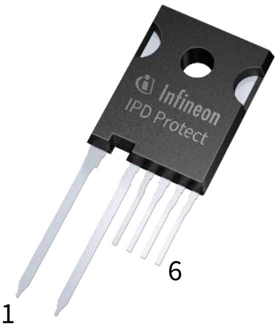
IPD Protect

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 forindustrial applications according to the relevant tests of JEDEC47/20/22
- PG-TO247-6 package
- http://www.infineon.com/IPD-Protect



1	C	Collector
2	E/COM	Emitter/Ground
3	VCC	Supply
4	CS	Current Sense
5	INN	PWM Input
6	VDET	Voltage Sense

Applications

- Induction cooking

Description

The IPD (Integrated Power Device) Protect includes an IGBT with Gate Driver IC in a TO247 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.

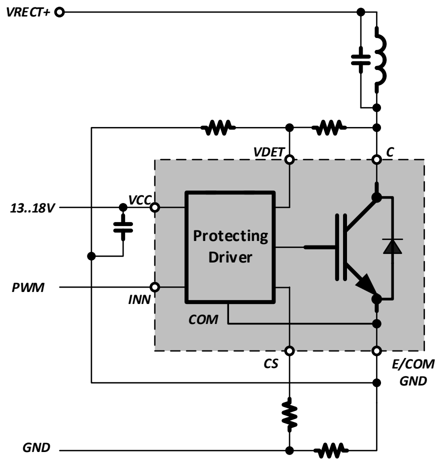


Figure 1 Typical Application

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1 Block Diagram

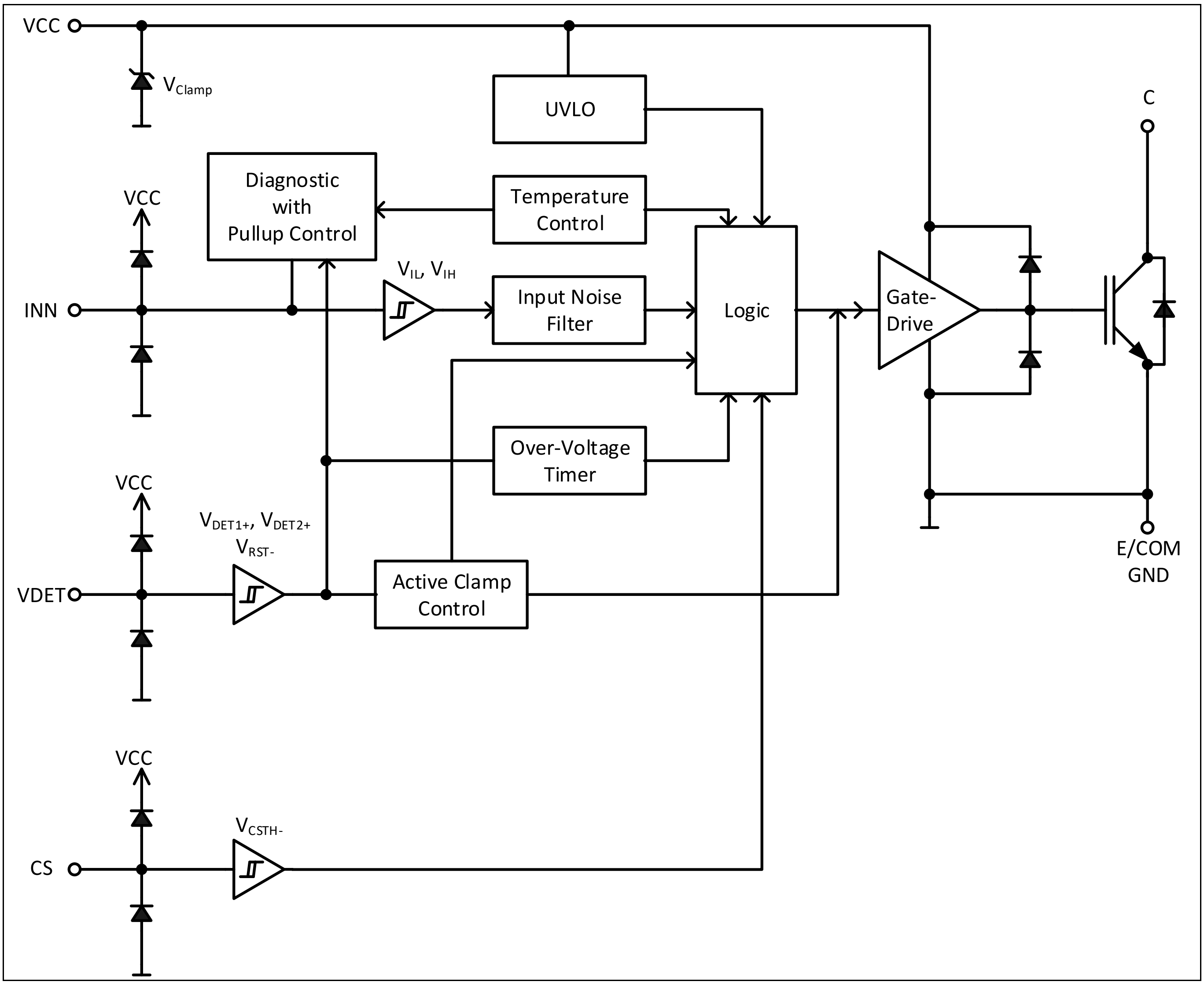


Figure 2 Block Diagram of IEWS20R5135IPB

2 State Diagram

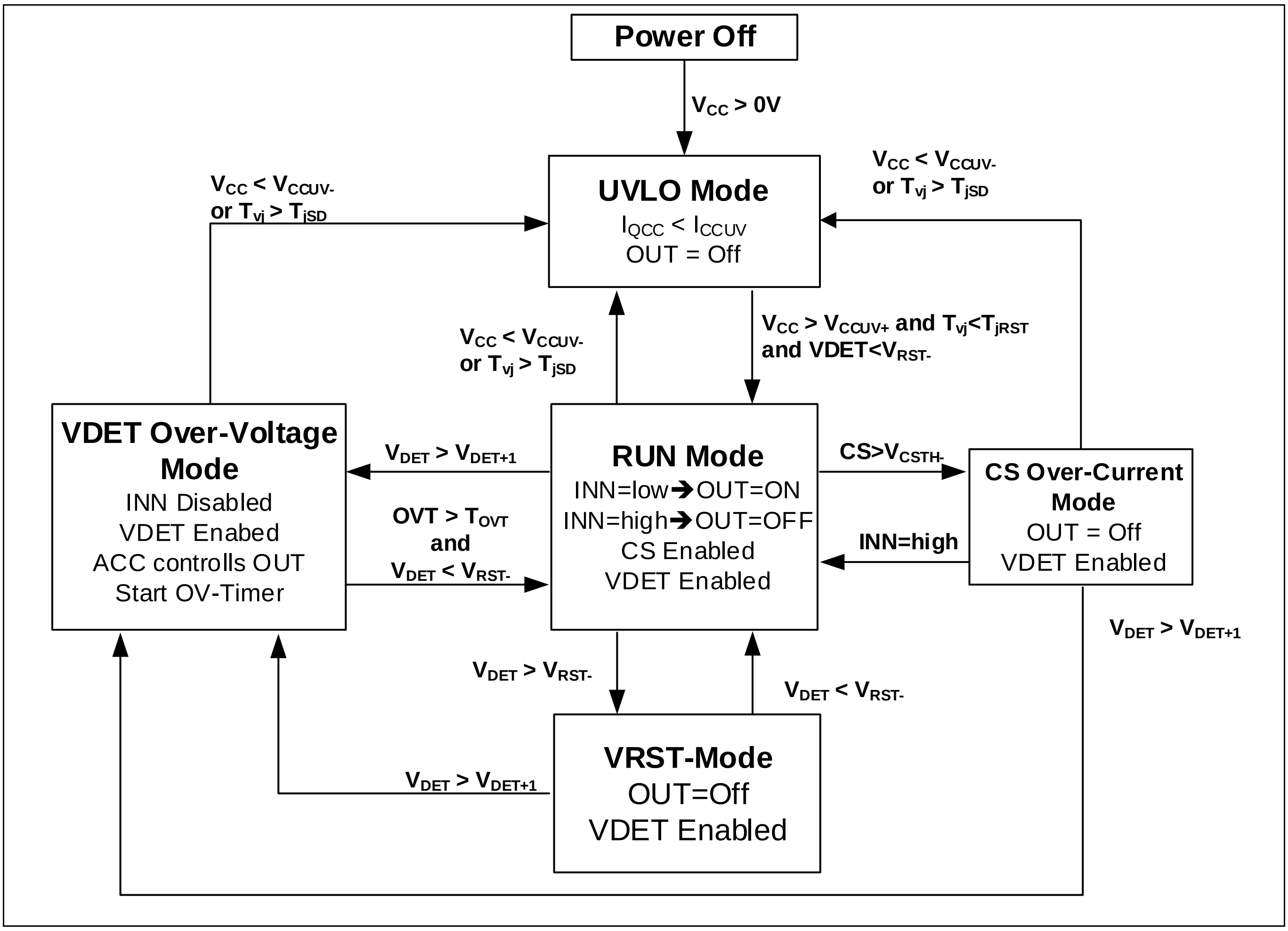


Figure 3 State diagram of IEWS20R5135IPB

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	V	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°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

[1] This 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.
[2] According to the JESD22-C101 CDM standard
[3] According 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_{CSTH-}	-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	---		

