VAREDAN
TECHNOLOGIES

VSA Series Digital PWM Servo Amplifier

VSA1-0510 Series
VSA2-1530 Series

Technical Reference Manual

Manual Part Number: 4055-42-005

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Document Revision History

Revision	Release Date	Notes
Beta	12-31-2019	Draft
Rev A	06-26-2022	
Rev B	07-20-2023	Updated based on Rev D hardware.
Rev C	12-05-2024	Draft VSA2-1530 spec.
Rev D	04-11-2025	Updated VSA2 details.

CAUTION! READ THIS SECTION BEFORE PROCEEDING.

- Warning! Potentially lethal voltages exist within the amplifier when power is applied. Never attempt to handle or probe the amplifier with power applied.
- Hazardous voltages are present at the motor output terminals, input power connection, and within the sheet metal enclosure. Disconnect the power before plugging / unplugging any connections or before servicing or disassembling the enclosure.
- These amplifiers are capable of producing large amounts of energy. Serious injury or death can result from improper motor or load movement.
- Do not connect the motor to the system load during initial testing and installation.
- Be sure power is off when inserting or removing connectors or connections.

Contents

1 Introduction

This manual describes the operation and installation of the VSA Series digital Pulse Width Modulated (PWM) Servo Amplifiers manufactured by Varedan Technologies.

The VSA Series are designed for high performance OEM applications requiring PWM switching type amplifiers. These fully digital servo amplifiers are available in a variety of power ranges to drive three-phase brushless motors, single-phase brush-type motors or voice coils. These amplifiers operate in position, velocity, or torque (current) mode using either an analog input, a digital command, or 2-phase sine analog input mode.

Programmable commutation options include sinusoidal from a motor mounted encoder, externally commutated 2-phase sine inputs or trapezoidal commutation using motor mounted hall sensors.

The design of these amplifiers includes an on-board high-speed Digital Signal Processor (DSP) which performs the PID loop controls as well as monitors all key system functions in real-time to protect the amplifier in the event of a system fault.

Communication options include Ethernet and RS-232 interfaces. An intelligent operating system allows setup and storage of all system parameters using simple ASCII commands over the communications interface. The communications interface can also be used to view all operating parameters in real-time. Non-volatile memory provides storage of the parameters during power off conditions. To automate the process of setting up multiple units with the same configuration, a text file can be downloaded to each unit.

A PC based graphical user interface (GUI) utility software with the built-in digital oscilloscope is provided to reduce testing and debugging time of the user applications.

Through this manual, VSA digital PWM amplifier is referred either as the Amplifier or the Drive.

2 Specifications

2.1 Electrical Specification

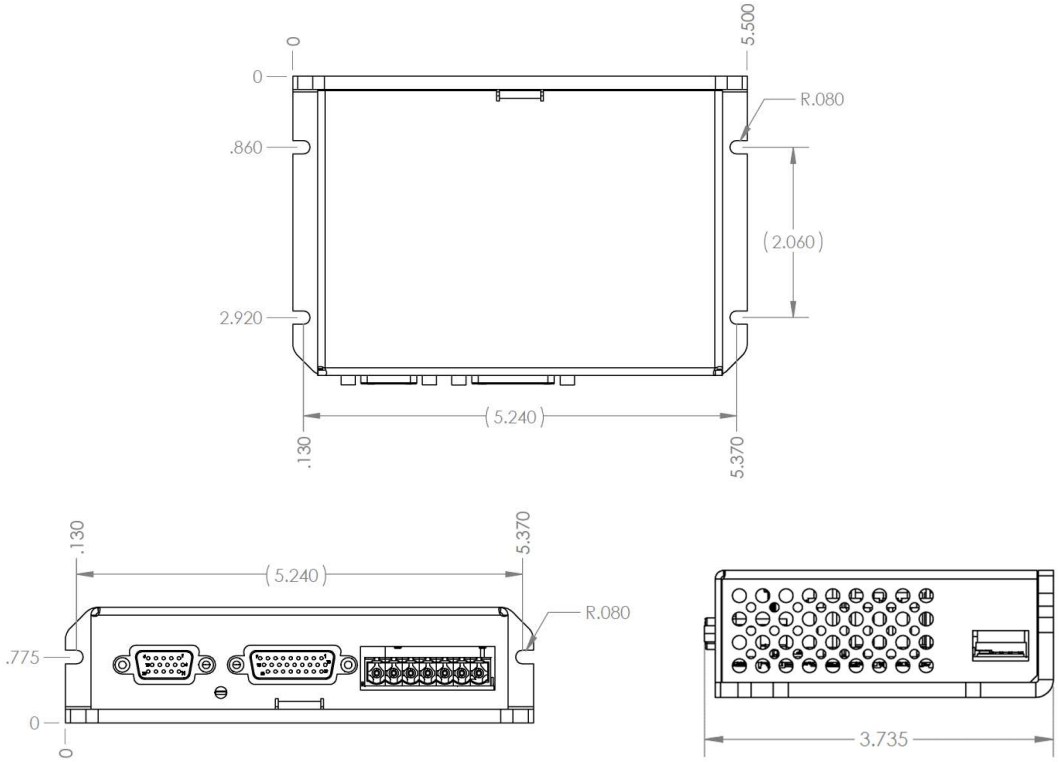
Parameter	VSA1-0510	VSA2-1530
AC Supply Voltage Input	N/A	80VAC – 240VAC, 1 or 3-phase
DC Bus Voltage Input	24VDC - 80VDC	90VDC – 380VDC
Keep Alive Voltage (optional)	24VDC	24VDC
Continuous Current	5A	15A
Peak Current	±10A	±30A
Power Dissipation at Continuous Current	325W	TBD
Switching Frequency	40 KHz	25 KHz
Current Loop Bandwidth	up to 6KHz	up to 4KHz
Current Command Signal	+/-10V Differential	+/-10V Differential
Current Transconductance	1Amp/1Volt	3Amp/1Volt
Operating Mode	3-phase Torque/Force mode with commutation 3-phase AB Current mode, no commutation Single-phase H-bridge current mode	
Feedbacks	Incremental Encoder Analog Sin/Cos Encoder Absolute Biss Encoder, Biss, EnDat Hall	
Motor Initialization Mode	Constant Current Phasing Pulse Current Phasing (TBD) Hall	

2.2 Mechanical Specification

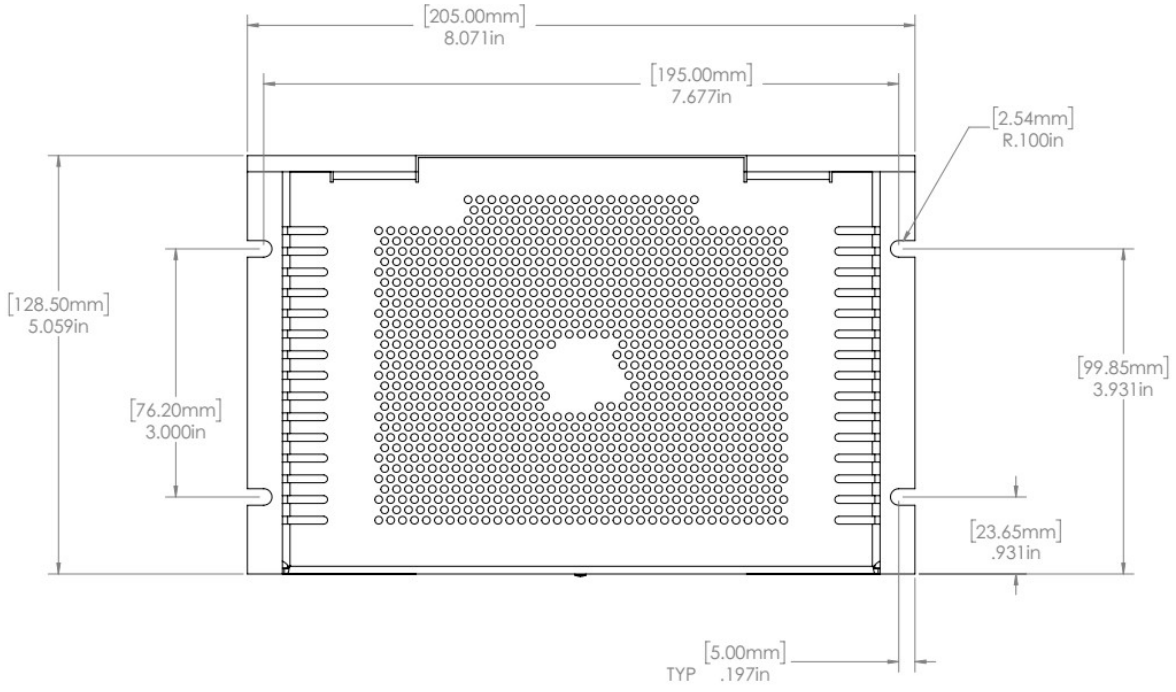
Parameters	VSA1-0510	VSA2-1530
Length	5.5 inch (139.7 mm)	8.07 inch (205 mm)
Width	1.3 inch (33.0 mm)	5.06 inch (128.5 mm)
Height	3.55 inch (90.1 mm)	2.64 inch (67 mm)
Weight	0.7 lb (0.31 kg)	3.0 lb (1.36 Kg)

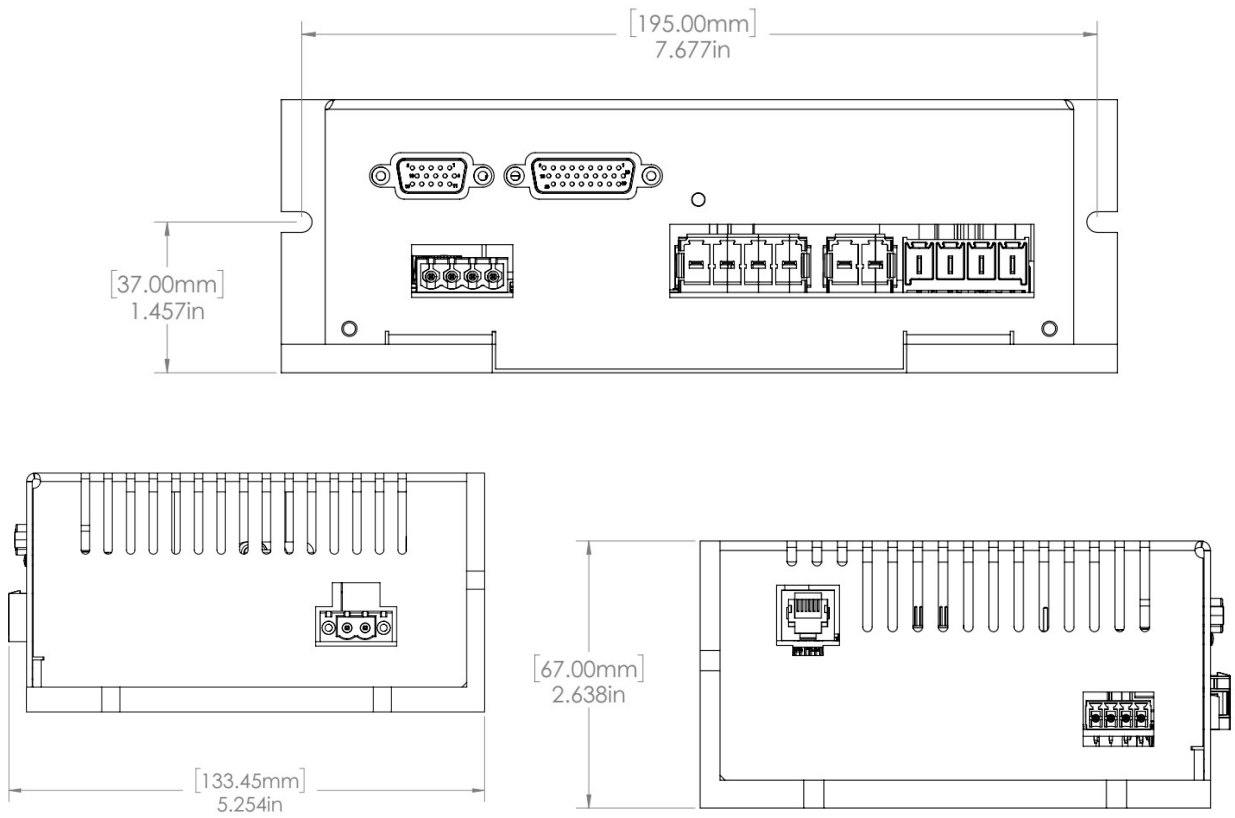
2.3 Mounting Dimensions

2.3.1 VSA1-0510 dimension



2.3.2 VSA2-1530 dimension





3 Model Numbering

(TBD) Model number breakdown: **VSAn-CCCC-XXYY_ZZZ**

Field Number	Description	Available Options	Notes
n	Varedan Digital PWM Amplifier	VSA1, VSA2	Product Series
CCCC	Current Level	0510 – 5A continuous, 10A peak	
		1530 – 15A continuous, 30A peak	
XX	EMI filter board	00 – No filter board 01 – 2MHz low pass filter	VSA1 only
YY	Expansion digital Interface board	00 – No Expansion board 01 – Customer specified interface	Optional
ZZZ	Customer configure code	Contact factory	Optional

4 Package overview

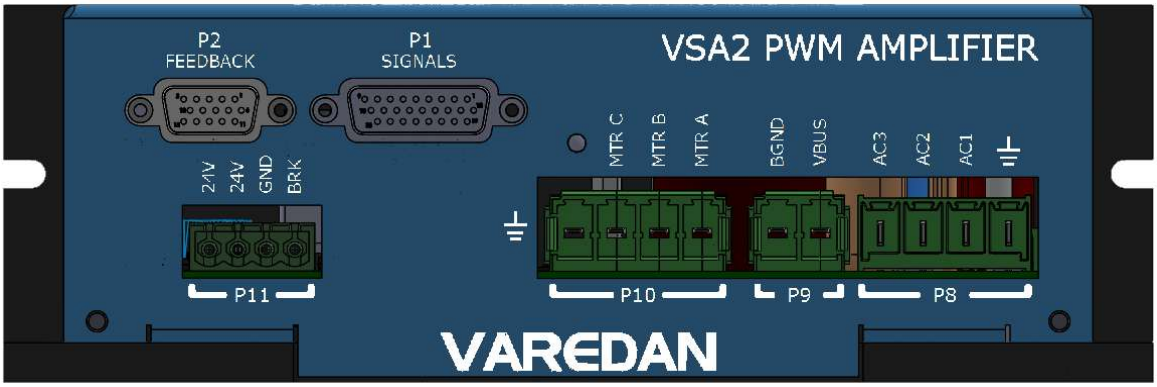
4.1 VSA1-0510 package overview

4.1.1 Front View

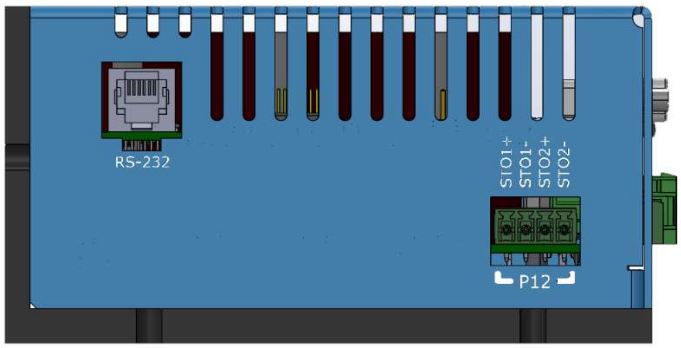
4.1.2 Side View

4.2 VSA2-1530 package overview

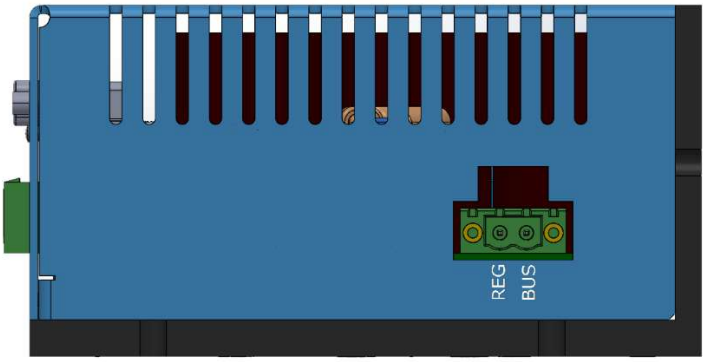
4.2.1 Front View



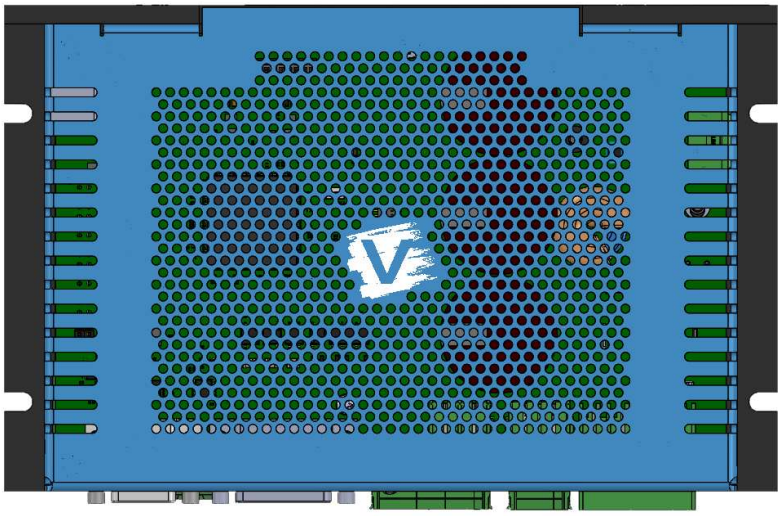
4.2.2 Left View



4.2.3 Right View



4.2.4 Top View



5 LED Display

One LED display indicates the basic status of VSA drive.

