

Power Distribution Controllers

This family of fully featured hot swap power controllers targets applications in the +2.5V to +12V range. The ISL6115 is for +12V control, the ISL6116 for +5V, the ISL6117 for +3.3V and the ISL6120 for +2.5V control applications. Each has a hard wired undervoltage (UV) monitoring and reporting threshold level approximately 80% of the aforementioned voltage.

The ISL6115 has an integrated charge pump allowing control of up to +16V rails using an external N-Channel MOSFET whereas the other devices utilize the +12V bias voltage to fully enhance the N-channel pass FET. All ICs feature programmable overcurrent (OC) detection, current regulation (CR) with time delay to latch off and soft start.

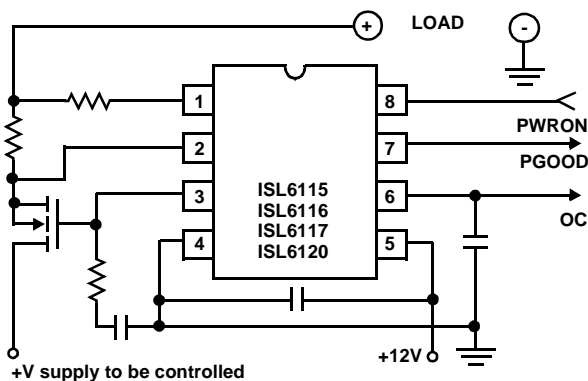
The current regulation level is set by 2 external resistors; R_{ISET} sets the CR V_{th} and the other is a low ohmic sense element across which the CR V_{th} is developed. The CR duration is set by an external capacitor on the CTIM pin which is charged with a 20uA current once the CR V_{th} level is reached. If the voltage on the CTIM cap reaches 1.9V the IC then quickly pulls down the GATE output latching off the pass FET.

This family although designed for high side switch control the ISL6116/17/20 can also be used in a low side configuration for control of much higher voltage potentials.

Ordering Information

PART NUMBER	TEMP. RANGE (°C)	PACKAGE	PKG. NO.
ISL6115CB	0 to 85	8 Lead SOIC	M8.15
ISL6116CB	0 to 85	8 Lead SOIC	M8.15
ISL6117CB	0 to 85	8 Lead SOIC	M8.15
ISL6120CB	0 to 85	8 Lead SOIC	M8.15

Application One - High Side Controller



Features

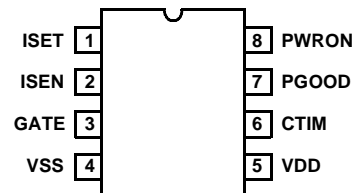
- HOT SWAP Single Power Distribution Control (ISL6115 for +12V, ISL6116 for +5V, ISL6117 for +3.3V and ISL6120 for +2.5V)
- Overcurrent Fault Isolation
- Programmable Current Regulation Level
- Programmable Current Regulation Time to Latch-Off
- Rail to Rail Common Mode Input Voltage Range (ISL6115)
- Internal Charge Pump Allows the use of N-Channel MOSFET for +12V control (ISL6115)
- Undervoltage and Overcurrent Latch Indicators
- Adjustable Turn-On Ramp
- Protection During Turn On
- Two Levels of Overcurrent Detection Provide Fast Response to Varying Fault Conditions
- 1µs Response Time to Dead Short

Applications

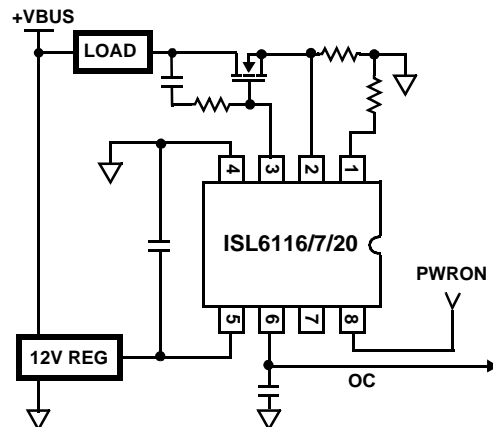
- Power Distribution Control
- Hot Plug Components and Circuitry

Pinout

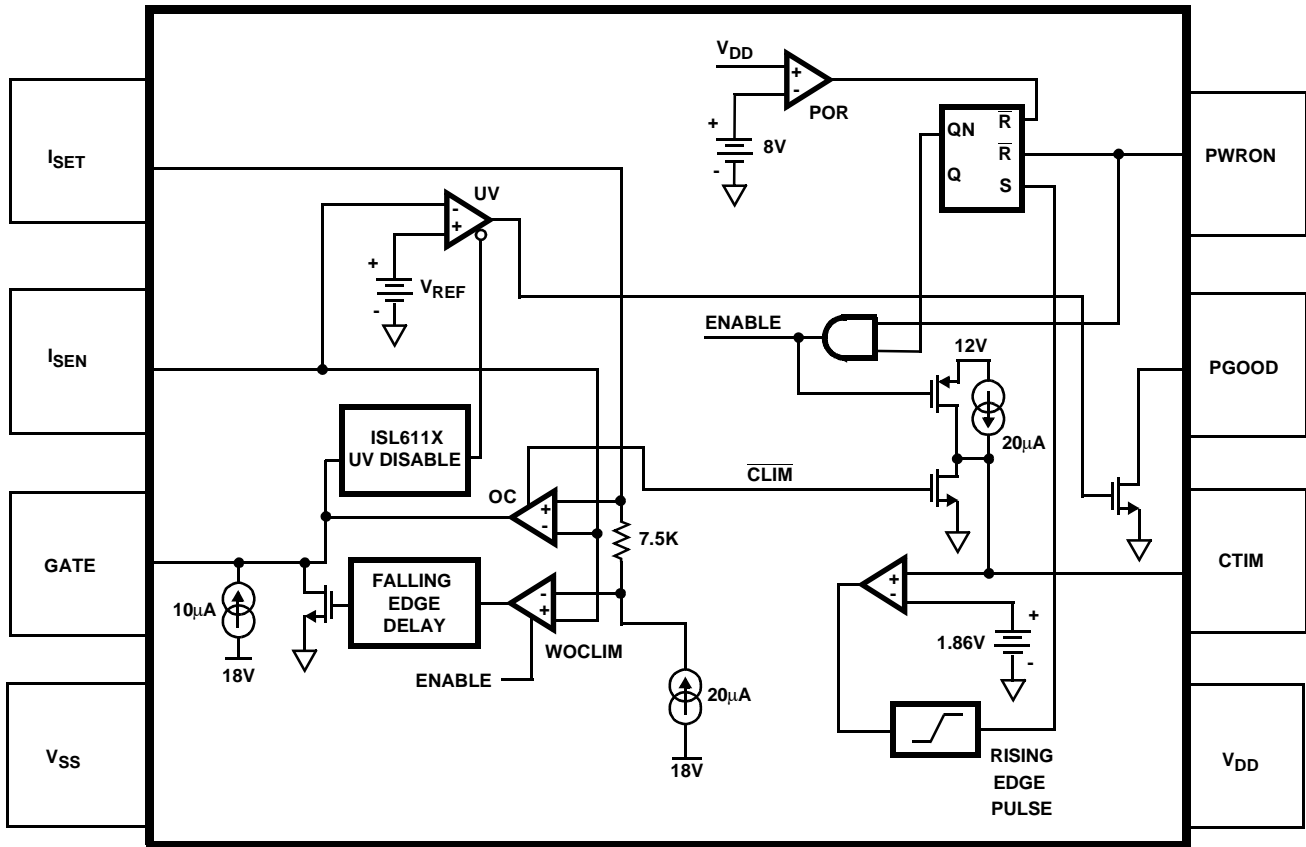
ISL6115, ISL6116, ISL6117, ISL6120 (SOIC)
TOP VIEW



