±5A / ±20A, 5V Isolated Current Sensor IC

MCA1001, MCR1001

FEATURES

- **AMR based integrated current sensor**
- **Superior Range, Noise, Linearity, & Accuracy**
  - ✓ **2% accuracy from 10% to 100% current**
- **Superior Frequency Response**
  - ✓ **1 MHz (min)**
- **Low Sense Resistance (<1 mΩ max (+25C))**
- **Single 5V Supply Operation**
- **Low power consumption (7mA typical)**
- **Small 12L DFN 5x6 mm package**
- **-40 to +125ºC Temp Range**
- **RoHS compliant**
- **Zero-Current Reference Pin (Vref)**

APPLICATIONS

Server, Telecom, & Industrial PWR Supplies
- ✓ **System Fault, Alarm & Performance Monitoring Circuitry**
- ✓ **Dynamic Load Sensing in Feedback Loops**
- ✓ **DC/Harmonic Current Monitor for PFC**

Motor Control and Industrial Systems
- ✓ **Automotive Anti-Pinch Systems**
- ✓ **Automation & Robotics**
- ✓ **Industrial Fans & Motor Control Loops**

Solar Inverters and Optimizers
- ✓ **Grid-Tie Current Monitoring**
- ✓ **MPPT Circuits**

Appliances
- ✓ **IOT and Remote Device Monitoring**
- ✓ **Home Automation Control**

DESCRIPTION

The MCA1001 and MCR1001 products are fully integrated bi-directional analog output current sensors that deliver both high accuracy and high bandwidth. MEMSIC's state-of-the-art Anisotropic Magneto Resistive (AMR) sensor technology provides inherently low noise, excellent linearity and repeatability.

A fully isolated current path is provided by a low resistance copper conductor integrated into the package making it suitable for both high-side and low side bi-directional current sensing. The high bandwidth makes it ideal for feedback loops in motor control and power supply applications.

These devices are factory-calibrated to achieve low offset error and provide a precise analog voltage output that is linearly proportional to the conduction current (AC or DC) with sensitivity (mV/A) compatible with A/D convertors and analog control loops in power systems. The AMR sensor device structure is designed to eliminate sensitivity to stray and common mode magnetic fields.

Due to the inherently low output noise of MEMSIC's sensor technology, additional filtering is not required to reduce noise that reduces accuracy at low-level currents in systems with dynamic load profiles.

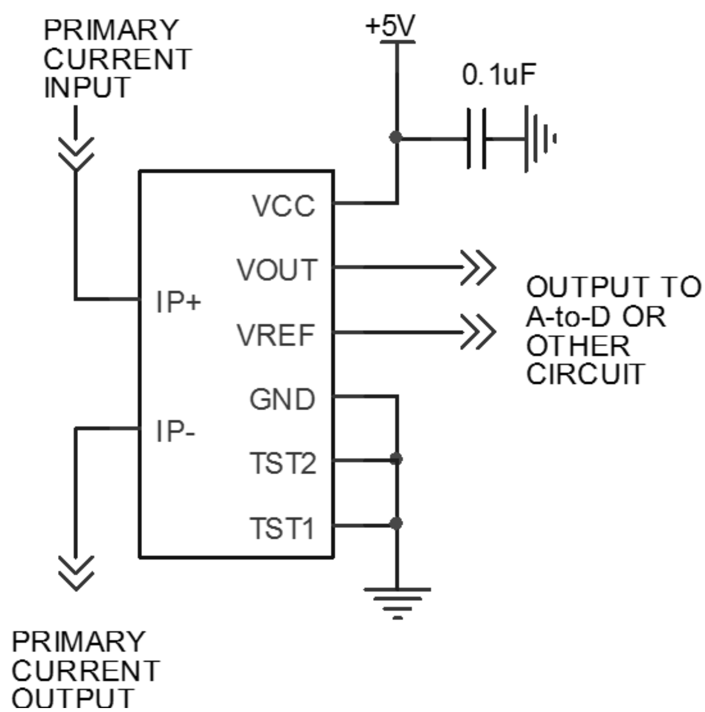

Figure 1 – Application Circuit

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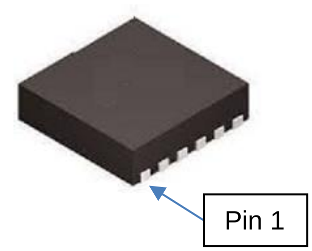
One Technology Drive, Suite 325, Andover, MA, 01810, USA
Tel: +1-978-738-0900, Fax: +1-978-738-0196, www.memsic.com

