IQAN-Open CM3033 Controller Module

MSG33-CM3033-IB/US User Guide

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Release	Description of Change
Rev. 001	First release of this document – 06/10/2022
Rev. 002	Updated figure 4 and 49.
Rev. 003	Added software license statement
Rev. 004	Corrected connector keying, section 4
Rev. 005	Output frequency updated
Rev. 006	Edits to output PWM frequency
Rev. 007	Added soft start application note in output section
Rev. 008	Added a link to the CM3033 Installation Sheet

This product uses the open source software MSP430 Driver Library. See below for the license statement.

1. Understanding the IQAN-Open CM3033

The IQAN-Open CM3033 (henceforth referred to as the "CM3033") is part of the standard CM (Controller Module) family of products from the IQAN-Open platform (note: any references to PHC1 (Parker Hannifin Controller) platform refer to the hardware architecture). The CM3033 is a general-purpose input/output controller that can be used to monitor system sensors and drive system loads. It is intended to be used in the on-highway truck and bus vehicle market. It can be used in systems where hydraulic control, lighting control, or general electrical control is required. The CM3033 is programmable using IEC 61131-3 standard programming interfaces. In addition, the CM3033 offers a software development kit providing an API for application development using C. Information about this software package is available from your Parker Account Representative.

The CM3033 has 30 inputs and 33 outputs with many software configurable options.

Inputs include:

- 4x programmable pullup/down voltage sensor analog with digital capability, including programmable wakeup support
- 10x programmable pullup/down voltage sensor analog with digital capability
- 4x programmable pullup/down resistive sensor analog with digital capability
- 10x programmable pullup/down, programmable gain analog with digital capability
- 2x programmable pullup frequency w/ quadrature, analog, digital capability

Outputs include:

- 6x 2.5 amp high-side with accurate current sense[1] – PWM 1000Hz max
- 4x 2.5 amp high-side – PWM 1000Hz max
- 2x 5 amp high-side with accurate current sense – PWM 1000Hz max
- 8x 5 amp high side – PWM 1000Hz max
- 2x 10 amp high side – PWM 1000Hz max
- 4x 10 amp high side w/ independent power input – PWM 1000Hz max
- 6x 10 amp low-side accurate current sense – PWM 1000Hz max
- Can be combined in harness with the 6x 10 amp high side outputs for half H-Bridge and full H-Bridge operation

[1] Accurate current sense is accurate to 2% over operating temperature range.

- 1x 5V/8V programmable regulated power supply output – 1A

Communications include:

- 5x CAN 2.0B w/ SAE J1939 protocol – 125kbps/250kbps/500kbps/1Mbps with programmable wakeups on each
- CAN FD at 2Mbps supported on one of the CAN ports
- 1x IEEE 100BASE-T1 (automotive) Ethernet with programmable wakeup

Optical Diagnostics Include:

- 1x multi-color product status LED
- 26x single-color I/O status LEDs – Multiplexed to provide full I/O status[2]

For additional information that is not contained in this document, please contact your Parker Account Representative.

Note: In this document there are section titles and references to function circuit types like “Analog Input Type x”. These names are references to the Parker’s IQAN-Open platform and do not imply anything beyond providing a unique identifier the function. For example, if there is a section titled “Analog Input Type 6” that does not imply that there are five other analog input types on this product.

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[2] I/O LEDs can be overridden by application software to provide custom status indication if needed

2. About the CM3033 User Guide

The CM3033 is designed with flexibility in mind and uses software configuration to allow the product to be optimized for various system solutions without the need to order alternate part numbers of the product with hardware configuration options.

This manual describes the hardware components of the CM3033 but does not explain how to write or configure the software. For more information about software, refer to the appropriate software manual or contact your Parker Account Representative.

Warning: Some of the functionality discussed in this User Guide is dependent on the version of platform software that is programmed on the CM3033. Refer to the software user documentation for additional information pertaining to functionality defined in this document.

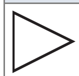
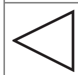
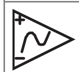
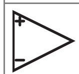
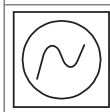
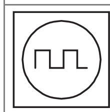
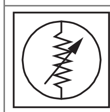
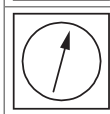
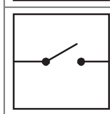
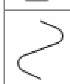
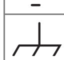
2.1. Section Types

There are three kinds of sections in this manual: instruction, information, and example.

- ***Instruction sections*** – The only instruction section in this manual is the Quick Start section, which provides procedures for connecting the CM3033 to a development system, powering it up, and downloading application software.
- ***Information sections*** – Most sections in this manual are informational. They describe the hardware components of the CM3033, and usually have three sub-sections: circuit block diagram, circuit capabilities, and transfer function / use cases information.
- ***Example sections*** – The only example section in this manual is the Application Examples section, which provides descriptions, diagrams, and explanations for possible CM3033 applications.

2.2. Diagram Conventions

The following symbols may be used in the schematic diagrams in this document.

Symbol	Meaning
	General input
	General output
	Frequency input
	Analog input
	Frequency sensor
	Pulse sensor
	Resistive sensor
	General sensor
	Application switch
	Load
	Pull-down resistor
	Pull-up resistor
	Battery
	Fuse
	Resistor
	Ground
	Chassis ground

3. Quick Start

This section provides step-by-step instructions on how to connect the CM3033 standalone controller to a development system, install the required software tools, and download the application software.

3.1. Overview

The following is a high-level overview of the steps involved with this section:

1. Gather the required materials.
2. Install the required software tools provided by Parker. (Installation of the SW requires full admin rights)
3. Connect the CM3033 to a development system (desktop) and power it up.
4. Download application software.

3.2. Gather Required Materials

The following materials are required for the procedures in this section:

- CM3033 standalone controller
- Personal computer (PC)
- Controller I/O board
- Controller I/O harness (connects the CM3033 to the controller I/O board)
- Evaluation kit power harness (connects the controller I/O board to the power supply)
- CAN to USB adapter (RP1210 compliant).
- Consider using a TX to T1 Ethernet adapter for software development. Refer to "Getting Started with CODESYS on PHC1", VA 1074000.
- Desktop power supply compatible with the CM3033 and controller I/O board loads (a 24 V DC, 3A fixed voltage supply is generally suitable, unless driving more significant loads)
- Software tools and files required for programming and downloading software for the CM3033

Note: With the exception of the PC and desktop power supply, all materials and software are available from Parker. Please consult your Parker Account Representative for specific details and pricing information.

3.3. Connect the CM3033 standalone controller to a Development System

It is a good idea to connect the CM3033 standalone controller to a development system (PC, Controller I/O Board, power source, and CAN to USB adapter) to verify your application. The development system is an ideal environment for creating and downloading software applications.

The following shows how to connect the CM3033 standalone controller in a development system:

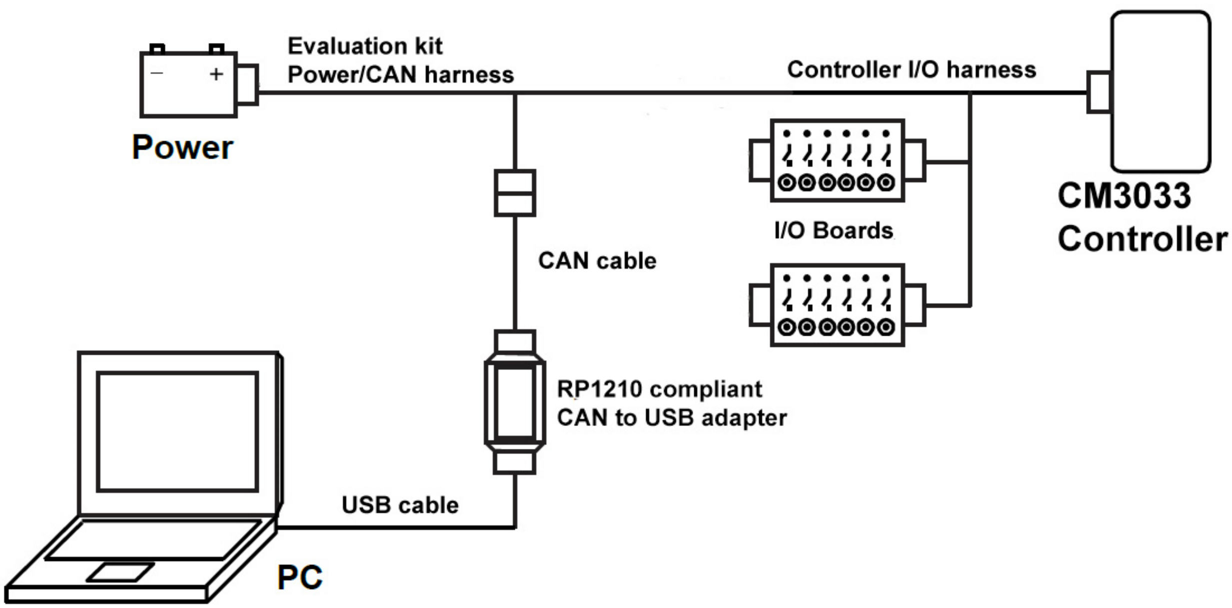


Figure 1: Development System Connection

To connect the CM3033 standalone controller in a development system, do the following:

> **Warning:** Before connecting anything in the development system, ensure that the power supply is set to a voltage that is less than 32 V DC.

1. Connect the Controller I/O harness to the CM3033 standalone controller.
2. Connect the Controller I/O harness to the controller I/O board connectors.
3. Connect the evaluation kit power/CAN harness to the controller I/O board's JP3 connector.
4. Do not connect the power wire (RED) from the evaluation kit power/CAN harness to the power supply (+) terminal at this time.

5. Connect the ground wire (BLACK) from the evaluation kit power/CAN harness to the power supply (-) terminal.
6. Connect the CAN connector from the evaluation kit power/CAN harness to the corresponding mating connector and harness on the CAN to USB adapter.

Note: Do not proceed to the next step until the CAN to USB adapter has been configured. See instructions for the device you are using.

7. Connect the CAN to USB adapter to a personal computer via the USB port.

3.3.1. Power Up the Development System

Once the CM3033 is connected in a development system, you need to power it up. To power up the CM3033 standalone controller, do the following:

1. Ensure all controller I/O board digital inputs, jumpers, and dip switches are properly configured for the CM3033. Refer to the Controller I/O Board Reference Manual for further details.
2. Connect the power wire (red) from the evaluation kit power/CAN harness to the power supply (+) and turn the power supply on.
3. Turn on the controller I/O board switch that corresponds with the power control input on the CM3033 (refer to the Controller I/O Board Reference Manual for details). The CM3033 will power up.

Note: If the module does not power up and you are unsure if a power control input is set on the CM3033, try switching INPUT1 to INPUT4 on the controller I/O board to high, and then to low. If you continue to have problems, consult the Troubleshooting/ FAQ section in the Controller I/O Board Reference Manual for help.

3.4. Download Application Software using PEDS

Please refer to material in the PEDS software release package provided by Parker EMC for details on downloading.

4. Connectors

The connector shells that are required on the system harness to interface with the CM3033 are:

- J1 = DT16-18SE-K004
- J2 = DT16-18SD-K004
- J3 = DT16-18SC-K004
- J4 = DT16-18SB-K004
- J5 = DT16-18SA-K004
- J6 = DTHD06-1-8S
- J7 = DTHD06-1-8S

The recommended contacts to be used with the mating harness connectors are:

- J1 to J5 = Deutsch 1062-16-0144
- J6 to J7 = Deutsch 0462-203-08141

Figure 2: J1 to J5 Harness Connectors

Figure 3: J6 to J7 Harness Connectors

4.1. Pinouts

Pins connect to power, ground, inputs, outputs, and communication channels. They provide the interface between the vehicle harness and the internal circuitry of the CM3033.

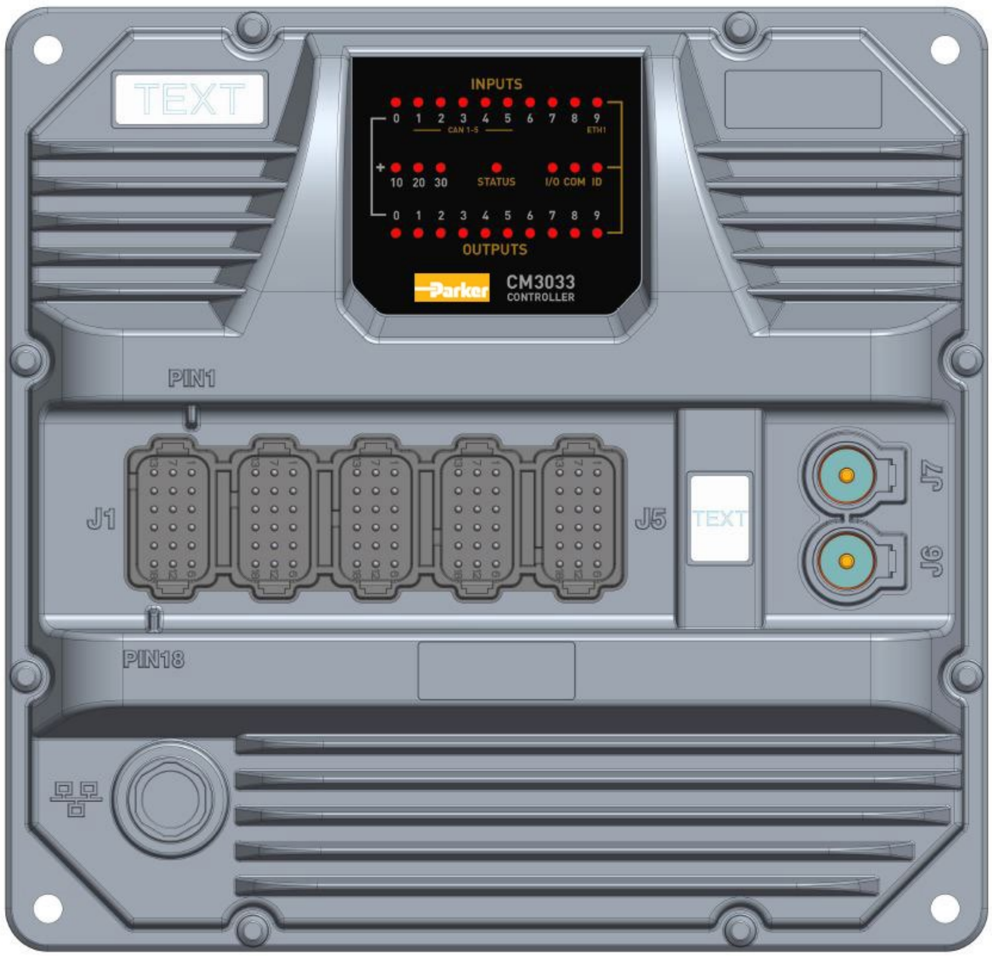


Figure 4: IQAN-Open CM3033 connector configuration

The following tables show the pinouts for each connector:

J1 Connector Pinout		
Pin	**Name**	**Function**
1	CAN5_HIGH	CAN
2	CAN5_LOW	CAN
3	INPUT31	IDTAG Address / Recovery (@ 24V)
4	CAN1_SHIELD	CAN / CAN FD
5	INPUT2	Digital Input w/ wakeup
6	ETH1_TRD_P	100Base-T1 Ethernet Positive Pin
7	CAN4_HIGH	CAN
8	CAN3_HIGH	CAN
9	CAN2_HIGH	CAN
10	CAN1_HIGH	CAN / CAN FD
11	GROUND	Battery Negative (System Ground)
12	ETH1_TRD_N	100Base-T1 Ethernet Negative Pin
13	CAN4_LOW	CAN
14	CAN3_LOW	CAN
15	CAN2_LOW	CAN
16	CAN1_LOW	CAN / CAN FD
17	INPUT1	Digital Input w/ wakeup
18	VBATT	Battery Power for Logic

J2 Connector Pinout		
Pin	**Name**	**Function**
1	INPUT29	Frequency Input
2	INPUT22	Analog Input
3	INPUT9	Analog Input
4	INPUT3	Digital Input w/ wakeup
5	OUTPUT32	Lowside Output – 10A PWM 200Hz w/CS
6	OUTPUT31	Lowside Output – 10A PWM 200Hz w/CS
7	INPUT26	Analog Input
8	INPUT21	Analog Input
9	INPUT8	Analog Input
10	GROUND_POWER	Battery Power for Lowside Outputs
11	GROUND_POWER	Battery Power for Lowside Outputs
12	OUTPUT30	Lowside Output – 10A PWM 200Hz w/CS
13	INPUT23	Analog Input
14	INPUT10	Analog Input
15	INPUT4	Analog Input
16	OUTPUT27	Lowside Output – 10A PWM 200Hz w/CS
17	OUTPUT28	Lowside Output – 10A PWM 200Hz w/CS
18	OUTPUT29	Lowside Output – 10A PWM 200Hz w/CS

J3 Connector Pinout		
Pin	**Name**	**Function**
1	OUTPUT17	Highside Output – 5A PWM 200Hz
2	OUTPUT3	Highside Output – 2.5A PWM 200Hz w/CS
3	INPUT19	Analog Input
4	INPUT14	Analog Input
5	OUTPUT2	Highside Output – 2.5A PWM 200Hz w/CS
6	OUTPUT18	Highside Output – 5A PWM 200Hz
7	OUTPUT15	Highside Output – 5A PWM 200Hz
8	INPUT28	Analog Input
9	INPUT20	Analog Input
10	GROUND_POWER	Battery Power for Lowside Outputs
11	GROUND_POWER	Battery Power for Lowside Outputs
12	OUTPUT16	Highside Output – 5A PWM 200Hz
13	OUTPUT13	Highside Output – 5A PWM 200Hz
14	INPUT30	Frequency Input
15	INPUT24	Analog Input
16	INPUT18	Analog Input
17	INPUT13	Analog Input
18	OUTPUT14	Highside Output – 5A PWM 200Hz

J4 Connector Pinout		
Pin	**Name**	**Function**
1	OUTPUT19	Highside Output – 5A PWM 200Hz
2	OUTPUT9	Highside Output – 2.5A PWM 200Hz w/ CS
3	VSENSOR	Regulated Output – 1A 5V/8V Programmable
4	INPUT12	Analog Input
5	OUTPUT10	Highside Output – 2.5A PWM 200Hz w/ CS
6	OUTPUT20	Highside Output – 5A PWM 200Hz
7	OUTPUT5	Highside Output – 2.5A PWM 200Hz
8	INPUT27	Analog Input
9	INPUT16	Analog Input
10	GROUND_SENSOR	Sensor Return Ground
11	INPUT11	Analog Input
12	OUTPUT8	Highside Output – 2.5A PWM 200Hz
13	OUTPUT7	Highside Output – 2.5A PWM 200Hz
14	OUTPUT1	Highside Output – 2.5A PWM 200Hz w/ CS
15	INPUT17	Analog Input
16	INPUT15	Analog Input
17	OUTPUT4	Highside Output – 2.5A PWM 200Hz w/ CS
18	OUTPUT6	Highside Output – 2.5A PWM 200Hz

J5 Connector Pinout		
Pin	**Name**	**Function**
1	OUTPUT25	Highside Output – 10A PWM 200Hz
2	VBATT_BANK_OUT25	VBATT for OUTPUT25
3	OUTPUT21	Highside Output – 10A PWM 200Hz
4	OUTPUT22	Highside Output – 10A PWM 200Hz
5	VBATT_BANK_OUT26	VBATT for OUTPUT26
6	OUTPUT26	Highside Output – 10A PWM 200Hz
7	VBATT_BANK_OUT23	VBATT for OUTPUT23
8	INPUT25	Analog Input
9	INPUT6	Analog Input
10	GROUND_POWER	Battery Power for Lowside Outputs
11	GROUND_POWER	Battery Power for Lowside Outputs
12	VBATT_BANK_OUT24	VBATT for OUTPUT24
13	OUTPUT23	Highside Output – 10A PWM 200Hz
14	OUTPUT11	Highside Output – 5A PWM 200Hz w/CS
15	INPUT7	Analog Input
16	INPUT5	Analog Input
17	OUTPUT12	Highside Output – 5A PWM 200Hz w/CS
18	OUTPUT24	Highside Output – 10A PWM 200Hz

J6 Connector Pinout		
Pin	**Name**	**Function**
1	VBATT_BANK2	Highside Bank Power for Even Numbered HS

J7 Connector Pinout		
Pin	**Name**	**Function**
1	VBATT_BANK1	Highside Bank Power for Odd Numbered HS

Download the CM3033 Installation Sheet Here: CM3033 Installation Sheet

4.2. Connector Configurations

There is only one connector configuration for the CM3033. This is defined in Figure 4 on page 13.

5. Inputs

The CM3033 has analog, frequency, and special function inputs.

Warning: Unless identified on specific input types in this document, do not connect inputs directly to unprotected inductive loads such as solenoids or relay coils, as these can produce high voltage spikes that may damage the CM3033. Connection of an inductive load on an input type that is not protected must use a protective diode on that load.

Warning: Some of the functionality discussed in this User Guide is dependent on the version of platform software that is programmed on the CM3033. Refer to the software user manuals for additional information pertaining to functionality defined in this document.

5.1. Analog Inputs

There are five types of analog inputs on the CM3033 product. Each input type has some variation on programmability of pull up or pull down resistors, and gain. Although all these inputs can be used to detect digital input sensors, Digital Input Type 2 is intended as a digital input type as its primary function.

All analog inputs share the following global characteristics:

Analog Input Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Software raw bit value at microcontroller pin [1]	-	1	-	mV/bit
Maximum sample rate [2]	-	-	1	ms
[1] This is the expected voltage per bit at the ADC pin of the microcontroller. Each input type will have an associated gain/attenuation factor that must be used to convert ADC value to CM3033 input pin voltage. This conversion may already be available to you at the application software level. [2] Unless otherwise mentioned below, all analog inputs are sampled based on the sample rates in this table.				

Note: The CM3033 reports analog readings in raw ADC at the microcontroller, voltage at the CM3033 input pin, resistance at the CM3033 input pin, or debounced digital state at the CM3033 input pin. This can be selected in application software based on the needs of the specific application and the type of sensor used.

5.1.1. Digital Input Type 2

There is a total of 4 of these input types on the CM3033, identified as INPUT1 through INPUT4.

This type of analog input provides programmable pull up and pull down resistance for high wetting current along with fixed attenuation. Each of these input types on the CM3033 can be used as digital wake-up sources. This input type is primarily intended to be used to detect state changes on system switches. Alternatively, it could be used to detect voltage level output on active voltage sensors. When used as an active voltage sensor input, both the pull up and pull down resistor configuration options should be disabled. When used as a switch input, the appropriate pull up or pull down resistor should be enabled based on the active state of the system switch. This input can be used to detect a double throw, center off switch by enabling both the pull up and the pull down configuration options at the same time and using on analog measurement to determine the switch states.

Warning: Wake-up functionality does not support use of a double throw, center off switch type.

