MT9211

Programmable Hall Effect Linear Current Sensor IC with Low Noise and High Bandwidth (150kHz)

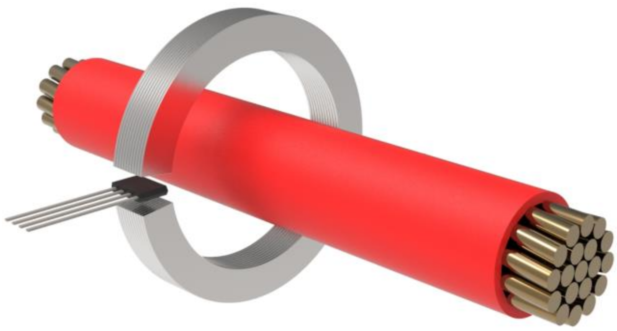
MagnTek

1 Product Description

The MagnTek® MT9211 product series is a monolithic programmable Hall effect linear sensor IC. The device can be used for accurate position sensing in a wide range of applications.

Each of the MT9211 consists of a highly sensitive Hall element, a low noise small-signal high-gain amplifier, a clamp and overcurrent protection output stage, and a high bandwidth dynamic offset cancellation technique.

The MT9211 provides an analog output voltage proportional to the applied magnetic flux density. The customer can configure the sensitivity and quiescent (zero field) output voltage through programming on the output pins, to optimize performance in the end application. The quiescent output voltage is user-adjustable around 50% of the supply voltage, VCC , and the output sensitivity is adjustable within the range of 0.7 to 22 mV/G.



2 Features

- End-of-line programmable
- Typical Accuracy:
  --- ±1.0% at 25℃
- High Linearity:
  --- ±0.2% at 25℃
- High Bandwidth:
  --- 150kHz
- Wide Operating Temperature:
  --- -40℃~150℃
- Fast Output Response Time:
  --- 4 μs (typ.)
- Package Option:
  ---SIP-4
- High stability over operation temperature range:
  ---2.5% at 25℃~150℃
  ---2.5% at -40℃~25℃
- Ratiometric Output from Supply Voltage
- Low-Noise Analog Signal Path
- RoHS Compliant: (EU)2015/863

3 Applications

- Inverter current sensing
- Motor phase and rail current sensing
- PV string inverters
- Battery management
- Switching power supplies
- Overcurrent protection

4 Product Overview of MT9211A

Part Number	Sensitivity Range	Package	Packing
MT9211A-01	0.707~1.414 mV/Gs	SIP-4	bulk packaging (1000pcs/bag)
MT9211A-02	1.414~2.828 mV/Gs	SIP-4	bulk packaging (1000pcs/bag)
MT9211A-04	2.828~5.656 mV/Gs	SIP-4	bulk packaging (1000pcs/bag)
MT9211A-08	5.656~11.312 mV/Gs	SIP-4	bulk packaging (1000pcs/bag)
MT9211A-16	11.312~22.624 mV/Gs	SIP-4	bulk packaging (1000pcs/bag)

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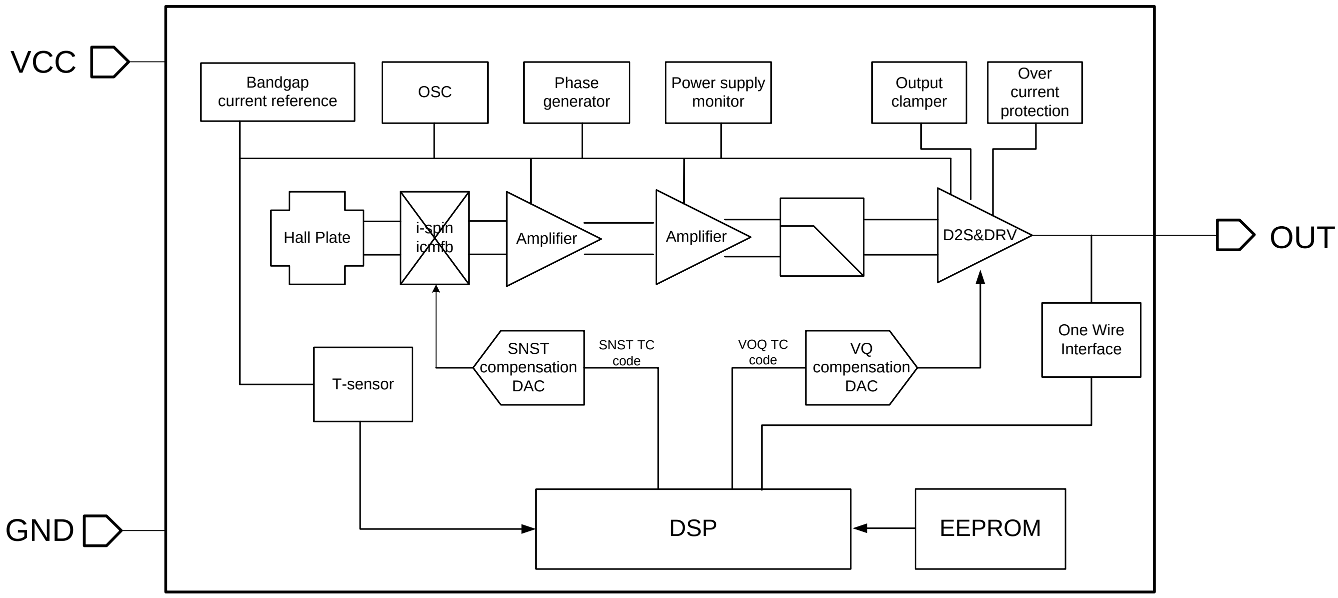

