21mΩ, 80V High-Side Switch with Advanced Diagnostics and Load Current Monitoring

MAX22910

Product Highlights

- Reduced Power and Heat Dissipation
  - 40mΩ (max) On-Resistance at T_A = 125°C
  - 1.2mA (typ) Supply Current with No Load
  - Adjustable Output Current Limit from 0.7A to 9A
- Robustness and Advanced Diagnostics
  - 80V Maximum Supply Range
  - Independent Load Current Monitor Output
  - ±6% (max) Accuracy in Monitoring Load Current more than 700mA
  - Open-Wire Detection with Switch Closed
  - Adjustable Open-Wire Detection Threshold
  - Thermal Overload and Short-Circuit Protection
  - Overload Diagnostic Output
  - -40°C to +125°C Ambient Operating Temperature
- High-Speed Operation
  - 110µs (max) Turn-On Propagation Delay
  - <1µs (typ) IMON Response Time
- Flexibility Design
  - Supply Voltage V_{DD} from 4.75V to 80V
  - Logic Voltage Interface V_L from 1.6V to 5.5V
  - Compact 4.5mm x 5.75mm FC2QFN

Applications

- Industrial Digital Output Modules
- Safety Output Modules
- Commercial Vehicle Controllers
- Motor Holding Brakes

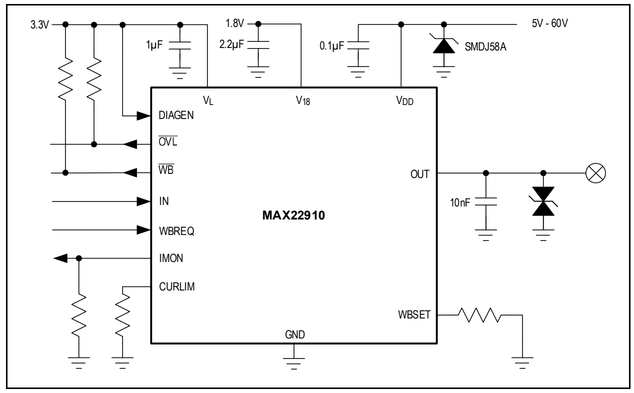
General Description

The MAX22910 is an industrial high-side switch that operates as a current sourcing output device. The high-side switch has an on-resistance R_{ON} of 21mΩ (typ) and 40mΩ (max). The maximum load current is limited and set via the CURLIM resistor in the range of 0.7A to 9A with ±10% accuracy. At +100°C ambient temperature, the maximum continuous load current is up to 7A.

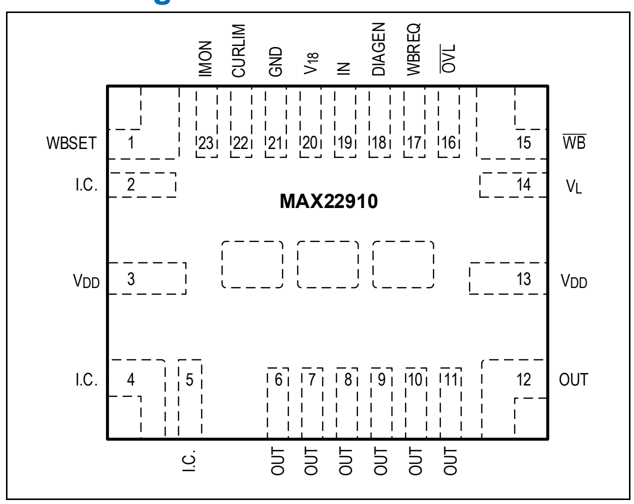
The MAX22910 is specified for operation up to 80V (max) supply voltage if OUT does not go below GND. The V_L logic supply allows flexible logic interface levels in the range of 1.6V to 5.5V.

Open-wire detection detects wiring faults when the switch is on for load current below a threshold in the range of 1mA to 7mA, as set by the WBSET resistor.

Simplified Application Diagram



Pin Configuration



Accurate load current monitoring at the IMON current output monitors the load current with ±4% accuracy between 2A and 9A and with ±6% accuracy between 0.7A and 2A when the device is not in the current limit.

The MAX22910 is protected against short-circuits, overcurrent, and thermal overload. Achieve fast load turn-off time by connecting an external TVS diode at OUT with a high clamp voltage to clamp inductive kickback energy.

The MAX22910 is available in a compact 4.5mm x 5.75mm FC2QFN package and is specified for operation from -40°C to +125°C ambient temperature.

***Ordering Information* appears at end of data sheet.**

19-101724; Rev 1; 01/24

Absolute Maximum Ratings

V_{DD} to GND .... -0.3V to +85V

OUT to GND.................................(V_{DD} - 85)V to (V_{DD} + 0.3)V

V_L, IN, WBREQ, DIAGEN, $\overline{WB}$, $\overline{OVL}$ to GND....... -0.3V to +6V

V_{18} to GND ....-0.3V to Min (+2.2, V_{DD} + 0.3)V

IMON, CURLIM, WBSET to GND ....-0.3V to (V_{18} + 0.3)V

OUT Load Current.. Internally Limited

Junction Temperature....................................Internally Limited

Continuous Power Dissipation (Multilayer Board) (T_A = +70°C, derate at 36.5mW/°C above +70°C)........................ 3469.7mW

Storage Temperature Range.......................... -65°C to +150°C

Lead Temperature (soldering, 10s)..............................+300°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.

Package Information

23 FC2QFN

Package Code	F234A5+1F
Outline Number	21-100606
Land Pattern Number	90-100213
Thermal Resistance, Four-Layer Board	
Junction to Ambient (θ_{JA})	27.38°C/W
Junction to Case Thermal Resistance (θ_{JC})	1.81°C/W

For the latest package outline information and land patterns (footprints), go to https://www.analog.com/en/design-center/packaging-quality-symbols-footprints/package-index.html. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

Package thermal resistances were obtained using JEDEC and the evaluation kit. For detailed information on package thermal considerations, refer to https://www.analog.com/en/technical-articles/thermal-characterization-of-ic-packages.html.

Electrical Characteristics

(V_{DD} = +4.75V to +80V, V_L = +1.6V to +5.5V, T_A = -40°C to +125°C, unless otherwise noted. Typical values are at V_{DD} = +24V, V_L = +3.3V, T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
POWER SUPPLY (V_{DD})							
V_{DD} Supply Voltage	V_{DD}			4.75		80	V
V_{DD} Supply Current	I_{DD}	V_{DD} = 36V, IN = DIAGEN = high	No load at OUT		1.2	1.7	mA
V_{DD} Undervoltage Lockout Threshold	V_{DD_UVLO}	V_{DD} rising		4.3	4.5	4.7	V
V_{DD} Undervoltage Lockout Hysteresis	V_{DD_UVHYST}				0.2		V
LOGIC SUPPLY (V_L)							
V_L Supply Voltage	V_L			1.6		5.5	V
V_L Supply Current	I_L	All logic inputs high or low			10	20	µA
V_L Undervoltage Lockout Threshold	V_{L_UVLO}	V_L falling		1.22	1.25	1.3	V
V_{18} LDO							
V_{18} Output Voltage	V_{18}	I_{18} = 1mA, 4.75V ≤ V_{DD} ≤ 80V			1.8		V
V_{18} Undervoltage Lockout Threshold	V_{18_UVLO}	V_{18} rising		1.60	1.64	1.68	V
V_{18} Undervoltage Lockout Hysteresis	V_{18_UVHYST}				0.06		V
V_{18} Current Limit	I_{18_LIM}			15	29	48	mA
HIGH-SIDE SWITCH (OUT)							
On-Resistance	R_{ON}	IN = high, WBREQ = low, V_{DD} ≥ 10V	I_{OUT} = 1A		21	40	mΩ
Off-Leakage Current	I_{LKG}	IN = low, V_{DD} = 40V, 0V ≤ OUT ≤ V_{DD}		-70		+70	µA
CURRENT LIMITING (CURLIM)							
Current Limit Range	I_{LIM}	Set by CURLIM resistor		0.7		9	A
CURLIM Current Ratio	CLCR	CLCR = Output Current Limit / I_{CURLIM}	IN = high, WBREQ = low		20900		A/A
Current Limit Threshold Accuracy	ACC_{ILIM}	Relative to CURLIM resistor value	IN = high, WBREQ = low, 0.7A ≤ I_{LIM} ≤ 9A	-10		+10	%
Current Limit Regulation Voltage	V_{REF_CURLIM}	Voltage on CURLIM during Current Limit			0.7		V
CURRENT MONITOR (IMON)							
IMON Current Ratio	IMCR	IMCR = I_{OUT}/IMON; IN = DIAGEN = high, WBREQ = low	0.7A ≤ I_{OUT} ≤ I_{LIM}		20900		A/A
IMON Accuracy	ACC_{CSF}	IN = DIAGEN = high, WBREQ = low	I_{OUT} = 0.08A	-35		+35	%
			0.2A ≤ I_{OUT} < 0.7A	-25		+25	
			0.7A ≤ I_{OUT} < 2A	-6		+6	
			2A ≤ I_{OUT} ≤ 9A	-4		+4	
IMON Full-Scale Range	FSR_{IMON}	Voltage Compliance		0		1.4	V

