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Vehicle Control Module (CS1430)
Board Specification

CSLLC Document #: **DOC0004063A**
Revision: **M**

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1 Introduction

The Vehicle Control Module, model CS1430, is a host system controller. It can directly drive some small loads, but primarily functions as a system management device and communicates with other modules (CS1435, CS1440, CS1441, CS1442) to drive more loads and enhance user interface capabilities.
This document describes the high-level design and specifications for the CS1430.

2 Revision History

The revision history and release status of this document is stored electronically in Agile. To locate this history in Agile, search and open this document and click on the **Changes** tab.

3 Background

3.1 References

[1] Floyd Bell **TMC-86-948-Q Horn**

3.2 Attachments

None.

3.3 Applicable Standards

IEC/UL/CSA 60335-1:2010 Household and similar electrical appliance – Safety – Part 1: General requirements
IEC/UL/CSA 60335-2-72:2016 Household and similar electrical appliances – Safety – Part 2-72: Particular requirements for floor treatment machines with or without traction drive, for commercial use Machinery Directive 2006/42/EC
ISO 2631-1:1997 Mechanical vibration and shock—Evaluation of human exposure to whole-body vibration—Part 1: General requirements
ISO 5349-1:2001 Mechanical vibration—Measurement and evaluation of human exposure to hand-transmitted vibration—Part 1: General requirements
ISO 5349-2:2001 Mechanical vibration—Measurement and evaluation of human exposure to hand-transmitted vibration—Part 2 Practical guidance for measurement at the workplace
ISO 11201:2010 Acoustics—Noise emitted by machinery and equipment—Determination of emission sound pressure levels at a work station and at other specified positions in an essentially free field over a reflecting plane with negligible environmental corrections
CSA/ANSI C22.2 No. 336-17 - Particular requirements for rechargeable battery-operated commercial robotic floor treatment machines with traction drives
CAN/CSA CISPR 12-1:2009 Vehicles, boats and internal combustion engines – Radio disturbance characteristics – Limits and method of measurement for the protection of off-board receivers
Directive 2014/30/EU Electromagnetic Compatibility
EN 62233:2008 Measurement methods for electromagnetic field of household appliances and similar apparatus with regard to human exposure
CISPR 14-2:2015 Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 2: Immunity – Product family standard
CISPR 12:2007 Vehicles, boats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of off-board receivers
FCC Part 15 Radio Frequency Devices Part B – Unintentional radiators
FCC Part 15 Radio Frequency Devices Part B – Intentional radiators

3.4 Acronyms and Abbreviations

A	Amps (Amperes)
ADC	Analog-to-digital Converter
CAN	Controller Area Network
EEPROM	Electrically Erasable Programmable Read-Only Memory
EMI	Electromagnetic Immunity
ESD	Electrostatic Discharge
FET	Field Effect Transistor
FFC	Flat Flexible Circuit
GPIO	General Purpose Input/Output
I^2C	Inter-Integrated Circuit
I/O	Input/Output
IC	Integrated Circuit
ICSP	In-circuit Serial Programming
IMU	Inertial Measurement Unit
MEMS	Micro-Electromechanical System
PCB	Printed Circuit Board
PWM	Pulse Width Modulation
SPI	Serial Peripheral Interface
UART	Universal Asynchronous Receiver/Transmitter
V	Volts
VCM	Vehicle Control Module
ZIF	Zero Insertion Force

4 Theory of Operation

4.1 Functional Block Diagram

The VCM is intended to be used in many control systems; the following is a functional block diagram of a typical system (the 'Basic Disk').

