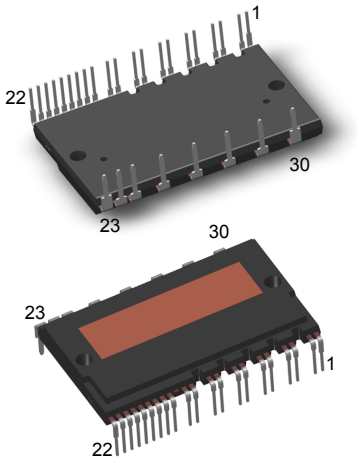
STGIK50CH65T

Datasheet

SLLIMM high power IPM, 3-phase inverter, 50 A, 650 V short-circuit rugged IGBT



SDIPHP-30L

Features

- IPM 650 V, 50 A 3-phase inverter bridge including control ICs for gates driving
- 3.3 V, 5 V TTL/CMOS inputs with hysteresis
- Under-voltage lockout of gate drivers
- Built-in bootstrap diodes
- Short-circuit protection
- Shutdown input/fault output
- Separate open emitter outputs
- Comparator for fault protection
- Short-circuit rugged
- Very fast, soft recovery diodes
- Fully isolated package
- Isolation rating of 2500 Vrms/min
- 100 kΩ NTC for temperature monitoring

Applications

- HVAC
- GPI
- Servo motor

Description

This new IPM (intelligent power module) is part of the high power SLLIMM (small low-loss intelligent molded module) family and provides a compact, high-performance AC motor drive in a simple, rugged design. It combines driver control with improved short-circuit rugged 650 V trench gate field-stop IGBTs, resulting ideal for 3-phase inverters motor drives.

Product status link
STGIK50CH65T

Product summary	
Order code	STGIK50CH65T
Marking	GIK50CH65T
Package	SDIPHP-30L
Packing	Tube

1 Internal schematic and pin description

Figure 1. Internal schematic diagram and pin configuration

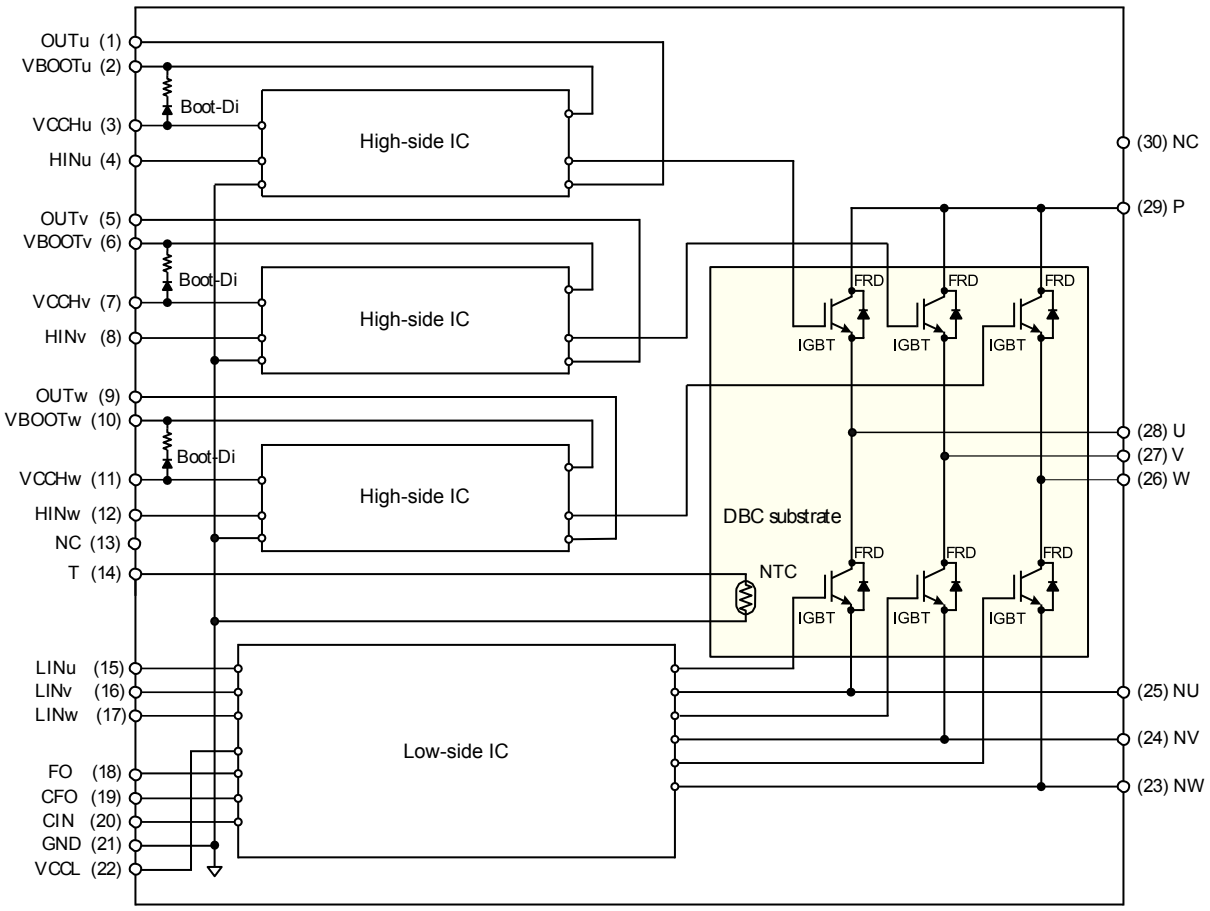


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Table 1. Pin description

Pin	Symbol	Description
1	OUTu	High-side reference output for U phase
2	VBOOTu	Bootstrap voltage for U phase
3	VCCHu	High-side voltage power supply for U phase
4	HINu	High-side logic input for U phase
5	OUTv	High-side reference output for V phase
6	VBOOTv	Bootstrap voltage for V phase
7	VCCHv	High-side voltage power supply for V phase
8	HINv	High-side logic input for V phase
9	OUTw	High-side voltage power supply for
10	VBOOTw	Bootstrap voltage for W phase
11	VCCHw	High-side voltage power supply for W phase
12	HINw	High-side logic input for W phase
13	NC	Not connected (cut pin)
14	T	NTC thermistor output
15	LINu	Low-side logic input for U phase
16	LINv	Low-side logic input for V phase
17	LINw	Low-side logic input for W phase
18	FO	Shutdown/fault output
19	CFO	Capacitor for fault output setting
20	CIN	Comparator input
21	GND	Ground
22	VCCL	Low-side voltage power supply
23	NW	Negative DC input for W phase
24	NV	Negative DC input for V phase
25	NU	Negative DC input for U phase
26	W	W phase output
27	V	V phase output
28	U	U phase output
29	P	Positive DC input
30	NC	Not connected

