AUTOMOTION
INFRANOR GROUP COMPANY

ADDED NEW IMAGE

MODEL ACE500-XXXX

~~Hardware~~ User's Manual

Digital Velocity/Torque/Position Mode Servo Drive

This manual covers the use and maintenance of the model ACE500 series Torque, Velocity and Position mode brushless motor control product family.

READ ENTIRE USER MANUAL FIRST BEFORE ATTEMPTING TO USE THIS PRODUCT. DO NOT RETURN PRODUCTS WITHOUT OBTAINING PRIOR AUTHORIZATION DIRECT FROM AUTOMOTION.

This manual describes the installation and operation of the ACE500 series of digital high voltage servo-amplifiers manufactured by Automotion, Inc.

This document applies to serial numbers ending with xxxx 0106.

We reserve the right to modify our products at any time. Information, specifications, and material data that appear within this user manual are subject to change without notice. For the latest revision of this manual please check our web site at www.automotioninc.com or contact Automotion.

If you require further assistance, please email, call, or fax:

AUTOMOTION INCORPORATED®

P.O. Box 7746

Ann Arbor, MI USA 48107

(734) 662-7771

Fax #(734) 662-3707

www.automotioninc.com
sales@automotioninc.com

Revision History

Release Number	Date	Product	Comments
1.0	1/9/06 12/29/05	ACE500 Main Processor Ver. 50016000 ACE500 I/O Processor Ver. 50016100	Initial Proto Release Date
2.0	3/22/07	ACE500 Main Processor Ver. ACE500 I/O Processor Ver.	Production Release Date

Document Filename: ~~AXXXX.doc~~ change to A11056 ACE500 UM Rev 1.0 10-01-08.doc
Document Control #: ~~AXXXX~~ change to A11056

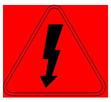
© Copyright 2006, 2007 Automotion Incorporated – All rights Reserved. Made in USA.
Windows® is a registered trademark of Microsoft Corporation.

Table of Contents

Table of Figures

1 Product Safety Precautions

Read this section and Section 1 before using the ACE500 series drive.



WARNING!

THIS PRODUCT USES HIGH VOLTAGE ELECTRICAL POWER. IT POSES A SHOCK HAZARD TO THE USER.

To operate your control successfully, these minimum safety precautions MUST be followed to insure proper performance without injury to the operator and damage to motor or control. **FAILURE TO OBSERVE THESE SAFETY PRECAUTIONS COULD RESULT IN <u>SERIOUS BODILY INJURY</u>, INCLUDING DEATH IN EXTREME CASES.**

1. DO NOT touch any of the output connector pins in connectors P1, P2, or P3 when power is applied. The voltages at these connector pins are dangerous and can produce an electric shock. Bare wires from adjacent connector pins must never be allowed to touch one another. P1, pin 1, must be connected to an external earth ground. Follow wiring procedures carefully. Know and understand which connectors are NOT electrically (galvanically) isolated from the AC/DC voltages within the drive.

2. Always operate the control within the prescribed voltage limits.

3. Each model has dangerous voltages on the circuit boards and stores a high voltage charge after being disconnected. **DO NOT REMOVE THE COVER IF ONE IS IN PLACE. DO NOT ATTEMPT TO SERVICE THIS PRODUCT IF A PROBLEM OCCURS**.

4. Do not parallel multiple motors off of the same control.

5. Under no circumstances must a phase output from the control be connected to anything other than a passive inductive/resistive motor load. See manual for minimum inductance requirements. Short circuit protection for the drive is limited to momentary conditions only! Repetitive short circuits on any of the output pins for P3 will likely cause permanent damage to the ACE.

6. Excessive speed and current can destroy some DC brushless motors and possibly injure the user. Check the motor manufacturer's specifications to ensure the maximum current and voltage output for your control model does not exceed their limitations.

7. External methods are advisable to limit both the top speed and travel motion of the motor and its load. Whenever the ACE drive is disabled for any reason, the motor is placed into a free/spinning coast mode.

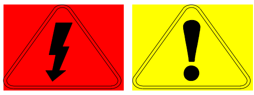
8. Do not remove the connectors on ports J2, J3, P1, P2, or P3 from the control while the motor is operating.

9. Read Automotion's Life Support Policy in Section 1.1 for application limitations.

10. To avoid a shock hazard always wait at least 5 minutes <u>after</u> disconnecting power from P1 before physically handling or touching any internal circuit boards. Use a voltmeter to be certain that all high voltage capacitors inside the ACE are fully discharged before physically handling or touching the internal circuit boards.

11. Follow precautionary guidelines in this manual with regard to proper installation of an external shunt resistor. See Sections 1.0 and ~~4.1.6~~ 6.6.

12. Do NOT operate the ACE in the vicinity of flammable or explosive materials. Do NOT use the ACE in environments where it is likely to be exposed to strong and/or frequent static discharge. See Section 1.0 for additional details.



READ THIS <u>ENTIRE</u> SECTION BEFORE ATTEMPTING TO USE THE ACE500 SERVO DRIVE! GIVE SPECIAL ATTENTION TO ALL BOLD PRINT ITEMS.

To operate the ACE500 successfully, these safety precautions MUST be followed to reduce the risk of injury to the operator and damage to motor or ACE500 control.
Failure to observe all safety precautions could result in serious bodily injury, including death in extreme cases.

1.1 LIFE SUPPORT POLICY

Automotion's products are not authorized for use as critical components in life support devices or systems without the express written approval of the President of Automotion Incorporated.

As described herein:

Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided in the User's Manual and in the labeling, can be reasonable expected to result in a significant injury to the user.

A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

1.2 Other safety issues

1.2.1 The ground on P1, pin 1, MUST always be connected to an appropriate external earth ground during use of the ACE. There is also a chassis ground stud located on the lower end of the ACE. This must be connected to a appropriate external earth ground.

1.2.2 If the ACE does not seem to function correctly, first consult section titled ``Troubleshooting." If this fails to solve the problem, ~~call~~ contact AUTOMOTION.

1.2.3 Always operate the ACE within the prescribed voltage limits. Any attempt to operate outside these bounds may result in damage to the ACE control.

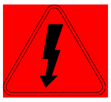
1.2.4 DO NOT LOCATE ANY ACE IN A POSITION WHERE IT WOULD HAVE CONTACT WITH LIQUIDS, WATER CONDENSATION, CORROSIVE CHEMICALS OR WHERE FOREIGN MATERIALS WOULD BE ALLOWED TO FALL INTO AND COLLECT INSIDE THE ACE.

1.2.5 DO NOT MOUNT THE ACE DIRECTLY UPON OR NEAR FLAMMABLE MATERIALS.

1.2.6 DO NOT OPERATE THE ACE IN AN EXPLOSIVE ATMOSPHERE OR IN THE VICINITY OF EXPLOSIVE MATERIALS. KEEP THE INSTALLATION VENTILATED SO THAT CLEAN FRESH AIR CAN MOVE FREELY THROUGH AND AROUND THE ACE ENCLOSURE.

1.2.7 Avoid frequently plugging connector P1 into the control while live power is applied to the connecting cables. Ignoring this precaution will cause electrical arcing at the connector pins which can cause permanent connector damage. AUTOMOTION recommends using a disconnect switch ahead of P1 to minimize contact arcing if the ACE must be disconnected often.

1. 1.2.8 Keep external shunt resistor far away from flammable materials. Read Sections ~~4.1.6 and 11~~ 1.0 and 6.6 carefully for more shunt installation details.



WARNING!

HIGH VOLTAGE MAY BE PRESENT AT THIS CONNECTOR.

1.2.9 If the user adds supplemental external capacitance via terminal P2 provisions should be made by the user to rapidly bleed this high voltage energy down to safe levels whenever the user's power source is disconnected from the system. Bleeder resistors are frequently used for this purpose. It will be necessary for the user to size this discharge method appropriately. The objective is to reduce the motor rail voltage down to safe levels (generally below +40 Volts DC) within an acceptable time period after the user's external power source is turned off or disconnected.

The remainder of this page is intentionally left blank.

2 Unpacking and Repacking the ACE500

When your package arrives, inspect the shipping box and the unit carefully, and save ALL packing materials. Contact the carrier promptly if damage is discovered. Your ACE500 has arrived carefully packaged from Automotion in an antistatic bag. As you unseal this bag inspect the contents carefully. There should not be any loose or damaged parts inside.

Compare the packing slip against all items included in the box. Any shortages or other inspection problems should be reported to AUTOMOTION immediately.

Never attempt to operate or power-up the ACE500 if there is any visible external damage or if it sounds as though there are loose materials inside the chassis. While unpacking, if you discover any loose or damaged parts, notify AUTOMOTION within two working days.

AUTOMOTION recommends that all packing materials be saved in case the ACE500 ever needs to be shipped again. Always place the ACE500 in the same antistatic bag used in the original shipment. Abundant anti-static filler material should always be placed around the ACE500 bag so that it cannot shift inside the box. Extreme care should be exercised when placing packing material around all external connectors to prevent mechanical stress damage.

All material to be returned to AUTOMOTION must have a Return Material Authorization (RMA) tracking number assigned before shipment. This may be obtained by contacting the AUTOMOTION Service Dept. Any product returned without this number will be rejected by AUTOMOTION.

Always insure your shipment for the proper replacement value of its contents. AUTOMOTION will not assume responsibility for any returned goods that have been damaged outside of our factory because of improper packaging or handling. All goods shipped to AUTOMOTION must be shipped FREIGHT PREPAID.

3 ACE500 Introduction

3.1 Amplifier

The ACE500 is a fully digital servo amplifier that uses DSP technology to provide a powerful feature set that is fully configurable by means of a RS232 serial port. The ACE500 servo drive is configurable as a Torque, Velocity, or Position mode servo amplifier. The ACE500 is designed to operate a single 3 phase Brushed or Brushless DC or AC, permanent magnet motor. The motor may have either a WYE or Delta wound stator. The ACE500 provides commutation using Hall sensors or encoder feedback.

Principal features of this product:

- User configurable operation modes: Torque, Velocity, Position.
- Selectable BLAC (sine wave, flux vector) or BLDC (Six step, trapezoidal) commutation.
- 4 Quadrant performance.
- 3 Phase output, PWM controlled output.
- Full digital control of all loops
- Variable servo rate from up to 10 kHz.
- Loop tuning via serial interface (No ~~pots~~ potentiometers!).
- Drive setup & status information available serially via RS232 link.
- 90 – 254 VAC input power supply range.
- Output current of 5 Amp continuous, 15 Amp peak.
- Compact package size.
- ***AutoMotionPLUS©*** Graphical Windows Interface for Set-up, Configuration and Tuning.

The ACE500 cCurrent, vVelocity or Position modes accept +/- 10 volt DC analog or digital PWM.

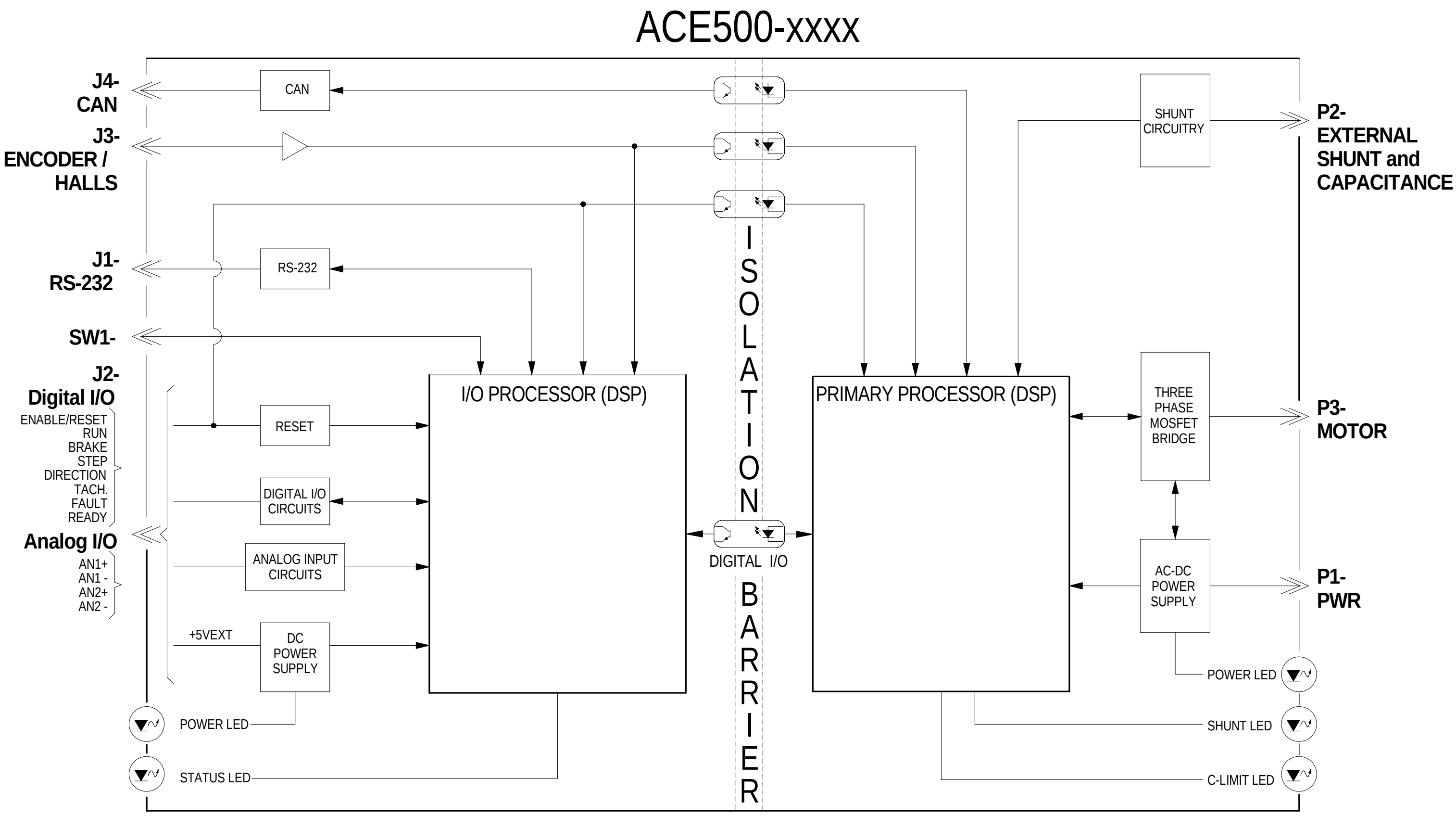
3.2 Theory of operation

The ACE500 operates as a “mode configurable” digital servo amplifier. This product is typically applied as a component within an end use industrial application. Within industry, application requirements for servo amplifiers vary widely. For example, one application may require an amplifier with an analog input reference for speed. Another application may require an amplifier that offers torque control and Hall sensor commutation only. For this reason the ACE500 offers a choice of many different servo-operating modes. This flexibility is made possible because all of the control functions within the ACE500 are implemented in software. The ACE500 physical I/O and closed loop functionality are selected using the *AutoMotionPLUS* Windows Setup utility. See Section 4, Introduction to the *AutoMotionPLUS* software, and the *AutoMotionPLUS* software User Manual for additional information on using this software.

The internal firmware architecture of the ACE500 is modular. ACE500 software is built as a series of components (or modules) that are linked together to form an ACE500 servo-operating mode. ACE500 software components are stored in ROM memory as a run time library. These components exist as Reference input modules, Feedback modules, PI (D) control modules, commutation modules and firmware extension modules. A detailed list of these components is found in Section 4 of this manual.

3.3 Simplified ACE500 block diagram

This following diagram is provided to familiarize the user with the internal architecture of the ACE500. An internal digital signal processor (ASIC) is used to read I/O signals, motor feedback signals and to process serial communication messages. ROM memory inside the ACE500 is used to store a library of modular software components. RAM memory is used for data logging and graphical tuning of the ACE500. The serial EEPROM provides nonvolatile memory for retention of user-configured parameters and operating mode. EEPROM memory is also used to extend the program functionality of the ACE500.



Move text below closer to diagram

Figure 1: ACE500 Block Diagram

3.4 ACE500 I/O.

Drive specific I/O operates independent of the user selected operating mode. Dive specific I/O signals have fixed functionality. These signals are used to interface the ACE500 to an outside control system. They provide “hand shaking” signals for enabling, disabling, and monitoring the status of the ACE500. For physical reference to the ACE hardware see Figure 2 below.

Connector J1 – RS232 Communications Port, RJ-11, 6 Pin Connector

Pin	I/O	Description
1	N/C	No Connect.
2	TX	RS232 TXD Output, RS232 signal level.
3	GND	COMMON
4	RTS	RS232 RTS Output, RS232 signal level.
5	RX	RS 232 RXD Input, RS232 signal level.
6	CTS	RS 232 CTS Input, RS232 signal level.

Connector J2 – User I/O Control, DB25 Plug with metal shell

Pin	I/O	Description
1	Input	+ 5 volts DC Power. User supplied regulated +5VDC power. 250 mA.
2		COMMON Return
3	Input	+ 5 volts DC Power. User supplied regulated +5VDC power. 250 mA
4	Input	COMMON Return
5	Input	Enable/Reset Control Signal Input. TTL compatible. +24 VDC maximum signal amplitude. 0 Volts minimum. 10K Ohm input impedance. Positive true logic. Forces a master hardware reset for entire drive on a falling edge. Drive recovers beginning after rising edge. Drive remains disabled while a logic “0” is applied to this input. When Enabled (logic “1” applied), the active inrush current limit relay will close after a 3 second delay. After this delay, the drive will be allowed to enter Run Mode as commanded by the Run Command Signal Input on pin 6.
6	Input	Run Command Signal Input. TTL compatible. +24 VDC maximum signal amplitude. 0 Volts minimum. 10K Ohm input impedance. Positive true logic. A logic “1” state will allow motor commutation once some level of current is commanded. A logic “0” state places motor into a coast state.

7	Input	Dynamic Brake Command Signal Input. TTL compatible. +24 VDC maximum signal amplitude. 0 Volts minimum. 10K Ohm input impedance. Positive true logic. A logic “1” state will suspend motor commutation and current delivery from drive. It shorts all three motor phases together to cause the motor’s BEMF to generate a dynamic braking torque within the motor.
8	Input	General Purpose Digital Input. TTL compatible. +24 VDC maximum signal amplitude. 0 Volts minimum. 10K Ohm input impedance. This input function is application specific. *Or* I2C Clock Input. 0V - +5V input signals
9	Input	General Purpose Digital Input. TTL compatible. +24 VDC maximum signal amplitude. 0 Volts minimum. 10K Ohm input impedance. This input function is application specific. *Or* I2C Data Input. 0V - +5V input signals
10		COMMON Return.
11	Input	Step or PWM Input; 0 to +5 VDC logic signal. TTL compatible. 10K ohm internal pull down. Used in step and direction mode. Used with direction input.
12	Input	Direction Input; Zero to +5 Volt logic signal. TTL compatible. +5.5 VDC maximum signal amplitude. 0 Volts minimum. 10K Ohm internal pull down. Selects relative direction of “Step” command.
13		Analog COMMON.
14	Input	AN1+ Differential Input; Zero to ±10 Volt external command signal input. The polarity of this signal controls the relative applied direction of output motor torque. Input is protected to ±24 Volt maximum.
15	Input	AN1- Differential Input; Zero to ±10 Volt external command signal input. The polarity of this signal controls the relative applied direction of output motor torque. Input is protected to ±24 Volt maximum.
16		COMMON Return.
17	Input	AN2+ Differential Input; Zero to ±10 Volt external command signal input. The polarity of this signal controls the relative applied direction of output motor torque. Input is protected to ±24 Volt maximum.
18	Input	AN2- Differential Input; Zero to ±10 Volt external command signal input. The polarity of this signal controls the relative applied direction of output motor torque. Input is protected to ±24 Volt maximum.
19	Output	General Purpose Digital Output. TTL compatible. +24 VDC maximum signal amplitude. 0 Volts minimum. 10K Ohm input impedance. This output function is application specific.
20		COMMON Return.
21	Output	Tachometer Signal Output. 250 Ohm output impedance. Zero to +5 Volt logic signal.
22	Output	General Purpose Digital Output. TTL compatible. +24 VDC maximum signal amplitude. 0 Volts minimum. 10K Ohm input impedance. This output function is application specific.
23	Output	!remove **exclamation mark** Fault Signal Output. 250 Ohm output impedance. Zero to +5 Volt logic signal. Negative true output signal. Logic “1” state indicates drive is NOT in a Fault mode.
24	Output	Ready Output; 0 to +5 VDC logic signal. Logic 0 when drive is in “Standby” or “Reset”. Logic 1 when drive is in “Run” mode and ready to deliver current.

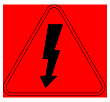
25		Frame Ground (OPTIONAL). Factory option to connect to servo drive frame. Its configuration for this purpose may violate certain safety agency requirements. Consult Automotion.
Shell		J1 Connector Frame. Connector shell is connected to servo frame ground.

Connector J3 – Motor Feedback Signals, DB15 receptacle type with metal shell

Pin	I/O	Description (for Hall based system)
1	Input	Hall signal Input S1.
2	Input	Hall Signal Input S2.
3	Input	Hall Signal Input S3.
4		+5 Volt DC Hall/Encoder supply voltage.
5		COMMON.
6	Input	A Encoder Signal Input.
7		!A Encoder Signal Input.
8		COMMON.
9	Input	B Encoder Signal Input.
10	Input	!B Encoder Signal Input.
11		Factory Optional Servo Frame Ground. Normally this pin is not connected.
12	Input	Z Encoder Signal Input.
13	Input	!Z Encoder Signal Input.
14		PTC/thermal switch contact for motor temp sensing.
15		PTC/thermal switch contact for motor temp sensing.
Shell		J2 Connector Frame. Connector shell is connected to servo frame ground.

Connector J4 (Optional) – CAN Communications Ports (2), RJ45 receptacle type

Pin	Description
1	CAN HI. CAN Bus Communication.
2	CAN LOW. CAN Bus Communication.
3	COMMON Return.
4	NO CONNECT
5	NO CONNECT
6	CAN SHIELD
7	CAN GROUND
8	+ 5 V
NOTE	Connectors are wired in parallel, same pin out for both connectors



WARNING!

THIS PRODUCT USES HIGH VOLTAGE ELECTRICAL POWER. IT POSES A SHOCK HAZARD TO THE USER. A SHOCK FROM HIGH VOLTAGE ELECTRICAL POWER MAY CAUSE SEVERE INJURY AND/OR DEATH IN EXTREME CIRCUMSTANCES.

The connectors shown below have High Voltage power applied to several of the associated pins. Use extreme care when making wire connections to them. All external electrical power should be OFF whenever wiring to these connectors to avoid a shock hazard.

Connector P1 – AC/DC Power Input, Phoenix type plug-able connector

Pin	Description
1	AC Input. 90 to 254 VAC, 50/60 Hz, 1 Phase AC or ±120 to 360 Volts DC.*
2	AC Input. 90 to 254 VAC, 50/60 Hz, 1 Phase AC or ±120 to 360 Volts DC.*

* These are UL operating voltage ranges at peak currents. Contact Automotion for application assistance for operating outside these specified ranges.

Connector P3 – Motor Phase Output, Phoenix type plug-able connector

Pin	Description
1	Motor Phase 1 Output. Peak voltage out of this terminal is dependant upon the incoming crest voltage on connector P1. Peak amperage is model dependant.
2	Motor Phase 2 Output. Peak voltage out of this terminal is dependant upon the incoming crest voltage on connector P1. Peak amperage is model dependant.
3	Motor Phase 3 Output. Peak voltage out of this terminal is dependant upon the incoming crest voltage on connector P1. Peak amperage is model dependant.