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 C
Logic "1" input voltage (OUT = LO)	V_{IH}	2.0	---	---		
INN pullup-voltage ➔ no fault	V_{IPUnf}	2.10	2.50	2.90		
INN pullup-voltage ➔ temp warning	V_{IPUtw}	4.00	4.50	5.00		
INN voltage ➔ over-voltage detection or over-temp shut-down	V_{IPUov}	---	---	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	V_{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, $T_{vj} \geq 25°C$	V_{CE}	1350	V
DC collector current, limited by T_{vjmax} $T_C = 25°C$ $T_C = 100°C$	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 ($V_{CE} \leq 1350V$, $T_{vj} \leq 175°C$, t_p=1µs)	-	60	A
Diode forward current, limited by T_{vjmax} $T_C = 25°C$ $T_C = 100°C$	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 (tp≤10µs, D<0.010)	V_{GE}	±20 ±25	V
Power dissipation $T_C = 25°C$ Power dissipation $T_C = 100°C$	P_{tot}	288.0 144.0	W
Virtual junction temperature	T_{vj}	-40...+175	°C
Operating junction temperature [1]	$T_{vj,op}$	-40...+150	°C
Storage temperature	T_{stg}	-40...+150	°C
Soldering temperature, 1.6mm (0.063 in.) from case for 10s	-	260	°C
Mounting torque, M3 screw Maximum of mounting processes: 3	M	0.6	Nm
ESD capability Charged Devices Model (CDM) [2]	V_{ESD}	750	V
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

[1] Limited by $T_{vj,max}$ of the driver I_C.
[2] According to the JESD22-C101 CDM standard
[3] According to the JESD22-A114 Rev. F standard

4.2 Electrical Characteristics

At T_{vj}=25°C and V_{CC}=15V, unless otherwise specified

Table 10 Static Characteristic

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

Table 11 Switching Characteristics, Inductive Load at T_{vj}=25°C

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Turn-on propagation time	$t_{PD,on}$	V_{DC}=600V, I_C=20.0A I_{NN}=open/0V L_σ=175nH, C_σ=40pF L_σ, C_σ fromFig. 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 = 67V/ µs From Fig. F Energy losses include "tail".	-	0.26	-	mJ

Table 12 Switching Characteristics, Inductive Load at T_{vj}=150°C

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Turn-on propagation time	$t_{PD,on}$	V_{DC}=600V, I_C=20.0A I_{NN}=open/0V L_σ=175nH, C_σ=40pF L_σ, C_σ fromFig. 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 = 67V/ µs From Fig. F Energy losses include "tail".	-	0.40	-	mJ

5 Pin Configuration, Description and Functionality

5.1 Pin Configuration and Description

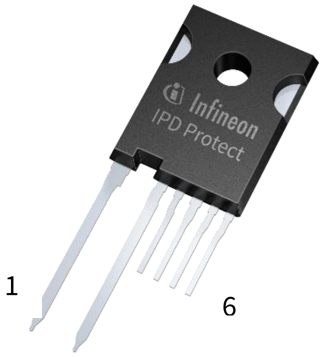


Figure 4 Pin Configuration

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 dectection 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.

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.

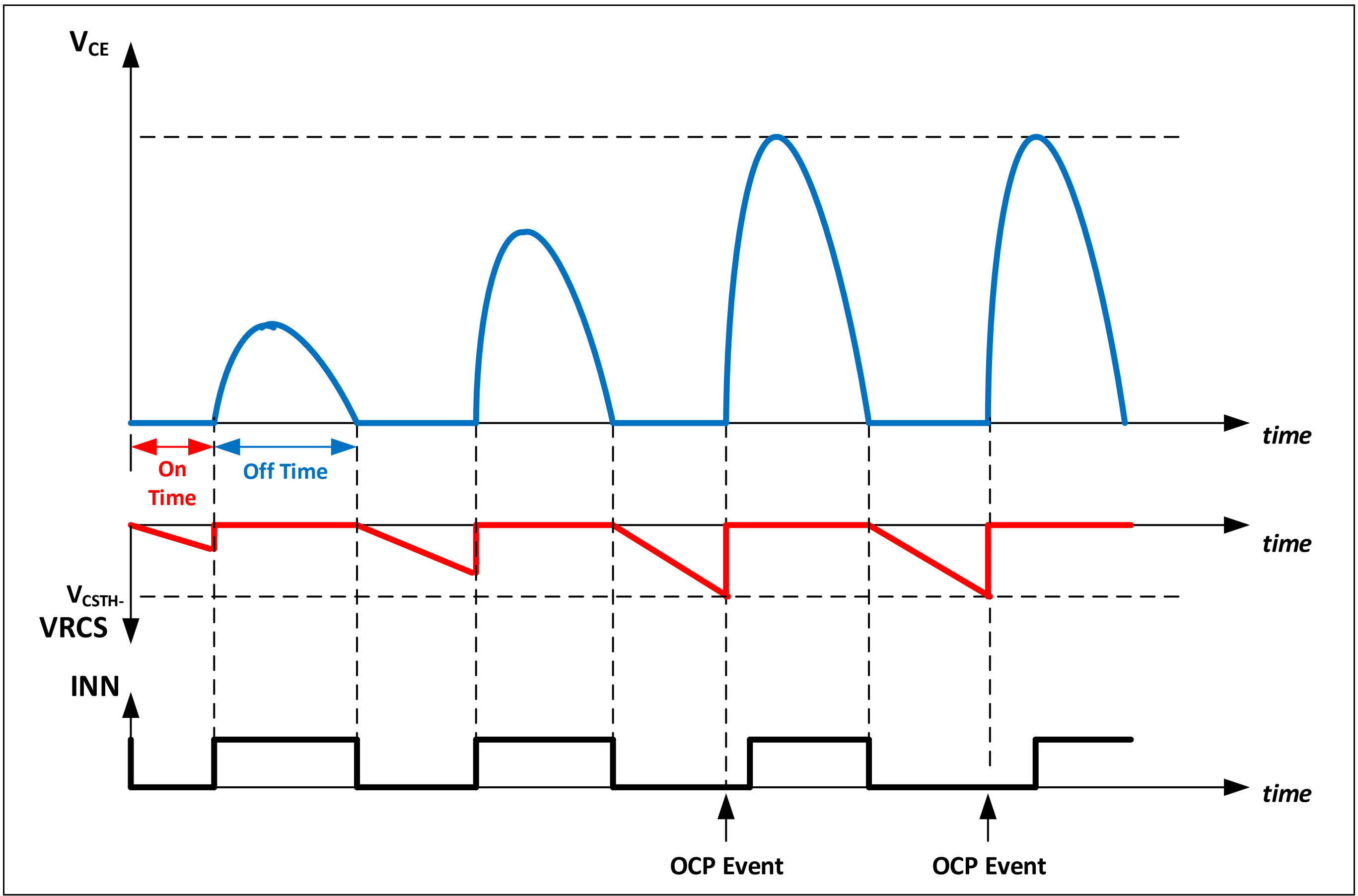


Figure 5 Cycle by cycle current limitation

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 pull-up voltage level according to the status (see Table 14 & 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.

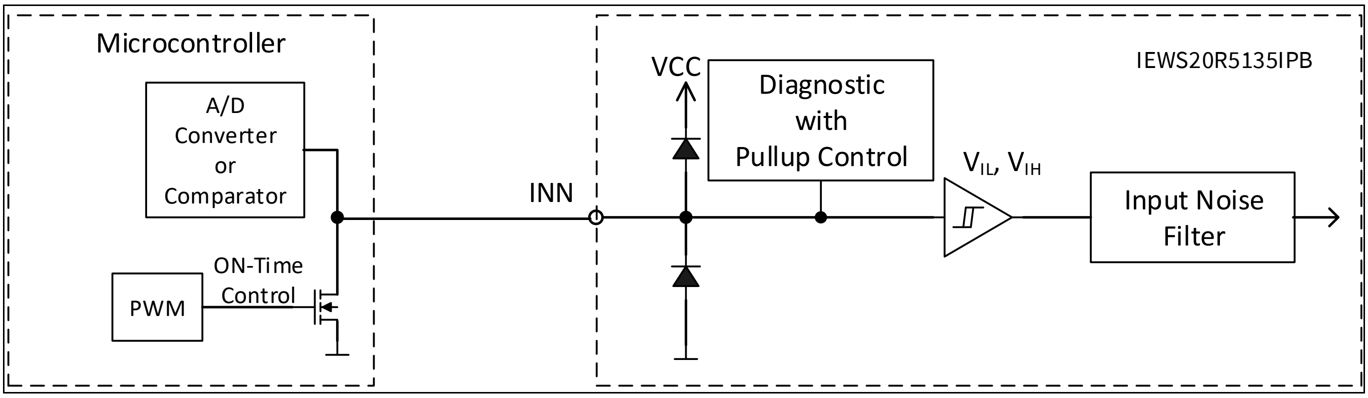


Figure 6 INN internal structure

Table 14 INN Diagnostic Pullup-Levels

Status	Pull-up 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 devider 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_{DET1+} , the Active Clamp Control (ACC) takes over and turns on the IGBT in order 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_{DET1+} within T_{clamp1} or below V_{DET2+} 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 falls below V_{RST-}, but the INN is not switched to GND compared to the OV-detection mode (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 for example when the vessel is removed from the cooking surface, 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.

