3L Power SiC 100 kW Motor Drive

Triton100-PsiC

pn PCS-M10C30

Date	Rev	Description	Author	Approved by
2/02/2018	0	First Draft	M Datta	C Cheek
3/08/2018	1	Picture update		
3/07/2019	2	Specs, pics as described on pg 2	V Bun	C Cheek
4/08/2019	3	Control power specs	C Cheek	

Description

The Triton100 Motor Drive is a three-phase motor drive that switches at PWM frequencies exceeding 100 kHz. It is a parallel SiC-based semiconductor drive that is configurable for voltages up to 900Vdc. This spec sheet is customized for a variant that operates with DC input voltages between 100 and 325 Vdc and resolver position feedback (PCS-M10C30).

Specification

Power	100 kW
Switching Frequency	20 – 150 kHz
Voltage input	100 – 325 Vdc
Inst. Max voltage withstand	400 Vdc
Vrms out max	230 Vrms
Iout max	250 Arms
Cooling	Copper plate / water cooled
Copper plate temp at max	45 °C
Control Power	24 Vdc nominal, 22-26V, 24W
Comms	Isolated CAN, USB GUI
Position Feedback	Resolver

1. Spec_PCS-M10C30 Revision 2: dtd 3/5/2019. Edit for new enclosure, Rev. B Intfc bd characteristics, DB9 pinouts, ratings consistent with sticker and testing.

Functional and Performance

The Triton100 drive takes in DC power and delivers 3-phase AC power for running a permanent magnet (PMSM) or induction motor with position feedback. Safety fusing and switchgear need to be applied external to the motor and drive as applicable.

PWM

The PWM state machine for running the motor exists in FPGA firmware, and can be configured for switching frequencies between 20 kHz and 150 kHz, with variable deadtimes. Switching frequencies can be configured to follow preloaded tables as a function of power, or remain static. The default switching frequency is 120 kHz, with frequency dropping in steps from 120 kHz to 40 kHz between 40 Arms and 110 Arms output.

Current/Torque Control

Typical motor control configurations include an inner torque / current control algorithm that relies on a current command, 3-phase feedback current, and a PI regulator that tries to match the actual current to the current command. Depending on the amount of other tasks running, the control loop can run between 10 Hz up to 50 kHz, though 20 kHz is the default loop frequency. Control loop gains are not limited, and can be set by parameter adjustment. Current PI regulator gains Kp and Ki have units of Volts/Amp and Volts/Amp-second respectively, and the resulting system bandwidth is dependent on other parameters, such as input voltage and output (load) impedance.

Current feedback and voltage feedback sampling rates occur at 250 kHz per channel and are constantly evaluated for fault scenarios in firmware.

Raw current feedback signals can be filtered with user-settable bandwidth, processed through a real-time RMS calculation, and processed through a DQ0 transform.

Velocity Control

Typical motor control configurations include an outer velocity control algorithm that relies on a velocity command, position feedback, and a PI regulator that tries to match the actual position time-derivative to the velocity command. The output of the PI regulator is a current command that is fed into the torque / current regulator, and this output has both negative and positive limits that are user-settable. As with the current regulator, the control loop can update at rates between 10 Hz and 50 kHz. Although PI regulator gains, Kp and Ki, are settable per user requirements, the regulator can go unstable if the velocity control regulator is faster than the inner loop current regulator.

Position feedback is fed to the Atlas board FPGA pins, and can include data from discrete hall effect sensors, analog hall effect sensors, digital encoders, or resolvers. This variant of the drive is configured for resolver feedback. Necessary bandwidth for the position feedback varies with the maximum electrical frequency (maximum mechanical speed times the number of motor pole pairs). It is desirable that the feedback hardware slew rates are greater than the slew rate of the motor position at full speed, and that change in position is discernible over the noise background at all operating speeds. In general, resolvers yield the best results for the Atlas control platform, with the most resolution. Position feedback information can be processed through digital low-pass filters with user-settable gain. Advanced calibration algorithms can also be employed to adjust for position feedback non-linearities.

Speed limits (forward and backward), speed slew rates (acceleration), and speed-versus torque profiles are all settable per user requirements.

Limits and Protections

When configured as a motor controller, the Atlas firmware has several operating parameter limits and fault thresholds.

Current: The current limit is a limitation on the current demand that comes from the speed regulator. The current regulator will never try to drive a current higher than the current limit. If the actual current exceeds the current limit, then the current regulator will try to reduce the current. Above the current limit, a current fault threshold exists. If the actual current exceeds the current fault threshold, then a fault will be flagged, and the switching state machine will stop (transistors stop switching).

