SGM42214AQ/SGM42214BQ
150mΩ, Quad-Channel, Smart High-side Switches for 12V Automotive Applications

GENERAL DESCRIPTION

The SGM42214xQ is a smart quad-channel, high-side switch with 150mΩ N-MOSFETs designed for automotive applications. It includes a full set of diagnostics and protection features along with an accurate current sensing circuit to enable intelligent load control. The device supports a variety of resistive, capacitive and inductive loads.

Besides the fixed internal current limit, an externally adjustable current limit is provided for better inrush and overload current protection and improved reliability.

The device is AEC-Q100 qualified (Automotive Electronics Council (AEC) standard Q100 Grade 1) and it is suitable for automotive applications.

The SGM42214xQ is available in a Green TSSOP-28 (Exposed Pad) package.

SIMPLIFIED SCHEMATIC

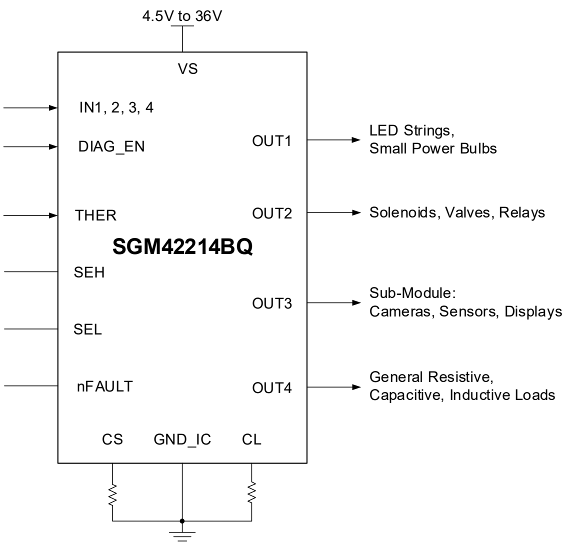


Figure 1. Simplified Schematic

FEATURES

- **AEC-Q100 Qualified for Automotive Applications**
  Device Temperature Grade 1
  T_A = -40℃ to +125℃
- **4.5V to 36V Wide Supply Voltage Range**
- **Quad-Channel High-side Switch: 150mΩ**
- **Full Set of Diagnostic Features on All Switches**
- **Open-Drain Diagnostics Fault Outputs**
- **Unified Analog Current Sense and Fault Output**
- **Ultra-Low Standby Current: 0.5μA (MAX) at +25℃**
- **Fixed Internal Current Limit Option**
- **Adjustable External Current Limit**
- **Individual Thermal Protection for Each Channel**
- **Latch Off or Auto-Retry Thermal Shutdown**
- **Reduced Current Limit after Thermal Shutdown**
- **Thermal Swing Protection:**
  - **Output Turns Off with Fast Temperature Rise**
  - **Auto-Retry with Normal Current Limit**
- **Output Clamp at Negative Voltage for Inductive Loads with Optimized Slew Rate**
- **Loss-of-GND and Loss-of-Battery Protections**
- **Overload and Short-to-GND Detection**
- **Open-Load/Short-to-Battery Detection**
- **Global Fault Report for Fast Interrupt Signaling**
- **-40℃ to +125℃ Operating Temperature Range**
- **Available in a Green TSSOP-28 (Exposed Pad) Package**

APPLICATIONS

PLC Digital Output Drivers
Multi-Channel LED Drivers, Light Bulb Drivers
Multi-Channel High-side Switches for Sub-Modules
Multi-Channel High-side Relays, Solenoid Drivers

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM42214AQ	TSSOP-28 (Exposed Pad)	-40℃ to +125℃	SGM42214AQPTS28G/TR	0YDPTS28 XXXXX	Tape and Reel, 4000
SGM42214BQ	TSSOP-28 (Exposed Pad)	-40℃ to +125℃	SGM42214BQPTS28G/TR	0OVPTS28 XXXXX	Tape and Reel, 4000

MARKING INFORMATION

NOTE: XXXXX = Date Code, Trace Code and Vendor Code.

XXXXX
- Vendor Code
- Trace Code
- Date Code - Year

Green (RoHS & HSF): SG Micro Corp defines "Green" to mean Pb-Free (RoHS compatible) and free of halogen substances. If you have additional comments or questions, please contact your SGMICRO representative directly.

ABSOLUTE MAXIMUM RATINGS (1)

Supply Voltage....................................40V
Reverse Polarity Voltage (2)....................................-36V
Maximum Jump Start Voltage for Single Pulse Short-Circuit Protection....................................28V
GND Pin Current (3).................................... -100mA to 250mA
INx, DIAG_EN, SEL, SEH, and THER Voltage.... -0.3V to 7V
INx, DIAG_EN, SEL, SEH, and THER Current (3).....> -10mA
nSTx or nFAULT Pin Voltage.................................... -0.3V to 7V
nSTx or nFAULT Pin Current (3).................... -30mA to 10mA
CS Pin Voltage.................................... -2.7V to 7V
CS Pin Current (3)....................................30mA
CL Pin Voltage.................................... -0.3V to 7V
CL Pin Current (3)....................................6mA
Inductive Load Switch-Off Energy Dissipation, Single Pulse, Single Channel (4)....................................28mJ
Package Thermal Resistance
  TSSOP-28 (Exposed Pad), θ_{JA}.................... 25.7℃/W
  TSSOP-28 (Exposed Pad), θ_{JB}.................... 8.7℃/W
  TSSOP-28 (Exposed Pad), $\theta_{JC\ (TOP)}$.................... 17.6℃/W
  TSSOP-28 (Exposed Pad), $\theta_{JC\ (BOT)}$.................... 0.9℃/W
Package Thermal Characterization Parameter
  TSSOP-28 (Exposed Pad), ψ_{JT}.................... 0.4℃/W
  TSSOP-28 (Exposed Pad), ψ_{JB}.................... 8.3℃/W
Storage Temperature Range....................-65℃ to +150℃
Lead Temperature (Soldering, 10s)....................+260℃
ESD Susceptibility (5) (6)
HBM (All Pins except VS, OUTx, GND)....................±4000V
HBM (Pins VS, OUTx, GND)....................±5000V
CDM....................................±1000V

RECOMMENDED OPERATING CONDITIONS

Operating Supply Voltage, V_S....................4.5V to 36V
INx, DIAG_EN, SEL, SEH, and THER Voltage.........0V to 5V
nSTx and nFAULT Voltage....................0V to 5V
Nominal DC Load Current....................0A to 1.5A
Operating Ambient Temperature Range......-40℃ to +125℃
Operating Junction Temperature Range..... -40℃ to +150℃

NOTES:
1. All voltage values are with respect to the ground plane.
2. Reverse polarity test condition: t < 60s, reverse current < I_{R2}, V_{INx} = 0V, all channels reverse, GND_IC pin network used: a 1kΩ resistor in parallel with a diode to ground plane.
3. Specified by design, not subject to production test.
4. Test condition: V_S = 13.5V, L = 8mH, R = 0Ω, T_A = +125℃. FR4 2s2p board, 2 × 70μm Cu, 2 × 35μm Cu. 600mm^2 thermal pad copper area.
5. For human body model (HBM), all pins comply with AEC-Q100-002 specification.
6. For charged device model (CDM), all pins comply with AEC-Q100-011 specification.

OVERSTRESS CAUTION

Stresses beyond those listed in Absolute Maximum Ratings may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect reliability. Functional operation of the device at any conditions beyond those indicated in the Recommended Operating Conditions section is not implied.

ESD SENSITIVITY CAUTION

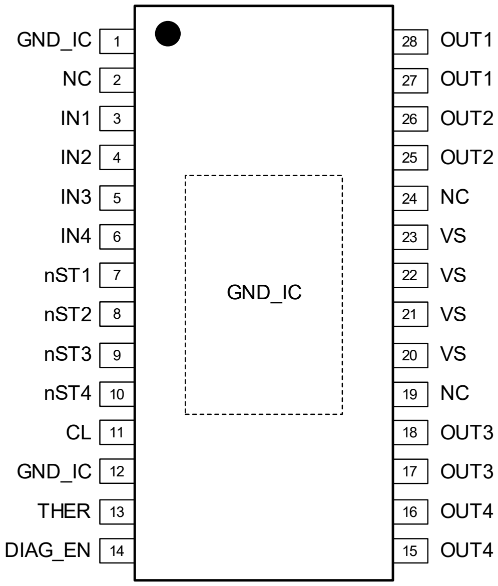
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because even small parametric changes could cause the device not to meet the published specifications.

DISCLAIMER

SG Micro Corp reserves the right to make any change in circuit design, or specifications without prior notice.

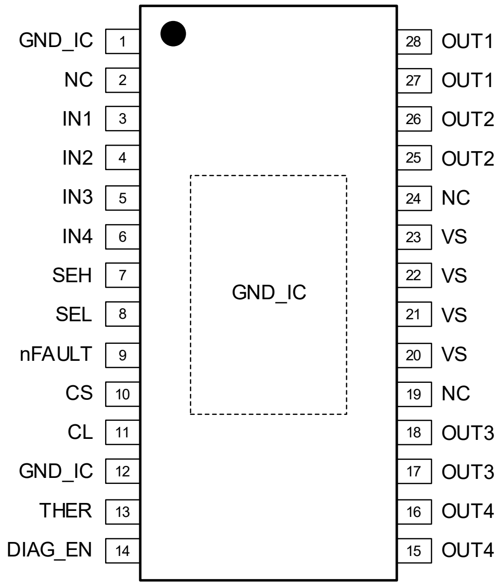
PIN CONFIGURATIONS

SGM42214AQ (TOP VIEW)



TSSOP-28 (Exposed Pad)

SGM42214BQ (TOP VIEW)



TSSOP-28 (Exposed Pad)

PIN DESCRIPTION

<table>
<tr><th colspan="3">PIN</th><th colspan="2" rowspan="2">FUNCTION</th></tr>
<tr><th>SGM42214AQ</th><th>SGM42214BQ</th><th>NAME</th></tr>
<tr><td>1, 12</td><td>1, 12</td><td>GND_IC</td><td colspan="2">Ground Return. An R-D network may be used between GND_IC and the PCB GND.</td></tr>
<tr><td>2, 19, 24</td><td>2, 19, 24</td><td>NC</td><td colspan="2">Not Connected to the Chip Internal Circuitry.</td></tr>
<tr><td>3</td><td>3</td><td>IN1</td><td colspan="2" rowspan="4">Input Turn-On/Off Control for Each Channel with Internal Pull-down.</td></tr>
<tr><td>4</td><td>4</td><td>IN2</td></tr>
<tr><td>5</td><td>5</td><td>IN3</td></tr>
<tr><td>6</td><td>6</td><td>IN4</td></tr>
<tr><td>7</td><td>-</td><td>nST1</td><td colspan="2" rowspan="4">Active-Low, Open-Drain Diagnostic Status Output for Each Channel.</td></tr>
<tr><td>8</td><td>-</td><td>nST2</td></tr>
<tr><td>9</td><td>-</td><td>nST3</td></tr>
<tr><td>10</td><td>-</td><td>nST4</td></tr>
<tr><td>-</td><td>7</td><td>SEH</td><td colspan="2">High Bit for Current Sensing Channel Selection with Internal Pull-down.</td></tr>
<tr><td>-</td><td>8</td><td>SEL</td><td colspan="2">Low Bit for Current Sensing Channel Selection with Internal Pull-down.</td></tr>
<tr><td>-</td><td>9</td><td>nFAULT</td><td colspan="2">Active-Low, Open-Drain Global Fault Output Signal. This output represents the combined fault conditions of all channels with OR logic in SGM42214BQ.</td></tr>
<tr><td>-</td><td>10</td><td>CS</td><td colspan="2">Current Sense Output.</td></tr>
<tr><td>11</td><td>11</td><td>CL</td><td colspan="2">External Current Limit Set Pin. A resistor from CL to GND_IC sets the output current limits. Short CL to GND_IC to use the fixed internal current limit setting.</td></tr>
<tr><td>13</td><td>13</td><td>THER</td><td colspan="2">Thermal Shutdown Behavior Control. High = latch-off, low = auto-retry.
It is internally pulled down that sets the default mode to auto-retry.</td></tr>
<tr><td>14</td><td>14</td><td>DIAG_EN</td><td colspan="2">Active-High Diagnostics Enable Input Pin with Internal Pull-down.</td></tr>
<tr><td>27, 28</td><td>27, 28</td><td>OUT1</td><td>Channel 1 Output.</td><td rowspan="4">The high-side power N-MOSFET source connects to the load.</td></tr>
<tr><td>25, 26</td><td>25, 26</td><td>OUT2</td><td>Channel 2 Output.</td></tr>
<tr><td>17, 18</td><td>17, 18</td><td>OUT3</td><td>Channel 3 Output.</td></tr>
<tr><td>15, 16</td><td>15, 16</td><td>OUT4</td><td>Channel 4 Output.</td></tr>
<tr><td>20, 21, 22, 23</td><td>20, 21, 22, 23</td><td>VS</td><td colspan="2">Power Supply Input (4.5V to 36V).</td></tr>
<tr><td>Exposed Pad</td><td>Exposed Pad</td><td>GND_IC</td><td colspan="2">Exposed Pad. The thermal pad can be connected to the device GND_IC or left float.</td></tr>
</table>