Green	Amplifier enabled, no faults
Amber	Amplifier disabled, no faults. Motor dynamic braking.
Red	Faults. Amplifier disabled. Motor in free-wheeling mode.

6 Interface Connecters Pinouts

6.1 P1 – IO, Aux-Encoder Interface, Current/Velocity/Position Analog Command

Mating Connector = Amphenol 17EHD-026-P-AA-0-00 or equivalent

Pin Number	Signal	Direction	Voltage Level	Description
1	IN1	Input	5-24V	Opto-Isolated Input - (Note1)
2	IN2	Input	5-24V	Opto-Isolated Input - (Note1)
3	IN3	Input	5-24V	Opto-Isolated Input - (Note1)
4	IN4	Input	5-24V	Opto-Isolated Input - (Note1)
5	IN5	Input	5-24V	Opto-Isolated Input - (Note1)

6	IN COM	–	–	Return for all Opto-Isolated Inputs - (Note1)
7	OUT1 (Fault)	Output	5-24V	Opto-Isolated Output - Fault - (Note2)
8	OUT2	Output	5-24V	Opto-Isolated Output - (Note2)
9	OUT3	Output	5-24V	Opto-Isolated Output - (Note2)
10	Analog Output	Output	0-5V	DAC generated Analog Output
11	CMD A+	Input	+/-10V	Differential Current/Velocity/Position Command
12	CMD A-	Input	+/-10V	Differential Current/Velocity/Position Command
13	CMD B+	Input	+/-10V	Differential Current/Velocity/Position Command
14	CMD B-	Input	+/-10V	Differential Current/Velocity/Position Command
15	Common	---	---	System Common
16	Common	---	---	System Common
17	OUT COM	–	–	Return for all Opto-Isolated Outputs - (Note2)
18	+5V Out	Supply	+5VDC	Encoder/IO power - (Note3)
19	+5V Out	Supply	+5VDC	Encoder/IO power - (Note3)
20	Common	---	---	System Common
21	Aux Encoder I-	In/Out	+/-5V	Auxiliary Encoder Interface - Index
22	Aux Encoder I+	In/Out	+/-5V	Auxiliary Encoder Interface - Index
23	Aux Encoder B-	In/Out	+/-5V	Auxiliary Encoder Interface – B Channel
24	Aux Encoder B+	In/Out	+/-5V	Auxiliary Encoder Interface – B Channel
25	Aux Encoder A-	In/Out	+/-5V	Auxiliary Encoder Interface – A Channel
26	Aux Encoder A+	In/Out	+/-5V	Auxiliary Encoder Interface – A Channel

6.2 P2 – Main Feedback Interface

Mating Connector = Amphenol 17EHD-015-P-AA-0-00 or equivalent.

Pin Number	Signal	Direction	Voltage Level	Description
1	Hall U	Input	0-5V	Hall Position Sensor Input
2	Hall V	Input	0-5V	Hall Position Sensor Input
3	Hall W	Input	0-5V	Hall Position Sensor Input
4	BiSS/Endat Data -	In/Out	+/-5V	Digital Encoder Data-
5	BiSS/Endat Data +	In/Out	+/-5V	Digital Encoder Data+
6	Main Encoder I +, BiSS/Endat Clock +	In/Out	+/-5V	Quadrature/Sine-Cosine Index +, Digital Encoder Clock +
7	Main Encoder I -, BiSS/Endat Clock -	In/Out	+/-5V	Quadrature/Sine-Cosine Index -, Digital Encoder Clock -

8	Motor Temp +	Input	---	NTC/PTC Motor Temp Sensor
9	Motor Temp -	Input	---	NTC/PTC Motor Temp Sensor
10	+5V Output	Output	+5VDC	Maximum current 1A
11	Common	---	---	System Common
12	Main Encoder A+	Input	+/-5V	Quadrature/Sine-Cosine A+
13	Main Encoder A-	Input	+/-5V	Quadrature/Sine-Cosine A-
14	Main Encoder B+	Input	+/-5V	Quadrature/Sine-Cosine B+
15	Main Encoder B-	Input	+/-5V	Quadrature/Sine-Cosine B-

6.3 RS232 Serial Communication

RS232 communication is provided through the expansion board option.

Mating Connector = Standard RJ11

Pin Number	Signal	Direction	Voltage Level	Description
1	No Connect	---	---	---
2	TXD	Input	+/-15V	Host TX. Data input to Amplifier
3	RXD	Output	+/-15V	Host RX. Data output from Amplifier
4	GND	---	---	System Common
5	DSP program	---	---	Short to GND for DSP programming. Leave open for normal operation.
6	GND	---	---	System Common

6.4 VSA1-0510

6.4.1 P3 – Power and Motor

Mating Connector = On-Shore EDZ950/7 or equivalent

Pin Number	Signal	Direction	Voltage Level	Description
1	Bus Common	---	---	Bus Common / Return
2	Keep Alive	In	+24V	Keep Alive Voltage Input, Shares return with Bus Input Pin1
3	Bus Input	In	+24-100 VDC	Bus Input Terminal
4	Motor Phase A	In/Out	---	Motor Lead A
5	Motor Phase B	In/Out	---	Motor Lead B
6	Motor Phase C	In/Out	---	Motor Lead C

7	Chassis Ground	---	---	Connection to Backplate

6.4.2 J2 – STO (Safe Torque Off) interface

Pin Number	Signal	Direction	Voltage Level	Description
1	+5V	---	---	+5V internal power
2	STO+	AC		Opto-isolated, AC input
3	STO-	AC		Opto-isolated, AC input
4	GND	---	---	GND

6.5 VSA2-1530

VSA2-1530 drive power input can be either AC or DC voltage. AC power input can be either 1-phase or 3-phase. Users cannot apply AC and DC power inputs at the same time.

6.5.1 P8 – AC Power Input

Mating Connector = Phoenix 1716923 or equivalent

Pin Number	Signal	Direction	Voltage Level	Description
1	AC 3	In	80 – 240VAC	AC input phase 3
2	AC 2	In	80 – 240VAC	AC input phase 2
3	AC 1	In	80 – 240VAC	AC input phase 1
4	Earth	---	---	Earth ground

6.5.2 P9 – DC Power input

Mating Connector = Phoenix 1777723 or equivalent

Pin Number	Signal	Direction	Voltage Level	Description
1	GND	---	---	Power ground
2	Bus Voltage	In	90 – 380VDC	DC bus voltage input

6.5.3 P10 – Motor

Mating Connector = Phoenix 1777749 or equivalent

Pin Number	Signal	Direction	Voltage Level	Description
1	Earth	---	---	Earth ground

2	Motor phase C	In/Out	---	Connect to motor lead C
3	Motor phase B	In/Out	---	Connect to motor lead B
4	Motor phase A	In/Out	---	Connect to motor lead A

6.5.4 P11 – Keep Alive and Brake

Mating Connector = Wurth 691351500004 or equivalent

Pin Number	Signal	Direction	Voltage Level	Description
1	Keep Alive	In	+24V	Maximum 30V
2	Keep Alive	In	+24V	Maximum 30V
3	GND	---	0V	Ground
4	Brake output	Out	---	Motor break

6.5.5 P6 – STO (Safe Torque Off) interface

VSA2-1530 has 2 independent STO input channels. Either STO channel in active state will disable the drive.

Mating Connector = Wurth 691361300004 or equivalent

Pin Number	Signal	Direction	Voltage Level	Description
1	STO IN1+	AC	Max 60V	Opto-isolated, AC input
2	STO IN1-	AC	Max 60V	Opto-isolated, AC input
3	STO IN2+	AC	Max 60V	Opto-isolated, AC input
4	STO IN2-	AC	Max 60V	Opto-isolated, AC input

6.5.6 P13 – Regen Resistor Connection

VSA2-1530 provides an external regen resistor connection.

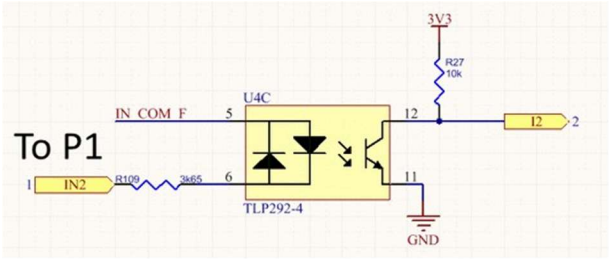
Mating Connector = Phoenix 1777989 or equivalent

Pin Number	Signal	Direction	Voltage Level	Description
1	Regen+	Out	---	Bus voltage to one side of external regen resistor
2	Regen-	Out	---	The other side of external regen resistor

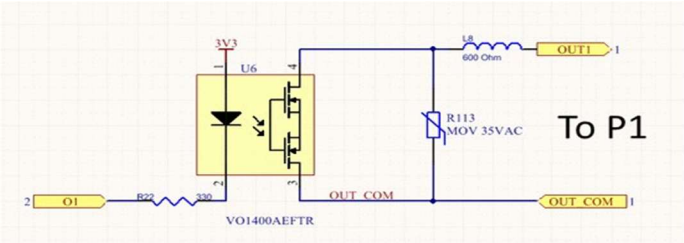
6.6 I/O Notes

Note1: Each Opto-isolated Input has the following circuit with bi-directional Opto-isolator. The Input circuit can be either pulled up or pulled down using the “IN COM” pin that is shared across all input channels. If no external voltage is available, and the opto-isolation is not required, +5V or Common from the amplifier

can be used.



Note2: Each Opto-isolated Output has the following circuit with a solid-state relay capable of 100mA load current. The Output circuit can be either pulled up or pulled down using the “OUT COM” pin that is shared across all output channels. If no external voltage is available, and the opto-isolation is not required, +5V or Common from the amplifier can be used.

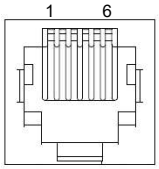


Note3: Total +5V Out current is limited to 1A.

Note6: Shells of DSUB connectors are Chassis Ground Referenced to the amplifier case cover.

7 Communication Interface

7.1 RS232 Serial Interface



The E1 port optional plug in card adds RS232 serial communications to the VSA1 amplifier. This card has a standard RJ11 connector which brings out RS232 level signals.
The VSA can communicate with a host via RS-232 using a three wire DTE to DTE cross over serial cable. The communication setting is 115.2K baud rate, 8 bit data, no parity, no handshake.

The VaredanGUI is the preferred method of communicating with the drive, but a standard ASCII terminal can also be used.

7.1.1 PC based terminal software options

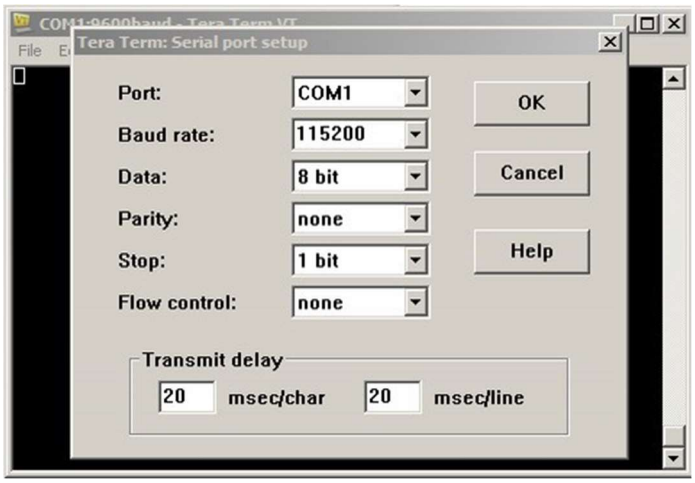
Many terminal programs can be used to communicate with the VSA1 series amplifiers over the serial port. We recommend the use of the freely available Open Source TeraTerm.

TeraTerm can be downloaded from the following link: https://ttssh2.osdn.jp/

7.1.2 RS232 serial port software configuration

The COM port settings for the VSA1 amplifier using the RS232 card are:

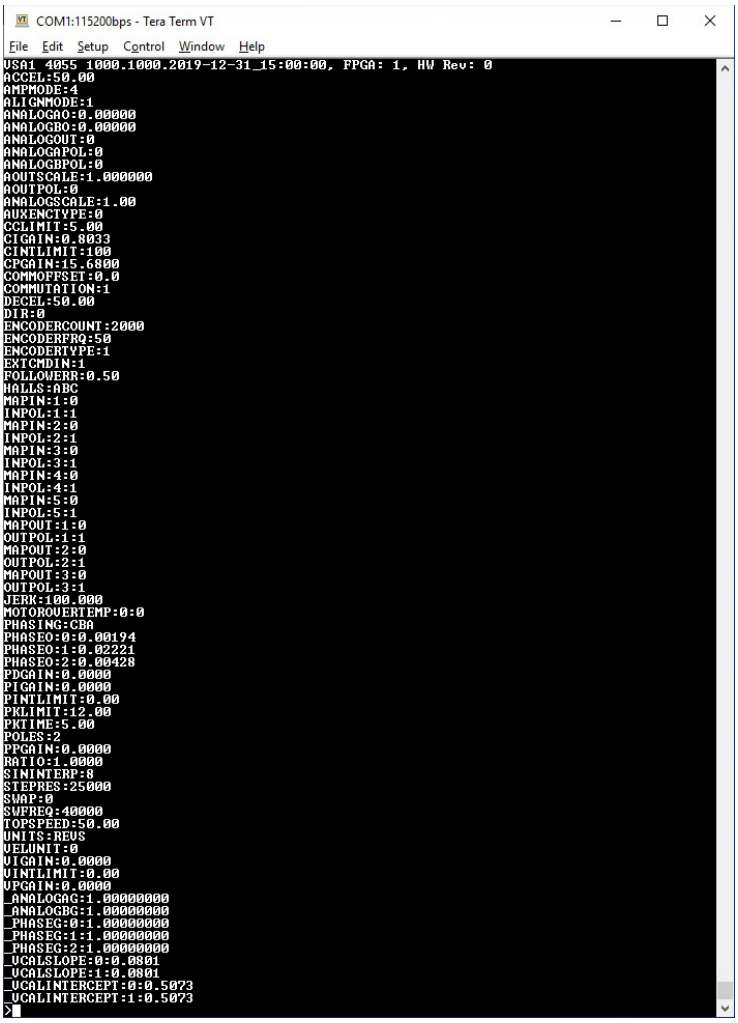
Baud Rate = 115200
Data = 8bit
Parity = none
Stop = 1bit
Flow Control = none
If using TeraTerm, we recommend a transmit delay of 20ms/char and 20ms/line while sending configuration files. Substitute your active COM port in the setup information shown.



7.1.3 Terminal Host Communication Protocol

Once the host communication program is properly configured and the host cable is connected, apply power to the VSA. The VSA should respond with the sign-on message which should look like the following text in the terminal window. When the amplifier is ready to accept a new command, the user prompt character "**>**" will be shown.

Commands can now be entered. The example below shows the reply from the **CONFIG?** command. It is recommended to confirm the configuration of the amplifier to make sure it matches the motor and the expected running parameters.



Once desired parameter values are found, use the **WRITE** command to save the changes. If a **RESET** is issued before the **WRITE** command, any parameter changes will be lost, and the amplifier will revert to the last saved set of parameters.

The following describes the command syntax and amplifier response format:

Commands are entered using ASCII characters from the terminal. To enter a command with a user entered data field, the command name is followed by a "**:**" or "**=**" followed by the data for the command, followed by Enter (carriage return) is used. As a minimum, all commands must be terminated by the carriage return character (ASCII 13). The line feed (ASCII 10) is optional and is not used by the amplifier.

A typical command has the following ASCII format. Control characters are shown in **<>**:

CONFIG?<Cr><Lf>

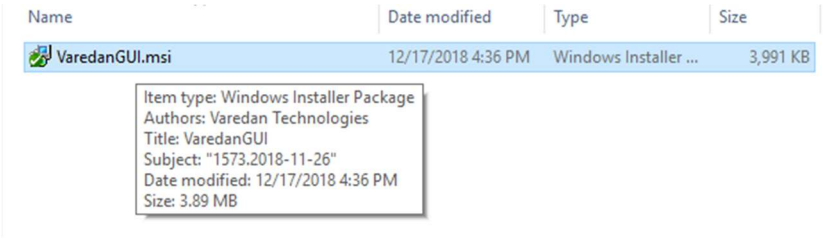
POLES=4<Cr><Lf>
All characters sent to the amplifier are echoed back if echo has been enabled. When the amplifier has accepted the command, the prompt "**>**" is returned.

8 Install GUI Software

The PC based Varedan GUI, with its built-in command stimulus and real-time oscilloscope signal tracer views, reduces the requirements for external equipment while setting up new systems. The standard RS232 and Ethernet based communications easily connects with all modern computers. Full system configuration can be saved and uploaded for quick and easy drive provisioning.

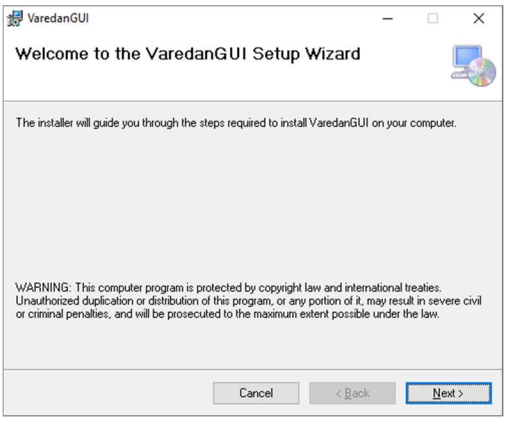
8.1 Open the installation file

Double click on the “VaredanGUI.msi” icon to run the installer.