PRODUCT ORDERING INFORMATION

Part Number	Current Range	Gain	Isolation Voltage	Package
MCR1001-5ED12	**+/-5 Amp**	**Ratiometric**	**2400V**	**12 Lead 5 x 6mm DFN**
MCA1001-5ED12	**+/-5 Amp**	**Fixed**	**2400V**	**12 Lead 5 x 6mm DFN**
MCR1001-20ED12	**+/-20 Amp**	**Ratiometric**	**2400V**	**12 Lead 5 x 6mm DFN**
MCA1001-20ED12	**+/-20 Amp**	**Fixed**	**2400V**	**12 Lead 5 x 6mm DFN**

PIN DESCRIPTION

Pin # 12L DFN	Name	Description
1,2,3	IP+	Input of Primary Current Path for Sensing, Fused internally
4,5,6	IP-	Output of Primary Current Path for Sensing, Fused internally
7	TST1	Used during initial factory calibration. This pin should be connected to ground during normal operation.
8	TST2	Used during initial factory calibration. This pin should be connected to ground during normal operation.
9	GND	Connect to system ground
10	VREF	Zero Current Analog Reference Output
11	VOUT	Analog Output Signal linearly proportional to Primary Path Current
12	VCC	System Power Supply



12 Lead 5 x 6mm DFN

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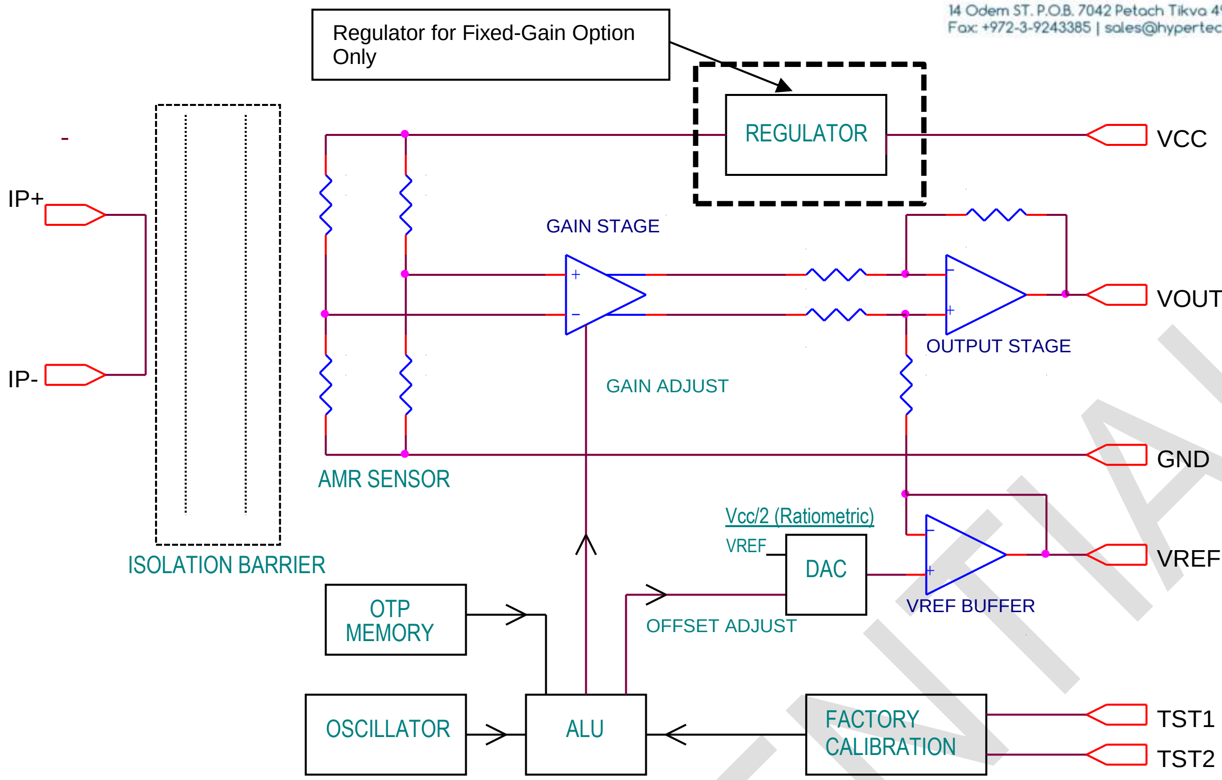