Application Two - Low Side Controller



Simplified Block Diagram



Pin Descriptions

PIN #	SYMBOL	FUNCTION	DESCRIPTION
1	ISET	Current Set	Connect to the low side of the current sense resistor through the current limiting set resistor. This pin functions as the current limit programming pin.
2	ISEN	Current Sense	Connect to the more positive end of sense resistor to measure the voltage drop across this resistor.
3	GATE	External FET Gate Drive Pin	Connect to the gate of the external N-Channel MOSFET. A capacitor from this node to ground sets the turn-on ramp. At turn-on this capacitor will be charged to $V_{DD} + 5V$ (ISL6115) and to V_{DD} (ISL6116,17,20) by a $10\mu A$ current source.
4	VSS	Chip Return	
5	V_{DD}	Chip Supply	12V chip supply. This can be either connected directly to the +12V rail supplying the switched load voltage or to a dedicated $V_{SS} + 12V$ supply.
6	CTIM	Current Limit Timing Capacitor	Connect a capacitor from this pin to ground. This capacitor determines the time delay between an overcurrent event and chip output shutdown (current limit time-out). The duration of current limit time-out is equal to $93k\Omega \times C_{TIM}$.
7	PGOOD	Power Good Indicator	Indicates that the voltage on the ISEN pin is satisfactory. PGOOD is driven by an open drain N-Channel MOSFET and is pulled low when the output voltage (V_{ISEN}) is less than the UV level for the particular IC.
8	PWRON	Power ON	PWRON is used to control and reset the chip. The chip is enabled when PWRON pin is driven high or is open. After a current limit time out, the chip is reset by a low level signal applied to this pin. This input has $20\mu A$ pull up capability.

ISL6115, ISL6116, ISL6117, ISL6120

Absolute Maximum Ratings $T_A = 25^{\circ}\text{C}$

V_{DD}	-0.3V to +16V
GATE	-0.3V to $V_{DD}+8\text{V}$
ISEN, PGOOD, PWRON, CTIM, ISET	-0.3V to $V_{DD} + 0.3\text{V}$
ESD Classification	5kV

Operating Conditions

V_{DD} Supply Voltage Range	+12V $\pm 15\%$
Temperature Range (T_A)	0°C to 85°C

Thermal Information

Thermal Resistance (Typical, Note 1)	θ_{JA} ($^{\circ}\text{C}/\text{W}$)
SOIC Package	98
Maximum Junction Temperature (Plastic Package)	150°C
Maximum Storage Temperature Range	-65°C to 150°C
Maximum Lead Temperature (Soldering 10s)	300°C (SOIC - Lead Tips Only)

CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

NOTES:

- θ_{JA} is measured with the component mounted on a high effective thermal conductivity test board in free air. (See Tech Brief, #TB379.1 for details.)
- All voltages are relative to GND, unless otherwise specified.

Electrical Specifications $V_{DD} = 12\text{V}$, $T_A = T_J = 0^{\circ}\text{C}$ to 85°C , Unless Otherwise Specified