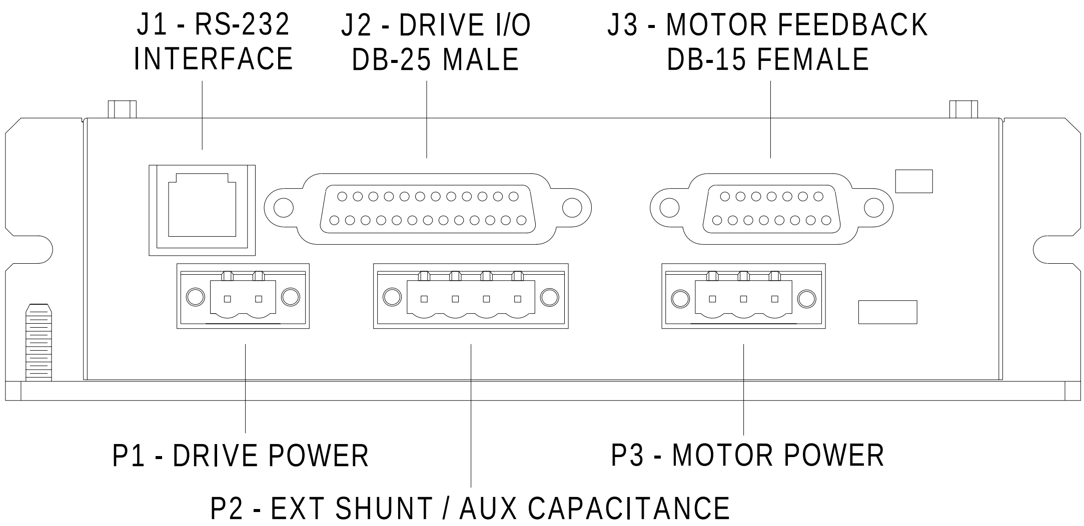
WARNING!

WHEN THIS PRODUCT USES AN INTERNAL OR EXTERNAL SHUNT RESISTOR, PRECAUTIONS MUST BE FOLLOWED TO PREVENT A POSSIBLE FIRE HAZARD.

The use of shunt resistor, either internal or external, requires careful placement to avoid a possible fire hazard. Never place the shunt resistor in the vicinity of flammable or explosive materials. See this manual for further precautionary details.

Connector P2 – External Shunt Resistor/External Supplemental Capacitors, Phoenix type plug-able connector. See 6.3 mating connectors.

Pin	Description
1	Shunt Resistor. Connection for external user supplied shunt resistor. The other side of the external shunt resistor connects to terminal 2 or 3.
2	B+ Motor Rail. High Voltage DC positive rail for motor power. This terminal is used for connecting external supplemental capacitance and/or an external user supplied shunt resistor. Peak voltage at this terminal.
3	B+ Motor Rail. High Voltage DC positive rail for motor power. This terminal is used for connecting external supplemental capacitance and/or an external user supplied shunt resistor. Peak voltage at this terminal.
4	B- Motor Rail. High Voltage DC negative rail for motor power. This terminal is used for connecting external supplemental capacitance supplied by user.



Move text below closer to diagram

Figure 2: ACE500 Connector Layout

3.5 ACE500 Status LEDs

3.5.1 Stat LED (User side - Yellow)

FLASH CODE	DESCRIPTION	POSSIBLE CAUSE	RESULT	RECOVERY METHOD
ON Steady	ACE500 is in RUN mode.	User commanded RUN mode via user interface or RS232 port.	Commanded power delivered to motor	NA
OFF	Processor is in reset or programming state.	Enable line low. CTS line on RS232 port is high.	Drive inoperable	Set enable line low and CTS line high.
16 Rapid flashes	Line side processor inoperable.	Line side processor not programmed, programmed incorrectly, or hardware problem.	Drive inoperable.	Flash new program into line side processor.
1	Drive is in Standby mode	The drive will not deliver current to the motor.	Motor phases not connected to drive.	Command RUN mode via RUN line.
moveup 2	Phase short.	Phase shorted or low impedance.	Drive placed in standby.	Correct short and toggle the RUN line.
moveup 3	1.8 Volt Fault.	Hardware or line power problem.	The drive is placed in standby mode.	Correct power problem and toggle the RUN line.
Font 10 4	5 Volt Fault or 15 Volt Fault.	Hardware or line power problem.	The drive is placed in standby mode.	Correct power problem and toggle the RUN line.
Font 10 5	~~15 Volt Fault.~~ PM or MT	~~Hardware or line power problem.~~ Power module damaged or motor temp. high.	The drive is placed in standby mode and faults.	Correct ~~power problem~~ over temperature and toggle the RUN line.
moveup 6	B+ Low.	Hardware or line power problem.	The drive is placed in standby mode.	Correct power problem and toggle the RUN line.
moveup 7	B+ High	Hardware or line power problem, or too much regeneration, due to aggressive deceleration.	The drive is placed in standby mode.	Correct problem and toggle the RUN line.
moveup 8	Shunt Fault	Shunt is on continuously longer than 5 seconds.	The drive is placed in standby mode.	Toggle the run line. If repeated faulting occurs, consider selecting a larger shunt.
9	Power Module Fault		The drive is placed in standby mode.	Toggle the RUN line.
10	Memory Fault	Either line side processor program checksum fault or new version installed on line side processor.	The drive is placed in standby mode.	Either follow instructions for installing new firmware or reprogram processor and then toggle the RUN line.
11	Locked Rotor Fault	Delivered current exceeded locked rotor current for a period exceeding selected safe limit without a new Hall state.	The drive is placed in standby mode.	Change locked rotor parameters or free motor and toggle RUN line.

12	Line Side Communications Fault	Hardware problem or software timing problem causing loss of communication detected by line side.	The drive is placed in standby mode.	Toggle RUN line or toggle Enable line, then RUN.
15	SELV 5 Volt Fault.	Incorrect user supplied 5 Volt supply.	The drive is placed in standby mode.	Correct user supply and toggle RUN line.
10	SELV side Communications Fault	Hardware problem or software timing problem causing loss of communication detected by SELV side.	The drive is placed in standby mode.	Toggle RUN line or toggle Enable line, then RUN.

Note 1: To toggle the run command set the Run/! Standby signal logic '0' state for 100mS, then back to a logic '1'. ALL ON ONE LINE

3.5.2 Power LED (User side - Green)

LED	Description	Possible Cause	Result	Recovery Method
ON	+5 VDC Power Indicator	On if user power is on	Required to Run	N/A
OFF	+5 VDC Power Indicator	No user supplied +5 volts	Drive will not Run	Apply +5volts

3.5.3 Power LED (Line side - Green)

LED	Description	Possible Cause	Result	Recovery Method
ON	+5 VDC Power Indicator	Logic power is on	Required to Run	N/A
OFF	+5 VDC Power Indicator	Logic power is not on	Drive will not Run	Check AC power

3.5.4 Current limit status LED (Line side – Red)

LED	Description	Possible Cause	Result	Recovery Method
ON	Steady State	Drive in Reset		Toggle the DRIVE ENABLE signal
ON	During Power Up	Soft Charge (Relay Opened)		Allow 5 second power-up delay to allow internal capacitors to charge.
OFF		N/A	Soft Charge Complete (Relay Closed)	N/A
DIM	Flickering – Drive current limit	Current is sensed to be more than the calibrated drive capacity		N/A

3.5.5 Shunt status LED (Line side -Yellow)

LED	Description	Possible Cause	Result	Recovery Method
ON		B+ Rail is high, above the Shunt turn on limit of 390V	The shunt resistor is turned on	
OFF		B+ Rail is below the shunt turn off limit of 375V	The shunt resistor is turned off	

The remainder of this page is intentionally left blank.

**********No more changes until page 41 Micky*********

4 Introduction to the *AutoMotionPLUS©* software:

The *AutoMotionPLUS* software can be used to:
- …Configure the Drive's Operation Mode.
- …Configure the Drive for operation of different motors.
- …Tune the Position, Velocity and Current control loops.
- …Save and Load parameter files to and from the drive.
- …Graph application variables like Velocity, Position, Current and Motor Voltage.
- …Update the Drive's internal firmware.

The following sections are intended to familiarize the user with the basic operation of this software only. A complete user manual for the Automotion Plus software is still under development at Automotion.

About Parameters and Variables:
Drive parameters are used to configure the drive for different operating modes and to tune the control structure that each operating mode presents. Variables are internal values that change while the Drive is running. For example, "Position Proportional Gain" is a parameter and motor "Position" is a variable. Parameters can be changed using the different parameter screens available in the Automotion Plus program. Variables can NOT be changed. Variables can only be recorded using the Graph Window. Variables are graphed to evaluate the effectiveness of set Parameters.

4.1 Getting started:

Connect the Comm Port Cable from your PC to the Drive. Locate the program file named "AutomotionPlus.exe" that you extracted from the supplied zip file and saved on your PC. Double-click on this file to run the program. The following screen will be displayed:

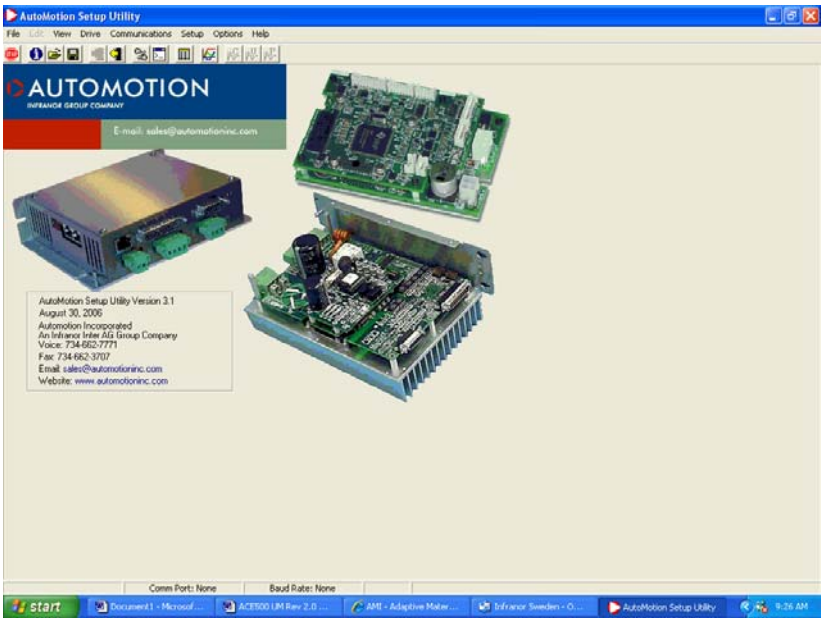


Figure 3: AutoMotionPLUS Screen

Select the Communications tab from the tool bar, then click on Comm Port Settings.

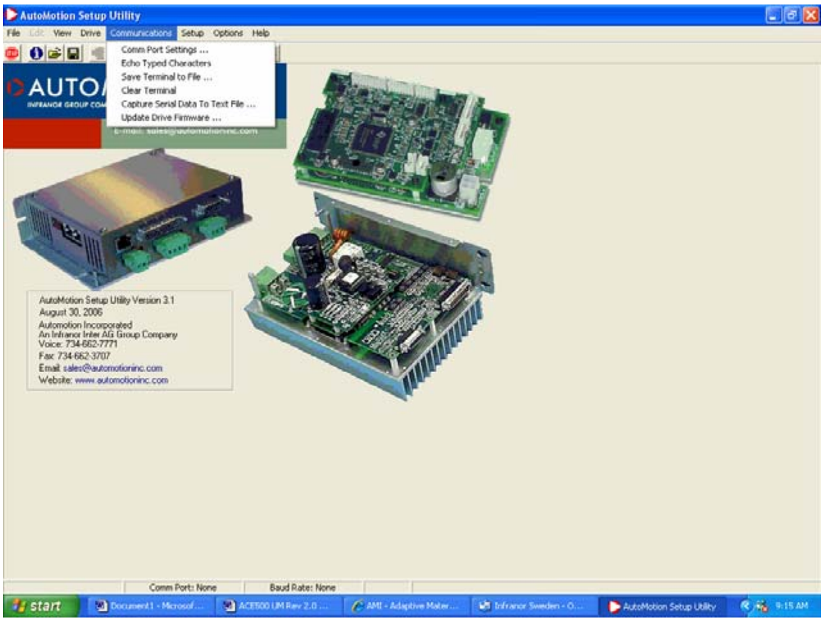


Figure 4: Communications Tab Screen

Use the drop box to select an available Com Port on your PC. Typically Com Port 1 or 2 is selected. **Note that for the ACE500 product line, the required communications Baud Rate is 38,400. If you select any other Baud Rate you will get a communications error message.**

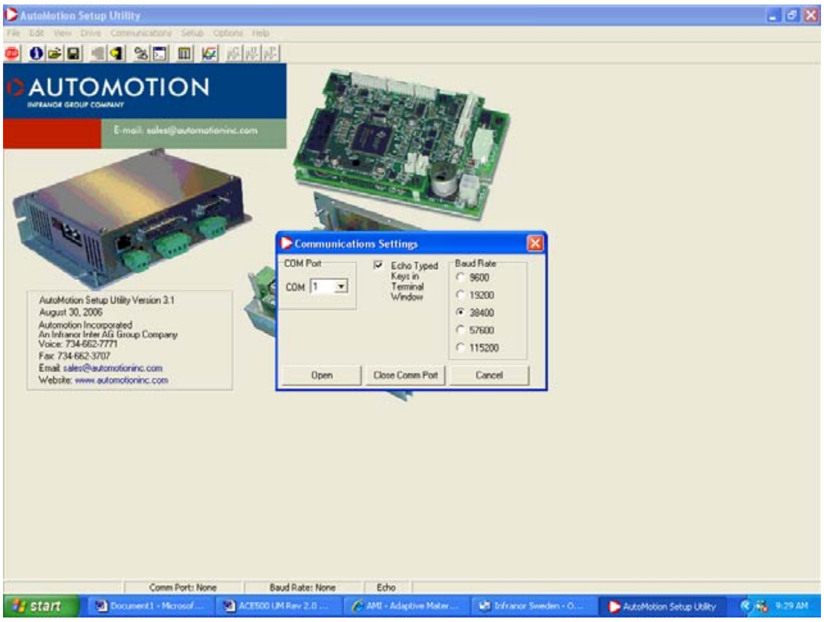


Figure 5: Communications Drop Down Box

After establishing communications with the drive, you can now read the existing drive parameters stored in the drive. Click on the "Read Parameters from Drive" icon button on the tool bar, or use the file menu to select "Drive" and then "Retrieve Parameters from Drive" option.

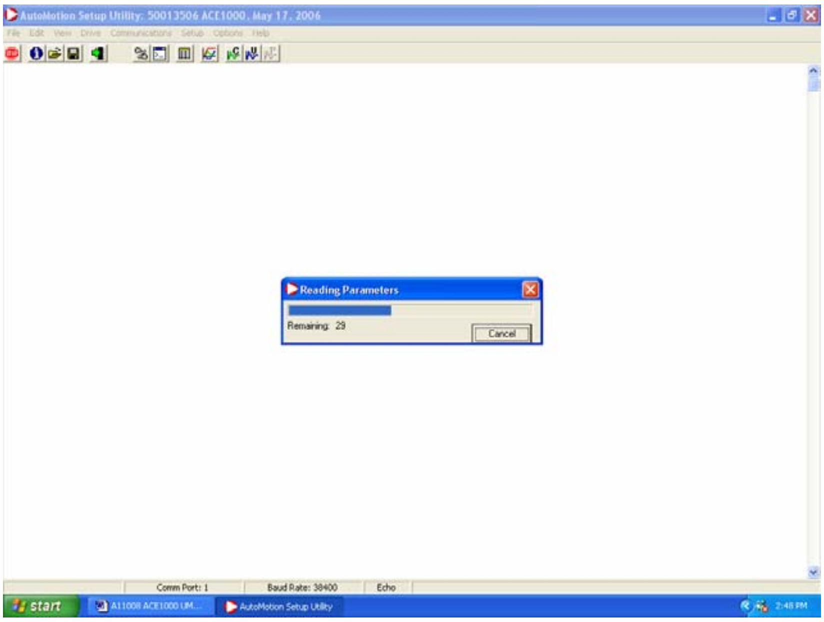


Figure 6: Read Parameters from Drive

Alternatively, you can load drive parameters from a file or disk, by clicking on the "Load Parameters from Disk" icon on the tool bar or "File" "Open" from the menu.

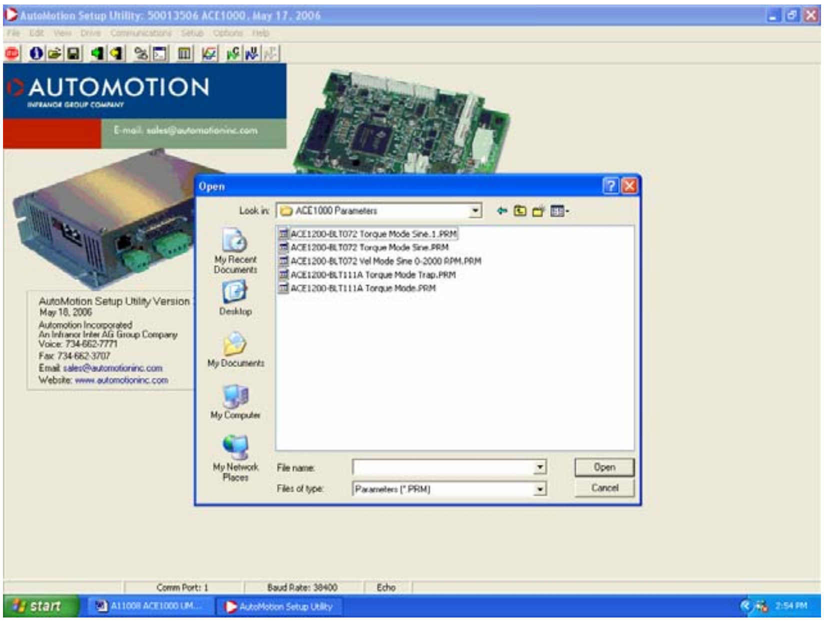
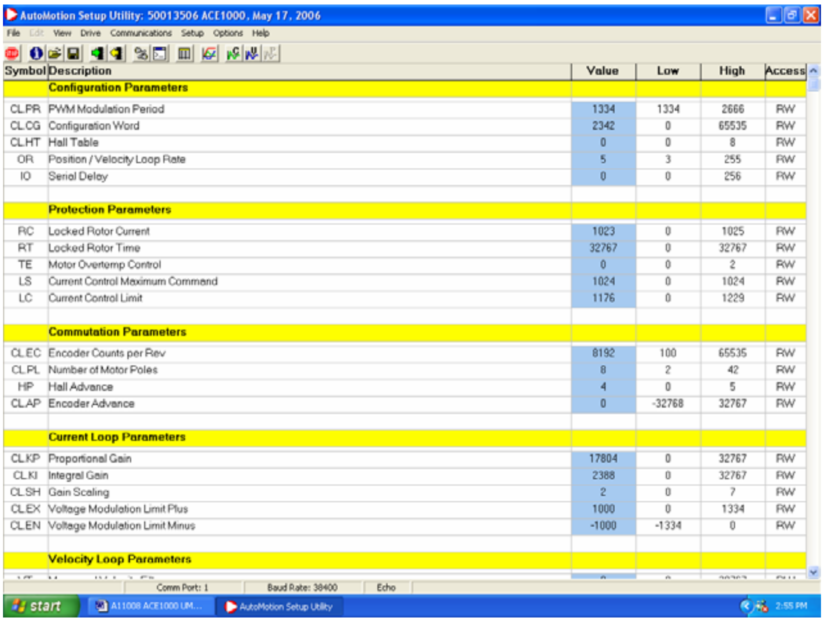


Figure 7: Load Parameters from File

In the above file open example, you can select from several pre-loaded parameter file sets that have been established for use with this drive when using the Infranor Mavilor motors.

Once communications have been established and the drive parameters have been retrieved, they can be displayed by clicking the "Parameters" icon on the tool bar, or selecting the "View" and then "Parameters" selection from the menu.

The following table of drive parameters will then be displayed.



Symbol	Description	Value	Low	High	Access
	Configuration Parameters				
CLPR	PWM Modulation Period	1334	1334	2666	RW
CLCG	Configuration Word	2342	0	65535	RW
CLHT	Hall Table	0	0	8	RW
OR	Position / Velocity Loop Rate	5	3	255	RW
IO	Serial Delay	0	0	256	RW
	Protection Parameters				
RC	Locked Rotor Current	1023	0	1025	RW
RT	Locked Rotor Time	32767	0	32767	RW
TE	Motor Overtemp Control	0	0	2	RW
LS	Current Control Maximum Command	1024	0	1024	RW
LC	Current Control Limit	1176	0	1229	RW
	Commutation Parameters				
CLEC	Encoder Counts per Rev	8192	100	65535	RW
CLPL	Number of Motor Poles	8	2	42	RW
HP	Hall Advance	4	0	5	RW
CLAP	Encoder Advance	0	-32768	32767	RW
	Current Loop Parameters				
CLKP	Proportional Gain	17804	0	32767	RW
CLKI	Integral Gain	2388	0	32767	RW
CLSH	Gain Scaling	2	0	7	RW
CLEX	Voltage Modulation Limit Plus	1000	0	1334	RW
CLEN	Voltage Modulation Limit Minus	-1000	-1334	0	RW
	Velocity Loop Parameters				

Figure 8: Drive Parameter Table

The parameter table lists all of the user accessible drive parameters, grouped by function type. The current drive parameter value is displayed along with the range of acceptable values, Low to High, and the parameter's access level, i.e. R/W stands for Read/Write. For R/W access parameters the user can both read the value as well as write a new value.

4.2 How to Save and Load Drive Parameter Files

Before you change any parameters, it is recommended that you first save the original parameters to a file so that you can restore them if needed at a later time. Notice the menu bar located on the top of the window. Either click the Diskette icon shown for "Save Parameters to Disk", or click the File menu, then "Save Parameters". Either selection will bring up a Windows "Save as" dialog box. If a "Parameter File" does not already exist on your PC, create one, and then name your file, i.e. "default.prm", and save it. The file will be saved on your PC.

To open this saved "default.prm" file from your PC, or any previously saved parameter files already on your PC or on a separate diskette, click the File Folder (Load Parameters from Disk) icon from the top of your Windows screen, or select the File menu, then "Open" and search for the desired parameter file on your PC or diskette.

Note: Opening a file will load the parameters from your PC or diskette to the ***AutoMotionPLUS***™Windows program only. It does not automatically change the parameter values stored in the drive itself.

A pop-up dialog box will appear any time you open a new parameter file from your PC or diskette that will ask if you wish to write the parameters to the drive. See example below.

If you are not certain that you want to replace the drive parameters with the new parameters just opened, select No. The new parameters will be loaded into the Windows program where you can refer them and change them if desired, but will not be uploaded to the drive.

When you are ready to upload the new parameters, you can then use the “write Parameters to Drive icon on the Tool bar, or select “Drive”, “Write Parameters to Drive”, from the menu line.

