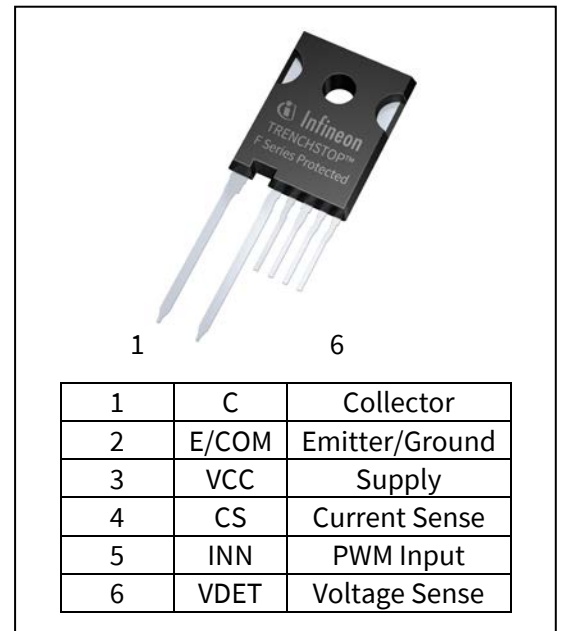


TRENCHSTOP™ Feature IGBT Protected Series

IGBT 20A/1350V RC-H5 technology with driver IC

Features

- Reverse conducting IGBT with monolithic body diode designed for soft commutation
- Integrated Driver with
 - over-voltage and over-current protection
 - Active clamp control circuit
 - Programmable over-voltage threshold
 - Programmable cycle-by-cycle over-current threshold
 - Integrated gate drive with 2 level turn-on current
 - Temperature warning
 - Over-temperature protection
 - VCC UVLO
 - Integrated ESD protection and latch immunity on all pins
- Qualified according to JEDEC
- TO-247 6-pin package
- www.infineon.com/protected-igbt



Applications

- Induction cooking

Description

The F Series Protected IGBT includes an IGBT with Gate Driver IC in a TO-247 6-pin package for induction cooking applications. Its innovative concepts provide protection against over-voltage, over-current, and over-temperature. Additional features include a unique active clamp control, fault condition notification, and a special two levels turn-on Gate driving that reduces significantly the typical high startup peak current. These integrated protection functions provide a simple and robust solution with increased overall system reliability.

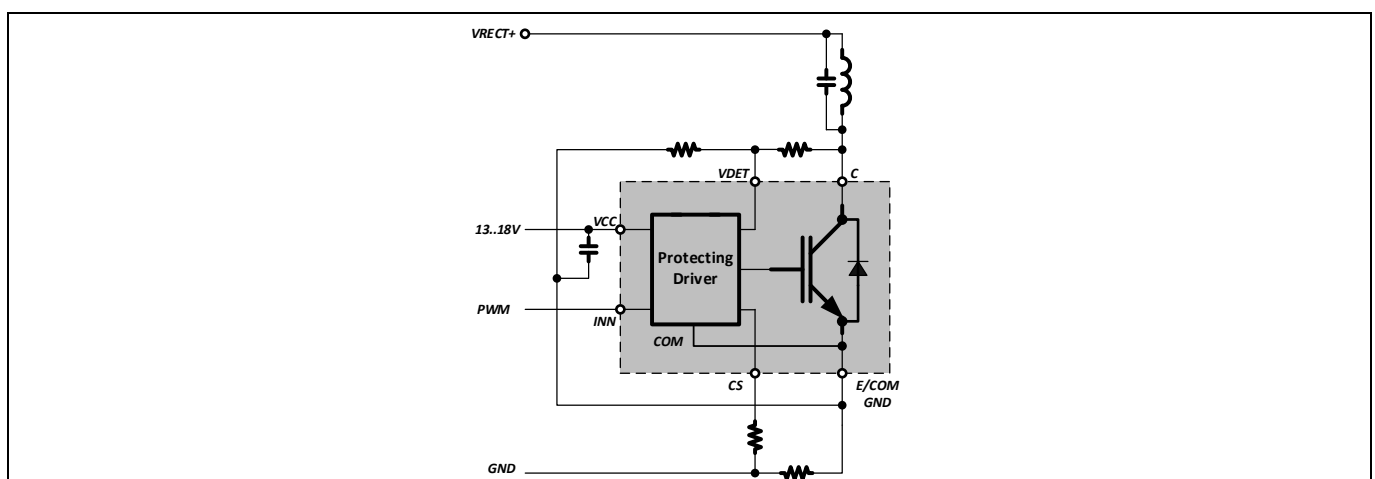


Figure 1 Typical Application

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Blockdiagram

1 Blockdiagram

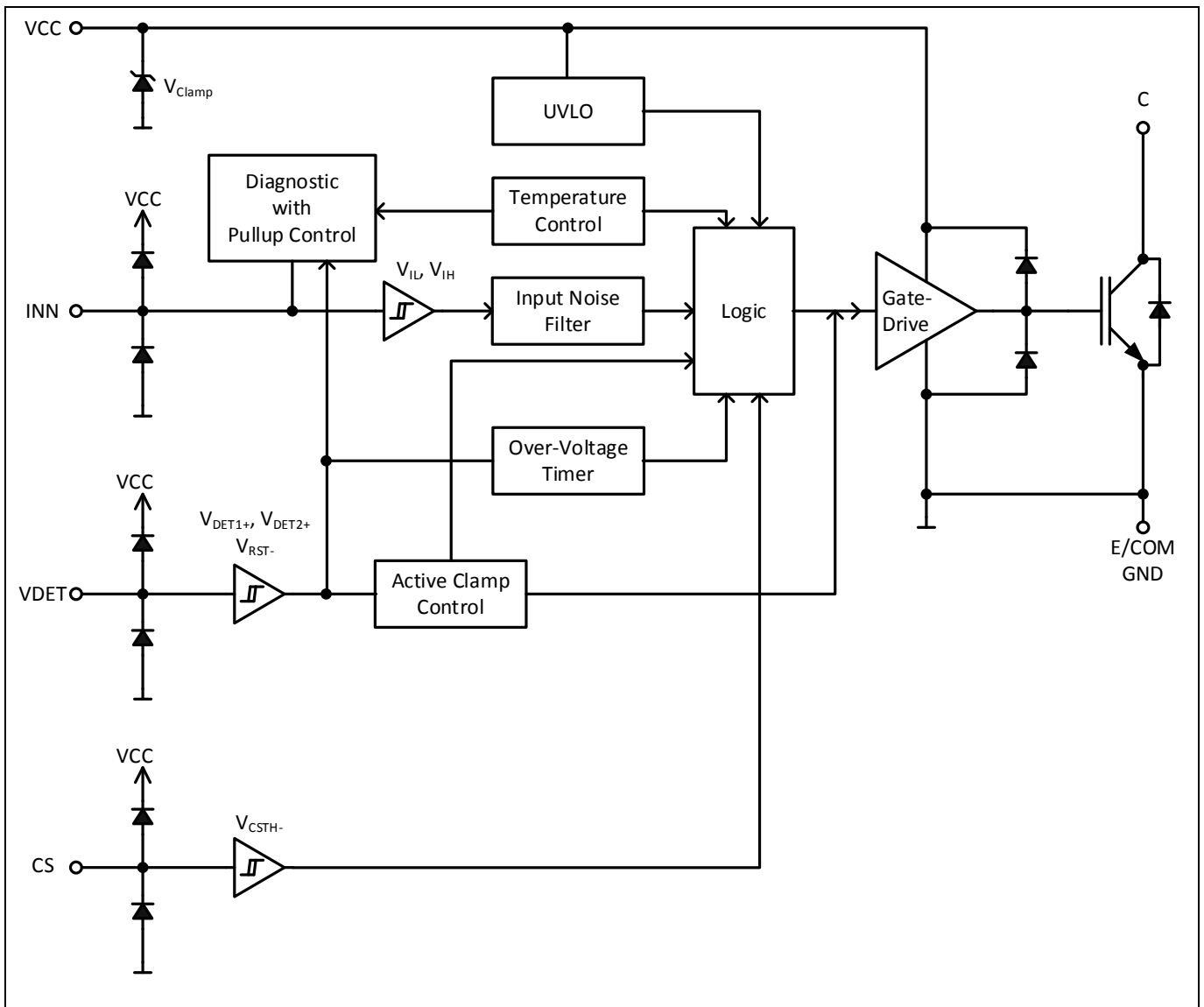


Figure 2 Blockdiagram of IEWS20R5135IPB

State Diagram

2 State Diagram

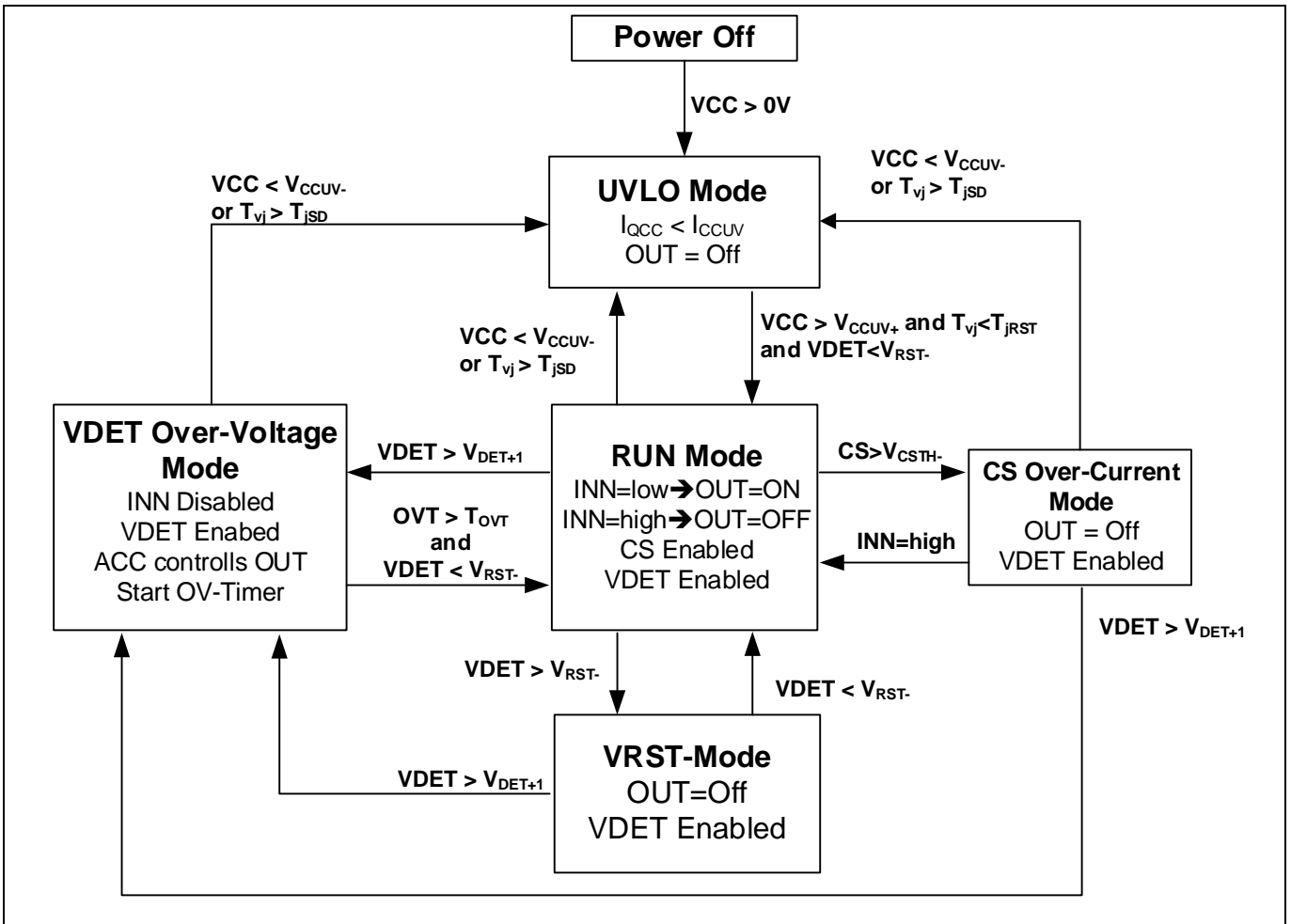


Figure 3 State diagram of IEWS20R5135IPB

3 Electrical Parameters Driver

3.1 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 COM, all currents are defined positive into any pin.