(V_{DD} = +4.75V to +80V, V_L = +1.6V to +5.5V, T_A = -40°C to +125°C, unless otherwise noted. Typical values are at V_{DD} = +24V, V_L = +3.3V, T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
WIRE-BREAK DETECTION ($\overline{WB}$, WBSET, WBREQ)							
Wire-Break Threshold Range	ΔI_{WB}	DIAGEN = WBREQ = high, IN = don't care		1		7	mA
Wire-Break Threshold Current	I_{WB_TH}	DIAGEN = WBREQ = high, IN = don't care	R_{WBSET} = 182kΩ		1.0		mA
			R_{WBSET} = 90kΩ		2.0		
			R_{WBSET} = 36kΩ	3.5	5.0	6.5	
			R_{WBSET} = 26.1kΩ		7.0		
WBSET Regulation Voltage	V_{WBSET}	Voltage on WBSET			0.9		V
LOGIC INPUTS (IN, WBREQ, DIAGEN)							
Input Voltage High	V_{IH}			0.7x V_L			V
Input Voltage Low	V_{IL}					0.3x V_L	V
Input Threshold Hysteresis	V_{IHYS}				0.11x V_L		V
Input Resistance	R_{IN}			120	200	290	kΩ
LOGIC OUTPUTS ($\overline{OVL}$, $\overline{WB}$)							
Output Voltage Low	V_{OL}	DIAGEN = high, I_{SINK} = 5mA				0.33	V
Output Tristate Leakage	I_{LEAK_FAULT}	$\overline{OVL}$ = $\overline{WB}$ = 0V or 5.5V	DIAGEN = low	-1		+1	µA
			DIAGEN = high and outputs in tristate	-1		+1	
THERMAL PROTECTION							
Switch Thermal Shutdown	T_{JSHDN}	Junction temperature rising			165		°C
Switch Thermal Shutdown Hysteresis	T_{JSHDN_HYST}				15		°C
Chip Thermal Shutdown	T_{CSHDN}	Temperature rising			150		°C
Chip Thermal Shutdown Hysteresis	T_{CSHDN_HYST}				10		°C
SWITCH TIMING (IN, OUT)							
Turn-Off Propagation Delay	t_{PD_OFF}	*Figure 1*	V_{DD} = 24V, WBREQ = low		82	160	µs
Turn-On Propagation Delay	t_{PD_ON}	*Figure 1*	V_{DD} = 24V, WBREQ = low		57	110	µs
Rise Time	t_R	*Figure 1*	V_{DD} = 24V		22	35	µs
Fall Time	t_F	*Figure 1*	V_{DD} = 24V		6	15	µs
WIRE-BREAK TIMING (WBREQ, $\overline{WB}$)							
Wire-Break Valid Delay, no Wire Broken	t_{WB1}	Wire-break detection time from WBREQ rising to $\overline{WB}$ valid, *Figure 3*	IN = low, I_{WB} = 5mA, C_L = 15nF, I_{LOAD} = 10mA			3	µs
Wire-Break Valid Delay, with Wire Broken	t_{WB2}	Wire-break detection time from WBREQ rising to $\overline{WB}$ valid, *Figure 3*	IN = low, I_{WB} = 5mA, C_L = 15nF, I_{LOAD} = 0mA			400	µs

(V_{DD} = +4.75V to +80V, V_L = +1.6V to +5.5V, T_A = -40°C to +125°C, unless otherwise noted. Typical values are at V_{DD} = +24V, V_L = +3.3V, T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Wire-Break Valid Delay, no Wire Broken	t_{WB2}	Wire-break detection time from WBREQ rising to $\overline{WB}$ valid, *Figure 2*	IN = high, I_{WB} = 5mA, C_L = 15nF, I_{LOAD} = 10mA			400	µs
Wire-Break Valid Delay, with Wire Broken	t_{WB1}	Wire-break detection time from WBREQ rising to $\overline{WB}$ valid, *Figure 2*	IN = high, I_{WB} = 5mA, C_L = 15nF, I_{LOAD} = 0mA			3	µs
EMC PROTECTION							
ESD	V_{ESD}	All pins, Human Body Model			±2		kV
		V_{DD}, OUT	Contact		+10		
			Airgap		+15		
Surge	V_{SURGE}	V_{DD}, OUT	With 42Ω source impedance, and 5.0SMDJ58A TVS diode at V_{DD}		+2		kV

Note 1: All devices are 100% production tested at T_A = +25°C. Specifications over temperature are guaranteed by design and characterization.

