19-0870; Rev 3; 9/10

可提供评估板

基于EEPROM的系统监控器，提供非易失故障存储

概述

MAX16031/MAX16032可配置EEPROM系统监测器内部集成了10位模/数转换器(ADC)，用于监测复杂系统的电压、温度和电流。EEPROM可配置器件允许用户自行设置工作范围、上限和下限、故障输出以及工作模式，并储存相关数据，从而实现更高的灵活性。

MAX16031可监测多达8路电压、3个温度点(1个内部温度/2个远端温度二极管)以及1路电流；MAX16032可以监测6路电压和2个温度点(1个内部温度/1个远端温度二极管)。所有监测参量都复用输入到ADC，并写入各自对应的寄存器，可通过SMBus™和JTAG接口读取。

测量值与用户设置的上限、下限进行比较。对于电压测量，有两个欠压门限和两个过压门限。对于电流和温度测量，有两组上限。一旦测量结果超出门限范围，将会产生报警信号并通报处理器。对于指定通道，提供独立的过流、过热和欠压/过压指示输出。器件还具有非特定的故障指示输出，为温度、电流或电压故障提供二级监测，也可以用作独立的过压检测输出。

发生严重故障(如系统关断)时，MAX16031/MAX16032自动将内部ADC寄存器的内容复制到非易失EEPROM寄存器，以便以后进行故障诊断时回读。

MAX16031/MAX16032提供辅助GPIO，用于电压排序、额外的故障检测输出、手动复位输入或读/写逻辑。具有独立输出的电流检测放大器在过流状态下可以快速关断。MAX16031/MAX16032采用7mm x 7mm TQFN封装，工作在-40°C至+85°C温度范围。

应用

服务器　　工作站

存储系统　　网络

电信

特性

- 供电电压范围：2.85V至14V
- 监测多达8路电压(单端输入或伪差分输入)，精度为1%
- EEPROM可配置门限
  - 2个欠压门限和2个过压门限
  - 2个过热门限
  - 2个过流门限
- 具有过流输出指示的高边电流检测放大器(MAX16031)
- 监测多达3个温度点(1个内部温度点/2个远端温度点)
- 非失易故障寄存器用于存储故障状态，便于随后的系统恢复
- 两个额外的可配置故障输出
- 两个可配置GPIO
- 具有ALERT输出和总线超时功能的SMBus/I²C兼容接口
- JTAG接口
- 7mm x 7mm、48引脚TQFN封装

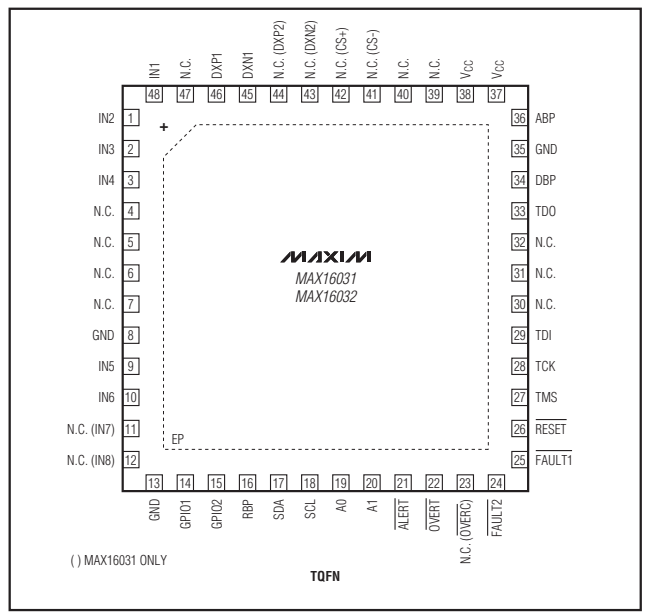
定购信息

PART	TEMP RANGE	PIN-PACKAGE
MAX16031ETM+	-40°C to +85°C	48 TQFN-EP*
MAX16032ETM+	-40°C to +85°C	48 TQFN-EP*

+表示无铅(Pb)/符合RoHS标准的封装。

**EP = 裸焊盘。*

引脚配置



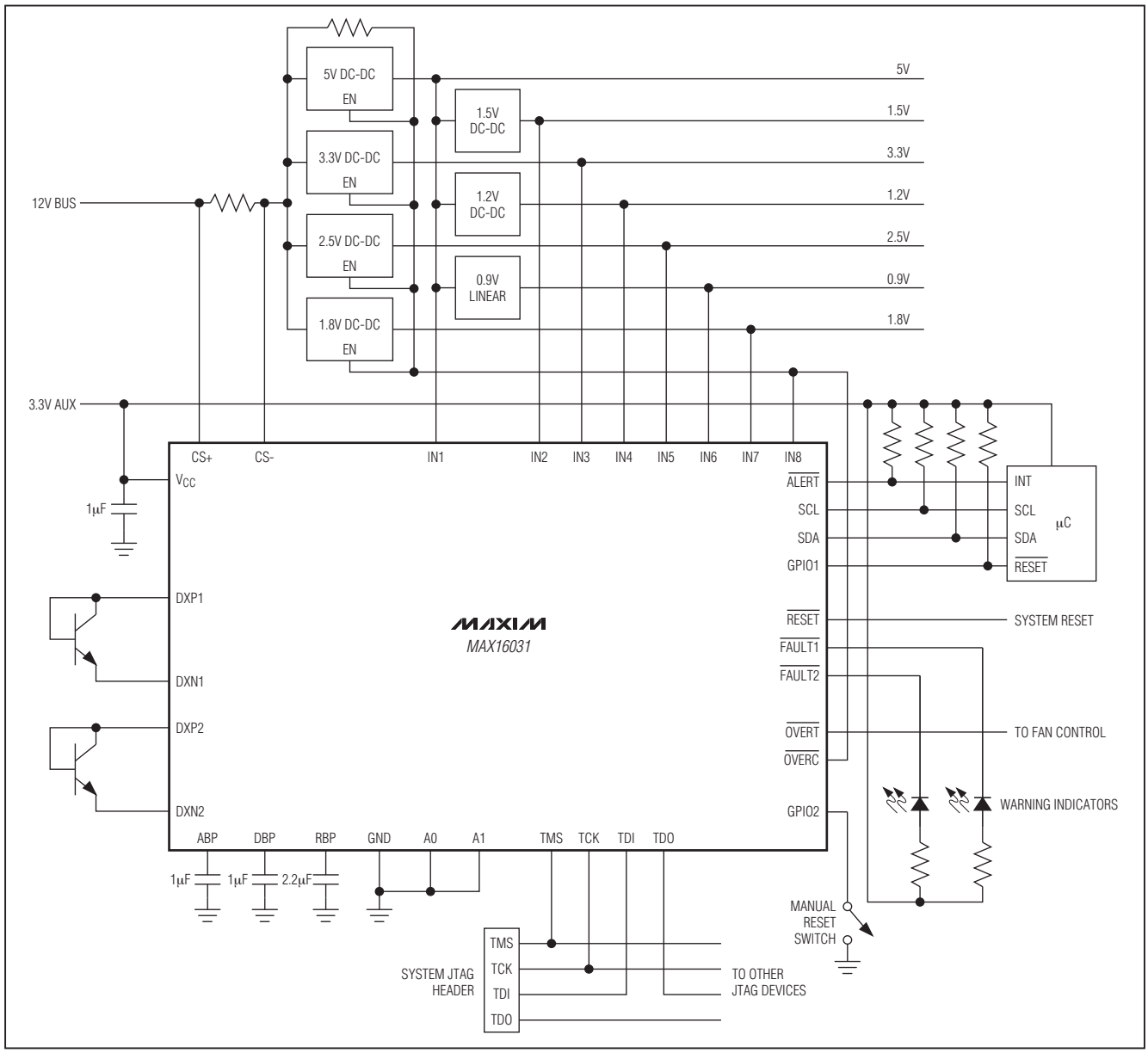
SMBus是Intel Corp.的商标。

基于EEPROM的系统监控器，提供非易失故障存储

选型指南

PART	VOLTAGE MONITORS		TEMPERATURE SENSORS		CURRENT-SENSE AMPS	FAULT OUTPUTS	GPIOs
	SINGLE ENDED	DIFFERENTIAL	INT	EXT			
MAX16031ETM+	8	4	1	2	1	4	2
MAX16032ETM+	6	3	1	1	—	4	2

典型应用电路



ABSOLUTE MAXIMUM RATINGS

V_{CC} to GND .....-0.3V to +15V
IN_, FAULT_, SCL, SDA, OVERT to GND .....-0.3V to +6V
A0, A1, TCK, TMS, TDI to GND .....-0.3V to +6V
OVERC, RESET, GPIO_, ALERT to GND .....-0.3V to +6V
RBP, ABP, DBP to GND ...-0.3V to lower of (6V and V_{CC} + 0.3V)
TDO, DXP1, DXP2 to GND .....-0.3V to V_{DBP} + 0.3V
CS+, CS- to GND .....-0.3V to +30V
(CS+ - CS-) .....±5V
DXN1, DXN2 to GND .....-0.3V to +0.8V
SDA, ALERT Current .....-1mA to +50mA
DXN1, DXN2 Current 1mA
Input/Output Current
(all except DXN1, DXN2, SDA, and ALERT) 20mA
Continuous Power Dissipation (T_A = +70°C)
48-Pin, 7mm x 7mm TQFN
(derate 27.8mW/°C above +70°C) 2222.2mW
Operating Temperature Range .....-40°C to +85°C
Junction Temperature .....+150°C
Storage Temperature Range .....-65°C to +150°C
Lead Temperature (soldering, 10s) .....+250°C
Soldering Temperature (reflow) .....+260°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

(V_{CC} = 2.9V to 14V, T_A = -40°C to +85°C, unless otherwise specified. Typical values are at V_{CC} = 3.3V, T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Operating Voltage Range	V_{CC}		2.90		14.00	V
Undervoltage Lockout	V_{UVLO}	Minimum voltage at V_{CC} to access the digital interfaces			2.8	V
Undervoltage Lockout Hysteresis	$V_{UVLOHYS}$			100		mV
Supply Current	I_{CC}	Static (EEPROM not accessed)		3	5	mA
ADC DC ACCURACY						
Resolution					10	Bits
Total Unadjusted Error		T_A = -40°C to +85°C			0.9	%FSR
Integral Nonlinearity				1		LSB
Differential Nonlinearity				1		LSB
ADC Total Monitoring Cycle Time	t_{CYCLE}	Eight supply inputs, three temperatures, and current sense		80	100	µs
ADC IN_ Voltage Ranges		Register map bit set to 00 (LSB = 5.46mV)		5.6		V
		Register map bit set to 01 (LSB = 2.73mV)		2.8		
		Register map bit set to 10 (LSB = 1.36mV)		1.4		
Reference Voltage	V_{RBP}		1.386	1.4	1.414	V
IN_ ANALOG INPUT						
Absolute Input Voltage Range (Referenced to GND)			0		5.6	V
Input Impedance			30	50	80	kΩ

ELECTRICAL CHARACTERISTICS (continued)

(V_{CC} = 2.9V to 14V, T_A = -40°C to +85°C, unless otherwise specified. Typical values are at V_{CC} = 3.3V, T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Input Hysteresis		Percent of programmed threshold	r5Ch[5] = 0		0.78		%
			r5Ch[5] = 1		1.17		
RESET OUTPUT							
Reset Timeout Period	t_{RP}	r20h[5:3] = 000; from $\overline{MR}$ going high		22.5	25	27.5	µs
		r20h[5:3] = 001		2.25	2.5	2.75	ms
		r20h[5:3] = 010		9	10	11	
		r20h[5:3] = 011		36	40	44	
		r20h[5:3] = 100		144	160	176	
		r20h[5:3] = 101		576	640	704	
		r20h[5:3] = 110		1152	1280	1408	
		r20h[5:3] = 111		2304	2560	2816	
TEMPERATURE MEASUREMENTS							
Internal Sensor Measurement Error		(Note 2)			±3		°C
External Remote Diode Temperature Measurement Error		(Note 2)			±5		°C
Temperature Measurement Resolution					0.5		°C
Temperature Measurement Noise		Internal sensor			0.1		°C
External Diode Drive High					84		µA
External Diode Drive Low					6		µA
Diode Drive Current Ratio					14		
DXN_ Impedance to GND					1.8		kΩ
Power-Supply Rejection	PSR	Internal sensor, DC condition			0.1		°C/V
CURRENT SENSE							
CS+ Input Voltage Range	V_{CS+}			3		28	V
Input Bias Current	I_{CS+}	$V_{CS+} = V_{CS-}$			14	25	µA
	I_{CS-}	$V_{CS-} = V_{CS+}$			3	8	
Primary Current-Sense Differential Thresholds	V_{CSTH}	$V_{CS+} - V_{CS-}$	A = 48	21.5	25	28.5	mV
			A = 24	45	50	55	
			A = 12	92	100	108	
			A = 6	190	200	210	
Primary Current-Sense Threshold	CS_{HYS}	Percent of V_{CSTH}			0.5		%
Secondary Overcurrent Threshold Timeout		r5Ch[1:0] = 00			50		µs
		r5Ch[1:0] = 01		3.6	4	4.4	ms
		r5Ch[1:0] = 10		14.4	16	17.6	
		r5Ch[1:0] = 11		57.6	64	70.4	

ELECTRICAL CHARACTERISTICS (continued)

(V_{CC} = 2.9V to 14V, T_A = -40°C to +85°C, unless otherwise specified. Typical values are at V_{CC} = 3.3V, T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Current-Sense Analog Input Range		V_{CS+} - V_{CS-}	A = 6		232		mV
			A = 12		116		
			A = 24		58		
			A = 48		29		
ADC Current-Sense Measurement Accuracy		V_{SENSE} = 150mV (A = 6 only)		-4	±0.2	+4	%
		V_{SENSE} = 50mV (A = 6, 12 only)		-10	±1.2	+10	
		V_{SENSE} = 25mV			±2		
		V_{SENSE} = 10mV			±10		
Gain Accuracy		V_{SENSE} = 20mV to 100mV, V_{CS+} = 12V, A = 6		-3		+3	%
Common-Mode Rejection Ratio	$CMRR_{CS}$	V_{CS+} > 4V			80		dB
Power-Supply Rejection Ratio	$PSRR_{CS}$				80		dB
$\overline{OVERC}$ Output Leakage Current	$I_{OVERCLKG}$					1	µA
$\overline{OVERC}$ Output Low Voltage	$V_{OLOVERC}$	I_{OUT} = 3mA				0.4	V
$\overline{OVERC}$ Propagation Delay	t_{OVERC}	V_{SENSE} - V_{CSTH} > 10% x V_{CSTH}				5	µs
SMBus INTERFACE (SCL, SDA)							
Logic-Input Low Voltage	V_{IL}	Input voltage falling				0.8	V
Logic-Input High Voltage	V_{IH}	Input voltage rising		2.0			V
Input Leakage Current		GND or 5.5V (V_{CC} = 5.5V) V_{SCL}, V_{SDA}		-1		+1	µA
Output Low Voltage	V_{OL}	I_{SINK} = 3mA				0.4	V
Input Capacitance	C_{IN}				5		pF
$\overline{ALERT}$, $\overline{FAULT\_}$, AND GPIO_ OUTPUTS							
$\overline{ALERT}$, $\overline{FAULT\_}$, and GPIO_ Output Low Voltage		I_{SINK} = 3mA				0.4	V
$\overline{ALERT}$, $\overline{FAULT\_}$, and GPIO_ Leakage Current		$V_{\overline{ALERT}}$, $V_{\overline{FAULT\_}}$, $V_{GPIO\_}$ = 5.5V or GND		-1		+1	µA
GPIO_ (INPUT)							
Logic-Low Voltage		GPIO_ voltage falling				0.8	V
Logic-High Voltage		GPIO_ voltage rising		2.0			V
SMBus ADDRESS (A0 and A1)							
Address Logic-Low						0.4	V
Address Logic-High				1.4			V
High-Impedance Leakage Current		Maximum current to achieve high-impedance logic level		-1		+1	µA
Input Leakage Current		0 to 3V, V_{CC} = 3V		-12		+12	µA

ELECTRICAL CHARACTERISTICS (continued)