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNITS
CURRENT CONTROL						
ISET Current Source	I_{ISET_ft}		18.5	20	21.5	μA
ISET Current Source	I_{ISET_pt}	$T_J = 15^{\circ}\text{C}$ to 55°C	19	20	21	μA
Current Limit Amp Offset Voltage	V_{io_ft}	$V_{ISET} - V_{ISEN}$	-6	0	6	mV
Current Limit Amp Offset Voltage	V_{io_pt}	$V_{ISET} - V_{ISEN}$, $T_J = 15^{\circ}\text{C}$ to 55°C	-2	0	2	mV
GATE DRIVE						
GATE Response Time To Severe OC	pd_woc_amp	V_{GATE} to 10.8V	-	100	-	ns
GATE Response Time to Overcurrent	pd_oc_amp	V_{GATE} to 10.8V	-	600	-	ns
GATE Turn-On Current	I_{GATE}	V_{GATE} to = 6V	8.4	10	11.6	μA
GATE Pull Down Current	$OC_GATE_I_4V$	Overcurrent	45	75		mA
GATE Pull Down Current	$WOC_GATE_I_4V$	Severe Overcurrent	0.5	0.8	1.5	A
ISL6115 Undervoltage Threshold	$12V_{UV_VTH}$		9.2	9.6	10	V
ISL6115 GATE High Voltage	$12VG$	GATE Voltage	$V_{DD}+4.5\text{V}$	$V_{DD}+5\text{V}$	-	V
ISL6116 Undervoltage Threshold	$5V_{UV_VTH}$		4.0	4.35	4.5	V
ISL6117 Undervoltage Threshold	$3V_{UV_VTH}$		2.4	2.6	2.8	V
ISL6120 Undervoltage Threshold	$2V_{UV_VTH}$		1.8	1.85	1.9	V
ISL6116,17,20 GATE High Voltage	VG	GATE Voltage	$V_{DD}-1.5\text{V}$	V_{DD}	-	V
BIAS						
V_{DD} Supply Current	I_{VDD}		-	3	5	mA
V_{DD} POR Rising Threshold	$V_{DD_POR_L2H}$	VDD Low to High	7.8	8.4	9	V
V_{DD} POR Falling Threshold	$V_{DD_POR_H2L}$	VDD High to Low	7.5	8.1	8.7	V
V_{DD} POR Threshold Hysteresis	$V_{DD_POR_HYS}$	$V_{DD_POR_L2H} - V_{DD_POR_H2L}$	0.1	0.3	0.6	V
PWRON Pull-Up Voltage	$PWRN_V$	PWRON Pin Open	2.7	3.2	-	V
PWRON Rising Threshold	PWR_Vth		1.4	1.7	2.0	V
PWRON Hysteresis	PWR_hys		130	170	250	mV
PWRON Pull-Up Current	$PWRN_I$		9	17	25	μA
CURRENT REGULATION DURATION						
C_{TIM} Charging Current	C_{TIM_ichg0}	$V_{CTIM} = 0\text{V}$	16	20	23	μA
C_{TIM} Fault Pull-Up Current			16	20	23	mA
Current Limit Time-Out Threshold Voltage	C_{TIM_Vth}	C_{TIM} Voltage	1.3	1.8	2.3	V

Description and Operation

The members of this family are single power supply distribution controllers for generic hot swap applications across the +2.5V to +12V supply range. The ISL6115 is targeted for +12V switching applications whereas the ISL6116 is targeted for +5V, the ISL6117 for +3.3V and the ISL6120 for +2.5V applications. Each IC has a hardwired undervoltage (UV) threshold level approximately 17% lower than the stated voltages.

These ICs feature a highly accurate programmable overcurrent (OC) detecting comparator, programmable current regulation (CR) with programmable time delay to latch off, and programmable soft start turn-on ramp all set with a minimum of external passive components. The ICs also include severe OC protection that immediately shuts down the MOSFET switch should a rapid load current transient such as a near dead short cause the CR V_{th} to exceed the programmed level by 150mV. Additionally, the ICs have an UV indicator and an OC latch indicator. The functionality of the PGOOD feature is enabled once the IC is biased, monitoring and reporting any UV condition on the ISEN pin.

Upon initial power up, the IC can either isolate the voltage supply from the load by holding the external N-Channel MOSFET switch off or apply the supply rail voltage directly to the load for true hot swap capability. The PWRON pin must be pulled low for the device to isolate the power supply from the load by holding the external N-channel MOSFET off. With the PWRON pin held high or floating the IC will be in true hot swap mode. In both cases the IC turns on in a soft start mode protecting the supply rail from sudden in-rush current.

At turn-on, the external gate capacitor of the N-Channel MOSFET is charged with a 10μA current source resulting in a programmable ramp (soft start turn-on). The internal ISL6115 charge pump supplies the gate drive for the 12V supply switch driving that gate to ~V_{DD} +5V, for the other three ICs the gate drive voltage is limited to the chip bias voltage, VDD.

Load current passes through the external current sense resistor. When the voltage across the sense resistor exceeds the user programmed CR voltage threshold value, (See Table 1 for R_{ISET} programming resistor value and resulting nominal current regulation threshold voltage, V_{CR}) the controller enters its current regulation mode. At this time, the time-out capacitor, on C_{TIM} pin is charged with a 20μA current source and the controller enters the current limit time to latch-off period. The length of the current limit time to latch-off duration is set by the value of a single external capacitor (see Table 2 for C_{TIM} capacitor value and resulting nominal current limited time out to latch-off duration) placed from the C_{TIM} pin (pin 6) to ground. The programmed current level is held until either the OC event passes or the time out period expires. If the former

is the case then the N-Channel MOSFET is fully enhanced and the C_{TIM} capacitor is discharged. Once C_{TIM} charges to 1.87V, signaling that the time out period has expired an internal latch is set whereby the FET gate is quickly pulled to 0V turning off the N-Channel MOSFET switch, isolating the faulty load.

TABLE 1.

R _{ISET} RESISTOR	NOMINAL OC V _{TH}
10kΩ	200mV
4.99kΩ	100mV
2.5kΩ	50mV
750Ω	15mV

NOTE: Nominal V_{th} = R_{ISET} × 20μA.

TABLE 2.

C _{TIM} CAPACITOR	NOMINAL CURRENT LIMITED PERIOD
0.022μF	2ms
0.047μF	4.4ms
0.1μF	9.3ms

NOTE: Nominal time-out period = C_{TIM} × 93kΩ.

This IC responds to a severe overcurrent load (defined as a voltage across the sense resistor >150mV over the OC V_{th} set point) by immediately, driving the N-Channel MOSFET gate to 0V in about 10μs. The gate voltage is then slowly ramped up turning on the N-Channel MOSFET to the programmed current regulation level, this is the start of the time out period.

Upon an UV condition the PGOOD signal will pull low when tied high through a resistor to the logic or VDD supply. This pin is an UV fault indicator. For an OC latch off indication, monitor C_{TIM}, pin 6. This pin will rise rapidly from 1.9V to VDD once the time out period expires.

See Figures 12 to 16 for waveforms relevant to text.

The IC is reset after an OC latch-off condition by a low level on the PWRON pin and is turned on by the PWRON pin being driven high.

Application Considerations

During the soft start and the time-out delay duration with the IC in its current limit mode, the V_{GS} of the external N-Channel MOSFET is reduced driving the MOSFET switch into a (linear region) high r_{DS(ON)} state. Strike a balance between the CR limit and the timing requirements to avoid periods when the external N-Channel MOSFETs may be damaged or destroyed due to excessive internal power dissipation. Refer to the **MOSFET SOA** information in the manufacturers data sheet.