When used as wake-up sources, these inputs can be selected for either active high wakeup or active low wakeup and the product will automatically select the appropriate pullup or pulldown based on those settings. When used as wake-up sources, these inputs are expected to be connected to switches as opposed to active voltage sensors.

5.1.1.1. Digital Input Type 2 Circuit Block

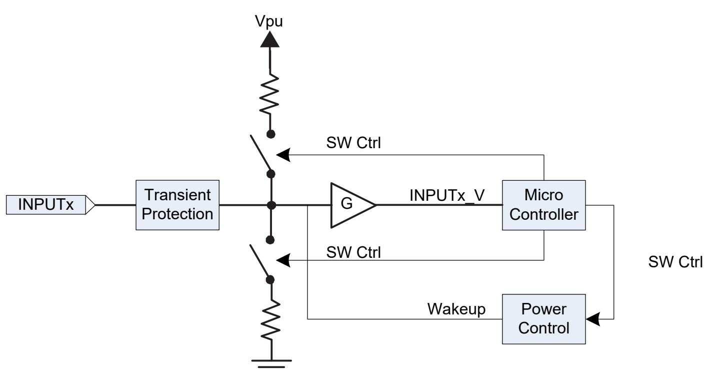


Figure 5: Digital Input Type 2 Block Diagram

5.1.1.2. Digital Input Type 2 Circuit Characteristics

These inputs have the following characteristics:

Wake-Up Parameters (INPUT1 to INPUT4)				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Active High Wake threshold	-	-	2.5	V
Active Low Wake threshold	0.8	-	-	V

Configuration Parameters[1]				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Pull up resistance • INx_PU_EN Active	-	470	-	Ω
Pull down resistance • INx_PD_EN Active	-	3.325	-	kΩ
Pull up voltage	-	4.5	-	V
Pull down voltage	-	GROUND (0V)	-	V
Wakeup Configurations via SW	-	Active High Active Low Not Active	-	-
[1] This table defines the software configurations available on this input type.				

Digital Measurement Parameters [1]				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Input voltage range (operational)	0	-	36	V
Input High Detection Threshold	3.9	-	-	V
Input Low Detection Threshold	-	-	2.33	V
Input pin capacitance	-	10	-	nF
Inductive Load Transient Protected?	-	Yes [2]	-	-
[1] This table is relevant when used with switch type inputs in a system (digital functionality) [2] Protected against inductive loads on signal lines as defined by Parker Environmental Test 948P03. Contact your Parker Account Representative for more details on the level of protection.				

Analog Measurement Parameters[1]				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Input voltage range (operational)	0	-	7	V
Input resistance - pull up and pull down inactive	-	79	-	kΩ
Input pin capacitance	-	10	-	nF
Single pole low pass cutoff (pull up and pull down inactive, 0 Ω sensor resistance)	-	330	-	Hz
Input gain (G) Micro pin voltage / Input pin voltage	-	0.583	-	V/V
Input resolution	-	1.7	-	mV/bit
Voltage Drift -40C to 85C	-2	-	2	%
Voltage offset @ INPUTx_CON -40C to 85C	-	-	75	mV
[1] This table is relevant when used with active voltage sensor types in a system (analog functionality)				

5.1.1.3. Digital Input Type 2 Usage Considerations

5.1.1.3.1. Analog Measurements

INPUT1 to INPUT4 can be used with active voltage sensors for analog readings. When used for analog measurements the software configurable pullup and pulldown resistors should be disabled. Analog inputs should be connected as shown in Figure 6. This assumes the sensor is being powered from the CM3033 Sensor Supply output type.

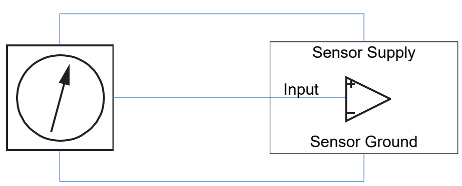


Figure 6: Digital Input Type 2 use for Analog Measurements

When using raw readings in the application software, conversion from raw analog readings to voltage values at the product input pin are achieved using the following transfer function (result in mV):

$$Vin = 1.715 \cdot ADC$$

5.1.1.3.2. Digital Measurements

INPUT1 to INPUT4 can be used with switches in a system for digital state readings. When used for digital measurements the inputs should be connected as shown in Figure 7 and Figure 8.

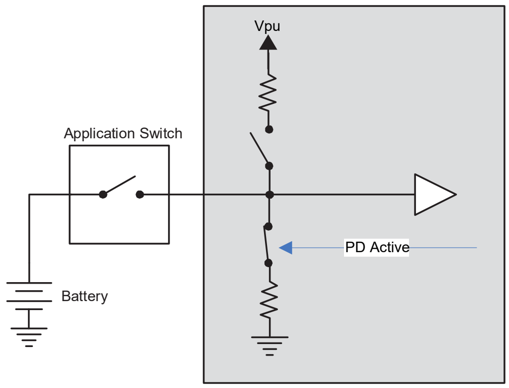


Figure 7: Digital Input Type 2 use for Active High Digital Measurements

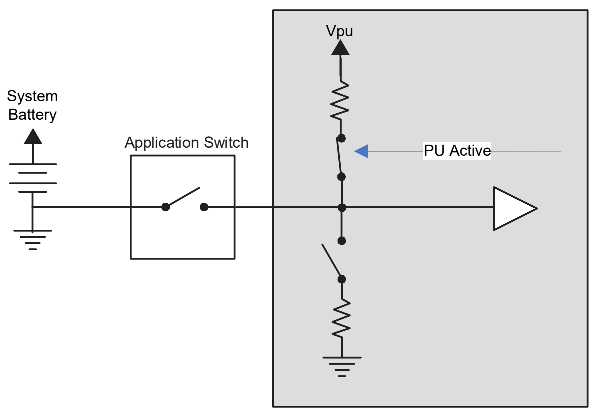


Figure 8: Digital Input Type 2 use for Active Low Digital Measurements

5.1.1.3.3. *Wakeup Connections*

INPUT1 to INPUT4 can be used to wakeup the product from a sleep state. This can be used in systems where permanent battery is applied to the CM3033 controllers and low current sleep states are needed when those systems are turned off. When used in this way, the same connection types as defined for digital measurements in Figure 7 and Figure 8 are still relevant, except the setting of the pullup and pulldown states are automatically set based on the wakeup configurations as shown below:

Wakeup State	Wakeup Polarity	PU_EN	PD_EN
Active	Active High	Disabled	Enabled
Active	Active Low	Enabled	Disabled
Disabled	N/A	SW Control	SW Control

5.1.2. Analog Input Type 4

There is a total of 10 of these input types on the CM3033, identified as INPUT5 through INPUT14.

This type of analog input provides programmable pull up and pull down resistance for use with digital measurements. This input type is primarily intended to detect voltage level output on active voltage sensors. Alternatively, it could be used to detect state changes on system switches. When used as an active voltage sensor input, both the pull up and pull down resistor configuration options should be disabled. When used as a switch input, the appropriate pull up or pull-down resistor should be enabled based on the active state of the system switch. This input can be used to detect a double throw, center off switch by enabling both the pull up and the pull down configuration options at the same time and using on analog measurement to determine the switch states.

Warning: This input type does not include inductive load transient protection and should not be connected to signals that will cause inductive pulses to voltage levels above the maximum levels defined for this input type.

5.1.2.1. Analog Input Type 4 Circuit Block

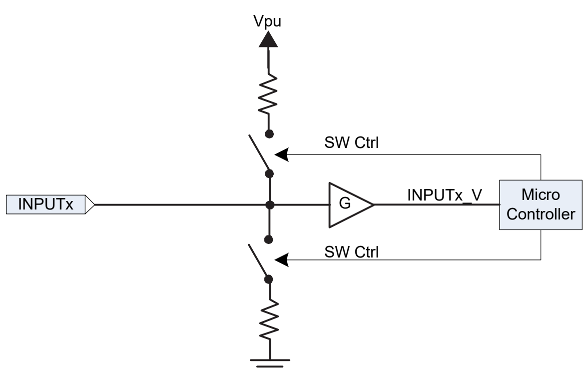


Figure 9: Analog Input Type 4 Block Diagram

5.1.2.2. Analog Input Type 4 Circuit Characteristics

These inputs have the following characteristics:

Configuration Parameters[1]				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Pull up resistance, INx_PU_EN Active	-	33.2	-	kΩ
Pull down resistance, INx_PD_EN Active	-	33.2	-	kΩ
Pull up voltage	-	4.5	-	V
Pull down voltage	-	GROUND (0V)	-	V
[1] This table defines the software configurations available on this input type.				

Analog Measurement Parameters [1]

Parameter	Min	Nom	Max	Unit
Input voltage range Absolute Max	0	-	36	V
Input voltage range (operational)	0	-	6	V
Input resistance - pull up and pull down inactive - input pin voltage < 6V	-	147	-	kΩ
Pull up voltage [2]	-	4.5	-	V
Input pin capacitance	-	10	-	nF
Single pole low pass cutoff (pull up and pull down inactive, 0 Ω sensor resistance)	-	224	-	Hz
Input gain (G)	-	0.678	-	V/V
Input resolution	-	1.475	-	mV/bit
Voltage Drift -40C to 85C	-1.3	-	1.3	%
Voltage offset @ INPUTx_CON -40C to 85C	-	-	50	mV
[1] This table is relevant when used with active voltage sensor type inputs in a system (analog functionality) [2] The pull up voltage is derived from an internal 5V regulator and is subject to open loop variation. This pull up voltage cannot be read by the software for this input type.				

Digital Measurement Parameters [1]				
Parameter	Min	Nom	Max	Unit
Input voltage range (operational)	0	-	36	V
Input High Detection Threshold	3.179	-	-	V
Input Low Detection Threshold	-	-	2.162	V
Input pin capacitance	-	10	-	nF
Inductive Load Transient Protected?	-	No	-	-
[1]This table is relevant when used with switch type inputs in a system (digital functionality)				

5.1.2.3. Analog Input Type 4 Usage Considerations

5.1.2.3.1. Analog Measurements

INPUT5 to INPUT14 can be used with active voltage sensors for analog readings. When used for analog measurements the software configurable pullup and pulldown resistors should be disabled. Analog inputs should be connected as shown in Figure 10. This assumes the sensor is being powered from the CM3033 Sensor Supply output type.

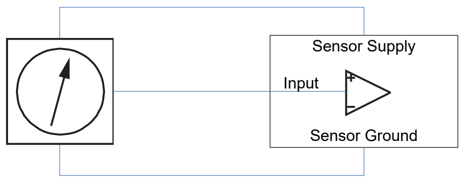


Figure 10: Analog Input Type 4 use for Analog Measurements

When using raw readings in the application software, conversion from raw analog readings to voltage values at the product input pin are achieved using the following transfer function (result in mV):

$$Vin = 1.475 \cdot ADC$$

5.1.2.3.2. Digital Measurements

INPUT5 to INPUT14 can be used with switches in a system for digital state readings. When used for digital measurements the inputs should be connected as shown in Figure 11 and Figure 12.

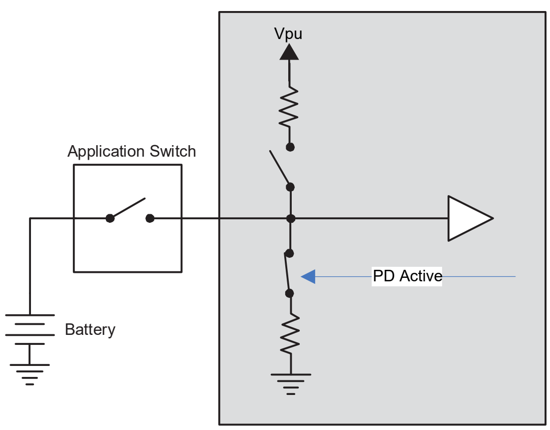


Figure 11: Analog Input Type 4 use for Active High Digital Measurements

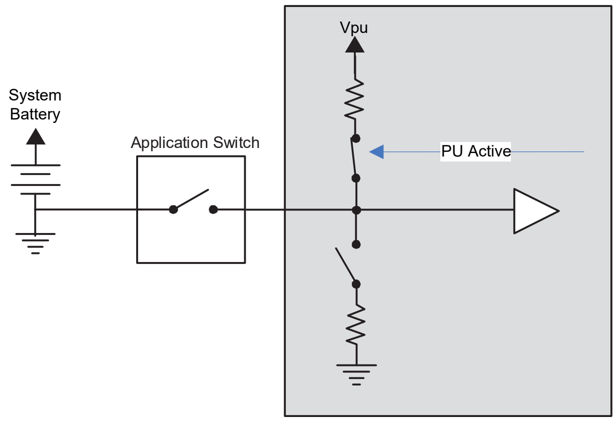


Figure 12: Analog Input Type 4 use for Active Low Digital Measurements

Note: Since the primary function of this input type is analog measurements, the wetting current available on the pullup and pulldown resistors is less than for input types with digital measurement as the primary function.

5.1.3. Analog Input Type 5

There is a total of 10 of these input types on the CM3033, identified as INPUT15 through INPUT24.

This type of analog input provides programmable pull up and pull down resistance for use with digital measurements and programmable gain for analog measurements. This input type is primarily intended to detect voltage level output on active voltage sensors. Alternatively, it could be used to detect state changes on system switches. When used as an active voltage sensor input, both the pull up and pull down resistor configuration options should be disabled. When used as a switch input, the appropriate pull up or pull-down resistor should be enabled based on the active state of the system switch. This input can be used to detect a double throw, center off switch by enabling both the pull up and the pull down configuration options at the same time and using on analog measurement to determine the switch states.

Warning: This input type does not include inductive load transient protection and should not be connected to signals that will cause inductive pulses to voltage levels above the maximum levels defined for this input type.

5.1.3.1. Analog Input Type 5 Circuit Block

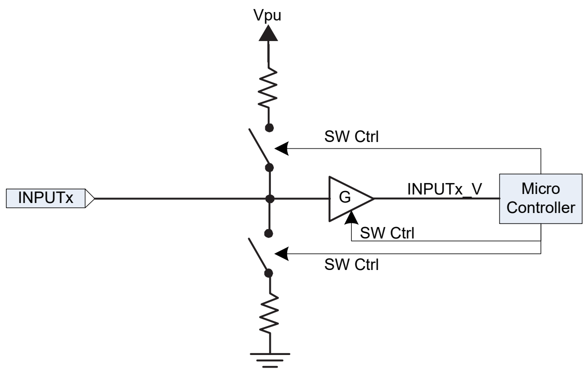


Figure 13: Analog Input Type 5 Block Diagram

5.1.3.2. Analog Input Type 5 Circuit Characteristics

These inputs have the following characteristics:

Configuration Parameters[1]				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Pull up resistance • INx_PU_EN Active	-	33.2	-	kΩ
Pull down resistance • INx_PD_EN Active	-	33.2	-	kΩ
Pull up voltage	-	4.5	-	V
Pull down voltage	-	GROUND (0V)	-	V
Gain – 8 Options – Gain (G)				
Option 1	-	1.000	-	V/V
Option 2	-	0.5	-	V/V
Option 3	-	0.349	-	V/V
Option 4	-	0.259	-	V/V
Option 5	-	0.154	-	V/V
Option 6	-	0.134	-	V/V
Option 7	-	0.120	-	V/V
Option 8	-	0.107	-	V/V
[1] This table defines the software configurations available on this input type.				

Analog Measurement Parameters [1]				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Input voltage range - Absolute Max	0	-	36	V
Input voltage range (operational) – 8 Gain Options				
Option 1	0	-	4.096	V
Option 2	0	-	8.192	V
Option 3	0	-	11.726	V
Option 4	0	-	15.822	V
Option 5	0	-	26.563	V
Option 6	0	-	30.659	V
Option 7	0	-	34.192	V
Option 8	0	-	38.288 [3]	V
Input resistance - 8 Gain Options				
Option 1	1000	-	-	kΩ
Option 2	-	95	-	kΩ
Option 3	-	73	-	kΩ
Option 4	-	64	-	kΩ
Option 5	-	56	-	kΩ
Option 6	-	55	-	kΩ
Option 7	-	54	-	kΩ
Option 8	-	53	-	kΩ
Pull up voltage[2]	-	4.5	-	V
Input pin capacitance	-	10	-	nF
Single pole low pass cutoff (pull up and pull down inactive, 0 Ω sensor resistance) – Depends on gain option	-	224	-	Hz
Input gain (G)	-	0.678	-	V/V
Input resolution	-	1.475	-	mV/bit
Voltage Drift -40C to 85C	-1.3	-	1.3	%
Voltage offset @ INPUTx_CON -40C to 85C	-	-	50	mV
[1] This table is relevant when used with active voltage sensor type inputs in a system (analog functionality) [2] The pull up voltage is derived from an internal 5V regulator and is subject to open loop variation. This pull up voltage cannot be read by the software for this input type [3] This is measurable maximum value as it related to the gain value. Actual applied value should never exceed the absolute maximum defined for the input.				

5.1.3.3. Analog Input Type 5 Usage Considerations

5.1.3.3.1. Analog Measurements

INPUT15 to INPUT24 can be used with active voltage sensors for analog readings. When used for analog measurements the software configurable pullup and pulldown resistors should be disabled. Analog inputs should be connected as shown in Figure 10. This assumes the sensor is being powered from the CM3033 Sensor Supply output type.

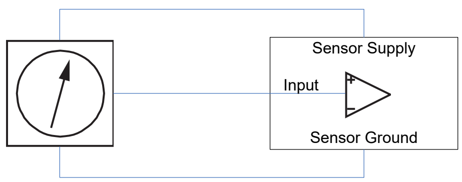


Figure 14: Analog Input Type 5 use for Analog Measurements

When using raw readings in the application software, conversion from raw analog readings to voltage values at the product input pin are achieved using the following transfer functions, dependent on gain option selected (result in mV):

- Option 1: $Vin = 1.475 \cdot ADC$
- Option 2: $Vin = 2 \cdot ADC$
- Option 3: $Vin = 2.865 \cdot ADC$
- Option 4: $Vin = 3.861 \cdot ADC$
- Option 5: $Vin = 6.494 \cdot ADC$
- Option 6: $Vin = 7.463 \cdot ADC$
- Option 7: $Vin = 8.333 \cdot ADC$
- Option 8: $Vin = 9.346 \cdot ADC$

5.1.3.3.2. *Digital Measurements*

INPUT15 to INPUT24 can be used with switches in a system for digital state readings. When used for digital measurements the inputs should be connected as shown in Figure 15 and Figure 16.

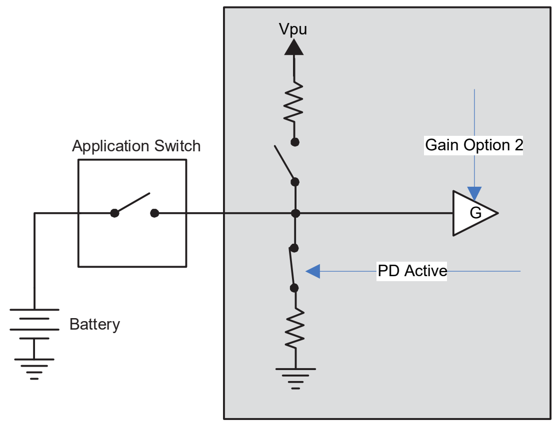


Figure 15: Analog Input Type 5 use for Active High Digital Measurements

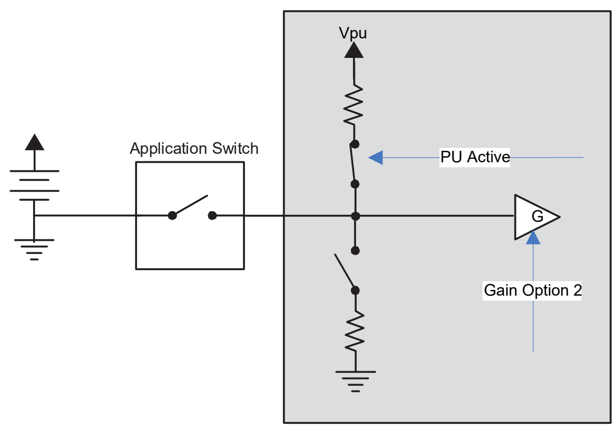


Figure 16: Analog Input Type 5 use for Active Low Digital Measurements

Note: Since the primary function of this input type is analog measurements, the wetting current available on the pullup and pulldown resistors is less than for input types with digital measurement as the primary function.

5.1.4. Analog Input Type 6

There is a total of 4 of these input types on the CM3033, identified as INPUT25 through INPUT28.

This type of analog input provides programmable pull up and pull down resistance for use with digital measurements and resistive sensor analog measurements. This input type is primarily intended to detect resistance values on resistive sensors.

Alternatively, it could be used to detect state changes on system switches. When used as a resistive sensor input, both the pull up options are used depending on the resistance range to be measured. When used as a switch input, the appropriate pull up or pull down resistor should be enabled based on the active state of the system switch. This input can be used to detect a double throw, center off switch by enabling both one of the pull up and the pull down configuration options at the same time and using analog measurement to determine the switch states.

Warning: This input type does not include inductive load transient protection and should not be connected to signals that will cause inductive pulses to voltage levels above the maximum levels defined for this input type.

5.1.4.1. Analog Input Type 6 Circuit Block

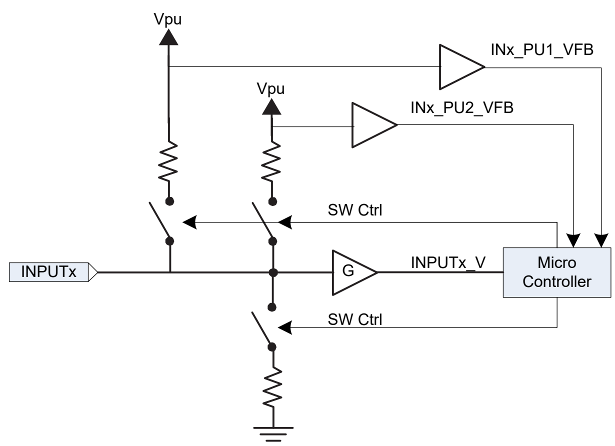


Figure 17: Analog Input Type 6 Block Diagram

5.1.4.2. Analog Input Type 6 Circuit Characteristics

These inputs have the following characteristics:

Configuration Parameters[1]				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Pull up resistance 1 - INx_PU1_EN active	-	375	-	Ω
Pull up resistance 2 - INx_PU2_EN active	-	33.2	-	kΩ
Pull down resistance - INx_PD_EN active	-	33.2	-	kΩ
Pull up voltage[2] - for both pullups	-	4.5	-	V
Pull down voltage	-	GROUND (0V)	-	V

[1]This table defines the software configurations available on this input type.

[2]The pull up voltage is derived by an internal 5V regulated power supply. The pullup voltage for each pullup resistor can be measured by software to provide accurate measurement of resistive sensor types.

