

**CLASS D AUDIO DRIVER**

**Features**

- Hi-side and Lo-side independent floating PWM input
- Programmable bidirectional over-current detection with self-reset function
- Over current sensing output
- Shoot-through prevention logic
- High noise immunity
- ±100 V ratings deliver up to 500 W in output power
- 3.3 V / 5 V logic compatible input
- Operates up to 800 kHz

**Product Summary**

V <sub>OFFSET</sub> (max)		± 100 V
Gate driver	Io+	2.0 A
	Io-	2.0 A
Propagation delay		120 ns
OC protection delay (max)		500 ns
Shutdown delay (max)		250 ns

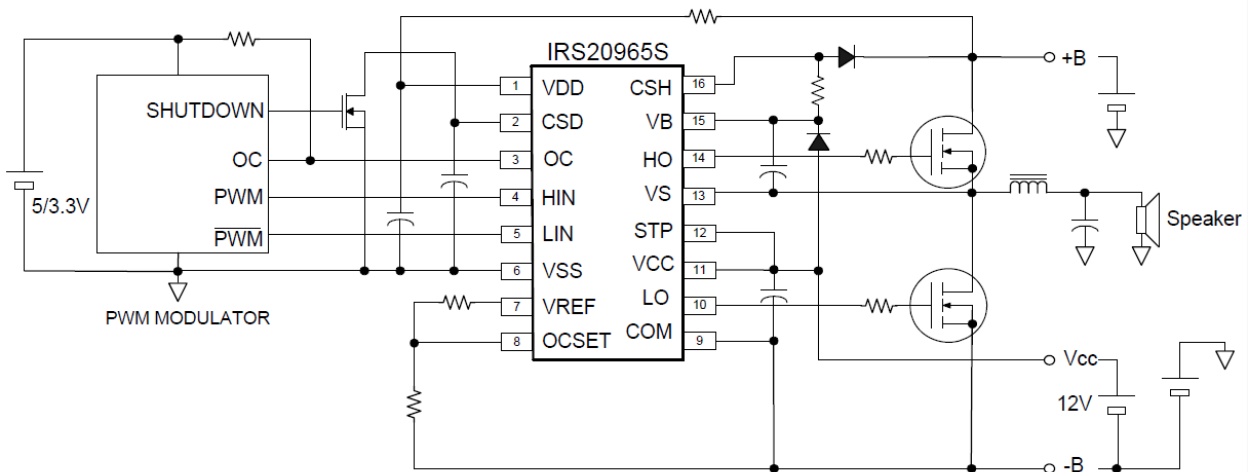
**Typical Applications**

- Class D audio amplifier
- Half bridge converter with digital controller

**Package Options**



**Typical Connection Diagram**



(Please refer to Lead Assignments for correct pin configuration. This diagram shows electrical connections only.)

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## Description

The IRS20965S is a high voltage, high speed MOSFET driver with floating PWM inputs designed for Class D audio amplifier applications.

Bi-directional current sensing using  $R_{DS(ON)}$  of the MOSFETs detects over current conditions during positive and negative load currents without any external shunt resistors. An over current flag output provides over current status without shutting down, enabling full external control over OCP protection sequences.

Independent HIN and LIN inputs offers independent control on HO and LO. Internal shoot-thru prevention logic provides safe operation by eliminating simultaneous ON state in the output MOSFET.

**Qualification Information<sup>†</sup>**

<b>Qualification Level</b>		Industrial <sup>††</sup>	
		Comments: This family of ICs has passed JEDEC's Industrial qualification. IR's Consumer qualification level is granted by extension of the higher Industrial level.	
<b>Moisture Sensitivity Level</b>		SOIC16N	MSL2 <sup>†††</sup> 260°C (per IPC/JEDEC J-STD-020)
<b>ESD</b>	<b>Machine Model</b>	Class B (per JEDEC standard EIA/JESD22-A115)	
	<b>Human Body Model</b>	Class 2 (per EIA/JEDEC standard JESD22-A114)	
<b>IC Latch-Up Test</b>		Class I, Level A (per JESD78D)	
<b>RoHS Compliant</b>		Yes	

† Qualification standards can be found at International Rectifier's web site <http://www.irf.com/>

†† Higher qualification ratings may be available should the user have such requirements. Please contact your International Rectifier sales representative for further information.

††† Higher MSL ratings may be available for the specific package types listed here. Please contact your International Rectifier sales representative for further information.

### Absolute Maximum Ratings

Absolute Maximum Ratings indicate sustained limits beyond which damage to the device may occur. All voltage parameters are absolute voltages referenced to  $V_{SS}$ ; all currents are defined positive into any lead. The Thermal Resistance and Power Dissipation ratings are measured under board mounted and still air conditions.

