity is reversed from command voltage. Scaling is 2 A/V. Measure relative to signal ground.
9	HALL 3	Single-ended Hall/Commutation Sensor Inputs (+5 V logic level)
10	HALL 2 [3]	
11	HALL 1	
12	+V HALL OUT	Hall Sensors Power(+5 V@30mA). Referenced to signal ground. Short circuit protected.
13	SIGNAL GND	Signal Ground (Common With Power Ground).
14	VEL MONITOR OUT [4]	Velocity Monitor (±2.5 V range). Analog output proportional to motor speed. In Hall Velocity mode and In Encoder Velocity mode , output is proportional to the electrical cycle frequency. Hall Velocity scaling is 385 Hz/V and Encoder Velocity scaling is 90 kHz/V.

1. For CABE10A36 only,this pin is reserved for other types of drivers.
2. For CABDC10A36 drive, Pin3 is the "DIRECTION" signal input, and Pin4 is the "PWM" signal input. For other types of drivers, Pin3 and 4 are ±10V analog signal input(Reference signal input).
3. For use with Single Phase (Brushed) motors, ground Hall 2 and only connect motor leads to Motor A and Motor B.
4. Only for CABE10A36 and CABH10A36 drives. This pin is reserved for other types of drivers.
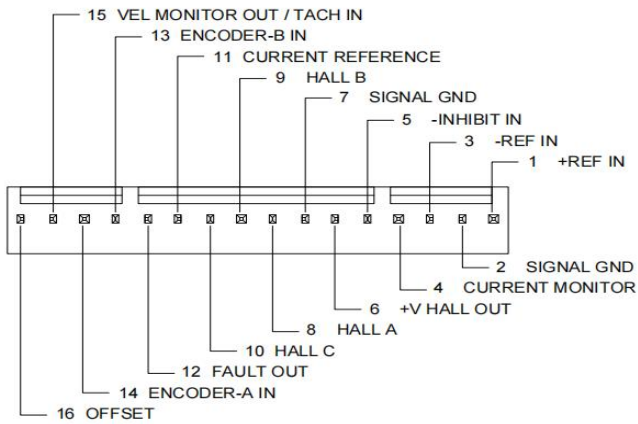
P2 Power Interface Definitions(CAB□□1 0A36)		
Connector information	KF250NH-3.81-5P Spring Clamp System Terminal Block	
Matching Connector	Part No.	N/A
	Remark	
Pin	Signal	Description
1	GND	Power Ground (Common With Signal Ground).
2	HV	DC+ Power Input
3	MC	Motor Phase W
4	MB	Motor Phase V
5	MA	Motor Phase U

1GND 2HV 3MC 4MB 5MA
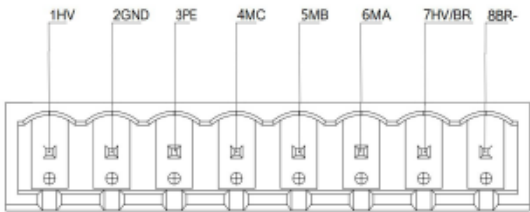
3.5.2 Connector Interface Definitions

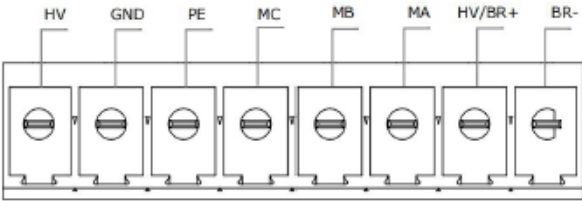| P1 Signal Interface Definitions		
(Except CAB□□1 0A36 model)		
Connector information		16 Pin, pitch 2.54 mm connector
Matching Connector	Part No.	Molex: P/N 22-01-3167 (Housings) and P/N 08-50-0114 (CRIMP TERMINAL)
	Remark	Connectors need to be ordered separately
Pin	Signal	Description
1	+REF IN / PWM / IN [1]	Differential Reference Input (±10 V Operating Range, ±15 V Maximum Input)
2	SIGNAL GND	Signal Ground
3	-REF IN / DIRECTION [1]	Differential Reference Input (±10 V Operating Range, ±15 V Maximum Input)
4	CURRENT MONITOR	Current Monitor. Analog output signal proportional to the actual current output. Polarity is reversed from command voltage.
5	INHIBIT IN	TTL level (+5 V) inhibit/enable input. Leave open to enable drive. Pull to ground to inhibit drive. Inhibit turns off all power devices.
6	+V HALL OUT	Low Power Supply For Hall Sensors (+6 V @ 30 mA). Referenced to signal ground. Short circuit protected.
7	SIGNAL GND	Signal Ground
8	HALL 1	Single-ended Hall/Commutation Sensor Inputs (+5 V logic level)
9	HALL 2 [2]	
10	HALL 3	
11	CURRENT REFERENCE	Measures the command signal to the internal current-loop. This pin has a maximum output of voltage when the drive outputs maximum peak current. Measure relative to signal ground.
12	FAULT OUT	TTL level (+5 V) output becomes high when power devices are disabled due to at least one of the following conditions: inhibit, invalid Hall state, output short circuit, over voltage, over temperature, power-up reset.
13	ENCODER-B IN [3]	Single-ended encoder channel B input. +5 V logic level.
14	ENCODER-A IN [3]	Single-ended encoder channel A input. +5 V logic level.
15	VEL MONITOR OUT / TACH IN [4]	Velocity Monitor (±10 V range). Analog output proportional to motor speed. In Hall Velocity mode, output is proportional to the electrical cycle frequency. For Tachometer Velocity mode, feedback voltage range is ± 60 VDC max
16	OFFSET	Connection to external resistance for command offset adjustments. Apply a ±VDC (10V Max) signal through an external potentiometer into this pin to offset the input gain.

1. For CABDC(X) drive, Pin1 is the "PWM IN" signal input, and Pin2 is the "DIRECTION" signal input. For other types of drivers, Pin1 and 2 are ±10V analog signal input(Reference signal input).
2. For use with Single Phase (Brushed) motors, ground Hall 2 and only connect motor leads to Motor A and Motor B.
3. For CABE(X) only,this pin is reserved for other types of drivers.
4. Only for CABE(X) and CABH(X) drives. This pin is reserved for other types of drivers.

P2 Power Interface Definitions(CAB☐☐6A80/8A80X/12A80/15A80X/20A80)

Connector information		8Pin pitch 5.08 mm Pluggable terminal block
Matching Connector	Part No.	KF2EDGK5.08
	Remark	Connectors need to be ordered separately
Pin	Signal	Description
1	HV	DC+ Power Input
2	GND	Power Ground (Common With Signal Ground).
3	PE	Protective ground (Connect motor cable shield)
4	MC	Motor Phase W
5	MB	Motor Phase V
6	MA	Motor Phase U
7	HV/BR+	External braking resistor connection. Connect a resistor between BR+ and BR-.
8	BR-	

P2 Power Interface Definitions(CAB☐☐40A80(X)/60A80/25A80X/16A175X/15A175X)

| Connector information		8Pin pitch 7.62 mm Pluggable terminal block
Matching Connector	Part No.	KF2EDGSK-7.62mm/KF2EDGAK-7.62mm
	Remark	Connectors need to be ordered separately
Pin	Signal	Description
1	HV	DC+ Power Input
2	GND	Power Ground (Common With Signal Ground).
3	PE	Protective ground (Connect motor cable shield)
4	MC	Motor Phase W
5	MB	Motor Phase V
6	MA	Motor Phase U
7	HV/BR+	External braking resistor connection. Connect a resistor between BR+ and BR-.
8	BR-	

3.6 Interface Circuitry Examples

This section introduces the interface circuit of the Golden Ding analog driver and also includes general connection rules and instructions.

➤ **DC Power Input**

The diagram below shows how a Golden Ding servo drive connects to an isolated DC Power Supply. Notice that the power supply wires are shielded, and that the power supply case is grounded at the single point system ground (PE Ground). The cable shield should be grounded on the driver's side to the chassis ground.

FIGURE 3.16 DC Power Input Wiring
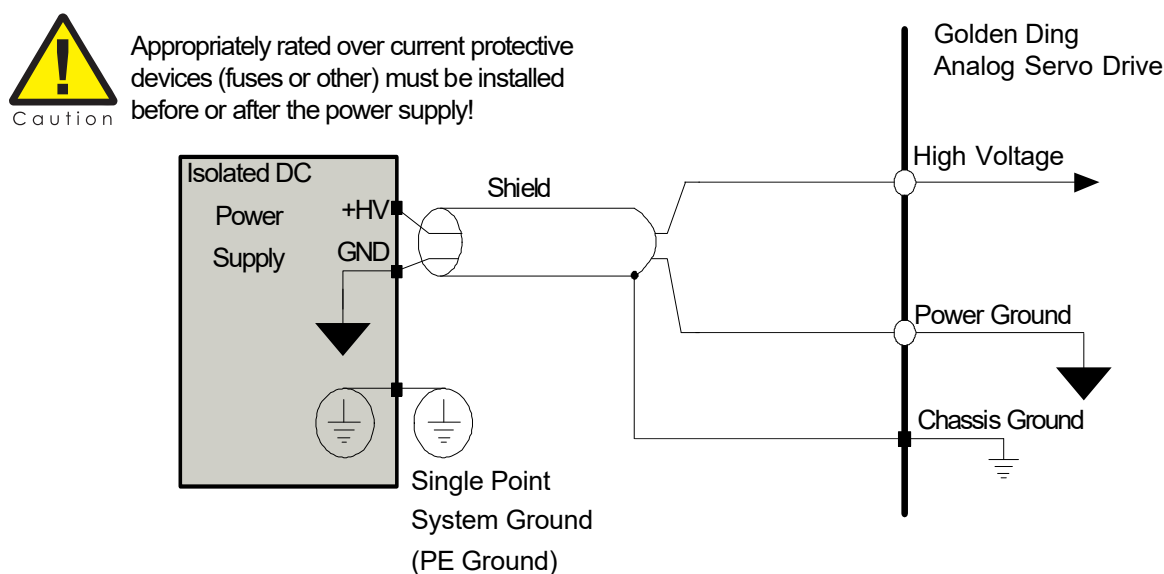
➤ *Motor Power Output*

The diagram below shows how a Golden Ding servo drive connects to a motor. Both brush-type and brushless motors should follow this general setup. Notice that the motor wires are shielded and that the motor housing is grounded to the single-point system ground (PE Ground). The cable shield should be grounded on the driver's side to the chassis ground.

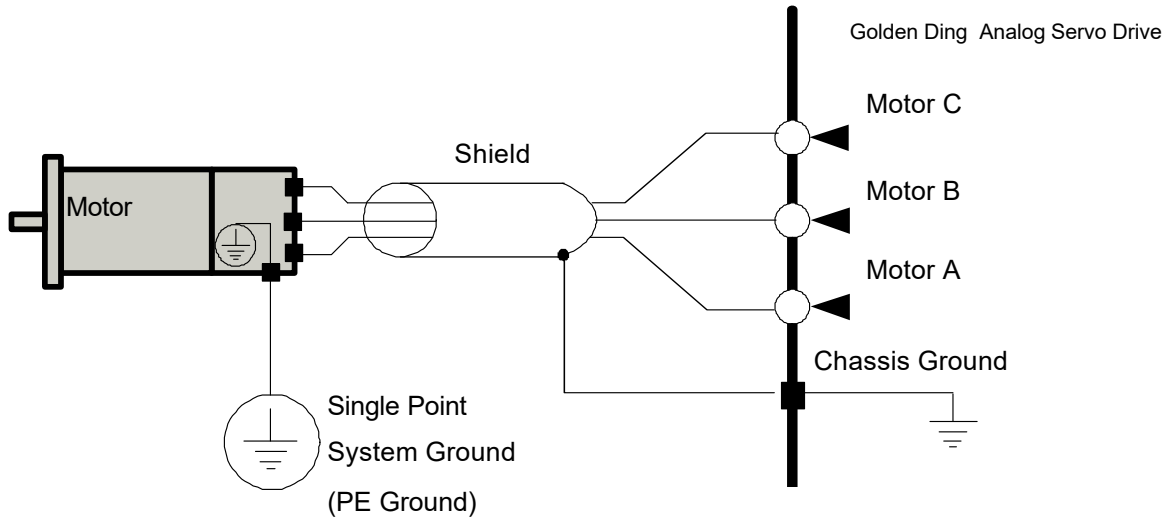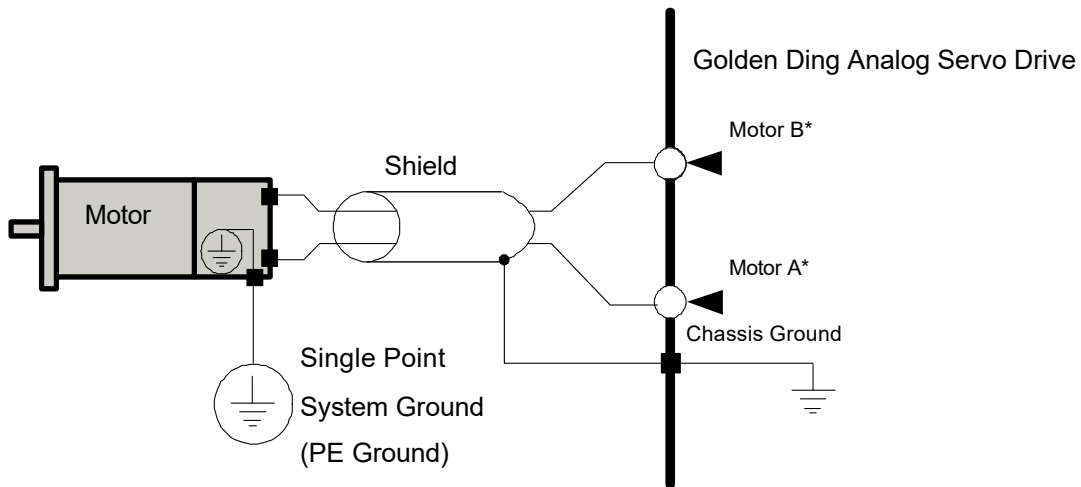### FIGURE 3.17 Three Phase Motor Power Output Wiring

FIGURE 3.18 Single Phase Motor Power Output Wiring

*Use only Motor A and Motor B if using 60 degree Hall phasing. If using 120 degree Hall phasing, consult the Commutation Sequence Table (Table 2.5) to determine which two motor phase outputs to connect.