Figure 2 – Block Diagram for ratiometric and fixed gain products

Table 1 – ABSOLUTE MAXIMUM RATINGS

Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation at these or any other conditions beyond those specified is not implied.

Parameters / Test Conditions	Symbol	Value	Unit
Supply Voltage	VCC_{MAX}	-0.5 to 7	V
Sensor Current (IP+, IP-), 5Amp products	IP_{MAX}	+/- 15	A
Sensor Current (IP+, IP-), 20Amp products	IP_{MAX}	+/- 60	A
Maximum Device Junction Temperature	T_{JMAX}	150	°C
Storage Temperature	T_{STG}	-65 to +150	°C
Operating Temperature Range	T_{OP}	-40 to 125	°C
Isolation Voltage, 12L DFN package Agency type-tested for 60 seconds per UL standard 60950-1 (edition 2);	V_{ISO}	2400	V
Working Voltage for Basic Isolation Maximum approved working voltage for basic (single isolation according to UL 60950-1 (edition 2)	V_{WVBI}	420 (Peak or DC) 297 (RMS)	V
ESD Human Body Model / per ANSI/ESDA/JEDEC JS-001	HBM	2000	V
ESD Charged Device Model / per JEDEC specification JESD22-C101	CDM	1500	V
MSL Rating	MSL	TBD	
Maximum Soldering Temperature, 10 seconds.	T_{SOLDER}	260	°C

Table 2 – ELECTRICAL CHARACTERISTICS

Unless otherwise noted: 4.5V ≤ VCC ≤ 5.5V, -40°C ≤ $T_{JUNCTION}$ ≤ 105°C, I(VOUT) = I(VREF) = 0 (Recommended Operating Conditions). Typical values are for VCC = 5V and $T_{JUNCTION}$ = 25°C.

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
DC Current Sense Accuracy (Transfer Function by Option) **MCA1001-5, I_{OUT} = (VOUT – VREF) x 2.778A/V** **MCR1001-5, I_{OUT} = (VOUT – VREF) x 2.5A/V x 5V / VCC**						
Zero Current Offset	IOFFSET	IP± = 0	-10	0	10	mA
Accuracy	IOUT	IP± = ±500mA to ±5A	-2		2	% MV
DC Current Sense Accuracy (Transfer Function by Option) **MCA1001-20, I_{OUT} = (VOUT – VREF) x 11.111A/V** **MCR1001-20, I_{OUT} = (VOUT – VREF) x 10A/V x 5V / VCC**						
Zero Current Offset	IOFFSET	IP± = 0	-40	0	40	mA
Accuracy	IOUT	IP± = ±2A to ±20A	-2		2	% MV

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Unless otherwise noted: 4.5V ≤ VCC ≤ 5.5V, -40°C ≤ $T_{JUNCTION}$ ≤ 105°C, I (VOUT) = I (VREF) = 0 (Recommended Operating Conditions). Typical values are for VCC = 5V and $T_{JUNCTION}$ = 25°C.