Symbol	Definition	Min.	Max.	Units
$V_B$	High side floating supply voltage	-0.3	215	V
$V_S$	High side floating supply voltage <sup>†</sup>	$V_B - 20$	$V_B + 0.3$	
$V_{HO}$	High side floating output voltage	$V_S - 0.3$	$V_B + 0.3$	
$V_{CSH}$	CSH pin input voltage	$V_S - 0.3$	$V_B + 0.3$	
$V_{CC}$	Low side fixed supply voltage <sup>†</sup>	-0.3	20	
$V_{LO}$	Low side output voltage	-0.3	$V_{CC} + 0.3$	
$V_{DD}$	Floating input supply voltage	-0.3	210	
$V_{SS}$	Floating input supply voltage <sup>†</sup>	(See $I_{DDZ}$ )	$V_{DD} + 0.3$	
$V_{HIN}$	PWM input voltage	$V_{SS} - 0.3$	$V_{DD} + 0.3$	
$V_{LIN}$	PWM input voltage	$V_{SS} - 0.3$	$V_{DD} + 0.3$	
$V_{CSD}$	CSD pin input voltage	$V_{SS} - 0.3$	$V_{DD} + 0.3$	
$V_{OC}$	OC pin input voltage	$V_{SS} - 0.3$	$V_{DD} + 0.3$	
$V_{OCSET}$	OCSET pin input voltage	-0.3	$V_{CC} + 0.3$	
$V_{REF}$	VREF pin voltage	-0.3	$V_{CC} + 0.3$	
$I_{DDZ}$	Floating input supply zener clamp current <sup>†</sup>	-	10	
$I_{CCZ}$	Low side supply zener clamp current <sup>†</sup>	-	10	
$I_{BSZ}$	Floating supply zener clamp current <sup>†</sup>	-	10	
$I_{OREF}$	Reference output current	-	5	V/ns
dVs/dt	Allowable Vs voltage slew rate	-	50	
dVss/dt	Allowable Vss voltage slew rate <sup>††</sup>	-	50	
dVss/dt	Allowable Vss voltage slew rate upon power-up <sup>†††</sup>	-	50	V/ms
Pd	Maximum power dissipation	-	1.0	W
RthJA	Thermal resistance, Junction to ambient	-	115	°C/W
T <sub>J</sub>	Junction Temperature	-	150	°C
T <sub>S</sub>	Storage Temperature	-55	150	
T <sub>L</sub>	Lead temperature (Soldering, 10 seconds)	-	300	

†  $V_{DD} - V_{SS}$ ,  $V_{CC} - COM$ , and  $V_B - V_S$  contain internal shunt zener diodes. Please note that the voltage ratings of these can be limited by the clamping current.

†† For the rising and falling edges of step signal of 10V.  $V_{SS} = 15V$  to 200V.

†††  $V_{SS}$  ramps up from 0V to 200V.

### Recommended Operating Conditions

For proper operation, the device should be used within the recommended conditions below. The Vs and COM offset ratings are tested with supplies biased at  $I_{DD} = 3\text{mA}$ ,  $V_{CC} = 12\text{V}$  and  $V_B - V_S = 12\text{V}$ .

Symbol	Definition	Min.	Max.	Units
$V_B$	High side floating supply absolute voltage	$V_S+10$	$V_S+14$	V
$V_S$	High side floating supply offset voltage	†	200	
$I_{DDZ}$	Floating input supply zener clamp current	1	5	mA
$V_{OC}$	OC pin input voltage	$V_{SS}$	$V_{DD}$	V
$V_{SS}$	Floating input supply absolute voltage	0	100	
$V_{HO}$	High side floating output voltage	$V_S$	$V_B$	
$V_{CC}$	Low side fixed supply voltage	10	15	
$V_{LO}$	Low side output voltage	0	$V_{CC}$	
$V_{HIN}$	HIN PWM input voltage	$V_{SS}$	$V_{DD}$	
$V_{LIN}$	LIN PWM input voltage	$V_{SS}$	$V_{DD}$	
$V_{CSD}$	CSD pin input voltage	$V_{SS}$	$V_{DD}$	
$I_{OREF}$	Reference output current to COM ††	0.3	0.8	
$V_{OCSET}$	OCSET pin input voltage	0.5	5	V
$T_A$	Ambient Temperature	-40	125	°C

† Logic operational for  $V_S$  equal to -5V to +200V. Logic state held for  $V_S$  equal to -5V to  $-V_{BS}$ .

†† Nominal voltage for  $V_{REF}$  is 5V.  $I_{OREF}$  of 0.3 – 0.8 mA dictates total external resistor value on  $V_{REF}$  to be 6.3k to 16.7k $\Omega$ .

**Electrical Characteristics**
 $V_{CC}, V_{BS} = 12\text{ V}, I_{DD} = 3\text{ mA}, V_{SS} = 20\text{ V}, C_L = 1\text{ nF}, STP = V_{CC}$  and  $T_A = 25^\circ\text{C}$  unless otherwise specified.