Figure.1 Functional Block Diagram

6 Pin Configuration and Functions

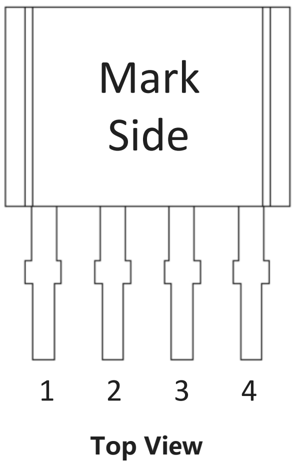

Figure.2 Pin Configuration & Functions

No.	Name	Description
1	VCC	Power Supply
2	VOUT	Analog Output Signal
3	NC	No Connect
4	GND	Signal Ground

7 Transfer Characteristics

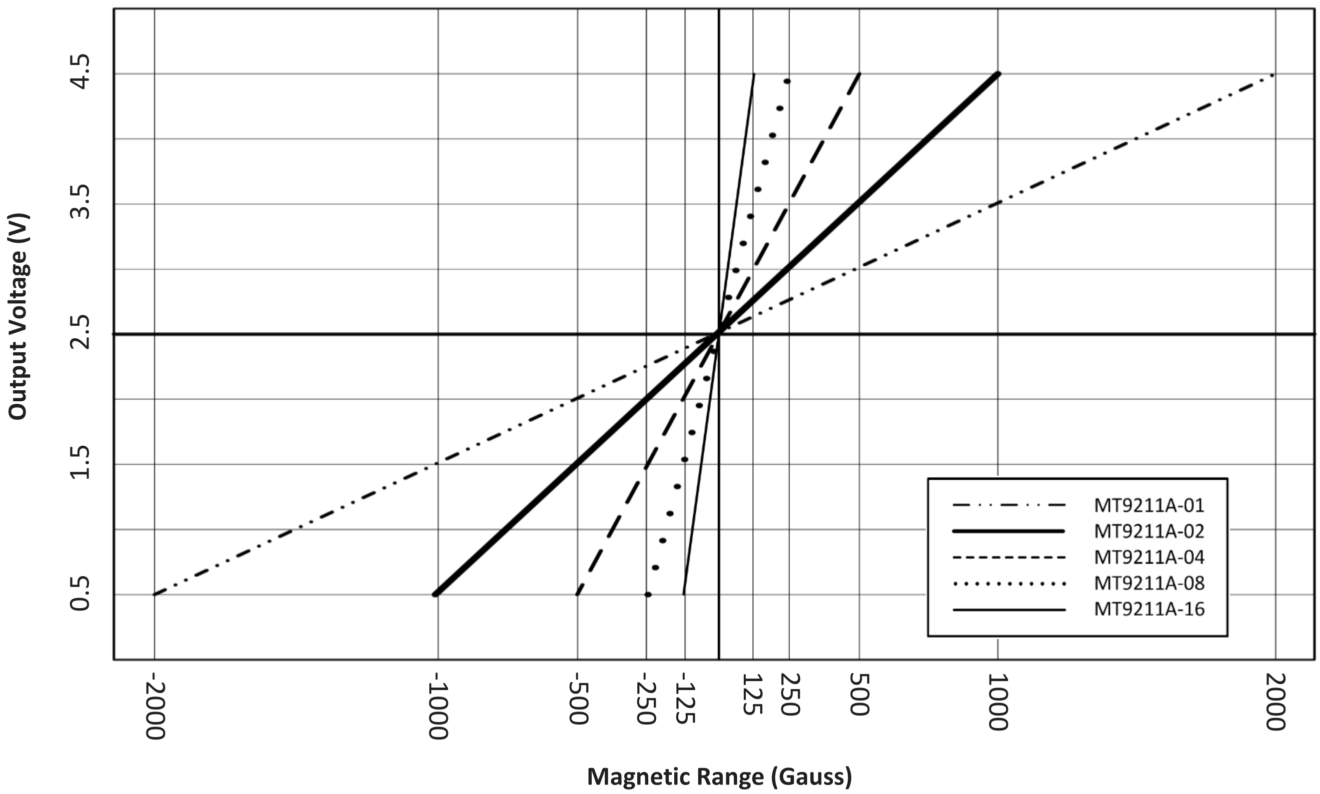

Figure.3 Transfer Characteristics

8 Typical Application Circuit

The typical application circuits of MT9211 series products include a bypass capacitor and a filter capacitor as an additional external components. **CBYPASS capacitor between VCC and GND is necessary**.
Magnetic field applied vertically to chip surface, the analog signal output is measured directly from the VOUT pin.

