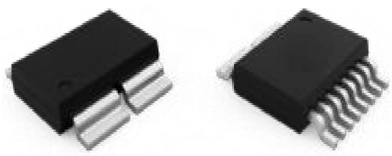
FSD7610-C 系列芯片式电流传感器



产品概述/Product overview

FSD7610-C 系列芯片式电流传感器基于电磁感应原理， 使用高灵敏度、高信噪比的隧道磁阻（TMR）设计，其内部 内置温漂补偿电路，在原副边电气隔离的情况下，可以精确 测量直流、交流和脉冲等形式的电流信号。

The FSD7610-C series on-chip current sensor is based on the principle of electromagnetic induction, using the tunnel reluctance (TMR) design with high sensitivity and high signal-to-noise ratio, and its internal temperature drift compensation circuit, under the condition of electrical isolation of the primary secondary side, it can accurately measure current signals in the form of DC, AC and pulse.

产品特性/Product characteristics

- 10-pin SOPW 封装/10-pin SOPW package
- 精度高/High precision
- 低噪声/Low noise
- 频带宽，响应快/Wide frequency band, fast response
- 优秀的温度稳定性/Excellent temperature stability
- 符合 RoHS & REACH/RoHS & REACH compliant

典型应用/Typical application

- 变频器电流检测/Inverter current detection
- 电源监控/Power monitoring
- 电机驱动/Motor drive
- 光伏逆变器/Photovoltaic inverter
- 过流保护/Overcurrent protection

产品选型表/Product selection table

型号 Type	供电电压 Supply voltage	测量电流范围 Measuring range	零点偏置电压 Zero bias voltage	灵敏度 sensitivity
FSD7610-050C3BFB	3.3 V	±50 A	1.65 V	26.4mV/A
FSD7610-075C3BFB	3.3 V	±75 A	1.65 V	17.6mV/A
FSD7610-100C3BFB	3.3 V	±100A	1.65 V	13.2 mV/A
FSD7610-150C3BFB	3.3 V	±150 A	1.65 V	8.8mV/A
FSD7610-200C3BFB	3.3 V	±200A	1.65 V	6.6mV/A
FSD7610-050C5BFB	5 V	±50 A	2.5 V	40 mV/A
FSD7610-075C5BFB	5 V	±75 A	2.5 V	26.67 mV/A
FSD7610-100C5BFB	5 V	±100 A	2.5 V	20 mV/A
FSD7610-150C5BFB	5 V	±150A	2.5 V	13.33 mV/A
FSD7610-200C5BFB	5 V	±200A	2.5 V	10 mV/A