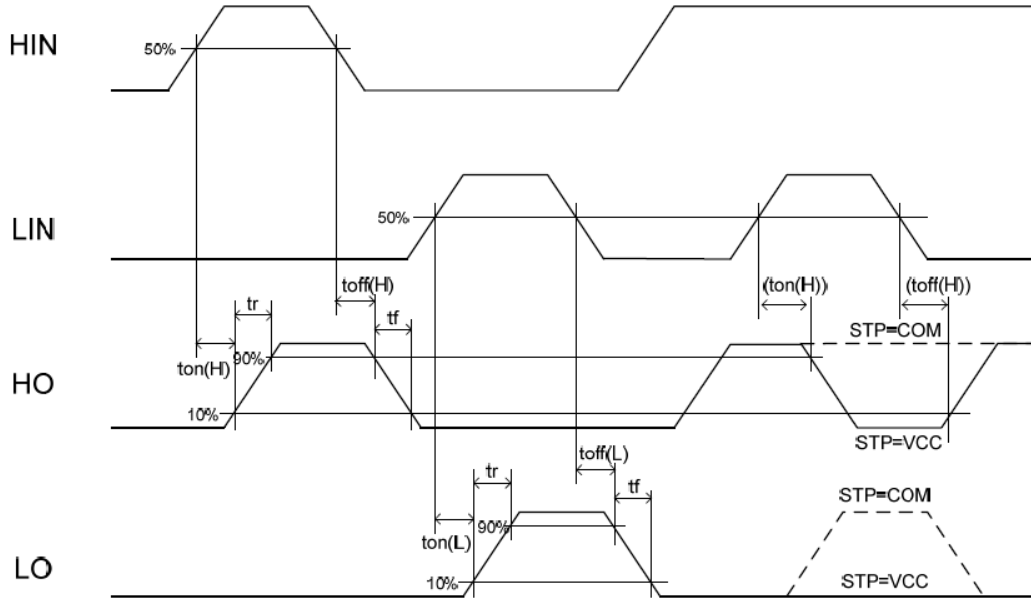
Symbol	Definition	Min	Typ	Max	Units	Test Conditions
<b>Low Side Supply</b>						
$UV_{CC+}$	Vcc supply UVLO positive threshold	8.4	8.9	9.4	V	
$UV_{CC-}$	Vcc supply UVLO negative threshold	8.2	8.7	9.2	V	
$I_{QCC}$	Low side quiescent current	-	-	1	mA	$V_{DT} = V_{CC}$
$V_{CLAMPL}$	Low side zener diode clamp voltage	19.6	20.4	21.6	V	$I_{CC} = 5\text{ mA}$
<b>High Side Floating Supply</b>						
$UV_{BS+}$	High side well UVLO positive threshold	8.0	8.5	9.0	V	
$UV_{BS-}$	High side well UVLO negative threshold	7.8	8.3	8.8	V	
$I_{QBS}$	High side quiescent current	-	-	1	mA	
$I_{LKH}$	High to Low side leakage current	-	-	50	$\mu\text{A}$	$V_B = V_S = 200\text{ V}$
$V_{CLAMPH}$	High side zener diode clamp voltage	14.7	15.3	16.2	V	$I_{BS} = 5\text{ mA}$
<b>Floating Input Supply</b>						
$UV_{DD+}$	$V_{DD}, V_{SS}$ floating supply UVLO positive threshold	8.2	8.7	9.2	V	$V_{SS} = 0\text{ V}$
$UV_{DD-}$	$V_{DD}, V_{SS}$ floating supply UVLO negative threshold	7.7	8.2	8.7	V	$V_{SS} = 0\text{ V}$
$I_{QDD}$	Floating Input quiescent current	-	-	1	mA	$V_{DD} = 9.5\text{ V} + V_{SS}$
$V_{CLAMPM}$	Floating Input zener diode clamp voltage	9.8	10.2	10.8	V	$I_{DD} = 5\text{ mA}$
$I_{LKM}$	Floating input side to Low side leakage current	-	-	50	$\mu\text{A}$	$V_{DD} = V_{SS} = 200\text{ V}$
<b>Floating PWM Input</b>						
$V_{IH}$	Logic "1" input threshold voltage	2.3	1.9	-	V	
$V_{IL}$	Logic "0" input threshold voltage	-	1.9	1.5	V	
$I_{IN+}$	Logic "1" input bias current	-	-	40	$\mu\text{A}$	$V_{IN} = 3.3\text{ V}$
$I_{IN-}$	Logic "0" input bias current	-	-	1	$\mu\text{A}$	$V_{IN} = V_{SS}$

**Electrical Characteristics (cont'd)**
 $V_{CC}, V_{BS} = 12\text{ V}$ ,  $I_{DD} = 3\text{ mA}$ ,  $V_{SS} = 20\text{ V}$ ,  $C_L = 1\text{ nF}$ ,  $STP = V_{CC}$  and  $T_A = 25^\circ\text{C}$  unless otherwise specified.