(V_{CC} = 2.9V to 14V, T_A = -40°C to +85°C, unless otherwise specified. Typical values are at V_{CC} = 3.3V, T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
SMBus TIMING (see Figure 1)						
Serial-Clock Frequency	f_{SCL}				400	kHz
Bus Free Time Between STOP and START Conditions	t_{BUF}		1.3			µs
START Condition Setup Time	$t_{SU:STA}$		0.6			µs
START Condition Hold Time	$t_{HD:STA}$		0.6			µs
STOP Condition Setup Time	$t_{SU:STO}$		0.6			µs
Clock Low Period	t_{LOW}		1.3			µs
Clock High Period	t_{HIGH}		0.6			µs
Data Setup Time	$t_{SU:DAT}$		100			ns
Output Fall Time	t_{OF}	C_{BUS} = 10pF to 400pF			250	ns
Data Hold Time	$t_{HD:DAT}$	From 50% SCL falling to SDA change	0.3		0.9	µs
Minimum Pulse Width Ignored				30		ns
SMBus Timeout	$t_{TIMEOUT}$	SCL time low for reset	25		35	ms
JTAG INTERFACE (see Figure 2)						
TDI, TMS, TCK Logic-Low Input Voltage	V_{IL}	Input voltage falling			0.4	V
TDI, TMS, TCK Logic-High Input Voltage	V_{IH}	Input voltage rising	2.2			V
TDO Logic-Output Low Voltage	V_{OL}	I_{SINK} = 4mA			0.4	V
TDO Logic-Output High Voltage	V_{OH}	I_{SOURCE} = 1mA	2.2			V
TDO Leakage Current		TDO high impedance	-10		+10	µA
TDI, TMS Pullup Resistors	R_{JPU}	Pullup to V_{DBP}	6.5	10	16	kΩ
I/O Capacitance	$C_{I/O}$			50		pF
TCK Clock Period	t_1				1000	ns
TCK High/Low Time	t_2, t_3	(Note 3)	60	500		ns
TCK to TMS, TDI Setup Time	t_4		15			ns
TCK to TMS, TDI Hold Time	t_5		35			ns
TCK to TDO Delay	t_6				500	ns
TCK to TDO High-Impedance Delay	t_7				500	ns
MISCELLANEOUS						
Power-On Delay	t_{D-PO}				4	ms
Single-Byte EEPROM Write Cycle Delay		(Note 4)			11	ms

Note 1: Limits to -40°C are guaranteed by design.
Note 2: Guaranteed by design.
Note 3: TCK stops either high or low.
Note 4: An additional cycle is required when writing to configuration memory for the first time.

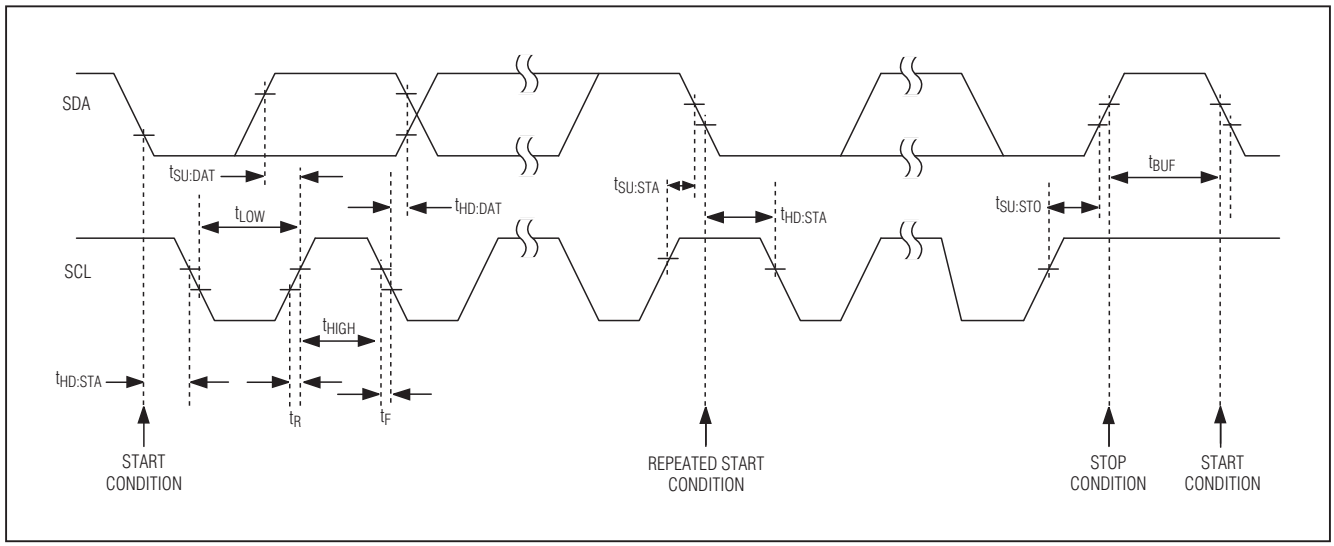


图1. SMBus接口时序图

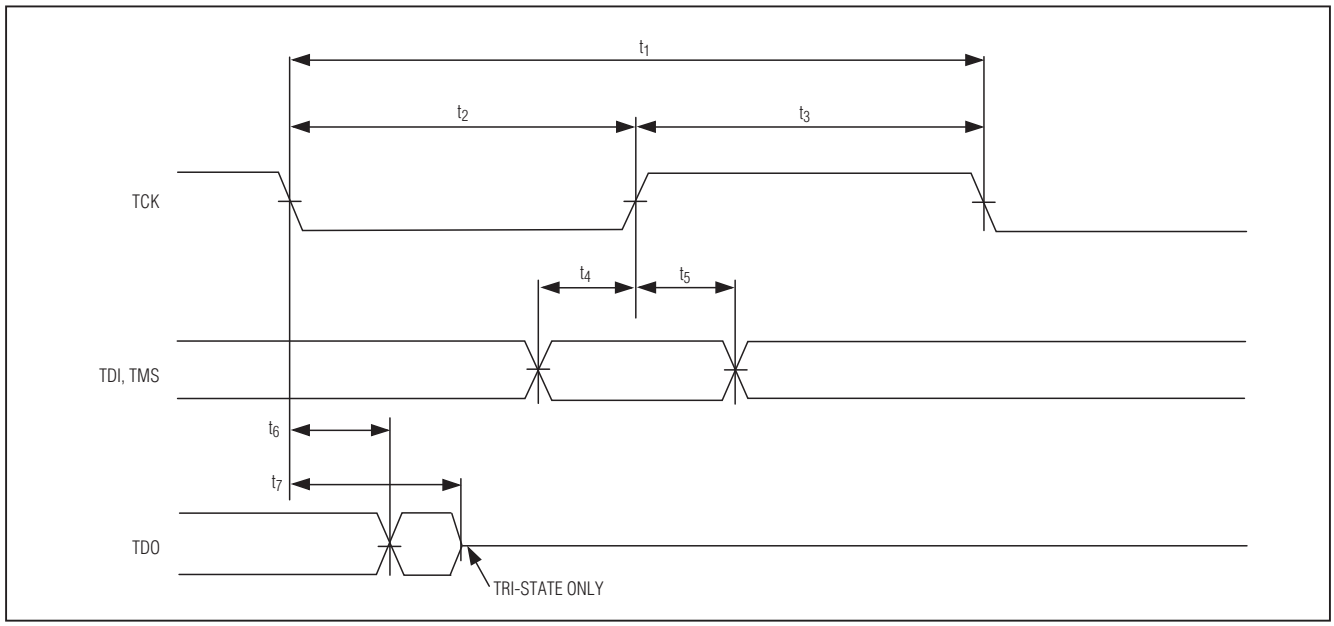


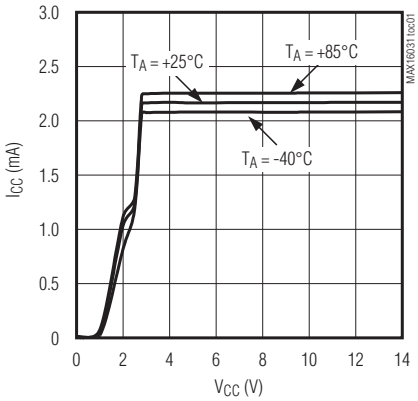
图2. JTAG接口时序图

基于EEPROM的系统监控器，提供非易失故障存储

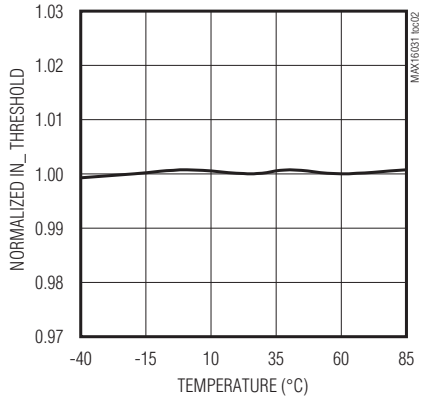
典型工作特性

(Typical values are at V_{CC} = 3.3V, T_A = +25°C, unless otherwise noted.)

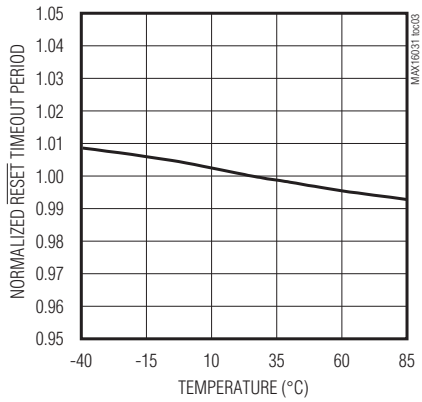
V_{CC} SUPPLY CURRENT vs. V_{CC} SUPPLY VOLTAGE



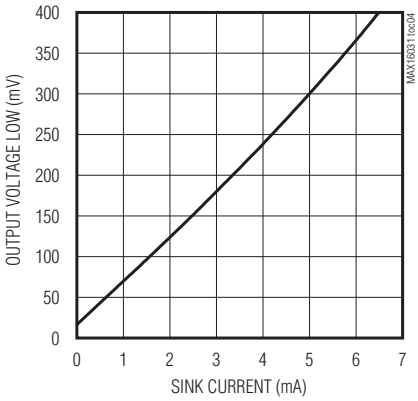
NORMALIZED IN_ THRESHOLD vs. TEMPERATURE



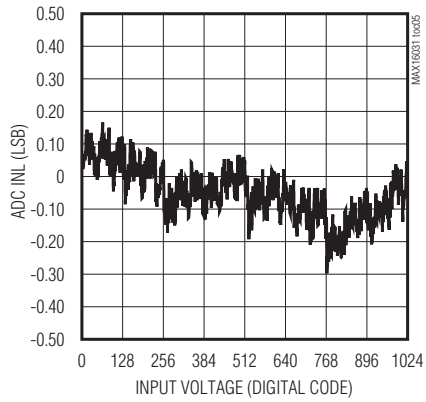
NORMALIZED $\overline{RESET}$ TIMEOUT PERIOD vs. TEMPERATURE



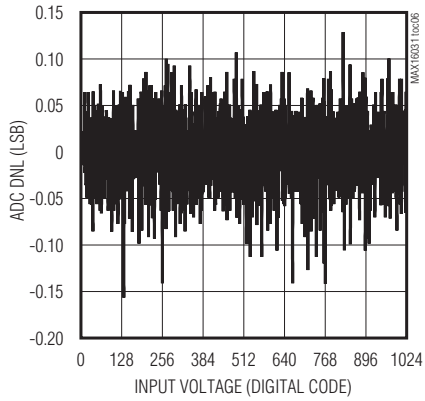
OUTPUT VOLTAGE LOW vs. SINK CURRENT



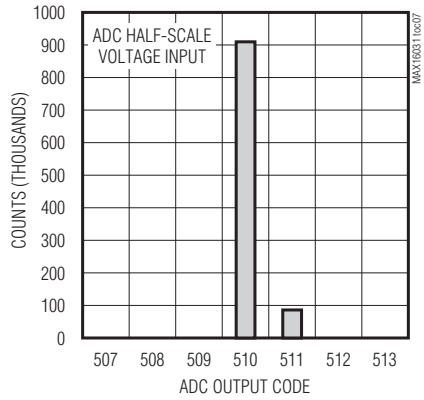
ADC INTEGRAL NONLINEARITY vs. INPUT VOLTAGE



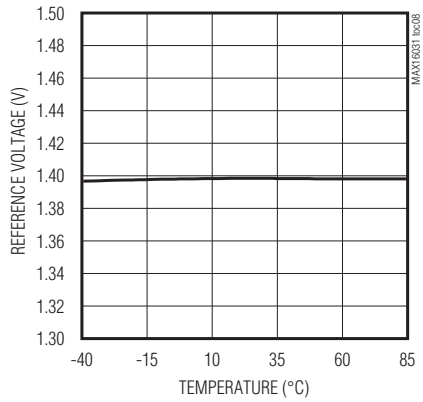
ADC DIFFERENTIAL NONLINEARITY vs. INPUT VOLTAGE



NOISE HISTOGRAM



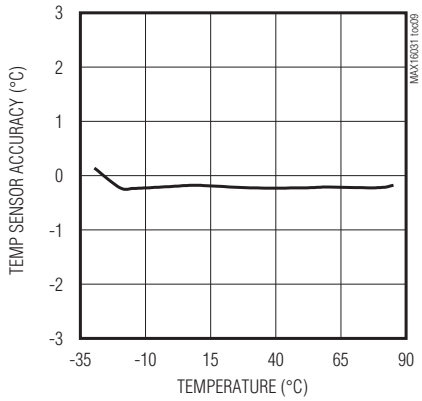
REFERENCE VOLTAGE vs. TEMPERATURE



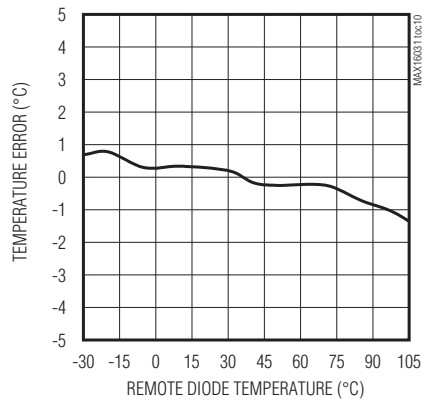
典型工作特性(续)

(Typical values are at V_{CC} = 3.3V, T_A = +25°C, unless otherwise noted.)