Table 1 Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Unit	Test Conditions
VDET pin voltage	V_{DET}	-0.3	V_{CLAMP}^1	V	
VCC pin voltage	V_{CC}				
CS pin voltage	C_S				
INN pin voltage	I_{NN}	-0.3	5	V	
Junction temperature	T_{vj}	-40	150	°C	
Storage temperature	T_S				
ESD capability	V_{ESD}		750	KV	Charged Devices Model (CDM) ²
ESD capability	V_{ESD}		2.0	KV	Human Body Model (HBM) ³

3.2 Recommended Operating Conditions

For proper operation the device should be used within the recommended conditions. ($T_A=25^\circ\text{C}$)

Table 2 Recommended Operating Conditions

Parameter	Symbol	Min.	Max.	Unit
VDET pin voltage	V_{DET}	-0.3	20	V
VCC pin voltage	V_{CC}			
CS pin voltage	C_S			
INN pin voltage	I_{NN}	-0.3	5	V
Junction temperature	T_{vj}	-40	125	°C

¹This IC contains a 25V voltage clamp structure between the VCC and COM pins. Please note that this pin should not be driven by a DC, low impedance power source greater than the V_{CLAMP} specified in the Electrical Characteristics section.

²According to the JESD22-C101 CDM standard

³According to the JESD22-A114 Rev. F standard

3.3 Electrical Characteristics

V_{CC}=15.0V, T_A = 25 °C unless otherwise specified. All parameters are referenced to COM.

Table 3 VCC Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Conditions
V _{CC} rising UVLO threshold	V _{CCUV+}	13.0	13.5	14.0	V	
V _{CC} falling UVLO threshold	V _{CCUV-}	12.0	12.5	13.0		
V _{CC} supply current during UVLO	I _{CCUV}	---	200	---	μA	V _{CC} =V _{CCUV-} -0.5V
V _{CC} quiescent supply current	I _{QCC}	---	3000	---		
V _{CC} internal Zener clamp voltage	V _{CLAMP}	---	25	---	V	I _{CC} =5mA

Table 4 CS Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Conditions
Over-current threshold voltage	V _{CS_{TH}}	-5%	-0.2	+5%	V	
Over-current detection internal blank time	t _{CSBLK}	3.5	---	4.5	μs	
Over-current detection propagation delay	t _{CS}	---	50	---	ns	

Table 5 VDET Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Conditions
Over-voltage rising threshold voltage 1	V _{DET+1}	-3%	3.91	+3%	V	Figure 8 + Figure 9
Over-voltage rising threshold voltage 2	V _{DET+2}	-3%	4.36	+3%		
Restart falling threshold voltage	V _{RST-}	-3%	1.37	+3%		
Over-voltage clamping time 1	t _{clamp1}	4.25	5.0	5.75	μs	
Over-voltage blank timer	t _{OVT}	3	---	---	ms	
Over-voltage blanking time @ turn-off IGBT	t _{VDETBLK}	---	1200	---	ns	

Table 6 Temperature Warning / Shutdown

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Conditions
Junction temperature warning	T _{vjTW}	---	75	---	°C	
Junction temperature thermal shutdown	T _{vjSD}	---	150	---		
Junction temperature thermal reset	T _{vjRST}	---	75	---		

Protected IGBT

IGBT 20A/1350V RC-H5 technology with driver IC

Electrical Parameters Driver

Table 7 INN / OUT Characteristics

Parameter	Symbol	Min.	Typ	Max.	Unit	Test Conditions
Logic "0" input voltage (OUT = HI)	V_{IL}	---	---	0.8	V	Figure. D
Logic "1" input voltage (OUT = LO)	V_{IH}	2.0	---	---		
INN pullup-voltage → no fault	$V_{IPU_{nf}}$	2.10	2.50	2.90		
INN pullup-voltage → temp warning	$V_{IPU_{tw}}$	4.00	4.50	5.00		
INN voltage → over-voltage detection or over-temp shut-down	$V_{IPU_{ov}}$	---	---	0.5		
Turn-on filter time	$t_{ONfilter}$	340	400	460	ns	
Turn-off filter time	$t_{OFFfilter}$	1275	1700	2200		
Logic "0" input bias current	I_{IN-}	---	-500	---	μA	$I_{NN}=0V$

4 Electrical Parameters IGBT

4.1 Absolute Maximum Ratings

For optimum lifetime and reliability, Infineon recommends operating conditions that do not exceed 80% of the maximum ratings stated in the datasheet.

Table 8 Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Collector-emitter voltage, $T_{vj} \geq 25^{\circ}\text{C}$	V_{CE}	1350	V
DC collector current, limited by T_{vjmax} $T_C = 25^{\circ}\text{C}$ $T_C = 100^{\circ}\text{C}$	I_C	40.0 20.0	A
Pulsed collector current, t_p limited by T_{vjmax}	I_{Cpuls}	60	A
Turn off safe operating area ($V_{CE} \leq 1350\text{V}$, $T_{vj} \leq 175^{\circ}\text{C}$, $t_p=1\mu\text{s}$)	-	60	A
Diode forward current, limited by T_{vjmax} $T_C = 25^{\circ}\text{C}$ $T_C = 100^{\circ}\text{C}$	I_F	40.0 20.0	A
Diode pulsed current, t_p limited by T_{vjmax}	I_{Fpuls}	60.0	A
Gate-emitter voltage Transient Gate-emitter voltage ($t_p \leq 10\mu\text{s}$, $D < 0.010$)	V_{GE}	± 20 ± 25	V
Power dissipation $T_C = 25^{\circ}\text{C}$ Power dissipation $T_C = 100^{\circ}\text{C}$	P_{tot}	288.0 144.0	W
Virtual junction temperature	T_{vj}	-40...+175	$^{\circ}\text{C}$
Operating junction temperature ¹	$T_{vj,op}$	-40...+150	$^{\circ}\text{C}$
Storage temperature	T_{stg}	-40...+150	$^{\circ}\text{C}$
Soldering temperature, 1.6mm (0.063 in.) from case for 10s	-	260	$^{\circ}\text{C}$
Mounting torque, M3 screw Maximum of mounting processes: 3	M	0.6	Nm
ESD capability Charged Devices Model (CDM) ²	V_{ESD}	750	KV
ESD capability Human Body Model (HBM) ³	V_{ESD}	2.0	KV

Table 9 Thermal Resistance

Parameter	Symbol	Value	Unit
IGBT thermal resistance, junction – case	$R_{th(j-c)}$	0.52	K/W
Diode thermal resistance, junction – case	$R_{th(j-c)}$	0.52	K/W
Thermal resistance, junction – ambient	$R_{th(j-a)}$	40	K/W

¹Limited by $T_{vj,max}$ of the driver I_C .

²According to the JESD22-C101 CDM standard

³According to the JESD22-A114 Rev. F standard

4.2 Electrical Characteristics

At $T_{vj}=25^{\circ}\text{C}$ and $V_{cc}=15\text{V}$, unless otherwise specified

Table 10 Static Characteristic

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Collector-emitter breakdown voltage	$V_{(BR)CES}$	$I_{NN}=\text{open}$, $I_C=0.5\text{mA}$	1350	-	-	V
Collector-emitter saturation voltage	$V_{CE(sat)}$	$V_{IN}=0\text{V}$, $I_C=20\text{A}$ $T_{vj}=25^{\circ}\text{C}$ $T_{vj}=125^{\circ}\text{C}$ $T_{vj}=150^{\circ}\text{C}$	- - -	1.65 1.85 1.90	- - -	
Diode forward voltage	V_F	$I_{NN}=\text{open}$ $I_F=20\text{A}$ $T_{vj}=25^{\circ}\text{C}$ $T_{vj}=125^{\circ}\text{C}$ $T_{vj}=150^{\circ}\text{C}$	- - -	1.71 1.85 1.97	1.90 - -	
Transconductance	g_{fs}	$V_{CE}=20\text{V}$, $I_C=20\text{A}$	-	15.8	-	S

Table 11 Switching Characteristics, Inductive Load at $T_{vj}=25^{\circ}\text{C}$

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Turn-on propagation time	$t_{PD,on}$	$V_{DC}=600\text{V}$, $I_C=20.0\text{A}$ $I_{NN}=\text{open}/0\text{V}$ $L_{\sigma}=175\text{nH}$, $C_{\sigma}=40\text{pF}$ L_{σ} , C_{σ} from Fig. F Energy losses include "tail".	-	668	-	ns
Turn-off propagation time	$t_{PD,off}$		-	2034	-	ns
Fall time	t_f		-	83	-	ns
Turn-off energy	E_{off}		-	1.2	-	mJ
Turn-off energy, soft switching	$E_{off,soft}$	$dV_{CE}/dt = 67\text{V}/\mu\text{s}$ From Fig. F Energy losses include "tail".	-	0.26	-	mJ

Table 12 Switching Characteristics, Inductive Load at $T_{vj}=150^{\circ}\text{C}$

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Turn-on propagation time	$t_{PD,on}$	$V_{DC}=600\text{V}$, $I_C=20.0\text{A}$ $I_{NN}=\text{open}/0\text{V}$ $L_{\sigma}=175\text{nH}$, $C_{\sigma}=40\text{pF}$ L_{σ} , C_{σ} from Fig. F Energy losses include "tail".	-	705	-	ns
Turn-off propagation time	$t_{PD,off}$		-	2257	-	ns
Fall time	t_f		-	231	-	ns
Turn-off energy	E_{off}		-	2.2	-	mJ
Turn-off energy, soft switching	$E_{off,soft}$	$dV_{CE}/dt = 67\text{V}/\mu\text{s}$ From Fig. F Energy losses include "tail".	-	0.40	-	mJ

5 Pin Configuration, Description and Functionality

5.1 Pin Configuration and Description

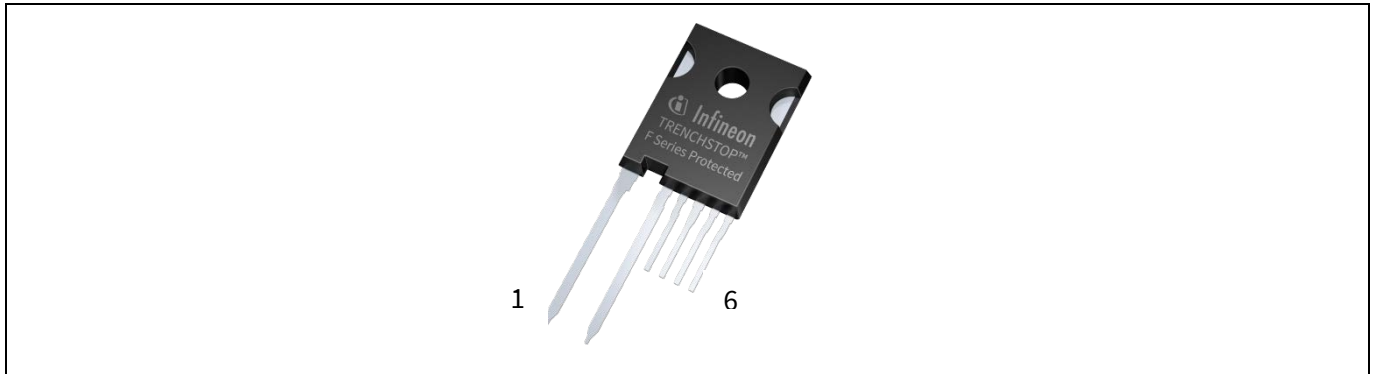


Figure 4 Pin Configuration

Table 13 Pin Description

Pin	Symbol	Description
1	C	Collector of IGBT
2	E/COM	Emitter of IGBT, ground connection for the driver
3	VCC	Supply-voltage of the driver
4	CS	Current-limitation input
5	INN	PWM input (low active) / Diagnostic output
6	VDET	Over-voltage detection input

5.2 IGBT connect pins (C, E/COM)

A RC-H5 IGBT is integrated into the TO247-6pin package. The chip includes a powerful monolithic body diode for soft commutation. The TRENCHSTOP™ technology offers

- Very tight parameter distribution
- High ruggedness and temperature stable behavior
- Low V_{CEsat}
- Low EMI

5.3 VCC and COM

VCC is the voltage supply for the logic and the driver output stage. All inputs and outputs are referenced to COM. The undervoltage lockout circuit enables the device to operate at power on when a typical supply voltage higher than V_{CCUV+} is present. Please see section 3.3 “VCC Characteristics” for further information.