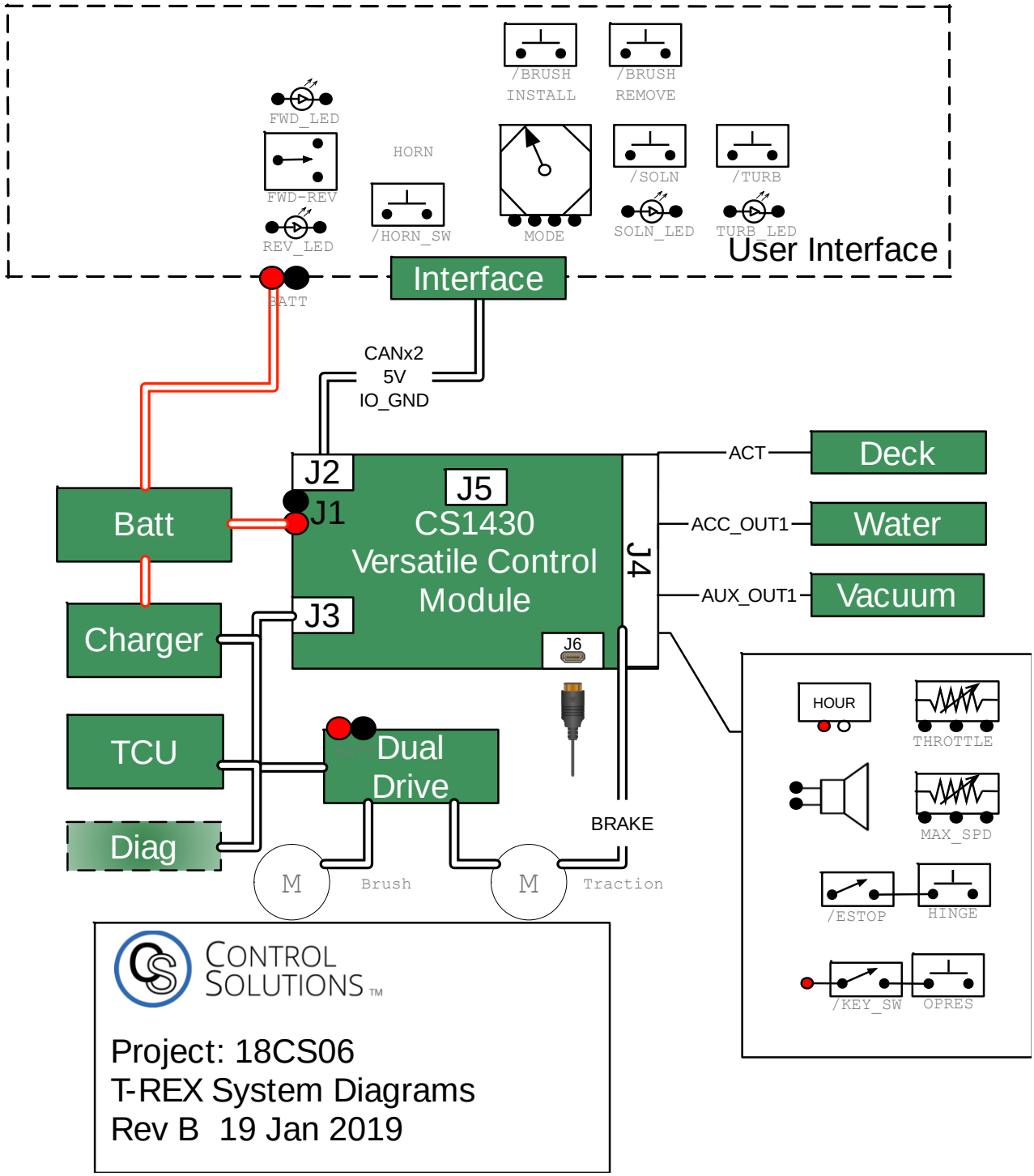


Figure 1: Basic Disk System

The primary VCM functions are shown in the following diagram:

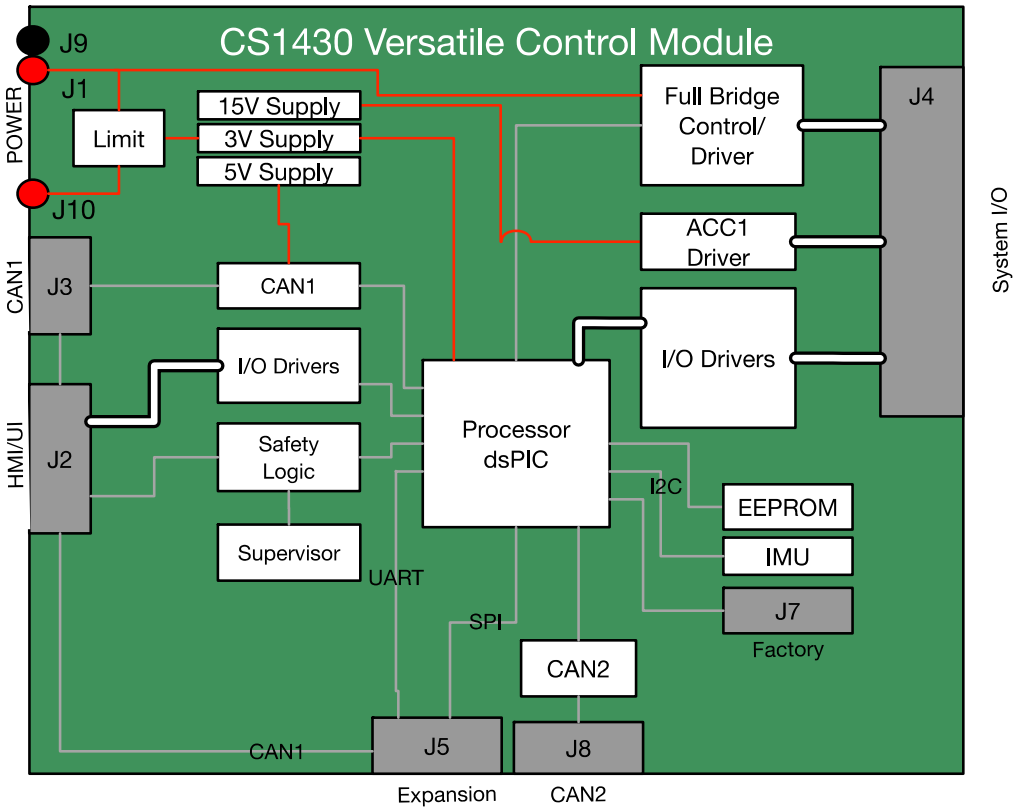


Figure 2: VCM Functional Block Diagram

4.2 Functional Block Descriptions

4.2.1 Processor dsPIC

The VCM contains an on-board microprocessor which coordinates the I/O and system-level functions of the vehicle. The microprocessor primary means of communication with off-board devices is the CANBUS interface.

4.2.2 Power Supply

The power supplies generate the required internal voltage rails from the DC input voltage as well as supply voltages to offboard devices via interface connectors. The power supply input uses a T-shaped mating connector to prevent incorrect or reverse-polarity connection.

4.2.3 ACTuator Full Bridge Control/Driver

The core of this block is a full H-bridge topology FET circuit. A redundant enable signal will be required to gate the control signals to the FETs. The circuitry will include a low-side current sense resistor providing current measurement to the microprocessor. Passive components are used as necessary to provide appropriate EMC mitigation.

4.2.4 IMU

The Inertial Measurement Unit (IMU) is a 3-axis gyroscopic sensor capable of detecting linear acceleration and angular velocity. This module utilizes MEMS technology to maximize EMI immunity. The sensor is

equipped with an internal microprocessor to provide digital output of the measured variables. An I2C interface is used to communicate with the microcontroller. Finally, the module incorporates an integrated temperature sensor that can be used to compensate for thermal drift in the measured signals.