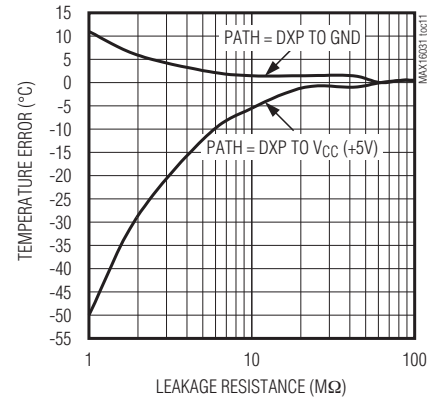
INTERNAL TEMPERATURE SENSOR ACCURACY vs. TEMPERATURE



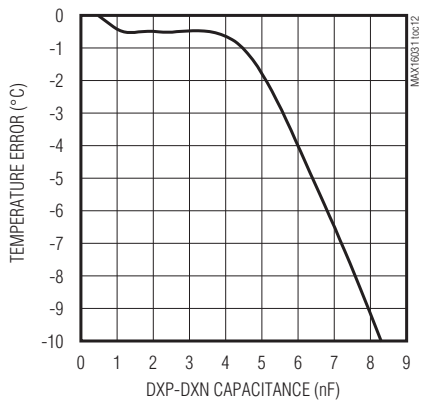
TEMPERATURE ERROR vs. REMOTE DIODE TEMPERATURE



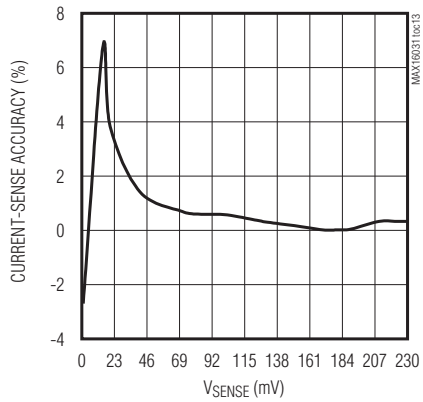
TEMPERATURE ERROR vs. LEAKAGE RESISTANCE



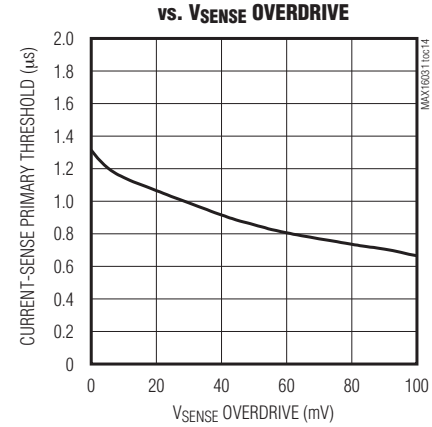
TEMPERATURE ERROR vs. DXP-DXN CAPACITANCE



CURRENT-SENSE ACCURACY vs. V_{SENSE}



CURRENT-SENSE PRIMARY THRESHOLD vs. V_{SENSE} OVERDRIVE



引脚说明

引脚		名称	功能
MAX16031	MAX16032		
1	1	IN2	电源监测器输入2。内部ADC对IN2进行采样，可配置为单极性/双极性和单端/伪差分输入。在伪差分模式下，IN1和IN2组成差分对的+、-端。必须确保每路输入在规定的ADC IN_电压范围内。
2	2	IN3	电源监测器输入3。内部ADC对IN3进行采样，可配置为单极性/双极性和单端/伪差分输入。在伪差分模式下，IN3和IN4组成差分对的+、-端。必须确保每路输入在规定的ADC IN_电压范围内。
3	3	IN4	电源监测器输入4。内部ADC对IN4进行采样，可配置为单极性/双极性和单端/伪差分输入。在伪差分模式下，IN3和IN4组成差分对的+、-端。必须确保每路输入在规定的ADC IN_电压范围内。
4–7, 30, 31, 32, 39, 40, 47	4–7, 11, 12, 23, 30, 31, 32, 39, 40–44, 47	N.C.	没有连接。悬空，不要使用。
8, 13, 35	8, 13, 35	GND	地，将所有GND引脚连接在一起。
9	9	IN5	电源监测器输入5。内部ADC对IN5进行采样，可配置为单极性/双极性和单端/伪差分输入。在伪差分模式下，IN5和IN6组成差分对的+、-端。必须确保每路输入在规定的ADC IN_电压范围内。
10	10	IN6	电源监测器输入6。内部ADC对IN6进行采样，可配置为单极性/双极性和单端/伪差分输入。在伪差分模式下，IN5和IN6组成差分对的+、-端。必须确保每路输入在规定的ADC IN_电压范围内。
11	—	IN7	电源监测器输入7。内部ADC对IN7进行采样，可配置为单极性/双极性和单端/伪差分输入。在伪差分模式下，IN7和IN8组成差分对的+、-端。必须确保每路输入在规定的ADC IN_电压范围内。
12	—	IN8	电源监测器输入8。内部ADC对IN8进行采样，可配置为单极性/双极性和单端/伪差分输入。在伪差分模式下，IN7和IN8组成差分对的+、-端。必须确保每路输入在规定的ADC IN_电压范围内。
14	14	GPIO1	可配置通用输入/输出1。
15	15	GPIO2	可配置通用输入/输出2。
16	16	RBP	ADC基准旁路，RBP是内部产生的1.4V基准，用于ADC。采用一只2.2µF的电容将RBP旁路至GND，不要用RBP向任何其它电路供电。
17	17	SDA	SMBus串行数据，漏极开路输入/输出。
18	18	SCL	SMBus串行时钟输入。
19	19	A0	SMBus地址输入0，可连接至DBP、GND或悬空，以选择所要求的器件地址。
20	20	A1	SMBus地址输入1，可连接至DBP、GND或悬空，以选择所要求的器件地址。

引脚说明(续)

引脚		名称	功能
MAX16031	MAX16032		
21	21	$\overline{ALERT}$	SMBus报警指示，漏极开路输出。$\overline{ALERT}$遵循SMBus 2.0附录A中所描述的SMBALERT#信号定义。当器件检测到故障时，触发$\overline{ALERT}$输出，从而中断主机，查询串行总线上哪个器件发生故障。
22	22	$\overline{OVERT}$	过热指示，漏极开路输出。当检测到过热状态时，触发$\overline{OVERT}$输出。
23	—	$\overline{OVERC}$	过流指示，漏极开路输出。当超出一级过流门限时，触发$\overline{OVERC}$输出。
24	24	$\overline{FAULT2}$	可配置漏极开路故障输出2。
25	25	$\overline{FAULT1}$	可配置漏极开路故障输出1。
26	26	$\overline{RESET}$	可配置漏极开路复位输出。
27	27	TMS	JTAG测试模式选择输入，采用一只10kΩ电阻内部上拉至V_{DBP}。
28	28	TCK	JTAG测试时钟输入。
29	29	TDI	JTAG测试数据输入，采用一只10kΩ电阻内部上拉至V_{DBP}。
33	33	TDO	JTAG测试数据输出。
34	34	DBP	内部数字电路稳压器输出。DBP和GND之间连接一只1µF的旁路电容，不要用DBP向外部电路供电。
36	36	ABP	内部模拟电路稳压器输出。ABP和GND之间连接一只1µF的旁路电容，不要用ABP向外部电路供电。
37, 38	37, 38	V_{CC}	器件电源电压。采用一只1µF电容将V_{CC}旁路至GND。
41	—	CS-	电流检测输入负极，必须偏置在3V至28V，以正常工作。
42	—	CS+	电流检测输入正极，必须偏置在3V至28V，以正常工作。
43	—	DXN2	远端二极管2负输入端。如果不使用远端检测功能，将DXP2连接至DXN2。
44	—	DXP2	远端二极管2正输入端。如果不使用远端检测功能，将DXP2连接至DXN2。
45	45	DXN1	远端二极管1负输入端。如果不使用远端检测功能，将DXP1连接至DXN1。
46	46	DXP1	远端二极管1正输入端。如果不使用远端检测功能，将DXP1连接至DXN1。
48	48	IN1	电源监测器输入1。内部ADC对IN1进行采样，可配置为单极性/双极性和单端/伪差分输入。在伪差分模式下，IN1和IN2组成差分对的+、-端。必须确保每路输入都在规定的ADC IN_电压范围内。
—	—	EP	裸焊盘。EP接地，EP内部与GND相连。不要作为主要接地端。

功能框图

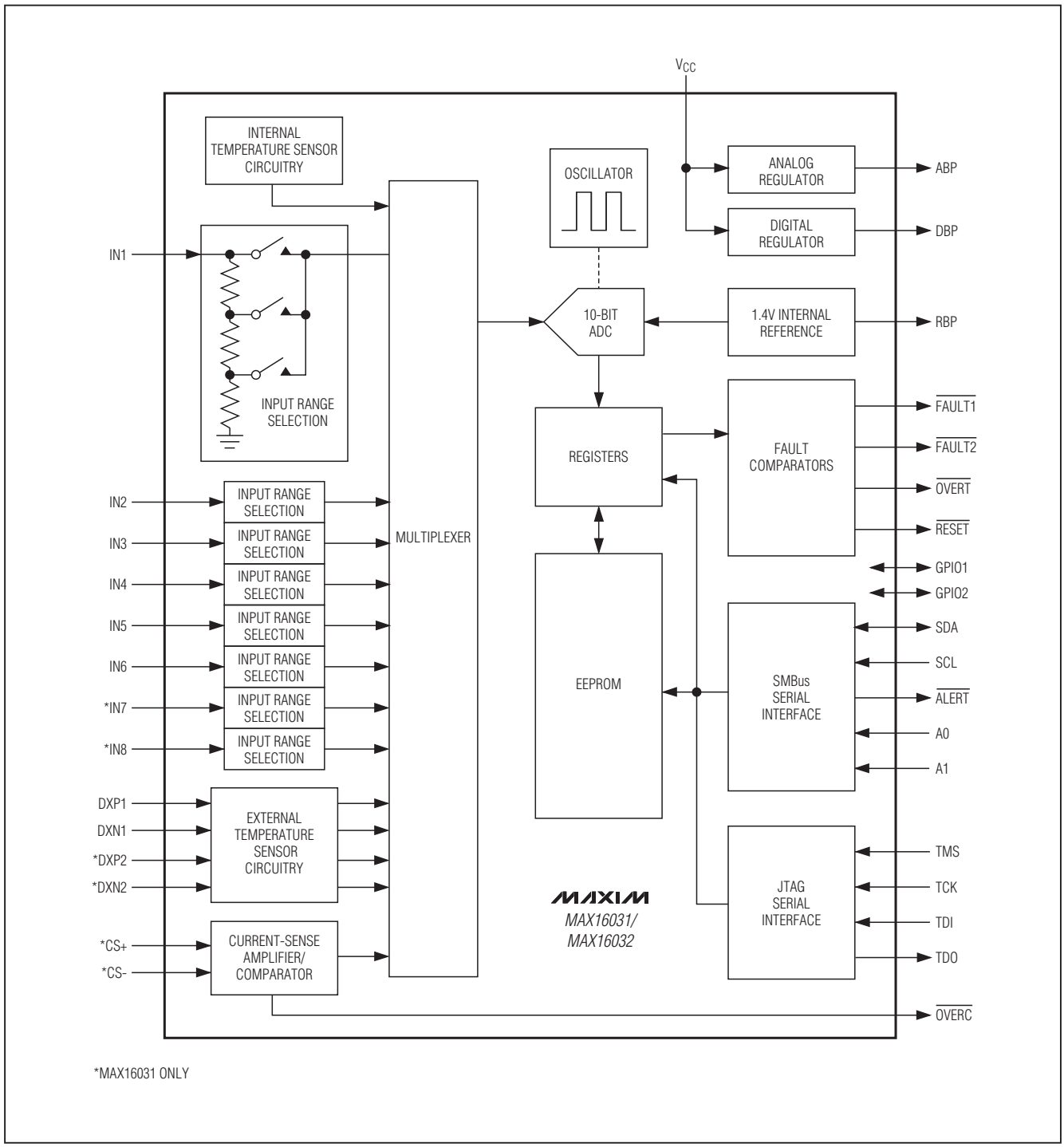

VCC
INTERNAL TEMPERATURE SENSOR CIRCUITRY
OSCILLATOR
ANALOG REGULATOR
ABP
DIGITAL REGULATOR
DBP
IN1
10-BIT ADC
1.4V INTERNAL REFERENCE
RBP
INPUT RANGE SELECTION
REGISTERS
FAULT COMPARATORS
FAULT1
FAULT2
OVERT
RESET
IN2
IN3
IN4
IN5
IN6
*IN7
*IN8
INPUT RANGE SELECTION
MULTIPLEXER
GPIO1
GPIO2
SDA
SCL
ALERT
A0
A1
EEPROM
SMBus SERIAL INTERFACE
DXP1
DXN1
*DXP2
*DXN2
EXTERNAL TEMPERATURE SENSOR CIRCUITRY
MAXIM
MAX16031/
MAX16032
JTAG SERIAL INTERFACE
TMS
TCK
TDI
TDO
*CS+
*CS-
CURRENT-SENSE AMPLIFIER/ COMPARATOR
OVERC
*MAX16031 ONLY

表1. 地址

REGISTER ADDRESS	EEPROM MEMORY ADDRESS	READ/ WRITE	DESCRIPTION
00h	—	R	IN1 ADC Result Register (MSB)
01h	—	R	IN1 ADC Result Register (LSB)
02h	—	R	IN2 ADC Result Register (MSB)
03h	—	R	IN2 ADC Result Register (LSB)
04h	—	R	IN3 ADC Result Register (MSB)
05h	—	R	IN3 ADC Result Register (LSB)
06h	—	R	IN4 ADC Result Register (MSB)
07h	—	R	IN4 ADC Result Register (LSB)
08h	—	R	IN5 ADC Result Register (MSB)
09h	—	R	IN5 ADC Result Register (LSB)
0Ah	—	R	IN6 ADC Result Register (MSB)
0Bh	—	R	IN6 ADC Result Register (LSB)
0Ch	—	R	IN7 ADC Result Register (MSB)*
0Dh	—	R	IN7 ADC Result Register (LSB)*
0Eh	—	R	IN8 ADC Result Register (MSB)*
0Fh	—	R	IN8 ADC Result Register (LSB)*
10h	—	R	Internal Temperature Sensor ADC Result Register (MSB)
11h	—	R	Internal Temperature Sensor ADC Result Register (LSB)
12h	—	R	Remote Temperature Sensor 1 ADC Result Register (MSB)
13h	—	R	Remote Temperature Sensor 1 ADC Result Register (LSB)
14h	—	R	Remote Temperature Sensor 2 ADC Result Register (MSB)
15h	—	R	Remote Temperature Sensor 2 ADC Result Register (LSB)
16h	—	R	Current-Sense ADC Result Register
17h	97h	R/W	Voltage Monitoring Input ADC Range Selection (IN1–IN4)
18h	98h	R/W	Voltage Monitoring Input ADC Range Selection (IN5–IN8)
19h	99h	R/W	Current-Sense Gain/Primary Threshold and Remote Temperature Sensor 1 Gain Trim
1Ah	9Ah	R/W	Voltage Monitoring Input Enable
1Bh	9Bh	R/W	Internal/Remote Temperature Sensor, Current Sense, and $\overline{\text{ALERT}}$ Enables and Remote Temperature Sensor 1 Offset Trim
1Ch	9Ch	R/W	Voltage Monitoring Input Single-Ended/Differential and Unipolar/Bipolar Selection
1Dh	9Dh	R/W	$\overline{\text{FAULT1}}$ Dependency Selection
1Eh	9Eh	R/W	$\overline{\text{FAULT2}}$ Dependency Selection
1Fh	9Fh	R/W	$\overline{\text{OVERT}}$ Dependency Selection
20h	A0h	R/W	$\overline{\text{RESET}}$ Dependency and Timeout Selection
21h	A1h	R/W	$\overline{\text{RESET}}$ IN1–IN8 Dependency Selection
22h	A2h	R/W	GPIO1 Configuration
23h	A3h	R/W	GPIO1 Dependency Selection
24h	A4h	R/W	GPIO2 Configuration

表1. 地址(续)

REGISTER ADDRESS	EEPROM MEMORY ADDRESS	READ/ WRITE	DESCRIPTION
25h	A5h	R/W	GPIO2 Dependency Selection
26h	A6h	R/W	IN1 Primary Undervoltage Threshold
27h	A7h	R/W	IN1 Primary Overvoltage Threshold
28h	A8h	R/W	IN1 Secondary Undervoltage Threshold
29h	A9h	R/W	IN1 Secondary Overvoltage Threshold
2Ah	AAh	R/W	IN2 Primary Undervoltage Threshold
2Bh	ABh	R/W	IN2 Primary Overvoltage Threshold
2Ch	ACh	R/W	IN2 Secondary Undervoltage Threshold
2Dh	ADh	R/W	IN2 Secondary Overvoltage Threshold
2Eh	AEh	R/W	IN3 Primary Undervoltage Threshold
2Fh	AFh	R/W	IN3 Primary Overvoltage Threshold
30h	B0h	R/W	IN3 Secondary Undervoltage Threshold
31h	B1h	R/W	IN3 Secondary Overvoltage Threshold
32h	B2h	R/W	IN4 Primary Undervoltage Threshold
33h	B3h	R/W	IN4 Primary Overvoltage Threshold
34h	B4h	R/W	IN4 Secondary Undervoltage Threshold
35h	B5h	R/W	IN4 Secondary Overvoltage Threshold
36h	B6h	R/W	IN5 Primary Undervoltage Threshold
37h	B7h	R/W	IN5 Primary Overvoltage Threshold
38h	B8h	R/W	IN5 Secondary Undervoltage Threshold
39h	B9h	R/W	IN5 Secondary Overvoltage Threshold
3Ah	BAh	R/W	IN6 Primary Undervoltage Threshold
3Bh	BBh	R/W	IN6 Primary Overvoltage Threshold
3Ch	BCh	R/W	IN6 Secondary Undervoltage Threshold
3Dh	BDh	R/W	IN6 Secondary Overvoltage Threshold
3Eh	BEh	R/W	IN7 Primary Undervoltage Threshold*
3Fh	BFh	R/W	IN7 Primary Overvoltage Threshold*
40h	C0h	R/W	IN7 Secondary Undervoltage Threshold*
41h	C1h	R/W	IN7 Secondary Overvoltage Threshold*
42h	C2h	R/W	IN8 Primary Undervoltage Threshold*
43h	C3h	R/W	IN8 Primary Overvoltage Threshold*
44h	C4h	R/W	IN8 Secondary Undervoltage Threshold*
45h	C5h	R/W	IN8 Secondary Overvoltage Threshold*
46h	C6h	R/W	Internal Temperature Sensor Primary Overtemperature Threshold (MSB)
47h	C7h	R/W	Internal Temperature Sensor Secondary Overtemperature Threshold (MSB)
48h	C8h	R/W	Remote Temperature Sensor 1 Primary Overtemperature Threshold
49h	C9h	R/W	Remote Temperature Sensor 1 Secondary Overtemperature Threshold
4Ah	CAh	R/W	Remote Temperature Sensor 2 Primary Overtemperature Threshold