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Pin Configuration, Description and Functionality

5.4 Current limitation input (CS)

The integrated cycle by cycle current limitation, given in the next figure, offers independent of the external control and input-voltage level, a voltage limitation across the IGBT. The negative current sense threshold (V_{CSTH-}) has the big advantage that the current sense resistor is not in the gate-drive loop. When the INN-input is switched to COM, the IGBT is turned on from the driver and the current-sense input gets enabled after a delay of t_{CSBLK} , to avoid miss-triggering during NZVS (Non Zero Voltage Switching) conditions. Once enabled, the voltage at the CS-pin gets monitored and when the current sense threshold is reached the IGBT turns off immediately, independent from the signal at the INN-input. A resistor of 1kOhm should be placed in series to the CS input to limit currents through the internal ESD-diodes due to transients.

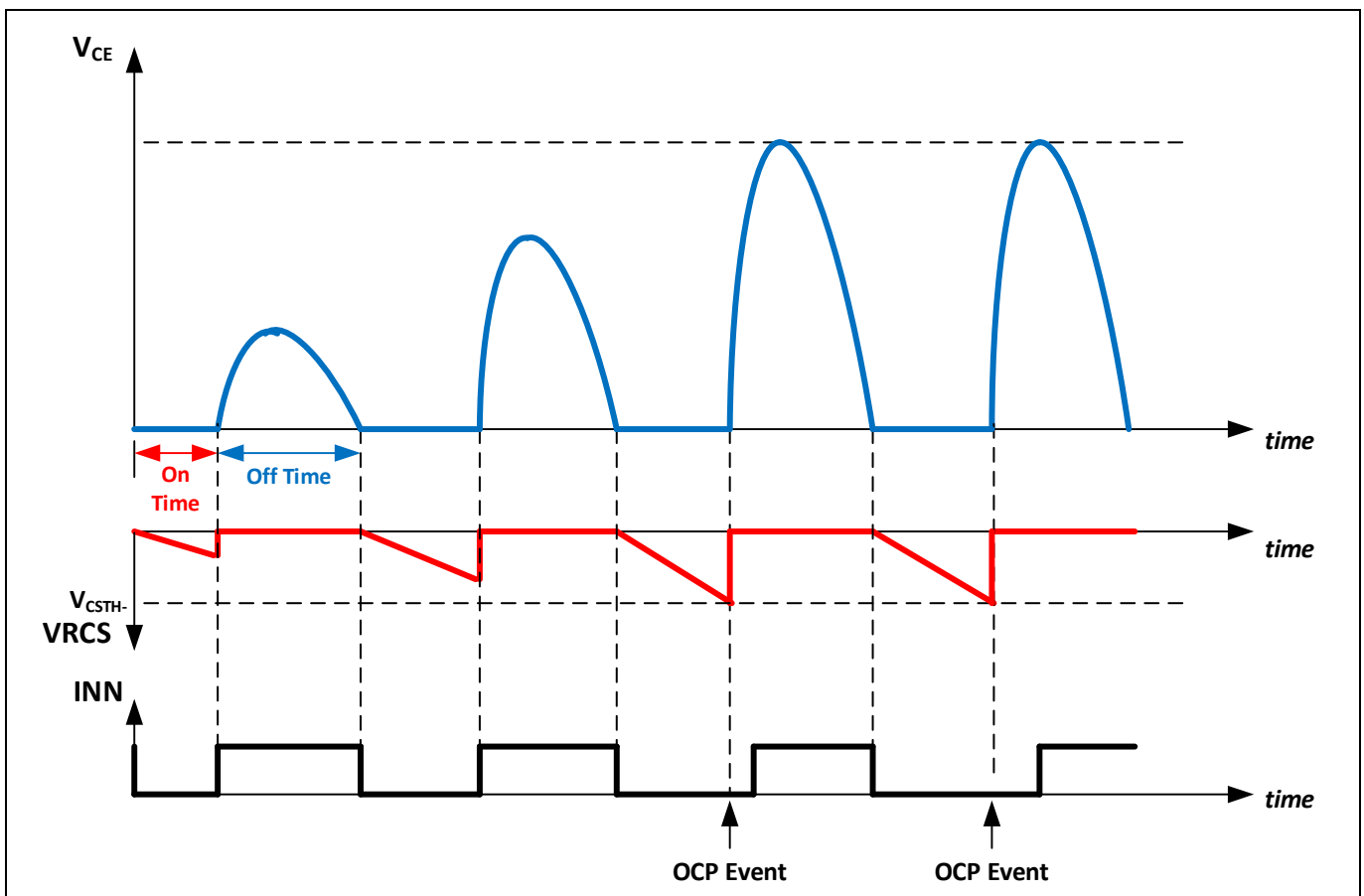


Figure 5 Cycle by cycle current limitation

5.5 PWM input / Diagnostic output (INN)

The INN pin is a multifunctional pin. It acts as an input to control the ON-time of the IGBT and during the OFF-time, the diagnostic block controls the pullup voltage level according to the status (see Table 15 & Figure 8). To control the turn-on of the IGBT an open drain output should be connected to the INN pin. The Schmitt trigger input is such to guarantee compatibility down to 3.3V controller. The input Schmitt trigger and noise filter provide beneficial noise rejection to short input pulses according to Figure 6 and Figure 10.

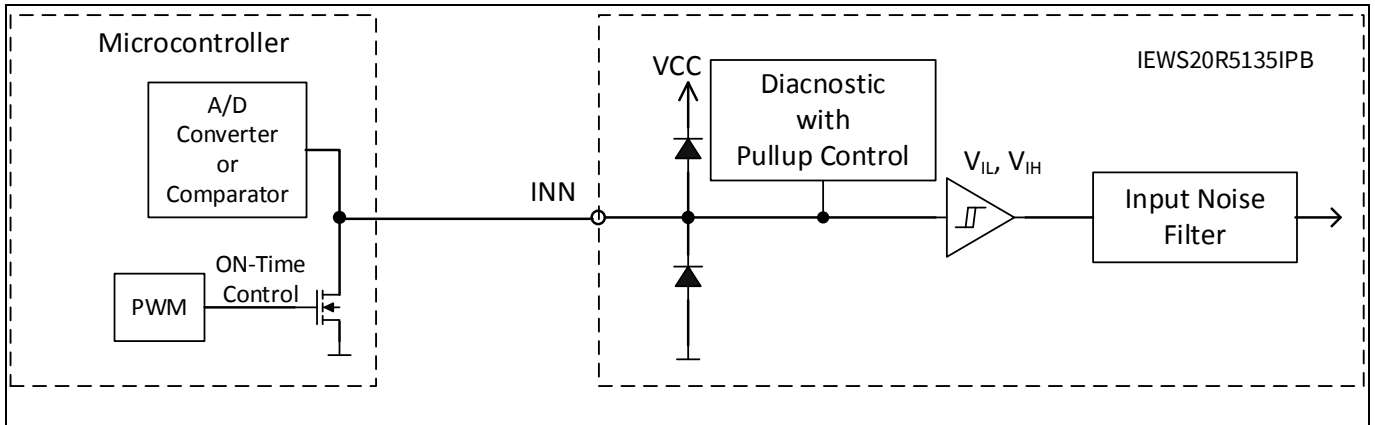


Figure 6 INN internal structure

Table 14 INN Diagnostic Pullup-Levels

Status	Pullup-Level(INN)
UVLO	<0,5V
No Fault	2,10V – 2,90V
OT-Warning	4V – 5V
OV-Detection	<0,5V
OT-Warning + OV-Detection	<0,5V (OV dominates)
OT-Shut-Down	<0,5V

5.6 Over-voltage detection input (VDET)

The integrated active clamp control level can be programmed on the VDET input with the resistor divider R1, R2 (Figure 7). After fixing R1, R2 can be calculated with the following equation:

$$R_2 = \frac{R_1}{\frac{V_{clamp1}}{V_{DET+1}} - 1}$$

V_{clamp} = programmed clamping level

V_{DET+1} = internal V_{DET+1} threshold

When the voltage at VDET goes above the internal threshold of V_{DET+1} , the Active Clamp Control (ACC) takes over and turns on the IGBT in a linear mode to regulate the voltage at VDET to V_{DET+1} and therefore the collector voltage to the programmed level V_{clamp1} . After the time T_{clamp1} the internal clamping level is increased by 11%. The ACC stay's active until the voltage at VDET drops below V_{DET+1} within T_{clamp1} or below V_{DET+2} after T_{clamp1} .

A third internal threshold at V_{DET} (V_{RST-}) takes care, that the IGBT is not turned on at a too high voltage level. Therefore the driver stay's disabled until the VDET voltage drops below V_{RST-} . The restart level (V_{RST-}) can be calculated with following equation:

$$V_{RST} = V_{clamp1} * \frac{V_{RST-}}{V_{DET+1}}$$

In normal operation the V_{RST-} threshold is also active and blocks the turn-on of the IGBT until the VDET voltage goes below V_{RST-} , but the INN is not switched to GND compared to the OV-detection mode

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Pin Configuration, Description and Functionality

(Table 15). If the INN is switched to GND from the control system when the $V_{CE} > V_{RST}$, the complete cycle is skipped (see Figure 9).

For short clamp situations, which can occur at pot removal conditions an over-voltage timer (OVT) is triggered in parallel. The OVT disables the driver for the over-voltage blank time so that the connected microcontroller has time to recognize and to react on the situation.

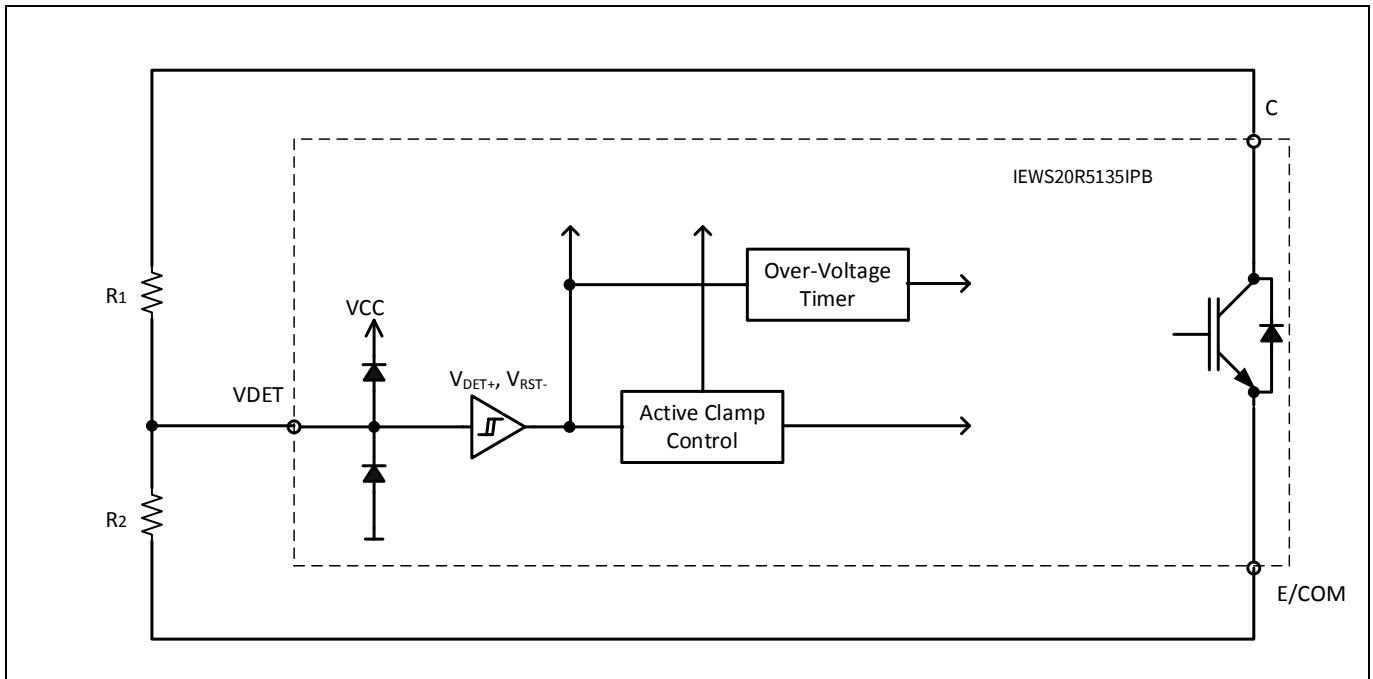


Figure 7 Active Clamp Control setting

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Pin Configuration, Description and Functionality

