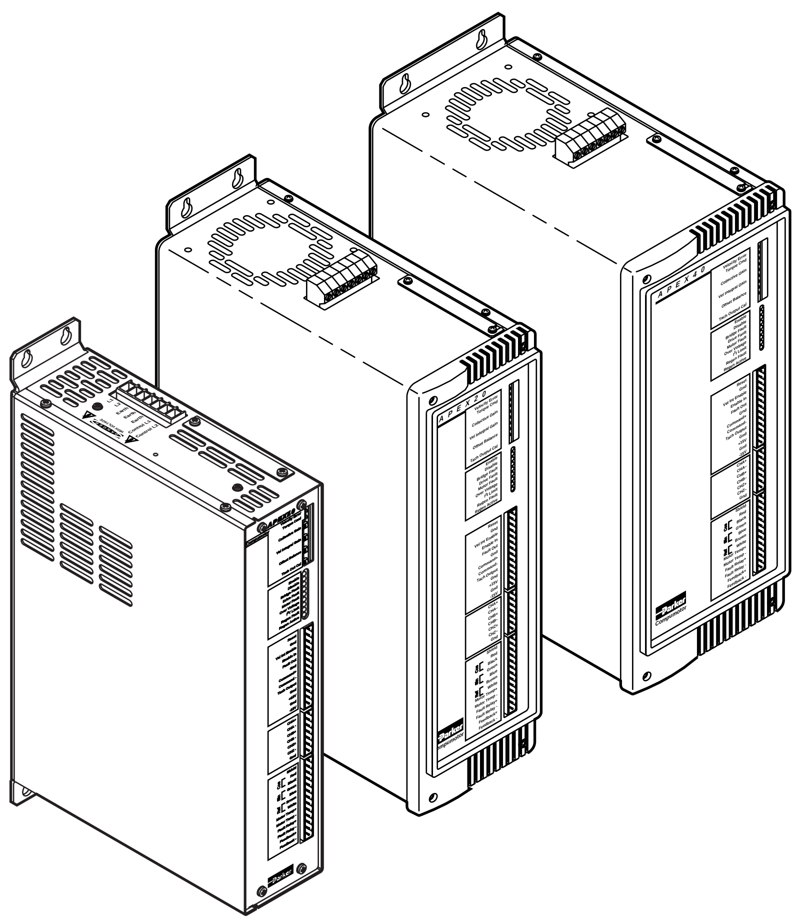
Compumotor

APEX10
APEX20 APEX40
Analog Servo Drive
User Guide



Compumotor Division
Parker Hannifin Corporation
p/n 88-013904-02 B

IMPORTANT

User Information

To ensure that the equipment described in this user guide, as well as all the equipment connected to and used with it, operates satisfactorily and safely, all applicable local and national codes that apply to installing and operating the equipment must be followed. Since codes can vary geographically and can change with time, it is the user's responsibility to identify and comply with the applicable standards and codes. **WARNING:** ***Failure to comply with applicable codes and standards can result in damage to equipment and/or serious injury to personnel.***

Personnel who are to install and operate the equipment should study this user guide and all referenced documentation prior to installation and/or operation of the equipment.

In no event will the provider of the equipment be liable for any incidental, consequential, or special damages of any kind or nature whatsoever, including but not limited to lost profits arising from or in any way connected with the use of this user guide or the equipment.

Since Parker Compumotor constantly strives to improve all of its products, we reserve the right to change this user guide and equipment mentioned therein at any time without notice.

Technical Assistance ⇨ *Contact your local automation technology center (ATC) or distributor,* ***or ...***

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Motion & Control

Compumotor

Change Summary

APEX Servo Drive User Guide

88-013904-02 B
May 2000

This user guide, part number 88-013904-03 B, replaces the previous user guide: **APEX10/20/40** Analog Servo Drive User Guide. p/n **88-013904-02 A**

Primary changes that appear in this new user guide are summarized below.

User Guide Incorporation

The changes made and published in APEX10/20/40 User Guide Addendum, p/n 88-016237-01 D, were incorporated.

Moved Apex Motors to Appendix

APEX motor information was moved; motors up to and through the APEX610 have been replaced by NeoMetric Motors.

APEX10 DIP Switch Changes

DIP Switch functions have been changed for:
- Current Loop Compensation
- Motor Thermal Time Constant

APEX20 DIP Switch Changes

DIP Switch functions have been changed for:
- Current Loop Compensation

APEX40 DIP Switch Changes

DIP Switch functions have been changed for:
- Peak Current
- Pole Pair Number

New Motor Information

Eight Compumotor 70mm and eight Compumotor 92mm NeoMetric Series motors have been included. The information includes:

DIP Switch Settings

Speed/Torque Curves

Motor Specifications

Motor Dimensions

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Table of Contents

CHAPTER ONE

Introduction

IN THIS CHAPTER

INTRODUCTION

This user guide describes three products.

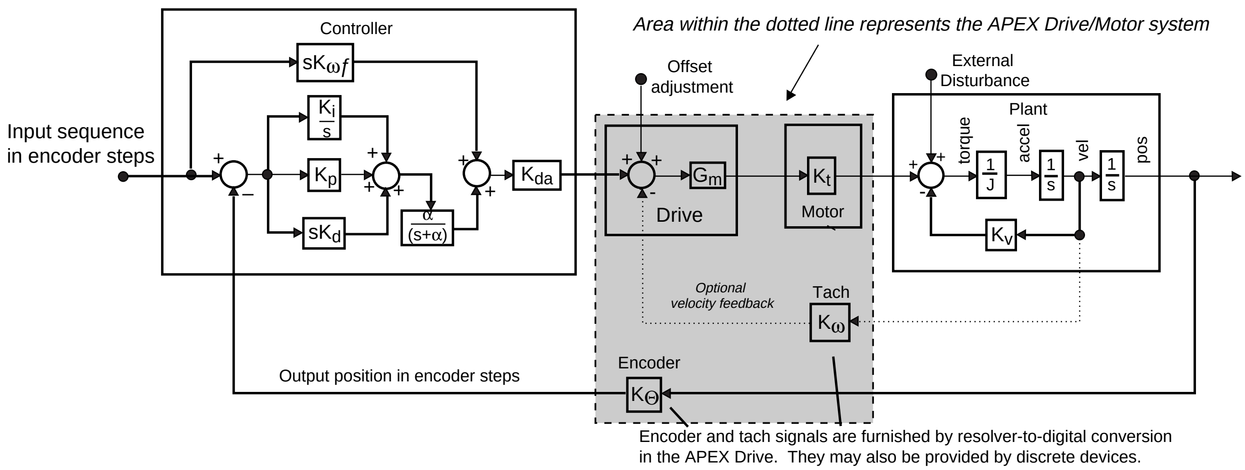
- APEX10 Servo Drive – 16A peak, 8A continuous; 1-phase AC input
- APEX20 Servo Drive – 24A peak, 12A continuous; 1- or 3-phase AC input
- APEX40 Servo Drive – 40A peak, 20A continuous; 1- or 3-phase AC input

NAMES IN THIS USER GUIDE

The drives listed above have many identical features. In this manual, when we describe features that are the same on each drive, we will use the name **APEX Drive**. When we describe features that are not the same on all drives, we will identify each by its full name—**APEX10 Drive**, **APEX20 Drive**, or **APEX40 Drive**. This will help call attention to differences between the drives.

APEX DRIVE0 – DESCRIPTION AND BLOCK DIAGRAM

The APEX Drive is a sinusoidal servo drive designed to run three phase brushless DC servo motors equipped with resolvers. The block diagram for a typical system is shown below.



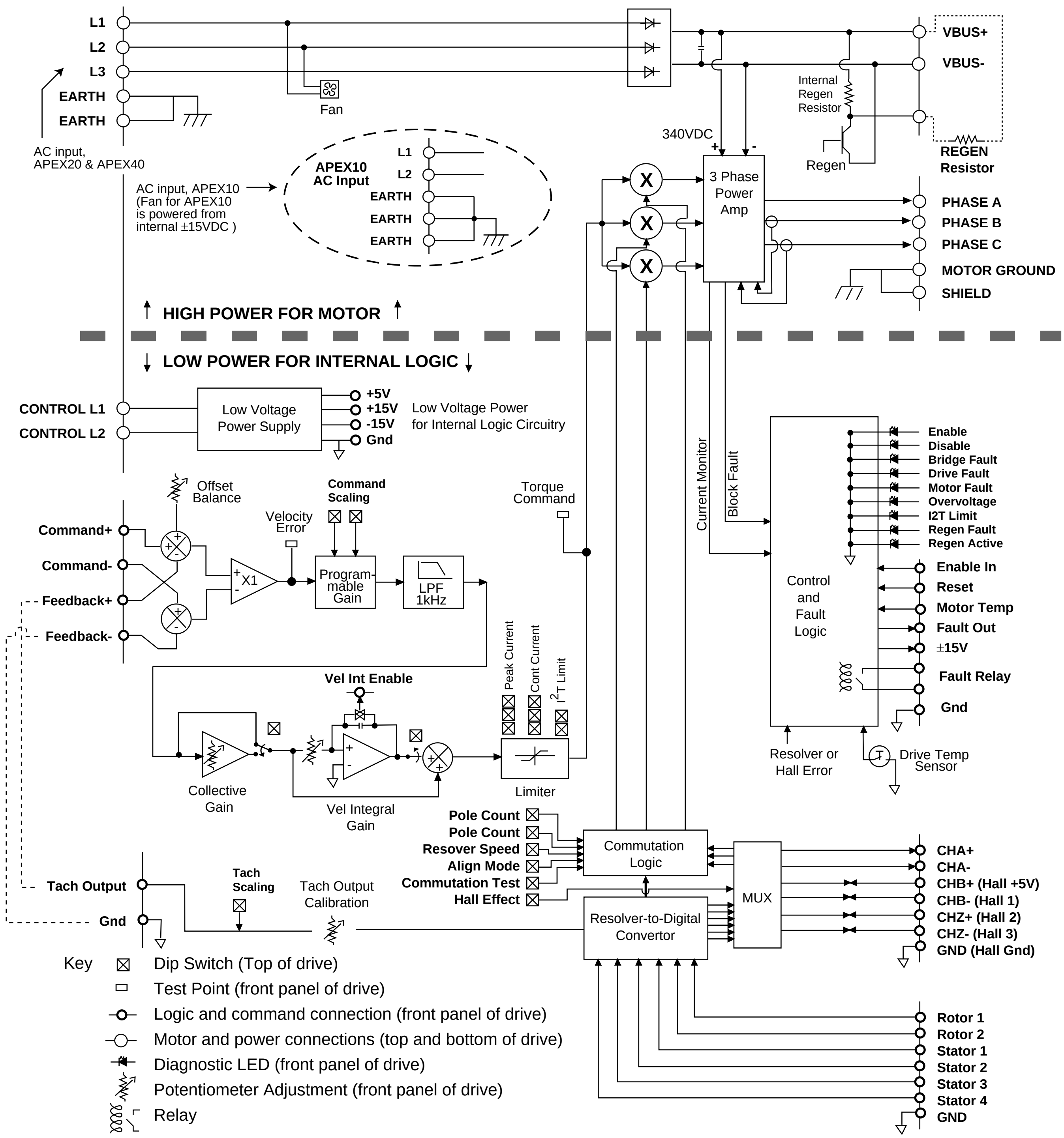
System Block Diagram

Output from the controller to the drive is an analog voltage that can range from -10VDC to +10VDC. This is a *torque command* that represents commanded current. The drive will produce output current to the motor that is proportional to the voltage level of the torque command.

Inside the APEX Drive (see the block diagram below), the torque command goes through input filtering and scaling circuitry, and on to a three phase power amplifier, where it is combined with commutation information from the motor. The power amplifier, an *insulated gate bipolar transistor* (IGBT) module, sends current of the correct phase and polarity to the motor. The amplifier contains pulse width modulation (PWM) and current loop feedback circuitry. The IGBT module also contains control and fault logic that drives the status LEDs and various inputs and outputs.

The drive has an internal regeneration resistor, and control circuitry that will automatically dissipate excess regenerated energy in the resistor. You can also install an external regeneration resistor to dissipate even more regenerated energy.

APEX DRIVE – BLOCK DIAGRAM



ADDITIONAL FEATURES

TWO AC POWER INPUTS

The drive has two AC inputs. One provides power for motor current, through the internal high-power three phase amplifier. The other input provides power for logic and control, through the internal low-voltage DC power supply. With these two separate inputs, you can remove power from the motor, but continue to power internal control circuits.

TORQUE MODE OR VELOCITY MODE

Most users will operate the drive with a servo controller, such as Compumotor's 6250 Servo Controller. With this type of controller, we recommend operating the drive in torque mode. This provides the best performance, and eliminates the need for tuning at the drive.

You can operate the drive in velocity mode if you use a P type controller (as opposed to PID type controller), or if you need to control the velocity of a spindle with an analog velocity command.

RESOLVER OR HALL EFFECT

The default setup for the Apex drives is to use a resolver for communtation. Encoder signals for feedback are also derived from the resolver information; however, a motor with Hall effects and an encoder can be used in place of a motor with a resolver.

DIP SWITCHES

The APEX Drive has a bank of DIP switches located on top of the drive. You can set these switches to configure the drive for your particular application.

INPUTS AND OUTPUTS

All input and output signal connections are made on the front panel of the drive, through removable screw terminal connectors. The power and motor connections are separated (top and bottom of the drive) and re-cessed from the front panel for safety.

COMPUMOTOR SERVO MOTORS

Compumotor sells three models of servo motors with the APEX Drive.

- ❏ APEX Series Servo Motors
- ❏ SM Series Servo Motors
- ❏ NeoMetric Series Servo Motors

Each model is available in many different sizes. See *Chapter 4 Hardware Reference* for motor specifications and dimensions.

COMPUMOTOR FAMILY OF PRODUCTS

The APEX Drive is completely compatible with Compumotor's broad range of single-axis and multi-axis motion control products.

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CHAPTER TWO

Installation

IN THIS CHAPTER

- ❏ Inspect the shipment
- ❏ Configure DIP switches
- ❏ Mount the APEX Drive and motor.
- ❏ Connect resolver, motor, and controller cables.
- ❏ Tune the system

INSTALLATION OVERVIEW

This chapter contains information you need to install your APEX Drive. Sections in the chapter are presented in the following order:

- Inspect the Shipment
- Set DIP Switches
- Mount the Drive
- Mount the Motor
- Connect the Resolver Cable
- Connect the Motor Cable
- Connect AC Power
- Adjust the Offset Balance potentiometer
- Connect the Drive to the Controller
- Connect the Encoder to the Controller
- Test the System—read the encoder, and turn the motor
- Connect the Motor to the Load
- Tune the System

To install your drive, complete each section in the order presented.

INSPECT THE SHIPMENT

Inspect your APEX shipment for obvious damage to its shipping container. Report any damage to the shipping company as soon as possible. Parker Compumotor cannot be held responsible for damage incurred in shipment. The items below should be present and in good condition. See Appendix A for APEX Motor Options/Accessories.

Part				**Part Number**
APEX10 Analog Servo Drive				APEX10
APEX20 Analog Servo Drive				APEX20
APEX40 Analog Servo Drive				APEX40
Ship kit:	8-pin Plug	(motor conn.)	(one included)	43-014533-01
	7-pin Plug	(AC input)	(one included)	43-013575-01
	7-pin Plug	(I/O)	(one included)	43-013801-01
	13-pin Plug	(I/O)	(two included)	43-013802-01
	Jumper Wires		(two included)	71-015237-01
	User Guide			88-013904-02

Options/Accessories		**Part Number**
SM Series Motor:	(motor with resolver)	SM-231AR SM-232AR SM-233BR
Resolver Cable:	(SM-23_R motors)	71-015870-xx
Resolver Hi-Flex:	(SM-23_R motors)	71-016374-yy
Motor Cable:	(SM-23_R motors)	71-014675-yy
Motor Hi-Flex:	(SM-23_R motors)	71-016023-yy
Cable Kit:	(Resolver & MotorCables for SM-23)	23RS CABLE-xx:

Options/Accessories *(continued)*		Part Number
NeoMetric Motors:	(motors with resolver)	N0701-R, N0341-R
		N0702-R, N0342-R
		N0703-R, N0343-R
		N0704-R, N0344-R
		N0921-R, N0922-R
		N0923-R, N0924-R
J-Series Motors:	(motors with resolver)	J0701_R, J0341_R
		J0702_R, J0342_R
		J0703_R, J0343_R
		J0921_R, J0922_R
		J0923_R
Resolver Cable:	(NeoMetric & J-Series Motors)	71-015870-xx
Resolver Hi-Flex:	(NeoMetric & J-Series Motors)	71-016374-yy
Motor Cable:	(NeoMetric & J-Series 70mm & 34-frame)	71-015531-xx
	(NeoMetric & J-Series 92mm)	71-015532-xx
Motor Hi-Flex:	(NeoMetric & J-Series 70mm & 34-frame)	71-016529-yy
	(NeoMetric & J-Series 92mm)	71-016530-yy
Cable Kit:	(Resolver & Motor for 70mm & 34-frame)	70RS CABLE-xx
	(Resolver & Motor for 92mm)	92RS CABLE-xx

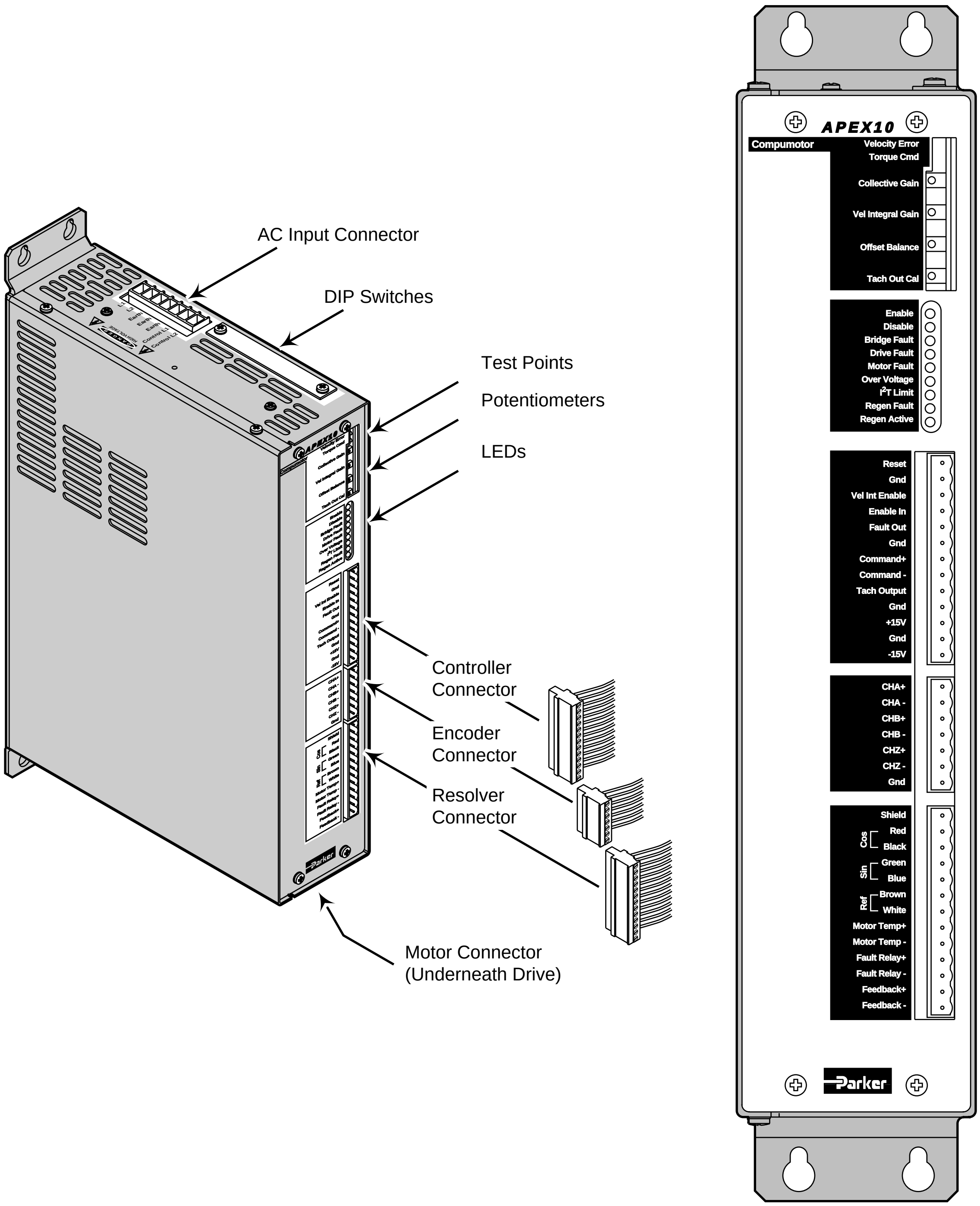
xx can be 10, 25, 35, 40 or 50 feet
yy can be 10, 25, 35 or 50 feet

APEX Drive – Component Locations

The next drawing shows locations and names of the various connectors, switches, and drive components that you will encounter during the installation procedure.

Illustrations in this User Guide

We will usually show the APEX10 Drive in the illustrations for this user guide. The APEX20 and APEX40 Drives have similar features.



Component Locations

BENCH TEST – GETTING STARTED QUICKLY

To familiarize yourself with the APEX Drive, you may wish to perform a *bench test* before you permanently install the drive. To do so, read this installation chapter, and perform the procedures that are necessary to produce motion:

- Set DIP Switches
- Connect the Resolver Cable
- Connect the Motor Cable
- Connect AC Power
- Adjust the Offset Balance potentiometer
- Connect the Drive to the Controller
- Connect the Encoder to the Controller
- Test the system—read the encoder, and turn the motor

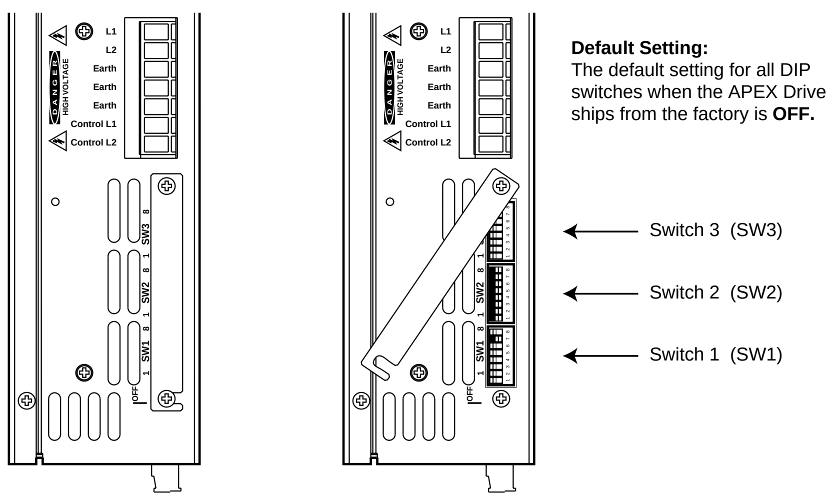
Read, but do not perform, permanent installation procedures:

- Mount the Drive
- Mount the Motor
- Connect the Motor to the Load
- Tune the System

When you are ready to permanently install your drive, you can complete these last four procedures.

CONFIGURE THE APEX DRIVE'S DIP SWITCHES

The APEX Drive has three 8-position DIP switches, located behind a small access cover on top of the drive. Loosen the two screws that hold the access cover. Rotate the cover to expose the DIP switches.

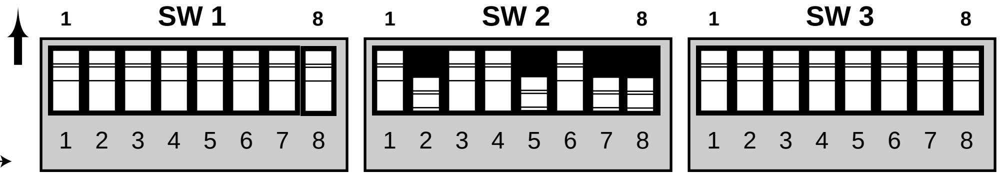


DIP Switch Location, with Cover Closed and Open

Set the switches to configure the drive for your application. The drive ships from the factory with all switches in the OFF position. Use a small screwdriver to set each switch. Tables on the next pages summarize switch settings for APEX10, APEX20, and APEX40 Drives. Small diagrams on the following pages show how to configure the drive for each SM or NeoMetric motor that we recommend for use with that drive. Instructions for setting each switch follow the tables. See *Appendix A* for APEX Motor Settings.

APEX10 DIPs

Shown Configured for SM231A Motor



SW 1

REGEN FAULT	1
Enable	OFF
Disable	ON

HALL DEGREES	2
120∞ Hall motor	OFF
60∞ Hall motor	ON

RESERVED	3
Off	OFF

POLE PAIR NUMBER	4	5
2	OFF	OFF
3	OFF	ON
Reserved	ON	OFF
Reserved	ON	ON

RESOLVER SPEED	6
1	OFF
2	ON

CURRENT LOOP COMPENSATION (motor inductance) with 120VAC Input:	with 240VAC Input:	7	8
1 – 2 mH	Not Applicable	OFF	OFF
2 – 5 mH	5 – 20 mH	OFF	ON
5 – 60 mH	20 – 60 mH	ON	OFF
Reserved		ON	ON

SW 2

CONTINUOUS CURRENT (peak of sine wave)	1	2	3
1.8 amps	OFF	OFF	OFF
2.6	OFF	OFF	ON
3.4	OFF	ON	OFF
4.0	OFF	ON	ON
5.0	ON	OFF	OFF
6.0	ON	OFF	ON
7.0	ON	ON	OFF
8.0	ON	ON	ON

PEAK CURRENT	4	5	6
6.5 amps	OFF	OFF	OFF
7.5	OFF	OFF	ON
9.5	OFF	ON	OFF
11.0	OFF	ON	ON
12.5	ON	OFF	OFF
14.0	ON	OFF	ON
15.0	ON	ON	OFF
16.0	ON	ON	ON

MOTOR THERMAL TIME CONSTANT	7	8
2 minutes	OFF	OFF
4	OFF	ON
8	ON	OFF
10	ON	ON

SW 3

VELOCITY INTEGRATOR	1
No	OFF
Yes	ON

ALIGNMENT MODE	2
No	OFF
Yes	ON

COMMUTATION TEST MODE	3
No	OFF
Yes	ON

HALL SELECT	4
Resolver Mode	OFF
Hall Mode	ON

TACH SCALING	5
One speed resolver (1V = 1,000 RPM with a one speed resolver)	OFF
Two speed resolver (1V = 1,000 RPM with a two speed resolver)	ON

COMMAND INPUT SCALING	6	7
10V = 16.0 amps	OFF	OFF
10V = 12.0 amps	OFF	ON
10V = 8.0 amps	ON	OFF
10V = 7.0 amps	ON	ON

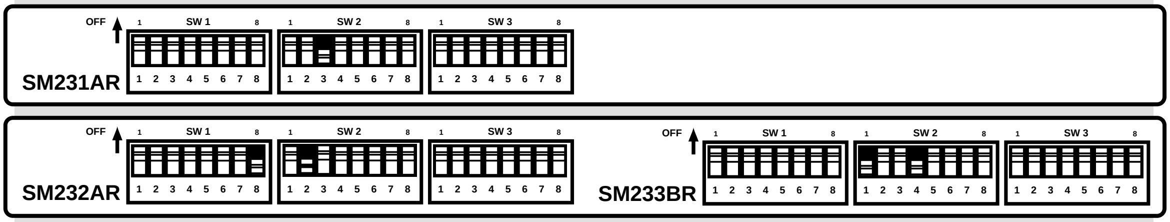
COLLECTIVE GAIN	8
Off	OFF
On	ON

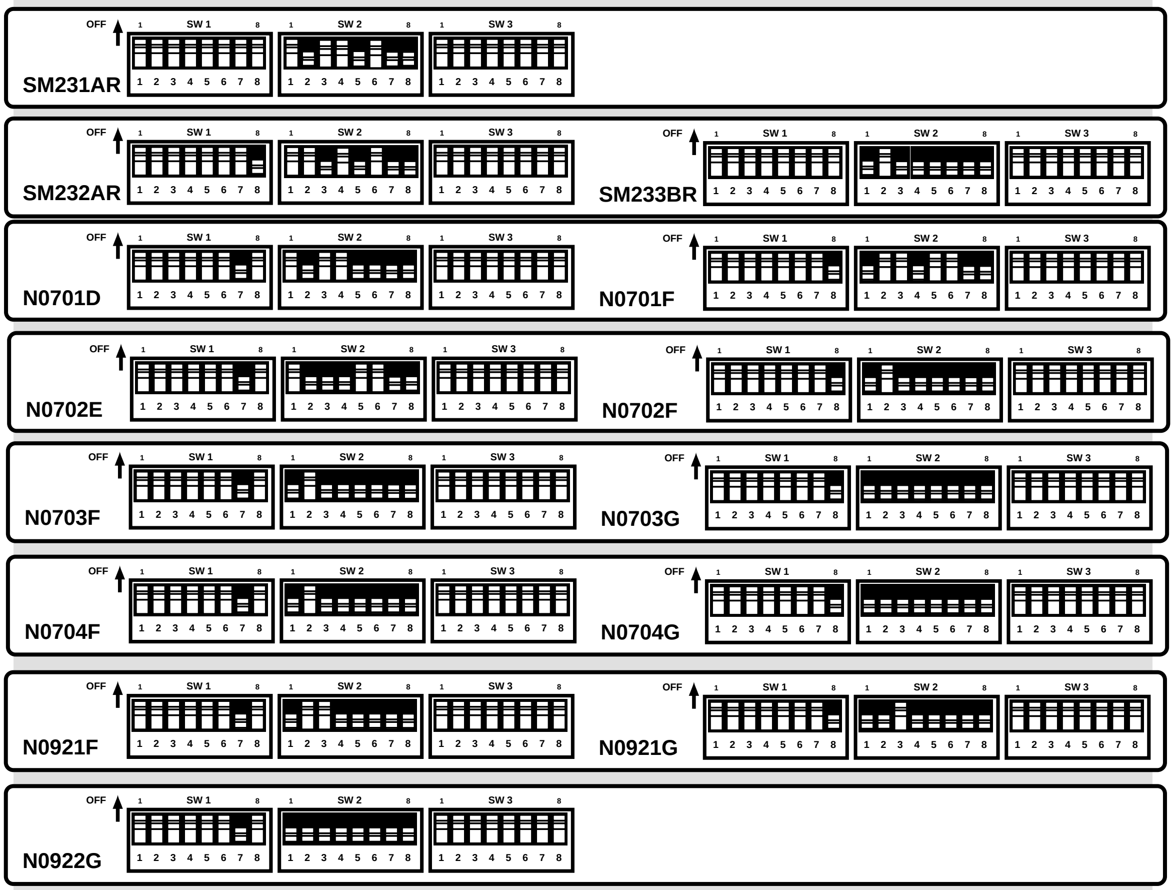
Note: $\sqrt{2}\,A_{rms}$ will give Amps per phase

APEX10
DIP SWITCH SETTINGS

OFF ↑

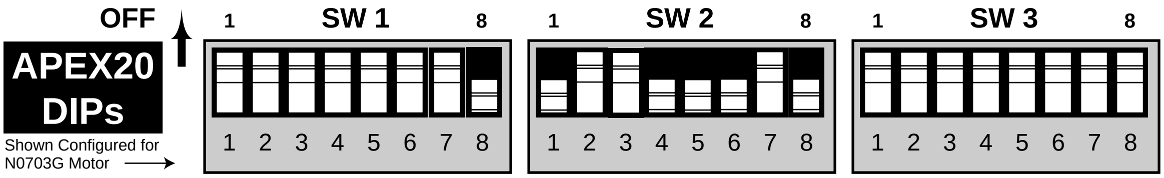
Initial Values for Tuning





These settings are valid for APEX10 units with serial numbers greater than: 9702700070. Call Compumotor's Applications Department for settings prior to this serial number.

See Appendix A for APEX Motor Settings.



SW 1

REGEN FAULT	1
Enable	OFF
Disable	ON

HALL DEGREES	2
120° Hall motor	OFF
60° Hall motor	ON

RESERVED	3
Off	OFF

POLE PAIR NUMBER	4	5
2	OFF	OFF
3	OFF	ON
Reserved	ON	OFF
Reserved	ON	ON

RESOLVER SPEED	6
1	OFF
2	ON

CURRENT LOOP COMPENSATION (motor inductance)	7	8
20 mH – 50 mH	OFF	OFF
4 mH – 10 mH	OFF	ON
10 mH – 20 mH	ON	OFF
Reserved	ON	ON

SW 2

CONTINUOUS CURRENT (peak of sine wave)	1	2	3
3.0 amps	OFF	OFF	OFF
4.2	OFF	OFF	ON
5.4	OFF	ON	OFF
6.6	OFF	ON	ON
7.8	ON	OFF	OFF
9.0	ON	OFF	ON
10.2	ON	ON	OFF
12.0	ON	ON	ON

PEAK CURRENT	4	5	6
9.0 amps	OFF	OFF	OFF
10.8	OFF	OFF	ON
13.2	OFF	ON	OFF
15.0	OFF	ON	ON
17.4	ON	OFF	OFF
19.2	ON	OFF	ON
21.6	ON	ON	OFF
24.0	ON	ON	ON

MOTOR THERMAL TIME CONSTANT	7	8
10 minutes	OFF	OFF
20	OFF	ON
30	ON	OFF
40	ON	ON

SW 3

VELOCITY INTEGRATOR	1
No	OFF
Yes	ON

ALIGNMENT MODE	2
No	OFF
Yes	ON

COMMUTATION TEST MODE	3
No	OFF
Yes	ON

HALL SELECT	4
Resolver Mode	OFF
Hall Mode	ON

TACH SCALING	5
One speed resolver (1V = 1,000 RPM with a one speed resolver)	OFF
Two speed resolver (1V = 1,000 RPM with a two speed resolver)	ON

COMMAND INPUT SCALING	6	7
10V = 24.0 amps	OFF	OFF
10V = 19.2 amps	OFF	ON
10V = 14.4 amps	ON	OFF
10V = 13.2 amps	ON	ON

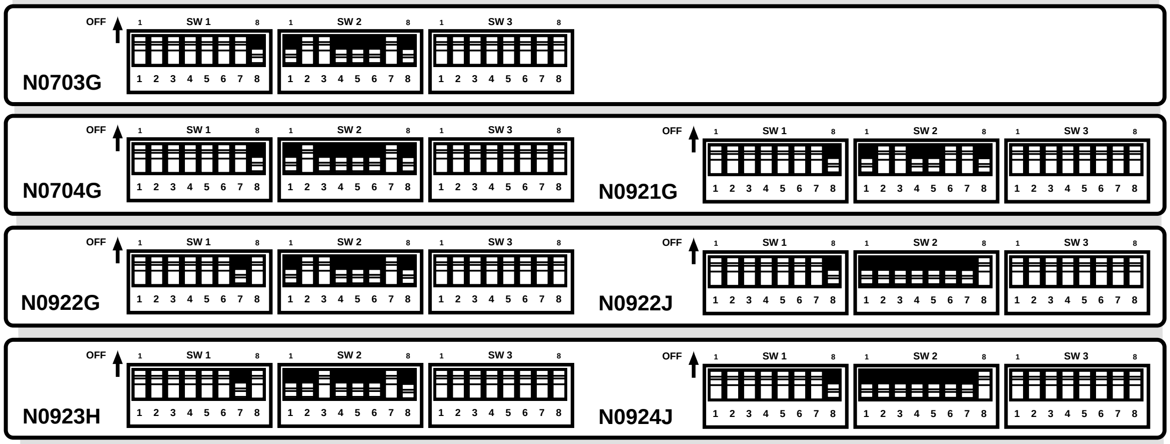
COLLECTIVE GAIN	8
Off	OFF
On	ON

Note: $\sqrt{2}\,A_{rms}$ will give Amps per phase

APEX20 DIP SWITCH SETTINGS

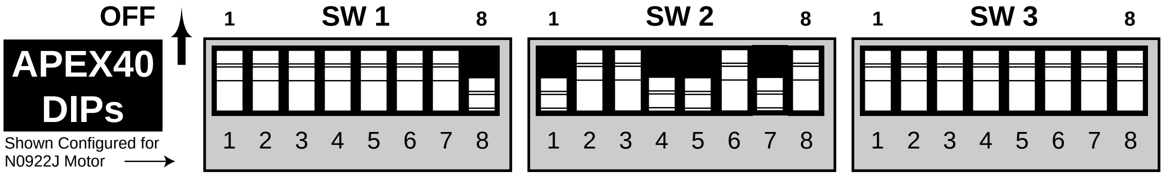
OFF ↑

Use these settings for your final configuration



These settings are valid for APEX20 units with serial numbers greater than: 97073000109. Call Compumotor’s Applications Department for settings prior to this serial number.

See Appendix A for APEX Motor Settings.



SW 1

	1	2	3	4	5	6	7	8
REGEN FAULT								
Enable	OFF							
Disable	ON							
HALL DEGREES								
120° Hall motor		OFF						
60° Hall motor		ON						
RESERVED								
Off			OFF					
POLE PAIR NUMBER								
2				OFF	OFF			
3				OFF	ON			
Reserved				ON	OFF			
Reserved				ON	ON			
RESOLVER SPEED								
1						OFF		
2						ON		
CURRENT LOOP COMPENSATION (motor inductance)								
20 mH – 50 mH							OFF	OFF
4 mH – 10 mH							OFF	ON
10 mH – 20 mH							ON	OFF
Reserved							ON	ON

SW 2

	1	2	3	4	5	6	7	8
CONTINUOUS CURRENT (peak of sine wave)								
5.0 amps	OFF	OFF	OFF					
7.0	OFF	OFF	ON					
9.0	OFF	ON	OFF					
11.0	OFF	ON	ON					
13.0	ON	OFF	OFF					
15.0	ON	OFF	ON					
17.0	ON	ON	OFF					
20.0	ON	ON	ON					
PEAK CURRENT								
15.0 amps				OFF	OFF	OFF		
18.0				OFF	OFF	ON		
22.0				OFF	ON	OFF		
25.0				OFF	ON	ON		
29.0				ON	OFF	OFF		
32.0				ON	OFF	ON		
36.0				ON	ON	OFF		
40.0				ON	ON	ON		
MOTOR THERMAL TIME CONSTANT								
10 minutes							OFF	OFF
20							OFF	ON
30							ON	OFF
40							ON	ON

SW 3

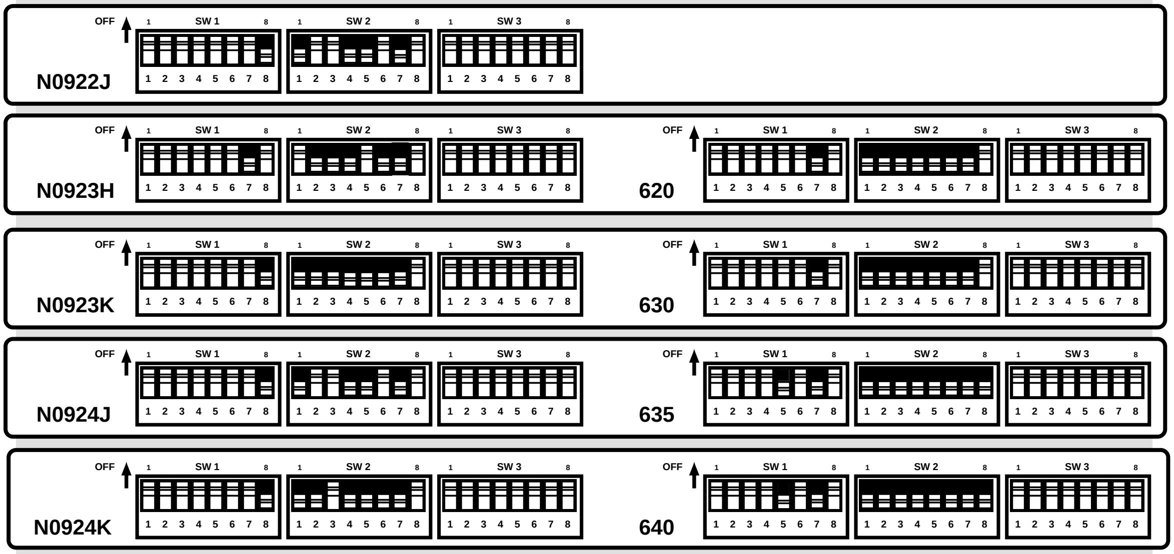
	1	2	3	4	5	6	7	8
VELOCITY INTEGRATOR								
No	OFF							
Yes	ON							
ALIGNMENT MODE								
No		OFF						
Yes		ON						
COMMUTATION TEST MODE								
No			OFF					
Yes			ON					
HALL SELECT								
Resolver Mode				OFF				
Hall Mode				ON				
TACH SCALING								
One speed resolver (1V = 1,000 RPM with a one speed resolver)					OFF			
Two speed resolver (1V = 1,000 RPM with a two speed resolver)					ON			
COMMAND INPUT SCALING								
10V = 40.0 amps						OFF	OFF	
10V = 32.0 amps						OFF	ON	
10V = 25.0 amps						ON	OFF	
10v = 22.0 amps						ON	ON	
COLLECTIVE GAIN								
Off								OFF
On								ON

Note: $\sqrt{2}\,A_{rms}$ will give Amps per phase

APEX40
DIP SWITCH SETTINGS

OFF ↑

Use these settings for your final configuration



These settings are valid for APEX40 units with serial numbers greater than: 97073000109. Call Compumotor’s Applications Department for settings prior to this serial number.

See Appendix A for APEX Motor Settings.

SWITCH 1 (SW1)

Regen Fault (position #1): Set this switch in the OFF position for normal operation of the APEX Drive's *internal* regeneration circuit. For most applications, this switch should be OFF. If you construct your own *external* regeneration circuit, set this switch ON to disable the APEX Drive's regeneration fault. For more information, see the discussion of regeneration in *Chapter 3 Special Features*.

Hall Sensor Degrees (position #2): Set this switch in the OFF position if you use a motor with a resolver, or with 120° Hall effect sensors. Set this switch in the ON position if you use a motor with 60° Hall effect sensors.

Reserved (position #3): Set this switch in the OFF position.

Motor Pole Pair Number (position #4, #5): Set these two switches according to the number of pole pairs your motor has. All APEX, SM and NeoMetric motors have two pole pairs (four poles), except the APEX635 and APEX640, which have three pole pairs (six poles).

Resolver Speed (position #6): For a motor with a single speed resolver, turn this switch OFF. This switch should be OFF for APEX, SM Series or NeoMetric motors, which have single-speed resolvers. For a motor with a two-speed resolver, turn this switch ON.

Current Loop Compensation (position #7, #8): These two switches control the dynamics of the APEX Drive's current feedback loop. Use these switches to match the drive's performance to your particular motor's characteristics. For APEX, SM and NeoMetric motors, set the switches according to the preceding dip switch tables. If you use a motor from another vendor, call Compumotor's Applications Department for instructions on setting these two DIP switches for your motor. (The toll-free telephone number is listed on the inside front cover of this manual.)