Note: It is required the external connection between the following couple of pins:

- *OUTu (1) and U (28)*
- *OUTv (5) and V (27)*
- *OUTw (9) and W (26).*

2 Absolute maximum ratings

T_J = 25 °C unless otherwise noted.

Table 2. Inverter parts

Symbol	Parameter	Value	Unit
V_{PN}	Supply voltage between P -N_U, -N_V, -N_W	500	V
$V_{PN(surge)}$	Supply voltage (surge) between P -N_U, -N_V, -N_W	550	V
V_{CES}	Collector-emitter voltage each IGBT	650	V
I_C	Continuous collector current each IGBT	50	A
I_{CP}	Peak collector current each IGBT (less than 1 ms)	100	A
P_{TOT}	Total power dissipation at T_C = 25 °C each IGBT	150	W
$V_{PN(SP)}$	Self-protection supply voltage limit, V_{CC} = 13.5 – 16.5 V, T_J = 150 °C, non-repetitive, less than 2µs	400	V

Table 3. Control parts

Symbol	Parameter	Min.	Max.	Unit
V_{CC}	Supply voltage applied between V_{CCHx}-GND, V_{CCL}-GND	- 0.5	25	V
V_{BOOT}	Bootstrap voltage	- 0.5	25	V
V_{OUT}	Output voltage applied between OUTx and GND	- 0.5	650	V
V_{CIN}	Comparator input voltage	- 0.5	V_{CCL}+0.3	V
V_{INH}	Logic input voltage applied between H_{INx} and GND	- 0.5	V_{CCHx}+0.3	V
V_{INL}	Logic input voltage applied between L_{INx} and GND	- 0.5	V_{CCL}+0.3	V
V_{FO}	Fault output voltage	- 0.5	V_{CCL}+0.3	V
I_{FO}	Fault output sink current		1	mA
$\Delta V_{CC}/\Delta t$	Change rate of V_{CC} supply voltage time	-1	1	V/µs

Table 4. Bootstrap diode

Symbol	Parameter	Min.	Max.	Unit
VR-BS	Bootstrap diode reverse voltage	-	650	V

Table 5. Total system

Symbol	Parameter	Value	Unit
V_{ISO}	Isolation withstand voltage applied between each pin and heat sink plate (AC voltage, t = 60 s)	2500	Vrms
T_J	IGBT and FRD operating junction temperature range	-40 to 175	°C
	Driver IC and bootstrap diode operating junction temperature range	-40 to 150	
T_C	Module case operating temperature range	-40 to 125	°C

Table 6. Thermal data

Symbol	Parameter	Value	Unit
R_{thJC}	Thermal resistance, junction-to-case single IGBT	1	°C/W
	Thermal resistance, junction-to-case single diode	2	

3 Electrical characteristics

T_J = 25 °C unless otherwise specified.

3.1 Inverter parts

Table 7. Inverter parts

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{CES}	Collector cut-off current	V_{CE} = 650 V, V_{CC} = V_{boot} = 15 V	-	25		µA
$V_{CE(sat)}$	Collector-emitter saturation voltage	V_{CC} = V_{boot} = 15 V, V_{IN}(1) = 5 V, I_C = 50 A	-	1.8	2.3	V
		V_{CC} = V_{boot} = 15 V, V_{IN}(1) = 5 V, I_C = 50 A, T_J = 175 °C	-	2.2		
V_F	Diode forward voltage	V_{IN}(1) = 0 V, I_C = 50 A	-	2.0	2.5	V
		V_{IN}(1) = 0 V, I_C = 50 A, T_J = 175 °C	-	2.25		

1. *Applied between HINx, LINx and GND for x = U, V, W.*

Table 8. Inductive load switching time and energy

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
High-side						
t_{on} (1)	Turn-on time	V_{DD} = 300 V, V_{CC} = V_{boot} = 15 V, V_{IN} (2) = 0 to 5 V, I_C = 50 A	-	860	-	ns
$t_{c(on)}$ (1)	Crossover time on		-	386	-	ns
t_{off} (1)	Turn-off time		-	1464	-	ns
$t_{c(off)}$ (1)	Crossover time off		-	137	-	ns
t_{rr} (1)	Reverse recovery time		-	370	-	ns
E_{on}	Turn-on switching energy		-	2.70	-	mJ
E_{off}	Turn-off switching energy		-	1.12	-	mJ
E_{rr}	Reverse recovery energy		-	0.244	-	mJ
Low-side						
t_{on} (1)	Turn-on time	V_{DD} = 300 V, V_{CC} = V_{boot} = 15 V, V_{IN} (2) = 0 to 5 V, I_C = 50 A	-	605	-	ns
$t_{c(on)}$ (1)	Crossover time on		-	266	-	ns
t_{off} (1)	Turn-off time		-	962	-	ns
$t_{c(off)}$ (1)	Crossover time off		-	110	-	ns
t_{rr} (1)	Reverse recovery time		-	405	-	ns
E_{on}	Turn-on switching energy		-	2.16	-	mJ
E_{off}	Turn-off switching energy		-	0.85	-	mJ
E_{rr}	Reverse recovery energy		-	0.192	-	mJ