Caution

If using relays or other means to disconnect the motor leads, be sure the drive is disabled before reconnecting the motor leads to the drive. Connecting the motor leads to the drive while it is enabled can generate extremely high voltage spikes which will damage the drive.

➤ Hall Sensor Inputs

Golden Ding Analog Servo Drives allow single-ended Hall Sensor inputs both for commutation, and in the special case of CABH drives, for velocity feedback. Certain models provide a +6V low power supply to power the Hall Sensors. The following is a schematic diagram of the Golden Ding analog driver connected to the Hall sensor.

FIGURE 3.19 Hall Sensor Interface Wiring
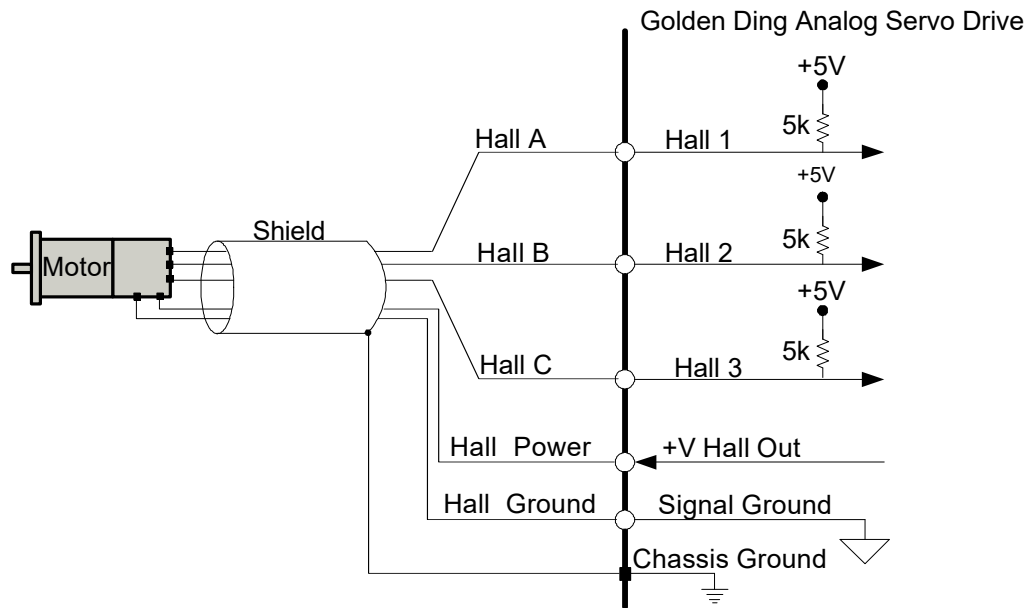
➤ Encoder Inputs

CABE(X) drives support single-ended incremental encoder inputs. The encoder must be powered by an external power supply. Check the motor and encoder specifications for the encoder voltage and current requirements. The following is a schematic diagram of the Golden Ding analog driver connected to the Hall sensor.

FIGURE 3.20 Encoder Input Interface Wiring
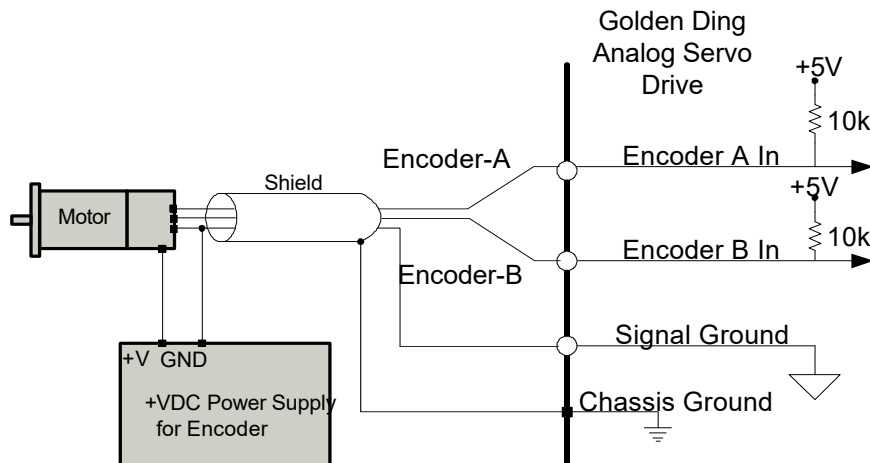
> ➤ **±10V Analog Reference Input**

When using a ±10V analog signal for an input command, it is important to consider the output impedance of the analog source when interfacing to input circuitry. A poorly designed ±10V analog input interface can lead to undesired command signal attenuation. Figure 3.21 shows an external analog source connected to an analog input. The ideal voltage delivered to the input is V_S. However, the voltage drop across R_{source} will reduce the signal being delivered to the drive input. This voltage drop is dependent on the value of R_{source} and the drive's input impedance.

**FIGURE 3.21 Analog Source and Drive Input**
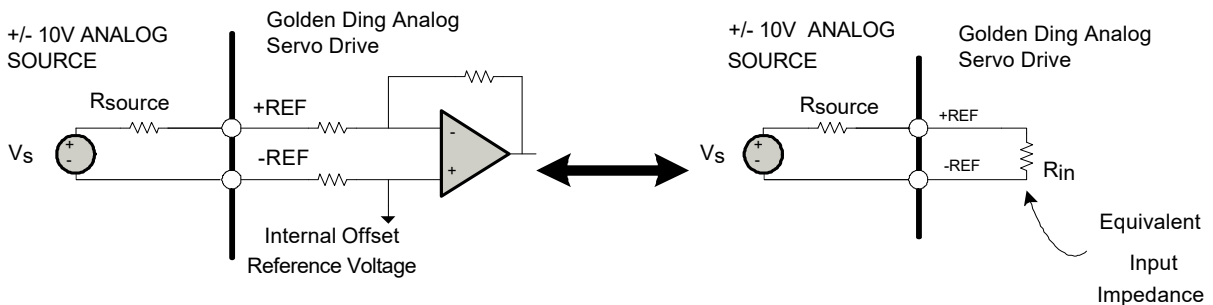
The drive's analog input can be simplified to a single impedance, R_{in}, as shown in Figure 3.21. If the impedance of R_{source} is of the same magnitude or larger than R_{in}, there will be a significant voltage drop across R_{source}. Reduced values of R_{source} cause a lower voltage drop that increases signal integrity. In order to avoid a voltage drop of more than 5% between the source and the drive, it is recommended
to use an R_{source} value of less than or equal to 2kohm.

> ➤ **Potentiometer Input**

Golden Ding Analog servo drives can be commanded with the use of an external potentiometer and a DC supply by varying the DC supply voltage across the potentiometer.
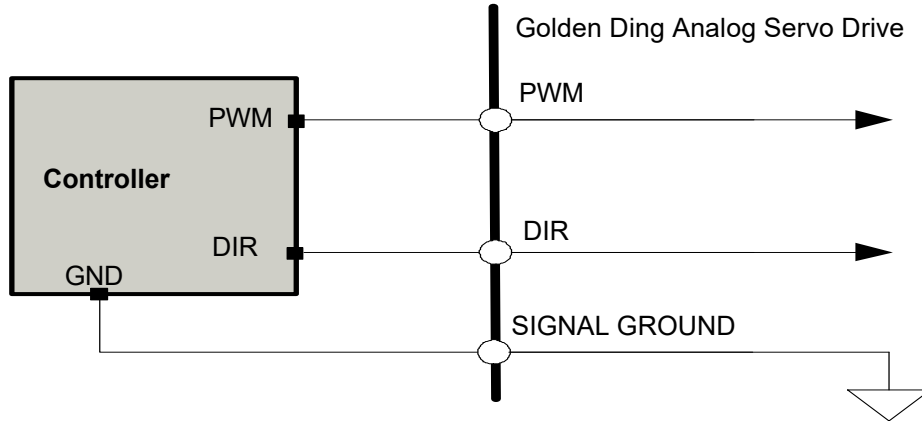
FIGURE 3.23 Potentiometer Input
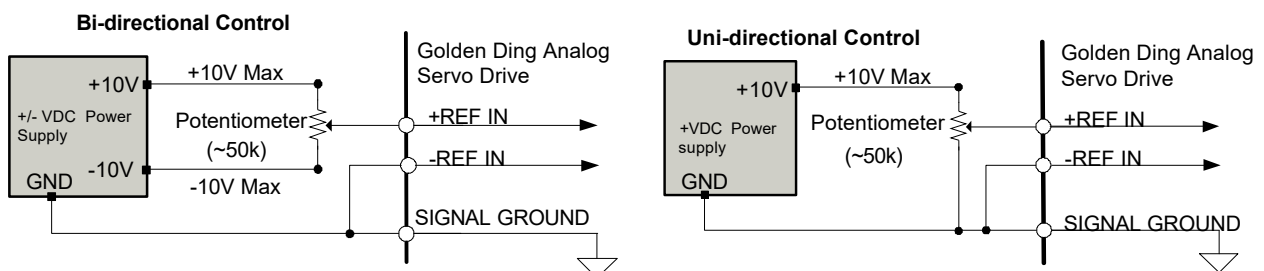
➢ PWM and Direction Input

For CABDC drive models, the PWM and Direction inputs should be connected to the PWM and DIR input pins on the drive.

FIGURE 3.24 PWM and Direction Input Wiring

➢ Tachometer Input

For drive models that allow an external DC Tachometer for velocity control, the tachometer is connected between the Velocity Monitor Output / Tachometer Input and signal ground. The tachometer is limited to a feedback voltage range of ±60 VDC. The diagram below shows the recommended connection method.
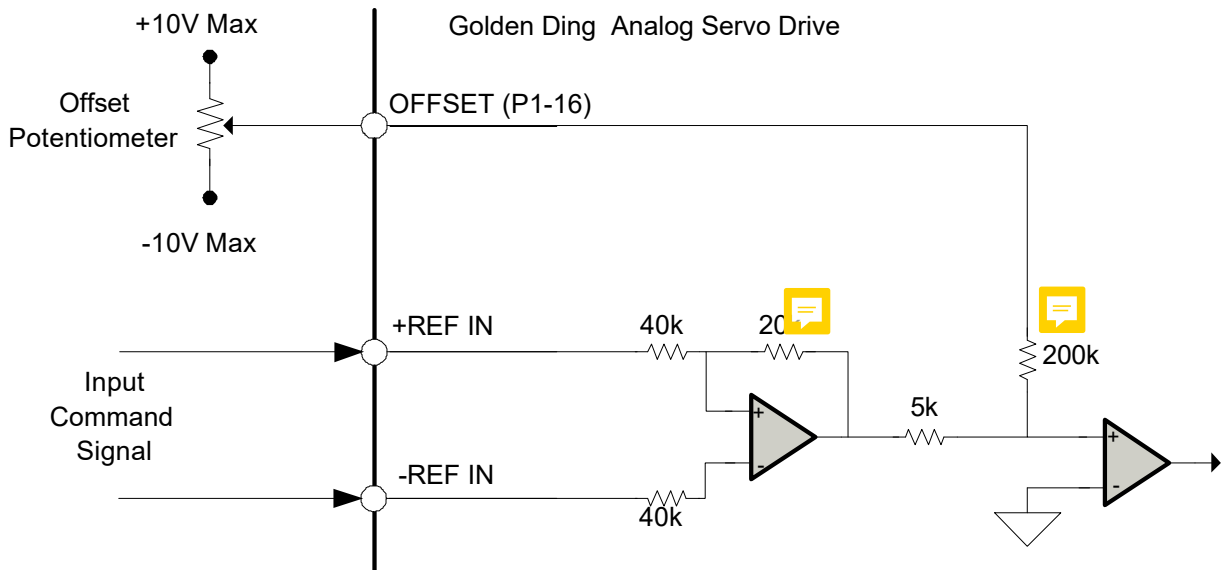
FIGURE 3.25 DC Tachometer Input Wiring
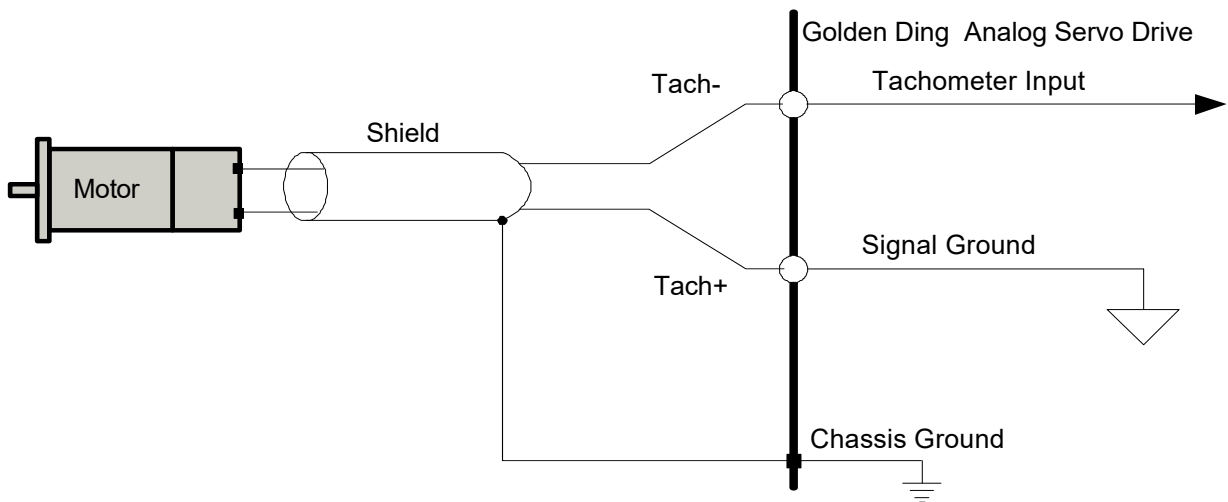
➢ Offset Input

For drive models that have an external offset input option where a potentiometer can be used in addition to the input command signal when an input offset adjustment is desired. The diagram below shows one possible connection method using a potentiometer for the offset input.