Analog Measurement Parameters – Sensor Type 1[1]				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Pull up resistance 1 (INx_PU1_EN)[2]	-	Enabled	-	-
Pull up resistance 2 (INx_PU2_EN)[2]	-	Enabled	-	-
Pull down resistance (_PDx_EN)	-	Disabled	-	-
Input resistance range	0	-	100	Ω
Input pin capacitance	-	5	-	nF
Single pole low pass cutoff	-	615	-	Hz
Input resolution	-	0.6	-	Ω /bit
Input accuracy (-40C to 85C) [3]	-6.5	-	6.5	Ω

[1] This table is relevant when used with resistance sensor type inputs with a low input resistance range (analog functionality)

[2] The pull up, pull down are recommended settings for this sensor type. Other settings can be enabled by software, but characteristics of those settings are not provided in this document.

[3] Accuracy error specifications provided here assume that the input is connected to a resistive sensor in the resistance range defined.

Analog Measurement Parameters – Sensor Type 2 Range 1 [1]				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Pull up 1 resistance (INx_PU1_EN) [2]	-	Enabled	-	-
Pull up 2 resistance (INx_PU2_EN) [2]	-	Enabled	-	-
Pull down resistance (INx_PDx_EN)	-	Disabled	-	-
Input resistance range	50	-	2400	Ω
Input resolution (Rsen = 30 Ω)	-	0.21	-	Ω /bit
Input resolution (Rsen = 1100 Ω)	-	1.3	-	Ω /bit
Input offset error [3] (-40C to 85C) (Rsen = 50 Ω)	-5.4	-	5.4	Ω
Input accuracy (25C) (Rsen = 50 Ω)	-.03	-	0.3	Ω
Input accuracy (-40C to 85C) (Rsen = 50 Ω)	-0.4	-	0.4	Ω
Input offset error [2] (-40C to 85C) (Rsen = 1100 Ω)	-34	-	34	Ω
Input accuracy (25C) (Rsen = 1100 Ω)	-11.5	-	11.5	Ω
Input accuracy (-40C to 85C) (Rsen = 1100 Ω)	-15.8	-	15.8	Ω

[1] This table is relevant when used with resistance sensor type inputs with a low input resistance range (analog functionality)

[2] The pull up, pull down, and attenuation settings shown in this table are recommended settings for this sensor type. Other settings can be enabled by software, but characteristics of those settings are not provided in this document.

[3] Offset and accuracy error specifications provided here assume that the input is connected to a resistive sensor in the resistance range defined.

Analog Measurement Parameters – Sensor Type 2 Range 2 [1]				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Pull up 1 resistance (INx_PU1_EN) [2]	-	Disabled	-	-
Pull up 2 resistance (INx_PU2_EN) [2]	-	Enabled	-	-
Pull down resistance (_PDx_EN)	-	Disabled	-	-
Attenuation 1 (_ATN1_EN)	-	Disabled	-	-
Attenuation 2 (_ATN2_EN)	-	Disabled	-	-
Input resistance range	2.4	-	110	kΩ
Input resistance (w.r.t. ground)	-	16.6	-	kΩ
Input pin capacitance	-	5	-	nF
Single pole low pass cutoff (Rsen = 89 kΩ)	-	77.5	-	Hz
Single pole low pass cutoff (Rsen = 1.1 kΩ)	-	100	-	Hz
Input resolution (Rsen = 1.1 kΩ)	-	5.4	-	Ω /bit
Input resolution (Rsen = 89 kΩ)	-	182.3	-	Ω /bit
Input offset error [3] (-40C to 85C) (Rsen = 1.5 kΩ)	-141	-	141	Ω
Input accuracy (25C) (Rsen = 1.5 kΩ)	-6.7	-	6.7	Ω
Input accuracy (-40C to 85C) (Rsen = 1.5 kΩ)	-11.9	-	11.9	Ω
Input offset error [3] (-40C to 85C) (Rsen = 89 kΩ)	-5	-	5	kΩ
Input accuracy (25C) (Rsen = 89 kΩ)	-2	-	2	kΩ
Input accuracy (-40C to 85C) (Rsen = 89 kΩ)	-4.5	-	4.5	kΩ

[1] This table is relevant when used with resistance sensor type inputs with a high input resistance range (analog functionality)

[2] The pull up, pull down, and attenuation settings shown in this table are recommended settings for this sensor type. Other settings can be enabled by software, but characteristics of those settings are not provided in this document.

[3] Offset and accuracy error specifications provided here assume that the input is connected to a resistive sensor in the resistance range defined.

Digital Measurement Parameters [1]				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Input voltage range (operational)	0	-	36	V
Input High Detection Threshold	2.25	-	-	V
Input Low Detection Threshold	-	-	1.08	V
Input pin capacitance	-	10	-	nF
Inductive Load Transient Protected?	-	No	-	-

[1] This table is relevant when used with switch type inputs in a system (digital functionality)

5.1.4.3. Analog Input Type 6 Usage Considerations

5.1.4.3.1. Analog Measurements

INPUT25 to INPUT28 can be used with resistive sensors for analog readings. When used for analog measurements the software configurable pullup resistors should be enabled depending on the resistance range for a given sensor. The settings for different ranges are shown below:

Pullup	Resistance Range	Unit
INx_PU1_EN Active INx_PU2_EN Active	0 to 2400	Ω
INx_PU1_EN Inactive INx_PU2_EN Active	2.4 to 110	kΩ

Analog inputs should be connected as shown in Figure 18.

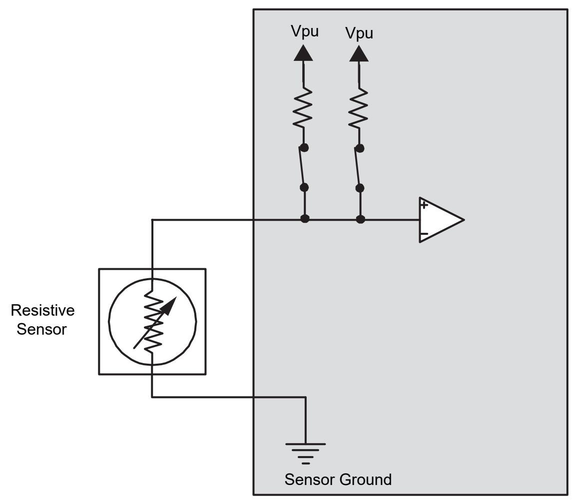


Figure 18: Analog Input Type 6 use for Analog Measurements

When using raw readings in the application software, conversion from raw analog readings to a resistance value using the following transfer functions, dependent on pullup option selected (result in Ω):

- INx_PU1_EN Active:

$$Rsensor = \frac{-(375 \cdot INPUTx\_V)}{INPUTx\_V - 2 \cdot INPUTx\_PU1\_VFB}$$

- INx_PU1_EN & INx_PU2_EN Active:

$$Rsensor = \frac{-370.81 \cdot INPUTx\_V}{INPUTx\_V - 2.0 \cdot INPUTx\_PU1\_VFB}$$

- INx_PU2_EN Active:

$$Rsensor = \frac{-(33200 \cdot INPUTx\_V)}{INPUTx\_V - 2 \cdot INPUTx\_PU2\_VFB}$$

5.1.4.3.2. Digital Measurements

INPUT25 to INPUT28 can be used with switches in a system for digital state readings. When used for digital measurements the inputs and pull settings should be connected as shown in Figure 15 and Figure 1620.

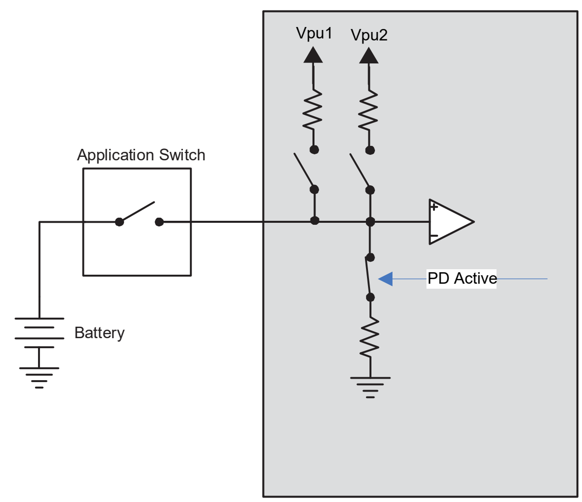


Figure 19: Analog Input Type 6 use for Active High Digital Measurements

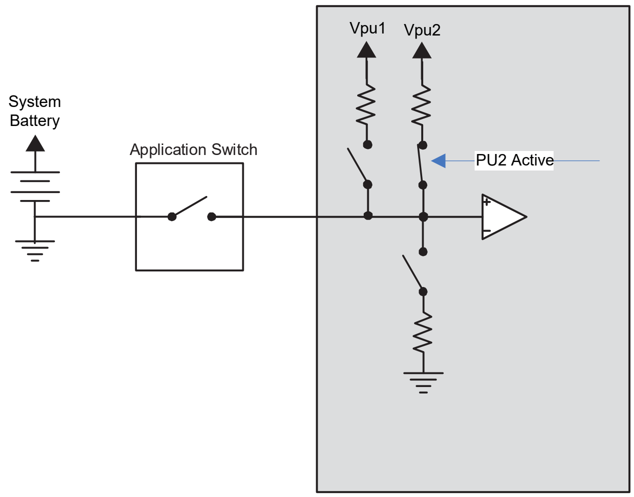


Figure 20: Analog Input Type 6 use for Active Low Digital Measurements

Note: Since the primary function of this input type is analog measurements, the wetting current available on the pullup and pulldown resistors is less than for input types with digital measurement as the primary function.

5.1.5. Analog Input Type 3 - Address Input

There is one of this input types on the CM3033, identified as INPUT31.

This type of analog input is dedicated for use with Parker ID Tag address resistors. This addressing can be used to detect whether the application software should run (if the product is in the right location) and provides support for product “Plug and Play” reprogramming.

This input type also provides a way to “bootstrap” the product to allow for reprogramming in the unlikely event that all memory becomes corrupted in the module.

Warning: This input type is only intended to be used as an address input using Parker ID Tag resistors or as a way to bootstrap the CM3033 in the event of “bricking”.

5.1.5.1. Analog Input Type 3 Circuit Block

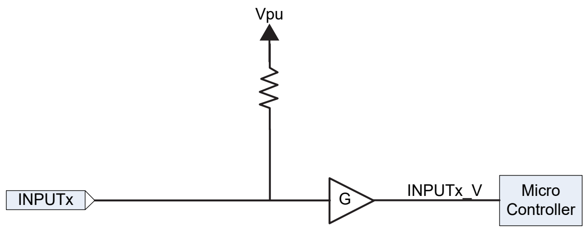


Figure 21: Analog Input Type 3 Block Diagram

5.1.5.2. Analog Input Type 3 Circuit Characteristics

These inputs have the following characteristics:

ID Tag Address Parameters			
Parker Part Number	**Address**	**Resistance[1]**	**Unit**
20085050	Address 0	294	Ω
20085060	Address/Terminate 0T	432	Ω
20085051	Address 1	590	Ω
20085061	Address/Terminate 1T	768	Ω
20085052	Address 2	976	Ω
20085062	Address/Terminate 2T	1210	Ω
20085053	Address 3	1500	Ω
20085063	Address/Terminate 3T	1820	Ω
20085054	Address 4	2230	Ω
20085064	Address/Terminate 4T	2740	Ω
20085055	Address 5	3360	Ω
20085065	Address/Terminate 5T	4170	Ω
20085056	Address 6	5300	Ω
20085066	Address/Terminate 6T	6900	Ω
20085057	Address 7	9530	Ω
20085067	Address/Terminate 7T	14000	Ω
[1]It is recommended that Parker ID Tag part numbers be used, but if a different part is used, the resistance shall have a tolerance of at 0.5% tolerance at 50 PPM or better.			

5.1.5.3. Analog Input Type 3 Usage Considerations

5.1.5.3.1. ID Tag Address Measurements

INPUT31 is used to detect ID Tag values to allow more than one CM3033 to be used in a system. This input should be used when software on the product must be aware of what position it is in within a system. This input should be connected as shown in Figure 22.

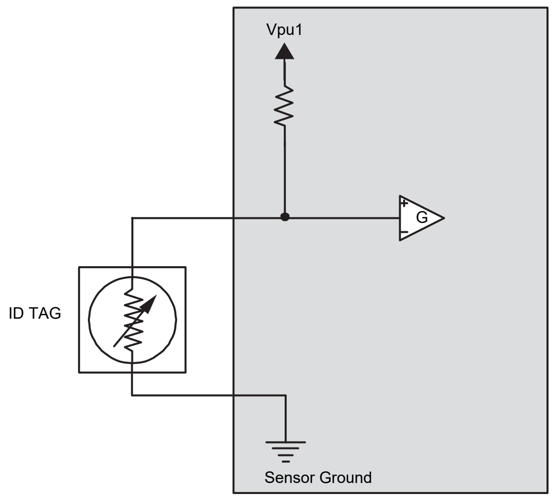


Figure 22: Analog Input Type 6 use for ID Tag Address Measurements

5.1.5.3.2. Recovery Input

This analog input can be used to place the CM3033 into a "recovery" mode that allows the product to be bootstrapped for reprogramming over the CAN1 port. This is usually only required in the unlikely event that a CM3033 product has fully corrupt memory. This allows an otherwise "bricked" CM3033 to be recovered in the field without having to return the product to Parker.

To initiate recovery mode, INPUT31 is connected to a voltage source that is 18V < INPUT31 < 32V. Then applying a voltage to the VBATT pin of 9V < VBATT < 32V to power up the CM3033. Once this is done, the CM3033 can be reprogrammed over CAN1 using Parker programming tools.

5.2. Frequency Inputs

Frequency inputs are typically used to read pulse signals. There is one type of frequency input on the CM3033 product. This frequency input offers programmability of pull up resistance values. This also offers analog input measurements that can be used as dedicated analog input or for diagnostics on frequency sensors.

All frequency inputs share the following global characteristics:

Analog Input Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Software raw bit value at microcontroller pin[1]	-	1	-	mV/bit
Maximum sample rate[2]	-	-	1	ms
[1]This is the expected voltage per bit at the ADC pin of the microcontroller. Each input type will have an associated gain/attenuation factor that must be used to convert ADC value to CM3033 input pin voltage. [2]Unless otherwise mentioned below, all analog inputs are sampled based on the sample rates in this table.				

5.2.1. Frequency Input Type 1

INPUT29 to INPUT30 are arranged as this type of frequency input on the CM3033. This type of frequency input provides programmable pull up resistance. This frequency input type is intended to be used to detect frequency and duty cycle values from frequency sensors. This frequency input also offers analog feedback that can be used as diagnostics on the frequency sensor connected to the input (depending on the sensor type used). When used with an open drain or open-source frequency sensor, the pull up configuration option is used to provide bias to the sensor and generate a voltage level at the input pin.

This frequency input supports quadrature sensor readings allowing for direction to be extracted from sensors that support quadrature phase shifted signals. To use quadrature sensing, both INPUT29 and INPUT30 must be used for the two sensor signals that provide the phase shifted information.

5.2.1.1. Frequency Input Type 1 Circuit Block

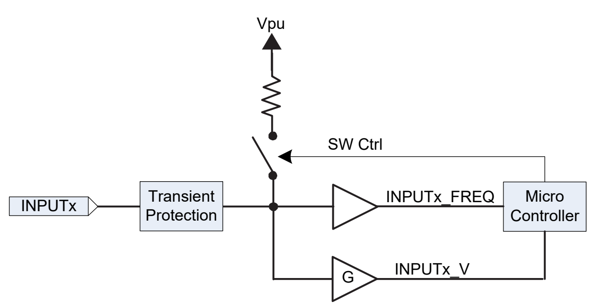


Figure 23: Frequency Input Type 1 Block Diagram

5.2.1.2. Frequency Input Type 1 Circuit Characteristics

These inputs have the following characteristics:

The general configuration parameters associated with this input type are given by the following table.

Configuration Parameters [1]				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Pull up resistance [2]	-	5.11	-	kΩ
Pull up voltage [3]	-	4.3	-	V
[1] This table defines the software configurations available on this input type. [2] The pull up resistor is enabled using the INx_PU1_EN signal in software. [3] The pull up voltage is derived from an internal 5V regulator and is subject to open loop variation. This pull up voltage cannot be read by the software for this input type.				

Frequency Measurement Parameters [1]				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Pull up resistance (INx_PU1_EN)	-	Enabled	-	-
Input frequency range	-	-	10	kHz
Input State Change Positive Threshold	-	3.36	-	V
Input State Change Negative Threshold	-	2.29	-	V
Input State Change Hysteresis	-	1.06	-	V
Input pin capacitance	-	10	-	nF
Detectable Duty Cycle 50Hz ≤ Fin ≤ 1000Hz[2]	5	-	95	%
Duty Cycle Accuracy 50Hz ≤ Fin ≤ 1000Hz [2]	-1	-	1	%
Frequency Accuracy (-40C to 85C)	-5	-	5	%
Frequency Resolution	-1	-	1	Hz

[1] This table is relevant when used with frequency type inputs in a system (frequency functionality)

[2] Duty cycle is only detectable to the accuracy specified in the frequency range identified.

Analog Measurement Parameters [1]				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Input voltage range - Absolute Max	0	-	36	V
Input voltage range (operational)	0	-	6.25	V
Input gain (G)	-	0.651	-	V/V
Input resistance [2]	-	30	-	kΩ
Input pin capacitance	-	1	-	nF
Single pole low pass cutoff	-	1.5	-	kHz
Input resolution	-	1.5	-	mV/bit
Input accuracy (-40C to 85C) [3]	-3	-	3	%
Offset (-40C to 85C) [3]	-50	-	50	mV

[1] This table is relevant when used with voltage type inputs in a system (analog functionality)

[2] Input resistance is given with respect to ground, ignoring the pull up resistor value.

[3] Accuracy and offset error specifications provided here assume that the input is connected to a low source impedance active voltage sensor.

5.2.1.3. Frequency Input Type 1 Usage Considerations

5.2.1.3.1. Frequency Measurements

INPUT29 to INPUT30 can be used with pulsed sensors in a system for frequency and duty cycle readings. When used for frequency measurements the inputs should be connected as shown in Figure 1124 and Figure 1225.

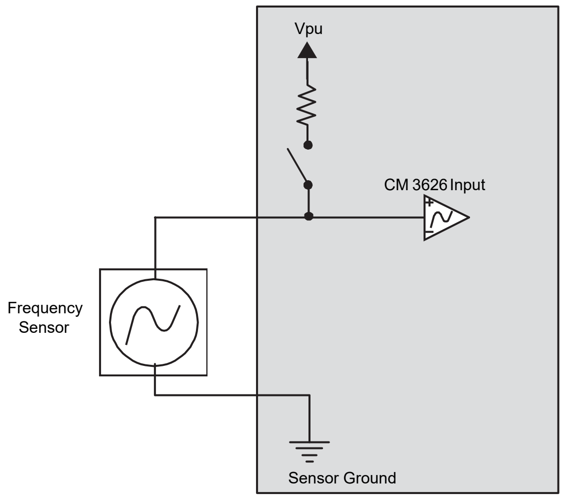


Figure 24: Frequency Input Type 1 use for Active Output Frequency Measurements

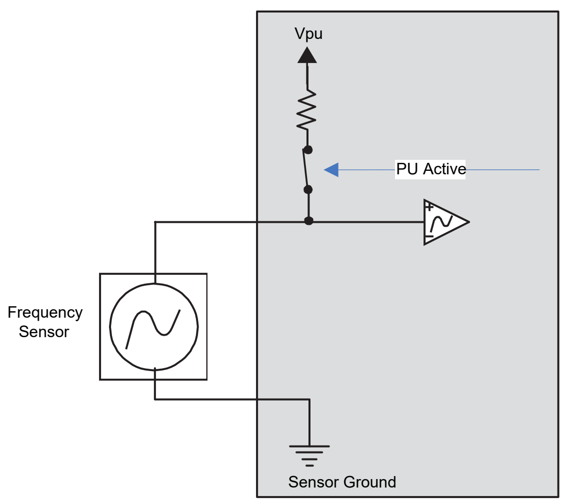


Figure 25: Frequency Input Type 1 use for Open Collector Frequency Measurements

Note: Since the primary function of this input type is analog measurements, the wetting current available on the pullup and pulldown resistors is less than for input types with digital measurement as the primary function.

5.2.1.3.2. *Analog Measurements*

INPUT29 to INPUT30 can be used with active voltage sensors for analog readings or for measuring the analog value when a frequency sensor is connected. When used for active voltage sensor analog measurements or measuring the analog value of an active output frequency sensor, the software configurable pullup resistor should be disabled. When used for measuring the analog value of an open collector frequency sensor, the software configurable pullup resistor should be enabled. Analog inputs should be connected as shown in Figure 10. This assumes the sensor is being powered from the CM3033 Sensor Supply output type.

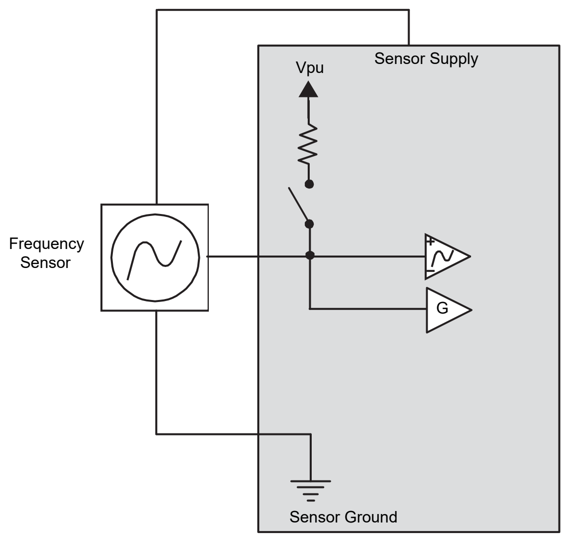


Figure 26: Frequency Input Type 1 Analog Measurements of Active Output Sensor (analog or frequency)

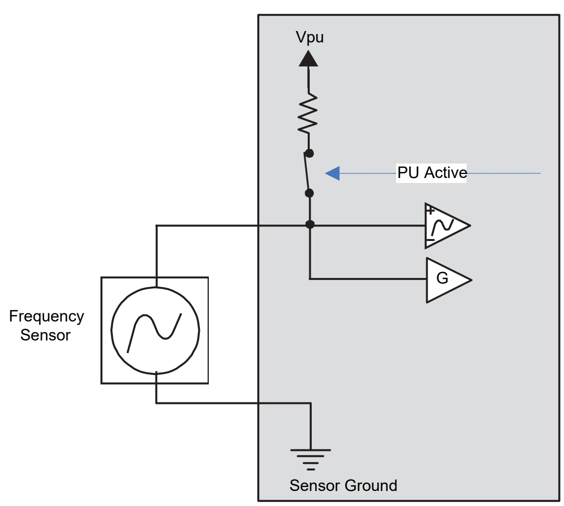


Figure 27: Frequency Input Type 1 Analog Measurements of Open Collector Sensor

When using raw readings in the application software, conversion from raw analog readings to voltage values at the product input pin are achieved using the following transfer function (result in mV):

$$Vin = 1.536 \cdot ADC$$

Some sensor types, like the Parker 01879-CL_Rev_D sensor offer switched resistance when active and inactive. This allows for detection of open circuit and short circuit conditions when combined with the pullup resistor on this input type. When this type of sensor is used, the expected voltage at the product input pin based on the sensor resistance can be determined using the following function:

$$Vin = (4.5) \cdot \frac{Rsensor}{Rsensor + 5110}$$

Note: This input type has a diode in series with the pullup resistor which has a forward voltage drop that will vary over temperature. The function above is given for a typical diode voltage drop at 25C. Detection of sensor status using this function is not intended to give a highly accurate result, rather it is intended to detect if a sensor is disconnected or shorted in a system.