表1. 地址(续)

REGISTER ADDRESS	EEPROM MEMORY ADDRESS	READ/ WRITE	DESCRIPTION
4Bh	CBh	R/W	Remote Temperature Sensor 2 Secondary Overtemperature Threshold
4Ch	CCh	R/W	Overcurrent Secondary Threshold
4Dh	CDh	R/W	Remote Temperature Sensor Primary/Secondary Overtemperature Threshold (LSBs). External Temperature Sensor 2 Offset Trim
4Eh	CEh	R/W	Remote Temperature Sensor 1/2 Primary/Secondary Overtemperature Threshold (LSBs)
4Fh	CFh	R/W	Remote Temperature Sensor 2 Gain Trim
50h	D0h	R/W	Remote Temperature Sensor Short/Open Status
51h	D1h	R/W	IN1–IN8 Primary Threshold Fault Status
52h	D2h	R/W	IN1–IN8 Secondary Threshold Fault Status
53h	D3h	R/W	Temperature/Current Threshold Fault Status
54h	D4h	R/W	Remote Temperature Sensor Short/Open Fault Mask
55h	D5h	R/W	IN1–IN8 Primary Threshold Fault Mask
56h	D6h	R/W	IN1–IN8 Secondary Threshold Fault Mask
57h	D7h	R/W	Temperature/Current Threshold Fault Mask
58h	D8h	R/W	IN1–IN8 Primary Undervoltage Faults Triggering Fault EEPROM
59h	D9h	R/W	IN1–IN8 Primary Overvoltage Faults Triggering Fault EEPROM
5Ah	DAh	R/W	Temperature/Current Faults Triggering Fault EEPROM
5Bh	DBh	R/W	Temperature Filter Selection and Postboot Fault Mask Time
5Ch	DCh	R/W	Threshold Fault Options and Overcurrent Fault Timeout
5Dh	DDh	—	Reserved
5Eh	DEh	R/W	Customer Firmware Version
5Fh	DFh	R/W	EEPROM and Configuration Lock
60h–7Fh	E0h–FFh	—	Reserved
—	80h	R	IN1–IN8 Primary Threshold Fault Status at Time of Fault
—	81h	R	IN1–IN8 Secondary Threshold Fault Status at Time of Fault
—	82h	R	Temperature/Current Threshold Fault Status at Time of Fault
—	83h	R	IN1 Conversion Result at Time of Fault
—	84h	R	IN2 Conversion Result at Time of Fault
—	85h	R	IN3 Conversion Result at Time of Fault
—	86h	R	IN4 Conversion Result at Time of Fault
—	87h	R	IN5 Conversion Result at Time of Fault
—	88h	R	IN6 Conversion Result at Time of Fault
—	89h	R	IN7 Conversion Result at Time of Fault*
—	8Ah	R	IN8 Conversion Result at Time of Fault*
—	8Bh	R	Internal Temperature Sensor Conversion Result at Time of Fault
—	8Ch	R	Remote Temperature Sensor 1 Conversion Result at Time of Fault
—	8Dh	R	Remote Temperature Sensor 2 Conversion Result at Time of Fault*
—	8Eh	R	Current-Sense Conversion Result at Time of Fault*

*仅限MAX16031。

基于EEPROM的系统监控器，提供非易失故障存储

详细说明

概要

MAX16031/MAX16032包括I²C/SMBus和JTAG串行接口，用于访问寄存器和EEPROM，某一时刻只能使用一种接口。通过这些接口访问内部存储器的详细说明请参考*I²C/SMBus兼容串行接口*和*JTAG串行接口*部分。本数据资料采用特殊约定表示对应地址位置的数据位。例如：r15h[3:0]对应于地址为15 (十六进制)的寄存器的第0位至第3位。

所有EEPROM的上电复位(POR)出厂默认值均为0。当V_{CC}达到2.8V欠压闭锁(UVLO)门限时，触发POR。POR过程中，器件启动上电顺序。上电期间，所有被监测输入处于故障屏蔽状态，并将EEPROM内容复制到相应的寄存器位。启动过程耗时1.81ms。通过编程r5Bh[3:0]，可以设置启动过程结束后禁止监测的时间，最长可达16s (参见*多项设置*部分)。$\overline{RESET}$在启动过程中为低电平，并在启动后，当所有被监测通道都达到其门限要求后，继续保持一个超时周期(可编程)的低电平。

MAX16031/MAX16032可监测多达8路电压、1路电流和3个温度点。启动后，内部多路复用器循环切换到每路输入。停止复用器切换时，10位ADC将模拟量转换为数字量，并将结果存储在寄存器中。多路复用器每循环一个周期，内部逻辑电路将转换结果与存储门限进行比较。当转换结果超出可编程门限时，此次转换将产生一个故障。逻辑输出可以根据多种故障组合设置。此外，还可设置发生故障时启动故障记录功能，从而将所有故障信息自动写入EEPROM。

电压监测

MAX16031提供8路输入IN1–IN8用于电压监测；MAX16032提供6路输入IN1–IN6用于电压监测。通过r17h[7:0]和r18h[7:0]设置每路输入电压的范围(参见表2)。通过设置r1Ah[7:0]使能每路输入电压的监测功能(参见表2)。每路电压监测输入具有4个可设置门限：一级欠压、二级欠压、一级过压、二级过压。所有电压门限字节宽度均为8位。仅将转换结果的8个高有效位与门限进行比较，门限滞回设置请参考*多项设置*部分。所有电压监测输入门限寄存器的地址如表1所示。

ADC输入可设置成伪差分和单端两种不同模式(参见表3)。伪差分模式下，两个输入组成了差分对，将差分对的每路输入进行单端转换，然后结果相减，完成伪差分转换。单极性或双极性输入均支持伪差分模式。单极性差分工作模式仅允许输入正极性的差分电压；双极性差分工作模式允许输入正、负极性的差分电压。双极性转换结果以二进制补码格式表示。例如：-1V差分输入(量程为5.6V)的十进制代码为-183，二进制补码表示为1101001001。单端模式下，转换单端输入与地之间的信号。选择单端模式时，无论r1Ch[7:4]为何值，转换结果始终为单极性。单端和伪差分模式下，ADC转换公式如下所示。

表2. 输入监测范围和使能

REGISTER ADDRESS	EEPROM MEMORY ADDRESS	BIT RANGE	DESCRIPTION
17h	97h	[1:0]	**IN1 Voltage Range Selection:** 00 = 5.6V, 01 = 2.8V 10 = 1.4V, 11 = Reserved
		[3:2]	**IN2 Voltage Range Selection:** 00 = 5.6V, 01 = 2.8V 10 = 1.4V, 11 = Reserved
		[5:4]	**IN3 Voltage Range Selection:** 00 = 5.6V, 01 = 2.8V 10 = 1.4V, 11 = Reserved
		[7:6]	**IN4 Voltage Range Selection:** 00 = 5.6V, 01 = 2.8V 10 = 1.4V, 11 = Reserved

表2. 输入监测范围和使能(续)

REGISTER ADDRESS	EEPROM MEMORY ADDRESS	BIT RANGE	DESCRIPTION
18h	98h	[1:0]	**IN5 Voltage Range Selection:** 00 = 5.6V, 01 = 2.8V 10 = 1.4V, 11 = Reserved
		[3:2]	**IN6 Voltage Range Selection:** 00 = 5.6V, 01 = 2.8V 10 = 1.4V, 11 = Reserved
		[5:4]	**IN7 Voltage Range Selection:** 00 = 5.6V, 01 = 2.8V 10 = 1.4V, 11 = Reserved
		[7:6]	**IN8 Voltage Range Selection:** 00 = 5.6V, 01 = 2.8V 10 = 1.4V, 11 = Reserved
1Ah	9Ah	[0]	**IN1 Monitoring Enable:** 0 = IN1 monitoring disabled 1 = IN1 monitoring enabled
		[1]	**IN2 Monitoring Enable:** 0 = IN2 monitoring disabled 1 = IN2 monitoring enabled
		[2]	**IN3 Monitoring Enable:** 0 = IN3 monitoring disabled 1 = IN3 monitoring enabled
		[3]	**IN4 Monitoring Enable:** 0 = IN4 monitoring disabled 1 = IN4 monitoring enabled
		[4]	**IN5 Monitoring Enable:** 0 = IN5 monitoring disabled 1 = IN5 monitoring enabled
		[5]	**IN6 Monitoring Enable:** 0 = IN6 monitoring disabled 1 = IN6 monitoring enabled
		[6]	**IN7 Monitoring Enable:** 0 = IN7 monitoring disabled 1 = IN7 monitoring enabled
		[7]	**IN8 Monitoring Enable:** 0 = IN8 monitoring disabled 1 = IN8 monitoring enabled

基于EEPROM的系统监控器，提供非易失故障存储

单极性单端模式：

$$X_{ADC} = INT\left(\frac{V_{IN-}}{V_{RANGE}} \times 1024\right)$$

其中，X_{ADC}是转换结果的十进制码，V_{IN-}是一路监测电压的输入，V_{RANGE}是r17h和r18h中设置的输入电压范围。

双极性/单极性伪差分模式：

$$X_{ADC} = INT\left(\frac{V_{IN+}}{V_{RANGE}} \times 1024\right) - INT\left(\frac{V_{IN-}}{V_{RANGE}} \times 1024\right)$$

其中，X_{ADC}是转换结果的十进制代码，V_{IN+}是差分监测电压输入对的正输入，V_{IN-}是差分监测电压输入对的负输入，V_{RANGE}是r17h和r18h中设置的ADC IN_电压范围。

表3. IN1–IN8 ADC输入模式选择

REGISTER ADDRESS	EEPROM MEMORY ADDRESS	BIT RANGE	DESCRIPTION
1Ch	9Ch	[0]	**IN1/IN2 Single-Ended/Pseudo-Differential:** 0 = IN1 and IN2 conversions are single-ended. 1 = IN1 and IN2 conversions are pseudo-differential (IN1 to IN2).
		[1]	**IN3/IN4 Single-Ended/Pseudo-Differential:** 0 = IN3 and IN4 conversions are single-ended. 1 = IN3 and IN4 conversions are pseudo-differential (IN3 to IN4).
		[2]	**IN5/IN6 Single-Ended/Pseudo-Differential:** 0 = IN5 and IN6 conversions are single-ended. 1 = IN5 and IN6 conversions are pseudo-differential (IN5 to IN6).
		[3]	**IN7/IN8 Single-Ended/Pseudo-Differential:** 0 = IN7 and IN8 conversions are single-ended. 1 = IN7 and IN8 conversions are pseudo-differential (IN7 to IN8).
		[4]	**IN1/IN2 Unipolar/Bipolar:** 0 = IN1 and IN2 conversions are unipolar. 1 = IN1 and IN2 conversions are bipolar (two's complement).
		[5]	**IN3/IN4 Unipolar/Bipolar:** 0 = IN3 and IN4 conversions are unipolar. 1 = IN3 and IN4 conversions are bipolar (two's complement).
		[6]	**IN5/IN6 Unipolar/Bipolar:** 0 = IN5 and IN6 conversions are unipolar. 1 = IN5 and IN6 conversions are bipolar (two's complement).
		[7]	**IN7/IN8 Unipolar/Bipolar:** 0 = IN7 and IN8 conversions are unipolar. 1 = IN7 and IN8 conversions are bipolar (two's complement).

电流监测

MAX16031提供电流检测输入CS+/CS-和一个电流检测放大器，用于电流监测(参见图3)。两个可编程电流检测门限：一级过流和二级过流。为快速检测故障，在$\overline{OVERC}$输出端接模拟比较器得到一级过流门限。一级门限公式为：

$$I_{TH} = \frac{V_{CSTH}}{R_{SENSE}}$$

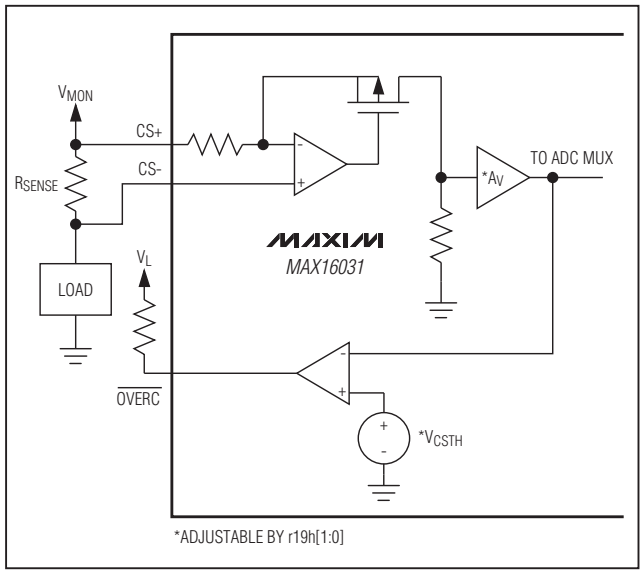


图3. 电流检测方框图

其中，I_{TH}是所设置的电流门限，V_{CSTH}是r19h[1:0]设置的门限，R_{SENSE}是检流电阻。r19h的功能说明如表4所示。电流检测转换的ADC输出为：

$$X_{ADC} = \frac{V_{SENSE} \times A_V}{V_{RBP}} \times \left(2^8 - 1\right)$$

其中，X_{ADC}是8位十进制ADC转换值，V_{SENSE}为V_{CS+} - V_{CS-}，A_V是r19h[1:0]设置的电流检测电压增益，V_{RBP}是RBP基准电压(典型值1.4V)。

当电流超过r5Ch[4]设置的一级过流门限时，$\overline{OVERC}$锁存。向r53h[6]写‘1’可清除锁存。$\overline{OVERC}$仅与一级过流门限有关。二级过流门限决定其它故障输出状态。通过ADC转换和数字比较获得二级过流门限。二级过流门限具有一个延时，在r5Ch[1:0]中进行设置。通过设置r1Bh[3]，可以使能/禁止一级和二级电流检测故障输出。

温度监测

MAX16031提供两组远端二极管输入DXP1/DXN1和DXP2/DXN2和一路内部温度检测；MAX16032则提供一组远端二极管输入DXP1/DXN1和一路内部温度检测。校准寄存器对增益和失调进行调整，以适合不同型号的远端二极管。内部温度检测由工厂校准。除了失调/增益校准功能外，该系列器件还具有一个可设置的低通滤波器。温度检测电路方框图如图4所示，远端二极管实际上是连接成二极管的晶体管。关于误差分析以及晶体管制造商的相关信息，请参考应用笔记AN1057和AN1944。

表4. 一级过流门限和远端温度检测增益调节

REGISTER ADDRESS	EEPROM MEMORY ADDRESS	BIT RANGE	DESCRIPTION
19h	99h	[1:0]	Overcurrent Primary Threshold and Current-Sense Gain Setting: 00 = 200mV threshold, AV = 6V/V 01 = 100mV threshold, AV = 12V/V 10 = 50mV threshold, AV = 24V/V 11 = 25mV threshold, AV = 48V/V
		[7:2]	Remote Temperature Sensor 1 Gain Trim. Note bit 6 is inverted.
4Fh	CFh	[5:0]	Remote Temperature Sensor 1 Gain Trim
		[7:6]	Not used