8.2 Start the installation

Click the “Next” button in the installation window to start the installation.

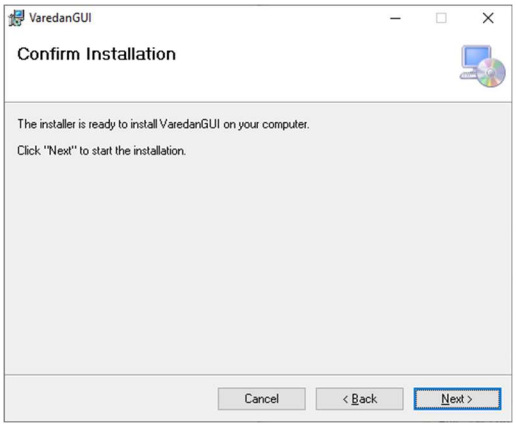


8.3 Select installation folder

Verify that the default installation location found in the “Folder” area is appropriate and click on the “Next” Button to continue. Alternatively, change the installation location if necessary, by clicking the “Browse” button and selecting a new location.

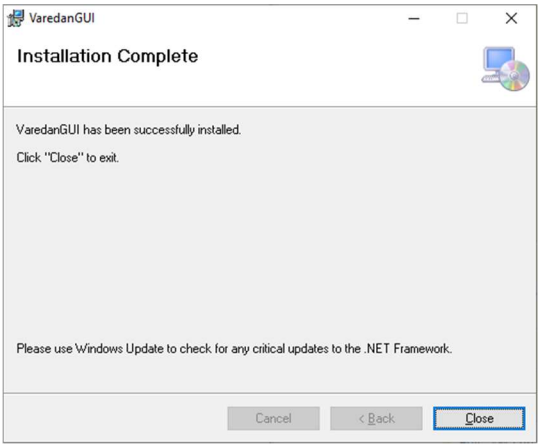
8.4 Confirm installation

Click the “Next” button to complete the installation.



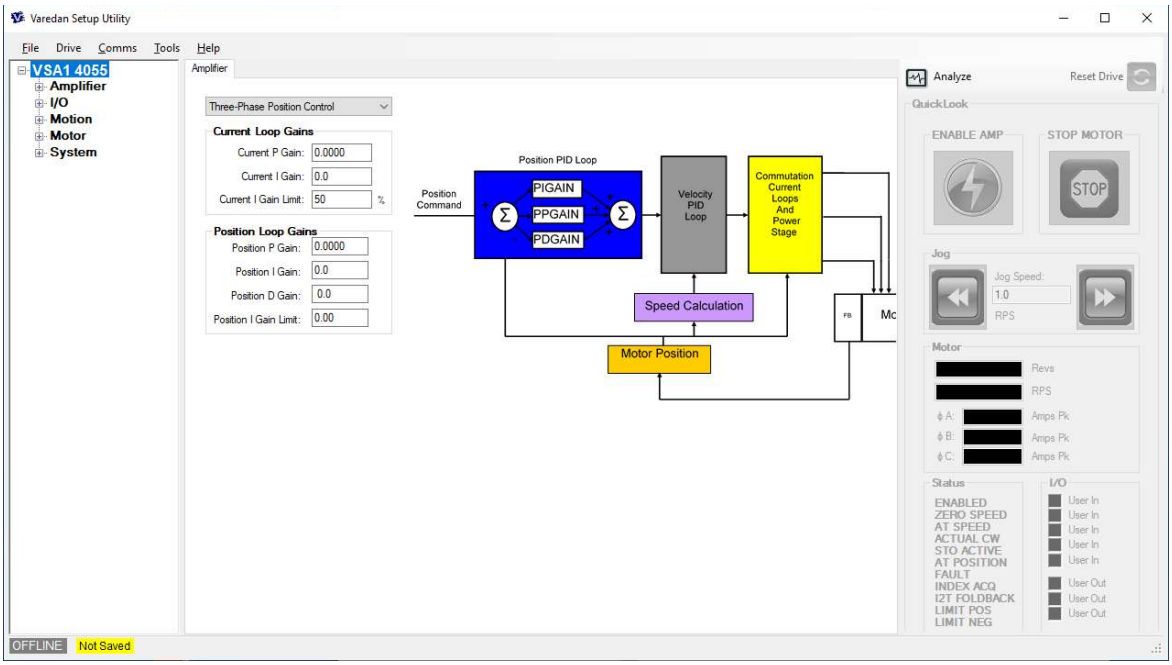
8.5 Complete and close installation window

Click on the “Close” button to close the installation window.



9 GUI Feature Details

The Varedan GUI main menu has five major function regions. It consists of top pull-down manual bar, side configuration tree, and right-side quick look status panel, and lower connection status and drive firmware version indicators. The detailed GUI descriptions can be read from “Help” pull-down manual.

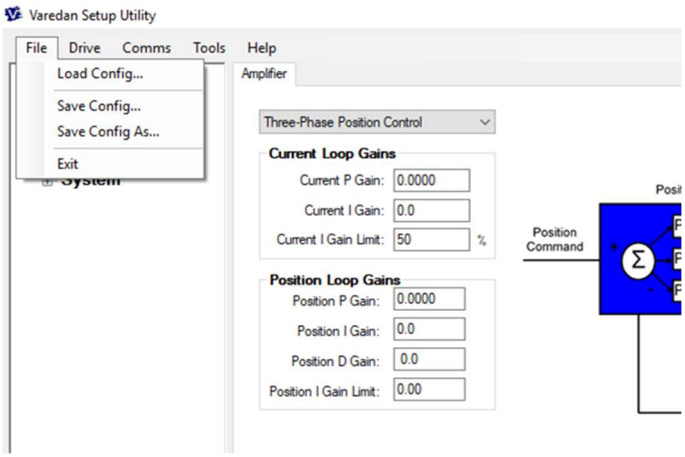


9.1 Top pull-down manual

The Varedan GUI when it first runs shows five major regions of functionality as shown below

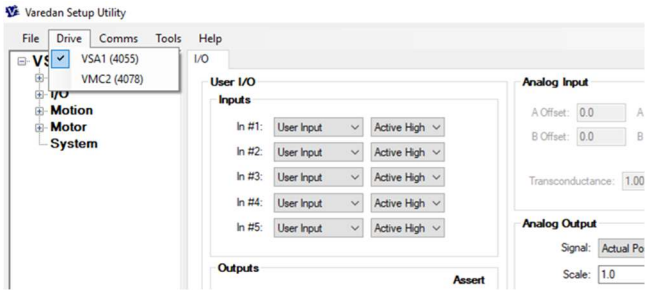
9.1.1 File

File menu allows users to load and save customized GUI configurations for a special application.



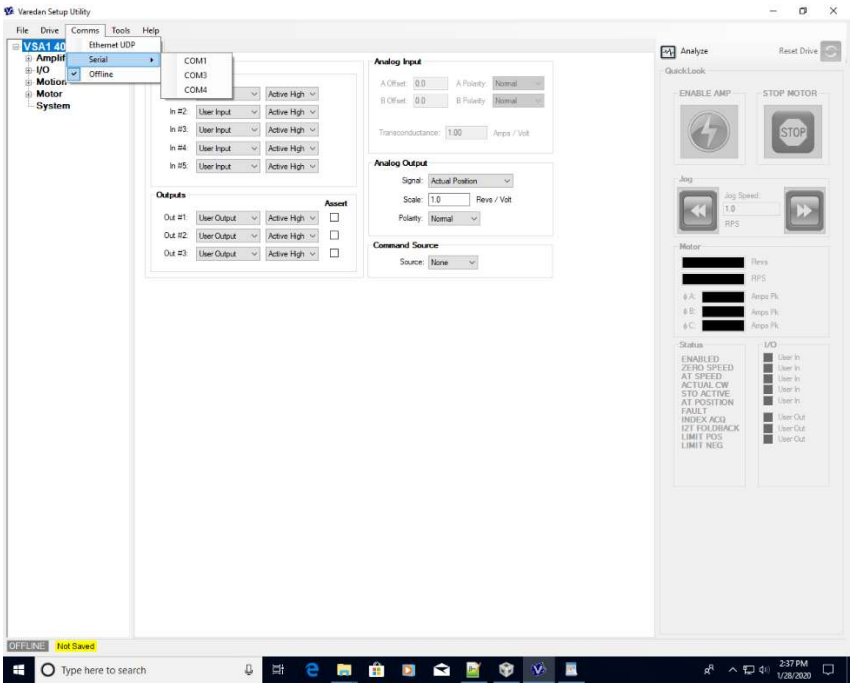
9.1.2 Drive

When the GUI is offline the Drive menu allows the selection of all supported Varedan Drives. Different menu items and form objects are enabled or hidden based on the supported features for the selected drive. For VSA1, Select drive “VSA1 (4055)”.

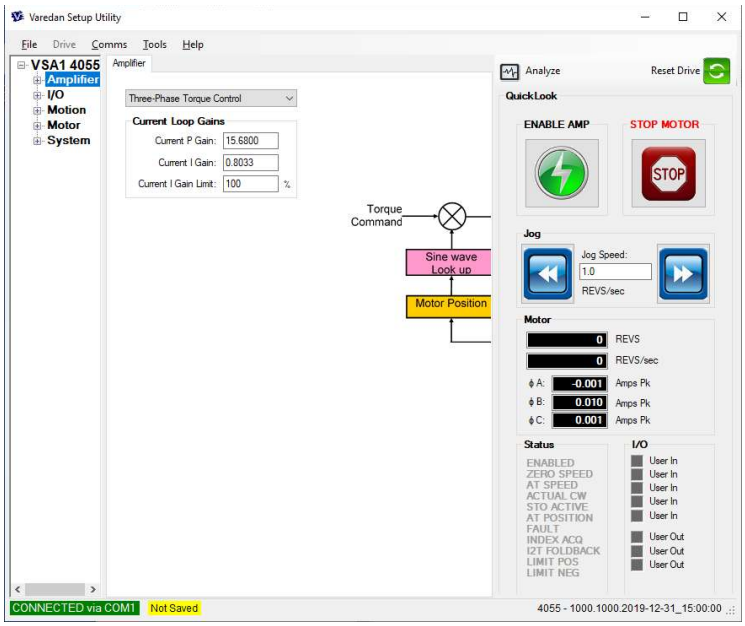


9.1.3 Comms

The VSA communicates with a host via RS-232 serial connection or via Ethernet if the option is enabled. The "Comms" menu allows you to select between the various methods of communications supported by the utility. For example for RS232, select “Serial->COM1”, if cable connecting to PC COM1 port.

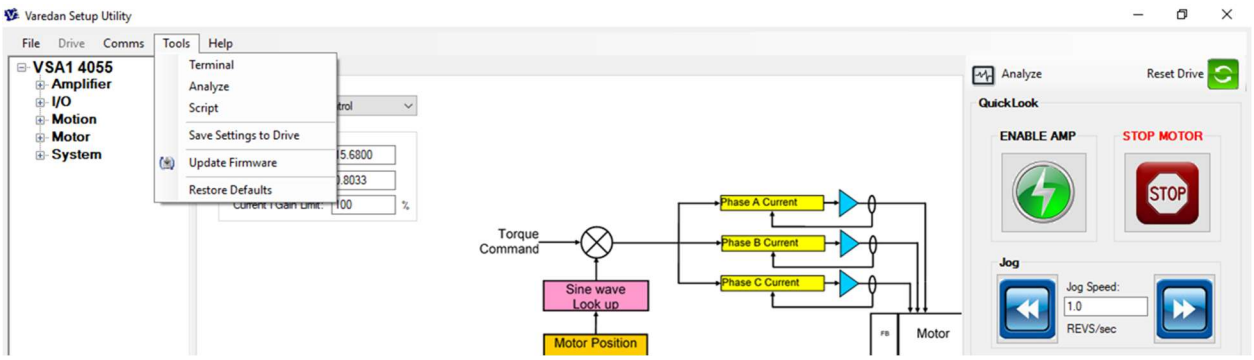


After right serial port get selected, a communication link should be built between GUI and the drive. The bottom grey “OFFLINE” status should turn to be green “CONNECTED via COM1”.



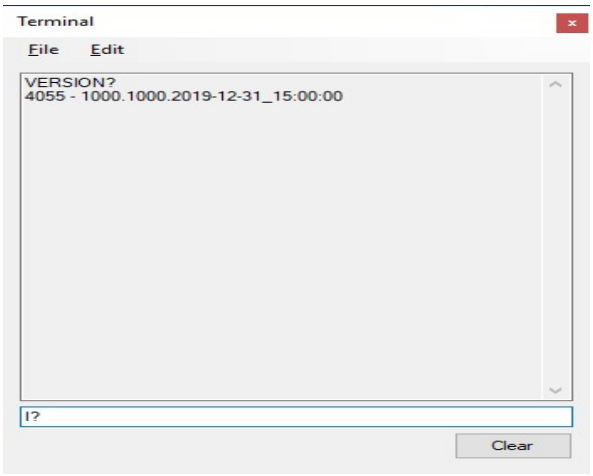
9.1.4 Tools

Tools" manual has the following function items: Terminal, Analyze, Script, Save settings to Drive, Update Firmware, and Restore Defaults.



9.1.4.1 Terminal

To open a live Terminal session with the attached drive, select "Terminal" from the main GUI menu. The Terminal opens in a separate window and provides a way to send commands to the drive, or observe the commands sent by the GUI to the drive. For example, you can type in VERSION? and I? at command line to show the attached drive version and check real-time 3 phase motor current readings.



9.1.4.2 Analyze

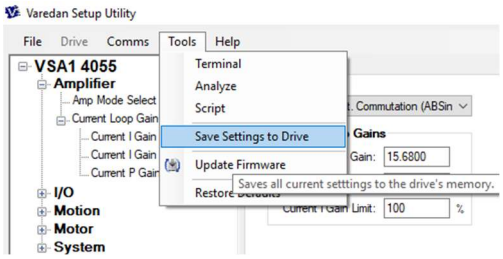
The GUI utility provides Signal Tracer, which allows sets of signals to be displayed on the oscilloscope interface. To open the Signal Trace, select "Analyze" located on the top-right of main GUI menu, or select “Tools->Analyze”. For detailed information, please reference “Help->GUI Help” menu.

9.1.4.3 Script

Script allows users to execute a series commands at user prefer sequence.

9.1.4.4 Save settings to Drive

The function allows users save their configurations to the flash memory of the attached drive. For a specific application, once users complete all drive settings, they save these settings to the drive. Otherwise if power is removed from attached drive, these settings will be lost.

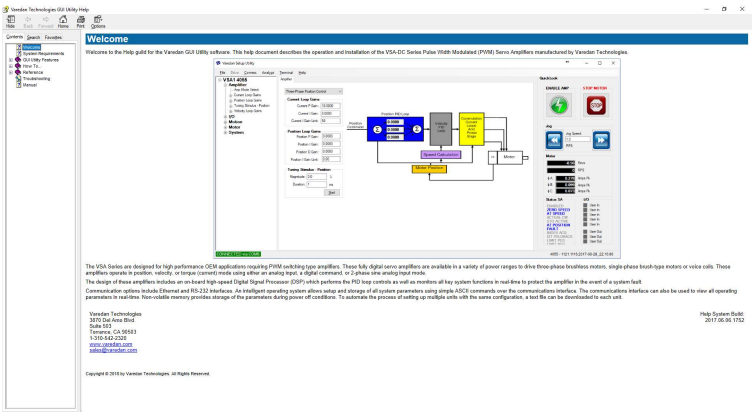


9.1.4.5 Update Firmware

Reference to section 14, Firmware Update.

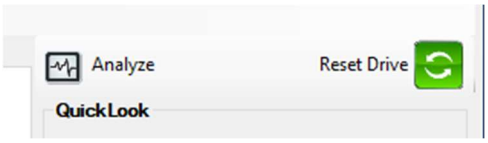
9.1.5 Help

"Help" manual provides detailed descriptions for all GUI functions. User should reference "Help" document for detailed GUI supports.



9.2 Main menu Analyze and Reset Drive buttons

Main GUI menu top-right side have 2 quick buttons



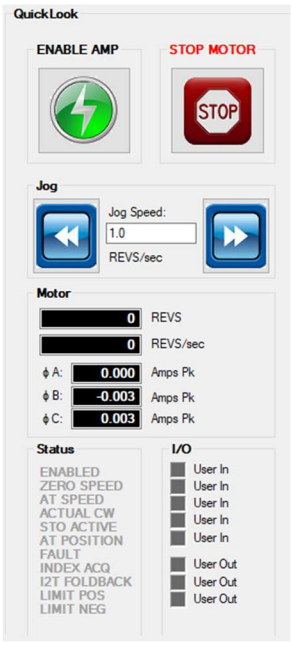
"Analyze" is used to open Signal Tracer, which allows sets of signals to be displayed on the oscilloscope. "Reset Drive" provides a hardware reset from GUI to the attached drive.

9.3 GUI analyze tool - real-time oscilloscope

Please reference to the section 9.1.4.2.

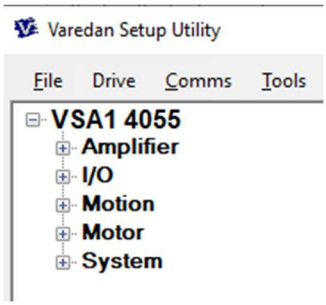
9.4 QuickLook panel

The QuickLook panel displays an overview of critical system flags and settings for the live operation of an attached drive. From this panel you can see the status of the inputs and outputs, the drive status flags, critical motor parameters, enable/disable the amp and stop motor motion. For detailed, check main menu "Help->GUI Help".