Note: Use of the analog measurement of a frequency sensor on this input type is only accurate when the connected sensor is not switching at a fast rate (in a DC condition is best).

5.3. Special Function Inputs

There is one special function input type on the CM3033. This input type is an internal temperature measurement.

All special function inputs share the following global characteristics:

Analog Input Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Software raw bit value at microcontroller pin [1]	-	1	-	mV/bit
Maximum sample rate [2]	-	-	1	ms
[1] This is the expected voltage per bit at the ADC pin of the microcontroller. Each input type will have an associated gain/attenuation factor that must be used to convert ADC value to CM3033 input pin voltage. [2] Unless otherwise mentioned below, all analog inputs are sampled based on the sample rates in this table.				

5.3.1. Temperature Sensor Type 1

There are three of these input types on the CM3033, identified as TEMPERATURE_V, TEMPERATURE_2V, TEMPERATURE_3V.

This input type is used to measure the internal temperature of the CM3033. These are used to sense temperature related to:

- TEMPERATURE_V = Low power output area of the product (away from heat generating components)
- TEMPERATURE2_V = High power output area of the product (near VBATT_BANK1 switch)
- TEMPERATURE3_V = High power output area of the product (near VBATT_BANK2 switch)

5.3.1.1. Temperature Sensor Type 1 Circuit Block

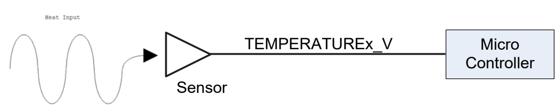


Figure 28: Temperature Sensor Type 1 Block Diagram

5.3.1.2. Temperature Sensor Type 1 Circuit Characteristics

These inputs have the following characteristics:

Analog Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Input Temperature Range [1]	-40	-	125	°C
Sensor Gain (Gsen)	-	6.25	-	mV/°C
Sensor Offset (Vos) @ 0°C	-	424	-	mV
Resolution	-	0.1	-	°C/bit
Accuracy – Drift error (-40C to 85C)	-6	-	6	°C
[1] This is the temperature range that the temperature sensor can detect. This does not imply that the CM3033 can be operated over this full range external to the product enclosure. External ambient temperature range is -40C to 85C. Continuous operation of the product with readings on TEMPERATURE_V of 105°C (plus maximum error) should be the maximum expected in normal applications. Peaks above this level are acceptable but should not be continuous conditions.				

5.3.1.3. Temperature Sensor Type 1 Usage Considerations

5.3.1.3.1. Temperature Measurements

TEMPERATURE_V, TEMPERATURE_2V, TEMPERATURE_3V can only be used to measure the temperature internal to the CM3033 product. Temperature sensors are connected as shown in Figure 28, are internal to the CM3033 and require no connections by a system designer to use.

When using raw readings in the application software, conversion from raw analog readings to temperature are achieved using the following transfer function (result in (in °C):

$$T(v) := \frac{(v - 424)}{6.25}$$

Note: Any diagnostics associated with temperature readings must be implemented within application software.

Application software can use the temperature reading for any purpose. Two potential uses include:

- Monitoring of temperature over time to determine the type of environment a system is being operated in for warranty purposes.
- Monitoring of temperature for peak conditions to identify potential environmental faults to an operator.

6. Outputs

The CM3033 has high side, low side, and regulated outputs designed for low to high current, high inrush, and inductive load switching. Output currents can range up to 10 A. The CM3033 also includes up to three regulated outputs used to power external sensors and one analog output used to drive current or voltage receivers.

Warning: Unless identified on specific output types in this document, do not connect inputs directly to unprotected inductive loads such as solenoids or relay coils, as these can produce high voltage spikes that may damage the CM3033. Connection of an inductive load on an output type that is not protected must use a protective diode on that load.

Warning: Some of the functionality discussed in this User Guide is dependent on the version of platform software that is programmed on the CM3033. Refer to the software user manuals for additional information pertaining to the functionality defined in this document.

High-side outputs include:

- PWM capabilities
- With and without high accuracy current sense
- Output current range from 2.5A to 10A

Low-side outputs include:

- PWM capabilities
- With high accuracy current sense
- Output current 10A

Sensor supply output includes:

- Programmable output voltage levels
- Output current range to 1A

For output types that include accurate current sense, the following global conditions apply to those current sense readings:

Current Sense Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Software raw bit value at microcontroller pin [1]	-	1	-	mV/bit
Maximum sample rate [2]	-	-	200	us
[1] This is the expected voltage per bit at the ADC pin of the microcontroller. Each input type will have an associated gain/attenuation factor that must be used to convert ADC value to CM3033 input pin voltage. [2] Unless otherwise mentioned below, all analog inputs are sampled based on the sample rates in this table.				

Soft Start Application Note: As part of the IQAN-Open product family, this controller, offers the ability to run outputs on for many loads. Some load types will draw a large amount of current at first turn on until they either heat up, charge or start moving. This initial current draw is referred to as “inrush” current and with certain loads, this inrush current can result in a nuisance trip for short circuit condition on the IQAN-Open controller outputs. To prevent this, the controller outputs are equipped with a soft start feature designed to reduce the effect of inrush on the short circuit protection of the outputs. Please refer to the IQAN-Open – Output Soft Start Application Note.

6.1. High Side Outputs

The CM3033 has 26 high side outputs. These outputs are divided up into five output types:

- HS Output Type 9 – 2.5A output without accurate current sense
- HS Output Type 10 – 2.5A output with accurate current sense
- HS Output Type 11 – 5A output with accurate current sense
- HS Output Type 12 – 5A output without accurate current sense
- HS Output Type 7 – 10A output without accurate current sense

High side outputs switch system battery power to output loads. The high side drivers are powered through switched power banks (VBATT_BANK1 and

VBATT_BANK2) or directly to system power (VBATT_BANK_OUT23 to OUT26). This arrangement is shown in Figure 29.

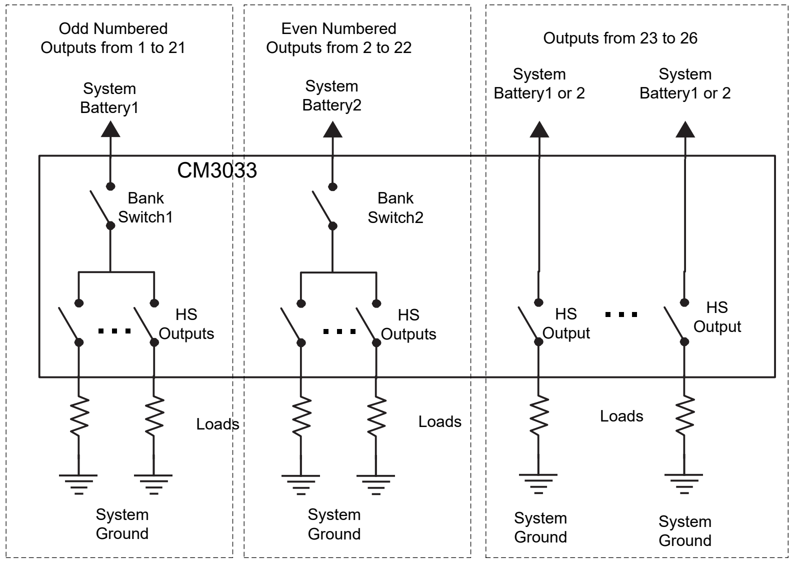


Figure 29: High Side Output Configuration

The bank switches are enabled or disabled by the CM3033 software and are not under application software control. The bank switches are used to prevent outputs from remaining active when an internal fault that could compromise system safety is detected by the CM3033 software.

The application software can monitor the voltage level of the power being provided to the HS outputs by the Bank Switches or on the directly connected outputs using the VBATT_BANKx_xxx_VFB signals. When the bank switch is active, this output from the bank switch should be no more than 1V lower than the value of VBATT_BANK1 or VBATT_BANK2 (measured from the PS_VBATT_BANKx_VFB signal). The characteristics of this signal are provided in the following table.

VBATT_BANKx_SW_VFB – Analog Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Detectable voltage range	0	-	36	V
Single pole low pass cutoff	-	368	-	Hz
Resolution	-	11	-	mV/bit
Accuracy – Drift error (-40°C to +85°C)	-3	-	3	%

6.1.1. HS Output Bank Switch

The CM3033 includes two high side bank switches that can disconnect power to the high side outputs that they connect to see Figure 2930. The bank switches are enabled or disabled by the CM3033 software and are not under application software control. The bank switches are used to prevent outputs from remaining active when an internal fault that could compromise system safety is detected by the CM3033 software.

6.1.1.1. HS Output Bank Switch Circuit Block

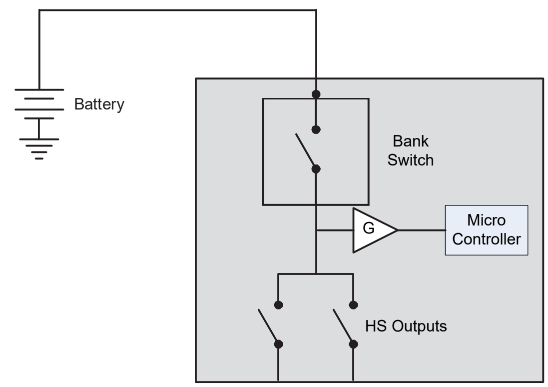


Figure 30: HS Output Bank Switch Block Diagram

6.1.1.2. HS Output Bank Switch Circuit Characteristics

The bank switches have the following characteristics:

Switch Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Voltage range (operational and non-operational)	6	-	36	V
Bank Current Range	0	-	30	A
Bank Switch Voltage Drop	-	-	1	V
Application Software control?	-	No	-	-

Analog Feedback Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**
VBATT_BANKx_SW_VFB Detectable voltage range	0	-	36	V
VBATT_BANKx_SW_VFB: Gain	-	0.09091	-	V
VBATT_BANKx_SW_VFB: Offset error	-250	-	250	mV
VBATT_BANKx_SW_VFB: Accuracy (-40°C to +85°C)	-5	-	5	%
Accuracy – Drift error (-40°C to +85°C)	-3	-	3	%

6.1.1.3. HS Bank Switch Usage Considerations

6.1.1.3.1. HS Bank Switch Control and Measurements

The application software cannot control the Bank Switches on the CM3033.

The application can monitor the voltage level of the power being provided to the HS outputs by the Bank Switches using the VBATT_BANK1_SW_VFB and VBATT_BANK2_SW_VFB signals. Monitoring of these signals can be used for application-level diagnostics on HS output power levels. This could be used for determining if the voltage applied to the HS outputs is in the expected range before activating any of the HS outputs connected to the Bank Switch.

When using raw readings in the application software, conversion from raw analog readings to voltage values at the product input pin are achieved using the following transfer function (result in mV):

$$Vbanksw = 11 \cdot ADC$$

6.1.2. HS Output Type 10

OUTPUT1 to OUTPUT4 and OUTPUT9 to OUTPUT10 on the CM3033 are of this HS output type.

This output type provides:

- Switched VBATT_BANK1 (odd numbered outputs) and VBATT_BANK2 (even numbered outputs) to external loads
- Up to 2.5A of continuous output current
- Accurate current sense analog feedback to the software
- Pulse width modulated (PWM) for output current control
- Integrated flyback diodes providing inductive load protection
- Soft start support for activation of high current inrush loads (bulbs, motors, capacitors, etc.)
- Connection to a variety of loads, including resistive, inductive, motor, lamp, and LED
- Software controllable open load detection feature that can be disabled to reduce the amount of output leakage current in the off state making the output usable with many LED load types
- When output is disabled:
- Usable as an active low digital input (with open load detection active)
- Usable as an active high digital input (with open load detection inactive)

This output type detects and reports the following faults:

- Short circuit to ground – while output is on
- Short circuit to battery – while output is off

- Open load – while output is off
- Open load – while output is on (via current sense with application SW)
- Over current – while output is on

Warning: These output types are only protected against short to battery conditions that are at or below the voltage of the VBATT_BANKx associated with the output.

6.1.2.1. HS Output Type 10 Circuit Block

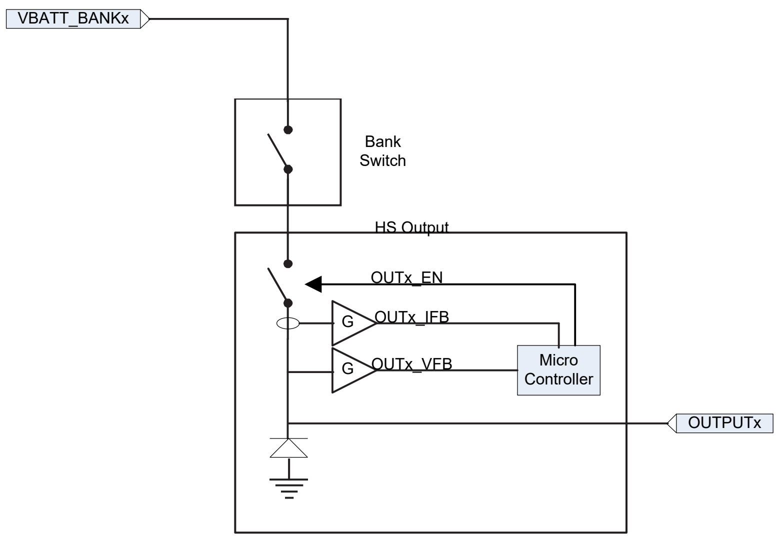


Figure 31: HS Output Type 10 Block Diagram

6.1.2.2. HS Output Type 10 Circuit Characteristics

This output type has the following characteristics:

Output Switch Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Output voltage range	0	-	36	V
Output Load Current Range	0	-	2.5	A
Short Circuit Current Limit	-	-	84	A
Over Current Detection	-	3	-	A
Output Resistance - w.r.t. ground: Output off state	-	36.52	-	kΩ
Output Resistance - w.r.t. VBATT_BANK_SWITCHED: • Output on state OUTx_OL_STROBE inactive	-	56	62	mΩ
Output Resistance - w.r.t. VBATT_BANK_SWITCHED: • Output off state OUTx_OL_STROBE active	-	37.4	-	kΩ
Output Leakage Current (output off state, OUTx_OL_STROBE inactive)	-	-	30	uA
Output PWM Frequency	65	-	200	Hz
Output Duty Cycle Resolution • up to maximum frequency	-	0.1	-	%
Output PWM Frequency • Extended PWM Range	>200	-	1000	Hz
Output Load Current Range • Extended PWM range	-	-	1	A
Output Duty Cycle Resolution • up to maximum frequency in extended range	-	0.2	-	%
• Maximum output voltage over extended PWM range	-	-	32	V
Load Types over extended PWM range	-	Resistive Inductive	-	-
Turn on Delay – Off to On state	-	50	150	µs
Turn off Delay – On to Off State	-	50	150	µs
Turn on/off Slew Rate	1.4	-	-	V / µs
Output pin capacitance	-	10	-	nF

Current Sense Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Detectable current range	0	-	3.0	A
Output voltage range [1]	-2	-	36	V
Gain (G)	-	763	-	mA/V
Accuracy – Drift error (-40°C to +85°C)	-2	-	2	%
Accuracy – Offset error (-40°C to +85°C)	-	24	-	mA
[1] This is the output voltage range that allows for detection of the current sense. There is a diode within the CM3033 circuitry that prevents the output voltage from dropping below the minimum specified value and allows current from inductive loads to continue to flow and be measured when the output is off.				

Voltage Feedback Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Detectable Voltage range	0	-	36	V
Gain (G)	-	0.09091	-	V/V
Accuracy – Drift error (-40°C to +85°C)	-5	-	5	%
Accuracy – Offset error (-40°C to +85°C)	-	100	-	mV

6.1.2.3. HS Output Type 10 Usage Considerations

6.1.2.3.1. Current Feedback Aliasing

Aliasing is an artifact of discretely sampled analog values where the waveform being sampled changes at a rate faster than the rate at which you are sampling. The resulting sampled waveform appears to change at a much slower frequency than the real waveform changes, known as an "alias" of the true waveform. This slow frequency looks like low frequency noise on the waveform and cannot be filtered out with application software filtering. Figure 32 shows a waveform sampled at a higher frequency than the waveform frequency and Figure 33 shows the result of aliasing, that is, sampling at a slower frequency than the waveform frequency.

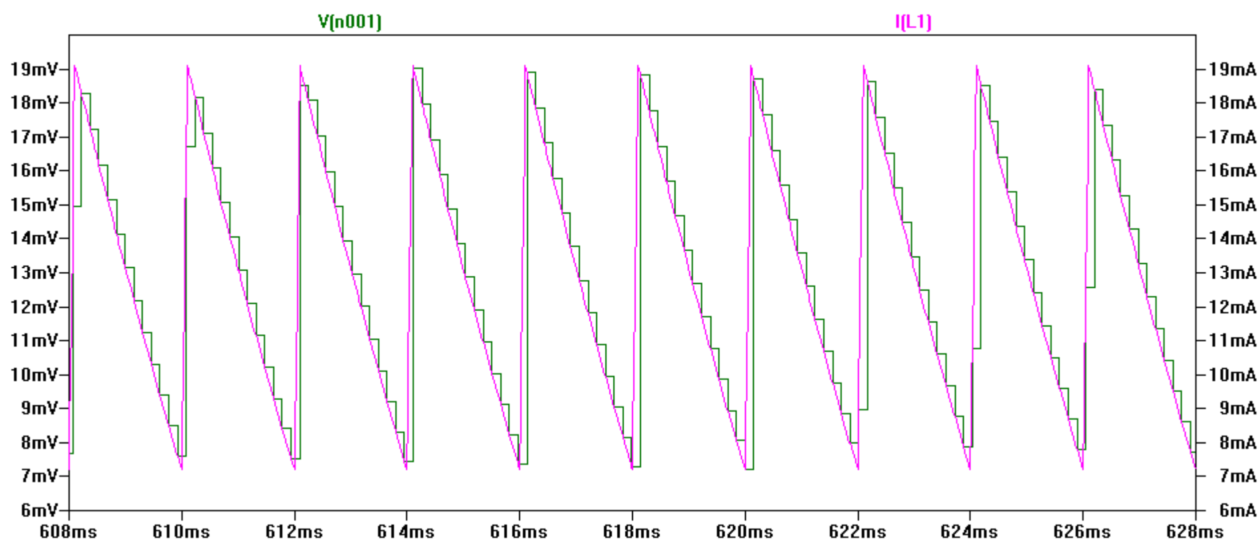


Figure 32: Sampled waveform (V(n001)) at a sample rate faster than analog waveform (I(L1))

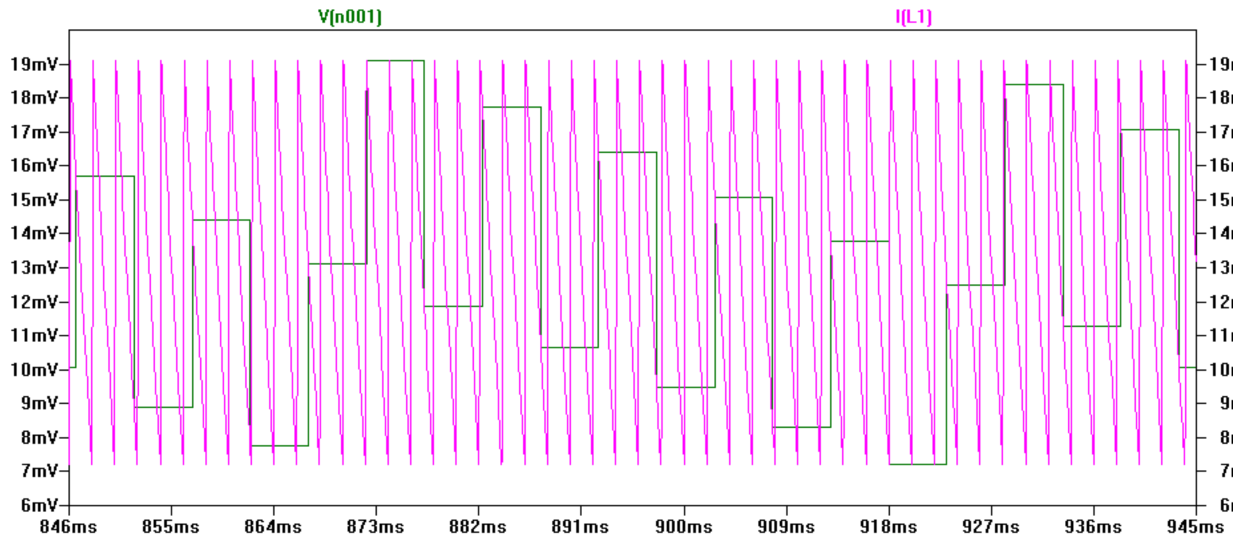


Figure 33: Sampled waveform (V(n001)) at a sample rate slower than analog waveform (I(L1))

The solution to aliasing is to ensure that a waveform is sampled at a frequency that is at least 2 times higher than the frequency of the physical waveform. For output PWM current control, application software samples the current sense feedback to determine what adjustments are required on the PWM duty cycle of an output to maintain a set current value. Since application software cannot always run at a rate fast enough rate to ensure the 2 times PWM rate, the CM3033 provides oversampling at a rate of 10 times the maximum PWM rate (excluding the extended PWM range) and provide software low pass filtering of the oversampled values. The cutoff frequency for these filters can be changed by application software if required, but it should not be selected as a value that is greater than half the frequency of the application run thread frequency.

6.1.2.3.2. Load Inrush Current

All outputs on the CM3033 include short circuit protection. Many load types have current inrush which is a high current value when a load is first activated that reduces in value to a steady state current value over time. Certain load types may require the use of "soft starting" to prevent inrush currents to trip short circuit protection. Soft Starting causes an output to PWM from 0% to the set output PWM value whenever the output is activated. Soft Start time and end PWM value can be selected by Application Software.