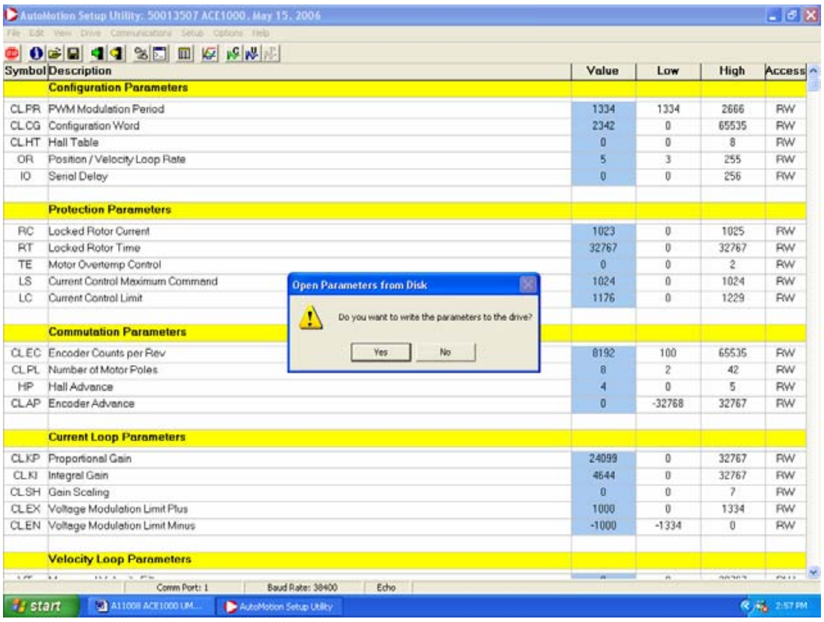


Figure 9: Uploading New Parameters

4.3 How to Change Individual Drive Parameters

Some Drive parameters can be changed while the Drive is running the motor. For example, Proportional, Integral and Derivative Gain parameters in any control loop may be changed at any time, and will take immediate effect.

However, some Drive parameters, if changed, will require you to reset the drive before proceeding. For example, the “Position/Velocity Loop Rate” parameter on this page is used to set the processing frequency for these control loops. The Drive must be placed into “Stop” using the Run/Stop! Switch when changing this parameter. After this parameter is changed, the drive must be Reset to function properly.

For example, to change the “Velocity Proportional Gain” parameter (VLKP) found under the “Velocity Loop Parameters” section, move your mouse pointer over the displayed value box and then click on it. This will bring up a pop-up dialog box as shown in the next frame.

To change the value simply type in the new value and hit OK. When the OK key is pressed the new parameter value will be uploaded to the drive immediately, so that the value shown on the Windows Parameter table is always the same as it is in the drive.

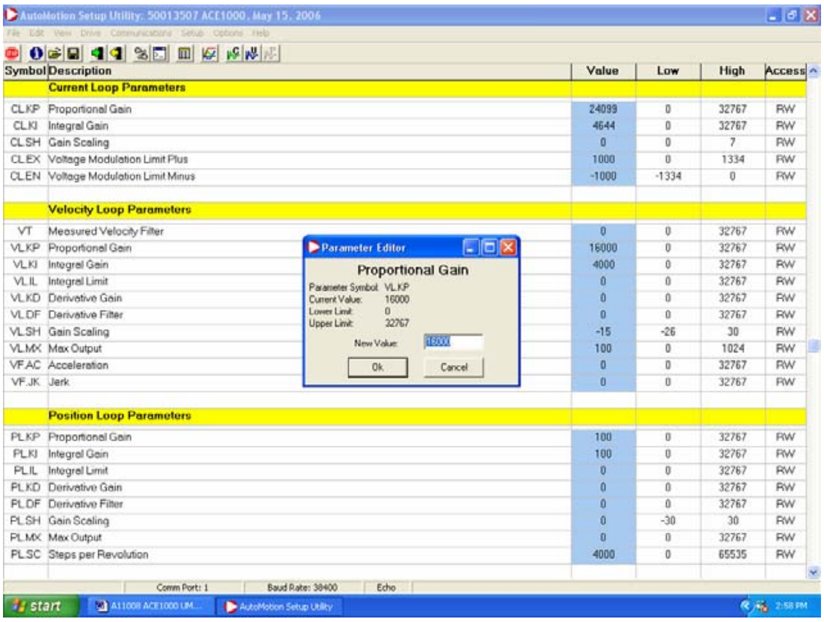


Figure 10: Changing Parameter Values

Note: When parameters are stored or written to the Drive, they are automatically saved in nonvolatile memory. If power is removed and re-applied, the Drive will retain any changed values. To restore the default drive values, Open and load the "default.prm". See 3.6.2 How to Save and Load Parameter files.

4.4 Drive Configuration

The ACE500 drive can be configured in one of three operational servo modes, torque, velocity, or position.

To determine the default configuration of the current drive select the "Configuration Word" CLCG value from the Configuration Parameters section of the Parameter table. The Configure Dialog pop-up box will appear. See Windows screen below.

You will use this Configure Dialog box to set up the drive for the desired operational mode, as well as to define the motor feedback, analog feedback, and position and auxiliary command feedback.

The torque mode of servo operation is the most basis set-up for this servo and it is set as the default drive mode. Torque mode is also required for operation of the other two servo modes, velocity and position mode.

The commutation mode can be one of three choices. The first, Trapezoidal, uses Hall feedback only. The other two, Sine, which operate the drive in Sinusoidal mode, offer operation with either "Sine with Halls Synchronized" or "Sine with Encoder Synchronized".

Sine commutation modes require "Halls and Encoder" commutation signals.

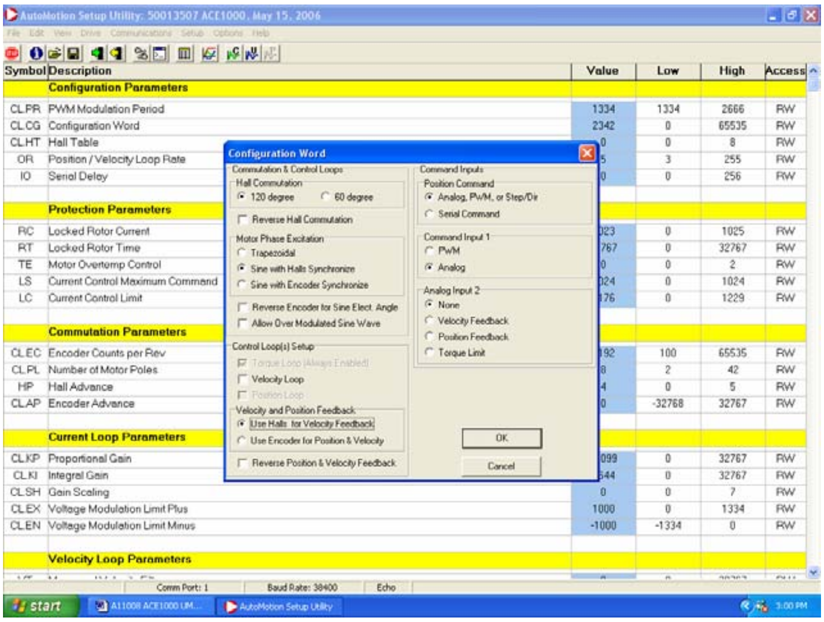


Figure 11: Drive Configuration Set-up

4.4.1 Requirements for Torque Mode Operation

To properly set up the ACE500 drive's operating mode, for all possible operating configurations, you will use the "Configuration Word" (CL.CG) found under "Configuration Parameters" section of the main "Parameter Page" of the Windows program.

If you click on the “Value” figure in the right hand column of this "Configuration Word" parameter, a pop up "Configuration Dialog" box will appear on the screen, as explained under section 4.4, and shown in Figure 11, above.

Note, for the drive to be configured properly with a new motor you will need to run the Auto-Phasing tool found under "Motor Setup", described in section 5.2.

However, before you run the "Motor Setup" routine, which determines the proper phasing for the commutation and the encoder feedback relationship, you first should set up the "Configuration Word".

Typically it is best to start with a simple Torque Mode set-up first until the unit is properly phased to the motor and the current loop is tuned, even if you will ulitamately wish to use the drive in closed loop Velocity or Position mode.

4.4.1.1 Setting up for Torque Mode Operation with Halls Only (no Encoder)

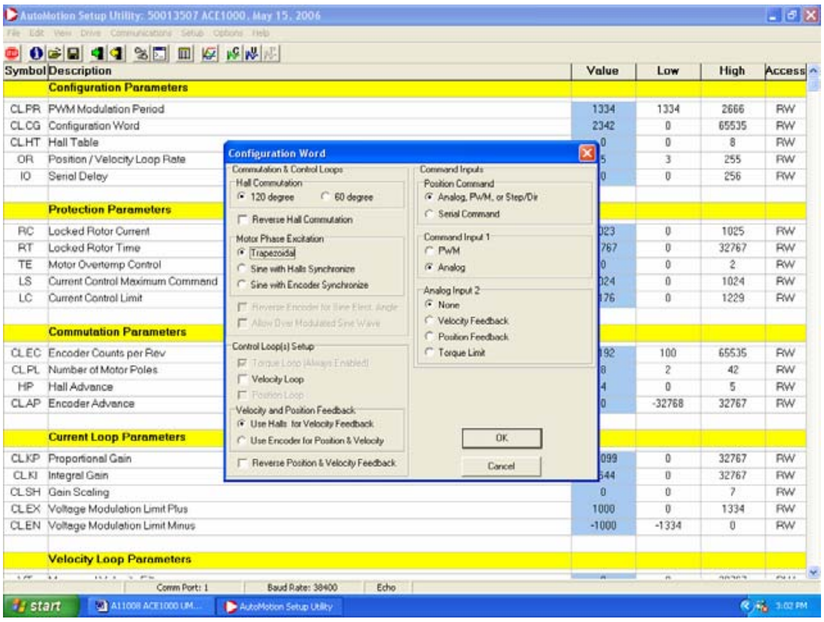


Figure 12: Set-up for Torque Mode with Halls

In this Torque Mode only configuration example, the drive is selected for Trapezoidal commutation. The motor does not have an encoder. Hall Commutation is set for 120 degree.

Reverse Hall Commutation is unchecked. After the Motor Setup is run this box may be checked automatically if the direction of rotation of the motor needs to be changed.

Control Loop(s) Setup is set for Torque Loop (always enabled).

The Velocity Loop option is unchecked, as we are planning to run in Torque Mode only at this time.

Feedback is selected for “Use Halls for Velocity Feedback”. However, this selection would only be effective when the velocity mode is also checked.

The Position Command is defaulted to Analog, PWM , or Step/Dir Input. Note, this is not used for the Torque Mode operation.

Command Input #1 is set for Analog. Other alternate is PWM command input.

Analog Input #2 is selected for “None” as we are not planning to use a second auxiliary analog input. An example of where we could use this additional analog input is as a flow control or pressure loop feedback application.

4.4.1.2 Setting up for Torque Mode Operation with Encoder

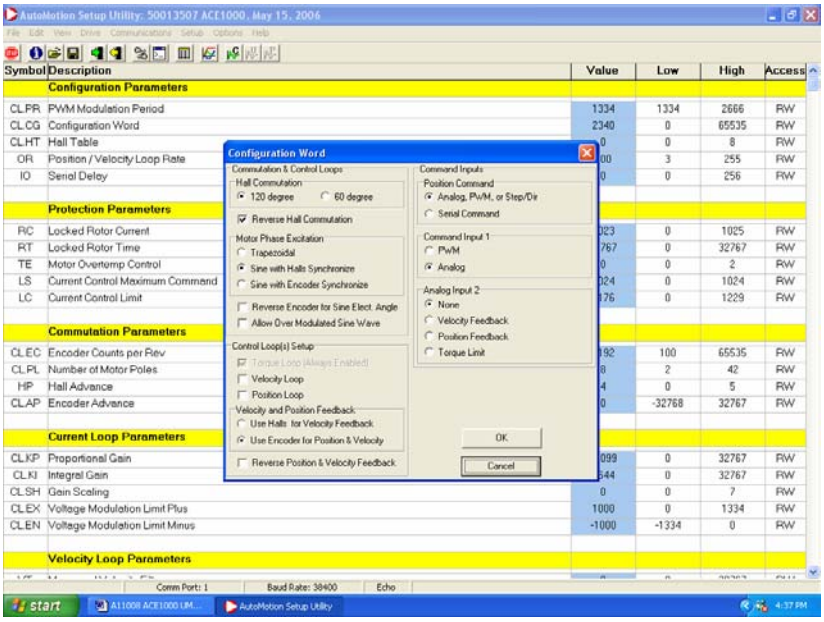


Figure 13: Set-up for Torque Mode with Encoder

In this Torque Mode only configuration example, we use the encoder for feedback to allow the drive to operate in Sine Wave commutation while running in closed loop Torque (or Current) mode operation.

Hall Commutation is set for 120 degree.

Reverse Hall Commutation is unchecked. After the Motor Setup is run this box may be checked automatically if the direction of rotation of the motor needs to be changed.

Control Loop(s) Setup is set for Torque Loop (always enabled).

The Velocity and Position Loop options are unchecked, as we are planning to run in Torque Mode only at this time.

Feedback is selected for “Use Encoder for Position & Velocity” feedback.

The Position Command is defaulted to Analog, PWM , or Step/Dir Input. Note, this is not used for the Torque Mode operation.

Command Input #1 is set for Analog. Other alternate is PWM command input.

Analog Input #2 is selected for “None” as we are not planning to use a second auxiliary analog input. An example of where we could use this additional analog input is as a flow control or pressure loop feedback application.

4.4.2 Requirements for Velocity Mode Operation

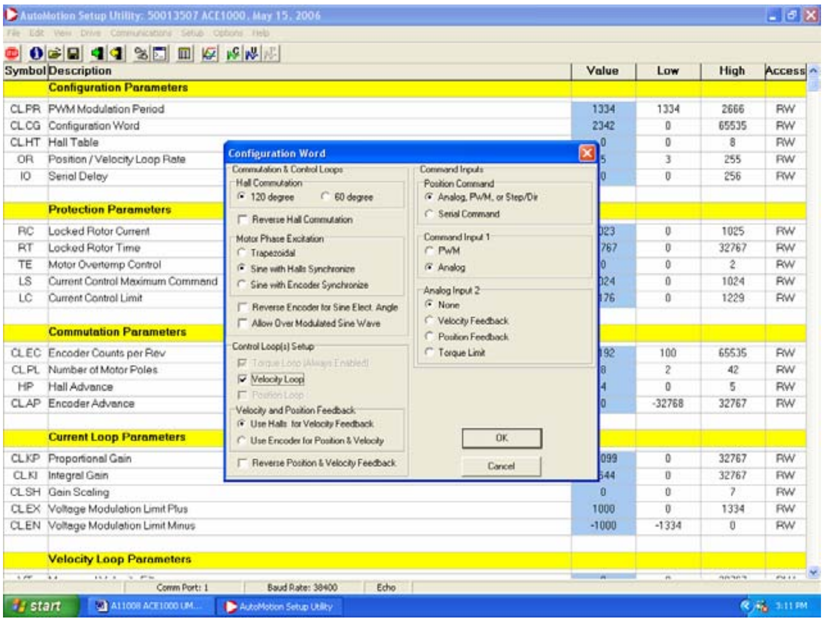


Figure 14: Set-up for Sine Velocity Mode with Halls

4.4.2.1 Velocity Mode Operation Using Halls Only

In this example we desire to run the drive in a closed loop Velocity mode using the Halls as our only velocity feedback device. See Figure #12 above.

Hall Commutation is still set for 120 degree.

Reverse Hall Commutation is unchecked. After the Motor Phasing is run this box may be checked automatically if the direction of rotation of the motor needs to be changed.

Motor Phase Excitation is set for Sine with Halls Synchronized, as Automotion's digital drives can run in either Trapezoidal mode or Sine mode with Halls only for feedback.

Control Loop(s) Setup is set for Velocity Loop (Torque Loop is always enabled).

Feedback is selected for "Use Halls for Velocity Feedback" since we are only running Halls at this time.

The Position Command is defaulted to Analog, PWM , or Step/Dir Input. Note, this is not used for the Torque Mode operation.

Command Input #1 is set for Analog. Other alternate is PWM command input.

Analog Input #2 is selected for "None" as we are not planning to use a second auxiliary analog input. An example of where we could use this additional analog input is as a flow control or pressure loop feedback application.

4.4.2.2 Sine Wave Velocity Mode Operation Using Encoder Feedback

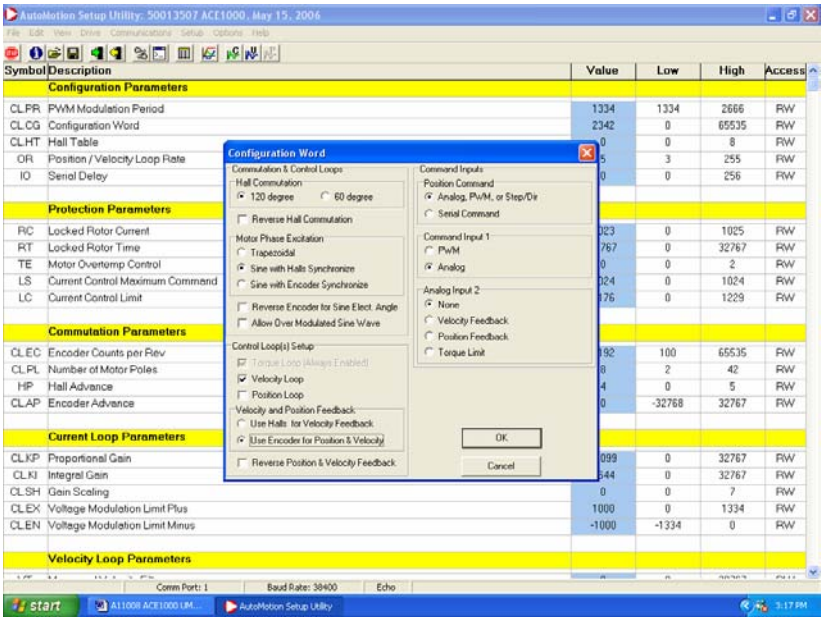


Figure 15: Set-up for Sine Velocity Mode with Encoder

In this Velocity Mode with Encoder Feedback example (Figure 13), the motor is equipped with an encoder that will be used for feedback. Hall Commutation is still set for 120 degree.

Reverse Hall Commutation is unchecked. After the Motor Phasing is run this box may be checked automatically if the direction of rotation of the motor needs to be changed.

Motor Phase Excitation is set for “Sine with Halls Synchronized” so that we can run in sine wave commutation. As an alternate, if desired, we could also run the Velocity Loop closure using encoder feedback in a Trapezoidal excitation mode only.

Control Loop(s) Setup is set for Torque Loop (always enabled).

The Velocity Loop option is checked, as we are planning to run in Velocity Mode.

Feedback is now selected for “Use Encoder for Position & Velocity”.

The Position Command is defaulted to Analog Input.

Command Input #1 is set for Analog. Other alternate is PWM command input.

Analog Input #2 is selected for “None” as we are not planning to use an auxiliary analog input. An example of where we could use this additional analog input is as a flow control or pressure loop feedback application.

4.4.3 Requirements for Position Mode Operation

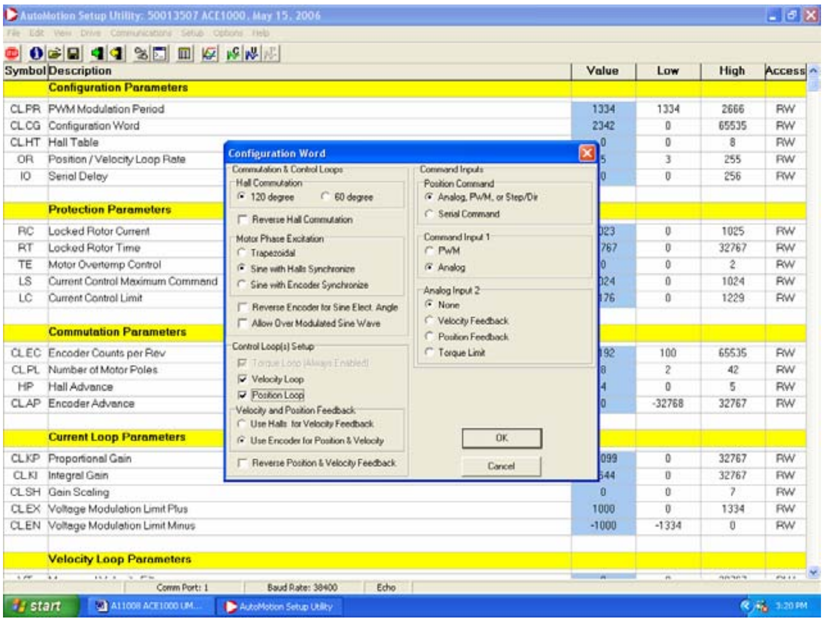


Figure 16: Set-up for Position Mode with Encoder

In this final example (Figure 16), we are setting the drive up for Position Mode with Step & Direction input.

For this mode the motor must have an encoder for position feedback. Hall Commutation is still set for 120 degree.

Reverse Hall Commutation is unchecked. After the Motor Phasing is run this box may be checked automatically if the direction of rotation of the motor needs to be changed.

Motor Phase Excitation is set for “Sine with Halls Synchronized” so that we can run in sine wave commutation. As an alternate, if desired, we could also run the Position Loop using encoder feedback in a Trapezoidal excitation mode only.

Control Loop(s) Setup is set for Torque Loop (always enabled), and the Velocity Loop option is checked.

In additon, the Position Loop is now checked and enabled.

Feedback is selected for “Use Encoder for Position & Velocity”.

The Position Command is set up for Analog, PWM, or Step & Direction Input.

Command Input #1 is set for Analog. Other alternate is PWM command input.

Analog Input #2 is selected for “None” as we are not planning to use an auxiliary analog input. An example of where we could use this additional analog input is as a flow control or pressure loop feedback application.

4.5 How to Graph Drive Variables

All of the variables discussed in the preceding section can be captured and displayed graphically using the Graph screen. In this way, control loop tuning can be evaluated.