4.2.5 CAN1 Transceiver

The CAN1 transceiver consists of a CAN transceiver chip and support circuitry to allow the microprocessor to communicate with off-board devices, such as a telematics control unit, battery chargers, battery packs/management systems, autonomous control units, and other CS-designed modules such as the Drive Module, Interface Module and/or HMI Module that can be used as building blocks to create a complete vehicle platform.

4.2.6 CAN2 Transceiver

The CAN2 block is optionally installed at the factory, and provides a second, independent CANBUS interface to the board and is managed by the SPI interface on the Microprocessor.

4.2.7 I/O Drivers

Interface circuits provide both analog and digital inputs and outputs. The analog inputs allow the software to read proportional inputs between 0 and 5VDC. These may be used for throttle, speed limiter, current sensor, etc. At least one digital input is connected to an interruptible processor IO port, so that the software can interface, for example with a flow meter which requires counting of pulses.

4.2.8 ACCessory OUTputs

The ACC_OUT1 is a 12V full bridge output controlling an actuator in on/off and forward/reverse states. The ACC_OUT2 and ACC_OUT3 drivers allow the software to switch on or off accessory loads up to 1A at battery voltage. Examples include water or chemical solenoids, shaker relay, hour meter, etc.

4.2.9 Brake Interface

The brake output supplies VBATT for the purpose of releasing an electromagnetic brake on the traction drive. Appropriate delays are defined in software, allowing brake operation to be customized. The brake module includes sensing which allows the software to determine whether the brake is connected when it is disengaged. A brake release input allows the brake to be disengaged (e.g. to allow pushing of the vehicle) when the VCM is powered.

4.2.10 Horn Output

The horn output is a software-controlled (PWM-able) output at battery voltage, which drives a horn device similar to reference [1]. The software activates the horn as a result of an input (switch closure) or CAN command.

4.2.11 Keyswitch

The keyswitch is an active-high (up to VBATT) signal. When INACTIVE, the VCM is in its lowest-power state (off) and does not respond to inputs. The ENABLE and FAULT outputs are not driven. The Keyswitch has a software-defined debouncing interval, to allow smooth operation of the vehicle.

4.2.12 E-STOP

The Emergency Stop input is an active-low signal that inhibits movement. When active (low), the ENABLE output is driven low (which signals the traction drive and other components to stop). The software may disable the ACT, ACC_OUT outputs as appropriate.

4.2.13 OpPres1

The Opres1 signal is connected to a Normally Open switch with the common connected to the battery. This signal is active high indicating the presence of the operator. This signal is the inverse of OpPres2.

4.2.14 OpPres2

The Opres2 signal is connected to a Normally Closed switch with the common connected to the battery. This signal is active low indicating the presence of the operator. This signal is the inverse of OpPres1.

4.2.15 Expansion Connector

The VCM incorporates mounting points and a board-to-board mating connector, suitable for future development of expansion module(s) to extend the functionality of the system. This connector includes power and communication signals which allow the Processor to either control or coordinate with electronics on the expansion board.

4.2.16 Contactor

The Contactor- output signal drives the state of the main contactor by controlling its low-side driver.

4.2.17 EEPROM

The VCM incorporates a serial EEPROM device from the Microchip 25LC series, to be used for non-volatile application data storage.

4.2.18 Supervisor Processor

The VCM incorporates a second processor monitoring the status of the Brake Release signal, Key Switch signal, Throttle signal, Operator Present1 signal, Operator Present2 signal, Estop signal, and Interlock signal. The safety processor will de-energize the contactor independently should the main processor fail. To energize the contactor, both the main processor and the safety processor must “agree” the controlling input signals are in the correct state. If not, the contactor will not energize.

4.3 Interfaces

4.3.1 Power Input (J1) / (J9) / (J10)

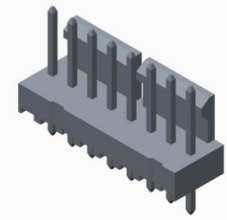
Connection Style: Wire-to-board Connector
Connector Manufacturer & Part Number: Molex 197054003. (2) 1/4" quick-disconnect terminals in a 'T' configuration to avoid reverse-polarity connection.