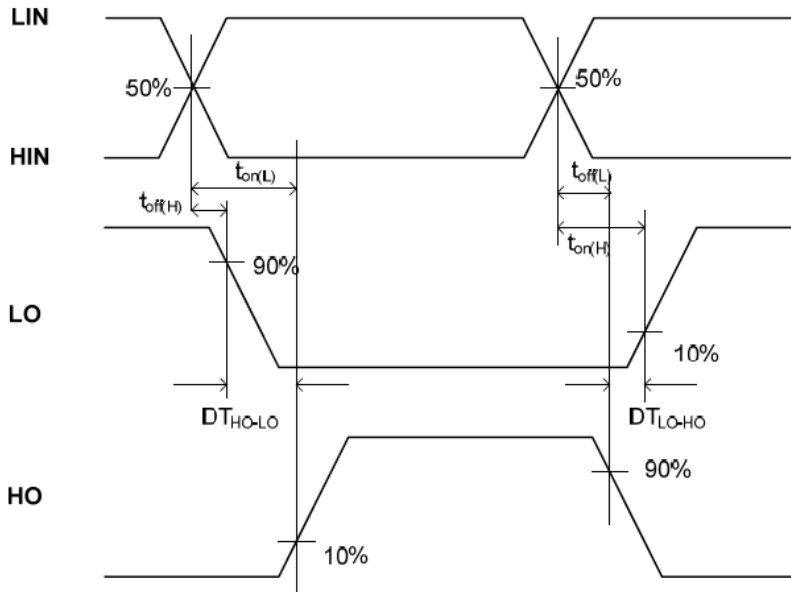
Protection						
$V_{REF}$	Reference output voltage	4.8	5.1	5.4	V	$I_{OREF} = 0.5\text{ mA}$
$V_{th_{OCL}}$	Low side OC threshold in $V_S$	1.1	1.2	1.3	V	$OCSET = 1.2\text{ V}$
$V_{th_{OCH}}$	High side OC threshold in $V_{CSH}$	$1.1 + V_S$	$1.2 + V_S$	$1.3 + V_S$	V	
$V_{th1}$	CSD pin shutdown release threshold	$0.62 \times V_{DD}$	$0.70 \times V_{DD}$	$0.78 \times V_{DD}$	V	$V_{SS} = 0\text{ V}$
$V_{th2}$	CSD pin self reset threshold	$0.26 \times V_{DD}$	$0.30 \times V_{DD}$	$0.34 \times V_{DD}$	V	$V_{SS} = 0\text{ V}$
$I_{CSD+}$	CSD pin charge current	70	100	130	$\mu\text{A}$	$V_{SD} = V_{SS} + 5\text{ V}$
$I_{CSD-}$	CSD pin discharge current	70	100	130	$\mu\text{A}$	$V_{SD} = V_{SS} + 5\text{ V}$
$I_{OCC}$	OC output sink current	10	-	-	$\text{mA}$	$V_{oc} = 1\text{ V}$
		1	-	-	$\text{mA}$	$V_{oc} = 0.1\text{ V}$
$t_{OCL}$	Propagation delay time from $V_S > V_{th_{OCL}}$ to Shutdown	-	-	500	ns	
$t_{OCH}$	Propagation delay time from $V_{CSH} > V_{th_{OCH}}$ to Shutdown	-	-	500	ns	
$PW_{OC}$	OC output minimum pulse width	1	-	-	$\mu\text{s}$	
Gate Driver						
$I_{o+}$	Output high short circuit current (Source)		2.0	-	A	$V_o = 0\text{ V}$ , $PW \leq 10\mu\text{S}$
$I_{o-}$	Output low short circuit current (Sink)		2.0	-	A	$V_o = 12\text{ V}$ , $PW \leq 10\mu\text{S}$
$V_{OL}$	Low level output voltage LO – COM, HO - VS	-	-	0.1	V	
$V_{OH}$	High level output voltage VCC – LO, VB - HO	-	-	1.4	V	$I_o = 0\text{ A}$
$t_r$	Turn-on rise time	-	15	-	ns	
$t_f$	Turn-off fall time	-	15	-	ns	
$t_{on\_1}$	High and low side turn-on propagation delay, floating inputs	-	120	-	ns	$V_S = 100\text{ V}$ , $V_{SS} = 100\text{ V}$
$t_{off\_1}$	High and low side turn-off propagation delay, floating inputs	-	120	-	ns	
$t_{on\_2}$	High and low side turn-on propagation delay, non-floating inputs	-	130	-	ns	
$t_{off\_2}$	High and low side turn-off propagation delay, non-floating inputs	-	130	-	ns	
DT	Intrinsic dead-time: LO turn-off to HO turn-on ( $DT_{LO-HO}$ ) & HO turn-off to LO turn-on ( $DT_{HO-LO}$ )	0	10	20	ns	
$PW_{min}$	Minimum pulse width for outputs to respond. Positive or Negative.	-	25	-	ns	$V_S = \text{COM}$ $V_{SS} = \text{COM}$
$OW_{min}$	Allowable LO/HO over wrap	10	-	-	ns	