基于EEPROM的系统监控器，提供非易失故障存储

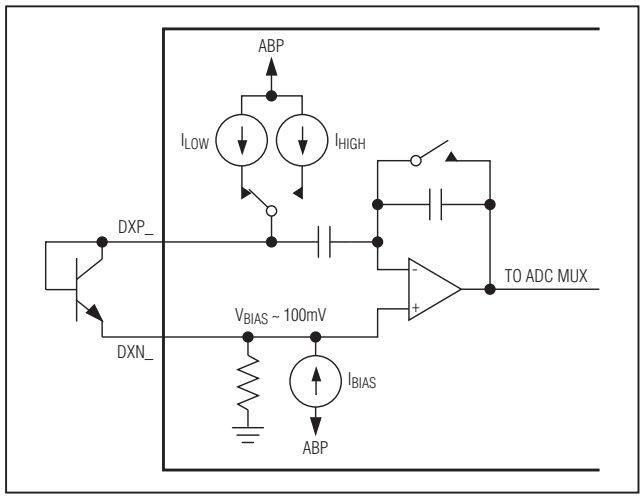


图4. 远端温度检测放大器电路

ADC对内部传感器和远端传感器放大器输出进行转换。ADC每转换一次所有使能的参量，都将温度转换结果与温度门限寄存器(r46h至r4Bh和r4Dh)的数值进行比较。与电压输入比较器不同的是，温度门限比较器的字节宽度为10位。虽然设置其它输出时与温度故障有关，但$\overline{\text{OVERT}}$专用于温度故障报警输出。有关可编程输出的相互关系，请参考*可编程输入/输出*部分，关于温度故障门限设置的详细信息请参考*故障管理*部分。

远端温度检测放大器可检测DXP_和DXN_之间的短路和开路故障。检测到此类事件后发出故障报警信号。温度门限和转换结果采用二进制补码格式表示，1 LSB对应于0.5°C。温度转换结果的数据格式如表5所示。

通过增益寄存器r19h[7:2]/r4Fh[5:0]和失调寄存器r1Bh[7:5]/r4Dh[6:4]，用户可对远端温度检测的失调和增益进行调节，如表4和表6所示。调节增益值可以得到较大的驱动电流(56µA)，以补偿远端二极管的n系数。失调量乘以4，并将其与转换结果相叠加。MAX16031/MAX16032的DXN_和DXP_端有一个内部低通滤波器，有助于降低噪声。关于滤波器截止频率的设置请参考*多项设置*部分。

读取ADC结果

可通过I^2C/SMBus兼容接口或JTAG接口从ADC转换寄存器读取ADC转换结果(表7)。这些寄存器还可用于故障门限比较，电压监测门限仅与转换结果的前8个MSB比较。

表5. 温度数据格式

TEMPERATURE (°C)	DIGITAL CODE
+128	1100000000
+125	1011111010
+100	1011010000
+25.5	1000110011
0	1000000000
-10	0111101100
-75	0101101010
-100	0100111000
-128	0100000000
Diode fault	0000000000

可编程输入/输出

MAX16031具有两路通用故障输出$\overline{\text{FAULT1}}$和$\overline{\text{FAULT2}}$、一路复位输出$\overline{\text{RESET}}$、一路温度故障报警输出$\overline{\text{OVERT}}$、一路电流故障输出$\overline{\text{OVERC}}$、两路通用输入/输出GPIO1和GPIO2以及一路SMBALERT#兼容输出$\overline{\text{ALERT}}$。MAX16032除了不提供$\overline{\text{OVERC}}$外，其它输出与MAX16031相同。所有输出都是漏极开路，需接上拉电阻。除$\overline{\text{OVERC}}$以外，故障输出均不闭锁，$\overline{\text{OVERC}}$是否闭锁取决于r5Ch中的相关位。但每个故障标志位闭锁(请参考*故障管理*部分)，必须通过写入对应闭锁位为‘1’、其它位为0的字节清除闭锁状态，一次清除一位。

通用输出($\overline{\text{FAULT1}}$和$\overline{\text{FAULT2}}$)的功能相同，并可根据过压、欠压、过热和过流参量进行设置。关于通用故障输出的详细信息，请参考表8中的r1Dh和r1Eh。

复位输出$\overline{\text{RESET}}$提供多种可编程输出条件和多种复位超时。关于$\overline{\text{RESET}}$输出和超时条件的详细信息请参考表8中的r20h和r21h。

温度故障输出$\overline{\text{OVERT}}$用来指示与温度相关的故障。$\overline{\text{OVERT}}$根据一级温度门限和/或远端二极管开路/短路标志进行设置。在二极管发生开路/短路故障时，$\overline{\text{OVERT}}$锁存为低电平，为了清除锁存，必须将相应的二极管开路/短路标志位清零。关于$\overline{\text{OVERT}}$输出条件的更多信息请参考表8中的r1Fh。

表6. 温度检测故障使能、电流检测故障使能、SMBALERT#使能以及温漂调节

REGISTER ADDRESS	EEPROM MEMORY ADDRESS	BIT RANGE	DESCRIPTION
1Bh	9Bh	[0]	**Internal Temperature Sensor Faults Enable:** 0 = Internal temperature sensor faults disabled 1 = Internal temperature sensor faults enabled
		[1]	**Remote Temperature Sensor 1 Faults Enable:** 0 = Remote temperature sensor 1 faults disabled 1 = Internal temperature sensor 1 faults enabled
		[2]	**Remote Temperature Sensor 2 Faults Enable:** 0 = Remote temperature sensor 2 faults disabled 1 = Remote temperature sensor 2 faults enabled
		[3]	**Current-Sense Fault Enable:** 0 = Current-sense faults disabled 1 = Current-sense faults enabled
		[4]	**SMBALERT# Enable ($\overline{\text{ALERT}}$):** 0 = SMBALERT# disabled 1 = SMBALERT# enabled
		[7:5]	**Remote Temperature Sensor 1 Offset Trim:** Offset = 4 × X, where X is the two's-complement 3-bit temperature code (1 LSB = 0.5°C). Since X is multiplied by 4, the offset LSB size is 2°C, allowing a total offset adjustment of ±6°C.
4Dh	CDh	[1:0]	Internal Temperature Sensor Primary Overtemperature Threshold LSB
		[3:2]	Internal Temperature Sensor Secondary Overtemperature Threshold LSB
		[6:4]	**Remote Temperature Sensor 2 Offset Trim:** Offset = 4 × X, where X is the two's-complement 3-bit temperature code (1 LSB = 0.5°C). Since X is multiplied by 4, the offset LSB size is 2°C, allowing a total offset adjustment of ±6°C.
		[7]	Not used.

电流故障输出$\overline{\text{OVERC}}$用来指示过流故障。$\overline{\text{OVERC}}$仅与一级过流故障模拟门限有关，关于电流检测放大器和一级门限的详细信息请参考*电流监测*部分。二级过流门限设置为数字量，用于其它输出。二级门限还具有一个可编程超时(见*多项设置*部分)。

GPIO1和GPIO2可编程设置为逻辑输入、手动复位输入、逻辑输出或与故障条件对应的输出。有关GPIO1/GPIO2功能的详细信息请参考表8中的r22h–r25h。配置为故障报警输出时，GPIO1和GPIO2为低电平。

$\overline{\text{ALERT}}$是SMBALERT#兼容的故障中断输出。使能时，$\overline{\text{ALERT}}$是$\overline{\text{RESET}}$、$\overline{\text{FAULT1}}$、$\overline{\text{FAULT2}}$、$\overline{\text{OVERT}}$、$\overline{\text{OVERC}}$和GPIO1/GPIO2 (使能为故障输出时)的逻辑“与”。发生任一故障报警输出时，$\overline{\text{ALERT}}$产生报警输出，中断SMBus主机进行故障查询。主机需要回复MAX16031/MAX16032特定的SMBus命令(ARA)，从而获取中断器件的从机地址，详细信息请参考*I²C/SMBus兼容串行接口*部分。

表7. ADC转换寄存器

REGISTER ADDRESS	EEPROM MEMORY ADDRESS	BIT RANGE	DESCRIPTION
00h	—	[7:0]	IN1 ADC Conversion Result (MSB)
01h	—	[1:0]	IN1 ADC Conversion Result (LSB)
		[7:2]	Reserved
02h	—	[7:0]	IN2 ADC Conversion Result (MSB)
03h	—	[1:0]	IN2 ADC Conversion Result (LSB)
		[7:2]	Reserved
04h	—	[7:0]	IN3 ADC Conversion Result (MSB)
05h	—	[1:0]	IN3 ADC Conversion Result (LSB)
		[7:2]	Reserved
06h	—	[7:0]	IN4 ADC Conversion Result (MSB)
07h	—	[1:0]	IN4 ADC Conversion Result (LSB)
		[7:2]	Reserved
08h	—	[7:0]	IN5 ADC Conversion Result (MSB)
09h	—	[1:0]	IN5 ADC Conversion Result (LSB)
		[7:2]	Reserved
0Ah	—	[7:0]	IN6 ADC Conversion Result (MSB)
0Bh	—	[1:0]	IN6 ADC Conversion Result (LSB)
		[7:2]	Reserved
0Ch	—	[7:0]	IN7 ADC Conversion Result (MSB)
0Dh	—	[1:0]	IN7 ADC Conversion Result (LSB)
		[7:2]	Reserved
0Eh	—	[7:0]	IN8 ADC Conversion Result (MSB)
0Fh	—	[1:0]	IN8 ADC Conversion Result (LSB)
		[7:2]	Reserved
10h	—	[7:0]	Internal Temperature Sensor ADC Conversion Result (MSB)
11h	—	[1:0]	Internal Temperature Sensor ADC Conversion Result (LSB)
		[7:2]	Reserved
12h	—	[7:0]	Remote Temperature Sensor 1 ADC Conversion Result (MSB)
13h	—	[1:0]	Remote Temperature Sensor 1 ADC Conversion Result (LSB)
		[7:2]	Reserved
14h	—	[7:0]	Remote Temperature Sensor 2 ADC Conversion Result (MSB)
15h	—	[1:0]	Remote Temperature Sensor 2 ADC Conversion Result (LSB)
		[7:2]	Reserved
16h	—	[7:0]	Current-Sense ADC Conversion Result

表8. 输出条件

REGISTER ADDRESS	EEPROM MEMORY ADDRESS	BIT RANGE	DESCRIPTION
1Dh	9Dh	[0]	1 = $\overline{\text{FAULT1}}$ depends on the secondary undervoltage thresholds of all enabled IN1–IN8.
		[1]	1 = $\overline{\text{FAULT1}}$ depends on the primary overvoltage thresholds of all enabled IN1–IN8.
		[2]	1 = $\overline{\text{FAULT1}}$ depends on the secondary overvoltage thresholds of all enabled IN1–IN8.
		[3]	1 = $\overline{\text{FAULT1}}$ depends on the secondary overtemperature threshold of the internal temperature sensor.
		[4]	1 = $\overline{\text{FAULT1}}$ depends on the secondary overtemperature threshold of remote temperature sensor 1.
		[5]	1 = $\overline{\text{FAULT1}}$ depends on the secondary overtemperature threshold of remote temperature sensor 2.
		[6]	1 = $\overline{\text{FAULT1}}$ depends on the secondary overcurrent threshold.
		[7]	Reserved
1Eh	9Eh	[0]	1 = $\overline{\text{FAULT2}}$ depends on the secondary undervoltage thresholds of all enabled IN1–IN8.
		[1]	1 = $\overline{\text{FAULT2}}$ depends on the primary overvoltage thresholds of all enabled IN1–IN8.
		[2]	1 = $\overline{\text{FAULT2}}$ depends on the secondary overvoltage thresholds of all enabled IN1–IN8.
		[3]	1 = $\overline{\text{FAULT2}}$ depends on the secondary overtemperature threshold of the internal temperature sensor.
		[4]	1 = $\overline{\text{FAULT2}}$ depends on the secondary overtemperature threshold of remote temperature sensor 1.
		[5]	1 = $\overline{\text{FAULT2}}$ depends on the secondary overtemperature threshold of remote temperature sensor 2.
		[6]	1 = $\overline{\text{FAULT2}}$ depends on the secondary overcurrent threshold.
		[7]	Reserved
1Fh	9Fh	[0]	1 = $\overline{\text{OVERT}}$ depends on the primary overtemperature threshold of the internal temperature sensor.
		[1]	1 = $\overline{\text{OVERT}}$ depends on the primary overtemperature threshold of the remote temperature sensor 1.
		[2]	1 = $\overline{\text{OVERT}}$ depends on the primary overtemperature threshold of the remote temperature sensor 2.

表8. 输出条件(续)

REGISTER ADDRESS	EEPROM MEMORY ADDRESS	BIT RANGE	DESCRIPTION
1Fh	9Fh	[3]	1 = $\overline{\text{OVERT}}$ depends on the diode short flag of remote temperature sensor 1. $\overline{\text{OVERT}}$ latches when the diode is shorted. Clear the latch by writing to r50h.
		[4]	1 = $\overline{\text{OVERT}}$ depends on the diode open flag of remote temperature sensor 1. $\overline{\text{OVERT}}$ latches when the diode is open. Clear the latch by writing to r50h.
		[5]	1 = $\overline{\text{OVERT}}$ depends on the diode short flag of remote temperature sensor 2. $\overline{\text{OVERT}}$ latches when the diode is shorted. Clear the latch by writing to r50h.
		[6]	1 = $\overline{\text{OVERT}}$ depends on the diode open flag of remote temperature sensor 2. $\overline{\text{OVERT}}$ latches when the diode is open. Clear the latch by writing to r50h.
		[7]	Reserved
20h	A0h	[2:0]	**$\overline{\text{RESET}}$ Configuration:** 000 = $\overline{\text{RESET}}$ has no dependencies; asserts during boot and boot-up timeout and then deasserts indefinitely. 001 = $\overline{\text{RESET}}$ depends on the primary undervoltage thresholds at inputs that are selected by r21h[7:0]. 010 = $\overline{\text{RESET}}$ depends on the primary overvoltage thresholds at inputs that are selected by r21h[7:0]. 011 = $\overline{\text{RESET}}$ depends on both the primary undervoltage and overvoltage thresholds at those inputs that are selected by r21h[7:0]. 100 = $\overline{\text{RESET}}$ depends on the primary undervoltage thresholds at inputs that are selected by r21h[7:0] and the internal temperature sensor primary overtemperature threshold. 101 = $\overline{\text{RESET}}$ depends on both the primary undervoltage and overvoltage thresholds at those inputs that are selected by r21h[7:0] and the internal temperature sensor primary overtemperature threshold. 110 = $\overline{\text{RESET}}$ depends on the primary undervoltage thresholds at inputs that are selected by r21h[7:0] and each internal/remote temperature sensor primary overtemperature threshold. 111 = $\overline{\text{RESET}}$ depends on both the primary undervoltage and overvoltage thresholds at those inputs that are selected by r21h[7:0] and each internal/remote temperature sensor primary overtemperature threshold.
		[5:3]	**$\overline{\text{RESET}}$ Timeout:** 000 = 25µs 001 = 2.5ms 010 = 10ms 011 = 40ms 100 = 160ms 101 = 640ms 110 = 1280ms 111 = 2560ms
		[7:6]	Reserved

表8. 输出条件(续)

REGISTER ADDRESS	EEPROM MEMORY ADDRESS	BIT RANGE	DESCRIPTION
21h	A1h	[0]	1 = $\overline{\text{RESET}}$ depends on IN1 with thresholds defined by r20h[2:0].
		[1]	1 = $\overline{\text{RESET}}$ depends on IN2 with thresholds defined by r20h[2:0].
		[2]	1 = $\overline{\text{RESET}}$ depends on IN3 with thresholds defined by r20h[2:0].
		[3]	1 = $\overline{\text{RESET}}$ depends on IN4 with thresholds defined by r20h[2:0].
		[4]	1 = $\overline{\text{RESET}}$ depends on IN5 with thresholds defined by r20h[2:0].
		[5]	1 = $\overline{\text{RESET}}$ depends on IN6 with thresholds defined by r20h[2:0].
		[6]	1 = $\overline{\text{RESET}}$ depends on IN7 with thresholds defined by r20h[2:0].
		[7]	1 = $\overline{\text{RESET}}$ depends on IN8 with thresholds defined by r20h[2:0].
22h	A2h	[2:0]	**GPIO1 Output Dependencies:** 000 = GPIO1 is a digital input that is read from r22h[7]. 001 = GPIO1 is a digital manual reset input that asserts $\overline{\text{RESET}}$ when asserted. The state of GPIO1 is read from r22h[7]. 010 = GPIO1 is a digital output that is written to through r22h[6]. 011 = GPIO1 is a digital fault output that depends on conditions selected by r23h[6:0]. 100 = GPIO1 is a digital output that depends on primary thresholds at the input selected by r22h[5:3]. 101 =GPIO1 is a digital output that depends on primary thresholds at the input selected by r22h[5:3] and on conditions selected by r23h[6:0]. 110 = Reserved 111 = Reserved
		[5:3]	GPIO1 Single-Input Primary Threshold Voltage Monitor (r22h[2:0] = 100 or 101 only). GPIO1 asserts low when any primary threshold of this input is exceeded: 000 = IN1 001 = IN2 010 = IN3 011 = IN4 100 = IN5 101 = IN6 110 = IN7 111 = IN8
		[6]	**GPIO1 Output (write to this bit):** 1 = GPIO1 is set high if GPIO1 is configured as an output. 0 = GPIO1 is set low if GPIO1 is configured as an output.
		[7]	**GPIO1 Input State (read from this bit):** 1 = Indicates that GPIO1 is high regardless if GPIO1 is set as an output or input. 0 = Indicates that GPIO1 is low regardless if GPIO1 is set as an output or input.