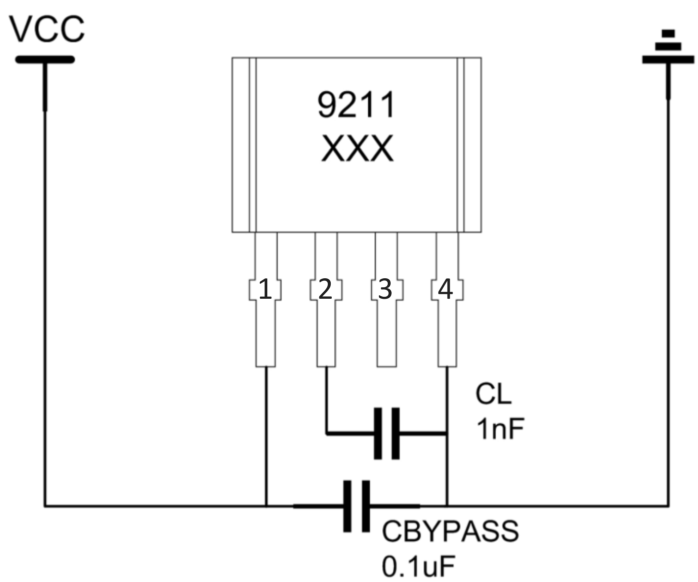

Figure.4 Typical Application Circuit

9 Electrical Magnetic Characteristics

9.1 Absolute Maximum Ratings

Absolute maximum ratings are limited values to be applied individually, and beyond which the serviceability of the circuit may be impaired. Functional operability is not necessarily implied. Exposure to absolute maximum rating conditions for an extended period of time may affect device reliability.

Symbol	Parameters	Min	Max	Units
VCC	Supply Voltage	-	6	V
VRCC	Reverse Battery Voltage	-0.1	-	V
VOUT	Output Voltage	-	VCC+0.5	V
VROUT	Reverse Output Voltage	-0.1	-	V
IOUT(source)	Continuous Output Current	-	80	mA
IOUT(sink)	Continuous Output Current	-	40	mA
TA	Operating Ambient Temperature	-40	150	℃
TS	Storage Temperature	-50	150	℃
TJ	Junction Temperature	-	165	℃
Endurance	Number of EEPROM Programming Cycles	200	-	cycle

9.2 ESD Ratings

Symbol	Parameters	Reference	Values	Unit
VESD	Human-body model (HBM)	AEC-Q100-002	Class IIIA	Grade
	Charged-device model (CDM)	AEC-Q100-011	Class C6	Grade
	Latch up	AEC-Q100-004	Class IIA	Grade

9.3 Electrical Specifications

At T_A=-40~150 ℃, V_{CC}=5V (unless otherwise specified)

Symbol	Parameters	Test Condition	Min	Typ	Max	Unit
VCC	Supply Voltage	-	4.5	5	5.5	V
ICC	Supply Current	TA = 25°C	-	10	15	mA
BW	Internal Bandwidth	Small signal –3 dB; CL = 1 nF	-	150	-	KHz
TPO	Power on time	TA = 25°C, CBYPASS = Open, CL = 1nF	-	145	-	us
TTC	Temperature compensation power on time	CBYPASS=Open, CL=1nF	-	45	-	us
VPORH	Power-On Reset High Voltage	TA = 25°C, VCC rising	3.75	4	4.25	V
VPORL	Power-On Reset Low Voltage	TA = 25°C, VCC falling	-	3.5	-	V
VPORHYS	Power-On Reset Hysteresis	TA = 25°C	-	0.5	-	V
TPORR	Power-On Reset Release Time	TA = 25°C, VCC rising	-	30	-	us
TPORA	Power-On Reset Analog Delay	TA = 25°C, VCC rising	-	5	-	us
ISCLP	Source Current of Over-Current-Limit	-	-	80	-	mA
ISCLN	Sink Current of Over-Current-Limit	-	-	40	-	mA
TSCLD	Detect Time for Over-Current-Limit	TA = 25°C, IOUT>ISCLP or IOUT<ISCLN	-	7	-	us
TSCLR	Release Time for Over-Current-Limit	TA = 25°C	-	0.62	-	ms
VOL	Analog Output Low Saturation Level	RL>=4.7KΩ	-	-	0.3	V
VOH	Analog Output High Saturation Level	RL>=4.7KΩ	VCC-0.3	-	-	V
CL	Output CAP Load	OUT to GND	-	-	10	nF
RL	Output RES Load	Pull-down to Ground	4.7	-	-	KΩ
		Pull-up to VCC	4.7	-	-	KΩ
ROUT	DC Output resistance		-	5	-	Ω
TR	Rise time	B = B(max), TA = 25°C, CL = 1nF	-	3	-	us
TPD	Propagation Delay	B = B(max), TA = 25°C, CL = 1nF	-	2	-	us
TRESP	Response Time	B = B(max), TA = 25°C, CL = 1nF	-	4	5	us