**Waveform Definitions**



**Figure 1: Timing Diagram**



**Figure 2: Deadtime Waveform Definitions**

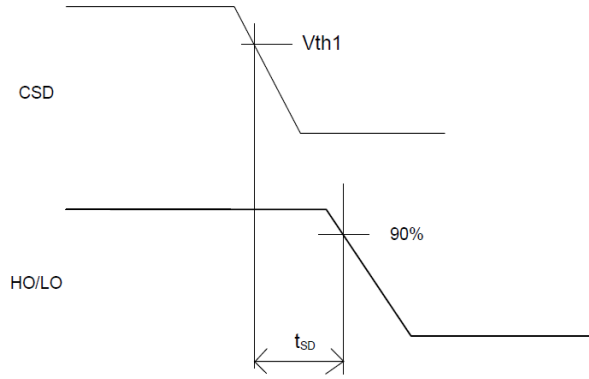


Figure 3: CSD to Shutdown Waveform Definitions

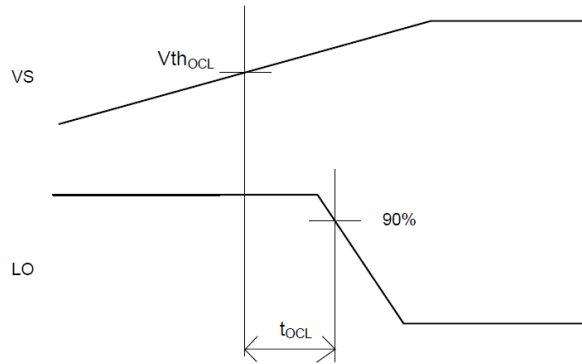


Figure 4:  $V_S > V_{th_{OCL}}$  to Shutdown Waveform

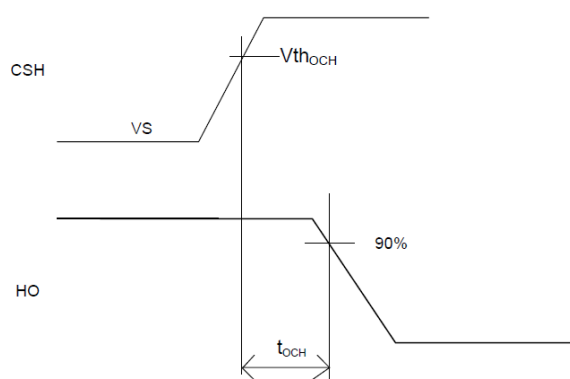
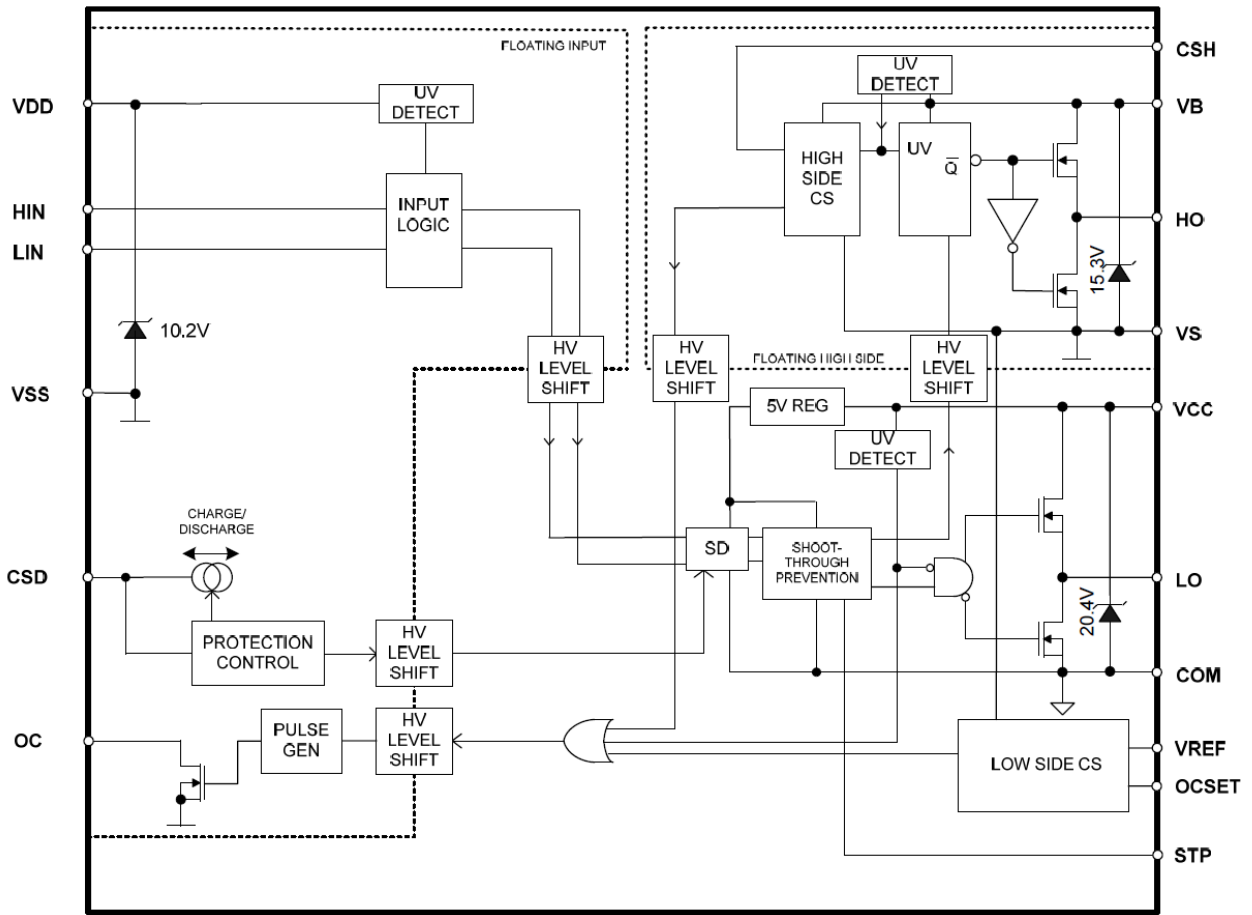