Pin	Signal Name	Type	Direction	Range	Other Requirements
J1	VBATT Power	Power	Input	18 - 55VDC	Load side of contactor
J9	GND	Ground	N/A	0VDC	
J10	VBATT Controller	Power	Input	18 - 55VDC	Supply side of contactor

J9 is ground return for both J1 and J10.
J1 is the battery supply input to the PCB from the load side of the main contactor. This supply is shared with connected motor controllers. When the contactor is opened, motor regeneration current is returned to the battery through the VCM from J1 to J10.
J10 is the battery supply input to the VCM from the supply side (battery side) of the main contactor enabling control functions. This is a current limited input. With power supplied to the VCM through J10, the VCM can only perform sensing functions. Power supplied to the actuators is from J1.

4.3.2 HMI / Interface Module / User Console (J2)

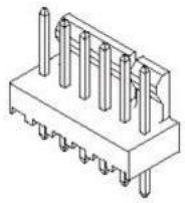
Connection Style: Connector Header Vertical Through Hole 0.100" (2.54mm)
Connector Manufacturer & Part Number: Molex 22-23-2101 or similar



Pin	Signal Name	Type	Direction	Range	Bandwidth	Other Requirements
1	CANH 1	Digital	Bi-directional	0 - 5VDC	1Mbps max	Differential signal with CANL 1.
2	CANL 1	Digital	Bi-directional	0 - 5VDC	1Mbps max	Differential signal with CANH 1.
3	P5V	Power	Output	5VDC		<1.5A total of all external P5V outputs
4	ENABLE	Digital	Output	0 - Vbatt		Pulled High, Active Low
5	FAULT	Digital	Input/Output	0 - 3.3VDC		Pulled High, Active Low by fault detecting device
6	Estop	Digital	Input	0 - Vbatt		Active Low to stop, Pulled Low
7	GND	Ground	N/A	N/A		
8	Key_Switch	Digital	Input	0 - Vbatt		Active High, pulled Low
9	Contactor-	Digital	Output	0 – Vbatt 2A max		Driven Low to engage contactor
10	P15V	Power	Output	15VDC		< 0.135A

4.3.3 CAN1 Interface (J3)

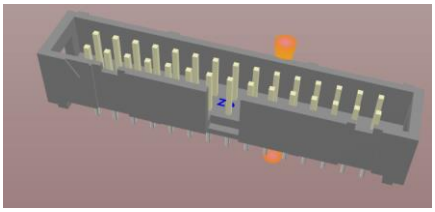
Connection Style: Connector Header Vertical Through Hole 0.100" (2.54mm)
Connector Manufacturer & Part Number: Molex 22-23-2061 or similar



Pin	Signal Name	Type	Direction	Range	Bandwidth	Other Requirements
1	CANH 1	Digital	Bi-directional	0 - 5VDC	1Mbps max	Differential signal with CANL 1.
2	CANL 1	Digital	Bi-directional	0 - 5VDC	1 Mbps max	Differential signal with CANH 1.
3	CANTERM1 1	Digital				Jumper CANTERM1 1 to CANTERM2 1 to insert 120-ohm termination resistance between CANH 1 and CANL 1.
4	CANTERM2 1	Digital				
5	FAULT	Digital	Input/Output	0 - 5VDC		
6	GND	Power	N/A	GND		Ground.

