

TMR7616-C

Current Sensor IC

Description

The TMR7616-C series current sensor IC operate on the principle of electromagnetic induction with high sensitivity, high signal-to-noise ratio tunneling magnetoresistance (TMR) sensors. With an internal conditioning circuit and electrical isolation between the primary and secondary sides, it can accurately measure current signals in forms of direct current (DC), alternating current (AC), and pulses.



Features and Benefits

- 16-pin SOPW package
- High sensitivity
- Low noise
- High bandwidth, fast response
- Excellent temperature stability
- RoHS and REACH compliant

Applications

- Frequency converter current detection
- Power supply monitoring
- Motor drive
- Photovoltaic inverter
- Overload protection

Selection Guide

Part Number	Supply Voltage	Current Measurement Range	Offset Voltage	Sensitivity
TMR7616-020C3BFB	3.3 V	±20 A	1.65 V	66 mV/A
TMR7616-030C3BFB	3.3 V	±30 A	1.65 V	44 mV/A
TMR7616-040C3BFB	3.3 V	±40 A	1.65 V	33 mV/A
TMR7616-050C3BFB	3.3 V	±50 A	1.65 V	26.4 mV/A
TMR7616-065C3BFB	3.3 V	±65 A	1.65 V	20.31 mV/A
TMR7616-020C5BFB	5 V	±20 A	2.5 V	100 mV/A
TMR7616-030C5BFB	5 V	±30 A	2.5 V	66.67 mV/A
TMR7616-040C5BFB	5 V	±40 A	2.5 V	50 mV/A
TMR7616-050C5BFB	5 V	±50 A	2.5 V	40 mV/A
TMR7616-065C5BFB	5 V	±65 A	2.5 V	30.77 mV/A

Catalogue

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1. Functional Block Diagram

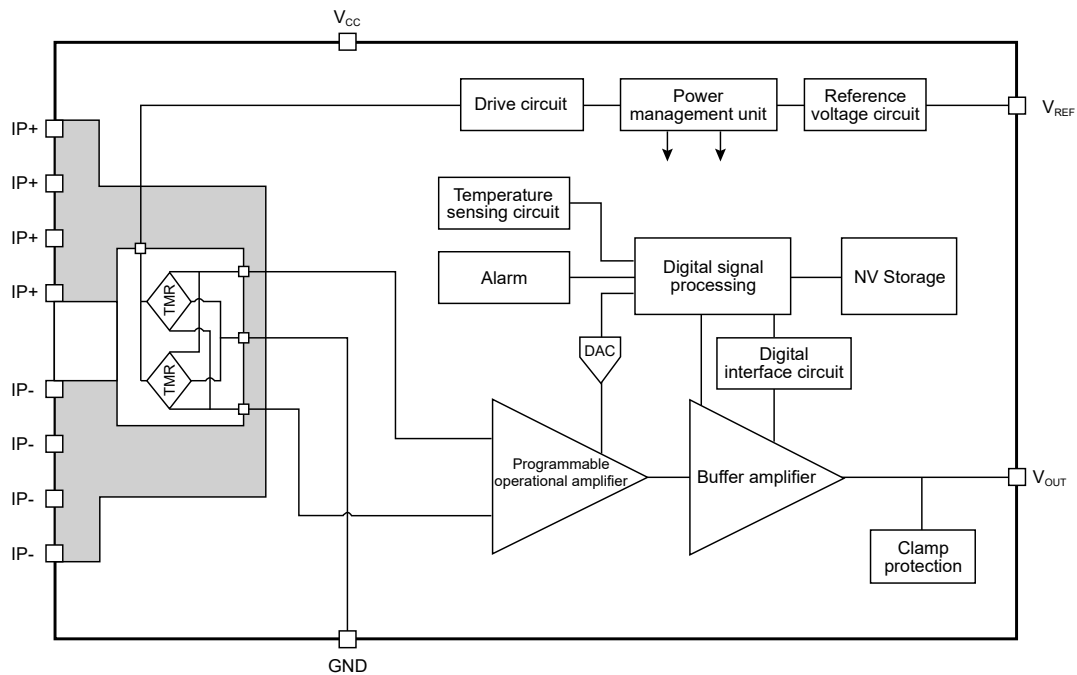


Figure 1. TMR7616-C functional block diagram

2. Absolute Maximum Rating

Parameter	Symbol	Min.	Max.	Unit
Supply voltage	V _{CC}	-	6	V
ESD (HBM)	V _{ESD}	-	4	kV
Operating temperature	T _A	-40	125	°C
Storage temperature	T _{STG}	-40	125	°C
Maximum junction temperature	T _{J(MAX)}	-	165	°C

3. Insulation Isolation Characteristics

Parameter	Symbol	Typ.	Unit
Dielectric strength	V _D	4.8	kV(50Hz, 1min)
Maximum working isolation voltage	V _{ISO}	1550	V _{PK}
		1097	V _{RMS}
Creepage distance	d _{CP}	8.2	mm
Electrical clearance	d _{CL}	8.2	mm
Relative Tracking Index	CTI	600	V