SWITCH 2 (SW2)

Continuous Current (position #1, #2, #3): If the APEX Drive goes into current foldback, it reduces its output current down to the continuous current level set by these three switches. For APEX, SM and NeoMetric motors, set the switches according to the preceding tables.

Peak Current (position #4, #5, #6): These three switches set the peak current that the APEX Drive will produce. For APEX, SM and NeoMetric motors, set the switches according to the preceding tables.

CAUTION

If you use an SM Motor, set the drive's DIP switches at the lowest peak current level for initial drive tuning. Motor damage due to excessive heating may result from high peak currents and improper tuning values.

Maximum peak current for SM and NeoMetric motors can be three times higher than the continuous current rating. If the motor oscillates during your tuning procedure, high peak current may cause overheating and damage the motor. When you tune your system, therefore, we recommend that you start with the lowest value for peak current. As you tune the drive and refine your gains, you can raise the peak current level. See *Tuning* at the end of this chapter for more details.

Time Constant (position #7, #8): These two switches set the motor thermal time constant, which the foldback circuit uses to estimate motor behavior. Consult your motor specifications to determine your motor's thermal time constant. The DIP switch tables show switch settings for time constants of 2, 4, 8, and 10 for the APEX10 and 10, 20, 30, and 40 for the APEX20 and APEX40. For APEX, SM and NeoMetric motors, set the switches according to the tables.

The time constant is ***NOT*** the time until foldback occurs. It is a parameter based upon the motor's physical characteristics, with the motor mounted to a suitable heatsink. For a full explanation of the foldback circuit, including the time constant, see *Chapter 3 Special Features*.

SWITCH 3 (SW 3)

Velocity Integrator (position #1): This switch controls the velocity integrator. Set the switch according to how you plan to operate the drive:

If you use the drive in:		SW
Torque Mode	(do not use the velocity integrator)	OFF
Velocity Mode	if you do not intend to use the velocity integrator	OFF
	if you intend to use the velocity integrator	ON

See *Tuning* at the end of this chapter for more information about the velocity integrator feature.

Alignment Mode (position #2): Turn this switch OFF. If you need to align the resolver, you will turn this switch ON during the alignment procedure, and turn it OFF when you have finished aligning the resolver. This switch must be OFF during normal operating conditions. See *Chapter 3 Special Features* for more information.

Commutation Test Mode (position #3): Turn this switch OFF. If you need to operate the drive in commutation test mode during a trouble-shooting procedure, you will turn this switch ON during the procedure, and turn it OFF when you are finished. This switch must be OFF during normal operating conditions. *See Chapter 5 Troubleshooting* for more information.

Hall Select (position #4): Turn this switch OFF if your motor has a resolver. This switch should be OFF for APEX, SM and NeoMetric Series servo motors, which have resolvers. Turn this switch ON if your motor has Hall effect sensors instead of a resolver.

Tachometer Scaling (position #5): This switch scales the drive's tachometer output. If you use a motor that has a single speed resolver, turn this switch OFF to scale the tachometer output to equal 1 volt per 1,000 rpm. This switch should be OFF for APEX, SM or NeoMetric Series servo motors, which have single-speed resolvers. If you use a motor that has a two-speed resolver, turn this switch ON. This will adjust gains of the internal circuitry, so that the tachometer output is scaled to equal 1 volt per 1,000 rpm for two speed resolvers.

Command Input Scaling (position #6, #7): Use these two switches to scale the relationship (full-scale) between command input voltage and motor output current. For full current, with a 10V input corresponding to maximum peak output current, both switches should be OFF. Set the switches according to the preceding DIP switch tables for other currents.

Collective Gain (position #8): This switch controls the collective gain function. Set the switch according to how you plan to operate the drive:

If you use the drive in:		SW
Torque Mode	collective gain is not used in torque mode	OFF
Velocity Mode	collective gain is used in velocity mode	ON

See *Tuning* later in this chapter for more information about collective gain.

Mount the APEX Drive

The APEX Drive should be installed in an enclosure that will protect it from atmospheric contaminants such as oil, metallic particles, moisture, and dirt. The National Electrical Manufacturers Association (NEMA) has established standards that define the degree of protection that electrical enclosures provide. Because industrial application environments may contain airborne contaminants, the enclosure you use should, as a minimum, conform to a NEMA TYPE 12 standard.

Installation Precautions

To ensure personal safety and long life of system components, pay special attention to the following installation precautions.

Temperature

Maximum Ambient Temperature:	50°C	(122°F)
Minimum Ambient Temperature:	0°C	(32°F)

Humidity

Maximum Relative Humidity:	95% (non-condensing)

Liquids

Do not allow liquids or fluids to come into contact with the APEX Drive or its cables.

Airborne Contaminants

The APEX Drive's fan provides internal forced air cooling whenever the drive is powered. However, the drive ***does not have*** any type of intake air filter. You must protect the drive's intake air supply from contamination if you operate the drive in an environment where dust or metallic particles are present, or where there may be airborne condensing moisture, solvents, or lubricants.

Electrical Noise

Minimize the possibility of electrical noise problems *before* installing the APEX Drive, rather than attempting to solve such problems after installation. Prevent electrical noise problems by observing the following guidelines:

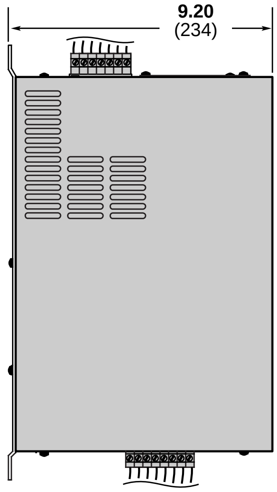
- ❏ Do not route high-voltage wires and low-level signals in the same conduit.
- ❏ Ensure that all components are properly grounded
- ❏ Ensure that all wiring is properly shielded

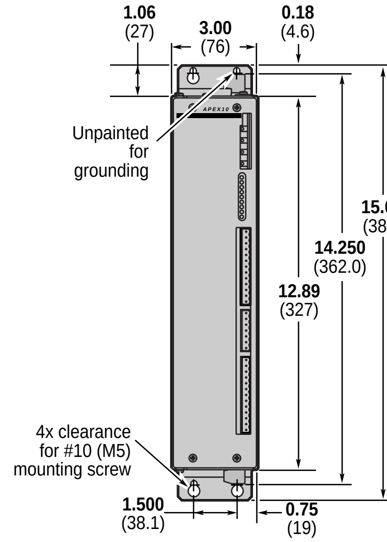
Mounting and Grounding

The APEX Drive's mounting bracket is notched with keyhole type slots to accept four screws for flat panel surface mounting. One of the slots—upper right—is unpainted. You can use a star washer between the mounting screw and this slot, to help provide additional electrical grounding between the APEX Drive and the mounting surface. The drive must also be grounded through the Earth terminal on the AC power connector.

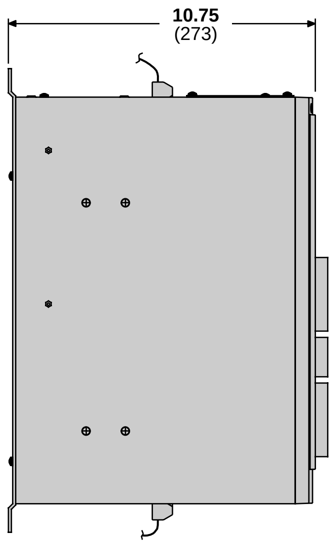
DIMENSIONS

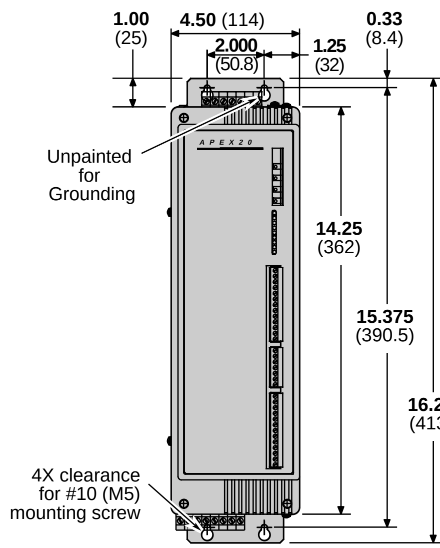
APEX10 Dimensions



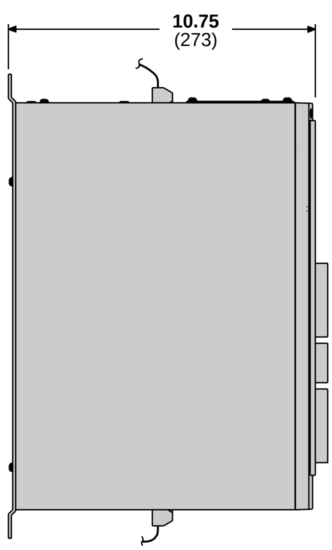


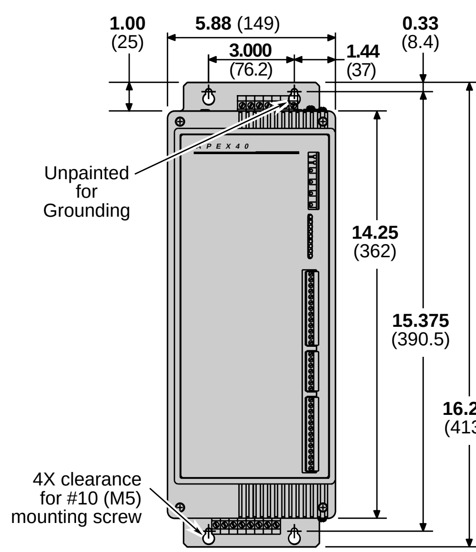
APEX20 Dimensions





APEX40 Dimensions

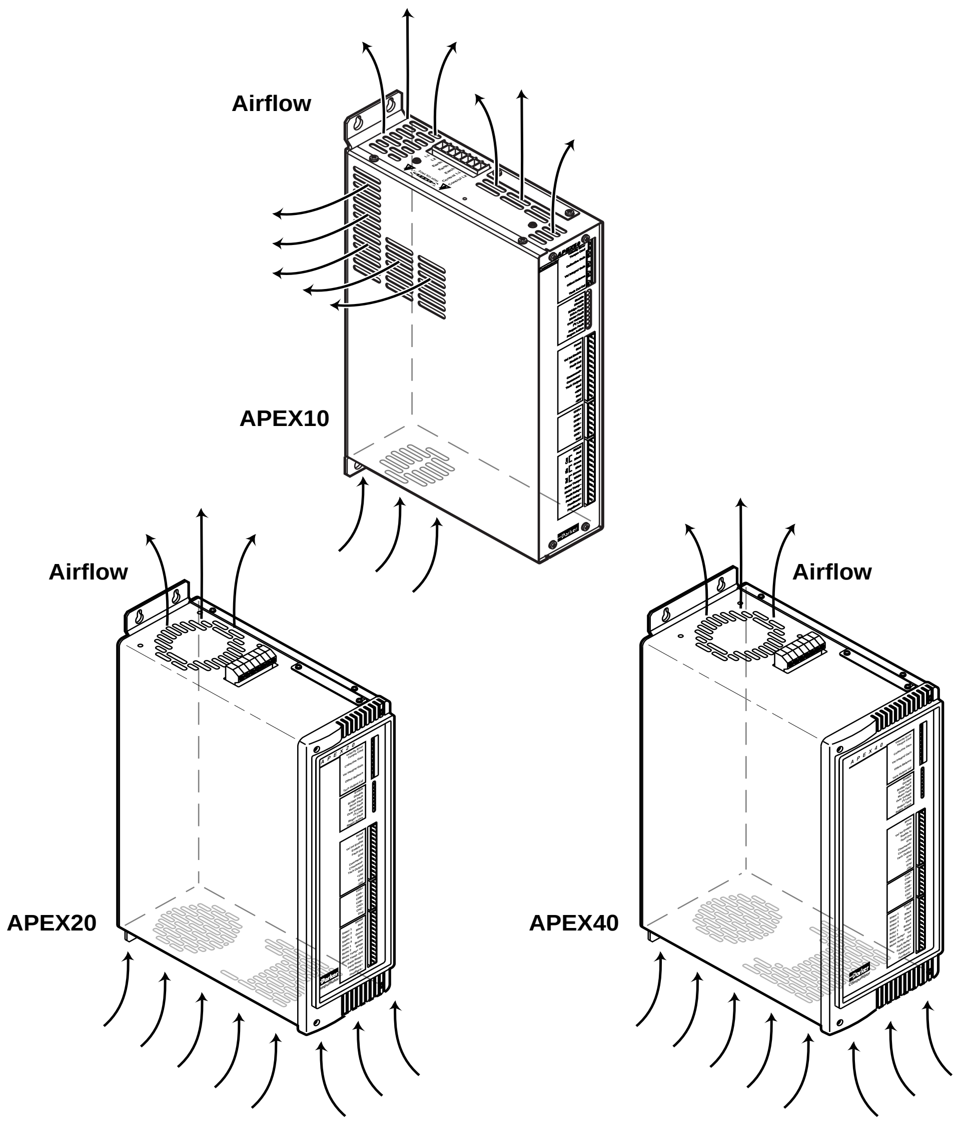




Dimensions in
inches (millimeters)

AIRFLOW & COOLING

You can operate the APEX Drive in an ambient temperature environment of 0°C to 50°C (32°F to 122°F). It is cooled by an internal fan mounted at the bottom of the drive. The fan draws air in through the bottom, forces it upward over the heatsink, and out the top of the drive (APEX20 and APEX40); or out the side and top of the drive (APEX10). The air directly beneath the APEX Drive must not exceed 50°C (122°F).



Airflow through APEX Drives

MAXIMUM DISSIPATION

The APEX Drive produces heat that must be dissipated. Heat produced by drives operating at maximum continuous current may be as much as that shown in the following table.

Drive	Continuous Current (amps)	Maximum Dissipation (watts)
APEX10	8 A	100 W
APEX20	12 A	150 W
APEX40	20 A	200 W

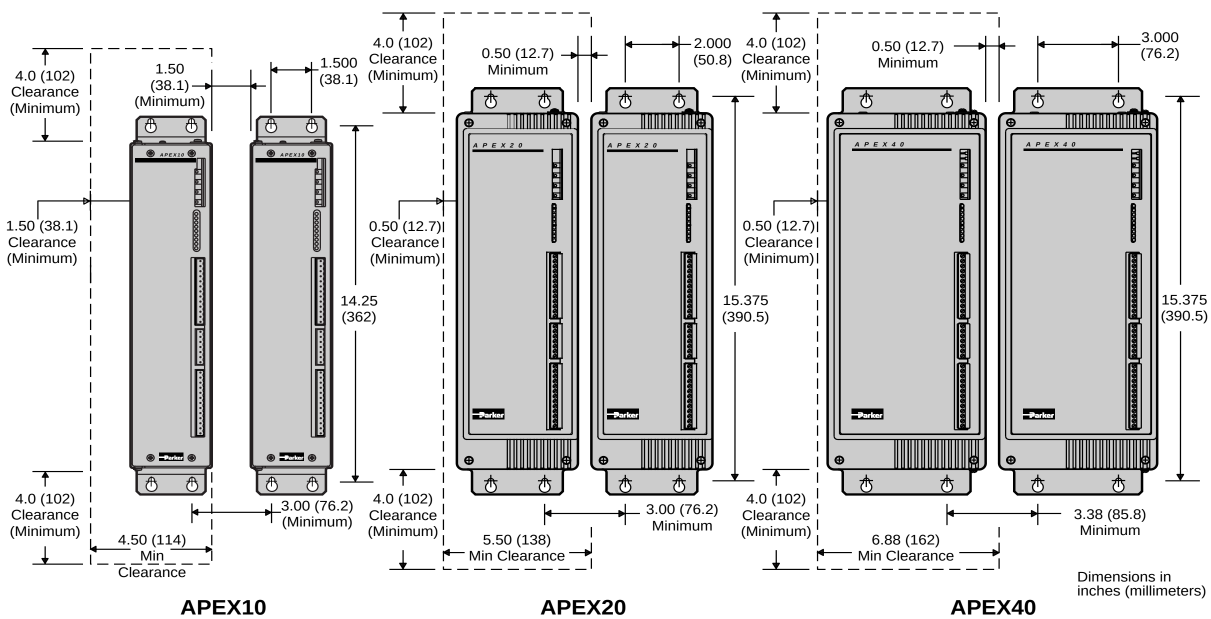
The actual dissipation will vary depending on the application duty cycle, motor size, and load inertia.

INTERNAL TEMPERATURE SENSORS

The APEX Drive has two temperature sensors. One is mounted on the control board, near the microprocessor. The other is mounted within the power bridge. If the internal temperature is too high—perhaps because of blocked airflow, a fan that has stopped working, or external ambient temperatures higher than 50°C (122°F)—one of these sensors will shut down the drive. When the sensor on the control board shuts down the drive, it also illuminates the Drive Fault LED. When the sensor on the power bridge shuts down the drive, it illuminates the Bridge Fault LED.

PANEL LAYOUT

Panel layout dimensions are shown below.



When you design your panel layout, follow these precautions for adequate cooling:

① The vertical distance between the APEX Drive and other equipment, or the top and bottom of the enclosure, should be no less than 4 inches (100 mm).

② The horizontal distance between the APEX10's side air vents and other equipment should be no less than 1.5 inches (38.1 mm).

③ Do not mount the APEX Drive directly below heat-sensitive equipment, such as a controller.

④ Large heat-producing equipment (such as a transformer) should not be mounted directly beneath the APEX Drive.

MOUNT THE MOTOR

The following guidelines present important points about motor mounting and its effect on performance. For dimensions and specifications for APEX, SM and NeoMetric Series servo motors, see *Chapter 4 Hardware Reference.*

Warning
Improper motor mounting can jeopardize personal safety and reduce system performance.

Servo motors used with the APEX Drive can produce large torques and high accelerations. These forces can shear shafts and mounting hardware if the mounting is not adequate. High accelerations can produce shocks and vibrations that require much heavier hardware than would be expected for static loads of the same magnitude.

The motor, under certain move profiles, can produce low-frequency vibrations in the mounting structure. These vibrations can cause metal fatigue in structural members. Have a mechanical engineer check the machine design to ensure that the mounting structure is adequate.

CAUTION
Modifying or machining the motor shaft will void the motor warranty. Contact a Compumotor Applications Engineer (800-358-9070) about shaft modifications as a custom product.

Servo motors should be mounted by bolting the motor's face flange to a suitable support. Foot mount or cradle configurations are not recommended because the motor's torque is not evenly distributed around the motor case.

MOTOR HEATSINKING

Performance of a servo motor is limited by the amount of current that can flow in the motor's coils without causing the motor to overheat. Most of the heat in a brushless servo motor is dissipated in the stator—the outer shell of the motor. The primary pathway through which you can remove the heat is through the motor's mounting flange. Therefore, mount the motor with its flange in contact with a suitable heatsink.

Current foldback (I^2T Limit) settings and motor specifications assume that the motor is mounted to an aluminum plate of the following dimensions:

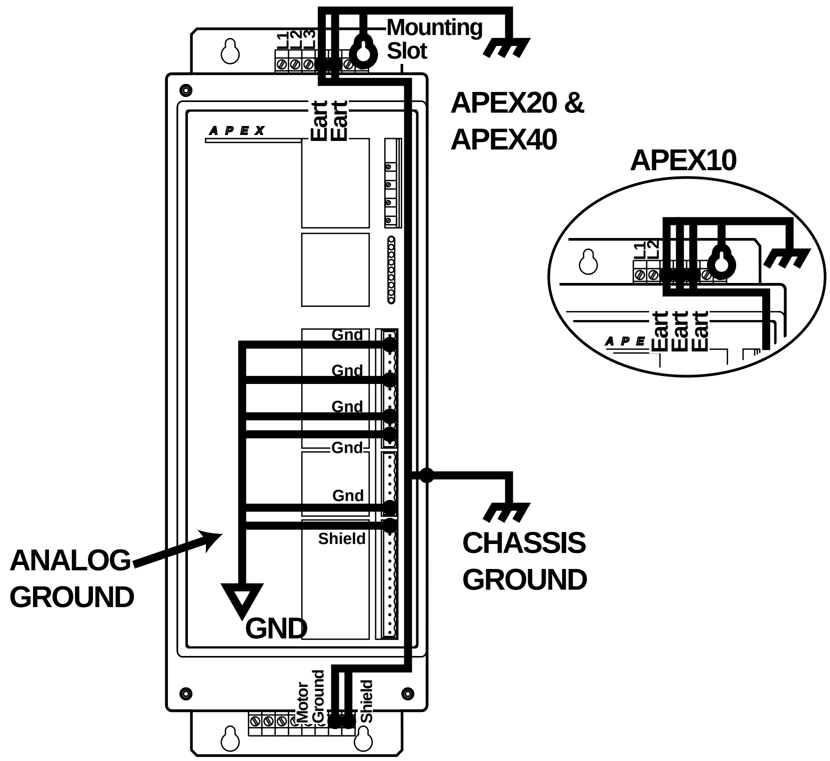
SM Series Motors	NeoMetric
10" x 10" x 0.25" aluminum	10" x 10" x 0.25" aluminum
(250 x 250 x 6.3 mm)	(250 x 250 x 6.3 mm)

To get rated performance in your application, you must mount the motor to a heatsink of at least the same thermal capability as those listed above. Mounting the motor to a smaller heatsink may result in decreased performance and a shorter service life. Conversely, mounting the motor to a larger heatsink can result in enhanced performance.

WARNING
The motor case can become very hot, even under normal operating conditions. Do not touch or contact the motor. Keep heat-sensitive equipment away from the motor.

GROUND SYSTEM

The APEX Drive has two ground systems, shown in the next drawing.



Apex Drive – Ground System

CHASSIS GROUND

The following terminals are internally connected to each other, and to the chassis. You can connect these terminals to an external earth ground by connecting any of the **Earth** terminals on the **AC Input** power connector the external earth ground.

Motor Ground	The **Motor Ground** terminal on the motor connector connects to chassis ground.
Shield	The **Shield** terminal on the motor connector connects to chassis ground.
Earth	All terminals labeled **Earth** on the **AC Input** power connector connect to chassis ground. (Multiple **Earth** terminals are provided for convenience.)
Mounting Slot	The upper right mounting slot is unpainted. You can use a star washer with the mounting screw in this slot to provide a grounding path from the chassis ground to the mounting surface.

Circuit Ground (Gnd)

The following terminals are internally connected to each other. They are not connected to the chassis ground.

Gnd All terminals labeled **Gnd** are internally connected.

Shield The **Shield** terminal on the resolver connector is internally connected to the **Gnd** terminals.

Connect the Resolver Cable

The *resolver cable* connects the motor's resolver output to the APEX Drive's resolver input. APEX, SM and NeoMetric resolver cables are shielded, and have an MS style connector on the end that attaches to the motor. You must wire the other end of the cable to the APEX Drive's resolver connector, which is a 13-pin removable connector. The connector can accept wire diameters as large as 12 AWG (4 mm^2).

Hall Effect Motors

For instructions on connecting a Hall effect motor, rather than a motor with a resolver, see *Chapter 4 Hardware Reference*.

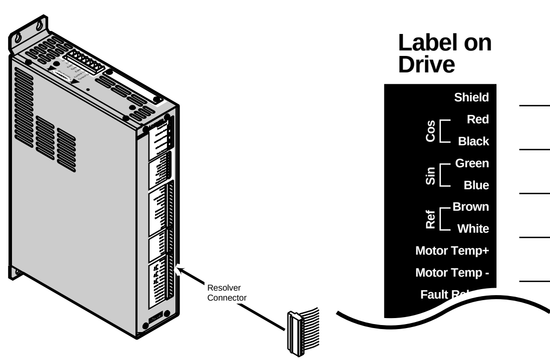
Separate Conduits

Compumotor recommends installing the motor and resolver cables in separate conduits for safety, and to minimize electrical noise problems.

Resolver Connections (Cos, Sin, Ref)

Use the color code shown in the next drawing when you connect SM or NeoMetric resolver cables. This code is also printed on the front panel of the APEX Drive, near the resolver connector.

The **Shield** terminal is internally connected to **Gnd** (ground) terminals on the front panel of the drive. If you make your own resolver cable, use shielded cable to keep electrical noise from corrupting the resolver signal.



Label on Drive	Function	SM/NeoMetric Cable Color Code
Shield	Shield	Uninsulated
Cos Red	Stator 3	Red
Cos Black	Stator 1	Black
Sin Green	Stator 2	Green
Sin Blue	Stator 4	Blue
Ref Brown	Rotor 1	Brown
Ref White	Rotor 2	White
Motor Temp+	Motor Temp+	Yellow
Motor Temp -	Motor Temp -	Yellow

Refer to Appendix A for APEX Motor information.

Resolver Cable Color Code

MOTOR TEMPERATURE (MOTOR TEMP±)

To connect your motor's thermostat, follow these instructions:

- ❏ APEX Motor – connect the yellow wire in the resolver cable to **Motor Temp+**. Connect the orange wire to **Motor Temp–**.
- ❏ SM Motor – both wires are yellow. Connect one to **Motor Temp+**, the other to **Motor Temp–**.
- ❏ Other Motors – for motors with normally-closed temperature sensors, connect the sensor's two wires to **Motor Temp–** and **Motor Temp–**.
- ❏ Motor with no Thermostat – if your motor does not have a thermostat, short **Motor Temp+** and **Motor Temp–** together by connecting an insulated jumper wire between them. The drive will experience a motor fault if neither a thermostat nor a jumper wire is attached to the **Motor Temp** terminals.

The APEX Drive's motor temperature fault can, in many cases, protect the motor against overheating. Through its **Motor Temp+** and **Motor Temp–** terminals, the drive checks for electrical continuity provided by a normally-closed thermostat mounted on the motor. If the motor overheats and the thermostat opens, the loss of continuity triggers protection circuitry in the APEX Drive. It will turn off power output to the motor, and illuminate the LED labeled **Motor Fault**.

The thermostat may not protect the motor in every possible application. It works best in cases where the temperature rise occurs slowly over a long period of time. In this situation, the thermostat and motor windings will be at the same temperature. When the windings and thermostat reach the thermostat's threshold temperature, the thermostat can trigger the overtemperature circuit.

In cases where the temperature rise is caused by a flow of continuous peak current—an unstable or oscillating motor during tuning, or a mechanical jam, for example—the winding temperature may rise much more quickly than the thermostat temperature rises. In this situation, the windings may be damaged from overheating *before* the thermostat can trigger the overtemperature circuit.

MOTOR BRAKING (FAULT RELAY±)

If the APEX Drive faults, for any reason, the drive will be disabled and the motor will freewheel. (Refer to *Chapter 5 Troubleshooting* for a list of all fault conditions.) If a freewheeling load is unacceptable, you can use the fault relay terminals, **Fault Relay +** and **Fault Relay–**, to control a motor brake. For complete instructions, see *Chapter 3 Special Features*.

FEEDBACK±

If you operate the APEX Drive in torque mode, make no connections to the **Feedback+** or **Feedback–** terminals.

If you operate the APEX Drive in velocity mode, connect the **Feedback** input terminals to a tachometer output signal. If you use the APEX Drive's internal tachometer:

① Connect **Tach Output** on the controller connector to **Feedback+** on the resolver connector.

② Connect any of the **Gnd** (ground) terminals on the controller connector to **Feedback–** on the resolver connector.

If you use an external tachometer:

① Connect the tachometer's output to **Feedback+** on the resolver connector.

② Connect the tachometer's ground to **Feedback–** on the resolver connector.

Use twisted pair wire for these connections, to minimize noise problems.

See *Chapter 4 Hardware Reference* for a schematic diagram of the **Feedback±** input terminals.

CONNECT THE MOTOR CABLE

After wiring the connector to the resolver cable, as described above, connect the motor cable to the motor and to the APEX Drive.

CONNECT THE MOTOR CABLE

The *motor cable* connects the APEX Drive's power output terminals, located on the bottom of the drive, to the motor's power input terminals. APEX, SM and NeoMetric motor cables have an MS style connector on the end that attaches to the motor. You must wire the other end of the cable to the APEX Drive's motor connector, which is an 8-pin removable connector located on the bottom of the drive. The connector can accept wire diameters as large as 10 AWG (6 mm^2).

SEPARATE CONDUIT

Compumotor recommends installing the motor and resolver cables in separate conduits to minimize electrical noise problems, as well as for safety.

MOTOR CONNECTIONS

Wire the cable to the motor connector. Use the following color code for SM and NeoMetric motor cables.

Connector Terminal	**SM/NeoMetric Cable Wire Color**
Phase A	Red/Yellow
Phase B	White/Yellow
Phase C	Black/Yellow
Motor Ground	Green/Yellow
Shield	Uninsulated

Motor Grounding

The motor cable should have a motor ground wire and also a cable shield wire. Connect the ground wire to the terminal labeled **Motor Ground**. Connect the shield wire to the terminal labeled **Shield**. Inside the drive, the **Motor Ground** and **Shield** terminals are connected to each other, and to the **Earth** terminal on the **AC Input** power connector. On some APEX or SM cables, the ground wire and shield wire are crimped together when the cables are manufactured. You can insert both cables into the **Motor Ground** terminal.

WARNING

DO NOT OMIT the Motor Ground connection. Internal failure of motor insulation can place the motor frame at deadly potential if it is not properly grounded. Do not rely solely on mounting bolts for motor grounding.

Regen Resistor

The APEX Drive can dissipate regenerated energy in its internal regeneration resistor. If your system must dissipate more energy than the resistor is rated for, use the Regen Resistor terminal to connect an external regeneration resistor on either an APEX 10 or 40. Refer to *Chapter 3 Special Features* for instructions on connecting an external regeneration resistor.

V_{Bus}+, V_{Bus}–

These terminals can connect the high voltage power bus between two or more APEX Drives. Use these terminals to allow one drive to use the power another drive produces during regeneration. Refer to *Chapter 3 Special Features* for instructions on using this feature.

Connect the Cable

After wiring the connector to the cable, attach the motor end of the cable to the motor. Plug the drive end of the cable into the APEX Drive's motor connector.

WARNING

The motor connector and cable produce lethal voltages. Never insert or remove the motor cable with AC power turned on to the APEX.

Connect Power

Connect AC power to the APEX Drive's **AC Input** connector, which is a 7-pin removable connector located on top of the drive. The connector can accept wire diameters as large as 10 AWG (6 mm^2).

The AC power requirements for each model of APEX Drive are as follows:

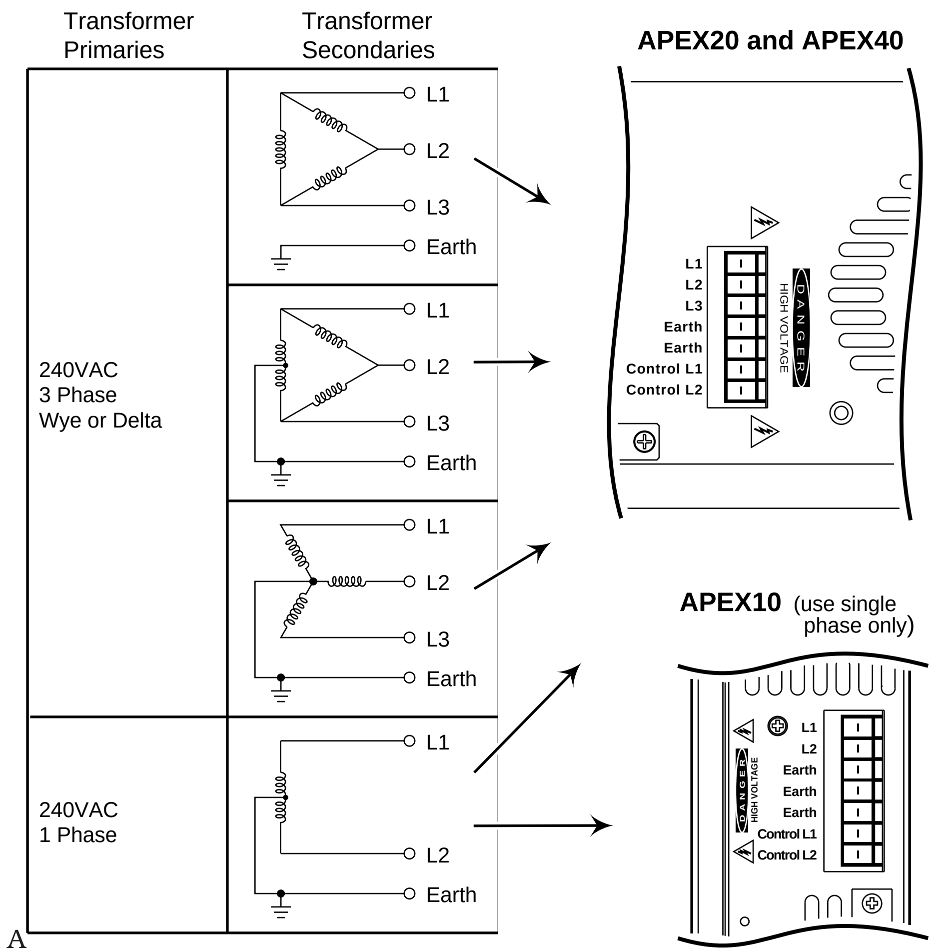
AC Power Requirements

APEX10 Drive	APEX20 Drive	APEX40 Drive
85 – 252VAC Single Phase (SM Motor: 120VAC only)	85 – 252VAC 3-ph greater than 202VAC preferred; or 1-ph	85 – 252VAC 3-ph greater than 202VAC preferred; or 1-ph

Note: Input power less than 202VAC 3-phase severely decreases the potential speed of the motor

AC Power Connections

The next drawing shows several ways to connect a 240VAC power system to the **L1**, **L2**, and **L3** terminals on the APEX20 and APEX40; or to the **L1** and **L2** terminals on the the APEX10.



AC Power System – Connections to APEX Drive Input Terminals

Equation for the transformer KVA:

$$KVA = \frac{\frac{Pout}{eff} + 80W}{PF}$$

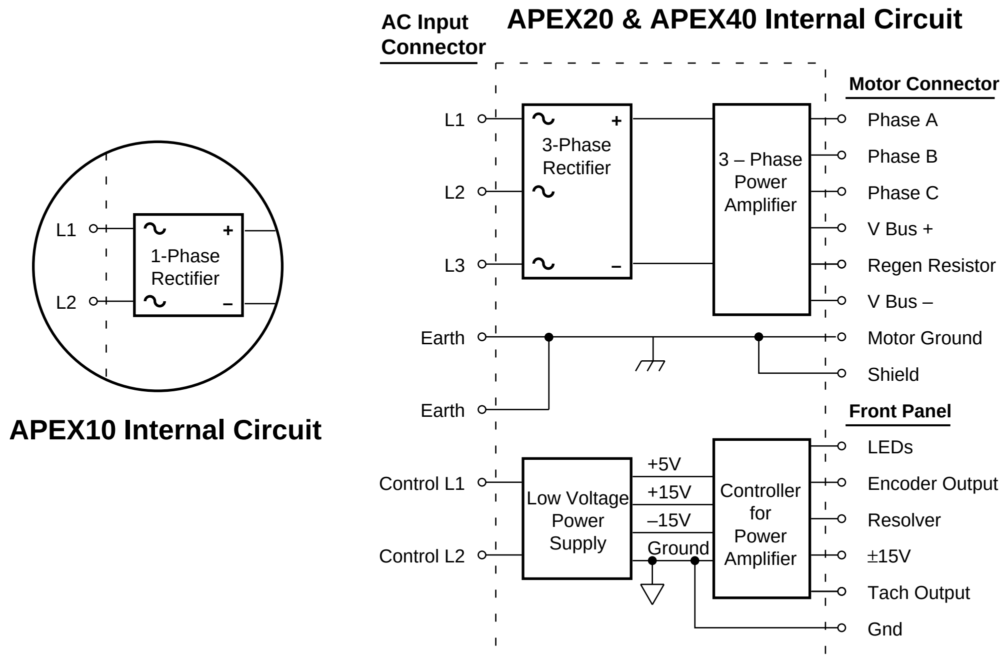
Pout: power out of the drive
eff: drive efficiency
PF: power factor
80W: max. power draw of internal power supply

Consult the Compumotor Applications Department for more information.

CONNECT AC POWER IN TWO PLACES

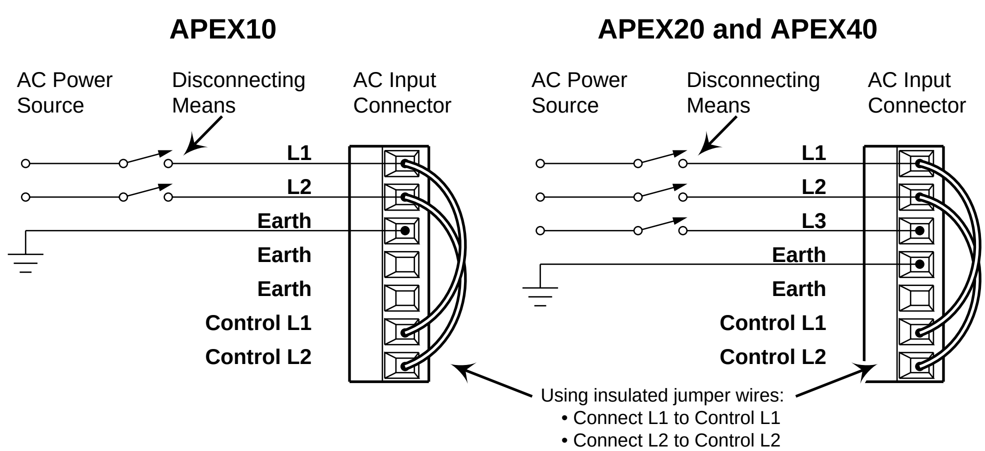
Inside the APEX Drive, there are two power systems, each with its own AC input terminals. One system provides high voltage power to the power amplifier—its terminals are labeled **L1**, **L2**, and **L3** (or **L1** and **L2** on the APEX10 Drive). The other system provides low voltage power to the power amplifier's controller—its terminals are labeled **Control L1** and **Control L2** **and have the same power specs as listed above**. Two AC Power inputs allow you to remove power from the motor, but continue to power internal control circuits.

These two internal power systems are shown in the next drawing.



AC Power – Internal Connections

You must connect AC power to both **L1/L2/L3** and **Control L1/Control L2** (or to both **L1/L2** and **Control L1/Control L2** on the APEX10). The next drawing shows a simple way to do this.



AC Connector with Jumpers Attached

Follow these steps in making connections:

1. Connect your AC input lines to **L1, L2** and **L3** on the AC input connector (**L1** and **L2** on the APEX10).
2. Using insulated wire jumpers (provided in the ship kit), connect **L1** to **Control L1**, and connect **L2** to **Control L2**.
3. Connect your AC ground to **Earth** on the AC input connector.

Wiring Options

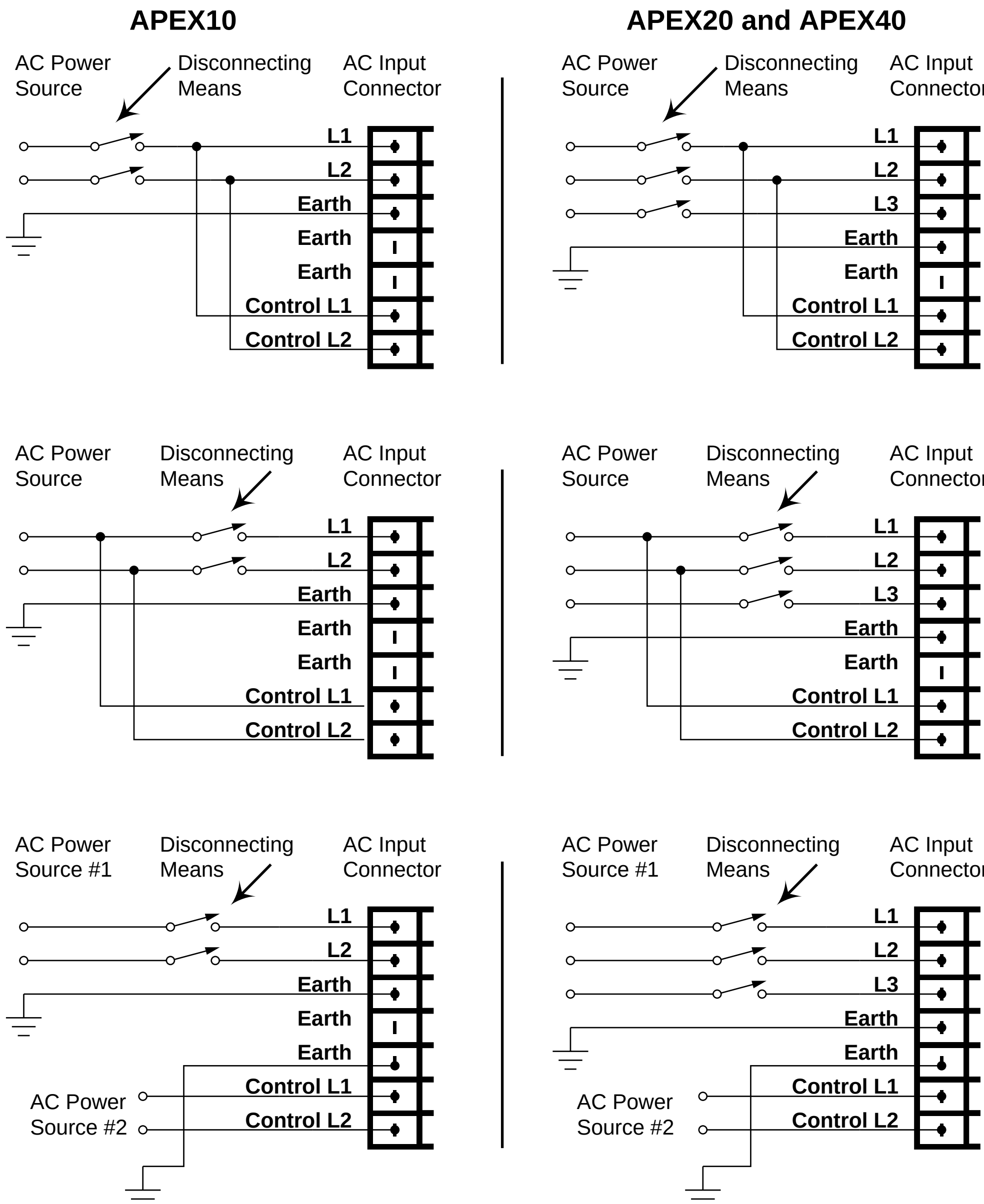
The diagram below illustrates options for connecting AC power.