Timing Diagrams

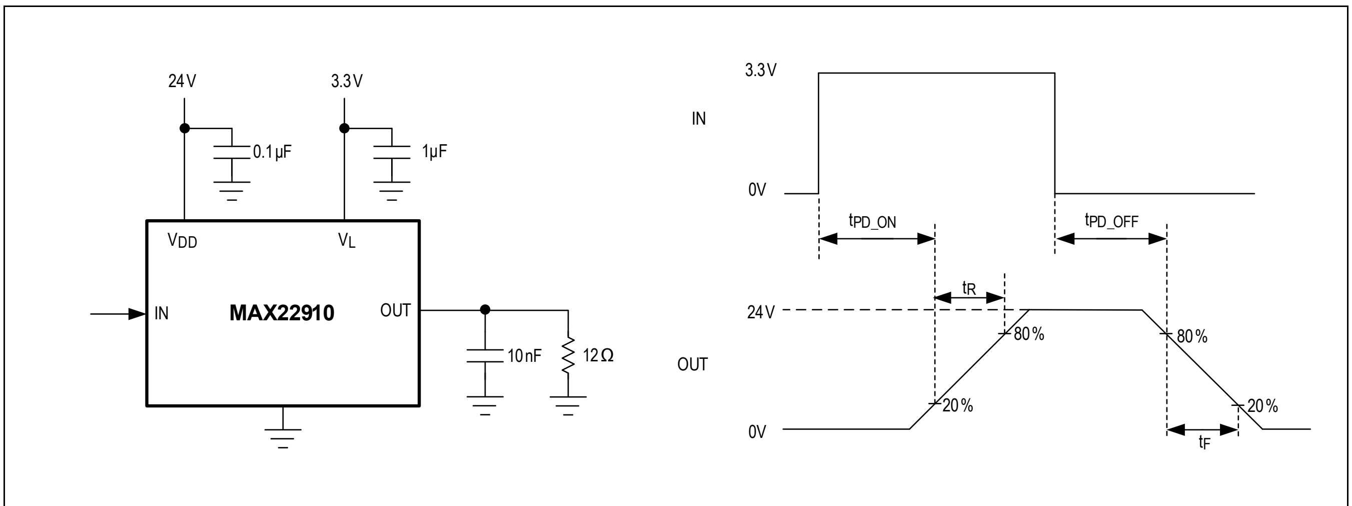


Figure 1. IN to OUT Propagation Delay and OUT Rising and Falling Time

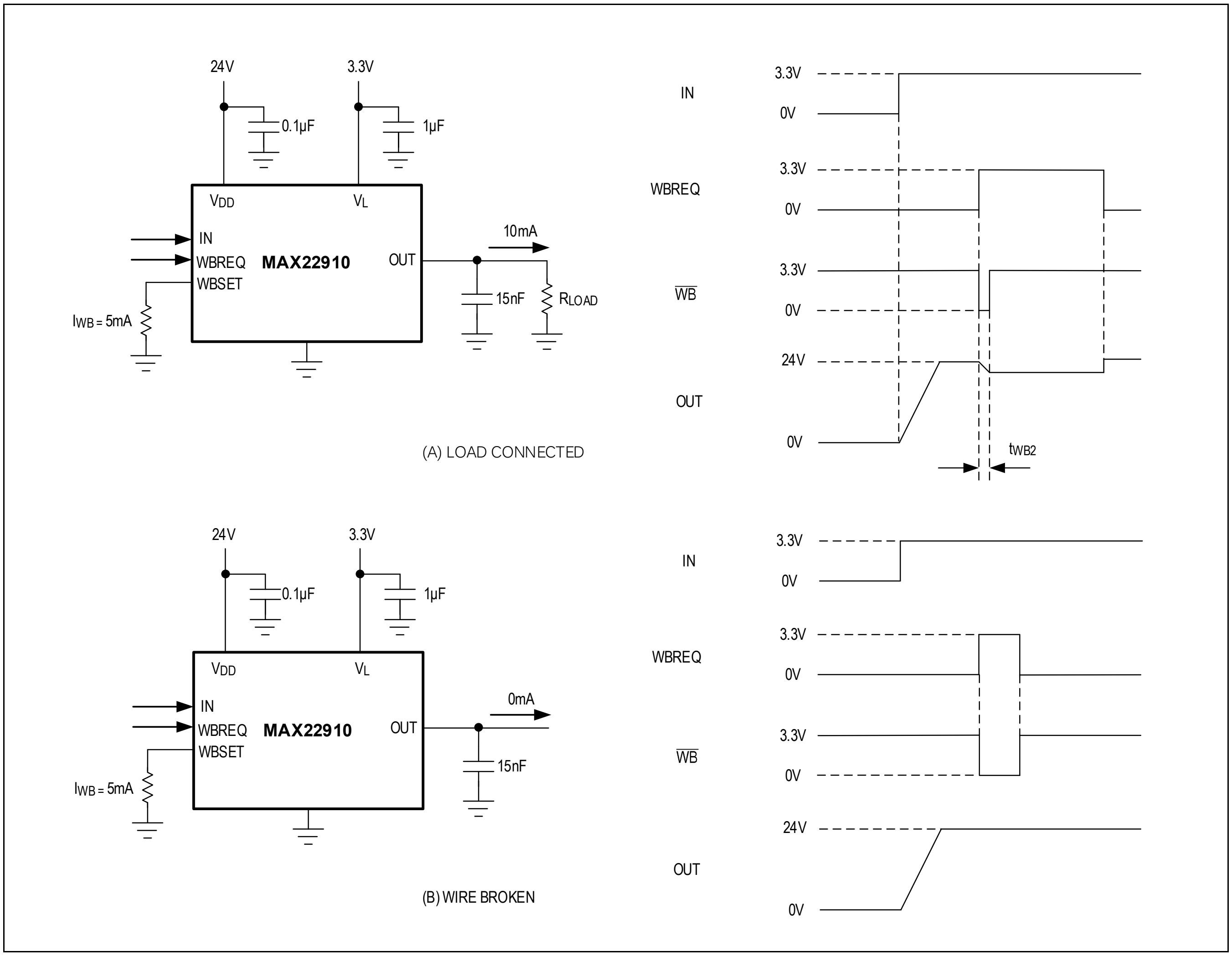


Figure 2. Wire-Break Detection Timing (IN High)

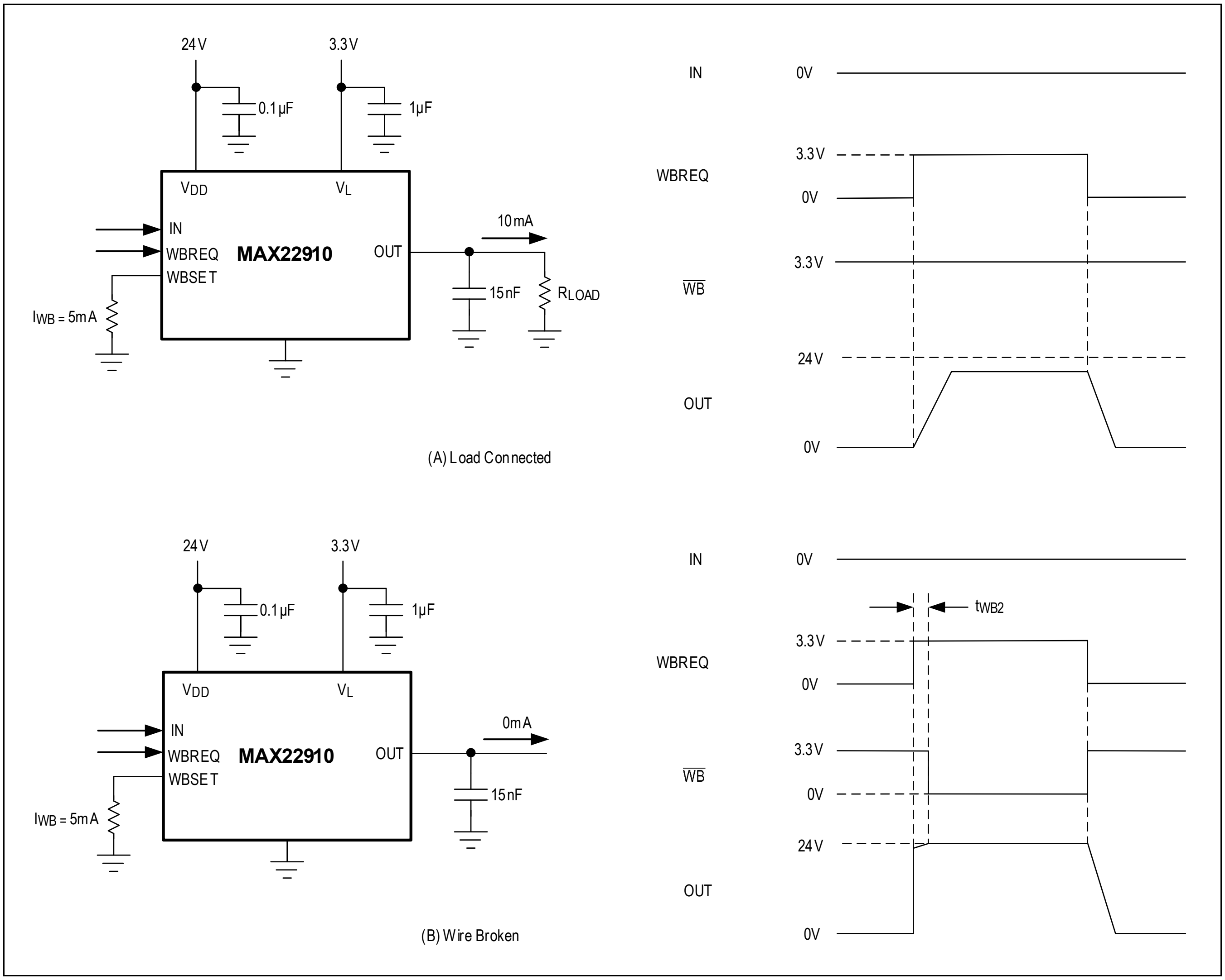
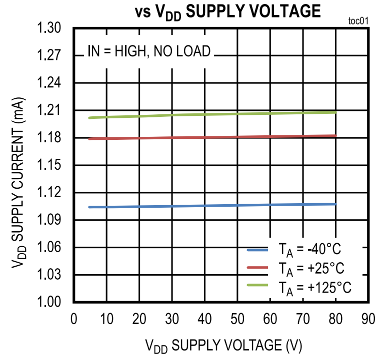


Figure 3. Wire-Break Detection Timing (IN Low)

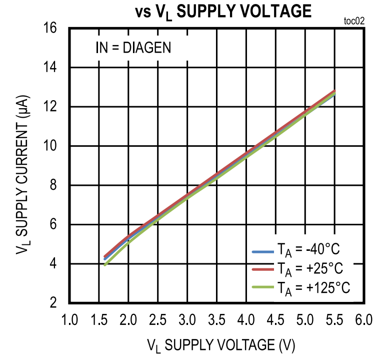
Typical Operating Characteristics

V_{DD} = 24V, V_L = 3.3V, DIAGEN = high, WBREQ = low, T_A = +25°C, unless otherwise noted.

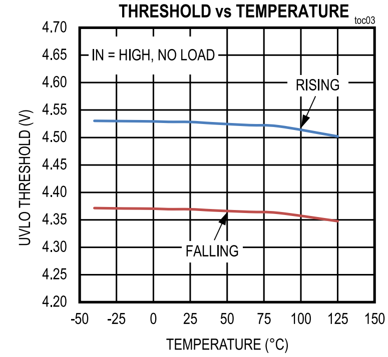
V_{DD} SUPPLY CURRENT vs V_{DD} SUPPLY VOLTAGE



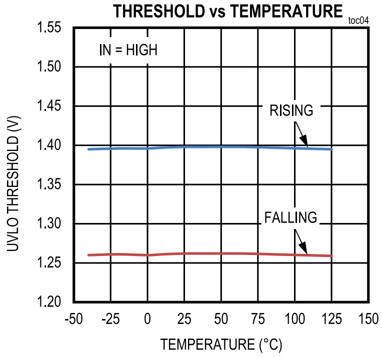
V_L SUPPLY CURRENT vs V_L SUPPLY VOLTAGE



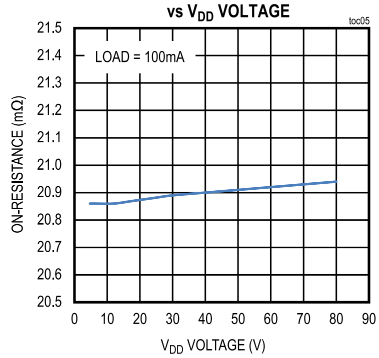
V_{DD} UNDERVOLTAGE LOCKOUT THRESHOLD vs TEMPERATURE