6.1.2.3.3. Inductive Load PWM

When combining this output with an inductive load and a pulse width modulation output signal, the off state cycle of the output will conduct current from the ground connection of the load back through vehicle ground into the product through the integrated diode on the output circuit. To reduce the amount of electrical noise generated in this type of setup, it is recommended that the load be grounded close to the power ground of the module. Some techniques that can help reduce system noise include running twisted pair wire for load positive and negative connections or running shielded cable to the loads.

It is the system designer's responsibility to ensure that noise induced on a system design due to output load PWMing does not result in violating electromagnetic emissions requirements for that system.

6.1.2.3.4. High Impedance Load PWM

When PWMing this output type, which is low resistance when on and high resistance when off, the shape of the output waveform may not be symmetrical. The rising edge (output turning on) is dominated by the slew rate for the output. The falling edge (output turning off) is dominated by on product output resistance to ground in parallel with any system load resistance which are both in parallel with the specified output pin capacitance.

Note: In systems where this output type is being used to PWM a high impedance load (like a digital input into another controller product), additional system load resistance to ground may be needed to make the corresponding output wave shape as symmetrical as required to meet the duty cycle requirements for that system function. It is up to the system designer to ensure that adequate loading is attached to achieve the system goals for these types of functions.

6.1.2.3.5. Output Open Load Detection

This output type is equipped with open load detection circuitry. This feature is available for on state as well as off state of the output. For on state detection, open load is determined by the current flow on the OUTPUTx_IFB current sense reading. For the off state detection, the output injects a small leakage current on the output pin to detect the value of load connected. The activation of the open load off state current injection can be controlled by Application Software. Some load types may not tolerate the leakage current injected and therefore Application Software will want to disable the off state open load detection for those outputs. The following off state open load control is available:

- OUTPUT1 = Independently controlled
- OUTPUT2 = Independently controlled
- OUTPUT3, 5, 7, 9 = Batch controlled with 13, 15, 17, 19, 23, 25
- OUTPUT4, 6, 8, 10 = Batch controlled with 14, 16, 18, 20, 24, 26

When enabled, outputs of this type will check for open loads. When disabled outputs of this type will not check for open loads.

It is the system designer's responsibility to ensure that the loads connected to outputs of this type are not adversely affected by the leakage current specified. If they are, the open load detection feature should be disabled.

6.1.2.3.6. Output Used as Digital Input

This output type can be used as a digital input when the output is disabled and configured as a digital input in application software. This output type uses the off state open load strobe functionality to allow for digital input readings. When open load strobe is active, this allows the output to detect active low digital inputs on a switch that is high impedance in the off state. When open load strobe is inactive, this output can be used to detect active high digital inputs on a switch that is high impedance in the off state or is low in off state and high in the on state.

6.1.3. HS Output Type 9

OUTPUT5 to OUTPUT8 on the CM3033 are of this HS output type.

This output type provides:

- Switched VBATT_BANK1 (odd numbered outputs) and VBATT_BANK2 (even numbered outputs) to external loads
- Up to 2.5A of continuous output current
- Pulse width modulated (PWM) for output current control
- Soft start support for activation of high current inrush loads (bulbs, motors, capacitors, etc.)
- Connection to a variety of loads, including resistive, lamp, and LED
- Software controllable open load detection feature that can be disabled to reduce the amount of output leakage current in the off state making the output usable with many LED load types
- When output is disabled:
    - Usable as an active low digital input (with open load detection active)
    - Usable as an active high digital input (with open load detection inactive)

This output type detects and reports the following faults:

- Short circuit to ground – while output is on
- Short circuit to battery – while output is off
- Open load – while output is off
- Over current – while output is on

Warning: These output types are only protected against short to battery conditions that are at or below the voltage of the VBATT_BANKx associated with the output.

6.1.3.1. HS Output Type 9 Circuit Block

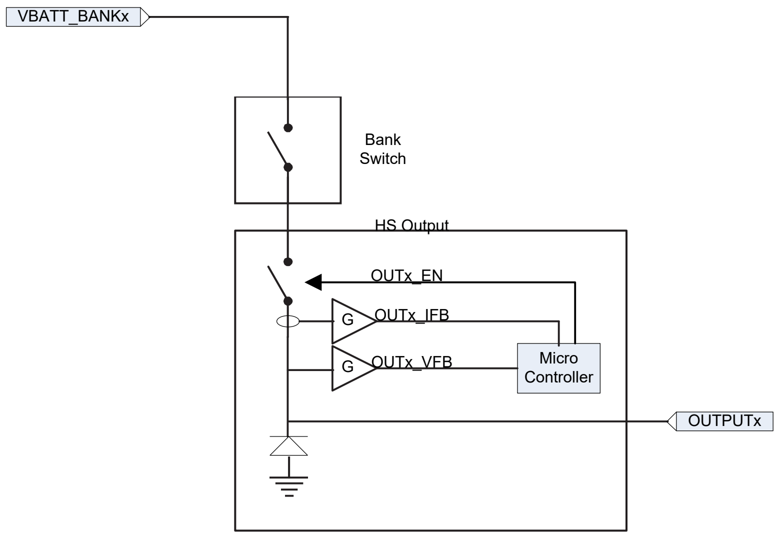


Figure 34: HS Output Type 9 Block Diagram

6.1.3.2. HS Output Type 9 Circuit Characteristics

This output type has the following characteristics:

Output Switch Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Output voltage range	0	-	36	V
Output Load Current Range	0	-	2.5	A
Short Circuit Current Limit	-	-	84	A
Over Current Detection	-	3.4	-	A
Output Resistance - w.r.t. ground: Output off state	-	36.52	-	kΩ
Output Resistance - w.r.t. VBATT_BANK_SWITCHED: Output on state, OUTx_OL_STROBE inactive	-	56	62	mΩ
Output Resistance - w.r.t. VBATT_BANK_SWITCHED: Output off state, OUTx_OL_STROBE active	-	37.4	-	kΩ
Output Leakage Current Output off state, OUTx_OL_STROBE inactive	-	-	30	uA
Output PWM Frequency	65	-	200	Hz
Output Duty Cycle Resolution- up to maximum frequency	-	0.1	-	%
Output PWM Frequency - Extended Range	>200	-	1000	Hz
Output Load Current Range • Extended PWM range	-	-	1	A
Output Duty Cycle Resolution - up to maximum frequency in extended range	-	0.2	-	%
Maximum output voltage over extended PWM range	-	-	32	V
Load Types over extended PWM range	-	Resistive Inductive	-	-
Turn on Delay – Off to On state	-	50	150	µs
Turn off Delay – On to Off State	-	50	150	µs
Turn on/off Slew Rate	1.4	-	-	V/µs
Output pin capacitance	-	10	-	nF

Current Sense Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Detectable current range [1]	0	-	33	A
Output voltage range [2]	-2	-	36	V
Gain (G)	-	8	-	A/V
Accuracy – Drift error				
• 0 – 500mA	-50%	-	+50%	%
• 500mA – 1.5A	-25%	-	+25%	%
• 1.5A – 2.5A	-12%	-	+9%	%
[1] The current sense on this output is intended for output protection and diagnostics and not for precision detection of current over the normal output operating range. This spec does not imply that the output can be driven up to this current level, refer to the switch parameters for more details. [2] This is the output voltage range that allows for detection of the current sense. A diode within the CM3033 circuitry prevents the output voltage from dropping below the minimum specified value and allows current from inductive loads to continue to flow and be measured when the output is off.				

Voltage Feedback Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Detectable Voltage range	0	-	36	V
Gain (G)	-	0.09091	-	V/V
Accuracy – Drift error (-40°C to +85°C)	-5	-	5	%
Accuracy – Offset error (-40°C to +85°C)	-	100	-	mV

Digital Measurement Parameters [1]				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Input voltage range (operational)	0	-	36	V
Input High Detection Threshold	-	2.2	-	V
Input Low Detection Threshold	-	1.1	-	V
Input pin capacitance	-	10	-	nF
[1] This table is relevant when the output is used as an input to detect digital states when the output is disabled (digital input functionality)				

6.1.3.3. HS Output Type 9 Usage Considerations

6.1.3.3.1. Load Inrush Current

All outputs on the CM3033 include short circuit protection. Many load types have current inrush which is a high current value when a load is first activated that reduces in value to a steady state current value over time. Certain load types may require the use of “soft starting” to prevent inrush currents to trip short circuit protection. Soft Starting causes an output to PWM from 0% to the set output PWM value whenever the output is activated. Soft Start time and end PWM value can be selected by Application Software.

6.1.3.3.2. Inductive Load PWM

When combining this output with an inductive load and a pulse width modulation output signal, a flyback diode is recommended to be added across the load in the system harness. There is no flyback diode present on this output type on the CM3033.

6.1.3.3.3. High Impedance Load PWM

When PWMing this output type, which is low resistance when on and high resistance when off, the shape of the output waveform may not be symmetrical. The rising edge (output turning on) is dominated by the slew rate for the output. The falling edge (output turning off) is dominated by on product output resistance to ground in parallel with any system load resistance which are both in parallel with the specified output pin capacitance.

Note: In systems where this output type is being used to PWM a high impedance load (like a digital input into another controller product), additional system load resistance to ground may be needed to make the corresponding output wave shape as symmetrical as required to meet the duty cycle requirements for that system function. It is up to the system designer to ensure that adequate loading is attached to achieve the system goals for these types of functions.

6.1.3.3.4. Output Open Load Detection

This output type is equipped with open load detection circuitry. This feature is available for off state of the output. For the off state detection, the output injects a small leakage current on the output pin to detect the value of load connected. The activation of the open load off state current injection can be controlled by Application Software. Some load types may not tolerate the leakage current injected and therefore Application Software will want to disable the off state open load detection for those outputs. The following off state open load control is available:

- OUTPUT5, 7 = Batch controlled with 3, 9, 13, 15, 17, 19, 23, 25
- OUTPUT6, 8 = Batch controlled with 4, 10, 14, 16, 18, 20, 24, 26

When enabled, outputs of this type will check for open loads. When disabled outputs of this type will not check for open loads.

It is the system designer's responsibility to ensure that the loads connected to outputs of this type are not adversely affected by the leakage current specified. If they are, the open load detection feature should be disabled.

6.1.3.3.5. Output Used as Digital Input

This output type can be used as a digital input when the output is disabled and configured as a digital input in application software. This output type uses the off state open load strobe functionality to allow for digital input readings. When open load strobe is active, this allows the output to detect active low digital inputs on a switch that is high impedance in the off state. When open load strobe is inactive, this output can be used to detect active high digital inputs on a switch that is high impedance in the off state or is low in off state and high in the on state.

6.1.4. HS Output Type 11

OUTPUT11 to OUTPUT12 on the CM3033 are of this HS output type.

This output type provides:

- Switched VBATT_BANK1 (odd numbered outputs) and VBATT_BANK2 (even numbered outputs) to external loads
- Up to 5A of continuous output current
- Accurate current sense analog feedback to the software
- Pulse width modulated (PWM) for output current control
- Integrated flyback diodes providing inductive load protection
- Soft start support for activation of high current inrush loads (bulbs, motors, capacitors, etc.)
- Connection to a variety of loads, including resistive, inductive, motor, lamp, and LED
- Software controllable open load detection feature that can be disabled to reduce the amount of output leakage current in the off state making the output usable with many LED load types
- When output is disabled:
    - Usable as an active low digital input (with open load detection active)
    - Usable as an active high digital input (with open load detection inactive)

This output type detects and reports the following faults:

- Short circuit to ground – while output is on
- Short circuit to battery – while output is off

- Open load – while output is off
- Open load – while output is on (via current sense with application software)
- Over current – while output is on

Warning: These output types are only protected against short to battery conditions that are at or below the voltage of the VBATT_BANKx associated with the output.

6.1.4.1. HS Output Type 11 Circuit Block

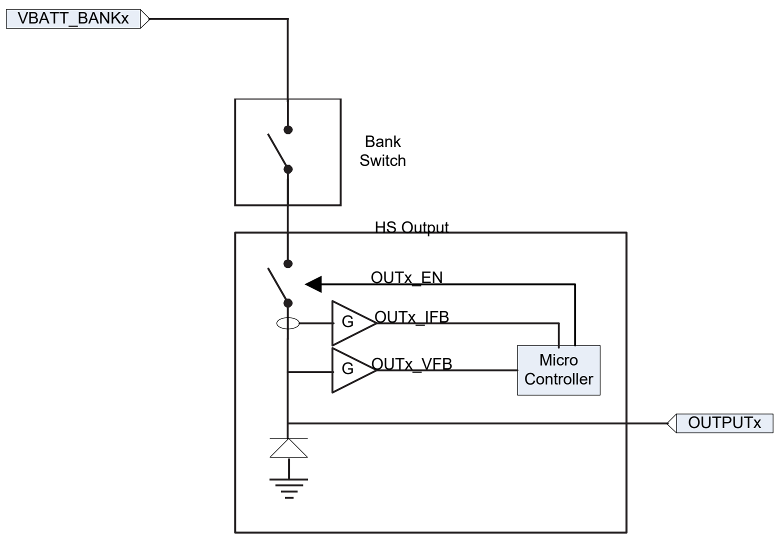


Figure 35: HS Output Type 11 Block Diagram

6.1.4.2. HS Output Type 11 Circuit Characteristics

This output type has the following characteristics:

Output Switch Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Output voltage range	0	-	36	V
Output Load Current Range	0	-	5	A
Short Circuit Current Limit	-	-	84	A
Over Current Detection	-	5.5	-	A
Output Resistance - w.r.t. ground: Output off state	-	36.52	-	kΩ
Output Resistance - w.r.t. BATT_BANK_SWITCHED: Output on state, OUTx_OL_STROBE inactive	-	21	23	mΩ
Output Resistance - w.r.t. BATT_BANK_SWITCHED: Output off state, OUTx_OL_STROBE active	-	37.4	-	kΩ
Output Leakage Current: Output off state, OUTx_OL_STROBE inactive	-	-	30	uA
Output PWM Frequency	65	-	200	Hz
Output Duty Cycle Resolution - up to maximum frequency	-	0.1	-	%
Output PWM Frequency - Extended Range	>200	-	1000	Hz
Output Load Current Range • Extended PWM range	-	-	1	A
Output Duty Cycle Resolution - up to maximum frequency in extended range	-	0.2	-	%
Maximum output voltage over extended PWM range	-	-	32	V
Load Types over extended PWM range	-	Resistive Inductive	-	-
Turn on Delay – Off to On state	-	70	150	μs
Turn off Delay – On to Off State	-	70	150	μs
Turn on/off Slew Rate	1.4	-	-	V / μs
Output pin capacitance	-	10	-	nF

Current Sense Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Detectable current range	0	-	5.5	A
Output voltage range [1]	-2	-	36	V
Gain (G)	-	1.33	-	A/V
Accuracy – Drift error (-40°C to +85°C)	-2	-	2	%
Accuracy – Offset error (-40°C to +85°C)	-	50	-	mA
[1] This is the output voltage range that allows for detection of the current sense. There is a diode within the CM3033 circuitry that prevents the output voltage from dropping below the minimum specified value and allows current from inductive loads to continue to flow and be measured when the output is off.				

Voltage Feedback Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**

Detectable Voltage range	0	-	36	V
Gain (G)	-	0.09091	-	V/V
Accuracy – Drift error (-40°C to +85°C)	-5	-	5	%
Accuracy – Offset error (-40°C to +85°C)	-	100	-	mV

Digital Measurement Parameters [1]				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Input voltage range (operational)	0	-	36	V
Input High Detection Threshold	-	2.2	-	V
Input Low Detection Threshold	-	1.1	-	V
Input pin capacitance	-	10	-	nF
[1] This table is relevant when the output is used as an input to detect digital states when the output is disabled (digital input functionality)				

6.1.4.3. HS Output Type 11 Usage Considerations

6.1.4.3.1. Current Feedback Aliasing

Aliasing is an artifact of discretely sampled analog values where the waveform being sampled changes at a rate faster than the rate at which you are sampling. The resulting sampled waveform appears to change at a much slower frequency than the real waveform changes, known as an “alias” of the true waveform. This slow frequency looks like low frequency noise on the waveform and cannot be filtered out with application software filtering. Figure 32 shows a waveform sampled at a higher frequency than the waveform frequency and Figure 337 shows the result of aliasing, that is, sampling at a slower frequency than the waveform frequency.

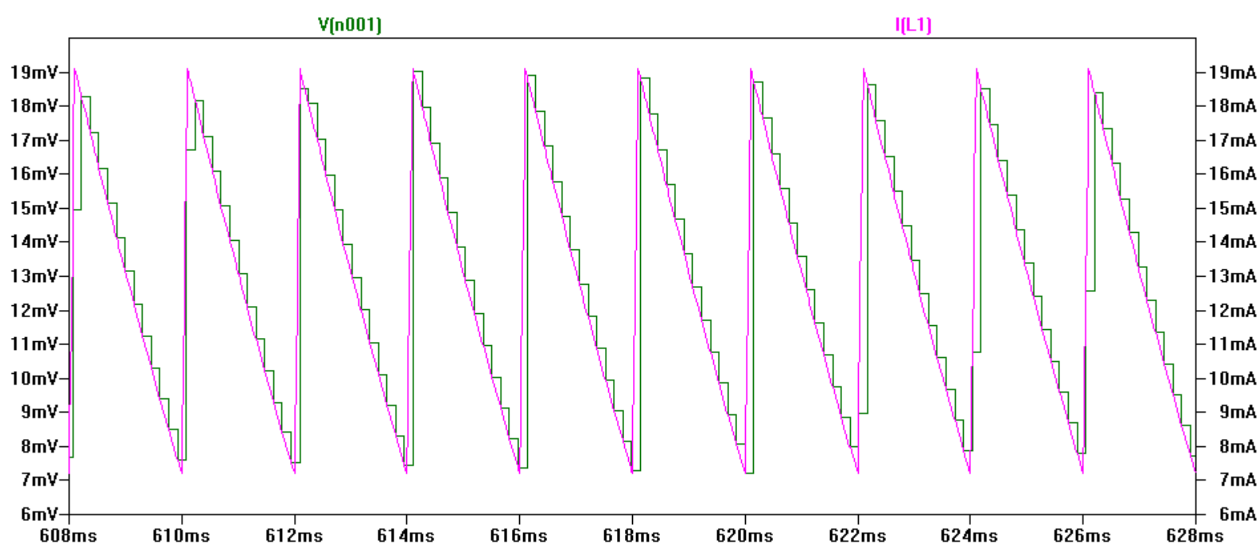


Figure 36: Sampled waveform (V(n001)) at a sample rate faster than analog waveform (I(L1))

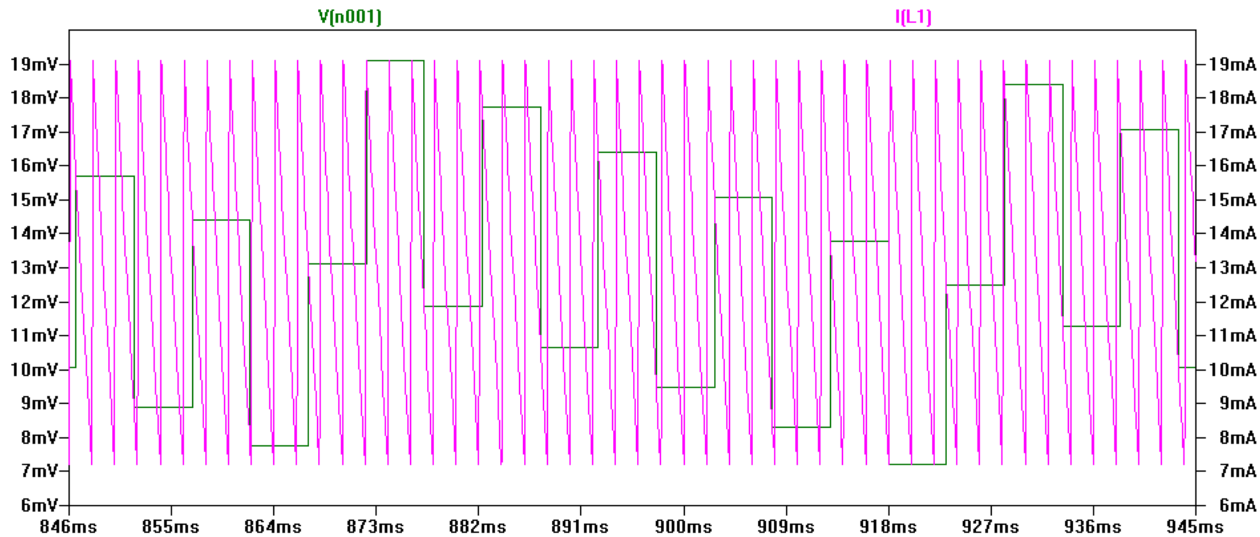


Figure 37: Sampled waveform (V(n001)) at a sample rate slower than analog waveform (I(L1))

The solution to aliasing is to ensure that a waveform is sampled at a frequency that is at least 2 times higher than the frequency of the physical waveform. For output PWM current control, application software samples the current sense feedback to determine what adjustments are required on the PWM duty cycle of an output to maintain a set current value. Since application software cannot always run at a rate fast enough to ensure the 2 times PWM rate, the CM3033 provides the ability to oversample at a rate of 10 times the maximum PWM rate and provide software low pass filtering of the oversampled values. The cutoff frequency for these filters can be changed by application software if required, but it should not be selected as a value that is greater than half the frequency of the application run thread frequency.

6.1.4.3.2. Load Inrush Current

All outputs on the CM3033 include short circuit protection. Many load types have current inrush which is a high current value when a load is first activated that reduces in value to a steady state current value over time. Certain load types may require the use of "soft starting" to prevent inrush currents to trip short circuit protection. Soft Starting causes an output to PWM from 0% to the set output PWM value whenever the output is activated. Soft Start time and end PWM value can be selected by Application Software.

6.1.4.3.3. Inductive Load PWM

When combining this output with an inductive load and a pulse width modulation output signal, the off state cycle of the output will conduct current from the ground connection of the load back through vehicle ground into the product through the integrated diode on the output circuit. To reduce the amount of electrical noise generated in this type of setup, it is recommended that the load be grounded close to the power ground of the module. Some techniques that can help reduce system noise include running twisted pair wire for load positive and negative connections or running shielded cable to the loads.

It is the system designer's responsibility to ensure that noise induced on a system design due to output load PWMing does not result in violating electromagnetic emissions requirements for that system.

6.1.4.3.4. *High Impedance Load PWM*

When PWMing this output type, which is low resistance when on and high resistance when off, the shape of the output waveform may not be symmetrical. The rising edge (output turning on) is dominated by the slew rate for the output. The falling edge (output turning off) is dominated by on product output resistance to ground in parallel with any system load resistance which are both in parallel with the specified output pin capacitance.

Note: In systems where this output type is being used to PWM a high impedance load (like a digital input into another controller product), additional system load resistance to ground may be needed to make the corresponding output wave shape as symmetrical as required to meet the duty cycle requirements for that system function. It is up to the system designer to ensure that adequate loading is attached to achieve the system goals for these types of functions.