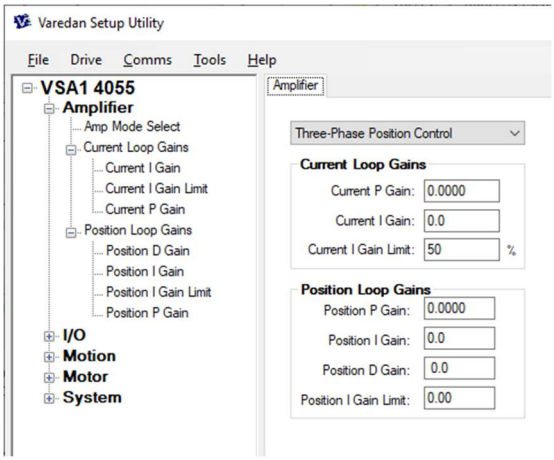
9.5 Configuration Tree

Configuration tree allows users to set operation details from GUI. It consists of Amplifier, I/O, Motion, Motor, and System 5 tabs.

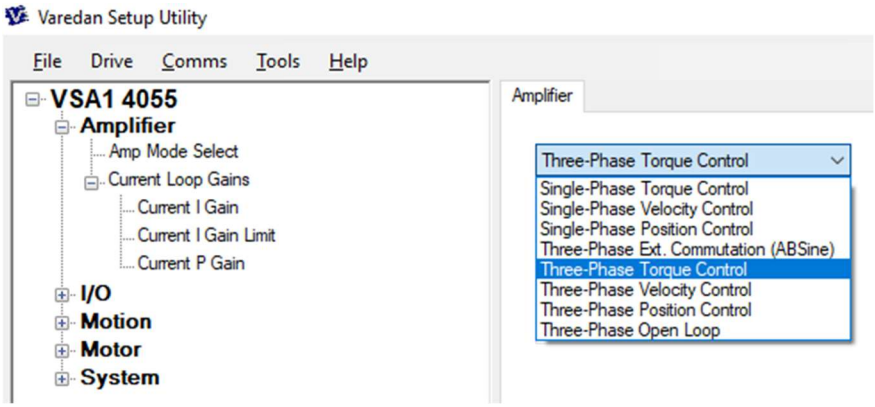


9.5.1 Amplifier Tab

“Amplifier” tab selects Amp mode, setup current loop gains, and position loop gains.



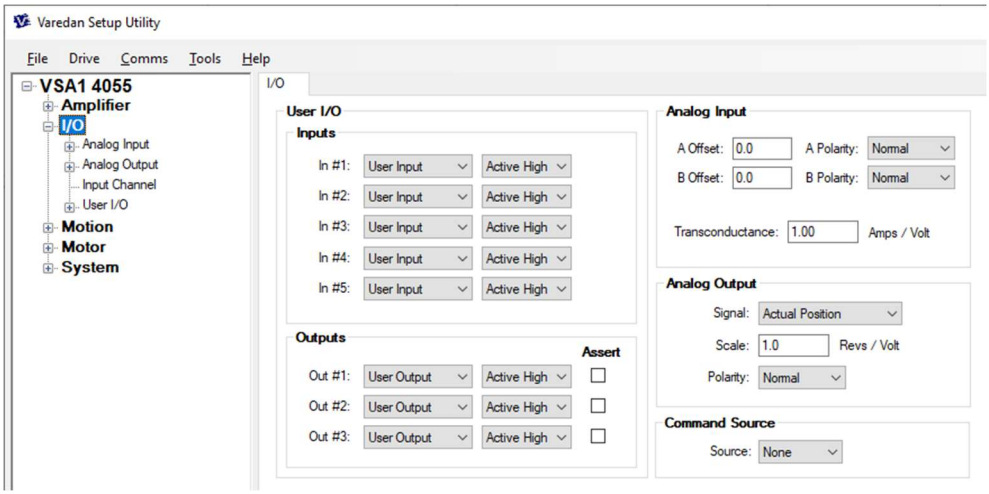
Current available Amp Mode Select as:



AMP Mode Selection	Description
Single-Phase Torque Control	Single phase motor like VCM, or single coil current control. H-bridge drive. Motor leads connect to phase A and C outputs.
Three-Phase Ext. Commutation (ABSine)	3-phase motor current control. Host sends 2 current reference commands. Amplifier does not perform motor commutation.
Three-Phase Torque	3-phase synchronous torque/force/current control. Host send 1 torque/force/current command. Drive take care of motor commutation.

9.5.2 I/O Tab

"I/O" tab selects user I/O inputs and outputs, current command input sources, DAC analog output to interface I/O connector. VSA1 has 5 general purpose input IOs and 3 general purpose output IOs. Users can select available functions and active state for each IO.



User I/O – Inputs	Description
User Input	General purpose user input (for use in programs)
Enable Amplifier	Enable amplifier from input I/O signal
Program Select	N/A
Limit Pos	N/A
Limit Neg	N/A
Stop	N/A
SFI	Special user function input
Reset Amplifier	Hardware reset amplifier

User I/O – Outputs	Description
User Output	General purpose user output (for use in programs). Click “Assert” to set active state to IO.
Fault	Amplifier fault
At Speed	N/A
Zero Speed	N/A
I2T Foldback	N/A
At Position	N/A
Disable	Amplifier enabled or disabled (handshaking to enable input)

Analog Input	Description
A offset	N/A
B offset	N/A
A Polarity	Normal/Inverted. Command A input polarity control
B Polarity	Normal/Inverted. Command B input polarity control
Transconductance	1V/1A, unchangeable

For 3-phase torque/force control and single phase motor, user can select command A or command B as input resource. For 3-phase ABsine mode, the selection is ignored. Both command A and B are current command inputs.

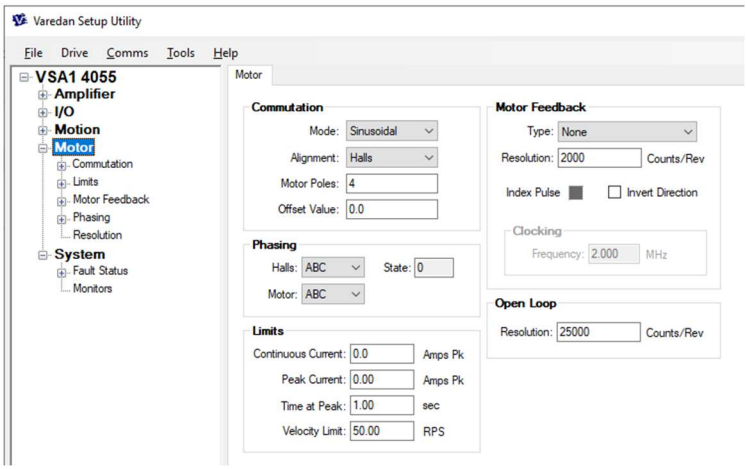
Command Source	Description
None	No command inputs
Cmd A	Select command A as torque/current source
Cmd B	Select command B as torque/current source

N/A	N/A
Step & Dir	N/A

For functionality of “Analog Output”, reference to section 10, user analog DAC output.

9.5.3 Motor Tab

Motor tab allows users to set commutation method, to change motor phase leads, to set continuous and peak current limits, and to set motor encoder feedbacks.



9.5.3.1 Commutation

3-phase motor commutation parameters setups.

9.5.3.1.1 Mode

select one of the commutation modes. Currently only sinusoidal is valid

.**Mode**	**Description**
6 state	N/A. Hall sensors
Sinusoidal	Encoder sinusoidal commutation
1.8º stepper	N/A. 1.8 degree step move
3.6º stepper	N/A. 3.6 degree step move

9.5.3.1.2 Alignment

3-phase motor phasing and initialization options.

Alignment	**Description**
Halls	Use hall sensor provide initial phase angle.
Halless	Constant current phasing
Absolute	Absolute encoder feedback

9.5.3.1.3 Motor poles

For rotary motor, set the number of motor poles. For linear motor, set the number of motor poles = 2.

9.5.3.1.4 Offset Value

Sets direct commutation angle offset in electrical degrees. Typically, this is used for aligning absolute feedback devices.

9.5.3.2 Phasing

Sets motor phase leads relationship.

9.5.3.2.1 Halls

Set the hall state relationship to the motor phases. This has same action as swapping the hall wires. For example, setting the sequence to "ACB" swaps phase B and C.

Halls	Description
ABC	Hall sequence – ABC
ACB	Hall sequence – ACB
BAC	Hall sequence – BAC
BCA	Hall sequence – BCA
CAB	Hall sequence – CAB
CBA	Hall sequence – CBA

9.5.3.2.2 Motor

Swap motor leads to change move direction.

Motor	Description
ABC	Normal motor phase leads ABC
ACB	N/A
BAC	N/A
BCA	N/A
CAB	N/A
CBA	Swap motor phase leads A and C

9.5.3.3 Motor feedbacks

Sets motor encoder feedback configuration.

9.5.3.3.1 Type

Encoder feedback type

Type	Description
None	No feedbacks, open loop
Incremental (A Quad B)	Incremental encoder
Biss (Single Turn)	Absolute Biss encoder
Incremental (Aux A Quad B)	Auxiliary incremental encoder
EnDat	Absolute EnDat encoder
Analog Sin/Cos	Analog sin/cos encoder

9.5.3.3.2 Resolution

For rotary motor, enters encoder counts per mechanical revolution. For linear encoder, selects motor poles equals 2 and enters encoder counts per pole pair.

9.5.3.3.3 Invert Direction
TBD. Check this box to reverse actual position direction.

9.5.3.4 Limits

For user applications, sets current limits for safety operation.

9.5.3.4.1 Continuous current
Maximum continuous current (Amp) for safety operation. When actual motor phase current exceeds this setting, the motor I2T over-current protection becomes active.

9.5.3.4.2 Peak current
Maximum peak current (Amp) allowed for safety operation. Drive will be in fault state if actual current is over the limit.

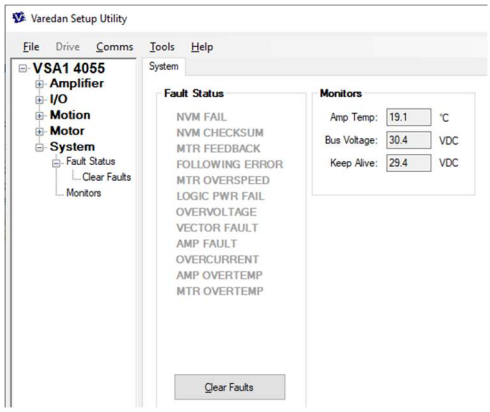
9.5.3.4.3 Time at Peak
Time in seconds to determine I2T integration limit. If I2T over the limit, drive will report I2T over current fault.

I2T limit setting is computed as:

I2T limit setting = $[(\text{Peak current})^2 - (\text{Continuous current})^2]$*(Time at Peak)

9.5.3.4.4 Velocity limit
TBD.

9.5.4 System Tab



System tab displays the drive fault status. Details refences to protection function at section 13. “Clear Faults” clears the fault condition if the fault does not reoccur.

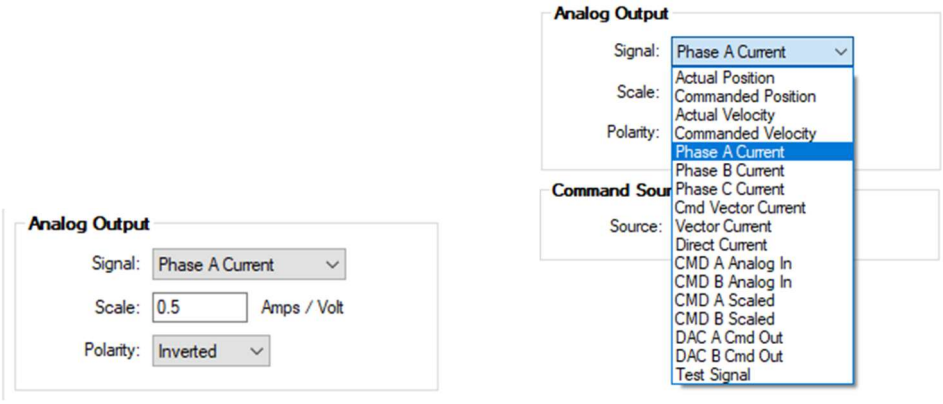
System tab also displays “Amplifier Temperature”, “Bus voltage”, and “Keep Alive” voltage level. Displayed voltage values may have +/-10% measurement errors.

10 User programmable analog output

VSA1 amplifier has a programmable analog output for user monitoring. Hardware output is located at connector P1-pin10, with voltage range from 0 to 5V, where 2.5V references to 0 signal level. Users can select and scale output signal either form GUI or from host terminal.

10.1 Select analog output from GUI

The 1 channel analog output signal can be selected from GUI configuration tree I/O tab.



For example, the above setts that the analog output is phase A measured current. 0.5A/1V, that means maximum measurement is 2.5A(+/-1.25A) for 5V scale. Reverse the polarity of the signal.

Analog Output = Signal*Scale*Polarity

Available signals can be selected from “Signal” pull-down menu.

Signal	Description
Actual Position	N/A. Actual position measured from encoder
Commanded Position	N/A. Position reference from host
Actual Velocity	N/A. Measured velocity from encoder
Commanded Velocity	N/A. Velocity loop reference
Phase A Current	Motor phase A current measured from current sensor
Phase B Current	Motor phase B current measured from current sensor
Phase C Current	Motor phase C current measured from current sensor
Cmd Vector Current	N/A
Vector Current	3-phase synchronous current control, q axis current feedback
Direct Current	3-phase synchronous current control, d axis current feedback
CMD A Analog In	Current reference input from CMD A differential pair
CMD B Analog In	Current reference input from CMD B differential pair
CMD A Scaled	N/A
CMD B Scaled	N/A
DAC A Cmd Out	N/A
DAC B Cmd Out	N/A
Test Signal	Electrical angle in 3-phase synchronous current control

10.2 Select and scale analog output from host terminal

If GUI is not available. Users can use host terminal to set up analog output signal for monitoring.

Step 1: use ANALOGOUT command to select output signal. Refence to serial command list for details.

For example, to select “Phase A Current” as the analog output signal, at console

> ANALOGOUT:4 <CR>

Step 2: use ANALOGSCALE command to scale the output signal level

For example, to scale the output signal 0.5V/A, at console

> ANALOGSCALE:0.5 <CR>

Step 3: use AOUTPOL to set output signal polarity

For example, to reverse the output signal polarity, at console

> AOUTPOL:1 <CR>

11Applications Information

The VSA current loop controls apply to different operation modes. For 3-phase motors, users can configure the drive as 3-phase synchronous control mode or 3-phase ABSine mode. For single phase motor or single coil, the drive can be configured as single phase H-bridge mode. How that current gets commanded and where the command comes from is determined by the amplifier’s mode of operation. In all modes of operation, a “command current” must be generated from either an external controller or from inside the amplifier. The amplifier uses this current command to internally close the current loop in each motor phase using pulse-width modulation (PWM) by allowing more or less current to flow through the output transistors.

For modes that use an external command current, the command current can come from one of two sources; the analog input(s) or as a user command from the user interface.

For modes that generate the current command internal to the amplifier as in the case of velocity or position modes, a higher-level control loop is used to generate the command. For velocity mode, the current command comes from the output of the velocity loop. The command for the velocity loop comes from either the analog input, or as a user command from the user interface. The position loop command comes from either an external source over the user interface or from the internal indexer when the amplifier is commanded to move to a specific position

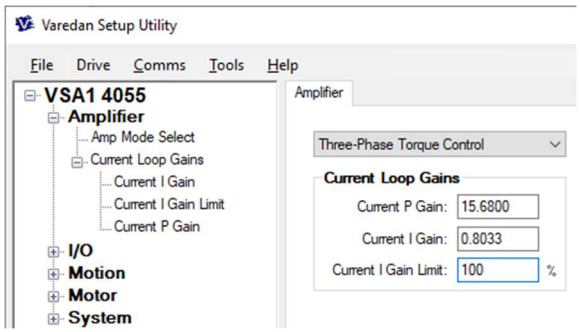
11.1 3-phase motor synchronous force/torque/current control

In this mode, users send 1 channel force/torque command to the drive. The amplifier uses encoder to provide motor commutation. The current controllers generate internal 2 channel d,q current references

synchronized with motor electrical angle and close current loops. With synchronous current control, phase delay caused by sinusoidal motor commutation is removed. Balanced space vector PWM is applied to obtain additional 15% phase voltage gain.

3 Phase A/B Current Mode	**Description**	
Motor leads connection	Drive phase A, B, C outputs	
Force/Torque/Current command CMD A or CMD B	CMD A +/-10V differential	If CMD Source = CMD A
	CMD B +/-10V differential t	If CMD Source = CMD B
Current control	Synchronous PI controllers	
Transconductance	1V/1A	
PWM	Space vector PWM	

11.1.1 Amplifier operation mode and gains



From GUI configuration tree->Amplifier tab, selecting operate mode “Three-Phase Torque Control”.

Sets current PI control loop gains. “Current I Gain Limit” is not implemented and should be ignored.