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Electrical Specifications (*continued*)

At T_A=-40~150 ℃, V_{CC}=5V (unless otherwise specified)

Symbol	Parameters	Test Condition	Min	Typ	Max	Unit
VCLP_LO	Clamp Low Output Level	TA = 25℃, RL = 10kΩ to VCC	0.15	-	0.45	V
VCLP_HI	Clamp High Output Level	TA = 25℃, RL = 10kΩ to GND	4.55	-	4.85	V
TCLP	Delay to Clamp	TA=25°C, magnetic field step from 800 to 1200G, CL=1nF, SNST=2 mV/Gs	-	8	-	us
IND	Noise Density	Input-referenced noise density; TA = 25°C, CL = 1 nF	-	1.45	-	mG/√Hz
Accuracy Specification						
ELIN	Nonlinearity Sensitivity Error		-1.0	±0.2	1.0	%
ESYM	Symmetry Sensitivity Error		-1.0	-	1.0	%
ERAT_SNST	Ratiometry Sensitivity Error	VCC = 4.5 to 5.5 V, TA = 25°C	-	±1.5	-	%
ERAT_VOQ	Ratiometry Quiescent Voltage Output Error	VCC = 4.5 to 5.5 V, TA = 25°C	-	±1	-	%
ERAT_CLP	Ratiometry Clamp Error	VCC = 4.5 to 5.5 V, TA = 25°C	-	±1	-	%
ΔSNST_PKG	Sensitivity Drift Due to Package Hysteresis	TA = 25°C, temperature cycling, 25°C to 150°C and back to 25°C	-	±1.25	-	%
Programming Specification						
VOQ_INIT	Initial Unprogrammed Quiescent Voltage Output	TA = 25°C, VCC=5V	2.475	2.5	2.525	V
VOQ_PR	Quiescent Voltage Output Programming Range	TA = 25°C, VCC=5V	2.423	-	2.580	V
VOQ_STEP	Average Quiescent Voltage Output Programming Step Size	TA = 25°C, VCC=5V	-	±2.5	-	mV
EVOQ_STEP	Quiescent Voltage Output Programming Resolution	TA = 25°C, VCC=5V	-	±1.25	-	mV
SNST_INIT	Initial Unprogramming Sensitivity	TA = 25°C, VCC=5V	-	1	-	mV/Gs
			-	2	-	mV/Gs
			-	4	-	mV/Gs
			-	8	-	mV/Gs
			-	16	-	mV/Gs
SNST_PR	Sensitivity Programming Range	TA = 25°C, VCC=5V	0.707	-	1.414	mV/Gs
			1.414	-	2.828	mV/Gs
			2.828	-	5.656	mV/Gs
			5.656	-	11.312	mV/Gs
			11.312	-	22.624	mV/Gs

Continued on the next page...

Electrical Specifications (*continued*)

At T_A=-40~150 ℃, V_{CC}=5V (unless otherwise specified)

Symbol	Parameters	Test Condition	Min	Typ	Max	Unit
SNST_INIT_ERR	Initial Unprogrammed Sensitivity Error	TA = 25°C, VCC=5V	-	±2.5	-	%
SNST_STEP	Average Sensitivity Programming Step Size	TA = 25°C, VCC=5V	-	±1.25	-	%
ESNST_STEP	Sensitivity Programming Resolution	TA = 25°C, VCC=5V	-	±0.625	-	%
Factory Temperature Coefficient Programed Specification						
ΔSNST_TC	Sensitivity Drift Through Temperature Range	TA = 25°C to 150°C	-2.5	-	2.5	%
		TA = –40°C to 25°C	-2.5	-	2.5	%
SNST_TC_STEP	Average Sensitivity Temperature Compensation Step Size		-	±0.25	-	%
ΔVOQ_TC	Quiescent Voltage Output Drift Through Temperature Range	TA = 25°C to 150°C	-15	-	15	mV
		TA = –40°C to 25°C	-20	-	20	mV
VOQ_TC_STEP	Average Quiescent Voltage Output Temperature Compensation Step Size		-	2.5	-	mV
Lock Bit Programming						
EELOCK_BIT	EEPROM Lock Bit		-	1	-	bit

10 Characteristic Definitions

Power On Time---TPO

When the supply is ramped to its operating voltage, the device requires a finite time to power its internal components before responding to an input magnetic field.
The Power-On Time (TPO) is defined as the time taken between the supply reaching the minimum operating voltage VCCmin (t1), and the output voltage to settling to within ±10% of its steady state value under an applied magnetic field (t2) (See Figure 5).

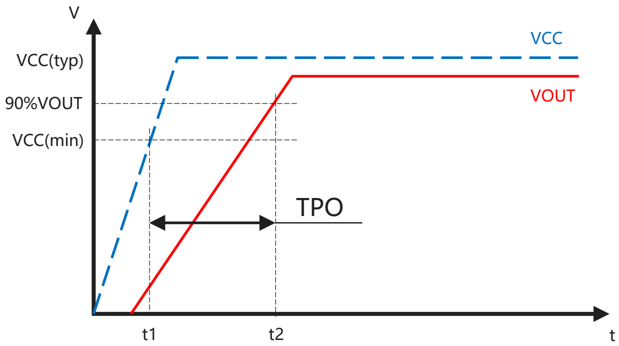


Figure.5 **Power On Time Definition**

Temperature Compensation Power-On Time---TTC

After Power-On Time, TPO , elapses TTC is also required before a valid temperature compensated output.