- If you want to completely shut down the drive when you disconnect AC power, follow the top connection diagram. (This is a schematic version of the previous drawing.) Use insulated wire jumpers (provided in the ship kit) to connect **L1** to **Control L1**, and to connect **L2** to **Control L2**.
- If you want to shut down power to the motor when you disconnect AC power, but keep the amplifier controller energized, follow the middle connection diagram. This shows that **Control L1** and **Control L2** are connected to the AC power source *before* the disconnecting means.
- If you want to use separate AC power sources for **L1/L2** and **Control L1/ Control L2**, follow the bottom connection diagram. For example, you can connect 240VAC and a disconnecting means to **L1** and **L2**, and connect 120VAC to **Control L1** and **Control L2**.

Disconnecting AC power turns off power output to motor, and turns off controller

Disconnecting AC power turns off power output to motor; controller remains powered

Disconnecting AC Power #1 turns off power output to motor; controller remains powered by AC Power #2



AC Power – Connections

Using Single Phase AC Power with APEX20 and APEX40

If you use single phase AC power with the APEX20 or APEX40, connect your two power wires to the **L1** and **L2** terminals on the APEX Drive.

Fuse recommendations given above are for three phase, 240VAC operation, with a drive and motor operating at rated speed, rated torque, and 100% duty. To choose a fuse for single phase operation, scale the above value by your actual requirements, and obtain a de-rated fuse value.

CONNECTING AC GROUND

The terminals labeled **Earth** are internally connected to the APEX Drive's chassis, and to the **Motor Ground** and motor **Shield** terminals. For safety, connect the ground from your AC power system to at least one of the **Earth** terminals (for convenience, multiple terminals are provided).

WARNING
DO NOT OMIT the AC Ground connection. Be sure the APEX Drive's chassis is properly and securely grounded to reduce the chance of electrical shock.

FUSING INFORMATION

The APEX Drive has no internal fuses. For safety purposes, you should provide a fuse in each of the AC input lines. Recommended fuses are:

Fuse Recommendations

APEX10 Drive (240VAC)	APEX20 Drive (240VAC)	APEX40 Drive (240VAC)
250V Slow Blow 12 – 15 amp Littelfuse 326-012 or equivalent	250V Slow Blow 12 – 15 amp Littelfuse 326-012 or equivalent	250V Slow Blow 20 – 25 amp Littelfuse 326-020 or equivalent
APEX10 Drive (120VAC)		
125V Slow Blow 15 – 25 amp Littelfuse 326-025 or equivalent		

Also provide a fuse for the Control L1/L2 inputs: 250V Slow Blow
3 amp
Littelfuse 326-003 or equivalent

WARNING
The APEX Drive has no internal fuses. For safety purposes, provide a fuse in each of the AC input lines.

PLUG IN THE CONNECTOR

After wiring the connector to the cable, plug the cable into the APEX Drive's input power connector. ***Do not energize*** the power at this time. The APEX Drive does not have an ON/OFF switch. You must provide a safe means of energizing AC power to the drive (indicated as "disconnecting means" in the previous drawings). Use a safety interlock switch or resettable circuit breaker to conveniently de-energize the drive in an emergency and/or service situation.

WARNING
The motor connector and cable produce lethal voltages. Never insert or remove the motor cable with AC power turned on to the APEX Drive.

ADJUST OFFSET BALANCE

Follow the procedure below to adjust the APEX Drive's offset balance potentiometer. This procedure also serves as a quick test to verify that all system connections made thus far have been done correctly. Because the motor will turn during this procedure, make sure that all components are properly mounted or supported.

WARNING
Even a small offset can cause the motor to quickly accelerate up to high speeds. Please use extreme care and be ready to disable the drive if necessary.

Proceed to the appropriate option below—*Torque Mode* or *Velocity Mode*—based upon how you intend to use the APEX Drive.

OPTION 1: TORQUE MODE

If you intend to operate your system in torque mode, perform the following procedure. The controller and encoder output should be disconnected from the drive; the motor should be disconnected from the load.

① Power to the APEX Drive should be OFF when you begin this procedure.

② Connect a wire between **Enable In** and Ground (**Gnd**) on the controller connector. This shorts the enable input to ground, and enables the APEX Drive when you turn on AC power.

NOTE: The next two steps – ③ & ④ – were performed at the factory. If yours is a new APEX Drive, you do not need to perform these two steps—use the default factory settings. You can proceed to step ⑤.

③ Turn the **Collective Gain** and **Vel Integral Gain** potentiometers at least 15 turns counterclockwise. This will ensure that the collective gain and velocity integral gain functions are turned off.

④ Center the **Offset Balance** potentiometer—turn it at least 15 turns clockwise, then back it off approximately 7 1/2 turns counterclockwise, to put it in the center of its travel.

⑤ Turn on AC power to the APEX Drive.

⑥ If the motor shaft is turning, adjust the **Offset Balance** potentiometer to stop the shaft from turning. (For smaller motors, the null range may be quite narrow—it may be difficult to find the exact position where the motor shaft stops completely.)

⑦ **TEST**: Turn the **Offset Balance** potentiometer clockwise. The motor shaft should turn clockwise (when viewed from the front of the motor).

⑧ **TEST**: Turn the **Offset Balance** potentiometer counterclockwise. The motor shaft should turn counterclockwise.

⑨ After you have performed these tests, adjust the **Offset Balance** potentiometer to stop the motor shaft from turning.

⑩ Turn off AC power; remove the wire between enable input and ground.

Successful completion of these tests verifies that the APEX Drive is configured correctly, and that the AC power cable, motor cable, and resolver cable are properly wired. Proceed to *Connect a Controller* below.

If your motor does not turn, or does not turn in the correct direction, check the DIP switch settings and cable connections, and perform the test procedure again.

OPTION 2: VELOCITY MODE

If you intend to operate your system in velocity mode, perform the following procedure before you connect a controller. The controller and encoder output should be disconnected from the drive; the motor should be disconnected from the load.

① Power to the APEX Drive should be OFF when you begin this procedure.

② Connect a wire between **Enable In** and Ground (**Gnd**) on the controller connector. This shorts the enable input to ground, and will enable the APEX Drive when you turn on the AC power.

NOTE: The next two steps – ③ & ④ – were performed at the factory. If yours is a new APEX Drive, you do not need to perform these two steps—use the default factory settings. You can proceed to step ⑤.

③ Turn the **Collective Gain** and **Vel Integral Gain** potentiometers at least 15 turns counterclockwise. This will ensure that the collective gain and velocity integral gain functions are turned off. (These functions may or may not be turned off on DIP switch #3, positions 1 and 8, depending upon how you configured the drive for velocity mode.)

④ Center the **Offset Balance** potentiometer—turn it at least 15 turns clockwise, then back it off approximately 7 1/2 turns counterclockwise, to put it in the center of its travel.

⑤ Connect **Tach Output** (on the controller connector) to **Feedback+** (on the resolver connector). Connect **Gnd** (next to **Tach Output**) to **Feedback–**. Use twisted pair wire for these connections, to minimize noise problems.

(Optional: if you are using an external tachometer, connect its output to **Feedback+**. Connect its ground to **Feedback–**. Make no connections to the APEX Drive's **Tach Output**).

See *Chapter 4 Hardware Reference* for a schematic drawing of these terminals.

⑥ Turn on AC power to the APEX Drive.

⑦ If the motor shaft is turning, adjust the **Offset Balance** potentiometer to stop the shaft from turning. (For smaller motors, the null range may be quite narrow—it may be difficult to find the exact position where the motor shaft stops completely.)

⑧ **TEST**: Turn the **Offset Balance** potentiometer clockwise. The motor shaft should turn clockwise (when viewed from the front of the motor).

⑨ **TEST**: Turn the **Offset Balance** potentiometer counterclockwise. The motor shaft should turn counterclockwise.

⑩ After you have performed these tests, adjust the **Offset Balance** potentiometer to stop the motor shaft from turning. Turn off AC power, and remove the wire between enable input and ground.

Successful completion of these tests verifies that the APEX Drive is configured correctly, and that the AC power cable, motor cable, and resolver cable are properly wired. Proceed to *Connect a Controller* below.

If your motor does not turn, or does not turn in the correct direction, check the DIP switch settings and cable connections, and perform the test procedure again.

CONNECT A CONTROLLER

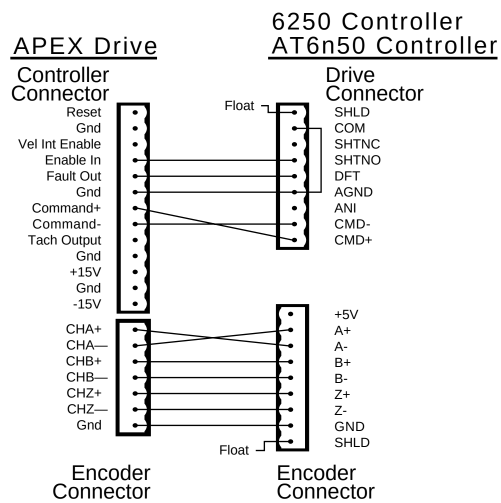
The above procedures were done without a controller connected. This should have made it easy to isolate and fix any problems. In this section, you will connect your controller to the APEX Drive.

The controller connector is a removable 13-pin connector located on the front panel of the APEX Drive. The connector can accept wire diameters as large as 12 AWG (4 mm^2). Wire your controller cable to the connector, according to the following instructions.

For detailed descriptions of each terminal, including schematic diagrams, see *Chapter 4 Hardware Reference*.

CONNECTIONS TO COMPUMOTOR CONTROLLERS

The next drawing shows how to connect an APEX Drive to Compumotor's 6250 or AT6n50 servo controllers.



Connections to Compumotor Controllers

Connections to other controllers are described in the following sections.

CONNECTIONS TO NON-COMPUMOTOR CONTROLLERS

COMMAND INPUT

If your controller has a *differential output*:

① Connect the controller's positive command output to the APEX Drive's **Command+** input.

② Connect the controller's negative command output to the APEX Drive's **Command–** input.

③ Connect the controller's signal ground to any of the ground inputs (labeled **Gnd**) on the APEX Drive's controller connector.

If your controller has a *single-ended output*:

① Connect the controller's command output to the APEX Drive's **Command+** input.

② Connect the controller's signal ground to the APEX Drive's **Command–** input.

③ Connect a wire between the APEX Drive's **Command–** input and any of the ground inputs (labeled **Gnd**) on the APEX Drive's controller connector. This will reference the **Command–** input to ground.

If your controller has *isolated outputs*: some controllers have isolated command outputs, and may require a voltage source to power their outputs. The APEX Drive has ±15V available to power isolated outputs on a controller.

① Connect the APEX Drive's ±15V outputs to your controller's ±15V inputs.

② Connect your controller's single-ended or differential outputs to the APEX Drive, as described above.

See *Chapter 4 Hardware Reference* for a schematic of the command input.

Enable Input

Connect the controller's enable output to the APEX Drive's enable input, labeled **Enable In**. The enable input is *active low*—this means that when it is connected to ground, the APEX Drive is enabled. Therefore, your controller must pull the APEX Drive's enable input low (0 – 1.0VDC) to enable the drive. See *Chapter 4 Hardware Reference* for a schematic of the enable input.

Fault Output

Connect the APEX Drive's fault output, labeled **Fault Out**, to the controller's fault input. The fault output is *active high*—under normal conditions, the drive holds the fault output low (0 – 1.0VDC). To signal a fault, the drive will let the fault output float. Your controller may need to pull up the fault output signal to an appropriate level. See *Chapter 4 Hardware Reference* for a schematic of the fault output.

Ground

Connect the controller's signal ground to one of the ground inputs on the APEX Drive's controller connector. All of the ground inputs (labeled Gnd) on the front panel of the APEX Drive are connected together internally. They are isolated from the chassis, from **Motor Ground**, and from **Earth** on the AC input connector.

Reset (optional)

If the controller has a reset output, and you wish to use it, connect it to the APEX Drive's reset input (labeled **Reset**). The reset input is *active low*. To reset the APEX Drive's processor, the controller must pull the reset input low (less than 1.0V) for at least 20 milliseconds. Reset begins upon release of the low level. See *Chapter 4 Hardware Reference* for a schematic of the reset input.

CONNECT ENCODER TO CONTROLLER

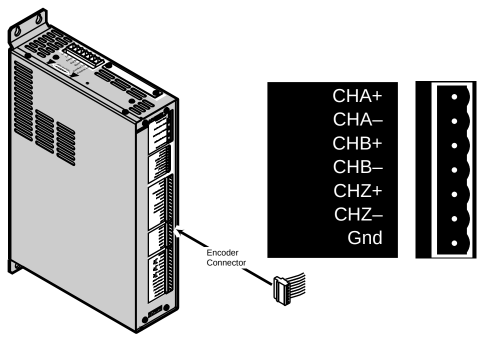
Connect the APEX Drive's encoder output to the controller. The encoder connector is a removable 7-pin connector located on the front panel of the APEX Drive. The connector can accept wire diameters as large as 12 AWG (4 mm^2).

The APEX Drive uses a resolver–to–digital converter to produce its encoder outputs. Encoder features are:

ENCODER RESOLUTION:	1024 counts per revolution, pre-quadrature 4096 counts per revolution, post-quadrature
CLOCKWISE ROTATION:	Channel A leads Channel B
COUNTERCLOCKWISE ROTATION:	Channel B leads Channel A

See *Chapter 4 Hardware Reference* for complete encoder specifications.

The encoder on the APEX Drive has the following outputs:



Encoder Output

Name	Function:
CHA+	Channel A+
CHA-	Channel A–
CHB+	Channel B+
CHB-	Channel B–
CHZ+	Channel Z+
CHZ-	Channel Z–
Gnd	Ground

Connect these outputs to your controller's encoder inputs. If you use a Compumotor controller, see the connection diagram in the previous section. (See pg. 37: A+ connected to A-; A- connected to A+)

If the motor has Hall Effects instead of a resolver, the Hall Effects connect to the Encoder Output connector, as shown in Chapter 4, and the encoder on the motor goes to the connector.

TEST: ROTATE MOTOR SHAFT

Perform the following steps to verify that the encoder is connected properly.

① Disable the APEX Drive. (Use your controller to disable the drive, or remove the wire between the enable input and ground on the controller connector.)

② Turn on power to the APEX Drive. The drive should power up, but be disabled. The **Disable** LED should illuminate to indicate that the drive is disabled.

③ Note the encoder position. (Use your controller, or any other method you prefer, to read the encoder position.)

④ With the motor disconnected from the load, manually rotate the motor shaft clockwise, approximately one revolution. Read the new encoder position. One revolution *exactly* will produce 4,096 counts, post-quadrature. Your reading should be approximately near this number, and should be positive for clockwise rotation.

If you intend to operate the APEX Drive in torque mode, successful completion of the above procedures verifies that your APEX Drive is configured and operating properly in torque mode. You may now proceed to *Preliminary Tuning* below.

If you intend to operate the APEX Drive in velocity mode, you should calibrate the tachometer, as described immediately below, before tuning your system.

CALIBRATE TACHOMETER (VELOCITY MODE ONLY)

In the procedures above, you connected the tachometer output (**Tach Output** on the APEX Drive's controller connector) to the velocity feedback signal, **Feedback+**, on the resolver connector. (See "Adjust Offset Balance")

In this procedure, you will adjust two potentiometers on the front panel of the APEX Drive—**Offset Balance** and **Tach Out Cal**—to precisely calibrate the APEX Drive's tachometer output.

① Energize AC power to the APEX Drive and enable the drive.

② Use your controller to command a velocity of zero (ØV input to the drive). Adjust the **Offset Balance** potentiometer so that motor shaft velocity is zero (the shaft does not turn).

③ Use your controller to command a positive velocity. Monitor the actual shaft velocity, and adjust the **Tach Out Cal** potentiometer so that actual velocity matches commanded velocity.

EXAMPLE: For a system that will run at a maximum of 4,000 rpm, command a velocity of 4,000 rpm (4.0V command input). As you monitor shaft velocity, adjust the **Tach Out Cal** potentiometer so that actual motor shaft velocity is 4,000 rpm.

If you intend to operate the APEX Drive in velocity mode, successful completion of the above procedures verifies that your APEX Drive is configured and operating properly in velocity mode. You may now proceed to *Preliminary Tuning,* below.

PRELIMINARY TUNING (WITH NO LOAD ATTACHED)

Before you attach the motor to the load, use your controller to perform preliminary tuning on your system. Consult your controller's user guide for instructions on how to tune your system with no load attached. Setting tuning gains now will ensure that your system behaves predictably when you first turn it on with a load attached to the motor.

TUNING WITH SM MOTORS

Maximum peak current for SM motors can be three times higher than the continuous current rating. If the motor oscillates during your tuning procedure, high peak current may cause overheating and damage the motor. When you tune your system, therefore, we recommend that you start with the lowest value for peak current. As you tune the drive and refine your gains, you can raise the peak current level. See *Tuning* at the end of this chapter for more details.

CAUTION
If you use an SM Motor, set the drive's DIP switches at the lowest peak current level for initial drive tuning. Motor damage due to excessive heating may result from high peak currents and improper tuning values.

CONNECT THE MOTOR TO THE LOAD – COUPLERS

Your mechanical system should be as stiff as possible. Because of the high torques and accelerations of servo systems, the ideal coupler joining a motor and load would be completely rigid. Rigid couplers require perfect alignment, however, which can be difficult or impossible to achieve. In real systems, some misalignment is inevitable. Therefore, a certain amount of flexibility may be required in the system. Too much flexibility can cause resonance problems, however.

These conflicting requirements are summarized below.

❏ Maximum Stiffness (in the mechanical system)

❏ Flexibility (to accommodate misalignments)

❏ Minimum Resonance (to avoid oscillations)

The best design solution may be a compromise between these requirements.

CAUTION
Modifying or machining the motor shaft will void the motor warranty. Contact a Compumotor Applications Engineer (800-358-9070) about shaft modifications as a custom product.

MISALIGNMENT & COUPLERS

Align the motor shaft and load as accurately as possible. In most applications, some misalignment is unavoidable, due to tolerance buildups in components. However, excessive misalignment may degrade your system's performance.

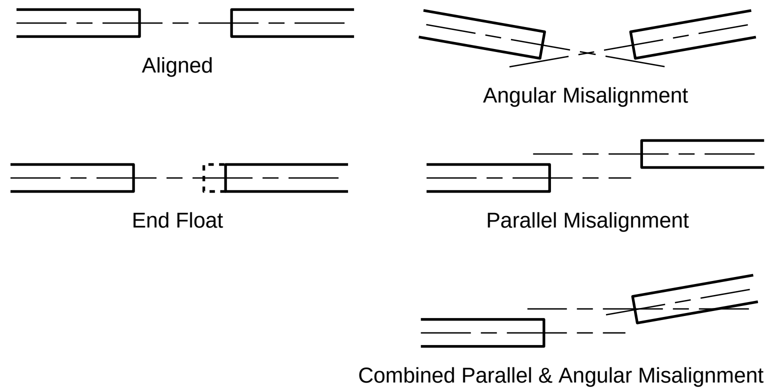
There are three misalignment conditions:

❏ Angular Misalignment: The center lines of two shafts intersect at an angle other than zero degrees.

❏ Parallel Misalignment: The offset of two mating shaft center lines, although the center lines remain parallel to each other.

❏ End Float: A change in the relative distance between the ends of two shafts.

These conditions can exist in any combination. They are illustrated below:



Misalignment Conditions

The type of misalignment in your system will affect your choice of coupler.

Single-Flex Coupler

Use a single-flex coupler when you have angular misalignment only. Because a single-flex coupler is like a hinge, one and only one of the shafts must be free to move in the radial direction without constraint. ***Do not use a double-flex coupler in this situation***: it will allow too much freedom and the shaft will rotate eccentrically, which will cause large vibrations and catastrophic failure. ***Do not use a single-flex coupler with a parallel misalignment***: this will bend the shafts, causing excessive bearing loads and premature failure.

Double-Flex Coupler

Use a double-flex coupler whenever two shafts are joined with parallel misalignment, or a combination of angular and parallel misalignment (the most common situation).

Single-flex and double-flex couplers may or may not accept end play, depending on their design.

Rigid Coupler

Rigid couplers are generally not recommended, because they cannot compensate for *any* misalignment. They should be used only if the motor or load is on some form of floating mounts that allow for alignment compensation. Rigid couplers can also be used when the load is supported entirely by the motor's bearings. A small mirror connected to a motor shaft is an example of such an application.

Coupler Manufacturers

HUCO
70 Mitchell Blvd, Suite 201
San Rafael, CA 94903
(415) 492-0278

ROCOM CORP.
5957 Engineer Drive
Huntington Beach, CA 92649
(714) 891-9922

HELI-CAL
P.O. Box1460
Santa Maria, CA 93456
(805) 928-3851

Resonance Issues

A coupler that is too flexible may cause a motor to overshoot its commanded position. When the encoder sends a position feedback signal, the controller will command a correction move in the opposite direction. If the resonant frequency of the system is too low (too flexible), the motor may overshoot again and again. In extreme cases, the system could become an oscillator.

To solve resonance problems, increase the mechanical stiffness of the system to raise the resonant frequency so that it no longer causes a problem.

If you use a servo as a direct replacement for a step motor, you may need to modify your mechanical coupling system to reduce resonance. For example, we recommend using a bellows-style coupler with servo motors, rather than the helical-style coupler that is often used with step motors. Helical couplers are often too flexible, with resonant frequencies that can cause problems. Bellows couplers are stiffer, and perform better in servo systems.

Tuning

Servo systems rely on feedback to control the motor motion. A servo loop consists of the forward path through the motor, and the feedback path to the drive. You can tune your system to optimize performance.

The APEX Drive can be configured as either a velocity or torque servo. When operated in torque mode, the APEX Drive amplifies a torque command, but does not actually close a servo loop around the motor. Velocity measured by the resolver is used as a feedback signal. The APEX Drive *does* close an inner current loop, which ensures that actual current matches commanded current. When operated in velocity mode, the APEX Drive closes a servo loop around the motor and drive.

When using the APEX Drive with a PID servo controller, you should operate the APEX Drive in torque mode. In this mode minimal tuning is required at the drive. When using the APEX Drive as a stand alone velocity controller, or with a controller requiring additional damping, you should operate the APEX Drive in velocity mode. Since brushed servo motors are traditionally operated in velocity mode, controllers in PLC and CNC type systems operate better when the drive is in velocity mode.

The APEX Drive is a reliable and simple component in a complete motion control system. Unless you are operating it as a stand-alone velocity system, the real tuning of your system will take place in the controller servo algorithm. The entire tuning process of the drive itself should take only a few minutes, and should be completed before tuning the controller. Your goal in tuning the APEX Drive is to make it perform responsively and predictably.

TUNING WITH SM MOTORS

Maximum peak currents for APEX, SM, and NeoMetric Motors are three times higher than the motor's continuous current rating. If your system is not tuned properly, and the motor oscillates or becomes unstable, excessive peak currents may cause the motor to overheat. The motor may be quickly damaged, before the thermostat can trigger the drive's **Motor Fault** circuit.

To avoid motor damage, we recommend the following iterative tuning procedure for a system.

① Adequately heatsink your motor, especially in temporary "bench top" procedures. Motors dissipate excess heat through their faceplate; the faceplate must be mounted to a heatsink to ensure proper motor cooling.

② Set the drive's DIP switches for the lowest peak current.

③ Apply tuning gains, and test your system's response. Adjust the gains until you achieve a satisfactory response. Before proceeding to the next step, ensure that the system is stable and that there are no mechanical problems that cause binding or jamming.

④ Using the drive's DIP switches, increase peak current to the next higher level. Do not set the peak current higher than that specified for your particular motor.

⑤ Repeat steps 3 and 4 until you achieve performance satisfactory for your application.

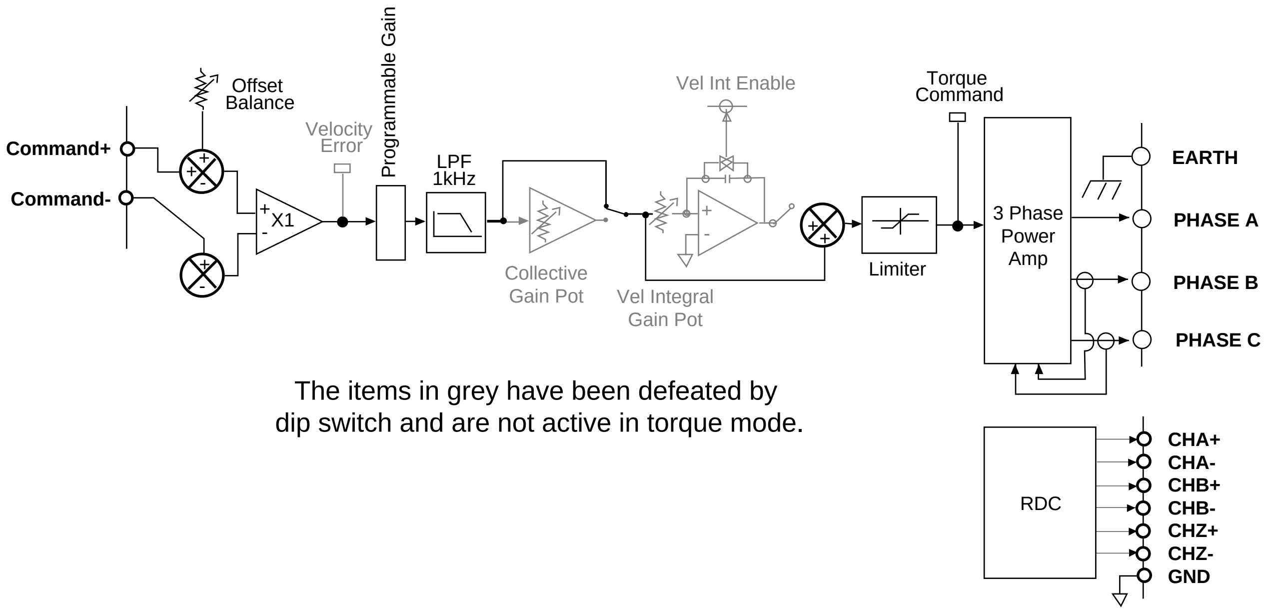
CAUTION

If you use an SM Motor, set the drive's DIP switches at the lowest peak current level for initial drive tuning. Motor damage due to excessive heating may result from high peak currents and improper tuning values.

TORQUE MODE TUNING

In torque mode, the drive is a block of fixed gain (transconductance) set at 5 mhos (amp/volt). The bandwidth of the drive is approximately 1 KHz.

APEX TORQUE LOOP



TORQUE MODE TUNING – PROCEDURE

In torque mode the only adjustment is to the **Offset Balance** potentiometer. This adjustment can remove, or zero, a DC voltage offset in the torque amplifier. The procedure for adjusting the **Offset Balance** potentiometer was described earlier in this chapter.

SYMPTOMS

You will need to balance the Offset Balance potentiometer if your system displays the following symptoms:

Offset Voltage: If the position controller is required to output a command voltage larger than 0.25V, the balance may need adjustment. This condition is only detrimental if it limits the top end command. If the load is affected by gravity or large amounts of friction, the controller may need to command a higher voltage to overcome these forces and should not be balanced.

Motor Runs Away: If the motor runs away when enabled (without a position loop closed) you should adjust the offset to zero.

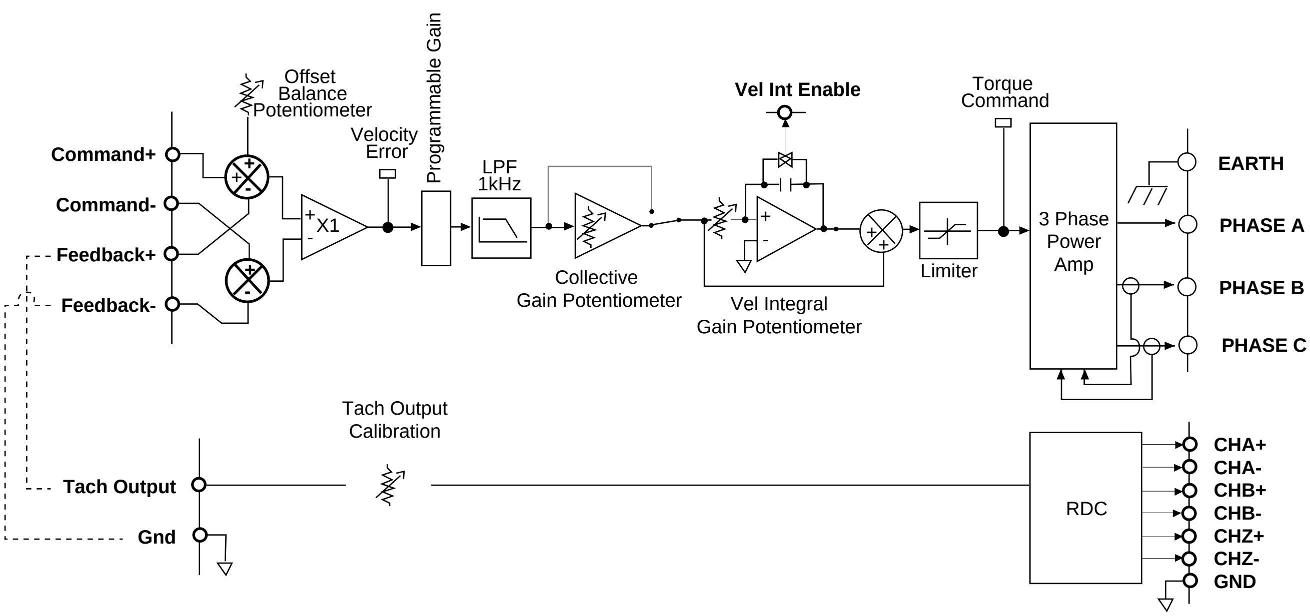
Velocity Mode Tuning

Velocity Loop

In velocity mode, the gain is adjustable from 5 to 30 mhos and provision is made for analog velocity feedback from a tachometer. Additionally, the APEX Drive incorporates an optional integrator in the forward path which may be useful in spindle applications. The integrator is normally disabled (zero gain) unless it is enabled by a logic signal at the **Vel Int Enable** input. This allows the integrator to be selectively left out of the loop at certain times so that it does not participate in gross move dynamics, such as acceleration/deceleration transients.

When you tune in velocity mode, you will adjust the overall collective gain (and the integrator gain if used). Unlike the **Offset Balance** and **Tach Output Cal** potentiometers, the tuning controls are not used to compensate for spurious variations from one unit to the next. Rather they are set according to system requirements and their settings should be identical among all similar APEX Drives. Test points are provided to allow the potentiometers to be set to the desired values using a digital voltmeter while the drive is powered down. The test moves described in the following are more for prototyping than for production testing.

APEX Velocity Loop



Adjustments

In velocity mode the **Offset Balance**, **Collective Gain**, and **Vel Integral Gain** potentiometers are the active adjustments.

Adjustment	Type	Description
Offset Balance	15 (±3) turn pot	Positive and negative adjustment of the DC value of the velocity command signal.
Collective Gain	15(±3) turn pot	Overall amplification of the velocity error. This adjustment should be used as velocity gain when operating with a position c ontroller. The gain will be high with large inertia and will add damping to a position servo system. This gain is defeatable by dip switch.
Velocit Integral Gain	15(±3) turn pot	Corrects for steady state errors in velocity. Should only be used in stand alone velocity applications. This gain is defeatable by dip switch.

Symptoms

You will need to adjust the velocity gains if your system displays any of the following symptoms:

Offset Voltage: If the position controller is required to output a command voltage larger than 0.25V when the motor is under no load, the balance may need adjustment. This condition is only detrimental if it limits the top end command. If the load is affected by gravity or large amounts of friction, the controller may need to command a higher voltage to overcome these forces and should not be balanced.

Motor Runs Away: If the motor runs away when enabled (without a position loop closed) the offset can be adjusted to zero so the motor will not run away when enabled.

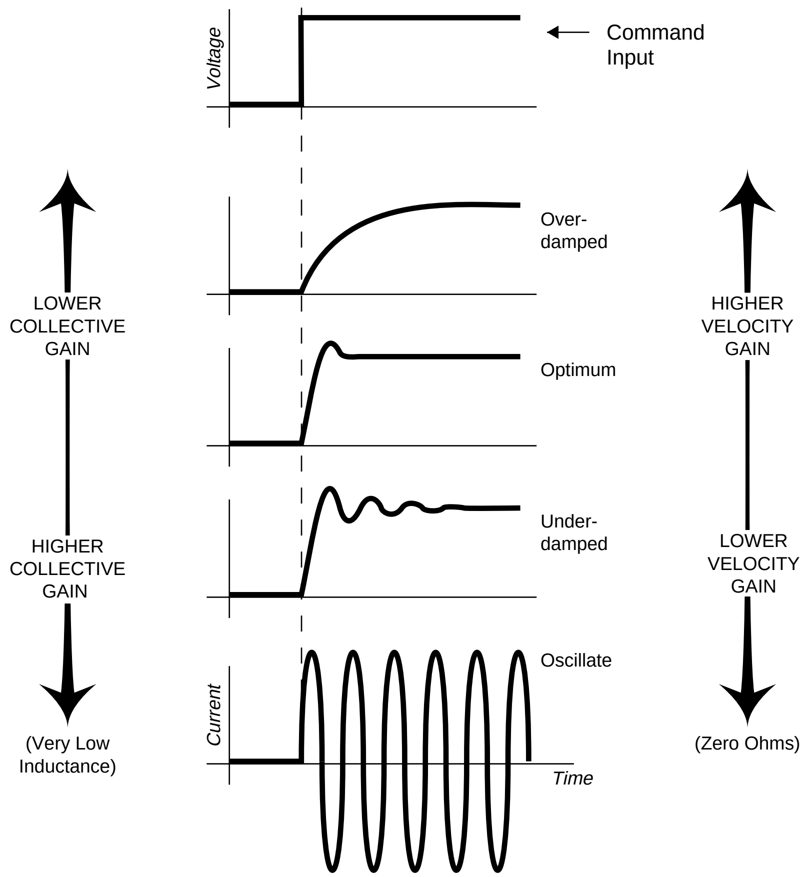
Sluggish System: If the motor lacks stiffness, the collective gain is too low. When the load inertia increases, the collective gain must be increased proportionally.

Ringing: If the system rings excessively when changing position and velocity, your system is either underdamped or aggravating a mechanical resonance in the system. By increasing the Collective gain you will increase the responsiveness of the velocity loop and increase damping.

Steady State Errors: This will occur when operating the APEX Drive in a velocity mode only (no position controller). If the motor will not reach the commanded velocity, an external force such as friction is restraining the motor. By increasing the Velocity Integral Gain, the APEX Drive will increase the command voltage to overcome steady state velocity errors.

Velocity Mode Tuning – Procedure

For best results tune the gains in the order presented here. The velocity loop gains should be tuned independently and prior to the tuning of the position loop gains.



Response Waveforms

Adjust Offset Balance

The procedure for adjusting the **Offset Balance** potentiometer was described earlier in this chapter.

Adjust Collective Gain

The **Collective Gain** potentiometer is a 15 turn potentiometer with zero at fully counterclockwise and maximum at 15 turns clockwise. The factory default is fully counterclockwise and should be verified before beginning this procedure.

The best way to gauge velocity loop response is to command a velocity step with a function generator and measure the tach output signal (the tach output signal needs to remain connected to the **Feedback+/-** input). Many controllers, such as the 6250 from Compumotor, have utilities and commands for velocity loop tuning and for interpreting the results. Consult the appropriate user guides for more information.

① With the APEX Drive enabled, command a voltage step.

② Measure the tach out signal with an oscilloscope or with a software data acquisition package that can plot the results.

③ When the DC voltage input is changed the APEX Drive will attempt to track that change as quickly as possible. With the Collective Gain high, the APEX Drive is very responsive to changes. With the Collective Gain low, the APEX Drive is less responsive to these changes. The Collective Gain should be set as high as possible without causing the system to oscillate when it changes velocity.

Velocity Integral Gain

The velocity integral gain is only required in applications for stand alone velocity control. Stand alone velocity control is defined as an application where motor position is not measured. The system is required to respond to and maintain a commanded velocity based on the ±10 volt velocity command. In these applications, friction or other external forces can keep the motor from attaining the commanded velocity. Raising the velocity integral term will improve velocity accuracy.

The **Vel Integral Gain** potentiometer is set empirically. The velocity integral gain is adjusted by a 15 turn pot with zero at fully counterclockwise and maximum at 15 turns clockwise. The factory default is fully counterclockwise and should be verified before beginning this procedure.

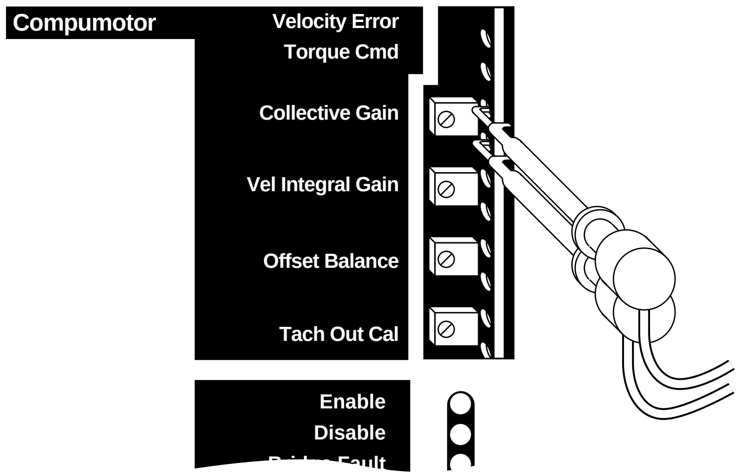
① With the APEX Drive enabled, command a voltage step.

② Measure the tach out signal with an oscilloscope or with a software data acquisition package that can plot the results.

③ When the DC voltage input is changed the APEX Drive will attempt to track that change as quickly as possible. The Velocity Integral Gain should be set to a level where the response does not ring and has only a small amount of overshoot.

TUNING MULTIPLE SYSTEMS

If you have more than one APEX Drive doing the same application, you can use the gain values from a prototype system to configure the subsequent systems. By measuring the resistance of the potentiometer with the power off, as shown in the figure, a value of Collective or Velocity Integral Gain can be attained. On the second APEX Drive simply turn the potentiometer until the resistance matches the value of the prototype APEX Drive.



Tuning Potentiometers - Measuring Resistance

CHAPTER THREE

Special Features

IN THIS CHAPTER

MOTOR BRAKING (FAULT RELAY±)

If the APEX Drive faults, for any reason, the drive will be disabled and the motor will freewheel. If a freewheeling load is unacceptable, use the fault relay terminals, **Fault Relay+** and **Fault Relay–**, to control a motor brake.

The fault relay inside the APEX Drive is *normally open*. This means that when the drive is faulted or disabled, or when the power is off, the relay will be open. When the APEX Drive is enabled, it energizes the relay coil, and holds the relay closed. The relay is rated for 5 amps at 24VDC or 120VAC.

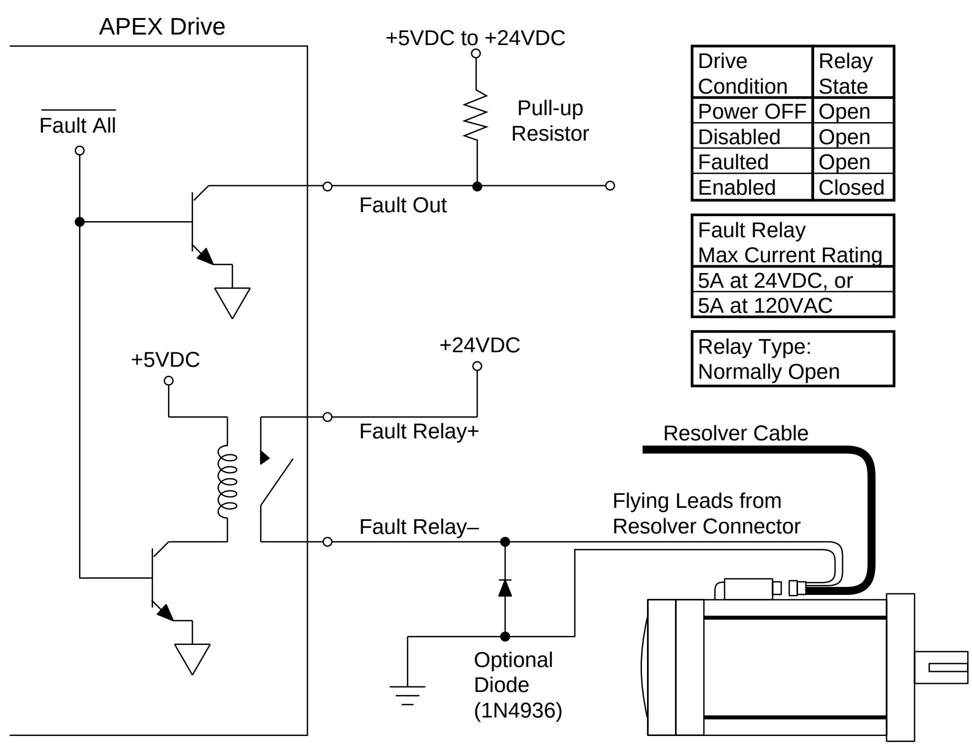
Most motor brakes have a coil that, when energized, will release the brake. To control a brake with the fault relay terminals:

① Connect the power source for the brake to one of the fault relay terminals.

② Connect the other fault relay terminal to the brake.

③ If you use a DC power source, you may need to connect a diode across the brake coil to reduce voltage spikes when the brake is engaged or disengaged. A 1N4936 diode, or equivalent, should be sufficient.

EXAMPLE 1: APEX and NeoMetric motors are available from Compumotor with an optional mechanical brake. Call Compumotor's Customer Service Department (800-722-2282) for more information. The next drawing shows how to connect the brake to the fault relay terminals.

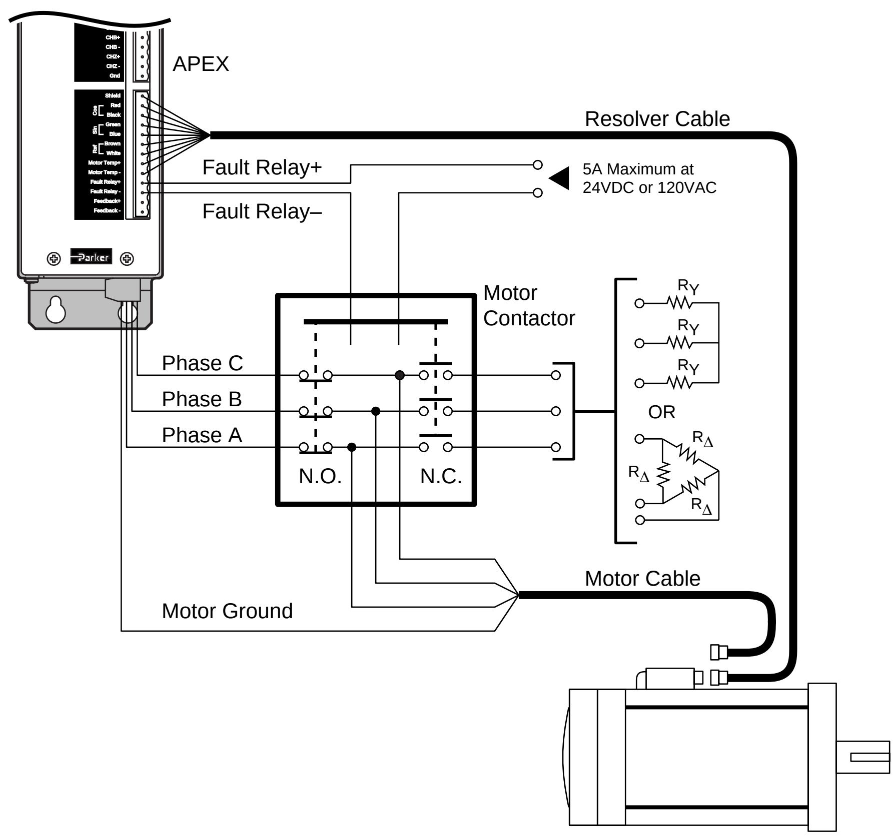


Fault Relay with Mechanical Brake

24VDC is applied, through the fault relay terminals, to one of the flying leads on the motor's resolver connector. The other lead is connected to ground. An optional diode is shown installed between the two leads. The diode's polarity is correct as shown.