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
VOUT Output						
Transresistance (Gain)	GAIN	MCR1001-5 @ VCC=5V		400		mV/A
		MCR1001-20 @ VCC=5V		100		mV/A
Load Regulation	$VOUT_{LR}$	Increase I (VOUT) from 0 to -2mA. Measure change in VOUT voltage		2	4	mV
Source Current	$VOUT_{SRC}$	VOUT shorted to GND	6	8	12	mA
Sink Current	$VOUT_{SNK}$	VOUT shorted to VCC	8	11	15	mA
Frequency Response (-3dB)	$VOUT_{BW}$	Note 1	1000	TBD		kHz
Capacitive Loading	$CVOUT_{MAX}$	Note 1			200	pF
Response Time	$VOUT_{RESP}$	IP± = 0 to +/-100% step input, measure VOUT = 10% to 90%. Note 1		0.35	0.6	µs
Noise (Input Referred)	$VOUT_{NOISE}$	IP± = 0, Measure (VOUT – VREF). Note 1		40	50	µA/$\sqrt{Hz}$
VREF Output						
Output Voltage	VREF	I (VREF) = 0 to -1mA, Fixed Gain Products	2.089	2.1	2.111	V
		I (VREF) = 0 to -1mA, Ratiometric Gain Products	VCC/2 -0.5%	VCC /2	VCC/2 +0.5%	V
Load Regulation	$VREF_{LR}$	Increase I (VREF) from 0 to -1mA. Measure change in VREF voltage		2	4	mV
Source Current	$VREF_{SRC}$	VREF shorted to GND	5	8	11	mA
Sink Current	$VREF_{SNK}$	VREF shorted to VCC	5	8	11	mA
Capacitive Loading	$CVREF_{MAX}$	Note 1			100	pF

Note 1 – Guaranteed by design and characterization. Not production tested.

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Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
VCC Bias Supply						
Supply Current	IVCC	VCC=5.0 V		7	10	mA
Power Up Time	TVCC	Time from VCC > 4.5V to valid VOUT and VREF (Note 1)		0.75	1.25	ms
Under Voltage Lockout Rising	UVLO+	IP± = 0, Measure VCC when Vout & VREF exceed 2V. (Note 1)	3.35	3.45	3.55	V
Under Voltage Lockout Falling	UVLO-	IP± = 0, Measure VCC when Vout & VREF decrease below 2V. (Note 1)	3.0	3.1	3.2	V
Under Voltage Lockout Hysteresis	UVLOH	(UVLO+) - (UVLO-) (Note 1)		350		mV
Primary Side Sensor						
Primary Conductor Resistance	R_{PC}	Measure resistance between IP+ and IP- (Note 1)		0.75	1.0	mΩ

Note 1 – Guaranteed by design and characterization. Not production tested.

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AMR TECHNOLOGY

Anisotropic magnetoresistance (AMR) makes use of a common material, Permalloy, to act as a magnetometer. Permalloy is an alloy containing roughly 80% nickel and 20% iron. The alloy's resistance depends on the angle between the magnetization and the direction of current flow. In a magnetic field, magnetization rotates toward the direction of the magnetic field and the rotation angle depends on the external field's magnitude. Permalloy's resistance decreases as the direction of magnetization rotates away from the direction in which current flows, and is lowest when the magnetization is perpendicular to the direction of current flow. The resistance changes roughly as the square of the cosine of the angle between the magnetization and the direction of current flow. Permalloy is deposited on a silicon wafer and patterned as a resistive strip. The film's properties cause it to change resistance in the presence of a magnetic field. In a current sensor application, two of these resistors are connected in a Wheatstone bridge configuration to permit the measurement of the magnitude of the magnetic field produced by the current.

AMR properties are well behaved when the film's magnetic domains are aligned in the same direction. This configuration ensures high sensitivity, good repeatability, and minimal hysteresis. During fabrication, the film is deposited in a strong magnetic field that sets the preferred orientation, or "easy" axis, of the magnetization vector in the Permalloy resistors. AMR has better sensitivity than other methods and reasonably good temperature stability. The AMR sensor has sensitivity which is approximately a linear function of temperature.