FIGURE 3.26 Offset Input Wiring

> **Inhibit Input**

Golden Ding Series Analog Servo Drives feature an Inhibit Input pin that is used to either enable or disable the drive. By default, the Inhibit Input should be left open to enable the drive, and brought to Signal Ground to disable the drive. If you want to reverse this logic, please contact AMC China

FIGURE 3.27 Inhibit Input Wiring
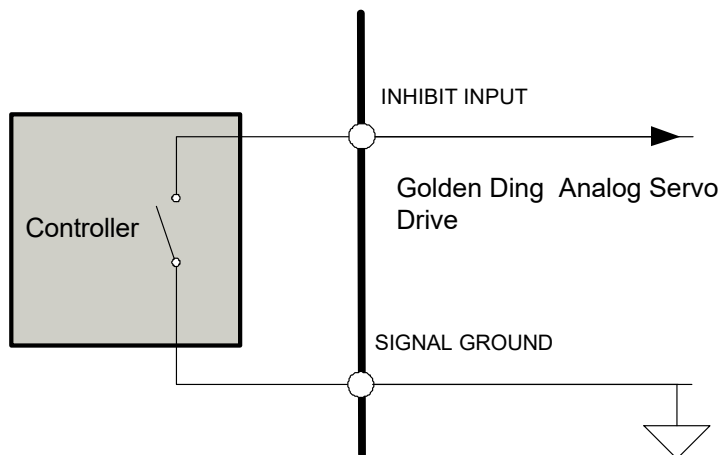
Default Logic: Open to Enable / Short to Disable

➢ **Current Monitor Output**

Golden Ding Analog Servo Drives feature a Current Monitor output that provides an analog voltage output signal that is proportional to the actual current output. The Current Monitor output should be measured relative to Signal Ground.

FIGURE 3.28 Current Monitor Output Wiring

CURRENT MONITOR 10K

DVM or
Controller

GND

Golden Ding Analog
Servo Drive

SIGNAL GROUND
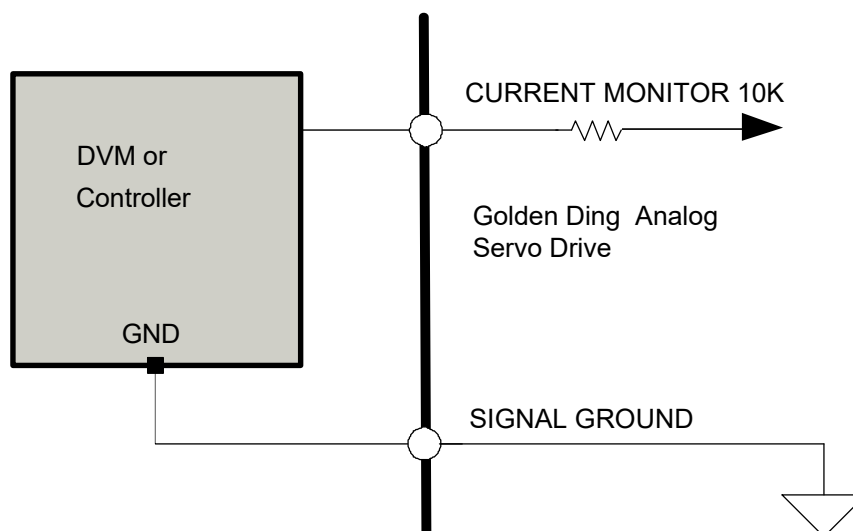
➢ **Current Reference Output**

Some Golden Ding Analog Servo Drives feature a Current Reference output that provides an analog voltage output signal that is proportional to the command signal to the internal current loop. The Current Reference output should be measured relative to Signal Ground.

FIGURE 3.29 Current Reference Output Wiring

CURRENT REFERENCE

DVM or
Controller

GND

Golden Ding Analog
Servo Drive

SIGNAL GROUND
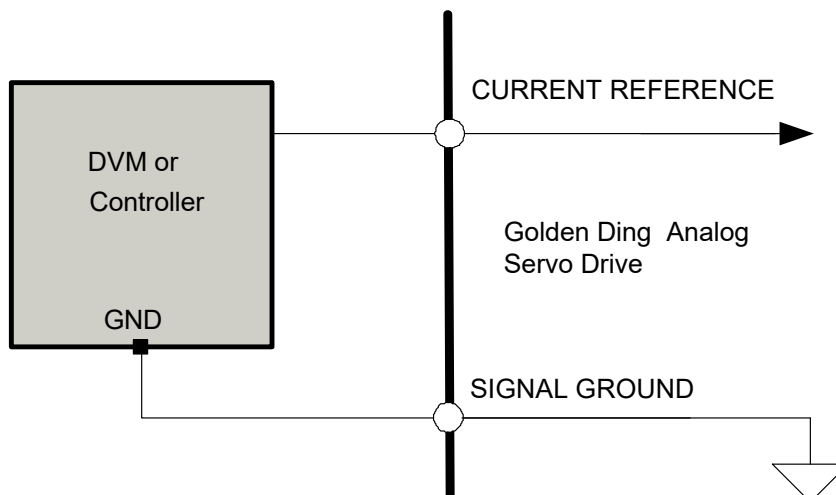
➢ **Fault Output**

Golden Ding Analog Servo Drives feature a +5V TTL Fault output that will become high when the drive is subject to a fault condition (see "Fault Output" on page 50 for a list of fault conditions). The Fault output should be measured relative to Signal Ground. The Fault output can also be used with an external LED as shown in Figure 3.30.

FIGURE 3.30 Fault Output Wiring
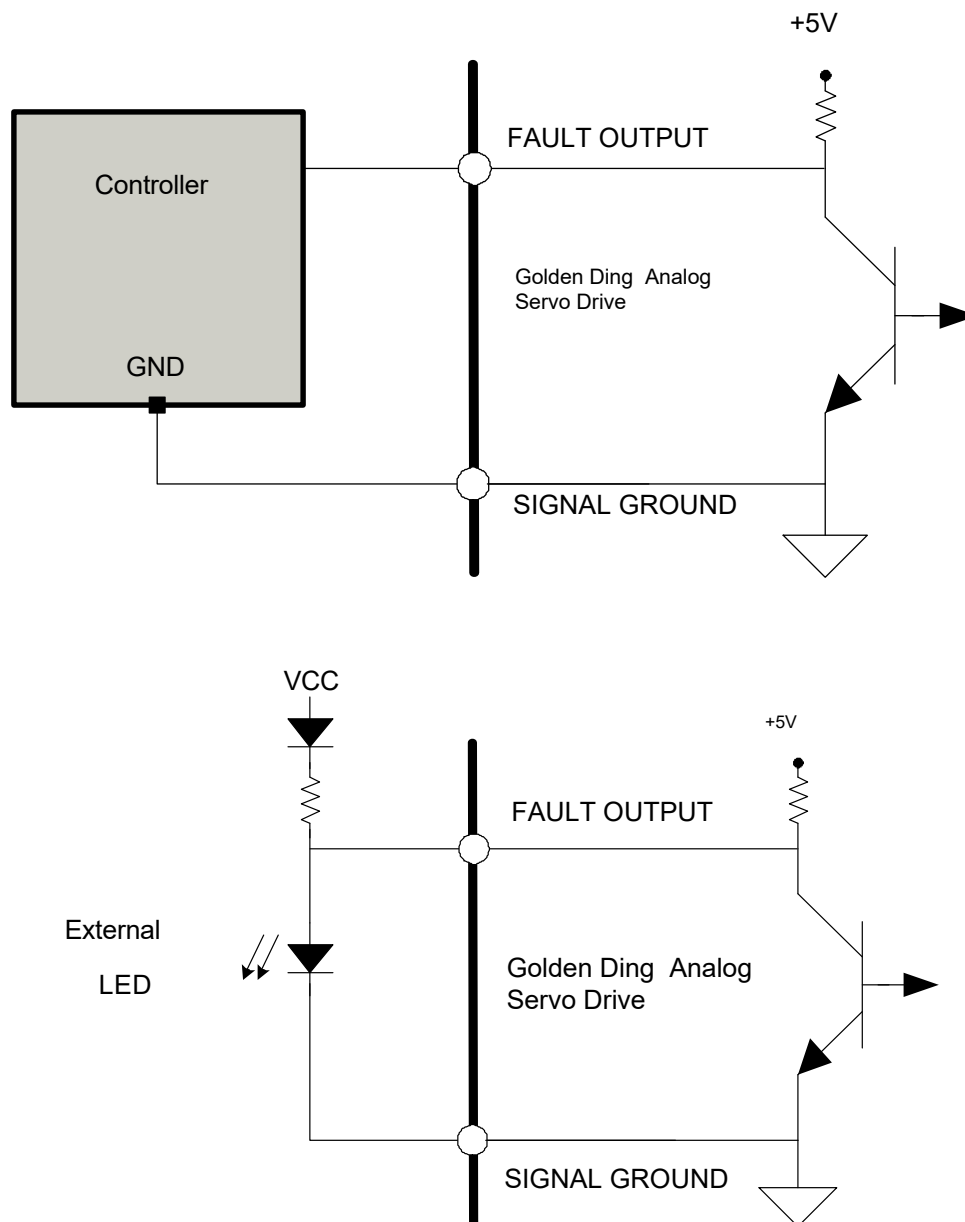
4. Operation

This chapter will present a brief introduction on how to test and operate a Golden Ding Series Analog Servo Drive. Read through this entire section before attempting to test the drive or make any connections.

4.1 Getting Started

To begin operation with your Golden Ding series Analog Servo Drive, be sure to read and understand the previous chapters in this manual as well as the drive datasheet. Be sure that all system specifications and requirements have been met, and become familiar with the capabilities and functions of the drive. Also, be aware of the

"Troubleshooting" section at the end of this manual for solutions to basic operation issues.

4.1.1 Input/Output Pin Functions

The family of Golden Ding Servo Drives provides a number of various input and output pins for parameter observation and drive configuration options. Consult the drive datasheet to see which input/output pin functions are available for each drive.

> *Current Monitor Output*

The current monitor pin is available on all Dolden Ding Analog Servo Drive models. Measured relative to signal ground, it provides an analog voltage output signal that is proportional to the actual current output. The scaling factor for each individual drive can be found on the drive datasheet. Note that the polarity of the current monitor measurement will be reversed from the current command.

Example Measurement

The current monitor pin on a drive with a current monitor scaling factor of 4 A/V is measured to be -1.3V. With the polarity reversed on the current monitor pin, this would mean the drive is outputting: (4 A/V)(1.3V) = **5.2A**.

> *Current Reference Output*

The current reference pin is available on 80V and 175V drive models. Measured relative to signal ground, it provides an analog voltage output signal that is proportional to the command signal to the internal current loop. When the drive output reaches the maximum peak current value, the current reference pin will read 7.45V. The command to the internal current loop can be solved for by the following equation

$$I_{\text{command}} = V_{\text{current ref}} \cdot \frac{I_{\text{peak}}}{7.45\,V}$$

Where:

I_{command} -command current to the internal current loop

$V_{\text{current ref}}$ -measured voltage at current reference pin

I_{peak} -peak current value of Golden Ding Analog Servo Drive

Example Measurement

The current reference pin on a Golden Ding Analog Servo Drive with a peak current value of 12A is measured to be 2.63V. Following the above equation to solve for I_{command}, the command current to the internal current loop would be **4.24A**.

➢ *Fault Output*

The fault output is available on all Golden Ding Analog Servo Drive models. This pin provides a +5V TTL output that will become high when the drive is subject to one of the following fault conditions: inhibit (except on CA_10A4 models), invalid Hall State, output short circuit, over voltage, over temperature, or power-up reset. This pin will remain low when the drive is enabled.

Golden Ding Analog Servo Ddrives automatically self-reset once all active fault conditions have been removed. For instance if the DC power supply rises above the over-voltage shutdown level of the drive, the Fault Output will go high, and the drive will be disabled. Once the DC power supply level is returned to a value below the drive over-voltage shutdown level, the Fault Output will become low, and the drive will automatically become enabled.

➢ *Inhibit Input*

The inhibit input pin is available on all Golden Ding Series Analog Servo drive models. This pin provides a +5V TTL input that allows a user to enable/disable the drive by either connecting this pin to ground or by applying a +5VDC voltage level to this pin, referenced to signal ground. By default, the drives will be enabled if this pin is high, and disabled if this pin is low. If you want to reverse this logic, please contact AMC China.

➢ **Low Power Supply Output for Hall Sensors**

The low power supply provides a +6 VDC, 30 mA output that can be used to power Hall Sensors on three phase drives (consult the motor datasheet to find out which feedback wire is the Hall Sensor power supply wire) or for other user requirements on single phase drives.

Do not use this +6V supply to power an encoder. An encoder will require a separate external power supply. Consult the encoder datasheet or specifications to determine the encoder voltage and current requirements. Typical values are +5VDC at 150mA.

Notice

> ➢ *Velocity Monitor Output*

The velocity monitor output pin is available on CABE(X) and CABH(X) drive models only. This pin provides an analog voltage output that is proportional to the actual motor speed.

- For CABE(X) drives in Encoder Velocity Mode, substitute the voltage value read at the velocity monitor pin, Vmonitor, into the below equation to determine the motor RPM:

$$\text{Motor Velocity [RPM]} = \frac{V_{\text{monitor}} \cdot 22\frac{kHz}{V} \cdot 60}{\text{Number of encoder lines}}$$

- For CABH(X) drives in Hall Velocity Mode, substitute the voltage value read at the velocity monitor pin, V_{monitor}, into the below equation to determine the motor RPM:

$$\text{Motor Velocity [RPM]} = \frac{V_{\text{monitor}} \cdot 100\frac{Hz}{V} \cdot 120}{\text{Number of motor poles}}$$

> ➢ *Tachometer Input*

For CABE(X) and CABH(X) drive models, when the drive is set to Tachometer Velocity mode by DIP-switch setting, the Velocity Monitor Output pin is used as a DC Tachometer Input. The drive *must* be in Tachometer Velocity Mode in order to properly use the tachometer input. The maximum input allowed at the tachometer input pin is ±60 VDC.