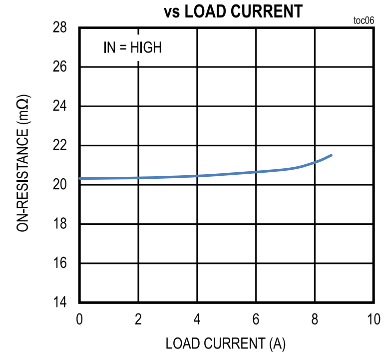
V_L UNDERVOLTAGE LOCKOUT THRESHOLD vs TEMPERATURE



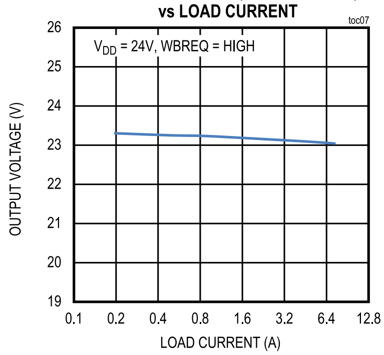
SWITCH ON-RESISTANCE vs V_{DD} VOLTAGE



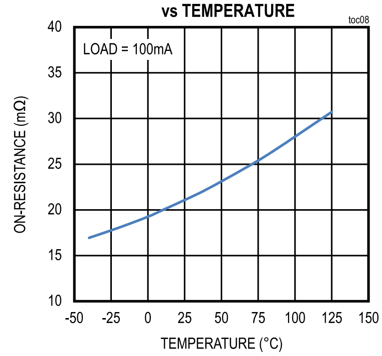
SWITCH ON-RESISTANCE vs LOAD CURRENT



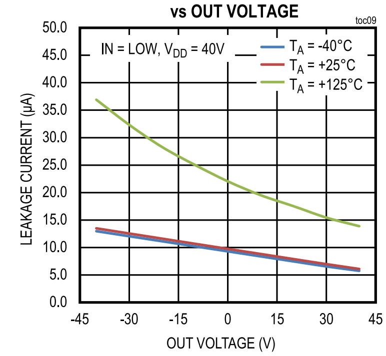
OUTPUT VOLTAGE (WBREQ = HIGH) vs LOAD CURRENT