1.功能框图/Functional block diagram

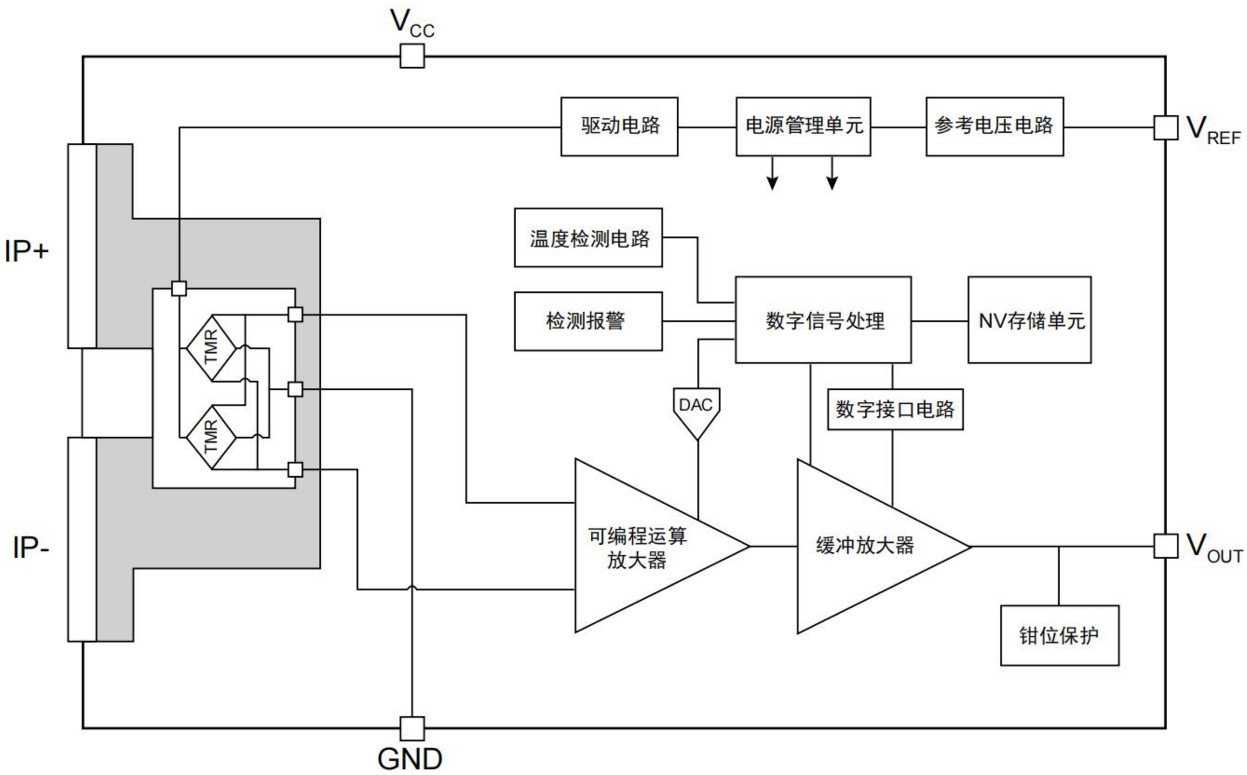


图 1 FSD7610-C 功能框图

2.绝对最大额定值/Absolute maximum rating

参数 Parameter	符号 Symbol	最小值 Minimum value	最大值 Maximum value	单位 Unit
供电电压 Supply voltage	VCC	-	6	V
ESD 性能（HBM） ESD Performance (HBM)	VESD	-	4	kV
使用温度 Service temperature	TA	-40	125	°C
储存温度 Storage temperature	TSTG	-40	125	°C
最大结温 Maximum junction temperature	TJ(MAX)	-	165	°C

3. 绝缘隔离特性/Insulation isolation characteristic

参数 Parameter	符号 Symbol	额定值 Rated value	单位 Unit
绝缘耐压强度 Compressive strength of insulation	V_D	4.8	kV(50Hz, 1min)
最大工作隔离电压 Maximum operating isolation voltage	V_{ISO}	1618	V_{PK}
		1144	V_{RMS}
爬电距离 Creepage distance	d_{CP}	8.2	mm
电气间隙 Electrical clearance	d_{CL}	8.2	mm
相对漏电起痕指数 Relative leakage marking index	CTI	≥ 600	V

4. 电气参数/Electrical parameter

参数 Parameter	符号 Symbol	条件 Conditions	最小值 Minimum value	典型值 Typical value	最大值 Maximum value	单位 unit
供电电压 Supply voltage	V_{CC}	FSD7610-XXXC3BFB	3	3.3	3.6	V
		FSD7610-XXXC5BFB	4.5	5	5.5	
零点偏置电压 Zero bias voltage	V_{OFF}	I_P = 0, V_{CC} = 3.3 V, FSD7610-XXXC3BFB	-	1.65	-	V
		I_P = 0, V_{CC} = 5 V, FSD7610-XXXC5BFB	-	2.5	-	
输出饱和电压 Output saturation voltage	V_{OL}	-	0.2	-	-	V
	V_{OH}	-	-	-	VCC - 0.2	
电流消耗 Current consumption	I_C	V_{CC} = 3.3 V	-	-	6	mA
		V_{CC} = 5 V	-	-	6	
上电时间 Power-on time	t_{ON}	从 V_{CC} ≥ 2.5V 至 V_{OUT} 达到稳定水平 Stable level from VCC ≥ 2.5V to VOUT	-	200	-	μs
原边导体电阻 Primary side conductor resistance	R_{IN}	T_A = 25°C	-	0.27	-	mΩ
输出电阻负载 Output resistance load	R_L	V_{OUT} 与 GND 之间 Between VOUT and GND	1	10	-	kΩ
输出电容负载 Output capacitance load	C_L	V_{OUT} 与 GND 之间 Between VOUT and GND	-	-	10	nF
输出拉电流 Output pull current	$I_{OUT(SOURCE)}$	V_{CC} = 3.3 V, V_{OUT} 短路到 GND VCC = 3.3V, VOUT shorted to GND	-	43	-	mA
		V_{CC} = 5 V, V_{OUT} 短路到 GND	-	45	-	

		VCC = 5 V, VOUT shorted to GND				
输出灌电流 Output filling current	IOUT(SINK)	VCC = 3.3 V, VOUT 短路到 VCC VCC = 3.3V, VOUT shorted to VCC	-	43	-	mA
		VCC = 5 V, VOUT 短路到 VCC VCC = 5 V, VOUT shorted to VCC	-	45	-	
VREF 电阻负载 VREF resistance load	RLREF	VREF 与GND 之间 Between VREF and GND	10	100	-	kΩ
VREF 电容负载 VREF capacitive load	CLREF	VREF 与GND 之间 Between VREF and GND	-	1	10	nF
VREF拉电流 VREF pull current	IREF(SOURCE)	VCC = 3.3 V, VREF 短路到GND VCC = 3.3V, VREF short-circuited to GND	-	3.7	-	mA
		VCC = 5 V, VREF 短路到GND VCC = 5 V, VREF short-circuited to GND	-	8.7	-	
VREF灌电流 VREF perfusion current	IREF(SINK)	VCC = 3.3 V, VREF 短路到 VCC VCC = 3.3V, VREF short circuit to VCC	-	0.125	-	mA
		VCC = 5 V, VREF 短路到 VCC VCC = 5 V, VREF short circuit to VCC	-	0.135	-	
电源抑制比 Power supply rejection ratio	PSRR	DC~1kHz, 100mV pk-pk ripple aroud VCC = 5 V, IP = 0	-	-40	-	dB
共模磁场抑制比 Common-mode magnetic field rejection ratio	CMFRR	均匀外磁场 Uniform external magnetic field	-	-40	-	dB
上升时间 Rise time	trise	从最终的VOUT 的 10% 至90% 的时间 10% to 90% of the time from the final VOUT	-	1.1	-	µs
延迟时间 Delay time	tD	从最终的 Ip 的20% 至相应的VOUT 的20% 时间 20% time from the final IP to the corresponding VOUT	-	0.4	-	µs
响应时间 Response time	tR	从最终的 Ip 的90% 至相应的VOUT 的90% 时间 90% of the time from the final IP to the corresponding VOUT	-	1.2	-	µs
带宽 bandwidth	BW	Ip = 10 A, 幅值衰减至-3dB IP = 10A, amplitude attenuation to -3dB	-	350	-	kHz