表8. 输出条件(续)

REGISTER ADDRESS	EEPROM MEMORY ADDRESS	BIT RANGE	DESCRIPTION
23h	A3h	[0]	1 = GPIO1 depends on the secondary undervoltage thresholds of all enabled IN1–IN8.
		[1]	1 = GPIO1 depends on the primary overvoltage thresholds of all enabled IN1–IN8.
		[2]	1 = GPIO1 depends on the secondary overvoltage thresholds of all enabled IN1–IN8.
		[3]	1 = GPIO1 depends on the secondary overtemperature threshold of the internal temperature sensor.
		[4]	1 = GPIO1 depends on the secondary overtemperature threshold of remote temperature sensor 1.
		[5]	1 = GPIO1 depends on the secondary overtemperature threshold of remote temperature sensor 2.
		[6]	1 = GPIO1 depends on the secondary overcurrent threshold.
		[7]	Reserved
24h	A4h	[2:0]	**GPIO2 Output Dependencies:** 000 = GPIO2 is a digital input that is read from r24h[7]. 001 = GPIO2 is a digital manual reset input that asserts $\overline{\text{RESET}}$ when asserted. The state of GPIO2 is read from r24h[7]. 010 = GPIO2 is a digital output that is written to through r24h[6]. 011 = GPIO2 is a digital fault output that depends on conditions selected by r25h[6:0]. 100 = GPIO2 is a digital output that depends on primary thresholds at the input selected by r24h[5:3]. 101 = GPIO2 is a digital output that depends on primary thresholds at the input selected by r24h[5:3] and on conditions selected by r25h[6:0]. 110 = Reserved 111 = Reserved
		[5:3]	GPIO2 Single-Input Primary Threshold Voltage Monitor (r24h[2:0] = 100 or 101 only). GPIO2 asserts low when the primary threshold of this input is exceeded: 000 = IN1 001 = IN2 010 = IN3 011 = IN4 100 = IN5 101 = IN6 110 = IN7 111 = IN8
		[6]	**GPIO2 Output (write to this bit):** 1 = GPIO2 is set high if GPIO2 is configured as an output. 0 = GPIO2 is set low if GPIO2 is configured as an output.
		[7]	**GPIO2 Input (read from this bit):** 1 = Indicates that GPIO2 is high regardless if GPIO2 is set as an output or input. 0 = Indicates that GPIO2 is low regardless if GPIO2 is set as an output or input.

表8. 输出条件(续)

REGISTER ADDRESS	EEPROM MEMORY ADDRESS	BIT RANGE	DESCRIPTION
25h	A5h	[0]	1 = GPIO2 depends on the secondary undervoltage thresholds of all enabled IN1–IN8.
		[1]	1 = GPIO2 depends on the primary overvoltage thresholds of all enabled IN1–IN8.
		[2]	1 = GPIO2 depends on the secondary overvoltage thresholds of all enabled IN1–IN8.
		[3]	1 = GPIO2 depends on the secondary overtemperature threshold of the internal temperature sensor.
		[4]	1 = GPIO2 depends on the secondary overtemperature threshold of remote temperature sensor 1.
		[5]	1 = GPIO2 depends on the secondary overtemperature threshold of remote temperature sensor 2.
		[6]	1 = GPIO2 depends on the secondary overcurrent threshold.
		[7]	Reserved

故障管理

MAX16031/MAX16032提供多种可配置选项，用于检测和管理系统故障。故障门限在r26h–r4Eh中设置，如表9所示。通过设置r54h–r57h，可以随时屏蔽触发故障的门限，使其不会触发故障报警，如表10所示。故障标志代表了指定输入的故障状态。可随时从r50h–r53h中读取器件检测到的输入故障，如表11所示。向标志寄存器的相应位写‘1’可清除故障标志。

表9. 故障门限

REGISTER ADDRESS	EEPROM MEMORY ADDRESS	BIT RANGE	DESCRIPTION
26h	A6h	[7:0]	IN1 Primary Undervoltage Threshold
27h	A7h	[7:0]	IN1 Primary Overvoltage Threshold
28h	A8h	[7:0]	IN1 Secondary Undervoltage Threshold
29h	A9h	[7:0]	IN1 Secondary Overvoltage Threshold
2Ah	AAh	[7:0]	IN2 Primary Undervoltage Threshold
2Bh	ABh	[7:0]	IN2 Primary Overvoltage Threshold
2Ch	ACh	[7:0]	IN2 Secondary Undervoltage Threshold
2Dh	ADh	[7:0]	IN2 Secondary Overvoltage Threshold
2Eh	AEh	[7:0]	IN3 Primary Undervoltage Threshold
2Fh	AFh	[7:0]	IN3 Primary Overvoltage Threshold
30h	B0h	[7:0]	IN3 Secondary Undervoltage Threshold
31h	B1h	[7:0]	IN3 Secondary Overvoltage Threshold
32h	B2h	[7:0]	IN4 Primary Undervoltage Threshold
33h	B3h	[7:0]	IN4 Primary Overvoltage Threshold

表9. 故障门限(续)

REGISTER ADDRESS	EEPROM MEMORY ADDRESS	BIT RANGE	DESCRIPTION
34h	B4h	[7:0]	IN4 Secondary Undervoltage Threshold
35h	B5h	[7:0]	IN4 Secondary Overvoltage Threshold
36h	B6h	[7:0]	IN5 Primary Undervoltage Threshold
37h	B7h	[7:0]	IN5 Primary Overvoltage Threshold
38h	B8h	[7:0]	IN5 Secondary Undervoltage Threshold
39h	B9h	[7:0]	IN5 Secondary Overvoltage Threshold
3Ah	BAh	[7:0]	IN6 Primary Undervoltage Threshold
3Bh	BBh	[7:0]	IN6 Primary Overvoltage Threshold
3Ch	BCh	[7:0]	IN6 Secondary Undervoltage Threshold
3Dh	BDh	[7:0]	IN6 Secondary Overvoltage Threshold
3Eh	BEh	[7:0]	IN7 Primary Undervoltage Threshold
3Fh	BFh	[7:0]	IN7 Primary Overvoltage Threshold
40h	C0h	[7:0]	IN7 Secondary Undervoltage Threshold
41h	C1h	[7:0]	IN7 Secondary Overvoltage Threshold
42h	C2h	[7:0]	IN8 Primary Undervoltage Threshold
43h	C3h	[7:0]	IN8 Primary Overvoltage Threshold
44h	C4h	[7:0]	IN8 Secondary Undervoltage Threshold
45h	C5h	[7:0]	IN8 Secondary Overvoltage Threshold
46h	C6h	[7:0]	Internal Temperature Sensor Primary Overtemperature Threshold MSB (2 LSBs are in r4Dh[1:0]).
47h	C7h	[7:0]	Internal Temperature Sensor Secondary Overtemperature Threshold MSB (2 LSBs are in r4Dh[3:2]).
48h	C8h	[7:0]	Remote Temperature Sensor 1 Primary Overtemperature Threshold MSB (2 LSBs are in r4Eh[1:0]).
49h	C9h	[7:0]	Remote Temperature Sensor 1 Secondary Overtemperature Threshold MSB (2 LSBs are in r4Eh[3:2]).
4Ah	CAh	[7:0]	Remote Temperature Sensor 2 Primary Overtemperature Threshold MSB (2 LSBs are in r4Eh[5:4]).
4Bh	CBh	[7:0]	Remote Temperature Sensor 2 Secondary Overtemperature Threshold MSB (2 LSBs are in r4Eh[7:6]).
4Ch	CCh	[7:0]	Current-Sense Secondary Threshold
4Dh	CDh	[1:0]	Internal Temperature Sensor Primary Overtemperature Threshold LSB
		[3:2]	Internal Temperature Sensor Secondary Overtemperature Threshold LSB
		[6:4]	Remote Temperature Sensor 2, Offset Trim
		[7]	Not used
4Eh	CEh	[1:0]	Remote Temperature Sensor 1 Primary Overtemperature Threshold LSB
		[3:2]	Remote Temperature Sensor 1 Secondary Overtemperature Threshold LSB
		[5:3]	Remote Temperature Sensor 2 Primary Overtemperature Threshold LSB
		[7:6]	Remote Temperature Sensor 2 Secondary Overtemperature Threshold LSB

表10. 故障屏蔽

REGISTER ADDRESS	EEPROM MEMORY ADDRESS	BIT RANGE	DESCRIPTION
54h	D4h	[0]	1 = Short-circuit detection at remote temperature sensor 1 is masked.
		[1]	1 = Open-circuit detection at remote temperature sensor 1 is masked.
		[2]	1 = Short-circuit detection at remote temperature sensor 2 is masked.
		[3]	1 = Open-circuit detection at remote temperature sensor 2 is masked.
		[7:4]	Not used.
55h	D5h	[0]	1 = IN1 primary overvoltage and undervoltage faults are masked.
		[1]	1 = IN2 primary overvoltage and undervoltage faults are masked.
		[2]	1 = IN3 primary overvoltage and undervoltage faults are masked.
		[3]	1 = IN4 primary overvoltage and undervoltage faults are masked.
		[4]	1 = IN5 primary overvoltage and undervoltage faults are masked.
		[5]	1 = IN6 primary overvoltage and undervoltage faults are masked.
		[6]	1 = IN7 primary overvoltage and undervoltage faults are masked.
		[7]	1 = IN8 primary overvoltage and undervoltage faults are masked.
56h	D6h	[0]	1 = IN1 secondary overvoltage and undervoltage faults are masked.
		[1]	1 = IN2 secondary overvoltage and undervoltage faults are masked.
		[2]	1 = IN3 secondary overvoltage and undervoltage faults are masked.
		[3]	1 = IN4 secondary overvoltage and undervoltage faults are masked.
		[4]	1 = IN5 secondary overvoltage and undervoltage faults are masked.
		[5]	1 = IN6 secondary overvoltage and undervoltage faults are masked.
		[6]	1 = IN7 secondary overvoltage and undervoltage faults are masked.
		[7]	1 = IN8 secondary overvoltage and undervoltage faults are masked.
57h	D7h	[0]	1 = Internal temperature sensor primary overtemperature fault masked.
		[1]	1 = Remote temperature sensor 1 primary overtemperature fault masked.
		[2]	1 = Remote temperature sensor 2 primary overtemperature fault masked.
		[3]	1 = Internal temperature sensor secondary overtemperature fault masked.
		[4]	1 = Remote temperature sensor 1 secondary overtemperature fault masked.
		[5]	1 = Remote temperature sensor 2 secondary overtemperature fault masked.
		[6]	1 = Current-sense primary overcurrent fault masked.
		[7]	1 = Current-sense secondary overcurrent fault masked.

表11. 故障标志

REGISTER ADDRESS	EEPROM MEMORY ADDRESS	BIT RANGE	DESCRIPTION
50h	D0h	[0]	1 = Short circuit detected at remote temperature sensor 1.
		[1]	1 = Open circuit detected at remote temperature sensor 1.
		[2]	1 = Short circuit detected at remote temperature sensor 2.
		[3]	1 = Open circuit detected at remote temperature sensor 2.
		[7:4]	Not used.
51h	D1h	[0]	1 = IN1 conversion result exceeds primary overvoltage or undervoltage thresholds.
		[1]	1 = IN2 conversion result exceeds primary overvoltage or undervoltage thresholds.
		[2]	1 = IN3 conversion result exceeds primary overvoltage or undervoltage thresholds.
		[3]	1 = IN4 conversion result exceeds primary overvoltage or undervoltage thresholds.
		[4]	1 = IN5 conversion result exceeds primary overvoltage or undervoltage thresholds.
		[5]	1 = IN6 conversion result exceeds primary overvoltage or undervoltage thresholds.
		[6]	1 = IN7 conversion result exceeds primary overvoltage or undervoltage thresholds.
		[7]	1 = IN8 conversion result exceeds primary overvoltage or undervoltage thresholds.
52h	D2h	[0]	1 = IN1 conversion result exceeds secondary overvoltage or undervoltage thresholds.
		[1]	1 = IN2 conversion result exceeds secondary overvoltage or undervoltage thresholds.
		[2]	1 = IN3 conversion result exceeds secondary overvoltage or undervoltage thresholds.
		[3]	1 = IN4 conversion result exceeds secondary overvoltage or undervoltage thresholds.
		[4]	1 = IN5 conversion result exceeds secondary overvoltage or undervoltage thresholds.
		[5]	1 = IN6 conversion result exceeds secondary overvoltage or undervoltage thresholds.
		[6]	1 = IN7 conversion result exceeds secondary overvoltage or undervoltage thresholds.
		[7]	1 = IN8 conversion result exceeds secondary overvoltage or undervoltage thresholds.
53h	D3h	[0]	1 = Internal temperature sensor conversion exceeds its primary overtemperature threshold.
		[1]	1 = Remote temperature sensor 1 conversion exceeds its primary overtemperature threshold.
		[2]	1 = Remote temperature sensor 2 conversion exceeds its primary overtemperature threshold.
		[3]	1 = Internal temperature sensor conversion exceeds its secondary overtemperature threshold.
		[4]	1 = Remote temperature sensor 1 conversion exceeds its secondary overtemperature threshold.
		[5]	1 = Remote temperature sensor 2 conversion exceeds its secondary overtemperature threshold.
		[6]	1 = Current-sense conversion exceeds its primary overcurrent threshold.
		[7]	1 = Current-sense conversion exceeds its secondary overcurrent threshold.

表12. 故障记录条件

REGISTER ADDRESS	EEPROM MEMORY ADDRESS	BIT RANGE	DESCRIPTION
58h	D8h	[0]	1 = Fault log triggered when IN1 is below its primary undervoltage threshold.
		[1]	1 = Fault log triggered when IN2 is below its primary undervoltage threshold.
		[2]	1 = Fault log triggered when IN3 is below its primary undervoltage threshold.
		[3]	1 = Fault log triggered when IN4 is below its primary undervoltage threshold.
		[4]	1 = Fault log triggered when IN5 is below its primary undervoltage threshold.
		[5]	1 = Fault log triggered when IN6 is below its primary undervoltage threshold.
		[6]	1 = Fault log triggered when IN7 is below its primary undervoltage threshold.
		[7]	1 = Fault log triggered when IN8 is below its primary undervoltage threshold.
59h	D9h	[0]	1 = Fault log triggered when IN1 is above its primary overvoltage threshold.
		[1]	1 = Fault log triggered when IN2 is above its primary overvoltage threshold.
		[2]	1 = Fault log triggered when IN3 is above its primary overvoltage threshold.
		[3]	1 = Fault log triggered when IN4 is above its primary overvoltage threshold.
		[4]	1 = Fault log triggered when IN5 is above its primary overvoltage threshold.
		[5]	1 = Fault log triggered when IN6 is above its primary overvoltage threshold.
		[6]	1 = Fault log triggered when IN7 is above its primary overvoltage threshold.
		[7]	1 = Fault log triggered when IN8 is above its primary overvoltage threshold.
5Ah	DAh	[0]	1 = Fault log triggered when current sense is above its primary overcurrent threshold.
		[1]	1 = Fault log triggered when internal temperature sensor is above its overtemperature threshold.
		[2]	1 = Fault log triggered when remote temperature sensor 1 is above its overtemperature threshold.
		[3]	1 = Fault log triggered when remote temperature sensor 2 is above its overtemperature threshold.
		[7:4]	Not used.