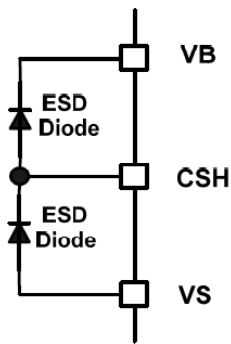
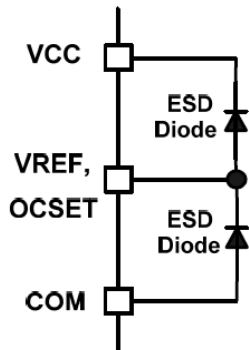
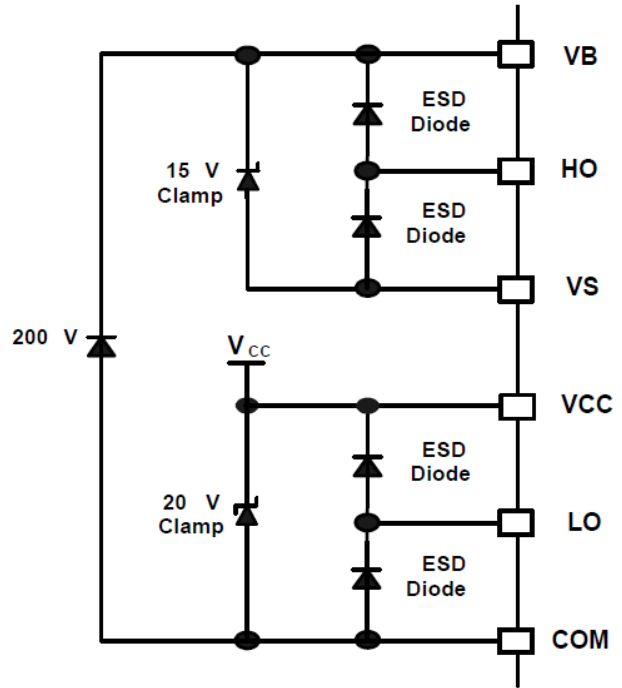
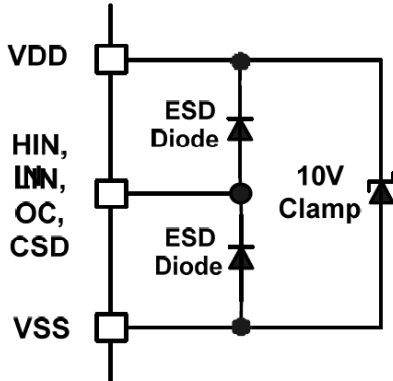


Figure 5:  $V_{CSH} > V_{th_{OCH}}$  to Shutdown Waveform

## Functional Block Diagram



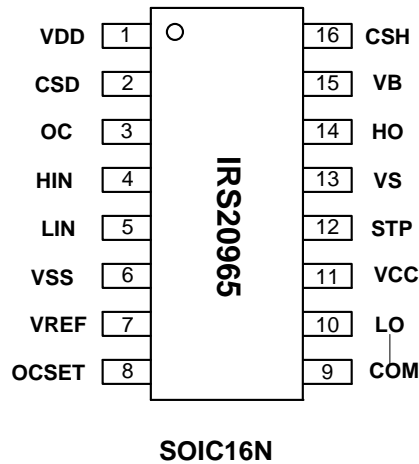
**Input/Output Pin Equivalent Circuit Diagrams:**