4. Electrical Specifications

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Supply voltage	V_{CC}	TMR7616-XXXC3BFB	3	3.3	3.6	V
		TMR7616-XXXC5BFB	4.5	5	5.5	
Offset voltage	V_{OFF}	$I_P = 0$, $V_{CC} = 3.3$ V, TMR7616-XXXC3BFB	-	1.65	-	V
		$I_P = 0$, $V_{CC} = 5$ V, TMR7616-XXXC5BFB	-	2.5	-	
Output voltage limit	V_{OL}	-	0.2	-	-	V
	V_{OH}	-	-	-	$V_{CC} - 0.2$	
Current consumption	I_C	$V_{CC} = 3.3$ V	-	-	6	mA
		$V_{CC} = 5$ V	-	-	6	
Power on time	t_{ON}	From when $V_{CC} \geq 2.5$ V to when V_{OUT} reaches stable output	-	200	-	μ s
Primary conductor input resistance	R_{IN}	$T_A = 25^\circ\text{C}$	-	0.95	-	m Ω
Load resistance	R_L	Between V_{OUT} and GND	1	10	-	k Ω
Load conductance	C_L	Between V_{OUT} and GND	-	-	10	nF
Output pull-up current	$I_{OUT(SOURCE)}$	$V_{CC} = 3.3$ V, V_{OUT} shorted to GND	-	43	-	mA
		$V_{CC} = 5$ V, V_{OUT} shorted to GND	-	45	-	
Output pull-down current	$I_{OUT(SINK)}$	$V_{CC} = 3.3$ V, V_{OUT} shorted to V_{CC}	-	43	-	mA
		$V_{CC} = 5$ V, V_{OUT} shorted to V_{CC}	-	45	-	
V_{REF} resistance	R_{LREF}	Between V_{REF} and GND	10	100	-	k Ω
V_{REF} conductance	C_{LREF}	Between V_{REF} and GND	-	1	10	nF
V_{REF} pull-up current	$I_{REF(SOURCE)}$	$V_{CC} = 3.3$ V, V_{REF} shorted to GND	-	3.7	-	mA
		$V_{CC} = 5$ V, V_{REF} shorted to GND	-	8.7	-	
V_{REF} pull-down current	$I_{REF(SINK)}$	$V_{CC} = 3.3$ V, V_{REF} shorted to V_{CC}	-	0.125	-	mA
		$V_{CC} = 5$ V, V_{REF} shorted to V_{CC}	-	0.135	-	
Power supply rejection ratio	PSRR	DC~1kHz, 100mV pk-pk ripple around $V_{CC} = 5$ V, $I_P = 0$	-	-40	-	dB
Common-mode magnetic field rejection ratio	CMFRR	Uniform external magnetic field	-	-40	-	dB
Rise time	t_{rise}	$T_A = 25^\circ\text{C}$, $I_P = I_{PM(max)}$	-	0.5	-	μ s
Delay	t_D	$T_A = 25^\circ\text{C}$, $I_P = I_{PM(max)}$	-	0.4	-	μ s
Response time	t_R	$T_A = 25^\circ\text{C}$, $I_P = I_{PM(max)}$	-	0.8	-	μ s
Bandwidth	BW	$I_P = 10$ A, amplitude attenuates to -3dB	-	600	-	kHz

5. TMR7616-XXXC3BFB Specifications

$T_A = 25\text{ }^{\circ}\text{C}$, $V_{CC} = 3.3\text{ V}$, $R_L = 10\text{ k}\Omega$, unless otherwise noted

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Primary measured current	I_{PM}	TMR7616-020C3BFB	-20	-	20	A
		TMR7616-030C3BFB	-30	-	30	
		TMR7616-040C3BFB	-40	-	40	
		TMR7616-050C3BFB	-50	-	50	
		TMR7616-065C3BFB	-65	-	65	
Sensitivity	S	TMR7616-020C3BFB	-	66	-	mV/A
		TMR7616-030C3BFB	-	44	-	
		TMR7616-040C3BFB	-	33	-	
		TMR7616-050C3BFB	-	26.4	-	
		TMR7616-065C3BFB	-	20.31	-	
Accuracy	X_G	$T_A = 25\text{ }^{\circ}\text{C}$, $I_P = I_{PM(min)} \sim I_{PM(max)}$	-	± 1	-	% $I_{PM(max)}$
		$T_A = -40\text{ }^{\circ}\text{C} \sim +125\text{ }^{\circ}\text{C}$, $I_P = I_{PM(min)} \sim I_{PM(max)}$	-3	-	3	
Linearity error	ϵ_L	$I_P = I_{PM(min)} \sim I_{PM(max)}$	-	0.5	1	% $I_{PM(max)}$
Sensitivity error	ϵ_S	$T_A = 25\text{ }^{\circ}\text{C}$, $I_P = I_{PM(min)} \sim I_{PM(max)}$	-1	-	1	%
		$T_A = -40\text{ }^{\circ}\text{C} \sim +25\text{ }^{\circ}\text{C}$, $I_P = I_{PM(min)} \sim I_{PM(max)}$	-1.5	-	1.5	
		$T_A = 25\text{ }^{\circ}\text{C} \sim +125\text{ }^{\circ}\text{C}$, $I_P = I_{PM(min)} \sim I_{PM(max)}$	-2	-	2	
Reference voltage	V_{REF}	$T_A = 25\text{ }^{\circ}\text{C}$	1.645	-	1.655	V
		$T_A = -40\text{ }^{\circ}\text{C} \sim +125\text{ }^{\circ}\text{C}$	1.635	-	1.665	
Offset error	V_{OE}	$T_A = 25\text{ }^{\circ}\text{C}$, $I_P = 0$, $V_{OUT} - V_{REF}$	-10	-	10	mV
		$T_A = -40\text{ }^{\circ}\text{C} \sim +25\text{ }^{\circ}\text{C}$, $I_P = 0$, $V_{OUT} - V_{REF}$	-25	-	25	
		$T_A = 25\text{ }^{\circ}\text{C} \sim +125\text{ }^{\circ}\text{C}$, $I_P = 0$, $V_{OUT} - V_{REF}$	-25	-	25	
Hysteresis	V_{OH}	$I_P = I_{PM(min)}$ or $I_{PM(max)} \rightarrow 0$	-	± 10	-	mV
Noise	V_N	$T_A = 25\text{ }^{\circ}\text{C}$, BW = 100 kHz	-	10	-	mV _{pp}