4.5.1 Initial Graph Channel Set-up

Select “View->Graph” from the AutomotionPlus menu bar. The following screen will be displayed:

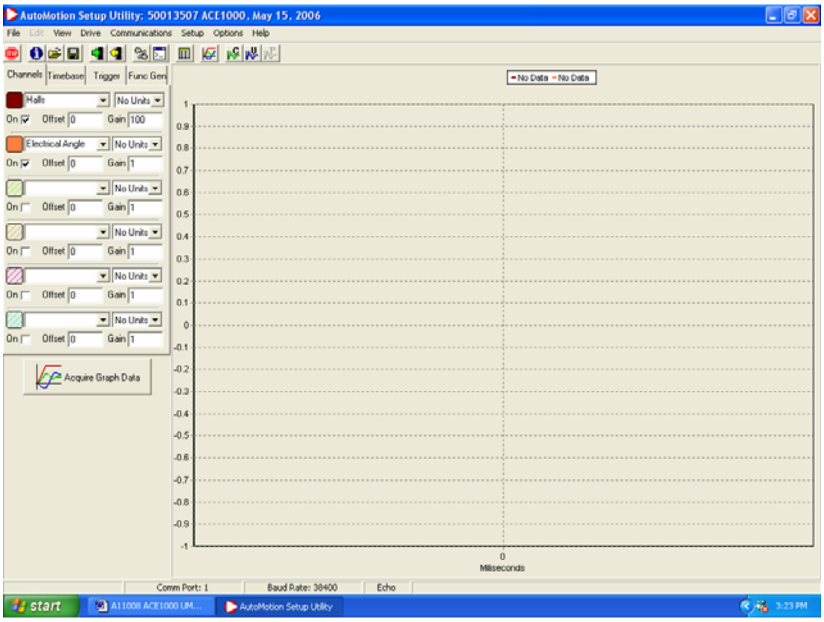


Figure 17: Graph Channel Set-up

Use the drop down list box in the upper left corner of this screen to select a variable to be graphed. For example select the variable named “Position Error” by scrolling down with your

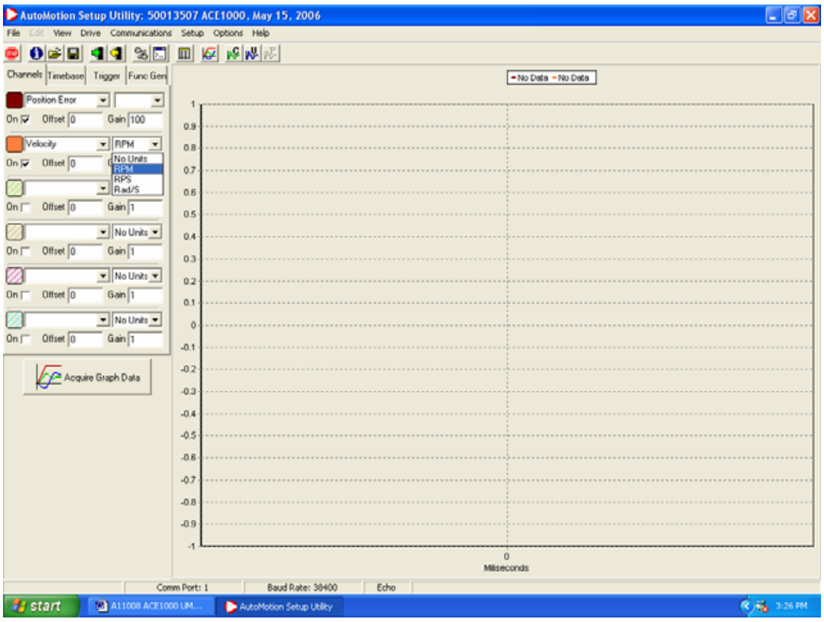


Figure 18: Selecting Variables to Graph

mouse and then clicking on it. You can then click on the second drop down box to select a second variable to graph, such as “Velocity”. Additional variables of interest can be selected in a similar fashion.

Note that a check mark appears in the “On” box located just below both selected variables. This means that both variables are enabled for data collection. You can disable a variable by clicking on this box.

You can also enter a number in the “Offset” box adjacent to each variable, to scale each variable as desired. This feature is useful for displaying variables in user units, or to display variables of different numerical ranges on a single graph.

As shown in Figure 18, many variables will have a number of choices for the units to be displayed. In the Fro example, in the case of the Velocity graph we have selected the data to be displayed in units of motor RPM. Other choices include units in RPS, or Rad/s.

You can also change the color of the Data being displayed on the graph by clicking on the color box associated with each variable for easier viewing.

Click in the Graph window and drag a box from the upper left, to the lower right. A zoomed view of the graph will appear. To zoom out, click and drag a box from the lower right, to the upper left. Click and hold the right mouse button to PAN the graph. Additional view functions are also available by right clicking on the graph.

4.5.2 Graph Timebase Set-up

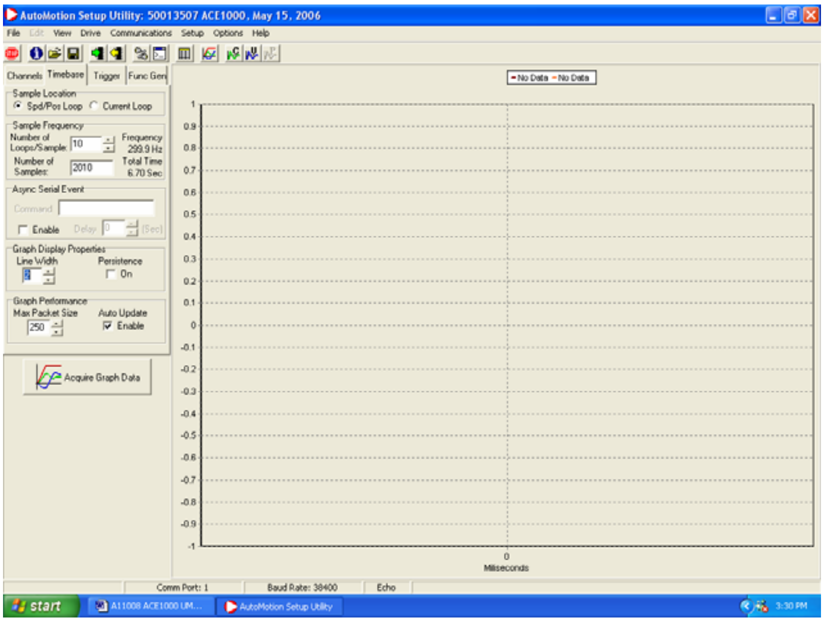


Figure 19: Graph Timebase Set-up

After selecting the initial variables to include in your graph, you will need to select the timebase for your data collection.

Within the Timebase set-up you first must select your Sample Location, either from within the Speed/Position Loop, or from within the Current Loop.

Next you determine your Sample Frequency. This is influenced by your Sample Location selection above, and is determined by both the number of loops per sample used, as well as the number of sample points desired.

Note that as the “Number of loops per sample” figure is adjusted, both the frequency as well as the total time for the samples to be collected will change. When just the “Number of Samples” is adjusted after setting the number of loops per sample, just the “Total Time” required to collect the sample data will change.

In the Graph Display Properties box you can select the thickness of the graph display lines, and also determine if you will retain the last graph data to be overlaid by the next graph run using the “Persistence On” feature. This feature is useful when wishing to compare two consecutive data runs results on the same graph.

Finally, the “Graph Performance” box allows the user to adjusted the maximum data packet size from 20 to 500 for best upload performance, while the Auto Update Enable allows incoming data to be displayed as it is received, rather than waiting until all data is collected. This can be turned off when desirable.

4.5.3 Graph Trigger Set-up

The ***AuotMotionPLUS***™ graphing utility is supplied with an additional data trigger feature to allow the user to more easily capture specific events of interest.

While data can be captured any time that the drive is in Run mode, by clicking on the "Acquire Graph Data" button at the bottom left of any graph screen, this special trigger feature allows the user to start data capture upon a particular event or action.

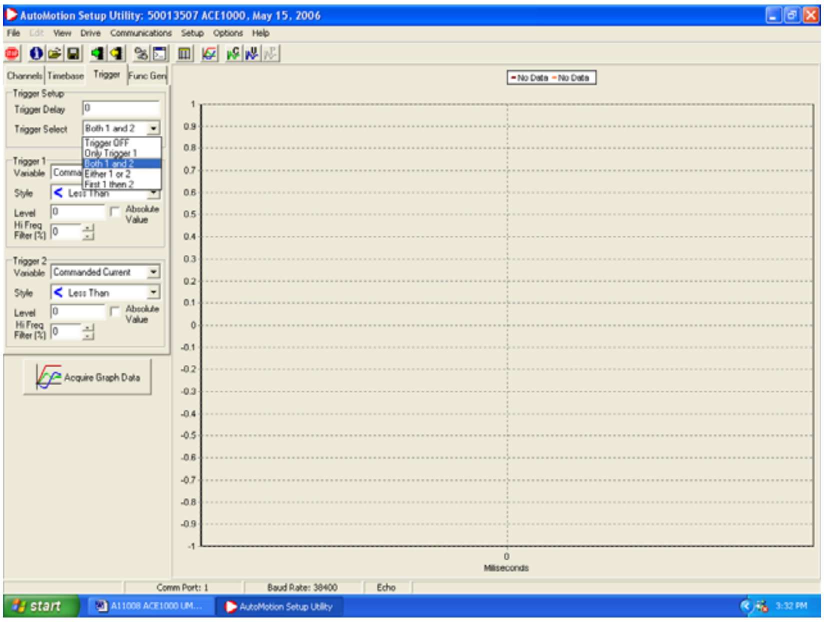


Figure 20: Graph Trigger Set-up

The first step in using the graph trigger function is to turn on the trigger function by selecting one of the five options in the drop down box. In the example above, Both 1 and 2 trigger functions has been selected, activating the Trigger 1 and Trigger 2 set-up boxes.

At the same time the "Trigger Delay" function can be selected to better capture the exact moment of the event you are looking for. The figures inserted into this box are in "number of samples", not time. This figure can be either positive or negative. A negative number would be used in the case where it was desirable to capture some data ahead of the event you are looking for. S an example, if 500 samples had been selected in the Timebase set-up (see section 4.2 Graph Timebase Set-up) and you chose to collect 100 samples prior to your trigger event, you would insert a minus 100 (-100) into the Trigger Delay box. In this case the total of 500 samples would be spread over the selected tripper event with 100 samples displayed before the event took place, and 400 samples displayed after the trigger event occurred. The actual amount of time that elapses over the 100-sample size will be dependent upon the sample location and the number of loops per sample as explained in section 4.2.

In each Trigger box a desired Variable to trigger the graph on can be selected from among the 27 variables offered in the drop down display box.

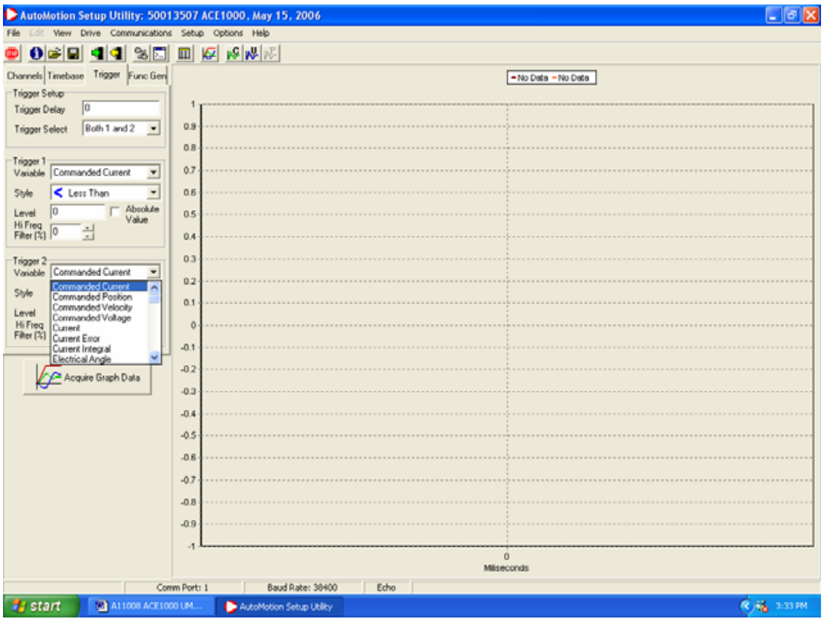


Figure 21: Selecting Trigger Variable to Graph

4.5.4 The Function Generator

4.5.4.1 Function Generator Overview

To tune the drive's current, velocity, and/or position loops, you can make use of the built-in function generator feature found in the Graph window menu.

Note: To stimulate the Velocity or Position control loops using the function generator, these loops must first be enabled in the Configuration word. By default, the current (torque) loop is always enabled.

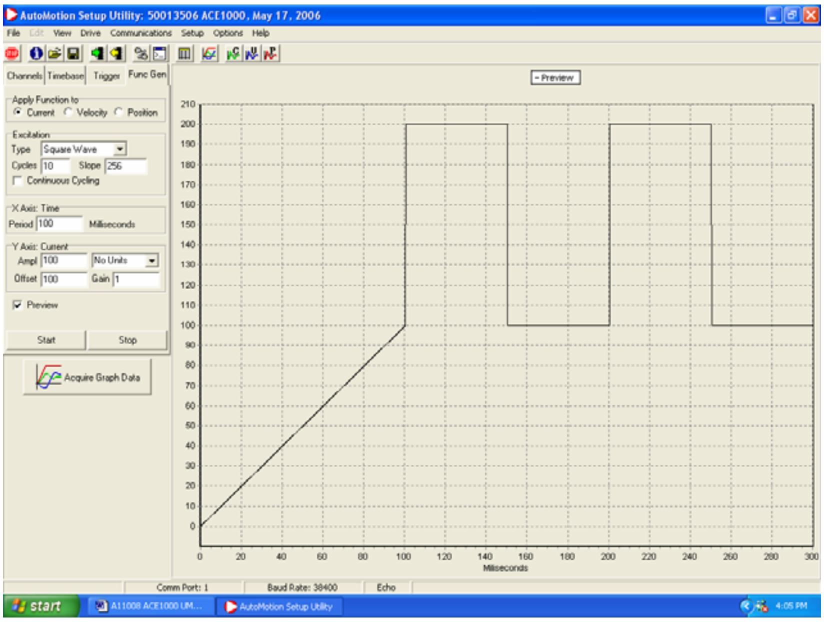


Figure 22: The Graph Function Generator Screen

4.5.4.2 Enabling the function generator

Place the drive into standby. Select "Function generator" from the menu bar on the Graph page to enable the function generator. The function generator is used to output a user configured reference signal to either the current, velocity or position control loops. To stimulate the Velocity or Position control loops using the function generator, these loops must first be enabled in the Configuration word.

(Hint: It is best to reset the drive when any changes have been made to the configuration word)

When the "Start" button is pressed in the function generator window, the drive's Command input signal (as determined by the configuration word) is replaced with the function generator signal, the drive is enabled in software and graphing begins automatically.

(Hint: Before pressing the start button, loop variables and other recording options should first be selected in the graph window.)

4.5.4.3 Configuring the Graph window:

In the example below, Commanded Current, Current and Commanded Voltage are recorded in the current loop. The variable “Command current” has been replaced with the function generator.

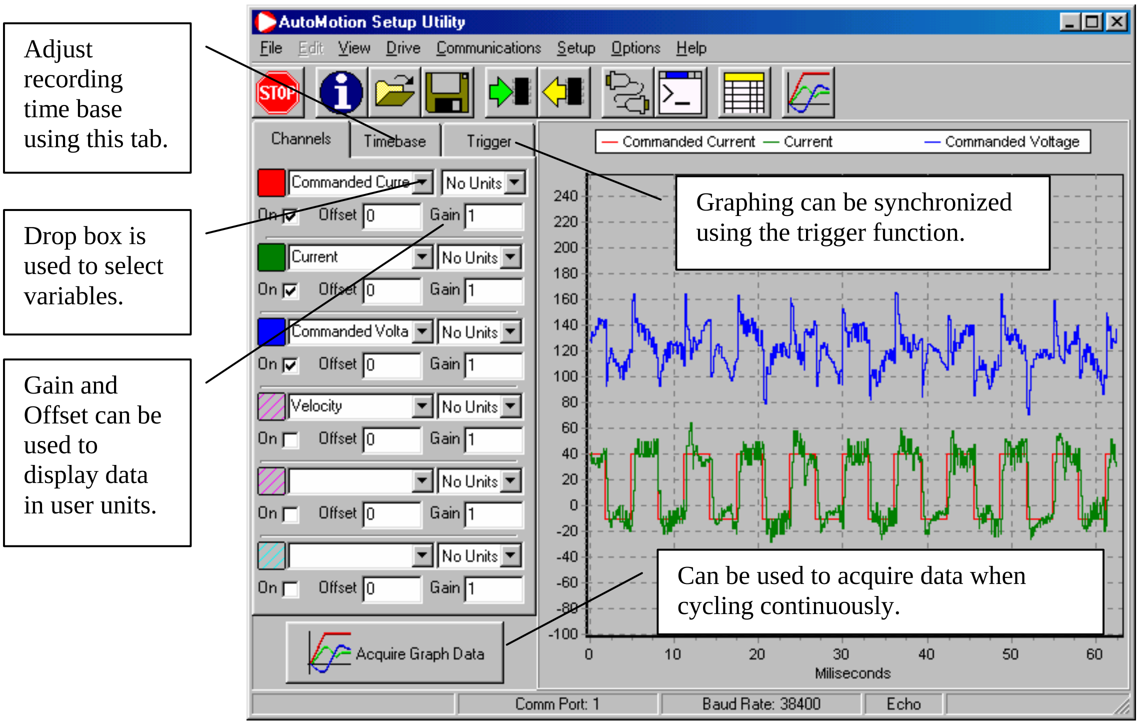


Figure 23: Configuring the Graph Window for the Function Generator

4.5.4.4 Configuring the Function Generator

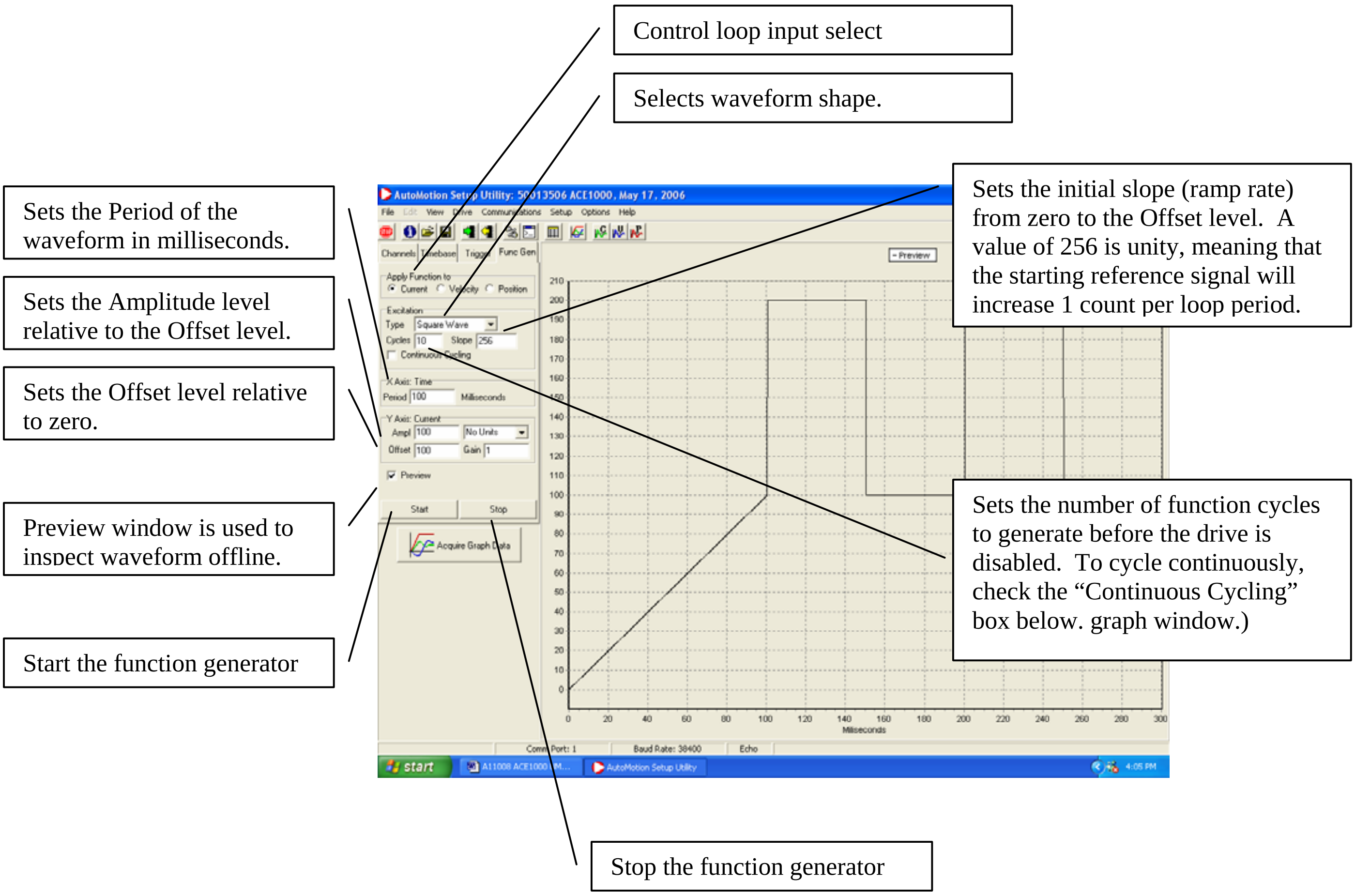


Figure 24: Configuring the Function Generator Screen

A typical graph of the current loop tuning with square wave excitation.

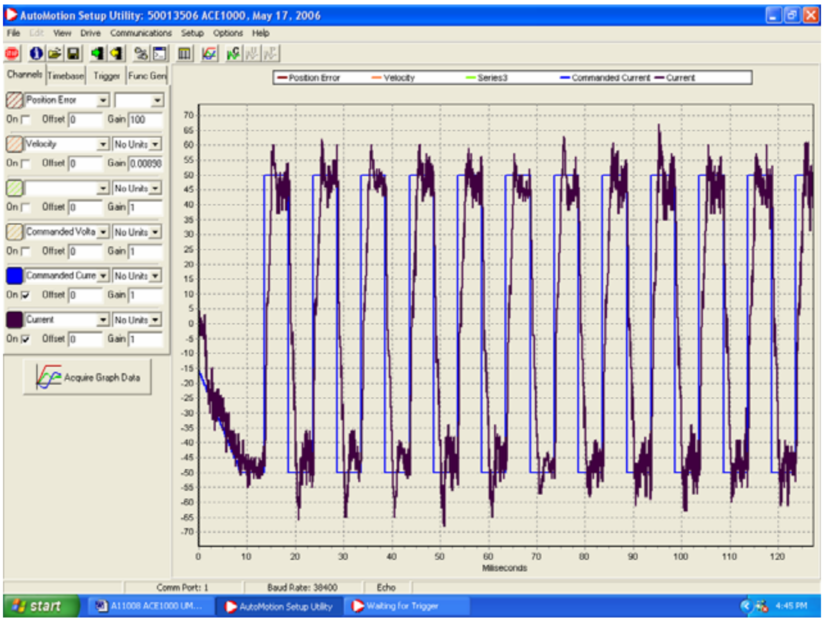
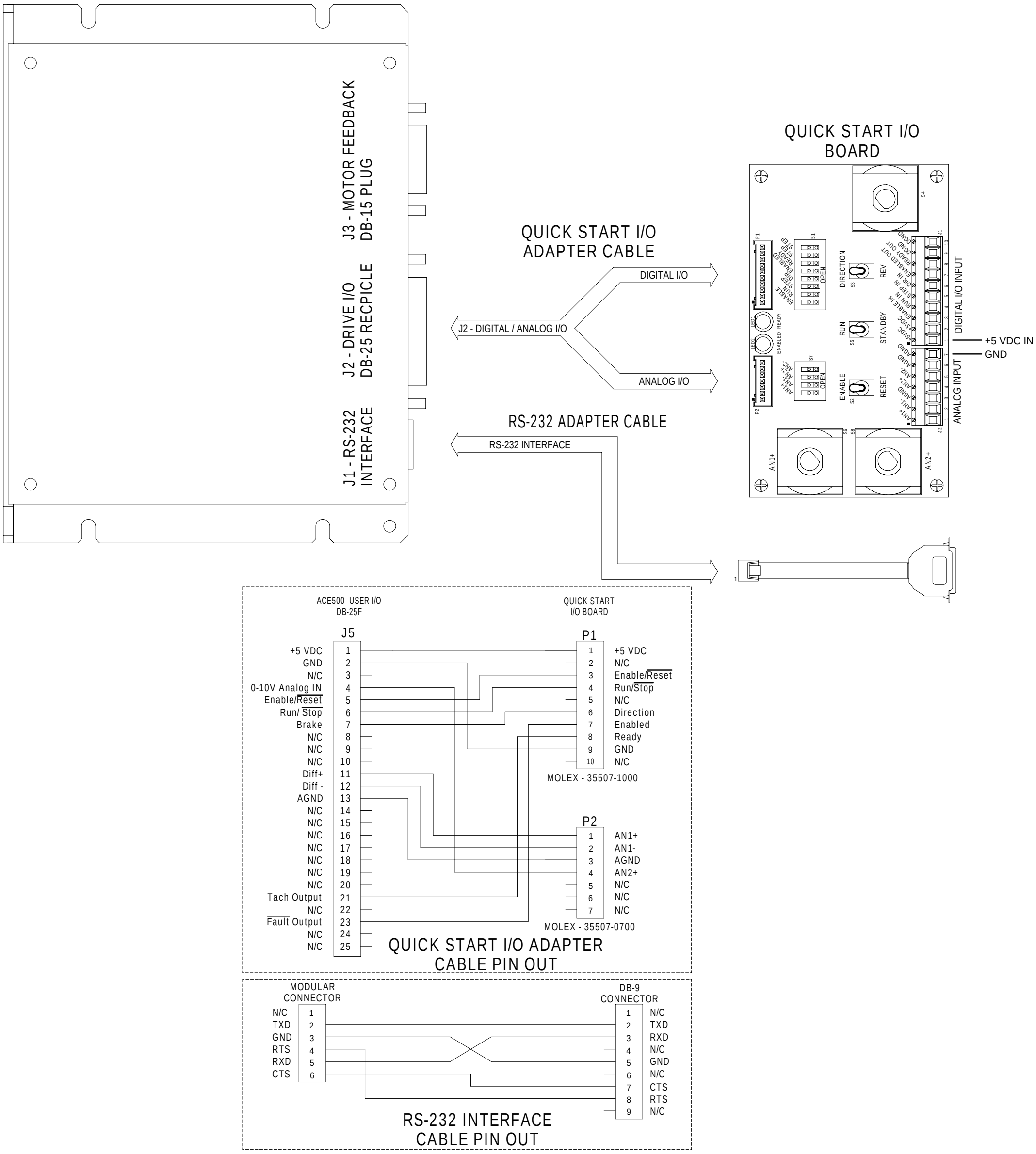


Figure 25: Sample Graph of Current Loop Tuning In Function Generator

5 Working with the ACE500 – Helpful Notes and Procedures

5.1 Recommended minimum hookup



Move text below closer to diagram

Micky I added a NEW recommended hookup diagram that has a +5v input shown

No more changes until page

Figure 26: Drive Motor Set-up

5.2 First time operation

5.2.1 Phasing the Motor

Automotion has determined the correct motor phasing for all Mavilor motors sold by Infranor Inter AG. If your drive was ordered with a Mavilor motor specified, the correct parameter set for the mating Mavilor motor in your system was loaded into your drive at the factory prior to shipment.