Propagation Delay---TPD

The time interval between a) when the applied magnetic field reaches 20% of its final value, and b) when the output reaches 20% of its final value (see Figure 6).

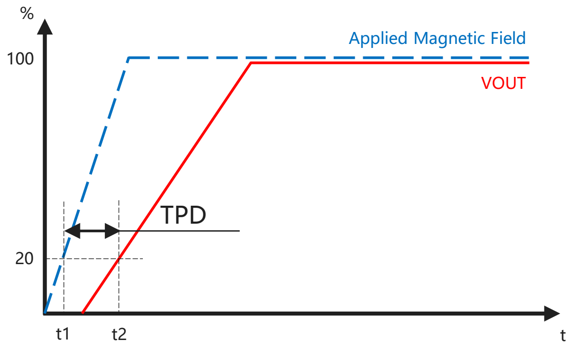


Figure.6 **Propagation Delay Definition**

Rise Time---TR

Rise Time is the time interval between the sensor VOUT reaching 10% of its full scale value (t1), and it reaching 90% of its full scale value (t2). (see Figure 7). Both TR and TRESP can be negatively affected by any eddy current losses created if a conductive ground plane is used.

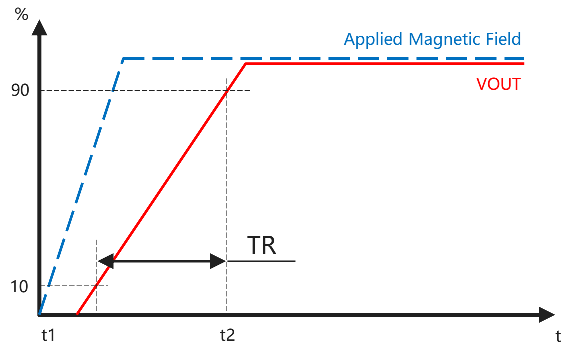


Figure.7 **Rise Time Definition**

Response Time---TRESP

The time interval between a) when the applied magnetic field reaches 80% of its final value, and b) when the sensor reaches 80% of its output corresponding to the applied magnetic field (see Figure 8). Both TR and TRESP can be negatively affected by any eddy current losses created if a conductive ground plane is used.

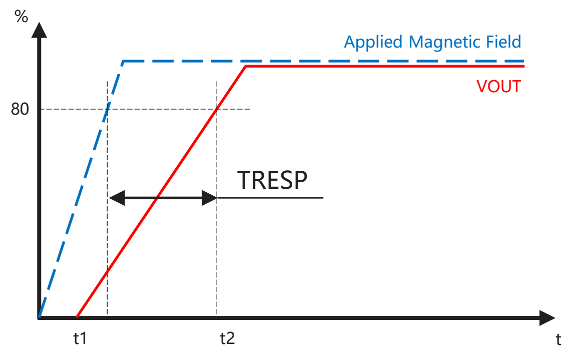


Figure.8 **Response Time Definition**

Delay to Clamp---TCLP

A large magnetic input step may cause the clamp to overshoot its steady state value. The Delay to Clamp, TCLP, is defined as: the time it takes for the output voltage to settle within ±1% of its steady state value, after initially passing through its steady state voltage (see Figure 9).

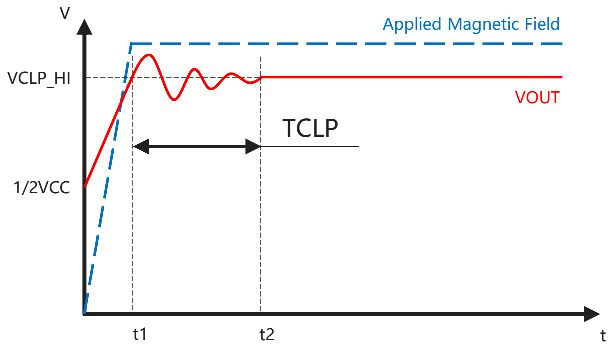


Figure.9 **Delay to Clamp Definition**

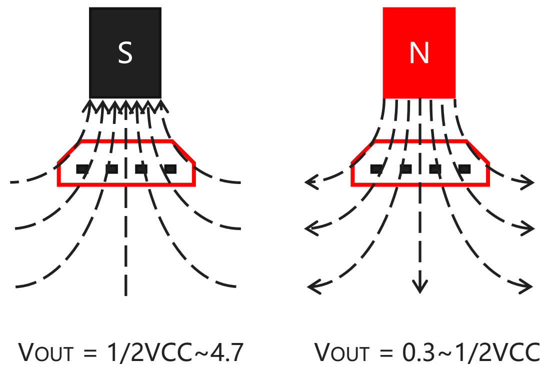


Figure.10 **Flux Direction Polarity**

Quiescent Voltage Output---VOQ

In the quiescent state (no significant magnetic field: (B=0Gs), the output (VOQ), has a constant ratio to the supply voltage (VCC), throughout the entire operating ranges of VCC and ambient temperature (TA).