ELECTRICAL CHARACTERISTICS

(V_S = 5V to 36V, T_A = -40℃ to +125℃, typical values are at T_A = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage						
Operating Voltage Range	V_{S_NOM}		4.5		36	V
Under-Voltage Protection Threshold	V_{S_UVR}	V_S rising	3.1	3.7	4.4	V
	V_{S_UVF}	V_S falling	2.9	3.3	4.2	V
Under-Voltage Shutdown Hysteresis	V_{UV_HYS}			0.4		V
Operating Current						
Nominal Operating Current	I_{OP}	V_S = 13.5V, V_{INx} = 5V, V_{DIAG_EN} = 0V, I_{OUTx} = 0.5A, current limit = 2A, all channels on			6.5	mA
Standby Current	I_{OFF}	V_S = 13.5V, V_{INx} = V_{DIAG_EN} = V_{CS} = V_{CL} = V_{OUTx} = V_{THER} = 0V, T_A = +25℃			0.5	μA
		V_S = 13.5V, V_{INx} = V_{DIAG_EN} = V_{CS} = V_{CL} = V_{OUTx} = V_{THER} = 0V, T_A = +125℃			3	
Standby Current with Diagnostic Enabled	I_{OFF_DIAG}	V_S = 13.5V, V_{INx} = 0V, V_{DIAG_EN} = 5V, V_{CL} = 0V, V_S - V_{OUTx} > V_{OL_OFF}, not in open-load mode			6.5	mA
Standby Mode Deglitch Time	t_{OFF_DEG}	When INx is going from high-to-low, if deglitch time is longer than t_{OFF_DEG}, the device enters standby mode.	25		75	ms
Output Leakage Current in Off-State	I_{LKG_OUT}	V_S = 13.5V, V_{INx} = V_{DIAG_EN} = V_{OUTx} = 0V			0.5	μA
Output Leakage Current with Diagnostic Enabled	$I_{LKG\_DIAG\_OUT}$	V_S = 13.5V, V_{INx} = V_{OUTx} = 0V, V_{DIAG_EN} = 5V			10	μA
Power Stage						
On-Resistance	R_{DSON}	V_S = 13.5V, T_A = +25℃		150		mΩ
		4.5V ≤ V_S ≤ 13.5V, T_A = +125℃			300	
		13.5V ≤ V_S, T_A = +125℃			270	
Internal Current Limit	I_{CL_INT}	Normal internal value (when CL pin is grounded). V_S = 13.5V, (5V ≤ V_S ≤ 18V)	3.5	4.6	5.5	A
		Normal internal value (when CL pin is grounded). V_S = 28V, (21V ≤ V_S ≤ 36V)	1.3	2.1	2.9	
Current Limit during Thermal Shutdown	I_{CL_TSD}	During a thermal shutdown (when CL pin is grounded). V_S = 13.5V, (5V ≤ V_S ≤ 18V)	2.1	3.1	4.1	A
		During a thermal shutdown (when CL pin is grounded). V_S = 28V, (21V ≤ V_S ≤ 36V)	1.3	2.1	2.9	
		Current limit during thermal shutdown. When CL is set externally, the actual limit drops to a percentage of the normal current limit. V_S = 13.5V, (5V ≤ V_S ≤ 18V)		70		%
		Current limit during thermal shutdown. When CL is set externally, the actual limit drops to a percentage of the normal current limit. V_S = 28V, (21V ≤ V_S ≤ 36V)		100		
Drain-to-Source Internal Clamp Voltage	V_{DS_CLAMP}	I_S = 20mA	40		45	V
Output Diode Characteristics						
Drain to Source Diode Forward Voltage	V_F	V_{INx} = 0, I_{OUTx} = -0.15A	0.58	0.77	0.95	V
Continuous Reverse Current from Source to Drain [(1)]	I_{R1}, I_{R2}	t < 60s, V_{INx} = 0V, T_A = +25℃, single channel reversed, short-to-battery condition		2.5		A
		t < 60s, V_{INx} = 0V, T_A = +25℃, GND_IC connected to PCB and supply GND_IC through R-D network (Diode parallel with a 1kΩ resistor). Reverse polarity condition, all channels reversed.		2		

NOTE: 1. Specified by design, not subject to production test.

ELECTRICAL CHARACTERISTICS (continued)

(V_S = 5V to 36V, T_A = -40℃ to +125℃, typical values are at T_A = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Logic Inputs (INx, DIAG_EN, SEL, SEH, THER)						
High-Level Input Voltage	V_{IH}		2			V
Low-Level Input Voltage	V_{IL}				0.8	V
Internal Pull-Down Resistance	R_{PD}	V_{INx} = V_{SEL} = V_{SEH} = V_{THER} = 5V	105	180	285	kΩ
		V_{DIAG_EN} = 5V	170	290	450	
Diagnostics						
Output (OUTx Pins) Leakage Current	I_{LKG}	OUTx current under the loss-of-GND condition			200	μA
Open-Load Detection Threshold	V_{OL_OFF}	V_{INx} = 0V, open-load is detected in off-state when the duration of V_S - V_{OUTx} < V_{OL_OFF} status lasts longer than t_{OL_OFF} for a channel.	1.6		2.6	V
Open-Load Detection Deglitch Time	t_{OL_OFF}		300	550	800	μs
Off-State Output (OUTx) Sink Current	I_{OL_OFF}	V_{INx} = 0V, V_{DIAG_EN} = 5V, V_S = V_{OUTx} = 13.5V, open-load condition, T_A = +125℃	-75			μA
Status Low Output Voltage	V_{OL_STx}	I_{STx} = 2mA, SGM42214AQ			0.2	V
nFAULT Pin Low Output Voltage	V_{OL_FAULT}	I_{FAULT} = 2mA, SGM42214BQ			0.2	V
Deglitch Time During Current Limit	t_{CL_DEG}	V_{INx} = V_{DIAG_EN} = 5V, deglitch time from a current limit occurrence or clearance until updating nFAULT, nSTx and CS outputs.		130	220	μs
Thermal Shutdown Threshold (1)	T_{SD}			158		℃
Thermal Shutdown Status Reset Threshold (1)	T_{SD_RST}			125		℃
Thermal Swing Shutdown Threshold (1)	T_{SW}	Magnitude of the switch T_J jump (difference to the logic circuit T_{LOGIC} temperature) that is typically due to current limit, to trigger thermal swing.		30		℃
Hysteresis for Thermal Shutdown or Thermal Swing (1) Reset	T_{HYS}	Magnitude of the switch T_J drop to recover from thermal swing or thermal shutdown.		10		℃
Current Sense (SGM42214BQ)						
Current Sense Ratio and Accuracy 100 × (I_{CS} × K_{CS} - I_{OUT})/I_{OUT}	K_{CS}	1/K_{CS} is the ratio of the CS pin current mirror to the selected channel output current. V_{CS} = I_{OUTx} × (R_{CS}/K_{CS}); V_S = 13.5V, I_{OUTx} ≥ 25mA	290	330	430	A/A
		V_S = 13.5V, I_{OUTx} ≥ 50mA	300	330	385	
		V_S = 13.5V, I_{OUTx} ≥ 0.1A	305	330	365	
		V_S = 13.5V, I_{OUTx} ≥ 0.5A	310	330	355	
Current Sense Voltage Linear Range	V_{CS_LIN}	V_S ≥ 6.5V	0		4	V
		V_S = 5V	0		V_S - 2.5	
Output Current Linear Range	I_{OUTx_LIN}	V_S ≥ 21V, V_{CS_LIN} ≤ 4V	0		1.9	A
		6.5V ≤ V_S < 18V, V_{CS_LIN} ≤ 4V	0		2.5	
		V_S = 5V, V_{CS_LIN} ≤ V_S - 2.5V	0		2.5	
CS Pin Output Voltage	V_{CS_H}	V_S ≥ 7V, R_{CS} = 2.4kΩ, fault mode	4.5		6.5	V
		5V ≤ V_S < 7V, R_{CS} = 2.4kΩ, fault mode	MIN(V_S - 2, 4.5)		6.5	V
CS Pin Output Current	I_{CS_H}	V_{CS} = 0V, V_S = 13.5V	15			mA
CS Pin Leakage Current in Disabled State	I_{LKG_CS}	V_{DIAG_EN} = 0V, T_A = +125℃			0.5	μA

NOTE: 1. Specified by design, not subject to production test.

ELECTRICAL CHARACTERISTICS (continued)