4.3.4 I/O Connector (J4)

Connection Style: Connector, Boxed Header 2x15 Male Pins .100 in Pitch straight pins w/ Key
Connector Manufacturer & Part Number: KLS KLS1-202-30-S-B



Pin	Signal Name	Type	Direction	Range	Bandwidth	Other Requirements
1	VBATT1	Power	Output		N/A	Electronically fused – 2.5A
2	P5V	Power	Output	4.75 - 5.25V	N/A	Electronically fused – 2.5A
3 4 5	ACT+	PWM Motor Drive	Output	0 - VBATT	N/A	Deck lift actuator
6 7 8	ACT-	PWM Motor Drive	Output	0 - VBATT	N/A	Deck lift actuator return
9	BRAKE-	Digital	Output	Ground & Open	N/A	1A Traction motor EM brake return.
10	Ground	Power	Output	0V		1A
11	ACC_OUT1+	Motor Drive	Output	12VDC 0.25A nominal, 1A max	N/A	Reversible Actuator Drive1
12	ACC_OUT1-	Motor Drive	Output	12VDC 0.25A nominal, 1A max	N/A	Reversible Actuator Drive1
13	ACC_OUT2+	Digital	Output	VBATT 0.5A nominal, 1A max	N/A	Source for accessory output load
14	ACC_OUT2-	Digital	Output	0V 0.5A nominal, 1A max	N/A	Accessory load driver (low side)
15	ACC_OUT3+	Digital	Output	VBATT 0.5A nominal, 1A max	N/A	Source for accessory output load
16	ACC_OUT3-	Digital	Output	0V 0.5A nominal, 1A max	N/A	Accessory load driver (low side)
17	HORN	Digital	Output	0 - VBATT		
18	ANIN1	Analog	Input	0 - 5VDC		e.g. Max Speed Pot

19	ANIN2	Analog	Input	0 - 5VDC		e.g. external current sensor
20	THROTLE	Analog	Input	0 - 5VDC		ESD Protected
21	INTERLOCK	Digital	Input	0 - VBATT		Pulled High Active Low to engage charger
22	Bag/Flow In	Digital	Input	0 - VBATT		
23	OP_PRES1	Digital	Input	0 - VBATT		
24	OP_PRES2	Digital	Input	0 - VBATT		
25	BRK_REL	Digital	Input	0 - VBATT		
26	ACC_EN	Digital	Output	0 - VBATT		
27	GP In	Digital	Input	0 - VBATT		General purpose input.
28 29 30	GND	Ground	N/A	N/A	N/A	Signal return.

4.3.5 Expansion (J5)

Connection Style: Conn 2x5 pin male Boxed & Keyed Header Vertical Through Hole 0.100" pitch
Connector Manufacturer & Part Number: Sullins SBH11-PBPC-D05-ST-BK

Pin	Signal Name	Type	Direction	Range	Bandwidth	Other Requirements
1	P5V	Power	Output	4.75V ~ 5.25V	N/A	<1.2A total external P5V outputs
2	CANH 1	Digital	Bi-directional	0 - 5VDC	1Mbps max	Differential signal with CANL 1.
3	CANL 1	Digital	Bi-directional	0 - 5VDC	1Mbps max	Differential signal with CANH 1.
4	SDI	Digital	Input	0 - 5VDC	15 Mbps	SPI
5	P3V3	Power	Output	3.15VDC ~ 3.45VDC	N/A	
6	SDO	Digital	Output	0 - 5VDC	15 Mbps	SPI
7	SCK	Digital	Output	0 - 5VDC	15 Mbps	SPI
8	CS LED	Digital	Input	0 - 5VDC		
9	GND	Power	Output	0	N/A	< 3A
10	UART_TX	Digital	Output	0 - 3.3VDC		
11	UART_RX	Digital	Input	0 - 3.3VDC		
12	CS1	Digital	Output	0 - 5VDC		Chip select for SPI
13	CS2	Digital	Output	0 - 5VDC		Chip select for SPI
14	VBATT	Power	Output	0 - VBATT		Electronically fused – 2.5A

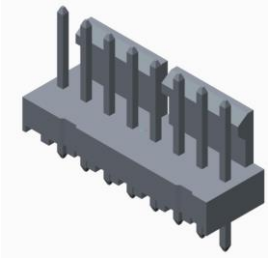
4.3.6 Microprocessor Programming Interface (J7)

Connection Style: Wire-to-board Connector
Connector Manufacturer & Part Number: Footprint only, for TAG cable / Connector. Intended for initial factory programming of microprocessor FLASH.