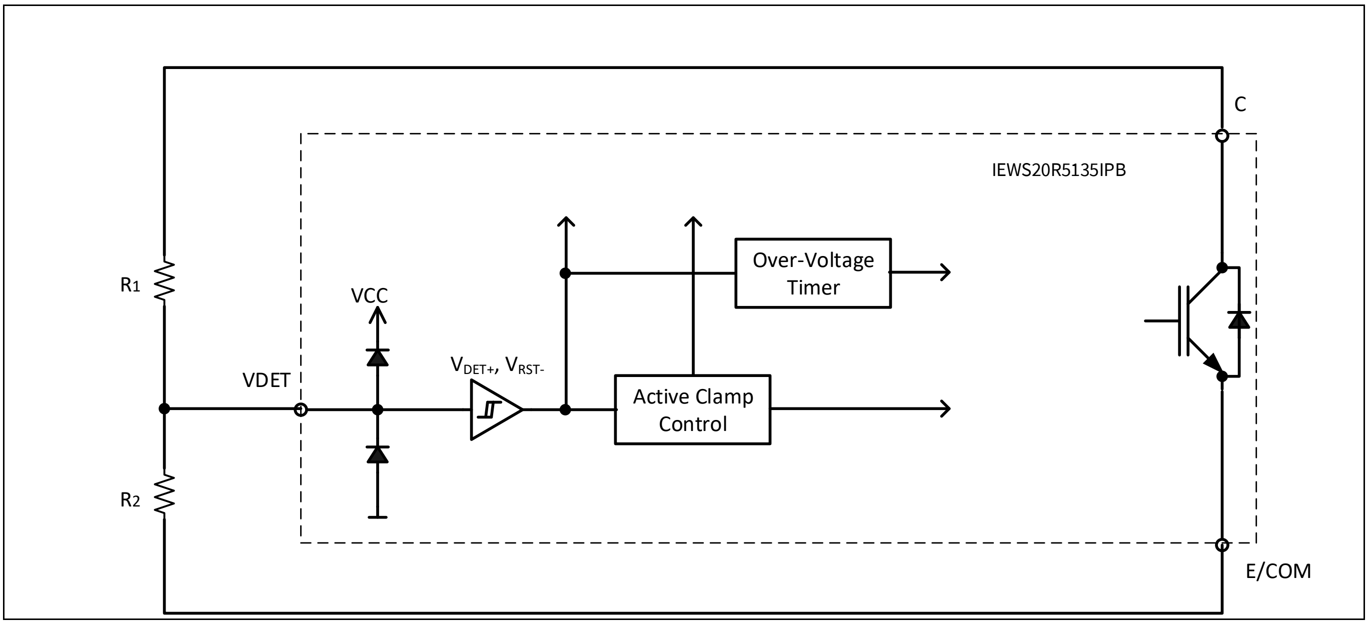


Figure 7 Active Clamp Control setting

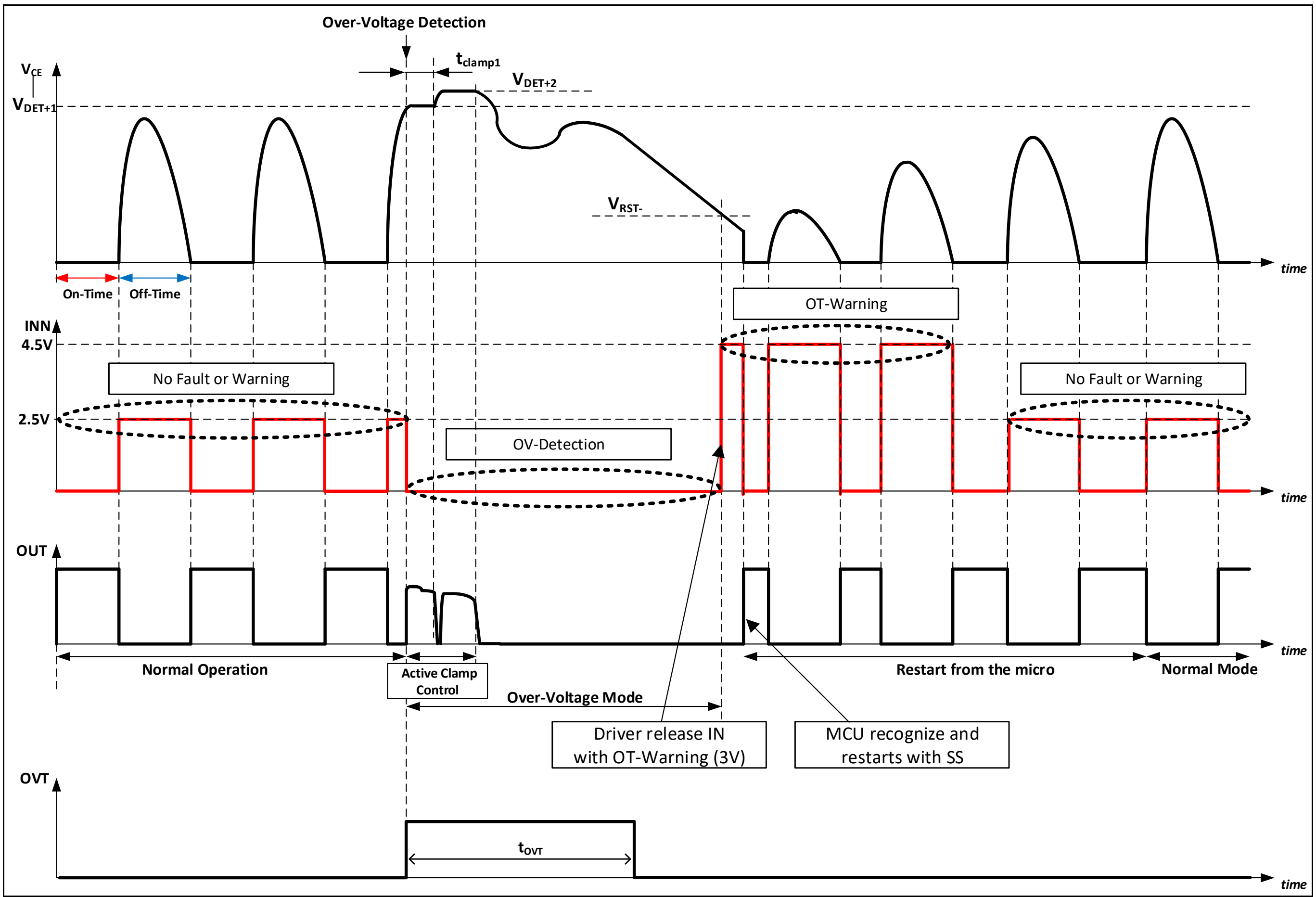


Figure 8 Active Clamp Control timing & Diagnostic

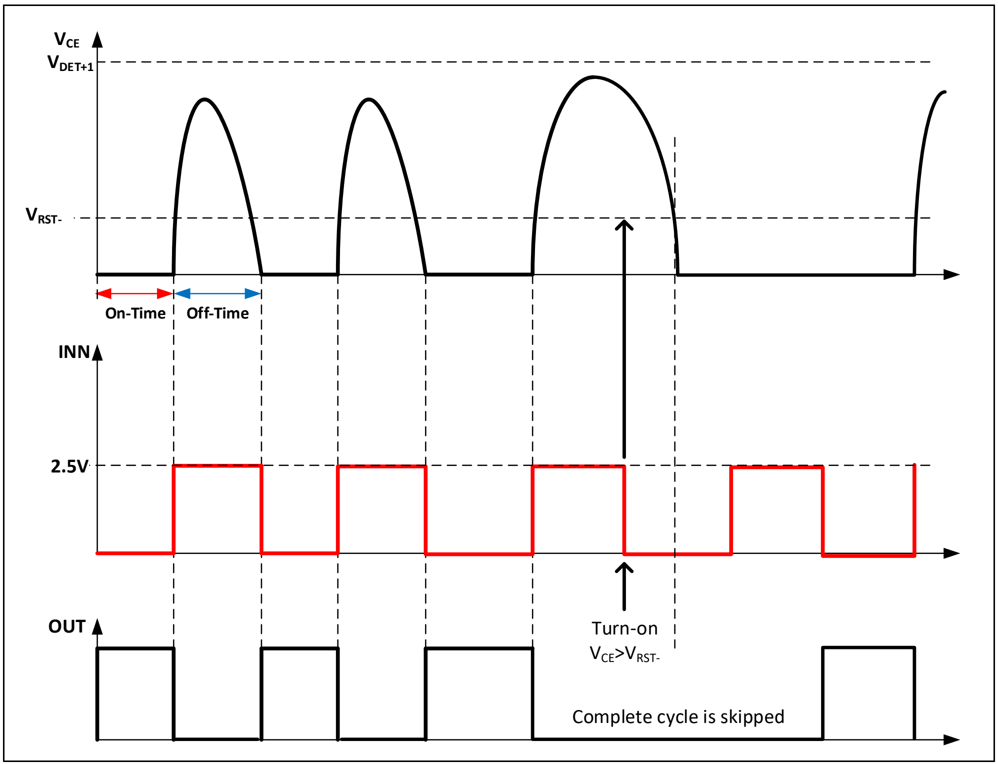


Figure 9 Function turn-on, if V_{CE}>V_{RST-}

6 Timing Diagrams

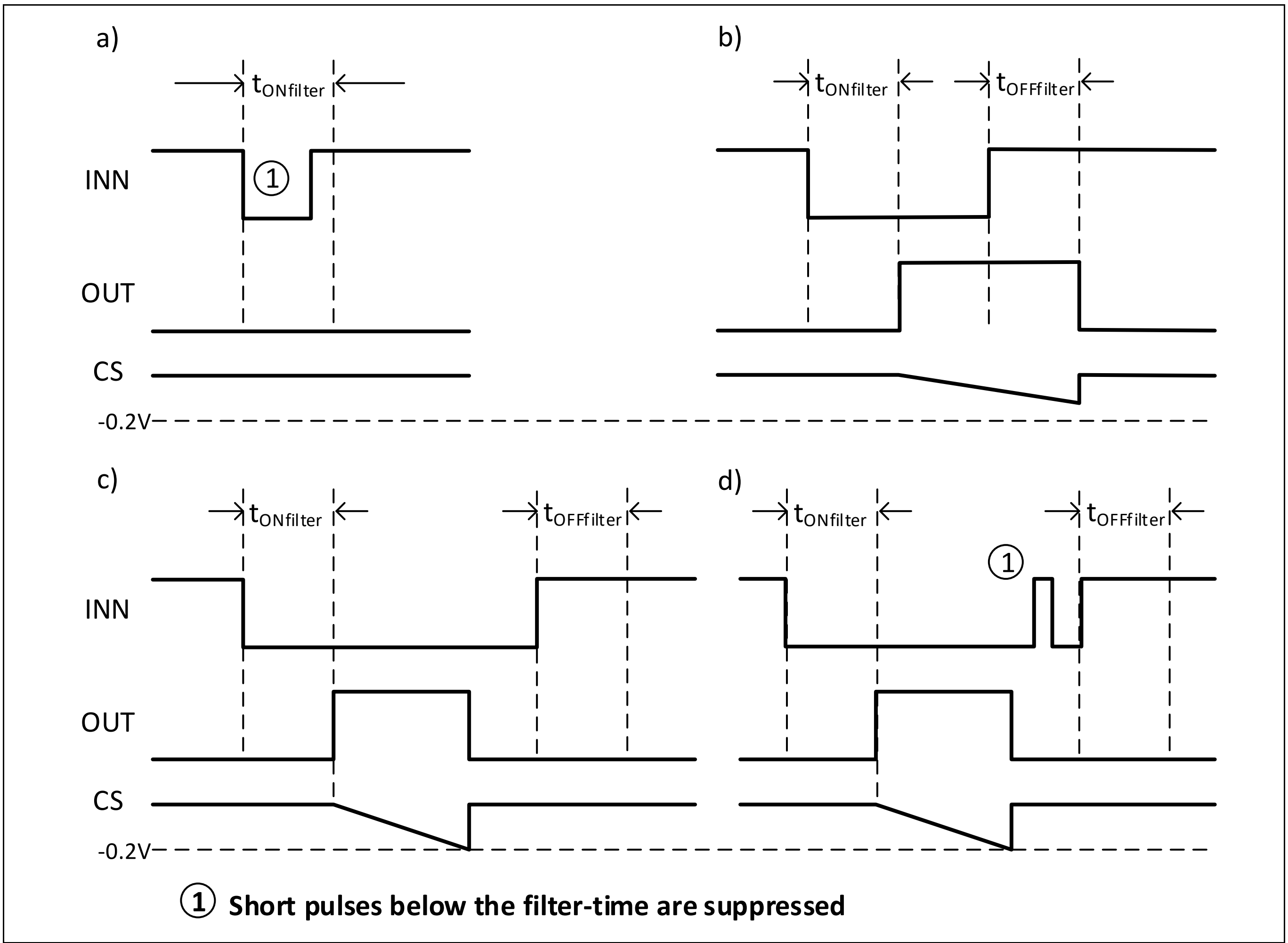