When using a DC Tachometer in Tachometer Velocity mode, the velocity monitor output function is inactive.

4.1.2 Potentiometer Function Details

CABE(X) and CABH(X) drives models utilize two 0 to 50 kΩ potentiometers for Loop Gain and Offset functions. Both potentiometers vary in resistance from 0 to 50 kΩ, over 12 turns. An additional full turn that does not effect resistance is provided on either end, for a total of 14 turns. When the end of potentiometer travel is reached, it will click once for each additional turn.

TABLE 4.1 Potentiometer Function Details

Potentiometer	Description
Loop Gain Adjustment (POT1)	This potentiometer must be set completely counter-clockwise in Current Mode. In Velocity or Duty Cycle Mode, this potentiometer adjusts the gain in the velocity forward position of the closed loop. Turning this potentiometer clockwise increases the gain. Start from the full counter-clockwise position, turn the potentiometer clockwise until the motor shaft oscillates, then back off one turn.
Offset (POT2)	This potentiometer is used to adjust a small amount of command offset in order to compensate for offsets that may be present in the servo system. Turning this potentiometer clockwise adjusts the offset in a negative direction relative to the +Ref input command. Before offset adjustments are made, the reference inputs must be grounded or commanded to 0 volts.

4.2 Initial Setup

Carefully follow the grounding and wiring instructions in the previous chapters to make sure your system is safely and properly set up. For initial testing purposes, it is not necessary to use a controller to provide a command input, or to have any load attached to the motor. The items required will be:

- ➢ Golden Ding Analog Servo Drive
- ➢ Motor
- ➢ DC Power Supply for supplying power to system
- ➢ Digital Multimeter (or ohmmeter and voltmeter)

4.2.1 Current (Torque) Mode Test

Initially, the drive should be placed in Current (Torque) Mode. By default, all Golden Ding Series Analog Servo Drives are shipped already set for Current (Torque) Mode. However, certain drives have the option of using DIP switches to configure the drive for other modes. If using a drive model with multiple possible modes, check the DIP switch configuration to be certain the drive is in Current (Torque) Mode. Mode configuration tables can be found on the drive datasheet.

➢ *Connections Test*

Before applying power to the drive, using an ohmmeter or digital multimeter, check for any shorts or open circuits. At this point, also check the ground connection of the whole system (Drive, Motor). All equipment should have its case or chassis connected to a central grounding point in a "star" configuration. For review, see "Grounding".

➢ **Power Supply**

1. Before wiring the DC power supply to drive, use a voltmeter or digital multimeter to make sure the DC voltage level is within specifications.
2. Do not turn on the DC power supply yet. Connect the DC power supply wires to the driver power interface. Be sure the high voltage and ground connections do not get reversed, as this will damage the drive.
3. Turn on the DC power supply. Monitor the DC voltage to be sure the voltage level is within specifications. Once certain that power is being properly applied to the drive, turn the DC power supply off.

➢ *Input Command Wiring*

Follow the instructions below to properly wire the input command of the drive, but do not apply any power or input signal yet.

- For drives that use ±10 V analog input, one method of testing the functionality of the drive within the system is by using an external reference potentiometer (approximately 50 k   ) as an input command signal. By applying a positive DC voltage (10V max) to one end of the potentiometer, and a negative DC voltage (10V max) to the other end of the potentiometer, a ± analog signal can be sent through the potentiometer's wiper into the +REF input pin on the driver (see drive data sheet or "Potentiometer Input") The voltages applied to the external reference potentiometer should come from a "test" power supply that is different than the main DC power. This separate ±VDC "test" power supply should be referenced to the drive signal ground.

FIGURE 4.1 Reference Input Potentiometer
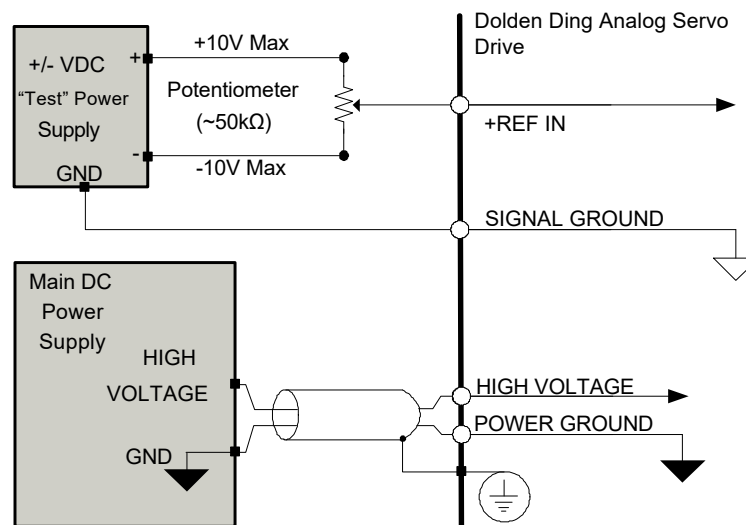
- ❖ Without connecting the potentiometer wiper to the driver interface,apply the "test" ±VDC to the two sides of the potentiometer.
- ❖ Measure the wiper of the potentiometer with a voltmeter or digital multimeter, and verify that by turning the potentiometer in both directions, the full range of ±VDC is observable on the potentiometer wiper. This voltage will serve as a "test" command.
- ❖ Once the full range of ±VDC has been verified, turn the potentiometer so that approximately 0 VDC is observed on the potentiometer wiper, then turn off the "test" power supply.
- ❖ With no voltage command applied to the potentiometer, connect the wiper to the +REF IN input pin on the driver interface. Connect the "test" power supply ground or common to the drive signal ground on the driver interface.

- For drives that use PWM and Direction input, a Function Generator should be set up to generate a simple +5V square wave at a frequency of 10-25 kHz. Connect the Function Generator signal to the PWM input pin on the drive, (see drive datasheet) and the common to the signal ground pin on the drive.

➢ **Hall Sensor**

1. (For brushless motors) With the DC power supply still turned off, connect the Hall Sensors to the Hall input pins on the driver interface. Also, connect the +V HALL OUT +6V supply from the drive to the Hall Power line (consult the motor data sheet to see which wires from the motor are the Hall Input lines and Hall Power line).
(For brushed motors) If using 60-degree Hall phasing, leave all Hall input pins open. If using 120-degree Hall phasaing, tie one of the Hall inputs to ground, and leave the other two open.

2. Turn on the DC power supply to the system.

3. Use a digital multimeter or voltmeter, to monitor the Fault Output pin (see "Fault Output" for more information).

4. Manually rotate the motor shaft by hand a few revolutions. If all the Hall Sensors are functioning properly, the Fault Output signal should stay low. If the Fault Output signal goes high, this could indicate either a short or bad connection in the Hall Sensor wires, or an invalid commutation state. See "Hall Sensors" for information on Hall commutation.

5. Once verified, turn off the DC power supply.

➢ *Motor*

With the DC power supply still turned off, connect the motor wires to the appropriate motor output pins on the Golden Ding Analog Servo Drive interface.

❖ For three phase (brushless) motors, there will be three wires to connect. For now, connect the wires in any order to the motor output pins on the Golden Ding Analog Servo Drive interface. These may need to be changed later in order to properly commutate the motor.

❖ For single phase (brushed) motors, there will be two wires to connect. If using 60-degree Hall phasing, connect the wires to motor output phases A and B in any order. If using 120-degree Hall phasing, then the proper motor output phases will depend on the Hall commutation state. See "Using a Single Phase Motor" for more information.

➢ *Applying a Command (Analog Input)*

At this stage, everything that is needed to test operation should be connected to the drive interface, all the elements should be properly grounded in a central point location, and no power or input command should be applied to any element in the system.
Once certain that all these steps have been safely and properly followed, turn on the main DC power supply. Use a voltmeter or digital multimeter to once again check the DC power supply level.

❖ **Analog Input Drives**

1. Turn on the "test" power supply connected to the external potentiometer.
2. Slowly turn the potentiometer in one direction while observing the motor shaft.

⚠ Caution

Only make very slight adjustments to the reference potentiometer to avoid causing damage to the motor. Since the drive is in Current (Torque) Mode and there is no load on the motor shaft, even a small potentiometer adjustment can create high speeds at the motor shaft. Exercise caution when adjusting the potentiometer.

- For single phase motors, this should cause the motor shaft to energize in one direction. Slowly turning the potentiometer further in that same direction, and also in the opposite direction should cause the motor shaft to move smoothly in response to the input.
- For three phase motors, the three motor wires may have to be changed in order to properly commutate the motor. There are six different ways that the three motor wires can be attached to the mounting card or PCB interface. All six will have to be tested in order to find the right commutation.

⚠ Warning

Before removing the motor wires, turn off both the main DC power supply and the "test" power supply. Never remove or make any connections to the drive while power is applied!

The proper combination of motor wires will yield smooth motion and identical speeds in both directions. Improper combinations will cause jerky motion, slow movement in one direction, and/or audible noise. Once the proper combination has been found, turning the potentiometer slowly in both directions should cause the motor shaft to rotate appropri-ately in response to the input.

❖ *PWM Input Drives*

1. Turn on the function generator to apply the PWM signal to the PWM IN pin.
2. Monitor the Function Generator PWM signal on an oscilloscope. Be sure to keep the PWM frequency within the 10-25 kHz range. By varying the duty cycle of the PWM input signal, the motor shaft should rotate in response to the input.
3. The three motor wires may have to be changed in order to properly commutate the motor. There are six different ways that the three motor wires can be attached to the drive interface. All six will have to be tested in order to find the right commutation.

- For single phase motors, this should cause the motor shaft to energize in one direction. Slowly varying the PWM duty cycle should cause the motor shaft to move smoothly in response to the input.
- For three phase motors, the three motor wires may have to be changed in order to properly commutate the motor. There are six different ways that the three motor wires can be attached to the mounting card or PCB interface. All six will have to be tested in order to find the right commutation.

⚠ Warning

Before removing the motor wires, turn off both the main DC power supply and the Function Generator. Never remove or make any connections to the drive while power is applied!

The proper combination of motor wires will yield smooth motion and identical speeds in both directions. Improper combinations will cause jerky motion, slow movement in one direction, and/or audible noise. Once the proper combination has been found, varying the duty cycle should cause the motor shaft to rotate appropriately in response to the input.

➤ *Motor Direction*

For brushless motors, if it is desired to change the motor direction for a given command input, interchange Hall 1 and Hall 3, then Motor A and Motor B.

4.3 Tuning Procedure

The standard tuning values used in Golden Ding Series Analog Servo Drives are conservative and work well in over 90% of applications. However some applications and some motors require more complete current loop tuning to achieve the desired performance. The following are indications that additional current loop tuning is necessary:

➢ Motor rapidly overheats even at low current
➢ Drive rapidly overheats even at low current
➢ Vibration sound comes from the drive or motor
➢ The motor has a high inductance (+10mH)
➢ The motor has a low inductance (near minimum rating of the drive)
➢ Slow system response times
➢ Excessive torque ripple
➢ Difficulty tuning position or velocity loops
➢ Electrical noise problems
➢ High power supply voltage (power supply is significantly higher than the motor voltage rating or near the drive's upper voltage limit)
➢ Low power supply voltage (power supply voltage is near the drive's lower voltage limit)

The above indicators are subjective and suggest that the current loop may need to be tuned. These can also be signs of other problems not related to current loop tuning.

The resistors and capacitors shown under the current control block on the datasheet block diagram determine the frequency response of the current loop. It is important to tune the current loop appropriately for the motor inductance and resistance, as well as the bus voltage to obtain optimum performance. The loop gain and integrator capacitance of the current loop must both be adjusted for the tuning to be complete.

⚠ Caution	Improper current loop tuning may result in permanent drive and/ or motor damage regardless of drive current limits. So we don't recommend customers to adjust these parameters by themselves, please contact AMC China if necessary.

Since most AMC China servo drives close the current loop internally, poor current loop tuning cannot be corrected with tuning from an external controller. Only after the current loop tuning is complete can optimal performance be achieved with the velocity and position loops.

The general current loop tuning procedure for drives follows these steps:

1. Determine if additional current loop tuning is necessary.
2. If tuning is necessary, then the current loop components must be changed.

❖ Tune the current loop proportional gain.
❖ Tune the current loop integral gain.

3. Once the current loop is tuned, then the velocity and/or position loops may be tuned as well if necessary.

Equipment Necessary for Tuning

- Function Generator
- Oscilloscope
- Current Probe or Resistor (high powered, low resistance)
- Soldering Iron

➢ ***Current Loop Proportional Gain Adjustment***

The Current Loop Gain should be adjusted with the motor uncoupled from the load, and the motor secured as sudden motor shaft movement may occur. To keep the motor from commutating during tuning, make sure the Hall Sensor wires are not connected to the drive at this point.

1. Use the DIP switches on Velocity Mode capable drives to select Current Mode (other drives are automatically in Current Mode).
2. Connect only the motor power leads to the drive. No other connections should be made at this point.
3. Using a function generator, apply a ±0.5 V, 50-100 Hz square wave reference signal to the input reference pins.
4. Short out the current loop integrator capacitor(s). Contact AMC China for capacitor location.

⚠ Any damage done to the drive while performing these modifications will void the product warranty.

Notice

5. Apply power to the drive. Use a bus voltage that is approximate to the desired application voltage or the current loop compensation will not be optimized.
6. The drive should be enabled. Observe the motor current with an oscillscope by using a current probe or resistor in series with the motor (<10% of motor resistance). Depending on the motor type, the drives need to be set up differently to view the current loop response properly, as shown in the following figures.