Alternate Mavilor motor parameters can be selected from the motor selection file on the software disk supplied with your drive, or you can contact Automotion for these files.

In addition, Automotion has established the correct motor phasing relationships for many other popular US and foreign motor manufacturers. A listing of these additional motor manufacturers may be obtained from Automotion upon request.

5.2.2 Using *AutoMotionPLUS*™ Auto-Phasing Tool

5.2.2.1 Getting Started

Please refer to the *AutoMotionPLUS*™ Windows Motor Set-up screen, figure 27 below. To establish the correct motor phasing for a new or unknown motor Automotion has provided a new feature called Auto-Phasing. To make use of this feature proceed as follows:

1. Connect all phase and hall wires to the drive.

2. Place drive into standby

3. Connect power and establish communications (38400 baud rate required)

4. Load a starting parameter set (select from Automotion motor tables, use default already in drive, or contact Automotion for assistance)

5. On the ***AutoMotionPLUS***™ Windows menu, select "Setup" -> "Motor setup"
   On the Motor setup screen check to see that the number of poles shown for the motor you are using is correct. If not, put in the correct value.
   If you are using an encoder, check to see that the encoder resolution shown is correct. If not, change it as required.
   The motor commutation scheme will be automatically determined by the Auto-Phasing program and displayed as either 60 or 120 degrees.

6. Select "Start Auto Config" button in lower right corner of "Motor Setup" window.

7. When the “Auto Config” is complete, place drive in standby

8. Select "close" button in lower right corner of "Motor Setup" window

9. The motor should now be properly phased for the ACE500. You can now proceed with drive loop tuning.

5.2.2.2 Error Messages During Auto-phasing

1. "Electrical angle and Hall state do not match." Possible cause of this error is insufficient current applied when dragging the motor to overcome friction or load. Recommend increasing the applied current (normally defaulted to 10%) to a maximum of 33%. in the motor, and try again.

2. "Electrical angle and Hall state do not match." Possible bad Hall device. Check to see that Halls are operating normally by placing drive into standby and rotating the motor shaft manually, observing the Hall indicators, S1, S2, and S3, as they change from Yellow to Green during rotation of the motor.

3. "Encoder resolution and pole count do not match detected value". Possible causes for this error include, wrong value given for encoder counts, wrong number of motor poles selected. Place drive in standby. Check motor nameplate information to confirm encoder resolution and number of poles used. You can also manually rotate motor shaft while drive is in standby and observe the "Raw Encoder Position" count on display. Check to see how many counts are indicated for one complete 360° rotation of the motor. If different than the value entered under Encoder Resolution change to match observed value and try again.

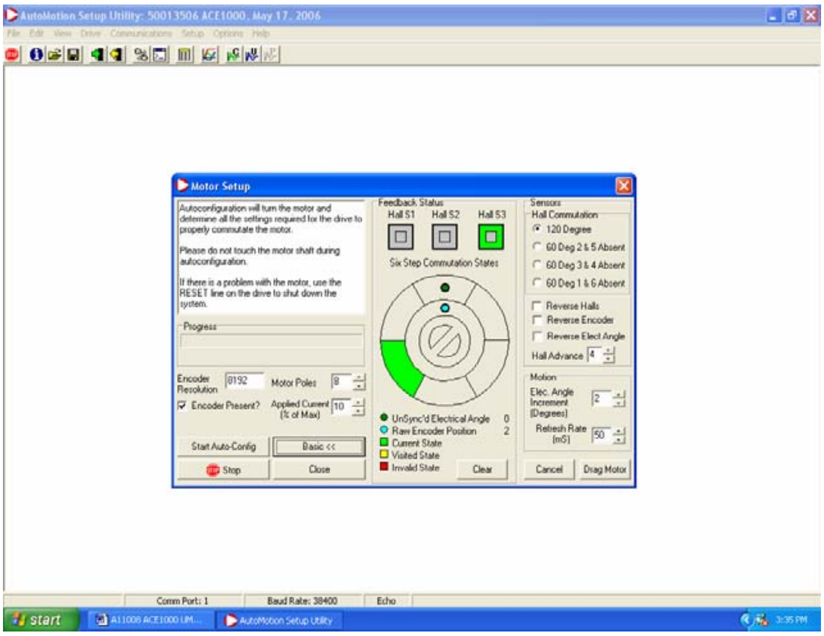


Figure 27: Motor Set-up Screen

5.2.3 Scaling the Analog Inputs

To properly adjust the analog inputs to match the desired input analog command voltage range with the desired output (i.e. Current, Velocity, etc.) you must first calculate the proper analog gain and offset values for entry into the drive's parameter page, under "I/O Configuration".

To assist you in this conversion Automotion has developed a user tool under the Setup tab in the menu bar called "Analog/PWM Setup" This tool will automatically convert your calculated or measured analog input values to the required analog gain and offset values in the Configuration Table to achieve the desired command input ranges.

5.2.3.1 Analog Input for Current Control – Pins 14 & 15 Diff Analog Command

An ACE command input "pop up" menu box will appear once you selected the "Analog/PWM Setup" option from the menu bar item, Setup.

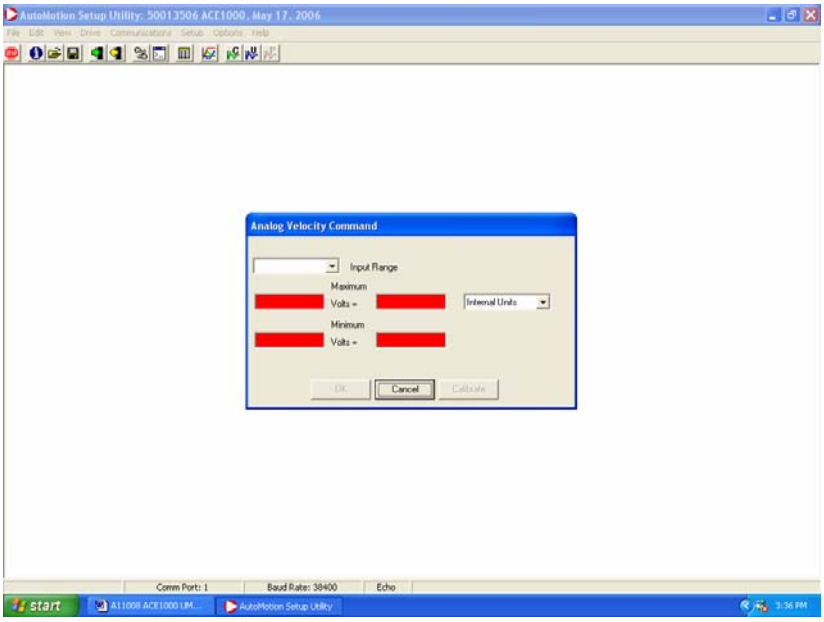


Figure 28: Analog Current Command Set-up Screen

This menu will appear either as an Analog Current Command form, an Analog Velocity Command form, or a Analog Position Command form, depending upon which mode of operation, Torque, Velocity, or Position, you have previously selected in the Configuration Word for your drive.

The analog voltage "Input Range" value for the Analog Command can be selected from one of the standard inputs in the drop down box, such as 0 – 5 VDC, +/- 10 VDC, etc., whichever represents your analog input signal, or you can select the Custom option if you are using a range not listed.

After selecting the Input range that matches your desired Analog Command input, you can then select the drive output format that this command will represent.

In the example below, Figure #23, we have selected the Input Analog Command to be +/- 5 VDC. We wish for this input voltage range to represent 0 to 90% current output of the amplifier's nameplate rating.

Once this information has been entered and the OK button selected, the required internal values for Command Offset (VF.OF) and Command Gain (VF.GN) of the Analog input are calculated and placed into the drive’s configuration page under the I/O Configuration section.

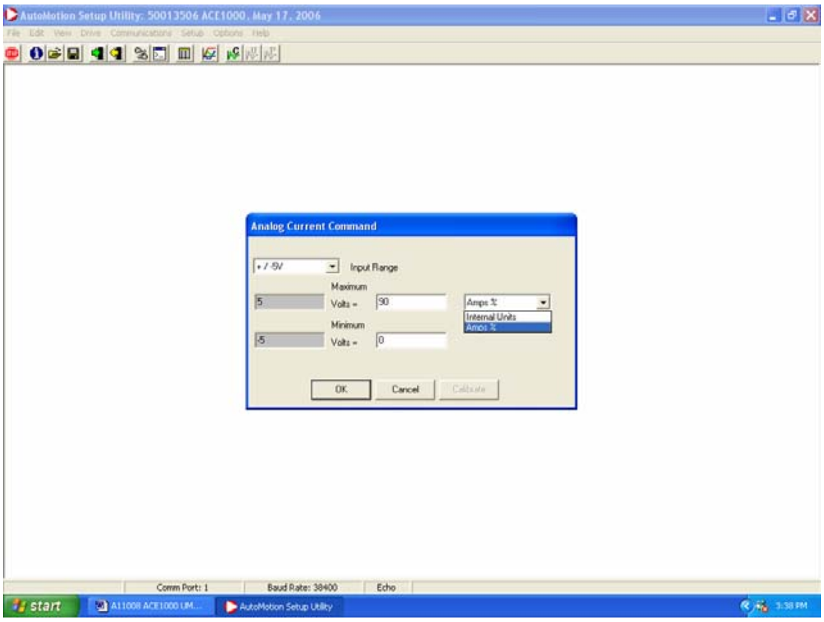


Figure 29: Analog Current Command Output Selection

5.2.4 Scaling the Analog Input Commands for Velocity and Position

5.2.4.1 Analog Input Command for Velocity Control

An ACE “Analog Velocity Command” input “pop up” menu box will appear once you selected the “Analog/PWM Setup” option from the menu bar item, Setup, assuming that you have already selected the Velocity configuration in the drive Configuration Word set-up box.

In the example below we have chosen a +/- 10 VDC signal as our position analog command source.

We have selected the desired output to be in motor RPM’s. Other options are RPS and Rad/s.

We wish to have +10 VDC analog input command equal 5000 RPM (forward direction), and –10 VDC analog input command equal –5000 RPM (in the opposite direction).

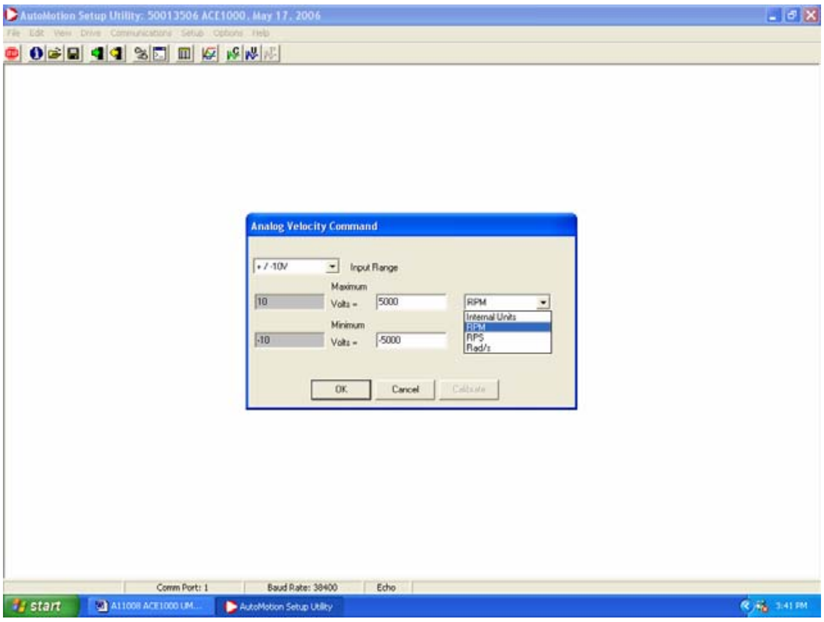


Figure 30: Analog Velocity Command Selection Screen

5.2.4.2 Analog Input Command for Position Control

An ACE "Analog Position Command" input "pop up" menu box will appear once you selected the "Analog/PWM Setup" option from the menu bar item, Setup, assuming that you have already selected the Position configuration in the Drive configuration set-up box.

In the example below we have chosen a +/- 10 VDC signal as our input analog command source.

We have selected the desired output to be in motor degrees. Other options are Revs and Radians. We wish to have +10 VDC analog input command equal 500 degrees (forward direction), and –10 VDC analog input command equal –500 degrees (in the opposite direction).

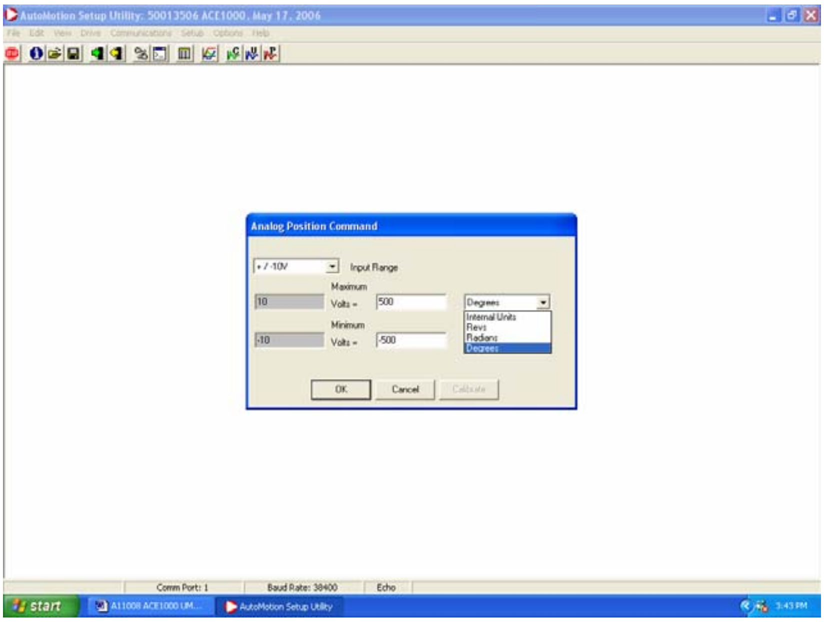


Figure 31: Analog Position Command Selection Screen

5.3 Initial Parameter Calculations

If your drive was supplied with a Mavilor motor initial parameters for that motor may already be loaded in the ACE500 drive, or a set of factory default parameters may be loaded.

From assistance in determining an initial set of drive parameters to begin your evaluation please contact Automotion applications support.

5.4 Tuning the Control Loops

To assist you in tuning the ACE drive’s control loops; Current, Velocity, and Position, for your specific motor and load, Automotion has developed a set of tuning tools that incorporate a built-in function generator (to excite the motor and load), graphing function, and slide bar adjustments for selecting various amounts of selected loop tuning parameters, to achieve the best possible closed loop servo performance.

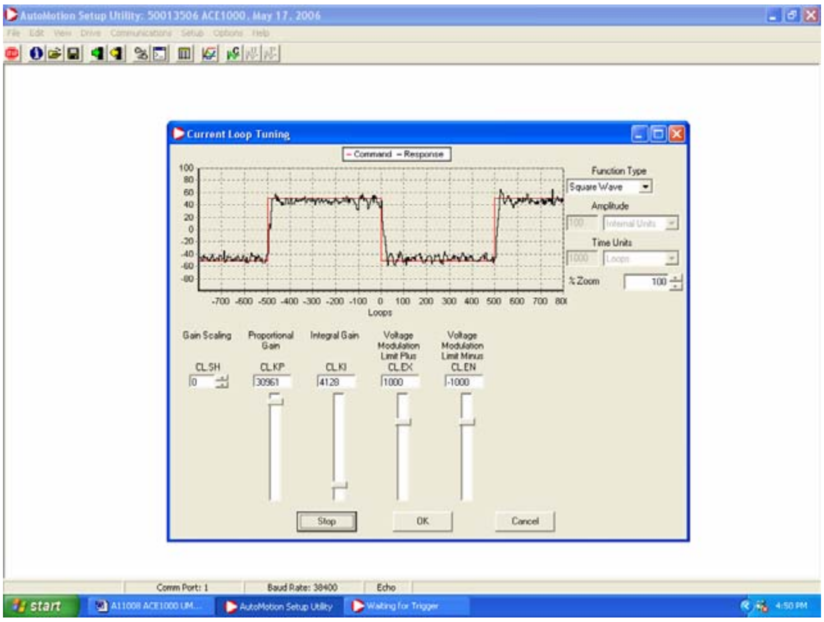


Figure 32: Current Tuning Screen

5.4.1 Tuning the Current Loop

In the example above, we have selected the Current loop for tuning by clicking on the Current tuning icon button found in the tool bar.

Note- If our drive were configured for current mode operation only, the other tuning icons for Velocity and Position would be grayed out and inaccessible.

Set the excitation of the function generator to Square Wave. Set the frequency to 100 loops or 100 Hz typically.

Set the amplitude of the applied current to no more than 10% of the drives continuous current rating. Verify that the amplitude of the applied current is not excessive for the motor.

Note- For very high friction motors, or motors that have a load attached (not recommended) you may have to increase this applied current value to obtain better results.

Start the function generator by clicking on the start button at the bottom of the pop-up window.

Then use the parameter slide bars shown to adjust the current loop proportional gain (CL.KP) by first:

a) setting the current loop integral gain (CL.KI) to zero.

b) Increase or decrease the proportional gain (CL.KP) until the desired step response is obtained. Typically, the desired result is little or no overshoot with a 100 Hz, low-current square wave applied.

c) If the proportional gain (CL.KP) is too large, ringing may occur. If the proportional gain is set too low, the response bandwidth will suffer, i.e. decrease.

Next, adjust the current loop integral gain (CL.KI) from zero until the desired settling time is obtained.

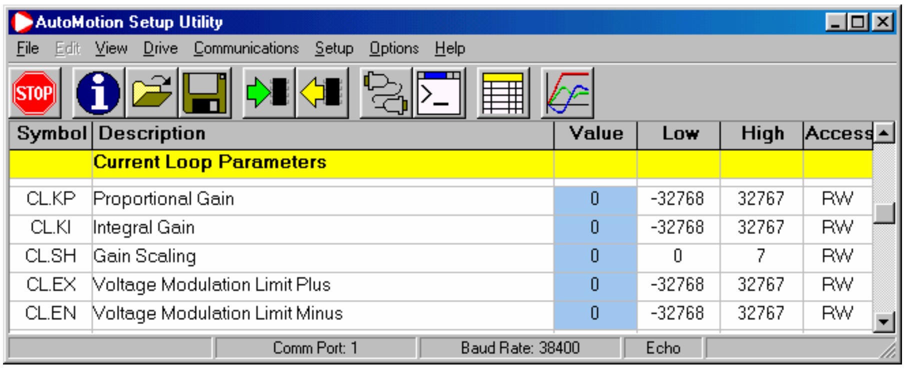
Once the desired current step response is obtained for the selected motor, save the values of CL.KI and CL.KP to the drive by first stopping the function generator by clicking on the Stop button. Then select the OK button to save these value.

If you wish to exit the tuning program without saving the new current tuning values select Cancel instead of OK.

If the amplifier is to be used in current mode only, you can skip the velocity and position loop tuning steps, sections 5.5 and 5.6.

The Gain Scaling Parameter

Proportional and Integral gains operate on the variable *Current Error*. Proportional and Integral gain are integer values between 0 and +32767, representing 0 to 100% gain. (Note: gains can be set to negative values but this practice is not recommended)



The gain scaling parameter, CL.SH, is a binary multiplier applied to both the Proportional (KP) and Integral (KI) gain values. For example, If CL.SH=1 then KP & KI range of 0 to 32767 represents 0 to 200% gain. If CL.SH=2 then the KP & KI range of 0 to 32767 represents 0 to 400% gain, etc.
When adjusting current loop gain values, Automotion recommends using the lowest possible value for CL.SH. For example, use KP=10000, Ki=2000 and SH=0, rather than KP=5000, Ki=1000 and SH=1.
The variable *commanded voltage* is the output signal of the current control loop. This signal is compared to an internal modulator to produce applied motor PWM (i.e. voltage). CL.EX and CL.EN can be used to limit the maximum PWM (i.e. voltage) applied to the motor.
Automotion recommends initially setting CL.EX and CL.EN to +32767 and –32767 respectively. Internal firmware will then automatically limit the maximum and minimum values to the numerical limit of the internal modulating signal. This internal limit can then be determined by typing “CL.MX<enter>” at the terminal window. The returned value can then be used to scale CL.EX and CL.EN parameters. For example, if CL.MX<enter> returns a value of “642” then scaling is calculated as follows:

CL.EX = [(Desired +Limit) / (Supply Voltage)] * 642.
CL.EN = [(Desired -Limit) / (Supply Voltage)] * 642.

One the CL.MX value is determined, the variable *Commanded voltage* can also be displayed in the graph window in units of volts. For example, if CL.MX returns a value of 642, then the “variable gain” in graph window is calculated as follows:

Commanded voltage Gain $_{\text{(located in graph window)}}$ = (Supply Voltage) / 642

Note: Gain and Offset values in the Graph window are not stored in the drive. These values are only used in the windows interface to manipulate displayed data.

5.4.2 Tuning the Velocity Loop

To select the Velocity loop for tuning click on the Velocity tuning icon button found in the tool bar.