Figure 10 Input Noise Filter

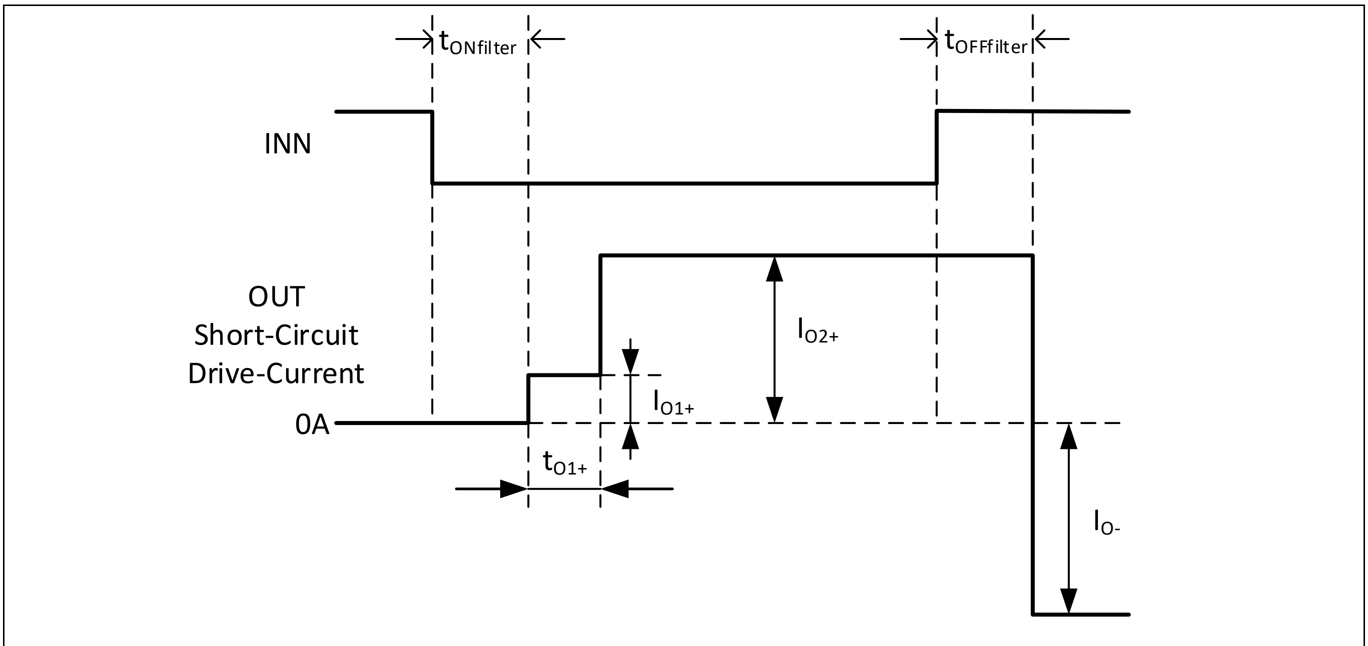


Figure 11 OUT Short-Circuit Drive-Current

7 Electrical Characteristics Diagrams

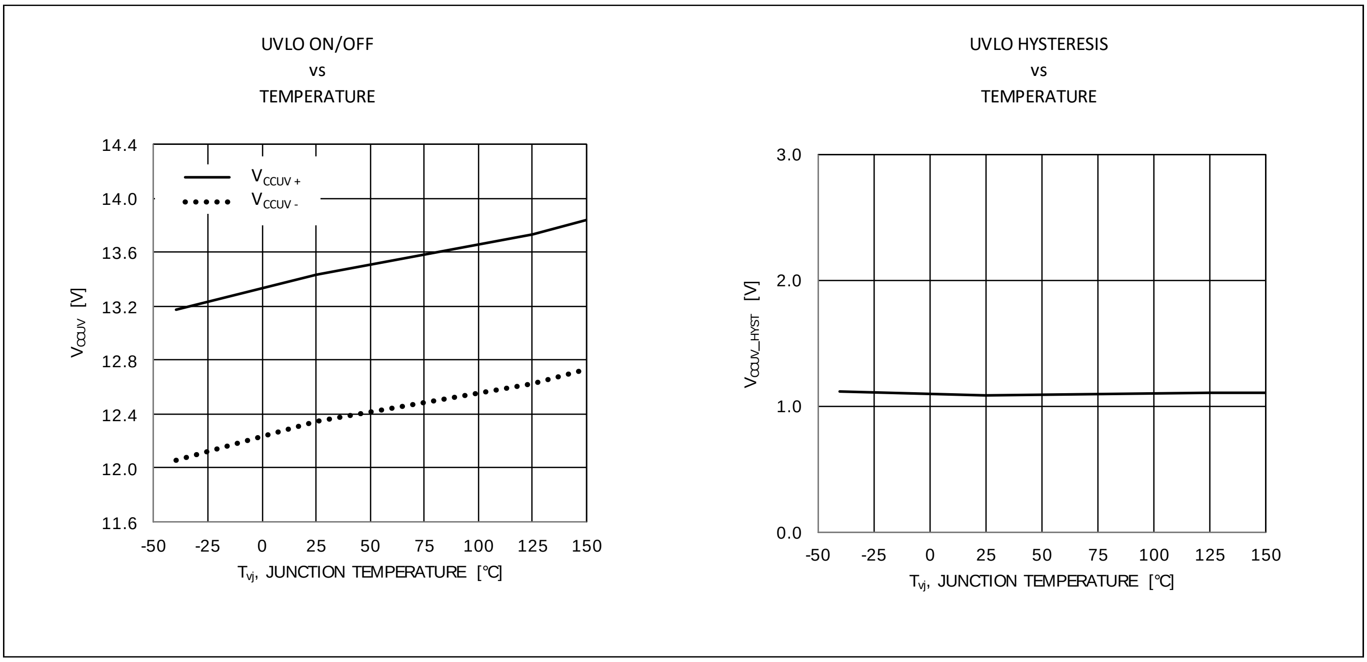


Figure 12. Undervoltage Lockout

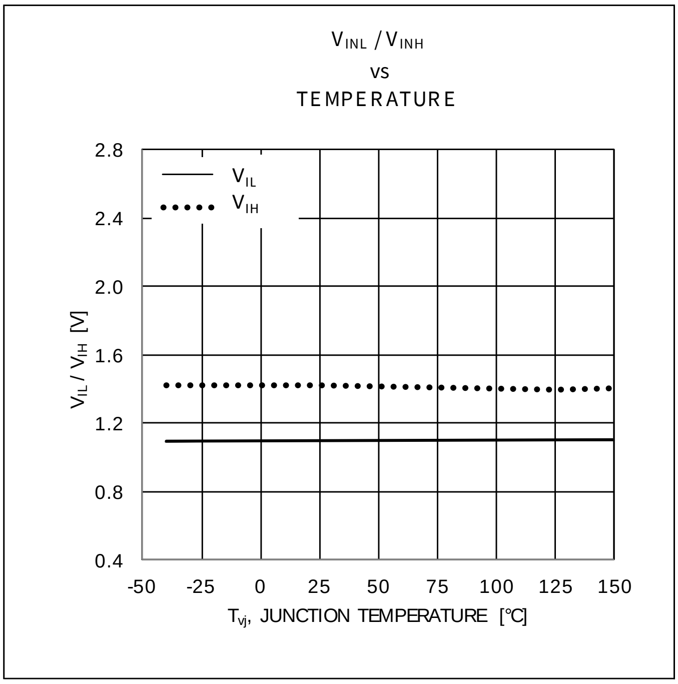
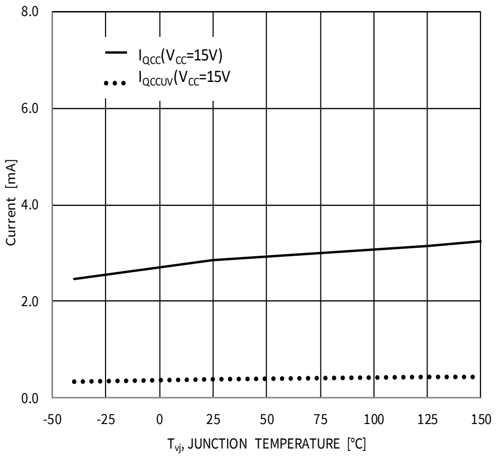