Without GUI, users can also set the same amplifier operation mode and gains from host terminal as:

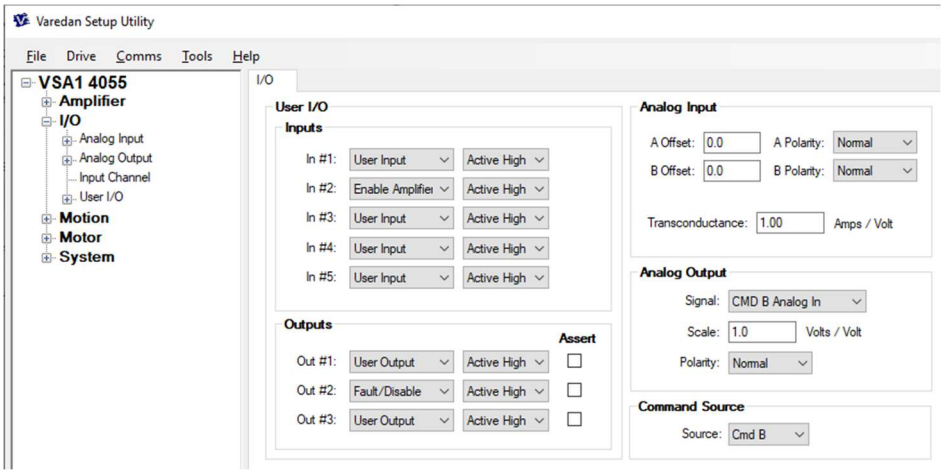
> AMPMODE:4 <CR> (Amplifier operation mode – Three Phase Torque Control)

> CPGAIN:15.68 <CR> (Current loop proportional gain 15.68)

> CIGAIN:0.8033 <CR> (Current integral gain 0.8033)

Reference to serial command list for detailed descriptions.

11.1.2 I/O selection



An IO setup example is shown on the above GUI, “User I/O Input #2” is selected as the amplifier enable signal, active high. “Cmd B” input is configured as force or torque command source. Cmd “B Polarity” is normal, non-inverted. Notice that “Out #2” is selected to be “Disable” signal, active high. The output #2 can be used as the handshake signal of amplifier’s enable signal. If Out #2 level is low, the amplifier is enabled. Otherwise, it is disabled. In this mode, when host issues the enable amplifier command, the amplifier will first check if motor initialization (phasing) has been complete. If this is the first enable command after power up, the amplifier performs motor initialization (or motor phasing) and then close the current loop. Motor phasing may take several seconds to complete depending on which the initialization method. Therefore, host should check the enable handshaking signal to make sure the amplifier has been enabled before issuing a current command.

Without GUI, users can also set the same amplifier I/O selections from host terminal as:

> MAPIN:2:1 <CR> (User input #2, as Enable Amplifier)

> INPOL:2:1 <CR> (User input #2, active high)

> EXTCMDIN:2 <CR> (Command source – Cmd B)

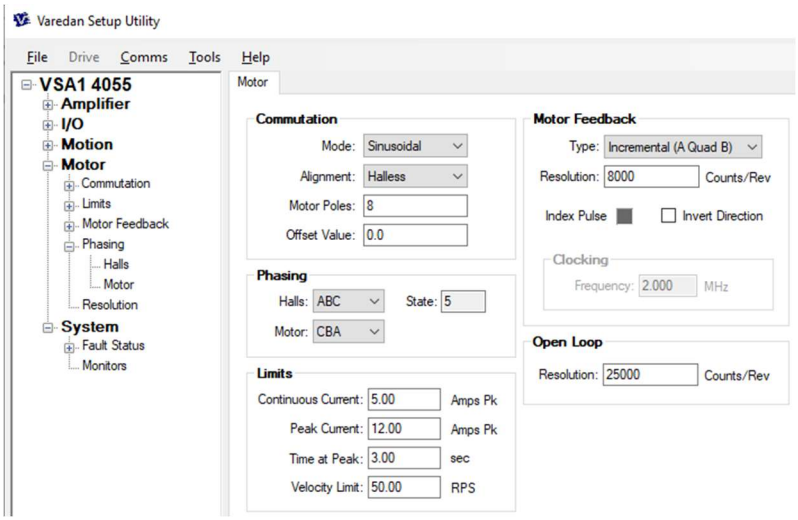
> ANALOGBPOL:0 <CR> (Analog input B polarity - normal)

> **MAPOUT:2:6 <CR>** (Map user output #2, as Disable amplifier)

> **OUTPOL:2:1 <CR>** (User output #2, active high)

Reference to serial command list for detailed descriptions.

11.1.3 Motor configuration and current limits



On the above GUI setups, Mode is select as “Sinusoidal” commutation and “Alignment” select is “Halless”. Current firmware only supports “Sinusoidal” commutation. Stepper mode is not implemented yet. For this selection, to align the motor permanent magnets to its coil flux, a constant current motor phasing will apply for initialization. This rotary motor has 8 poles. Incremental encoder provides 8000 quadrature counts per mechanical revolution.

For linear motor application, select “Motor Poles” to 2. Encoder resolution is the quadrature counts for per pole pairs.

Motor “Phasing” is CBA. That means that the amplifier swapped phase A and phase C outputs to match the encoder direction. If you want to reverse current direction, swap phase A and C by selecting ABC from “Phasing” menu.

Current limits set as “Continuous current” 5.0A, “Peak Current” 12.0A, “Time” 3 seconds. That means if motor current over 12A at any time, the drive will be disabled. An over current fault will report. Also, if motor $(\text{current}^2 - 5^2)*\text{time}$ is greater than $(12^2 - 5^2)*3$, an I2T fault will report.

Without GUI, users can set motor output configuration from host terminal console as:

> COMMUTATION:1 <CR> (Sinusoidal commutation)

> ALIGNMODE:1 <CR> (Motor current phasing or initialization)

> POLES:8 <CR> (8 poles motor)

> PHASING:CBA <CR> (Motor phase A and C)

> ENCODERTYPE:1 <CR> (Quadrature encoder)

> ENCODERCOUNT:8000 <CR> (8000 encoder counts per mechanical revolution)

Set current limits as:

> CCLIMIT:5.0 <CR> (continuous current 5.0A)

> PKLIMIT:12.0 <CR> (peak current 12.0A)

> PKTIME:3.0 <CR> (peak Current Time 3 seconds)

Reference to serial command list for detailed descriptions.

11.1.4 Motor initialization (phasing)

For 3-phase synchronous motor, to obtain maximum torque/force, the motor phase current must be in phase with the motor back-emf. If the motor phasing is not correct, the motor cannot get its maximum torque/force and the current control loops may become unstable.

The firmware provides different choices for motor initialization (phasing), including current phasing, pulse current phasing, hall sensor phasing, and absolute encoder phasing. Users can select motor initialization method from Commutation->Alignment tab.

11.1.4.1 Constant current phasing

This method does motor initialization by applying a constant current with known electrical angle.

The constant current is defined as 50% of the peak current value, which users defined at current limits. During motor phasing, current ramps up from 0 to the constant current in 2 seconds. To avoid motor initially stay at unstable pole position (180-degree phase reverse to the stable one), electrical angle also linearly turns from 0 degree to 90 degree as current ramping. Then drive holds the constant current and the 90-degree electrical angle for 3 seconds. Encoder position is recorded at the end of 3 second hold time as the electrical angle offset value.

These phasing parameters are not implemented as user parameters yet.

11.1.4.2 Hall phasing

Some user applications require no motion during motor initialization. If hall sensors are available, the amplifier can read a coarse phasing value from hall states. For 3 hall sensors setup, total 6 different states for a 360-degree electrical angle range. Each hall state represents 60-degree electrical angle range. Therefore, there is a maximum +/-30-degree electrical angle error from the first reading of a hall state. However, with this coarse phase information, the amplifier can close the current loop and is under host control. To get a better accurate phasing information, electrical angle offset gets updated if the encoder position of the first hall transition is detected. Encoders are then required to calculate electrical angle changes after the motor initialization completed.

11.1.4.3 Pulse current phasing

For the applications require no motion before the amplifier gets enabled, another choice is current pulse phasing. Hall sensors are not required. In this case, the amplifier sends a sequence of positive and negative current pulses to the motor. Encoder detects the very small motor vibrations (in um) and calculates the phase angle. The disadvantage of this method is that the phase angle calculated is not accurate as the constant current phasing.

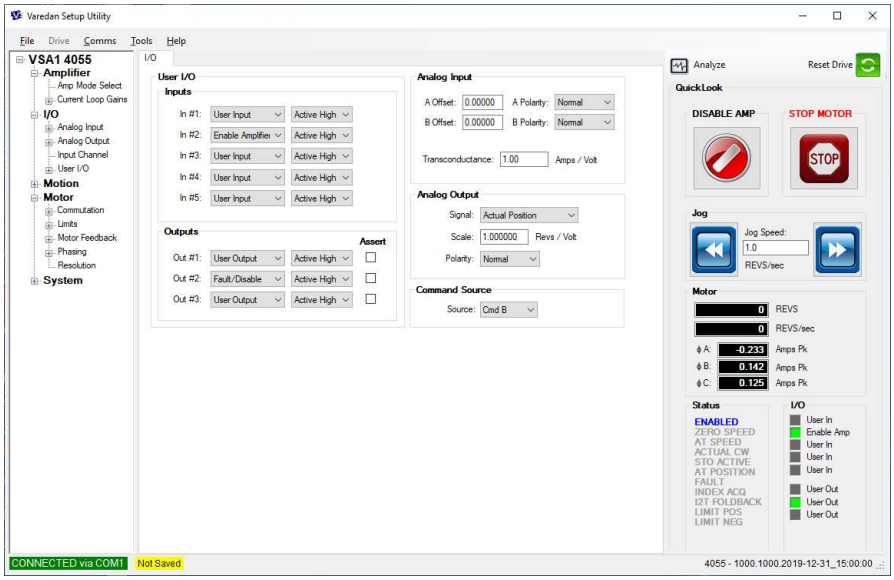
This method is not under GUI control yet.

11.1.4.4 Absolute encoder

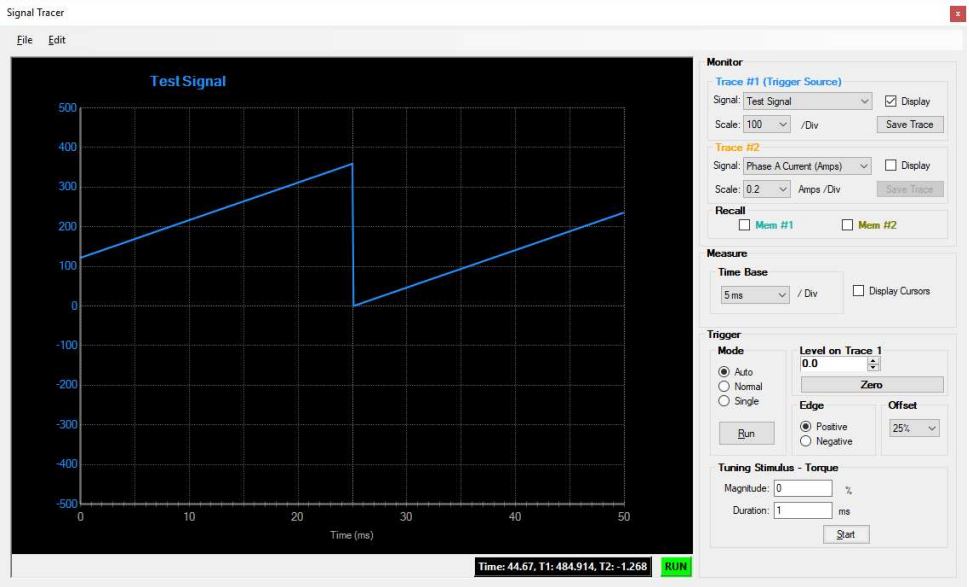
For absolute encoder, motor commutation information to encoder is fixed and will not change if the drive power is removed. In this case, users can directly enter the known motor initial phase offset into “Offset Value” of motor commutation tab.

11.1.5 Motor test run

The test motor is a 3-phase rotary motor with phase-to-phase inductance 6mH and phase-to-phase resistance 1.3 ohm. Amplifier get enabled by active high signal from connector P1 pin-2. GUI “QuickLook” panel I/O sector shows the enable amp is asserted and “Status” bar shows the amplifier is enabled. Output #2 “Disable” is highlighted to show the signal is active.



Clicking “Analyze” icon at the main menu to open a signal tracer scope. Trace 1, blue color, shows motor electrical angle signal for a constant speed rotation. The test signal is configured as the motor electrical angle.



11.1.6 Save user configurations to Drive

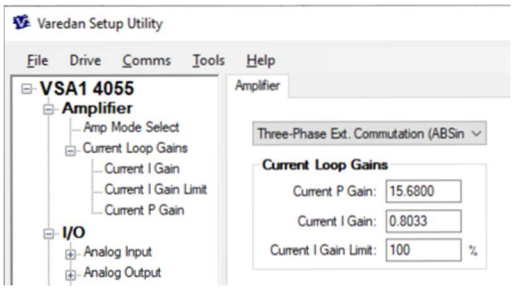
All new parameter settings will be lost if drive's power is removed or a reset command is issued. Users can save these parameters to the drive's flash memory either from GUI tools or to use **WRITE** command from terminal console.

11.2 3-phase motor A/B sinusoidal current control

Host sends two current channel commands, CMD A and CMD B, as motor phase A and phase B current references. The amplifier has 2 independent current control loops for phase A and Phase B, and generate balanced phase C control output. Host controller takes care of motor commutation. The amplifier does not perform motor commutation. Encoder feedback is not required. Balanced space vector PWM is applied to obtain additional 15% phase voltage gain.

3 Phase A/B Current Mode	**Description**
Motor leads connection	Drive phase A, B, C outputs
Current command A	Motor phase A current reference. CMD A +/-10V differential.
Current command B	Motor phase B current reference. CMD B +/- 10V differential.
Current control	2 independent PI controllers
Transconductance	1V/1A
PWM	Space vector PWM

11.2.1 Amplifier operation mode and gains



From GUI configuration tree->Amplifier tab, selecting operate mode “Three-Phase Ext. Commutation (ABSine)”.

Sets current PI control loop gains. “Current I Gain Limit” is not implemented and should be ignored.

Without GUI, users can also set the same amplifier operation mode and gains from host terminal as:

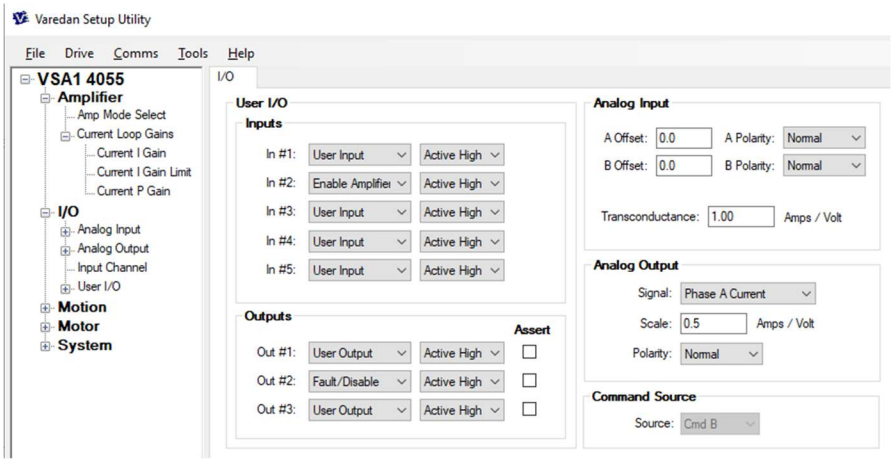
> AMPMODE:3 <CR> (Amplifier operation mode – Three Phase Ext Commutation Control (AB Sine))

> CPGAIN:15.68 <CR> (Current loop proportional gain 15.68)

> CIGAIN:0.8033 <CR> (Current integral gain 0.8033)

Reference to serial command list for detailed descriptions.

11.2.2 I/O selection



An IO selection example is shown on the above GUI. “User I/O Input #2” is selected as the amplifier enable signal, active high. Notice that “Out #2” is selected to be “Disable” signal, active high. The output #2 can be used as the handshake signal of amplifier’s enable signal. If Out #2 level is low, the amplifier is enabled. Otherwise, it is disabled.

Cmd A and Cmd B polarity” set as normal, non-inverted. In this mode, command source selection is disabled.

Without GUI, users can also set the same amplifier I/O selections from host terminal as:

> MAPIN:2:1 <CR> (map user input #2, as Enable amplifier)

> INPOL:2:1 <CR> (User input #2, active high)

> **MAPOUT:2:6 <CR>** (Map user output #2, as Disable amplifier)

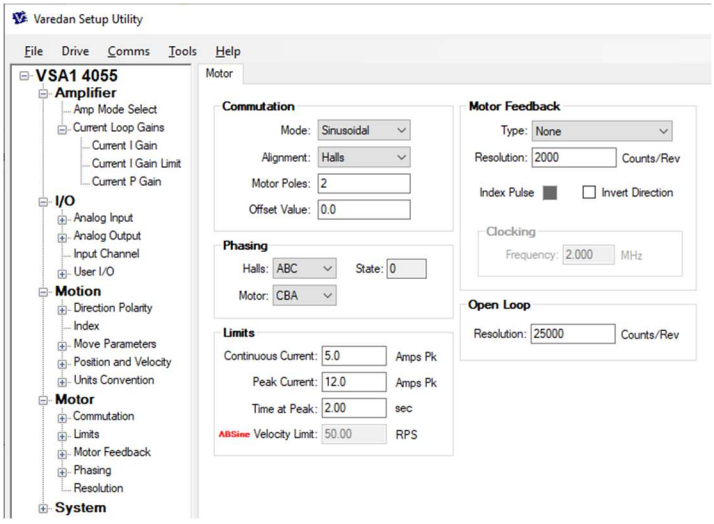
> **OUTPOL:2:1 <CR>** (User output #2, active high)

> ANALOGAPOL:0 <CR> (Analog input A polarity - normal)

> ANALOGBPOL:0 <CR> (Analog input B polarity - normal)

Reference to serial command list for detailed descriptions.

11.2.3 Motor configuration and current limits



On the above GUI setups, motor “Phasing” is CBA. That means that the amplifier swapped phase A and phase C outputs. If you want to reverse current direction, swap phase A and C by selecting ABC from “Phasing” menu. In this mode, ignore motor commutation tab.