The drawing also shows that the fault output and the fault relay are controlled by the same internal signal. Any fault condition that triggers the fault output will also cause the fault relay to turn off (relay will be opened).

EXAMPLE 2: The next drawing illustrates how to connect auxiliary resistors to control motor braking. The drawing shows that during normal operations, the motor contactor is energized and provides a direct connection between the motor and drive. The motor contactor *(N.O. = normally open with power removed; N.C. = normally closed with power removed)* is controlled by the fault relay terminals on the APEX Drive's resolver connector. If the drive faults or if the line voltage is disconnected, the contactor connects the motor braking resistors across the motor.



Motor Braking with Resistors

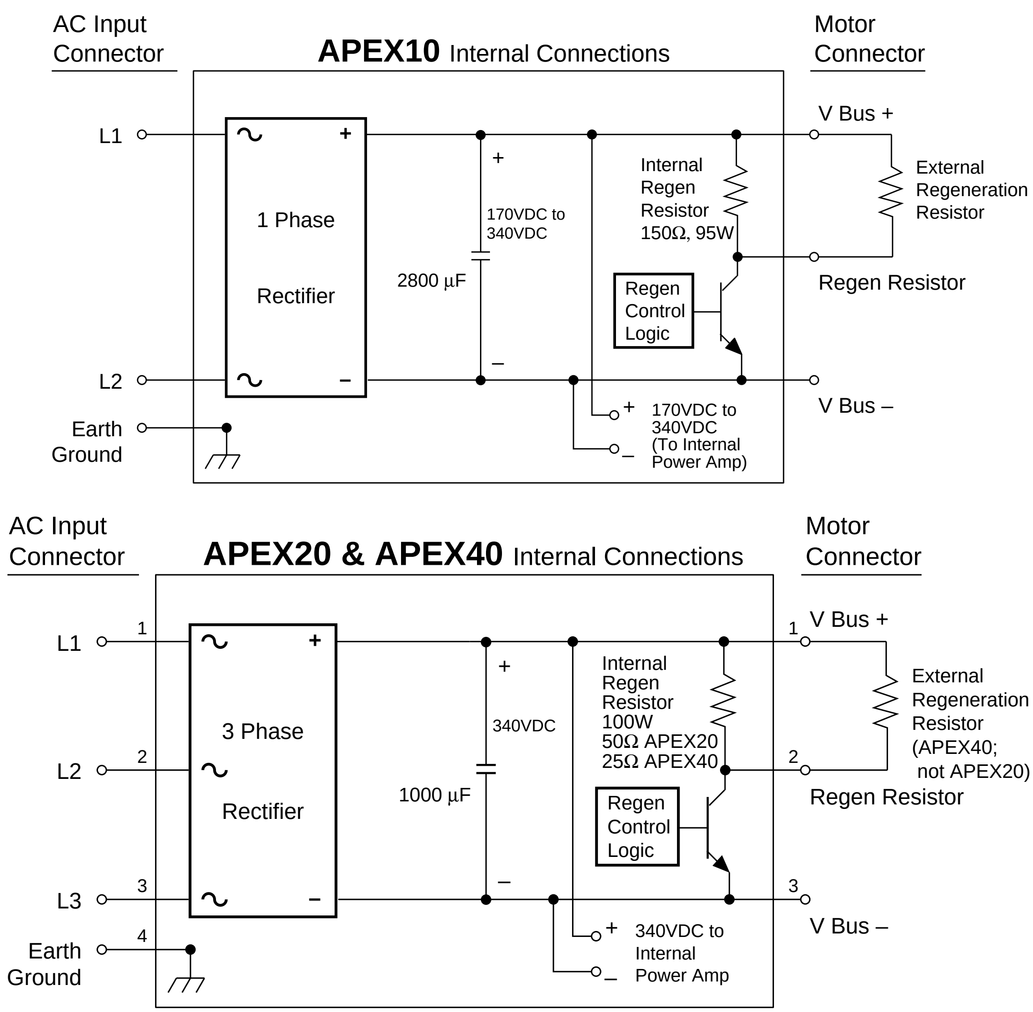
The braking resistors can be sized by analyzing specific applications. If the total load inertia is less than five times the rotor inertia, non-inductive 200 watt power resistors can be used as the braking resistors. For a wye configuration, use 5 ohms or more (R_Y = 5Ω). For a delta configuration, use 15 ohms or more (R_D = 15Ω). If quicker stopping is required, the braking resistor values can be lowered, but you must increase their power ratings.

REGENERATION AND THE APEX DRIVE

The APEX Drive can dissipate regenerated energy in its internal *regeneration resistor*. If an APEX system regenerates more energy than the internal resistor can dissipate, you can connect an external resistor between two terminals labeled **V Bus+** and **Regen Resistor**, located on the motor connector. The external resistor will double the dissipation capabilities of the APEX10 and APEX40. To increase the APEX20's dissipation capabilities, you can add a resistor network, as explained later in this chapter.

The APEX Drive's regeneration circuit works automatically—there are no adjustments to make. The circuit monitors the voltage on the power bus. If regenerated energy from the motor causes the bus voltage to rise above a threshold value, the circuit closes a switch, thus connecting the regeneration resistor between the positive and negative sides of the power bus, **V Bus+** and **V Bus–**. The energy is then dissipated in the resistor. During the regeneration event, the red LED labeled **Regen Active**, located on the APEX Drive's front panel, will be illuminated.

The next drawing shows a schematic that includes the internal regeneration resistor, terminals for an external regeneration resistor, and the DC power bus.



Regeneration Circuit

Faults Caused by Excessive Regeneration

The APEX Drive's protection circuitry monitors regeneration activity, and can trigger one of two fault conditions if excess regeneration occurs. The drive's internal IGBT power switch is the component that determines the limits. Exceeding the regeneration resistor's *continuous* power rating will cause a **Regen Fault**. Exceeding the resistor's *peak* power rating will cause an **Overvoltage Fault**. Either of these faults will shut down the drive, to

Important specifications for the regeneration circuit are:

	Nominal Operating Voltage: (based on AC input)	Regen Resistor Turns ON:	Overvoltage Fault Turns ON:
APEX10	170VDC-340VDC	390VDC	420VDC
APEX20	360VDC	390VDC	420VDC
APEX40	340VDC	390VDC	420VDC

Dissipation ratings for the internal regeneration resistor are:

	Continuous Power Dissipaton Rating	Peak Power Dissipation Rating
APEX10	95 watts	1KW
APEX20	100 watts	3KW
APEX40	100 watts	6KW

safeguard the system.

Details regarding the regeneration fault and overvoltage fault are explained below.

Regeneration Fault

A regeneration fault indicates that the *continuous* power dissipation capabilities of the regeneration resistor have been exceeded.

The resistor's temperature is determined by the *average* power dissipation over time and is affected by such things as the length of time the resistor is on, how much power it dissipates, and the length of time it is off. When regeneration occurs, the temperature will increase during deceleration and during a repetitive move profile. The temperature will decrease after regeneration stops—when the motor is accelerating, moving at constant velocity, or at rest.

If the average power dissipated in the resistor is less than the continuous rating in the table above, the temperature will stay below damaging levels. If the average power dissipated is greater than the continuous rating, the temperature may rise to a level that can permanently damage the resistor; however, the regeneration fault circuit will shut down the drive before temperatures reach this level. The purpose of the regeneration fault is to protect the regeneration resistor from damage due to high temperatures.

You can clear the regeneration fault by cycling power or sending a reset signal to the APEX Drive's reset input. To cycle power, turn off AC power to **Control L1/Control L2**, then turn the power back on. However, if the resistor has not had adequate time to cool, and the conditions leading to the regeneration fault persist, ***you may damage the regeneration resistor by cycling power repeatedly***. Information about continuous power dissipation in the regeneration resistor is lost when power is cycled.

CAUTION

Repeatedly cycling power or resetting the drive to clear regeneration faults may damage the regeneration resistor.

Overvoltage Fault

An overvoltage fault indicates that the *peak* power dissipation capabilities of the regeneration resistor have been exceeded.

Regeneration causes the voltage on the DC power bus to rise. The regeneration resistor will turn on when the bus voltage reaches 390VDC. Peak power dissipation occurs at the moment the resistor turns on. The peak power value is determined by the size of the resistor, in ohms, and the voltage across it:

$$APEX10\ Peak\ Power = \frac{V^2}{R} = \frac{(390VDC)^2}{150\Omega} \approx 1000W \quad (1KW)$$

$$APEX20\ Peak\ Power = \frac{V^2}{R} = \frac{(390VDC)^2}{50\Omega} \approx 3000W \quad (3KW)$$

$$APEX40\ Peak\ Power = \frac{V^2}{R} = \frac{(390VDC)^2}{25\Omega} \approx 6000W \quad (6KW)$$

As soon as the resistor turns on, regenerated power begins to be dissipated in the resistor, and, in most applications, bus voltage drops. When the voltage falls below 375VDC, the resistor turns off. If the motor is still producing regenerated power, the bus voltage will rise again, the resistor will turn on at 390VDC, and the cycle will repeat over and over until the motor no longer produces enough power to turn on the regeneration resistor.

However, some applications can regenerate more than the peak power shown in the above three equations. Too much peak power can overwhelm the regeneration circuit—the bus voltage will continue to rise, even while the resistor is on. To protect the system from excessive voltages, an overvoltage circuit monitors the bus voltage, and triggers the overvoltage fault if the voltage exceeds 420VDC.

An overvoltage fault will shut down the drive. The red LED labeled **Over Voltage**, located on the APEX Drive's front panel, will be illuminated. You can clear the fault by sending a reset signal to the APEX Drive's reset input, or by cycling power.

When Do You Need an External Regeneration Resistor?

The APEX Drive’s regeneration control circuit was designed to automatically deal with regenerated power from almost all applications. Occasionally, however, an application situation arises in which regeneration will cause more power dissipation than the internal resistor can safely tolerate. If you have an APEX10 or APEX40 Drive, you can connect an external regeneration resistor to double the power that the system can dissipate.

If you have an APEX20 Drive, you cannot simply add an external resistor. The drive's internal power switch is already at its maximum rated current; adding an external resistor would increase the current, and damage the drive. You can, however, build your own external resistor network in place of the internal circuit. Use the procedures in this section to determine your system's needs. Then, if you need more continuous dissipation capability, see *Building Your Own Regeneration Circuit* in the next section.

To determine whether or not you need an external resistor, you can use one of two methods:

- ❑ Empirical Method
- ❑ Calculation Method

Empirical Method

The empirical method uses a trial procedure to determine whether excess regeneration will cause a regeneration or overvoltage fault. Operate your system (or a prototype of your system) and observe the results of regeneration. When your system decelerates, the **Regen Active** LED will be illuminated whenever regeneration turns the internal resistor on.

If the system’s regeneration levels are too high, eventually either a regeneration fault or an overvoltage fault will shut down the APEX Drive. (Be sure to let your system run for a long enough time to see if the regeneration fault will be triggered.) At this point, you have two options:

- ❑ Modify the system’s move profile
- ❑ Install an external regeneration resistor

By changing the move profile—less torque, slower velocities, or a longer time between moves, for example—you may be able to reduce the regeneration to a lower level, so that the fault no longer occurs.

By installing an external resistor, you can double the regeneration circuit’s power dissipation capabilities. With the resistor installed, the circuit’s specifications become:

	Continuous Power Dissipation Rating	**Peak Power Dissipation Rating**
APEX10	100 watts	2 KW
APEX20	N/A	N/A
APEX40	180 watts	12KW

After you alter the move profile, or install the external resistor, run the system again to verify that regeneration no longer causes a fault.

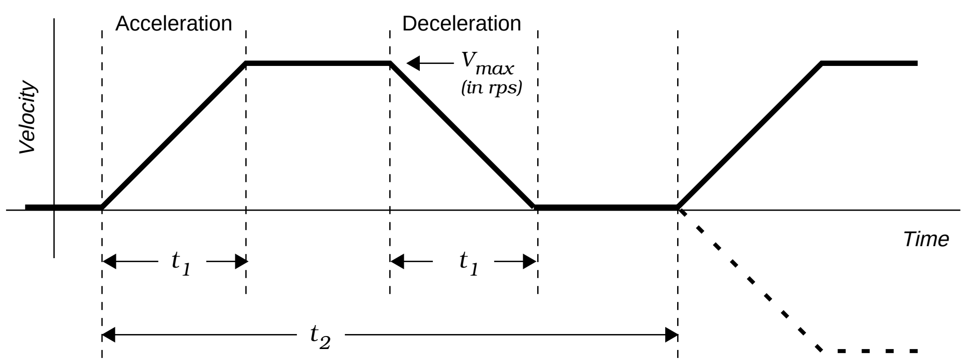
CALCULATION METHOD

You can use the calculation method to predict peak power dissipation and average power dissipation. If peak power or average power exceed the ratings given above for the internal resistor only, you should install an external regeneration resistor.

A NOTE ABOUT UNITS: We want a solution for power that is expressed in *watts*. To be consistent, we will use SI (metric) units in the following equations. If you want to use other units, apply conversion factors in the appropriate places.

CALCULATING PEAK POWER

A typical trapezoidal move profile is shown below.



Move Profile for Regeneration Calculations

Regeneration only occurs during the deceleration portion of the move. At any moment during deceleration, the amount of power regeneration is equal to the shaft power:

$$P_{shaft} = \omega T = 2\pi v T$$

where

T = torque, in newton meters (Nm)

ω = shaft velocity, in radians per second

v = shaft velocity, in revolutions per second (rps)

Peak power regeneration occurs at the moment deceleration begins, when the velocity is highest.

$$P_{shaft(peak)} = 2\pi v_{max} T$$

Not all of this peak power must be dissipated in the power resistor. Some of it will be dissipated in the copper windings of the motor—these power losses are known as *copper losses*.

$$P_{copper} = I^2 R = \frac{3}{2}\left(\frac{|T|}{k_T}\right)^2 R$$

where

I = motor current, in amps (A)

R = line – to – line motor resistance, in ohms (Ω)

k_t = motor torque constant, in newton meters per amp rms $(Nm / A\ rms)$

Power is also dissipated in the drive itself—these losses are known as *drive losses*. (Notice that we use the absolute value of the torque.)

$$P_{drive} = 5\sqrt{2}\left(\frac{|T|}{k_T}\right)$$

The peak power dissipated in the regeneration resistor, then, is equal to the peak shaft power, less copper and drive losses.

$$P_{peak} = P_{shaft} - P_{copper} - P_{drive}$$

Substituting the values from the previous equations, we obtain the equation for calculating peak power:

$$P_{peak} = (2\pi v_{\max} T) - \tfrac{3}{2}\left(\frac{T}{k_T}\right)^2 R - 5\sqrt{2}\left(\frac{|T|}{k_T}\right)$$

Substitute values from your application into this equation.

- If P_{peak} is less than the Peak Power Dissipation Rating, the internal resistor is adequate
- If P_{peak} is greater than the Peak Power Dissipation Rating, install an external resistor

Calculating Average Power

Time plays a role in average power calculations. Total regenerated energy is equal to the area of the triangle under the deceleration portion of the move profile. In the move profile shown earlier, the time of deceleration is t_1. Total energy, W, is therefore:

$$W_{regen} = \tfrac{1}{2}(height)(base) = \tfrac{1}{2}(2\pi v_{max} T)t_1$$

During the deceleration time, copper losses and drive losses will dissipate some of the regenerated energy. To determine how much energy these losses will dissipate, each of these losses must be multiplied by the time t_1:

$$W_{copper} = \left[\tfrac{3}{2}\left(\frac{T}{k_T}\right)^2 R\right]t_1 \qquad W_{drive} = \left[5\sqrt{2}\left(\frac{|T|}{k_T}\right)\right]t_1$$

The total energy that must be dissipated in the regeneration resistor consists of the total regenerated energy, less copper and drive losses:

$$W_{total} = \left[\tfrac{1}{2}(2\pi v_{\max} T) - \tfrac{3}{2}\left(\frac{T}{k_T}\right)^2 R - 5\sqrt{2}\left(\frac{|T|}{k_T}\right)\right]t_1$$

To find the average power, we must consider how frequently energy is "dissipated" into the resistor. The period of the move profile is the time t_2. Frequency and period are related by:

$$frequency = f = \frac{1}{t_2}$$

To find the average power dissipation in the resistor, we can multiply the equation for total energy by the frequency, or, as shown below, we can divide by the period of the repetitive move profile.

Finally, we obtain the equation for average power:

$$P_{average} = \left[\tfrac{1}{2}\left(2\pi v_{\max} T\right) - \tfrac{3}{2}\left(\frac{T}{k_T}\right)^2 R - 5\sqrt{2}\left(\frac{|T|}{k_T}\right) \right] \frac{t_1}{t_2}$$

Substitute values from your application into this equation.

- ❏ If $P_{average}$ is less than the Continuous Power Dissipation Rating, the internal resistor is adequate
- ❏ If $P_{average}$ is greater than the Continuous Power Dissipation Rating, install an external resistor

Installing an External Regeneration Resistor

If you install an external resistor, ensure that it is properly mounted and adequately cooled. The internal resistor is cooled by the APEX Drive's fan. The external resistor should be maintained at the same temperature, or cooler, as the internal resistor. Excessive heating of the external resistor can cause component failure.

CAUTION

Adequately cool the external resistor. Forced air cooling may be required. Maintain resistor temperature at same or lower temperature as internal resistor.

Specifications for the internal resistor are as follows:

APEX10:

- ❏ 150 ohm, 95 watt, 5% non-inductive resistor
- ❏ Manufacturer Name: Dale
- ❏ Manufacturer Part Number: NHL-95-16N 150 OHM 5%, 3/16 QUICK CONNECT
- ❏ You can order this resistor from Compumotor. The part name is: APEX10 REGEN KIT

APEX20: (for reference only; do not install external resistor)

- ❏ 50 ohm, 100 watt, 5% non-inductive resistor
- ❏ Manufacturer Name: Memcor-Truohm Inc.
- ❏ Manufacturer Part Number: FRV01006-2500-QM-NI ("NI" - Non Inductive)
- ❏ Mounting Bracket: Memcor-Truohm Inc. Part Number 1141-006-001

APEX40:

- ❏ 25 ohm, 100 watt, 5% non-inductive resistor
- ❏ Manufacturer Name: Memcor-Truohm Inc.
- ❏ Manufacturer Part Number: FRV01006-2250-QM-NI ("NI" - Non Inductive)

- ❏ Mounting Bracket: Memcor-Truohm Inc.
  Part Number 1141-006-001
- ❏ You can order this resistor from
  Compumotor. The part name is: APEX40 REGEN KIT

Use these, or equivalently rated resistors, for your external resistor. Be sure to specify a *non-inductive* resistor.

To connect the external resistor, wire its two terminals to *V Bus+* and *Regen Resistor*, located on the motor connector. Do not install more than one external resistor. The regeneration control circuit will automatically dissipate half of the excess regenerated power in the external resistor (provided that the external resistor has the same resistance (ohms) as the internal resistor.)

CAUTION

Do not install more than one external regeneration resistor with the APEX10 or APEX40.
Do not install an external regeneration resistor with the APEX20.

Building Your Own Regeneration Circuit

If you need more continuous power dissipation than the resistors provide (internal and external for the APEX10 and APEX40; internal only for the APEX 20), you can design and build your own network of external regeneration resistors.

The next table shows specifications for maximum continuous and peak dissipation that the drive can sustain. It also shows the minimum resistance for an external network. Do not use a resistor network with less resistance than the values in this table.

	Continuous	Peak	Resistance (min)
APEX10	286 watts	2080 watts	75 ohms
APEX20	1560 watts	3112 watts	50 ohms
APEX40	5760 watts	12480 watts	12.5 ohms

The drive's internal IGBT power switch is the component that determines the specifications above. With the standard external resistors discussed earlier, the switch is already at its peak power dissipation level. However, the switch can dissipate more continuous power than the standard resistors allow. Your network, therefore, can dissipate additional continuous power—but must not dissipate more peak power. This is shown in the table above.

To use an external network, you must take the following two steps.

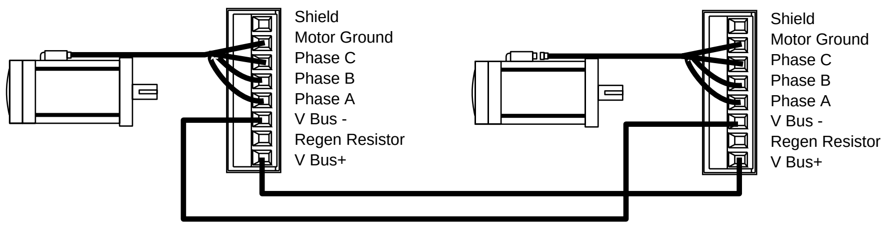
1. Set DIP Switch 1, position #1, in the ON position. This disables the drive's Regen Fault circuit.
2. Disconnect the internal regeneration resistor.

Step 2 above requires opening the drive's cover. Please call Compumotor's Applications Engineering department (see the inside front cover of this manual for the toll free number) for instructions on opening the cover and disconnecting the resistor, and to obtain additional information about designing your external resistor network.

SHARING THE HIGH VOLTAGE POWER BUS, USING *V BUS+* AND *V BUS–*

In some applications with multiple drives, one or more drives continuously receive regenerated power from their loads. For example, in a tensioning application, two drives apply tension (opposite torques) to a single moving load. In this situation, one drive could receive substantial regenerated power from its motor.

In such applications, you can connect the power buses from the drives in parallel, through the ***V Bus+*** and ***V Bus–*** terminals, located on the motor connector. With the buses connected in parallel, the regenerated power from one drive is dissipated by the power consumption of other drives. Otherwise, all of a drive's regenerated power would be continuously dumped into its own internal resistor.



CURRENT FOLDBACK (I^2T LIMIT)

The purpose of the current foldback circuit is to protect the motor from overheating due to prolonged high currents. The eight switches of DIP Switch#2 are used to set the parameters for the current foldback circuit. These parameters are:

- ❑ **PEAK CURRENT** – the highest current that the APEX Drive will produce.
- ❑ **CONTINUOUS CURRENT** – the APEX Drive reduces its current to this level when it goes into current foldback.
- ❑ **TIME CONSTANT** – the motor's thermal time constant, which is a physical parameter usually specified by the motor's manufacturer.

The APEX Drive uses an internal circuit to model the motor's thermal behavior, and predict motor temperature. Heat dissipated in the motor's windings is directly proportional to I^2, the square of the motor current, and the length of time the current flows.

The drive monitors motor current, and uses its internal microprocessor to simulate a capacitor being charged by the motor current. The result is a number, similar to voltage on a capacitor, that represents an average, over time, of the motor's temperature.

The following equation gives an approximate time before foldback occurs, for a motor that operates from a cold start, when $I_{actual} > I_{continuous}$.

$$time_{(minutes)} = Time\ Constant\left\{-\ln\left[1-\left(\frac{I_{continuous}}{I_{actual}}\right)^2\right]\right\}$$

Three variables affect this equation:

- ❏ $I_{continuous}$ is the continuous current (set by DIP switches)
- ❏ *Time Constant* is the motor's time constant (set by DIP switches)
- ❏ I_{actual} is the current that actually flows in the motor. It can be as low as Ø amps, or as high as the peak current (which was set by DIP switches).

The shortest time until foldback occurs will be when $I_{actual} = I_{peak}$. Notice that this can be much shorter than the time constant in the equation above.

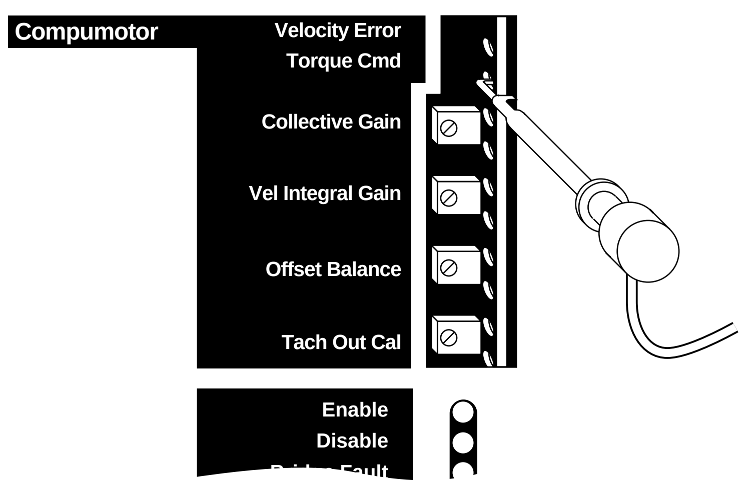
When current foldback occurs, the APEX Drive clamps its output current at the $I_{continuous}$ level, and illuminates the LED labeled **I^2T Limit**, located on the drive's front panel. The drive does not put out a fault signal on its fault output. However, because torque will be reduced as a result of the drive clamping its output current, the controller will probably detect a position or following error, and produce a controller fault.

To recover from current foldback, there are three options:

- ❏ **WAIT**—allow a period of time to pass for the motor to cool. Usually, several minutes will be required.
- ❏ **REDUCE COMMAND INPUT**—lower the commanded current to a level below continuous current. This will bleed off the voltage on the simulated capacitor, and clear the foldback condition.
- ❏ **RESET the APEX Drive (or cycle power)**—this will reset the internal microprocessor, and clear the foldback condition. However, this method is not recommended if the motor is actually hot, because the motor temperature information in the microprocessor will be lost. The motor should be allowed to cool before the drive is reset (or power is cycled), and operations continue.

FRONT PANEL TEST POINTS

The APEX Drive has two test points located on the front panel. You can connect an oscilloscope probe or meter to these points, and monitor the velocity error or the torque command.



Test Points, with Probe Attached

The test point is a through-hole located near the front edge of the APEX Drive's internal circuit board. Place the tip of the test probe in the hole, as shown in the drawing above.

You can connect the negative lead of your probe to any of the drive's ground terminals, labeled **Gnd**, on the APEX Drive's front panel.

TORQUE COMMAND

The torque command test point allows you to measure the actual commanded torque in the APEX Drive's current loop.

The signal voltage at this test point is scaled so that:

- ❏ APEX10: 1 volt = 2 amps commanded torque
- ❏ APEX20: 1 volt = 3 amps commanded torque
- ❏ APEX40: 1 volt = 5 amps commanded torque

This scaling is not affected by the command input scaling (set by DIP switch #3). The torque command test point scaling will be as listed above, regardless of the command input scaling.

The voltage at this output can range from zero to ±8V.

VELOCITY ERROR

The velocity error test point allows you to directly measure the difference between commanded velocity and the feedback signal.

ALIGNING THE RESOLVER

You can operate the APEX Drive in *alignment mode* if you need to align your motor's resolver.

This is a rarely used feature. Resolvers on APEX and SM Series motors are aligned at the factory, and need no further adjustments. It is usually not necessary to align resolvers on other manufacturer's motors.

However, if you need to replace the resolver on a motor, if you have a motor with unknown characteristics, or if poor speed/torque performance leads you to suspect that the resolver is out of alignment, you can follow the procedure below.

To align the resolver, perform the following steps.

① Turn OFF AC power to the APEX Drive.

② Remove the load from the motor. The motor's shaft must be able to turn freely.

③ Turn DIP Switch#3, position 2, ON. Turn on AC power to the drive.

④ Short together the **Command+** and **Command-** inputs. Then, using only enough current in the motor to maintain holding torque (set the current below the continuous current), do one of the following:
- 2-pole-pair motor: turn the **Offset Balance** potentiometer counterclockwise until the motor shaft turns and locks into position.
- 3-pole-pair motor: turn the **Offset Balance** potentiometer clockwise until the motor shaft turns and locks into position.

⑤ With the motor shaft locked in the alignment position, loosen the screws on the resolver so that it can turn.

⑥ Slowly rotate the resolver while you observe the APEX Drive's front panel LEDs. When the resolver is in the correct position, both the *Motor Fault* and the *I^2T Limit* LEDs will be illuminated. When the resolver is close to the correct position, only one of the LEDs will be illuminated. When the rotor is not close to the correct position, no LED will be illuminated.

⑦ With the resolver in the correct position (both LEDs illuminated), tighten the screws on the resolver so that its case can no longer rotate.

⑧ You may need to adjust the offset balance potentiometer, to stop the motor from turning. See instructions in *Chapter ② Installation* for adjusting the offset balance potentiometer for more information.

⑨ Turn off AC power, and turn DIP Switch#3, position 2, OFF.

⑩ Resolver alignment is now complete. You can resume normal operations.

While the drive is in alignment mode, it commutates current as follows:

❏ For 2–pole motors:	Current out of Phase B and into Phase C
❏ For 3–pole motors:	Two equal currents out of Phase B and C. Both currents into Phase A.

COMMUTATION TEST MODE

You can operate the APEX Drive in *commutation test mode* to troubleshoot problems. The drive ignores resolver or Hall effect input, and commutates the motor at one revolution per second. Motor current is proportional to command input voltage.

See *Chapter 5 Troubleshooting* for a full description of commutation test mode operations.

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CHAPTER FOUR

Hardware Reference

IN THIS CHAPTER

- ❏ APEX Drive Specifications
- ❏ Input/Output Pinouts and Circuit Diagrams
- ❏ Motor Specifications, Speed/Torque curves, and Dimensions

APEX Drive General Specifications

Input Power – L1/L2/L3

	APEX10	APEX20	APEX40
Voltage Range	85-252VAC (1-phase)	85 – 252VAC (1- or 3-phase)	85 – 252VAC (1- or 3-phase)
Frequency Range	47-66 Hz	47-66 Hz	47-66 Hz
Current (max. continuous)	10A (rms) at 120VAC 1-ph; 10A (rms) at 240VAC 1-ph;	8A (rms) 3-ph	15A (rms) 3-ph
Fuses	No internal fuses. Recommended external fuse: see *Chapter 2 Installation.*		
Isolation Transformer	Not required	Not required	Not required

Actual input power and current is a function of the motor's operating point (speed and torque) and the duty cycle. The numbers above reflect the servo motor and drive operating at rated speed and rated torque at 100% duty.

Input Power – Control L1/Control L2

	All APEX Drives
Voltage Range	85-252VAC (1-phase)
Frequency Range	47-66 Hz
Current (max. continuous)	1 amp
Power (max. continuous)	0.08 KVA
Fuses	3.0A 250VAC internal fuse. Not user replaceable.
Isolation Transformer	Not required

Output Power

		APEX10	APEX20	APEX40
Voltage	**(nominal)***	170 or 340VDC	340VDC	340VDC
	(maximum)	420VDC	420VDC	420VDC
Frequency	**(fundamental)**	0 – 400 Hz 15 KHz PWM	0 – 400 Hz 8 KHz PWM	0 – 400 Hz 8 KHz PWM
Current	**continuous (per phase)**	8A sinusoidal 5.66A rms	12A sinusoidal 8.50A rms	20A sinusoidal 14.14A rms
	peak (per phase)	16A sinusoidal 11.31A rms	24A sinusoidal 17.0A rms	40A sinusoidal 28.3A rms
Power (max. continuous)		2.35 KW	3.5 KW	5.9 KW

*"Nominal" is with 120VAC or 240VAC input. Output voltage depends on input voltage.
120VAC input --> 170VDC output
240VAC input --> 340VDC output

Weight of Drives

APEX10	APEX20	APEX40
9.5 lbs	16.5 lbs	21.5 lbs

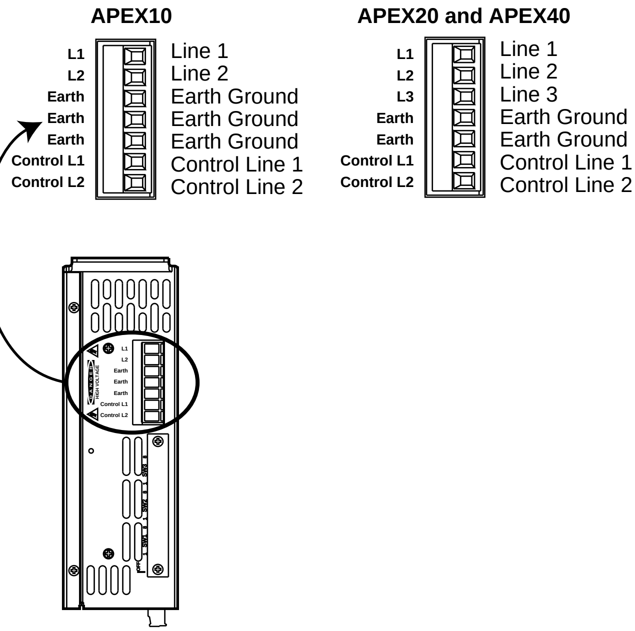
I/O PINOUTS & CIRCUIT DRAWINGS

This section is organized by connector. Pin outs and circuit drawings for all APEX Drive input and output connectors are shown in this section.

AC INPUT CONNECTOR AND MOTOR CONNECTOR

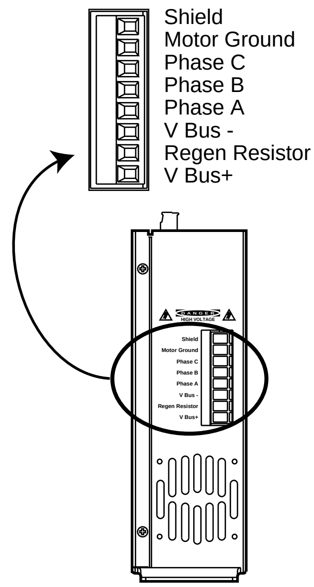
For illustration, the APEX10 Drive is shown below. The other APEX Drives are similar.

AC Input Connector
(Located on top of drive)



Mating Connector:
7 pin screw terminal connector
Compumotor P/N 43-013575-01

Motor Connector
(Located on bottom of drive)



Color Code – Motor Cable

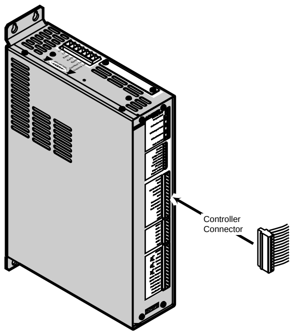
Connector Terminal	SM Cable Wire Color	NeoMetric Cable Wire Color
Phase A	Red/Yellow	Red/Yellow
Phase B	White/Yellow	White/Yellow
Phase C	Black/Yellow	Black/Yellow
Motor Ground	Green/Yellow	Green/Yellow

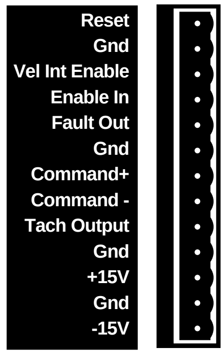
Mating Connector:
8 pin screw terminal connector
Compumotor P/N 43-014533-01

GROUNDING

Motor Ground and **Shield** (on the motor connector) are connected together internally, and are also connected internally to **Earth** on the AC Input connector, and to the chassis.

CONTROLLER CONNECTOR





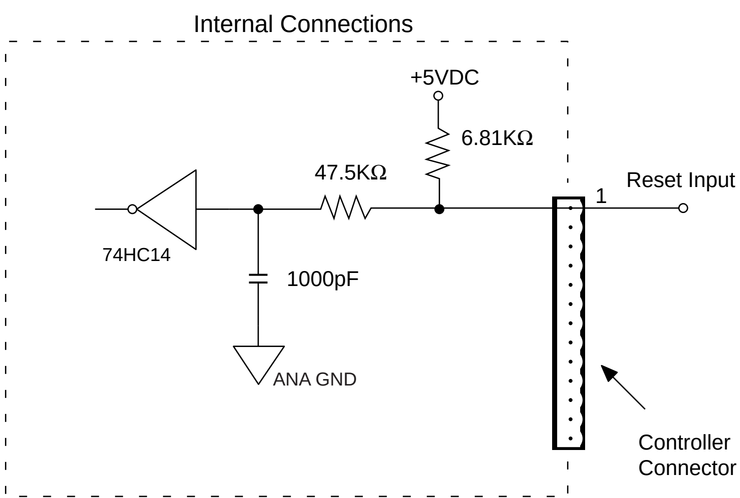
Controller Connector

Pin #:	Function:
1	Reset
2	Ground
3	Velocity Integrator Enable
4	Enable In
5	Fault Output
6	Ground
7	Command+
8	Command—
9	Tachometer Output
10	Ground
11	+15V
12	Ground
13	—15V

Mating Connector:
13 pin screw terminal connector
Compumotor P/N 43-013802-01

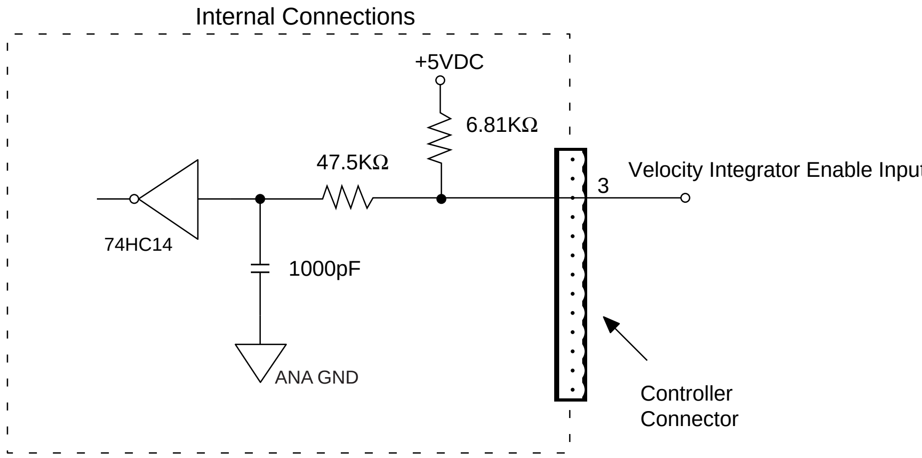
Schematic diagrams of each input and output on the controller connector are shown below.

RESET INPUT



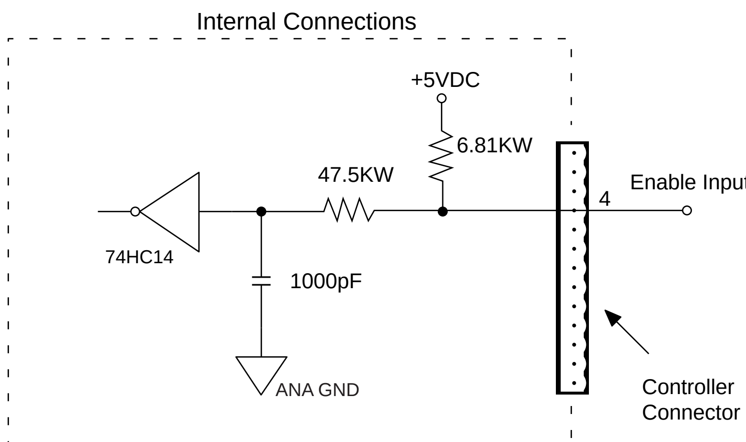
- ❏ *Active Low:* to reset drive, hold reset input at low voltage for at least 20 milliseconds.
- ❏ Voltage Low = 1.0V maximum
- ❏ Voltage High = 3.25V – 5.0V
- ❏ Reset will begin when input reset signal (a low voltage) is released.