Figure 13. Input Voltage Characteristic

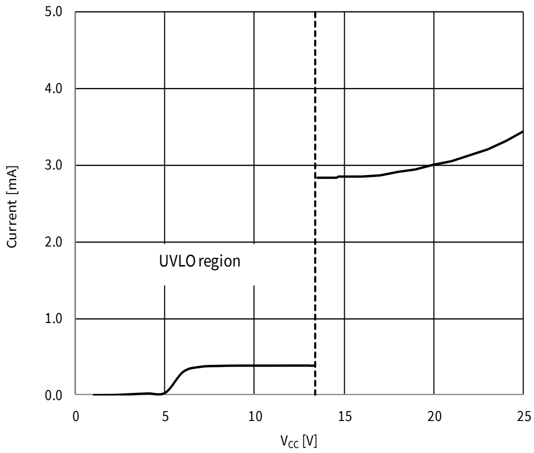
Electrical Characteristics Diagrams

CURRENT CONSUMPTION vs
TEMPERATURE



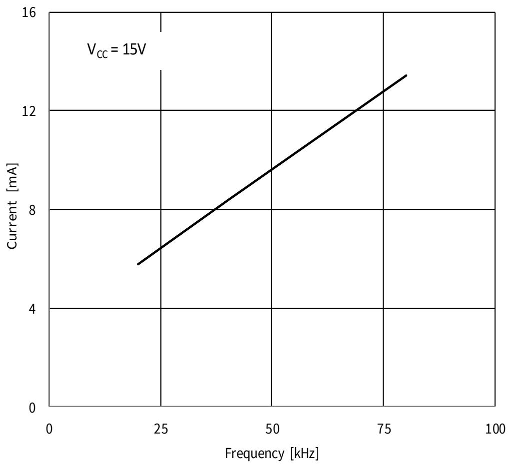
(INN floating)

CURRENT CONSUMPTION vs
OPERATING SUPPLY V_{CC}



(Tvj = 25°C, INN floating)

CURRENT CONSUMPTION
vs
FREQUENCY



Electrical Characteristics Diagrams

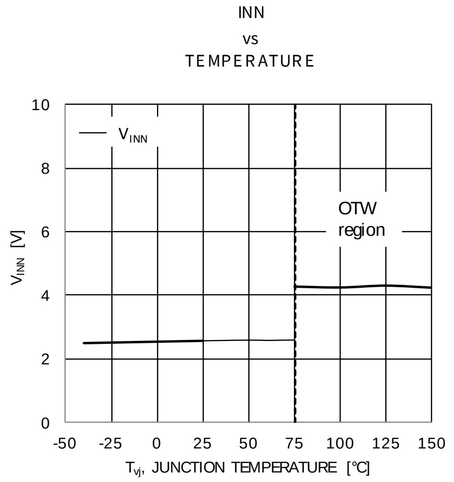


Figure 15. INN vs T_{vj}

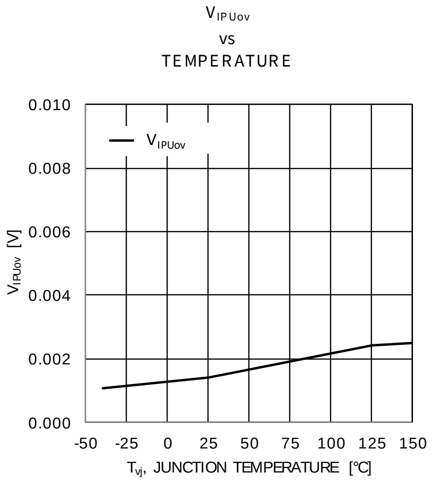


Figure 16. V_{IPUov} vs T_{vj}

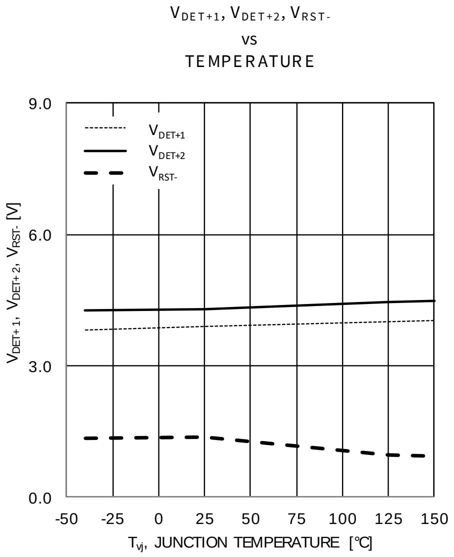


Figure 17. V_{DET+1}, V_{DET+2}, V_{RST-} vs T_{vj}

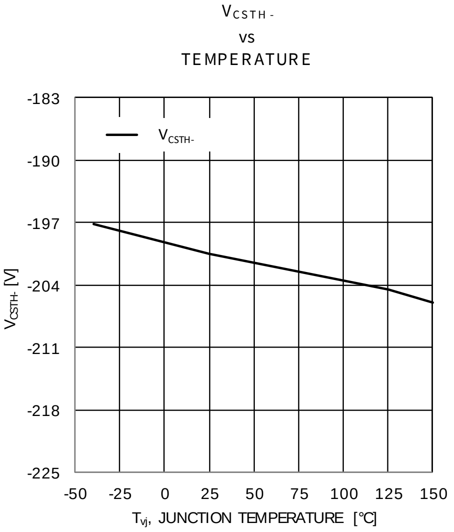


Figure 18. V_{CSTH-} vs T_{vj}

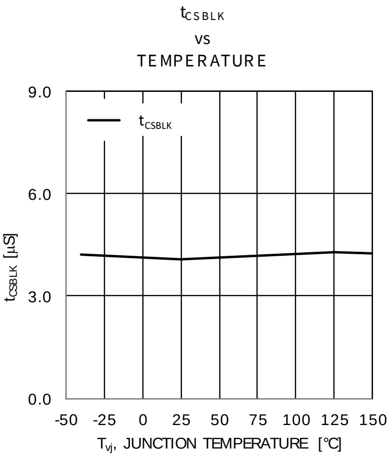


Figure 19. t_{CSBLK} vs T_{vj}

Electrical Characteristics Diagrams

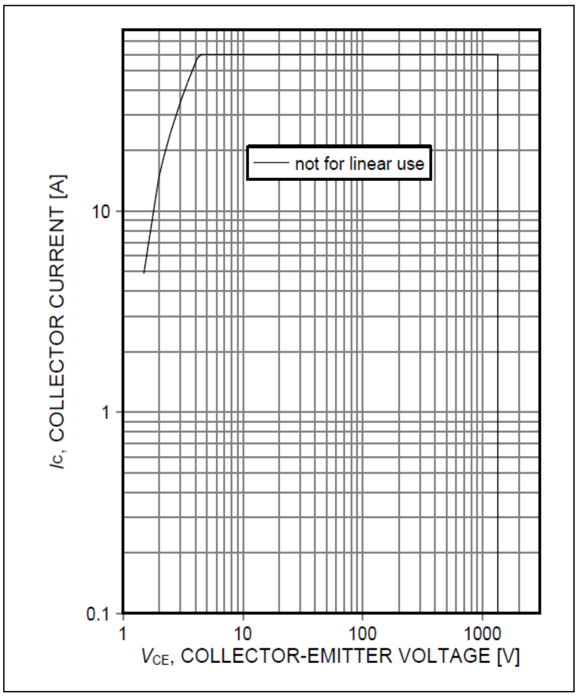


Figure 20. Safe operating area
(D=0, T_C=25°C, T_{vj}=175°C; V_{CC}=15V, t_p=1µs)

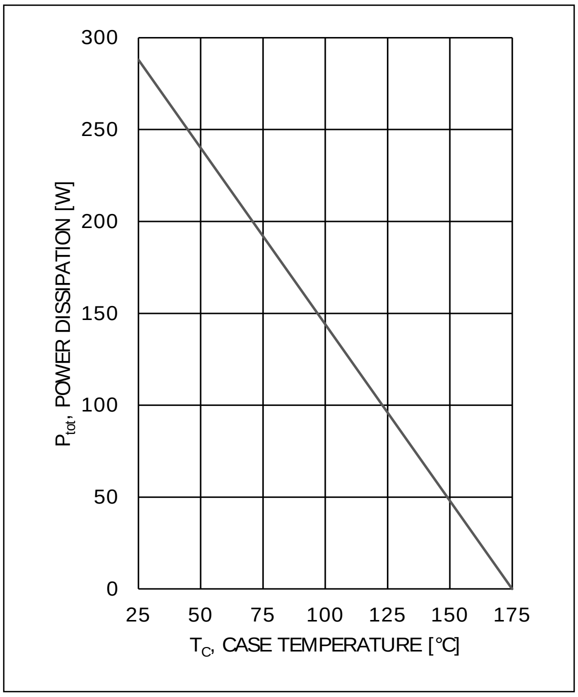


Figure 21. Power dissipation as a function of case temperature
(T_{vj}≤175°C)