5. FSD7610-XXXC3BFB 性能参数/Performance parameter

除特殊说明外 TA = 25 °C, VCC = 3.3 V, RL = 10 kΩ

TA = 25 °C, VCC = 3.3V, RL = 10 kΩ unless otherwise specified

参数 Parameter	符号 Symbol	条件 Conditions	最小值 Minimum value	典型值 Typical value	最大值 Maximum value	单位 Unit
测量电流范围 Measuring range	IPM	FSD7610-050C3BFB	-50	-	50	A
		FSD7610-075C3BFB	-75	-	75	
		FSD7610-100C3BFB	-100	-	100	
		FSD7610-150C3BFB	-150	-	150	
		FSD7610-200C3BFB	-200	-	200	
灵敏度 Sensitivity	S	FSD7610-050C3BFB	-	26.4	-	mV/A
		FSD7610-075C3BFB	-	17.6	-	
		FSD7610-100C3BFB	-	13.2	-	
		FSD7610-150C3BFB	-	8.8	-	
		FSD7610-200C3BFB	-	6.6	-	
基本误差 Basic error	XG	TA = 25 °C, IP = IPM(min) ~ IPM(max)	-	±1	-	%IPM(max)
		TA = -40 °C ~ +25 °C, IP = IPM(min) ~ IPM(max)	-2	-	2	
		TA = 25 °C ~ +125 °C, IP = IPM(min) ~ IPM(max)	-3	-	3	
线性度误差 Linearity error	εL	IP = IPM(min) ~ IPM(max)	-	0.5	1	%IPM(max)
灵敏度误差 Sensitivity error	εS	TA = 25 °C, IP = IPM(min) ~ IPM(max)	-1	-	1	%
		TA = -40 °C ~ +25 °C, IP = IPM(min) ~ IPM(max)	-1.5	-	1.5	
		TA = 25 °C ~ +125 °C, IP = IPM(min) ~ IPM(max)	-2	-	2	
参考电压 Reference voltage	VREF	TA = 25 °C	1.645	-	1.655	V
		TA = -40 °C ~ +125 °C	1.635	-	1.665	
零点失调电压 Zero offset voltage	VOE	TA = 25 °C, IP = 0, VOUT - VREF	-10	-	10	mV
		TA = -40 °C ~ +25 °C, IP = 0, VOUT - VREF	-12	-	12	
		TA = 25 °C ~ +125 °C, IP = 0, VOUT - VREF	-20	-	20	
磁滞 hysteresis	VOH	IP = IPM(min) or IPM(max) → 0	-10	-	10	mV
噪声 noise	VN	TA = 25 °C, BW = 100 kHz	-	10	-	mVPP

6. FSD7610-XXXC5BFB 性能参数

除特殊说明外 TA = 25 °C, VCC = 5 V, RL = 10 kΩ

TA = 25 °C, VCC = 5 V, RL = 10 kΩ unless otherwise specified

参数 Parameter	符号 Symbol	条件 Conditions	最小值 Minimum value	典型值 Minimum value	最大值 Minimum value	单位 Unit
测量电流范围 Measuring range	IPM	FSD7610-050C5BFB	-50	-	50	A
		FSD7610-075C5BFB	-75	-	75	
		FSD7610-100C5BFB	-100	-	100	
		FSD7610-150C5BFB	-150	-	150	
		FSD7610-200C5BFB	-200	-	200	
灵敏度 Sensitivity	S	FSD7610-050C5BFB	-	40	-	mV/A
		FSD7610-075C5BFB	-	26.67	-	
		FSD7610-100C5BFB	-	20	-	
		FSD7610-150C5BFB	-	13.33	-	
		FSD7610-200C5BFB	-	10	-	
基本误差 Basic error	XG	TA = 25 °C, IP = IPM(min) ~ IPM(max)	-	±1	-	%IPM(max)
		TA = -40 °C ~ +25 °C, IP = IPM(min) ~ IPM(max)	-2	-	2	
		TA = 25 °C ~ +125 °C, IP = IPM(min) ~ IPM(max)	-3	-	3	
线性度误差 Linearity error	εL	IP = IPM(min) ~ IPM(max)	-	0.5	1	%IPM(max)
灵敏度误差 Sensitivity error	εS	TA = 25 °C, IP = IPM(min) ~ IPM(max)	-1	-	1	%
		TA = -40 °C ~ +25 °C, IP = IPM(min) ~ IPM(max)	-1.5	-	1.5	
		TA = 25 °C ~ +125 °C, IP = IPM(min) ~ IPM(max)	-2	-	2	
参考电压 Reference voltage	VREF	TA = 25 °C	2.495	-	2.505	V
		TA = -40 °C ~ +125 °C	2.48	-	2.52	
零点失调电压 Zero offset voltage	VOE	TA = 25 °C, IP = 0, VOUT - VREF	-10	-	10	mV
		TA = -40 °C ~ +25 °C, IP = 0, VOUT - VREF	-15	-	15	
		TA = 25 °C ~ +125 °C, IP = 0, VOUT - VREF	-20	-	20	
磁滞 hysteresis	VOH	IP = IPM(min) or IPM(max) → 0	-10	-	10	mV
噪声 noise	VN	TA = 25 °C, BW = 100 kHz	-	10	-	mVPP