Quiescent Voltage Output Drift Through Temperature Range---ΔVOQ_TC

Due to internal component tolerances and thermal considerations, the Quiescent Voltage Output (VOQ), may drift from its nominal value through the operating ambient temperature (TA). The Quiescent Voltage Output Drift Through Temperature Range, ΔVOQ_TC , is defined as:

$$\Delta VOQ\_TC = VOQ(TA) - VOQ\_EXPECT(TA)$$

VOQ_TC should be calculated using the actual measured values of VOQ(TA) and VOQEXPECT(TA) rather than programming target values.

Sensitivity---SNST

The presence of a south polarity magnetic field, perpendicular to the branded surface of the package face, increases the output voltage from its quiescent value toward the supply voltage rail. The amount of the output voltage increase is proportional to the magnitude of the magnetic field applied.
Conversely, the application of a north polarity field decreases the output voltage from its quiescent value. This proportionality is specified as the magnetic sensitivity, Sens (mv/G), of the device, and it is defined as:

$$SNST = \frac{V_{OUT(BPOS)} - V_{OUT(BNEG)}}{BPOS - BNEG}$$

where BPOS and BNEG are two magnetic fields with opposite polarities.

Sensitivity Drift Through Temperature Range---ΔSNST_TC

Second order sensitivity temperature coefficient effects cause the magnetic sensitivity, to drift from its expected value over the operating ambient temperature range (TA). The Sensitivity Drift Through Temperature Range, ΔSNST_TC, is defined as:

$$\Delta SNST\_TC = \frac{SNST(TA) - SNST\_EXPECT(TA)}{SNST\_EXPECT(TA)} * 100\%$$

Sensitivity Drift Due to Package Hysteresis ---ΔSNST_PKG

Second order sensitivity temperature coefficient effects cause the magnetic sensitivity, to drift from its expected value over the operating ambient temperature range (TA). The Sensitivity Drift Through Temperature Range, ΔSNST_TC, is defined as:

$$\Delta SNST\_PKG = \frac{SNST\_25℃\_2 - SNST\_25℃\_1}{SNST\_25℃\_1} * 100\%$$

where SNST_25°C_1 is the programmed value of sensitivity at TA=25°C, and SNST_25°C_2 is the value of sensitivity at TA=25°C, after temperature cycling TA up to 150°C/168hrs and back to 25°C.

Nonlinearity Sensitivity Error---ELIN

Ideally input magnetic field vs sensor output function is a straight line. The non-linearity is an indication of the worst deviation from this straight line. The ELIN in % is defined as:

$$ELIN = \left(\frac{SNST\_B1}{SNST\_B2} - 1\right) * 100\%$$

Where:

$$SNST\_B1=\left(\frac{VOUT\_BPOS1-VOUT\_BNEG1}{BPOS1-BNEG1}\right)$$

$$SNST\_B2=\left(\frac{VOUT\_BPOS2-VOUT\_BNEG2}{BPOS2-BNEG2}\right)$$

and BPOSx and BNEGx are positive and negative magnetic fields, with respect to the quiescent voltage output such that |BPOS2| = |BNEG2| = Bmax, and |BPOS2| = 2 × |BPOS1| and |BNEG2| = 2 × |BNEG1|.

Symmetry Sensitivity Error---ESYM
The magnetic sensitivity of an MT9211 device is constant for any two applied magnetic fields of equal magnitude and opposite polarities. Symmetry Error (ESYM), is measured and defined as:

$$ESYM=\left(\frac{SNST\_BPOSx}{SNST\_BNEGx}-1\right)*100\%$$

Where:

$$SNST\_BPOSx=\frac{VOUT\_Bx-VOQ}{Bx}$$

$$SNST\_BNEGx=\frac{VOQ-VOUT\_Bx}{Bx}$$

BPOSx and BNEGx are positive and negative magnetic fields such that |BPOSx| = |BNEGx|.

Ratiometry Error---ERAT
The MT9211 device features ratiometric output. This means that the Quiescent Voltage Output (VOQ) , magnetic sensitivity (SNST), and Output Voltage Clamp (VCLP_HI) and (VCLP_LO), are proportional to the Supply Voltage, VCC. In other words, when the supply voltage increases or decreases by a certain percentage, each characteristic also increases or decreases by the same percentage. Error is the difference between the measured change in the supply voltage relative to 5 V, and the measured change in each characteristic.