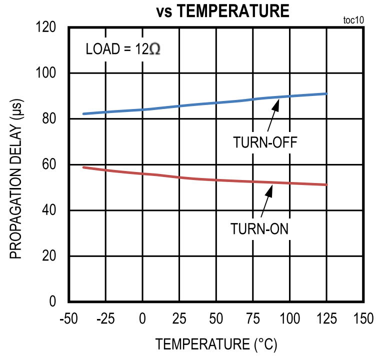
SWITCH ON-RESISTANCE vs TEMPERATURE



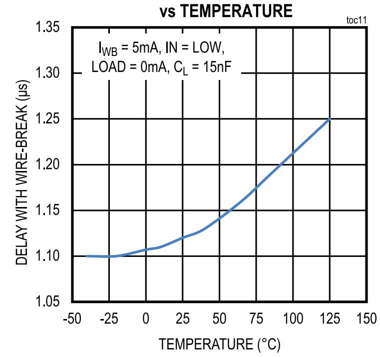
SWITCH LEAKAGE CURRENT vs OUT VOLTAGE



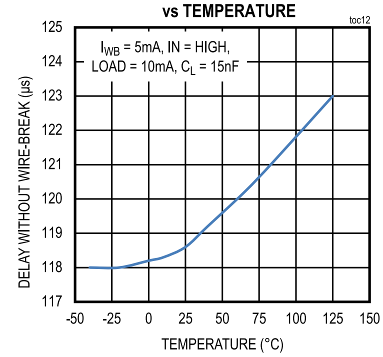
PROPGATION DELAY vs TEMPERATURE



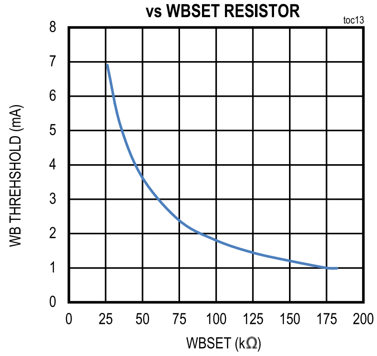
WIRE-BREAK VALID DELAY vs TEMPERATURE



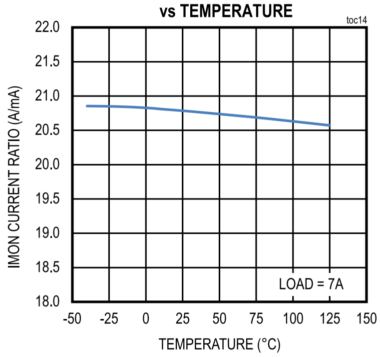
WIRE-BREAK VALID DELAY vs TEMPERATURE



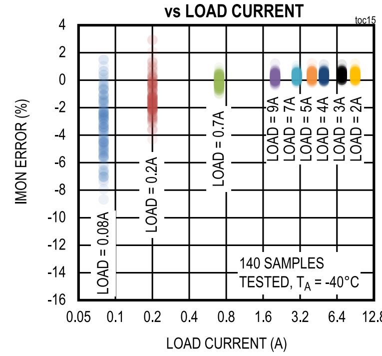
WIRE-BREAK THRESHOLD vs WBSET RESISTOR



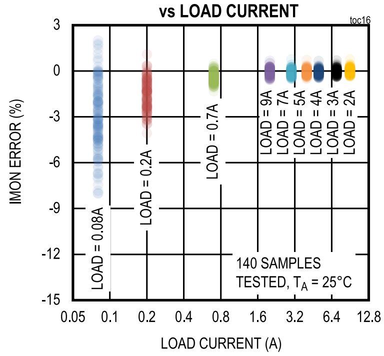
IMON CURRENT RATIO vs TEMPERATURE



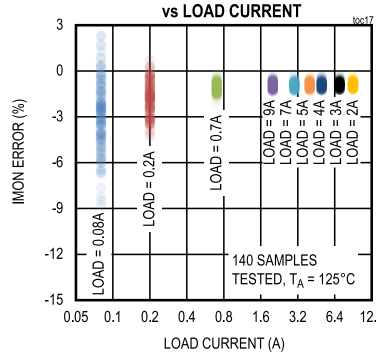
IMON ACCURACY vs LOAD CURRENT



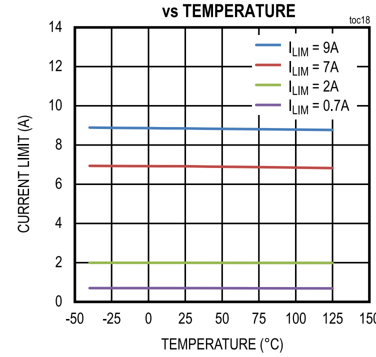
IMON ACCURACY vs LOAD CURRENT



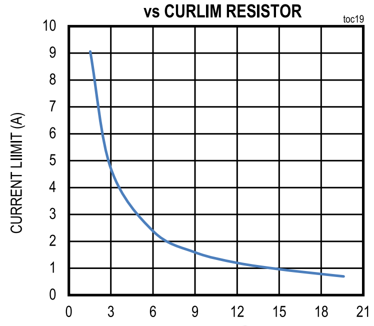
IMON ACCURACY vs LOAD CURRENT



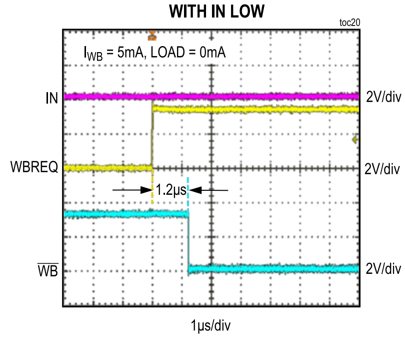
CURRENT LIMIT vs TEMPERATURE



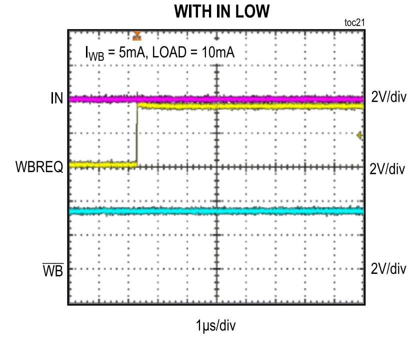
CURRENT LIMIT vs CURLIM RESISTOR

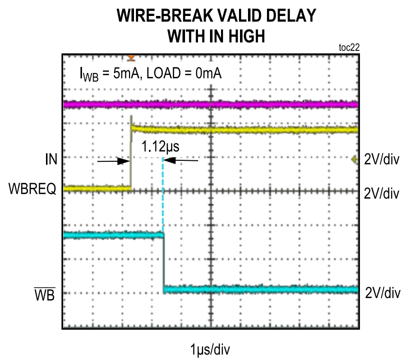


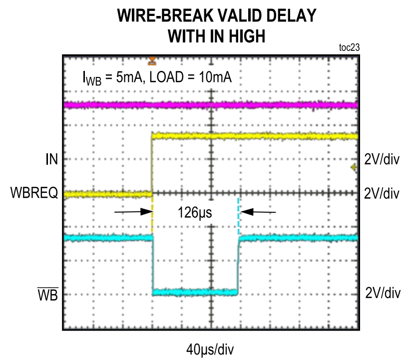
WIRE-BREAK VALID DELAY WITH IN LOW

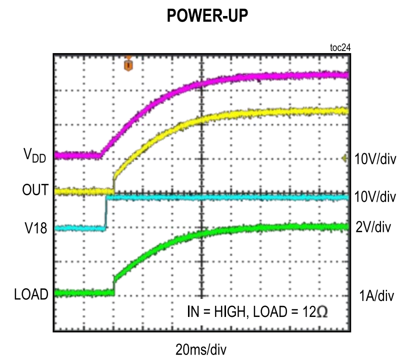


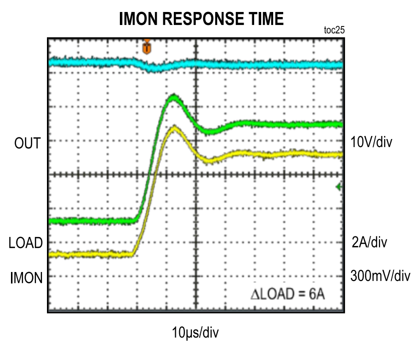
WIRE-BREAK VALID DELAY WITH IN LOW



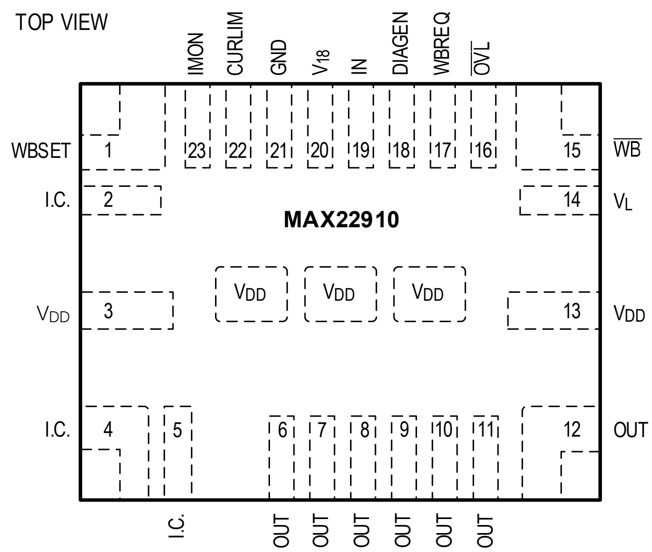

WIRE-BREAK VALID DELAY
WITH IN HIGH
toc22
I_WB = 5mA, LOAD = 0mA
1.12µs
IN
WBREQ
WB
2V/div
2V/div
2V/div
1µs/div


WIRE-BREAK VALID DELAY
WITH IN HIGH
toc23
I_WB = 5mA, LOAD = 10mA
126µs
IN
WBREQ
WB
2V/div
2V/div
2V/div
40µs/div


POWER-UP
toc24
VDD
OUT
V18
LOAD
10V/div
10V/div
2V/div
1A/div
IN = HIGH, LOAD = 12Ω
20ms/div


IMON RESPONSE TIME
toc25
OUT
LOAD
IMON
10V/div
2A/div
300mV/div
ΔLOAD = 6A
10µs/div

Pin Configuration

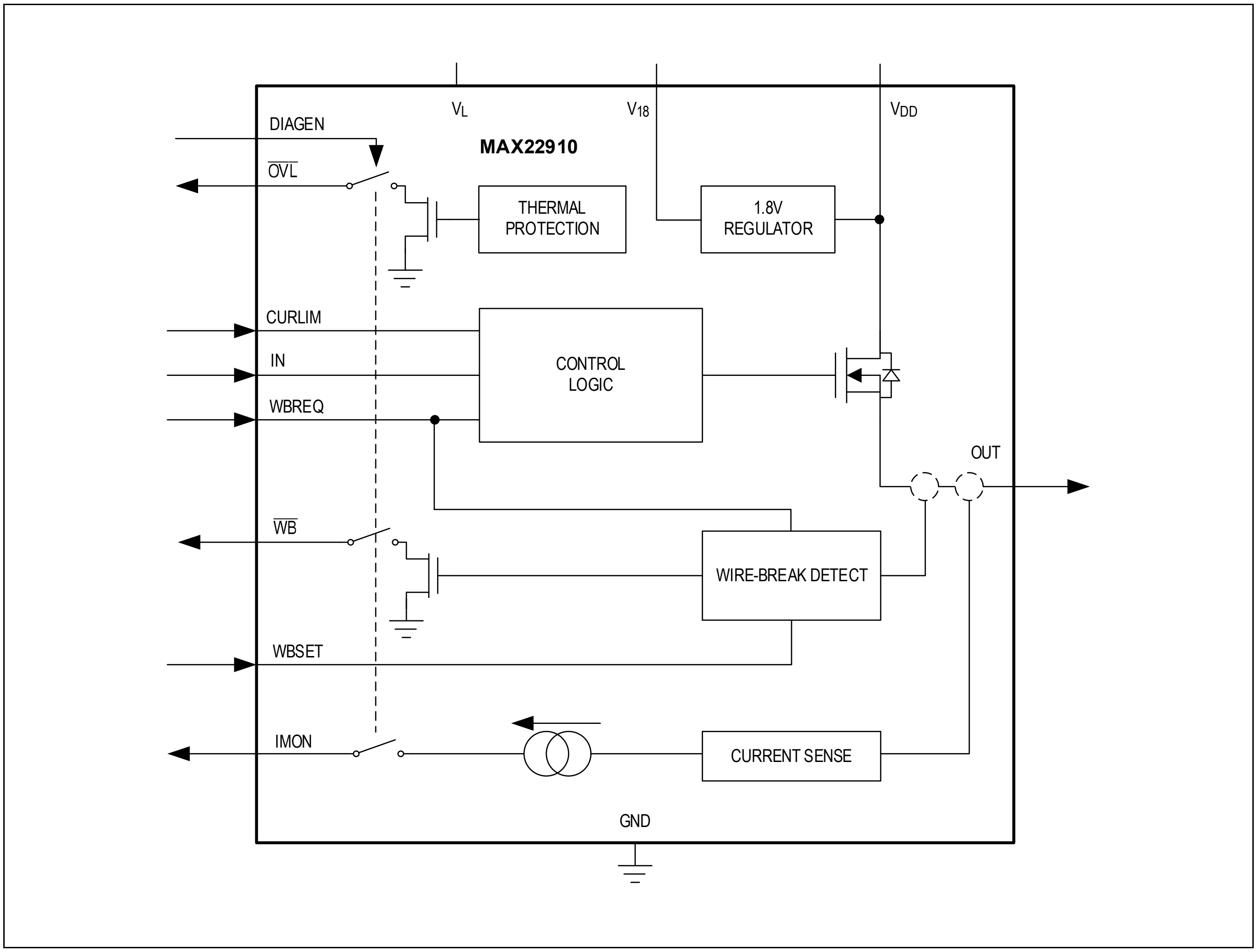


23 FC2QFN
(4.5mm x 5.75mm)

Pin Descriptions

PIN	NAME	FUNCTION	Type
POWER SUPPLY			
3, 13	V_{DD}	Power Supply Input. Bypass V_{DD} to GND with a 0.1µF capacitor as close to the pin as possible.	Supply
20	V_{18}	1.8V LDO Output. Bypass V_{18} to GND with a 2.2µF capacitor as close to the pin as possible. V_{18} is only for internal use; do not drive any loads at V_{18}.	Supply
14	V_L	Logic Supply Input. Connect an external voltage supply from 1.6V to 5.5V. Bypass V_L to GND with a 1µF capacitor as close to the pin as possible.	Supply
21	GND	Ground Reference.	Supply
EP	–	Exposed Pad. Connect to V_{DD}.	Supply
SWITCH OUTPUT			
6, 7, 8, 9, 10, 11, 12	OUT	High-Side Switch Output. Connect a TVS to GND to protect against inductive kickback voltage, ESD, and surge transients. Connect a 10nF/100V capacitor to GND to protect from EFT and conducted immunity transients.	Power
CONTROL INPUTS			
19	IN	Switch Control Input. Have an internal 200kΩ pulldown to GND. Set IN high to close the high-side switch or low to open the high-side switch.	Logic
22	CURLIM	Current Limit Set Input. Connect a resistor between CURLIM and GND to set the current limit. Connect the resistor as close to the CURLIM pin as possible. The capacitance from CURLIM to GND should not exceed 10pF.	Analog
18	DIAGEN	Diagnostics Enable Input. Have an internal 200kΩ pulldown to GND. Set DIAGEN high to enable the IMON, $\overline{WB}$, and $\overline{OVL}$ outputs. Set DIAGEN low to make the IMON, $\overline{WB}$, and $\overline{OVL}$ outputs high impedance.	Logic
17	WBREQ	Wire-Break Request Input. Have an internal 200kΩ pulldown to GND. Drive WBREQ high to enable wire-break detection. Drive WBREQ low after wire-break detection is completed and clears the $\overline{WB}$ output. See the *Wire-Break Detection* section for more information.	Logic
1	WBSET	Wire-Break Threshold Set Input. Connect a resistor between WBSET and GND to set the wire-break detection threshold current. See the *Wire-Break Detection* section for more information.	Analog
DIAGNOSTIC OUTPUTS			
16	$\overline{OVL}$	Overload Output. The $\overline{OVL}$ output is open-drain. Connect a pullup resistor to V_L. The $\overline{OVL}$ is asserted low when either the high-side switch or the device is in thermal shutdown. $\overline{OVL}$ is high impedance when DIAGEN is low. See the *Thermal Overload Protection* section for more information.	Logic
15	$\overline{WB}$	Wire-Break Output. The $\overline{WB}$ output is open-drain. Connect a pullup resistor to V_L. The $\overline{WB}$ is asserted low if the load current is less than the wire-break threshold current when WBREQ is driven high. $\overline{WB}$ is high impedance when WBREQ or DIAGEN is low.	Logic
23	IMON	Load Current Monitor Output. The IMON current is 1/20900 of the load current. Connect a resistor from IMON to GND to convert the IMON current to a voltage. IMON is high impedance when DIAGEN is low.	Analog
NO CONNECT			
2, 4, 5	I.C.	Internally Connected. Do not connect.	