7. 典型输出特性曲线/Typical output characteristic curve

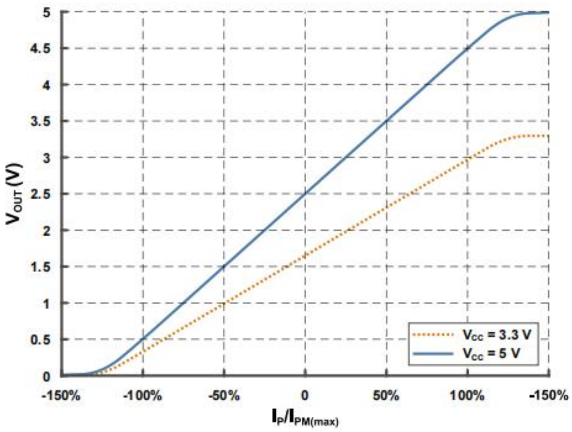


图 2 输入电流与输出电压关系曲线

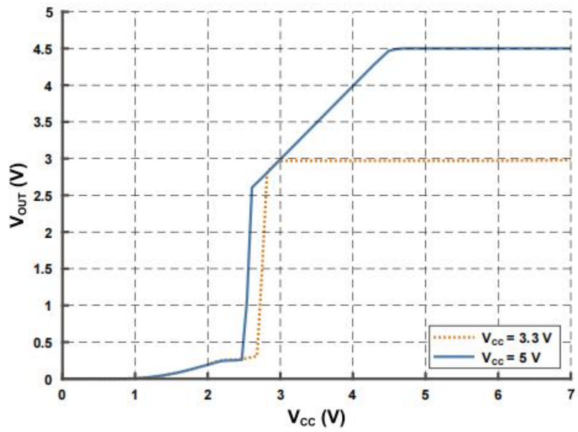


图 3 供电电压与输出电压关系曲线（@I_P = $I_{PM(Max)}$）

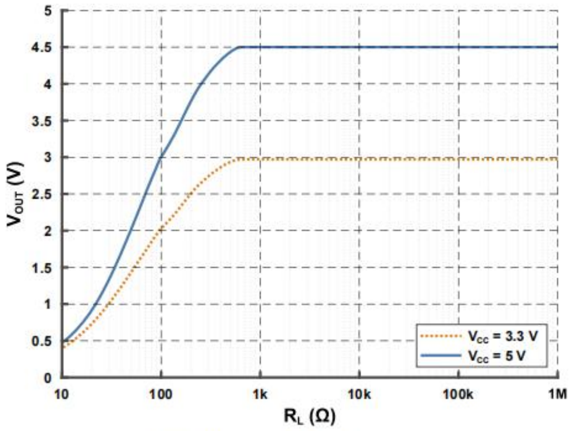


图 4 电阻负载特性曲线（@I_P = $I_{PM(Max)}$）

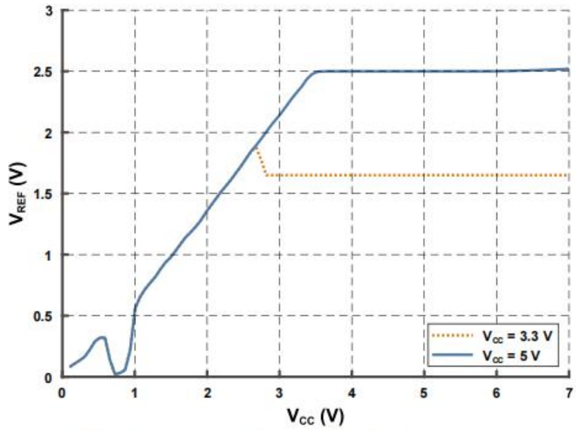


图 5 供电电压与参考电压关系曲线（@I_P = $I_{PM(Max)}$）

8. 上电启动时间波形/Power-on startup time waveform

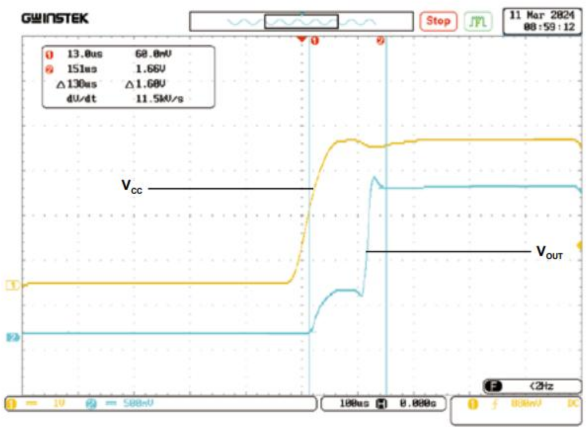


图 6 FSD7610-xxxC3BFB 上电启动波形

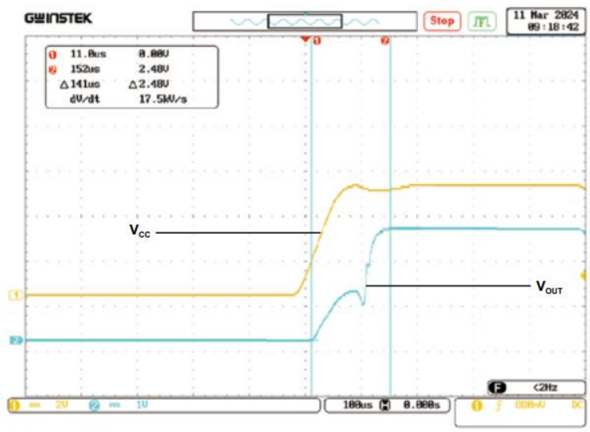


图 7 FSD7610-xxxC5BFB 上电启动波形

9. 频响特性曲线

以下曲线按FSD7616-050C5BFB 测试为例：

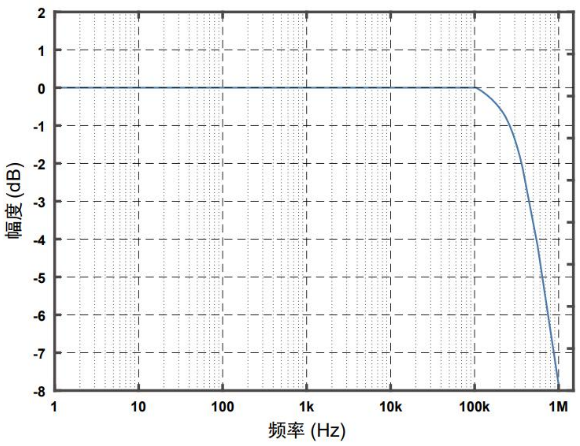


图8 FSD7610-C 幅频响应特性曲线

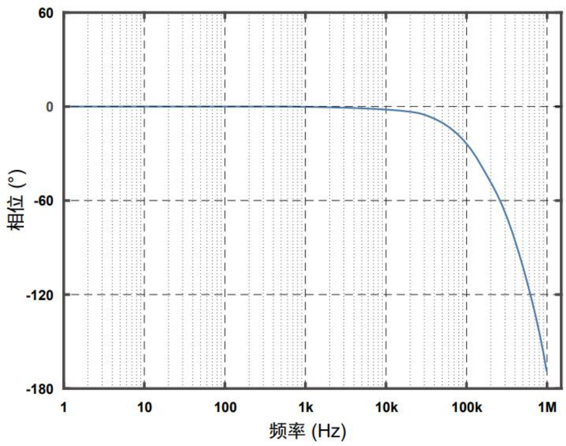


图9 FSD7610-C 相频响应特性曲线

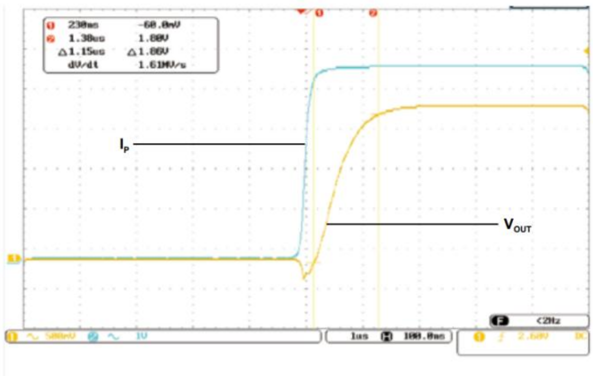


图10 FSD7610-C 响应时间

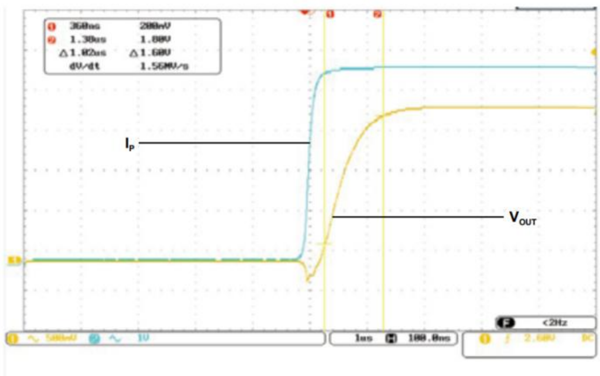


图11 FSD7610-C 上升时间

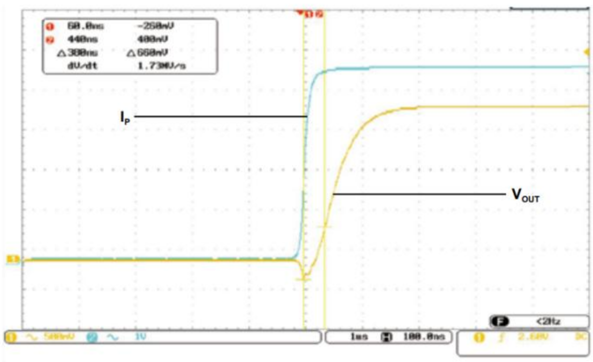


图12 FSD7610-C 传播延迟时间

10. 参数定义及计算公式/Parameter definition and calculation formula

1) 基本误差/Basic error

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

式中，Ip为传感器原边输入待测电流，IPM(max) 、IPM(min) 为电流测量范围内的最大值、最小值，V_{OUT}为原边输入电流Ip时传感器输出， S为传感器灵敏度， VREF为传感器参考电压。