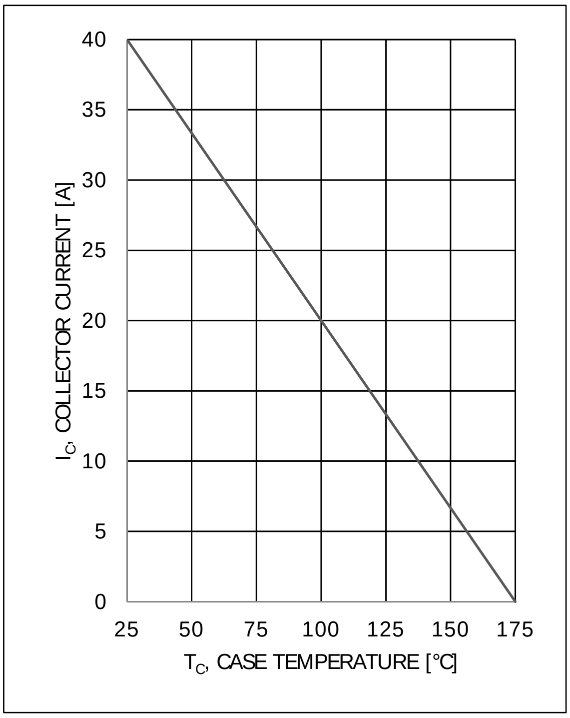


Figure 22. Collector current as a function of case temperature
(V_{CC}≥15V, T_{vj}≤175°C;tp=1µs)

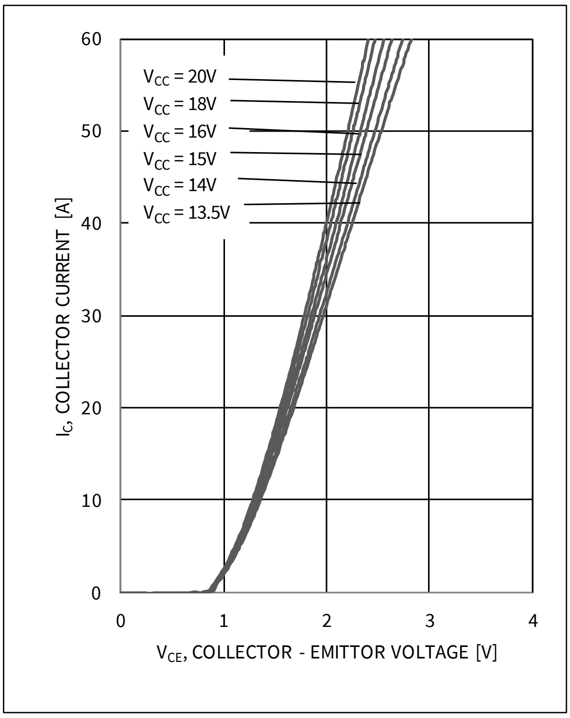


Figure 23. Typical output characteristic
(T_{vj}=25°C)

Electrical Characteristics Diagrams

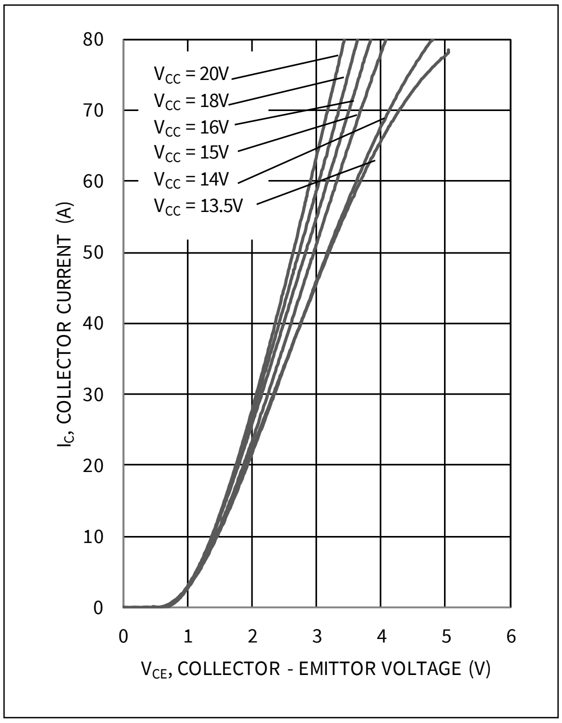


Figure 24. Typical output characteristic
(T_{vj}=150°C)

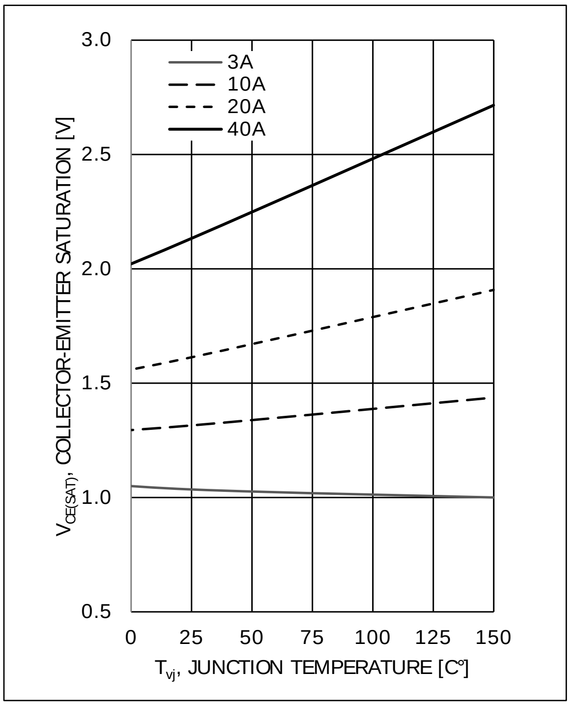


Figure 25. Typical collector-emitter saturation voltage as a function of junction temperature
(V_{CC}=15V)

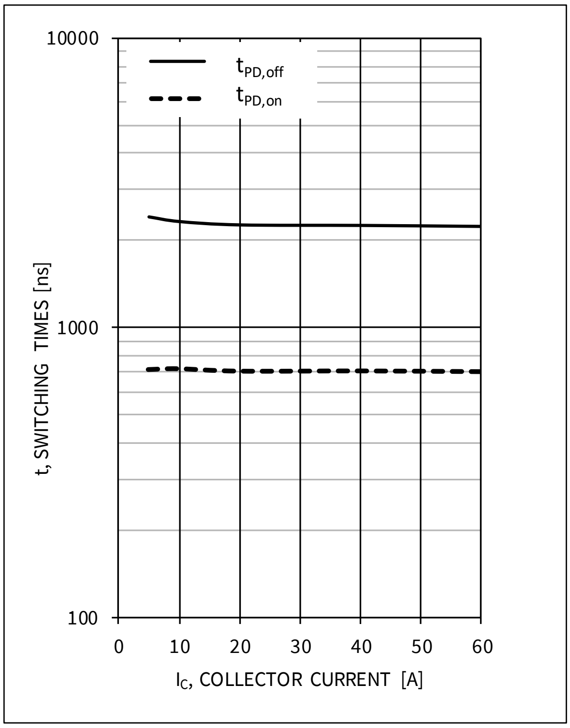


Figure 26. Typical switching times as a function of collector current
(inductive load, T_{vj}=150°C, V_{CE}=600V, V_{CC}= 15, dynamic test circuit in Figure F)

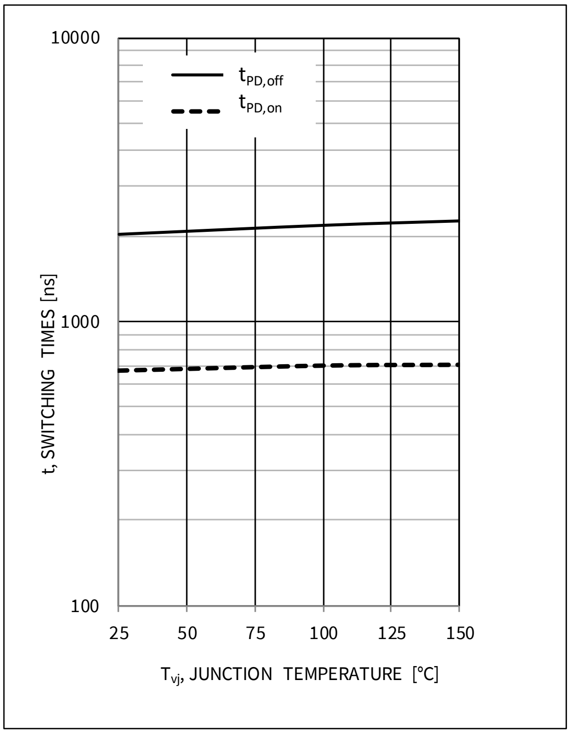


Figure 27. Typical switching times as a function of junction temperature
(inductive load, V_{CE}=600V, V_{CC}= 15V, I_C=20A, Dynamic test circuit in Figure F)

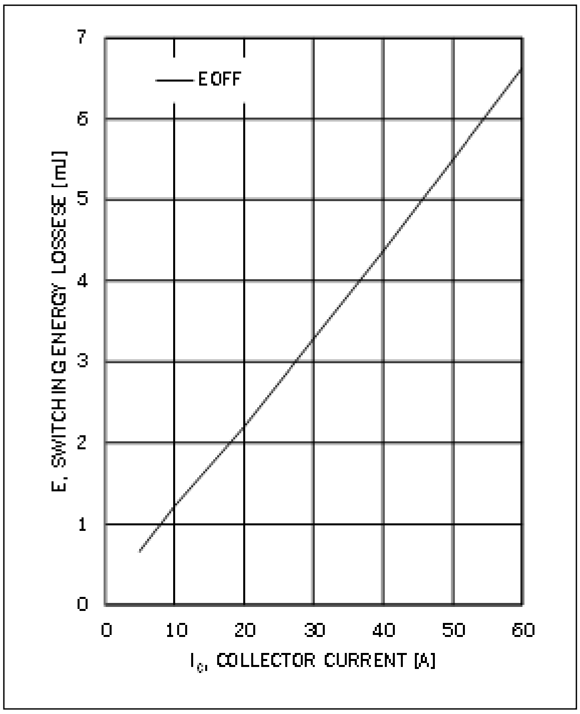


Figure 28. Typical switching energy losses as a function of collector current
(inductive load, T_{vj}=150°C,V_{CE}=600V, V_{CC}=15V, Dynamic test circuit in Figure F)