FIGURE 4.2 Brushed Motors
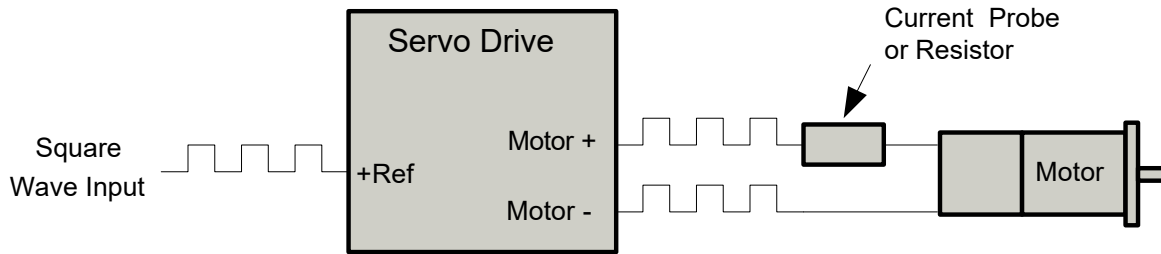
Since the two motor wires are in series, the current through the wires is the same. The current probe can be attached to either wire with the same results. To keep the motor from turning during the tuning process the motor shaft must be locked.

FIGURE 4.3 Brushless Motors
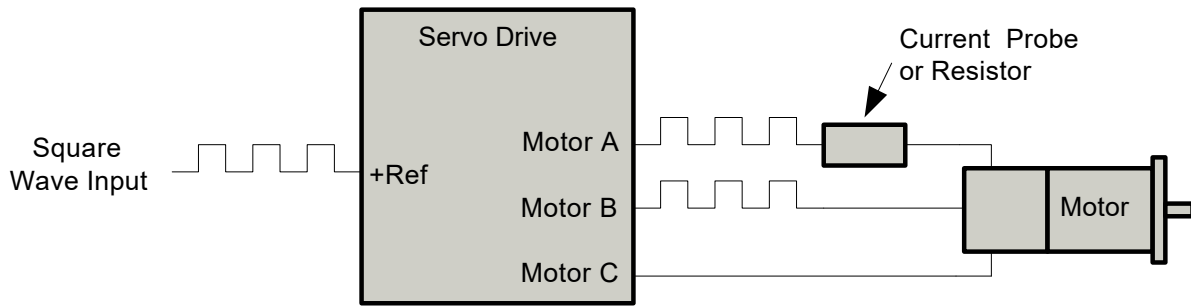
The current out of the drive can be forced to go through Motor A and Motor B by:

Disconnecting the Hall sensors from the drive
Jumper Hall 2 input to Signal Ground

The motor shaft does not need to be locked since the drive will not commutate without the Hall Sensors.

7. The drive output should follow the input command. The best response will be a critically damped output waveform, similar to what is shown in Figure 4.4.

FIGURE 4.4 Current Loop Response
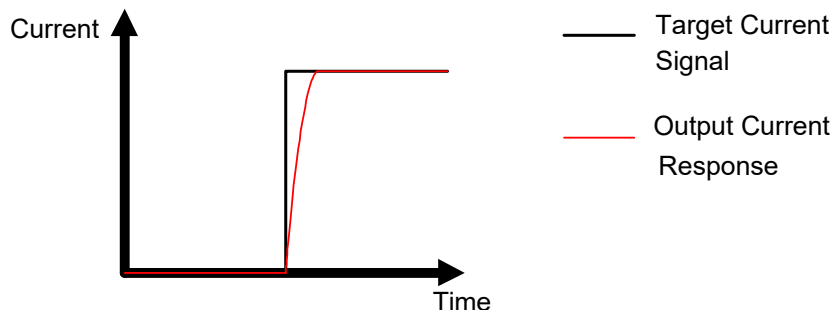
. If the drive output did not result in a proper square wave response, then the current loop gain resistors may need to be changed to optimize the response. See "Loop Tuning" for more information.

. When the proper response has been achieved, remove the input signal from the drive, and disconnect power.

➢ *Current Loop Integrator Adjustment*

1. Enable the Current Loop Integrator by removing the jumper previously used to short it during the proportional gain adjustment, and start with the default capacitor.

2. Using a function generator, apply a ±0.5V, 50-100 Hz square wave reference signal.

3. Apply power to the drive. Use a bus voltage that is approximate to the desired application voltage or the current loop compensation will not be correct.

4. The drive should be enabled. Observe the motor current with an oscilloscope by using a current probe or resistor in series with the motor (<10% of motor resistance). The output should settle to a flat top with minimal current following error (difference between commanded current and actual current). There can be some overshoot, but it should be less than 10%.

> Because the oscilloscope measurements are voltage representations of current, the commanded and actual currents will most likely have different current to voltage scalings and tolerances. Therefore, even with perfect current loop tuning, the two amplitudes (scope traces) may not line up as shown in Figure 4.4.

Notice

5. If the square wave output overshoots too much or is over-damped (sluggish), the current loop integrator capacitor will need to be changed to optimize the response. See "Loop Tuning" for more information.

> ➢ *Duty Cycle or Velocity Loop Tuning*

For CABE and CABH drives, the velocity loop proportional gain can be tuned for the system requirements by adjusting the Loop Gain potentiometer. These adjustments should initially be performed with the motor uncoupled from the mechanical load.

Configure the drive for the desired operation mode using the DIP Switchs (see the drive datasheet for the specific settings).

- Duty Cycle Loop - Compensating the duty cycle loop requires the least amount of effort. Turn the Loop Gain potentiometer clockwise until oscillation occurs, then back off one turn.
- Velocity Loop (Encoder, Halls, or Tachometer) - The velocity loop response is determined by the Loop Gain potentiometer as well. A larger resistance value (clockwise) results in a faster response. A smaller resistance value (counter-clockwise) results in a slower response. Adjust the Loop Gain potentiometer as necessary for the desired application performance.

If adjustments to the Loop Gain potentiometer do not result in the desired performance, the velocity loop integrator capacitor may need to be changed to optimize the response. See "Loop Tuning" for more information.

5. Loop Tuning

In general, AMC China Golden Ding Analog Servo Drives will not need to be further tuned. However, for applications requiring more precise tuning, the drive can be manually modified with resistors and capacitors as denoted in Table 5.1 below.
It is recommended to contact AMC China to discuss application requirements and proper drive tuning prior to making any adjustments.

> ⚠ **Notice**
>
> Any damage done to the drive while performing these modifications will void the product warranty.

Before attempting to change components on the board, see "Tuning Procedure". Some general rules to follow when changing components are:

➢ A larger resistor value will increase the proportional gain, and therefore create a faster response time.
➢ Use non-polarized capacitors.
➢ A larger capacitor value will increase the integration time, and therefore create a slower response time.

5.1 Loop Tuning

Proper tuning will require careful observation of the loop response on a digital oscilloscope to find the optimal component values for the specific application.

The following are some helpful hints to make the loop tuning process easier:

➢ **Use a potentiometer to find the correct current loop gain value -** A potentiometer can be used to continuously adjust the gain resistance value during the tuning process. Install a potentiometer in place of the gain resistor. Adjust the potentiometer while viewing the current loop response on an oscilloscope. When the optimal response is achieved turn off the drive, remove the potentiometer, and measure the potentiometer resistance. Use the closest resistor value available. (Note: This method will not work if the optimal tuning value is beyond the range of the potentiometer).
➢ **If no potentiometer is available, progressively double the resistance value when tuning the current loop gain for faster results -** If the gain resistor needs to be increased during the tuning process the fastest results are achieved by doubling the resistance from the last value tried. Use this method until overshoot is observed and then fine tune from there.
➢ **Safety**

> ⚠ **Caution** Always remove power when changing components on the drive.

> ⚠ **Caution** Float the oscilloscope and function generator grounds to avoid large ground currents.

> ⚠ **DANGER** Decouple the motor from the load to avoid being injured by sudden motor movements.

Table 5.1 lists the different components that can be used for loop tuning. Please contact AMC China Applications Engineering for assistance in determining the PCB location of the component options for the drive model in use.

TABLE 5.1 Through-Hole Tuning Component

Component	Description
Current Loop Proportional Gain Resistor	Resistor that can be changed for more precise current loop tuning.
Current Loop Integrator Capacitor	Capacitor that can be changed for more precise current loop tuning.
Velocity Loop Integrator Capacitor	Capacitor that can be changed for more precise velocity loop tuning.

5.1.1 Procedure

Tune the Current Loop Proportional Gain

❖ Follow the steps outlined in "Current Loop Proportional Gain Adjustment" up through Step 8.

❖ Observe the drive current response on an oscilloscope. Small step tuning is different than large step tuning, so adjust the function generator square wave amplitude so the drive outputs a current step similar to what will be expected in typical operation.

a. If the current response does not rise quickly enough to the step input command, or if it never reaches the input command, the resistance of the current loop proportional gain resistor will need to be increased. This will increase the current loop proportional gain, and achieve a faster, more aggressive response.

b. If the current response overshoots the step input command, the resistance of the current loop proportional gain resistor will need to be

decreased. This will decrease the current loop proportional gain, and provide a slower, more stable response.

3.   Finding an acceptable resistance may take a few iterations. As outlined in the previous section, using an external potentiometer will make the process easier. Remember to remove power from the drive prior to removing or adding any components to the PCB.

4.   Use a resistance value that brings the current response right to the point of overshoot. If there is a large amount of overshoot, or if there are oscillations, decrease the resistance value until there is little or no overshoot. Depending on the application requirements, a little overshoot is acceptable, but should never exceed 10%.

5.   When an acceptable resistance value has been found, remove power from the drive.

Tune the Current Loop Integral Gain

1.   After the proportional gain resistance has been adjusted to an acceptable value, re-enable the current loop integrator capacitor.
2.   Using the same function generator input command as in the previous section, apply power to the drive and observe the current loop response on an oscilloscope.
3.   The current loop integrator capacitor can be changed or shorted out of the circuit. Test both settings while observing the current loop response.

   a. If the current response square wave oscillates or overshoots, a larger capacitance value is necessary.
   b. If the current response square wave corners are too rounded, a smaller capacitance value is necessary to sharpen the corners.

4.   Although the ideal current loop response after integral gain tuning will be a critically damped square wave, the application requirements will determine what the desired response will be (i.e. how much overshoot, steady-state error, oscillation, is acceptable).

Velocity Loop Tuning

The velocity loop proportional gain is adjusted by the on-board Loop Gain potentiometer. The velocity loop integral gain can be adjusted similar to the current loop integral gain (capacitance value can be changed, capacitor can be shorted out). As in tuning the current loop integral gain, use larger value capacitors to correct for overshoot or oscillation, and smaller value capacitors for a quicker response time.

6. Specifications

6.1 Specifications Tables

Table 6.1 Power Specifications

Description	Units	CAB☐10A36	CAB☐6A80	CAB☐12A80	CAB☐20A80	CAB☐40A80	CAB☐60A80	CAB☐10A175	CAB☐25A175
DC Supply Voltage Range	VDC	10-36	20-80			10-80		40-175	
DC Bus Over Voltage Limit	VDC	40	88					195	193
DC Bus Under Voltage Limit	VDC	8	18		9			36	
Maximum Peak Output Current	A	10	6	12	20	40	60	10	25
Maximum Continuous Output Current	A	5	3	6	12	20	30	6	12.5
Maximum Power Dissipation at Continuous Current	W	9	12	24	48	80	120	53	110
Minimum Load Inductance	μH	100	100					250	
Switching Frequency[1]	kHz	40	31					20.7	

1. Switching frequency for CABE/CABH40A80 and CABE/CABH60A80 drive models is 33 kHz. Switching frequency for CABE/CABH10A175 and CABE/CABH_25A175 is 22 kHz.

Special Environment drives Power Specifications						
Description	Units	CAB_8A80X	CAB_15A80X	CAB_25A80X	CAB_40A80X	CAB_16A175X
DC Supply Voltage Range	VDC	10-80				40-175
DC Bus Over Voltage Limit	VDC	88				195
DC Bus Under Voltage Limit	VDC	9				32
Maximum Peak Output Current	A	8	15	25	40	16
Maximum Continuous Output Current	A	4	7.5	12.5	20	8
Maximum Power Dissipation at Continuous Current	W	16	30	50	80	70
Minimum Load Inductance	μH	100				

Table 6.2 Control Specifications

Description	CAB(X)	CABDC(X)	CABE(X)[1]	CABH(X)[2]
Command Sources	± 10V Analog	PWM and Direction	± 10V Analog	± 10V Analog
Commutation Methods	Trapezoidal	Trapezoidal	Trapezoidal	Trapezoidal
Control Modes	Current	Current	Current, Duty Cycle, Encoder Velocity, Tachometer Velocity	Current, Duty Cycle, Hall Velocity, Tachometer Velocity
Motors Supported	Three Phase Single Phase	Three Phase Single Phase	Three Phase Single Phase	Three Phase Single Phase

1. CABE10A36 models operate solely in Encoder Velocity mode.
2. CABH10A36 models operate solely in Hall Velocity mode.

Table 6.3 Feedback Supported

Description	AZB	AZBDC	AZBE	AZBH
Hall Sensors for Commutation	✔	✔	✔	✔
Hall Sensors for Velocity Control				✔
Single- Ended Incremental Encoder			✔	

Table 6.4 Hardware Protection

Description[1]	All Golden Ding Analog Drives
Over Current	✔
Over Temperature	✔
Over Voltage	✔
Under Voltage	✔
Short Circuit (Phase-Phase)	✔
Short Circuit (Phase-Ground)	✔
Invalid Hall Commutation	✔