Where, IP is the input current to be measured at the primary side of the sensor, IPM(max) and IPM(min) are the maximum and minimum values within the current measurement range, VOUT is the output of the sensor when the input current IP is at the primary side, S is the sensitivity of the sensor, and VREF is the reference voltage of the sensor.

2) 灵敏度/sensitivity

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

式中， $V_{OUT}(@I_{PM}(max))$ 、$V_{OUT}(@I_{PM}(min))$ 分别为原边输入电流为 IPM(max) 、IPM(min)时传感器的输出。

Where, $V_{OUT}(@I_{PM}(max))$ and $V_{OUT}(@I_{PM}(min))$ are the output of the sensor when the input current on the primary side is $I_{PM}(max)$ and $I_{PM}(min)$ respectively.

3) 线性度/linearity

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

式中， $\overline{S}$ 、 $\overline{V_{REF}}$分别为传感器实际多次测量的平均灵敏度和参考电压。

Where $\overline{S}$ and $\overline{V_{REF}}$ are respectively the average sensitivity and reference voltage of the actual multiple measurements of the sensor.

4) 零点失调电压/Zero offset voltage

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

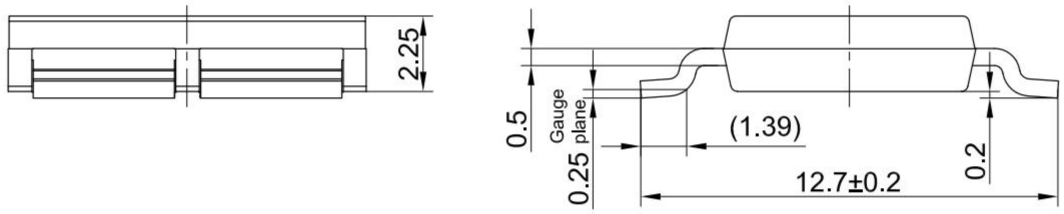
5) 磁滞/hysteresis

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

式中，ΔH 为同一输入电流 Ip时传感器在上、下行程实际输出的差值。

Where ΔH is the difference between the actual output of the sensor in the upper and lower stroke when the same input current IP is used.

11. 封装



侧视图　　　　侧视图

图 13 SOPW10 封装尺寸图（尺寸单位：mm）

12.引脚定义及接线图/Pin definition and wiring diagram

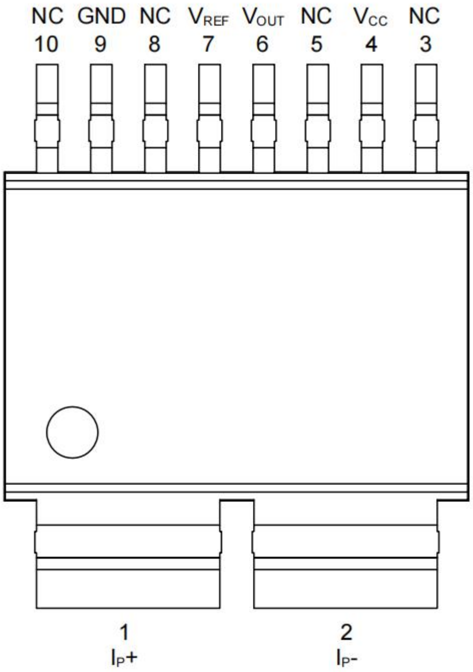


图 14　引脚定义/Figure 14 Pin definition

序号 Serial number	引脚名 Pin name	功能 Feature
1	IP+	电流流入，正方向 Current flowing in, positive direction
2	IP-	电流流出，负方向 Current flowing out, negative direction
3	NC	内部无电气连接，默认悬空 No internal electrical connection, suspended by default
4	VCC	供电电源 Power supply
5	NC	内部无电气连接，默认悬空 No internal electrical connection, suspended by default
6	VOUT	模拟电压输出 Analog voltage output
7	VREF	参考电压 Reference voltage
8	NC	内部无电气连接，默认悬空 No internal electrical connection, suspended by default
9	GND	电源地 electrically
10	NC	内部无电气连接，默认悬空 Internal no electrical connection, default suspension Internal no electrical connection, default suspension