(V_S = 5V to 36V, T_A = -40℃ to +125℃, typical values are at T_A = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Current Limit							
Over-Voltage Protection Threshold	V_{S_OVP}	Voltage threshold for current limit foldback		18		21	V
Current Limit Ratio and Accuracy, 100 × (I_{OUTx} - I_{CL} × K_{CL})/(I_{CL} × K_{CL}) (1) (2)	K_{CL}	Ratio of the output current limits to the threshold current set in the CL pin (I_{CL} flows in the R_{CL} external resistor). Limiting occurs when V_{CL} reaches V_{CL_TH} threshold. I_{LIMIT} = K_{CL} × (V_{CL_TH}/R_{CL}), T_A = +25℃	V_S = 13.5V, 1A ≤ I_{LIMIT} < 2A	1290	2350	3010	A/A
			V_S = 13.5V, 2A ≤ I_{LIMIT} < 4.2A	1680	2350	2815	
			V_S = 13.5V, 4.2A ≤ I_{LIMIT}	2040	2350	2660	
			V_S = 28V, 1A ≤ I_{LIMIT} < 1.9A	1290	2350	3010	
			V_S = 28V, 1.9A ≤ I_{LIMIT}	1680	2350	2815	
Current Limit Internal Threshold	V_{CL_TH}	Voltage threshold for current limit	V_S = 13.5V, (5V ≤ V_S ≤ 18V)		0.8		V
			V_S = 28V, (21V ≤ V_S ≤ 36V)		0.4		
Switching Characteristics							
Turn-On Delay Time	t_{D_ON}	V_S = 13.5V, V_{DIAG_EN} = 5V, I_{OUTx} = 0.5A, delay is from INx rising edge to V_{OUTx} reaching 10%.		30	50	65	μs
Turn-Off Delay Time	t_{D_OFF}	V_S = 13.5V, V_{DIAG_EN} = 5V, I_{OUTx} = 0.5A, delay is from INx falling edge to V_{OUTx} reaching 90%.		30	45	65	μs
Turn-On Slew Rate	dV_{OUT}/dt_{ON}	V_S = 13.5V, V_{DIAG_EN} = 5V, I_{OUTx} = 0.5A, V_{OUTx} is from 10% to 90%.		0.18	0.35	0.56	V/μs
Turn-Off Slew Rate	dV_{OUT}/dt_{OFF}	V_S = 13.5V, V_{DIAG_EN} = 5V, I_{OUTx} = 0.5A, V_{OUTx} is from 90% to 10%.		0.18	0.3	0.56	V/μs
t_{D_RISE} - t_{D_FALL}	t_{D_MATCH}	V_S = 13.5V, I_L = 0.5A. t_{D_RISE} is from the INx rising edge to 90% of V_{OUTx}. t_{D_FALL} is from the INx falling edge to 10% of V_{OUTx}. It is 0 if rise and fall delays are match.		-30		30	μs
Current Sense Characteristics							
CS Response (Settle) Time to DIAG_EN Disabled	t_{CS_OFF1}	V_S = 13.5V, V_{INx} = 5V, I_{OUTx} = 0.5A, current limit is 2A. From DIAG_EN falling edge to V_{CS} reaching 10%.				20	μs
CS Response (Settle) Time to DIAG_EN Enabled	t_{CS_ON1}	V_S = 13.5V, V_{INx} = 5V, I_{OUTx} = 0.5A, current limit is 2A. From DIAG_EN rising edge to V_{CS} reaching 90%.				20	μs
CS Response (Settle) Time to INx Falling	t_{CS_OFF2}	V_S = 13.5V, V_{DIAG_EN} = 5V, I_{OUTx} = 0.5A, current limit = 2A. From INx falling edge to V_{CS} reaching 10%.				20	μs
CS Response (Settle) Time to INx Rising	t_{CS_ON2}	V_S = 13.5V, V_{DIAG_EN} = 5V, I_{OUTx} = 0.5A, current limit = 2A. From INx rising edge V_{CS} reaching 90%.		80		200	μs
Multi-Sense Transition Delay from Channel to Channel (CS Voltage Settling Time after Changing Channel)	t_{SEx}	V_S = 13.5V, V_{DIAG_EN} = 5V, current sense output delay when sensed channel is modified by changing the multi-sense pins, SEL and SEH, (transition to another channel).				20	μs

NOTES:
1. The external current limit accuracy is only used for overload conditions greater than 1.5 times the current limit setting.
2. When the current limit function is used, the resistance between CL and GND_IC should be greater than 500Ω.

TIMING DIAGRAMS

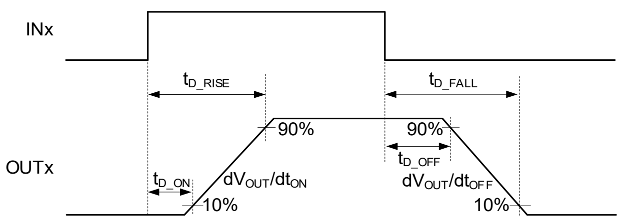


Figure 2. Timing Parameters

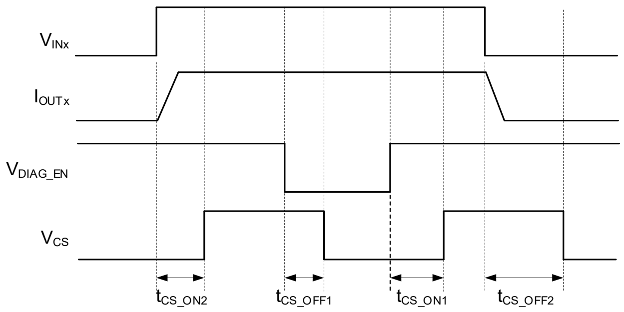


Figure 3. Current Sense Delay Time

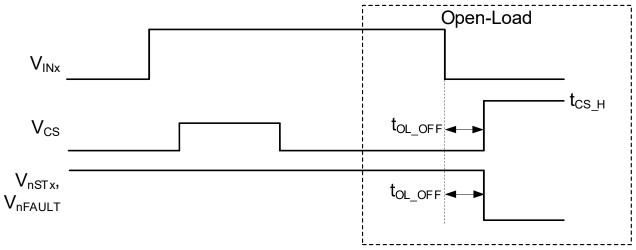


Figure 4. Open-Load Fault Detection Blanking-Time (Deglitch)

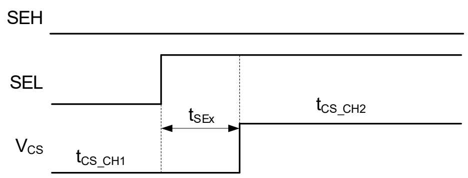
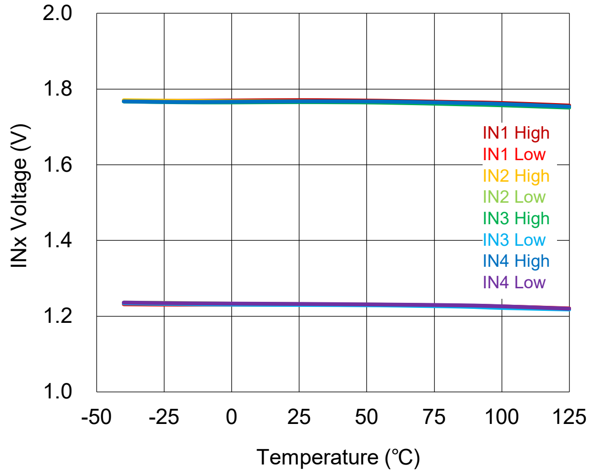


Figure 5. Multi-Sense (Sense Channel Multiplexing) Transition Delay

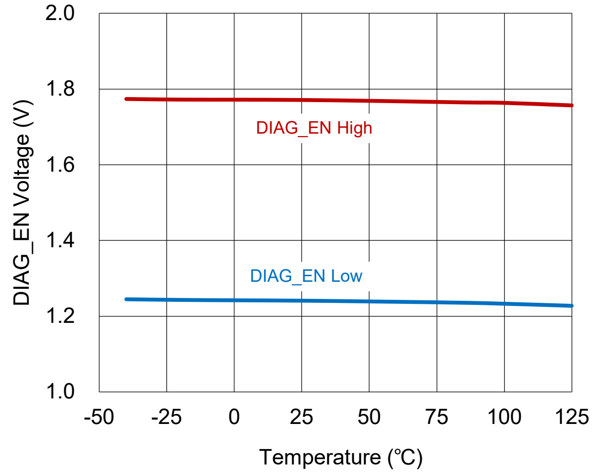
TYPICAL PERFORMANCE CHARACTERISTICS

T_A = +25℃, unless otherwise noted.

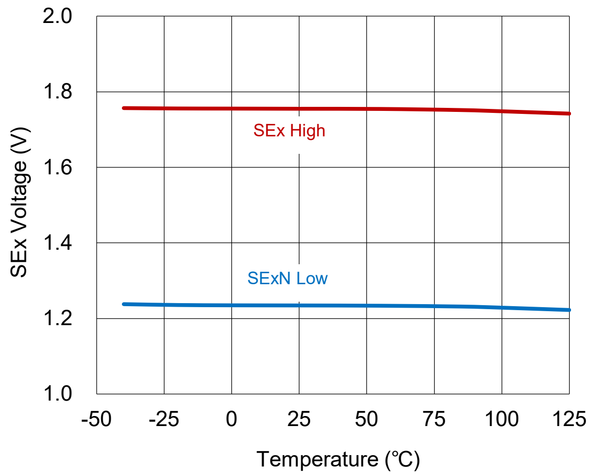
INx Voltage Threshold vs. Temperature



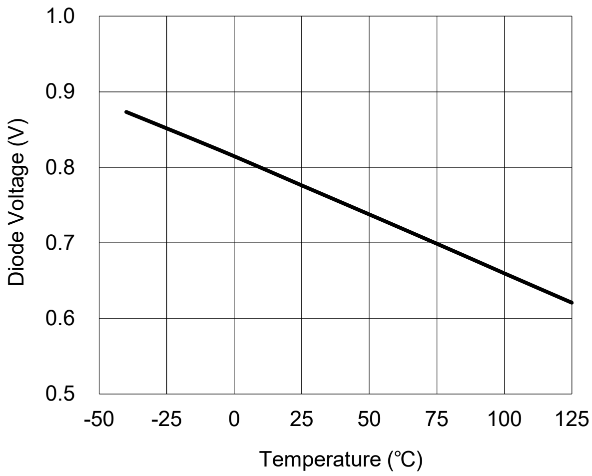
DIAG_EN Voltage Threshold vs. Temperature



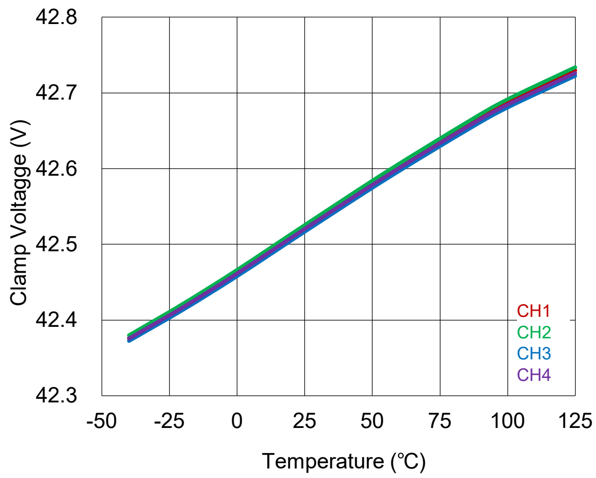
SEx Voltage Threshold vs. Temperature



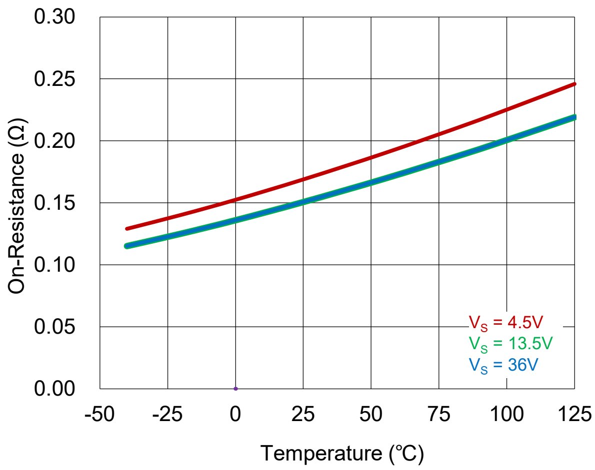
Body Diode Forward Voltage vs. Temperature



Drain-to-Source Clamp Voltage vs. Temperature



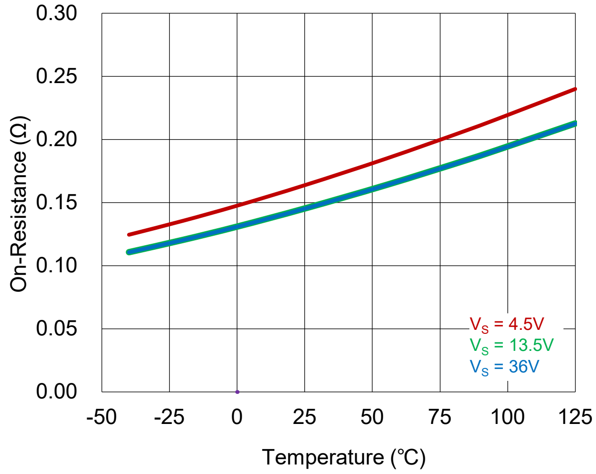
CH1 FET On-Resistance vs. Temperature



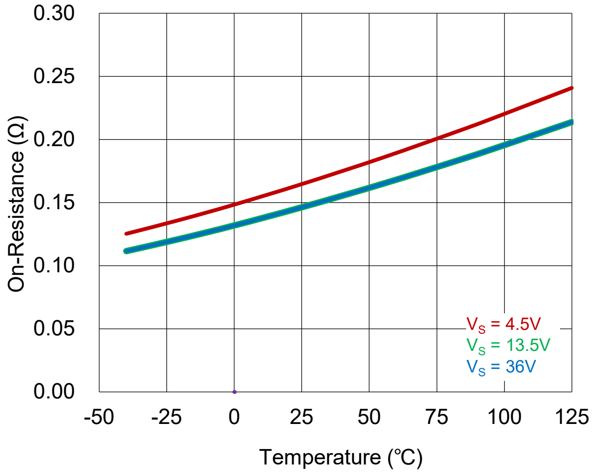
TYPICAL PERFORMANCE CHARACTERISTICS

T_A = +25℃, unless otherwise noted.