6.1.4.3.5. *Output Open Load Detection*

This output type is equipped with open load detection circuitry. This feature is available for on state as well as off state of the output. For on state detection, open load is determined by the current flow on the OUTPUTx_IFB current sense reading. For the off state detection, the output injects a small leakage current on the output pin to detect the value of load connected. The activation of the open load off state current injection can be controlled by Application Software. Some load types may not tolerate the leakage current injected and therefore Application Software will want to disable the off state open load detection for those outputs. The following off state open load control is available:

- OUTPUT11 = Independently controlled
- OUTPUT12 = Independently controlled

When enabled, outputs of this type will check for open loads. When disabled outputs of this type will not check for open loads.

It is the system designer's responsibility to ensure that the loads connected to outputs of this type are not adversely affected by the leakage current specified. If they are, the open load detection feature should be disabled.

6.1.4.3.6. *Output Used as Digital Input*

This output type can be used as a digital input when the output is disabled and configured as a digital input in application software. This output type uses the off state open load strobe functionality to allow for digital input readings. When open load strobe is active, this allows the output to detect active low digital inputs on a switch that is high impedance in the off state. When open load strobe is inactive, this output can be used to detect active high digital inputs on a switch that is high impedance in the off state or is low in off state and high in the on state.

6.1.5. HS Output Type 12

OUTPUT13 to OUTPUT20 on the CM3033 are of this HS output type.

This output type provides:

- Switched VBATT_BANK1 (odd numbered outputs) and VBATT_BANK2 (even numbered outputs) to external loads
- Up to 5A of continuous output current
- Pulse width modulated (PWM) for output current control
- Soft start support for activation of high current inrush loads (bulbs, motors, capacitors, etc.)
- Connection to a variety of loads, including resistive, lamp, and LED
- Software controllable open load detection feature that can be disabled to reduce the amount of output leakage current in the off state making the output usable with many LED load types
- When output is disabled:
  - Usable as an active low digital input (with open load detection active)
  - Usable as an active high digital input (with open load detection inactive)

This output type detects and reports the following faults:

- Short circuit to ground – while output is on
- Short circuit to battery – while output is off
- Open load – while output is off
- Open load – while output is on (via current sense with application SW)
- Over current – while output is on

Warning: These output types are only protected against short to battery conditions that are at or below the voltage of the VBATT_BANKx associated with the output.

Warning: These outputs do not include an internal flyback diode for inductive load protection. If connecting inductive loads to these outputs, use of a flyback diode across the load in the system harness should be used to prevent potential damage to these outputs.

6.1.5.1. HS Output Type 12 Circuit Block

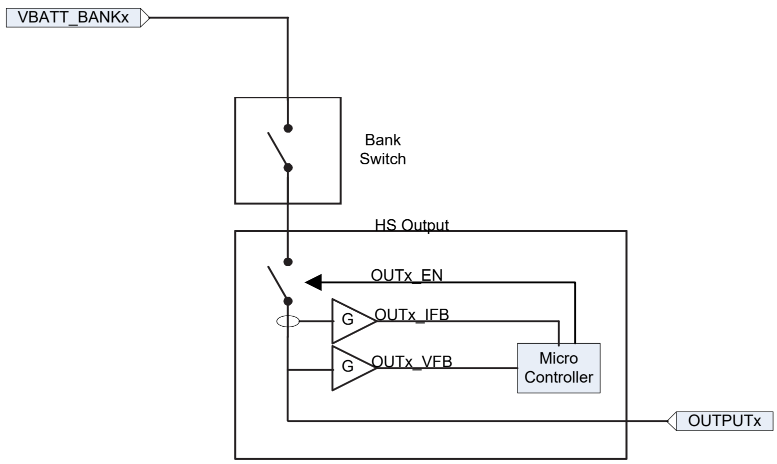


Figure 38: HS Output Type 11 Block Diagram

6.1.5.2. HS Output Type 12 Circuit Characteristics

This output type has the following characteristics:

Output Switch Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Output voltage range	0	-	36	V
Output Load Current Range	0	-	5	A
Short Circuit Current Limit	-	-	84	A
Over Current Detection	-	5.5	-	A
Output Resistance - w.r.t. ground: Output off state	-	36.52	-	kΩ
Output Resistance - w.r.t. VBATT_BANK_SWITCHED: Output on state, OUTx_OL_STROBE inactive	-	21	23	mΩ
Output Resistance - w.r.t. VBATT_BANK_SWITCHED: Output off state, OUTx_OL_STROBE active	-	37.4	-	kΩ
Output Leakage Current: Output off state, OUTx_OL_STROBE inactive	-	-	30	uA
Output PWM Frequency	65	-	200	Hz
Output Duty Cycle Resolution - up to maximum frequency	-	0.1	-	%
Output PWM Frequency - Extended Range	>200	-	1000	Hz
Output Load Current Range • Extended PWM range	-	-	1	A
Output Duty Cycle Resolution - up to maximum frequency in extended range	-	0.2	-	%
Maximum output voltage over extended PWM range	-	-	32	V
Load Types over extended PWM range	-	Resistive Inductive	-	-
Turn on Delay – Off to On state	-	70	150	μs
Turn off Delay – On to Off State	-	70	150	μs
Turn on/off Slew Rate	1.4	-	-	V/μs
Output pin capacitance	-	10	-	nF

Current Sense Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Detectable current range [1]	0	-	57	A
Output voltage range [2]	-2	-	36	V
Gain (G)	-	14	-	A/V
Accuracy – Drift error				
• 0 – 50mA	-50%	-	+50%	%
• 50mA – 500mA	-40%	-	+40%	%
• 500mA – 2A	-18%	-	+18%	%
• 2A – 4A	-10%	-	+10%	%
• 4.0A – 5A	-9%	-	+9%	%
[1] The current sense on this output is intended for output protection and diagnostics and not for precision detection of current over the normal output operating range. This spec does not imply that the output can be driven up to this current level, refer to the switch parameters for more details. [2] This is the output voltage range that allows for detection of the current sense. There is a diode within the CM3033 circuitry that prevents the output voltage from dropping below the minimum specified value and allows current from inductive loads to continue to flow and be measured when the output is off.				

Voltage Feedback Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Detectable Voltage range	0	-	36	V
Gain (G)	-	0.09091	-	V/V
Accuracy – Drift error (-40°C to +85°C)	-5	-	5	%
Accuracy – Offset error (-40°C to +85°C)	-	100	-	mV

Digital Measurement Parameters [1]				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Input voltage range (operational)	0	-	36	V
Input High Detection Threshold	-	2.2	-	V
Input Low Detection Threshold	-	1.1	-	V
Input pin capacitance	-	10	-	nF
[1] This table is relevant when the output is used as an input to detect digital states when the output is disabled (digital input functionality)				

6.1.5.3. HS Output Type 12 Usage Considerations

6.1.5.3.1. Load Inrush Current

All outputs on the CM3033 include short circuit protection. Many load types have current inrush which is a high current value when a load is first activated that reduces in value to a steady state current value over time. Certain load types may require the use of “soft starting” to prevent inrush currents to trip short circuit protection. Soft Starting causes an output to PWM from 0% to the set output PWM value whenever the output is activated. Soft Start time and end PWM value can be selected by Application Software.

6.1.5.3.2. *Inductive Load PWM*

When combining this output with an inductive load and a pulse width modulation output signal, a back EMF diode is recommended to be added across the load in the system harness. There is no back EMF diode present on this output type on the CM3033.

6.1.5.3.3. *High Impedance Load PWM*

When PWMing this output type, which is low resistance when on and high resistance when off, the shape of the output waveform may not be symmetrical. The rising edge (output turning on) is dominated by the slew rate for the output. The falling edge (output turning off) is dominated by on product output resistance to ground in parallel with any system load resistance which are both in parallel with the specified output pin capacitance.

Note: In systems where this output type is being used to PWM a high impedance load (like a digital input into another controller product), additional system load resistance to ground may be needed to make the corresponding output wave shape as symmetrical as required to meet the duty cycle requirements for that system function. It is up to the system designer to ensure that adequate loading is attached to achieve the system goals for these types of functions.

6.1.5.3.4. *Output Open Load Detection*

This output type is equipped with open load detection circuitry. This feature is available for off state of the output. For the off state detection, the output injects a small leakage current on the output pin to detect the value of load connected. The activation of the open load off state current injection can be controlled by Application Software. Some load types may not tolerate the leakage current injected and therefore Application Software will want to disable the off state open load detection for those outputs. The following off state open load control is available:

- OUTPUT13, 15, 17, 19 = Batch controlled with 3, 5, 7, 9, 23, 25
- OUTPUT14, 16, 18, 20 = Batch controlled with 4, 6, 8, 10, 24, 26

When enabled, outputs of this type will check for open loads. When disabled outputs of this type will not check for open loads.

It is the system designer’s responsibility to ensure that the loads connected to outputs of this type are not adversely affected by the leakage current specified. If they are, the open load detection feature should be disabled.

6.1.5.3.5. *Output Used as Digital Input*

This output type can be used as a digital input when the output is disabled and configured as a digital input in application software. This output type uses the off state open load strobe functionality to allow for digital input readings. When open load strobe is active, this allows the output to detect active low digital inputs on a switch that is high impedance in the off state. When open load strobe is inactive, this output can be used to detect active high digital inputs on a switch that is high impedance in the off state or is low in off state and high in the on state.

6.1.6. HS Output Type 7

OUTPUT21 to OUTPUT26 on the CM3033 are of this HS output type.

This output type provides:

- Switched VBATT_BANK1 (OUTPUT21) and VBATT_BANK2 (OUTPUT22) to external loads
- Independent VBATT_BANK_OUTx connections on product connector for OUTPUT23 to OUTPUT26
- Up to 10A of continuous output current
- Pulse width modulated (PWM) for output current control
- Connection to a variety of loads, including resistive, lamp, and LED
- Software controllable open load detection feature that can be disabled to reduce the amount of output leakage current in the off state making the output usable with many LED load types
- Connection with LS Output Type 2 outputs to create half H-Bridge and full H-Bridge functionality
- When output is disabled:
    - Usable as an active low digital input (with open load detection active)
    - Usable as an active high digital input (without open load detection)

This output type detects and reports the following faults:

- Short circuit to ground – while output is on
- Short circuit to battery – while output is off
- Open load – while output is off
- Open load – while output is on (via current sense with application SW)
- Over current – while output is on

Warning: These output types are only protected against short to battery conditions that are at or below the voltage of the VBATT_BANKx associated with the output.

Warning: These outputs do not include an internal flyback diode for inductive load protection. If connecting inductive loads to these outputs, use of a flyback diode across the load in the system harness should be used to prevent potential damage to these outputs.

6.1.6.1. HS Output Type 7 Circuit Block

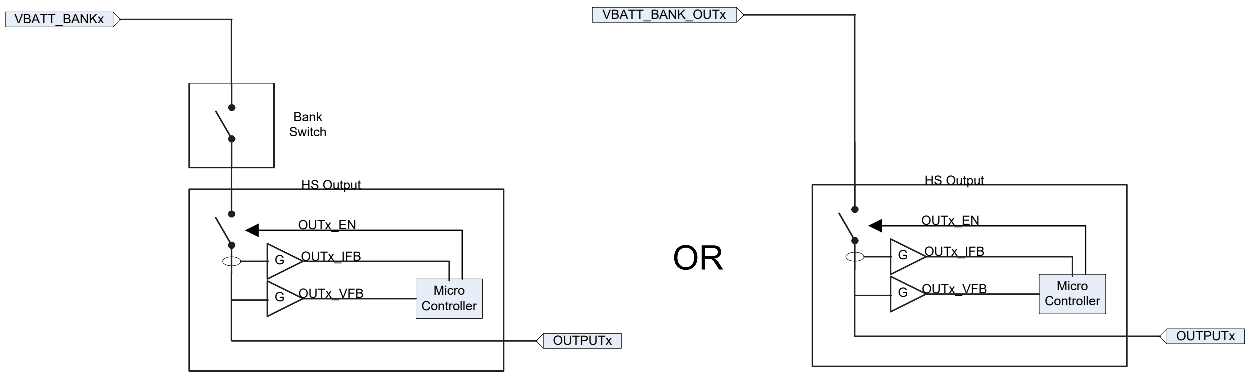


Figure 39: HS Output Type 7 Block Diagram

6.1.6.2. HS Output Type 7 Circuit Characteristics

This output type has the following characteristics:

Output Switch Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Output voltage range	0	-	36	V
Output Load Current Range	0	-	10	A
Short Circuit Current Limit	-	-	84	A
Over Current Detection	-	10.5	-	A
Output Resistance - w.r.t. ground: Output off state	-	9.72	-	kΩ
Output Resistance - w.r.t. Output on state	-	8.2	9.5	mΩ
Output Leakage Current - Output OFF state	-		100	uA
Output PWM Frequency	-	-	200	Hz
Output Duty Cycle Resolution – up to maximum frequency	-	0.1	-	%
Output PWM Frequency – Extended Range	>200	-	1000	Hz
Output Load Current Range • Extended PWM range	-	-	1	A
Output Duty Cycle Resolution – up to maximum frequency in extended range	-	0.2	-	%
Maximum load voltage over extended PWM range	-	-	32	V
Load Types over extended PWM range	-	Resistive	-	-
Output pin capacitance	-	10	-	nF

Current Sense Parameters[1]				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Detectable current range	0	-	10.5	A
Gain (G)	-	13	-	A/V
Accuracy – Drift error				
• 4A	-46	-	36	%
• 10A	-36	-	25	%
[1] The current sense on this output is intended for output protection and diagnostics and not for precision detection of current over the normal output operating range. This spec does not imply that the output can be driven up to this current level, refer to the switch parameters for more details.				

Digital Feedback Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Voltage range (operational)	0	-	36	V
Output High Detection Threshold	-	2.5	-	V
Output Low Detection Threshold	-	2.1	-	V
Input pin capacitance	-	10	-	nF

6.1.6.3. HS Output Type 7 Usage Considerations

6.1.6.3.1. Load Inrush Current

All outputs on the CM3033 include short circuit protection. Many load types have current inrush which is a high current value when a load is first activated that reduces in value to a steady state current value over time. Certain load types may require the use of “soft starting” to prevent inrush currents to trip short circuit protection. Soft Starting causes an output to PWM from 0% to the set output PWM value whenever the output is activated. Soft Start time and end PWM value can be selected by Application Software.

6.1.6.3.2. *Inductive Load PWM*

When combining this output with an inductive load and a pulse width modulation output signal, a back EMF diode is recommended to be added across the load in the system harness. There is no back EMF diode present on this output type on the CM3033.

6.1.6.3.3. *High Impedance Load PWM*

When PWMing this output type, which is low resistance when on and high resistance when off, the shape of the output waveform may not be symmetrical. The rising edge (output turning on) is dominated by the slew rate for the output. The falling edge (output turning off) is dominated by on product output resistance to ground in parallel with any system load resistance which are both in parallel with the specified output pin capacitance.

Note: In systems where this output type is being used to PWM a high impedance load (like a digital input into another controller product), additional system load resistance to ground may be needed to make the corresponding output wave shape as symmetrical as required to meet the duty cycle requirements for that system function. It is up to the system designer to ensure that adequate loading is attached to achieve the system goals for these types of functions.

6.1.6.3.4. *Output Open Load Detection*

This output type is equipped with open load detection circuitry. This feature is available for off state of the output. For the off state detection, the output injects a small leakage current on the output pin to detect the value of load connected. The activation of the open load off state current injection can be controlled by Application Software. Some load types may not tolerate the leakage current injected and therefore Application Software will want to disable the off state open load detection for those outputs. The following off state open load control is available:

- OUTPUT21 = Independently controlled
- OUTPUT22 = Independently controlled
- OUTPUT23, 25 = Batch controlled with 3, 5, 7, 9, 13, 15, 17, 19
- OUTPUT24, 26 = Batch controlled with 4, 6, 8, 10, 14, 16, 18, 20

When enabled, outputs of this type will check for open loads. When disabled outputs of this type will not check for open loads.

It is the system designer's responsibility to ensure that the loads connected to outputs of this type are not adversely affected by the leakage current specified. If they are, the open load detection feature should be disabled.

6.1.6.3.5. Output Used as Digital Input

This output type can be used as a digital input when the output is disabled and configured as a digital input in application software. This output type uses the off state open load strobe functionality to allow for digital input readings. When open load strobe is active, this allows the output to detect active low digital inputs on a switch that is high impedance in the off state. When open load strobe is inactive, this output can be used to detect active high digital inputs on a switch that is high impedance in the off state or is low in off state and high in the on state.

Detection of the digital states is handled by the CM3033 software using the digital feedback signals on these outputs.

6.1.6.3.6. H-Bridge Connection

This output type can be wired with Low Side Output Type 2 outputs to create half H-Bridge and full H-Bridge outputs. A total of 6 half H-Bridges and 3 full H-Bridges can be configured. The configurations are shown below:

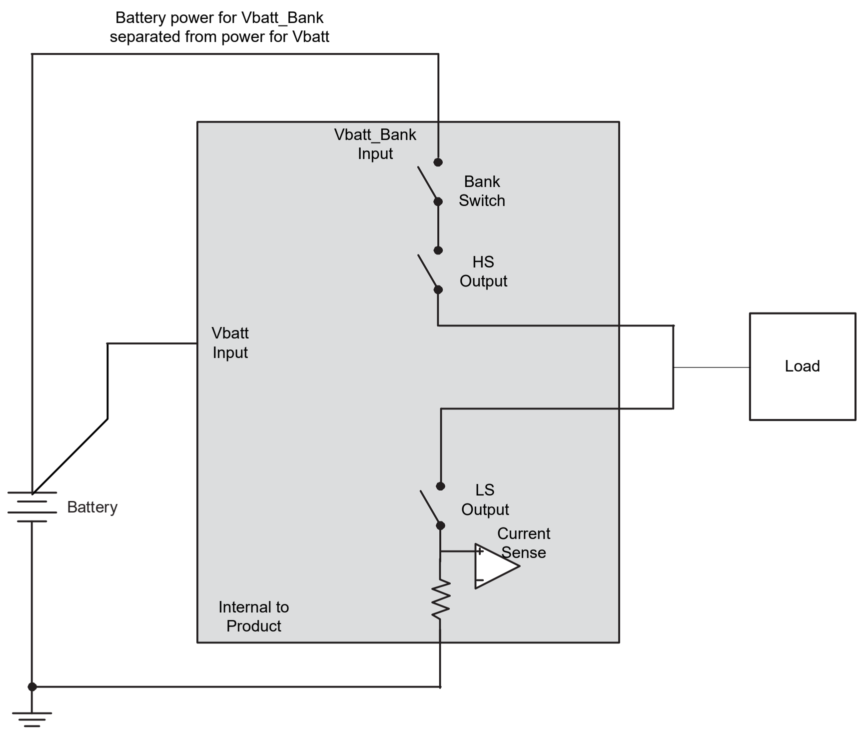


Figure 40: Half H-Bridge Output Configuration – Push/Pull Output

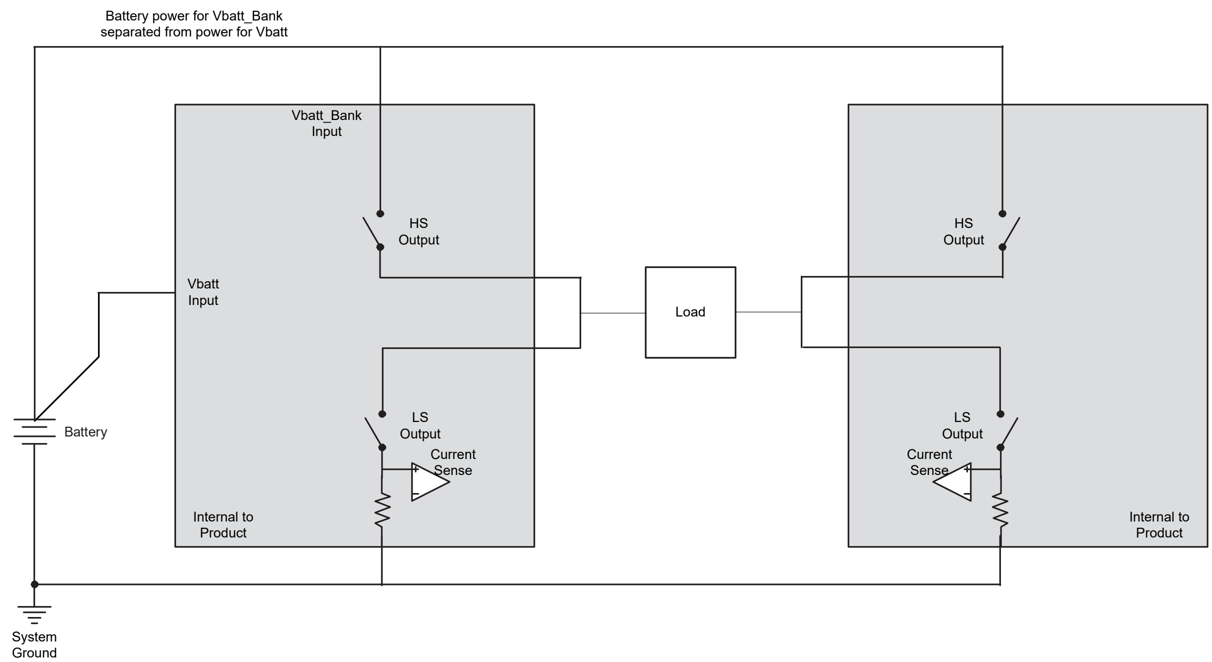


Figure 41: Full H-Bridge Output Configuration – Directional Control

When outputs are configured for use as half or full H-Bridges, the CM3033 software ensures proper timing control to prevent "shoot through" when activating/ deactivating the high side and low side outputs. Application Software is not required to handle activation timing between the output types.

6.2. Low Side Outputs

The CM3033 has 6 low side outputs.

- LS Output Type 2 – 10A output with current sense

Low side outputs are used to switch ground to the output pin of the CM3033. They switch loads on and off according to the following diagram:

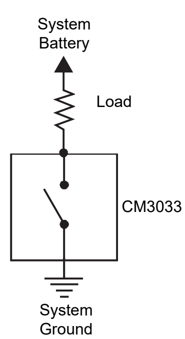


Figure 42: Low Side Output Configuration

6.2.1. LS Output Type 2

OUTPUT27 to OUTPUT32 on the CM3033 are of this LS output type.