1. *t_{on} and t_{off} include the propagation delay time of the internal drive. $t_{c(on)}$ and $t_{c(off)}$ are the switching times of the IGBT itself under the internally given gate driving conditions.*
2. *Applied between HINx, LINx and GND for x = U, V, W.*

Figure 2. Switching time test circuit

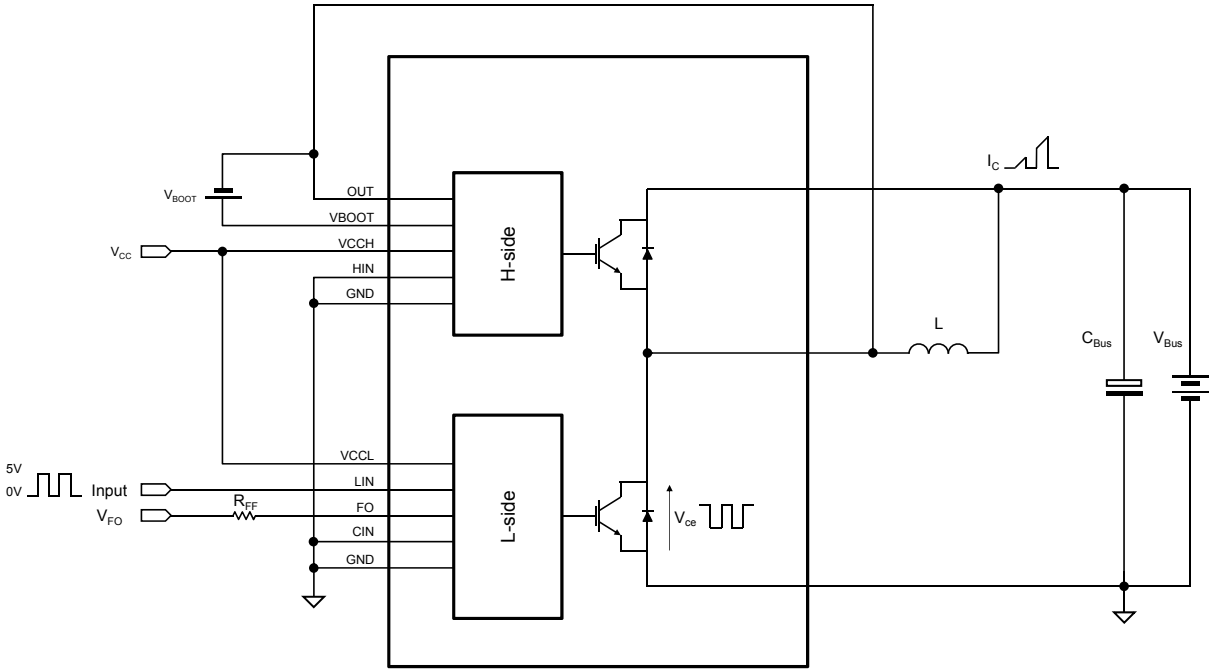

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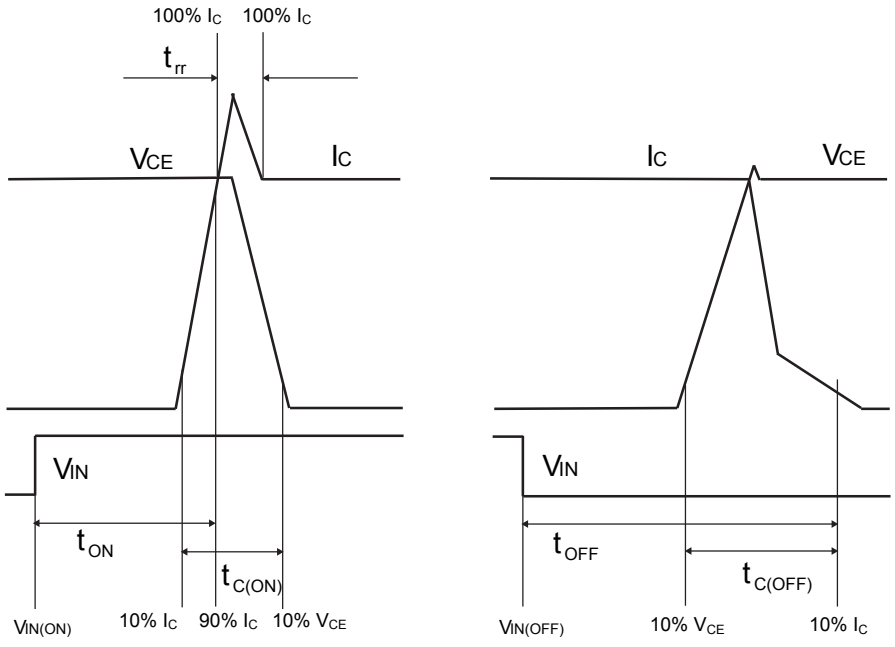
Figure 3. Switching time definition



(a) turn-on

(b) turn-off

AM09223V1

3.2 Control/protection parts

Unless specifically noted, T_C = -40 °C to 125 °C, V_{PN} = 300 V, V_{VCCxH} = V_{VCCL} = 15 V, R_{FF} = 10 kΩ, C_{FF} = 0 µF, and V_{FO} = 5 V. The shipping test is performed at T_A = 25 °C and 125 °C for the electrical characteristics shown below (except for the parameters specified by design and not tested in production).