1. See "Fault Conditions and Symptoms" for more information on hardware protection.

Table 6.5 Golden Ding Analog Servo Drive datasheet

Golden Ding Analog Servo Drive		Current Reference Scaling Factor [1]	Current Monitor Scaling Factor	Hall Velocity Scaling Factor	Encoder Velocity Scaling Factor	Tachometer feedback voltage range
CAB	10A36	/	2A/V	/	/	/
	6A80	±7.45	2A/V			
	12A80	±7.45	4A/V			
	20A80	±7.45	6.4A/V			
	40A80	±7.3	13.5A/V			
	60A80	±7.3	20A/V			
	25A175	±7.3	8.3A/V			
	8A80X	±7.3	2.7A/V			
	15A80X	±7.3	5.13A/V			
CABH	10A36	/	2A/V	385HZ/V	/	/
	6A80	±7.32	2A/V	100HZ/V		±60VDC
	12A80	±7.32	4A/V			
	20A80	±7.5	5.3A/V			
	40A80(X)	±7.3	13.3A/V			
	60A80	±7.2	20A/V			
	25A175	±7.3	8.3A/V			
	8A80X	±7.3	2.7A/V			
	15A80X	±7.3	5.13A/V			
	16A175X	±7.3	5.13A/V			
	25A80X	±7.3	5.13A/V			
CABE	10A36	/	2A/V	/	90KHZ/V	/
	6A80	±7.45	2A/V		22KHZ/V	±60VDC
	12A80	±7.45	4A/V			
	20A80	±7.5	5.3A/V			
	40A80	±7.3	13.3A/V			
	60A80	±7.2	20A/V			
	25A175	±7.3	8.33A/V		21KHZ/V	
	8A80X	±7.3	2.7A/V		22KHZ/V	
	15A80X	±7.3	5.13A/V			
	25A80X	±7.3	13.3A/V			
	40A80X	±7.23	13.3A/V			
CABDC	10A36	/	2A/V	/	/	/
	6A80	±7.45	2A/V			
	12A80	±7.45	4A/V			
	20A80	±7.45	6.4A/V			
	40A80(X)	±7.3	13.5A/V			
	60A80	±7.3	20A/V			
	25A175	±7.3	8.3A/V			
	8A80X	±7.3	2.7A/V			
	15A80X	±7.3	5.13A/V			
	25A80X	±7.3	13.5A/V			

1. **The values in this column correspond to the maximum peak current output by the driver, measure relative to the signal ground.**
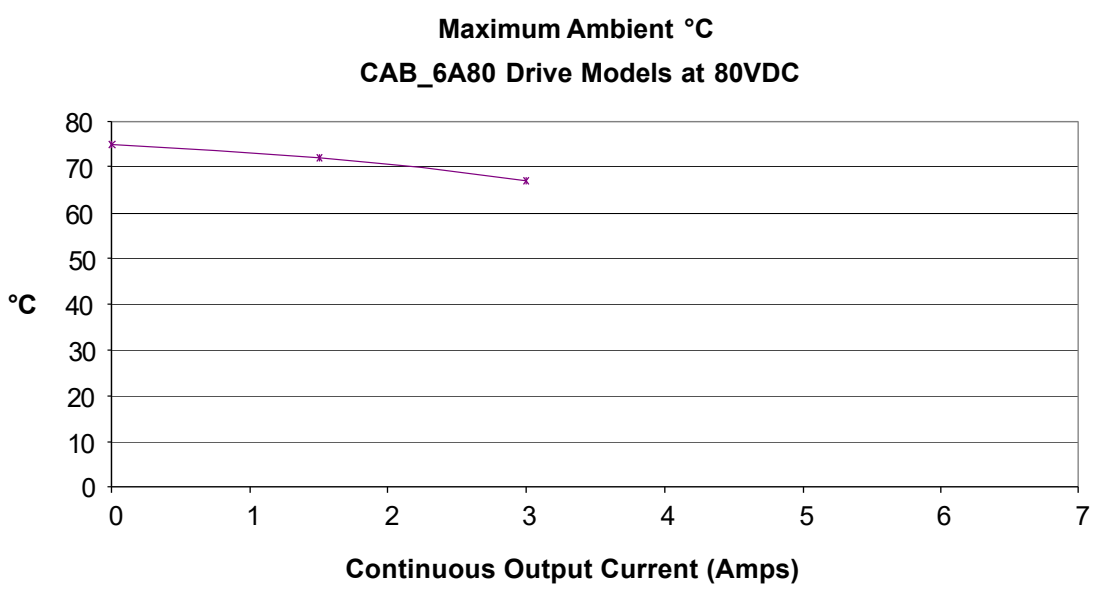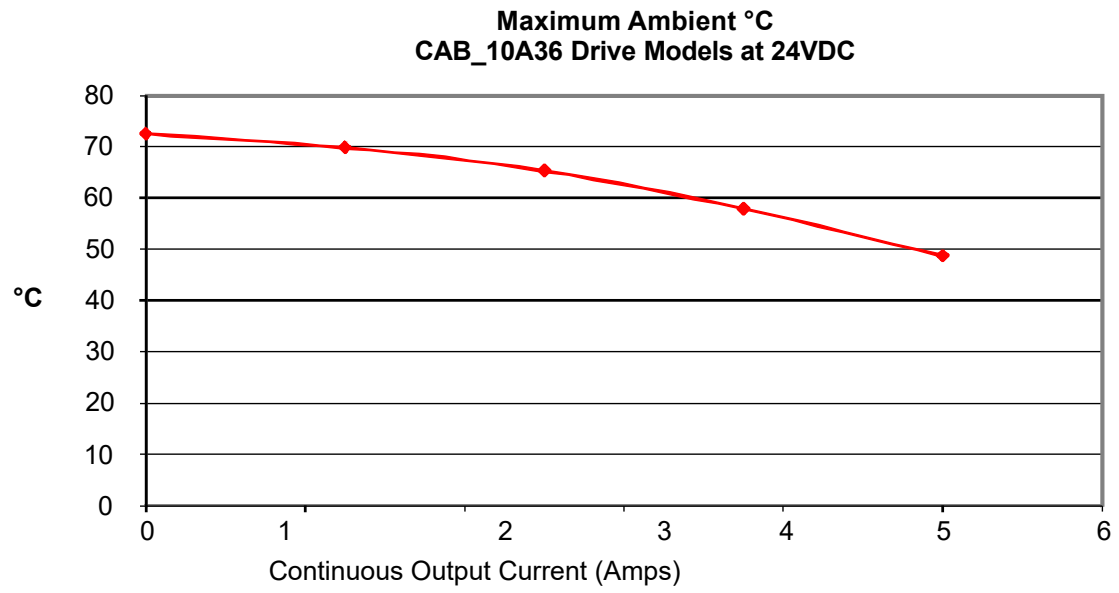
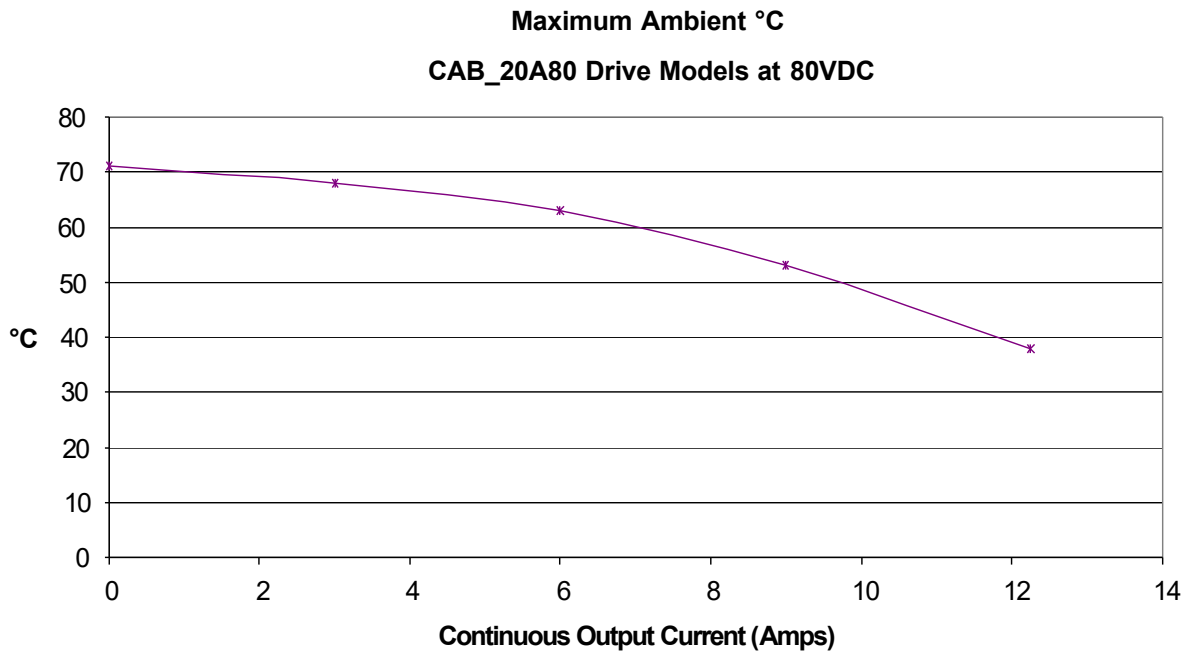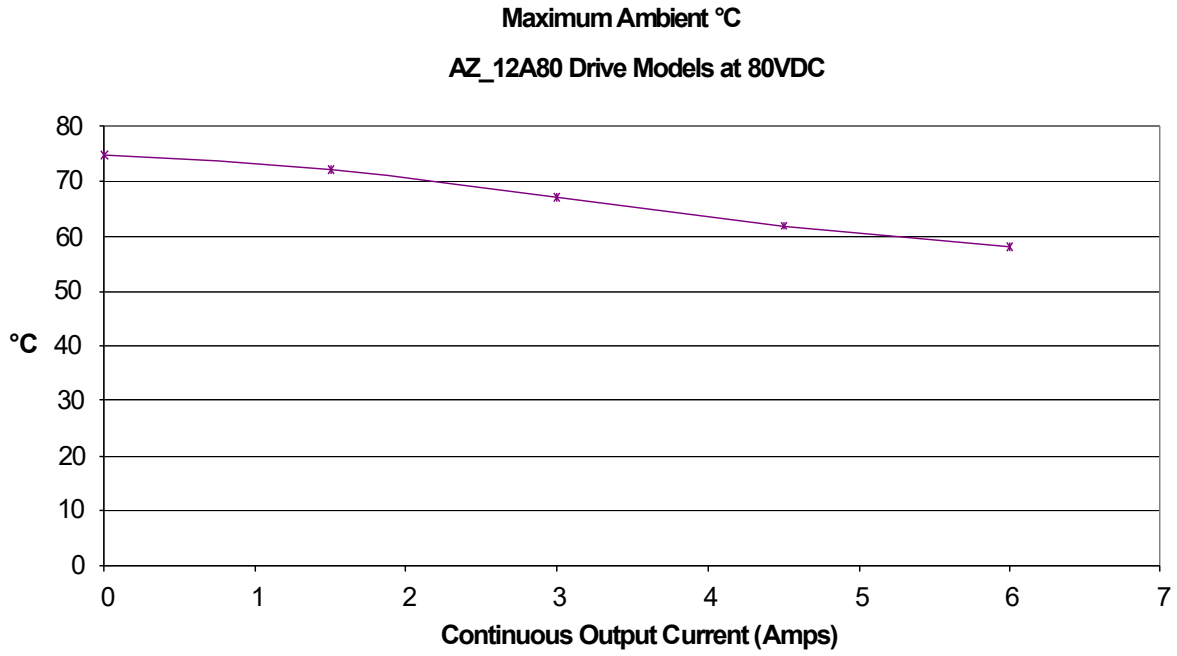## Table 6.6 Golden Ding Series Analog Servo Drive Model List

| Rated Current / PeakCurrent (A$_{rms}$)	Input voltage range (VDC)	Shunt Regulator (REGEN)	Input Command			
			+/-10V Analog			PWM &Direction
			Feedback Hall	Feedback Hall Tachometer	Feedback Hall Incremental Encoder Tachometer	Feedback Hall
			Modes Of Operation Current	Modes Of Operation Current Duty Cycle (Open Loop) Hall Velocity Tachometer Velocity	Modes Of Operation Current Duty Cycle (Open Loop) Encoder Velocity Tachometer Velocity	Modes Of Operation Current
5/10	10-36	Built-in Shunt Regulator	CAB10A36	CABH10A36*	CABE10A36*	CABDC10A36
3/6	10-80		CAB6A80	CABH6A80	CABE6A80	CABDC6A80
6/12			CAB12A80	CABH12A80	CABE12A80	CABDC12A80
12/20			CAB20A80	CABH20A80	CABE20A80	CABDC20A80
20 /40			CAB40A80	CABH40A80	CABE40A80	CABDC40A80
30/60			CAB60A80	CABH60A80	CABE60A80	CABDC60A80
12.5/25	40-175		CAB25A175	CABH25A175	CABE25A175	CABDC25A175
6/8	10-80		CAB6A80X	CABH6A80X	CABE6A80X	CABDC6A80X
7.5/15			CAB15A80X	CABH15A80X	CABE15A80X	CABDC15A80X
12.5/25			CAB25A80X	CABH25A80X	CABE25A80X	CABDC25A80X
20/40			CAB40A80X	CABH40A80X	CABE40A80X	CABDC40A80X
8/16	40-175		CAB16A175X	CABH16A175X	CABE16A175X	CABDC16A175X
Motors Supported:Three Phase (Brushless),Single Phase (Brushed, Voice Coil, Inductive Load)						
*CABH10A36 only support Hall Velocity，CABE only suppoert Encoder Velocity						

(Left column vertical labels: -25-75℃ for upper section, -40-65℃ for lower section)