6. TMR7616-XXXC5BFB Specifications

$T_A = 25\text{ }^{\circ}\text{C}$, $V_{CC} = 5\text{ V}$, $R_L = 10\text{ k}\Omega$, unless otherwise noted

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Primary measured current	I_{PM}	TMR7616-020C5BFB	-20	-	20	A
		TMR7616-030C5BFB	-30	-	30	
		TMR7616-040C5BFB	-40	-	40	
		TMR7616-050C5BFB	-50	-	50	
		TMR7616-065C5BFB	-65	-	65	
Sensitivity	S	TMR7616-020C5BFB	-	100	-	mV/A
		TMR7616-030C5BFB	-	66.67	-	
		TMR7616-040C5BFB	-	50	-	
		TMR7616-050C5BFB	-	40	-	
		TMR7616-065C5BFB	-	30.77	-	
Accuracy	X_G	$T_A = 25\text{ }^{\circ}\text{C}$, $I_P = I_{PM(min)} \sim I_{PM(max)}$	-	± 1	-	% $I_{PM(max)}$
		$T_A = -40\text{ }^{\circ}\text{C} \sim +125\text{ }^{\circ}\text{C}$, $I_P = I_{PM(min)} \sim I_{PM(max)}$	-3	-	3	
Linearity error	ϵ_L	$I_P = I_{PM(min)} \sim I_{PM(max)}$	-	0.5	1	% $I_{PM(max)}$
Sensitivity error	ϵ_S	$T_A = 25\text{ }^{\circ}\text{C}$, $I_P = I_{PM(min)} \sim I_{PM(max)}$	-1	-	1	%
		$T_A = -40\text{ }^{\circ}\text{C} \sim +25\text{ }^{\circ}\text{C}$, $I_P = I_{PM(min)} \sim I_{PM(max)}$	-1.5	-	1.5	
		$T_A = 25\text{ }^{\circ}\text{C} \sim +125\text{ }^{\circ}\text{C}$, $I_P = I_{PM(min)} \sim I_{PM(max)}$	-2	-	2	
Reference voltage	V_{REF}	$T_A = 25\text{ }^{\circ}\text{C}$	2.495	-	2.505	V
		$T_A = -40\text{ }^{\circ}\text{C} \sim +125\text{ }^{\circ}\text{C}$	2.48	-	2.52	
Offset error	V_{OE}	$T_A = 25\text{ }^{\circ}\text{C}$, $I_P = 0$, $V_{OUT} - V_{REF}$	-10	-	10	mV
		$T_A = -40\text{ }^{\circ}\text{C} \sim +25\text{ }^{\circ}\text{C}$, $I_P = 0$, $V_{OUT} - V_{REF}$	-30	-	30	
		$T_A = 25\text{ }^{\circ}\text{C} \sim +125\text{ }^{\circ}\text{C}$, $I_P = 0$, $V_{OUT} - V_{REF}$	-30	-	30	
Hysteresis	V_{OH}	$I_P = I_{PM(min)}$ or $I_{PM(max)} \rightarrow 0$	-	± 10	-	mV
Noise	V_N	$T_A = 25\text{ }^{\circ}\text{C}$, BW = 100 kHz	-	10	-	mV _{pp}