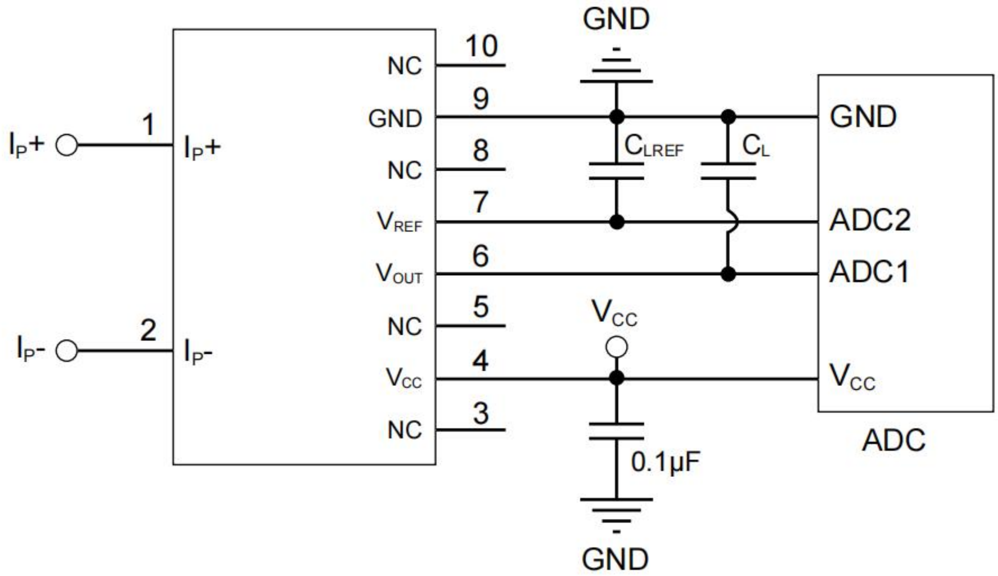


图 15 接线图/Figure 15 Wiring diagram

13. PCB 推荐布局/Recommended layout

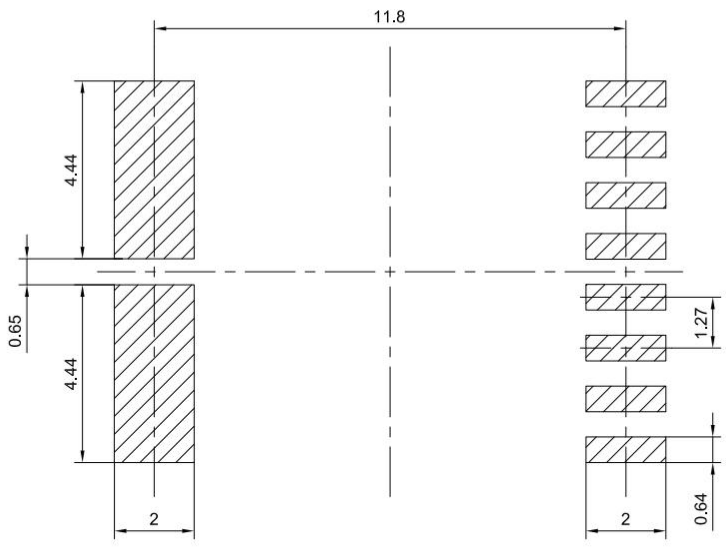
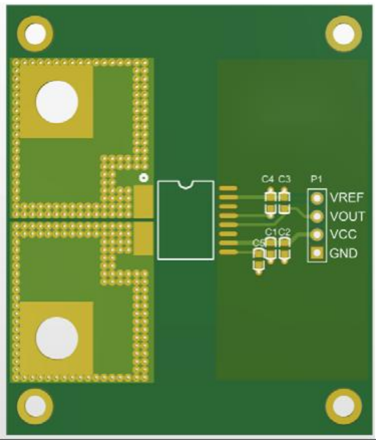


图 16 PCB 布局图（尺寸单位：mm）/Figure 16 PCB layout (size unit: mm)

14. 芯片结温与原边电流/Chip junction temperature and primary current

采用如下实验 DEMO 板条件下测得FSD7610-C 系列芯片结温与原边电流关系。

The relationship between junction temperature and primary current of FSD7610-C series chips is measured with the following experimental DEMO board.