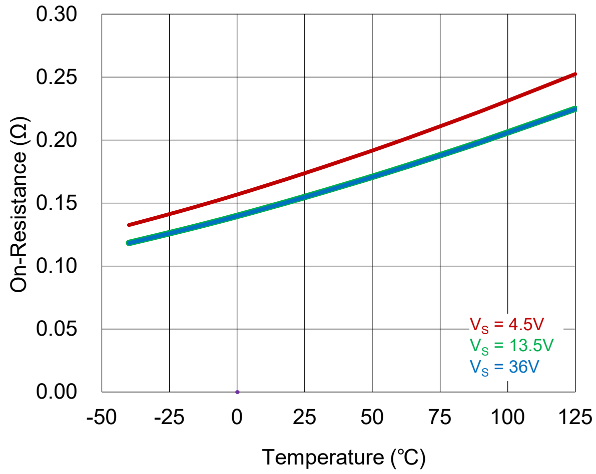
CH2 FET On-Resistance vs. Temperature



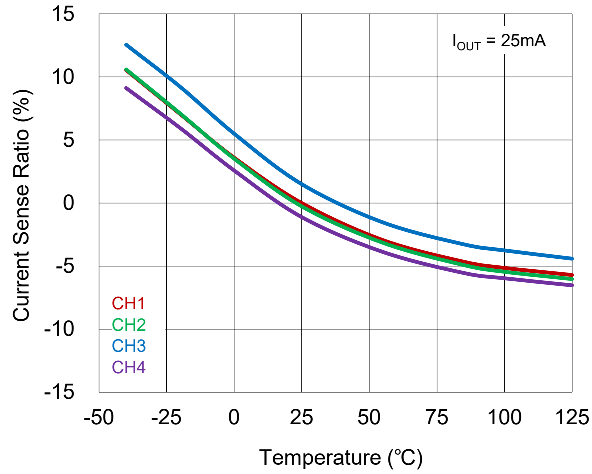
CH3 FET On-Resistance vs. Temperature



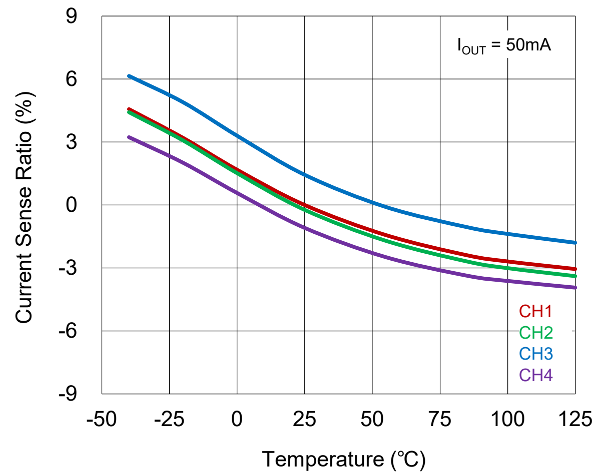
CH4 FET On-Resistance vs. Temperature



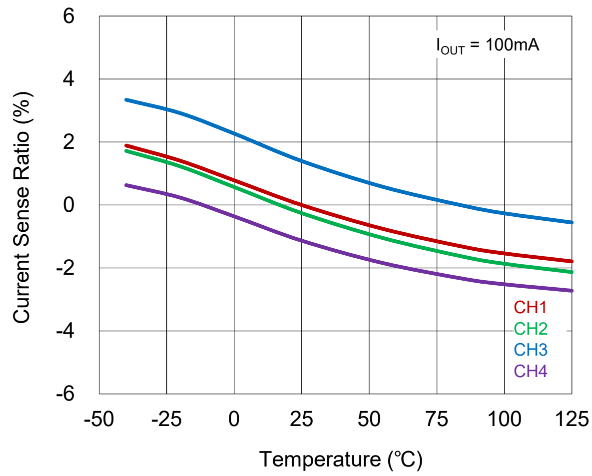
Current Sense Ratio vs. Temperature



Current Sense Ratio vs. Temperature



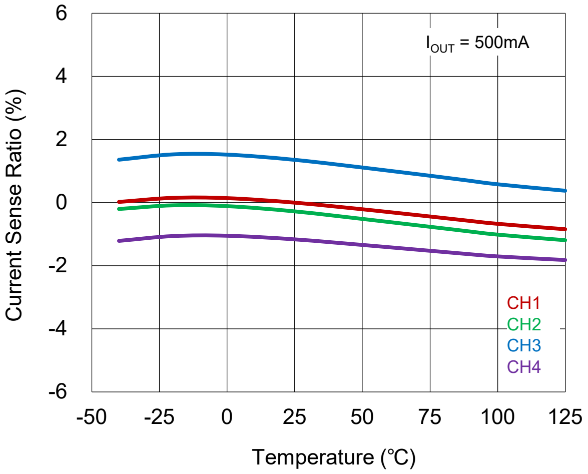
Current Sense Ratio vs. Temperature



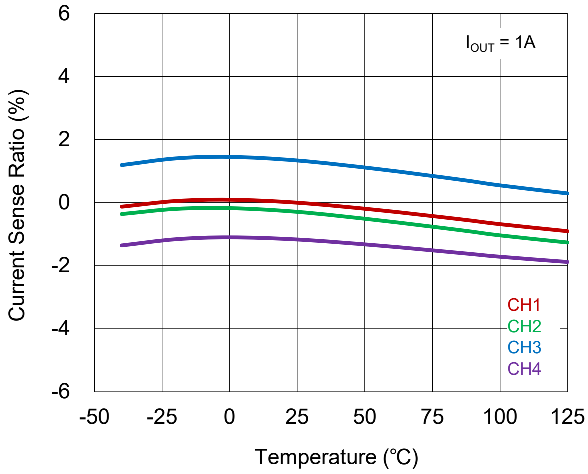
TYPICAL PERFORMANCE CHARACTERISTICS

T_A = +25℃, unless otherwise noted.