7. Typical Output Characteristics

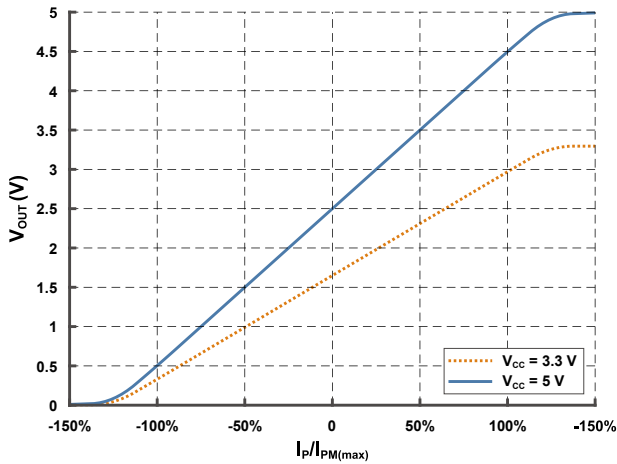


Figure 2. Output Voltage vs Primary Current

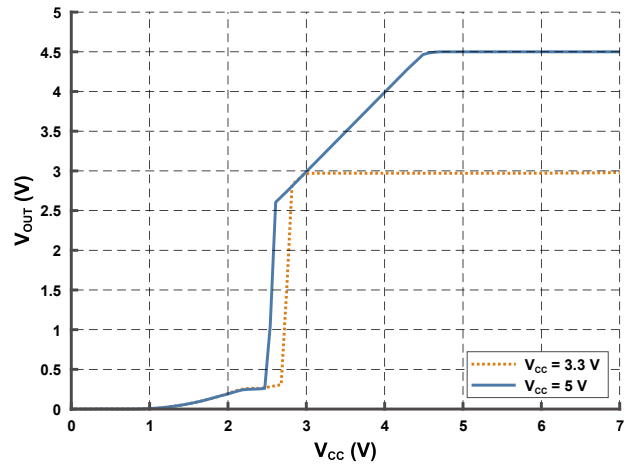


Figure 3. Output voltage vs supply voltage (@ $I_P = I_{P(Max)}$)

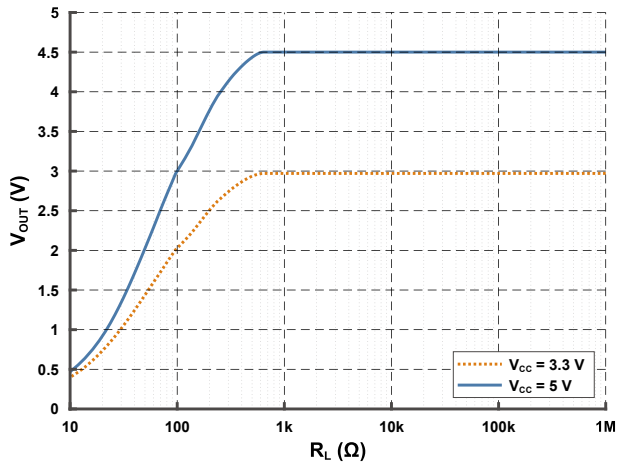


Figure 4. Output voltage vs load resistance (@ $I_P = I_{P(Max)}$)

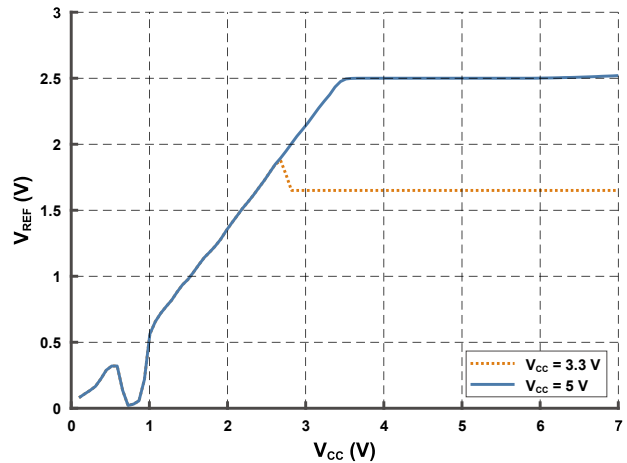


Figure 5. Reference voltage vs supply voltage (@ $I_P = I_{P(Max)}$)