PCB DEMO 板信息/PCB DEMO board information	
层数 Number of floors	2 层/2 layer
原边路径覆铜单层面积 Original side path copper-covered single-layer area	450 mm^2
单层覆铜厚度 Single layer copper coating thickness	4Oz

图 17 PCB DEMO 参考布局图/Figure 17 PCB DEMO reference layout diagram

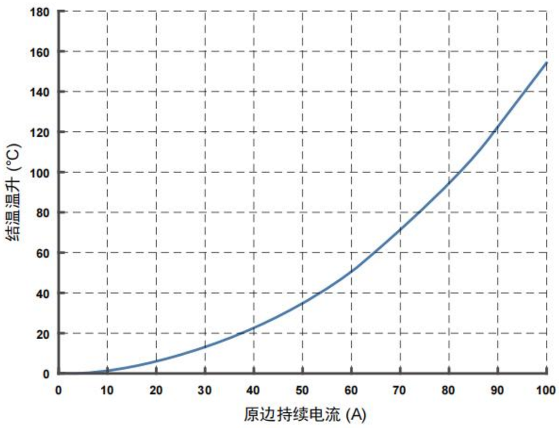


图 18 原边持续电流（RMS）与结温温升关系曲线

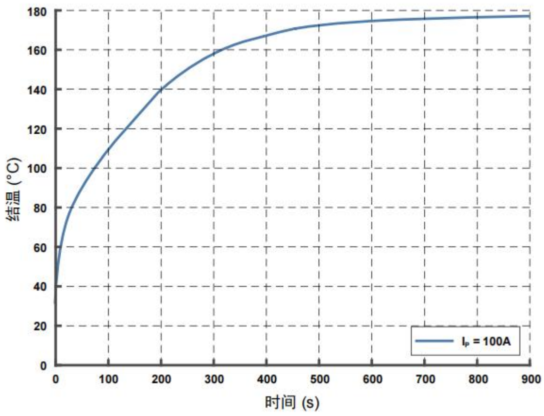


图 19 常温下原边持续加载直流电流 50A 与结温关系曲线

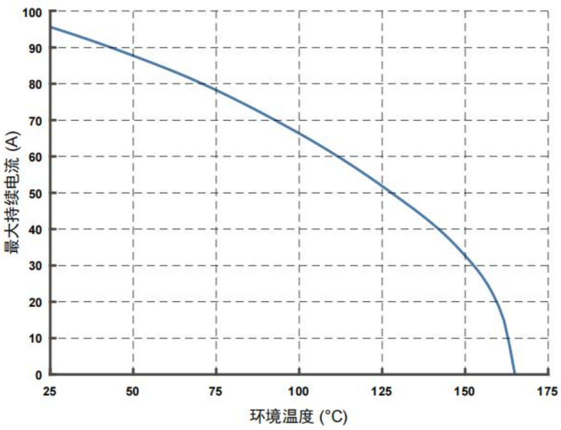


图 20 环境温度与最大持续电流（RMS）关系曲线

FSD7610-C 结温温升主要由于电流流经原边导体路径的自发热，热量经塑封体、引线框架、PCB 与空气 传导。在常温下，FSD7610-C 持续加载电流（有效值）与结温上升增量关系曲线见图 18。在常温空气自然流 通环境下，一般持续电流加载 10min 左右，FSD7610-C 的结温基本趋于稳定，如图 19，在26°C 下持续加载 直流电流 100A，结温上升与加载电流时间的关系曲线，大概电流加载时间 350s，芯片结温接近 165°C。

FSD7610-C 最大持续电流加载能力（电流有效值）与运行环境温度的关系曲线如图20，环境温度25°C 时， 最大持续电流有效值 96A；125°C 时，大概54A。在结温不超过 165°C 的情况下，允许浪涌或脉冲电流超过 图中所列最大值。

The temperature rise of the FSD7610-C junction is mainly due to the spontaneous heat of the current flowing through the path of the primary conductor, and the heat is conducted through the plastic sealing body, lead frame, PCB and air. At normal temperature, the relationship curve between continuous loading current (RMS) of FSD7610-C and junction temperature rise increment is shown in Figure 18. In the environment of natural air flow at normal temperature, the junction temperature of FSD7610-C generally tends to be stable when the continuous current is loaded for about 10min. As shown in Figure 19, when the DC current is continuously loaded for 100A at 26°C, the relationship between the junction temperature rise and the loading current time is about 350s. The chip junction temperature is close to 165°C.

The relationship curve between the maximum continuous current loading capability (current RMS) of FSD7610-C and operating ambient temperature is shown in Figure 20. When the ambient temperature is 25°C, the maximum continuous current RMS is 96A. At 125 degrees, that's about 54A. If the junction temperature does not exceed 165°C, the surge or pulse current is allowed to exceed the maximum value listed in the diagram.

15.使用说明/Instructions

1) 错误接线可能导致传感器损坏。

Incorrect cables may damage the sensor.

2) 产品供电电压V_{CC}需要满足规格要求，过低会导致产品无法准确输出，过高则会导致产品损坏。

The product power supply voltage V_{CC} must meet specifications. If the voltage is too low, the product cannot be accurately output. If the voltage is too high, the product may be damaged.

3) 产品输出V_{OUT}与GND之间可根据实际需求增设RC 滤波环节，以调整产品输出频率特性。

The RC filtering link between product output V_{OUT} and GND can be added according to actual requirements to adjust product output frequency characteristics.

4) 可根据客户需求定制传感器，包括供电电压、测量电流范围、引脚定义等。

Sensors can be customized according to customer requirements, including supply voltage, measurement current range, pin definition, and more.