Table 9. Control/protection parts

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
V_{VCCHx_H}	VCCHx pin operating voltage		9.2	10.2	11.3	V
V_{VCCHx_L}	VCCHx pin operating stop voltage		8.7	9.7	10.8	V
V_{VCCHx_HYS}	VCCHx pin hysteresis			0.5		V
V_{VCCL_H}	VCCL pin operating voltage		11.2	12.6	13.3	V
V_{VCCL_L}	VCCL pin operating stop voltage		10.7	12.1	12.8	V
V_{VCCL_HYS}	VCCL pin hysteresis			0.5		V
$V_{VBOOTx-OUTx\_H}$	VBOOTx-OUTx operating voltage		11.0	12.1	12.8	V
$V_{VBOOTx-OUTx\_L}$	VBOOTx-OUTx operating stop voltage		10.5	11.6	12.3	V
$V_{VBOOTx-OUTx\_HYS}$	VBOOTx-OUTx hysteresis			0.5		V
I_{VCCHx}	VCCHx pin input current	V_{HINx} = 0 V, each pin		1.1	2.0	mA
		V_{HINx} = 5 V, each pin		1.1	2.0	mA
I_{VCCL}	VCCL pin input current	V_{LINx} = 0 V		1.9	3.2	mA
		V_{LINx} = 5 V		1.9	3.2	mA
$I_{VBOOTx-OUTx}$	VBOOTx-OUTx input current	$V_{VBOOTx-OUTx}$ = 15 V, V_{INxH} = 0 V, in 1-phase operation		0.09	0.30	mA
		$V_{VBOOTx-OUTx}$ = 15 V, V_{INxH} = 5 V, in 1-phase operation		0.11	0.30	mA
Input signal						
V_{HINx_H}	HINx pin high-level input threshold voltage			2.0	2.5	V
V_{HINx_L}	HINx pin low-level input threshold voltage		1.0	1.5		V
V_{HINx_HYS}	HINx pin hysteresis			0.5		V
V_{LINx_H}	LINx high-level input threshold voltage			2.0	2.5	V
V_{LINx_L}	LINx pin low-level input threshold voltage		1.0	1.5		V
V_{LINx_HYS}	LINx pin hysteresis			0.5		V
I_{HINx}	HINx pin input Current	V_{HINx} = 5 V, each pin		0.25	0.50	mA
I_{LINx}	LINx pin input Current	V_{LINx} = 5 V, each pin		0.25	0.50	mA
$t_{HINx\_MIN(ON)}$ (1)	HINx pin minimum response pulse width (On)			0.34	0.50	µs
$t_{HINx\_MIN(OFF)}$ (2)	HINx pin minimum response pulse width (Off)			0.36	0.50	µs

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
$t_{LINx\_MIN(ON)}$ (2)	LINx pin minimum response pulse width (On)		-	0.26	0.50	µs
$t_{LINx\_MIN(OFF)}$ (2)	LINx pin minimum response pulse width (Off)		-	0.27	0.50	µs
Fault signal output and shutdown signal input						
V_{FO_H}	FO pin shutdown release voltage			2.0	2.5	V
V_{FO_L}	FO pin shutdown threshold voltage		1.0	1.5		V
V_{FO_HYS}	FO pin shutdown hysteresis			0.5		V
V_{FO_H}	FO pin output voltage in normal operation	V_{FO} = 5 V, R_{FF} = 10 kΩ, V_{CIN} = 0 V	4.8	5.0		V
V_{FO_L}	VFO pin error signal output voltage	V_{FO} = 5 V, R_{FF} = 10 kΩ, V_{CIN} = 1 V	-	0.05	0.50	V
t_{FO} (1)(2)	FO pin CIN hold time	C_{CFO} = 0 µF	0.012	0.030	0.060	ms
		C_{CFO} = 0.001 µF	0.20	0.32	0.44	ms
		C_{CFO} = 0.01 µF	2.0	3.2	4.4	ms
		C_{CFO} = 0.1 µF	20	32	44	ms
		C_{CFO} = 1 µF	200	320	440	ms
Protection						
V_{CIN_H}	CIN pin overcurrent detection voltage		0.46	0.50	0.54	V
V_{CIN_L}	CIN pin overcurrent release voltage		0.32	0.38	0.44	V
V_{CIN_HYS}	CIN pin overcurrent hysteresis			0.12		V
t_{CIN_DELAY}	CIN pin detection delay time			0.3	0.5	µs
I_{CIN}	CIN pin input current	V_{CIN} = 0.5 V		2.5		µA

1. *Specified By Design – Not tested in production.*
2. *For a relation between t_{FO} and C_{CFO}, see Figure 5. The shipping test is performed with the condition at C_{CFO} = 0.01 µF only.*