Speed: The speed limit is a limitation on the speed demand that comes from the user or external controller. The speed regulator will never try to drive a speed higher than the speed limit. If the actual speed exceeds the speed limit, then the speed regulator will try to reduce the motor speed. Above the speed limit, an overspeed fault threshold exists. If the actual speed exceeds the overspeed fault threshold, then a fault will be flagged, and the switching state machine will stop (transistors stop switching).

Voltage: Motor controllers typically do not regulate output or input voltages, therefore there is no voltage limit when operating the Atlas board as a motor controller. An input voltage fault threshold exists such that if the input voltage ever exceeds the threshold, a fault will be flagged, and the switching state machine will stop (transistors stop switching).

All limits and fault thresholds discussed above are settable per user requirements.

Other faults: The motor controller maintains several fail safe features to detect abnormal digital controls behavior such as loss communication with the host, or a logic lockup within either the DSP or FPGA. All of the fault scenarios listed below will generate a unique fault ID and halt the motor operation.

1) Loss of communication – If the controller does not receive a communication packet within 2x period of the normal communication period, a communication fault is declared.
2) DSP Watchdog timer – If the DSP does not receive an interrupt from the FPGA within a 2x period of the normal interrupt period, a DSP watchdog fault is declared.
3) FPGA Watchdog timer – If the FPGA's control register is not written to by the DSP within a 2x period of the normal PWM period, a FPGA watchdog fault is declared.
4) DSP Internal Watchdog – If the software on the DSP freezes, a watchdog timer integrated into the DSP silicon will trigger another fault.

Heat Dissipation

The controls system and gate drivers require about 6W of control power when quiescent and about 20W when running with 150kHz PWM. As further described in the Mechanical Interface portion of this specification, the drive is bolted to a heatsink that must stay below 45 °C under rated current output conditions. While staying below 45 °C at rated current, the heatsink needs to be able to dissipate about 2.5 kW of losses.

Field Weakening

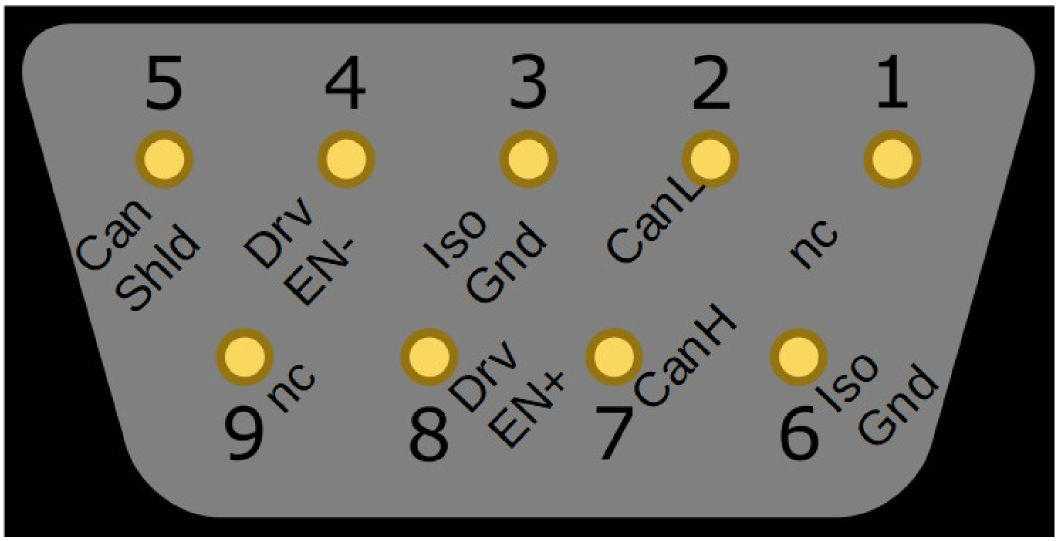
If the motor BEMF magnitude plus voltage across the load impedance exceeds the DC link voltage, the motor can no longer be driven at unity power factor. If desired, field weakening can be used to drive the motor to higher speeds than would otherwise be achievable, at the cost of having to drive non-torque-producing current. The amount of speed gain per Amp of D-axis current (non-torque-producing) varies with the inductance of the stator's d-axis versus the field strength of the rotor. The speed threshold (RPM) at which field weakening starts can be set, and the amount of d-axis current driven per RPM over the threshold can be set (Amps/RPM). Care should be taken when setting these parameters so that the rotor does not get demagnetized.