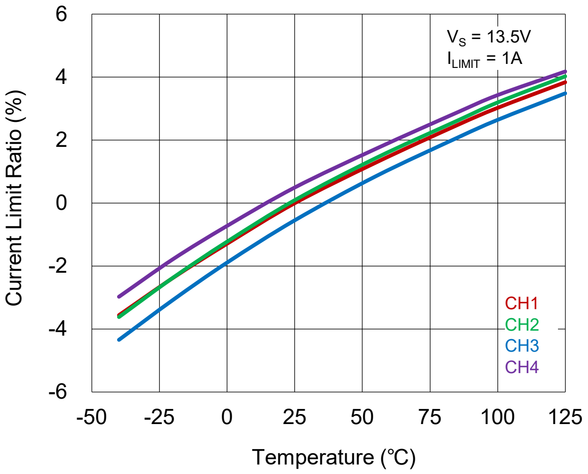
Current Sense Ratio vs. Temperature



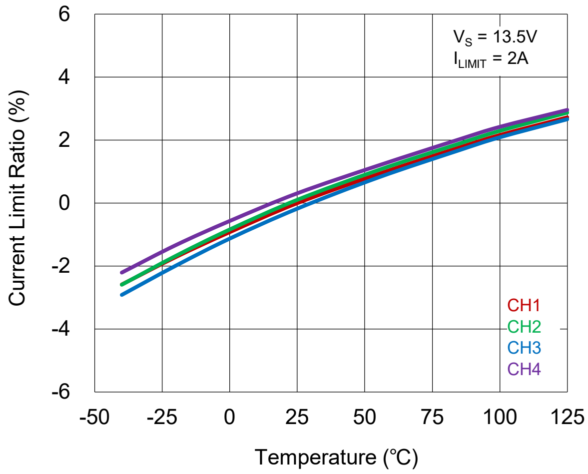
Current Sense Ratio vs. Temperature



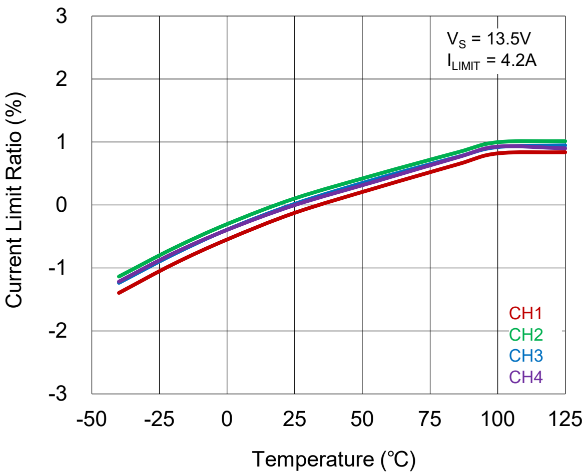
Current Limit Ratio vs. Temperature



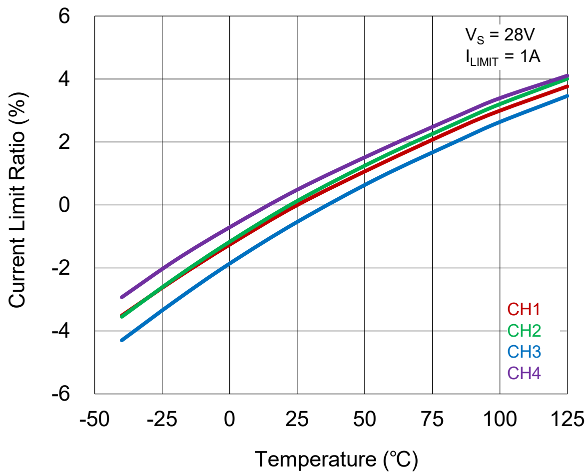
Current Limit Ratio vs. Temperature



Current Limit Ratio vs. Temperature

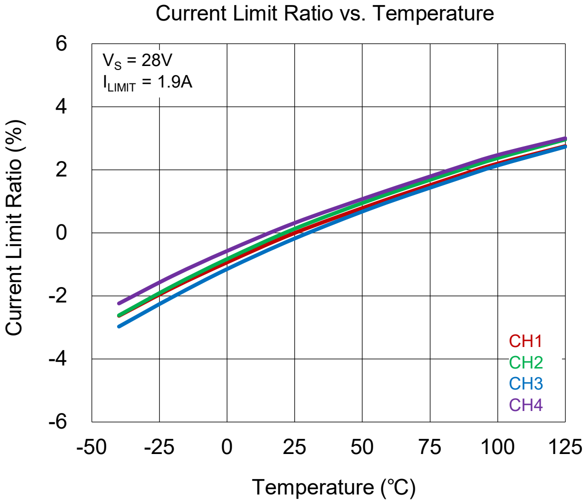


Current Limit Ratio vs. Temperature

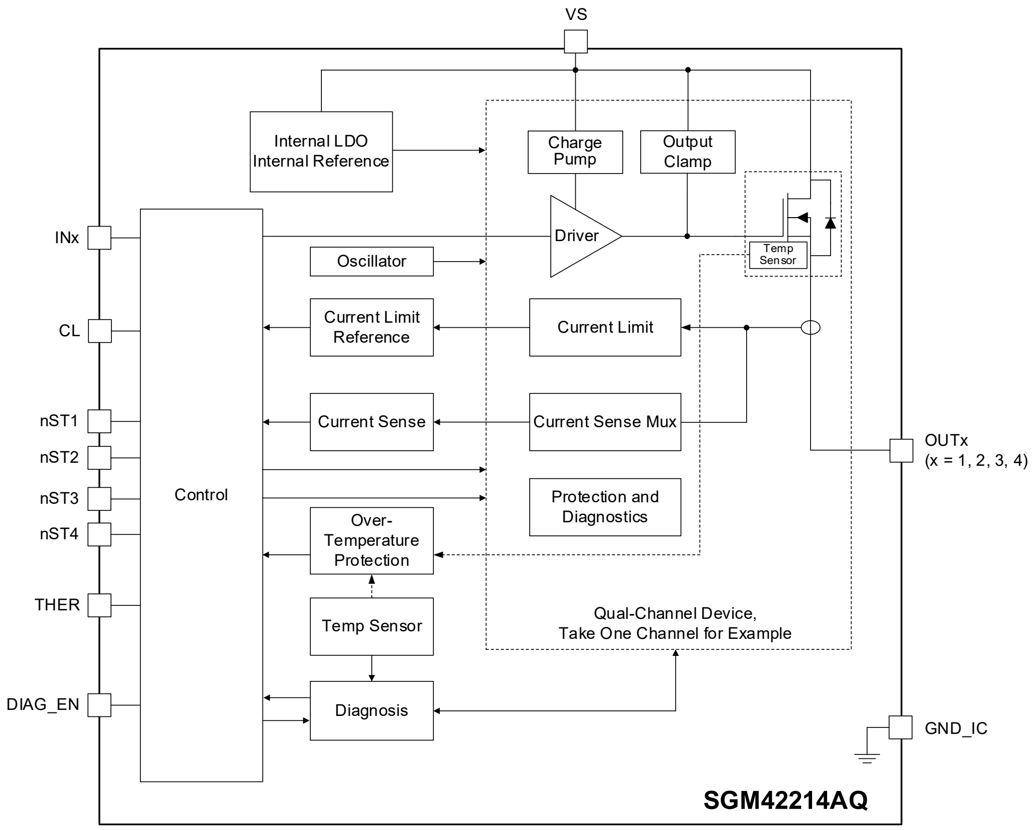


TYPICAL PERFORMANCE CHARACTERISTICS

T_A = +25℃, unless otherwise noted.



FUNCTIONAL BLOCK DIAGRAMS



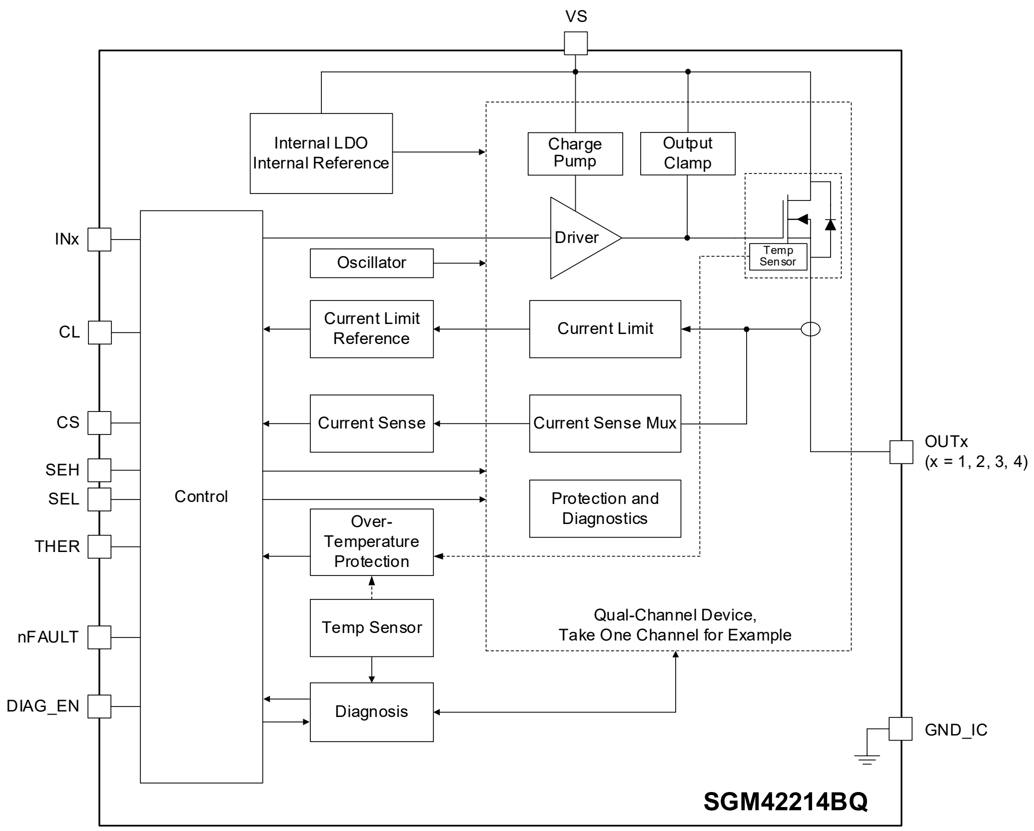


Figure 6. Block Diagrams

DETAILED DESCRIPTION

The SGM42214xQ is a smart four-channel high-side switch with internal charge pump. The switches are N-type power MOSFETs and can drive resistive, inductive, and capacitive loads like low-wattage bulbs, LEDs, relays, solenoids, valves, heaters, and sub-modules.

Smart load control is achieved with a comprehensive set of diagnostic features and accurate current sensing. System reliability is also significantly improved thanks to the device adjustable current limit. The SGM42214xQ is offered in two versions. SGM42214AQ provides individual open-drain diagnostic reporting digital outputs (nSTx) for each channel, while SGM42214BQ offers an analog output for the sensed current (CS) that can be multiplexed among channels.

In SGM42214AQ, when a fault occurs in channel x, the nSTx is pulled down to GND_IC. The nSTx pins must be externally pulled up to 3.3V or 5V whichever matches the microcontroller (MCU) voltage. Some or all nSTx outputs can be tied together as a global status output.

The SGM42214BQ has precise current sensing that provides more accurate diagnostics with no additional calibration. An internal current mirror sources $1/K_{CS}$ of the selected channel load current through the CS output. A resistor from CS to GND_IC converts that to the current sense voltage on the CS pin. K_{CS} is fixed and does not change with temperature and supply voltage variations. This voltage has a linear ratio with the load current over a wide (0V to 4V) range. This is a desired feature for accurate real-time load current monitoring. The CS is also a report pin and if a fault occurs, it will be pulled up to V_{CS_H} voltage that is sufficiently above the linear range. These faults include current limit or overheat in on-state, and open-load, short-to-battery or reverse polarity in off-state.

Output current limit can be fixed to an internal value or set accurately using an external resistor connected to the CL pin. An adjustable current limit improves reliability of the system during over-current events by clamping the inrush current to the preferred safe levels. It also helps cost reduction by keeping the PCB and connector current ratings low and close to the nominal system ratings and power capacity.

An internal active clamp mechanism between each drain and source protects the switches against over-voltage caused by inductive load switching. The over-voltage occurs when an inductive load is turned off. The clamp allows safe levels of negative output voltage for quick discharge of the inductor magnetic energy. The switching off slew rate is also optimized while the clamp is active to reduce EMI and following transients.

Device Pins Polarity Definitions

Figure 7 shows the current direction and voltage polarity conventions for each individual pin of the device in this document. The arrows show positive pin current. All pin voltages except CL are referred to the ground plane that can be different from GND_IC pin. CL pin is referred to GND_IC.

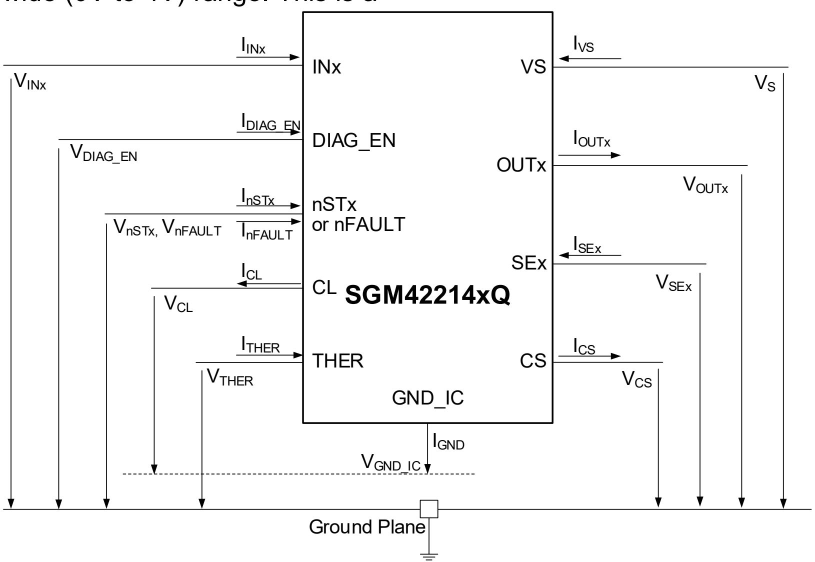


Figure 7. Typical Application Diagram
Polarity Definitions for Voltages and Currents

DETAILED DESCRIPTION (continued)

Accurate Current Sensing (SGM42214BQ)

The SGM42214BQ accurate current sensing offers better real-time monitoring and diagnostics without additional calibration (Figure 8).

One channel is selected for current sensing using SEL and SEH inputs. A current mirror sources $1/K_{CS}$ of the load current in the CS pin to create a voltage signal over the R_{CS} external resistor. K_{CS} is fixed and remains constant with the temperature and supply voltage variations. No post-calibration is required.

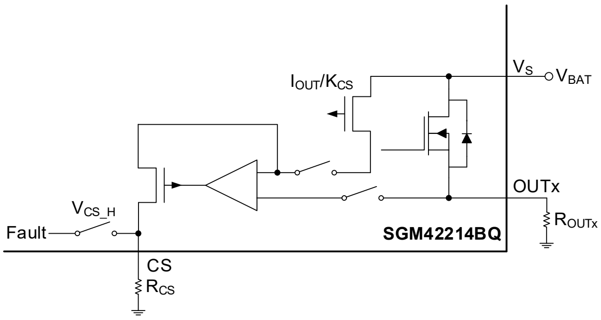


Figure 8. Load Current Sensing (SGM42214BQ)

The CS pin also acts as a fault report pin. When a fault occurs it is internally pull-up to V_{CS_H} voltage that is above the linear range of the V_{CS} (Figure 9).

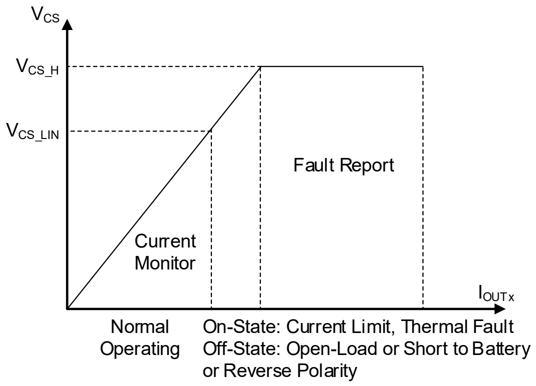


Figure 9. CS Voltage vs. Load Current and Faults

To set the ratio of current sense voltage (V_{CS}) to I_{OUT}, the required R_{CS} resistance can be calculated from Equation 1:

$$R_{CS} = \frac{V_{CS}}{I_{CS}} = \frac{V_{CS} \times K_{CS}}{I_{OUTx}} \quad (1)$$

Consider the following conditions for selecting R_{CS}:
1) Choose R_{CS} small enough to keep V_{CS} in the linear region (LIN), over the full load range Equation 2:

$$R_{CS} = \frac{V_{CS}}{I_{CS}} \leq \frac{V_{CS\_LIN}}{I_{CS}} \quad (2)$$

2) Choose R_{CS} large enough to keep the I_{CS} within the capacity of the CS pin ($I_{CS} < I_{CS\_H}$) in fault states Equation 3:

$$R_{CS} = \frac{V_{CS}}{I_{CS}} \geq \frac{V_{CS\_H\_MIN}}{I_{CS\_H\_MIN}} \quad (3)$$

Current Limit

System reliability improves with a more accurate current limit as it allows better over-current protection for the system, power supply and load during power-up or a short-to-GND fault.