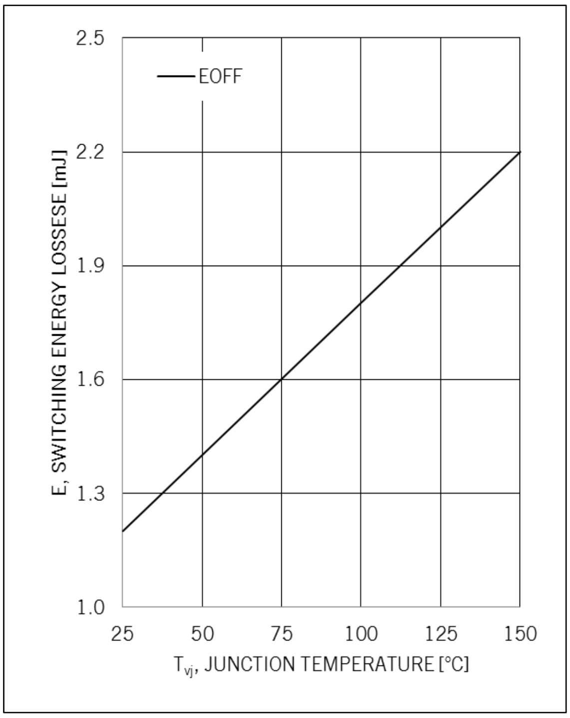


Figure 29. Typical switching energy losses as a function of junction temperature
(inductive load,V_{CE}=600V, V_{CC}=15V, I_C=20A, Dynamic test circuit in Figure F)

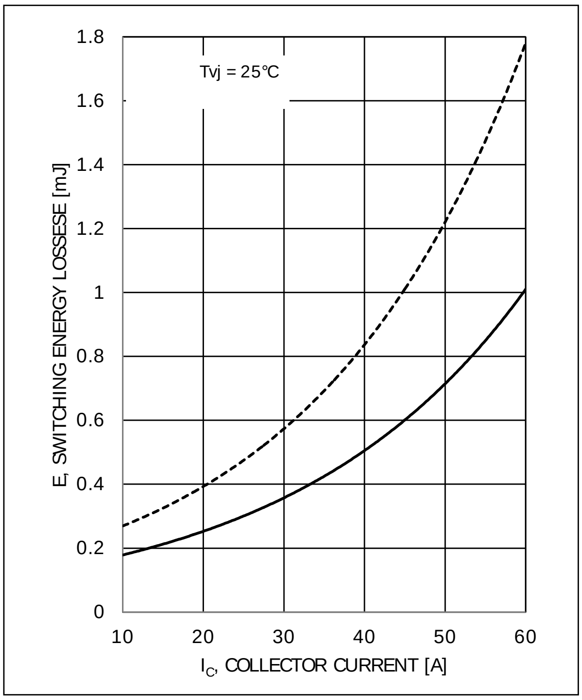


Figure 30. Typical turn off switching energy loss for soft switching
(Inductive load,V_{CE}=600V, V_{CC}=15V, Dynamic test circuit in Figure F)

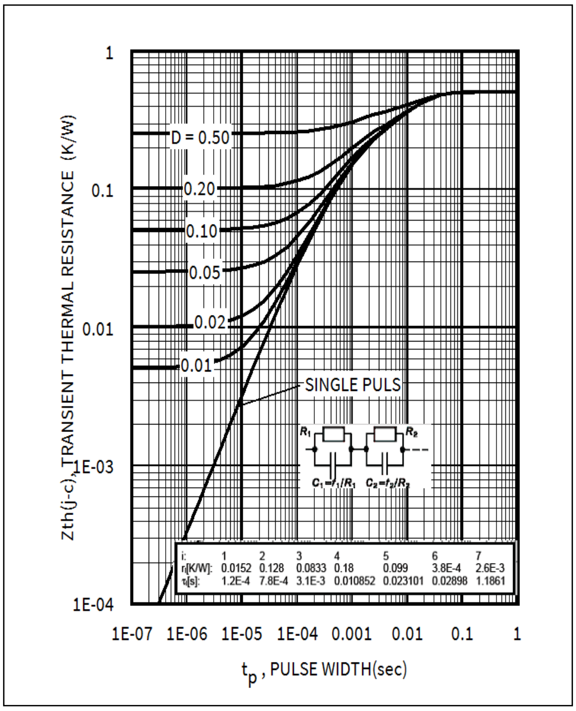


Figure 31. IGBT transient thermal impedance
($D=t_p/T$)

Electrical Characteristics Diagrams

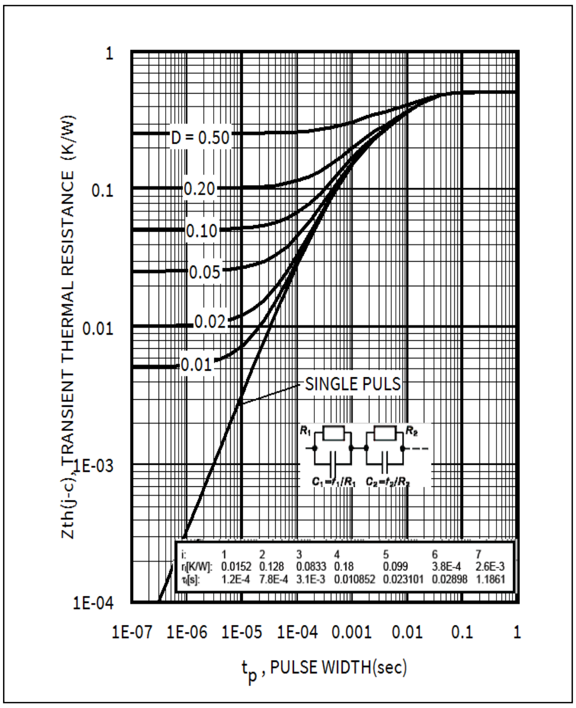


Figure 32. Diode transient thermal impedance as a function of pulse width

($D=t_p/T$)