When driving particularly large capacitive loads a longer soft start time to prevent current regulation upon charging and a short CR time may offer the best application solution relative to reliability and FET MTF.

Physical layout of R_{SENSE} resistor is critical to avoid the possibility of false overcurrent occurrences. Ideally trace routing between the R_{SENSE} resistors and the IC is as direct

and as short as possible with zero current in the sense lines.
(See Figure 1.)

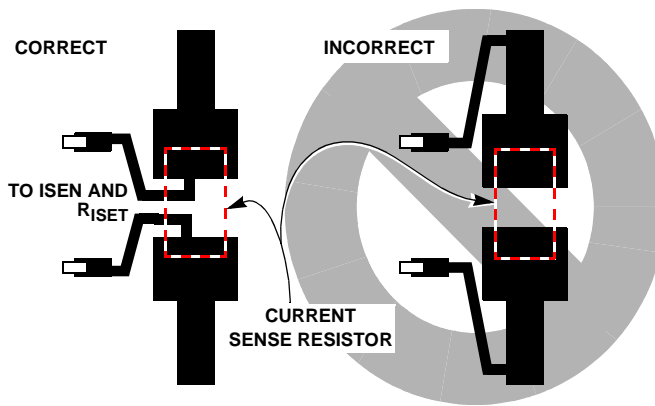


FIGURE 1. SENSE RESISTOR PCB LAYOUT

Using the ISL6116 as a -48V Low Side Hot Swap Power Controller

To supply the required V_{DD} , it is necessary to maintain the chip supply 10 to 16V above the -48V bus. This may be accomplished with a suitable regulator between the voltage rail and pin 5 (VDD). By using a regulator, the designer may ignore the bus voltage variations. However, a low-cost alternative is to use a Zener diode (See Figure 2 for typical 5A load control) this option is detailed below.

Note that in this configuration the PGOOD feature (pin 7) is not operational as the I_{SEN} pin voltage is always < UV threshold.

See Figures 17 to 20 for waveforms relevant to -48V and other high voltage application.

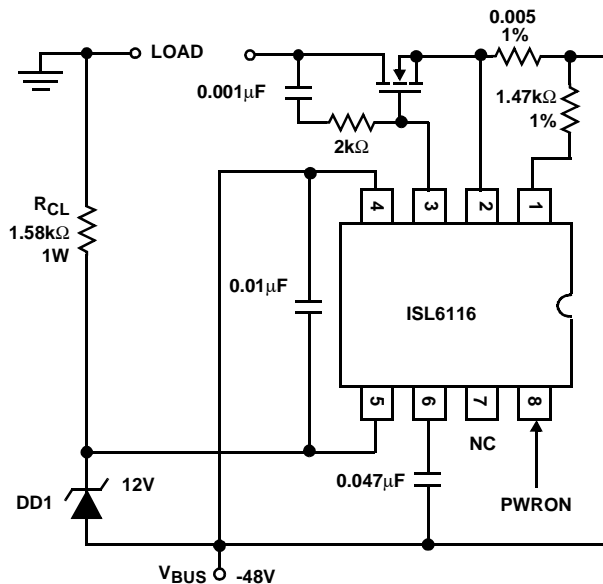


FIGURE 2.

Biasing the ISL6116

Table 3 gives typical component values for biasing the ISL6116 in a $\pm 48V$ application. The formulas and calculations deriving these values are also shown below.

TABLE 3. TYPICAL VALUES FOR A -48V HOT SWAP APPLICATION

SYMBOL	PARAMETER
R_{CL}	1.58k Ω , 1W
DD1	12V Zener Diode, 50mA Reverse Current

When using the ISL6116 to control -48V, a Zener diode may be used to provide the +12V bias to the chip. If a Zener is used then a current limit resistor should also be used. Several items must be taken into account when choosing values for the current limit resistor (R_{CL}) and Zener Diode (DD1):

- The variation of the V_{BUS} (in this case, -48V nominal)
- The chip supply current needs for all functional conditions
- The power rating of R_{CL} .
- The current rating of DD1

Formulas

1. Sizing R_{CL} :
 $R_{CL} = (V_{BUS,MIN} - 12) / I_{CHIP}$
2. Power Rating of R_{CL} :
 $P_{RCL} = I_C (V_{BUS,MAX} - 12)$
3. DD1 Current Rating:
 $I_{DD1} = (V_{BUS,MAX} - 12) / R_{CL}$

Example

A typical -48V supply may vary from -36 to -72V. Therefore,
 $V_{BUS,MAX} = -72V$
 $V_{BUS,MIN} = -36V$

$I_{CHIP} = 15mA$ (max)

Sizing R_{CL} :

$$R_{CL} = (V_{BUS,MIN} - 12) / I_C$$

$$R_{CL} = (36 - 12) / 0.015$$

$$R_{CL} = 1.6k\Omega \text{ [Typical Value = 1.58k}\Omega\text{]}$$

Power Rating of R_{CL} :

$$P_{RCL} = I_C (V_{BUS,MAX} - 12)$$

$$P_{RCL} = (0.015)(72 - 12)$$

$$P_{RCL} = 0.9W \text{ [Typical Value = 1W]}$$

DD1 Current Rating:

$$I_{DD1} = (V_{BUS,MAX} - 12) / R_{CL}$$

$$I_{DD1} = (72 - 12) / 1.58k\Omega$$

$$I_{DD1} = 38mA \text{ [Typical Value = 12V rating, 50mA reverse current]}$$

Typical Performance Curves

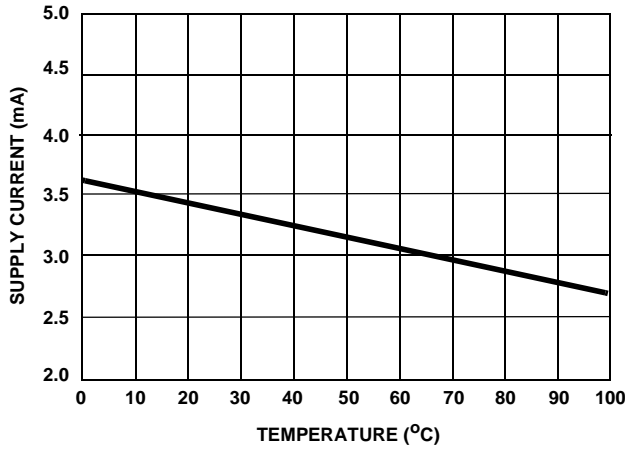


FIGURE 3. VDD BIAS CURRENT

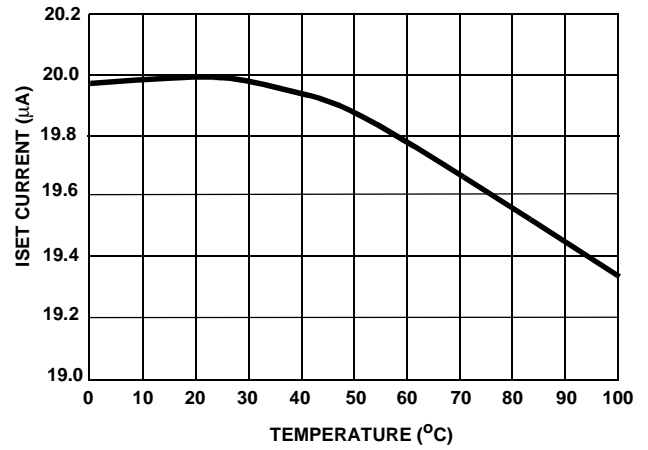


FIGURE 4. ISET SOURCE CURRENT

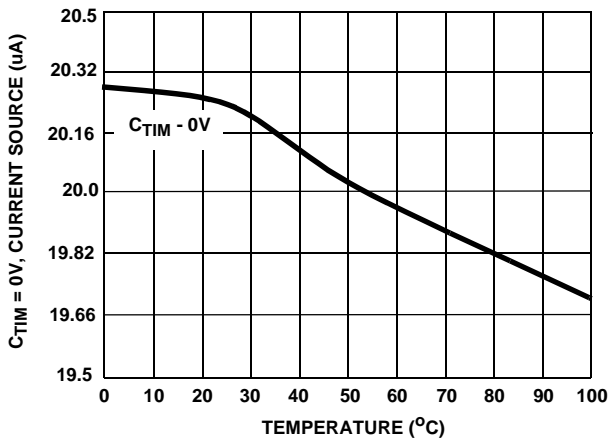


FIGURE 5. C_{TIM} CURRENT SOURCE

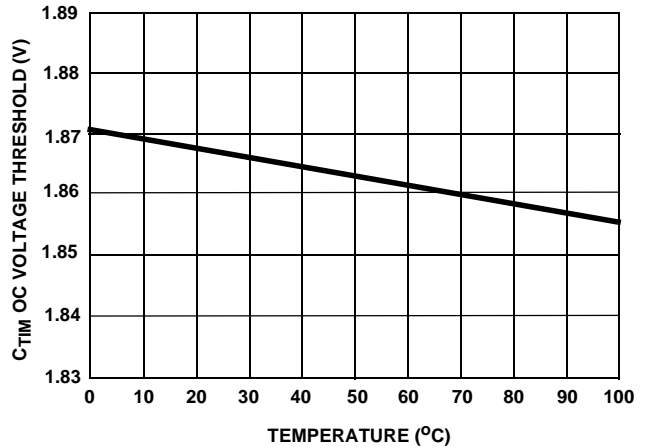


FIGURE 6. C_{TIM} OC VOLTAGE THRESHOLD

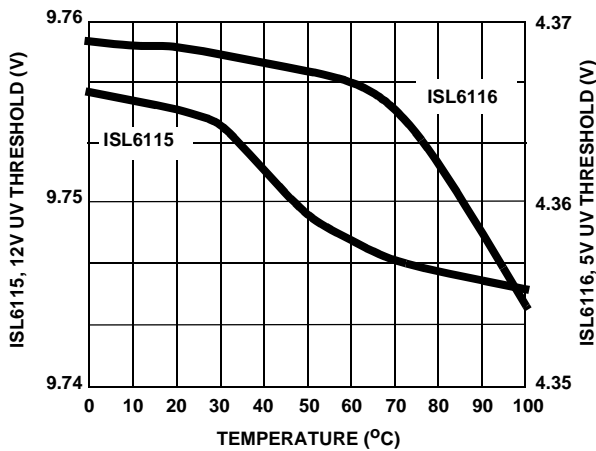


FIGURE 7. ISL6115/6116 UV THRESHOLD

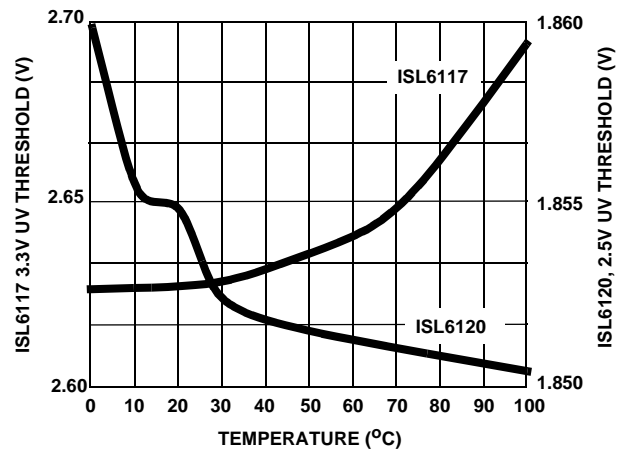


FIGURE 8. ISL6117/6120 UV THRESHOLD

Typical Performance Curves (Continued)