When a channel current exceeds the limit, the load current is immediately clamped at the CL set value through a control loop, and a fault signal is asserted. Usually, the switch temperature rises due to the increased MOSFET loss during current limit. To reduce overheating in such conditions, if the thermal shutdown threshold is reached, the current limit is reduced to a lower level (I_{CL_TSD}) to decrease switch loss (See Figure 10).

There are two options to set the current limit threshold:

- Fixed internal limit: The I_{CL_INT} internal current limit is selected by tying the CL and GND_IC pins. This option is used for applications with large transient currents. For details, please see the electrical characteristics on page 3.
- Externally adjustable limit: This option allows design flexibility and is set with the resistor R_{CL} between CL and GND_IC pins based on Equation 4. K_{CL} is the ratio of the output current to the CL pin current (I_{CL}). V_{CL_TH} is related to V_S voltage, when V_S < 18V, V_{CL_TH} is 0.8V and if V_S > 21V, it is 0.4V.

$$I_{CL} = \frac{V_{CL\_TH}}{R_{CL}} = \frac{I_{OUT}}{K_{CL}} \qquad R_{CL} = \frac{V_{CL\_TH} \times K_{CL}}{I_{OUT}} \quad (4)$$

If a GND network with level shifts between GND_IC pin and board GND is used, the CL pin must be connected to the GND_IC pin.

DETAILED DESCRIPTION (continued)

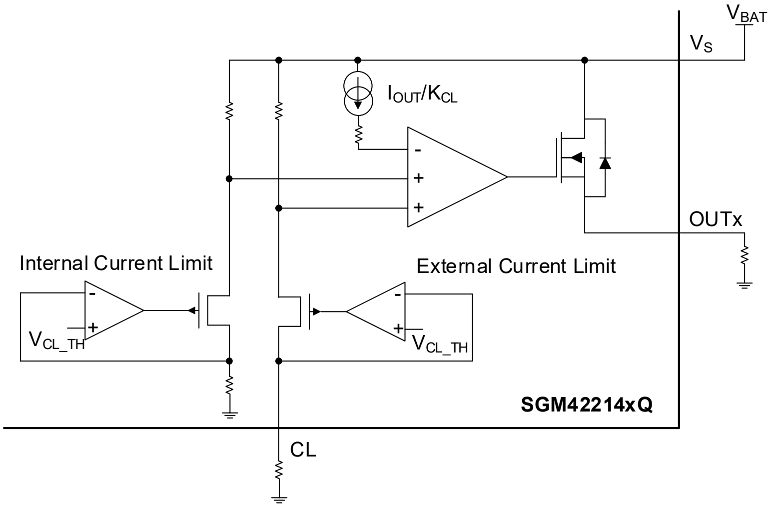


Figure 10. Current Limit Circuit Block Diagram

A hard short-to-GND fault, for example, when IN = high and a sudden short-to-GND occurs, can rapidly increase the switch current before the relatively slow current limit loop reacts. To improve hard short-to-GND protection, a secondary fast-trip protection circuit is implemented to turn off the channel while the current limit loop is initiating. The response time of the fast-trip is below 1μs typically and improves the inrush current attenuation as well.

Inductive Load Switch-Off Clamp

When an inductive load is turned off, the stored magnetic energy of the inductor tends to keep the inductor current flowing. This induces a large voltage across drain-source because switch resistance is increasing during turn-off and results in a negative output voltage. If the negative voltage is too large, it can break down and damage the MOSFET. An internal clamp is activated across the switch to limit the voltage to V_{DS_CLAMP} (45V) and circulate and damp the current until inductor stored energy is dissipated. The V_{DS} clamp results in a negative load voltage (see Figure 11 and Figure 12).

$$V_{DS\_CLAMP} = V_S - V_{OUT} \tag{5}$$

During demagnetization (t_{DECAY}), the high-side MOSFET is kept on in active region (but not saturated) to dissipate the magnetic energy. In the clamping period, the total energy dissipated in the high-side switch (E_{HSS}), includes the inductor energy (E_L), and the energy coming from the power supply (E_{VS}), but a portion of the load energy is dissipated in its own series resistance, E_R (that is $E_{LOAD} = E_L - E_R$), so:

$$E_{HSS} = E_{VS} + E_L - E_R \tag{6}$$

E_{HSS} causes thermal stress on the switch and the whole device during turn-off. The maximum power that the device can dissipate depends on its thermal capacity, ambient temperature, and PCB heat sinking capability. E_{HSS} can be calculated from Equation 7:

$$E_{HSS} = \int_0^{t_{DECAY}} V_{DS\_CLAMP} \times I_{OUT}(t)dt$$

where,

$$t_{DELAY} = \frac{L}{R} \times \ln\left(\frac{R \times I_{OUT} + |V_{OUT}|}{|V_{OUT}|}\right)$$

So

$$E_{HSS} = L \times \frac{V_S + V_{OUT}}{R^2} \times \left[R \times I_{OUT} - |V_{OUT}| \ln\left(\frac{R \times I_{OUT} + |V_{OUT}|}{|V_{OUT}|}\right)\right] \tag{7}$$

When R is insignificant ($R \approx 0$), E_{HSS} simplifies as:

$$E_{HSS} = \frac{1}{2} \times L \times {I_{OUT}}^2 \frac{V_S + |V_{OUT}|}{|V_{OUT}|} \tag{8}$$

Figure 13 and Figure 14 show the V_{IN}, V_S, V_{OUT} and I_{OUT} waveforms for an inductive load with two different time scales along with the calculated power dissipation (E_{HSS}) waveform.

The switch-off slew-rate is optimized during the clamping. As shown in Figure 13 and Figure 14, the controlled slew rate is around 0.65V/μs and the V_{OUT} total fall time from V_S to ($V_S - V_{DS\_CLAMP}$) is slowed down to about 70μs.

DETAILED DESCRIPTION (continued)

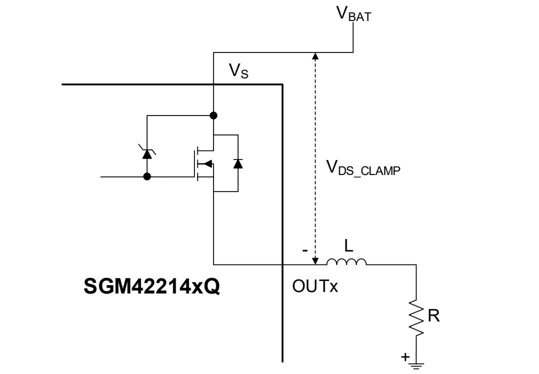


Figure 11. Drain-to-Source Clamping to V_{DS_CLAMP}

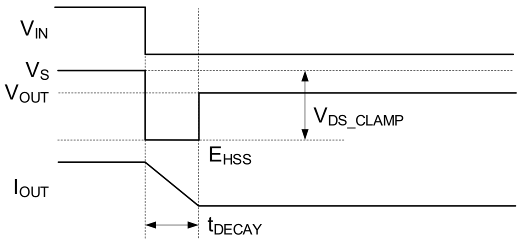
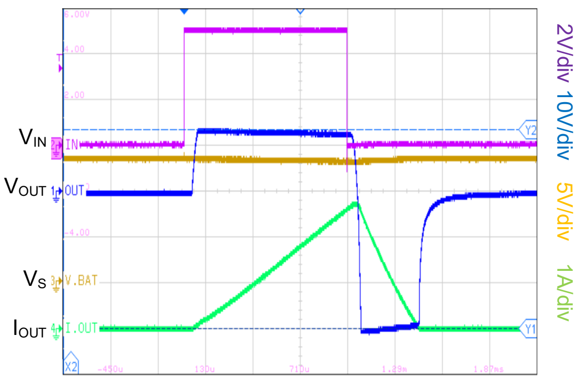
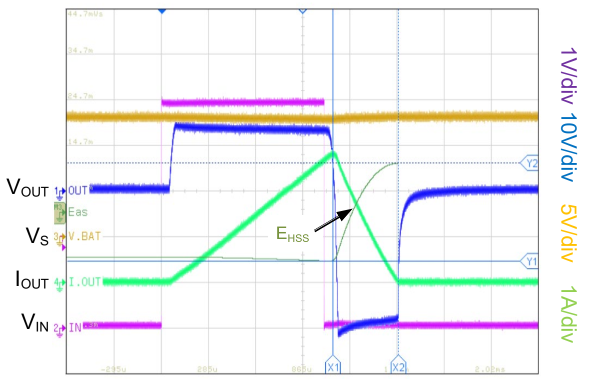


Figure 12. Inductive Load Switch-Off and Clamping



Time (290μs/div)

Figure 13. Inductive Load Switch-Off Waveforms



Time (290μs/div)

Figure 14. Inductive Load Switch-Off Expanded Waveforms along with Switch Loss E_{HSS}

If PWM control is used to drive an inductive load, the output should be protected from repetitive stress. So, it is recommended to add an external freewheeling circuit with TVS and freewheeling diodes as shown in Figure 15. The TVS diode provides fast magnetic energy decay by allowing a large voltage across inductor during demagnetization, TVS breakdown voltage less than internal clamp V_{DS_CLAMP}.

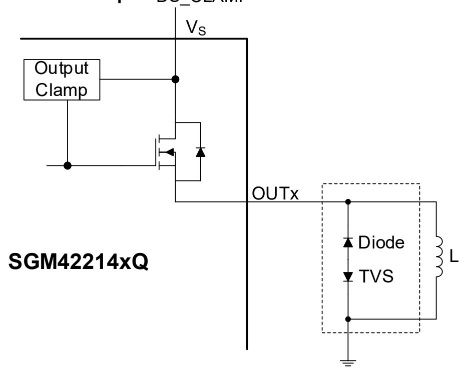


Figure 15. Output Protection with External Freewheeling for PWM Driven Inductive Loads

Status Detection and Fault Reporting

Diagnostic Enable

Diagnostic functions can be enabled or disabled with the DIAG_EN pin. When multiple devices are connected to a microcontroller (MCU) with limited number of ADC channels, some GPIO lines of the MCU can be connected to DIAG_EN pins to enable only one of them each time, or to save power by setting the DIAG_EN and IN inputs of the inactive devices low to disable them.

Current Sense Multiplexing among Channels

The current sense circuitry in the SGM42214BQ is shared among the 4 channels. The SEL and SEH inputs are used to select (multiplex) the channel as explained in Table 1. Table 2 provides the details of faults and protection functions when the DIAG_EN pin is enabled.