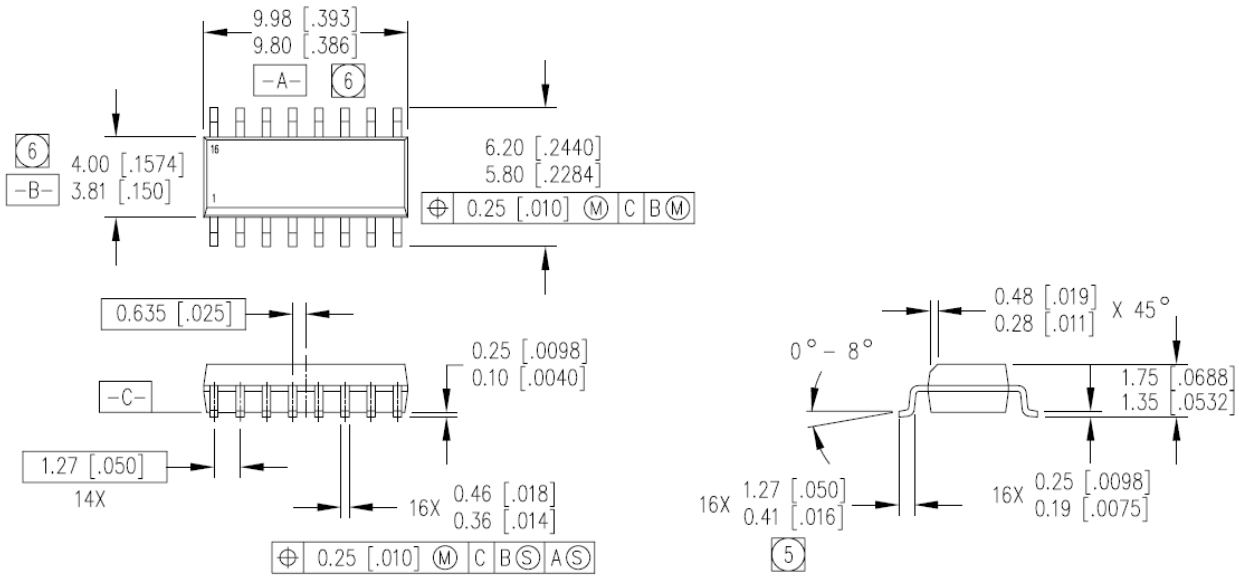
### Lead Definitions

Pin #	Symbol	Description
1	VDD	Floating input positive supply
2	CSD	Shutdown timing capacitor, referenced to VSS
3	OC	Over current warning output, open drain referenced to VSS
4	HIN	PWM input, in phase with HO, referenced to VSS
5	LIN	PWM input, in phase with LO, referenced to VSS
6	VSS	Floating input supply return
7	VREF	5V reference output for setting OCSET, reference to COM
8	OCSET	Low side over current threshold setting, referenced to COM
9	COM	Low side supply return
10	LO	Low side output
11	VCC	Low side logic supply
12	STP	Shoot-thru prevention logic override (VCC: enabled, COM: disabled)
13	VS	High side floating supply return
14	HO	High side output
15	VB	High side floating supply
16	CSH	High side over current sensing input, referenced to VS