Figure 4. Total bootstrap current vs f_{sw}

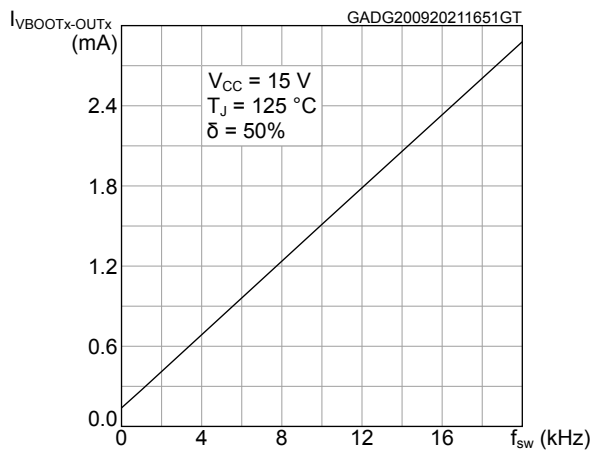


Figure 5. t_{FO} - C_{CFO} characteristics

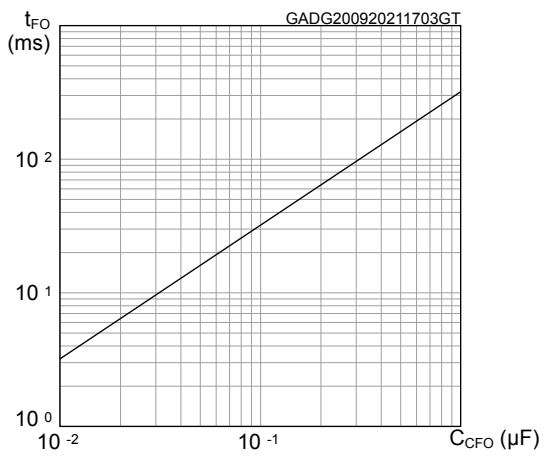
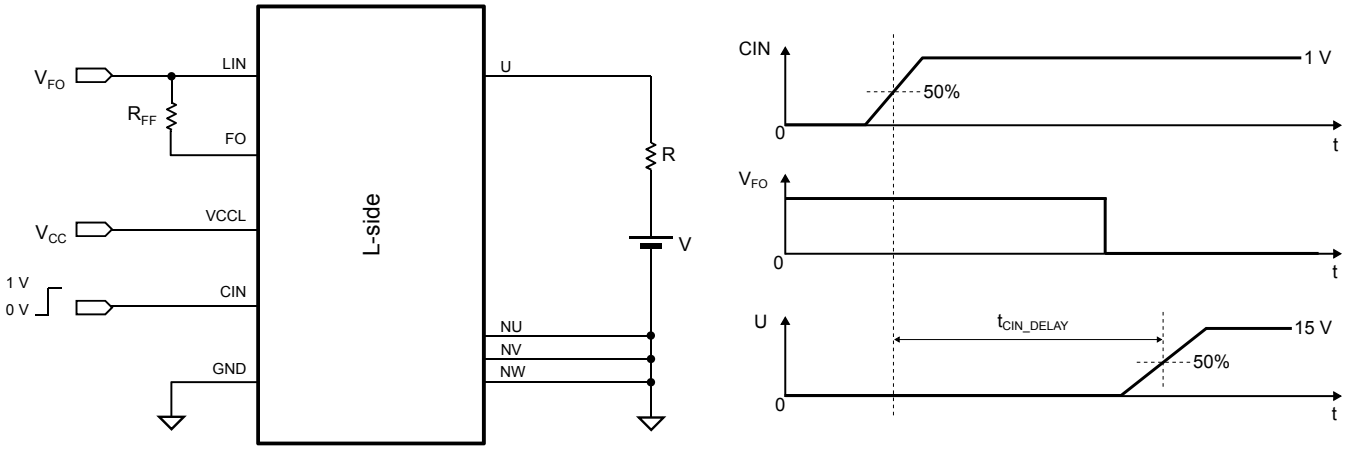


Figure 6. CIN test circuit and time definition



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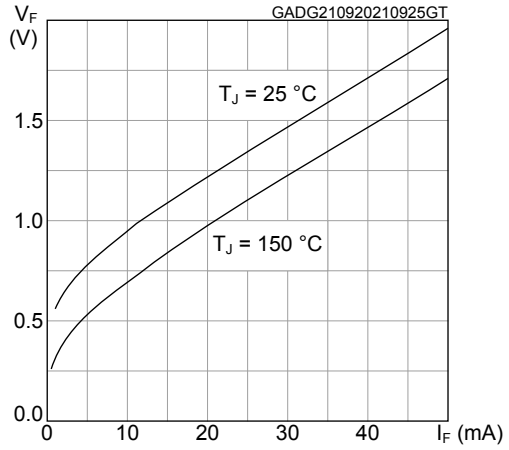
4 Bootstrap diode

Table 10. Bootstrap diode

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{F_BS}	Bootstrap diode forward voltage	I_{F_BS} = 10 mA	0.4	0.9	1.4	V
R_{S_BS}	Bootstrap diode series resistor		12	20	28	Ω

Figure 7. Bootstrap diode static characteristics



5 NTC thermistor

Table 11. **NTC thermistor**

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
R_{25}	Resistance	T_A = 25 °C		100		kΩ
$B_{25/85}$	B-constant (25−85 °C)			4395		K
T	Operating temperature range		-40		175	°C