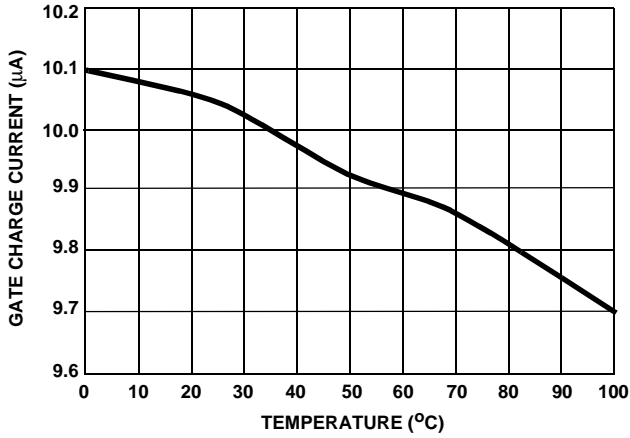


FIGURE 9. GATE CHARGE CURRENT

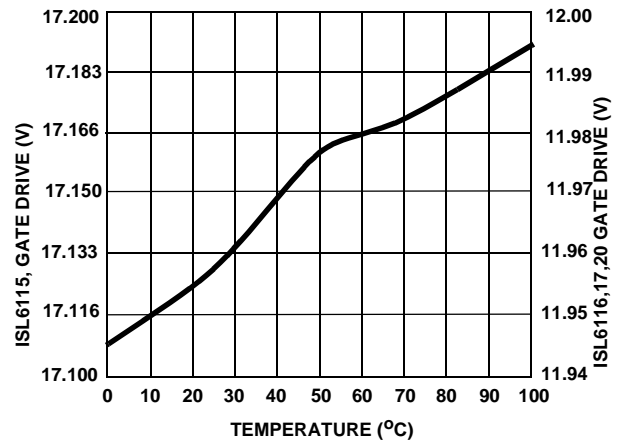


FIGURE 10. GATE DRIVE VOLTAGE, VDD = 12V

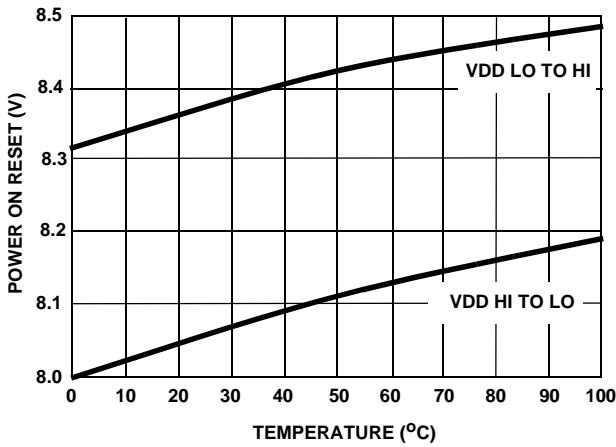
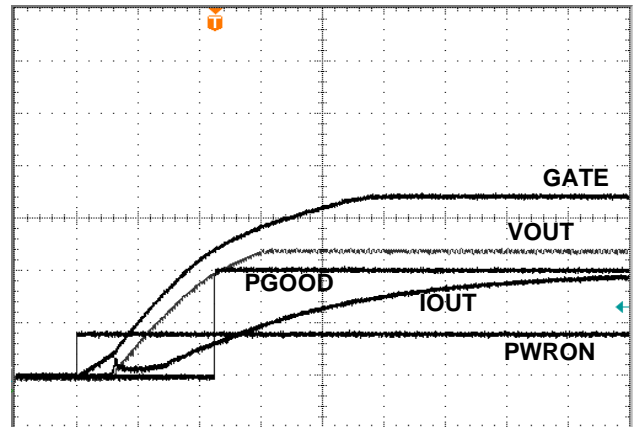
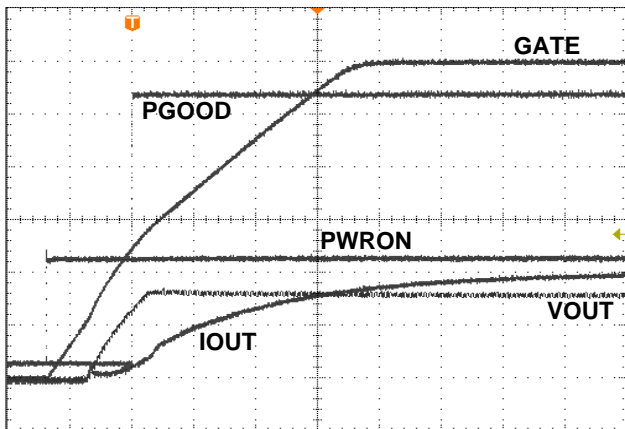


FIGURE 11. POWER ON RESET VOLTAGE THRESHOLD



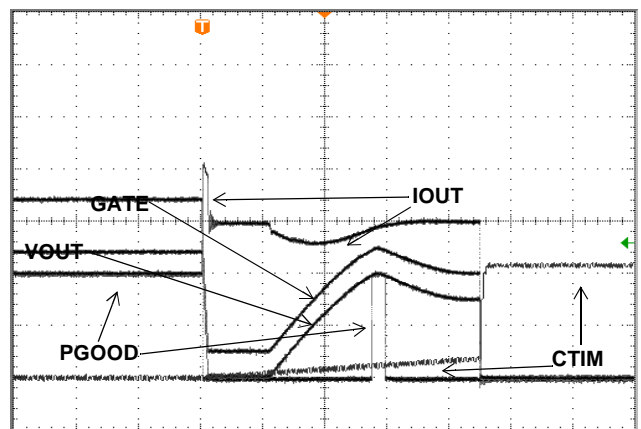
5V/DIV. 0.5A/DIV 1ms/DIV.

FIGURE 12. ISL6115 +12V TURN-ON



2V/DIV. 0.5A/DIV 1ms/DIV.

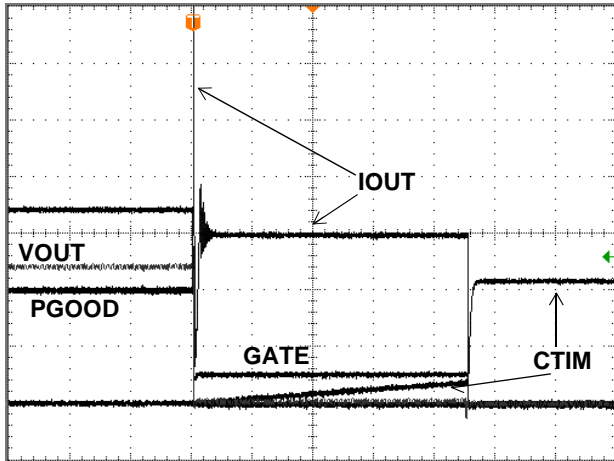
FIGURE 13. ISL6116 +5v TURN-ON



5V/DIV. 0.5A/DIV 1ms/DIV.