FUNCTIONAL DESCRIPTION

Figures 2 and 3 provide block diagrams of the two product types; fixed and ratiometric gain. The AMR sensor monitors the magnetic field generated by the current flowing through the U shaped IP+/IP- package lead frame. The AMR sensor produces a voltage proportional to the magnetic field created by the positive or negative current in the IP+/IP- current loop while rejecting external magnetic interference. The sensor voltage is fed into a differential amplifier whose gain is temperature compensated. This is followed by an instrumentation amplifier output stage that provides a voltage that indicates the current passing through the IP+/IP- pins. To provide both positive and negative current data the VOUT output pin is referenced to the VREF output pin. The voltage on the VREF output is typically one half of the full scale positive and negative range of the VOUT current sense output signal. With no current flowing in the IP+/IP- pins, the voltage on the VOUT output will typically equal the voltage on the VREF output. Positive IP+/IP- current causes the voltage on VOUT to increase relative to VREF while negative IP+/IP- current will cause it to decrease.

FIXED GAIN PRODUCTS

The sensor resistors are biased by an internal 4.2V reference voltage and the voltage on the VREF output is 2.1V (typical). This arrangement provides a fixed gain and enhanced supply rejection. The VOUT pin drives to approximately 3.9V at full positive current and 0.3V at full negative current.

RATIOMETRIC GAIN PRODUCTS

The sensor resistors are biased to the VCC supply voltage and produce a differential voltage that is ratiometric to VCC. This configuration is suited to applications where the A-to-D or other circuitry receiving the current sensor output signals are biased by and ratiometric to the same supply voltage as the current sensor. The ratiometric configuration provides increased gain and resolution compared to fixed gain. The user can also provide a well-regulated 5V supply or monitor the VCC voltage and factor it into the current measurement to take advantage of the ratiometric configuration.

The voltage on the VREF output is VCC / 2 and the VOUT pin drives to 90% of VCC at full positive current and 10% of VCC at full negative current.

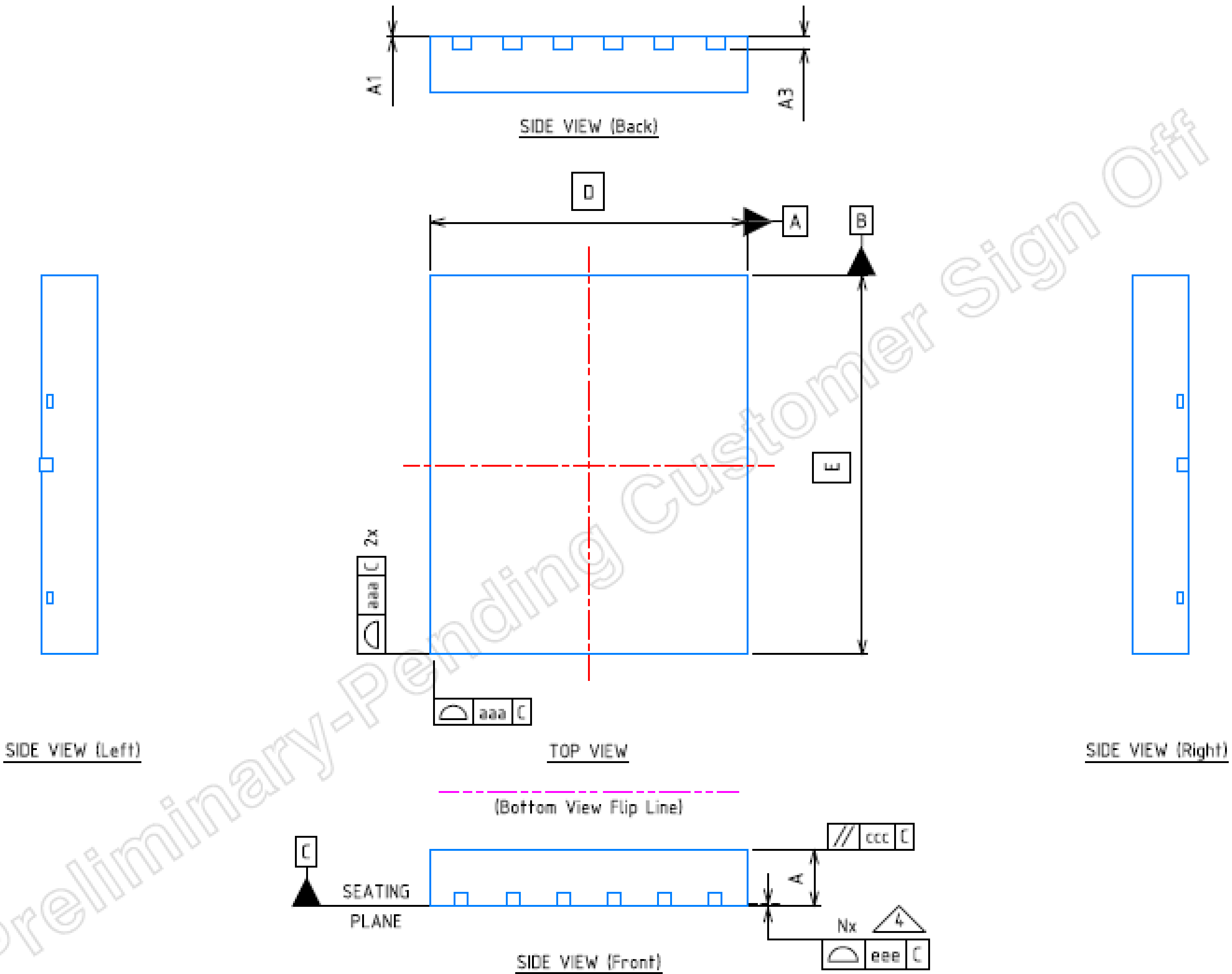
The nominal transresistance (gain) versus VCC voltage is 400mV per amp x VCC / 5V for the 5 amp products and 100mV per amp x VCC / 5V for the 20 amp products.