This output type provides:

- Switched ground to external loads
- Up to 10A of continuous output current
- Accurate current sense analog feedback to the software
- Connection to a variety of loads, including resistive, inductive, motor, and lamp
- Open load detection feature
- Connection with HS Output Type 7 outputs to create half H-Bridge and full H-Bridge functionality
- When output is disabled:
    - Usable as an active high digital input

This output type detects and reports the following faults:

- Short circuit to battery – while output is on
- Short circuit to ground – while output is off
- Open load – while output is off
- Open load – while output is on (via current sense with application SW)
- Over current – while output is on

Warning: These outputs do not include an internal flyback diode for inductive load protection. If connecting inductive loads to these outputs, use of a flyback diode across the load in the system harness should be used to prevent potential damage to these outputs.

6.2.1.1. LS Output Type 2 Circuit Block

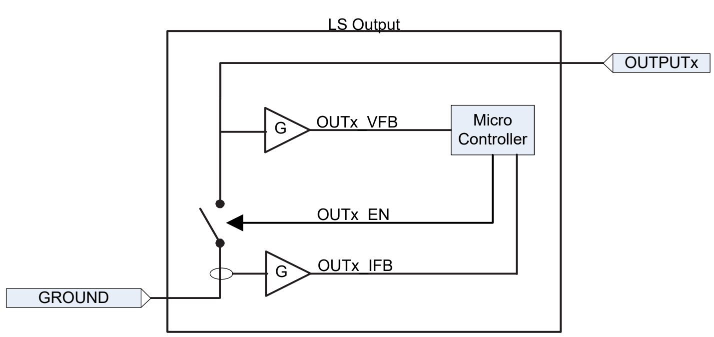


Figure 43: LS Output Type 2 Block Diagram

6.2.1.2. LS Output Type 2 Circuit Characteristics

This output type has the following characteristics:

Output Switch Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Output voltage range	0	-	36	V
Output Load Current Range	0	-	10	A
Short Circuit Current Limit	-	-	84	A
Over Current Detection	-	5.5	-	A
Output Resistance - w.r.t. ground: Output off state	-	36.52	-	kΩ
Output Resistance - w.r.t. VBATT_BANK_SWITCHED: Output on state, OUTx_OL_STROBE inactive	-	21	23	mΩ
Output Resistance - w.r.t. VBATT_BANK_SWITCHED: Output off state, OUTx_OL_STROBE active	-	37.4	-	kΩ
Output Leakage Current: Output off state, OUTx_OL_STROBE inactive	-	-	30	uA
Output PWM Frequency	65	-	200	Hz
Output Duty Cycle Resolution - up to maximum frequency	-	0.1	-	%
Output PWM Frequency - Extended Range	>200	-	1000	Hz
Output Load Current Range • Extended PWM range	-	-	1	A
Output Duty Cycle Resolution - up to maximum frequency in extended range	-	0.2	-	%
Maximum output voltage over extended PWM range	-	-	32	V
Load Types over extended PWM range	-	Resistive Inductive	-	-
Turn on Delay – Off to On state	-	70	150	μs
Turn off Delay – On to Off State	-	70	150	μs
Turn on/off Slew Rate	1.4	-	-	V/μs
Output pin capacitance	-	10	-	nF

Current Sense Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Detectable current range	0	-	10.5	A
Gain (G)	-	5.76	-	A/V
Accuracy – Drift error (-40°C to +85°C)	-2	-	2	%
Accuracy – Offset error (-40°C to +85°C)	-	100	-	mA
Note 1: The current sense on this output is intended for output protection and diagnostics and not for precision detection of current over the normal output operating range. This spec does not imply that the output can be driven up to this current level, refer to the switch parameters for more details. ***Note 2:*** This is the output voltage range that allows for detection of the current sense. A diode in the CM3033 circuitry prevents the output voltage from dropping below the minimum specified value and allows current from inductive loads to continue to flow and be measured when the output is off.				

Digital Feedback Parameters

Parameter	Min	Nom	Max	Unit
Voltage range (operational)	0	-	36	V
Output High Detection Threshold	2.10	-	-	V
Output Low Detection Threshold	-	-	0.803	V
Input pin capacitance	-	10	-	nF

6.2.1.3. LS Output Type 2 Usage Considerations

6.2.1.3.1. Current Feedback

This output type has current sense feedback to indicate the current being delivered to a load. Typically, this is used when the Low Side output is combined with a high side driver that can be PWM'd. When combined in this way, the current sense values from this low side output are used to control the PWM duty cycle of the high side output. This can be useful in systems where two outputs are required to ensure that the load current can be turned off even in the event of a short circuit to battery or ground within the harness. This is also useful if there are no high side PWM outputs with current sense available. This arrangement is shown below.

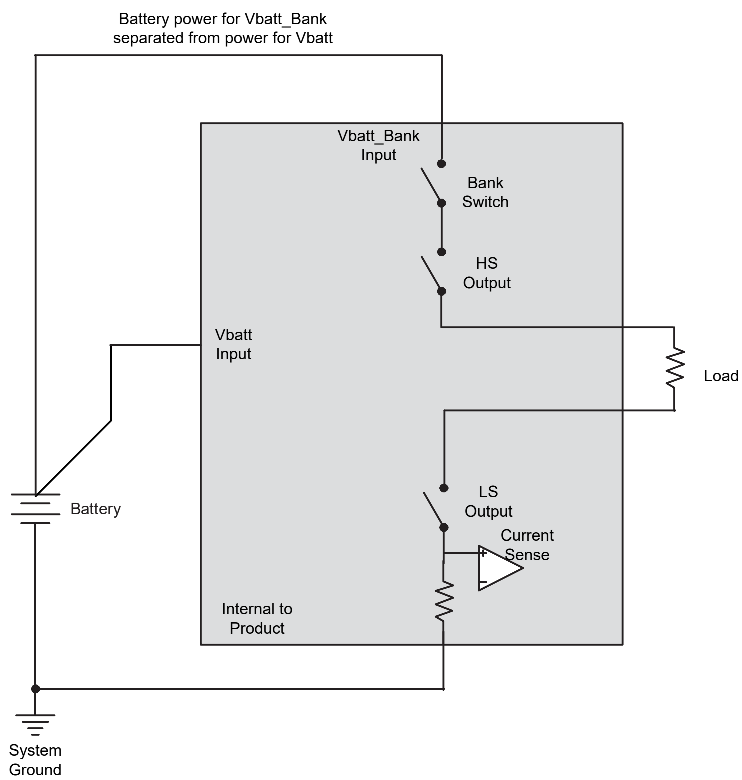


Figure 44: Low Side Output Combined with High Side Output

6.2.1.3.2. Current Feedback Aliasing

The aliasing considerations provided in section 6.1.2.3.1 also apply on this output type.

6.2.1.3.3. Load Inrush Current

All outputs on the CM3033 include short circuit protection. Many load types have current inrush which is a high current value when a load is first activated that reduces in value to a steady state current value over time. Certain load types may require the use of “soft starting” to prevent inrush currents to trip short circuit protection. Soft Starting causes an output to PWM from 0% to the set output PWM value whenever the output is activated. Soft Start time and end PWM value can be selected by Application Software.

6.2.1.3.4. Output Wiring

When this output is combined with a high side driver, it is recommended that twisted pair wire (or shielded twisted pair) be used for the positive (from the high side output) and negative (from this output) wiring. This will reduce the electromagnetic noise induced within the wire harness when the output combination is pulse width modulating.

It is the system designer’s responsibility to ensure that noise induced on a system design due to output load PWMing does not result in violating electromagnetic emissions requirements for that system.

6.2.1.3.5. Output Open Load Detection

This output type is equipped with open load detection circuitry. This feature is available for on state as well as off state of the output. For on state detection, open load is determined by the current flow on the OUTPUTx_IFB current sense reading. For the off state detection, the output injects a small leakage current on the output pin to detect the value of load connected. The activation of the open load off state current injection can be controlled by Application Software. Some load types may not tolerate the leakage current injected and therefore Application Software will want to disable the off state open load detection for those outputs. The following off state open load control is available:

- OUTPUT27 to OUTPUT32 = Batch controlled

When enabled, outputs of this type will check for open loads. When disabled outputs of this type will not check for open loads.

It is the system designer's responsibility to ensure that the loads connected to outputs of this type are not adversely affected by the leakage current specified. If they are, the open load detection feature should be disabled.

6.2.1.3.6. Output Used as Digital Input

This output type can be used as a digital input when the output is disabled and configured as a digital input in application software. This output can be used to detect active high digital inputs on a switch that is high impedance in the off state or is low in off state and high in the on state.

6.2.1.3.7. H-Bridge Connection

This output type can be wired with High Side Output Type 7 outputs to create half H-Bridge and full H-Bridge outputs. Refer to section 6.1.6.3.6 for information on H-Bridge connections of this output type.

6.2.1.3.8. High Impedance Load PWM

When PWMing this output type, which is low resistance when on and high resistance when off, the shape of the output waveform may not be symmetrical. The falling edge (output turning on) is dominated by the slew rate for the output. The rising edge (output turning off) is dominated by any system load resistance which interacts with the specified output pin capacitance.

Note: In systems where this output type is being used to PWM a high impedance load (like a digital input into another controller product), additional system load resistance to power may be needed to make the corresponding output wave shape as symmetrical as required to meet the duty cycle requirements for that system function. It is up to the system designer to ensure that adequate loading is attached to achieve the system goals for these types of functions.

6.3. Regulated Outputs

The CM3033 has one regulated output type.

6.3.1. Regulated Output Type 1

OUTPUT33 is of this regulated output type.

This output type provides:

- Regulated output with software selection of either 5V or 8V

- Up to 1A of continuous output current
- Voltage sense analog feedback to the software
- Connection to power external system sensors

This output type does not report any faults directly, but the voltage feedback can be used by software to detect voltage out of range conditions. This output type is protected against:

- Short circuit to ground

Warning: Regulated output type 1 is not protected against short to battery conditions.

6.3.1.1. Regulated Output Type 1 Circuit Block

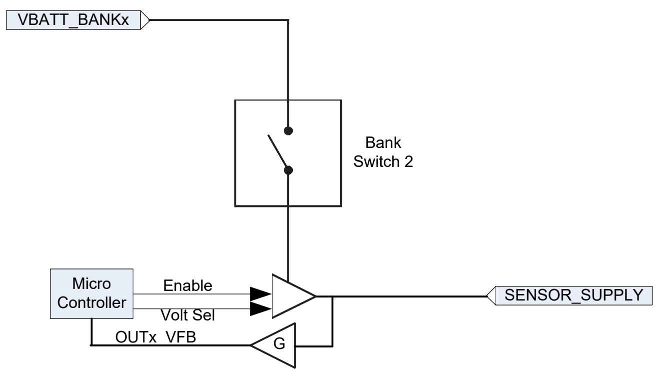


Figure 45: Regulated Output Type 1 Block Diagram

6.3.1.2. Regulated Output Type 1 Circuit Characteristics

This output type has the following characteristics:

Output Regulator Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**
VBATT minimum for proper operation (-40C to 85C) OUTx_8V_EN inactive [1]	6	-	-	V
Output Pin Voltage Range (-40C to 85C) OUTx_8V_EN inactive	4.73	5.02	5.31	V
VBATT minimum for proper operation (-40C to 85C) OUTx_8V_EN active	10	-	-	V
Output Pin Voltage Range (-40C to 85C) OUTx_8V_EN active	7.62	8.1	8.57	V
Output Current	0	-	1	A
Output Ripple Voltage (peak to peak)	-	85	-	mV
Output Resistance (with respect to ground) Output off state	-	20	-	kΩ
Output Capacitance	-	220	-	µF
[1] If the voltage drops below approximately Vout + 1V the output voltage will start to drop out of regulation. So, when configured for voltages greater than 5V, ensure that VBATT on the appropriate bus bar is higher than the output voltage.				

Voltage Feedback Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Detectable output voltage range	0	-	9.4	V
Gain (G)	-	0.434	-	V/V
Cutoff Freq	-	736	-	Hz
Accuracy – Offset error (-40°C to +85°C) OUTx_SENSOR_CON from 0V to 8.0V	-9.2	-	9.2	mV
Accuracy – Drift error (-40°C to +85°C)	-3	-	3	%

6.3.1.3. Regulated Output Type 1 Usage Considerations

6.3.1.3.1. Output Voltage Selection

This output is implemented as a circuit that can be programmed for one of two output voltages (5V or 8V). This is intended to allow this output to be used to connect to either 5V or 8V sensor types. The output should be disabled prior to selecting the 5V or 8V option. The output should only be re-enabled after the appropriate output voltage setting has been selected.

See the CM3033 Software documentation for more information on how to select the output voltage for this output type.

6.3.1.3.2. Output Loads

This output type is intended to be used to power external sensors in a system. This output is not to be used with inductive, motor, or bulb loads.

6.3.1.3.3. Voltage Feedback

The voltage feedback provided on this output is intended to be used in conjunction with the reading on the analog input that a sensor is connected to. If for example a resistive three wire sensor is powered by this supply and its output signal is being measured on INPUT9, the software should measure the value of the OUTPUT33 along with INPUT9 to reduce measurement error associated with the OUTPUT33 voltage tolerance.

This does not completely eliminate the error associated with OUTPUT33 because there is measurement error associated with measuring the SENSOR_SUPPLY_VFB.

6.3.1.3.4. Output Fall Time

This output does not sink current it can only source current. This means that the fall time is dependent on the load attached to the output pin and the output pin capacitance. As soon as this output is deactivated, the charge on the output pin capacitance will start discharging through the loads connected.

Output fall time is only a concern for systems that require loads connected to this output to turn off in a certain period of time. This is usually not a constraint in most systems because the sensors being driven by this output type are being measured by the CM3033 inputs and those input values can be ignored by software if this output is disabled.

It is the system designer’s responsibility to ensure that loads connected to this output turn off in the required time to satisfy system design requirements.

6.3.1.3.5. *Output Wiring*

This output is intended to provide low current sensor power to systems sensors that are then measured by the CM3033 analog inputs. To ensure that the system reduces the amount of voltage drop noise induced on analog measurements, a dedicated low current “sensor ground” pin has been provided on the CM3033 (see section 4.1 for the sensor ground pin location). All sensors connected to this product should include a return ground pin that is connected back to the sensor ground pin on the CM3033. Sensors that are grounded to locations other than this sensor ground pin will see increased error due to additional current induced voltage drops in the system.

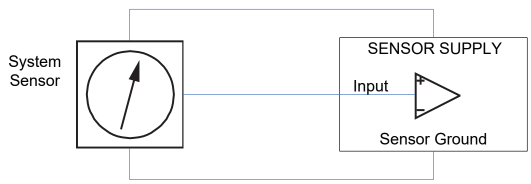


Figure 46: Ground wiring scheme that is RECOMMENDED

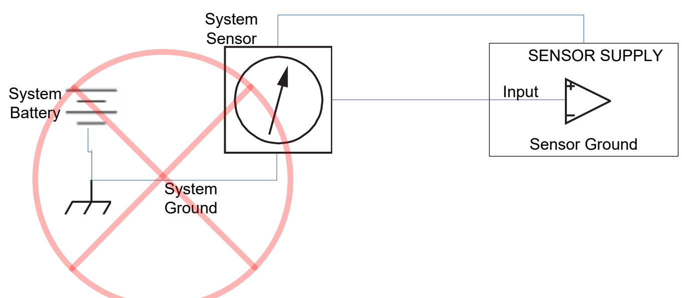


Figure 47: Ground wiring scheme that is NOT recommended

It is the system designer’s responsibility to ensure that error on sensors due to the wiring (or the sensors themselves) is within the required tolerance for the application. The accuracy and offset error provided in this document for any analog reading are related to the CM3033 internal error and do not include error due to system sensors or system wiring.

7. Power

The CM3033 is powered by direct battery connections to the VBATT, VBATT_BANKx, and GROUND connector pins. The CM3033 is turned on by applying power to VBATT connector pin and at least one wake-up that has been configured for wake-up (one of 5 inputs, one of 5 CAN, ethernet TC10). If no wake-ups are configured, the CM3033 will turn on when VBATT is applied.

The direct battery inputs are protected against vehicle transients such as load dump and inductive load switching, etc. The VBATT power pin is also protected against reverse battery voltage of -32 V through the use of a high-current path that will cause an external fuse to blow.

Warning: An external fuse (or Parker approved circuit breaker) must be present in the system wire harness on the wire connecting to the VBATT power input pin for reverse polarity protection of the CM3033. Failure to include the recommended fuse in the system harness may result in CM3033 damage during reverse polarity events.

Warning: Some of the functionality discussed in this User Guide is dependent on the version of platform software that is programmed on the CM3033. Refer to the software user manuals for additional information pertaining to functionality defined in this document.

The CM3033 operates in a 12 V or 24 V system and can operate based on the information provided in the following tables:

Direct Battery Input (VBATT)				
Parameter	**Min**	**Nom**	**Max**	**Units**
Input voltage for normal operation	9	-	32	V
Minimum cranking voltage [1]	6	-	-	V
Overvoltage protection (DC)	-	-	36	V
Reverse battery protection [2]	-	-	-32	V
Operating current @ 12V	-	300	-	mA
Rating of External Fuse [3]	-	-	10	A
Rating of External Circuit Breaker [4]	-	-	6	A

[1] The unit will operate down to 6 V, but with some impact on the characteristics of some features on the product.

[2] A reverse battery condition causes an external fuse to blow.

[3] Requires use of an ATC-x automotive fuse only. Either a fuse or a circuit breaker can be used. If a circuit breaker is used the maximum current rating is different, see footnote 4.

[4] Requires use of an ETA 127-P10-H-xA automotive circuit breaker only.

Direct Battery Input (VBATT_BANK1)				
Parameter	**Min**	**Nom**	**Max**	**Units**
Input voltage for normal operation	9	-	32	V
Minimum cranking voltage [1]	6	-	-	V
Overvoltage protection (DC)	-	-	36	V
Reverse battery protection [2]	-	-	-32	V
Maximum continuous current [3]	-	-	30	A
[1]The unit will operate down to 6 V, but with some impact on the characteristics of some features on the product. [2]A reverse battery condition is blocked by internal circuitry. No external fuse is required on this battery input line to protect against reverse polarity. [3]The maximum current is based on expected worst case operating conditions for the CM3033.				

Direct Battery Input (VBATT_BANK2)				
Parameter	**Min**	**Nom**	**Max**	**Units**
Input voltage for normal operation	9	-	32	V
Minimum cranking voltage [1]	6	-	-	V
Overvoltage protection (DC)	-	-	36	V
Reverse battery protection [2]	-	-	-32	V
Maximum continuous current [3]	-	-	30	A
[1] The unit will operate down to 6 V, but with some impact on the characteristics of some features on the product. [2] A reverse battery condition is blocked by internal circuitry. No external fuse is required on this battery input line to protect against reverse polarity. [3] The maximum current is based on expected worst case operating conditions for the CM3033.				

Direct Battery Input (VBATT_BANK_OUT23,24,25,26) [4]				
Parameter	**Min**	**Nom**	**Max**	**Units**
Input voltage for normal operation	9	-	32	V
Minimum cranking voltage [1]	6	-	-	V
Overvoltage protection (DC)	-	-	36	V
Reverse battery protection [2]	-	-	-32	V
Maximum continuous current [3]	-	-	10	A
[1] The unit will operate down to 6 V, but with some impact on the characteristics of some features on the product. [2] Each of these power inputs require at most a 15A ATO fuse to protect against reverse battery conditions. If fuses cannot be used, then an alternate system level method to prevent reverse current flow in reverse battery conditions must be implemented by the system designer. [3] The maximum current is based on expected worst case operating conditions for the CM3033. [4] Outputs 23 to 26 have independent power bus bars allowing these outputs to be connected to 12V or 24V power as required. When used in H-Bridge configurations, the voltage applied to the outputs must be the same.				

Direct Battery Ground (GROUND_POWER)				
Parameter	**Min**	**Nom**	**Max**	**Units**
Maximum continuous current [1]	-	-	60	A
[1] The low side outputs (Outputs 27 to 32) use the GROUND_POWER connection for return to system battery. The current through the low side outputs the unit will operate down to 6 V, but with some impact on the characteristics of some features on the product. The maximum current is based on expected worst case operating conditions for the CM3033.				

Sleep Mode Current (All Power Inputs)				
Parameter	**Min**	**Nom**	**Max**	**Units**
Sleep Mode Current @ 12V • All Power Inputs Connected • All LS Outputs Connected	-	1.5	-	mA
Sleep Mode Current @ 12V • VBATT, VBATT_BANK1 & BANK2 Connected • **VBATT_BANK_OUT23 to OUT26 Disconnected** • All LS Outputs Connected	-	1.3	-	mA
Sleep Mode Current @ 12V • VBATT, VBATT_BANK1 & BANK2 Connected • VBATT_BANK_OUT23 to OUT26 Connected • **All LS Outputs Disconnected**	-	0.62	-	mA
Sleep Mode Current @ 12V • VBATT, VBATT_BANK1 & BANK2 Connected • **VBATT_BANK_OUT23 to OUT26 Disconnected** • **All LS Outputs Disconnected**	-	0.37	-	mA
Sleep Mode Current @ 24V • All Power Inputs Connected • All LS Outputs Connected	-	2.78	-	mA
Sleep Mode Current @ 24V • VBATT, VBATT_BANK1 & BANK2 Connected • **VBATT_BANK_OUT23 to OUT26 Disconnected** • All LS Outputs Connected	-	2.34	-	mA
Sleep Mode Current @ 24V • VBATT, VBATT_BANK1 & BANK2 Connected • VBATT_BANK_OUT23 to OUT26 Connected • **All LS Outputs Disconnected**	-	1.03	-	mA
Sleep Mode Current @ 24V • VBATT, VBATT_BANK1 & BANK2 Connected • **VBATT_BANK_OUT23 to OUT26 Disconnected** • **All LS Outputs Disconnected**	-	0.59	-	mA

7.1. Logic and Output Power

The CM3033 has power connections for both the logic (low current) circuitry of the CM3033 and the high side output (high current) circuitry of the CM3033. In short circuit conditions, there may be enough impedance in the power wiring to result in voltage dips that may drop below the minimum operational voltage level. It is therefore recommended that the VBATT_BANK power inputs be pulled from sources as close to the battery as possible. This will prevent voltage drops on the VBATT_BANK input from affecting the VBATT input logic circuitry.

7.2. Power Control

The CM3033 provide a multi-source fully programmable power control function. The following CM3033 functions can act as wake-up sources:

- INPUT1 to INPUT4 (digital)
  - Configurable active high or active low wake-up
- CAN1 to CAN5
  - Wakes on any activity
- Ethernet
  - Wake-up functionality as per TC10 standard

All wake-up sources can be configured through software to be enabled or disabled. When disabled, the signals on that source will no longer wake-up the CM3033 but can still be used for their main functionality. Configuration of wake-up sources, active states, and activation thresholds is done through Application Software. The power control functionality will only allow the product to wake-up if the voltage on VBATT is within a valid operating range of the CM3033. Application Software can query the power control function to determine the reason for a wake-up of the CM3033.

Warning: It is important that all application software check for the reason for wakeup before activating any outputs on the CM3033. If a wakeup has occurred but is not valid for the specific application, the application software should initiate another shutdown and should not activate outputs.