VELOCITY INTEGRATOR ENABLE



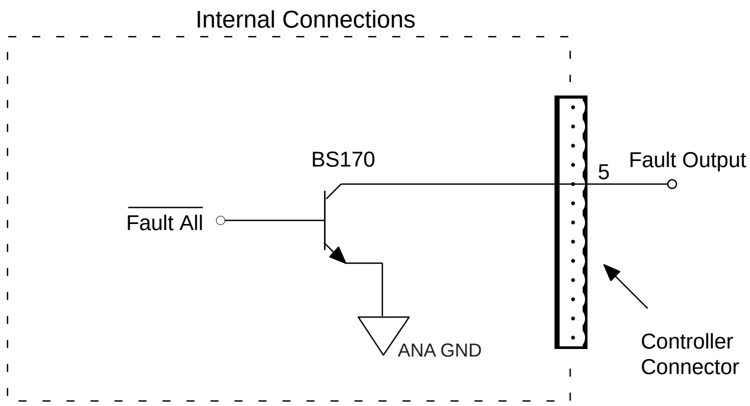
- ❏ *Active Low:* to enable the velocity integrator, hold input at low voltage
- ❏ Voltage Low = 1.0V maximum
- ❏ Voltage High = 3.25V – 5.0V
- ❏ DIP Switch #3, Position 1, must be ON

ENABLE INPUT



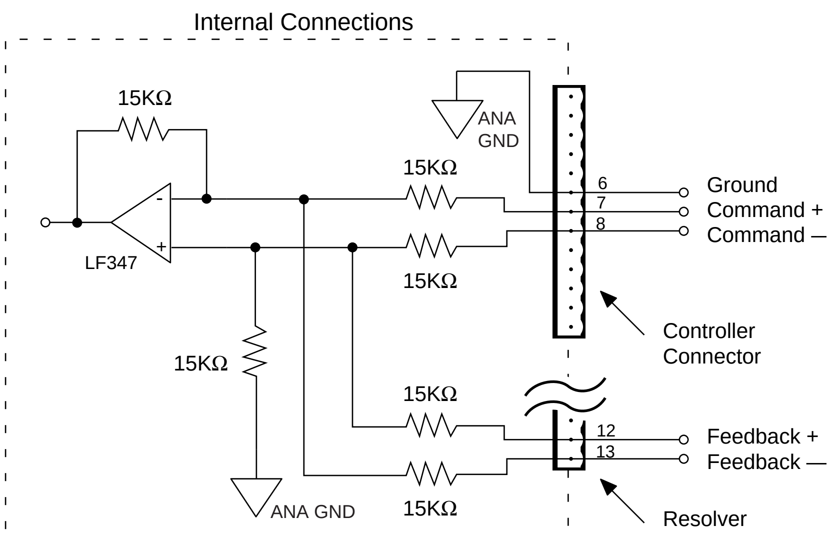
- ❏ *Active Low:* to enable the APEX Drive, hold Enable Input at low voltage
- ❏ Voltage Low = 1.0V maximum
- ❏ Voltage High = 3.25V – 5.0V

Fault Output



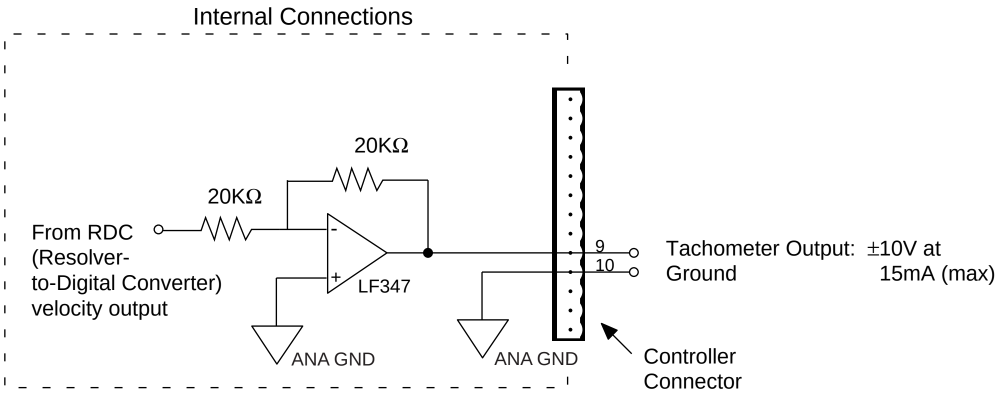
- ❑ Active *HIGH* — NO FAULT = Output will be low; FAULT = Output will float (go HIGH)
- ❑ Maximum Applied Voltage: 40VDC
- ❑ Maximum Current 200mA

Command±



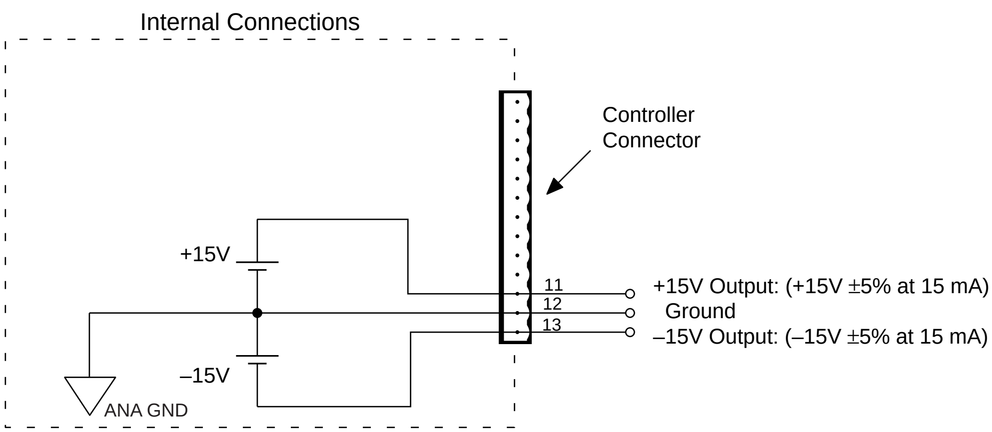
- ❑ Maximum Input Voltage: 15V
- ❑ Use DIP Switch #3, positions 6 & 7, to scale input

TACHOMETER OUTPUT

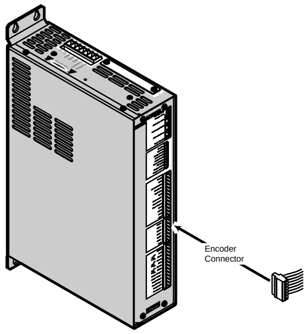


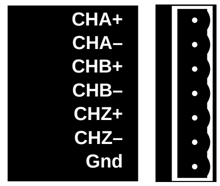
- ❑ Use DIP Switch #3, position 5, to scale output:
  - OFF = 1V/1000 rpm for one speed resolvers
  - ON = 1V/1000 rpm for two speed resolvers.

±15V OUTPUT



ENCODER CONNECTOR





Encoder Output		Hall Effect Input	
Pin #:	Function:	Pin #:	Function:
1	Channel A+	1	No Connect
2	Channel A–	2	No Connect
3	Channel B+	3	Hall +5VDC
4	Channel B–	4	Hall 1
5	Channel Z+	5	Hall 2
6	Channel Z–	6	Hall 3
7	Ground	7	Hall Ground

Mating Connector:
7 pin screw terminal connector
Compumotor P/N 43-013801-01

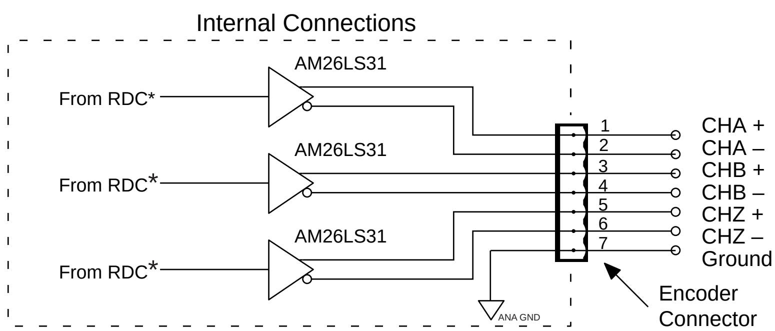
The encoder connector is a dual use connector. It can be used for either Encoder Output or for Hall Effect Input. Use DIP Switch #3, position 4, to select the desired function.

OFF = Encoder Output mode

ON = Hall Effect Input mode

Schematic diagrams of the Encoder Output circuit and of the Hall Effect Input circuit are shown below.

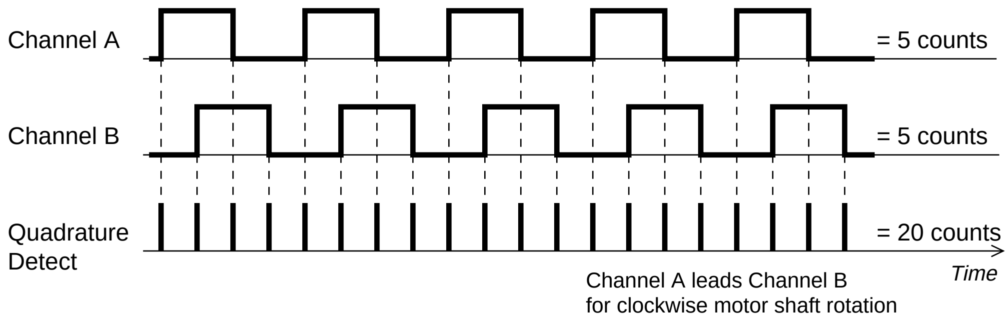
ENCODER – QUADRATURE OUTPUTS



*RDC = Resolver-to-Digital Converter

The APEX Drive's encoder outputs are pseudo-quadrature outputs. These quadrature outputs are called *pseudo* because they are derived from resolver information and not from an actual encoder. Resolution is 1024 counts per revolution (pre-quadrature), or 4096 counts per revolution (post-quadrature).

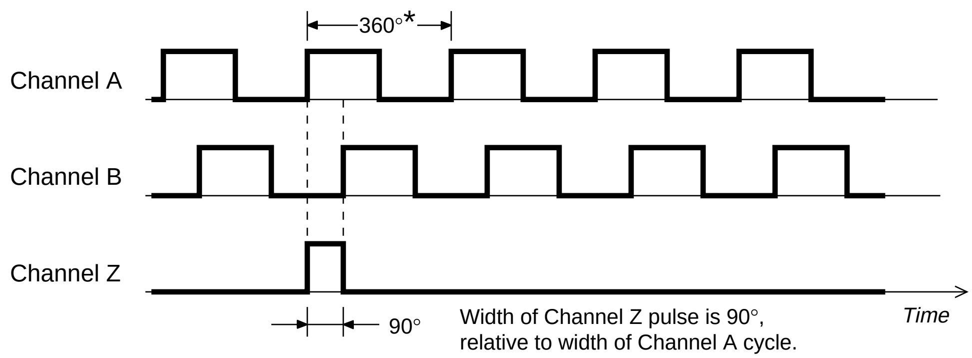
The position of the motor shaft can be determined by counting pulses. The APEX Drive has a *quadrature detect circuit* that enhances resolution. Channels A and B produce two square waves that are 90 electrical degrees apart. When the drive monitors the rising and falling edges of CHA and CHB, each pulse is equivalent to four counts. In this way, the 1024 counts are translated into 4096 counts, as the next figure shows.



The drive determines direction by comparing the phase shift of Channel A relative to Channel B. For example, if Channel A leads channel B, as shown in the previous drawing, the motor shaft is turning in a clockwise direction.

The quadrature outputs are differential (or complementary) outputs. When Channel A+ goes high, Channel A- goes low, and vice versa. Differential outputs increase the system's noise immunity.

The Z Channel, or marker, provides a reference pulse once per revolution. The Z channel outputs (CHZ+, CHZ–) are differential outputs.

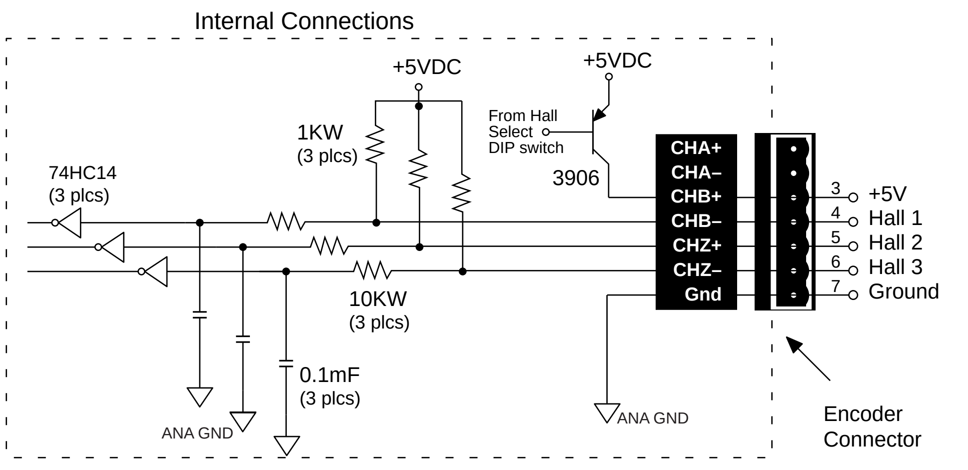


* One electrical revolution. 1024 electrical revolutions = 1revolution.

The width of the Z channel pulse, relative to the A channel cycle, is 90°.

Hall Effect Input

When DIP Switch #3, position 4, is in turned ON, the function of the encoder connector changes. The circuit below is connected (instead of the circuit shown on the previous page).



With this circuit active, you can use the connector for Hall effect sensor inputs. The APEX Drive uses the Hall sensor information to determine rotor position, so that it can commutate the motor correctly.

If you use a motor with Hall effect sensors rather than a resolver, connect the Hall cable to the APEX Drive's encoder connector according to the diagram above. Make sure that DIP Switch#3, position#4, is ON *BEFORE* you power up the drive.

Refer to the Resolver Connector section for resolver connections when the APEX drive is in Hall Effect Mode.

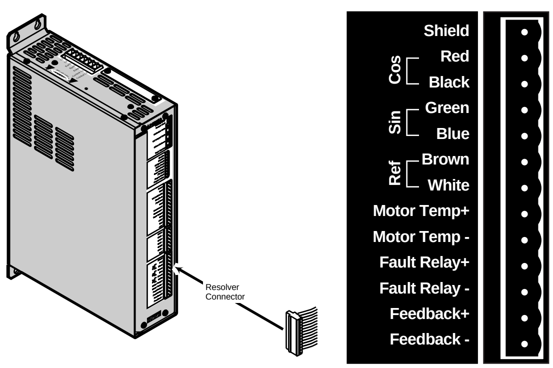
Any encoder connections on the motor will need to be connected to the controller in order to be used.

CAUTION

Turn the Hall Select DIP Switch ON before you apply AC power to the APEX Drive. Damage to system components may result from powering up the drive in resolver mode, with Hall effect motors attached.

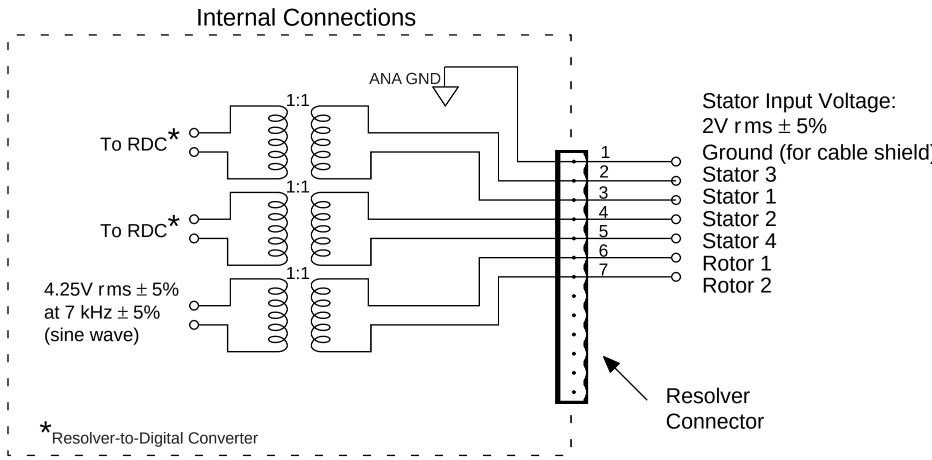
RESOLVER CONNECTOR

Schematic diagrams of each input and output on the resolver connector are shown below.



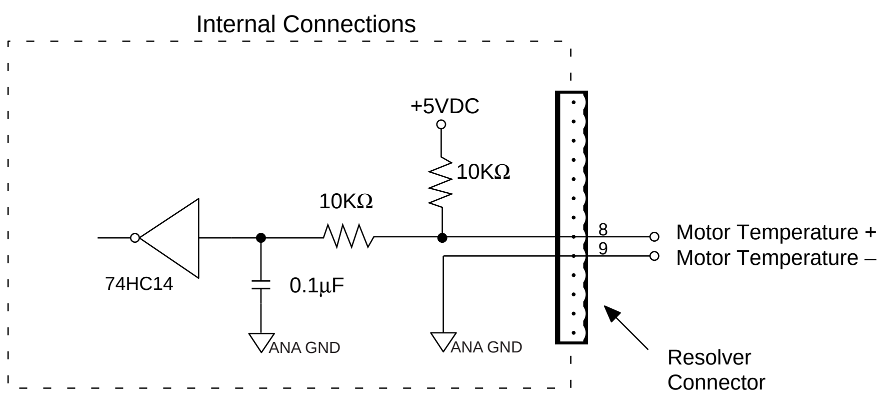
Function	SM Cable Color Code	NeoMetric Color Code
Shield	Uninsulated	Uninsulated
Stator 3	Red	Red
Stator 1	Black	Black
Stator 2	Green	Green
Stator 4	Blue	Blue
Rotor 1	Brown	Brown
Rotor 2	White	White
Motor Temp+	Yellow	Yellow
Motor Temp -	Yellow	Yellow
Fault Relay+		
Fault Relay -		
Feedback +		
Feedback -		

Mating Connector:
13 pin screw terminal connector
Compumotor P/N 43-013802-01



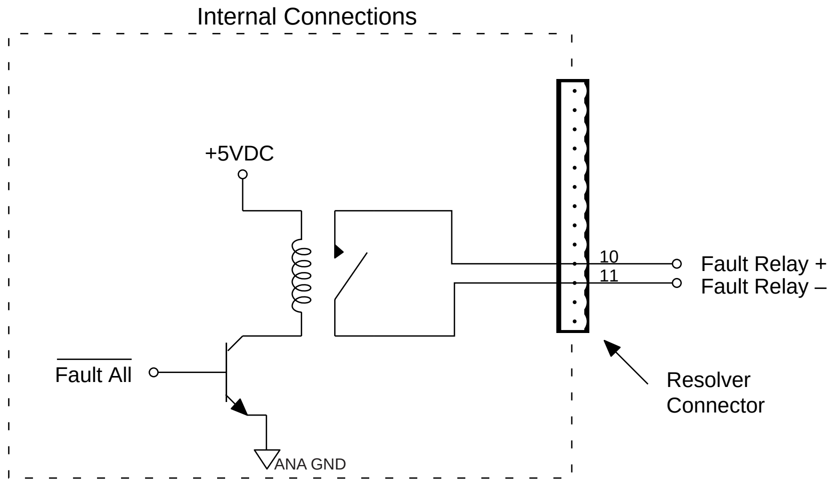
- ❏ DIP Switch #3, position 4, must be OFF so that:
  - Internal microprocessor uses resolver information for commutation
  - Encoder output will be enabled
  - Hall Effect input will be disabled
- ❏ **Shield** (on the resolver connector) is internally connected to all ground terminals (labeled **Gnd**) on the APEX Drive's front panel. These terminals are isolated from **Earth** and **Motor Ground**, and from the chassis.

MOTOR TEMP±



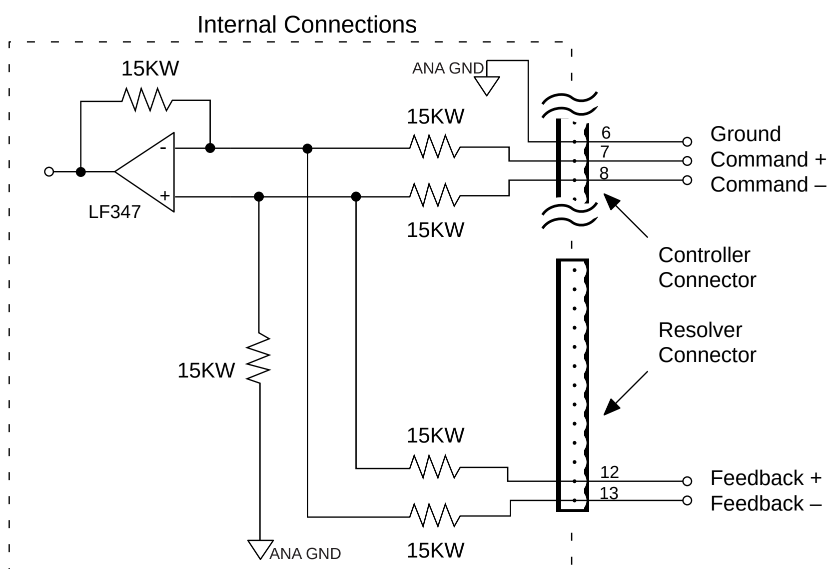
- ❏ Motor's temperature sensor should be *normally closed* (closed at low temperatures; opens at high temperatures.)
- ❏ Short together Motor Temp+ and Motor Temp- if motor does not have a temperature sensor.

FAULT RELAY ±



- ❑ Relay Type: Normally Open
  - Relay will be *OPEN* if drive is disabled, faulted, or power is off
  - Relay will be *CLOSED* when drive is enabled
- ❑ Maximum current rating: 5A at 24VDC, or 5A at 120VAC
- ❑ For more information, see *Motor Braking* in *Chapter 3 Special Features*

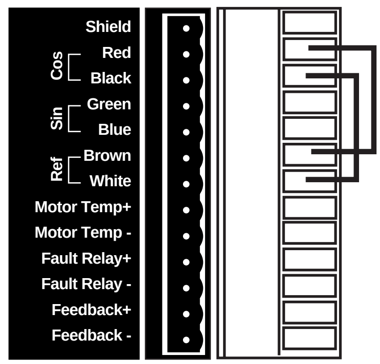
FEEDBACK ±



- ❑ Use for velocity mode operation

RESOLVER CONNECTOR JUMPERS WHEN IN HALL EFFECT MODE

When using the APEX615n in Hall effect mode, Compumotor recommends installing jumper wires on the resolver connector as shown below. Also use the SFB1 command in your start-up program to select an external encoder as your feedback source. Direct questions on this topic to the Compumotor Applications Department at the phone numbers provided on the inside front cover of this document.



Jumpers:
Red to Brown
Black to White

MOTOR SPECIFICATIONS

Speed/torque curves, motor specifications, and dimensions are shown on the following pages.

MOTOR BRAKES

Optional motor brakes are available. They are mounted directly behind the motor and are pre-assembled at the factory. When ordering the brake option, specify the motor type.

Brakes	**70mm or 34 frame**	**92mm**
Static rated torque	24 in-lb	72 in-lb
Coil voltage	24 VDC	24 VDC
Coil current	0.8 amps	0.52 amps
Weight	1.0 lbbs	2.51 lbs
Inertia	0.000038 lbs-in-sec2	0.00015 lb-in-sec2

MOTOR CABLES

SM and NeoMetric cables are available in 10, 25, and 35 foot lengths; APEX motor cables are available in 25, 50, and 100 foot lengths. You can also order custom cables of any length. Call Compumotor's Customer Service Department (800-722-2282). Cable lengths in excess of 100 feet are not recommended.

MOTOR DATA

The data sheets do not assume operation from an APEX drive. The torque specifications reflect the motor's capabilities. In most cases, the motor windings match the drive's output power with an additional safety margin.

POSITIONAL REPEATABILITY

Repeatability: ±0.088 degrees, unloaded

POSITIONAL ACCURACY

Resolver Accuracy: ±10 arc minutes

Resolver-to-Digital Converter Accuracy: ±10 arc minutes

RESOLUTION

Resolver: 4096 counts/rev

SELECTING DRIVE/MOTOR COMBINATIONS

We recommend selecting motors for use with APEX Drives as follows:

APEX10 Drive: SM-231A, SM-232A, SM-233B, N0701F, N0702E, N0703F, N0703G, N0704F, N0704G, N0921F, N0921G, N0922G

APEX20 Drive: N0703G, N0704G, N0921G, N0954G, N0922G, N0922J, N0923H

APEX40 Drive: APEX620, APEX630, APEX635, APEX640, N0922J, N0923H, N0923K, N0924J, N0924K

Resolution Resolver: 4096 counts/REV

SPEED/TORQUE CURVES

Speed/torque curves on these pages represent the available shaft torque at different operating speeds, under the following conditions:

SM and NeoMetric Motors:

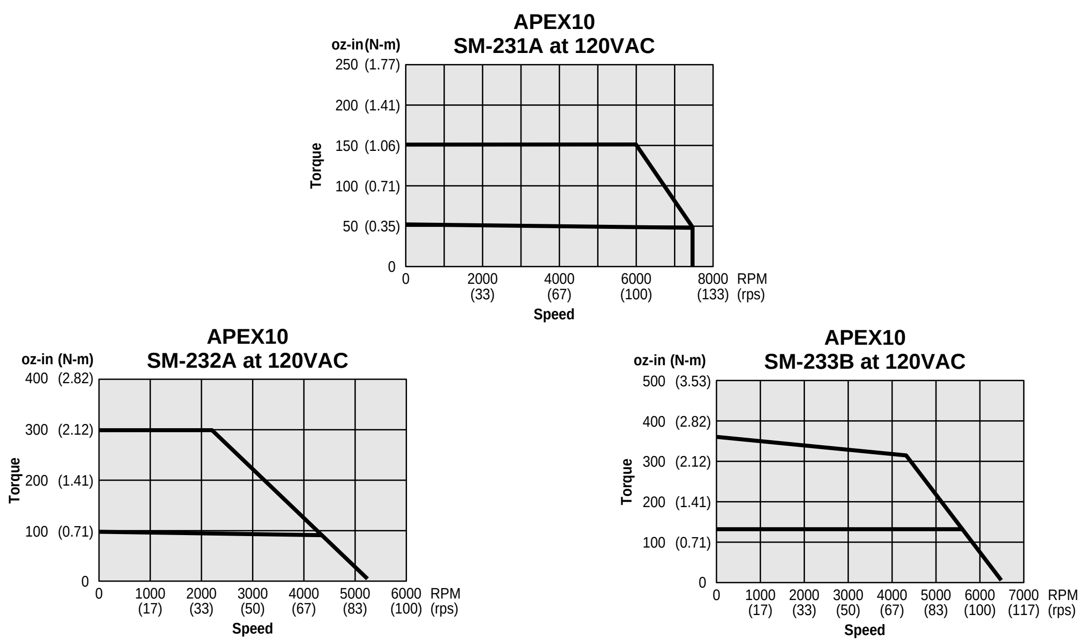
25° C (77°F) ambient temperature

Nominal torque constant K_t

Motor mounted to heatsink:

10" x 10" x 0.25" aluminum
(250 x 250 x 6.3 mm)

Motor torque may vary ±10% due to motor manufacturing variances.

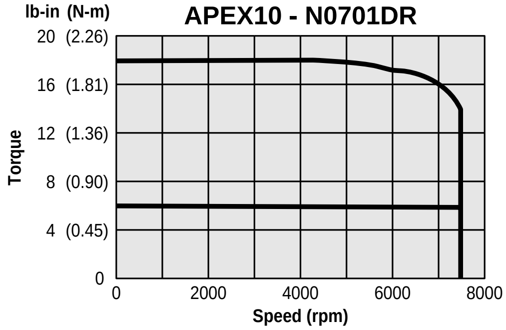


SM Series Motors – Speed Torque Curves

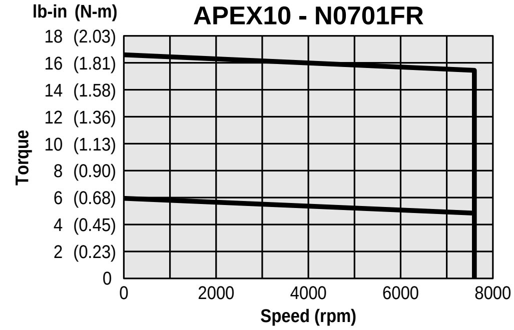
CAUTION

SM Series Servo Motors are optimized for operation with APEX Drives at 120VAC. Do not power the drive with 240VAC if you use an SM Motor.

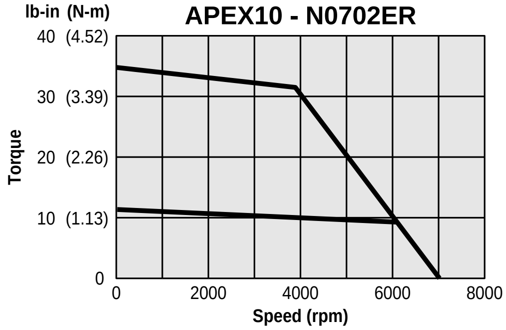
APEX10 - N0701DR



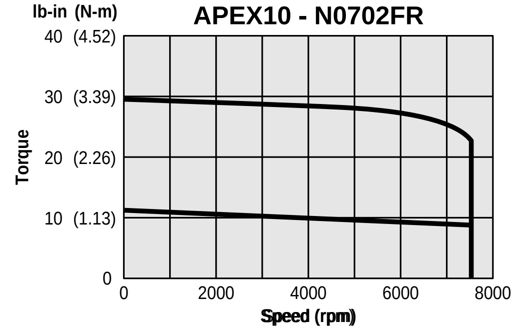
APEX10 - N0701FR



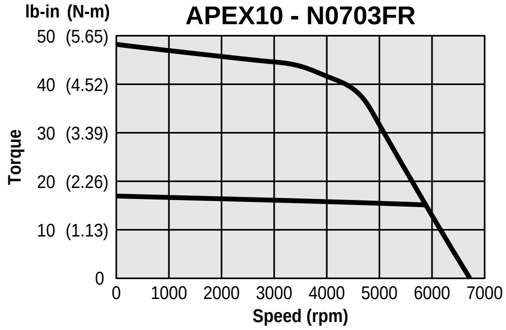
APEX10 - N0702ER



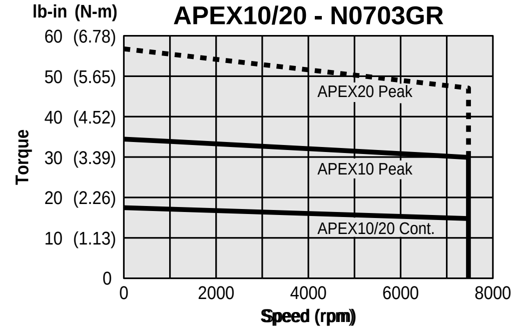
APEX10 - N0702FR



APEX10 - N0703FR



APEX10/20 - N0703GR



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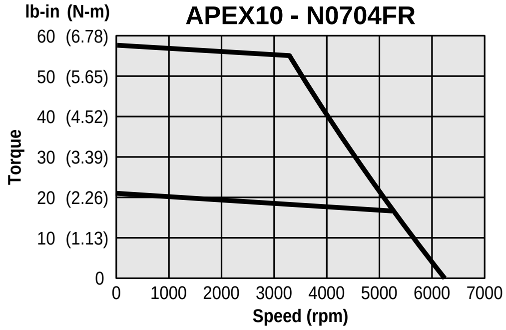

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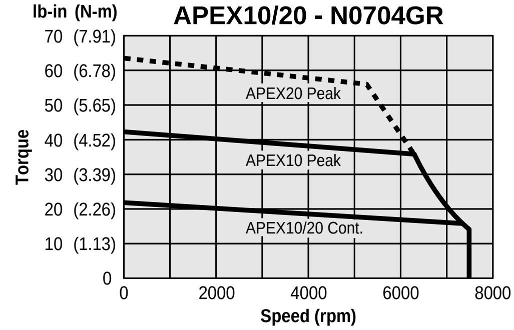
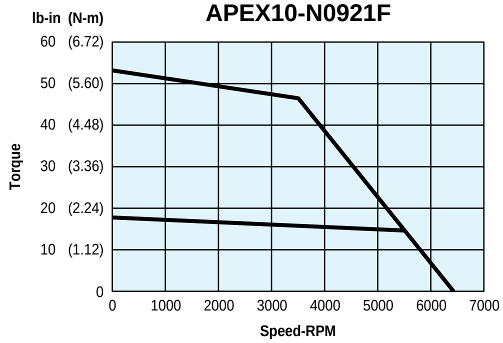
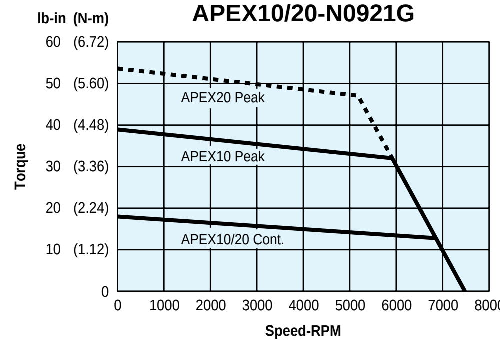


APEX10-N0921F



APEX10/20-N0921G



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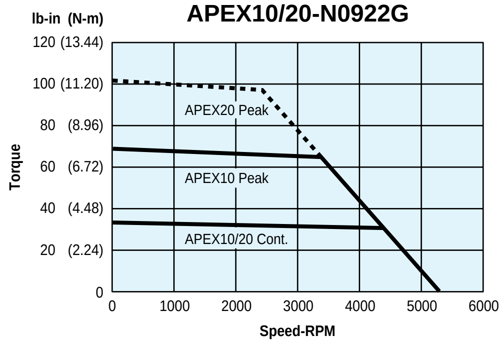
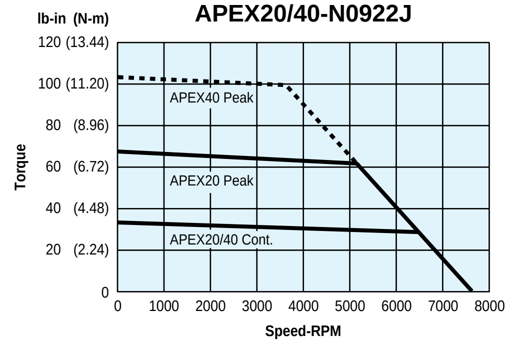


APEX20/40-N0922J



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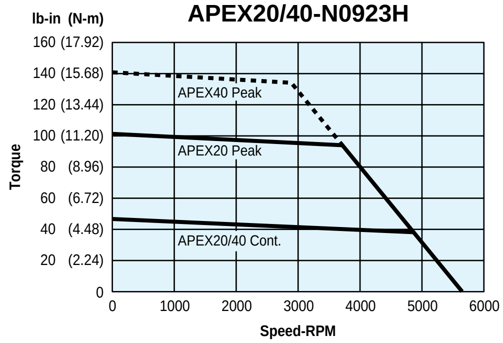
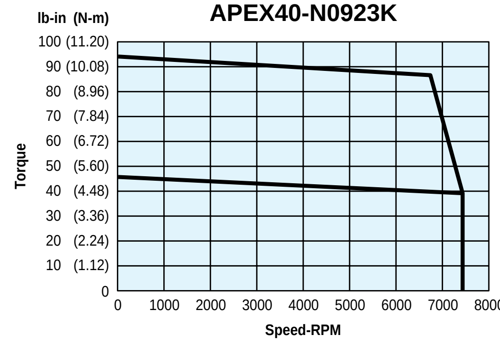


APEX40-N0923K



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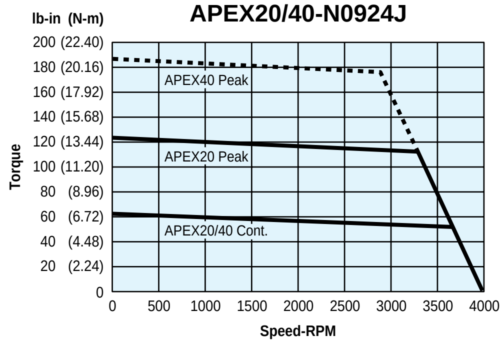

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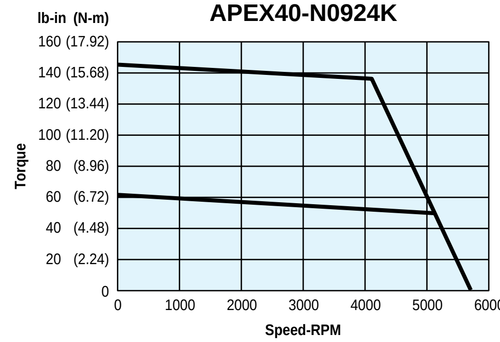

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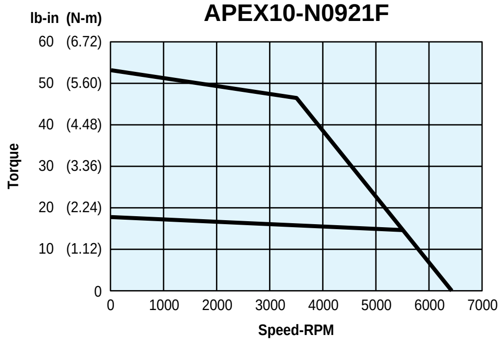
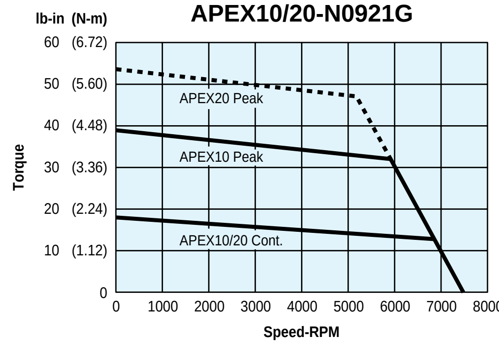
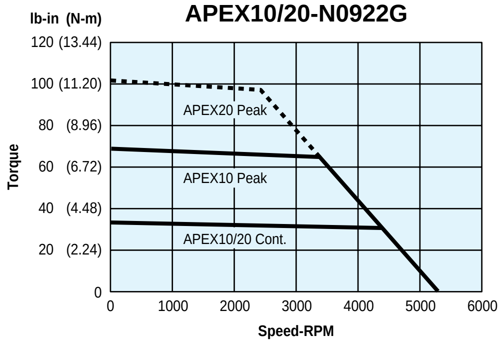


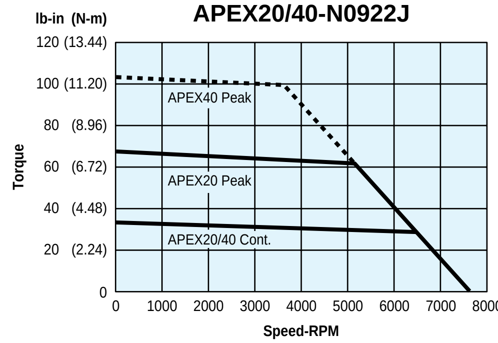
APEX10/20-N0921G



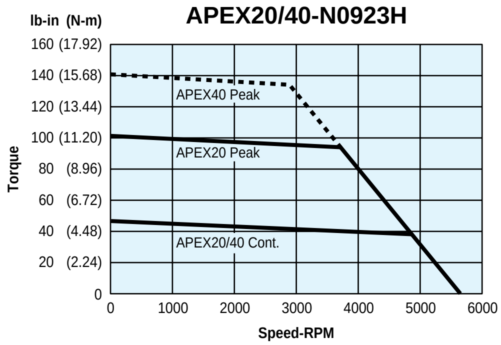
APEX10/20-N0922G



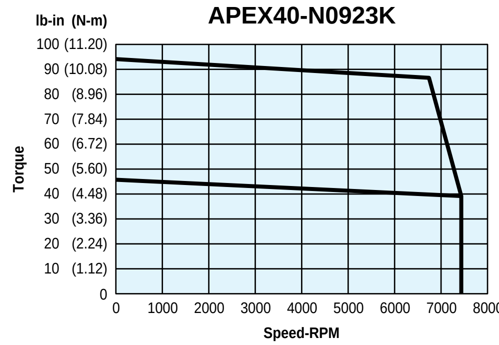
APEX20/40-N0922J



APEX20/40-N0923H



APEX40-N0923K



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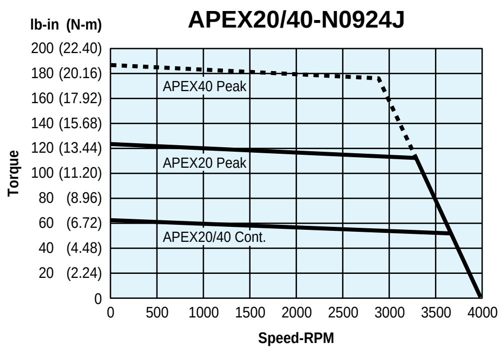
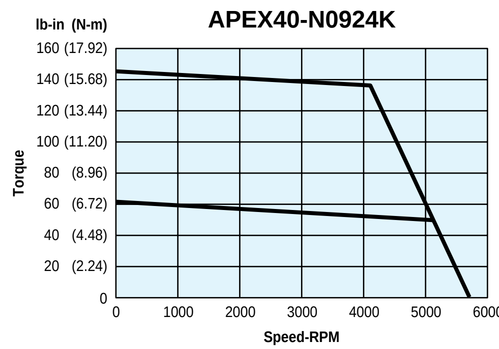
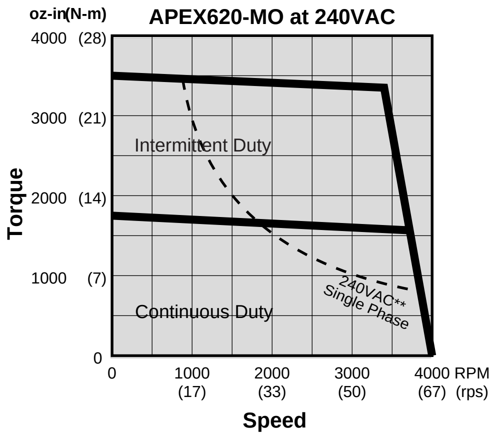
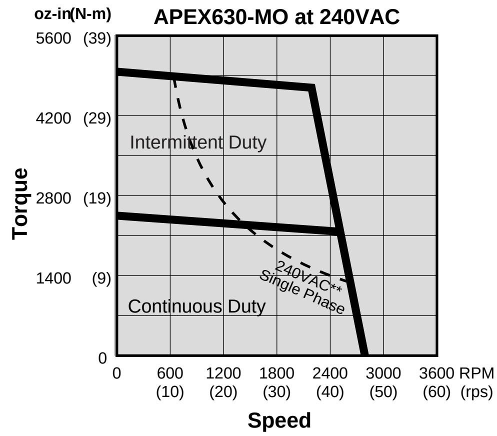
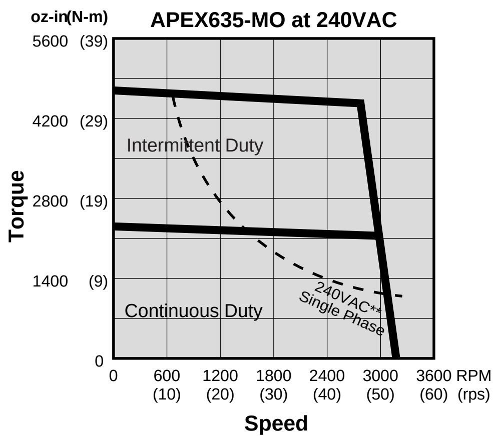


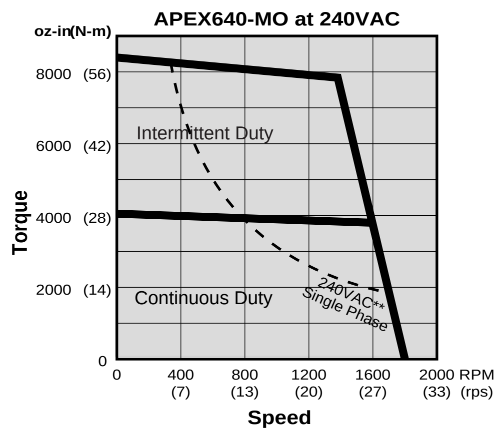
APEX40-N0924K











*240VAC single phase, 8A rms line current
**240VAC single phase, 20A rms line current

Motor Specifications – Compumotor SM Series Motors

The specifications table shows motor charactertistics. Torque specifications are with rated and peak current for the *motors*. Rated and peak current for the *drive* may be lower — thus, torque may be lower. Consult the specifications table for *motor* capabilities. Consult the speed/torque curves for APEX system capabilities.