Pin	Signal Name	Type	Direction	Range	Bandwidth	Other Requirements
1	MCLR	Digital	Input	0 - 3.3VDC	N/A	See Microchip recommendations for ICSP connection.
2	P3.3V	Power	Input	3.3VDC	N/A	N/A
3	GND	Ground	N/A	0VDC	N/A	N/A
4	PGD	Digital	Bi-directional	0 - 3.3VDC	N/A	See Microchip recommendations for ICSP connection.
5	PGC	Digital	Bi-directional	0 - 3.3VDC	N/A	See Microchip recommendations for ICSP connection.
6	N/C	No connection				

4.3.7 CAN2 Interface (J8)

Connection Style: Wire-to-board
Connector Manufacturer & Part Number: Molex 22-23-2051



Pin	Signal Name	Type	Direction	Range	Bandwidth	Other Requirements
1	CANH 2	Digital	Bi-directional	0 - 5VDC	1Mbps max	Differential signal with CANL 2.
2	CANL 2	Digital	Bi-directional	0 - 5VDC	1Mbps max	Differential signal with CANH 2.
3	CANTERM1 2	Jumper	N/A			Jumper CANTERM1 2 to CANTERM2 2 to insert 120-ohm termination resistance between CANH 2 and CANL 2.
4	CANTERM2 2	Jumper	N/A			
5	GND	Ground	N/A	0VDC		

5 Environmental Specifications

Parameter	Minimum	Nominal	Maximum	Notes
Operating Temperature	-40℃	--	85℃	Refers to required component specifications, not ambient operating temperature.
Operating Humidity	--	--	95% non-condensing	
Pollution Degree	--	III	--	

6 General Electrical Specifications

Parameter	Minimum	Nominal	Maximum	Notes
Input Voltage	18VDC	36VDC	55 VDC	
Input Current	<50mA			Minimum current is for SLEEP mode.
Power Supply P3.3V Output Voltage	3.15V	3.3V	3.45V	
Power Supply P3.3V Output Current			0.15A	
Power Supply P5V Output Voltage	4.75V	5.0V	5.25V	
Power Supply P5V Output Current			1.5A	Assumes ~300mA for onboard use
Power Supply P15V Output Voltage	14.25V	15V	15.75V	
Power Supply P15V Output Current			1.5A	
CAN1 Bus frequency		500 kHz		
ESD protection to survive 30KV air discharge/16KV contact discharge per Karcher ESD guideline 21.03.2017 Rev 1.3 on all connector pins				

7 Mechanical Specifications

Parameter	Minimum	Nominal	Maximum	Notes
Length		~5.5 in	9.0 in	These specifications represent an estimated envelope that is subject to change during the design of the product.
Width		~8.1 in	9.0 in	
Height	0.50 in		2.0 in	
Weight	0.5 lb.		2 lb.	

8 Processor/Storage Specifications

Parameter	Minimum	Nominal	Maximum	Notes
Family	dsPIC33EP	dsPIC33EP	dsPIC33EP	
Program Flash	64KB	128KB	512KB	
SRAM	8KB	16 KB	48KB	

9 Manufacturing/Test Strategy

The CS1430 will be designed with bottom-side access to as many circuit nets as practical. The initial test approach will be functional. The design will be configured to provide as much ICT access as feasible in the event that future production volumes justify that test approach.

9.1 Identification

A unique serial number will be assigned by CS during manufacturing. The serial number and part number (e.g. CS1430) will be printed on a label attached to each controller. The serial number will also be stored in the PIC Program Flash memory.

9.2 Factory Programming

The controller will be programmed with a Bootloader image upon shipment from CS. The bootloader allows the application firmware (stored in PIC Program Flash memory) to be reprogrammed via CAN.