Ratiometry Quiescent Voltage Output Error---ERAT_VOQ
ERAT_VOQ, for a given supply voltage, is defined as:

$$ERAT\_VOQ=\left(\frac{VOQ(VCC)/VCC}{VOQ(5V)/5V}-1\right)*100\%$$

Ratiometry Sensitivity Error---ERAT_SNST
ERAT_SNST, for a given supply voltage, is defined as:

$$ERAT\_SNST=\left(\frac{SNST\_B1(VCC)/VCC}{SNST\_B1(5V)/5V}-1\right)*100\%$$

Ratiometry Clamp Error---ERAT_CLP
ERAT_CLP, for a given supply voltage, is defined as:

$$ERAT\_CLP=\left(\frac{VCLP(VCC)/VCC}{VCLP(5V)/5V}-1\right)*100\%$$

Where VCLP is either VCLP_HI or VCLP_LO.

Over Current Limit---ISCLP & ISCLN
The MT9211 has over-current protection function. When IOUT ≥ ISCLP or ISCLN, the output driver will be closed and the output will be turned into high resistance state.

Power-On Reset---POR

The descriptions in this section assume temperature = 25°C, no output load (RL, CL) , and no significant magnetic field is present.

Power-Up. At power-up, as VCC ramps up, the output is in a high-impedance state. When VCC crosses VPORH, the output will go to VCC/2 after POR Release counter (TPORR) + POR Analog delay (TPORA).

VCC drops below VCC(min) = 4.5 V. If VCC drops below VPORL, the output will be in a high-impedance state. If VCC recovers and exceeds VPORH, the output will go back to normal operation after POR Release counter (TPORR) + POR Analog delay (TPORA) (See Figure. 11).