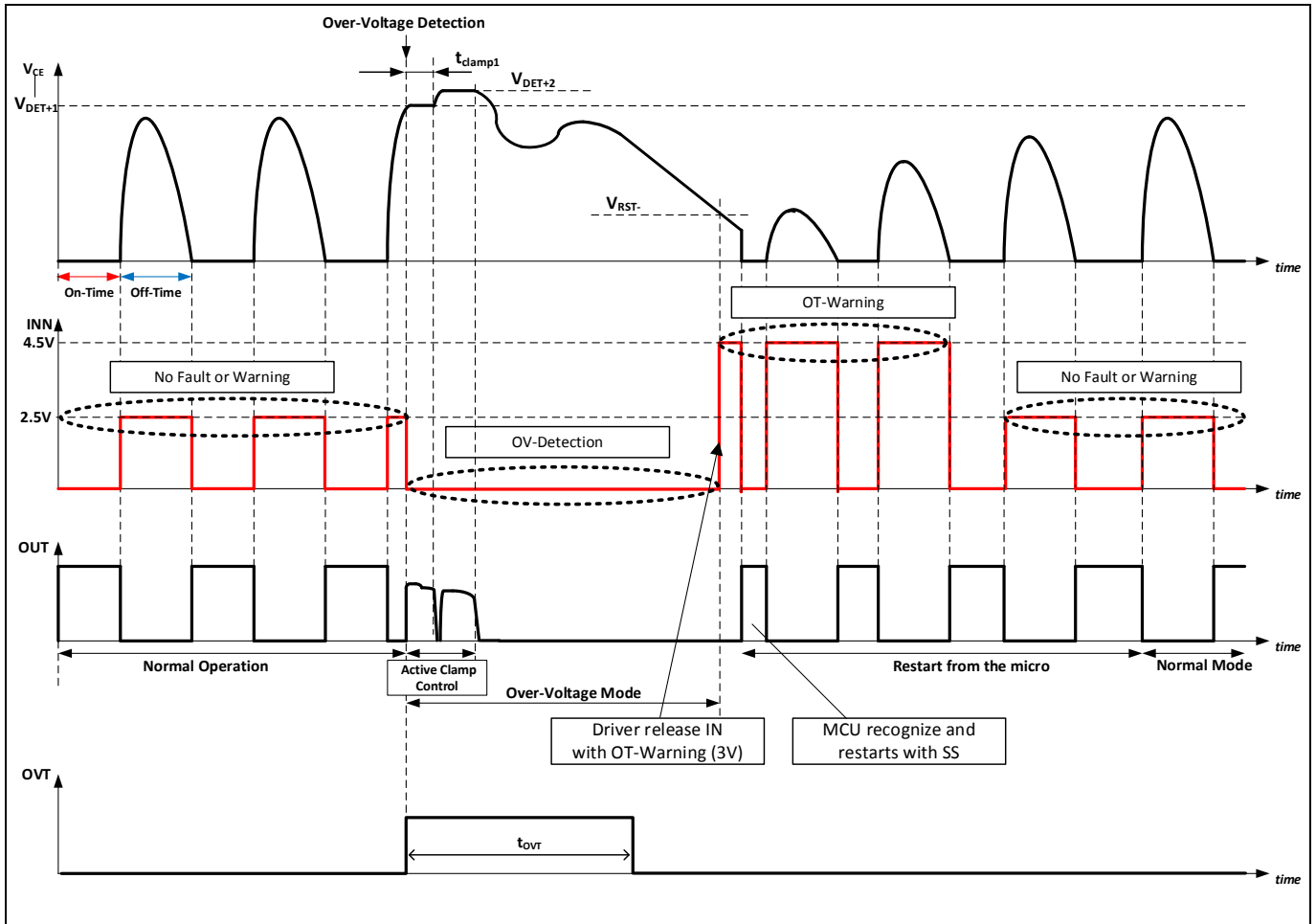


Figure 8 Active Clamp Control timing & Diagnostic

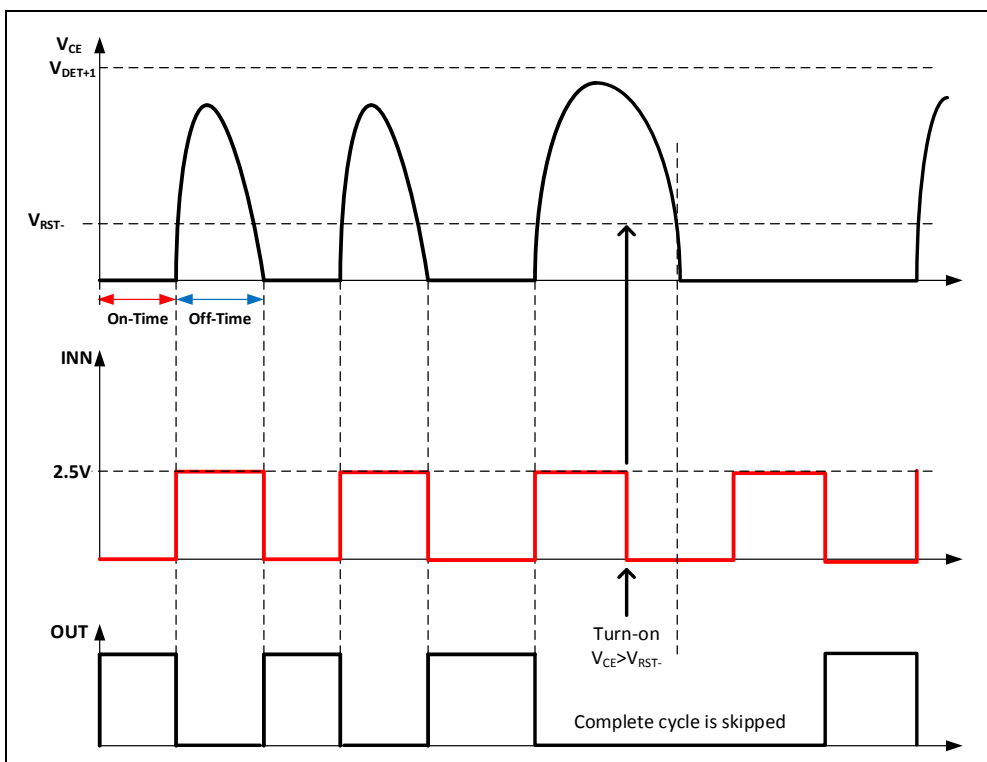


Figure 9 Function turn-on, if $V_{CE} > V_{RST-}$

6 Timing Diagrams

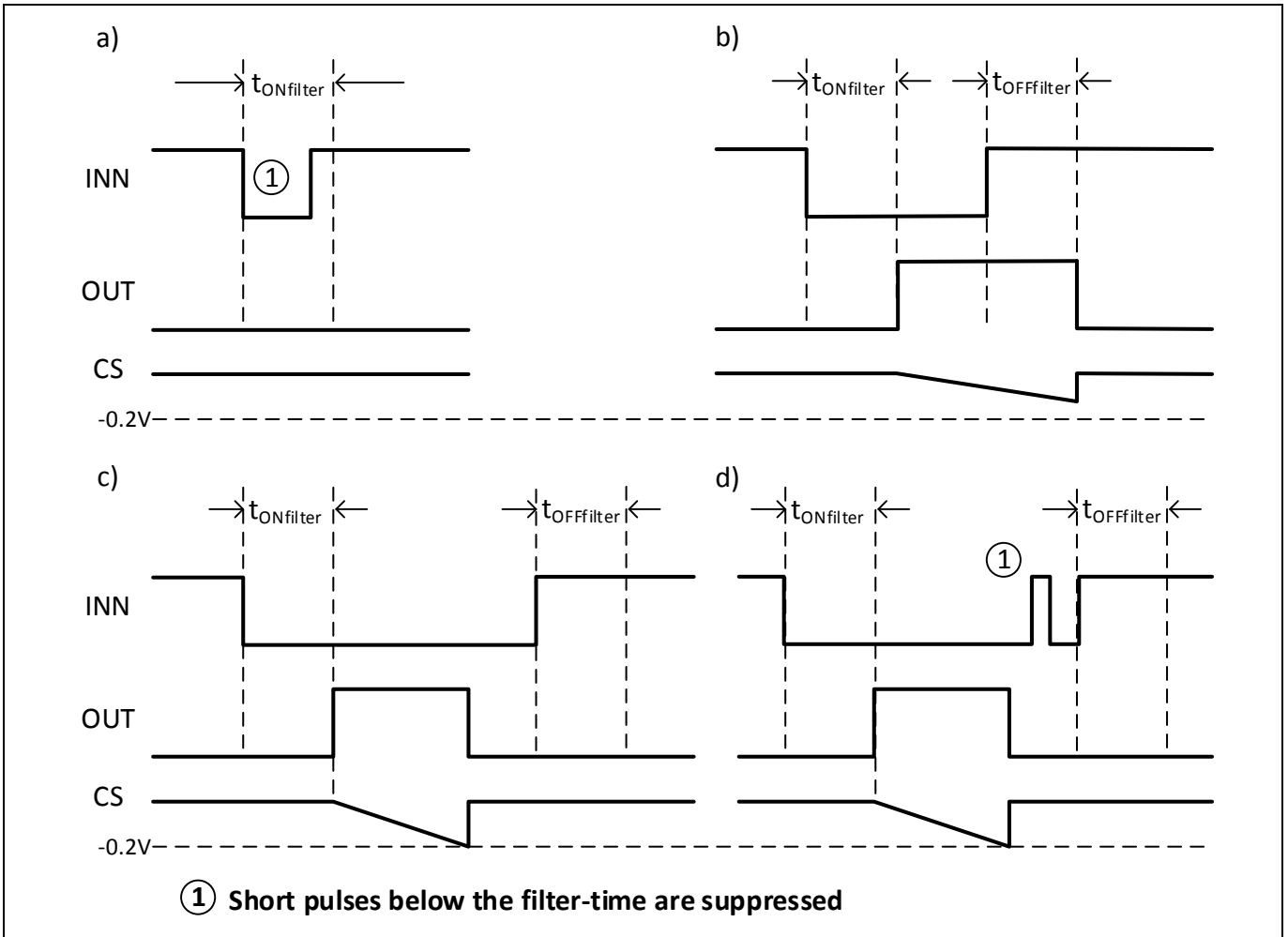


Figure 10 Input Noise Filter

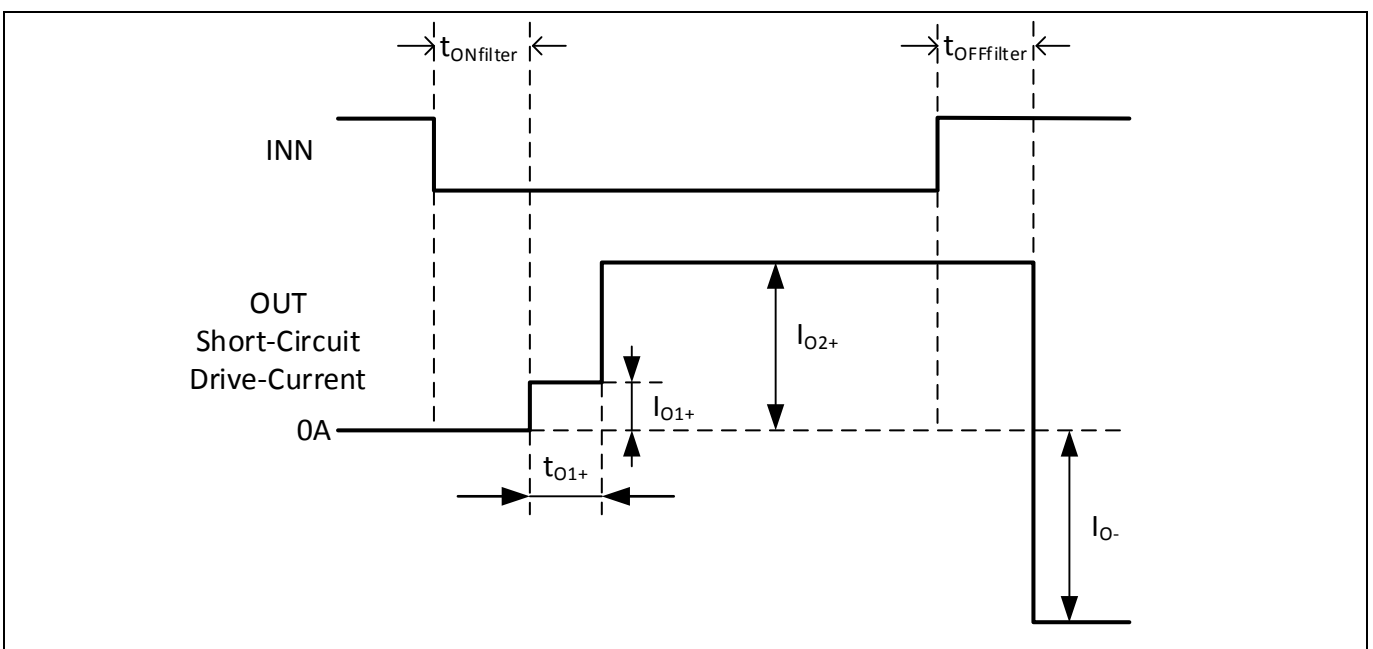


Figure 11 OUT Short-Circuit Drive-Current

7 Electrical Characteristics Diagrams

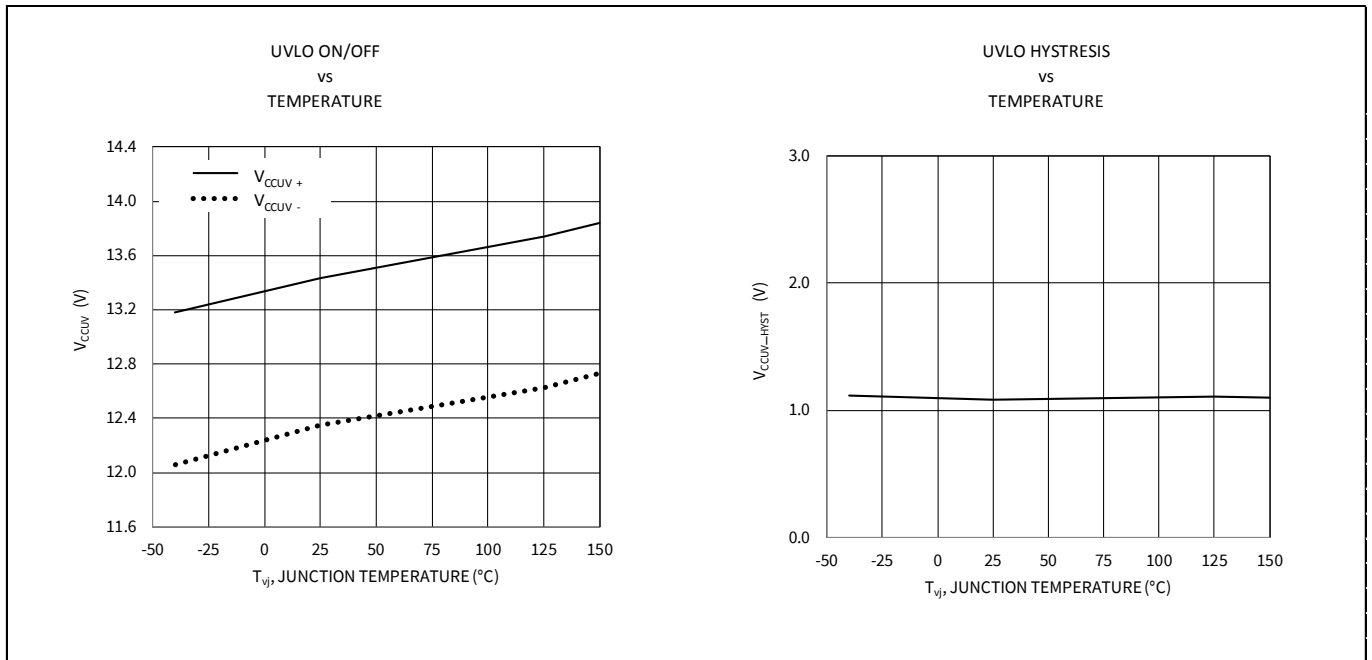