### Lead Assignments



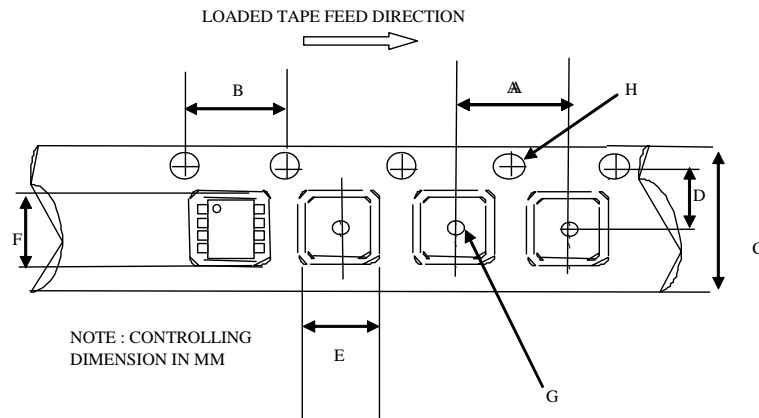
## Package Details: SOIC16N



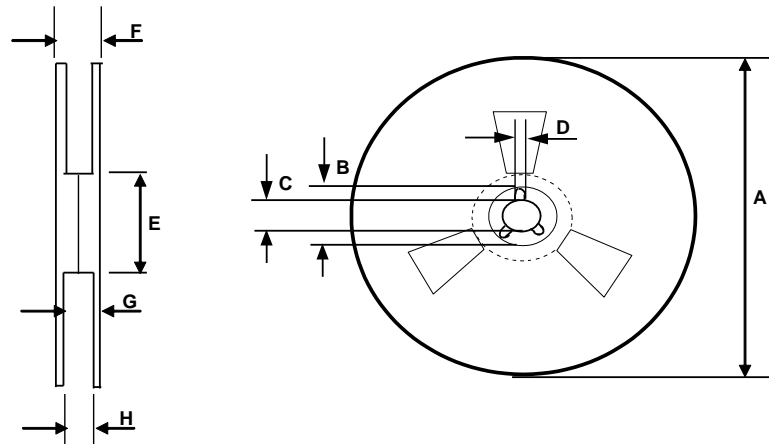
**NOTES:**

1. DIMENSIONING & TOLERANCING PER ANSI Y14.5M-1982.
2. CONTROLLING DIMENSION: MILLIMETER
3. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
4. OUTLINE CONFORMS TO JEDEC OUTLINE MS-012AC.

5. DIMENSION IS THE LENGTH OF LEAD FOR SOLDERING TO A SUBSTRATE.
6. DIMENSION DOES NOT INCLUDE MOLD PROTUSIONS. MOLD PROTUSIONS SHALL NOT EXCEED 0.15 [ .006 ].

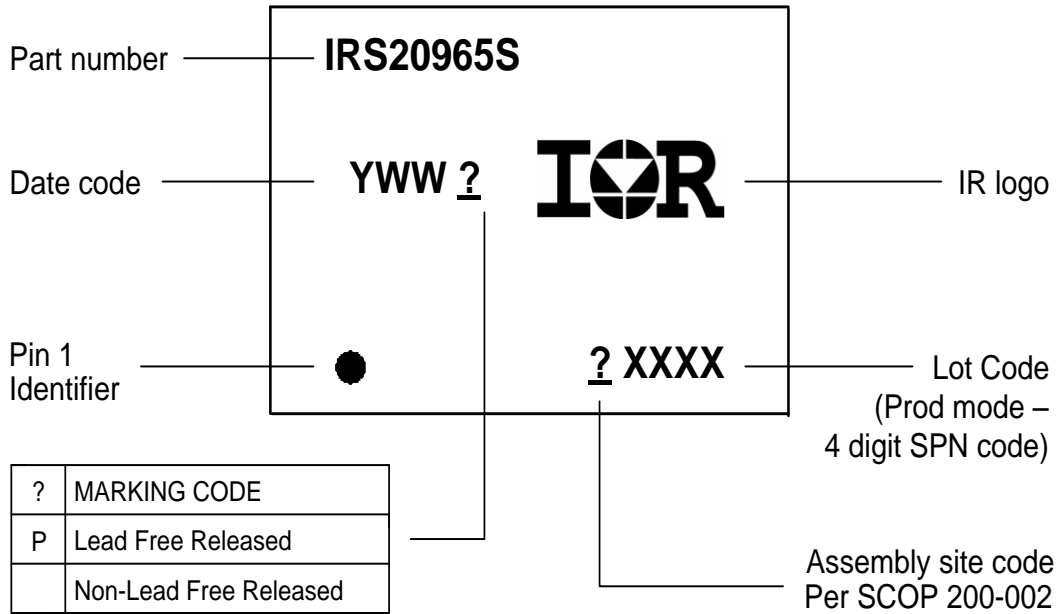
**Tape and Reel Details: SOIC16N**

**CARRIER TAPE DIMENSION FOR 16SOICN**

Code	Metric		Imperial	
	Min	Max	Min	Max
A	7.90	8.10	0.311	0.318
B	3.90	4.10	0.153	0.161
C	15.70	16.30	0.618	0.641
D	7.40	7.60	0.291	0.299
E	6.40	6.60	0.252	0.260
F	10.20	10.40	0.402	0.409
G	1.50	n/a	0.059	n/a
H	1.50	1.60	0.059	0.062


**REEL DIMENSIONS FOR 16SOICN**

Code	Metric		Imperial	
	Min	Max	Min	Max
A	329.60	330.25	12.976	13.001
B	20.95	21.45	0.824	0.844
C	12.80	13.20	0.503	0.519
D	1.95	2.45	0.767	0.096
E	98.00	102.00	3.858	4.015
F	n/a	22.40	n/a	0.881
G	18.50	21.10	0.728	0.830
H	16.40	18.40	0.645	0.724

**Part Marking Information**



**Ordering Information**

Base Part Number	Package Type	Standard Pack		Complete Part Number
		Form	Quantity	
IRS20965SPBF	SO16N	Tube/Bulk	45	IRS20965SPBF
		Tape and Reel	2500	IRS20965STRPBF

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**WORLD HEADQUARTERS:**  
 233 Kansas St., El Segundo, California 90245  
 Tel: (310) 252-7105