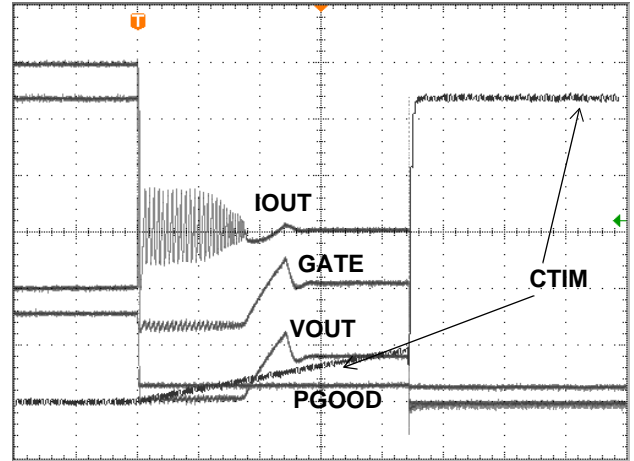
FIGURE 14. ISL6115 'LOW' OVER CURRENT RESPONSE

Typical Performance Curves (Continued)



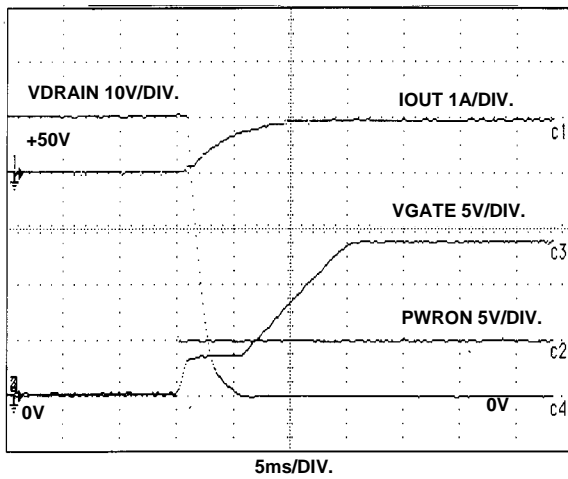
5V/DIV. 0.5A/DIV 1ms/DIV.

FIGURE 15. ISL6115 'HIGH' OVER CURRENT RESPONSE



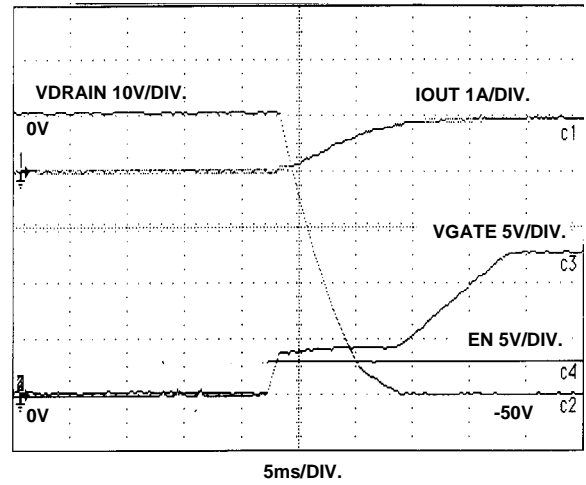
2V/DIV. 0.5A/DIV 1ms/DIV.

FIGURE 16. ISL6116 'HIGH' OVER CURRENT RESPONSE



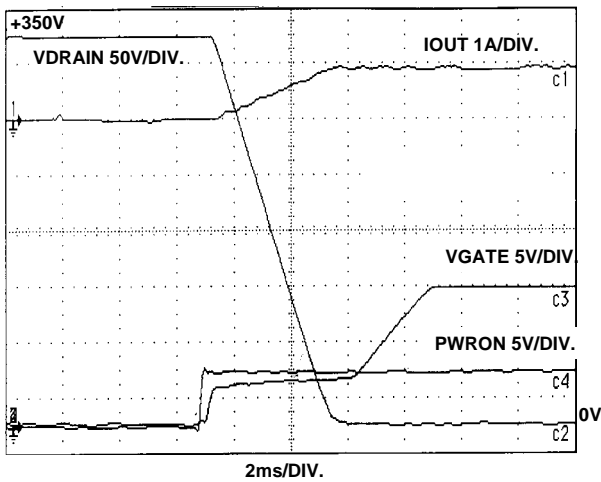
5ms/DIV.

FIGURE 17. +50V LOW SIDE SWITCHING CGATE = 100pF



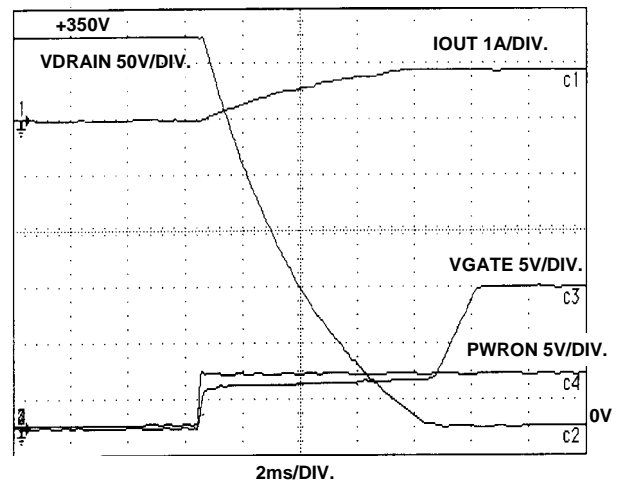
5ms/DIV.

FIGURE 18. -50V LOW SIDE SWITCHING CGATE = 1000pF



2ms/DIV.

FIGURE 19. +350V LOW SIDE SWITCHING CGATE = 100pF



2ms/DIV.