Figure 12. Undervoltage Lockout

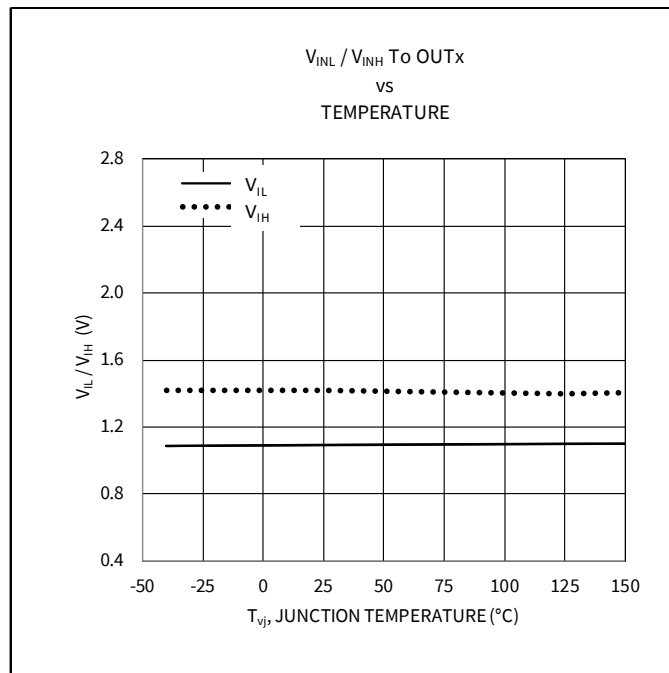


Figure 13. Input Voltage Characteristic

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Electrical Characteristics Diagrams

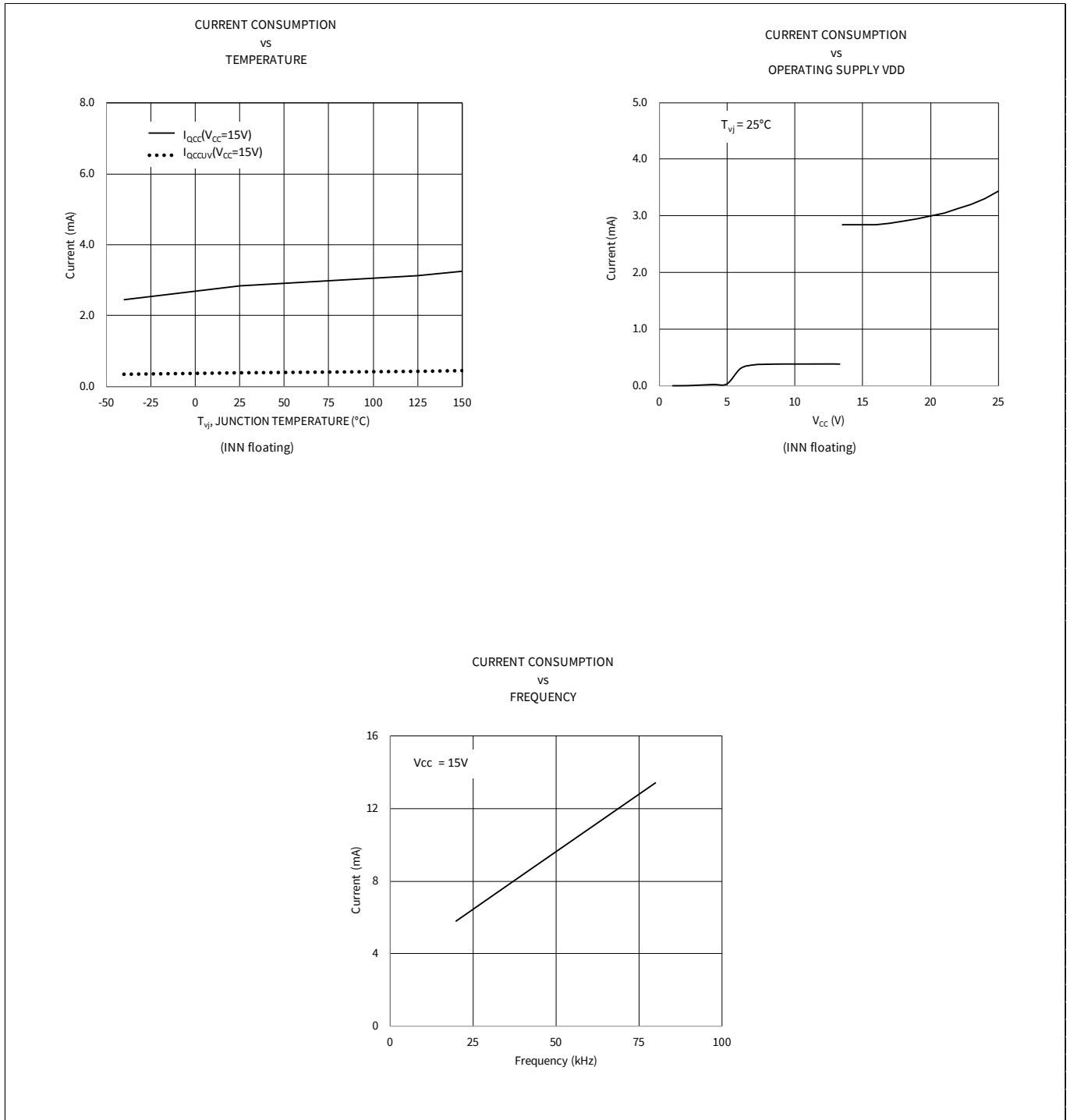


Figure 14. Power Consumption Related to Temperature, Voltage Supply and Frequency

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Electrical Characteristics Diagrams