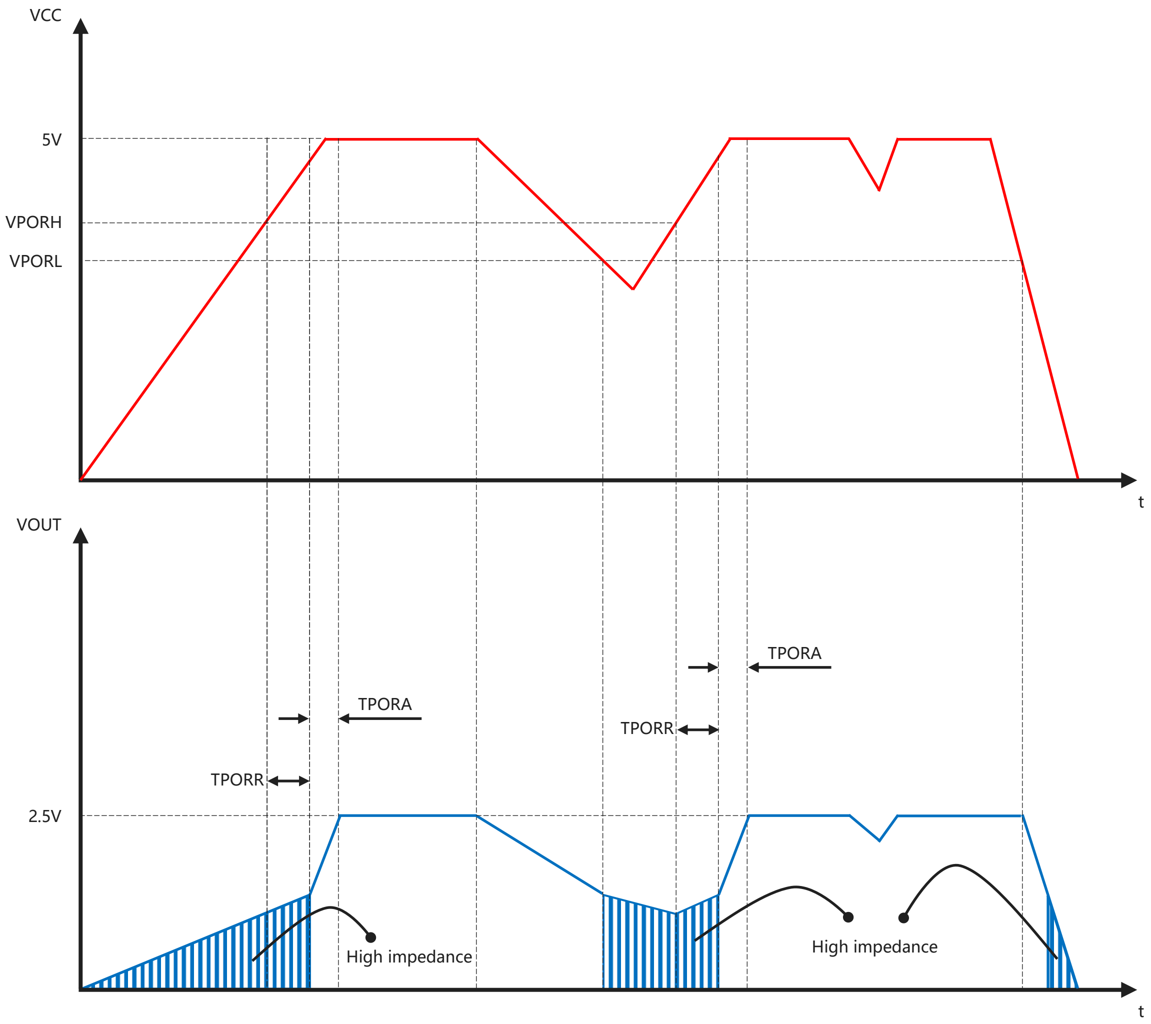
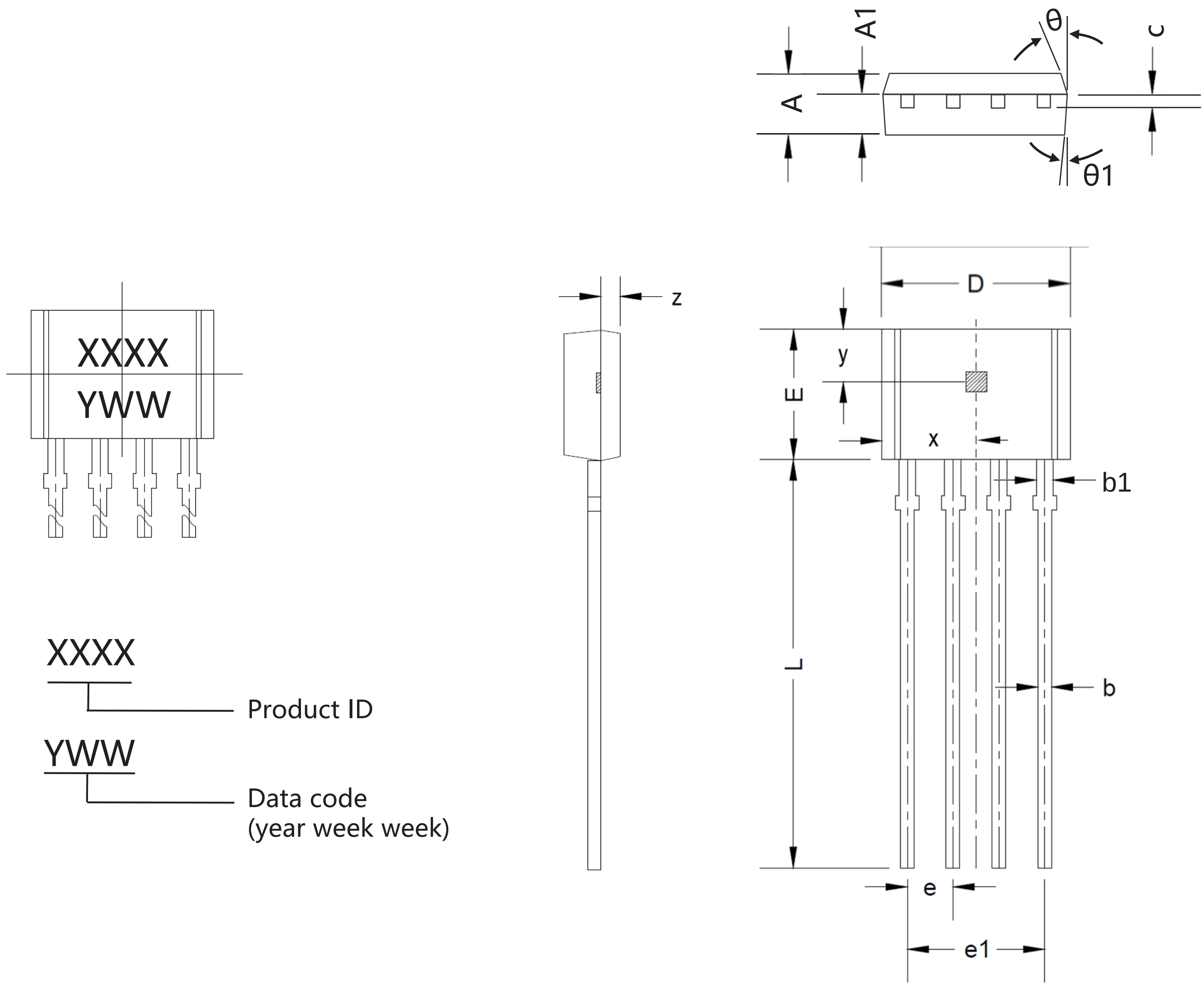


Figure.11 **Power-On Reset Definition**

11 Package Material Information (For Reference Only – Not for Tooling Use)

11.1 SIP-4 Package Information



Symbol	Dimensions in Millimeters		Dimensions in Inches	
	Min	Max	Min	Max
A	1.460	1.660	0.057	0.065
A1	0.660	0.860	0.026	0.034
b	0.350	0.560	0.014	0.022
b1	0.380	0.550	0.015	0.022
c	0.360	0.510	0.014	0.020
D	5.120	5.320	0.202	0.209
E	3.550	3.750	0.140	0.148
e	1.270(BSC)		0.050(BSC)	
e1	3.810(BSC)		0.150(BSC)	
L	13.500	15.500	0.531	0.610
x	2.565(BSC)		0.101(BSC)	
y	1.170(BSC)		0.046(BSC)	
z	0.500(BSC)		0.020(BSC)	
Θ	11°		11°	
Θ1	6°		6°	

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