Current limits set as “Continuous current” 5.0A, “Peak Current” 12.0A, “Time” 2 seconds. That means if motor current over 12A at any time, the drive will be disabled. An over current fault will report. Also, if motor $(\text{current}^2 - 5^2)$*time is greater than $(12^2 - 5^2)$*2, an I2T fault will report.

Without GUI, users can set motor output configuration from host terminal console as:

> PHASING:CBA <CR> (Motor phase A and C)

Set current limits as:

> CCLIMIT:5.0 <CR> (continuous current 5.0A)

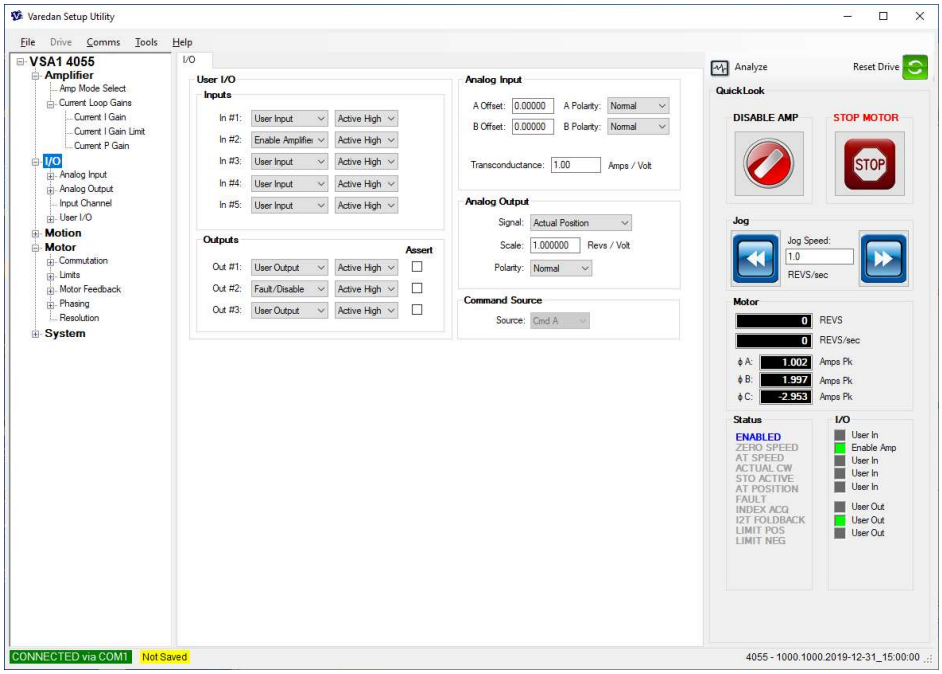
> PKLIMIT:12.0 <CR> (peak current 12.0A)

> PKTIME:2.0 <CR> (peak Current Time 2 seconds)

Reference to serial command list for detailed descriptions.

11.2.4 Motor Test Results

The test motor is a 3-phase motor with phase-to-phase inductance 6mH and phase-to-phase resistance 1.3 ohm. Amplifier get enabled by active high signal from connector P1 pin-2. GUI "QuickLook" panel I/O sector shows the enable amp is asserted and "Status" bar shows the amplifier is enabled. Output #2 "Disable" is highlighted to show the signal is active.



Phase A command analog signal is 1.0V DC input and phase B analog signal is 2.0V DC input. At the QuickLook menu, you can see real-time phase A current is 1.002 Amp and Phase B current is 1.997 Amp. Phase C current measured is -2.953 Amp, which theoretical should equal to the reverse sum of phase A and B currents.

11.2.5 Save user configurations to Drive

All new parameter settings will be lost if drive's power is removed or a reset command is issued. Users can save these parameters to the drive's flash memory either from GUI tools or to use **WRITE** command from terminal console.

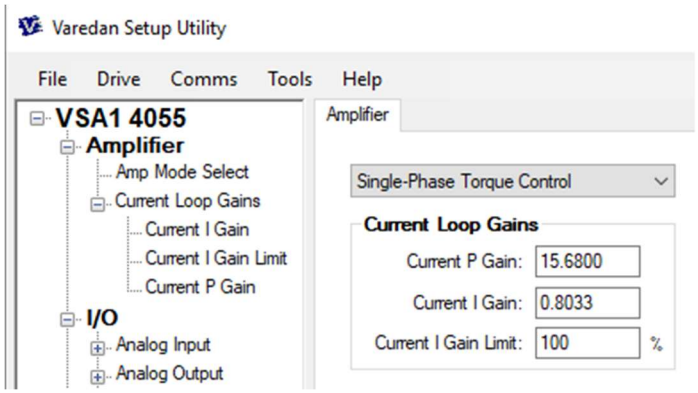
11.3 Single phase motor or coil current control

This mode is for single phase voice coil motor, brushed DC motor, or single coil current control. Motor leads connecting to phase A and C of the drive outputs.

Single Phase Current Mode	**Description**
Motor leads connection	Drive phase A and C outputs

Current command (reference) CMD A or CMD B	CMD A +/-10V differential	If CMD Source = CMD A
	CMD B +/-10V differential t	If CMD Source = CMD B
Current control	1 PI controller	
Transconductance	1V/1A	
PWM	H-Bridge PWM	

11.3.1 Amplifier operation mode and gains



From GUI configuration tree->Amplifier tab, select “Single-Phase Torque Control”.

Sets current PI control loop gains. “Current I Gain Limit” is not implemented and should be ignored.

Without GUI, users can also set the same amplifier operation mode and gains from host terminal as:

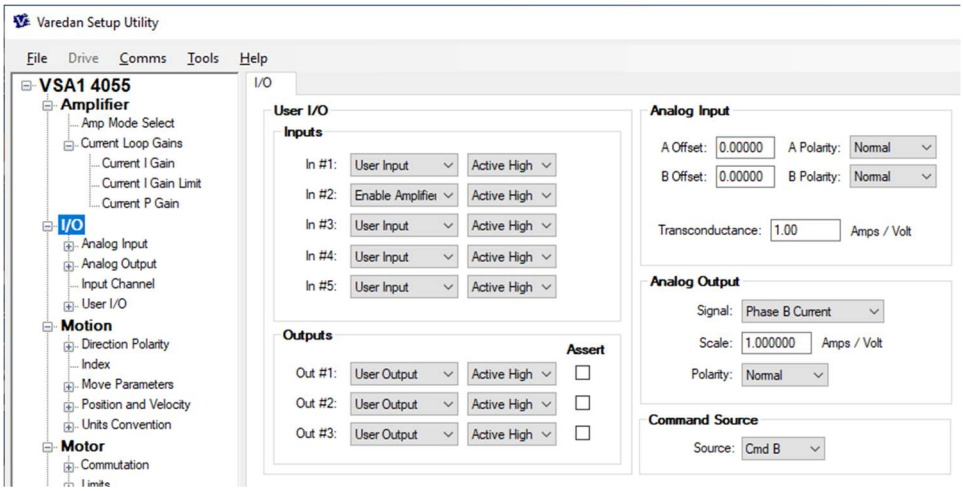
> AMPMODE:0 <CR> (Amplifier operation mode – Single-Phase Torque Control)

> CPGAIN:15.68 <CR> (Current loop proportional gain 15.68)

> CIGAIN:0.8033 <CR> (Current integral gain 0.8033)

Reference to serial command list for detailed descriptions.

11.3.2 IO selection



An IO setup example is shown on the above GUI, “User I/O Input #2” is selected as the amplifier enable signal, active high. “Cmd B” input is configured as current command source. Cmd “B Polarity” is normal, non-inverted.

Without GUI, users can also set the same amplifier I/O selections from host terminal as:

> MAPIN:2:1 <CR> (User input #2, as Enable Amplifier)

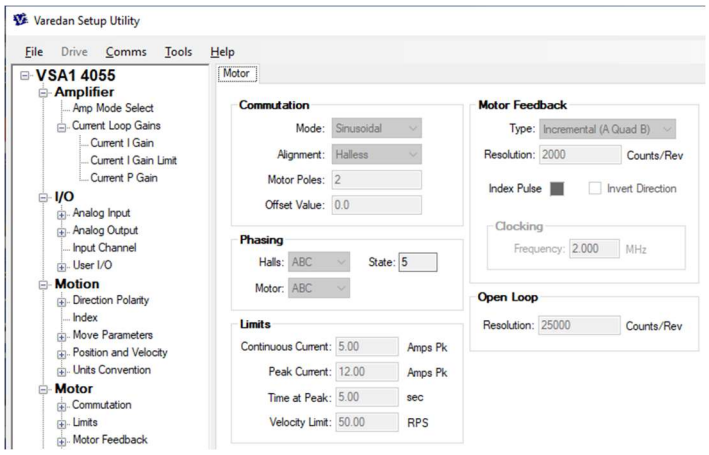
> INPOL:2:1 <CR> (User input #2, active high)

> EXTCMDIN:2 <CR> (Command source – Cmd B)

> ANALOGBPOL:0 <CR> (Analog input B polarity - normal)

Reference to serial command list for detailed descriptions.

11.3.3 Motor output configuration and current limits



On the above GUI example, motor “Phasing” is ABC. For single phase motor, phase B is ignored. If you want to reverse current direction, swap phase A and C by selecting CBA from “Phasing” menu.

Current limits set as “Continuous current” 5.0A, “Peak Current” 12.0A, “Time” 5 seconds. That means if motor current over 12A at any time, the drive will be disabled. An over current fault will report. Also, if motor ($current^2 – 5^2$)*time is greater than ($12^2 – 5^2$)*5, an I2T fault will report.

Without GUI, users can set motor output configuration from host terminal console as:

> PHASING:ABC <CR> (Motor phase A and C)

Set current limits as:

> CCLIMIT:5.0 <CR> (continuous current 5.0A)

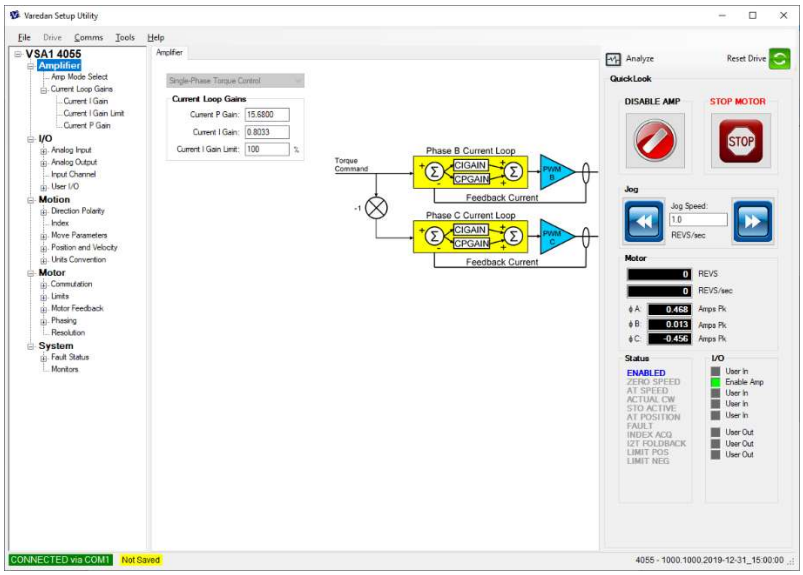
> PKLIMIT:12.0 <CR> (peak current 12.0A)

> PKTIME:5.0 <CR> (peak Current Time 5 seconds)

Reference to serial command list for detailed descriptions.

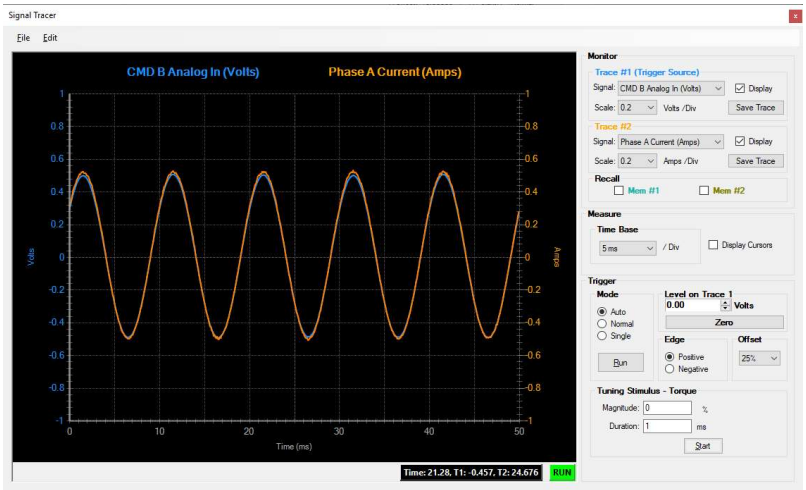
11.3.4 Motor test results

A test motor with coil inductance 6mH and resistance 1.3 ohm is connected to P3 pin-4 and pin-6. Amplifier get enabled by active high signal from connector P1 pin-2. GUI “QuickLook” panel I/O sector shows the enable amp is asserted and “Status” bar shows the amplifier is enabled.



A current command signal, 100Hz 1.0V peak-2-peak sinusoidal signal, is loaded to CMD B differential inputs at connector P1-13 and P1-14.

Clicking “Analyze” icon at the main menu to open a signal tracer scope. Trace 1, blue color, shows 100Hz 1V peak-to-peak sinusoidal command. With 1A/1V transconductance, it sends 1A peak-to-peak current reference. The phase A current feedback, 1A peak-to-peak, is shown in yellow.



11.3.5 Save user configurations to Drive

All new parameter settings will be lost if drive’s power is removed or a reset command is issued. Users can save these parameters to the drive’s flash memory either from GUI tools or to use **WRITE** command from terminal console.

12 External Safety Interface

12.1 Safety Torque off (STO)

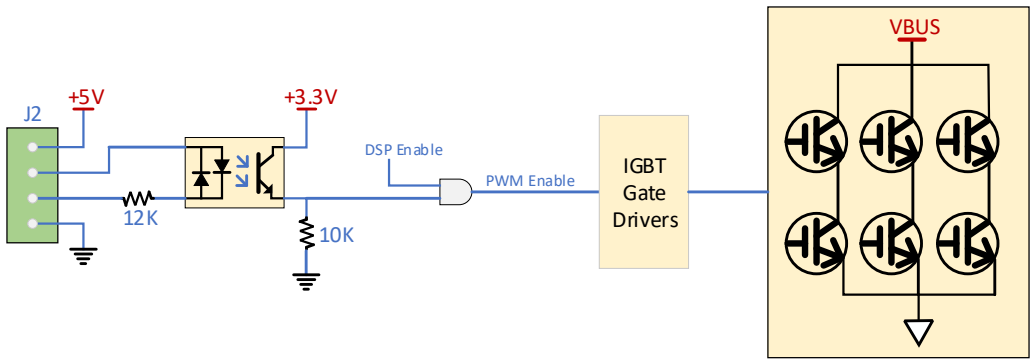
Both VSA1 and VSA2 have the safe torque off function. In the safe state, the drive get disabled by hardware and the motor is in free-whell state.

The STO inputs are opto-isolated. The maximum input voltage to the opto-couplers should not over 60V.

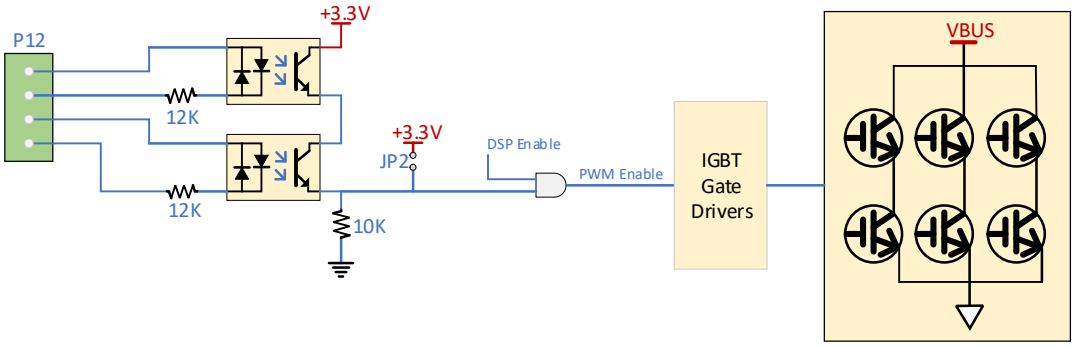
The user can bypass STO funcition if it does not apply to the applications.

For VSA1, plugging a jumper between pin-1 and pin-2, and the other jumper to short pin-3 and pin-4.

For VSA2, plugging a jumper at JP2 on the PCBA to bypass STO function.