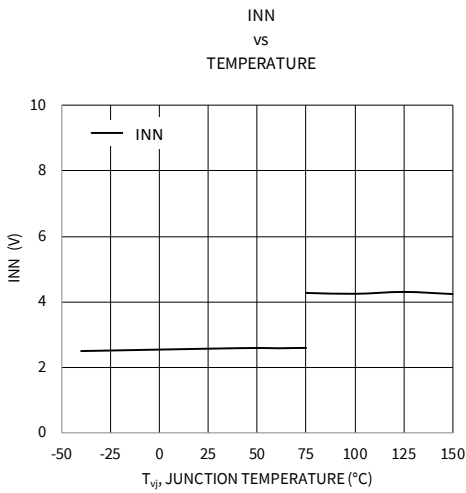


Figure 15. INN vs T_{j}

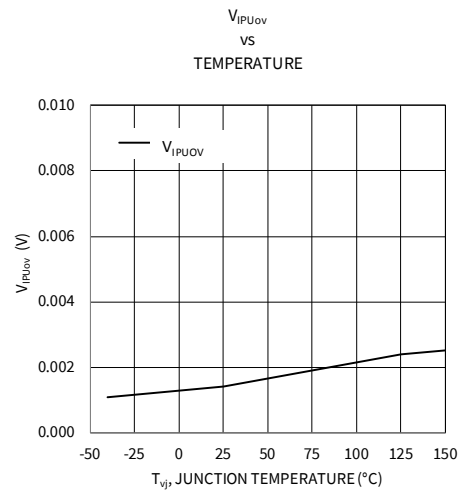


Figure 16. V_{IPUov} vs T_{j}

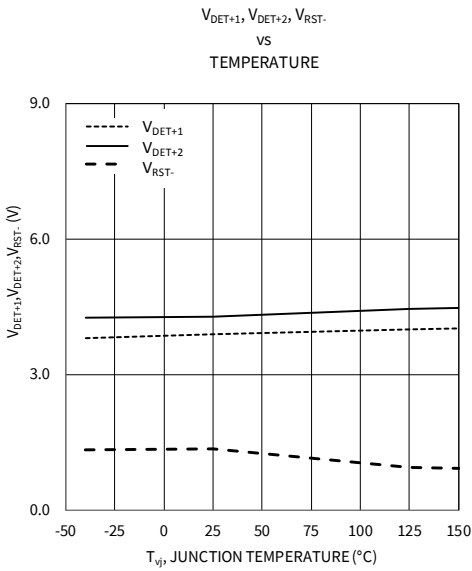


Figure 17. V_{DET+1} , V_{DET+2} , V_{RST-} vs T_{j}

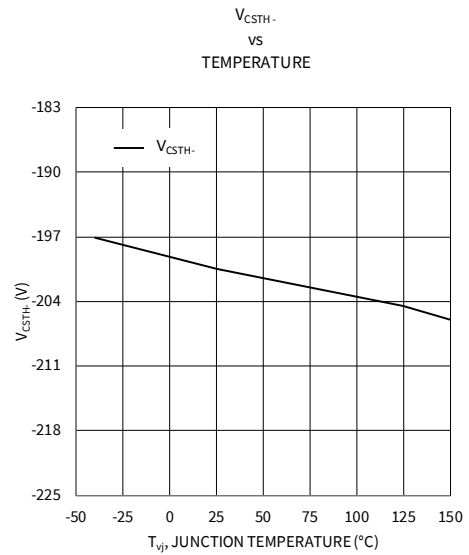


Figure 18. V_{CSTH-} vs T_{j}

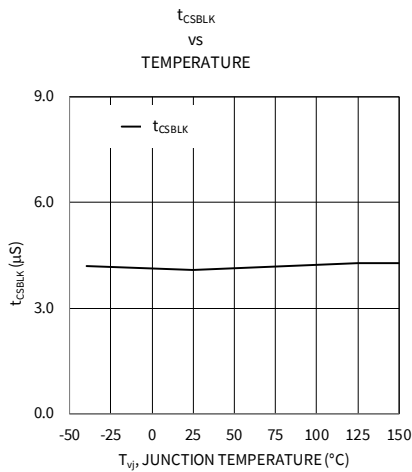


Figure 19. t_{CSBLK} vs T_{j}

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Electrical Characteristics Diagrams

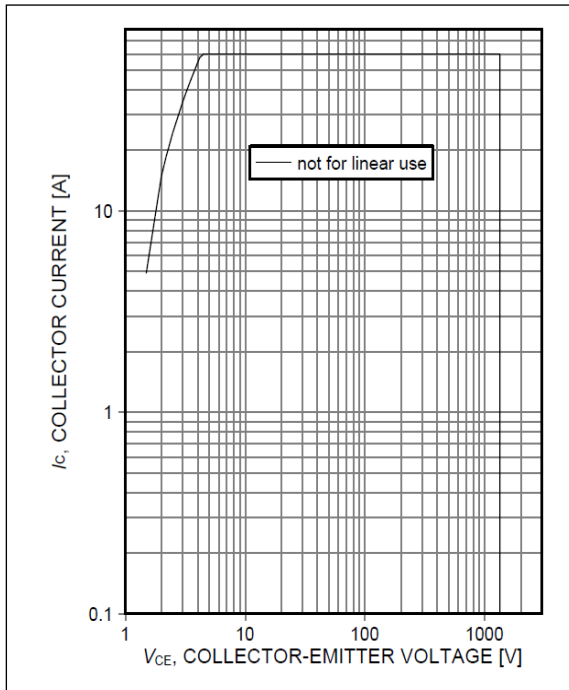


Figure 20. Safe operating area
 (D=0, T_c=25°C, T_{vj}=175°C; V_{CC}=15V, t_p=1μs)

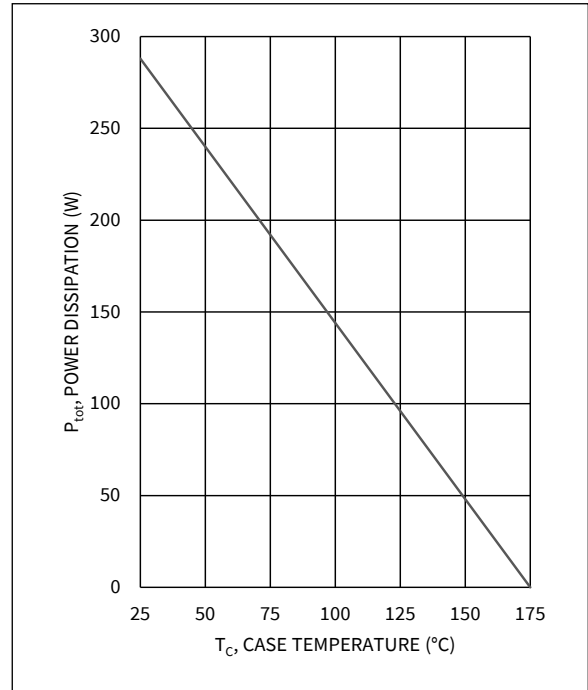


Figure 21. Power dissipation as a function of case temperature
 (T_{vj}≤175°C)

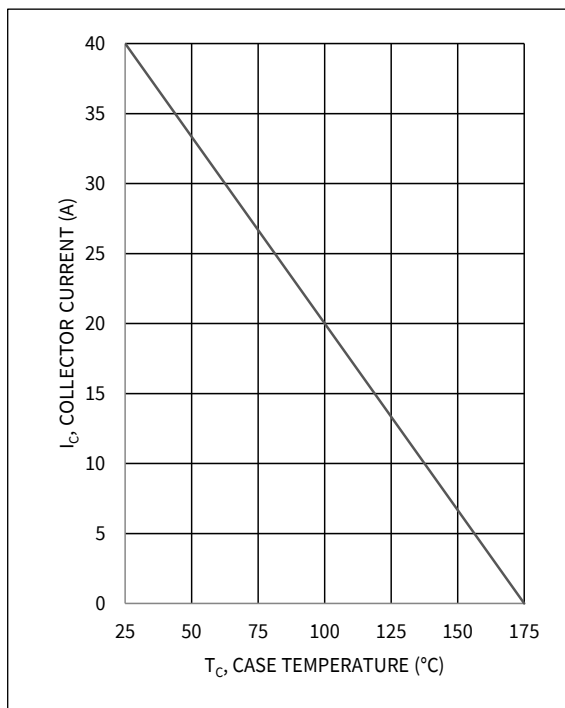


Figure 22. Collector current as a function of case temperature
 (V_{CC}≥15V, T_{vj}≤175°C; t_p=1μs)

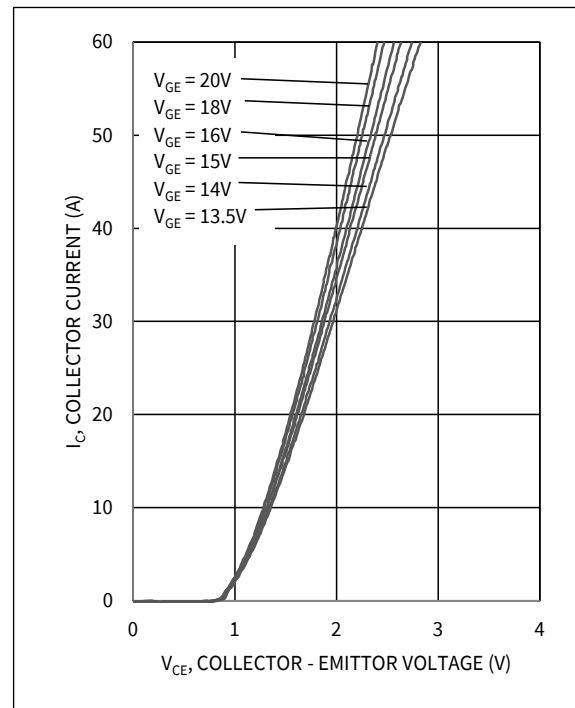


Figure 23. Typical output characteristic
 (T_{vj}=25°C)

Protected IGBT

IGBT 20A/1350V RC-H5 technology with driver IC

Electrical Characteristics Diagrams

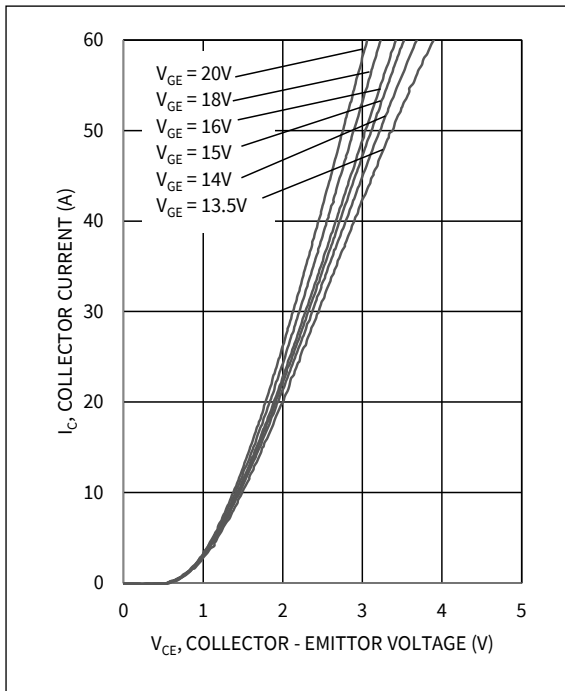


Figure 24. Typical output characteristic
($T_{vj}=150^{\circ}\text{C}$)

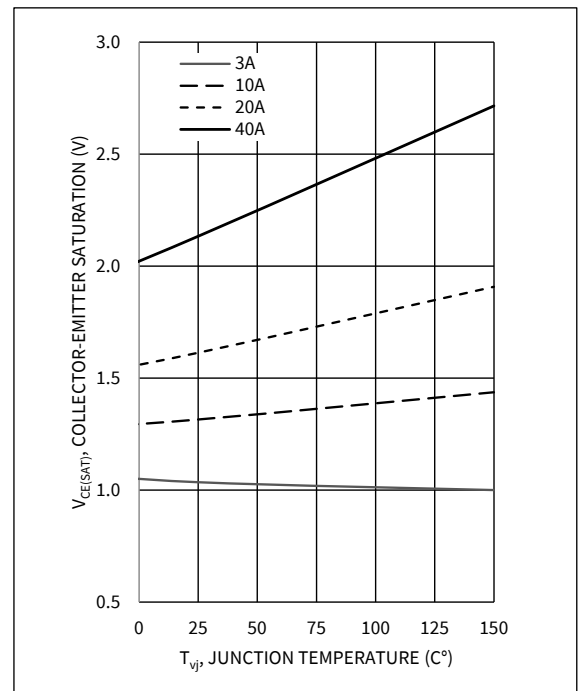


Figure 25. Typical collector-emitter saturation voltage as a function of junction temperature
($V_{CC}=15\text{V}$)

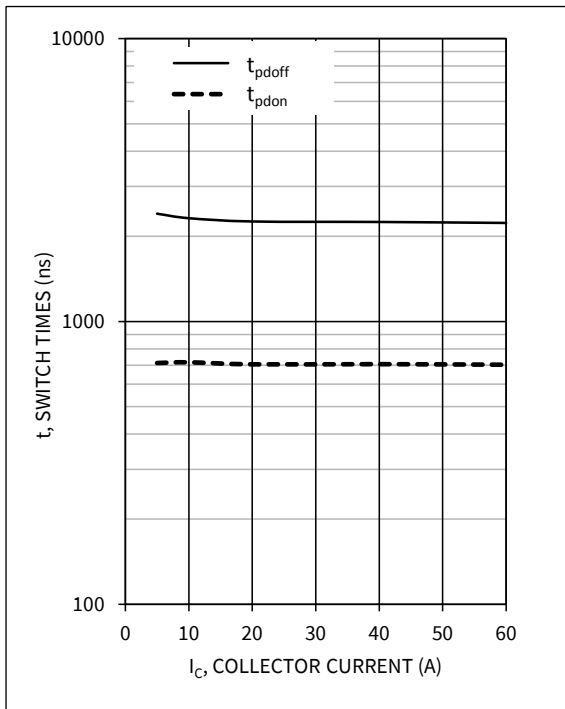


Figure 26. Typical switching times as a function of collector current
(inductive load, $T_{vj}=150^{\circ}\text{C}$, $V_{CE}=600\text{V}$, $V_{CC}=15$, dynamic test circuit in Figure F)