Functional Block Diagram



Detailed Description

The MAX22910 is a high-side single-channel switch that operates as an industrial digital output. The MAX22910 features an on-resistance R_{ON} of 40mΩ (max) and can switch load currents up to 9A (max). The MAX22910 is specified for operation with up to +80V (max) supply voltage at V_{DD} if OUT does not go below GND. The MAX22910 offers flexible logic levels by supplying voltages from 1.6V to 5.5V at the V_L logic input.

The MAX22910 features active output current limiting with a high accuracy of ±6% with output load current higher than 700mA. The output load current can be accurately monitored at the IMON current output pin. The MAX22910 detects open-wire faults and protects the switch under thermal overloading conditions. The wire-break threshold current can be set by an external resistor, ranging from 1mA to 7mA.

To enable a flexible design and allow fast turn-off of inductive loads, connect an external TVS diode or clamping circuit to the OUT pin. High inductive clamping voltages can be achieved by connecting an external ground-referenced TVS diode to the OUT pin.

Output Switch

The MAX22910 high-side switch has a low on-resistance of 21mΩ (typ) or 40mΩ (max) for high current industrial digital output applications. The switch supports up to 9A (max) continuous load current with up to 80V (max) supply voltage at V_{DD} when the WBREQ is low. Drive IN high to close the high-side switch or drive low to open.

Logic Interface

The MAX22910 features flexible CMOS logic levels as defined by the V_L supply voltage between 1.6V and 5.5V to support most MCUs or GPI/Os. The $\overline{\text{OVL}}$ and $\overline{\text{WB}}$ logic outputs are open-drain outputs that require pullup resistors to V_L.

Linear Regulator

The MAX22910 has an integrated 1.8V linear regulator to power internal circuitry. Do not use V_{18} to drive any external loads. Connect a 2.2µF bypass capacitor between V_{18} and the ground and place it as close to the pin as possible.

Undervoltage Lockout

The V_{DD} supply voltage of MAX22910 has an undervoltage lockout of 4.5V (typ). The V_L supply voltage has an undervoltage lockout of 1.25V (typ). The integrated 1.8V LDO has an undervoltage lockout of 1.64V (typ). When the V_{DD}, V_L, and V_{18} voltages are under their respective UVLO threshold, the high-side switch is turned off and OUT is in tristate. The MAX22910 high-side switch automatically turns on once all three voltages rise above their respective UVLO threshold when IN is high.

Diagnostic Enable

The MAX22910 provides three diagnostic outputs: the thermal overload condition at $\overline{\text{OVL}}$, the wire-break condition at $\overline{\text{WB}}$, and the load current monitor output at IMON. The diagnostic outputs are enabled by setting DIAGEN high. Setting DIAGEN low makes the $\overline{\text{OVL}}$, $\overline{\text{WB}}$, and IMON outputs high impedance.

Thermal Overload Protection

The MAX22910 features thermal overload protection on both the high-side switch and the entire device.

The thermal overload condition on the high-side switch occurs when the external load attempts to source a higher current than the MAX22910 current limit set by the CURLIM resistor. It results in the heating-up of the high-side switch and the switch is automatically turned off. The $\overline{OVL}$ output is asserted low when the internal temperature rises above its thermal threshold of +165°C (typ). After the high-side switch, the internal temperature drops by 15°C (typ) to normal operating temperature, and the switch automatically turns back on if IN is high.

The thermal overload condition on the entire device happens when the ambient temperature rises above the chip thermal shutdown threshold of +150°C (typ). The high-side switch is automatically turned off and the $\overline{OVL}$ output is asserted low. After the ambient temperature drops by 10°C (typ), the switch automatically turns back on if IN is high.

The $\overline{OVL}$ fault output is real-time and not latched. If the overload condition persists, the MAX22910 autonomously cycles in and out of the thermal shutdown conditions, and the high-side switch automatically cycles between on and off states and $\overline{OVL}$ output between high and low levels.

Wire-Break Detection

The MAX22910 detects the wire-break condition when the high-side switch is closed by checking whether the load current is lower than the wire-break threshold current, I_{WB}, as set by the WBSET resistor, R_{WBSET}. See *Table 1* to set the wire-break threshold current from 1mA to 7mA.

Table 1. Wire-Break Detect Threshold Range

I_{WB} (mA)	1	2	5	7
R_{WBSET} (kΩ)	182	90	36	26.1

Drive WBREQ high to enable the wire-break detection. Drive WBREQ low to disable the wire-break detection and clear the $\overline{WB}$ output and set $\overline{WB}$ output to high impedance. WBREQ can be set high either when the high-side switch is on (IN is high) or when the switch is off (IN is low). In both cases, the switch turns on and the OUT voltage is within 1V of the V_{DD} supply.

If the load current is lower than the wire-break threshold current, a wire-break condition is signaled by asserting $\overline{WB}$ output low. The $\overline{WB}$ output is real-time and not latched. If the load current is close to the wire-break threshold current and varies, typically with charging or discharging capacitive loads, the $\overline{WB}$ output changes dynamically in real-time when the WBREQ is driven high.

When the WBREQ is set high, the high-side switch has a voltage drop of 800mV (typ) below the V_{DD} supply. A large continuous load current results in significant heating due to the power dissipation associated with this voltage drop in the high-side switch. Enable the wire-break detection using a short pulse to avoid unnecessary heat on the high-side switch. See the *Wire-Break Detection with Large Load Current* section for more information.

IMON Current Monitor

The MAX22910 features a load current monitor output at IMON that allows the load current to be monitored with high accuracy. Connect a resistor from IMON to GND to convert the IMON current into a voltage to use with an external monitoring circuit such as an MCU with an integrated ADC. The maximum voltage at IMON output is limited to 1.4V (max).

Drive DIAGEN high to enable IMON current output. IMON current output is high-impedance when DIAGEN is set low. Use DIAGEN to select and monitor IMON currents among multiple MAX22910s by connecting all IMON current outputs to a common resistor.

The IMON output current is 1/20900 (typ) of the load current. For load current between 0.7A and 2A, the accuracy is ±6%; for load current between 2A and 9A, the accuracy is ±4%. The IMON accuracy is calculated using the following equation:

$$\text{IMON Accuracy (\%)} = [I_{OUT}\text{ (A)} / \text{IMON (A)} - 20900\text{ (A/A)}] / 20900\text{ (A/A)} \times 100\%$$

IMON output has an ultra-fast transient response with a response time less than 1µs (typ), as shown in Figure 4.