Note- If your drive is configured for Velocity mode operation only, the Position tuning icon will be grayed out and inaccessible.

Set the excitation of the function generator to Square Wave. Set the frequency to 5 Hz typically.

Set the amplitude of the applied current to no more than 10% of the drives maximum velocity value. Verify that the amplitude of the applied velocity value is not excessive for the motor.

Note- The Velocity loop typically needs to be tuned with the load attached. This may require you to increase the applied drive velocity value to obtain better results.

Start the function generator by clicking on the start button at the bottom of the pop-up window and adjust the velocity loop proportional gain (VL.KP) and the velocity loop integral gain (VL.KI) to obtain the desired waveform.

Using the adjustable slide bars adjust the velocity loop proportional gain (VL.KP) by first:

a) setting the velocity loop integral gain (VL.KI) to zero.

b) Increase or decrease the velocity loop proportional gain (VL.KP) until the desired step response is obtained. Typically, the desired result is little or no overshoot with a 5 Hz, slow-speed square wave applied.

Next, adjust the velocity loop integral gain (VL.KI) from zero until the desired settling time is obtained.

Once the desired velocity step response is obtained for the selected motor, save the values of VL.KI and VL.KP before proceeding to the next step, position loop tuning, by clicking on the stop button, and then the OK button.

If the amplifier is to be used in velocity mode only, you can skip the position loop tuning step in section 5.6.

5.4.3 Tuning the Position Loop

To tune the position loop, minimize the following error and any oscillations by running profiles and adjusting the position proportional gain (PL.KP), position integral gain (PL.KI), and position derivative gain (PL.KD), and other settings to obtain the desired performance.

The remainder of this page is intentionally left blank.
Probably could move this section to page 49.

6 ACE500 Hardware Reference

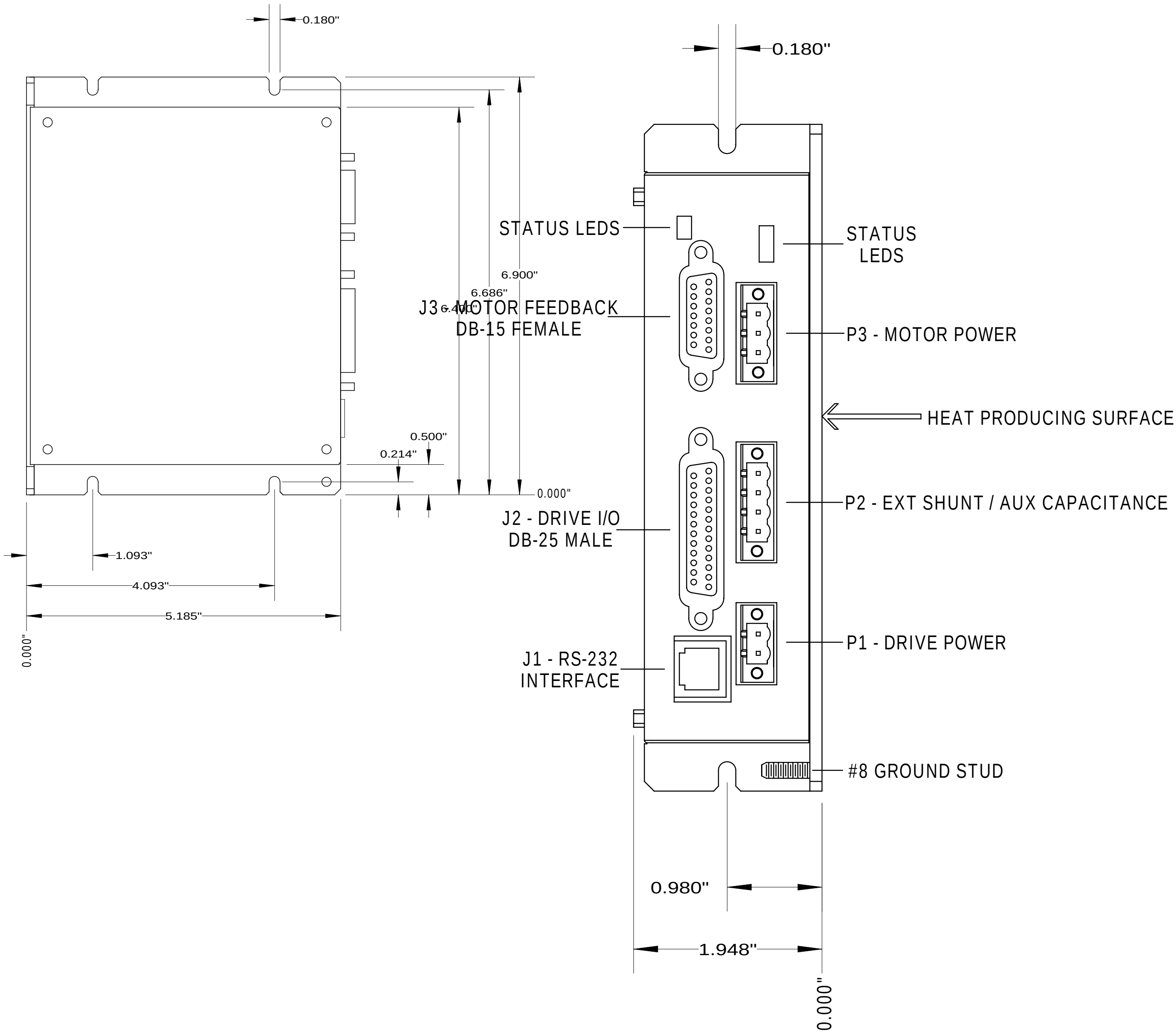
6.1 ACE500 electrical ratings

Ratings at Tamb = 0…50°C, (unless otherwise noted)

Parameter	Conditions	Value	Units
Supply			
Supply voltage	Nominal operating	100 to 240	VAC
Supply current, surge	Inrush pulse duration <=100mS		A
Supply current, idle	No load condition.		mA
Supply current, operating			A
Over Voltage protection	Internal peak supply limited.		VAC
Reversed polarity withstand	Continuous; supply current externally limited to:		A
+5VDC User Supplied - regulation	Encoder Inputs, Hall Inputs and Digital I/O	4.75 to 5.25	V
+5VDC User Supplied - current required	Encoder Inputs, Hall Inputs and Digital I/O	250 minimum	mA
Motor Outputs – P3			
Output current, continuous	No additional heatsink	7.5	Arms
Output current, peak		15	A
Short circuit withstand	Phase-to-phase, phase-to-ground, phase to- supply threshold.	+/-	Amp
Short circuit protection delay		3 to 4	uS
On state voltage drop	Phase current = +/-5Amp	~~to~~ 2.5	V
Off-state leakage current	Phase Voltage = +/-48V.	~~To~~ 250	uA
PWM frequency	Programmable, PWMPER	~~-0~~ 15 to 30	kHz
Digital I/O Maximum Ratings – J2			
Input voltage	All inputs (opto-isolated); referenced to +COM	0 to 5.5	V
Input current	All inputs (opto-isolated); referenced to +COM	5.0 to 6.0	mA
Output voltage	All outputs	5 to 5.5	V
Output current	All outputs	40 to 50	mA
Digital Inputs – J2			
On state voltage threshold	Referenced to +com	1.0 to 2.0	V
Off state voltage threshold	Referenced to +com	0.6 to 1.5	V
On state current	Input = -5V	~~To~~ 20	~~mA~~uA
~~On state pulse width~~	~~Off voltage = 0V , On voltage = -3V~~	***REMOVE ROW***	~~uS~~
~~Off state pulse width~~	~~On voltage = -5V , Off voltage = -1V~~	***REMOVE ROW***	~~uS~~
Digital Outputs) – J2			
On state current	Referenced to +com	7.8 to 9.0	mA
On state voltage drop	On state current = 15 mA	0.40 to 0.46	V
~~Off state voltage~~	~~Sustained~~	***REMOVE ROW***	~~V~~
~~Off state leakage current~~	~~Off state = 5.5V~~	***REMOVE ROW***	~~uA~~
Analog Inputs – J2			
Input voltage Common-mode	Referenced to AGND	-10 to +10	V
Input voltage differential	Nominal operating	0 to 10	V
Input impedance	Differential	15.4 to 15.6	K Ohm
Input impedance	Common mode, referenced to AGND	15.4 to 15.6	K Ohm
Analog ground current	Maximum AGND to GND	0 to 50	mA

Encoder Inputs – J3			
Input voltage, Max.	Common-mode, referenced to GND	-25 to +25	V
Input voltage, Max.	Differential peak A to A , B to B , Z to Z	-30 to +30	V
Input voltage, differential	RS422 receiver, A to A , B to B , Z to Z operating.	-5 to +5	V
Halls – J3			
Input voltage range	Transient peak	-0.3 to +5.3	V
Low level voltage	Operating	0 to 1.8	V
Low level input current	Internal 1 K pull up to +5V	4 to 5	mA
Input hysteresis		0.2 to 0.5	V
Other			
Thermal resistance	Case to ambient		°C/W
Frame isolation voltage withstand	GND to Frame.	4000	VAC / Minute
Operating temperature	powered	0 to +50	°C
Storage temperature	Not powered	-20 to +85	°C
Humidity	Non-condensing	5 to 95	%RH
Weight		1.9 / 0.86	Lb./Kg

6.2 ACE500 Package Outline



Move text below closer to diagram

Micky I added a NEW Package Ouline diagram with a missing dimension added

Figure 33: ACE500 Package Outline

Move text below to same page

6.3 List of ACE500 mating connectors

Ref.	Connector name	Manufacturer	P/N
P1	PWR	PHOENIX CONTACT	MST BT 2,5/2-STF-5, 08
P2	EXTERNAL SHUNT / AUX CAPACITORS	PHOENIX CONTACT	MST BT 2,5/4-STF-5, 08
P3	MOTOR POWER	PHOENIX CONTACT	MST BT 2,5/3-STF-5, 08
J1	RS-232	TYCO	5-641337-3
J2	DIGITAL & ANALOG I/O	AMP / TYCO	5-747908-2
J3	MOTOR FEEDBACK	AMP / TYCO	5-747913-2

6.4 Interface circuitry

6.4.1 J2 – Digital & Analog I/O

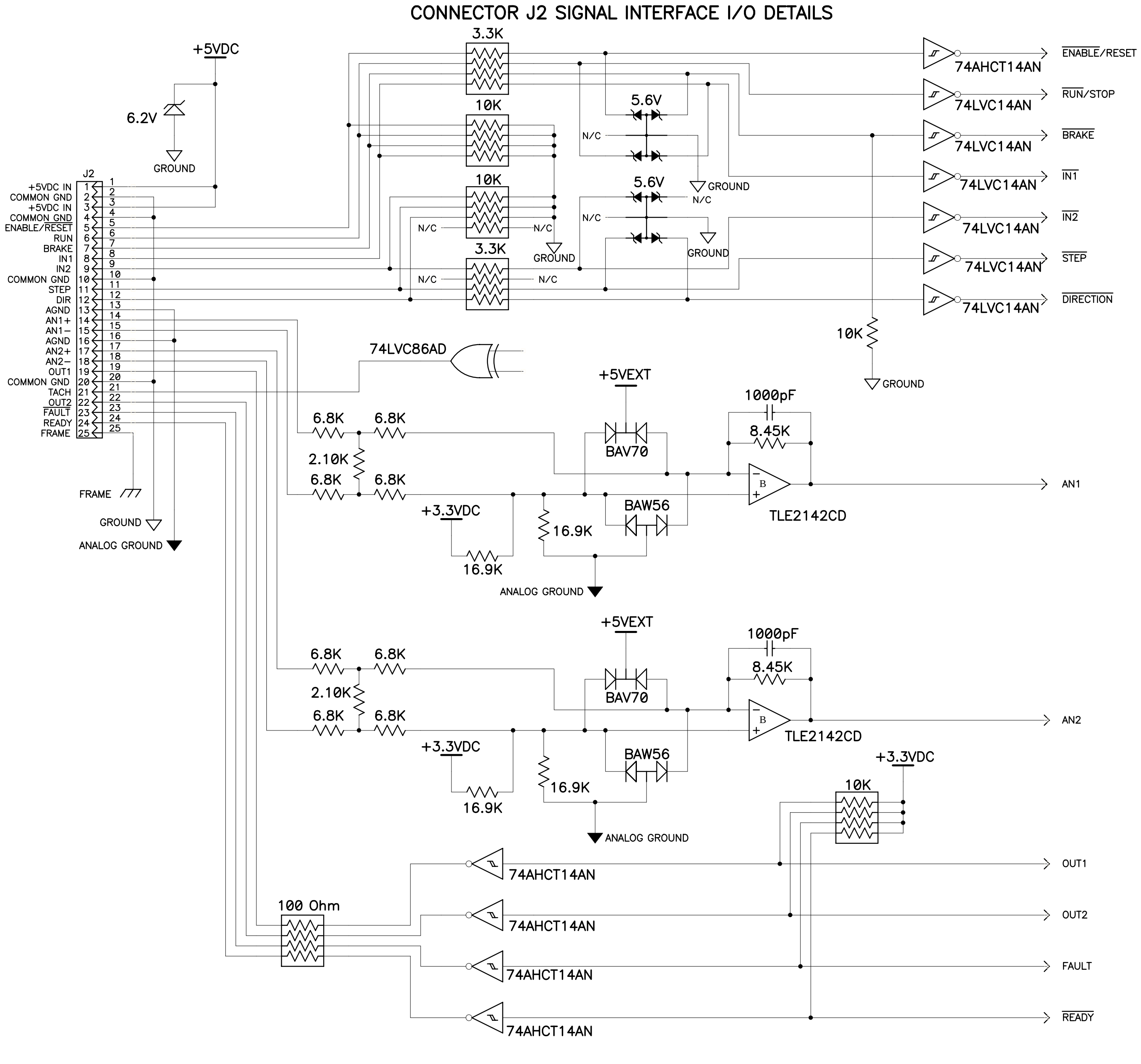
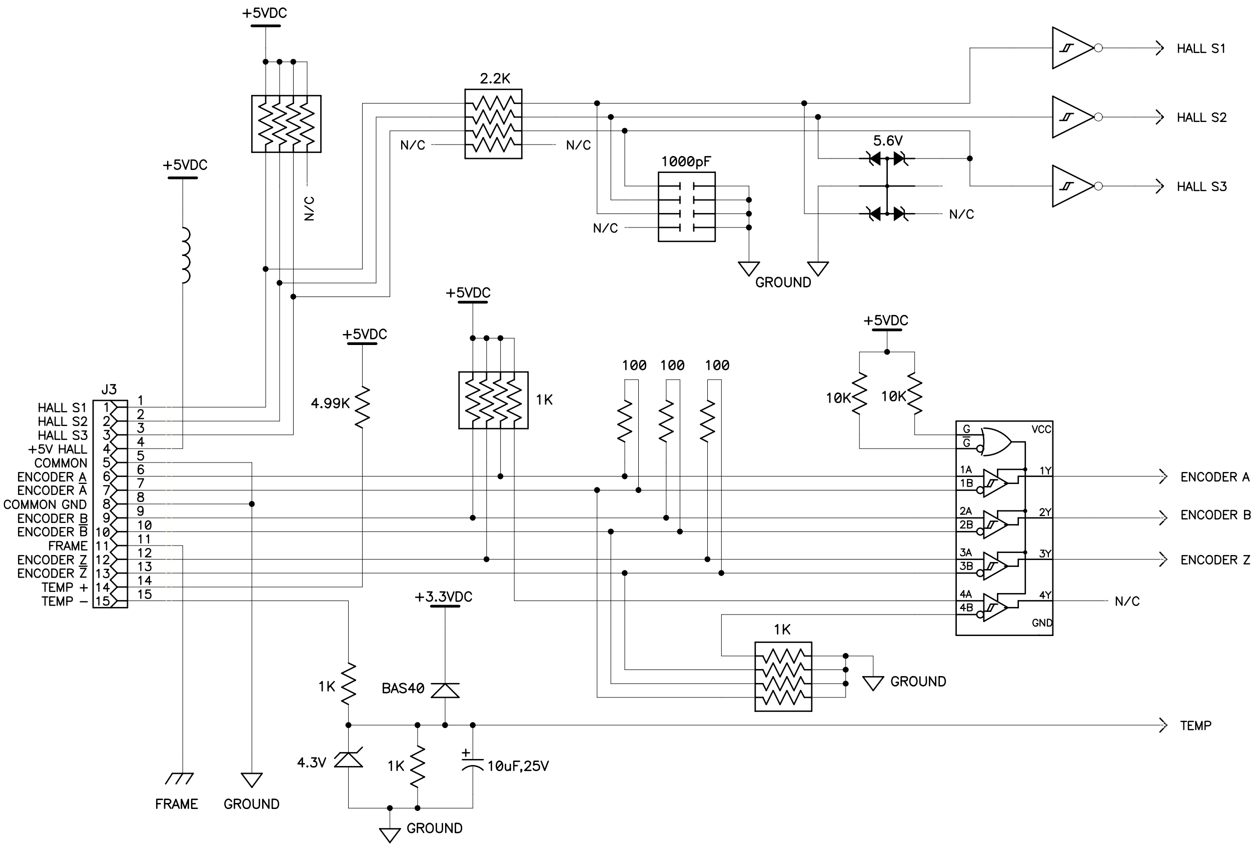


Figure 34: ACE500 J2 I/O Interface Circuitry

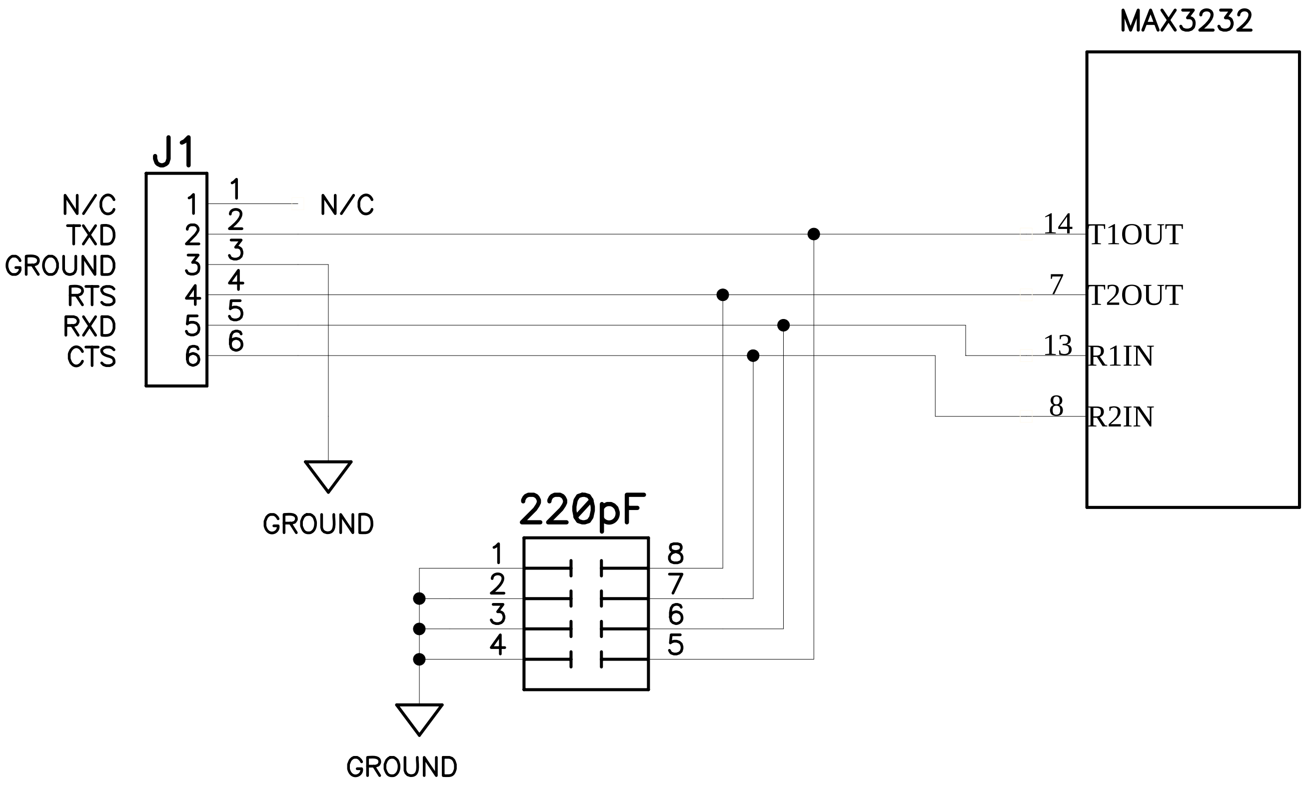
6.4.2 J3 – Motor Interface



Move text below closer to diagram

Figure 35: ACE500 J3 Motor Interface Circuitry

6.4.3 J1 RS232 Communications Interface



Make image smaller

Figure 36: ACE500 J1 RS232 Communications Interface Circuitry

6.5 Recommended Cabling and Installation

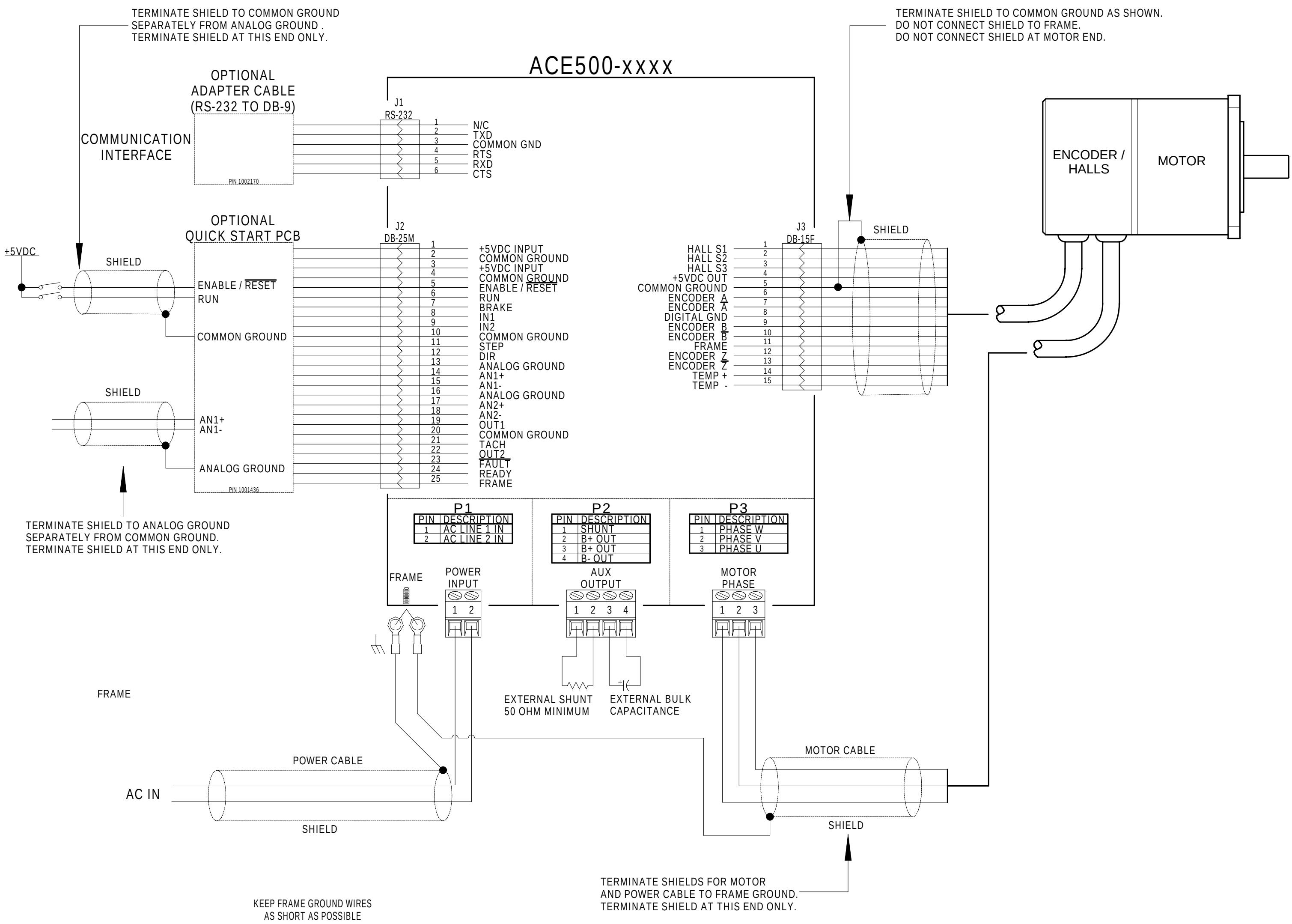


Figure 37: Recommended Cabling and Installation

6.6 Use & Selection Of The External Shunt Resistor

CAUTION! SHOCK HAZARD!
FIRE HAZARD!