8. Power-on Start-up Characteristics

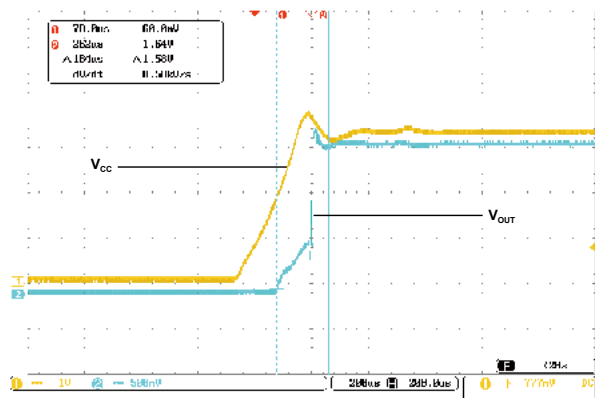


Figure 6. TMR7616-xxxC3BFB power-on start-up characteristics

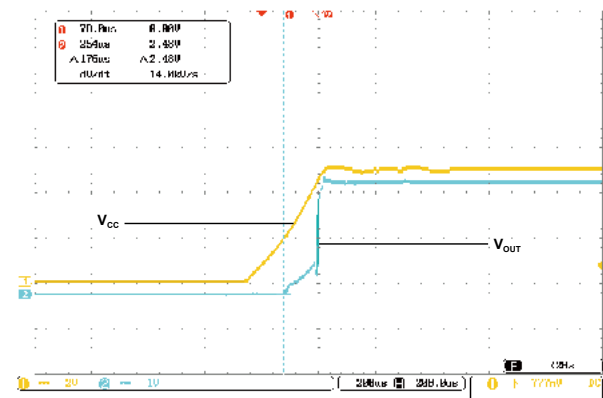


Figure 7. TMR7616-xxxC5BFB power-on start-up characteristics

9. Frequency Response Characteristics

Characteristics below tested with TMR7616-050C5BFB

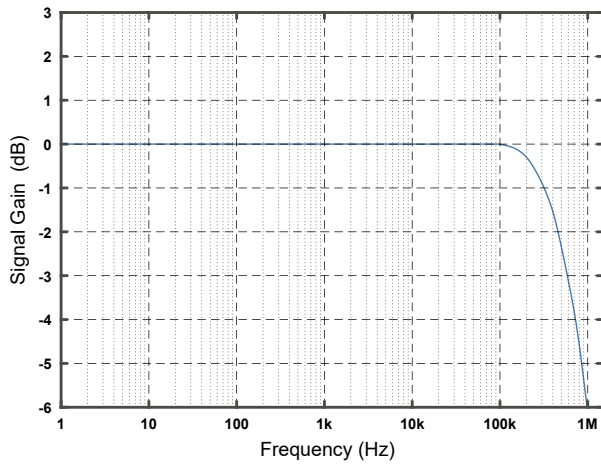


Figure 8. TMR7616-C bode plot

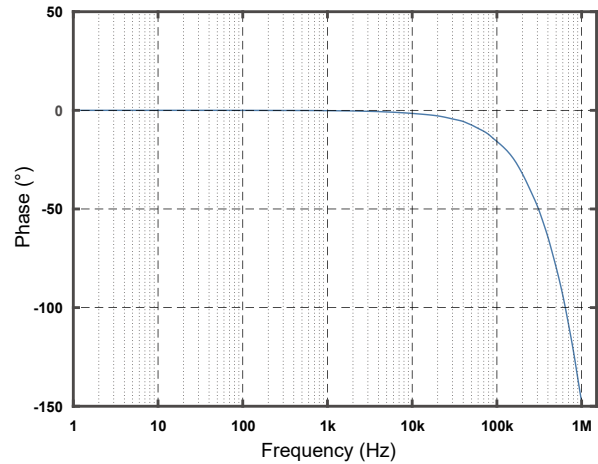


Figure 9. TMR7616-C phase frequency plot

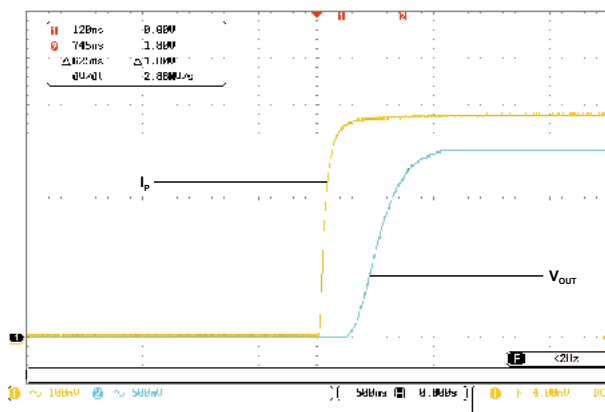


Figure 10. TMR7616-C response time

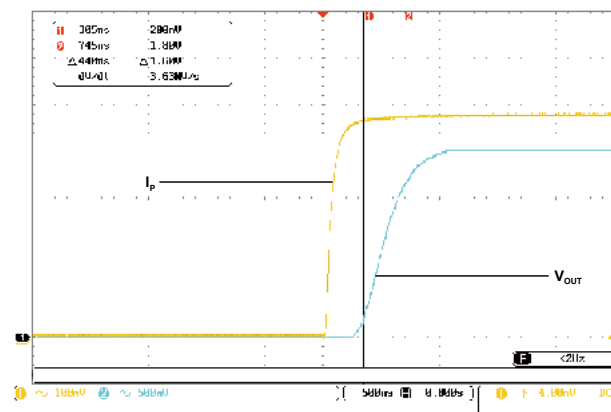


Figure 11. TMR7616-C rise time

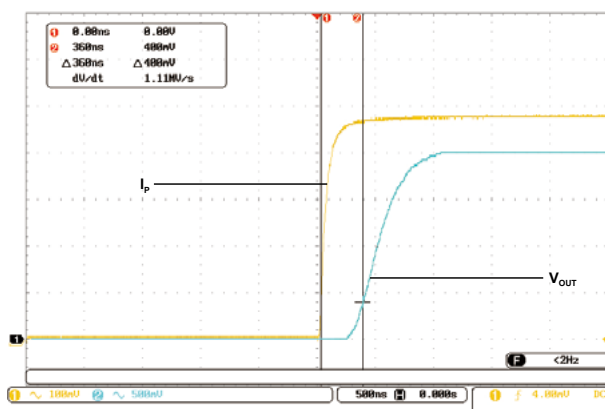


Figure 12. TMR7616-C propagation delay

10. Parameters Definition and Formula

1) Accuracy

$$X_G = \max_{I_p \in [I_{PM(min)}, I_{PM(max)}]} \left(\frac{V_{OUT} - (I_p \times S + V_{REF})}{I_{PM(max)} \times S} \times 100\% \right)$$

I_p stands for primary current, $I_{PM(max)}$ 、 $I_{PM(min)}$ stands for maximum and minimum within current measurement range, V_{OUT} stands for output voltage at given primary current I_p , S stands for sensitivity, V_{REF} stands for reference voltage.