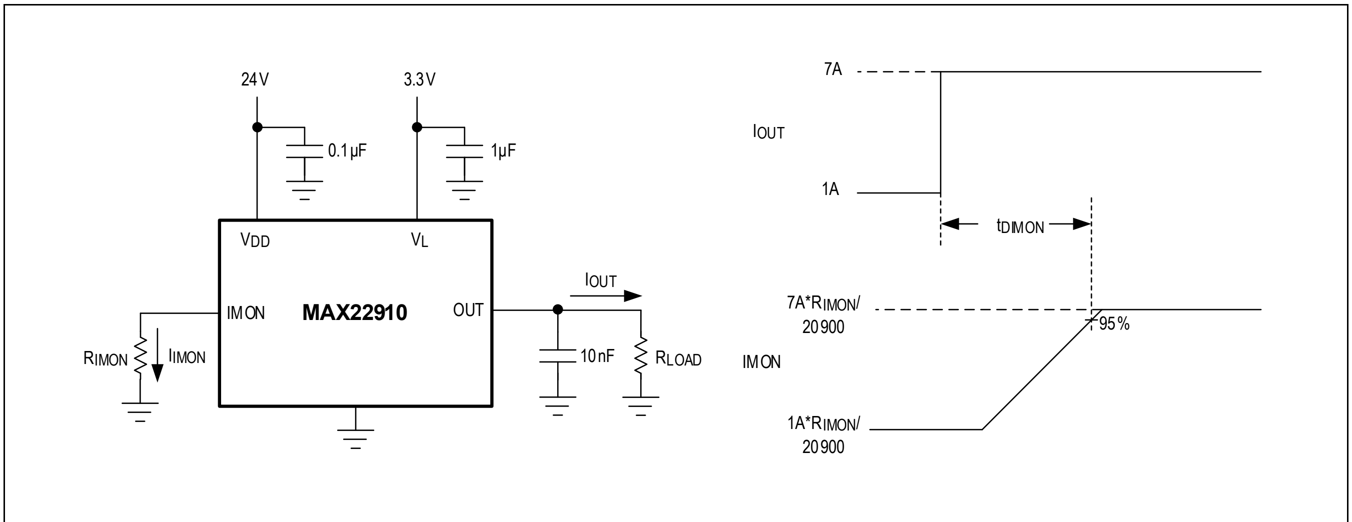


Figure 4. IMON Response Time

Load Current Limiting

The MAX22910 high-side switch limits the load current as set by the CURLIM resistor, R_{LIM}. The current limit ranges from 0.7A to 9A with ±10% accuracy when WBREQ is set low. Use the following equation and see Table 2 to find the required CURLIM resistor value:

$$R_{LIM}\ (\Omega) = 0.7\text{ (V)} \times 20900\text{ (A/A)} / I_{LIM}\text{ (A)}$$

Table 2. Load Current Limiting Range

I_{LIM} (A)	0.7	2	4	7	9
R_{LIM} (kΩ)	20.9	7.315	3.658	2.09	1.625

During current limiting, the CURLIM voltage is regulated at 0.7V (typ).

Applications Information

Inductive Load Switching

During inductive load switching-off, it is required to dissipate the inductive kickback energy properly to avoid the MAX22910 being damaged by the voltage at OUT exceeding its *Absolute Maximum Ratings*. The ground-connected inductive load results in a negative kickback voltage at the high-side switch output. The MAX22910 does not have an internal clamp to protect the device from such kickback energy. Thus, it requires an external TVS diode to safely clamp the voltage and dissipate the kickback energy.

Select a TVS diode that limits the (V_{DD} – OUT) voltage to less than +85V (max), and with its power rating and package size can safely dissipate the kickback energy within the required turn-off time. A diode with a higher clamping voltage results in a faster turn-off time.

The TVS diode can be ground-referenced or V_{DD}-referenced. A ground-referenced TVS diode has the advantage that the energy dissipated in the diode is much lower than that of a V_{DD}-referenced diode, which eases the selection of a TVS diode. A V_{DD}-reference TVS diode has the advantage that the kickback energy can be dissipated in the diode faster at a lower supply voltage, but the clamping energy is much higher and can be up to 2x of the load inductive energy, depending upon the supply voltage and clamping voltage.

Figure 5 shows the MAX22910 configured in a high-side digital output application supporting up to 60V supply voltage while achieving 36.7V (min) inductive clamping voltage with a V_{DD} supply of +30V. The TVS diode allows for inductive energy clamping of a 1.2H/2.4A load with up to a 60V supply voltage.

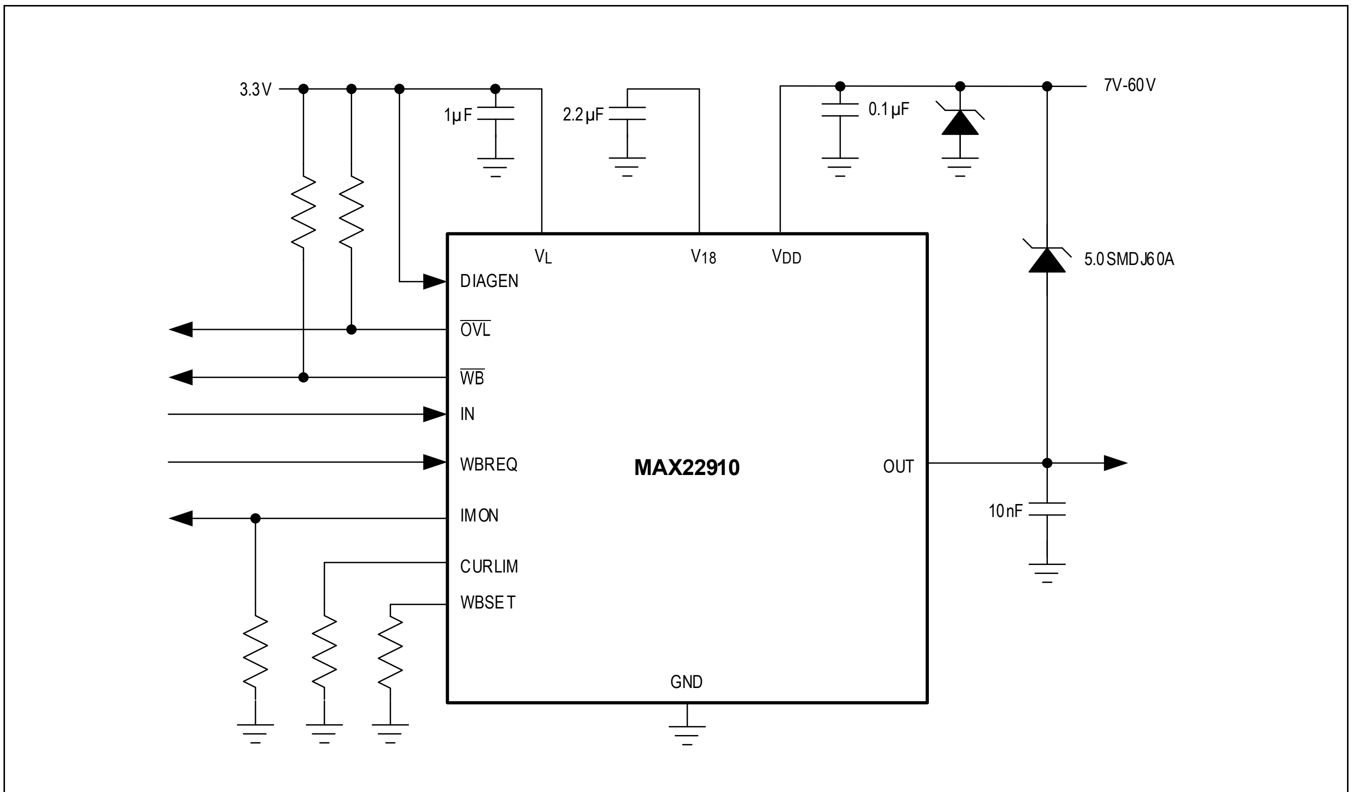


Figure 5. Inductive Energy Clamping with V_{DD}-referenced TVS Diode

Sharing Diagnostic Outputs

The IMON, $\overline{OVL}$, and $\overline{WB}$ diagnostic outputs are high impedance when the DIAGEN input is driven low, allowing sharing of these diagnostic outputs from multiple MAX22910s. Figure 6 shows two MAX22910s controlled by a single microcontroller with 8 digital I/Os and one integrated ADC input. Select the IMON resistor to ensure the voltage at the IMON current output is below +1.4V (max) for all devices.