DETAILED DESCRIPTION (continued)

Table 1. DIAG_EN Diagnostics Configurations

DIAG_EN	INx	SEH	SEL	CS Activated Channel	CS, nFAULT, nSTx	Protections and Diagnostics
L	H	-	-	-	Hi-Z	Diagnostics disabled, full protection
	L					Diagnostics disabled, no protection
H	-	0	0	Channel 1	See Table 2	See Table 2
		0	1	Channel 2		
		1	0	Channel 3		
		1	1	Channel 4		

Table 2. Fault Detection and Reporting for the Selected Channel (When DIAG_EN = High)

Conditions	INx	OUTx	THER	Criterion	nSTx (SGM42214AQ)	CS (SGM42214BQ)	nFAULT (SGM42214BQ)	Fault Recovery (After fault is cleared)
Normal	L	L	-	-	H	$V_{CS} \approx 0$	H	-
	H	H	-	-	H	V_{CS} in linear region	H	-
Overload, Short to Ground	H	L	-	Current limit triggered	L	V_{CS_H}	L	Auto
Open-Load [1], Short to Battery, Reverse Polarity	L	H	-	$V_S - V_{OUTx} < V_{OL\_OFF}$	L	V_{CS_H}	L	Auto
Thermal Shutdown	H	-	L	T_{SD} triggered	L	V_{CS_H}	L	Output auto-retry. Output is recovered when $T_J < T_{SD\_RST}$ or when INx toggles.
			H					Output latches off. Output recovers when INx toggles.
Thermal Swing	H	-	-	T_{SW} triggered	L	V_{CS_H}	L	Auto

NOTE: 1. An external pull-up is required for open-load detection.

nSTx and nFAULT Outputs

SGM42214AQ has four individual status outputs (nSTx pins) that report fault conditions of the corresponding channel. In SGM42214BQ, one global nFAULT pin reports the faults for all channels. All these output pins are open-drain and need external pull-up to a 3.3V or 5V rail (match with the MCU supply). They are pulled down when a fault occurs. For SGM42214AQ, some or all nSTx pins can be tied together if a common fault output is preferred.

In SGM42214BQ, the microcontroller can identify the channel causing fault by multiplexing the current sense circuit among them. The CS pin itself also reports faults and is internally pulled up to V_{CS_H} upon detecting a fault condition.

Detected Fault Conditions

Short-to-GND and Overload Detection

While an output is on, an over-current caused by overload or short-to-GND can exceed the internal or external current limit threshold and trigger a fault. The MCU can respond by turning off the channel in fault condition. But with no reaction from MCU, the device may overheat and end up in a thermal shutdown. In such condition, the current limit drops to I_{CL_TSD} to reduce stress on the switch. Normal operation will recover automatically when the fault condition is cleared.

Open-Load Fault Detection with Channel On

While a channel is on, the accurate current sensing can be used to detect open-load condition. It is detected by a very small V_{CS} value. This fault is not reported by nSTx or nFAULT and the MCU must actively multiplex the SEL and SEH to detect the on channels with open-load condition.

Open-Load Fault Detection with Channel Off

When an output is off and load is connected, normally the output voltage will be low or near zero, but if the load is open, V_{OUT} will be close to zero. So, to improve the open-load detection, it is recommended to use an external pull-up resistor (R_{PU}) around 20kΩ to offset that leakage current as shown in Figure 16.

DETAILED DESCRIPTION (continued)

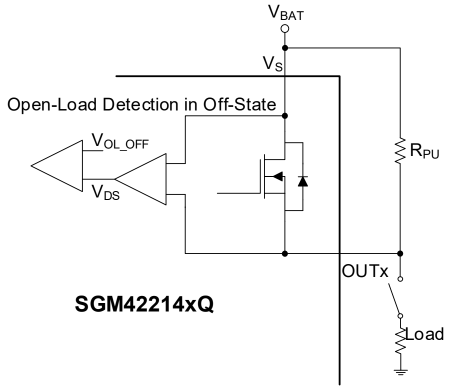


Figure 16. Off-State Open-Load Detection

Reverse Polarity Fault

If an energized load pushes current back to the output, the fault is called a reverse polarity fault. It is also detected the same as an open-load fault in on-state or off-state (see Table 2). Like a short-to-battery, an off-state reverse polarity fault is worse. The current in the MOSFET must be limited to I_{R2}. To minimize losses, MCU can set the IN input to high.

Thermal Fault Detection

Two types of overheating prevention mechanisms are implemented to protect the device against overheating damage. The absolute temperature protection acts similar to the conventional thermal shutdown while the thermal swing provides a dynamic temperature protection. Thermal sensors are integrated close to each MOSFET, so each channel can report overheating individually. This will minimize the cross-channel effect when some channels are in a thermal fault condition.

Thermal Shutdown

If a channel junction temperature exceeds the absolute shutdown threshold ($T_J > T_{SD}$), a thermal shutdown will occur on that channel and the respective output turns off. The recovery mode is selected by the THER pin.

If THER = low, the channel will recover automatically when T_J sufficiently drops ($T_J < T_{SD} - T_{HYS}$), but the current limit reduces to I_{CL_TSD} to avoid cyclic thermal shutdown. The current limit resets to normal value only when $T_J < T_{SD\_RST}$, or after toggling the channel INx pin.

If THER = high, the channel will latch in off-state until toggling the respective INx input or if the THER pin goes low and thermal protection changes to auto-retry mode.

Thermal swing protection is activated when a sharp jump in MOSFET temperature is detected and results in output turn-off (see Figure 18). It is detected when $\Delta T = T_{FET} - T_{LOGIC}$) exceeds the T_{SW} threshold. T_{LOGIC} is the sensed temperature of the logic circuitry. When ΔT is reduced below $T_{SW} - T_{HYS}$, the output recovers and if there is no other fault (like CL), the fault signal will be cleared automatically. The thermal swing improves reliability especially when the device operates under repetitive and fast thermal variations. Figure 18 shows how multiple thermal swings may be triggered before a thermal shutdown occurs.

Under-Voltage Lockout (UVLO) Protection

The supply voltage is continuously monitored and if it is too low ($V_S < V_{S\_UVF}$), the device is shut down to prevent unexpected behaviors. It will turn on when V_S exceeds the V_{S_UVR} threshold.

Loss-of-GND Protection

The SGM42214xQ is protected against two types of ground loss conditions: loss of device GND_IC and loss of load module GND. Upon a load GND or device GND_IC disconnection, the outputs will shut down regardless of the INx input.

Loss-of-Power Protection

If the power on the supply pin is lost, the outputs will shut down regardless of the INx inputs. Supply loss is not a risk for resistive or capacitive loads. But in case of an energized inductive load, the inductive current tries to continue flowing through other paths like other device pins after supply removal. To protect the system in such situation, it is recommended to either use an R-D GND network (Figure 17), or an external free-wheeling diode parallel to the load (Figure 19).

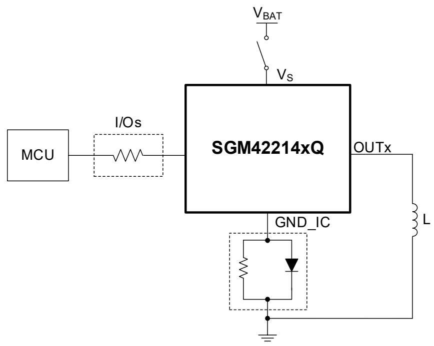


Figure 17. Loss of Power Protection Method 1 (R-D GND Network)

DETAILED DESCRIPTION (continued)

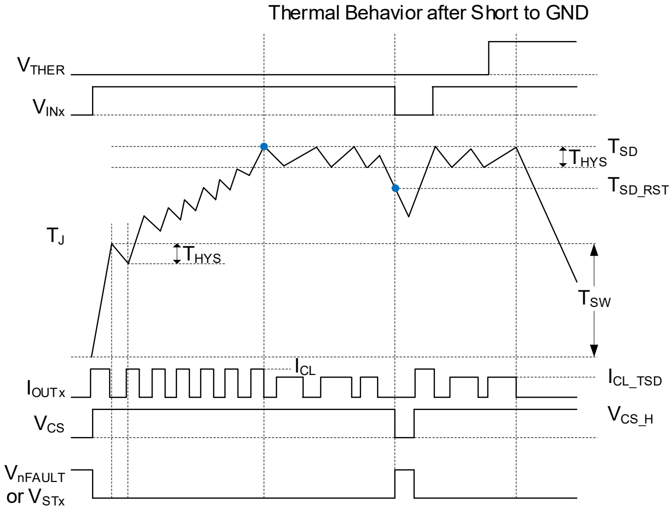


Figure 18. Thermal Protection Behavior

NOTE: Load is too large and causes current limit fault every time, it is turned on by setting V_{INx} high.

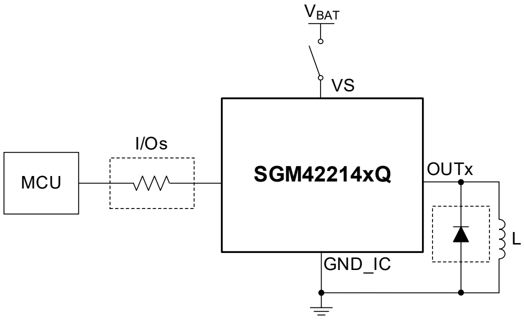


Figure 19. Loss of Power Protection Method 2 (Free-Wheeling Diode)

Reverse Current Protection

An output reverse current can occur due to a short-to-battery or a reverse polarity condition. With a short-to-battery, the reverse current path is through the body diode (or MOSFET itself, if it is on) and circulates through V_S pin. The specified limit for the current in this case is I_{R1}.

In a reverse polarity condition, the reverse current flows through the body diode (or MOSFET itself, if it is on) and circulates through the device GND_IC. The limit for this reverse current is specified as I_{R2}.

Two types of external circuits are recommended for protection against reverse current. Method 1 is adding a blocking diode in the supply line as shown in Figure 20. This will protect both the device and the load.

In method 2, a GND network (blocking diode and a parallel resistor) is placed between the device GND_IC pin and system GND as shown in Figure 21. This will block reverse current through the device GND_IC. But the MOSFET reverse current is limited by the load itself. The recommended network resistor value is about 1kΩ and the diode should be rated above 100mA with less than 0.6V forward voltage. If multiple devices are used, one GND network can be shared for all of them. Add 4.7kΩ or larger series resistors to all I/O lines to limit current through them as well.

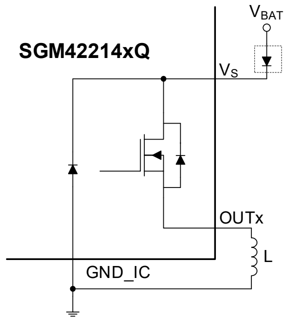


Figure 20. External Reverse Current Protection with a Blocking Diode in Supply Line (Method 1)

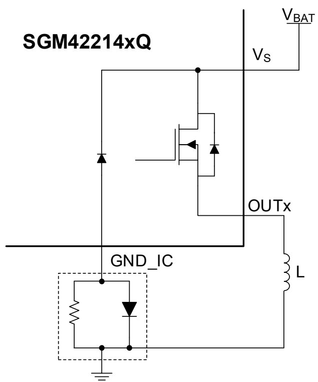


Figure 21. External Reverse Current Protection with R-D GND Network (Method 2)

DETAILED DESCRIPTION (continued)

MCU I/O Protection

In severe conditions, such as battery loss with inductive loads or the ISO7637-2 test requirements for automotive applications, a negative pulse appears on the ground pin that can damage the connected microcontroller. Placing series resistors with I/O lines is recommended to protect the MCU (e.g., 4.7kΩ for a 3.3V MCU and 10kΩ for 5V).

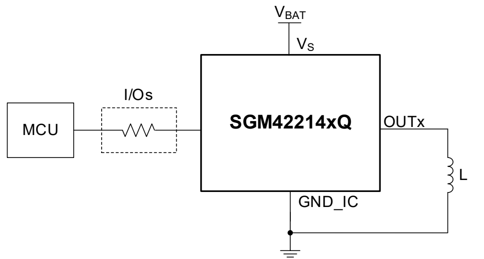


Figure 22. External MCU I/O Protection with Series Resistors

Functional Modes

Each channel in the SGM42214xQ has 3 operational modes: normal, standby, and diagnostics. Operating mode can be changed as explained by the diagram in Figure 23.

To enter standby mode, the INx input must be low for a minimum duration of t_{OFF_DEG}. The t_{OFF_DEG} is the deglitch time to avoid false trigger entry to the standby mode.