FIGYRE 6.1 Golden Ding Series Analog Servo Drives Ambient Temperature Ranges

Maximum Ambient °C
CAB_10A36 Drive Models at 24VDC

Maximum Ambient °C

CAB_6A80 Drive Models at 80VDC

Maximum Ambient °C

AZ_12A80 Drive Models at 80VDC

Maximum Ambient °C
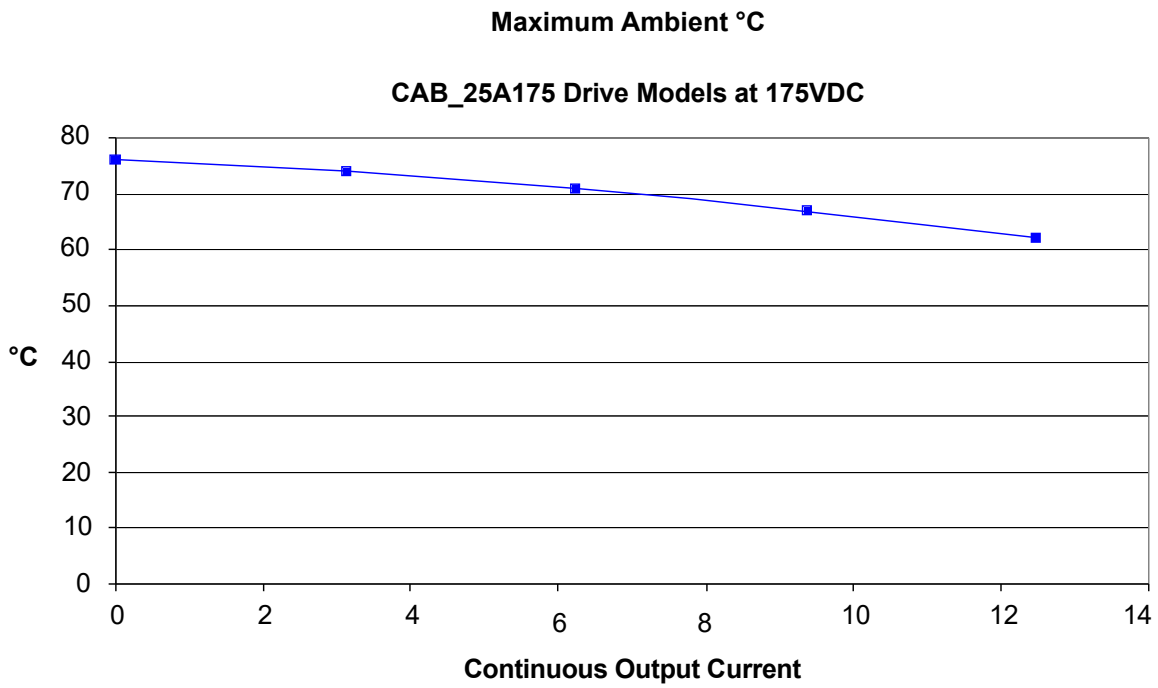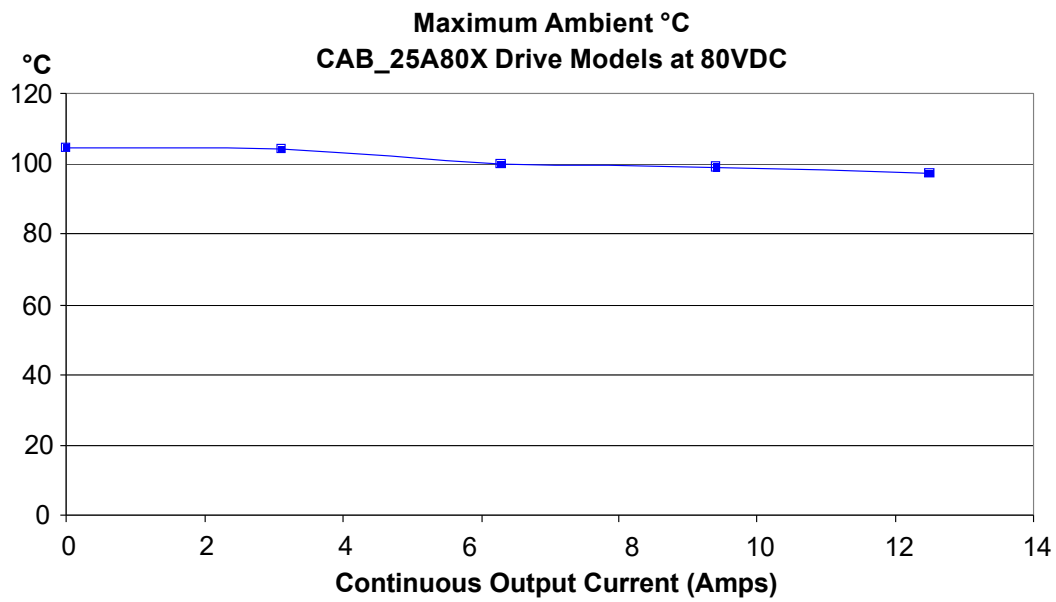
CAB_20A80 Drive Models at 80VDC

Maximum Ambient °C

CAB_40A80 Drive Models at 80VDC
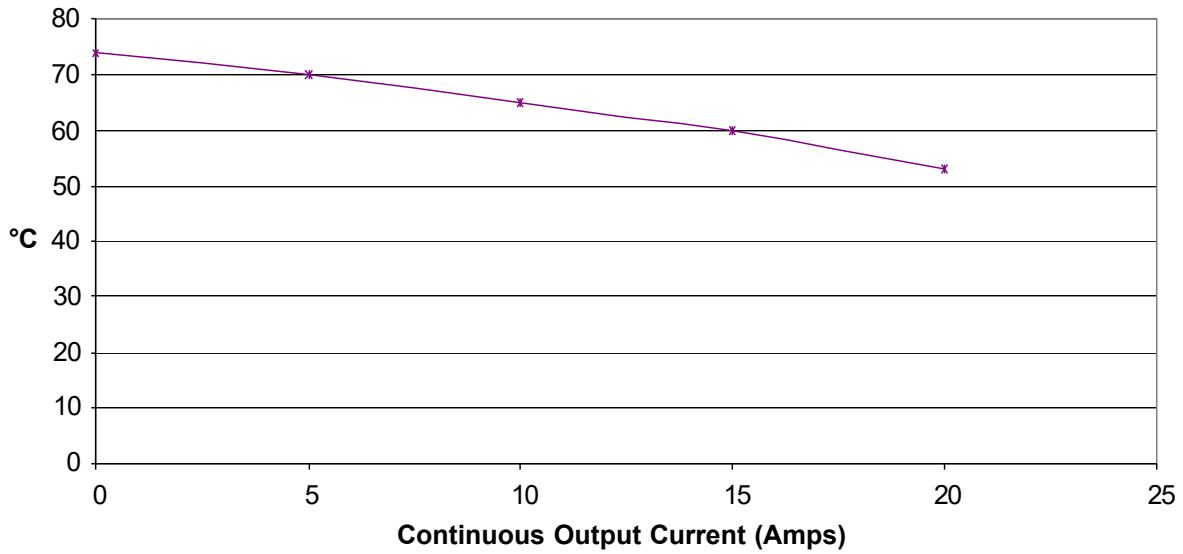
Maximum Ambient °C

CA_60A80 Drive Models at 80VDC

Maximum Ambient °C

CAB_10A175 Drive Models at 175VDC

Maximum Ambient °C

CAB_25A175 Drive Models at 175VDC

Maximum Ambient °C
CAB_8A80X / CAB_15A80X Drive Models at 80VDC

°C

Continuous Output Current (Amps)

Maximum Ambient °C
CAB_25A80X Drive Models at 80VDC

°C

Continuous Output Current (Amps)
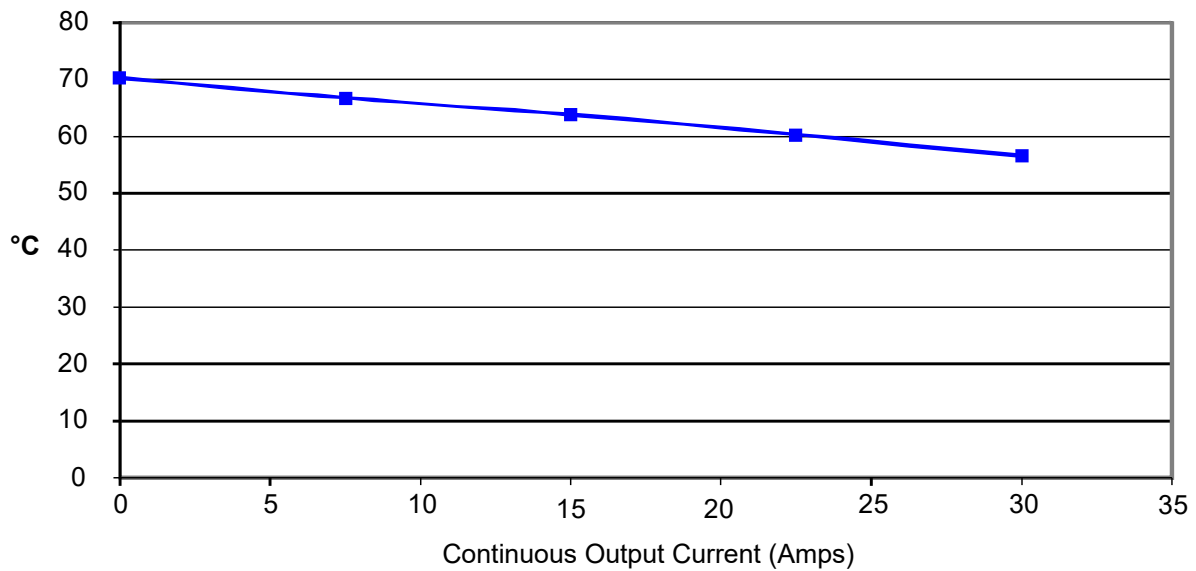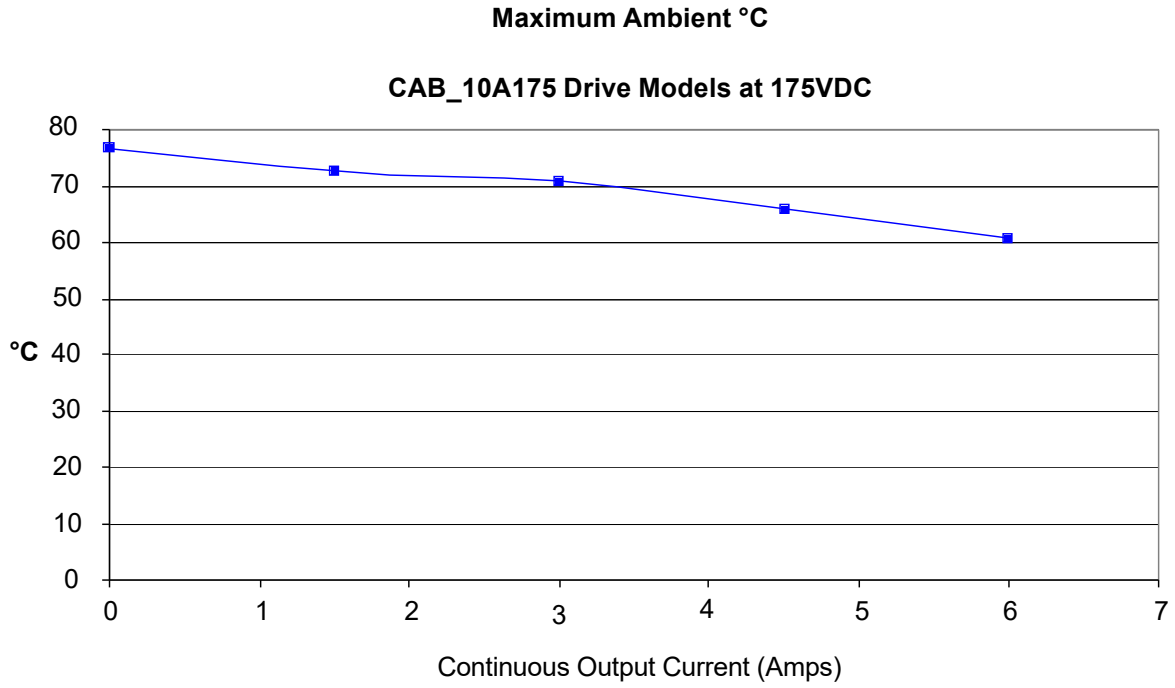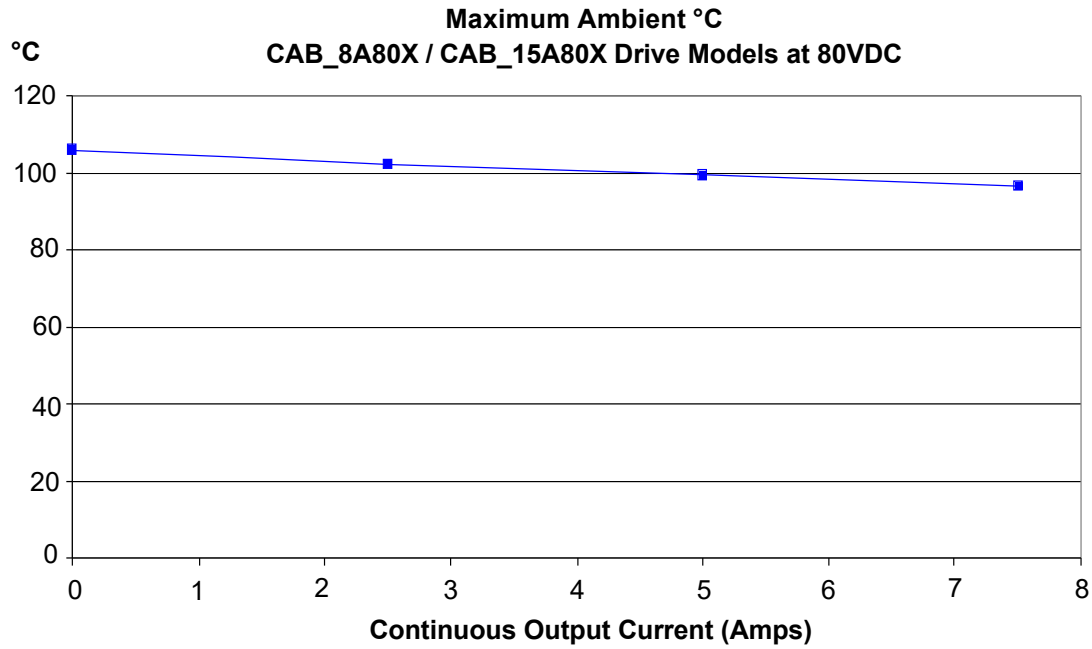
1. Contact AMC China for anther Golden Ding Analog Servo Drive thermal data.