Figure 8. **NTC resistance vs temperature**

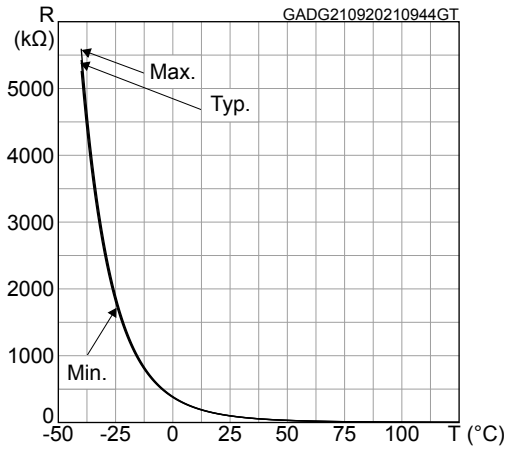
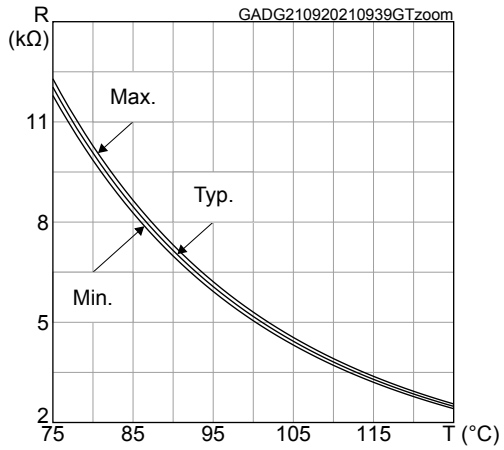
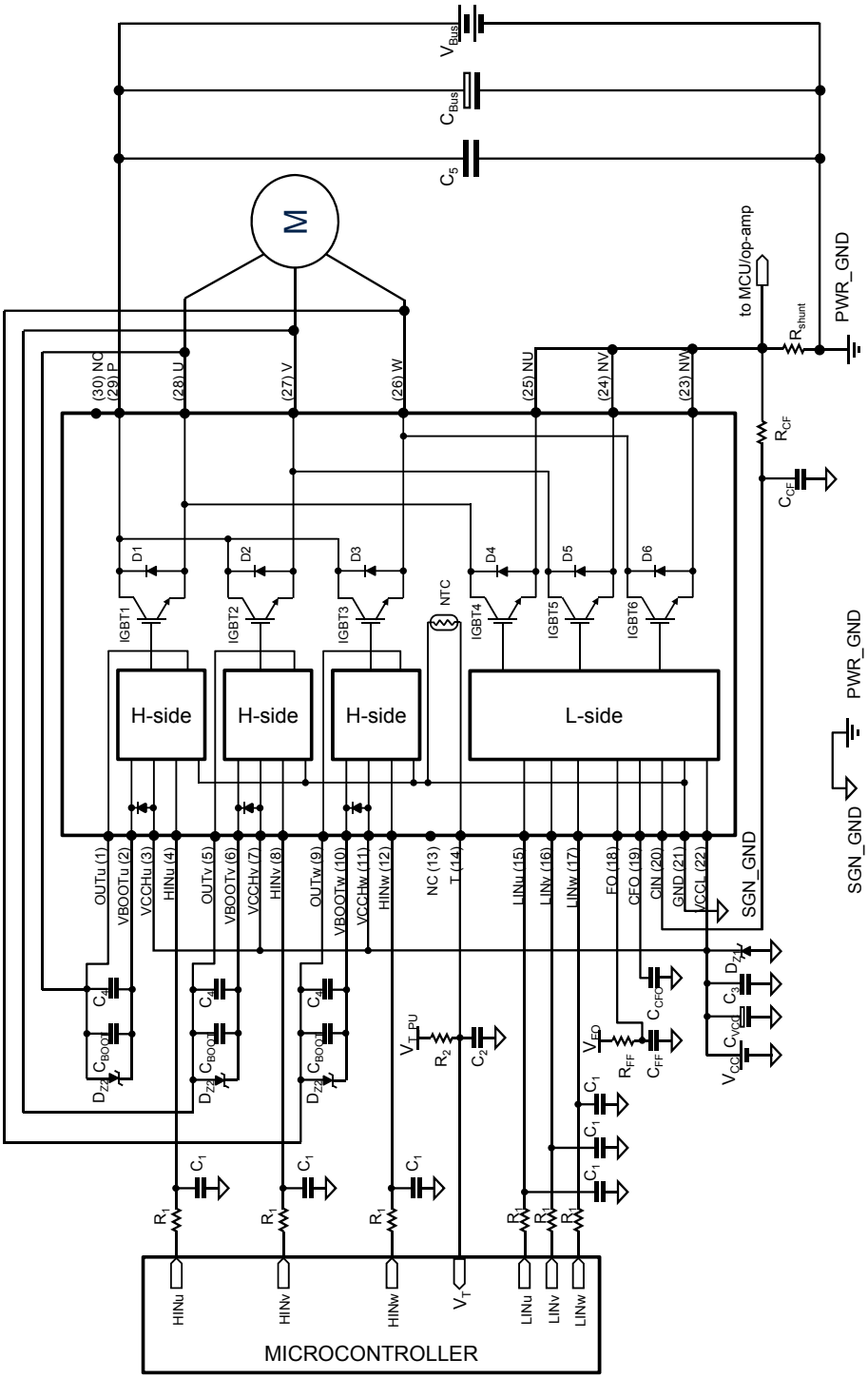


Figure 9. **NTC resistance vs temperature zoom**



6 Application circuit example

Figure 10. **Application circuit example**



Application designers are free to use a different scheme according to the device specifications.

6.1 Guidelines

1. External connections between the pins OUTu-U, OUTv-V and OUTw-w are required.
2. Input signals HIN, LIN are active-high logic. A 20 kΩ (typ.) pull-down resistor is built-in for each input pin. To prevent input signal oscillation, the wiring of each input should be as short as possible and the use of RC filters (R_1, C_1) on each input signal is suggested. The filters should be done with a time constant of about 100 ns and placed as close as possible to the IPM input pins.
3. The use of a bypass capacitor C_{VCC} (aluminum or tantalum) can help reduce the transient circuit demand on the power supply. Also, to reduce high frequency switching noise distributed on the power lines, it is suggested to place a decoupling capacitor C_3 (100 to 220 nF, with low ESR and low ESL), as close as possible to each V_{CC} pin and in parallel with the bypass capacitor.
4. The use of RC filter (R_{CF}, C_{CF}) for preventing protection circuit malfunction is suggested. The time constant (R_{CF} x C_{CF}) should be set to 1 µs and the filter must be placed as close as possible to the CIN pin.
5. The FO is an input/output pin. It should be pulled up to a power supply (i.e., MCU bias at 3.3 - 5 V) by a resistor value able to match the V_{FO_L} and V_{FO_H} threshold voltages mainly. In case of 3.3 or 5 V pull up voltage, the suggested resistor value is from 5.6 kΩ to 68 kΩ.The RC filter on FO could have also impact on the re-starting time after a fault event so it must be placed as close as possible to the FO pin.
6. A decoupling capacitor C_2 between 1 nF and 10 nF can be used to increase the noise immunity of the signal on the NTC thermistor. Its effectiveness is improved if the capacitor is placed close to the MCU.
7. The decoupling capacitor C_4 (100 to 220 nF with low ESR and low ESL) in parallel with each C_{BOOT} is useful to filter high frequency disturbances. Both C_{BOOT} and C_4 (if present) should be placed as close as possible to each U, V, W and respective V_{BOOT} pins.
8. To prevent overvoltage on the V_{CC} pins, a Zener diode (D_{Z1}) can be used. Similarly, on the V_{BOOT} pins, a Zener diode (D_{Z2}) can be placed in parallel with each C_{BOOT}.
9. The use of the decoupling capacitor C_5 (100 to 220 nF, with low ESR and low ESL) in parallel with the electrolytic capacitor C_{Bus} is useful to prevent surge destruction. Both capacitors C_5 and C_{Bus} should be placed as close as possible to the IPM (C_5 has priority over C_{Bus}).
10. When the application requires a galvanic isolation between low and high voltage, use of high speed (high CMR) opto-coupler is recommended.
11. Low inductance shunt resistors should be used for phase leg current sensing.
12. In order to avoid malfunction, the wiring between N pins, the shunt resistor and PWR_GND should be as short as possible.
13. The connection of SGN_GND to PWR_GND at only one point (close to the shunt resistor terminal) can help to reduce the impact of power ground fluctuation.
14. Parallel connection of switches or legs on the same or multiple IPMs is not suggested.