Warning: If wake on CAN or wake on Ethernet are being used as wake-up sources for an application, the application software should verify that valid messages are present on the communication ports prior to turning on CM3033 outputs.

7.3. Undervoltage Protection

The CM3033 is equipped with internal detection of under voltages of the internal power supplies. Detection of this event will result in the halting of the currently running software.

Under voltage detection will force a hardware reset that will temporarily stop software operation for the duration of the under-voltage event. Under-voltage detection events occur on every normal power down of the product. Under-voltage is not expected to occur on the product while it is in normal operating modes unless the product is set to enter sleep mode, or the power feeding the VBATT power input pin is removed.

8. User Interface

Warning: Some of the functionality discussed in this User Guide is dependent on the version of platform software that is programmed on the CM3033. Refer to the software user manuals for additional information pertaining to functionality defined in this document.

The user interface on the CM3033 consists of the following:

- 1 multicolor diagnostic LED
- 26 single color IO state diagnostic LEDs

8.1. Diagnostic LEDs

The CM3033 has 27 LEDs that provide information for the CM3033's health as well as diagnostic state information for the product I/O and communication ports. The CM3033 provides a default functionality for diagnostic LED functionality which can be overridden by Application Software. Overriding the default functionality allows application specific configuration of the LED functions to customize the information displayed at any given time.

The default functionality provides:

- CM3033 programmed state and general health diagnostic information on the "Status" multicolor LED
- Cycling of Input / Output States, Communication status, and ID (Address) via the "Indicator" single-colored LEDs
    - Multiplexing of the range of inputs and outputs are provided by the +10, 20, 30 LEDs
    - Multiplexing of the functions displayed are provided by the I/O, COM, ID LEDs
    - These are cycled through at a fixed rate by default

The LEDs are arranged as shown:

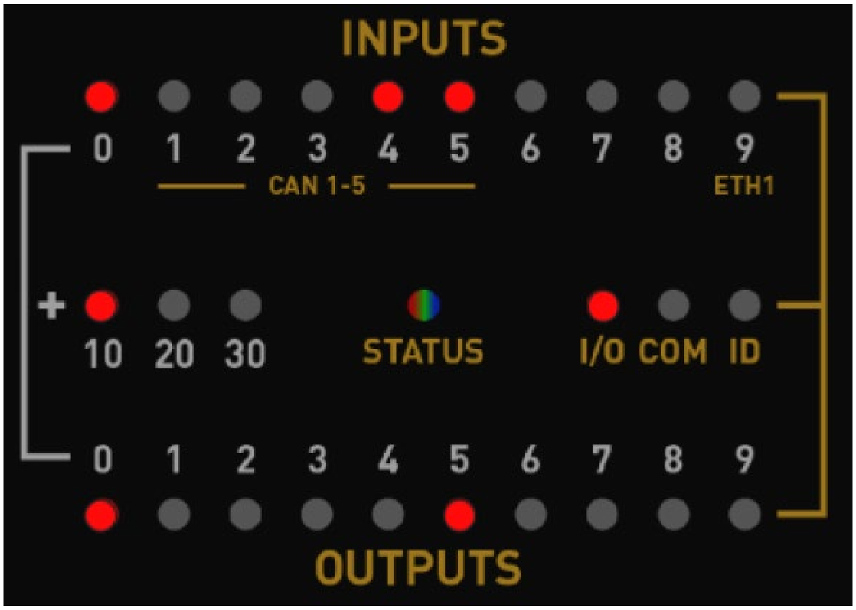


Figure 48: Diagnostic LED Arrangement

8.1.1. Diagnostic LED Usage Considerations

8.1.1.1. Status LED Codes

The default Status LED codes are as follows:

- Off
  - The product is not powered, or
  - The product is in sleep mode, or
  - The application has turned off the LED
- Solid red
  - The platform base software has entered a critical fault recovery mode, or
  - The platform base software is invalid, or
  - The platform base software is not programmed, or
  - The product is in bootstrap mode
- Flashing red (2 Hz, 50% DC)
  - The platform base software is running, but neither the boot block nor the customer application software is running.
    - ➢ This can occur on power-up if the boot block and customer application software are invalid. This is considered a sub-state of critical fault recovery mode.
- Flashing red (1 Hz, 50% DC)

- The boot block is running and not in any special mode (such as programming).
  - This can occur on power-up if the customer application software is invalid.
- Flashing red (0.5 Hz, 50% DC)
  - The product is running and in programming mode.

8.1.1.1.1. Indicator LED Codes

The default Indicator LED status codes are as follows:

- INPUTS (I/O Mux LED on)
  - Solid On
    - Input voltage is above the Digital Measurement Positive Going Threshold
  - Solid Off
    - Input voltage is below the Digital Measurement Negative Going Threshold
- INPUTS (COM Mux LED on)
  - Non-periodic Flashing
    - Communication Port is transmitting or receiving messages
  - Solid Off
    - Communication Port is not transmitting or receiving messages
  - Flashing (5 Hz, 50% DC)
    - CAN Port is in a Bus Off state
- INPUTS (ID Mux LED on)
  - Solid On
    - Indicates the current CM3033 address as read on INPUT33, see section 5.1.5
  - Solid Off
    - Not the current CM3033 address
  - Flashing (5 Hz, 50% DC)
    - An invalid CM3033 address is read on INPUT33, see section 5.1.5
- OUTPUTS (I/O Mux LED on)
  - Solid On
    - Output voltage is greater than 2.2V on the output pin
  - Solid Off
    - Output voltage is less than 1.1V on the output pin
  - Flashing (5 Hz, 50% DC)
    - Output Fault – Short to Ground or Short to Power
    - Open Circuit Condition – When output is mapped in application software

9. Communication

Warning: Some of the functionality discussed in this User Guide is dependent on the version of platform software that is programmed on the CM3033. Refer to the software user manuals for additional information pertaining to functionality defined in this document.

The CM3033 uses CAN and Ethernet 100BASE-T1 (automotive) as the method of communication with other modules in a system. There are five CAN communication ports and one Ethernet port that can be used for this purpose.

9.1. Controller Area Network (CAN)

There is one type of CAN ports available on the CM3033:

- CAN Type 1 – CAN 2.0B with CAN FD support

All CAN Ports support wake on CAN functionality. Wake on CAN functionality can be selected as active or inactive by Application Software. When selected as active, any detection of a dominant bit on the selected CAN buses will wake the product. When selected as inactive, bit changes on the inactive CAN busses will not wake the product.

9.1.1. CAN Type 1

CAN1 to CAN5 on the CM3033 are of CAN type 1. This CAN port operates as a standard CAN 2.0B port and offers an SAE J1939 protocol selectable as 250kbps, 500kbps, and 1Mbps baud rates. In addition, this CAN port supports operation as a CAN Flexible Datarate (FD) port to a maximum baud rate of 2Mbps on the CAN1 port. The CAN2 to CAN5 ports do not offer CAN FD functionality. This CAN port type includes a Wake on CAN feature that allows the product to be woken up via any CAN port activity when selected to do so by Application Software.

9.1.1.1. CAN Port

The following table defines the parameters for the CAN port

CAN Port Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Internal bus terminator	-	Not available	-	-
CANx_HIGH_CON Dominant Voltage with 60Ω bus term resistance	2.75	-	4.5	V
CANx_LOW_CON Dominant Voltage with 60Ω bus term resistance	0.5	-	2	V
CANx_HIGH_CON Recessive Voltage with 60Ω bus term resistance	2	2.5	3	V
CANx_LOW_CON Recessive Voltage with 60Ω bus term resistance	2	2.5	3	V
CANx_HIGH to LOW Diff Dominant Voltage with 60Ω bus term resistance	1.5	2	3	V
CAN1_SHIELD_CON resistance [1]	-	1	-	Ohm
CAN1_SHIELD_CON capacitance	-	660	-	nF
CANx_HIGH_CON & LOW_CON Short Circuit Protection Level	0	-	32	V
Supported Baud Rate [2]	250	-	1000	kbps
Supported Baud Rate – CAN FD	-	2000	-	kbps
Supported CAN bus length (250 and 500kbps)	-	-	40	m
Supported CAN bus length (1000kbps)	-	-	30	m
CANx_HIGH_CON pin capacitance	-	53	-	pF
CANx_LOW_CON pin capacitance	-	53	-	pF
CANx_HIGH_CON to LOW_CON diff capacitance	-	26	-	pF
[1] CAN1 is the only bus that provides a shield pin on the CM3033. All other CAN ports are expected to operate as either unshielded twisted pair OR to share the shield pin for CAN1. [2] This CAN port can support protocols other than the J1939 protocol but to do so requires a software stack within the application software. Platform software supports J1939 at the defined bit rate only.				

9.1.1.2. Wake On CAN

The following table defines the parameters for the Wake On CAN function.

Wake On CAN Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Activation Level [1]	-	Dominant Bit State	-	-
[1] Wake on CAN latches active and wakes up the CM3033 whenever the CAN ports are set to active wake functionality. CAN ports that do not have active wake functionality selected by Application Software will not wake up the product if there is active data on that bus. All CAN ports can be deactivated for wakeup which means they will no CAN activity will wake the product.				

9.1.1.3. Usage Considerations

9.1.1.3.1. Protocol

The CM3033 is designed for use in SAE J1939 protocol CAN environments. For information on the J1939 stack and its usage, see the CM3033 Software documentation. Protocols other than the J1939 protocol can be used, but the CM3033 does not natively support these other protocols. For a protocol other than J1939, the protocol stack would be the responsibility of the application software designer.

9.1.1.3.2. CAN Bus Loading

When this product is connected to a system CAN bus, it is recommended that the average CAN bus loading be less than 50% for non-critical applications and should be less than 30% for critical applications. It is the responsibility of the system designer to ensure that CAN bus loading is acceptable for any system designed with this product.

9.1.1.3.3. Wake on CAN

The wake on CAN feature associated with this communication type allows the product to be changed from a sleep state to powered up state when a CAN bus dominate state is detected. When using this feature, it is important to note the following:

- Wake on CAN provides a signal to the power control circuitry of this product whenever a dominant bus state is detected.
    - It is the application software's responsibility to act appropriately to CAN wakeup conditions. Application should confirm that the CAN port that woke the product is receiving valid messages before it proceeds to activate product outputs.
    - If CAN wakeup is not a valid wakeup mode for the application, the application software should not enable any product outputs and should initiate a return to sleep state.
    - The application software can determine why the module woke up from the power control function of the product.
- When initiating a wakeup on this product from another node on the CAN bus, it is important to note that any messages transmitted during the boot time of this product (up until the product transfers control to the application software) will be lost.
    - If a node is sending messages awaiting a response from this product upon wakeup, that node must continue to transmit those messages until it has received a valid response from this product since initial messages will be lost.
    - It is recommended that a node transmitting messages to this product continue to transmit for a minimum of 2 seconds to ensure that message is received and read after application software has started running.

Warning: All applications shall check for valid wakeup signals prior to activating any outputs. This will prevent unexpected CAN activity or dominant bit state changes external to the product resulting in output activation. If the product wakes up with no valid wake up signals, the application can place the product back into sleep state. A valid wakeup signal for a wake on CAN event is to have received and processed at least one valid CAN message from another CAN node.

9.1.1.3.4. Wiring

It is recommended that the physical CAN bus architecture follow that dictated by SAE J1939. This includes requirements for bus dimensions, cable characteristic impedance, connectors, and terminations. The physical media defined in the SAE J1939 specification was used when testing this product for EMC susceptibility and emissions.

9.2. Ethernet

There is one type of Ethernet port available on the CM3033.

9.2.1. Ethernet Type 2

ETH1 on the CM3033 are of Ethernet Type 2. This Ethernet port operates as a IEEE 802.3:2018 100BASE-T1 physical layer. It uses a standard MAC layer for use with standard software layers in software. TCP/IP and UDP are supported by this interface.

9.2.1.1. Ethernet Port

The following table defines the parameters for the Ethernet port

CAN Port Parameters				
Parameter	**Min**	**Nom**	**Max**	**Unit**
Physical Layer	-	100 ohm T1 (single twisted pair)	-	-
Bit Rate	-	-	100	Mbps
Wake Up Standard	-	TC10	-	-

9.2.1.2. Usage Considerations

9.2.1.2.1. Wake on Ethernet

The wake on Ethernet feature associated with this communication type allows the product to be changed from a sleep state to powered up state when a specific TC10 standard wakeup message is received. When using this feature, it is important to note the following:

- Wake on Ethernet provides a signal to the power control circuitry of this product whenever a valid TC10 wakeup message is received.
    - It is the application software’s responsibility to act appropriately to Ethernet wakeup conditions. Application should confirm that the Ethernet port that woke the product is receiving valid messages before it proceeds to activate product outputs.

- If Ethernet wakeup is not a valid wakeup mode for the application, the application software should not enable any product outputs and should initiate a return to sleep state.
- The application software can determine why the module woke up from the power control function of the product.

When initiating a wakeup on this product from another node on the Ethernet bus, it is important to note that the other node shall be compliant to the TC10 wakeup and sleep standard.

Warning: All applications shall check for valid wakeup signals prior to activating any outputs. This will prevent unexpected Ethernet TC10 wakeup activity resulting in output activation. If the product wakes up with no valid wake up signals, the application can place the product back into sleep state. A valid wakeup Ethernet is to have received and processed at least one valid Ethernet frame from another Ethernet node.

9.2.1.2.2. Wiring

It is recommended that the physical Ethernet bus architecture follow that dictated by IEEE 802.3:2018 Clause 96. Using standard CAT5e or CAT6 cable is acceptable for this communication port.

10. Installation

Because every system is different, it is not feasible to provide detailed installation instructions that will be suitable for every assembly. This chapter therefore provides only high-level guidelines on installing the CM3033.

The system designer is responsible for creating procedures for mounting the CM3033 in a system or vehicle during production assembly.

10.1. Environmental requirements

The CM3033 is intended to be mounted on the body or chassis of vehicles, which may be subject to extreme temperatures and other environmental conditions.

The CM3033 warranty does not cover damage caused by exposure of the product to environmental conditions that exceed its design limitations. For more information on environmental test levels for the CM3033 contact your Parker account representative.

General environmental considerations:

1. Mount the CM3033 in an environment that is within its ambient temperature range of –40 °C to +85 °C.
2. Mount the CM3033 in an environment that minimizes its exposure to radiated or conducted electrical noise.
3. Mount the CM3033 in an environment that minimizes its exposure to moisture and dust. The sealing standard for the CM3033 is IP66 and IP69K.
4. Mount the CM3033 in an environment that minimizes its exposure to vibration and shock.

Note: Although the CM3033 was designed and tested to a stringent set of environmental standards, the environment that the CM3033 is installed within should include some margin from specified levels during continuous operation. Operation at or very near environmental extremes on a continuous basis may impact long term reliability of this product.

10.2. Electrical installation procedures

Use the following guidelines when installing the CM3033 in a vehicle.

10.2.1. Logic and Output power connections

When connecting the CM3033 logic and output power, note that

Logic power connections are made using the VBATT and GROUND pins.

Output power connections are made using the VBATT_BANKx and GROUND pins.

The number of wires needed to connect the CM3033 power depends on the amount of current required by the application.

- It is recommended that you use one 16 AWG wire for every 8 A of expected output current; however, this is not always true and depends on your application.
- It is recommended that 8 AWG or 10 AWG be used for connections to J6 and J7 bus bars.

The CM3033 is protected against reverse-battery connections by an internal high-current conduction path that goes from ground to power on the VBATT pin. To protect the CM3033 from damage in a reverse-battery condition, place a fuse or circuit breaker of size and type defined in section 7 in series with the VBATT power wire in the application harness.

- A fuse is not required on the VBATT_BANKx power connections to protect the CM3033 against reverse-battery conditions. Refer to note in specific output sections of this document for special instructions related to OUTPUT23 to OUTPUT26.

Warning: Do not use slow-blow fuses for this application. Failure to use the recommended fuse or circuit breaker part numbers and values may result in damage to the CM3033 and/or the application harness during reverse-battery conditions.

All power connections to the CM3033 should be fused to protect the vehicle harness. It is the system designer's responsibility to ensure proper fuse or circuit breakers are used to protect the wires and connections within the application harness.

10.2.2. Power Ground connections

When connecting the CM3033 Power Ground in a system, note that

- Power Ground connections to the product are identified as GROUND in the product pinout in section 4.1.
- All Power Ground connections should be connected to the battery negative in a system.
- All Power Ground connections should use 14 AWG wire to reduce the effect of ground voltage shifts during system power up.

10.2.3. Sensor Ground connections

When connecting the CM3033 Sensor Ground in a system, note that

- The Sensor Ground connection to the product is identified as SENSOR_GROUND in the product pinout in section 4.1.
- The Sensor Ground connection should only be used to provide a return path to product ground from system sensors.
- The Sensor Ground connection should not be used with sensors that are grounded through their connection to the chassis of the system they are installed in. Doing so could result in the sensor ground acting as a Power Ground return path through the sensor connection to chassis.
- The larger the wire used on the Sensor Ground connection, the less voltage drop will occur between sensors connecting to it and the CM3033 internal ground.
- The Sensor Ground connection should not be used in a system setup where it sinks more current than the maximum Sensor Supply output current.

10.3. Mechanical installation procedures

Use the following guidelines when installing the CM3033 in a system.

10.3.1. CM3033 dimensions

The CM3033 is approximately 252 mm wide x 242 mm high x 45 mm deep. It has four mounting holes designed to accept four mounting bolts.

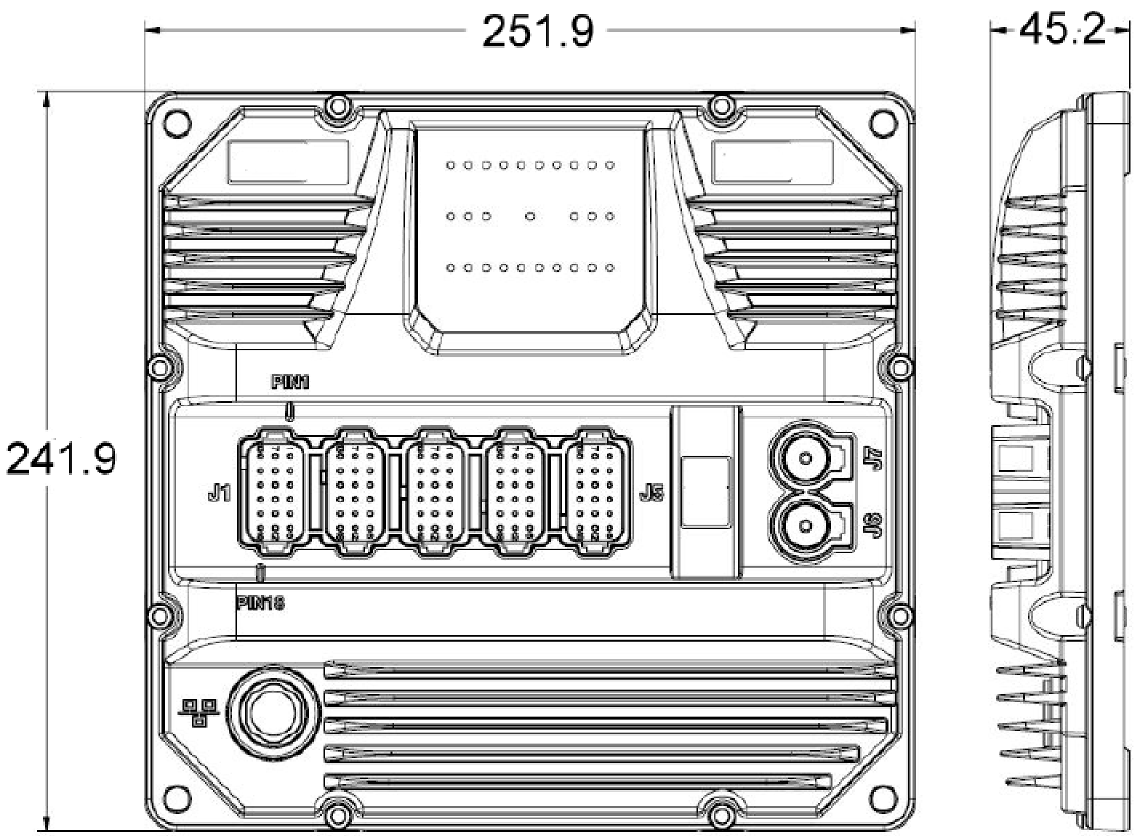


Figure 49: CM3033 dimensions (mm)

10.3.2. Mounting the CM3033

The CM3033 should be mounted into a system using four into a system using four 0.25 inch (or 6mm) fasteners.

Note: It is the system designer's responsibility to establish a torque rating that is adequate to ensure the CM3033 is securely mounted within the system. The torque required depends on the system the CM3033 is mounted into.

The CM3033 enclosure has no DC connection to the ground pins on the connectors. The CM3033 can therefore be mounted to a grounded portion of the system without impact to electrical operation.

Note: Although the CM3033 is designed to withstand environments where water and dust ingress may come in contact with the product, it is recommended that where possible the product be placed in as benign a location as possible. See section 10.1 for additional mounting considerations.

10.3.3. Removing the CM3033

In general, the CM3033 must be returned to Parker Hannifin Electronic Controls for service or replacement. There is no requirement for a specific bolt removal order during removal.

10.4. Startup

Warning: If the control system is not fitted properly, the system could move uncontrollably. Do not start the system before the control system is completely fitted and its signals have been verified. It is the system designer's and application software designer's responsibility to ensure that the system signals and connections are correct and that the software is correct prior to activation of the system.

Warning: Prior to applying power to the system and/or prior to downloading application software into the CM3033, ensure that no one is in dangerous proximity to the system and its moving parts. After reprogramming is complete, the CM3033 will start running application software.

For a system with CM3033 controllers installed, the startup procedure for the CM3033 controllers is as follows:

1. Apply battery power to the VBATT and VBATT_BANKx input power connections.
2. Wake up the CM3033 by applying battery voltage any wakeup activated digital inputs, CAN ports or Ethernet ports. If no wakeup sources were previously defined for the product, applying power will wakeup the product.
3. If the CM3033 has been connected correctly, you should see diagnostic LEDs activity depending on the programmed state of the product.

In a system where the CM3033 controller is not yet programmed with application software or requires an application software update, the controller can be programmed within the system via Plug and Play provided other CM3033 modules are present in the system. For more information on product programming refer to the CM3033 Software documentation.

Note: If you require programming tools for the CM3033 product, contact your Parker sales representative for information on reprogramming hardware and software tools options available.

Note: In the unlikely event that a CM3033 requires embedded boot block software updates, this is done through CAN1 and the recovery function of INPUT31.

When application software is present in the CM3033, the application software will start running after power up. The CM3033 will function based on the application software which varies from system to system. As such, CM3033 startup operation after application programming is complete is beyond the scope of this document.

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