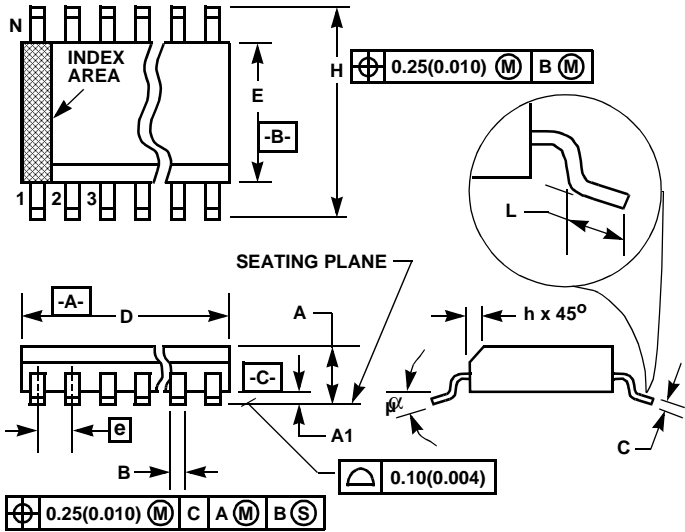
FIGURE 20. +350V LOW SIDE SWITCHING CGATE = 1000pF

ISL6115, ISL6116, ISL6117, ISL6120

TABLE 4. BILL OF MATERIALS, ISL6115EVAL1, ISL6116EVAL1

COMPONENT DESIGNATOR	COMPONENT NAME	COMPONENT DESCRIPTION
Q1	HUF76132SK8	11.5mΩ, 30V, 11.5A Logic Level N-Channel Power MOSFET or equiv.
Q2	HUF7554S3S	10mΩ, 80V, 75A N-Channel Power MOSFET or equiv.
R1	Load Current Sense Resistor	Dale, WSL-2512 10mΩ 1W Metal Strip Resistor
HIGH SIDE R2	Overcurrent Voltage Threshold Set Resistor	750Ω 805 Chip Resistor (Vth = 15mV)
LOWSIDE R2	Overcurrent Voltage Threshold Set Resistor	1.21kΩ 805 Chip Resistor (Vth = 24mV)
C2	Time Delay Set Capacitor	0.047μF 805 Chip Capacitor (4.5ms)
C1	Gate Timing Capacitor	0.001μF 805 Chip Capacitor (<2ms)
C3	IC Decoupling Capacitor	0.1μF 805 Chip Capacitor
R3	Gate Stability Resistor	20Ω 805 Chip Resistor
R7	Gate to Drain Resistor	2kΩ 805 Chip Resistor
JP1	Bias Voltage Selection Jumper	Install if switched rail voltage is = +12V+/-15%. Remove and provide separate +12V bias voltage to U1 via TP5 if ISL6116,7,20 being evaluated.
R4, R5	LED Series Resistors	2.32kΩ 805 Chip Resistor
D1, D2	Fault Indicating LEDs	Low Current Red SMD LED
DD1	Fault Voltage Dropping Diode	3.3V Zener Diode, SOT-23 SMD 350mW
OT1	PWRON Level Shifting Opto-Coupler	PS2801-1 NEC
R8	Level Shifting Bias Resistor	2.32kΩ 805 Chip Resistor
R9	Level Shifting Bias Resistor	1.18kΩ 805 Chip Resistor
R10	Level Shifting Bias Resistor	200Ω 805 Chip Resistor
RG1	HIP5600IS	High Voltage Linear Regulator
R6	Linear Regulator RF1	1.78kΩ 805 Chip Resistor
R11	Linear Regulator RF2	15kΩ 805 Chip Resistor
TP1-TP8	Test Points for Device Pin Numbers 1-8	

Small Outline Plastic Packages (SOIC)



M8.15 (JEDEC MS-012-AA ISSUE C)
8 LEAD NARROW BODY SMALL OUTLINE PLASTIC PACKAGE

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.0532	0.0688	1.35	1.75	-
A1	0.0040	0.0098	0.10	0.25	-
B	0.013	0.020	0.33	0.51	9
C	0.0075	0.0098	0.19	0.25	-
D	0.1890	0.1968	4.80	5.00	3
E	0.1497	0.1574	3.80	4.00	4
e	0.050 BSC		1.27 BSC		-
H	0.2284	0.2440	5.80	6.20	-
h	0.0099	0.0196	0.25	0.50	5
L	0.016	0.050	0.40	1.27	6
N	8		8		7
α	0°	8°	0°	8°	-

NOTES:

1. Symbols are defined in the "MO Series Symbol List" in Section 2.2 of Publication Number 95.
2. Dimensioning and tolerancing per ANSI Y14.5M-1982.
3. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion and gate burrs shall not exceed 0.15mm (0.006 inch) per side.
4. Dimension "E" does not include interlead flash or protrusions. Interlead flash and protrusions shall not exceed 0.25mm (0.010 inch) per side.
5. The chamfer on the body is optional. If it is not present, a visual index feature must be located within the crosshatched area.
6. "L" is the length of terminal for soldering to a substrate.
7. "N" is the number of terminal positions.
8. Terminal numbers are shown for reference only.
9. The lead width "B", as measured 0.36mm (0.014 inch) or greater above the seating plane, shall not exceed a maximum value of 0.61mm (0.024 inch).
10. Controlling dimension: MILLIMETER. Converted inch dimensions are not necessarily exact.

Rev. 0 12/93

All Intersil U.S. products are manufactured, assembled and tested utilizing ISO9000 quality systems. Intersil Corporation's quality certifications can be viewed at www.intersil.com/design/quality

Intersil products are sold by description only. Intersil Corporation reserves the right to make changes in circuit design, software and/or specifications at any time without notice. Accordingly, the reader is cautioned to verify that data sheets are current before placing orders. Information furnished by Intersil is believed to be accurate and reliable. However, no responsibility is assumed by Intersil or its subsidiaries for its use; nor for any infringements of patents or other rights of third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of Intersil or its subsidiaries.

For information regarding Intersil Corporation and its products, see www.intersil.com