These guidelines ensure the device specifications for application designs. For further details, please refer to the relevant application note.

Table 12. Recommended operating conditions

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{PN}	Supply voltage	Applied between P-Nu, N_V, N_w		300	400	V
V_{CCHx}	Control supply voltage	Applied between V_{CCHx}-GND	13.5	15	16.5	V
V_{CCL}	Control supply voltage	Applied between V_{CCL}-GND	13.5	15	16.5	V
V_{BS}	High-side bias voltage	Applied between V_{BOOTi}-OUT_i for i = U, V, W	13	15	18.5	V
t_{dead}	Blanking time to prevent arm-short	For each input signal	1.5			µs
f_{PWM}	PWM input signal	-40 °C < T_C < 100 °C -40 °C < T_J < 125 °C			20	kHz
T_C	Case operation temperature				125	°C

7 Electrical characteristics (curves)

Figure 11. Output characteristics

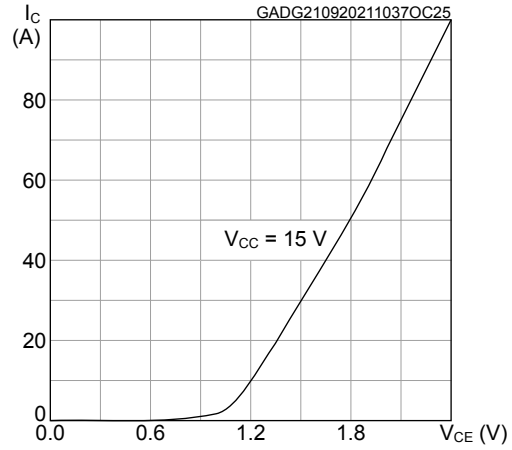


Figure 12. $V_{CE(sat)}$ vs collector current

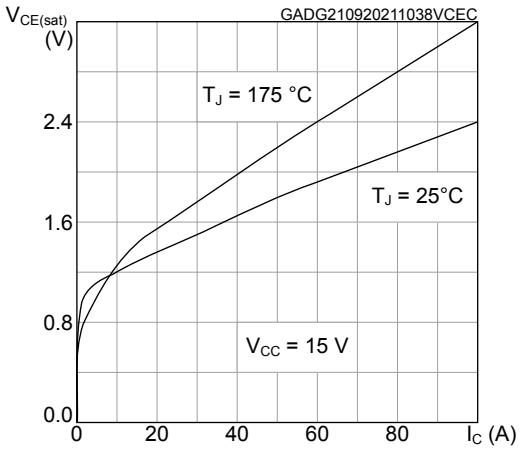


Figure 13. I_C vs case temperature

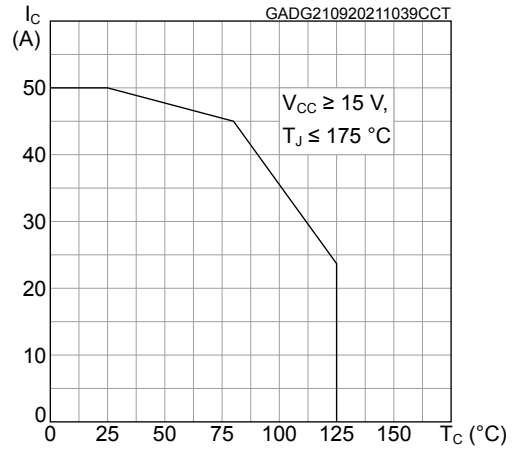