WHEN THIS PRODUCT USES AN EXTERNAL SHUNT RESISTOR, PRECAUTIONS MUST BE FOLLOWED TO PREVENT A POSSIBLE FIRE HAZARD.

Shunt resistors may function using high voltage electrical power. Avoid physical contact with them whenever the ACE is powered. Shunt resistors can also become extremely hot. Follow the precautions stated below to help prevent a fire hazard.

In most applications when heavy dynamic braking and/or regenerative braking is involved, the ACE500 will require an external shunt resistor.

If an external shunt resistor is used, this is wired to connector P2. The minimum permissible ohmic value for the external shunt resistor is 50 Ohms. If a lower resistance is needed for any reason, consult AUTOMOTION.

External shunt resistor connections to connector P2 must be made across P2 pin terminals 1 and 2 or 1 and 3.

- DO NOT CONNECT THE EXTERNAL SHUNT RESISTOR ACROSS PIN TERMINALS 2 or 3 to PIN Terminal 4.
- DO NOT SHORT PIN TERMINALS 1, 2, 3 OR 3 TO FRAME GROUND.
- DO NOT USE A SHUNT RESISTOR WITH A VALUE LOWER THAN 50 OHMS AND RATED FOR HIGH MOMENTARY OVERLOADS.

It is important that this external shunt resistor be adequately sized to be reliable. It is also essential that this shunt resistor be located where it cannot cause a fire hazard should it ever overheat. AUTOMOTION recommends that the shunt resistor be placed in a well ventilated location and be kept far away from flammable materials.

The shunt operates in conjunction with a transistor switch that places it across the motor high voltage rail. Should the transistor ever fail in the ON condition the resistor would remain powered continuously. This could result in the shunt resistor becoming very hot. A user-supplied heat shield may be required to limit a possible fire hazard.

CAUTION! FIRE HAZARD!

Never mount the external shunt resistor where it can make contact with flammable materials, flammable liquid and/or flammable chemicals. If the ACE contains an optional shunt resistor mounted internal to the chassis, it too must be kept far away from flammable materials, flammable liquid and/or flammable chemicals. Never use the ACE, either with or without a shunt resistor of any type, in an explosive atmosphere. Never place the shunt resistor in the proximity of flammable materials that could melt or drop upon the shunt resistor body or the ACE drive.

The electrical terminals of this resistor are also a shock hazard. High voltage electricity is present on these terminals whenever the ACE is powered. A safety cover or shield is recommended to avoid a shock hazard.

The selected wattage rating for the shunt resistor is application dependent. Usually a heavy-duty wire wound resistor will work best. However, not all wire wound resistors are suitable for shunt service.

Through years of experience, AUTOMOTION has found the Ohmite type 250 series works reliably in many shunt applications.

If the user is supplying their own shunt resistor contact AUTOMOTION for further application advice. Ask for Field Application Bulletin #101-0195.

6.7 Model Identification

ACE500 - X XXX

Model Designator

Drive Customization Code

Final Assembly Code

7 Description of ACE500 parameters and variables

General: Each command entry is headed by the ASCII command followed by its descriptive label. The allowable value range follows. That is followed by the applications that can make use of this parameter or variable. Finally, the scaling and use of the variable follows.

In any formula, the value entered is denoted by ‘X’. The parameters are not typically changed once the user has tuned the drive to a specific application.

To read the value: From the terminal page type the ASCII command followed by a return.

To write a new value: Type the ASCII command followed by the new value (X) and a return.

Backspace allows you to start over in case a mistake is made.

7.1 The Parameter Page

7.1.1 Configuration Parameters

CL.PR **PWM (Current) Modulation Period**

Range: 1000 (1334 for the ACE500) to 2666

Applications: All

Use: The current loop and PWM rates in hertz are $2*10^7$ / X

The current loop period = 2 x PR x [CPU clock period]
= 2 x PR x [6.67 ns] (for the ACE500)

The current loop frequency = [CPU clock frequency] / (2 x PR)
= [150 MHz] / 2 x PR (for the ACE500)

CL.CG **Configuration Word**

Range: 0 to 65535

Application: All DSP based drives.

Use: This command is used to specify what servo loops are running and to control other features of the drive. When this field is clicked in the user interface, a popup appears to allow the user to set this configuration word.

Bits	**Usage**
~~0~~	~~On if the position loop is to be used. The position loop will not be used if the velocity feedback is analog.~~
~~1~~	~~On if the velocity loop is to be used~~
~~2~~	~~On if velocity feedback is to be computed from halls edges or off if velocity is to be computed from encoder edges. On the ACE-1000, this must only be changed if a hardware change is also made. This bit is overridden by analog velocity feedback.~~
~~3,12,13~~	~~If these bits are 8 hex (3 on, 12, 13 off), velocity feedback is from analog input (AN2).~~ ~~If these bits are 1000 hex (3 off, 12 on, 13 off), position feedback is from analog input (AN2).~~

	~~If these bits are 1008 hex (3,12 on, 13 off), the torque limit is from analog input. This is not used for a current mode drive.~~
~~4~~	~~On if position command is to be supplied from the serial port.~~
~~5~~	~~On if sine commutation is to be used synchronized from a halls edge.~~

2	On if the position loop is to be used. The position loop will not be used if its output – the *input* to the velocity loop - is supplanted by using analog velocity feedback.
3	On if the velocity loop is to be used. Note the velocity loop is always on in velocity mode, optional in position mode, and off in current mode.
2	On if velocity is to be computed from encoder edges, off if computed from Hall edges. If using analog velocity feedback, this bit is ignored. Note this bit must be on (and bits 3, 12, and 13 must be off) in order to read the present encoder position using the PL.AC command. (On the ACE-1000, this bit can only be used if a hardware change is also made.)
3,12,13	If bit 3 is on, and bits 12 and 13 are off, measured *velocity* comes from analog input feedback (AN2). If bit 3 is off, bit 12 is on, and bit 13 is off, measured *position* comes from analog input feedback (AN2). If bits 3 and 12 are on, and bit 13 is off, a maximum torque limit comes from analog input feedback (AN2) (not used if in current mode). This is not used for a current mode drive.
6	On if the position command is to be supplied from the serial port.
7	On if sine commutation is to be used synchronized from a Halls edge.

Bits	Usage
~~8~~	~~On if sine commutation is to be used synchronized from the encoder index. Bits 4 and 5 cannot both be on. Note that sine mode is available on the ACE500 only if a hardware change is made.~~
~~9~~	~~On to allow sine mode over modulation.~~
~~8 and 9~~	~~Halls table to use. These bits can be overridden by the Hall Table command CL.HT.~~ ~~If these bits are 0, use the standard 120 degree table.~~ ~~If these bits are 100 hex, use the 120 degree table with hall S1 and S3 swapped.~~ ~~If these bits are 200 hex, use the standard 60 degree table.~~ ~~If these bits are 300 hex, use the 60 degree table with hall S1 and S3 swapped.~~
~~10~~	~~On if encoder direction is reversed.~~
~~11~~	~~ACE500 only. On if command input is analog (AN1). Off for PWM command input.~~
10	On if sine commutation is to be used synchronized from the encoder index. Bits 5 and 6 can both be off – meaning trapazoidal commutation is used instead of sine - but both bits cannot be on. (Note that sine mode is available on older ACE1000 drives only if a hardware change is made.)
11	On to allow sine mode over-modulation.
8 and 9	On the ACE500, these bits are overridden by the Hall Table command CL.HT. For other (older) drives, these bits control which Hall Table to use: If these bits are 0, use the standard 120 degree table. If these bits are 100 hex, use the 120 degree table with Hall S1 and S3 swapped. If these bits are 200 hex, use the standard 60 degree table. If these bits are 300 hex, use the 60 degree table with Hall S1 and S3 swapped.
12	On if encoder direction is reversed.
13	On if command input is analog (AN1). Off for PWM command input.
14	On if sine commutation is to be reversed.

OR — Position/Velocity Loop Rate

Range: 3 to 255

Application: Encoder based, velocity mode, or position mode drives.

Use: The velocity loop rate is ‘current loop rate’ / X.

The velocity and position loops run every OR number of current loops. So, e.g., the velocity loop period = [current loop period] x OR.

IO — Serial Delay

Range: 0 to 256

Application: All

Use: For most late model host machines this is typically set to “0”. However, for slower host processors this value inserts a delay in the characters to avoid overflowing the host buffer.

7.1.2 Protection Parameters

RC — **Locked Rotor Current**

Range: 0 to 1023

Applications: All

Use: Used in conjunction with 'Locked Rotor Time' to check for locked rotor. If X is zero, the locked rotor check is not performed. Otherwise, the current is checked at every current loop. If the current level is greater or equal to the current level specified for the amount of time specified by locked rotor current without a halls change, a locked rotor fault occurs. The current level is 'Rated output' * X / 1024.

RT — **Locked Rotor Time**

Range: 0 to 32767

Applications: All

Use: Used in conjunction with 'Locked Rotor Current' to check for locked rotor. If the current level is greater or equal to the current level specified for the amount of time specified by locked rotor current without a halls change, a locked rotor fault occurs. X is the time in milliseconds.

TE — **Motor Temp Control**

Range: 0 to 2

Use: All.

Application: This is used to configure and enable the motor over temperature fault.

0 Motor temperature not used
1 PTC motor temperature sensor
2 NTC motor temperature sensor

LC — **Current Control Limit**

Range: 0 to 4096

Use: All drives

Application: If the current feedback (DI) greater than or equal to LC, then the current control filter multiplies the current error (current command – current feedback) by 4. This gives the effect of increasing the current loop gain by 4 when the current is greater than LC.

7.1.3 Commutation Parameters

CL.EC — **Encoder Counts per Rev –" make text Bold"**

Range: 0 to 65535

Applications: All applications using an encoder.

Use: Used for sine wave modulation. Also used by the PC front end to convert internal velocity to RPM. X is the number of encoder counts per mechanical revolution of the motor. (four times the number of encoder lines)

CL.PL	**Number of Motor Poles** **Range**: 2 to 42 (must be even) **Applications**: All applications using an encoder. **Use**: Used for sine wave modulation. X is the number of motor poles.
HT	**Hall Table** **Range**: 0 to 7 **Applications**: All drives. **Use**: Selects the sequence of Hall states which appear when the motor is rotating. Used in conjunction with the HP command below.
HP	**Halls Advance**–" make text Bold" **Range**: 0 to 5 **Applications**: All drives. **Use**: Advances the 6 step modulation by X states. Used in conjunction with the HT command (above). HP identifies which of the Hall states (in the sequence identified by HT) as the 'first' or initial state.
CL.AP	**Encoder Advance** **Range** –32768 to 32767 **Applications**: Sine mode **Use**: Advances the electrical angle by X encoder counts. Used to correctly phase the sine wave output to the motor angle.

Move line below up-reduce space

7.1.4 Current Loop Parameters

Note that current is expressed as units of full scale / 1024. However, if the current is commanded through the analog input, the result is divided by 16 before moving it to the current.

CL.KP	**Current Proportional Gain** **Range**: 0 to 32767 **Use**: All drives. **Application**: This is performed every current loop. The Proportional portion of the Voltage Modulation output value is set to KP*'Current error.
CL.KI	**Current Integral Gain** **Range**: 0 to 32767 **Use**: All drives.

Application: This is performed every current loop. ‘Current error’ * KI/32 is added to ‘working current integral’.
Note: changing the KI value will not change the ‘working current integral’.

CL.KP — Current Proportional Gain

Range: 0 to 32767

Use: All drives.

Application: This is performed every current loop.
The Proportional portion of the Voltage Modulation output value is set to KP*‘Current error.

CL.SH — Current Gain Scaling

Range: 0 to 7

Use: All drives.

Application: This is performed every current loop. The Voltage Modulation output value is multiplied by 2^{SH}.

CL.EX — Voltage Modulation Limit Plus

Range: -32768 to 32767

Use: All drives.

Application: This is an additional restraint to the Voltage Modulation output.
CL.DO<= CL.EX <= CL.MX

CL.EN — Voltage Modulation Limit Minus

Range: -32768 to 32767

Use: All drives.

Application: This is an additional restraint to the Voltage Modulation output.
CL.DO>=CL.EN>=CL.~~E~~MX

7.1.5 Velocity Loop Parameters

Hall based velocity: The velocity is computed using the 1/T method along with a filter to even out the irregularities in the timing of the halls signals. Internal velocity for halls based is in RPM. Acceleration in RPM per second is ‘internal acceleration’ * ‘velocity loop rate’ / 8. Jerk in RPM per second per second is ‘Jerk’ * ‘velocity loop rate’^{2} / 2048.

Encoder based velocity: The velocity is computed using the 1/T method or counting the number of counts in a velocity loop. The method is changed dynamically when it is deemed advantageous. The internal velocity is in units of ‘counts per velocity loop’ * 256. Therefore, velocity in RPM is ‘internal velocity’ * ‘velocity loop rate’ * (60 / 256) / ‘Encoder Counts per Rev’. Acceleration in RPM per second is
‘internal acceleration’ * ‘velocity loop rate’^{2} * (60 / 32,768) / ‘Encoder Counts per Rev’. Jerk in RPM per second per second is ‘Jerk’ * ‘velocity loop rate’^{3} * (60 / 2^{23}) / ‘Encoder Counts per Rev’.

Analog based velocity: The velocity is supplied by an analog value which will be filtered and have a gain and offset applied. This value may represent velocity or some other physical value such as pressure.

A serial command, an analog signal, or the output of the position loop can supply ‘velocity command’. If there is no position loop and the command gain is zero, then the velocity command is from a serial command. The velocity loop is also used to control the drive based on an external analog feedback signal.

The ‘velocity error’ is ‘velocity command’ – ‘velocity’.

The ‘velocity integral’ is the sum of the ‘velocity errors’. This value is limited by the
‘Velocity Integral Limit’ * 256. The ‘velocity limit’ is not summed if the current or velocity loops are saturated.

The ‘velocity derivative’ is (‘old velocity derivative’ * ‘Velocity Derivative Filter’ + (32768 – ‘Velocity Derivative Filter) * (‘velocity error’ – ‘old velocity error’)) / 32768.

The output of the velocity loop goes to the current command.

VT — **Measured Velocity Filter**

Range: 0 to 32767

Use: Halls velocity drives.

Application: Every time a new hall based velocity is computed, the result is filtered. The computed velocity is (‘old computed velocity * X + ‘new velocity’ * (32768 – X)) / 32768.
This is also used to filter the velocity command if the position and velocity feedbacks are both encoder, the position command is from step and direction, and both position and velocity loops are active. In this case, the computed velocity command is (‘old velocity command’ * X + ‘new velocity command’ * (32768 – X)) / 32768.

VL.KP — **Velocity Proportional Gain**

Range: -32768 to 32767

Use: Velocity mode or position mode drives.

Application: This is performed every velocity loop.
‘Working current correction’ is set to ‘velocity error’ * X.

VL.KI **Velocity Integral Gain**

Range: -32768 to 32767

Use: Velocity mode or position mode drives.

Application: This is performed every velocity loop.
'Velocity integral' * X / 256 is added to 'working current correction'.

VL.IL **Velocity Integral Limit**

Range: 0 to 32767

Use: Velocity mode or position mode drives.

Application: This is performed every velocity loop. The absolute value of 'velocity integral' is limited to 256 * X.

VL.KD **Velocity Derivative Gain**

Range: -32768 to 32767

Use: Velocity mode or position mode drives.

Application: This is performed every velocity loop. 'Velocity Derivative' * X is added to 'working current correction'.

VL.DF **Velocity Derivative Filter**

Range: 0 to 32767

Use: Velocity mode or position mode drives.

Application: This is performed every velocity loop. The 'velocity derivative is set to ('old velocity derivative' * X + ('velocity error' – 'old velocity error') * (32768 – X)) / 32768.

VL.SH **Velocity Gain Scaling**

Range: -26 to 30

Use: Velocity mode or position mode drives.

Application: This is performed every velocity loop. 'Working current correction' is multiplied by 2^{X-4}.

VL.MX **Velocity Max Output**

Range: 0 to 1023

Use: Velocity mode or position mode drives.

Application: This is performed every velocity loop. The absolute value of 'working current correction' is limited to X and placed in 'commanded current'.

VF.AC **Acceleration**

Range: 0 to 32767

Application: All applications for which an analog from AN1 (or PWM for the ACE500) is used for the command.

Use: This command is used every velocity loop unless it is a current mode drive in which case it is used every current loop. If X is zero, then the velocity command is the output of the analog command (if 'Command Gain' is nonzero) or the serial command. Otherwise, if 'Command Gain' is not zero, X/128 is the maximum amount that the absolute value of the velocity command can change in an update cycle. If X is nonzero, 'Command Gain' is zero, and 'Jerk' is zero, X/128 represents the absolute value of the change in command every velocity loop. If X is nonzero, 'Command Gain' is zero, and 'Jerk' is nonzero, X represents the maximum absolute value the internal acceleration can attain. In that case, the internal acceleration divided by 128 represents the change of the velocity command.

VF.JK **Jerk**

Range: 0 to 32767

Application: Velocity mode drives.

Use: This command is used every velocity loop unless it is a current mode drive in which case it is unused. This command is not used unless 'Command Gain' is zero and 'Acceleration' and 'Jerk' are nonzero. The jerk is used to generate an s-curve velocity command profile. The amount that the absolute value of the internal acceleration changes is X/256.

7.1.6 Position Loop Parameters

The position feedback will be from the encoder if the drive is not configured for analog position feedback. The position measurement will then be the number of encoder counts. Otherwise, the position feedback will be from analog.

For the ACE500 position command may come from a step and direction signal, an analog signal, or a serial command. The command is from step and direction if the drive is not configured for a serial position command and command gain is zero.

The ‘position error’ is ‘position command’ – ‘position’.

The ‘position integral’ is the sum of the ‘position errors’. This value is limited by the ‘Position Integral Limit’ * 256. The ‘position limit’ is not summed if the current loop or the position loop are saturated.

The ‘position derivative’ is (‘old position derivative’ * ‘Position Derivative Filter’ + (32768 – ‘Position Derivative Filter) * (‘position error’ – ‘old position error’)) / 32768.

The output of the position loop goes to the velocity command if there is a velocity loop. Otherwise, it is divided by 16 and put in the current command.

PL.KP **Position Proportional Gain**

Range: 0 to 32767

Use: Position mode drives.

Application: This is performed every velocity loop. ‘Working velocity correction’ is set to ‘velocity error’ * X.

PL.KI **Position Integral Gain**

Range: 0 to 32767

Use: Position mode drives.

Application: This is performed every velocity loop. ‘Position integral’ * X / 256 is added to ‘working velocity correction’.

PL.IL **Position Integral Limit**

Range: 0 to 32767

Use: Position mode drives.

Application: This is performed every velocity loop. The absolute value of ‘position integral’ is limited to 256 * X.

PL.KD **Position Derivative Gain**

Range: 0 to 32767

Use: Position mode drives.

Application: This is performed every velocity loop. ‘Position derivative’ * X is added to ‘working current correction’.

PL.DF **Position Derivative Filter**

Range: 0 to 32767

Use: Position mode drives.

Application: This is performed every velocity loop. 'Position derivative is set to ('old position derivative' * X + ('position error' – 'old position error') * (32768 – X)) / 32768.

PL.SH **Position Gain Scaling**

Range: -30 to 30

Use: Position mode drives.

Application: This is performed every velocity loop. 'Working velocity correction' is multiplied by 2^X.

PL.MX **Position Max Output**

Range: 0 to 32767

Use: Position mode drives.

Application: This is performed every velocity loop. The absolute value of 'working velocity correction' is limited to X * 16. 'Commanded velocity' is set to ('position command' – 'old position command') * 256 + 'working velocity correction'

PL.SC **Steps per Revolution**

Use: Position mode drives. Command Gain (VF.GN) must be zero and the Configuration word must not be set for serial position command.

Application: This is performed every velocity loop. Every step pulse while the drive is in run, the desired position is incremented or decremented (depending on the direction signal) by Encoder Counts per Rev (CL.EC) / Steps per Revolution. The calculation is accurate to within one encoder count both within one revolution and long term. This will try to position the motor as if it were a stepper motor with the correct number of steps for one revolution. Unfortunately, because of an error in the DSP silicon, the first step is always lost. If position feedback is encoder and velocity command is step and direction, the velocity command is incremented by 256 * encoder count difference in addition to the velocity command from the position PID loop.

7.1.7 I/O Configuration

VF.FL **Command Filter**

Range: 0 to 32767

Application: All applications for which an analog from AN1 is used for the command.

Use: This is used every velocity loop unless the drive is in current mode only in which case it is used every current loop. This is used for the first operation in converting the analog command to an actual command. The output of this command is used as the input to the 'Command Offset'. This command may represent position, current, velocity, or a value represented by the analog feedback signal. The output of the filter is ('Old Value' * X + 'New Value' * (32768 – X)) / 32768. For the ACE200 the input range is 0 to 8191.

VF.OF **Command Offset**

Range: -32768 to 32767

Application: All applications for which an analog from AN1 is used for the command.

Use: This command is used every velocity loop unless it is a current mode drive in which case it is used every current loop. Used as the second operation in converting the analog command to an actual command. The output of this command is used as the input to the 'Command Gain'. X is added to the input to get the output.

VF.GN **Command Gain**

Range: -32768 to 32767

Application: All applications for which an analog from AN1 is used for the command.

Use: This command is used every velocity loop unless it is a current mode drive in which case it is used every current loop. Used as the third operation in converting the analog command to an actual command for the outer loop used. If the gain is zero, then there is no analog command and the command must be provided serially or by step and direction for position mode. Note that step and direction is not available on the ACE500. The output is 'input' * X / 4096 for current command or 'input' * X / 256 for velocity or position command. The output is the command in internal units.

CF.FL Make Bold Aux Analog Filter

Range: 0 to 32767

Application: All.

Use: This is used every velocity loop unless the drive is in current mode only in which case it is used every current loop. This is used for the first operation in converting the analog feedback to an actual feedback. The output of this command is used as the input to the 'Aux Analog Offset'. This feedback may represent position, velocity, or a current limit. The output of the filter is ('Old Value' * X + 'New Value' * (32768 – X)) / 32768. The input range is 0 to 8191.

CF.OF **Aux Analog Offset**

Range: -32768 to 32767

Application: All.