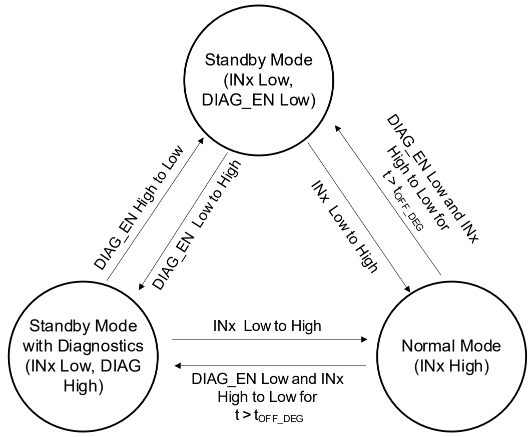


Figure 23. SGM42214xQ Channels Operating Modes

APPLICATION INFORMATION

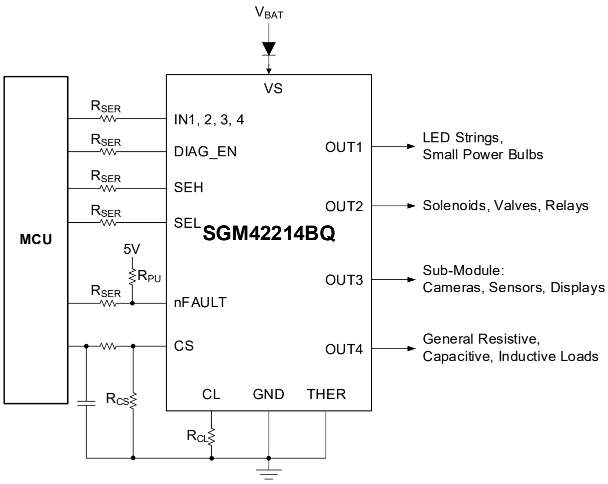


Figure 24. Typical Application Diagram

The SGM42214xQ quad channel smart switch can be used in automotive or industrial applications to control a wide variety of resistive, inductive, and capacitive loads, such as small bulbs, LEDs, relays, solenoids, heaters, and sub-modules.

A comprehensive set of diagnostic features and an accurate current sense circuit provide the tools needed for smart load control. System reliability is also improved with an externally adjustable current limit that clamps the inrush and overload currents to the desired safe levels.

Typical Application

Figure 24 shows one typical application of the SGM42214BQ. In the following section, the design process for a typical application is explained.

Requirement

- V_S range: 9V to 16V.
- Load range (each channel): 0.1A to 1A.
- Fault monitoring: by current sense output.
- Desired current limit: 1A.
- Thermal shutdown recovery: automatic recovery
- Use full diagnostics with a 5V MCU.
- Reverse voltage protection: supply line diode.

Design Procedure

To design the current sense resistor (R_{CS}), the full load current (1A) must remain in the 0V to 4V linear sensing range of CS. R_{CS} can be calculated from Equation 9:

$$R_{CS} = \frac{V_{CS}}{I_{CS}} = \frac{V_{CS} \times K_{CS}}{I_{OUT}} = \frac{4 \times 330}{1} = 1320\Omega \quad (9)$$

It is recommended to use resistors with 1% or better tolerance for more accurate current sensing.

Similarly, to set the current limit at 1A, the R_{CL} resistor can be calculated using Equation 10 or Equation 11:

$$V_S < 18V: \quad R_{CL} = \frac{V_{CL\_TH} \times K_{CL}}{I_{OUT}} = \frac{0.8 \times 2350}{1} = 1880\Omega \quad (10)$$

$$V_S > 21V: \quad R_{CL} = \frac{V_{CL\_TH} \times K_{CL}}{I_{OUT}} = \frac{0.4 \times 2350}{1} = 940\Omega \quad (11)$$

The R_{CL} between CL and GND_IC should be greater than 500Ω.

For the protective series resistances in MCU lines, using R_{SER} = 10kΩ is recommended considering the 5V supply. Finally, to reduce the number of items in the bill of materials a R_{PU} = 10kΩ resistor is used for the nFAULT pull-up.

APPLICATION INFORMATION (continued)

Power Supply Recommendations

The SGM42214xQ is qualified for automotive applications. Typically, the nominal power supply voltage is 12V for automotive applications. In any application, the peak and minimum supply voltage must remain within the specified recommended operating conditions of the device (4.5V to 36V).

Layout Guidelines

A well-designed PCB layout is important for proper operation and long-term reliability of the system. To avoid unwanted thermal shutdowns, the ambient temperatures in each channel (T_A), must remain below +125℃. The TSSOP-28 (Exposed Pad) package provides low thermal impedance. However, the PCB layout is still critical to optimize transferring heat away from the chip and extend its lift-time reliability.

To improve the board thermal conductivity, the exposed pad should be soldered and connected to large copper planes. Also the overall copper coverage of the PCB should be maximized as it is usually the main heat dissipation path from the package to the ambient especially if there is no heatsink attached to the opposite side of the PCB.

Use a lot of thermal vias directly under the package exposed pad to maximize the thermal conductivity from the chip to the copper planes and the board. Adding conductive vias under the GND_IC and OUT pins will also improve heat transfer away from the device.

To avoid solder voids under the exposed pad, all thermal vias must be plated or plugged and capped on both sides of the PCB to prevent solder from getting sucked out of the exposed pad area through the vias or pushed away due to gas release from the via holes during reflow. For a reliable performance, the solder coverage should be at least 85% (less than 15% voids). Filling thermal vias with high thermal conductivity, materials improve thermal performance and cools the device more effectively.

REVISION HISTORY

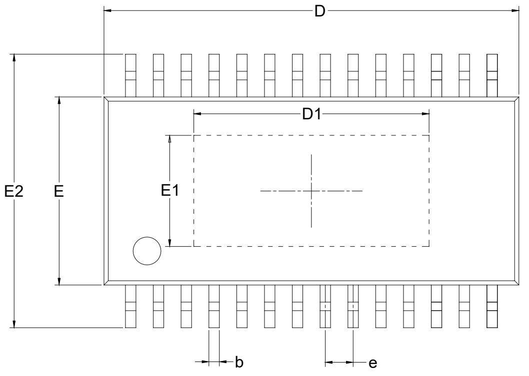
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

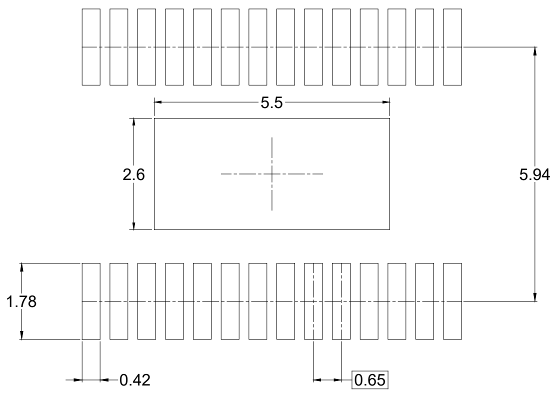
DECEMBER 2025 – REV.A to REV.A.1	Page
Updated Recommended Operating Conditions section	2
Updated Electrical Characteristics section	4, 5, 6
Updated Typical Performance Characteristics section	9, 10, 11
Updated Application Information section	21

Changes from Original to REV.A (NOVEMBER 2025)	Page
Changed from product preview to production data	All

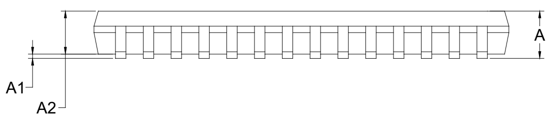
PACKAGE OUTLINE DIMENSIONS

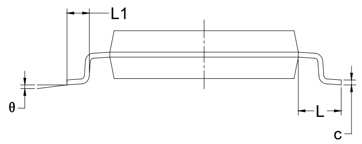
TSSOP-28 (Exposed Pad)





RECOMMENDED LAND PATTERN (Unit: mm)





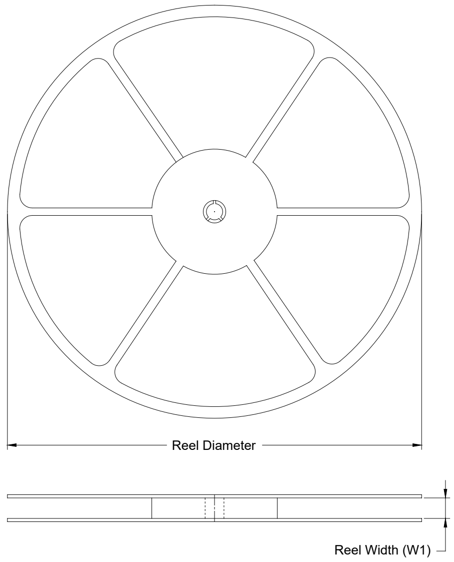
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A		1.200		0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	9.600	9.800	0.378	0.386
D1	4.700	5.700	0.185	0.224
E	4.300	4.500	0.169	0.177
E1	2.400	2.800	0.094	0.110
E2	6.200	6.600	0.244	0.260
e	0.650 BSC		0.026 BSC	
L	1.000 BSC		0.039 BSC	
L1	0.450	0.750	0.018	0.030
θ	0°	8°	0°	8°

NOTES:

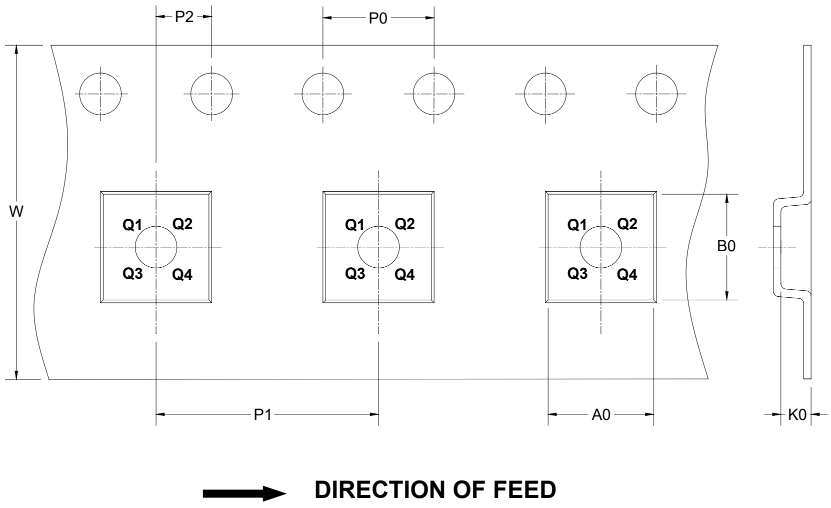
1. Body dimensions do not include mode flash or protrusion.
2. This drawing is subject to change without notice.
3. Reference JEDEC MO-153.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



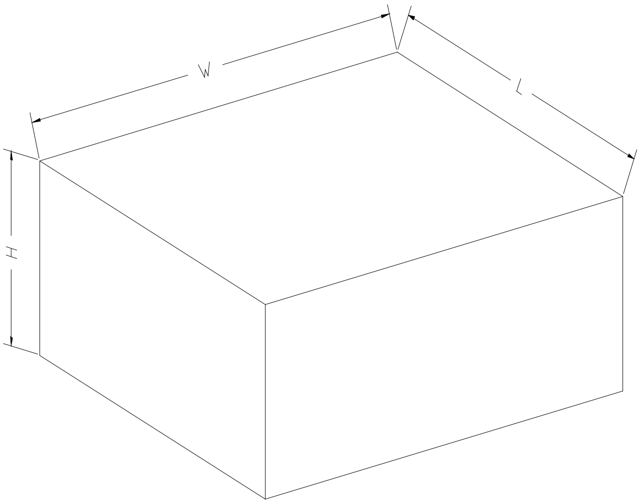
NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
TSSOP-28 (Exposed Pad)	13"	16.4	6.80	10.25	1.60	4.0	8.0	2.0	16.0	Q1

DD0001

CARTON BOX DIMENSIONS



NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF CARTON BOX

Reel Type	Length (mm)	Width (mm)	Height (mm)	Pizza/Carton
13″	386	280	370	5

DD0002