2) Sensitivity

$$S = \frac{V_{OUT(@I_{PM(max)})} - V_{OUT(@I_{PM(min)})}}{2 \times I_{PM(max)}}$$

$V_{OUT(@I_{PM(max)})}$ and $V_{OUT(@I_{PM(min)})}$ stand for the voltage output at $I_{PM(max)}$ 、 $I_{PM(min)}$ respectively.

3) Linearity

$$\varepsilon_L = \max_{I_p \in [I_{PM(min)}, I_{PM(max)}]} \left(\frac{|V_{OUT} - (I_{PM(max)} \times \bar{S} + \overline{V_{REF}})|}{I_{PM(max)} \times S} \times 100\% \right)$$

$\bar{S}$ and $\overline{V_{REF}}$ stand for the average values of the sensitivity and offset voltage.

4) Zero Offset Voltage

$$V_{OE} = V_{OUT(@I_p = 0)} - V_{REF}$$

5) Hysteresis

$$V_{OH} = \text{MAX } \Delta H$$

ΔH is the maximum residual voltage between full scale positive and negative nominal current.

11. Dimensions

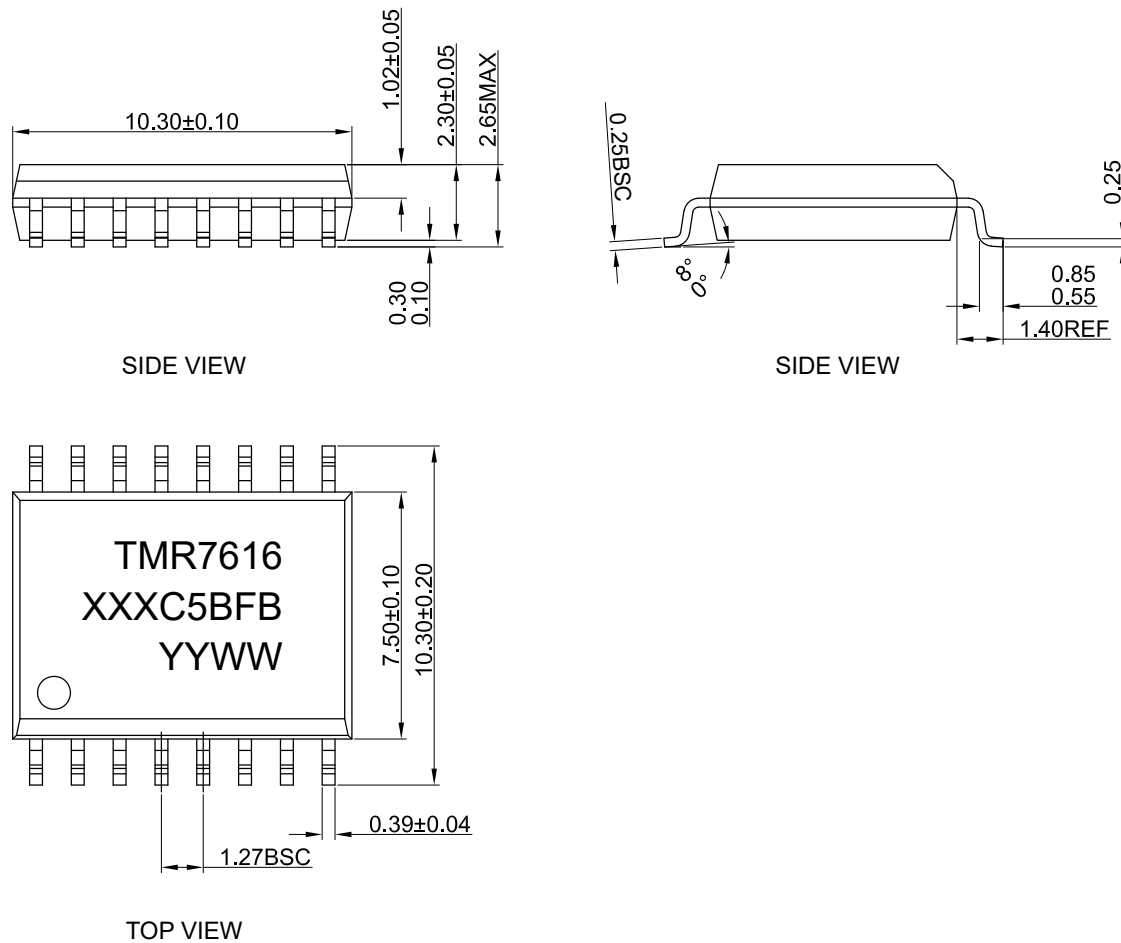
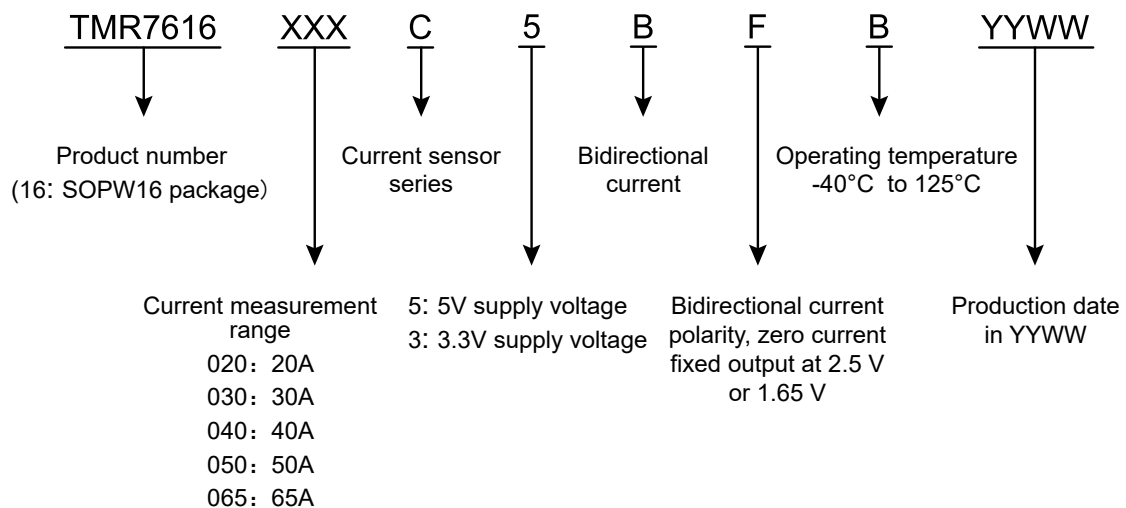
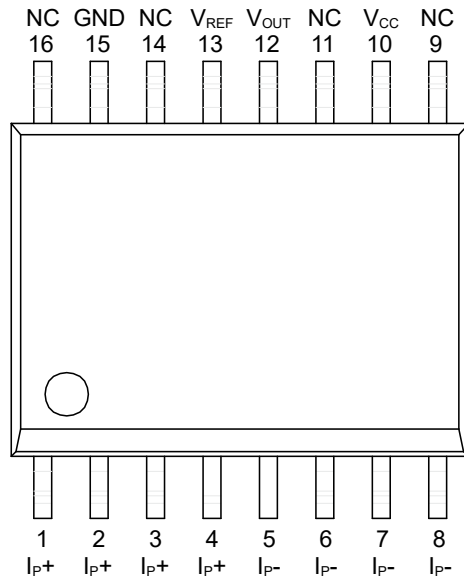