Use: This is used every velocity loop unless it is a current mode drive in which case it is used every current loop. Used as the second operation in converting the analog feedback to an actual feedback. The output of this command is used as the input to the 'Command Gain'. X is added to the input to get the output.

CF.GN **Aux Analog Gain**

Range: -32768 to 32767

Application: All applications for which an analog from AN1 (or PWM for the ACE500) is used for the command.

Use: This is used every velocity loop unless it is a current mode drive in which case it is used every current loop. Used as the third operation in converting the analog feedback to an actual feedback. The output is 'input' * X / 256. The output is the feedback in internal units.

7.2 Graphing Variables

General: The following are operational variables are used for data gathering and graphing. Any parameter or variable that can be read can be graphed. These are the variables used by the Windows interface.

CL.CC **Commanded Current**

The commanded current can have values from –1024 to 1023. Units are full scale current / 1024. Commanded current can only be written if there is no position or velocity loop and command gain is zero.

PL.CM
PL.CH **Commanded Position (PL.CM low order, PL.CH high order)**

The commanded position can have a value from –2147483648 to 2147483647. PL.CM when not used as a data gathering variable returns the value of both words together. Both PL.CM and PL.CH need to be used while setting up data gathering to get both words. Units are encoder counts if serial position command is off and command gain is zero, filtered analog with gain and offset if serial position command is off and command gain is not zero, or a serial command. Commanded position may be written only if there is a position loop and the serial position bit of the configuration is set.

VL.CM
VL.CH **Commanded Velocity (VL.CM low order,VL.CH high order)**

The commanded velocity can have a value from –2147483648 to 2147483647. VL.CM when not used as a data gathering variable returns the value of both words together. Both VL.CM and VL.CH need to be used while setting up data gathering to get both words. Units are:

1 RPM for halls based velocity
2 Encoder counts per position servo cycle * 256 for halls based velocity.
3 Filtered analog with gain and offset for if there is no position loop, a velocity loop and analog velocity is set in the configuration word. Commanded velocity may be written only if there is no position loop, a velocity loop and the command gain is zero.

CL.DO **Commanded Voltage**

DI **Current**

CL.ER **Current Error**

This variable is read only. Current error is commanded current – current.

CL.IN
CL.IH **Current Integral (CL.IN low order, CL.IH high order)**

This variable is read only. The current integral is the sum of the current errors. The integral is not summed if the current loop is saturated. The current integral can have a value between –2147483648 to 2147483647. . IN or CL.IN when not used as a data gathering variable returns the value of both words together. Both IN or CL.IN and IH or CL.IH need to be used while setting up data gathering to get both words.

VF.VD
VF.VA

Filtered Command (VF.VD low order, VF.VA high order)

This variable is read only. See command filter (VF.FL) for details about how the filter operates. When not used as a data gathering variable, VF.VA returns the integer part of the filtered command and VF.VD returns both the integer and fractional parts * 65536.

CF.VD
CF.VA

Filtered Feedback (CF.VD low order, CF.VA high order)

This variable is read only. See aux. analog filter (CF.FL) for details about how the filter operates. When not used as a data gathering variable, CF.VA returns the integer part of the filtered feedback and CF.VD returns both the integer and fractional parts * 65536.

PL.DD
PL.DE

Filtered Position Derivative (PL.DD low, PL.DE high order)

This variable is read only. See position loop description and position derivative filter (PL.DF) for descriptions of the position derivative. When not used as a data gathering variable, PL.DE returns the integer part of the position derivative and PL.DD returns both the integral and fractional parts * 65536.

VL.DD
VL.DE

Filtered Velocity Derivative (VL.DD low, VL.DE high order)

This variable is read only. See velocity loop description and velocity derivative filter (VL.DF) for descriptions of the velocity derivative. When not used as a data gathering variable, VL.DE returns the integer part of the velocity derivative and VL.DD returns both the integral and fractional parts * 65536.

CL.ID

Flux Current

Sine mode only. This variable is read only. The DSP program calculates this value. It is the amount of current that is flowing in the drive that is perpendicular to the torque producing current. Because this current causes the motor to generate heat, the ideal value should be zero.

CL.DV

Flux Voltage

Sine mode only. This variable is read only. The DSP program calculates this value. It is the leading (+) or lagging (-) voltage that the drive is applying to the motor to reduce the flux current.

CH

Halls

This value is read only. The three hall signals are displayed as 0 or 1 in the order of s3,s2 & s1 and is the actual value of the three halls signals as read at the DSP.

MP

Motor Phase

This value is read only. Value is from 0 to 5 and is the motor phase derived from the halls.

DU	**Phase U Current** This value is read only. Value is from –32768 to 32767 and is proportional the phase U current. To calculate the actual current multiply by (IR)* (drive rating in amps)/2017152.
DV	**Phase V Current** This value is read only. Value is from –32768 to 32767 and is proportional the phase V current. To calculate the actual current multiply by (IR)* (drive rating in amps)/2017152.
DW	**Phase W Current** This value is read only. Value is from –32768 to 32767 and is proportional the phase W current. To calculate the actual current multiply by (IR)* (drive rating in amps)/2017152.
PL.AC **PL.AH**	**Position (PL.AC low order PL.AH high order)** This variable is read only. Position can have a value from –2147483648 to 2147483647. PL.AC when not used as a data gathering variable returns the value of both words together. Both PL.AC and PL.AH need to be used while setting up data gathering to get both words. Units are encoder counts if analog position feedback command is off or filtered analog with gain and offset if analog position feedback command is off.
PL.ER	**Position Error** This variable is read only. Position error can have a value of –32768 to 32767. It is commanded position – position.
PL.IN **PL.IH**	**Position Integral (PL.IN low order PL.IH high order)** This variable is read only. Position integral is the sum of the position errors. It is not accumulated if the position loop or current loop is saturated. The position integral can have a value between –8388352 to 8388352. PL.IN when not used as a data gathering variable returns the value of both words together. Both PL.IN and PL.IH need to be used while setting up data gathering to get both words.
CL.DS	**Scaled Current Integral**
VL.AC **VL.AH**	**Velocity (VL.AC low order VL.AH high order)** This variable is read only. Velocity can have a value from –2147483648 to 2147483647. VL.AC when not used as a data gathering variable returns the value of both words together. Both VL.AC and VL.AC need to be used while setting up data gathering to get both words. Units are: 1 RPM for halls based velocity 2 Encoder counts per position servo cycle * 256 for halls based velocity. 3 Filtered analog with gain and offset for if analog velocity is set in the configuration word.

VL.ER — Velocity Error

This variable is read only. Velocity error can have a value of –32768 to 32767. It is commanded velocity – velocity.

VL.IN VL.IH — Velocity Integral (VL.IN low order VL.IH high order)

This variable is read only. Velocity integral is the sum of the velocity errors. It is not accumulated if the velocity loop or current loop is saturated. The velocity integral can have a value between –8388352 to 8388352. VL.IN when not used as a data gathering variable returns the value of both words together. Both VL.IN and VL.IH need to be used while setting up data gathering to get both words.

CL.EA — Electrical Angle

Sine mode only. The electrical angle is a value between 0 and 1535 with 1536 representing 360 degrees. The electrical angle may be set to a value and that value will be held regardless of the position until it is changed by writing a new value or released by writing a negative number to the electrical angle.

7.3 Data Gathering Variables

7.3.1 Setting up Triggering:

7.3.1.1 No Trigger:

If there is no trigger, a sample is collected every sample period after a delay of a specified number of sample periods. A sample is a snapshot of the variables specified during the data gathering setup. A sample period is a specified number of current or velocity loops. There are 32768 words available to store the samples. The space required to store all the samples is # of variables * (number of samples + 1). Note that double precision variables such as commanded velocity require two words to store. To set up data gathering, set the start up delay and the sample rate as desired followed by a data specification start, then list the variables in order that you want, then the data specification end.

7.3.1.2 Using Trigger:

If triggering is desired, then a negative sample delay is the number of samples before the trigger event to be displayed and a positive sample delay is the number of samples after the trigger event to delay. No data will be sent until the trigger event occurs.

DG.TC **Clear trigger table**

This must be the first command before setting up the trigger table if there is to be one. This command clears both the trigger table and the data gathering table.

DG.TR **Set the trigger control word**

This sets the trigger control word. The trigger control word cannot be read. This command must be directly followed by a command which is the command to read the data variable. The data variable must be followed by a DG.CN command.

Control information format:

Bits Description
15 Must be set to zero.

13-14 Comparison type which takes one of these four values:
- 0: Variable < constant
- 1: Variable > constant
- 2: Falling edge, Variable was greater or equal to constant, now is less
- 3: Rising edge, Variable was less or equal to constant, now is greater

11-12 Relationship type which takes one of these four values:
- 0: Last entry in table
- 1:Both this comparison and the next one must be true
- 2: Either this comparison or the next must be true
- 3: This comparison must become true and then the next one must become true

9-10 Variable type which takes one of the following three values:
- 0: Variable and constant are unsigned
- 2: Variable is signed, constant is unsigned and comparison is absolute value

- 3: Variable and constant are signed

8 On for double precision variable and constant

0-7 Filter

Filter operation:

Let FO be the old filtered value (with fraction), FN be the new filtered value, F be the filter and V be the actual variable value. Then: FN = (V * F + (256 – F) * FO) / 256.

DG.CN Set the trigger constant

This sets the trigger constant. The constant is signed or unsigned and single or double precision depending on the value of the DG.TR command. The trigger constant cannot be read. This command must be directly preceded by a command that specifies the data variable desired.

7.3.2 Setting up Data Gathering

DG.DW **Start up Delay**

The number of sample periods to delay before starting the first sample. This variable may have a value from 0 to 32767. If there is triggering, the value may be from –32767 to 32767. If the value is negative, its absolute value must be less than of equal to the number of samples able to be collected (see DG.DE).

DG.DR **Sample Rate**

The number of current or position loops – 1 between each sample period. This variable may have a value from 0 to 65535.

DG.DS **Data Specification Start**

Specifies current loop (1) or position loop (0). After this command the variables desired must be entered. This variable must have a value, either 1 or zero. If triggering is to be used, it must be set up before this command is issued.

DG.DE **Data Specification End**

Specifies the number of samples to collect. All the variables desired must be entered before this command. This variable must have a value from zero to 32767. Each sample has the number of variables entered between the data specification start and the data specification end. Note that if a variable is double precision, the location of the variable and the location of the high order of the variable must both be specified. The maximum number of samples is (32767 – 5 * Number of single precision triggers – 7 * Number of double precision triggers) / Number of variables specified.

7.3.3 Retrieving Data Gathering Words

DG.RM **Data Read**

This variable is read only. Read a word of data from data gathering memory. The value is returned in hexadecimal. The values are returned in sample number order and within samples in order by the data variables entered.

DG.ST **Data Read Streaming**

This command starts data streaming. The number of samples to be returned are in the command parameter. Each variable is returned as two 8 bit characters. After all data is streamed, a carriage return followed by a line feed is put out. It is up to the user to make sure the number of points specified are available before issuing this command (see DG.PA). The values are sent in the same order as DG.RM.

DG.PA **Data Points Remaining**

This variable is read only. Returns the total number of points which have been collected but not read.

DG.DA **Data Address**

This variable is the number of words which have been read. This can be used in conjunction with data CRC to set the back to the place where the CRC was last valid in case the CRC does not match.

DG.CR **Data CRC**

For every word which is read by way of a read data command, a CRC is computed by the code shown below. When Data CRC is written, it is written to the upper 16 bits of GraphCRC. When DataCRC is read, it is read from the upper 16 bits of GraphCRC. By setting GraphCRC to a known number from 0 to 65535 (65535 is recommended) and keeping track of the CRC as each data word is sent, the data can be verified with a very small probability of undetected error.

```
unsigned long int GraphCRC;
unsigned short int Data;

Graphic CRC += Data;
for (Ix = 0; Ix < 16; Ix++)
{
if ((long int)GraphCRC < 0)
GraphCRC ^= 0xC0028000;
GraphCRC <<= 1;
}
```

7.3.4 Operational Values for Data Gathering

Any parameter or variable that can be read can be graphed. These are the variables used by the AutoMotionPLUS Windows interface.

CL.CC or CC	**Commanded Current** The commanded current can have values from –1024 to 1023. Units are full scale current / 1024. Commanded current can only be written if there is no position or velocity loop and command gain is zero.
PL.CM PL.CH	**Commanded Position (low order) Commanded Position (high order)** The commanded position can have a value from –2147483648 to 2147483647. PL.CM when not used as a data gathering variable returns the value of both words together. Both PL.CM and PL.CH need to be used while setting up data gathering to get both words. Units are encoder counts if serial position command is off and command gain is zero, filtered analog with gain and offset if serial position command is off and command gain is not zero, or a serial command. Commanded position may be written only if there is a position loop and the serial position bit of the configuration is set.
VL.CM VL.CH	**Commanded Velocity (low order) Commanded Velocity (high order)** The commanded velocity can have a value from –2147483648 to 2147483647. VL.CM when not used as a data gathering variable returns the value of both words together. Both VL.CM and VL.CH need to be used while setting up data gathering to get both words. Units are: 4 RPM for halls based velocity 5 Encoder counts per position servo cycle * 256 for halls based velocity. 6 Filtered analog with gain and offset for if there is no position loop, a velocity loop and analog velocity is set in the configuration word. Commanded velocity may be written only if there is no position loop, a velocity loop and the command gain is zero.
CL.DO or DO	**Commanded Voltage**
DI	**Current**
CL.ER or ER	**Current Error** This variable is read only. Current error is commanded current – current.
CL.IN or IN	**Current Integral (low order)**
CL.IH or IH	**Current Integral (high order)** This variable is read only. The current integral is the sum of the current errors. The integral is not summed if the current loop is saturated. The current

integral can have a value between –2147483648 to 2147483647. . IN or CL.IN when not used as a data gathering variable returns the value of both words together. Both IN or CL.IN and IH or CL.IH need to be used while setting up data gathering to get both words.

CL.EA **Electrical Angle**

Sine mode only. The electrical angle is a value between 0 and 1535 with 1536 representing 360 degrees. The electrical angle may be set to a value and that value will be held regardless of the position until it is changed by writing a new value or released by writing a negative number to the electrical angle.

VF.VD **Filtered Command (low order)**
VF.VA **Filtered Command (high order)**

This variable is read only. See command filter (VF.FL) for details about how the filter operates. When not used as a data gathering variable, VF.VA returns the integer part of the filtered command and VF.VD returns both the integer and fractional parts * 65536.

CF.VD **Filtered Feedback (low order)**
CF.VA **Filtered Feedback (high order)**

This variable is read only. See aux. analog filter (CF.FL) for details about how the filter operates. When not used as a data gathering variable, CF.VA returns the integer part of the filtered feedback and CF.VD returns both the integer and fractional parts * 65536.

PL.DD **Filtered Position Derivative (low order)**
PL.DE **Filtered Position Derivative (high order)**

This variable is read only. See position loop description and position derivative filter (PL.DF) for descriptions of the position derivative. When not used as a data gathering variable, PL.DE returns the integer part of the position derivative and PL.DD returns both the integral and fractional parts * 65536.

VL.DD **Filtered Velocity Derivative (low order)**
VL.DE **Filtered Velocity Derivative (high order)**

This variable is read only. See velocity loop description and velocity derivative filter (VL.DF) for descriptions of the velocity derivative. When not used as a data gathering variable, VL.DE returns the integer part of the velocity derivative and VL.DD returns both the integral and fractional parts * 65536.

CL.ID **Flux Current**

Sine mode only. This variable is read only. The DSP program calculates this value. It is the amount of current that is flowing in the drive that is perpendicular to the torque producing current. Because this current causes the motor to generate heat, the ideal value should be zero.

CL.DV	**Flux Voltage** Sine mode only. This variable is read only. The DSP program calculates this value. It is the leading (+) or lagging (-) voltage that the drive is applying to the motor to reduce the flux current.
CH	**Halls** ~~This value is read only. The three hall signals are displayed as 0 or 1 in the order of s3,s2 & s1~~ ~~And is the actual value of the three halls signals as read at the DSP.~~ This value is read only. The three Hall signals are displayed as 0 or 1 in the order of s3,s2 & s1, and is the actual value of the three Halls signals as read at the DSP.
MP	**Motor Phase** This value is read only. Value is from 0 to 5 and is the motor phase derived from the halls.
DU	**Phase U Current** This value is read only. Value is from –32768 to 32767 and is proportional the phase U current. To calculate the actual current multiply by (IR)* (drive rating in amps)/2017152.
DV	**Phase V Current** This value is read only. Value is from –32768 to 32767 and is proportional the phase V current. To calculate the actual current multiply by (IR)* (drive rating in amps)/2017152.
DW	**Phase W Current** This value is read only. Value is from –32768 to 32767 and is proportional the phase W current. To calculate the actual current multiply by (IR)* (drive rating in amps)/2017152.
PL.AC **PL.AH**	**Position (low order)** **Position (high order)** This variable is read only. Position can have a value from –2147483648 to 2147483647. PL.AC when not used as a data gathering variable returns the value of both words together. Both PL.AC and PL.AH need to be used while setting up data gathering to get both words. Units are encoder counts if analog position feedback command is off or filtered analog with gain and offset if analog position feedback command is off.
PL.ER	**Position Error** This variable is read only. Position error can have a value of –32768 to 32767. It is commanded position – position.
PL.IN **PL.IH**	**Position Integral (low order)** **Position Integral (high order)**

This variable is read only. Position integral is the sum of the position errors. It is not accumulated if the position loop or current loop is saturated. The position integral can have a value between –8388352 to 8388352. PL.IN when not used as a data gathering variable returns the value of both words together. Both PL.IN and PL.IH need to be used while setting up data gathering to get both words.

CL.DS or DS	**Scaled Current Integral**

VL.AC	**Velocity (low order)**
VL.AH	**Velocity (high order)**

This variable is read only. Velocity can have a value from –2147483648 to 2147483647. VL.AC when not used as a data gathering variable returns the value of both words together. Both VL.AC and VL.AC need to be used while setting up data gathering to get both words. Units are:

4 RPM for halls based velocity
5 Encoder counts per position servo cycle * 256 for halls based velocity.
6 Filtered analog with gain and offset for if analog velocity is set in the configuration word.

VL.ER	**Velocity Error**

This variable is read only. Velocity error can have a value of –32768 to 32767. It is commanded velocity – velocity.

VL.IN	**Velocity Integral (low order)**
VL.IH	**Velocity Integral (high order)**

This variable is read only. Velocity integral is the sum of the velocity errors. It is not accumulated if the velocity loop or current loop is saturated. The velocity integral can have a value between –8388352 to 8388352. VL.IN when not used as a data gathering variable returns the value of both words together. Both VL.IN and VL.IH need to be used while setting up data gathering to get both words.

7.3.5 Function Generator

A built in function generator allows an easy check of the servo response of any of the loops to a generated signal. The generator ramps from the current command to the base of the response signal so that a gradual initial change is provided.

FG.SL **Function Generator Ramp Slope**

This is the slope of the initial ramp. Units are signal change per loop divided by 256. This is an unsigned number that will adjust the signal upward or downward until the base value is reached.

FG.BS **Function Generator Base Value**

This is the base of the wave. It is a double precision signed value.

FG.AM **Function Generator Amplitude**

This is the amplitude of the wave. It is a double precision signed value. The signal value for the main part of the wave generation is between the base and base plus amplitude. Therefore, if the amplitude is negative, the signal will start at the top after the ramp.

FG.CY **Function Generator Cycle Time**

This is the cycle time for the complete wave. It is a single precision unsigned value. The value is in number of loops. The actual cycle time may be close to this value, but not necessarily exact.

FG.CT **Function Generator Control Word**

This is the word which controls the operation of the function generator. Its format follows:

Bits	Value	Description
0-1	0	No motion generator
	1	Input to current loop
	2	Input to velocity loop
	3	Input to position loop
2-3	0	Square wave
	1	Triangle wave
	2	Sawtooth wave
	3	Sine wave (starts at 270°)
4-5	0	This field must be set to zero by the user

FG.ST **Start Function Generation**

This command validates the parameters, does some necessary computations, and starts the function generator. If the drive is in standby when this command is issued, the function generator will start when the drive goes into run.

FG.SP **Stop Function Generation**

This command stops the function generator. Going into standby mode will also disable the function generator.

FG.NC **Number of Cycles**

This command specifies the number of cycles to run before stopping. After stopping, the drive will be placed in standby unless this parameter is zero, in which case, the function generator will run until the drive is placed into standby.

7.3.6 Diagnostic Commands and Variables

Caution: Some of the commands and variables described here require specific knowledge and may cause problems if used incorrectly. These should be used only by someone knowledgeable about the drive.

DG.RS **Reset Drive**

This command will reset the drive if a 47802 is written to it, i.e. DG.RS 47802. Otherwise, it will return an error.

CV **Get Version String**

This is read only. Responds with the version string. The version string has the software ID number, version number, date, and description of drive type.

LR **Allow Low Rail Voltage**

If LR is zero, the drive may be enabled even if the rail voltage is too low or entirely absent. The user must assure that the voltages needed for drive operation are present.

CF **Display Fault String**

This is read only. Displays a string describing the state of the drive: run/standby, brake, and any faults.

CR **Restore Default Parameters**

This is read only. Restores factory default parameters and writes them to EEPROM. The previous parameters will be lost. On versions released after December 8, 2004, the command will be accepted only if typed as “CR23130”.

SR **Run Switch**

This sets the value of the run/standby switch.

0 Drive in standby with run line low or an error.
1 Drive in run with run line high.
2 Drive forced into standby regardless of the state of the run line.
3 Drive forced into run if there are no errors regardless of the state of the run line.

TT **Test Time**

Pulses for the specified number of current loop times. The test current is sent to the control loop and the test voltage overrides the output of the control loop if it is not zero. If the drive faults during the test the value of TT is equal to the remaining current loops.

TC	**Test Current**	Used in conjunction with the test time command to set the test current.
TV	**Test Voltage**	Used in conjunction with the test time command to set the test modulation voltage. Must be set to zero to use test current.
IO	**Set Output Delay**	Sets the time in milliseconds to delay between each character transmitted to the serial port. Normally should be zero (0).
AD.FV	**5 Volt Monitor**	Read only. Monitors the 5 volt bus. Range from 0 to 65535.
AD.RL	**Rail Voltage**	Read only. Range from 0 to 65535.
AD.VF	**15 Volt Monitor**	Read only. ACE only. Monitors the +15 volt bus. Range from 0 to 65535.
AD.FN	**15 Volt Monitor**	Read only. ACE only. Monitors the -15 volt bus. Range from 0 (0V) to 65535.
AD.IT	**Motor Temperature**	Read only. ACS only. Monitors the raw AD reading of motor temperature. Range from 0 to 65535.
AD.IA	**Analog Input 1**	Read only. For ACS, this is the raw AD reading. Range from 0 to 65535. For ACE, this is the PWM input or the raw AD input. Range from –4095 to 4095.
AD.IB	**Analog Input 2**	Read only. For ACS, this is the raw AD reading. Range from 0 to 65535. For ACE, this is the raw AD input. Range from 0 to 8191.
AD.EA	**Encoder Angle**	Read only. ACS and ACE. This is the motor mechanical angle. It is not initialized. Its range is from 0 to Encoder counts per Revolution minus 1.

CL.MN Actual Voltage Minimum

Read only. The actual minimum value the modulation voltage is allowed to attain.

CL.MX Actual Voltage Maximum

Read only. The actual maximum value the modulation voltage is allowed to attain.

CL.FD Current Feedback

Read only.