故障记录

如果某个特定的输入门限对于系统工作非常重要，则应启动自动故障记录功能，将故障信息传送到EEPROM。通过r58h–r5Ah设置各通道的故障记录条件，如表12所示。从EEPROM中的r80h–r8Eh可读取所记录的故障信息，如表13所示。一旦记录故障，将锁存故障记录，需要将其复位后才能记录新的故障。向r5Fh[1]写‘1’可复位故障记录。故障信息中始终包括故障标志寄存器的内容，还可通过设置r5Ch[7]使之也包括ADC转换结果寄存器的内容(参见*多项设置*部分)。所有存储的ADC转换结果都是8个MSB。

多项设置

表14列出了多种设置选项。寄存器r5Bh中包含启动超时和远端温度检测的滤波器截止频率设置。寄存器r5Ch[1:0]设置二级过流门限超时，即从发生过流故障到触发过流故障报警之间的延时。所有电压门限具有两个由r5Ch[5]设置的滞回选项。r5Ch[6] = 1时，产生故障记录的条件必须是在连续两次ADC转换中故障条件都成立，而非一次性地发生故障，以此提高噪声抑制。寄存器r5Ch[7]控制记录故障后是否将ADC转换结果存储在EEPROM中。寄存器r5Eh存储用户自定义配置或固件版本号。寄存器r5Fh[0]设置EEPROM和寄存器组的锁存和解锁。寄存器r5Fh[1]指示是否发生故障记录，并将相应的故障信息锁存到EEPROM。在向r5Fh[1]写‘1’之前，其它故障记录事件不会将新的故障信息写入故障EEPROM。

基于EEPROM的系统监控器，提供非易失故障存储

表13. 故障记录EEPROM

REGISTER ADDRESS	EEPROM MEMORY ADDRESS	BIT RANGE	DESCRIPTION
—	80h	[7:0]	Copy of r51h[7:0] at the time the fault log was triggered.
—	81h	[7:0]	Copy of r52h[7:0] at the time the fault log was triggered.
—	82h	[7:0]	Copy of r53h[7:0] at the time the fault log was triggered.
—	83h	[7:0]	IN1 conversion result at the time the fault log was triggered.
—	84h	[7:0]	IN2 conversion result at the time the fault log was triggered. 8 MSBs only.
—	85h	[7:0]	IN3 conversion result at the time the fault log was triggered. 8 MSBs only.
—	86h	[7:0]	IN4 conversion result at the time the fault log was triggered. 8 MSBs only.
—	87h	[7:0]	IN5 conversion result at the time the fault log was triggered. 8 MSBs only.
—	88h	[7:0]	IN6 conversion result at the time the fault log was triggered. 8 MSBs only.
—	89h	[7:0]	IN7 conversion result at the time the fault log was triggered. 8 MSBs only.
—	8Ah	[7:0]	IN8 conversion result at the time the fault log was triggered. 8 MSBs only.
—	8Bh	[7:0]	Internal temperature sensor conversion result at the time the fault log was triggered. 8 MSBs from 10-bit ADC conversion.
—	8Ch	[7:0]	Remote temperature sensor 1 conversion result at the time the fault log was triggered. 8 MSBs from 10-bit ADC conversion.
—	8Dh	[7:0]	Remote temperature sensor 2 conversion result at the time the fault log was triggered. 8 MSBs from 10-bit ADC conversion.
—	8Eh	[7:0]	Current-sense conversion result at the time the fault log was triggered.

I²C/SMBus兼容串行接口

MAX16031/MAX16032具有一个I²C/SMBus兼容的2线(SDA和SCL)串行接口，实现与主机设备的通信。所有可能的通信格式如图5所示，后续章节给出了有关从机地址和SMBALERT#的详细说明。图1为2线接口时序图，I²C和SMBus协议和术语请参考I²C总线2.1和系统管理总线(SMBus) 2.0规范。MAX16031/MAX16032支持最高400kHz的2线通信速率，SDA和SCL需要外部上拉电阻。

从机地址

从机地址输入(A0和A1)分别可监测3种不同状态，允许在同一串行总线上挂接9个相同设备。A0和A1接GND、DBP或悬空(N.C.)。所有可能的7位地址输入连接及对应的串行总线地址如表15所示。

SMBALERT#

SMBALERT#是SMBus规范附录A中定义的一个可选中断信号。MAX16031/MAX16032将输出$\overline{\text{ALERT}}$作为中断信号。$\overline{\text{ALERT}}$使能时，如果$\overline{\text{FAULT1}}$、$\overline{\text{FAULT2}}$、$\overline{\text{RESET}}$、$\overline{\text{OVERT}}$或$\overline{\text{OVERC}}$中的任一个被触发报警，$\overline{\text{ALERT}}$也将触发报警。此外，如果GPIO_配置为故障输出，则GPIO_处于故障报警状态时，$\overline{\text{ALERT}}$也将触发报警。所有故障解除(即所有故障输出为高电平)后，解除$\overline{\text{ALERT}}$的报警状态。

通常$\overline{\text{ALERT}}$连接到系统中的所有其它SMBALERT#漏极开路信号，与SMBALERT#输出构成“线或”逻辑。当主机被SMBALERT#输入信号中断时，主机停止或完成当前总线传输，并向总线发出报警响应地址(ARA)。将SMBALERT#信号拉低的从机应答ARA，并将其地址提供给总线，使主机获悉哪个从机导致了中断。7位ARA是‘0001100’，R/$\overline{\text{W}}$位为无关项。

Send Byte Format

S	ADDRESS	R/$\overline{W}$	ACK	COMMAND	ACK	P
↓	7 bits	0		8 bits		↑

Slave Address: Address of the slave on the serial interface bus.

Command Byte: Presets the internal address pointer or represents a command.

Receive Byte Format

S	ADDRESS	R/$\overline{W}$	ACK	DATA	NACK	P
↓	7 bits	1		8 bits		↑

Slave Address: Address of the slave on the serial interface bus.

Data Byte: Data is read from the location pointed to by the internal address pointer.

Write Byte Format

S	ADDRESS	R/$\overline{W}$	ACK	COMMAND	ACK	DATA	ACK	P
↓	7 bits	0		8 bits		8 bits		↑

Slave Address: Address of the slave on the serial interface bus.

Command Byte: Sets the internal address pointer.

Data Byte: Data is written to the locations set by the internal address pointer.

SMBALERT#

S	ADDRESS	R/$\overline{W}$	ACK	DATA	NACK	P
↓	0001100	D.C.		8 bits		↑

Alert Response Address: Only the device that interrupted the master responds to this address.

Slave Address: Slave places its own address on the serial bus.

Read Byte Format

S	SLAVE ADDRESS	R/$\overline{W}$	ACK	COMMAND	ACK	SR	SLAVE ADDRESS	R/$\overline{W}$	ACK	DATA BYTE	NACK	P
↓	7 bits	0		8 bits		↓	7 bits	1		8 bits		↑

Slave Address: Address of the slave on the serial interface bus.

Command Byte: Sets the internal address pointer.

Data Byte: Data is read from the locations set by the internal address pointer.

Block Write Format

S	ADDRESS	R/$\overline{W}$	ACK	COMMAND	ACK	BYTE COUNT = N	ACK	DATA BYTE 1	ACK	DATA BYTE …	ACK	DATA BYTE N	ACK	P
↓	7 bits	0		8 bits		8 bits		8 bits		8 bits		8 bits		↑

Slave Address: Address of the slave on the serial interface bus.

Command Byte: FAh

Data Byte: Data is written to the locations set by the internal address pointer.

Slave to master

Master to slave

Block Read Format

S	ADDRESS	R/$\overline{W}$	ACK	COMMAND	ACK	SR	ADDRESS	R/$\overline{W}$	ACK	BYTE COUNT = N	ACK	DATA BYTE 1	ACK	DATA BYTE …	ACK	DATA BYTE N	NACK	P
↓	7 bits	0		8 bits		↓	7 bits	1		8 bits		8 bits		8 bits		8 bits		↑

Slave Address: Address of the slave on the serial interface bus.

Command Byte: FBh

Slave Address: Address of the slave on the serial interface bus.

Data Byte: Data is read from the locations set by the internal address pointer.

S = START Condition
P = STOP Condition
Sr = Repeated START Condition
D.C. = Don't Care

ACK = Acknowledge, SDA pulled low during rising edge of SCL.
NACK = Not acknowledge, SDA left high during rising edge of SCL.

All data is clocked in/out of the device on rising edges of SCL.

↓ = SDA transitions from high to low during period of SCL.

↑ = SDA transitions from low to high during period of SCL.

图5. 通信格式

表14. 多项设置

REGISTER ADDRESS	EEPROM MEMORY ADDRESS	BIT RANGE	DESCRIPTION
5Bh	DBh	[3:0]	**Postboot Timeout (all faults and outputs masked):** 0h = No timeout 1h = 0.974ms 2h = 2.030ms 3h = 3.978ms 4h = 8.038ms 5h = 15.99ms 6h = 31.99ms 7h = 63.99ms 8h = 128ms 9h = 256.0ms Ah = 512ms Bh = 1024ms Ch = 2048ms Dh = 4096ms Eh = 8192ms Fh = 16384ms
		[6:4]	**Temperature Sensor Lowpass Filter Cutoff:** 000 = No filter 001 = 2.53Hz 010 = 5.06Hz 011 = 10.1Hz 100 = 20.2Hz 101 = 40.5Hz 110 = 81Hz 111 = 162Hz
		[7]	Not used.
5Ch	DCh	[1:0]	**Overcurrent Secondary Threshold Timeout:** 00 = 50µs 01 = 3.98ms 10 = 16ms 11 = 64ms
		[2]	**Latch $\overline{\text{OVERC}}$:** 0 = No latch 1 = Latched after assertion
		[4:3]	Not used.
		[5]	**Threshold Hysteresis (all thresholds):** 0 = 0.78% 1 = 1.17%

表14. 多项设置(续)

REGISTER ADDRESS	EEPROM MEMORY ADDRESS	BIT RANGE	DESCRIPTION
5Ch	DCh	[6]	**Consecutive Faults on Primary Thresholds:** 0 = Fault occurs after primary threshold is exceeded one time (normal operation). 1 = Fault occurs after primary threshold is exceeded twice.
		[7]	**Fault Log ADC Conversions Option:** 0 = When a fault log is triggered, only fault flags are saved in EEPROM. 1 = When a fault log is triggered, fault flags and ADC conversion results (8 MSBs) are saved in EEPROM.
5Eh	DEh	[7:0]	Firmware Version. 8 bits of memory for user-defined firmware version number.
5Fh	DFh	[0]	**Configuration Lock:** Write a '1' to r5Fh[0] to toggle this register bit. 0 = Register and EEPROM configuration unlocked. 1 = Register and EEPROM configuration locked.
		[1]	**Fault Log EEPROM Lock Flag (set automatically after fault log is triggered):** Write a '1' to r5Fh[1] to toggle this register bit. 0 = EEPROM is not locked. A triggered fault log stores fault information to EEPROM. 1 = A fault log has been triggered. Write a '1' to this bit to clear the flag and allow a new fault log to be triggered.
		[7:2]	Not used.

表15. I²C/SMBus从机地址设置

A1	A0	BUS ADDRESS
GND	GND	0011000
GND	N.C.	0011001
GND	DBP	0011010
N.C.	GND	0101001
N.C.	N.C.	0101010
N.C.	DBP	0101011
DBP	GND	1001100
DBP	N.C.	1001111
DBP	DBP	1001110

特殊命令

MAX16031/MAX16032提供软件重启和故障记录命令。软件重启用于初始化POR时的上电顺序。启动期间，将EEPROM配置数据复制到寄存器。通过软件重启时，按照字节发送格式发送0xFC。软件初始化故障记录与硬件初始化故障记录在功能上相同。记录故障时，ADC寄存器和故障信息记录到EEPROM。为了触发软件初始化的故障记录，按照字节发送格式发送0xFD。

IEEE是美国电气和电子工程师学会的注册服务标志。

JTAG串行接口

除了I²C/SMBus兼容串行接口外，MAX16031/MAX16032还包含一个IEEE® 1149.1兼容的JTAG口。两种接口都可用于访问内部储存器；但是，每次只允许采用一种接口。MAX16031/MAX16032的所有数字I/O都支持IEEE 1149.1边界扫描，并包括典型的JTAG边界扫描单元(允许输入/输出轮询或通过标准JTAG命令强制为高/低电平)。MAX16031/MAX16032含有JTAG规范中未提及的附加JTAG指令和附加段寄存器，用于访问内部存储器。附加指令为：LOAD ADDRESS、WRITE、READ、REBOOT、SAVE和USERCODE。附加段寄存器为：存储器地址、存储器写操作、存储器读操作、用户编码数据，JTAG接口的方框图如图6所示。

测试访问端口(TAP)控制器的状态机

TAP控制器是一个有限状态机，在TCK上升沿响应TMS的逻辑电平。有限状态机的框图如图7所示。

Test-Logic-Reset：上电后，TAP控制器进入test-logic-reset状态。IDCODE命令位于指令寄存器，器件的所有系统逻辑工作正常。

基于EEPROM的系统监控器，提供非易失故障存储

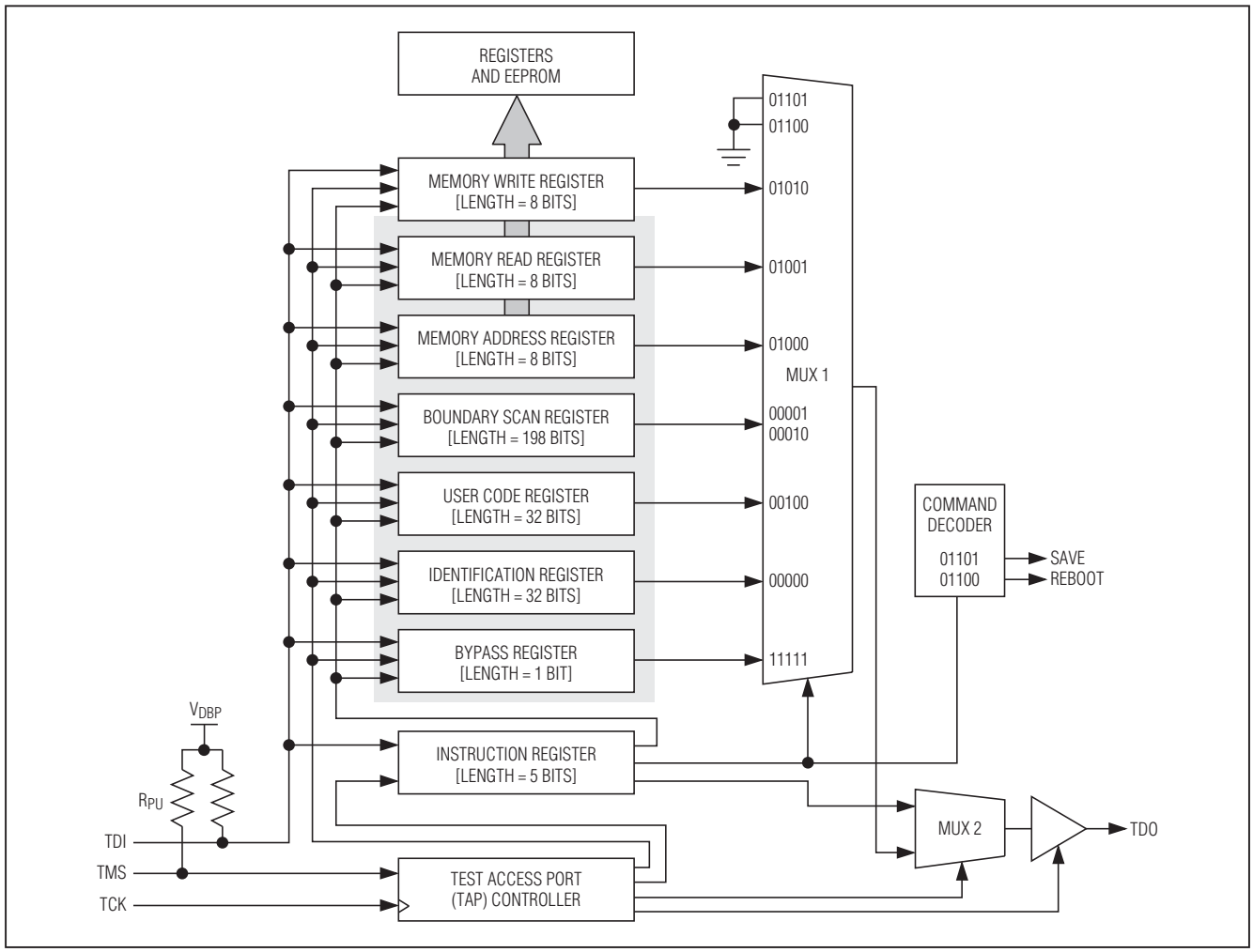


图6. JTAG方框图

Run-Test/Idle：Run-test/idle是扫描操作之间或特定测试期间的中间状态。该状态下指令寄存器和测试数据寄存器保持空闲。

Select-DR-Scan：所有测试数据寄存器保持其原先状态。如果TMS为低电平，在TCK的上升沿控制器进入capture-DR状态，并启动扫描程序；如果TMS为高电平，在TCK的上升沿控制器进入select-IR-scan状态。