Interface

CAN Interface

Commands and data requests are passed through the CAN communication ports or over a user interface connected to the USB port. The main automated communications interface is through the CAN communications port located on a 9-pin DB receptacle on the side of the drive. Refer to the Triton100 CAN communications specification (#Spec_Triton100CAN) for further details on message format and electrical specifications.

The pinout for the CAN communications port is shown below. CAN high and CAN low are on pins 7 and 2, respectively. Pins labeled "Iso Gnd" are connected to the isolated ground used for the CAN transceiver. Pins labeled "nc" are not connected to anything. The drive enable pins, labeled "Drv EN", provide an isolated digital input interface used to enable or disable the drive. These pins can be driven with a differential voltage between 5 and 48 Volts.



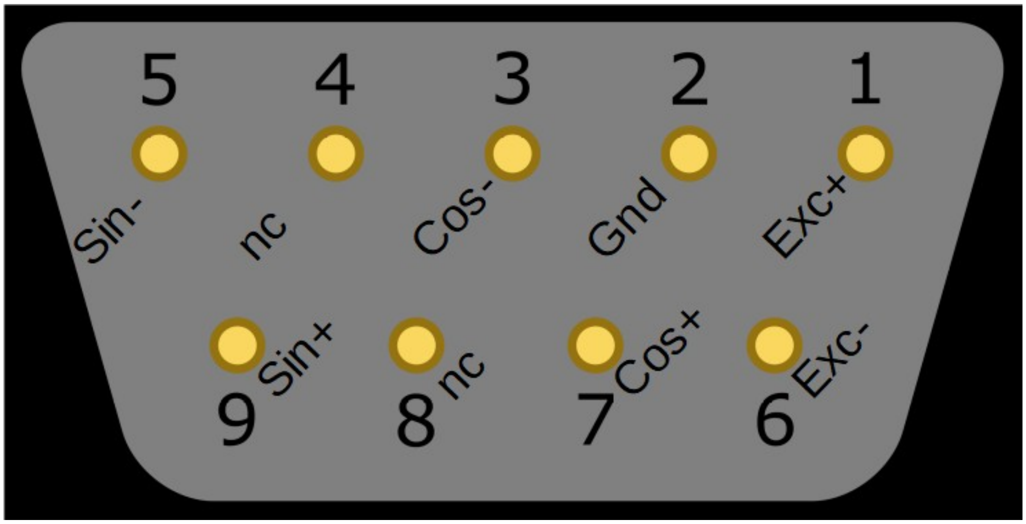
Graphical User Interface

The graphical user interface (GUI) can be accessed using a laptop with the 3L Power GUI application, plugged into the micro-USB port on the side of the drive. This GUI interface is used for non-automated communication with the drive, such as from a person that wants to manually control the drive during testing. Refer to the 3L Power Triton GUI manual and application for further information.

Feedback Interface(s)

Absolute mechanical shaft position is required. This can be provided by either a resolver or an encoder. 3-phase current and DC link voltage measurements through an ADC are also necessary and built into the drive. Standard digital communication interfaces are supported (SPI, I2C, SSI, etc). Resolution of the feedback sensor is specified by customer and programmed at the factory.

Resolver feedback and excitation for pn M10C30 occurs through the rightmost DB-9 receptacle, labeled “Resolver”. The pinout for this receptacle is shown below.



Power Interface

Control power is provided to the controller via a 2-pin connector supplied with the drive. The drive receptacle part number is Switchcraft 17282-2PG-300. The +24V pin is on the left (outboard side) when facing the inverter side with the 24V port.

DC plus voltage and minus voltage are supplied via cable (shielded or unshielded) to 1/0 connectors on the DC-side of the drive. A ground lug is located near the DC terminals for chassis ground connection.

AC output voltage is connected via cable to three 1/0 lugs on the AC-output side of the drive.

300 kcmil lugs are used in place of 1/0 lugs for applications that require >160 Arms current output.

Mechanical Interface

The drive is approximately 17”x7.75”x5.875” and is mounted to a 3/8” thick copper heat spreader. The drive is designed to bolt onto a thermally greased heatsink with six 1/4x20 or similar gauge threaded fasteners. Bolt hole locations can be customized. The drive can be supplied already bolted to a water- or air-cooled heatsink per request.

Environmental

Operating Environmental

Operating environmental temperature range: -40ºC to 85ºC (industrial) non-condensing (cold plate <45ºC)

Operating shock limit: 25G

Upon request, the drive can be packaged for variable / more rugged environments.