Parameter	Symbol	Units	SM231AR	SM232AR	SM233BR
Stall Torque Continuous [1]	T_{CS}	lb-in	3.5	6.7	10.2
		oz. in.	56	107	163
		N-m	0.40	0.76	1.15
Continuous Stall Current[1]	I_{CS}	amperes-rms	2.0	2.0	3.9
Rated Speed	ω_r	rpm	7500	4250	6000
		rps	125	71	100
Peak Torque[1]	T_{pk}	lb-in	17.5	33.4	50.9
		oz. in.	280	535	815
		N-m	1.98	3.78	5.76
Peak Current, rms[1]	I_{pk}	amperes	10	10	19.5
Torque @ Rated Speed[1]	T_C	lb-in	2.8	6.0	9.0
		oz. in.	46	96	145
		N-m	0.32	0.68	1.02
Rated Power-Output Shaft[1]	Po	watts	250	302	643
		hp	0.34	0.40	0.86
Voltage Constant [3,4,6]	K_b	volts/radian/sec	0.161	0.310	0.242
Voltage Constant [3,4,6]	K_e	volts/KRPM	16.86	32.45	25.33
Torque Constant [3,4,6]	K_t	oz. in./amp rms	27.82	53.54	41.76
		NM/ amp rms	0.20	0.38	0.29
Resistance [1,3]	R	ohms	5.22	7.5	2.58
Inductance [5]	L	millihenries	1.64	2.9	1.06
Thermal Resistance[1]	R_{th}	°C/watt	2.23	1.58	1.26
Motor Constant	K_m	oz. in./√watt	9.57	15.99	21.25
		Nm/√watt	0.07	0.11	0.15
Viscous Damping	B	oz. in./Krpm	.565	.525	.459
		Nm/Krpm	3.86 x 10^{-3}	3.74 x 10^{-3}	3.24 x 10^{-3}
Torque - Static Friction	T_f	oz.in.	1.2	2.0	2.25
		Nm	8.47 x 10^{-3}	14.10 x 10^{-3}	15.90 x 10^{-3}
Thermal Time Constant	τ_{th}	minutes	30	35	40
Electrical Time Constant	τ_e	milliseconds	0.31	0.39	0.41
Mechanical Time Constant	τ_m	milliseconds	13.7	14.5	7.0
Rotor Inertia	J	lb.in.sec^2	0.00048	0.00084	0.00119
		kgm^2*1E-6	54.23	94.91	134.50
Weight	#	pounds	2.6	3.5	4.4
		kg	1.18	1.59	2.00
Winding Class			H	H	H

[1] @25°C ambient with 10 x 10 x 0.25 in. mounting plate, 150°C winding temperature. For 40°C ambient operation, reduce values by 12%.

[2] RMS current through a single phase of a sinusoidally driven motor

[3] ±10% line-to-line

[4] Peak value

[5] +/-30% line-to-line, inductance bridge measurement @ 1KHz

[6] Performance with AC sinusoidal amplifiers can be approximated by review of the amplifiers phase current specification, determining whether ratings are RMS or Peak values. For peak current values, multiply Kt by 0.86. If specified as RMS, multiply Kt by 1.22

All specifications are subject to engineering change

MOTOR SPECIFICATIONS – COMPUMOTOR 70MM (34FRAME) NEOMETRIC SERIES MOTORS

The specifications table shows motor charactertistics. Torque specifications are with rated and peak current for the *motors.* Rated and peak current for the *drive* may be lower — thus, torque may be lower. Consult the specifications table for *motor* capabilities. Consult the speed/torque curves for APEX system capabilities.

Parameter	Symbol	Units	N0701DR	N0701FR	N0702ER	N0702FR	N0703FR	N0703GR	N0704FR	N0704GR
Stall Torque Continuous [1,2]	T_{CS}	lb-in	6.40	6.40	11.90	11.90	18.00	18.00	22.20	22.20
		N-m	0.72	0.72	1.34	1.34	2.03	2.03	2.50	2.50
Continuous Stall Current[1]	I_{CS}	amperes-rms	2.65	4.14	3.05	4.24	4.17	5.79	4.30	5.96
Rated Speed	ω_r	rpm	7,500	7,500	6,480	7,500	5,800	7,500	4,900	7,000
		rps	125	125	108	125	98	125	82	117
Peak Torque[1]	T_{pk}	lb-in	19.20	19.20	35.60	35.60	54.00	54.00	66.60	66.60
		N-m	2.17	2.17	4.02	4.02	6.10	6.10	7.50	7.50
Peak Current, rms[1,6]	I_{pk}	amperes	7.90	12.40	9.10	12.70	12.50	17.40	12.90	17.90
Torque @ Rated Speed[1]	T_C	lb-in	5.80	5.80	9.40	10.40	14.50	15.40	17.50	17.50
		N-m	0.66	0.66	1.06	1.18	1.64	1.74	1.98	1.98
Rated Power-Output Shaft[1]	Po	watts	510	515	718	919	1,004	1,367	1,014	1,450
Voltage Constant [3,4]	K_b	volts/radian/sec	0.221	0.14	0.353	0.253	0.392	0.282	0.468	0.338
Voltage Constant [3,4]	K_e	volts/KRPM	23.11	14.67	36.97	26.52	40.99	29.54	49.02	35.36
Torque Constant [3,4]	K_t	lb-in/amp rms	2.43	1.55	3.89	2.80	4.32	3.11	5.17	3.73
Resistance [3]	R	ohms	5.52	2.27	5.22	2.70	3.36	1.74	3.47	1.80
Inductance [3]	L	millihenries	12.98	5.23	15.86	8.16	12.13	6.30	14.50	7.55
Thermal Resistance[1]	R_{th}	°C/watt	1.44	1.44	1.15	1.15	0.96	0.96	0.87	0.87
Motor Constant	K_m	lb-in/√watt	0.83	1.03	1.70	1.70	2.36	2.36	2.77	2.78
Viscous Damping	B	lb-in/Krpm	0.0438	0.0438	0.050	0.050	0.0563	0.0563	0.0625	0.0625
Torque - Static Friction	T_f	oz.in.	1.40	2.10	2.10	2.80	2.80	2.80	3.50	3.50
Thermal Time Constant [7]	τ_{th}	minutes	45	45	45	45	45	45	45	45
Electrical Time Constant	τ_e	milliseconds	2.35	2.35	3.03	3.03	3.61	3.61	4.19	4.19
Mechanical Time Constant	τ_m	milliseconds	1.60	1.60	0.88	0.88	0.62	0.62	0.56	0.56
Rotor Inertia	J	lb.in.sec²	0.000128	0.000128	0.000196	0.000196	0.000262	0.000262	0.000329	0.000329
Weight	#	pounds	3.54	3.54	4.53	4.53	6.04	6.04	7.28	7.28
Winding Class			H	H	H	H	H	H	H	H

[1] @25°C ambient with 10 x 10 x 0.25 in. mounting plate, 150°C winding temperature. For 40°C ambient operation, reduce values by 12%

[2] RMS current through a single phase of a sinusoidally driven motor

[3] ±10%, line-to-line, inductance bridge measurement method @ 1 kHz

[4] Peak value

[5] +/-30% line-t0-line, inductance bridge measurement @ 1KHz

[6] Peak current for 2 seconds maximum with initial winding temperature of 40° C.

[7] Per NEMA specifications. For I^2t considerations, use 10 minutes.

All specifications are subject to engineering change

MOTOR SPECIFICATIONS – COMPUMOTOR 92MM NEOMETRIC SERIES MOTORS

The specifications table shows motor charactertistics. Torque specifications are with rated and peak current for the *motors*. Rated and peak current for the *drive* may be lower — thus, torque may be lower. Consult the specifications table for *motor* capabilities. Consult the speed/torque curves for APEX system capabilities.

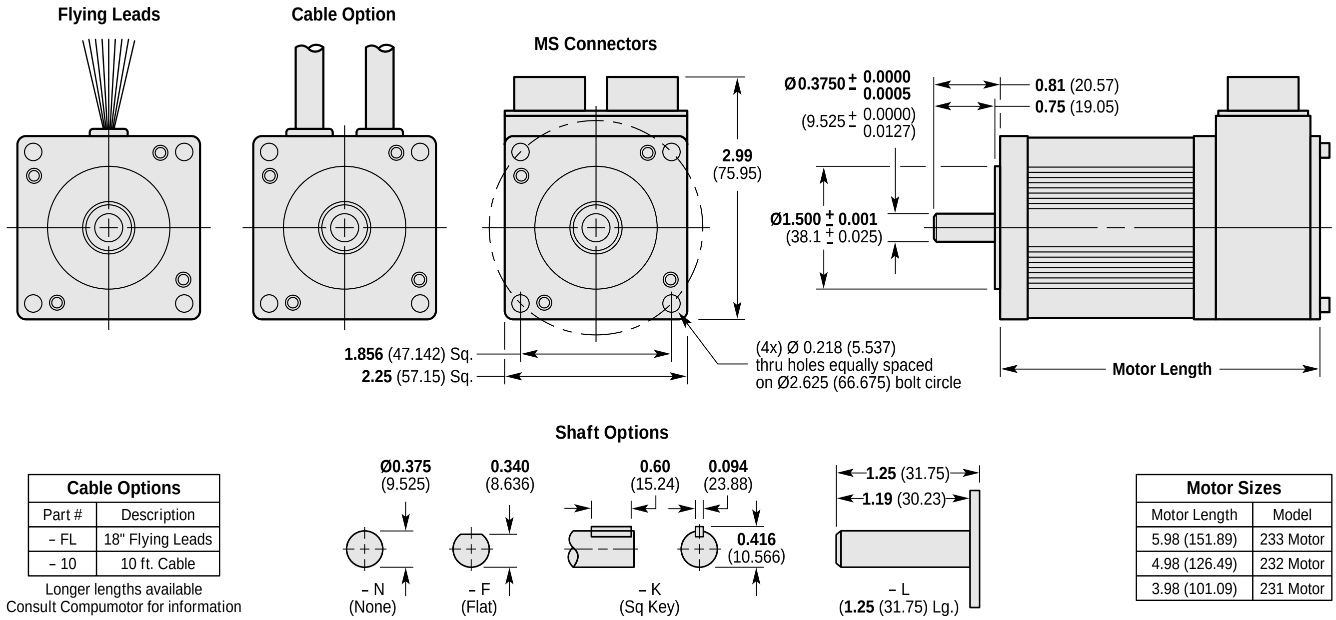
Parameter	Symbol	Units	N0921F	N0921G	N0922G	N0922J	N0923H	N0923K	N0924J	N0924K
Stall Torque Continuous [1,4]	T_{CS}	lb-in	17.7	17.7	34.3	34.3	46.6	46.6	62.5	62.5
		N-m	2.0	2.0	3.88	3.88	5.26	5.26	7.06	7.06
Continuous Stall Current[1,2]	I_{CS}	amperes-rms	3.77	5.22	5.6	8.67	7.89	13.85	8.64	12.07
Rated Speed	ω_r	rpm	5,700	7,500	4.375	6,975	4,350	7,500	3,325	4,825
		rps	95	125	72.9	116.2	72.5	125	55.4	80.4
Peak Torque[1]	T_{pk}	lb-in	53	53	103	103	140	140	188	188
		N-m	5.99	5.99	11.6	11.6	15.8	15.8	21.2	21.2
Peak Current, rms[1,6]	I_{pk}	amperes	11.3	15.7	16.8	26	23.7	41.6	25.9	36.2
Torque @ Rated Speed[1]	T_C	lb-in	14.0	14.7	27.0	27.0	36.2	36.3	49	47.7
		N-m	1.58	1.66	3.05	3.05	4.09	4.1	5.5	5.39
Rated Power-Output Shaft[1]	Po	watts	946	1,305	1,397	2,231	1,864	3,222	1,930	2,731
Voltage Constant [3,4]	K_b	volts/radian/sec	0.427	0.309	0.556	0.360	0.540	0.305	0.657	0.470
Voltage Constant [3,4]	K_e	volts/KRPM	44.66	32.27	58.18	37.69	56.54	31.96	68.83	49.17
Torque Constant [3,4]	K_t	lb-in/amp rms	4.71	3.41	6.13	3.97	5.96	3.37	7.25	5.18
Resistance [3]	R	ohms	3.72	1.94	2.32	0.96	1.28	0.42	1.22	0.62
Inductance [3]	L	millihenries	17.11	8.99	14.72	6.18	14.95	4.78	20.60	10.51
Thermal Resistance[1]	R_{th}	°C/watt	1.06	1.06	0.77	0.77	0.70	0.70	0.62	0.62
Motor Constant	K_m	lb-in/√watt	1.96	2.45	4.03	4.04	5.26	5.22	6.58	6.57
Viscous Damping	B	lb-in/Krpm	0.075	0.075	0.087	0.087	0.100	0.100	0.1125	0.1125
Torque - Static Friction	T_f	oz.in.	4	4	6	6	8	8	10	10
Thermal Time Constant [7]	τ_{th}	minutes	60	60	60	60	60	60	60	60
Electrical Time Constant	τ_e	milliseconds	4.6	4.6	6.4	6.4	11.5	11.5	16.9	16.9
Mechanical Time Constant	τ_m	milliseconds	1.13	1.13	0.64	0.64	0.5	0.5	0.41	0.41
Rotor Inertia	J	$lb.in.sec^2$	0.000532	0.000532	0.000792	0.000792	0.00106	0.00106	0.00132	0.00132
Weight	#	pounds	8.1	8.1	11.7	11.7	15.1	15.1	18.0	18.0
Winding Class			H	H	H	H	H	H	H	H

[1] @25°C ambient with 10 x 10 x 0.25 in. mounting plate, 150°C winding temperature.
[2] RMS current through a single phase of a sinusoidally driven motor
[3] ±10% line-to-line
[4] Peak value
[5] +/-30% line-to-line, inductance bridge measurement @ 1KHz
[6] Peak current for 2 seconds maximum with initial winding temperature of 40° C.
All specifications are subject to engineering change

SM and NeoMetric Motor Resolver Specifications

Parameter	Value
Input voltage @ 7000 Hz	4.25 volts
Input current, max.	55 ma
Input power, nominal	0.12 watts
Impedance ZSO (@90∞)	58+j145 ohms
Impedance ZRO	53 +j72 ohms
Impedance ZRS	42 +j55 ohms
Transformation ratio	0.470 ±5%
Output voltage	2.0 ±5% volts
D.C. rotor resistance	23 ±10% ohms
D.C. stator resistance	19 ±10% ohms
Sensitivity	35mV/Degree
Max. Error from EZ	±10 minutes
Phase shift, open circuit	5∞ leading ±3"
Null voltage (total)	20 mV rms
Impedance ZSS	50 +j128 ohms
Inertia	included in motor specification

DIMENSIONS — SM231, SM232, SM233



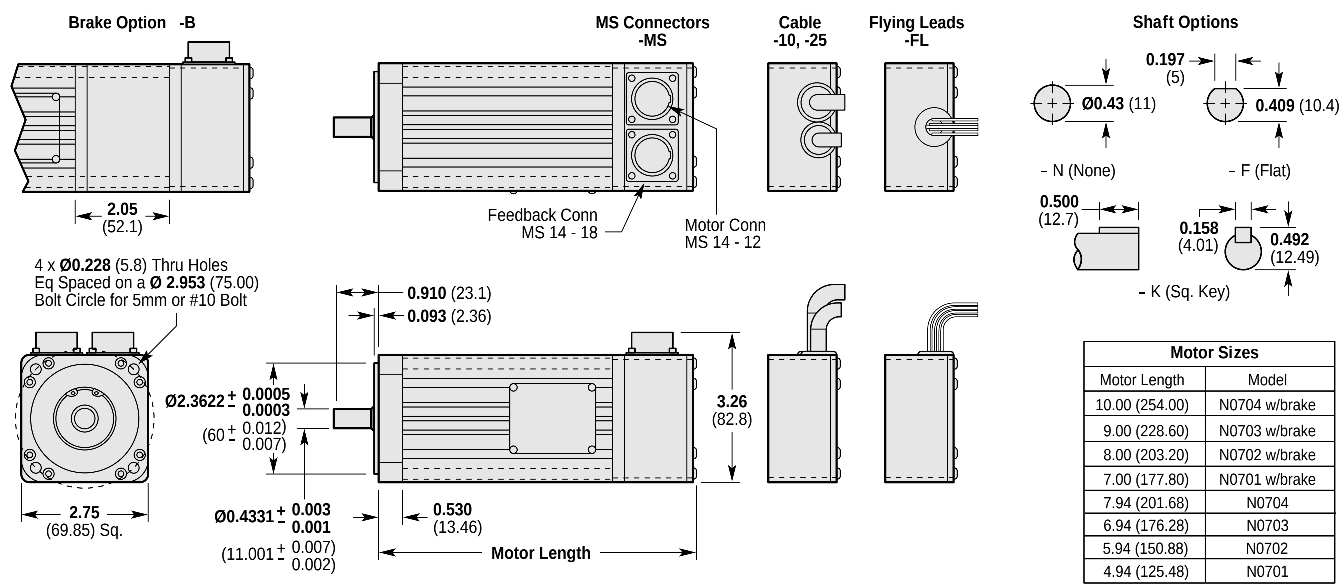
Cable Options	
Part #	Description
– FL	18" Flying Leads
– 10	10 ft. Cable

Longer lengths available
Consult Compumotor for information

Motor Sizes	
Motor Length	Model
5.98 (151.89)	233 Motor
4.98 (126.49)	232 Motor
3.98 (101.09)	231 Motor

SM231, SM232 & SM233 Motor Dimensions

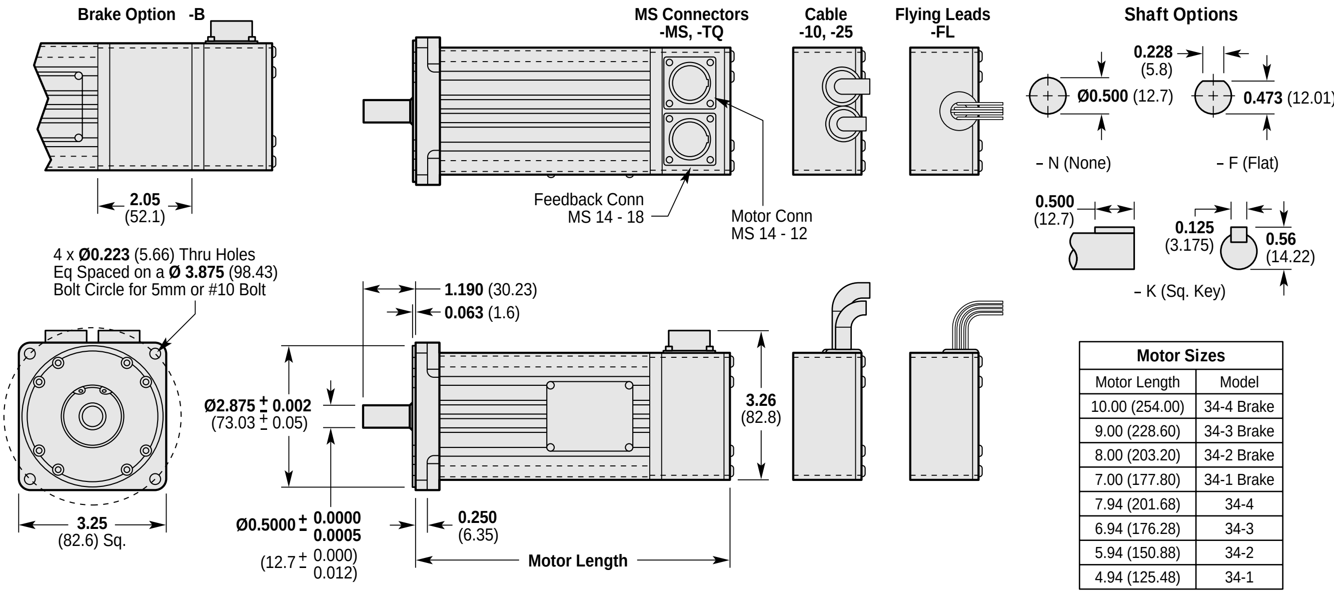
DIMENSIONS — NEOMETRIC 70MM



Motor Sizes	
Motor Length	Model
10.00 (254.00)	N0704 w/brake
9.00 (228.60)	N0703 w/brake
8.00 (203.20)	N0702 w/brake
7.00 (177.80)	N0701 w/brake
7.94 (201.68)	N0704
6.94 (176.28)	N0703
5.94 (150.88)	N0702
4.94 (125.48)	N0701

NeoMetric 70mm Motor Dimensions

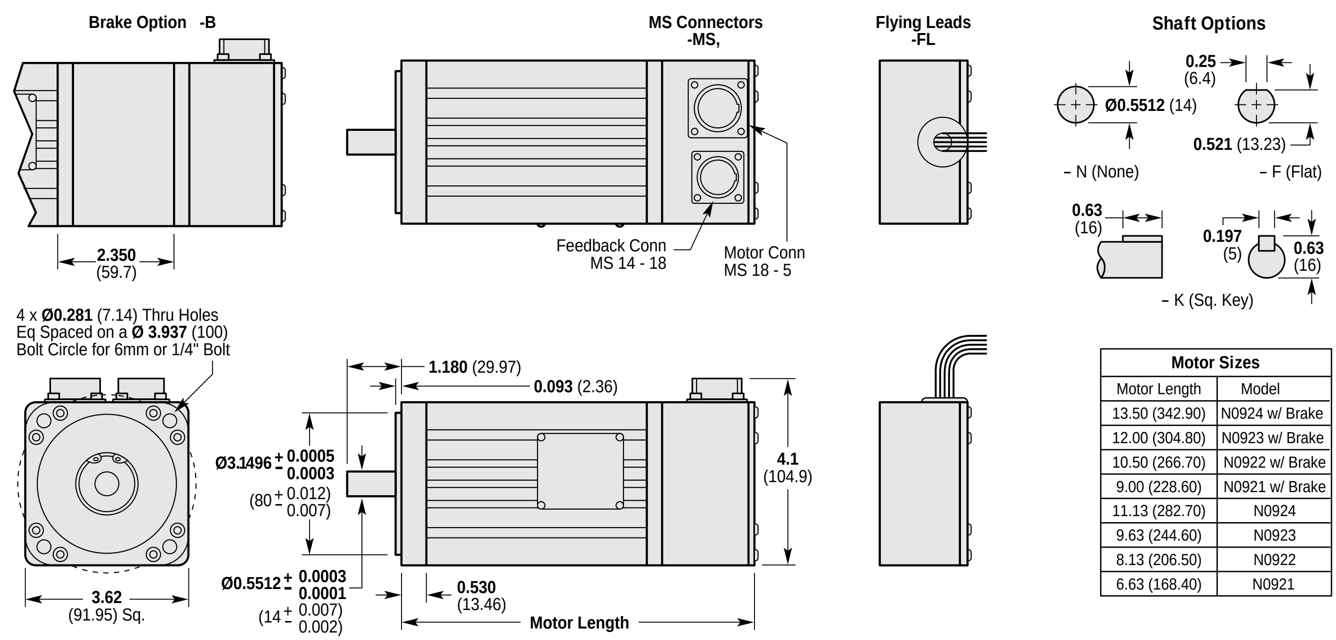
DIMENSIONS — NEOMETRIC 34



Motor Sizes	
Motor Length	Model
10.00 (254.00)	34-4 Brake
9.00 (228.60)	34-3 Brake
8.00 (203.20)	34-2 Brake
7.00 (177.80)	34-1 Brake
7.94 (201.68)	34-4
6.94 (176.28)	34-3
5.94 (150.88)	34-2
4.94 (125.48)	34-1

NeoMetric 34 Motor Dimensions

DIMENSIONS — NEOMETRIC 92MM



Motor Sizes	
Motor Length	Model
13.50 (342.90)	N0924 w/ Brake
12.00 (304.80)	N0923 w/ Brake
10.50 (266.70)	N0922 w/ Brake
9.00 (228.60)	N0921 w/ Brake
11.13 (282.70)	N0924
9.63 (244.60)	N0923
8.13 (206.50)	N0922
6.63 (168.40)	N0921

NeoMetric 92mm Motor Dimensions

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CHAPTER FIVE

Troubleshooting

IN THIS CHAPTER

- ❏ The information in this chapter will enable you to isolate and resolve system hardware problems.

TROUBLESHOOTING PROCEDURE

When your system does not function properly (or as you expect it to operate), the first thing that you must do is identify and isolate the problem. When you have accomplished this, you can effectively begin to resolve the problem.

The first step is to isolate each system component and ensure that each component functions properly when it is run independently. You may have to dismantle your system and put it back together piece by piece to detect the problem. If you have additional units available, you may want to exchange them with existing components in your system to help identify the source of the problem.

Determine if the problem is mechanical, electrical, or software-related. Can you repeat or recreate the problem? Do not attempt to make quick rationalizations about problems. Random events may appear to be related, but they are not necessarily contributing factors to your problem. You must carefully investigate and decipher the events that occur before the subsequent system problem.

You may be experiencing more than one problem. You must isolate and solve one problem at a time. Log (document) all testing and problem isolation procedures. You may need to review and consult these notes later. This will also prevent you from duplicating your testing efforts.

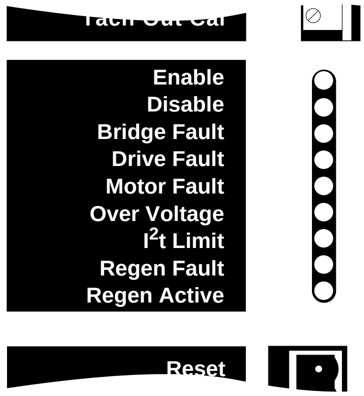
If you are having difficulty isolating a problem be sure to document all occurrences of the problem along with as much specific information, such as time of occurrence, APEX status, and anything else that was happening when the problem occurred.

Once you have isolated a problem, take the necessary steps to resolve it. Refer to the problem solutions contained in this chapter. If your system's problem persist, contact Parker Compumotor's Applications Department at the phone number provided on the inside front cover of this document.

DIAGNOSTIC LEDS

The APEX Drive has a bank of nine light emitting diodes (LEDs) on its front panel. Use these LEDs to isolate and identify problems.

The LED portion of the front panel is shown below. The **Enable** LED, when illuminated, is green. All other LEDs are red when illuminated.



If a problem arises, first check the LEDs for an indication of the problem's origin. The next table explains situations that can illuminate each LED. Also see *Recovering From Faults* in the next section.

LED	Description	Latched (yes/no)	How to reset the fault
Enable	Indicates drive is enabled	no	n/a
Disable	Indicates drive is disabled	no	see Note 1 and Note 2
Bridge Fault	Power stage overtemperature Power stage overcurrent Motor short circuit	yes yes yes	Note 1 Note 1 Note 1
Drive Fault	Control board overtemperature Undervoltage (brownout)	yes yes	Note 1 Note 2
Motor Fault	Resolver not connected Motor overtemperature Motor thermostat not connected	yes yes yes	Note 1 Note 1 Note 1
Over Voltage Fault	Bus voltage exceeded 420VDC	yes	Note 1
I^2T Limit	I^2T limit. Drive is in foldback. Output is limited to continuous current setting.	no	Note 3
Regen Fault	Excessive regeneration (external regeneration resistor may be required)	yes	Note 1
Regen Active	Regeneration circuit active (regeneration resistor is turned on, and dissipating excess power)	no	Note 3

Note 1: Activate **Reset** input on the controller connector (hold the input at a low voltage—less than 1.0V—for at least 20 milliseconds; reset begins upon release of the low voltage); or cycle power on Control L1/L2.

Note 2: When the bus voltage drops below 85VAC the **Drive Fault** LED will latch, indicating an undervoltage condition. When the bus voltage has recovered there are three ways to clear the drive fault: (1) issue a reset via the **RESET** input, (2) cycle power on **Control L1/L2**. (3) toggle the **Enable In** input.

Note 3: These conditions are not latched. Drive will recover on its own when foldback or regen event is over.

Recovering From Faults

Fault conditions will shut down the APEX Drive's current output to the motor. Before trying to restart your system, you should first solve the problem that caused the fault. For example, if a short circuit in a motor cable caused a bridge fault, the same fault will probably occur when you restart the drive—unless you first fix the problem.

Most of the fault conditions are *latched*. This means that after the problem is fixed, the drive will not start up again on its own. You must first reset the drive, or cycle power.

To *reset* the APEX Drive, send a reset signal to the APEX's **Reset** input. A reset signal is a low voltage—less than 1.0V. You can ground the input, or hold it at a low voltage, for at least 20 milliseconds. Reset begins upon release of the low voltage.

To *cycle power*, turn off AC power to the APEX Drive, then turn the power back on. If **L1/L2(/L3)** has a separate power input from **Control L1/L2**, you can cycle power by doing either of the following:

- ❑ Turn off AC power *only* to **Control L1/L2**
- ❑ Turn off AC power to *both* **Control L1/L2** *and* **L1/L2(/L3)**

Turning off AC power only to **L1/L2(/L3)** will not clear all fault conditions. Even if you corrected the original fault, cycling power on **L1/L2(/L3)** will result in a latched undervoltage fault. You would then need to cycle power on **Control L1/L2** to clear the undervoltage fault.

Recovery procedures for each fault condition are listed below.

Bridge Fault
Drive Fault
Motor Fault
Over Voltage
Regen Fault

For each of these faults, the APEX Drive's output current to the motor will be *latched off*.

To recover from these fault conditions, do either of the following:

- ❑ Reset the APEX Drive; or
- ❑ Cycle Power

To recover from a **Drive Fault** caused by an undervoltage, you can use either of the above methods; or, you can toggle the enable input after the voltage has recovered.

I^2T Limit

This condition is ***not latched***. It indicates that the APEX Drive is in current foldback, with its output current limited to the continuous current level. The drive may recover on its own, if the level of continuous current is low enough to permit the motor to cool.

Under some conditions, the drive may not recover on its own—it may stay in current foldback. To recover, turn off AC power to the drive, then wait for the motor to cool before you resume operations.

Do not use the **Reset** input to clear the fault. If you do so, the protective circuit loses all information about motor temperature. It assumes the motor operates from a cold start, and it may not protect the motor from overheating if the motor is hot when you reset the drive.

When an **I^2T Limit** occurs, it indicates that something is wrong with your system—a mechanical jam, the motor is undersized, the move is too aggressive for the motor, etc. You should solve the problem that caused the **I^2T Limit**.

The motor has less torque during an **I^2T Limit**. If you configure your controller to detect position errors, then an **I^2T Limit** will probably cause a position error fault in your controller.

Regen Active

This is not a fault condition. When the LED turns on, it indicates that the internal regeneration resistor is dissipating excess regenerated power. The LED will turn off when the resistor stops dissipating power.

Commutation Test Mode

You can operate the APEX Drive in *commutation test mode* to help identify and isolate problems. When it runs in commutation test mode, the APEX Drive does not use any motor feedback information for commutation. It ignores the resolver or the Hall effect sensor input, and commutates the motor in an open loop fashion at one revolution per second. The current it sends to the motor will be proportional to the command input voltage.

You can use commutation test mode to verify that your APEX Drive is commutating properly, and that the motor phases are wired correctly.

To operate in commutation test mode:

① Turn off AC power to the APEX Drive.

② Turn DIP Switch#3, Position#3, ON.

③ Turn on AC power to the APEX Drive.

④ Slowly increase the command input voltage until the motor starts to turn.

⑤ The APEX Drive should begin commutating the motor clockwise at the following speeds:

- 1 rps (for 2-pole motors)
- 2/3 rps (for 3-pole motors)

⑥ Depending upon your application, you may need to remove the load from the motor, or adjust command input to get adequate motor current. (Current will be scaled as set with DIP Switch#3, positions 6 & 7.)

RETURNING THE APEX DRIVE

If you must return your APEX system for repairs or upgrades, use the following steps:

① Get the serial number and the model number of the defective unit, and a purchase order number to cover repair costs in the event the unit is determined to be out of warranty.

② Before you return the unit, have someone from your organization with a technical understanding of the APEX Drive and its application include answers to the following questions:

- ❏ What is the extent of the failure/reason for return?
- ❏ How long did it operate?
- ❏ Did any other items fail at the same time?
- ❏ What was happening when the unit failed (e.g., installing the unit, cycling power, starting other equipment, etc.)?
- ❏ How was the product configured (in detail)?
- ❏ What, if any, cables were modified and how?
- ❏ With what equipment is the unit interfaced?
- ❏ What was the application?
- ❏ What was the system environment (temperature, enclosure, spacing, unit orientation, contaminants, etc.)?
- ❏ What upgrades, if any, are required (hardware, cables, user guide)?

③ In the USA, call your Automation Technology Center (ATC) for a Return Material Authorization (RMA) number. Returned products cannot be accepted without an RMA number. If you cannot obtain an RMA number from your ATC, call Parker Compumotor's Customer Service Department at (800) 722-2282.

Ship the unit to:
Parker Hannifin Corporation
Compumotor Division
5500 Business Park Drive, Suite D
Rohnert Park, CA 94928
Attn: RMA # xxxxxxx

④ In the UK, call Parker Digiplan for a GRA (Goods Returned Authorization) number. Returned products cannot be accepted without a GRA number. The phone number for Parker Digiplan Repair Department is 0202-690911. The phone number for Parker Digiplan Service/Applications Department is 0202-699000.

Ship the unit to:
Parker Digiplan Ltd.,
21, Balena Close,
Poole,
Dorset,
England.
BH17 7DX

⑤ Elsewhere: Contact the distributor who supplied the equipment.

A

APEX Motors

IN THIS APPENDIX

- ❏ Inspect the shipment
- ❏ Recommended replacements
- ❏ Configure DIP Switches
- ❏ Mount the motor
- ❏ Connect resolver and motor cables
- ❏ Motor Specifications

INSPECT THE SHIPMENT

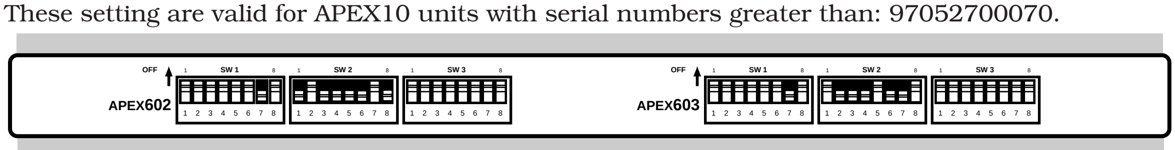
Options/Accessories		Part Number	
APEX Series Motor	(motor with resolver)	APEX602-MO,	APEX603-MO
		APEX604-MO,	APEX605-MO
		APEX606-MO,	APEX610-MO
		APEX620-MO,	APEX630-MO
		APEX635-MO,	APEX640-MO
Motor Cable:	(For APEX602, 603, 604, 605, 606)		71-013863-xx
	(For APEX610, 620, 630)		71-013864-xx
	(For APEX635, 640)		71-013865-xx
Resolver Cable:	(For all APEX Series Motors)		71-013862-xx
	(For APEX Series Motor with brake)		71-014082-xx
		xx can be 10, 25, 50, 100 feet	

RECOMMENDED REPLACEMENTS FOR APEX MOTORS

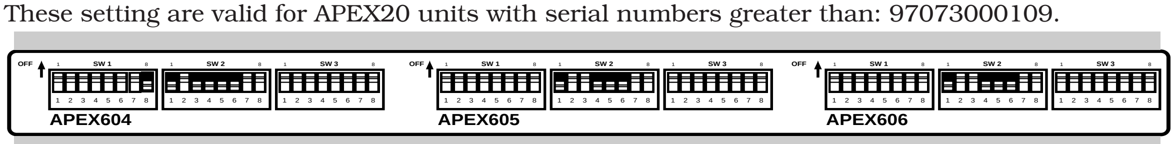
Apex Motor	Replacement
APEX602-MO-NC	N0703GR-KMSN
APEX603-MO-NC	N0704GR-KMSN
APEX604-MO-NC	N0922GR-KMSN
APEX605-MO-NC	N0922JR-KMSN
APEX606-MO-NC	N0923HR-KMSN
APEX610-MO-NC	N0924KR-KMSN

CONFIGURE THE APEX DRIVE'S DIP SWITCHES

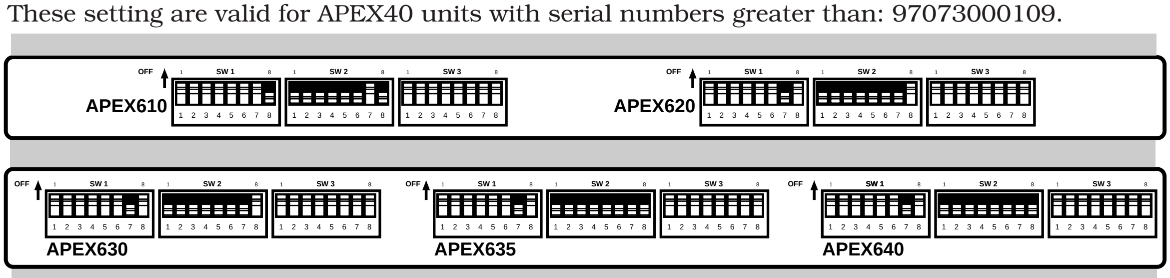
These setting are valid for APEX10 units with serial numbers greater than: 97052700070.



These setting are valid for APEX20 units with serial numbers greater than: 97073000109.



These setting are valid for APEX40 units with serial numbers greater than: 97073000109.



Call Compumotor's Applications Department for settings prior to these serial numbers

MOUNT THE MOTOR

MOTOR HEATSINKING

APEX (602 - 630 Motors)	APEX (635 & 640 Motors)
8" x 12" x 0.25"	11.5" x 12" x 0.75"
(203 x 304 x 6.3 mm)	(292 x 304 x 19 mm)

To get rated performance in your application, you must mount the motor to a heatsink of at least the same thermal capability as those listed above. Mounting the motor to a smaller heatsink may result in decreased performance and a shorter service life. Conversely, mounting the motor to a larger heatsink can result in enhanced performance.

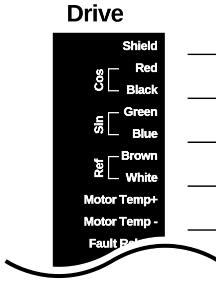
CONNECT THE RESOLVER CABLE

RESOLVER CONNECTIONS (COS, SIN, REF)

Use the color code shown in the next drawing when you connect APEX or SM resolver cables. This code is also printed on the front panel of the APEX Drive, near the resolver connector.

The **Shield** terminal is internally connected to **Gnd** (ground) terminals on the front panel of the drive. If you make your own resolver cable, use shielded cable to keep electrical noise from corrupting the resolver signal.

Label on Drive



Function	APEX Cable Color Code
Shield	Uninsulated
Stator 3	Red
Stator 1	Black
Stator 2	Green
Stator 4	Blue
Rotor 1	Brown
Rotor 2	White
Motor Temp+	Yellow
Motor Temp -	Orange

CONNECT THE MOTOR CABLE

MOTOR CONNECTIONS

Wire the cable to the motor connector. Use the following color code for APEX motor cables.

Connector Terminal	APEX Cable Wire Color
Phase A	Orange
Phase B	Blue
Phase C	Gray
Motor Ground	Green
Shield	Uninsulated

Motor Specifications

Motor Brakes

Optional motor brakes are available. They are mounted directly behind the motor and are pre-assembled at the factory. When ordering the brake option, specify the motor type.

Brake Characteristics	APEX602	APEX603	APEX604	APEX605 APEX606 APEX610	APEX620 APEX630 APEX635	APEX640
Supply voltage (VDC)	24	24	24	24	24	24
Supply current (amps)	0.57	1.27	0.57	1.27	0.93	1.27
Static braking torque (oz-in)	326	850	326	850	1130	6800
(Nm)	2.3	6.0	2.3	6.0	8.0	48

Selecting Drive/Motor Combinations

We recommend selecting motors for use with APEX Drives as follows:

APEX10 Drive: APEX602, APEX603

APEX20 Drive: APEX604, APEX605, APEX606

APEX40 Drive: APEX610, APEX620, APEX630, APEX635, APEX640,

Resolution Resolver: 4096 counts/REV

Speed/Torque Curves

Speed/torque curves on these pages represent the available shaft torque at different operating speeds, under the following conditions:

APEX Motors:

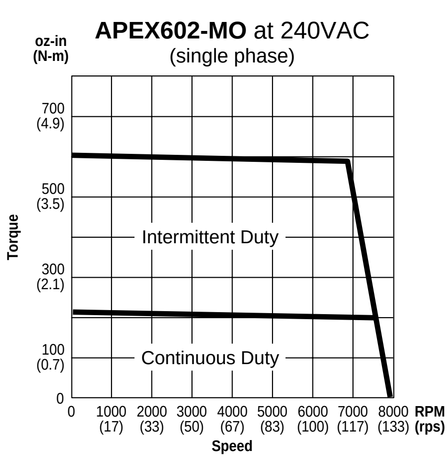
40°C (104°F) ambient temperature

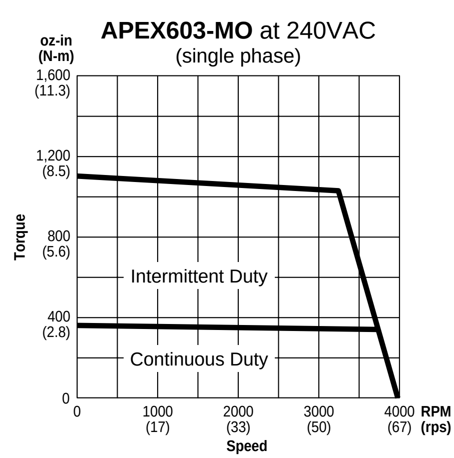
Nominal torque constant K_t

Motor mounted to aluminum heatsink:

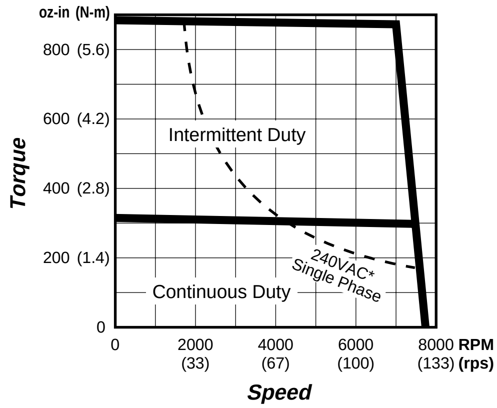
8" x 12" x 0.25"	for APEX602 – APEX630 (203 x 304 x 6.3 mm)
11.5" x 12" x 0.75"	for APEX635, APEX640 (292. x 304 x 19 mm)

Motor torque may vary ±10% due to motor manufacturing variances.