Figure 13. SOPW16 dimensions (unit: mm)

Marking Description:



12. Pin Definition and Wiring Diagram



No.	Pin	Description
1	I_{P+}	Current in, positive direction
2		
3		
4		
5	I_{P-}	Current out, negative direction
6		
7		
8		
9	NC	Not connected
10	V_{CC}	Voltage supply
11	NC	Not connected
12	V_{OUT}	Output voltage
13	V_{REF}	Reference voltage
14	NC	Not connected
15	GND	Ground
16	NC	Not connected

Figure 14. Pin definition

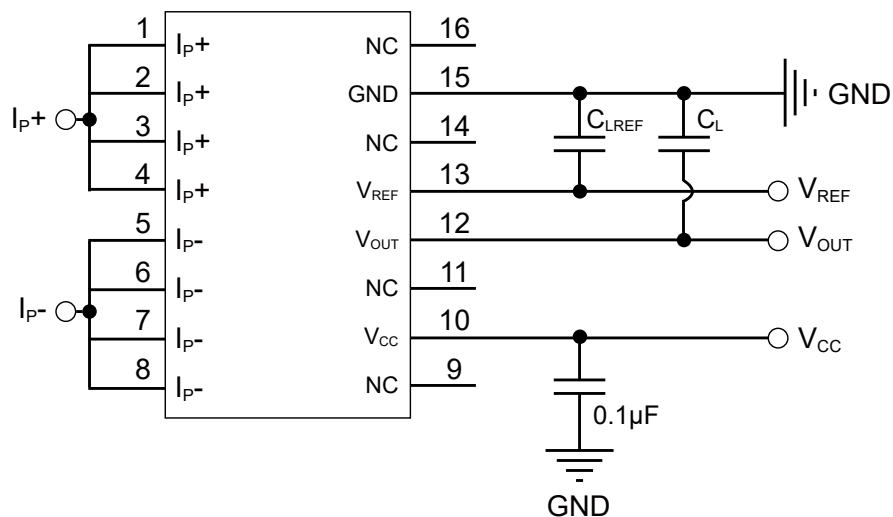


Figure 15. Wiring diagram

13. Recommended PCB Layout

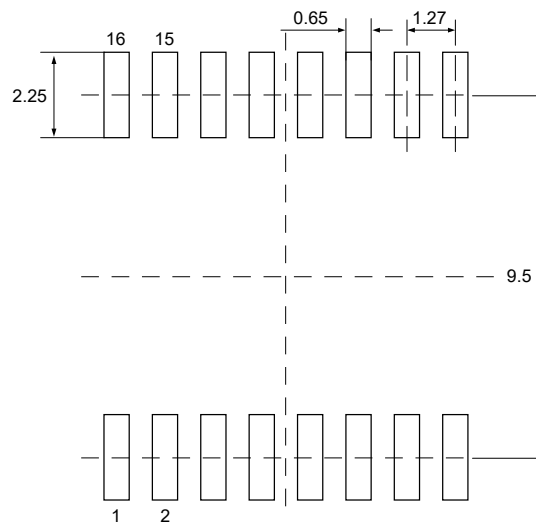
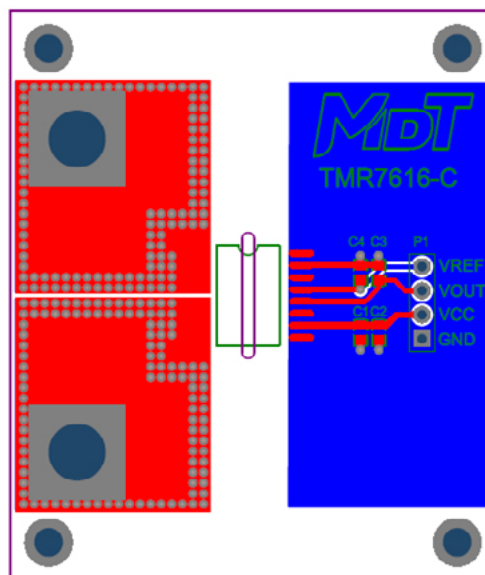


Figure 16. PCB Layout (Unit: mm)

14. Junction Temperature vs Primary Current

The relationship between the junction temperature and the primary current of the TMR7616-C series sensor IC was measured under the following experimental demo board conditions.



Demo Board Specifications	
Layers	2
Primary side trace copper single-layer area	910 mm ²
Single-layer copper thickness	4Oz

Figure 17. Demo board layout

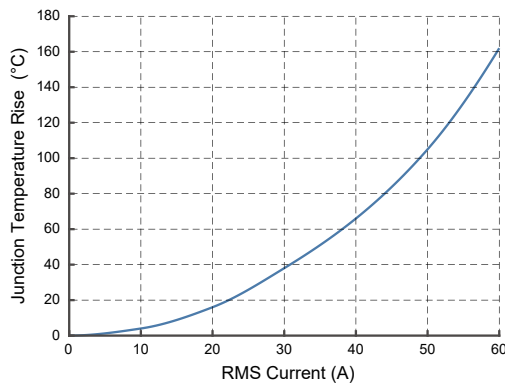


Figure 18. Junction temperature vs RMS current

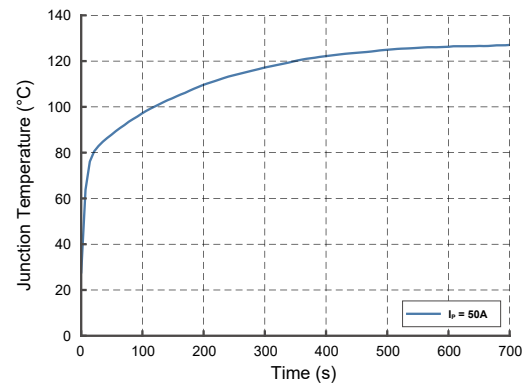


Figure 19. Junction temperature at 50A primary current at room temperature

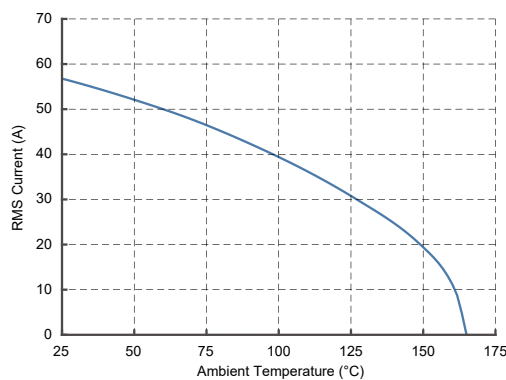


Figure 20. RMS current vs ambient temperature

The temperature rise of TMR7616-C is mainly due to the spontaneous heating of the current passing through the primary side conductor path. The heat is then conducted through the encapsulation, lead frame, PCB, and air. At room temperature, the relationship between the continuous current (RMS) of TMR7616-C and the temperature rise increment is shown in Figure 18. In a normal temperature environment with natural air circulation, the junction temperature of TMR7616-C generally stabilizes after continuous current loading for about 10 minutes, as shown in Figure 19. For example, when a direct current of 50A is loaded continuously at 25°C, the relationship between the temperature rise and the time of current loading shows that it takes about 100 seconds for the chip temperature to approach 100°C.

The relationship between the maximum continuous current (RMS) loading capability of TMR7616-C and the operating environment temperature is shown in Figure 20. When the ambient temperature is 25°C, the maximum continuous current effective value is 56A; at 125°C, it is approximately 30A. Under the condition that the junction temperature does not exceed 165°C, surge or pulse currents exceeding the maximum value listed in the figure are allowed. By using appropriate layout design, such as increasing the copper thickness, area, and number of PCB layers, better heat dissipation can be achieved.

15. Application Instructions

1. Improper wiring may damage sensor.
2. Supply voltage V_{CC} must match specification. Low supply voltage will cause inaccurate output. High supply voltage will damage sensor.
3. A RC filter may be added between the V_{OUT} and GND to adjust output frequency characteristics.
4. Contact MDT to request custom sensor specifications including voltage supply, current measurement range, and pin definition.

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