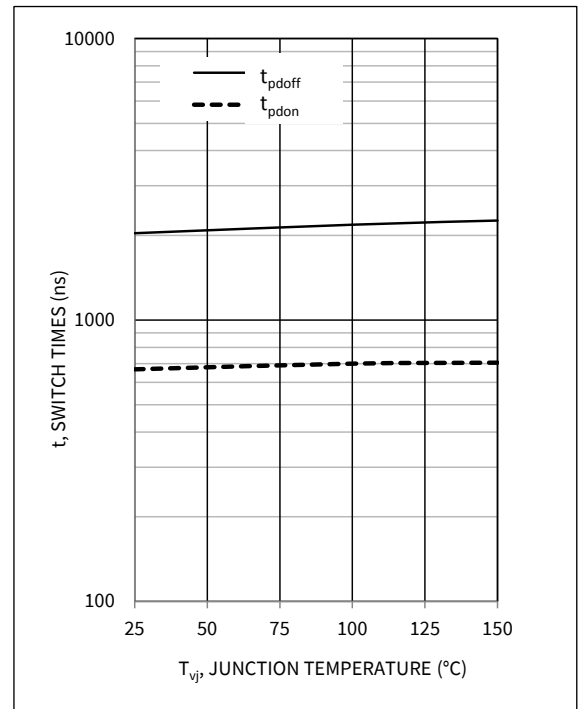


Figure 27. Typical switching times as a function of junction temperature
(inductive load, $V_{CE}=600\text{V}$, $V_{CC}=15\text{V}$, $I_C=20\text{A}$, Dynamic test circuit in Figure F)

Protected IGBT

IGBT 20A/1350V RC-H5 technology with driver IC

Electrical Characteristics Diagrams

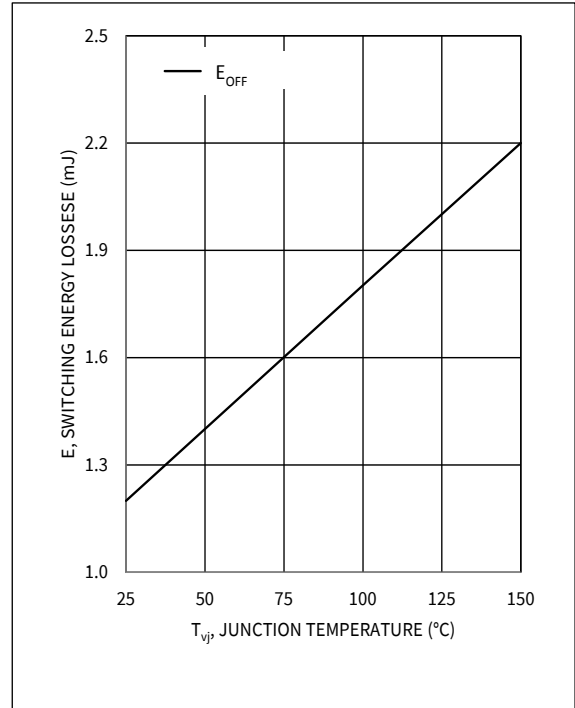
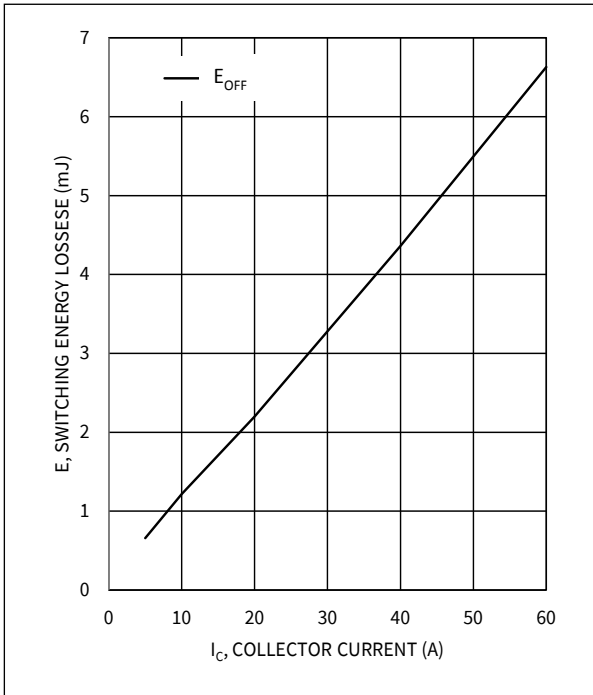


Figure 28. Typical switching energy losses as a function of collector current
(inductive load, $T_{vj}=150^{\circ}\text{C}$, $V_{ce}=600\text{V}$, $V_{cc}=15\text{V}$, Dynamic test circuit in Figure F)

Figure 29. Typical switching energy losses as a function of junction temperature
(inductive load, $V_{ce}=600\text{V}$, $V_{cc}=15\text{V}$, $I_c=20\text{A}$, Dynamic test circuit in Figure F)

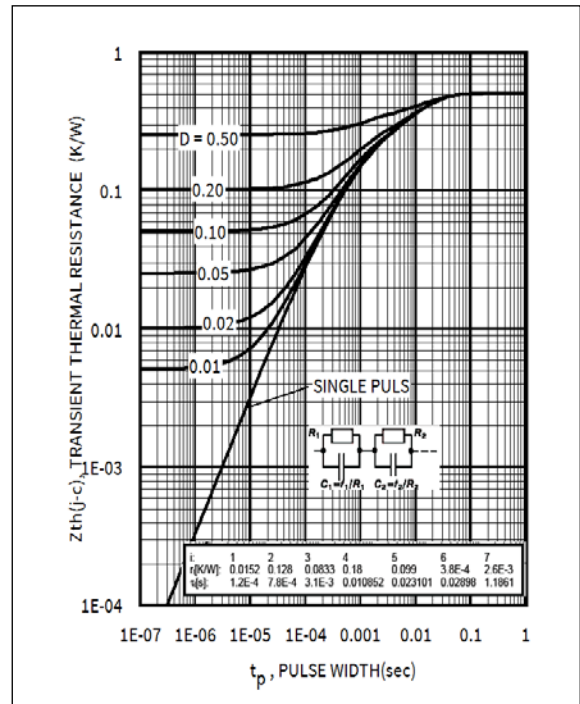
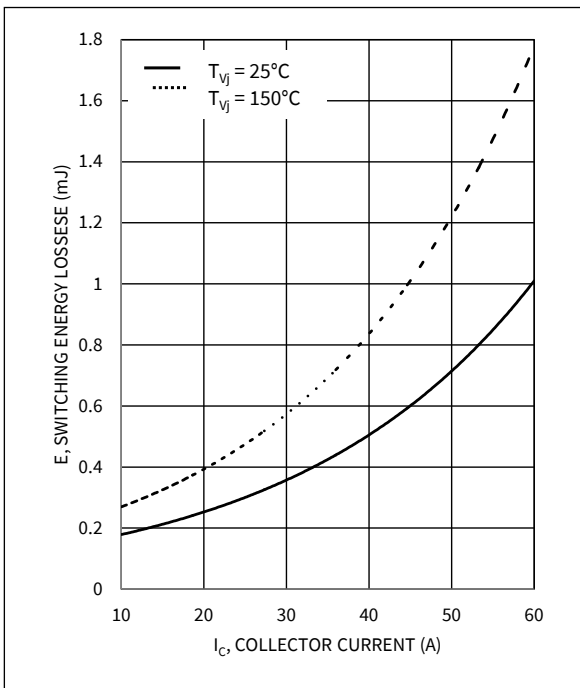


Figure 30. Typical turn off switching energy loss For soft switching
(Inductive load, $V_{ce}=600\text{V}$, $V_{cc}=15\text{V}$, Dynamic test circuit in Figure F)

Figure 31. IGBT transient thermal impedance
($D=tp/T$)

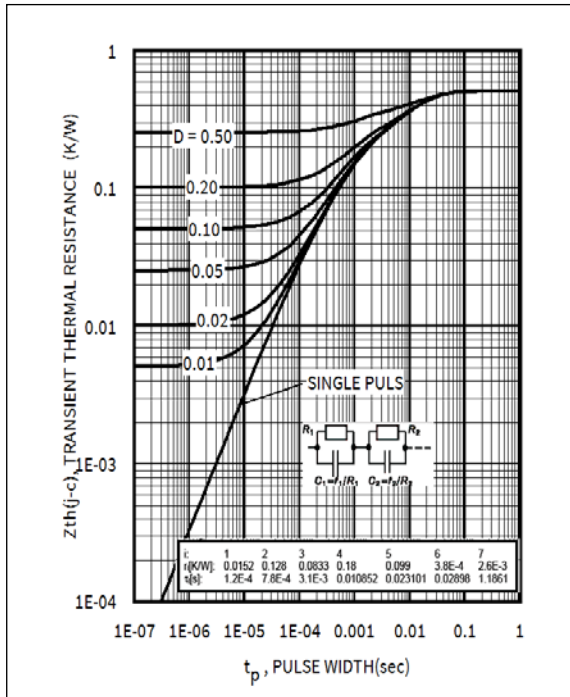


Figure 32. Diode transient thermal impedance as a function of pulse width
 ($D=tp/T$)