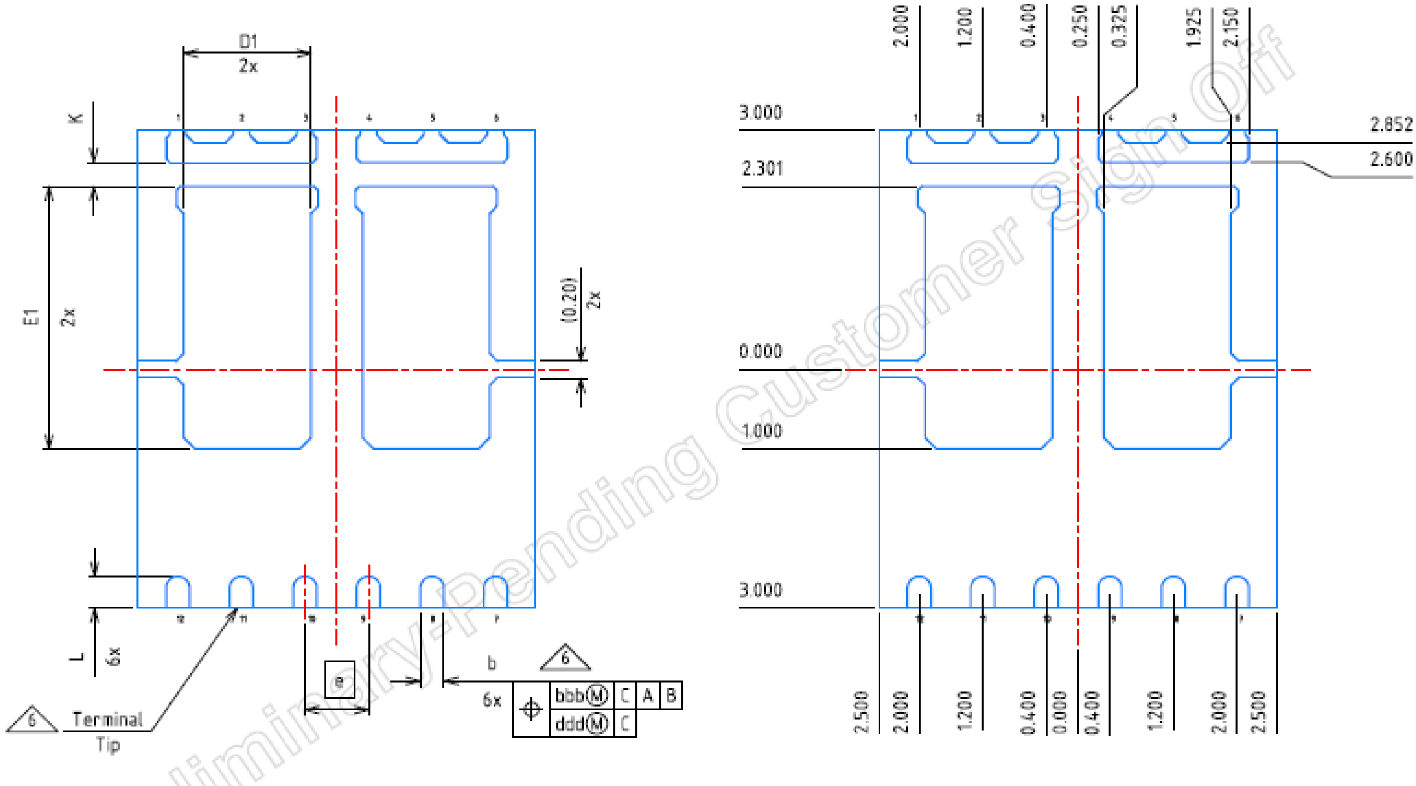
POWER UP / DOWN

An under-voltage lockout circuit monitors the voltage on the VCC pin. If the VCC voltage is less than the under-voltage threshold the MCx1001 is in an inactive state. VOUT and VREF both drive to ground and SDA and SCL are high impedance. If the VCC voltage exceeds the under-voltage threshold VOUT and VREF are released and will drive to approximately half the VCC supply voltage and an initial calibration will commence. Once the initial calibration has completed the MCx1001 becomes active. VOUT will slew to indicate the value of current flowing in the IP+/- conductor. Current flow in the IP+/- conductor with a VCC voltage less than the under-voltage threshold will not cause damage to the sensor.

PACKAGE INFORMATION – 5 x 6mm 12L DFN

Thermal Impedance - Φ_{JA} = 37 ºC/W, Φ_{JC} = TBD ºC/W





BOTTOM VIEW

Dimension Table							
Thickness / Symbol	V			W			NOTE
	MINIMUM	NOMINAL	MAXIMUM	MINIMUM	NOMINAL	MAXIMUM	
A	0.80	0.90	1.00	0.70	0.75	0.80	