Capture-DR：在capture-DR状态下，通过当前指令将数据并行加载到所选择的测试数据寄存器。如果指令不调用并行负载或所选择的测试数据寄存器不支持并行负载，则测试数据寄存器保持当前数值。如果TMS为低电平，在TCK的上升沿控制器进入shift-DR状态；如果TMS为高电平，控制器进入exit1-DR状态。

Shift-DR：Shift-DR状态下，当前指令选择的测试数据寄存器连接在TDI和TDO之间，TMS为低电平时，在每个TCK的上升沿将数据逐次移至串行输出端。如果TMS为高电平，在TCK的上升沿控制器进入exit1-DR状态。

Exit1-DR：该状态下，如果TMS为高电平，在TCK的上升沿将使控制器处于update-DR状态；如果TMS为低电平，在TCK的上升沿将使控制器进入pause-DR状态。

Pause-DR：该状态下，测试数据寄存器停止发送数据。所有测试数据寄存器保持原有状态。如果TMS为低电平控制器将保持该状态；如果TMS为高电平，在TCK的上升沿控制器将进入exit2-DR状态。

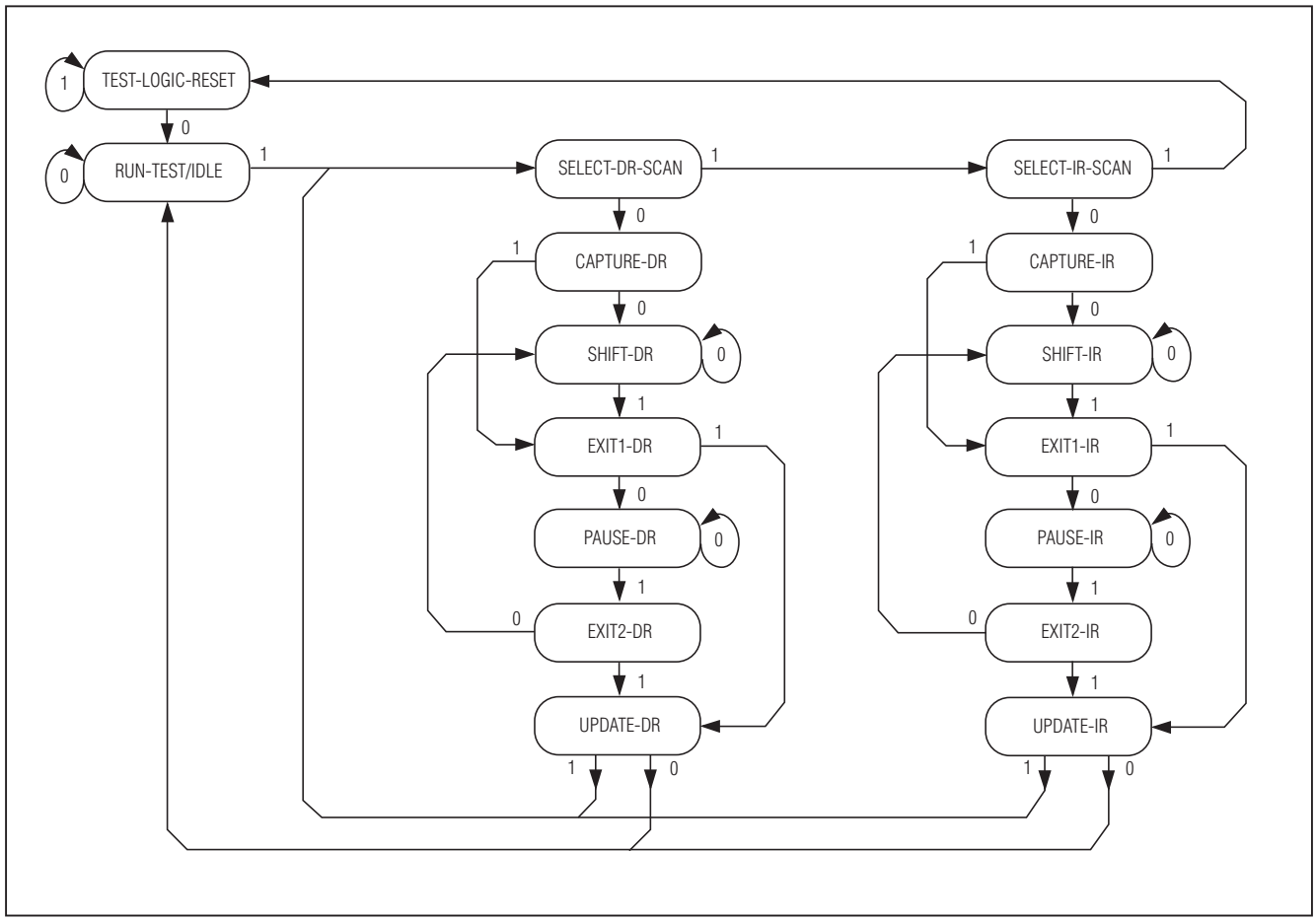


图7. TAP控制器状态图

Exit2-DR：该状态下，TMS为高电平时，在TCK上升沿控制器进入update-DR状态；TMS为低电平时，在TCK上升沿控制器进入shift-DR状态。

Update-DR：该状态下，在TCK下降沿，将数据从测试数据寄存器的移位寄存器锁存到输出，这样可避免并行输出由于移位寄存器内容的改变而改变。如果TMS为低电平，在TCK上升沿控制器回到run-test/idle状态；如果TMS为高电平，控制器则进入select-DR-scan状态。

Select-IR-Scan：该状态下所有测试数据寄存器保持原状态，指令寄存器保持不变。TMS为低电平时，在TCK上升沿控制器进入capture-IR状态。TMS为高电平时，在TCK上升沿控制器返回test-logic-reset状态。

Capture-IR：利用capture-IR状态可以将移位寄存器的数值装载到指令寄存器，在TCK上升沿载入。TMS为高电平时，在TCK上升沿控制器进入exit1-IR状态。TMS为低电平时，在TCK上升沿控制器进入shift-IR状态。

Shift-IR：此状态下，指令寄存器中的移位寄存器连接在TDI和TDO之间，TMS为低电平时，在每个TCK上升沿将数据向TDO的串行输出端依次移动。指令寄存器的并行输出和所有测试数据寄存器仍保持原状态。TMS为高电平时，在TCK上升沿控制器进入exit1-IR状态。TMS为低电平时，在TCK上升沿控制器进入shift-IR状态，将数据通过指令寄存器移动一次。

基于EEPROM的系统监控器，提供非易失故障存储

Exit-IR：TMS为低电平时，在TCK上升沿控制器进入pause-IR状态；TMS为高电平时，在TCK上升沿控制器进入update-IR状态。

Pause-IR：该状态下，移位寄存器的移位操作临时中断。TMS为高电平时，在TCK上升沿控制器进入exit2-IR状态；如果TMS为低电平，在TCK上升沿控制器仍处于pause-IR状态。

Exit2-IR：TMS为高电平时，在TCK上升沿控制器处于update-IR状态。该状态下，如果TMS为低电平，在TCK上升沿控制器返回shift-IR状态。

Update-IR：当控制器进入该状态时，已移入指令移位寄存器的命令在TCK下降沿锁存到指令寄存器的并行输出。一旦锁存，该指令将成为当前指命令。TMS为低电平时，在TCK的上升沿控制器处于run-test/idle状态；TMS为高电平时控制器进入select-DR-scan状态。

指令寄存器

指令寄存器包含移位寄存器和锁存的并行输出，长度为5位。当TAP控制器进入shift-IR状态时，指令移位寄存器连接在TDI和TDO之间。在shift-IR状态下，TMS为低电平时，在TCK上升沿将数据从TDO逐位串行输出。在exit1-IR状态或exit2-IR状态下，TMS为高电平时，在TCK上升沿控制器进入update-IR状态。同样在TCK下降沿将指令移位寄存器的数据锁存到指令寄存器的并行输出端。MAX16031/MAX16032所支持的指令及相应的二进制代码如表16所列。

SAMPLE/PRELOAD：SAMPLE/PRELOAD是IEEE 1149.1协议的强制指令，支持两种功能。利用capture-DR状态，用边界扫描测试数据寄存器对器件的数字I/O进行采样，无需中断器件的正常工作。利用shift-DR状态，SAMPLE/PRELOAD还允许器件通过TDI将数据移入边界扫描测试数据寄存器。

BYPASS：当BYPASS指令锁存在指令寄存器时，TDI通过1位旁路测试数据寄存器连接至TDO。从而允许数据由DTDI传递至TDO，不会影响器件的正常工作。

EXTEST：该指令允许测试器件的所有内部连接。当EXTEST指令锁存在指令寄存器时，将执行下列操作：一旦通过update-IR状态使能，则驱动所有数字输出的并行输出，边界扫描测试数据寄存器接在TDI和TDO之间。Capture-DR将所有数字输入采样到边界扫描测试数据寄存器。

IDCODE：当IDCODE指令锁存在并行指令寄存器时，选择识别测试数据寄存器。器件识别码在TCK上升沿载入识别测试数据寄存器，随后进入capture-DR状态。用shift-DR状态将识别码通过TDO串行移出。在test-logic-reset状态下，强制识别码进入指令寄存器。ID码的LSB位始终为1，随后11位是制造商的JEDEC码，然后是16位器件ID，最高4位是器件版本号，如表17所示。

表16. JTAG指令集

INSTRUCTION	BINARY CODE	SELECTED REGISTER/ACTION
BYPASS	11111	Bypass
IDCODE	00000	Identification
SAMPLE/PRELOAD	00001	Boundary scan
EXTEST	00010	Boundary scan
USERCODE	00100	User-code data
LOAD ADDRESS	01000	Memory address
READ	01001	Memory read
WRITE	01010	Memory write
REBOOT	01100	Resets the device
SAVE	01101	Stores current fault information in EEPROM

表17. 32位识别码

MSB			LSB
Version (4 bits)	Device ID (16 bits)	Manufacturer ID (11 bits)	Fixed value (1 bit)
0000	0000000000000001	00011001011	1

表18. 32位用户编码数据

MSB		
D.C. (don't cares)	I²C/SMBus Slave Address	User identification (firmware version)
00000000000000000	See Table 15	r5Eh[7:0] contents

USERCODE：当USERCODE指令锁存在并行指令寄存器时，选择用户编码数据寄存器。器件的用户编码在TCK上升沿锁存到用户编码寄存器，随后进入capture-DR状态。用shift-DR状态将用户编码串行移出TDO，如表18所示。

LOAD ADDRESS：标准IEEE 1149.1指令集的扩展部分，支持MAX16031/MAX16032的存储器访问。当LOAD ADDRESS指令锁存在指令寄存器时，在shift-DR状态下TDI通过8位存储器地址测试数据寄存器连接至TDO。

READ：标准IEEE 1149.1指令集的扩展部分，支持MAX16031/MAX16032的存储器访问。当READ指令锁存在指令寄存器时，在shift-DR状态下TDI通过8位存储器读测试数据寄存器连接至TDO。

WRITE：标准IEEE 1149.1指令集的扩展部分，支持MAX16031/MAX16032的存储器访问。当WRITE指令锁存在指令寄存器时，在shift-DR状态下TDI通过8位存储器写测试数据寄存器连接至TDO。

REBOOT：标准IEEE 1149.1指令集的扩展部分，用来启动MAX16031/MAX16032的软件控制复位。当REBOOT指令锁存到指令寄存器时，MAX16031/MAX16032复位并立即开始启动程序。

SAVE：标准IEEE 1149.1指令集的扩展部分，用来启动故障记录。当SAVE指令锁存到指令寄存器时，MAX16031/MAX16032将故障信息从寄存器复制到EEPROM。

边界扫描

边界扫描功能允许访问MAX16031/MAX16032的所有数字I/O。如果SAMPLE/PRELOAD或EXTEST指令被加载到指令寄存器，TDI通过198位边界扫描寄存器连接至TDO。每个数字I/O引脚对应边界扫描寄存器的1位(A0和A1引脚对应2位)。其它边界扫描位保留，并加载为0。

执行SAMPLE/PRELOAD指令时，数字输出的当前状态锁存至边界扫描寄存器，并通过TDO移出。执行该指令时无需中断器件的正常工作。执行EXTEST指令时，边界扫描寄存器各位取代I/O引脚的功能：边界扫描寄存器各位的值反映了对应的输出状态。

表19列出了边界扫描寄存器各位的功能。由于I²C地址选择引脚具有3种可能的状态，因此，需要2个边界扫描寄存器位表示，这些位的定义如表20所示。

应用信息

布局和旁路

采用一只1µF电容分别将V_{CC}、DBP和ABP旁路至GND。采用一只2.2µF电容将RBP旁路至GND。布线时应避免数字信号的返回电流通过敏感的模拟区域，如模拟电源输入回路或ABP旁路电容接地端，模拟地和数字地应分开。

表19. 边界单元序号

BOUNDARY CELL NO.	DESCRIPTION/PIN
0–147	Reserved
148	GPIO1 (output)
149	GPIO2 (output)
150	SDA (output)
151	$\overline{\text{ALERT}}$
152	$\overline{\text{FAULT2}}$
153	$\overline{\text{FAULT1}}$
154	$\overline{\text{OVERT}}$
155	$\overline{\text{RESET}}$
156	$\overline{\text{OVERC}}$
157–182	Reserved
183	GPIO2 (input)
184	GPIO1 (input)
185	SDA (input)
186	A0b
187	A0a
188	A1b
189	A1a
190	SCL
191–197	Reserved

表20. 地址引脚状态解码

A0A A0B	A0 PIN STATE
0 0	High impedance
0 1	Low
1 0	High
1 1	Not defined

芯片信息

PROCESS: BiCMOS

封装信息

如需最近的封装外形信息和焊盘布局，请查询 **china.maxim-ic.com/packages**。请注意，封装编码中的“+”、“#”或“-”仅表示RoHS状态。封装图中可能包含不同的尾缀字符，但封装图只与封装有关，与RoHS状态无关。

封装类型	封装编码	外形编号	焊盘布局编号
48 TQFN-EP	T4877+6	21-0144	90-0132

修订历史

修订号	修订日期	说明	修改页
0	7/07	最初版本。	—
1	10/07	修改了*定购信息*。	1
2	6/10	修改了*引脚说明*。	11
3	9/10	在*Electrical Characteristics*部分中修改了最小基准电压参数。	3

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