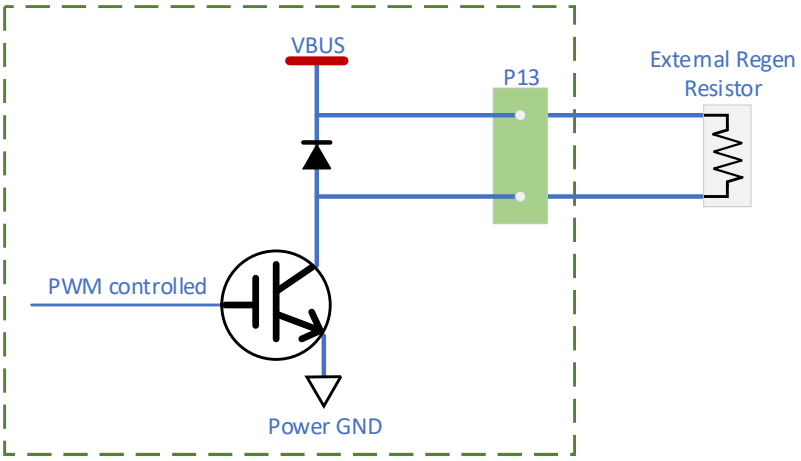
VSA1 STO Wiring Diagram



VSA2 STO wiring diagram

12.2 External Regen Resistor

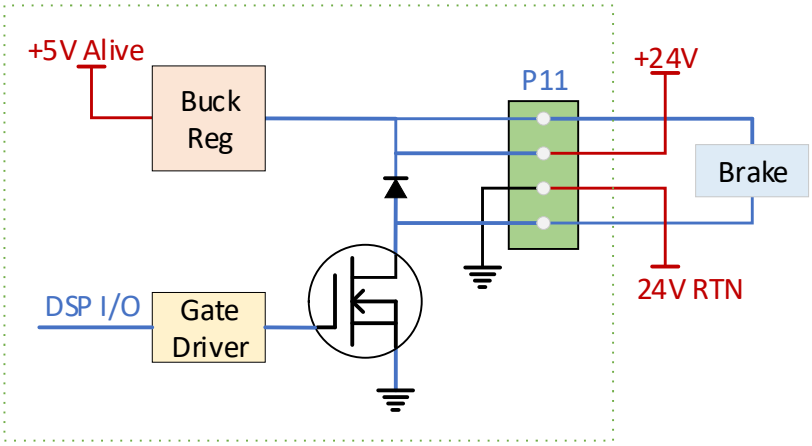
For VSA2 only, an external regen resistor can be connected to P13 to dissipate regenerative energy that exceeds the storage capacity of the bus capacitance. Users can set up turn on voltage through REGENVOLT command.



To avoid regen energy exceeds the power rating of the regen resistor, the regen turn on/off is PWM controlled. Users can set up PWM on duty cycle to control the regen energy that dumps to the external load resistor.

REGENPWMDC command is used to set PWM on duty cycle. The minimum on duty cycle is 5%. The drive allows to set 0 duty cycle to turn off the regen output.

12.3 Keep Alive and Motor Brake



12.3.1 Keep Alive

The user can provide an optional +24V input to keep the drive alive when the main bus voltage is removed. The external +24V generates +5V to keep all digital circuits alive without interrupting when the main bus voltage is turned off and then back on later.

12.3.2 Motor brake operation

Some applications apply a brake to hold the axis when the drive get disabled. The brake is controlled by DSP I/O. When the drive gets disabled, brake can be engaged. When the drive gets enabled, brake will be released. An additional delay or hold on time can be added. The details are TBD.

13 The Internal Protection Functions

The amplifier has a few built-in protective functions. The protective functions consist of 2 categories, warnings and faults. In the event of a fault sensed, the amplifier is disable and status LED is red. Motor is in free-wheeling mode. In the event of a warning detected, the amplifier does not take any action. It can report to host and host can decide if a necessary action should be taken.

13.1 Faults

13.1.1 Flash memory checksum error

For a code image or user parameters stored in flash memory, a given checksum is stored as the last word. When DSP loads the code image or user parameters to RAM, checksum is calculated and compares with the given checksum word. If the 2 checksums are not matched, this error is asserted.

13.1.2 Hardware over current

The amplifier hardware monitors the current flows to each motor phase. If any phase current over 42A, hardware detects short circuits and hardware over current fault is asserted.

13.1.3 Current I2T overload

I2T limit is defined from either the GUI setups or from the console commands. CCLIMIT, PKLIMIT, and PKTIME commands set maximum continuous current, peak current, and peak time.

I2T Limit = $(PKLIMIT^2 – CCLIMIT^2)*PKTIME$

If real-time i2t over this limit, the over current fault is declared.

For single phase motor,

$i2t = (I^2 – CCLIMIT^2)*t$

For 3-phase motor,

$i2t = [(2/3)*(Ia*Ia + Ib*Ib + Ic*Ic) – CCLIMIT^2]*t$

In i2t calculation, if $i2t < 0$, $i2t = 0$.

13.1.4 Motor phase over current

If any motor phase current over the peak current, the over current fault is asserted. Users can define the peak current either from GUI or use PKLIMIT command from the console.

13.1.5 Hardware safety torque off (STO)

This is not real fault. If the STO signal is detected, the drive treats it as hardware fault and motor is in free-wheeling mode. When STO signal removes, the error gets cleared itself.

Maximum input voltage between STO+ and STO- should be no more than 40V.

13.1.6 Quadrature encoder phase error

Normally 2 quadrature inputs of incremental encoder, A and B, should be 90-degree out of phase. If the same edge transition is detected simultaneously on quadrature A and quadrature B signals, the error is declared.

13.1.7 Bus over voltage

VSA1 bus voltage over 100V. VSA2 bus voltage over 430V.

13.1.8 Bus under voltage

VSA1 bus voltage is under +24V. VSA2 bus voltage under 100V.

13.1.9 Motor over temperature

TBD. User can set motor thermal resistance.

13.1.10 Amplifier over temperature

The amplifier inverter temperature is over 70-degree C.

13.1.11 +5V output supply fault

+5V voltage output over current or over temperature.

13.2 Warnings

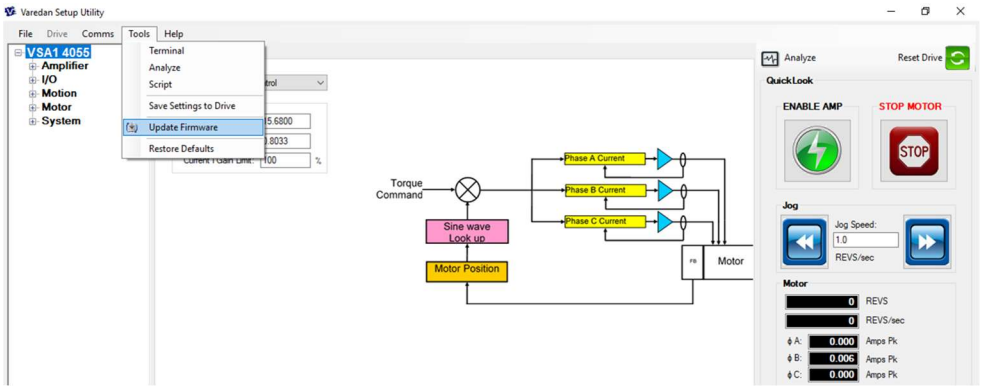
Current GUI does not support warning codes. Will be implemented in next GUI release.

14 Firmware Upgrade

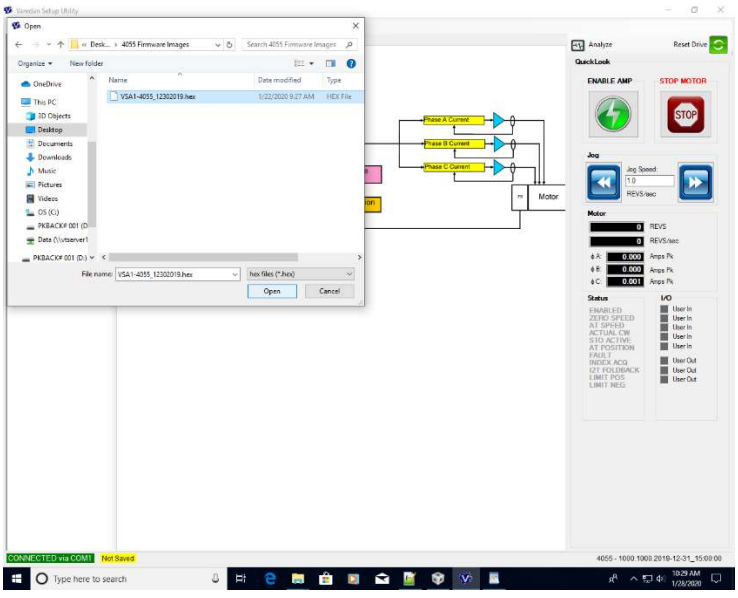
The VaredanGUI should be used as the primary tool for updating drive firmware. If this option is not available, the 3rd party C2Prog program can also be used. Contact Varedan Engineering for firmware images for different upload procedures.

14.1 Update firmware from GUI

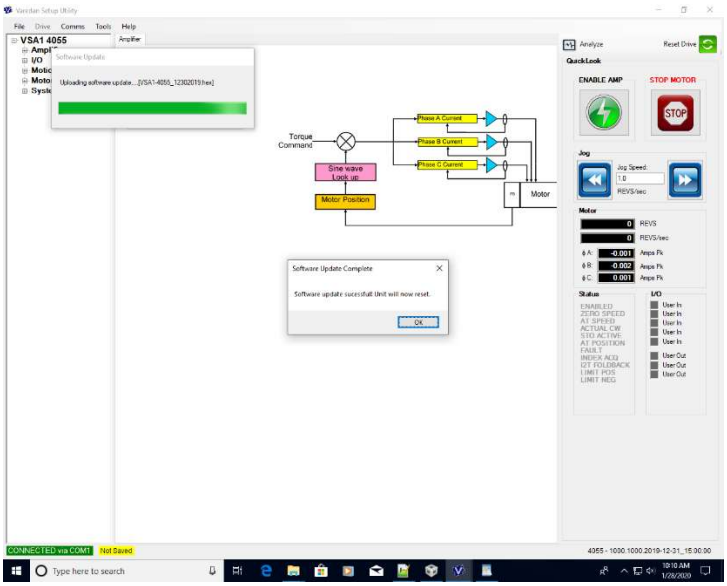
Step 1: From GUI pull-down manual, select Tools->Update Firmware



Step 2: Select the firmware image file to be uploaded. Click “Open”.



Step 3: Waiting for uploading to be complete. After complete, on “Software Update Complete” menu, click “OK”. VSA drive get reset and new firmware version should show on GUI right corner.



14.2 Update firmware from C2Prog

Step 1: Download and install CodeSkin C2Prog v1.7j from the following link:
http://www.codeskin.com/c2prog-download
C2Prog will be used to flash the firmware hex file onto the VSA amplifier.

Step 2: Connect serial cable from PC to the VSA amplifier's RS232 port, P4.

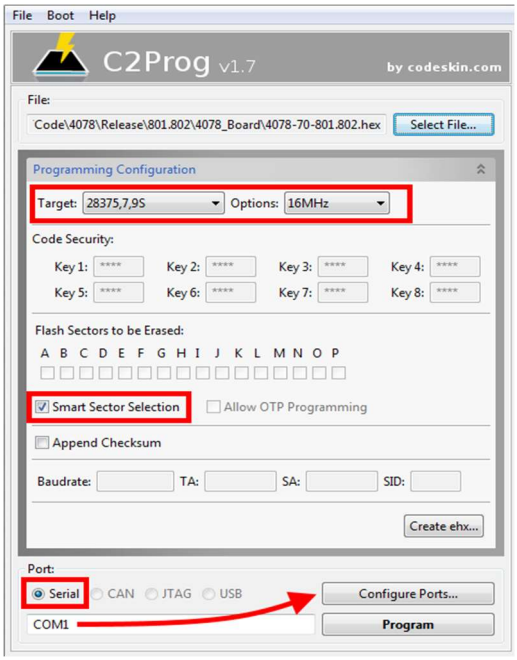
Step 3: Short P4 pin-5 and pin-6 for DSP programing mode before powering on the drive. When power is turned-on, the status LED should be solid orange, indicating that the amplifier is in Firmware Flash Mode. If it is not, power down the amplifier and repeat the process.

Step 4: Open C2Prog and select the firmware hex file from its saved location as shown.

Step 5: Expand the Programming Configuration section as shown by clicking on the double arrows.

Set the following fields as shown:

- Target: 28375,7,9S
- Options: 16MHz
- Smart Sector Selection: checked
- Port: Serial



Step 6: Click on the “Configure Ports...” button to open the Port Configuration pop-up.

Step 7: Click on the “Scan Ports” button and select the appropriate port from the pull-down menu. Close the Port Configuration pop-up window after the correct port has been selected.

Step 8: Click on the “Program” button to flash the firmware hex file onto the amplifier.

Step 9: Verify that the “Programming...OK” dialogue is present and close the Programming pop-up window.

Step 10: Recycle power of the amplifier. Be aware of previous user settings of the amplifier are wiped out at this moment. User needs to re-configure the amplifier from GUI or host terminal, or to reload the saved configuration file.

15 Serial Command Interface

15.1 Command Category

The serial commands are grouped as 3 categories, immediate, configuration, and status. Immediate commands tell the amplifier executes the command immediately. Configuration commands define the amplifier and motor parameters. Status commands monitor the status of the amplifier.

15.2 Command format

Commands are entered using ASCII characters from the terminal. To enter a command with a user entered data field, the command name is followed by a “**:**” or “**=**” followed by the data for the command, followed by

Enter (carriage return) is used. As a minimum, all commands must be terminated by the carriage return character (ASCII 13). The line feed (ASCII 10) is optional and is not used by the amplifier.
A typical command has the following ASCII format. Control characters are shown in **<>**:

CONFIG?<Cr><Lf>

POLES=4<Cr><Lf>

All characters sent to the amplifier are echoed back if echo has been enabled. When the amplifier has accepted the command, the prompt "**>**" is returned.
Note: The "**:**" and "**=**" can be used interchangeably to separate a command from the input parameter data.
The command data types are as follows:

Integer	ex: 100
Float	ex: 23.456
Character	ex: ABC

Configuration and status commands can be directly queried for their values by appending a "**?**" to the end of the command. For example:

>AMPMODE?
>4

would indicate an amplifier mode of "4" which is 3-phase torque mode.

Commands and values are case sensitive with commands requiring upper case convention. If the VSA encounters a problem any command it receives, it will respond with the following error states:

Error Message	**Description**
Invalid Command	Command was not recognized as a valid command
Invalid Parameter	Command parameter was not in the proper format
Invalid Mode	Requested operation is not valid in current operating mode
Invalid While Enabled	Requested operation is not available while amplifier is Enabled
Data Range Error	Command parameter is outside the valid range

15.3 Command List

In this list, data type "f" indicates float, "n" or "x" indicates integer, and "c" indicates a character.

15.3.1 ACCEL:f

Set desired acceleration rate.

Category	Configuration
Parameter	float
1.0 to 40,000.0	Acceleration in user units/sec^2

15.3.2 ALARMREST

Soft reset. Clear all faults and warnings status.

Category	Immediate
Parameter	N/A

15.3.3 ALIGNMODE:n

Select motor initialization (phasing) method.

Category	Configuration
Parameter	Integer
n	**Description**
0	Hall sensors for motor initialization. No motion required.
1	Halless, constant current motor phasing. Motor moves.
2	Absolute encoder, fixed phase angle offset

15.3.4 AMPMODE:n

Sets the operate mode of the amplifier. The amplifier must be disabled to change the mode.

Category	Configuration
Parameter	Integer
n	**Description**
0	Single phase motor torque/current control
1	TBD. Single phase motor velocity control
2	TBD. Single phase motor position control
3	3-phase motor, 2-phase external commutation control (ABSine)
4	3-phase motor torque/force/current control
5	TBD. 3-phase motor velocity control
6	TBD. 3-phase motor position control
7	TBD. 3-phase open-loop

15.3.5 ANALOGOUT:n

Selects the analog output signal for user monitoring.

Category	Configuration
Parameter	Integer
n	**Description**
0	Actual Position. TBD
1	Position reference. TBD.
2	Actual Velocity. TBD
3	Velocity reference. TBD
4	Phase A Current (Amp)
5	Phase B Current (Amp)
6	Phase C Current (Amp)
7	TBD
8	dq axis current, Iq (Amp)
9	dq axis current, Id (Amp)
10	CMD A analog input (voltage)
11	CMD B analog input (voltage)
12	CMD A analog input (voltage)
13	CMD B analog input (voltage)
14	TBD

15	TBD
16	Test signal, motor electrical angle (degree)

15.3.6 ANALOGAPOL:n

Sets input polarity for CMD A analog input.

Category	Configuration
Parameter	Integer
n	**Description**
0	Normal
1	Inverted the signal

15.3.7 ANALOGBPOL:n

Sets input polarity for CMD B analog input.

Category	Configuration
Parameter	Integer
n	**Description**
0	Normal
1	Inverted the signal

15.3.8 AOUTPOL:n

Sets polarity of the analog output signal, selected by ANALOGOUT command. Signal level 0 references to 2.5V.

Category	Configuration
Parameter	Integer
n	**Description**
0	Normal
1	Inverted the signal

15.3.9 AOUTSCALE:f

Scales the dynamic range of the analog output signal. The analog output signal is selected by ANALOGOUT command. For example,

> ANALOGOUT:4 Selects Phase A Current as the analog output signal

> AOUTSCALE:0.5 Set the analog output scale to 0.5VDC / Amp

Category	Configuration
Parameter	float
1e-6 to 1e6	Analog output signal scale factor

15.3.10 CCLIMIT:f

Sets the continuous motor current limit in Amps. This value is also used to determine the I2T protection limit. When the motor current exceeds this setting, the motor i2t over current protection becomes active.

Category	Configuration
Parameter	float
0.0 to 10.0	VSA1 – Continuous current in Amps
0.0 to 25.0	VSA2 – Continuous current in Amps

15.3.11 CIGAIN:f

Sets current loop integral gain value. CIGAIN? reads the setting value.

Category	Configuration
Parameter	float
0.0 to 200.0	Current PI controller, integral gain

15.3.12 CPGAIN:f

Sets current loop proportional gain. CPGAIN? reads the setting value.

Category	Configuration
Parameter	float
0.0 to 10000.0	Current PI controller, proportional gain

15.3.13 COMMOFFSET:f

Sets the commutation angle offset in electrical degrees. Typically used for the alignment of absolute feedback devices.