Figure 14. Diode V_F vs forward current

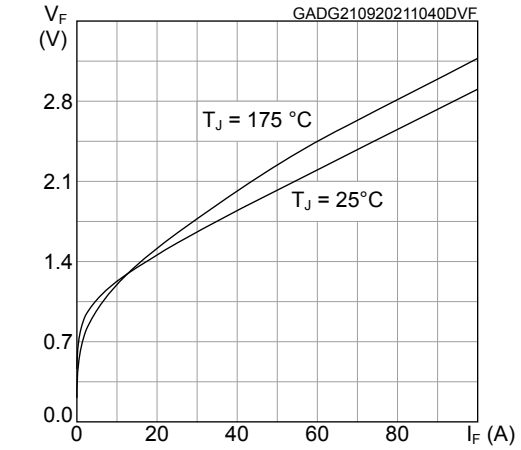


Figure 15. E_{on} switching energy vs collector current

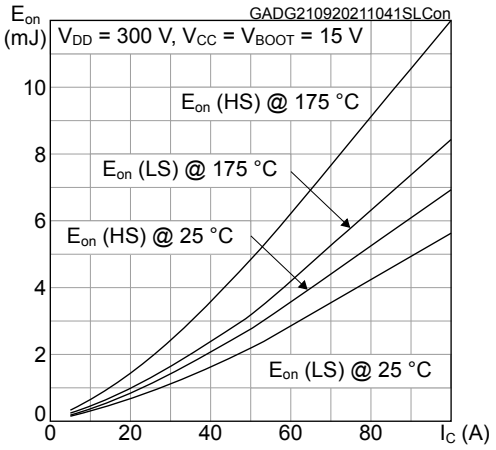


Figure 16. E_{off} switching energy vs collector current

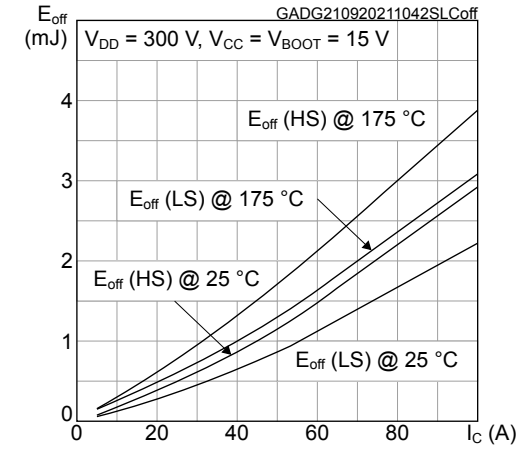


Figure 17. Normalized thermal impedance for IGBT

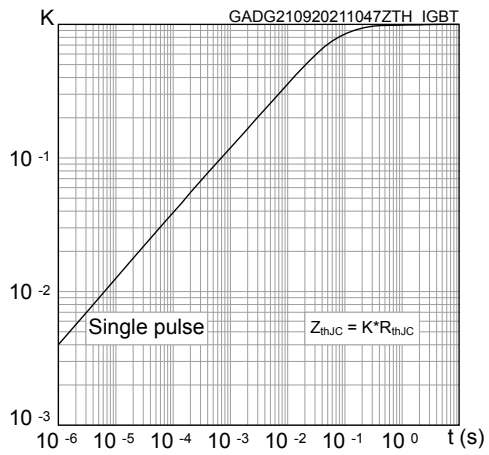
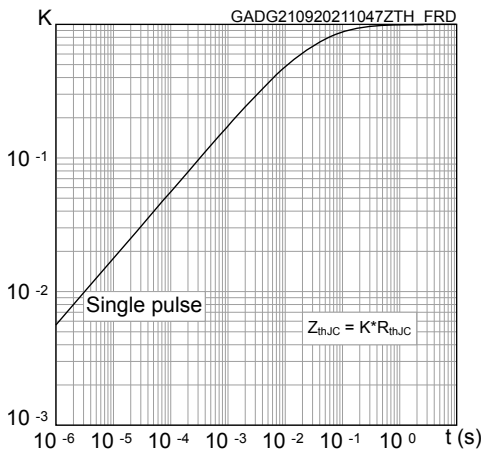


Figure 18. Normalized thermal impedance for FRD

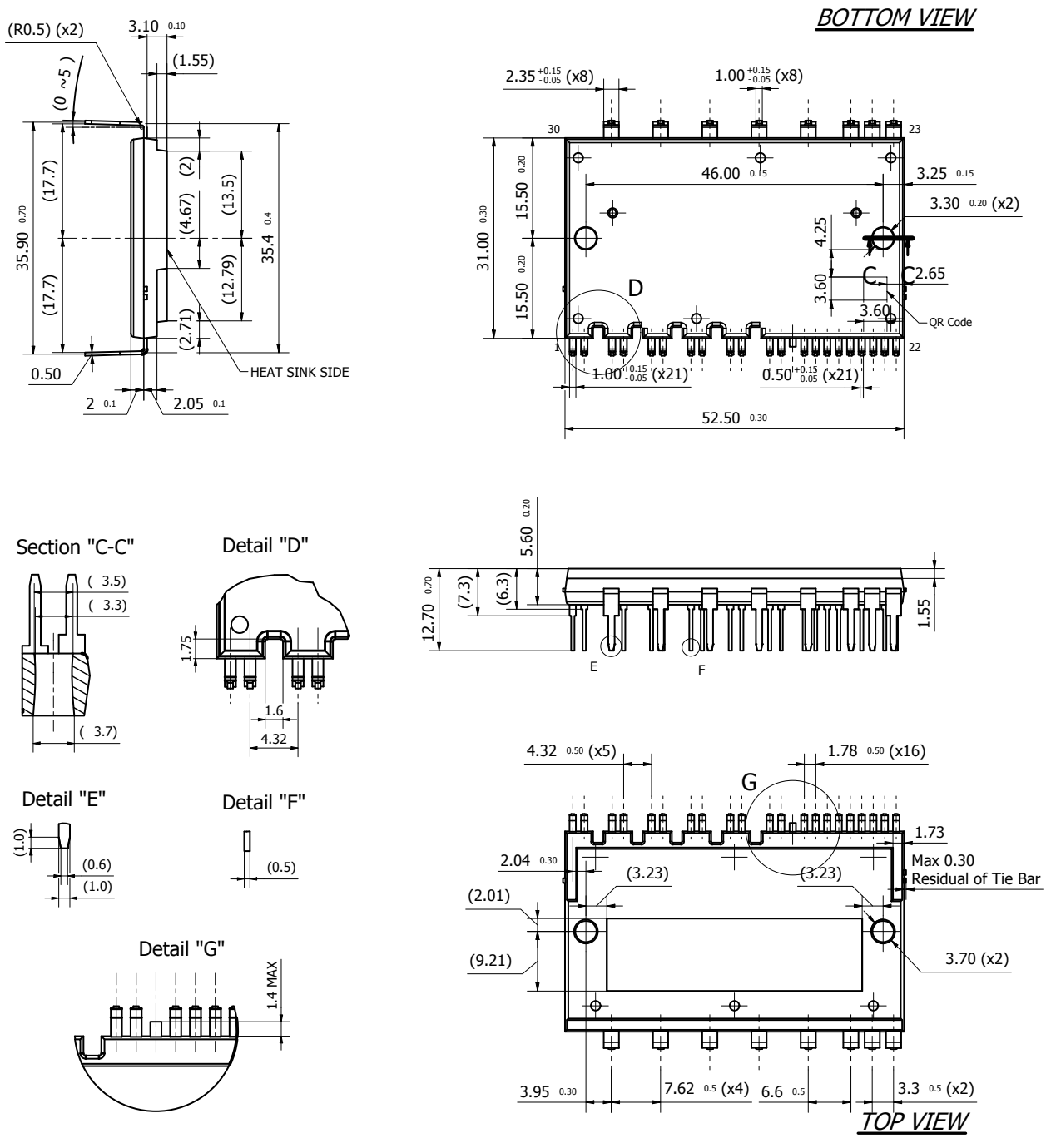


8 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK packages, depending on their level of environmental compliance. ECOPACK specifications, grade definitions and product status are available at: www.st.com. ECOPACK is an ST trademark.

8.1 SDIPHP-30L package information

Figure 19. SDIPHP-30L package outline and mechanical data (dimensions are in mm)



DM00727478_1

Revision history

Table 13. **Document revision history**

Date	Revision	Changes
23-Sep-2021	1	First release.

Contents