A1	0.00	0.02	0.05	0.00	0.02	0.05	
A3	---	0.20 Ref	---	---	0.20 Ref	---	
b	0.25	0.30	0.35	0.25	0.30	0.35	6
D		5.00 BSC			5.00 BSC		
E		6.00 BSC			6.00 BSC		
e		0.80 BSC			0.80 BSC		
D1	1.45	1.60	1.70	1.45	1.60	1.70	
E1	3.15	3.30	3.40	3.15	3.30	3.40	
K	0.20	---	---	0.20	---	---	
L	0.30	0.40	0.50	0.30	0.40	0.50	
aaa		0.05			0.05		
bbb		0.10			0.10		
ccc		0.10			0.10		
ddd		0.05			0.05		
eee		0.08			0.08		
N				12			3
ND				6			5
NOTES				1, 2			

NOTE:

1. Dimensioning and tolerancing conform to ASME Y14.5-2009.

2. All dimensions are in millimeters.

3. N is the total number of terminals.

4. Coplanarity applies to the terminals and all other bottom surface metalization.

5. ND refers to the maximum number of terminals on D side.

6. Dimension b applies to the metalized terminal and is measured between 0.15 and 0.30mm from the terminal tip. If the terminal has a radius on the other end of it, dimension b should not be measured in that radius area.

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