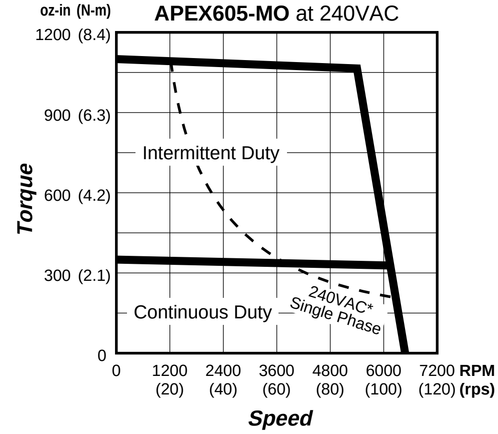




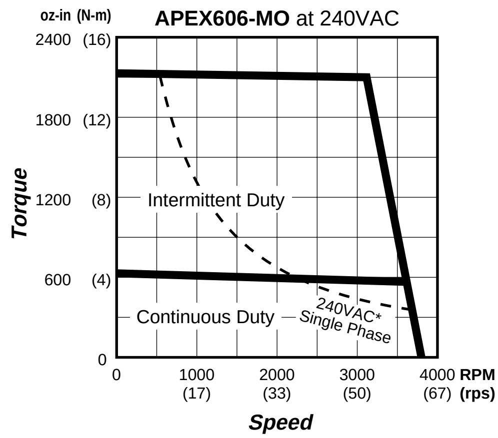
APEX604-MO at 240VAC



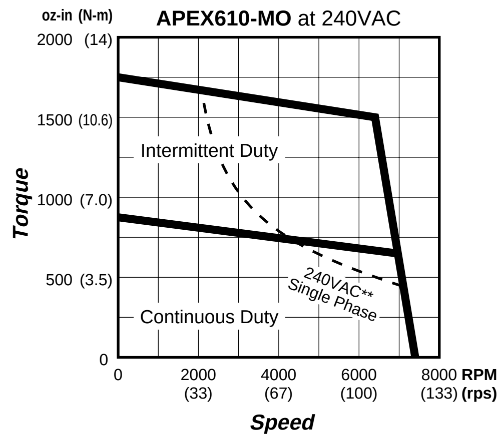
APEX605-MO at 240VAC



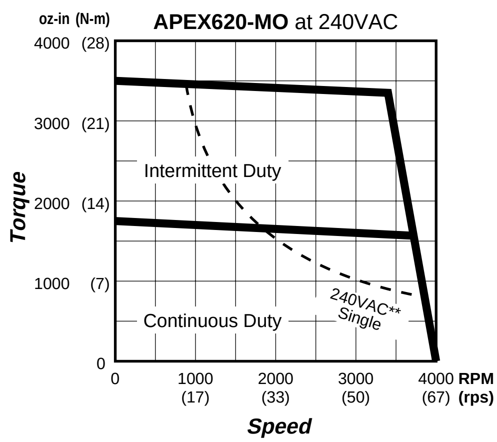
APEX606-MO at 240VAC



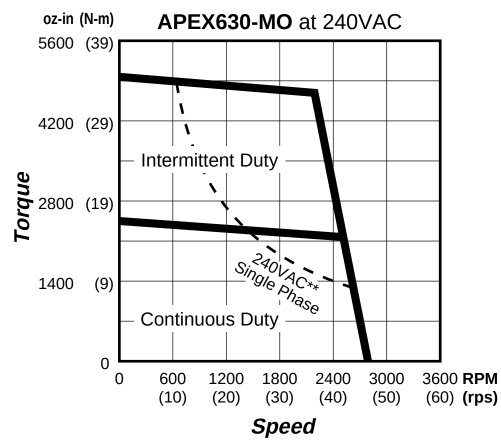
APEX610-MO at 240VAC



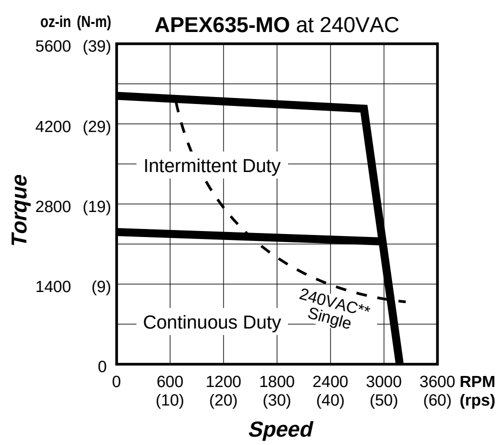
APEX620-MO at 240VAC



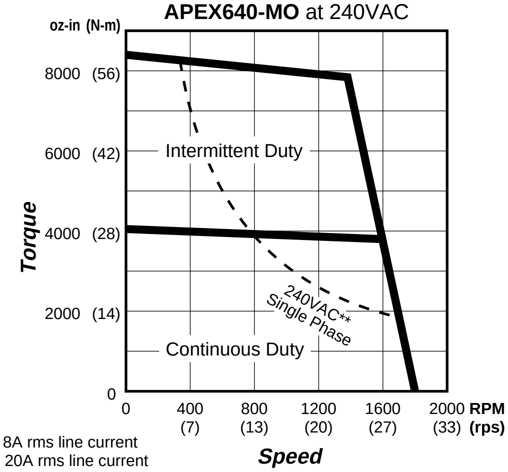
APEX630-MO at 240VAC



APEX635-MO at 240VAC



APEX640-MO at 240VAC



*240VAC single phase, 8A rms line current
**240VAC single phase, 20A rms line current

APEX Motor Resolver Specifications

Parameter	Value
Input voltage @ 7000 Hz	4.25 volts
Input current, max.	55 mA
Input power, nominal	0.12 watts
Impedance ZSO (@90∞)	58 +j145 ohms
Impedance ZRO	53 +j72 ohms
Impedance ZRS	42 +j55 ohms
Transformation ratio	0.470 ±5%
Output voltage	2.0 ±5% volts
D.C. rotor resistance	23 ±10% ohms
D.C. stator resistance	19 ±10% ohms
Sensitivity	35 mV/Degree
Max. Error from EZ	±10 minutes
Phase shift, open circuit	5∞ leading ±3
Null voltage (total)	20 mV rms
Impedance ZSS	50 +j128 ohms
Inertia	included in motor specification

APEX Motor Specifications

	Motor Size:	**APEX602**	Value	Units	Tolerance
1	Constant (s):	Torque	52.6 (0.37)	oz-in/A rms (Nm/A rms)	± 10%
2		Voltage (Sinusoidal)	22.5	V rms/Krpm	± 10%
3		Electrical Time	5.3	milliseconds	nominal
4		Mechanical Time	1.40	milliseconds	nominal
5		Thermal	11.0	minutes	nominal
6	Torque (s):	Continuous, Stall	236 (1.67)	oz-in (Nm)	min. [1]
7	(NOTE: Values are with	Continuous, Stall	223 (1.57)	oz-in (Nm)	min. [2]
8	rated and peak current,	Continuous, Rated	202 (1.43)	oz-in (Nm)	min. [2]
9	lines 15 & 16 below.	Peak, Max w/o Saturation	630 (4.45)	oz-in (Nm)	min. [1]
10	Drive current, and thus	Static Friction	7.68 (0.05)	oz-in (Nm)	max.
11	torque, may be lower.)	Ripple (of Rated Torque)	5	percent	max. [3]
12	Speed:	Rated	7500 (125)	rpm (rps)	reference
13		Maximum	7500 (125)	rpm (rps)	reference
14	Frequency	Rated	250	Hz	max.
15	Current:	Rated	4.2	A rms	max. [1]
16		Peak	12.6	A rms	nominal
17	Voltage:	Rated	240	V rms	reference
18		Max	250	V rms	maximum
19	Output Power	Rated	1.12 (1.5)	kWatts (hp)	min. [1]
20	Inductance	Terminal (line-line)	14.4	mH	± 30%
21	D.C. Resistance	Terminal (line-line)	2.72	ohms	± 10 % [1]
22	Acceleration at Rated Torque		96500	rads/sec^2	Theoretical
23	Rotor Inertia		2.52 (46.1)	oz-in^2 (kgm^2 ∗ 1E-6)	nominal
24	Damping		0.384 (0.0027)	oz-in/krpm (Nm/krpm)	nominal
25	Weight		7.0 (3.17)	lbs. (kg)	max.
26	Winding Temperature		170°C (338°F) [4]	°C (°F)	max.
27	Winding Temperature Rise (Above Ambient) [1]		145°C (293°F)	°C (°F)	reference
28	Insulation Class		H	—	reference
29	Thermostat TRIP Temperature		170°C (338°F)	°C (°F)	± 5° C
30	Thermostat RESET Temperature		135°C (275°F)	°C (°F)	± 10° C
31	Dielectric Strength, (Winding-to-Frame)		1750	VAC	min.
32	Winding Capacitance-to-Frame		0.000898	µF	max.
33	IP Classification		65 [8]	rated	standard
34	Shaft:	Radial-Play At End	12E-6 (68E-9)	in/lb (m/N)	reference
		At Faceplate	7.0E-6 (40E-9)	in/lb (m/N)	reference
35		Material [5]	RC-#30	—	reference
36		Magnet Type	NdFeB	—	—
37		Loading [6] 1000 rpm (17 rps)	81 (360)	lbs. (N)	max. [7]
		2000 rpm (33 rps)	65 (289)	lbs. (N)	max. [7]
		3000 rpm (50 rps)	56 (249)	lbs. (N)	max. [7]
		4000 rpm (67 rps)	51 (227)	lbs. (N)	max. [7]
		5000 rpm (83 rps)	48 (213)	lbs. (N)	max. [7]
38	Motor Vibration		N	ISO 2373	Standard
39	Bearing Class, Internal/External		1/Class 3	ABEC/AFBMA	reference
40	Bearing Grease		SRI #2	Manufacturer	reference
41	Shaft Seal Pressure		3 (0.21)	psi (kg/cm^2)	max.
42	Basic Motor Design		3 phase wye connected 2(P/2)		
43	Stator Phase Sequence		A-C-B (viewed from front face plate)		
44	Vendor/Supplier		Industrial Drives B-104-B		
45	Resolver Type/Accuracy		Single-Speed; Rotor-Excited; ± 10 arc min.		
46	Resolver Manufacturer/Model #		Fasco # 21-BRCX-335-J39		
47	Standard Resolver Cable Part Number		71-011777-xx		
48	Standard Motor Cable Part Number		71-011774-xx		
49	Options:	Brake—24VDC (0.57A)—326 oz-in (2.3 Nm) Holding Torque (requires resolver cable 71-014082-xx) IP67 Classification, No Keyway Incremental Encoder, Shaft Modifications Tachometer, IP65 Shaft Seal			

[1] 25°C (77°F) Ambient
[2] 40°C (104°F) Ambient
[3] Measured at 60 rpm (1 rps) in Velocity Mode
[4] Rated for 20,000 Hours or 40,000 Hours @ 155° C (311°F)
[5] Rotor steel is rated as fatigue proof
[6] Loads centered 1 inch from mounting flange
[7] Loads may be radial and axial such that the sum of the radial and two times the axial does not exceed this figure.
[8] Motor shaft is IP30 rated.

APEX Motor Specifications

	Motor Size:	**APEX603**		Value	Units	Tolerance
1	Constant (s):	Torque		114.6 (0.81)	oz-in/A rms (Nm/A rms)	± 10%
2		Voltage (Sinusoidal)		49.0	V rms/Krpm	± 10%
3		Electrical Time		9.7	milliseconds	nominal
4		Mechanical Time		-----	milliseconds	nominal
5		Thermal		18	minutes	nominal
6	Torque (s):	Continuous, Stall		367 (2.59)	oz-in (Nm)	min. [1]
7	(NOTE: Values are with	Continuous, Stall		346 (2.44)	oz-in (Nm)	min. [2]
8	rated and peak current,	Continuous, Rated		356 (2.51)	oz-in (Nm)	min. [2]
9	lines 15 & 16 below.	Peak, Max w/o Saturation		1046 (7.38)	oz-in (Nm)	min. [1]
10	Drive current, and thus	Static Friction		12.0 (0.08)	oz-in (Nm)	max.
11	torque, may be lower.)	Ripple (of Rated Torque)		5	percent	max. [3]
12	Speed:	Rated		3800 (63)	rpm (rps)	reference
13		Maximum		3800 (63)	rpm (rps)	reference
14	Frequency	Rated		126.7	Hz	max.
15	Current:	Rated		3.0	A rms	max. [1]
16		Peak		9.6	A rms	nominal
17	Voltage:	Rated		240	V rms	reference
18		Max		250	V rms	maximum
19	Output Power	Rated		1.0 (1.3)	kWatts (hp)	min. [1]
20	Inductance	Terminal (line-line)		68	mH	± 30%
21	D.C. Resistance	Terminal (line-line)		7.0	ohms	± 10 % [1]
22	Acceleration at Rated Torque			74150	rads/sec^2	Theoretical
23	Rotor Inertia			5.45 (99.6)	oz-in^2 (kgm^2 ∗ 1E-6)	nominal
24	Damping			0.960 (0.0068)	oz-in/krpm (Nm/krpm)	nominal
25	Weight			9.0 (4.08)	lbs. (kg)	max.
26	Winding Temperature			170°C (338°F) [4]	°C (°F)	max.
27	Winding Temperature Rise (Above Ambient) [1]			145°C (293°F)	°C (°F)	reference
28	Insulation Class			H	—	reference
29	Thermostat TRIP Temperature			170°C (338°F)	°C (°F)	± 5° C
30	Thermostat RESET Temperature			135°C (275°F)	°C (°F)	± 10° C
31	Dielectric Strength, (Winding-to-Frame)			1750	VAC	min.
32	Winding Capacitance-to-Frame			0.00122	µF	max.
33	IP Classification			65 [8]	rated	standard
34	Shaft:	Radial-Play	At End	14E-6 (80E-9)	in/lb (m/N)	reference
			At Faceplate	8.0E-6 (45E-9)	in/lb (m/N)	reference
35		Material [5]		RC-#30	—	reference
36		Magnet Type		NdFeB	—	—
37		Loading [6]	1000 rpm (17 rps)	85.4 (380)	lbs. (N)	max. [7]
			2000 rpm (33 rps)	67.8 (302)	lbs. (N)	max. [7]
			3000 rpm (50 rps)	59.1 (263)	lbs. (N)	max. [7]
			4000 rpm (67 rps)	53.8 (239)	lbs. (N)	max. [7]
			5000 rpm (83 rps)	50 (222)	lbs. (N)	max. [7]
38	Motor Vibration			N	ISO 2373	Standard
39	Bearing Class, Internal/External			1/Class 3	ABEC/AFBMA	reference
40	Bearing Grease			SRI #2	Manufacturer	reference
41	Shaft Seal Pressure			3 (0.21)	psi (kg/cm^2)	max.
42	Basic Motor Design			3 phase wye connected 2(P/2)		
43	Stator Phase Sequence			A-C-B (viewed from front face plate)		
44	Vendor/Supplier			Industrial Drives B-202-B		
45	Resolver Type/Accuracy			Single-Speed; Rotor-Excited; ± 10 arc min.		
46	Resolver Manufacturer/Model #			Fasco # 21-BRCX-335-J39		
47	Standard Resolver Cable Part Number			71-011777-xx		
48	Standard Motor Cable Part Number			71-011774-xx		
49	Options:	Brake—24VDC (0.57A)—845 oz-in (5.97 Nm) Holding Torque (requires resolver cable 71-014082-xx) IP67 Classification; No Keyway Incremental Encoder; Shaft Modifications Tachometer; IP65 Shaft Seal				

[1] 25°C (77°F) Ambient
[2] 40°C (104°F) Ambient
[3] Measured at 60 rpm (1 rps) in Velocity Mode
[4] Rated for 20,000 Hours or 40,000 Hours @ 155° C (311°F)
[5] Rotor steel is rated as fatigue proof
[6] Loads centered 1 inch from mounting flange
[7] Loads may be radial and axial such that the sum of the radial and two times the axial does not exceed this figure.
[8] Motor shaft is IP30 rated.

APEX Motor Specifications

	Motor Size:	**APEX604**	Value	Units	Tolerance
1	Constant (s):	Torque	52.6 (0.37)	oz-in/A rms (Nm/A rms)	± 10%
2		Voltage (Sinusoidal)	22.5	V rms/Krpm	± 10%
3		Electrical Time	58.7	milliseconds	nominal
4		Mechanical Time	1.30	milliseconds	nominal
5		Thermal	12	minutes	nominal
6	Torque (s):	Continuous, Stall	334 (2.36)	oz-in (Nm)	min. [1]
7	(NOTE: Values are with	Continuous, Stall	315 (2.22)	oz-in (Nm)	min. [2]
8	rated and peak current,	Continuous, Rated	269 (1.90)	oz-in (Nm)	min. [2]
9	lines 15 & 16 below.	Peak, Max w/o Saturation	899 (6.35)	oz-in (Nm)	min. [1]
10	Drive current, and thus	Static Friction	9.6 (0.07)	oz-in (Nm)	max.
11	torque, may be lower.)	Ripple (of Rated Torque)	5	percent	max. [3]
12	Speed:	Rated	7500 (125)	rpm (rps)	reference
13		Maximum	7500 (125)	rpm (rps)	reference
14	Frequency	Rated	250	Hz	max.
15	Current:	Rated	6.0	A rms	max. [1]
16		Peak	18.8	A rms	nominal
17	Voltage:	Rated	240	V rms	reference
18		Max	250	V rms	maximum
19	Output Power	Rated	1.5 (2.0)	kWatts (hp)	min. [1]
20	Inductance	Terminal (line-line)	9.4	mH	± 30%
21	D.C. Resistance	Terminal (line-line)	1.6	ohms	± 10 % [1]
22	Acceleration at Rated Torque		82980	rads/sec^2	Theoretical
23	Rotor Inertia		4.18 (76.5)	oz-in^2 (kgm^2 * 1E-6)	nominal
24	Damping		0.580 (0.0041)	oz-in/krpm (Nm/krpm)	nominal
25	Weight		8.5 (3.86)	lbs. (kg)	max.
26	Winding Temperature		170°C (338°F) [4]	°C (°F)	max.
27	Winding Temperature Rise (Above Ambient) [1]		145°C (293°F)	°C (°F)	reference
28	Insulation Class		H	—	reference
29	Thermostat TRIP Temperature		170°C (338°F)	°C (°F)	± 5° C
30	Thermostat RESET Temperature		135°C (275°F)	°C (°F)	± 10° C
31	Dielectric Strength, (Winding-to-Frame)		1750	VAC	min.
32	Winding Capacitance-to-Frame		0.00122	µF	max.
33	IP Classification		65 [8]	rated	standard
34	Shaft: Radial-Play	At End	12E-6 (68E-9)	in/lb (m/N)	reference
		At Faceplate	5.6E-6 (32E-9)	in/lb (m/N)	reference
35	Material [5]		RC-#30	—	—
36	Magnet Type		NdFeB	—	—
37	Loading [6]	1000 rpm (17 rps)	84 (374)	lbs. (N)	max. [7]
		2000 rpm (33 rps)	67 (298)	lbs. (N)	max. [7]
		3000 rpm (50 rps)	58 (258)	lbs. (N)	max. [7]
		4000 rpm (67 rps)	53 (236)	lbs. (N)	max. [7]
		5000 rpm (83 rps)	49 (218)	lbs. (N)	max. [7]
38	Bearing Class, Internal/External		1/Class 3	ABEC/AFBMA	reference
39	Bearing Grease		SRI #2	Manufacturer	reference
40	Shaft Seal Pressure		3 (0.21)	psi (kg/cm^2)	max.
41	Basic Motor Design		3 phase wye connected 2(P/2)		
42	Stator Phase Sequence		A-C-B (viewed from front face plate)		
43	Vendor/Supplier		Industrial Drives B-106-B		
44	Resolver Type/Accuracy		Single-Speed; Rotor-Excited; ± 10 arc min.		
45	Resolver Manufacturer/Model #		Fasco # 21-BRCX-335-J39		
46	Standard Resolver Cable Part Number		71-013862-xx		
47	Standard Motor Cable Part Number		71-013863-xx		
48	Options:	Brake—24VDC (0.57A)—326 oz-in (2.3 Nm) Holding Torque IP67 Classification Incremental Encoder Tachometer No Keyway			

[1] 25°C (77°F) Ambient
[2] 40°C (104°F) Ambient
[3] Measured at 60 rpm (1 rps) in Velocity Mode
[4] Rated for 20,000 Hours or 40,000 Hours @ 155° C (311°F)
[5] Rotor steel is rated as fatigue proof
[6] Loads centered 1 inch from mounting flange
[7] Loads may be radial and axial such that the sum of the radial and two times the axial does not exceed this figure.
[8] Motor shaft is IP30 rated.

APEX Motor Specifications

	Motor Size:	APEX605	Value	Units	Tolerance
1	Constant (s):	Torque	68.7 (0.49)	oz-in/A rms (Nm/A rms)	± 10%
2		Voltage (Sinusoidal)	29.4	V rms/Krpm	± 10%
3		Electrical Time	10.68	milliseconds	nominal
4		Mechanical Time	1.46	milliseconds	nominal
5		Thermal	18	minutes	nominal
6	Torque (s):	Continuous, Stall	367 (2.59)	oz-in (Nm)	min. [1]
7	(NOTE: Values are with	Continuous, Stall	346 (2.44)	oz-in (Nm)	min. [2]
8	rated and peak current,	Continuous, Rated	321 (2.27)	oz-in (Nm)	min. [2]
9	lines 15 & 16 below.	Peak, Max w/o Saturation	1085 (7.66)	oz-in (Nm)	min. [1]
10	Drive current, and thus	Static Friction	0.96 (0.007)	oz-in (Nm)	max.
11	torque, may be lower.)	Ripple (of Rated Torque)	5	percent	max. [3]
12	Speed:	Rated	6200 (103)	rpm (rps)	reference
13		Maximum	6200 (103)	rpm (rps)	reference
14	Frequency	Rated	207	Hz	max.
15	Current:	Rated	5	A rms	max. [1]
16		Peak	16.6	A rms	nominal
17	Voltage:	Rated	240	V rms	reference
18		Max	250	V rms	maximum
19	Output Power	Rated	1.5 (2.0)	kWatts (hp)	min. [1]
20	Inductance	Terminal (line-line)	25	mH	± 30%
21	D.C. Resistance	Terminal (line-line)	2.3	ohms	± 10 % [1]
22	Acceleration at Rated Torque		76870	rads/sec^2	Theoretical
23	Rotor Inertia		5.43 (99.6)	oz-in^2 (kgm^2 $*$ 1E-6)	nominal
24	Damping		0.96 (0.0068)	oz-in/krpm (Nm/krpm)	nominal
25	Weight		10 (4.5)	lbs. (kg)	max.
26	Winding Temperature		170°C (338°F) [4]	°C (°F)	max.
27	Winding Temperature Rise (Above Ambient) [1]		145°C (293°F)	°C (°F)	reference
28	Insulation Class		H	—	reference
29	Thermostat TRIP Temperature		170°C (338°F)	°C (°F)	± 5° C
30	Thermostat RESET Temperature		135°C (275°F)	°C (°F)	± 10° C
31	Dielectric Strength, (Winding-to-Frame)		1750	VAC	min.
32	Winding Capacitance-to-Frame		0.00122	µF	max.
33	IP Classification		65 [8]	rated	standard
34	Shaft: Radial-Play	At End	14E-6 (80E-9)	in/lb (m/N)	eference
		At Faceplate	8E-6 (45E-9)	in/lb (m/N)	reference
35	Material [5]		RC-#30	—	—
36	Magnet Type		NdFeB	—	—
37	Loading [6]	1000 rpm (17 rps)	85.4 (380)	lbs. (N)	max. [7]
		2000 rpm (33 rps)	67.8 (301)	lbs. (N)	max. [7]
		3000 rpm (50 rps)	59.1 (263)	lbs. (N)	max. [7]
		4000 rpm (67 rps)	53.8 (239)	lbs. (N)	max. [7]
		5000 rpm (83 rps)	50 (222)	lbs. (N)	max. [7]
38	Bearing Class, Internal/External		1/Class 3	ABEC/AFBMA	reference
39	Bearing Grease		SRI #2	Manufacturer	reference
40	Shaft Seal Pressure		3 (0.21)	psi (kg/cm^2)	max.
41	Basic Motor Design		3 phase wye connected 2(P/2)		
42	Stator Phase Sequence		A-C-B (viewed from front face plate)		
43	Vendor/Supplier		Industrial Drives B-202-C		
44	Resolver Type/Accuracy		Single-Speed; Rotor-Excited; ± 10 arc min.		
45	Resolver Manufacturer/Model #		Fasco # 21-BRCX-335-J39		
46	Standard Resolver Cable Part Number		71-013862-xx		
47	Standard Motor Cable Part Number		71-013863-xx		
48	Options:	Brake—24VDC (0.57A)—850 oz-in (6.0 Nm) Holding Torque IP67 Classification Incremental Encoder Tachometer No Keyway			

[1] 25°C (77°F) Ambient
[2] 40°C (104°F) Ambient
[3] Measured at 60 rpm (1 rps) in Velocity Mode
[4] Rated for 20,000 Hours or 40,000 Hours @ 155° C (311°F)
[5] Rotor steel is rated as fatigue proof
[6] Loads centered 1 inch from mounting flange
[7] Loads may be radial and axial such that the sum of the radial and two times the axial does not exceed this figure.
[8] Motor shaft is IP30 rated.

APEX Motor Specifications

	Motor Size:	**APEX606**	Value	Units	Tolerance
1	Constant (s):	Torque	120 (0.85)	oz-in/A rms (Nm/A rms)	± 10%
2		Voltage (Sinusoidal)	51.2	V rms/Krpm	± 10%
3		Electrical Time	15.32	milliseconds	nominal
4		Mechanical Time	0.896	milliseconds	nominal
5		Thermal	20	minutes	nominal
6	Torque (s):	Continuous, Stall	672 (4.75)	oz-in (Nm)	min. [1]
7	(NOTE: Values are with	Continuous, Stall	634 (4.48)	oz-in (Nm)	min. [2]
8	rated and peak current,	Continuous, Rated	576 (4.07)	oz-in (Nm)	min. [2]
9	lines 15 & 16 below.	Peak, Max w/o Saturation	1957 (13.82)	oz-in (Nm)	min. [1]
10	Drive current, and thus	Static Friction	0.96 (0.007)	oz-in (Nm)	max
11	torque, may be lower.)	Ripple (of Rated Torque)	5	percent	max. [3]
12	Speed:	Rated	3600 (60)	rpm (rps)	reference
13		Maximum	3600 (60)	rpm (rps)	reference
14	Frequency	Rated	120	Hz	max.
15	Current:	Rated	5.3	A rms	max. [1]
16		Peak	17.2	A rms	nominal
17	Voltage:	Rated	240	V rms	reference
18		Max	250	V rms	maximum
19	Output Power:	Rated	1.6 (2.1)	kWatts (hp)	min. [1]
20	Inductance:	Terminal (line-line)	38	mH	± 30%
21	D.C. Resistance	Terminal (line-line)	2.48	ohms	± 10 % [1]
22	Acceleration at Rated Torque		80000	rads/sec^2	Theoretical
23	Rotor Inertia		9.44 (172.9)	oz-in^2 (kgm^2 $*$ 1E-6)	nominal
24	Damping		1.344 (0.0095)	oz-in/krpm (Nm/krpm)	nominal
25	Weight		13.4 (6.1)	lbs. (kg)	max.
26	Winding Temperature		170°C (338°F) [4]	°C (°F)	max.
27	Winding Temperature Rise (Above Ambient) [1]		145°C (293°F)	°C (°F)	reference
28	Insulation Class		H	—	reference
29	Thermostat TRIP Temperature		170°C (338°F)	°C (°F)	± 5 °C
30	Thermostat RESET Temperature		135°C (275°F)	°C (°F)	± 10 °C
31	Dielectric Strength, (Winding-to-Frame)		1750	VAC	min.
32	Winding Capacitance to Frame		0.00201	µF	max.
33	IP Classification		65 [8]	rated	standard
34	Shaft:	Radial-Play At End	14E-6 (80E-9)	in/lb (m/N)	eference
		At Faceplate	8E-6 (45E-9)	In/lb (m/N)	reference
35		Material [5]	RC-#30	—	—
36		Magnet Type	NdFeB	—	—
37		Loading [6] 1000 rpm (17 rps)	90.1 (401)	lbs. (N)	rmax. [7]
		2000 rpm (33 rps)	71.6 (318)	lbs. (N)	max. [7]
		3000 rpm (50 rps)	62.4 (278)	lbs. (N)	max. [7]
		4000 rpm (67 rps)	N/A	lbs. (N)	max. [7]
		5000 rpm (83 rps)	N/A	lbs. (N)	max. [7]
38	Bearing Class, Internal/External		1/Class 3	ABEC/AFBMA	reference
39	Bearing Grease		SRI #2	Manufacturer	reference
40	Shaft Seal Pressure		3 (0.21)	psi (kg/cm^2)	max.
41	Basic Motor Design		3 phase wye connected 2(P/2)		
42	Stator Phase Sequence		A-C-B (viewed from front face plate)		
43	Vendor/Supplier		Industrial Drives B-204-B		
44	Resolver Type/Accuracy		Single-Speed; Rotor-Excited; ± 10 arc min.		
45	Resolver Manufacturer/Model #		Fasco # 21-BRCX-335-J39		
46	Standard Resolver Cable Part Number		71-013862-xx		
47	Standard Motor Cable Part Number		71-013863-xx		
48	Options:	Brake—24VDC (0.57A)—850 oz-in (6.0 NM) Holding Torque IP67 Classification Incremental Encoder Tachometer No Keyway			

[1] 25°C (77°F) Ambient
[2] 40°C (104°F) Ambient
[3] Measured at 60 rpm (1rps) in Velocity Mode
[4] Rated for 20,000 Hrs or 40,000 Hours@155°C (311°F)
[5] Rotor steel is rated as fatigue proof
[6] Loads centered 1 inch from mounting flange
[7] Loads may be radial and axial such that the sum of the radial and two times the axial does not exceed this figure.
[8] Motor shaft is IP30 rated.

APEX Motor Specifications

	Motor Size:	**APEX610**	Value	Units	Tolerance
1	Constant (s):	Torque	61.4 (0.43)	oz-in/A rms (Nm/A rms)	± 10%
2		Voltage (Sinusoidal)	26.2	V rms/Krpm	±10%
3		Electrical Time	13.16	milliseconds	nominal
4		Mechanical Time	0.762	milliseconds	nominal
5		Thermal	21	minutes	nominal
6	Torque (s):	Continuous, Stall	977 (6.90)	oz-in (Nm)	min. [1]
7	(NOTE: Values are with	Continuous, Stall	921.6 (6.51)	oz-in (Nm)	min. [2]
8	rated and peak current,	Continuous, Rated	653 (4.61)	oz-in (Nm)	min. [2]
9	lines 15 & 16 below.	Peak, Max w/o Saturation	2630 (18.57)	oz-in (Nm)	min. [1]
10	Drive current, and thus	Static Friction	0.96 (0.007)	oz-in (Nm)	max
11	torque, may be lower.)	Ripple (of Rated Torque)	5	percent	min. [3]
12	Speed:	Rated	7000 (117)	rpm (rps)	reference
13		Maximum	7000 (117)	rpm (rps)	reference
14	Frequency	Rated	233	Hz	max.
15	Current:	Rated	15	A rms	max. [1]
16		Peak	45	A rms	nominal
17	Voltage:	Rated	230	V rms	reference
18		Max	250	V rms	maximum
19	Output Power:	Rated	3.3 (4.5)	kWatts (hp)	min. [1]
20	Inductance:	Terminal (line-line)	5	mH	± 30%
21	D.C. Resistance	Terminal (line-line)	0.38	ohms	± 10 % [1]
22	Acceleration at Rated Torque		73934	rads/sec^2	Theoretical
23	Rotor Inertia		13.72 (251.2)	oz-in^2 (kgm^2 $*$ 1E-6)	nominal
24	Damping		1.728 (0.0122)	oz-in/krpm (Nm/krpm)	nominal
25	Weight		16.35 (7.43)	lbs. (kg)	max.
26	Winding Temperature		170°C (338°F) [4]	°C (°F)	max.
27	Winding Temperature Rise (Above Ambient) [1]		145°C (293°F)	°C (°F)	reference
28	Insulation Class		H	—	reference
29	Thermostat TRIP Temperature		170°C (338°F)	°C (°F)	± 5 °C
30	Thermostat RESET Temperature		135°C (275°F)	°C (°F)	± 10 °C
31	Dielectric Strength, (Winding-to-Frame)		1750	VAC	min.
32	Winding Capacitance-to-Frame		0.00205	µF	max.
33	IP Classification		65 [8]	rated	standard
34	Shaft: Radial-Play	At End	14E-6 (80E-9)	in/lb (m/N)	reference
		At Faceplate	8E-6 (45E-9)	in/lb (m/N)	reference
35	Material [5]		RC-#30		
36	Magnet Type		NdFeB		
37	Loading [6]	1000 rpm (17 rps)	93.5 (416)	lbs. (N)	max. [7]
		2000 rpm (33 rps)	74.2 (330)	lbs. (N)	max. [7]
		3000 rpm (50 rps)	64.8 (288)	lbs. (N)	max. [7]
		4000 rpm (67 rps)	59 (262)	lbs. (N)	max. [7]
		5000 rpm (83 rps)	54.7 (243)	lbs. (N)	max. [7]
38	Bearing Class, Internal/External		1/Class 3	ABEC/AFBMA	reference
39	Bearing Grease		SRI #2	Manufacturer	reference
40	Shaft Seal Pressure		3 (0.21)	psi (kg/cm^2)	max.
41	Basic Motor Design		3 phase wye connected 2(P/2)		
42	Stator Phase Sequence		A-C-B (viewed from front face plate)		
43	Vendor/Supplier		Industrial Drives B-206-D		
44	Resolver Type/Accuracy		Single-Speed; Rotor-Excited; ± 10 arc min.		
45	Resolver Manufacturer/Model #		Fasco # 21-BRCX-335-J39		
46	Standard Resolver Cable Part Number		71-013862-xx		
47	Standard Motor Cable Part Number		71-013864-xx		
48	Options:	Brake—24VDC (0.57A)—850 oz-in (6.0 Nm) Holding Torque IP67 Classification Incremental Encoder Tachometer No Keyway			

[1] 25°C (77°F) Ambient
[2] 40°C (104°F) Ambient
[3] Measured at 60 rpm (1 rps) in Velocity Mode
[4] Rated for 20,000 Hours or 40,000 Hours @ 155° C (311°F)
[5] Rotor steel is rated as fatigue proof
[6] Loads centered 1 inch from mounting flange
[7] Loads may be radial and axial such that the sum of the radial and two times the axial does not exceed this figure.
[8] Motor shaft is IP30 rated.

APEX Motor Specifications

	Motor Size:	**APEX620**		Value	Units	Tolerance
1	Constant (s):	Torque		124.2 (0.877)	oz-in/A rms (Nm/A rms)	± 10%
2		Voltage (Sinusoidal)		53	V rms/Krpm	± 10%
3		Electrical Time		23.4	milliseconds	nominal
4		Mechanical Time		0.82	milliseconds	nominal
5		Thermal		22	minutes	nominal
6	Torque (s):	Continuous, Stall		1974 (13.94)	oz-in (Nm)	min. [1]
7	(NOTE: Values are with	Continuous, Stall		1862 (13.15)	oz-in (Nm)	min. [2]
8	rated and peak current,	Continuous, Rated		1632 (11.52)	oz-in (Nm)	min. [2]
9	lines 15 & 16 below.	Peak, Max w/o Saturation		5299 (37.42)	oz-in (Nm)	min. [1]
10	Drive current, and thus	Static Friction		25 (0.176)	oz-in (Nm)	max.
11	torque, may be lower.)	Ripple (of Rated Torque)		4.5	percent	min. [3]
12	Speed:	Rated		3700 (62)	rpm (rps)	reference
13		Maximum		3700 (62)	rpm (rps)	reference
14	Frequency	Rated		123	Hz	max.
15	Current:	Rated		15	A rms	max. [1]
16		Peak		45	A rms	nominal
17	Voltage:	Rated		230	V rms	reference
18		Max		250	V rms	maximum
19	Output Power:	Rated		4.5 (6)	kWatts (hp)	min. [1]
20	Inductance:	Terminal (line-line)		15	mH	± 30%
21	D.C. Resistance	Terminal (line-line)		0.64	Ohms	± 10 % [1]
22	Acceleration at Rated Torque			57025	rads/sec^2	Theoretical
23	Rotor Inertia			35.8 (656)	oz-in^2 (kgm^2 ∗ 1E-6)	nominal
24	Damping			2.496 (0.0176)	oz-in/krpm (Nm/krpm)	nominal
25	Weight			29 (13.2)	lbs. (kg)	max.
26	Winding Temperature			170°C (338°F) [4]	°C (°F)	max.
27	Winding Temperature Rise (Above Ambient) [1]			145°C (293°F)	°C (°F)	reference
28	Insulation Class			H	—	reference
29	Thermostat TRIP Temperature			170°C (338°F)	°C (°F)	± 5 °C
30	Thermostat RESET Temperature			135°C (275°F)	°C (°F)	± 10 °C
31	Dielectric Strength, (Winding-to-Frame)			1750	VAC	min.
32	Winding Capacitance-to-Frame			0.0034	µF	max.
33	IP Classification			65 [8]	rated	standard
34	Shaft:	Radial-Play	At End	20E-6 (114E-9)	in/lb (m/N)	reference
			At Faceplate	7E-6 (40E-9)	in/lb (m/N)	reference
35		Material [5]		RC-#30	—	—
36		Magnet Type		NdFeB	—	—
37		Loading [6]	1000 rpm (17 rps)	154.7 (688)	lbs. (N)	max. [7]
			2000 rpm (33 rps)	122.8 (546)	lbs. (N)	max. [7]
			3000 rpm (50 rps)	107.2 (477)	lbs. (N)	max. [7]
			4000 rpm (67 rps)	N/A	lbs. (N)	max. [7]
			5000 rpm (83 rps)	N/A	lbs. (N)	max. [7]
38	Bearing Class, Internal/External			1/Class 3	ABEC/AFBMA	reference
39	Bearing Grease			SRI #2	Manufacturer	reference
40	Shaft Seal Pressure			3 (0.21)	psi (kg/cm^2)	max.
41	Basic Motor Design			3 phase wye connected 2(P/2)		
42	Stator Phase Sequence			A-C-B (viewed from front face plate)		
43	Vendor/Supplier			Industrial Drives B-404-D		
44	Resolver Type/Accuracy			Single-Speed; Rotor-Excited; ± 10 arc min.		
45	Resolver Manufacturer/Model #			Fasco # 21-BRCX-335-J39		
46	Standard Resolver Cable Part Number			71-013862-xx		
47	Standard Motor Cable Part Number			71-013864-xx		
48	Options:	Brake—24VDC (0.93A)—1130 oz-in (8.0 Nm) Holding Torque IP67 Classification Incremental Encoder Tachometer No Keyway				

[1] 25°C (77°F) Ambient
[2] 40°C (104°F) Ambient
[3] Measured at 60 rpm (1 rps) in Velocity Mode
[4] Rated for 20,000 Hours or 40,000 Hours @ 155° C (311°F)
[5] Rotor steel is rated as fatigue proof
[6] Loads centered 1 inch from mounting flange
[7] Loads may be radial and axial such that the sum of the radial and two times the axial does not exceed this figure.
[8] Motor shaft is IP30 rated.

APEX Motor Specifications

	Motor Size:	APEX630		Value	Units	Tolerance
1	Constant (s):	Torque		175.3 (1.24)	oz-in/A rms (Nm/A rms)	± 10%
2		Voltage (Sinusoidal)		74.9	V rms/Krpm	± 10%
3		Electrical Time		26.7	milliseconds	nominal
4		Mechanical Time		0.68	milliseconds	nominal
5		Thermal		28	minutes	nominal
6	Torque (s):	Continuous, Stall		2788 (19.69)	oz-in (Nm)	min. [1]
7	(NOTE: Values are with	Continuous, Stall		2630 (18.57)	oz-in (Nm)	min. [2]
8	rated and peak current,	Continuous, Rated		2304 (16.27)	oz-in (Nm)	min. [2]
9	lines 15 & 16 below.	Peak, Max w/o Saturation		7488 (52.88)	oz-in (Nm)	min. [1]
10	Drive current, and thus	Static Friction		40.7 (0.287)	oz-in (Nm)	max.
11	torque, may be lower.)	Ripple (of Rated Torque)		4.5	percent	min. [3]
12	Speed:	Rated		2500 (42)	rpm (rps)	reference
13		Maximum		2500 (42)	rpm (rps)	reference
14	Frequency	Rated		83	Hz	max.
15	Current:	Rated		15	A rms	max. [1]
16		Peak		45	A rms	nominal
17	Voltage:	Rated		230	V rms	reference
18		Max		250	V rms	maximum
19	Output Power:	Rated		4.3 (5.7)	kWatts (hp)	min. [1]
20	Inductance:	Terminal (line-line)		20	mH	± 30%
21	D.C. Resistance	Terminal (line-line)		0.75	Ohms	± 10 % [1]
22	Acceleration at Rated Torque			56934	rads/sec^2	Theoretical
23	Rotor Inertia			50.7 (929)	oz-in^2 (kgm^2 $*$ 1E-6)	nominal
24	Damping			2.88 (0.020)	oz-in/krpm (Nm/krpm)	nominal
25	Weight			32 (14.5)	lbs. (kg)	max.
26	Winding Temperature			170°C (338°F) [4]	°C (°F)	max.
27	Winding Temperature Rise (Above Ambient) [1]			145°C (293°F)	°C (°F)	reference
28	Insulation Class			H	—	reference
29	Thermostat TRIP Temperature			170°C (338°F)	°C (°F)	± 5 °C
30	Thermostat RESET Temperature			135°C (275°F)	°C (°F)	± 5 °C
31	Dielectric Strength, (Winding-to-Frame)			1750	VAC	min.
32	Winding Capacitance to Frame			0.0038	µF	max.
33	IP Classification			65 [8]	rated	standard
34	Shaft:	Radial-Play	At End	20E-6 (114E-9)	in/lb (m/N)	reference
			At Faceplate	7E-6 (40E-9)	in/lb (m/N)	reference
35		Material [5]		RC-#30	—	—
36		Magnet Type		NdFeB	—	—
37		Loading [6]	1000 rpm (17 rps)	160 (712)	lbs. (N)	max. [7]
			2000 rpm (33 rps)	127.1 (565)	lbs. (N)	max. [7]
			3000 rpm (50 rps)	N/A	lbs. (N)	max. [7]
			4000 rpm (67 rps)	N/A	lbs. (N)	max. [7]
			5000 rpm (83 rps)	N/A	lbs. (N)	max. [7]
38	Bearing Class, Internal/External			1/Class 3	ABEC/AFBMA	reference
39	Bearing Grease			SRI #2	Manufacturer	reference
40	Shaft Seal Pressure			3 (0.21)	psi (kg/cm^2)	max.
41	Basic Motor Design			3 phase wye connected 2(P/2)		
42	Stator Phase Sequence—CW rotor rotation			A-C-B (viewed from front face plate)		
43	Vendor/Supplier			Industrial Drives B-406-D		
44	Resolver Type/Accuracy			Single-Speed; Rotor-Excited; ± 10 arc min.		
45	Resolver Manufacturer/Model #			Fasco # 21-BRCX-335-J39		
46	Standard Resolver Cable Part Number			71-013862-xx		
47	Standard Motor Cable Part Number			71-013864-xx		
48	Options:	Brake—24VDC (0.93A)—1130 oz-in (8.0 Nm) Holding Torque IP67 Classification Incremental Encoder Tachometer No Keyway				

[1] 25°C (77°F) Ambient
[2] 40°C (104°F) Ambient
[3] Measured at 60 rpm (1 rps) in Velocity Mode
[4] Rated for 20,000 Hours or 40,000 Hours @ 155° C (311°F)
[5] Rotor steel is rated as fatigue proof
[6] Loads centered 1 inch from mounting flange
[7] Loads may be radial and axial such that the sum of the radial and two times the axial does not exceed this figure.
[8] Motor shaft is IP30 rated.