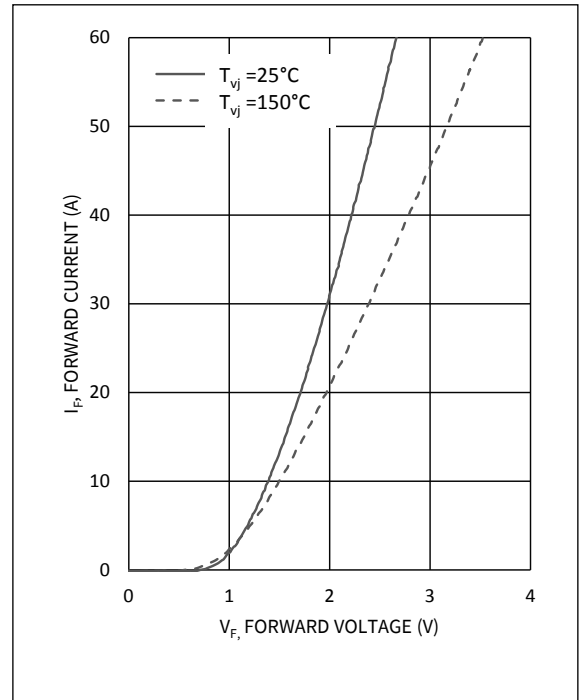


Figure 33. Typical diode forward current as a function of forward voltage

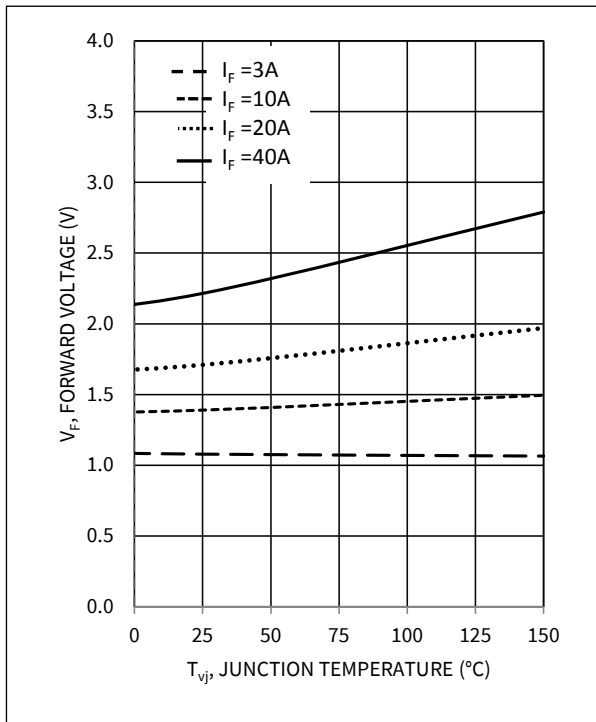


Figure 34. Typical diode forward voltage as a function of junction temperature

8 Test Conditions

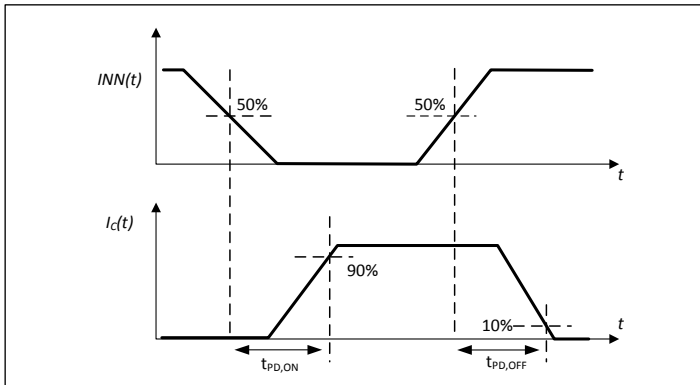


Figure A. Definition of switching times

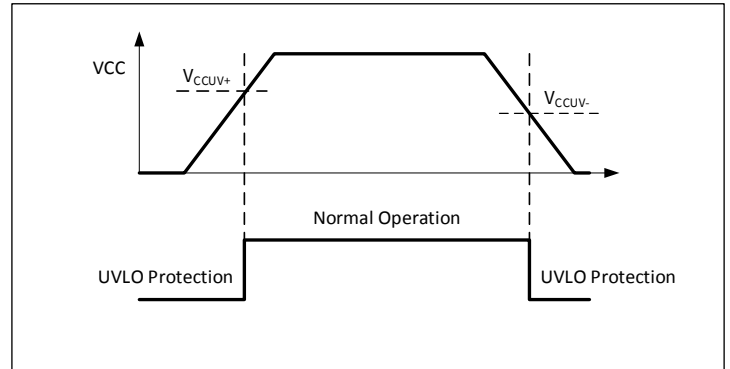


Figure D. UVLO Protection

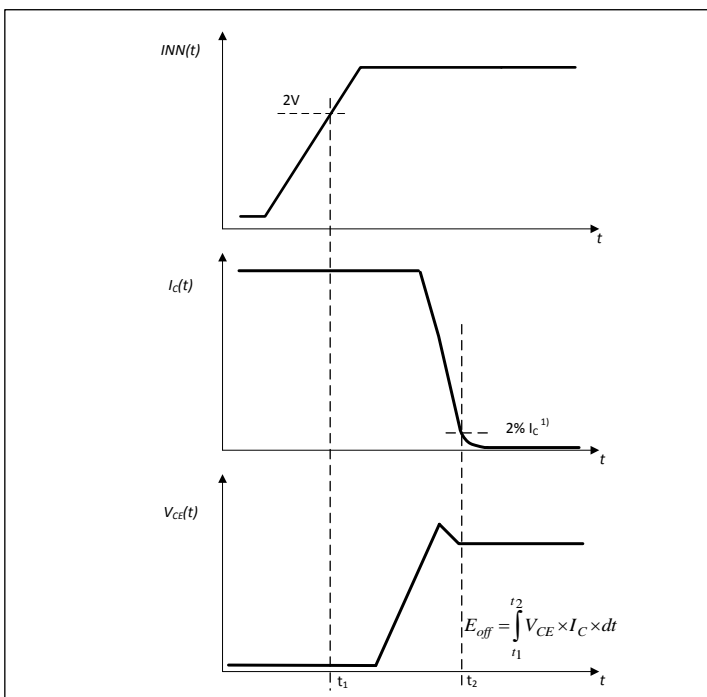


Figure B. Definition of switching losses

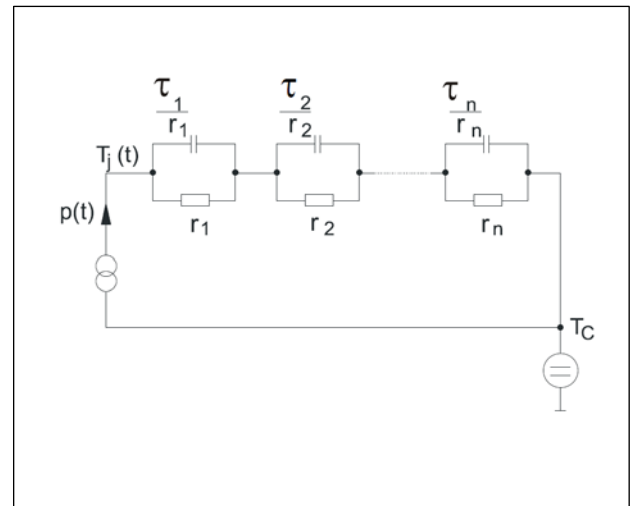


Figure E. Thermal equivalent circuit

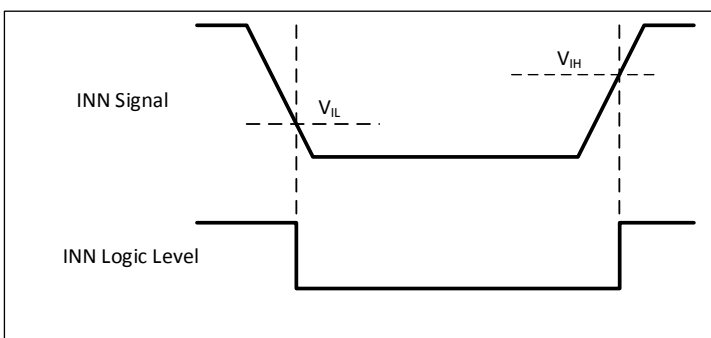


Figure C. INN Thresholds

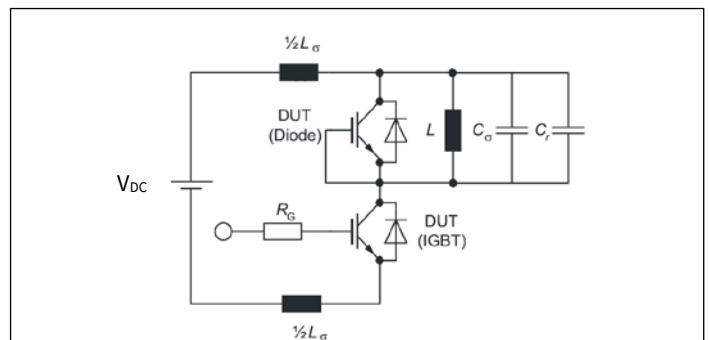
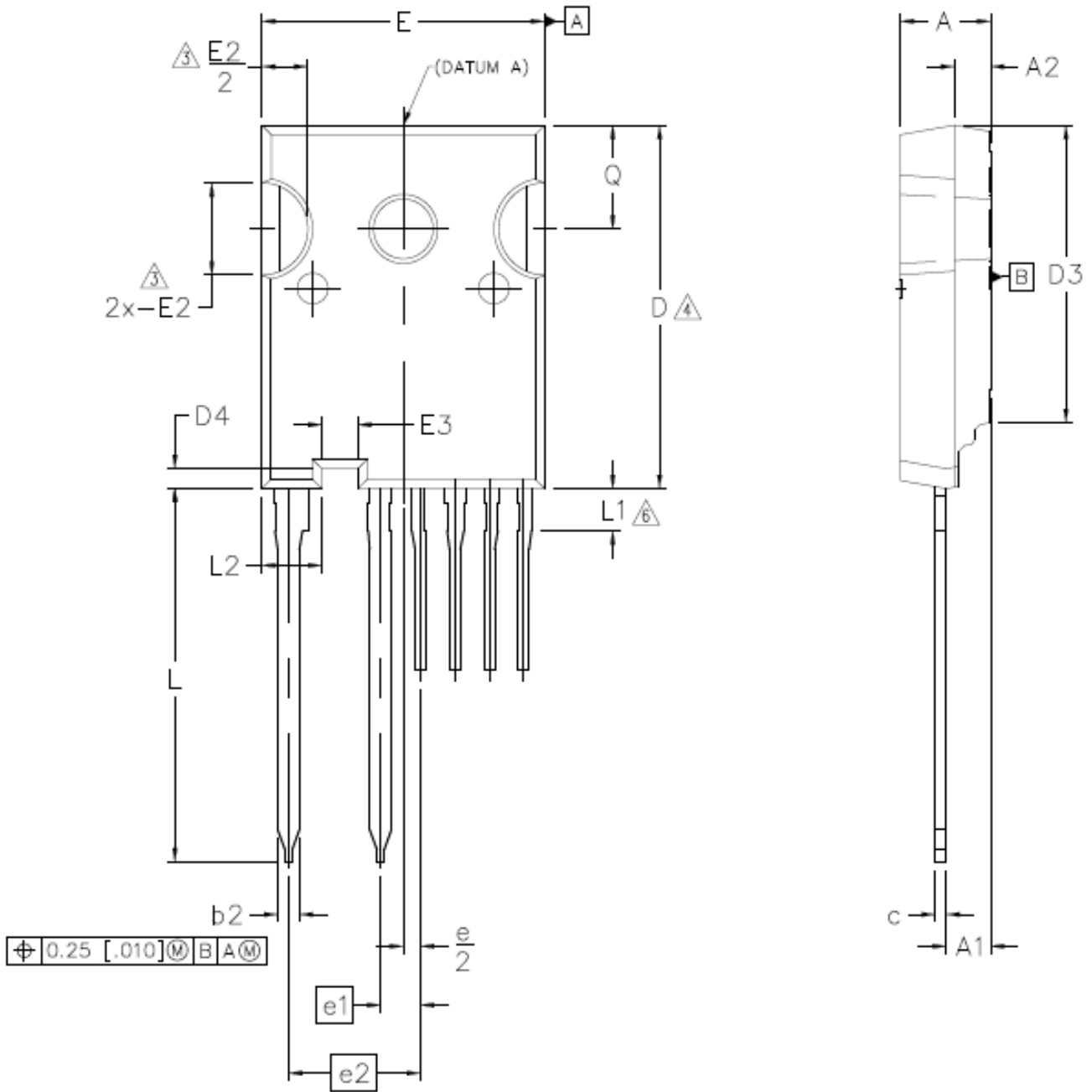


Figure F. Dynamic test circuit

¹ For soft switching is 1% Ic.

9 Package Drawing



Package Dimensions

9.1 Package Dimensions

NOTES:

1. DIMENSIONING AND TOLERANCING AS PER ASME Y14.5M 1994.
2. DIMENSIONS ARE SHOWN IN MILLIMETERS
3. CONTOUR OF SLOT OPTIONAL.
4. DIMENSION DOES NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.13 [.005"] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY.
5. THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSIONS D1 & E1.
6. LEAD FINISH UNCONTROLLED IN L1.
7. ϕP TO HAVE A MAXIMUM DRAFT ANGLE OF 1.5 ° TO THE TOP OF THE PART WITH A MAXIMUM HOLE DIAMETER OF .154 INCH.
8. A1 MEASUREMENT IS LOCATED AT 2.33 MM FROM THE PACKAGE EDGE.

SYMBOL	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	4.65	5.31	.183	.209	
A1	2.15	2.70	.085	.106	8
A2	1.50	2.50	.059	.098	
b	0.45	0.80	.018	.031	
b2	0.90	1.50	.035	.059	
c	0.45	0.90	.018	.035	
D	19.70	20.70	.776	.815	4
D1	12.20	–	.480	–	5
D2	1.00	1.80	.040	.071	
D3	16.00	17.00	.630	.670	
D4	0.90	1.30	.035	.051	4
E	15.30	15.90	.602	.626	4
E1	12.20	–	.480	–	5
E2	4.70	5.50	.185	.216	
E3	1.80	2.20	.071	.087	4
e	1.90	BSC	.075	BSC	
e1	2.20	BSC	.087	BSC	
e2	7.28	BSC	.287	BSC	
ϕk	0.25		.010		
L	19.80	21.00	.780	.827	
L1	2.03	2.64	.080	.104	6
L2	3.00	3.60	.118	.142	4
L4	9.40	10.60	.370	.417	
ϕP	3.48	3.76	.137	.148	4
$\phi P1$	–	7.39	–	.291	
Q	5.40	6.20	.212	.244	
S	5.72	BSC	.225	BSC	



Revision History

Revision History

Revision:2018-06-28, Rev.2.0

Revision	Date	Subjects (major changes since last revision)
2.0	2018-06-28	Final Datasheet

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