Category	Configuration
Parameter	float
0 – 360.0	Electrical angle phase offset in degree

15.3.14 COMMUTATION:n

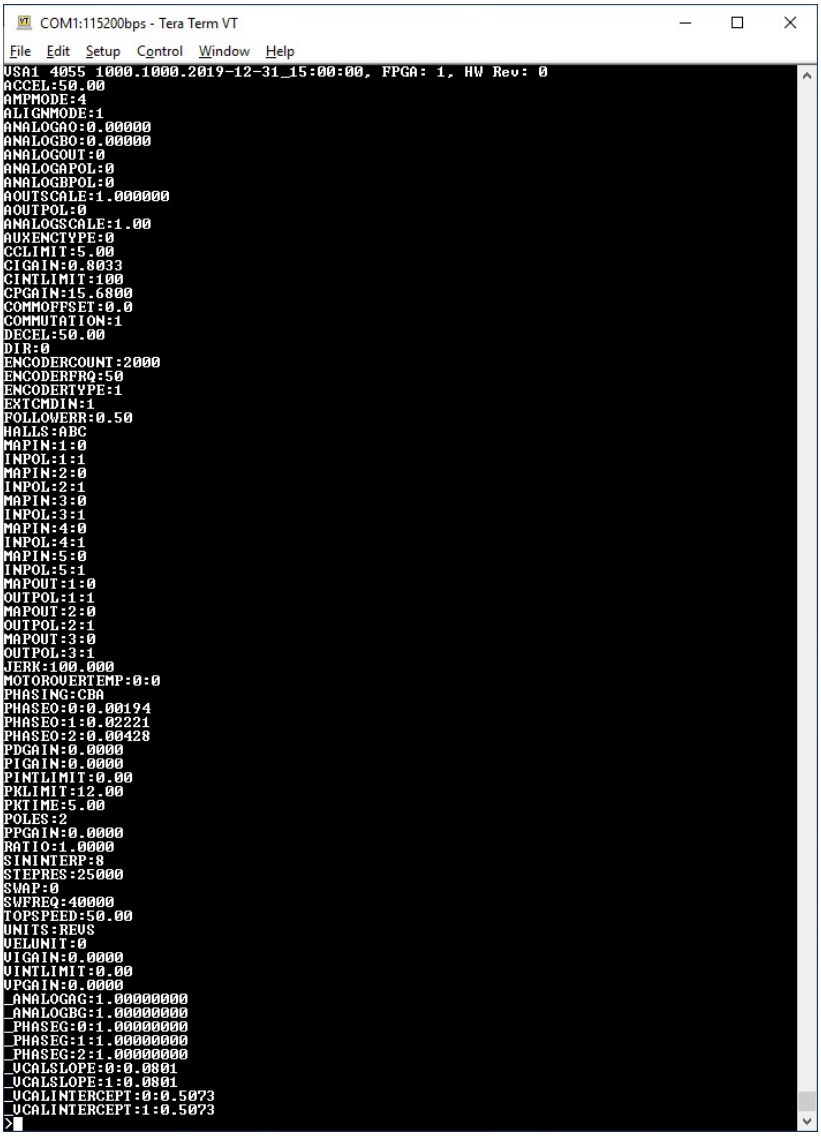
Sets the motor commutation mode.

Category	Configuration
Parameter	Integer
0	TBD, 6 step Hall commutation
1	Sinusoidal commutation
2	TBD, 1.8-degree stepper
3	TBD, 3.6-degree stepper

15.3.15 CONFIG?

Replies with a listing of the amplifier configuration in command format which can be saved to a file.

Category	Status
Parameter	N/A



15.3.16 DECEL:f

Sets the desired deceleration in user units/sec^2.

Category	Configuration
Parameter	float
1.0 to 4000.0	Deceleration in user units/sec^2

15.3.17 DIR:n

Sets the motor direction polarity as positive/clockwise or negative/counter-Clockwise. Only active when the amplifier is Disabled.

Category	Configuration
Parameter	Integer
0	Clockwise/positive

1	Counter-clockwise/negative

15.3.18 ECHO:n

Category	Immediate
Parameter	Integer
0	Echo off
1	Echo on

15.3.19 EN, ENABLE

Enables the amplifier. Don't use this command if a hardware I/O is selected to be host enable signal input.

Category	Immediate
Parameter	N/A

15.3.20 ENCODERCOUNT:n

Sets the encoder feedback resolution. For the incremental encoder, sets encoder counts per mechanical revolution for rotary motors, and sets encoder counts per pole pairs for linear motors. The valid range of this value is determined by the feedback device type set by the **ENCODERTYPE** command.

Category	Configuration
Parameter	Integer
Encoder type	**n**
Incremental encoder	200 to 100000
Biss	TBD
DnDat	TBD
Sin/Cos	TBD

15.3.21 ENCODERTYPE:n

Sets the main feedback encoder type.

Category	Configuration
Parameter	Integer
n	**Description**
0	No encoder feedbacks
1	Incremental quadrature encoder
2	Biss
3	DnDat
4	Analog encoder Sin/Cos

15.3.22 EXTCMDIN:n

Selects the external input command source. This command has no effect when **AMPMODE:3** is selected which uses both CMD A and CMD B as primary command inputs.

Category	Configuration
Parameter	Integer

n	Description
0	No external command source
1	CMD A Input as the command source
2	CMD B Input as the command source
3	TBD, external reference
4	TBD
5	TBD

15.3.23 FAULTS?

Returns faults as a bit encoded binary word.

Category	Status, binary
Parameter	N/A
FAULTS?	Description
Bit 0	Non-volatile memory checksum error
Bit 1	TBD
Bit 2	Motor feedback
Bit 3	Following error
Bit 4	Motor over speed
Bit 5	Logic power error
Bit 6	Bus over voltage
Bit 7	TBD
Bit 8	Amplifier fault, short circuits
Bit 9	Over current
Bit 10	Amplifier inverter over temperature
Bit 11	Motor over temperature
Bit 12	Bus under voltage
Bit 13-15	TBD

15.3.24 FAULTSA?

Returns an ASCII list of active faults otherwise returns “OK”.

Category	Status
Parameter	N/A

15.3.25 GAINS?

Lists control loop gain settings. Current PI loop CPGAIN, CIGAIN, CINTLIMIIT. Velocity PI loop VPGAIN, VIGAIN, VINTLIMIT. Position PID loop PPGAIN, PIGAIN, PDGAIN, PINTLIMIT.

Category	Status
Parameter	N/A

15.3.26 HALLS:ccc

Sets the hall state relationship to the motor phases. Default is “ABC”. For example, **HALLS:ACB** swaps hall phase B and C. If motor initialization (phasing) using hall sensors, users must set the correct hall sequence.

Category	Configuration

Parameter	Character
ccc	A, B, C

15.3.27 HELP?

Lists all available user commands.

Category	Status
Parameter	N/A

15.3.28 I?

Lists 3 phase currents, one per line.

Category	Status
Parameter	N/A

15.3.29 INPOL:x:n

Sets the active level or edge trigger for input number **x**

Category	Configuration
Parameter	Integer
x	**Input I/O number**
User I/O input number	1 to 5
n	**Trigger type**
0	Active low
1 – default	Active high
2	Positive edge
3	Negative edge

15.3.30 INPUTS?

Returns a binary word that is bit encoded with the state of the inputs.

Category	Status
Parameter	N/A
State bits	**Description**
Bit 0	IN1, user input #1
Bit 1	IN2, user input #2
Bit 2	IN3, user input #3
Bit 3	IN4, user input #4
Bit 4	IN5, user input #5
Bit 5	Hall A
Bit 6	Hall B
Bit 7	Hall C
Bit 8	STO
Bit 9	Encoder index latched
Bit 10	Auxiliary encoder index latched
Bit 11-15	TBD

15.3.31 INPUTSA?

Returns an ASCII list of the state of the inputs. Check bits description in INPUTS? command.

Category	Status
Parameter	N/A

15.3.32 JERK:f

Sets user desired maximum jerk limit value.

Category	Configuration
Parameter	float
0.0 to 40000.0	Jerk limit in user units/sec^2

15.3.33 MAPIN:x:n

Configures user input pin **x** functionality. For example: **MAPIN:2:1** maps input #2 as the amplifier enable.

Category	Configuration
Parameter	Integer, integer
x	**Input channel number**
User I/O input number	1 to 5
n	**Functionality**
0 – default	General purpose user input
1	Enable amplifier
2	TBD. Defines bit in program selection number
3	Limit+, motion positive limit
4	Limit-, motion negative limit
5	TBD. Stops motor using preset deceleration value.
6	SFI, special user function input
7	Hard reset

15.3.34 MAPOUT:x:n

Configures user I/O output number **x** functionality. For example: **MAPOUT:2:1** maps output #2 as a Fault Output. Active level is defined in OUTPOL:x:n command.

Category	Configuration
Parameter	Integer, integer
x	**Output channel number**
User I/O output number	1 to 3
n	**Functionality**
0 – default	General purpose user output
1	Fault
2	TBD. At speed.
3	TBD. Zero speed.
4	TBD
5	TBD. At position.
6	Disable. Amplifier is disabled if asserted.

15.3.35 MONITOR?

Lists the measured bus voltage, keep alive voltage, and the amplifier temperature. Voltage measurements may have 10% variation to its real values.

Category	Status
Parameter	N/A

15.3.36 MOTOROVERTEMP:x:n

Sets the motor over-temp protection mode and the sensor resistance threshold.

Category	Configuration
Parameter	Integer, integer
x	**Thermistor type**
0 – default	Disabled
1	NTC sensor
2	PTC sensor
n	**Description**
0 to 500,000	Thermal resistance in ohm

15.3.37 MOTORTEMP?

Returns the motor temperature sensor resistance in ohms.

Category	Status
Parameter	N/A

15.3.38 OUTPOL:x:n

Sets the active level polarity for output number **x**.

Category	Configuration
Parameter	Integer, integer
x	**Description**
1 to 3	User I/O output number
n	**Description**
0	Active Low
1 – default	Active High

15.3.39 OUTPUTS?

Returns a binary word that is bit encoded with the state of the outputs.

Category	Status
State bits	**Description**
Bit 0	OUT1, user output #1
Bit 1	OUT2, user output #2
Bit 2	OUT3, user output #3
Bit 3:15	TBD

15.3.40 OUTPUTSA?

Returns an ASCII list of the state of the user outputs.

Category	Status
Parameter	N/A

15.3.41 PDGAIN:f

Sets the position loop derivative gain.

Category	Configuration
Parameter	float
f	**Description**
0.0 to 1000.0	Position PID controller, derivative gain

15.3.42 PHASING:ccc

Sets the motor leads relationship to the drive phase outputs. This action equals to swap the motor lead wires. For example, **PHASING:CBA** swaps Phase A and C

Category	Configuration
Parameter	Character
ccc	**Description**
ABC	Drive phase A,B,C to motor leads A,B,C corresponding
CBA	Swap drive phase A and C outputs

15.3.43 PIGAIN:f

Sets the position loop integral gain.

Category	Configuration
Parameter	float
f	**Description**
0.0 to 1000.0	Position PID controller, integral gain

15.3.44 PKLIMIT:f

Sets the peak current in Amps for protection. If any motor phase current is over the given peak current, the amplifier gets disabled and over current fault will be reported. This value is also used to calculate I2T limit to trigger I2T fault.

Category	Configuration
Parameter	float
f	**Description**
0.0 to 12.0	VSA1 – Peak current in Amps
0.0 to 40.0	VSA2 – Peak current in Amps

15.3.45 PKTIME:f

Sets the peak current time in seconds. This value is also used to calculate I2T limit to trigger I2T fault.

Category	Configuration
Parameter	float
f	**Description**
0.0 to 25.0	Peak time in seconds to calculate I2T limit

15.3.46 POLES:n

Sets the number of magnetic motor poles (NOT pole pairs).

Category	Configuration
Parameter	integer
n	**Description**
0 to 100	Number of magnetic poles

15.3.47 PPGAIN:f

Sets the position loop proportional gain.

Category	Configuration
Parameter	float
f	**Description**
0.0 to 1000.0	Position PID controller, proportional gain

15.3.48 REGENVOLT

For VSA2 only, sets the bus voltage threshold for regen on.

Category	Configuration
Parameter	integer
n	**Description**
100 to 420	Bus voltage in volt to turn on regen circuits

15.3.49 REGENPWMDC

For VSA2 only, sets regen PWM control duty cycle. If duty cycle equals to 0, regen gets disabled. The minimum on duty cycle is 5%. For the duty cycle input less than 5% will be set as 5%.

Category	Configuration
Parameter	integer
n	**Description**
0 to 100	Regen PWM duty cycle in percentage

15.3.50 RESET

Performs a hard reset of the amplifier.

Category	Immediate
Parameter	N/A

15.3.51 S?

Returns the binary value of the 16-bit status flags. For ASCII version, see **SA?**

Category	Status
Parameter	N/A

15.3.52 SA?

Returns the hex ASCII value of the 16-bit status flags.

Category	Status
Flag bits	**Description**
Bit 0	Enable
Bit 1	TBD, Zero speed
Bit 2	TBD, At speed
Bit 3	TBD, Motion direction
Bit 4	STO
Bit 5	TBD. At position
Bit 6	Fault
Bit 7	TBD, encoder index captured
Bit 8-15	N/A

15.3.53 SETOUTPUT:x:n

Set the state of a general purpose output, where x is the output number 1-3 and n is the desired state 0 or 1. Note that the I/O pin must first be configured as user output using the **MAPIO:x:n** command to map the output n as a general purpose user output. For example,

Map Output 2 as a general purpose output: **MAPIO:2:1**

Set output 2 to 1: **SETOUTPUT:2:1**

OUTPOL:x:n defines output active level. If **SETOUTPUT:2:1** command drives output #2 pin is high, if the pin is defined as active high. Otherwise, output #2 pin is low, if the active low is set as active low.

Category	Immediate
Parameter	Integer, integer
x	**Description**
1 to 3	User I/O output number
n	**Description**
0 or 1	Output State

15.3.54 SININTERP:n

Sets the interpolation bits of analog Sin/Cos encoders.

Category	Configuration
Parameter	Integer
n	**Description**
1 to 16	Encoder interpolation bits

15.3.55 SPD?

Responds with the actual speed of the motor in user units.

Category	Immediate
Parameter	N/A

15.3.56 SWAP:n

Swap encoder counting direction.

Category	Configuration
Parameter	Integer
n	**Description**
0	Normal counting
1	Invert encoder counting direction

15.3.57 SWUPDATE:n

Places the amplifier into Bootloader mode to receive a new system software update over the specified communication interface.

Category	Immediate
Parameter	Integer
n	**Description**
1	SCI (serial)
2	TBD. UDP (Ethernet)

15.3.58 TBASE:n

Selects the data trace time base per division on the digital scope.

Category	Configuration
Parameter	Integer
n	**Time base per Division**
0	2.5 ms
1	5.0 ms
2	10 ms
3	25 ms
4 - default	50 ms
5	100 ms
6	250 ms
7	500 ms
8	1 sec

15.3.59 TLVL:f

Sets the data trace trigger level. The data trace trigger signal source is fixed to trace #1.

Category	Configuration
Parameter	float
f	**Description**
10e-6 to 10e6	Scope trace trigger level

15.3.60 TMODE:n

Selects the data trace trigger mode of the digital scope.

Category	Configuration
Parameter	integer
n	**Description**
0 – default	Auto
1	Normal
2	Single

15.3.61 TPOS:n

Sets the data trace horizontal trigger position of the digital scope.

Category	Configuration
Parameter	integer
n	**Description**
0 – default	25%, trigger position at 1/4 of the trace time window
1	50%, trigger position at the middle of the trace time window
2	75%, trigger position at 3/4 the trace time window

15.3.62 TRACE:x?

Returns the captured binary data buffer for the selected channel.

Category	Immediate
Parameter	Integer
n	**Description**
0	Both channels
1 – default	Trace #1
2	Trace #2

15.3.63 TSIG:x:n

Selects the data trace channel signal where **x** is the channel number and **n** is the signal.

Category	Configuration
Parameters	Integer, integer
x	**Channel #**
1	Trace #1
2	Trace #2
n	**Signal index**
0	apos, actual position
1	dpos, position reference
2	avel, actual velocity
3	dvel, velocity refence
4	Ia, motor phase A current
5	Ib, motor phase B current
6	Ic, motor phase C current
7	N/A

8	Iq, 3-phase synchronous control, dq axis current
9	Id, 3-phase synchronous control, dq axis current
10	CMD A
11	CMD B
12	CMD A
13	CMD B
14	N/A
15	N/A
16	Test signal (electrical angle)

15.3.64 TSLOPE:x

Sets the trigger slope of the digital scope.

Category	Configuration
Parameter	Integer
n	**Description**
0	Positive
1	Negative

15.3.65 UNIT:ccccc

Sets the user unit label for motion parameters limited to 5 characters.

Category	Configuration
Parameter	Character A to Z
ccccc	**Description**
REVS	Position or Velocity

15.3.66 VELUNIT:n

Sets the units of time for velocity commands as seconds or minutes.

Category	Configuration
Parameter	Integer
n	**Description**
0	Per second
1	Per minute

15.3.67 VERSION?

Returns the unit IDs and software revision.

Category	Status
Parameter	N/A

15.3.68 VIGAIN:f

Sets the velocity loop integral gain.

Category	Configuration
Parameter	float

f	Description
0 to 1000.0	Velocity PI controller, integral gain

15.3.69 VPGAIN:f

Sets the velocity loop proportional gain.

Category	Configuration
Parameter	float
f	**Description**
0 to 1000.0	Velocity PI controller, proportional gain

15.3.70 WRITE

Saves the user parameter settings to flash memory.

Category	Immediate
Parameter	N/A

16 Sales and Services

Varedan Technologies warrants this product to be free of manufacturing defects for a period of 1 year. If your product requires services, please contact our factory for troubling information and if needed, return material authorization (RMA) information.

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