APEX Motor Specifications

	Motor Size:	**APEX635**	Value	Units	Tolerance
1	Constant (s):	Torque	164.0 (1.154)	oz-in/A rms (Nm/A rms)	± 10%
2		Voltage (Sinusoidal)	70	V rms/Krpm	± 10%
3		Electrical Time	0.77	milliseconds	nominal
4		Mechanical Time	20.8	milliseconds	nominal
5		Thermal	28	minutes	nominal
6	Torque (s):	Continuous, Stall	2605 (18.39)	oz-in (Nm)	min. [1]
7	(NOTE: Values are with	Continuous, Stall	2458 (17.36)	oz-in (Nm)	min. [2]
8	rated and peak current,	Continuous, Rated	2054 (14.50)	oz-in (Nm)	min. [2]
9	lines 15 & 16 below.	Peak, Max w/o Saturation	7008 (49.49)	oz-in (Nm)	min. [1]
10	Drive current, and thus	Static Friction	69 (0.49)	oz-in (Nm)	max.
11	torque, may be lower.)	Ripple (of Rated Torque)	4.5	percent	min. [3]
12	Speed:	Rated	3000 (50)	rpm (rps)	reference
13		Maximum	3000 (50)	rpm (rps)	reference
14	Frequency	Rated	150	Hz	max.
15	Current:	Rated	15	A rms	max. [1]
16		Peak	45	A rms	nominal
17	Voltage:	Rated	230	V rms	reference
18		Max	250	V rms	maximum
19	Output Power:	Rated	4.5 (6.1)	kWatts (hp)	min. [1]
20	Inductance:	Terminal (line-line)	14	mH	± 30%
21	D.C. Resistance	Terminal (line-line)	0.647	Ohms	± 10 % [1]
22	Acceleration at Rated Torque		48945	rads/sec^2	Theoretical
23	Rotor Inertia		56.1 (1028)	oz-in^2 (kgm^2 $*$ 1E-6)	nominal
24	Damping		2.88 (0.020)	oz-in/krpm (Nm/krpm)	nominal
25	Weight		37 (16.8)	lbs. (kg)	max.
26	Winding Temperature		170°C (338°F) [4]	°C (°F)	max.
27	Winding Temperature Rise (Above Ambient) [1]		145°C (293°F)	°C (°F)	reference
28	Insulation Class		H	—	reference
29	Thermostat TRIP Temperature		170°C (338°F)	°C (°F)	± 5 °C
30	Thermostat RESET Temperature		135°C (275°F)	°C (°F)	± 5 °C
31	Dielectric Strength, (Winding-to-Frame)		1750	VAC	min.
32	Winding Capacitance to Frame		0.0038	µF	max.
33	IP Classification		65	rated	standard
34	Shaft: Radial-Play	At End	20E-6 (114E-9)	in/lb (m/N)	reference
		At Faceplate	7E-6 (40E-9)	in/lb (m/N)	reference
35	Material [5]		RC-#30		
36	Magnet Type		NdFeB		
37	Loading [6]	1000 rpm (17 rps)	243.5 (1,083)	lbs. (N)	max. [7]
		2000 rpm (33 rps)	193.3 (860)	lbs. (N)	max. [7]
		3000 rpm (50 rps)	168.8 (751)	lbs. (N)	max. [7]
		4000 rpm (67 rps)	N/A	lbs. (N)	max. [7]
		5000 rpm (83 rps)	N/A	lbs. (N)	max. [7]
38	Bearing Class, Internal/External		1/Class 3	ABEC/AFBMA	reference
39	Bearing Grease		SRI #2	Manufacturer	reference
40	Shaft Seal Pressure		3 (0.21)	psi (kg/cm^2)	max.
41	Basic Motor Design		3 phase wye connected 3(P/2)		
42	Stator Phase Sequence—CW rotor rotation		A-C-B (viewed from front face plate)		
43	Vendor/Supplier		Industrial Drives B-602-C		
44	Resolver Type/Accuracy		Single-Speed; Rotor-Excited; ± 10 arc min.		
45	Resolver Manufacturer/Model #		Fasco # 21-BRCX-335-J39		
46	Standard Resolver Cable Part Number		71-013862-xx		
47	Standard Motor Cable Part Number		71-013865-xx		
48	Options:	Brake—24VDC (0.93A)— 1130 oz-in(8.0 Nm) Holding Torque IP67 Classification Incremental Encoder Tachometer No Keyway			

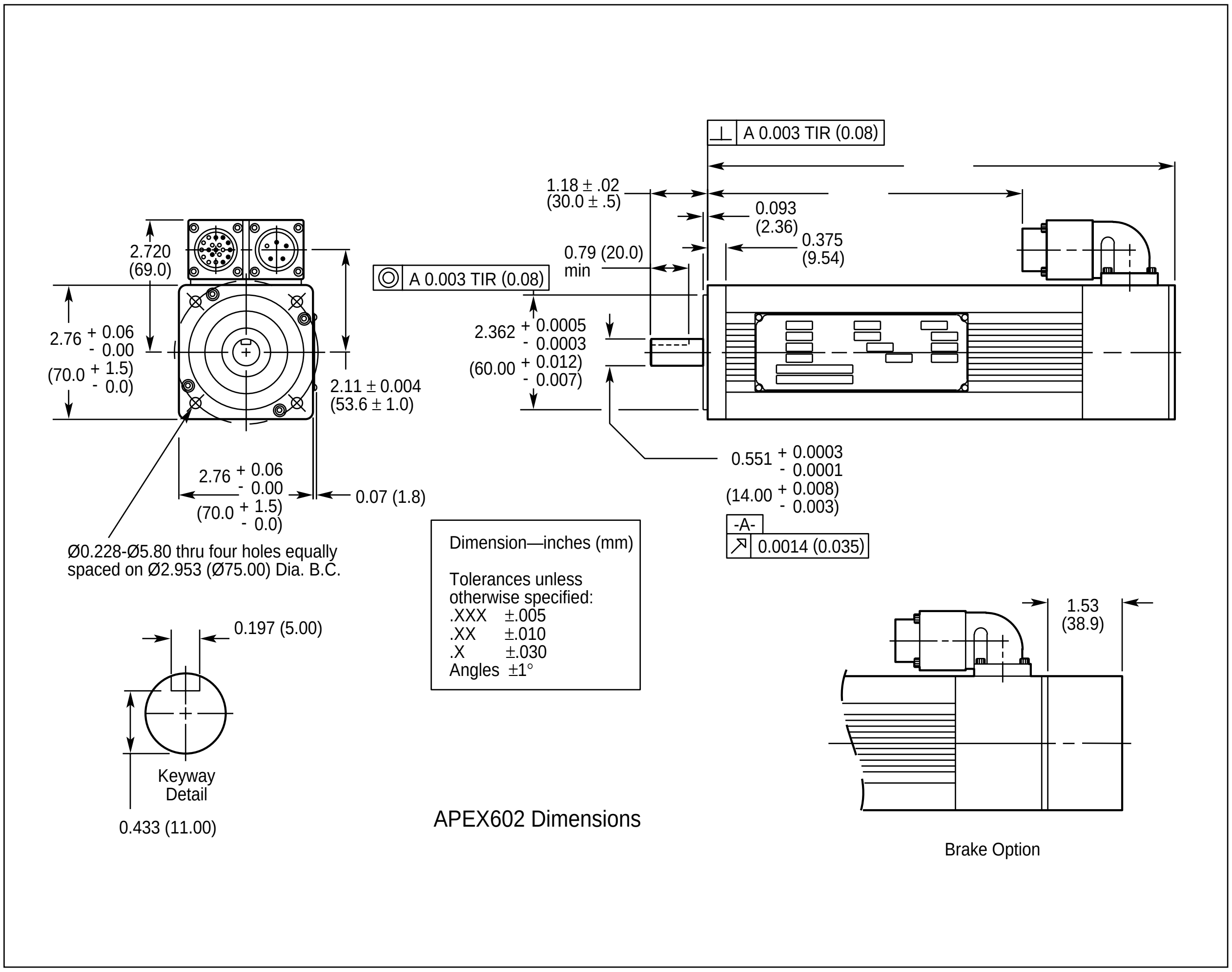
[1] 25°C (77°F) Ambient
[2] 40°C (104°F) Ambient
[3] Measured at 60 rpm (1 rps) in Velocity Mode
[4] Rated for 20,000 Hours or 40,000 Hours @ 155° C (311°F)
[5] Rotor steel is rated as fatigue proof
[6] Loads centered 1 inch from mounting flange
[7] Loads may be radial and axial such that the sum of the radial and two times the axial does not exceed this figure.
[8] Motor shaft is IP30 rated.

APEX Motor Specifications

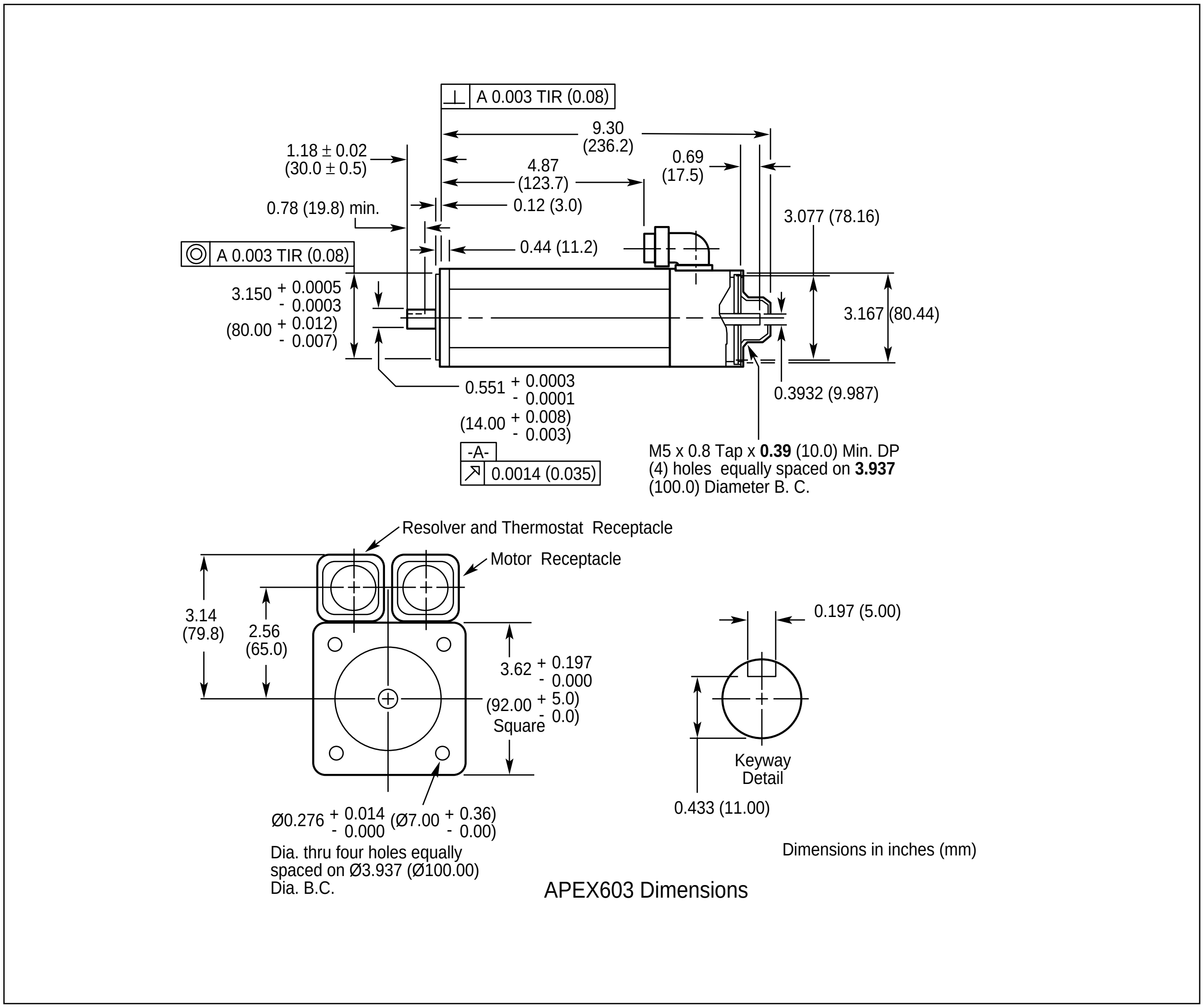
	Motor Size:	APEX640	Value	Units	Tolerance
1	Constant (s):	Torque	291.5 (2.06)	oz-in/A rms (Nm/A rms)	± 10%
2		Voltage (Sinusoidal)	124.5	V rms/Krpm	± 10%
3		Electrical Time	26.2	milliseconds	nominal
4		Mechanical Time	0.55	milliseconds	nominal
5		Thermal	33	minutes	nominal
6	Torque (s):	Continuous, Stall	4640 (32.76)	oz-in (Nm)	min. [1]
7	(NOTE: Values are with	Continuous, Stall	4378 (30.92)	oz-in (Nm)	min. [2]
8	rated and peak current,	Continuous, Rated	3955 (27.93)	oz-in (Nm)	min. [2]
9	lines 15 & 16 below.	Peak, Max w/o Saturation	12461 (87.99)	oz-in (Nm)	min. [1]
10	Drive current, and thus	Static Friction	73 (0.52)	oz-in (Nm)	max.
11	torque, may be lower.)	Ripple (of Rated Torque)	4.5	percent	max. [3]
12	Speed:	Rated	1600 (27)	rpm (rps)	reference
13		Maximum	1600 (27)	rpm (rps)	reference
14	Frequency	Rated	80	Hz	max.
15	Current:	Rated	15	A rms	max. [1]
16		Peak	45	A rms	nominal
17	Voltage:	Rated	230	V rms	reference
18		Max	250	V rms	maximum
19	Output Power:	Rated	4.7 (6.3)	kWatts (hp)	min. [1]
20	Inductance:	Terminal (line-line)	20	mH	± 30%
21	D.C. Resistance	Terminal (line-line)	0.763	Ohms	± 10 % [1]
22	Acceleration at Rated Torque		43667	rads/sec^2	Theoretical
23	Rotor Inertia		111.0 (2034)	oz-in^2 (kgm^2 * 1E-6)	nominal
24	Damping		15.36 (0.1085)	oz-in/krpm (Nm/krpm)	nominal
25	Weight		51 (23.2)	lbs. (kg)	max.
26	Winding Temperature		170°C (338°F) [4]	°C (°F)	max.
27	Winding Temperature Rise (Above Ambient) [1]		145°C (293°F)	°C (°F)	reference
28	Insulation Class		H	—	reference
29	Thermostat TRIP Temperature		170°C (338°F)	°C (°F)	± 5 °C
30	Thermostat RESET Temperature		135°C (275°F)	°C (°F)	± 10 °C
31	Dielectric Strength, (Winding-to-Frame)		1750	VAC	min.
32	Winding Capacitance to Frame		0.0082	µF	max.
33	IP Classification		65 [8]	rated	standard
34	Shaft:	Radial-Play At End	10E-6 (57E-9)	in/lb (m/N)	reference
		At Faceplate	4E-6 (23E-9)	in/lb (m/N)	reference
35		Material [5]	RC-#30	—	—
36		Magnet Type	NdFeB	—	—
37		Loading [6] 1000 rpm (17 rps)	255.6 (1,130)	lbs. (N)	max. [7]
		2000 rpm (33 rps)	N/A	lbs. (N)	max. [7]
		3000 rpm (50 rps)	N/A	lbs. (N)	max. [7]
		4000 rpm (67 rps)	N/A	lbs. (N)	max. [7]
		5000 rpm (83 rps)	N/A	lbs. (N)	max. [7]
38	Bearing Class, Internal/External		1/Class 3	ABEC/AFBMA	reference
39	Bearing Grease		SRI #2	Manufacturer	reference
40	Shaft Seal Pressure		3 (0.21)	psi (kg/cm^2)	max.
41	Basic Motor Design		3 phase wye connected 3(P/2)		
42	Stator Phase Sequence—CW rotor rotation		A-C-B (viewed from front face plate)		
43	Vendor/Supplier		Industrial Drives B-604-D		
44	Resolver Type/Accuracy		Single-Speed; Rotor-Excited; ± 10 arc min.		
45	Resolver Manufacturer/Model #		Fasco # 21-BRCX-335-J39		
46	Standard Resolver Cable Part Number		71-013862-xx		
47	Standard Motor Cable Part Number		71-013865-xx		
48	Options:	Brake—24VDC (1.27A)—6800 oz-in (48 Nm) Holding Torque IP67 Classification Incremental Encoder Tachometer No Keyway			

[1] 25°C (77°F) Ambient
[2] 40°C (104°F) Ambient
[3] Measured at 60 rpm (1 rps) in Velocity Mode
[4] Rated for 20,000 Hours or 40,000 Hours @ 155° C (311°F)
[5] Rotor steel is rated as fatigue proof
[6] Loads centered 1 inch from mounting flange
[7] Loads may be radial and axial such that the sum of the radial and two times the axial does not exceed this figure.
[8] Motor shaft is IP30 rated.

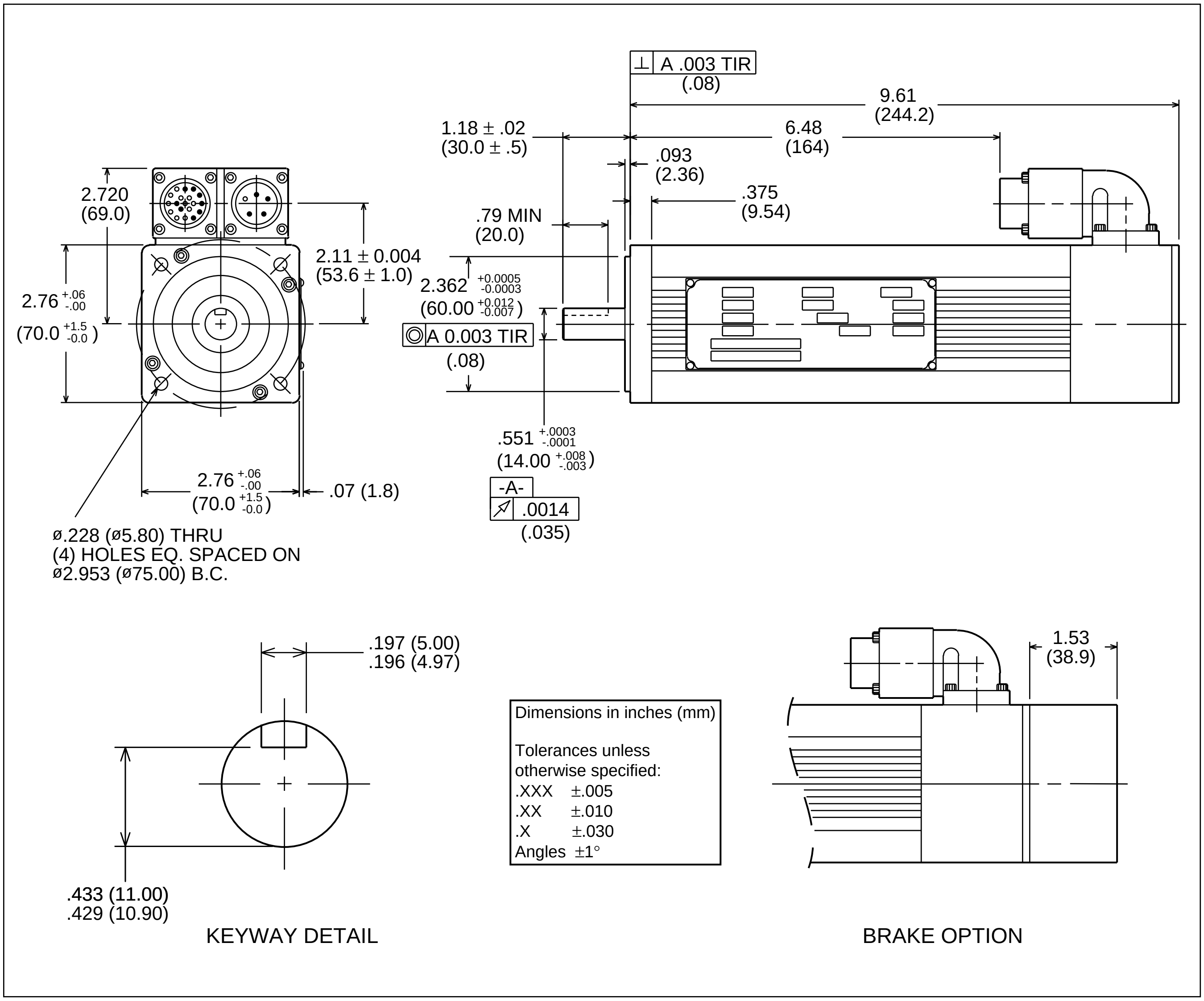
APEX MOTOR DIMENSIONS



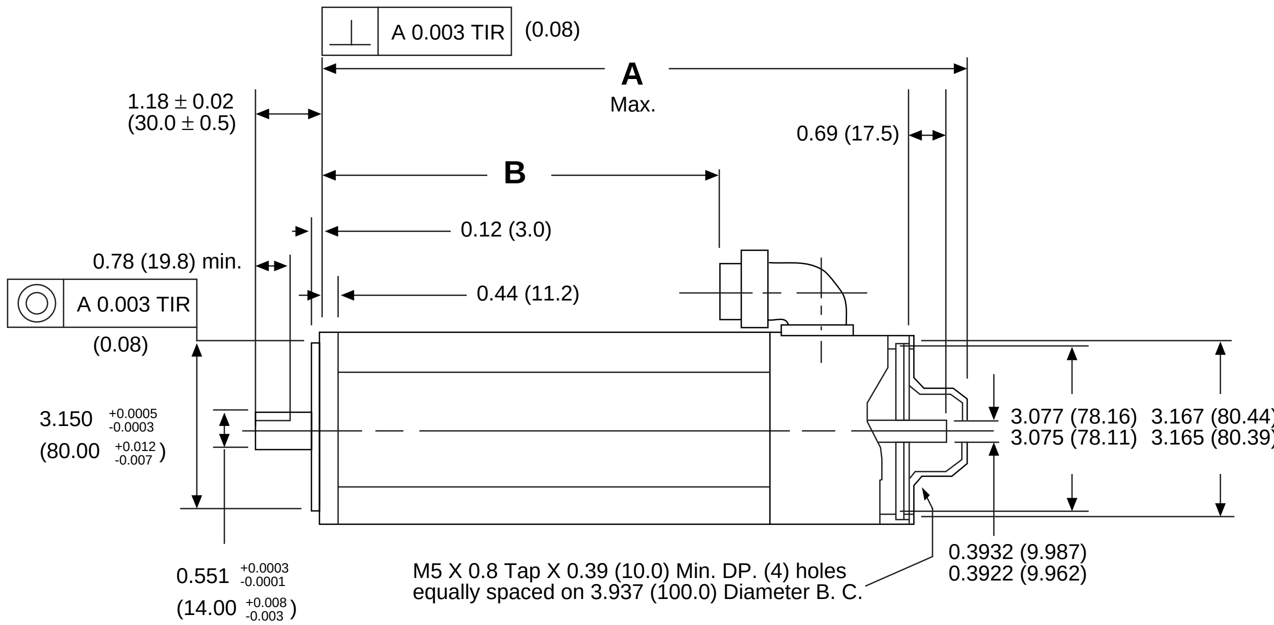
APEX602 Motor Dimensions



APEX603 Motor Dimensions

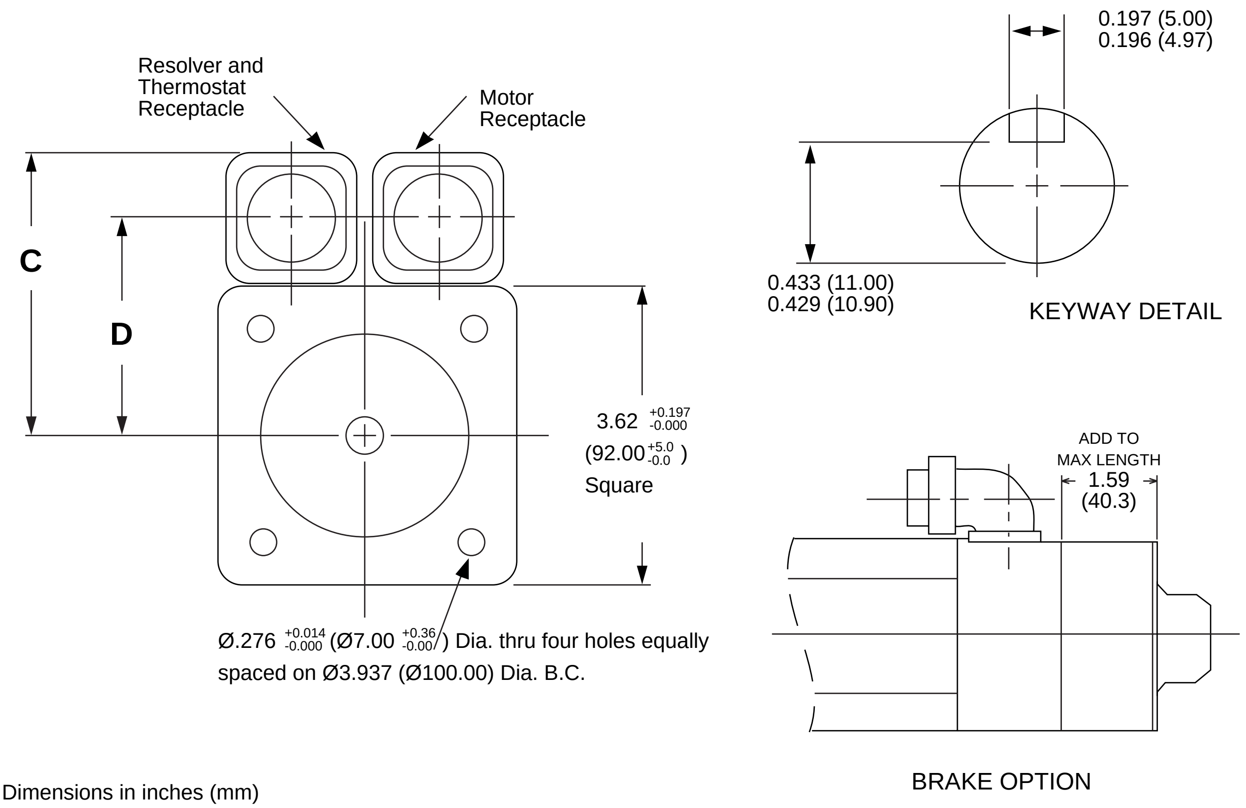


APEX604 Motor Dimensions



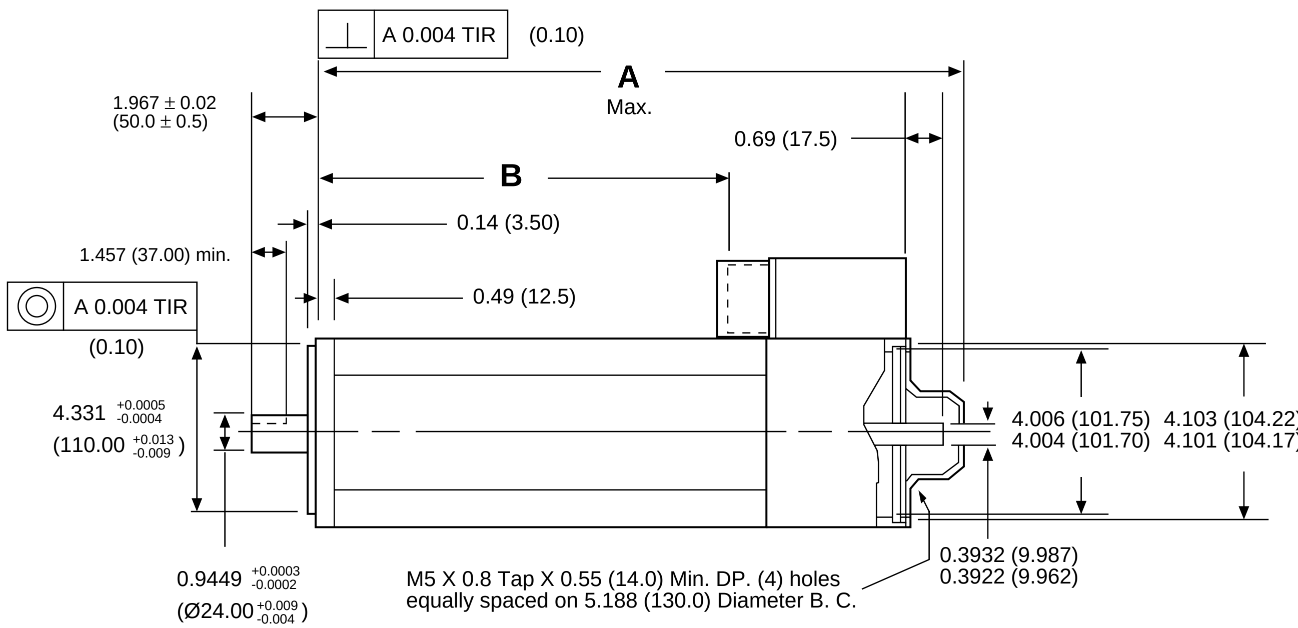
Motor	**A** Max	**B** ± 0.06 (1.5)
APEX605	9.30 (236.2)	4.87 (123.7)
APEX606	10.86 (275.8)	6.42 (163.1)
APEX610	12.42 (315.4)	7.23 (183.6)

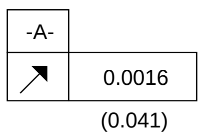
Motor	**C** Max	**D** Max
APEX605	3.14 (79.8)	2.56 (65.0)
APEX606	3.14 (79.8)	2.56 (65.0)
APEX610	3.42 (86.8)	2.62 (66.5)



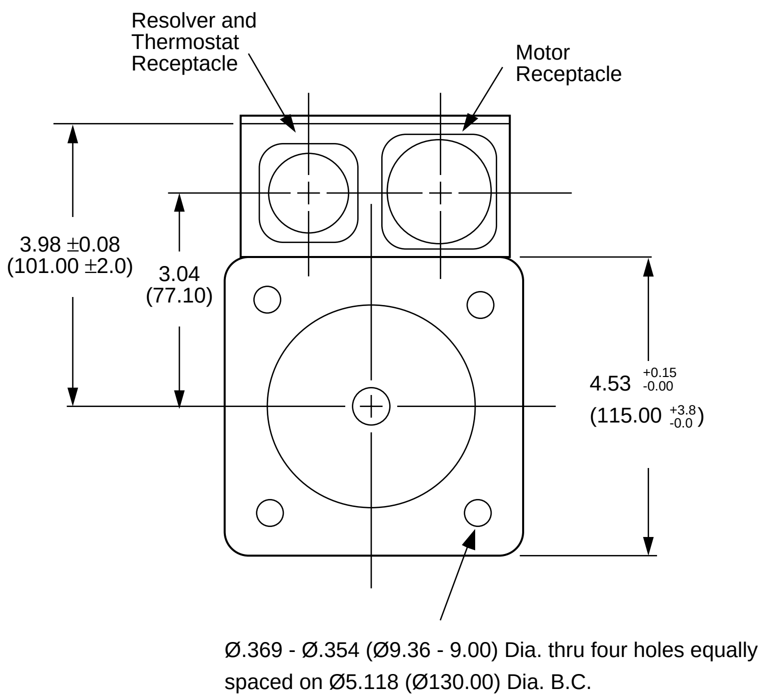
Dimensions in inches (mm)

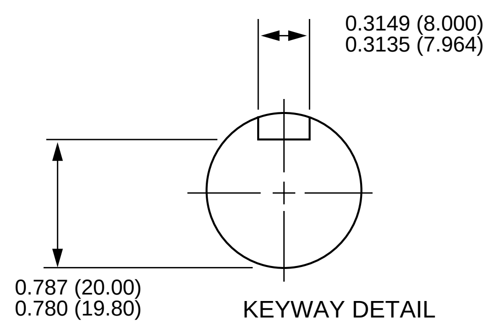
APEX605, APEX606, APEX610 Motor Dimensions



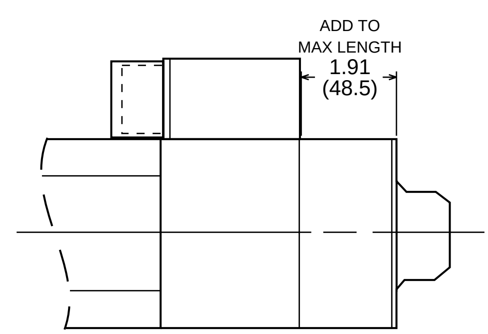


Motor	**A** Max	**B** ± 0.08 (2.0)
APEX620	12.55 (318.8)	8.30 (210.9)
APEX630	14.65 (372.1)	10.41 (264.3)





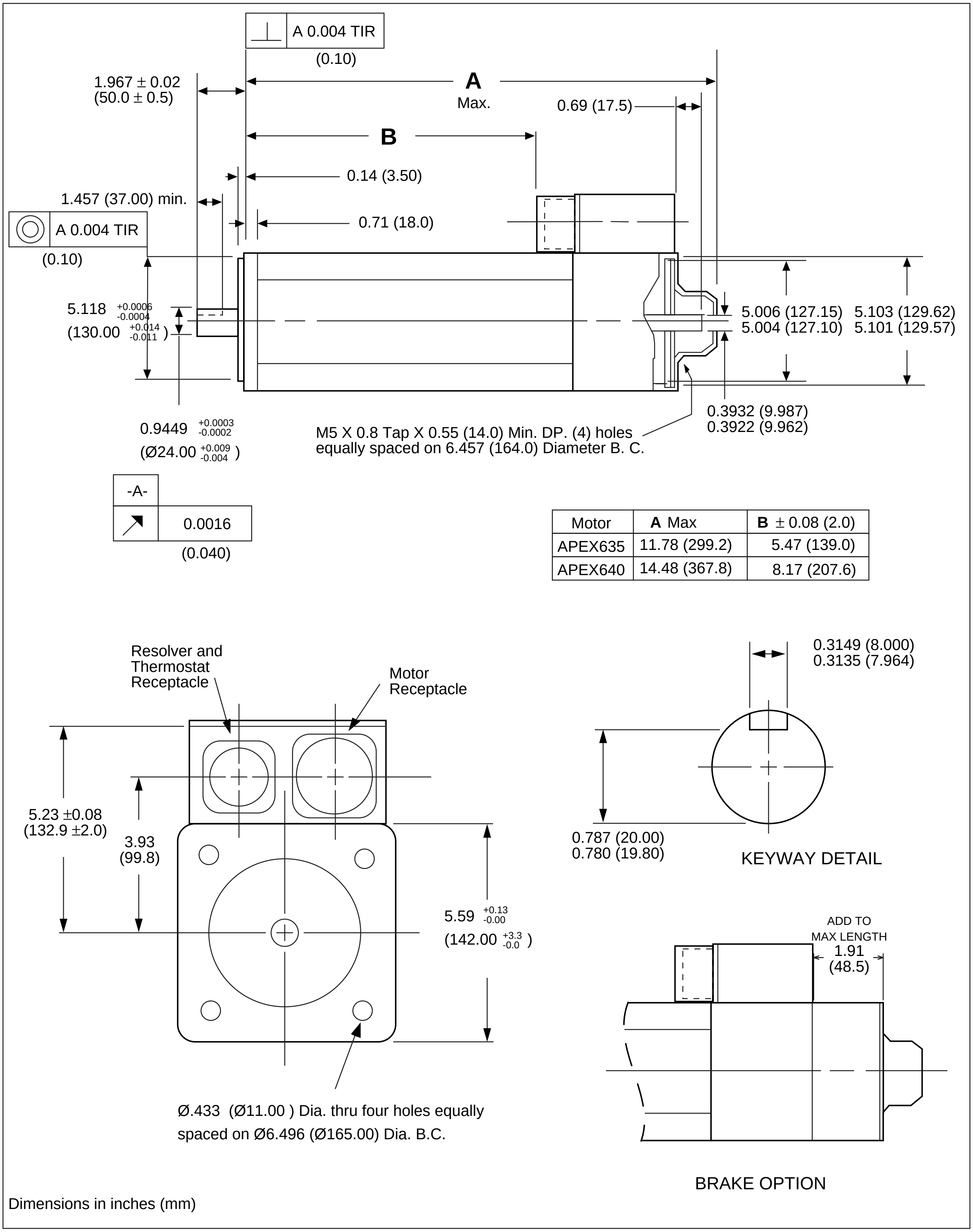
KEYWAY DETAIL



BRAKE OPTION

Dimensions in inches (mm)

APEX620 & APEX630 Motor Dimensions



Motor	**A** Max	**B** ± 0.08 (2.0)
APEX635	11.78 (299.2)	5.47 (139.0)
APEX640	14.48 (367.8)	8.17 (207.6)

APEX635 & APEX640 Motor Dimensions

Index

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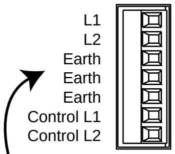
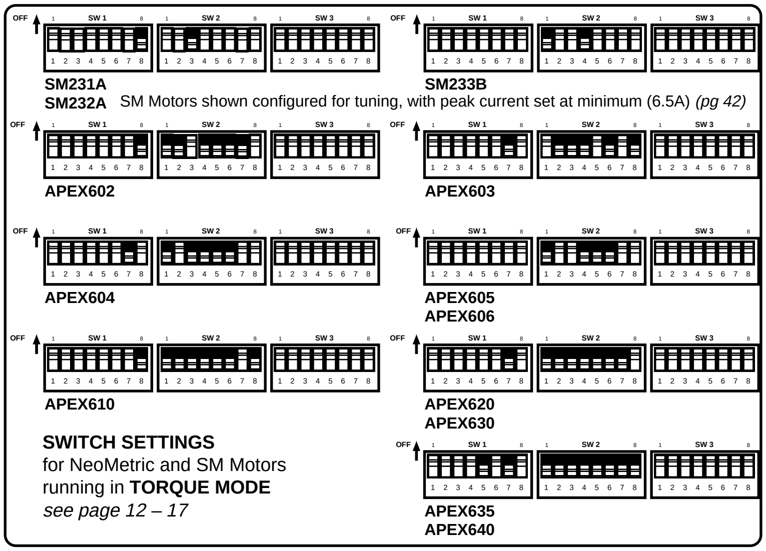
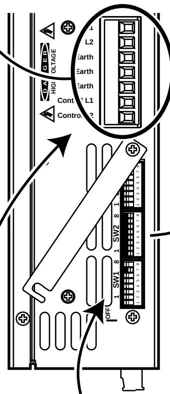
AC INPUT *– see page 31*
85— 252 VAC
47 — 66 Hz
Single-phase
L1 and L2 — Input for high-power amp.
Control L1 and Control L2 — Input for internal control logic



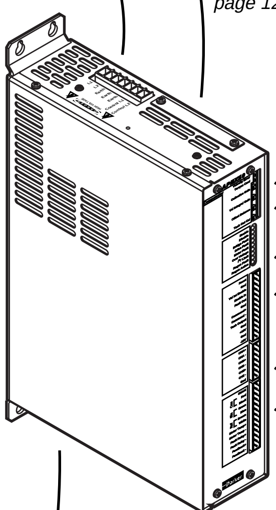


SWITCH SETTINGS
for NeoMetric and SM Motors running in **TORQUE MODE**
see page 12 – 17



AC Input Connector
page 31, 71

DIP Switches
page 12 – 17



Test Points *page 65*

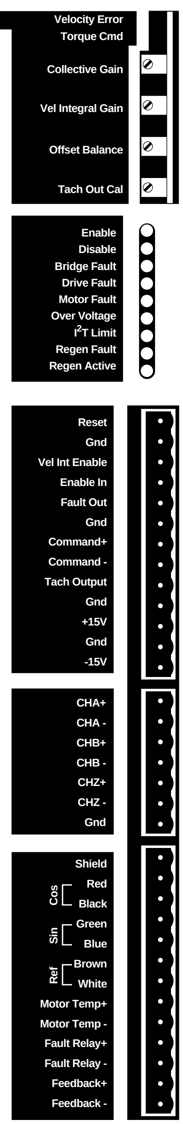
Pots *page 37, 49*

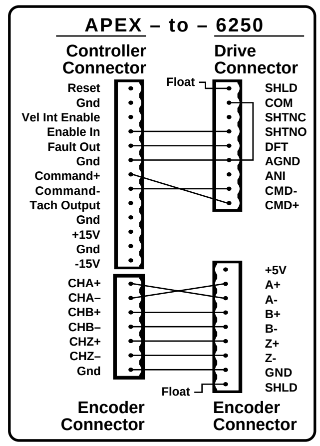
Status & Fault LEDs *page 97*

Controller Connector *page 39, 72*

Encoder/ Hall Connector *page 41, 76*

Resolver Connector *page 27, 78*





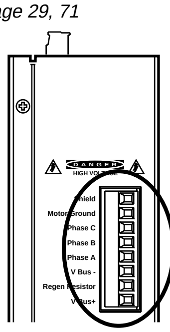
RESET INPUT	Active Low, <1.0V *page 39, 72*
VEL INT ENABLE	Active Low, <1.0V (DIP SW3-#1 ON) *page 48, 73*
ENABLE INPUT	Active Low, <1.0V *page 40, 73*
FAULT OUTPUT	Active HIGH (floats if fault occurs) (Output is held low if no fault) *page 40, 74*
COMMAND±	–10V = 16 amps Scale with DIP SW3 — pos. 6 & 7 *page 39, 74*
TACH OUTPUT	1V/1000 rpm; 1-speed resolver Scale by DIP SW3-#5 *page 38, 75*
±15V	15 mA at –15V *page 40, 75*
ENCODER OUTPUT	1024 counts/rev, pre-quadrature 4096 counts/rev, post-quadrature Ch A leads Ch B, for CW rotation Ch Z pulse width is 90¡ *see pages 41, 76 for more information*

RESOLVER CABLE: COLOR CODE

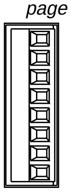
	Function	APEX Cable	SM Cable
	Shield	------	------
Cos	Stator 3	RED	RED
Cos	Stator 1	BLACK	BLACK
Sin	Stator 2	GREEN	GREEN
Sin	Stator 4	BLUE	BLUE
Ref	Rotor 1	BROWN	BROWN
Ref	Rotor 2	WHITE	WHITE
	Motor Temp+	YELLOW	YELLOW
	Motor Temp—	ORANGE	YELLOW

MOTOR TEMP±	Short Motor Temp+ and Motor Temp- if motor has no temperature sensor *page 28, 79*
FAULT RELAY±	Relay type: Normally Open Max Current: 5A at 24VDC/120VAC *see page 80 for more information* *see* Motor Braking *on page 54*

Motor Connector
(Underneath drive)
page 29, 71



MOTOR CONNECTOR
page 29, 71



Motor Cable Color Code *page 29, 56*

Terminal	APEX	SM
Phase A	Orange	Red/Yellow
Phase B	Blue	White/Yellow
Phase C	Gray	Black/Yellow
Motor Ground	Green	Green/Yellow