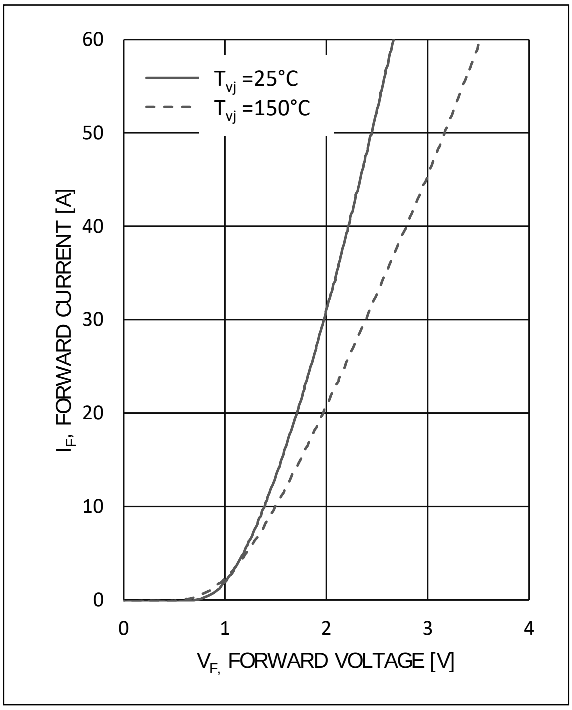


Figure 33. Typical diode forward current as a function of forward voltage

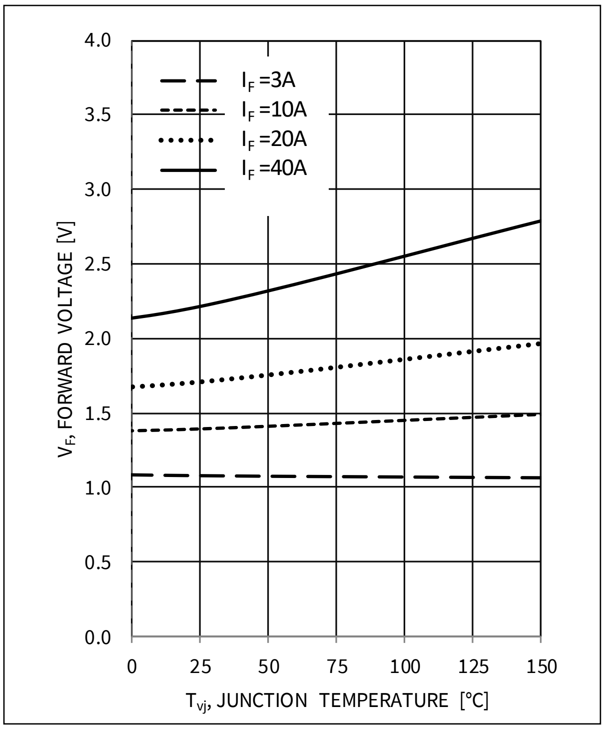


Figure 34. Typical diode forward voltage as a function of junction temperature

8 Test Conditions

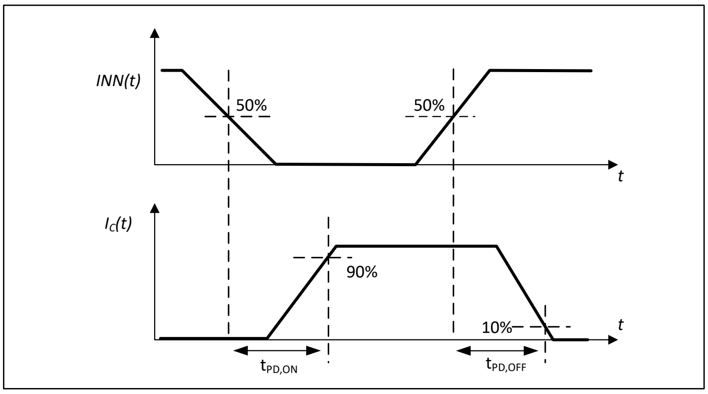


Figure A. Definition of switching times

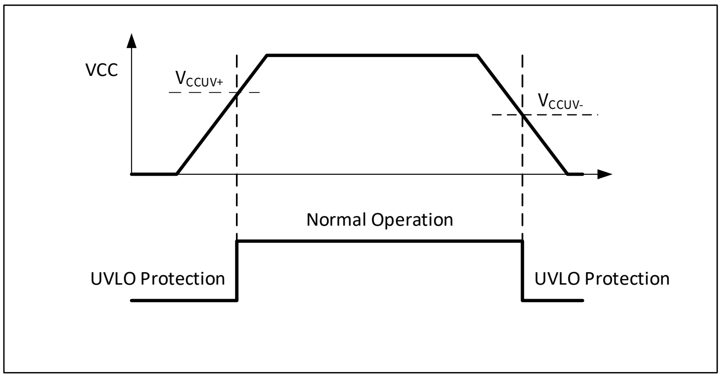


Figure D. UVLO Protection

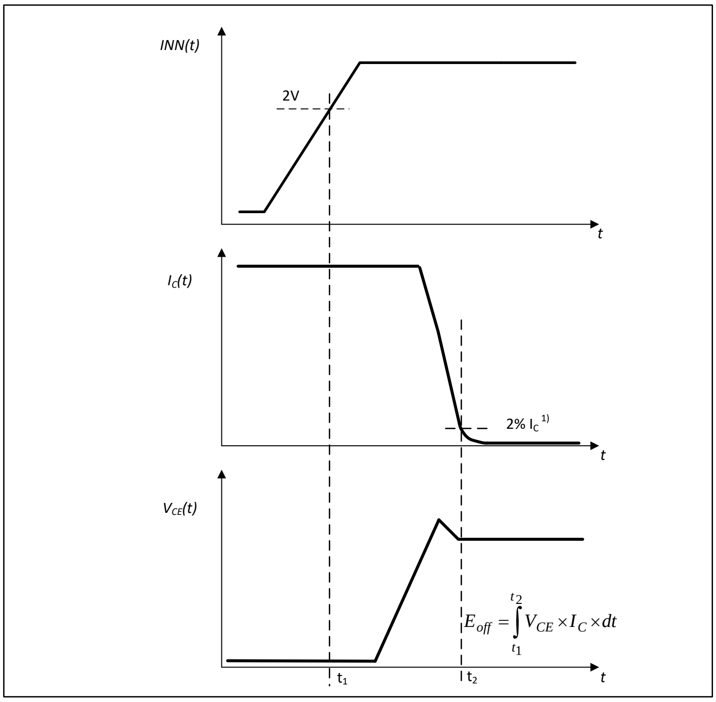


Figure B. Definition of switching losses

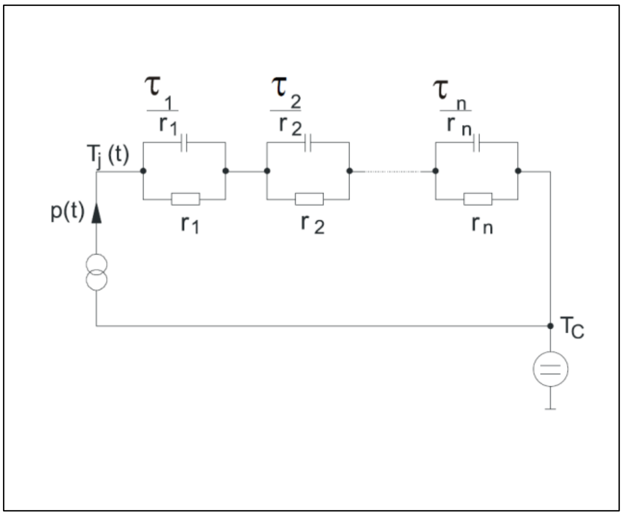


Figure E. Thermal equivalent circuit

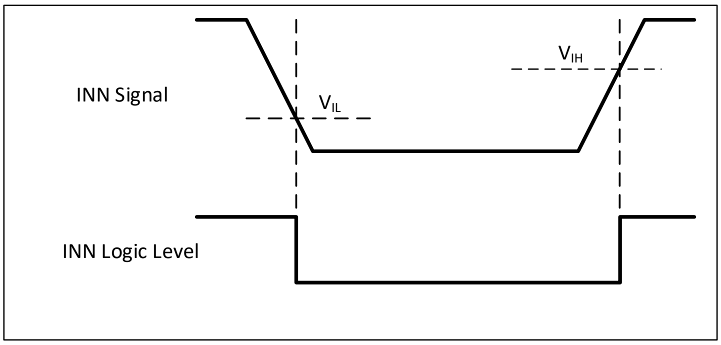


Figure C. INN Thresholds

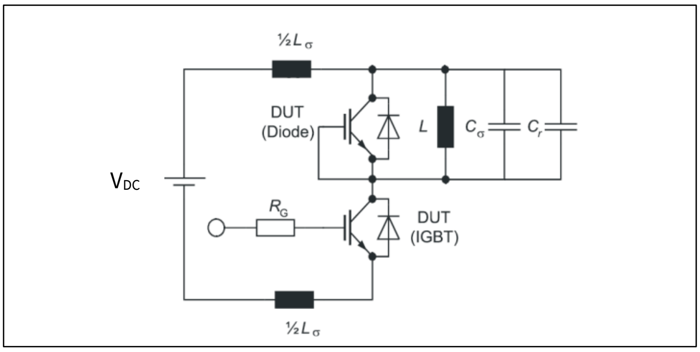
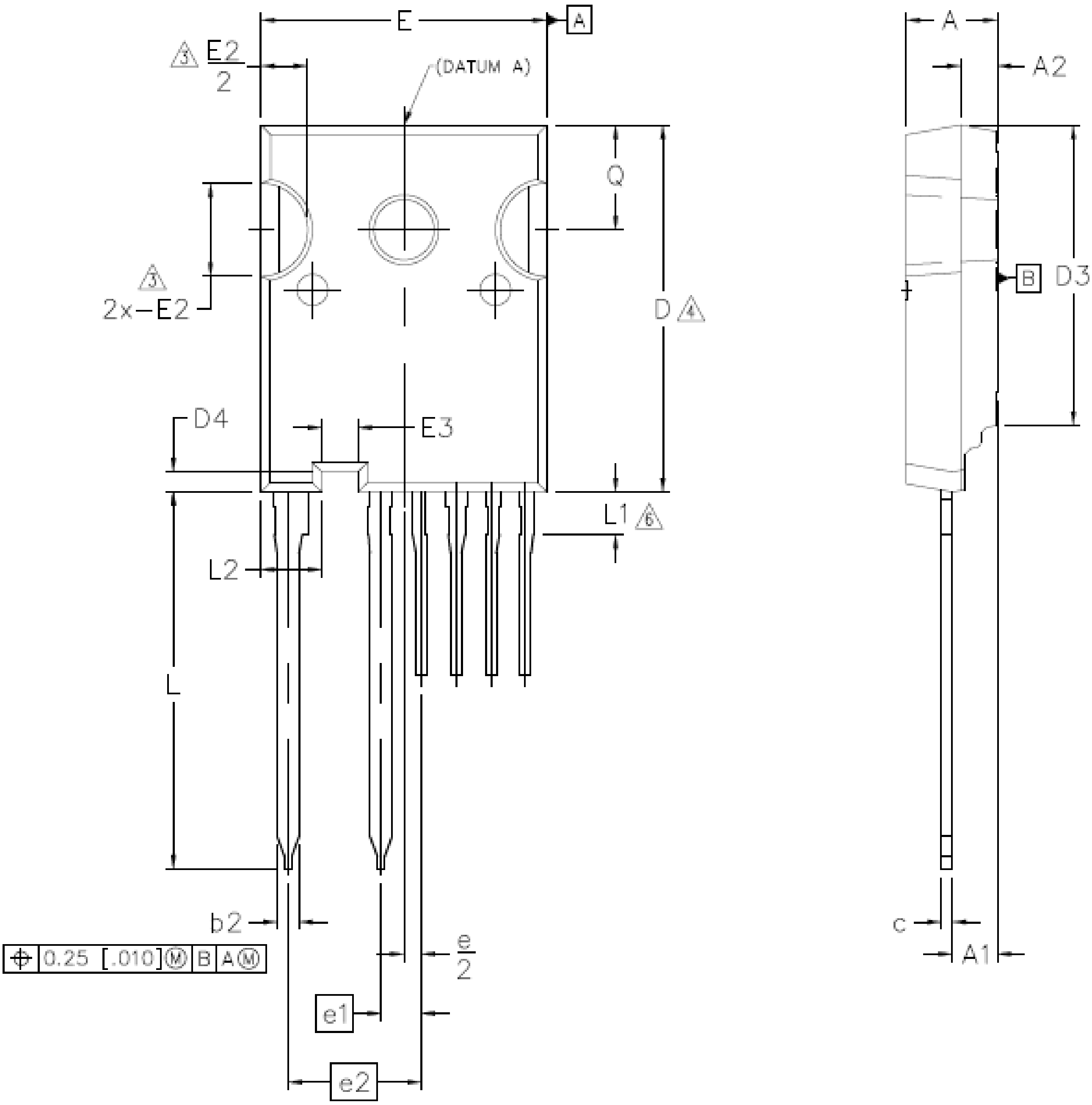


Figure F. Dynamic test circuit

[1] For soft switching is 1% I_C.

9 Package Drawing

PG-TO247-6



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. øP 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	
øk	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	
øP	3.48	3.76	.137	.148	4
øP1	–	7.39	–	.291	
Q	5.40	6.20	.212	.244	
S	5.72	BSC	.225	BSC	

Revision History

Revision: 2020-01-22, Rev.2.2

Revision	Date	Subjects (major changes since last revision)
2.0	2018-06-28	Final Datasheet
2.1	28-05-2019	Revised version
2.2	22-01-2020	Product name change
2.3	24-04-2020	Correction of acronym 'IPD' in page 1, correction of minor typos

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