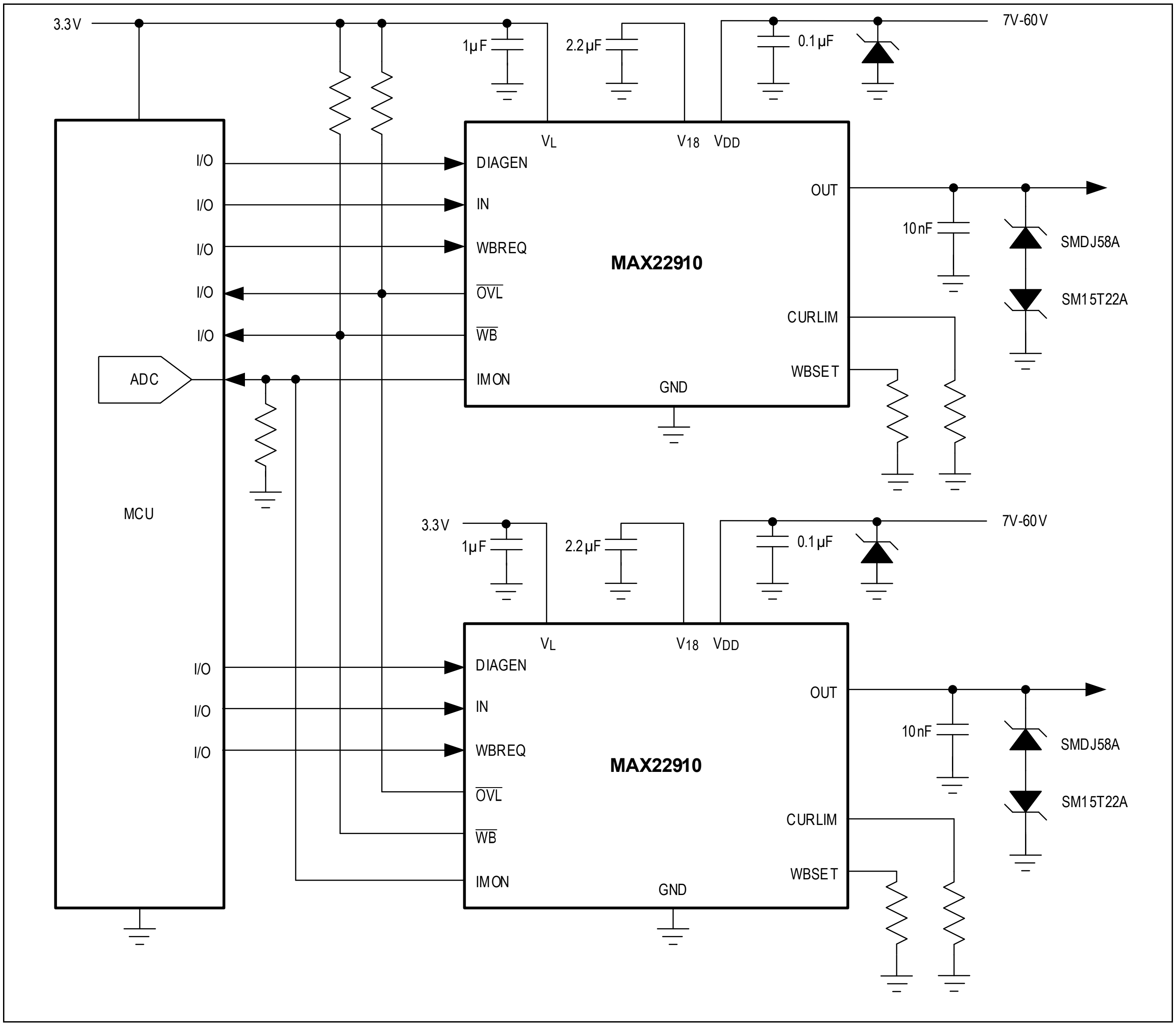


Figure 6. Sharing of Diagnostic Outputs

Wire-Break Detection with Large Load Current

To avoid significant heating of the MAX22910 under high load current due to the 800mV (typ) voltage drop between OUT and V_{DD} when the WBREQ is driven high, enable wire-break detection using a short pulse as described below:

- Drive IN high and turn on the high-side switch.
- Check the load current via the IMON current monitor output. Typically, the load current is much larger than the wire-break threshold current.
- If the load current is abnormally small, enable wire-break detection by driving a short pulse at WBREQ to avoid excessive heating.
- Verify the wire-break condition at $\overline{WB}$ output after the wire-break valid delay, as shown in *Figure 2* and *Figure 3*. The $\overline{WB}$ is asserted to be low if the load current is less than the wire-break threshold current.
- Drive WBREQ low after completing the wire-break detection.

Reverse Current into OUT

Load current flows reversely into the MAX22910 from the OUT pin when it is pulled higher than the V_{DD} supply voltage. It results in heating up of the switch due to the internal reverse current that flows from V_{DD} to GND. The internal current is proportional to the reverse load current flowing into OUT. High reverse load current into OUT can damage the device thermally. At 25°C ambient temperature, the reverse load current into OUT should be limited to 1.3A at V_{DD} = 36V and 1.5A at V_{DD} = 24V. Connect a reverse current protection device, such as an active diode, to the V_{DD}, to block the reverse load current flowing into the device if such a high reverse load current is expected.

Transient Protection

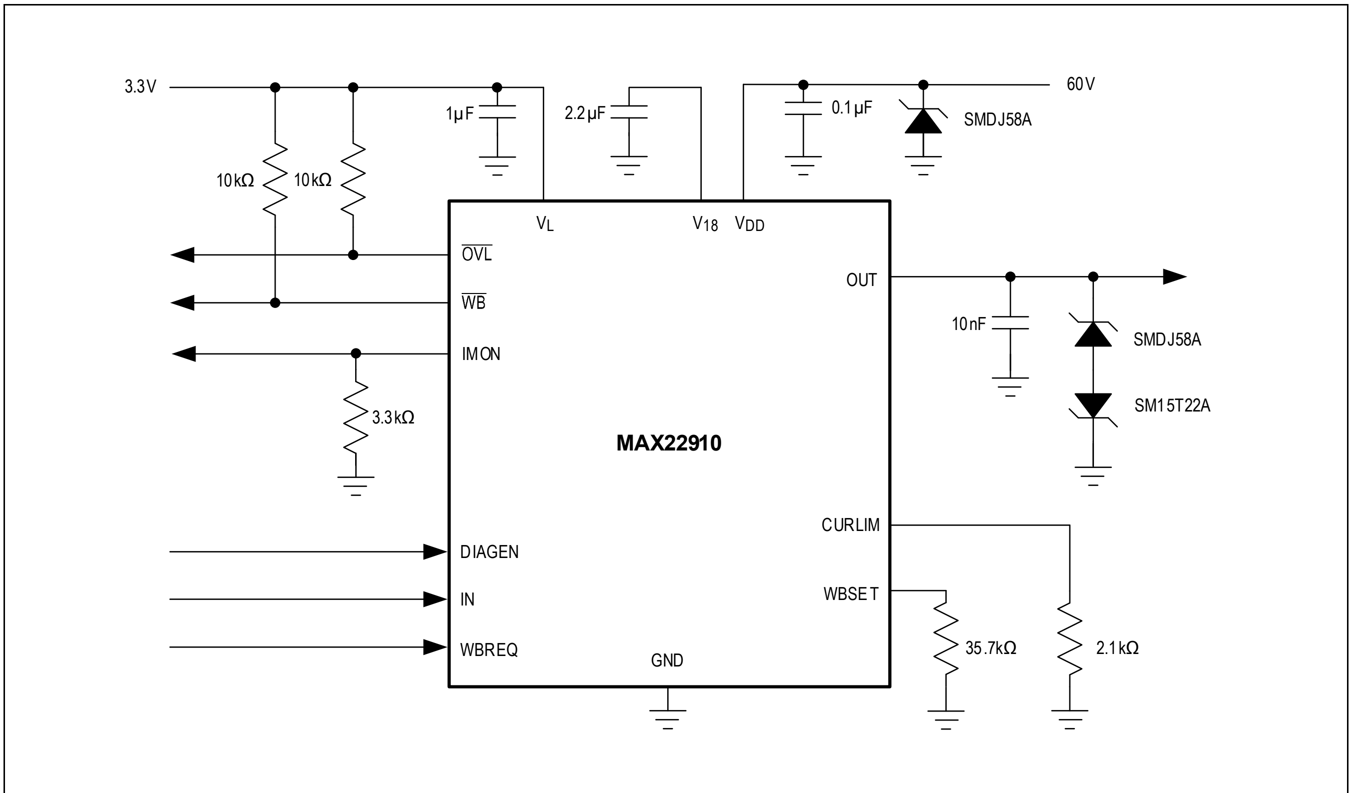
The MAX22910 needs to be protected against surge and ESD transients applied to OUT and V_{DD} with suitable TVS diodes that clamp the voltage at the OUT pin to (V_{DD} − 85V) (max), and the voltage at the V_{DD} pin to +85V (max). Connect proper TVS diodes between V_{DD}, OUT to GND to protect the MAX22910. Examples of suitable TVS diodes against ±2kV/42Ω surge, ±8kV contact ESD, and ±15kV airgap ESD are 5.0SMDJ60A, SMDJ54A, SMCJ48A, and SMBJ36A.

The transient current caused by positive surge and/or ESD voltages applied to the OUT pin flows through the body diode of the switch to the V_{DD} supply, which is clamped by the TVS diode connected to the V_{DD} pin. The MAX22910 device can tolerate +2kV/42Ω surge, +10kV contact ESD, and +15kV airgap ESD applied to its OUT pin.

Connect a 10nF/100V capacitor between OUT to GND to filter the EFT and conducted immunity noises.

Typical Application Circuits

60V, 7A Output, with 5mA Wire-Break Threshold



Ordering Information

PART NUMBER	TEMP RANGE	PIN-PACKAGE
MAX22910AFD+	-40°C to +125°C	23-Pin FC2QFN
MAX22910AFD+T	-40°C to +125°C	23-Pin FC2QFN

+Denotes a lead(Pb)-free/RoHS-compliant package.
T = Tape and reel.

Chip Information

PROCESS: BiCMOS

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	11/23	Release for market introduction	—
1	01/24	Updated Absolute Maximum Ratings section	2