Table 6.7 Environmental Specifications

Standard Drives Environmental Specifications	
Parameter	**Description**
Ambient Temperature Range	See Figure 6.1
Baseplate Temperature Range	See drive datasheet
Humidity	90%, non-condensing
Mechanical Shock	10g, 11ms, Half-sine
Vibration	2 - 2000 Hz @ 2.5g
Altitude	0-3000m

Special Environment Drives Environmental Specifications	
Parameter	**Description**
Ambient Temperature Range	See Figure B.1
Baseplate Operating Temperature Range	-40 to 105 ºC (-40 to 229 ºF)
Storage Temperature Range	-50 to 100 ºC (-58 to 212 ºF)
Thermal Shock	-40 - 85 ºC (-40 to 185 ºF) in 2 minutes
Relative Humidity	0-95%, non-condensing
Mechanical Shock	15g, 11ms, Half-sine
Vibration	30 Grms for 5 minutes in 3 axes
Altitude	0-3000m

Figure 6.2 Physical Dimensions

CAB☐☐10A36 Installation Dimensions (mm)

CAB☐☐6A80/15A80☐/12A80/20A80/16A175☐ Installation Dimensions (mm)

CAB☐☐25A80/40A80/60A80/25A175 Installation Dimensions (mm)
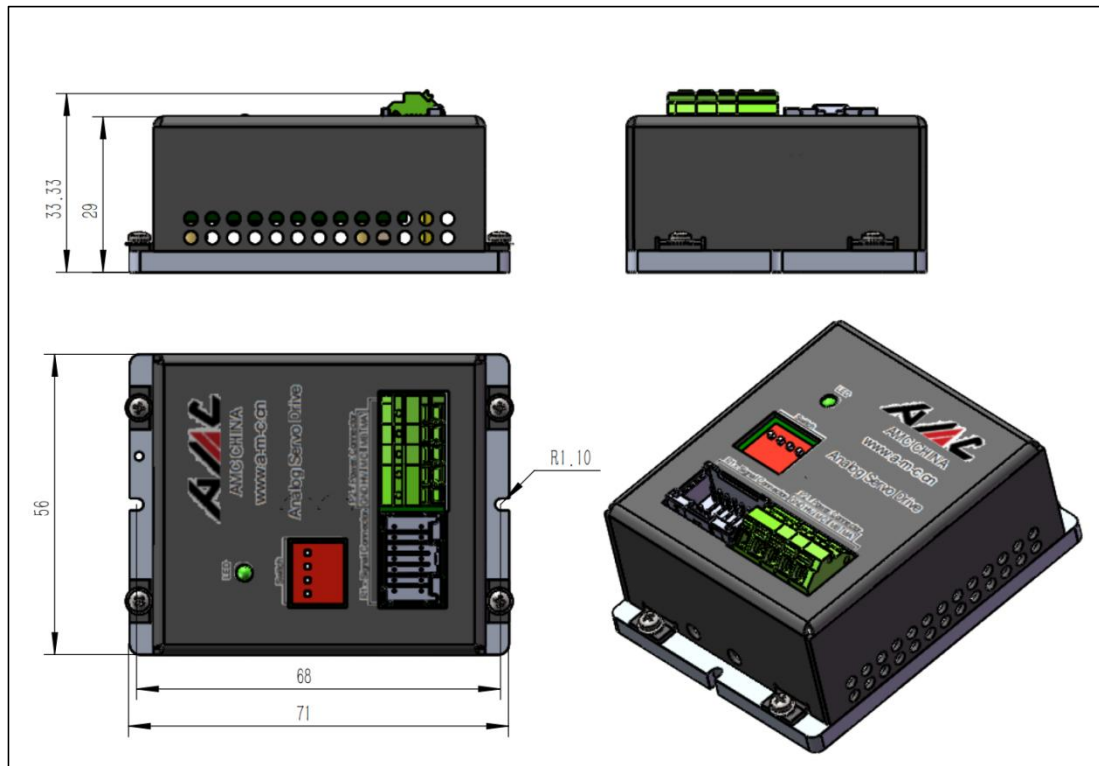
7. Troubleshooting

7.1 Fault Conditions and Symptoms

An inoperative drive can indicate any of the following fault conditions:

- over-temperature
- over-voltage
- under-voltage
- short-circuits
- invalid commutation
- inhibit input
- power-on reset

All of the above fault conditions are self-reset by the drive. Once the fault condition is removed the drive will become operative again without cycling power.

To determine whether the drive is in a fault state, measure the "Fault Output" pin with a digital multimeter or voltmeter. A high at this pin will indicate that the drive is subject to one of the above fault conditions, and the drive will be disabled until the drive is no longer in a fault state. To remove the fault condition, follow the instructions in the sections below describing each possible fault state.

➢ *Over-Temperature*

Verify that the baseplate temperature is less than 75ºC (167º F). The drive remains disabled until the temperature at the drive baseplate falls below this threshold.

➢ *Over-Voltage Shutdown*

1. Check the DC power supply voltage for a value above the drive over-voltage shutdown limit. If the DC bus voltage is above this limit, check the AC power line connected to the DC power supply for proper value.
2. Check the regenerative energy absorbed during deceleration. This is done by monitoring the DC bus voltage with a voltmeter or oscilloscope. If the DC bus voltage increases above the drive over-voltage shutdown limit during deceleration or regeneration, a shunt regulator may be necessary. See "Regeneration and Shunt Regulators" for more information.

➢ *Under-Voltage Shutdown*

Verify power supply voltages for minimum conditions per specifications. Also note that the drive will pull the power supply voltage down if the power supply

cann't provide the required current for the drive. This could occur when high current is demanded and the power supply is pulled below the minimum operating voltage required by the drive.

> ### Short Circuit Fault

1. Check each motor lead for shorts with respect to motor housing and power ground. If the motor is shorted it will not rotate freely when no power is applied while it is uncoupled from the load.
2. Disconnect the motor leads to see if the drive will enable without the motor connected.
3. Measure motor armature resistance between motor leads with the drive disconnected.

> ### Invalid Hall Sensor State

See the "Commutation Sequence" table in "Hall Sensors" for valid commutation states. If the drive is disabled check the following:

1. Make sure the commutation angle of the motor is 60 or 120 degrees，If driving a single phase (brushed type) motor, use the 60-degree phase setting (see "Using a Single Phase Motor" for more information on this particular configuration).
2. Check the voltage levels for all the Hall sensor inputs.
3. Make sure all Hall Sensor lines are connected properly.

> ### Inhibit Input

Check inhibit input for correct polarity (that is, pull-to-ground to inhibit or pull-to-ground to enable). Inhibit configuration depends on JE1 on the PCB. Also, keep in mind that noise on the inhibit line could be a cause for a false inhibit signal being given to the drive. If you want to reverse this logic, please contact AMC China.

> ### Power-On Reset

All drives have a power-on reset function to ensure that all circuitry on the board is functional prior to enabling the drive. The board will only be disabled momentarily, and will quickly enable upon power up.

7.1.1 Overload

Verify that the minimum inductance requirement is met. If the inductance is too low it could appear like a short circuit to the drive and thus it might cause the short circuit fault to trip. Excessive heating of the drive and motor is also characteristic of the minimum inductance requirement not being met. See drive data sheets for minimum inductance requirements.

7.1.2 Current Limiting

Golden Ding Analog Servo Drives incorporate a "fold-back" circuit for protection against over-current. This "fold-back" circuit uses an approximate "I^2t" algorithm to protect the drive.

- Maximum peak current output level can be sustained for about 2 seconds.
- To actually achieve maximum peak current output for 2 seconds requires the current command to fully swing from peak in one direction to the other.

**FIGURE 7.1 Maximum Peak Current Fold-Back**
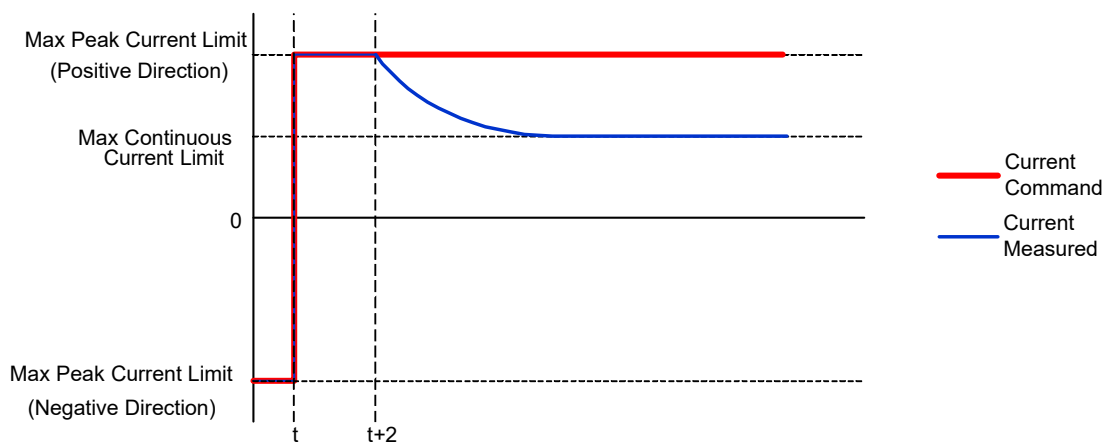
Sustained maximum current demand, when switching between positive and negative maximum current without allowing sufficient time for fold-back, will result in drive damage. Drive RMS current should be below the continuous current setting!

- For most applications, it's a rare occurrence to fully swing from peak in one direction to the other. It is more likely the drive will be commanded from zero to max peak current. Under this condition, the drive will only sustain the maximum peak current for about one second.

FIGURE C.2 Peak Current Fold-Back
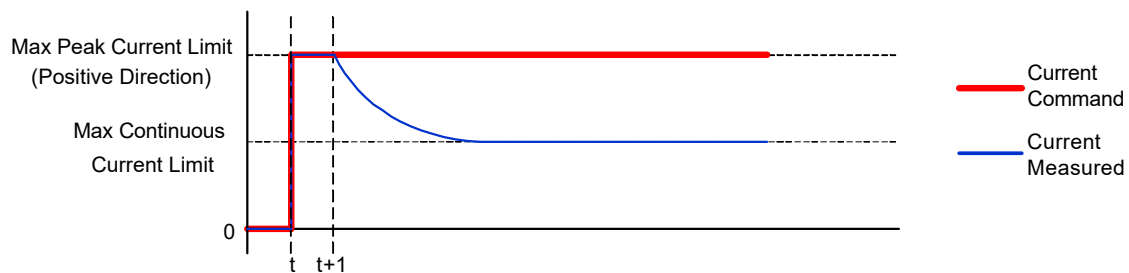
- Commanding maximum peak output current starting from above zero command will also yield reduced peak current output time.
- When commanding output current less than the max peak limit, but more than the max continuous limit, the current output can be sustained for a longer time period than a maximum peak command before folding back.

FIGURE C.3 Above Continuous Current Foldback
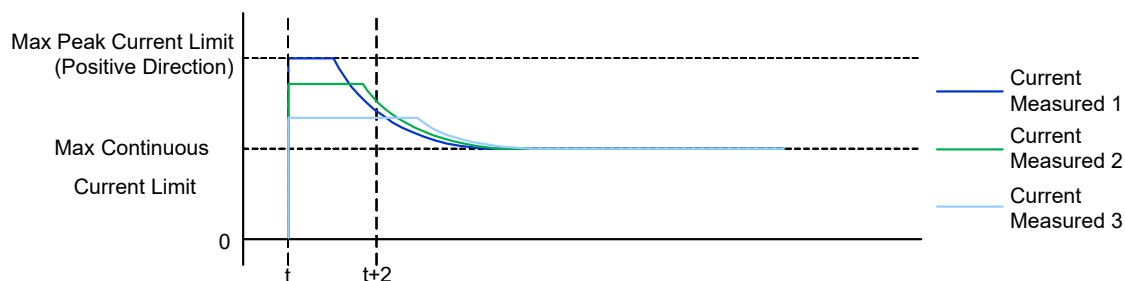
- The closer the commanded current is to the peak current limit, the shorter the peak output time will be.

- Any command at or below the maximum continuous current limit can be achieved for as long as there are no fault conditions present.
- When the drive is configured for any of the velocity modes, the user is no longer in direct control of the current output. The current commands will be determined by the velocity loop. Though internally the current loop still functions like it is described above, it will do only what is necessary to meet the velocity demand. The current output will be heavily dependent on:
  — How tight the velocity loop is tuned
  — The load characteristics
  — The speed the motor is already turning
  — Magnitude and slope of velocity step

7.1.3 Motor Problems

A motor run-away condition is when the motor spins rapidly with no control from the command input. The most likely cause of this error comes from having the feedback element connected for positive feedback. This can be solved by changing the order that the feedback element lines are connected to the drive, changing DIP switch settings, or removing a jumper (depending on the drive model).

Another common motor issue is when the motor spins faster in one direction than in the other. This is typically caused by improper commutation, usually because the motor power wires are connected in the wrong order. Try all six combinations of connecting the motor power wires to the drive to find the correct commutation order. The proper combination of motor wires will yield smooth motion and identical speeds in both directions. Improper combinations will cause jerky motion, slow movement in one direction, and/or audible noise. As a final verification that the commutation is correct, use the Velocity Monitor Output pin to measure motor speed in both directions. This can also be caused by invalid Hall Commutation. Check to see if the drive is set for 120- or 60-degree phasing, and whether this setting corresponds to the type of motor being used (typically 120-degree for three phase motors, and 60-degree for single phase motors). See "Hall Sensors" for more information.

For a brushless motor, if the opposite motor direction is desired for a given command input, interchange Hall 1 and Hall 3, then Motor A and Motor B.

7.1.4 Causes of Erratic Operation

- Improper grounding (for example, drive signal ground is not connected to source signal ground).
- Noisy command signal. Check for system ground loops.
- Mechanical backlash, dead-band, slippage, etc.
- Noisy inhibit input line.
- Excessive voltage spikes on bus.

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