

HybridPACK™ Drive Module

FS660R08A6P2FLB

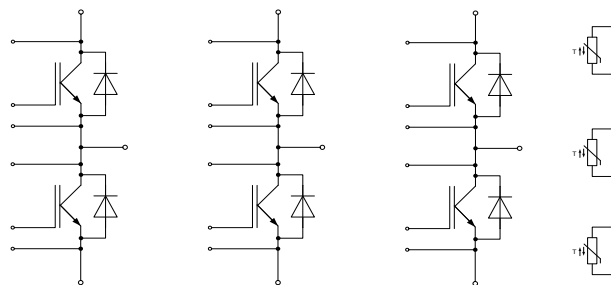
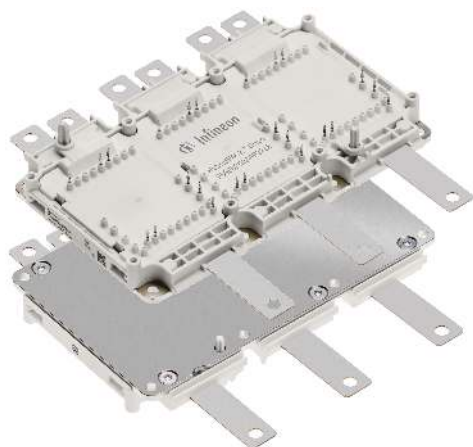
Final Data Sheet

V3.0, 2019-05-20

Automotive High Power

1 Features / Description

HybridPACK™ Drive module with EDT2 IGBT and Diode



$V_{CES} = 750 \text{ V}$
 $I_C = 660 \text{ A}$

Typical Applications

- Automotive Applications
- Hybrid Electrical Vehicles (H)EV
- Motor Drives
- Commercial Agriculture Vehicles

Electrical Features

- Blocking voltage 750V
- Low V_{CEsat}
- Low Switching Losses
- Low Q_g and Cr_{ss}
- Low Inductive Design
- $T_{vj\ op} = 150^\circ\text{C}$
- Short-time extended Operation Temperature
 $T_{vj\ op} = 175^\circ\text{C}$

Mechanical Features

- 4.2kV DC 1sec Insulation
- High Creepage and Clearance Distances
- Compact design
- High Power Density
- Copper Base Plate
- Guiding elements for PCB and cooler assembly
- Integrated NTC temperature sensor
- PressFIT Contact Technology
- RoHS compliant
- UL 94 V0 module frame

Description

The HybridPACK™ Drive is a very compact six-pack module optimized for hybrid and electric vehicles. The product FS660R08A6P2FLB comes with a flat baseplate and is a 750V/660A module derivate within the HybridPACK Drive family. The power module implements the new EDT2 IGBT generation, which is an automotive Micro-Pattern Trench-Field-Stop cell design optimized for electric drive train applications. The chipset has benchmark current density combined with short circuit ruggedness and increased blocking voltage for reliable inverter operation under harsh environmental conditions. The EDT2 IGBTs also show excellent light load power losses, which helps to improve system efficiency over a real driving cycle. The EDT2 IGBT was optimized for applications with switching frequencies in the range of 10 kHz.

The new The HybridPACK™ Drive power module family comes with mechanical guiding elements supporting easy assembly processes for customers. Furthermore, the press-fit pins for the signal terminals avoid additional time consuming selective solder processes, which provides cost savings on system level and increases system reliability. The two products in the The HybridPACK™ Drive family with flat baseplate in the FS660R08A6P2FLB and PinFin baseplate in the FS820R08A6P2LB allow a very cost effective scaling for different inverter power levels at a minimum inverter design effort.

| Product Name | Ordering Code |
|-----------------|---------------|
| FS660R08A6P2FLB | SP001850450 |

2 IGBT, Inverter

2.1 Maximum Rated Values

| Parameter | Conditions | Symbol | Value | Unit |
|-----------------------------------|--|--------------------|--------------------|------|
| Collector-emitter voltage | $T_{vj} = 25^{\circ}\text{C}$ | V_{CES} | 750 | V |
| Implemented collector current | | I_{CN} | 660 | A |
| Continuous DC collector current | $T_C = 80^{\circ}\text{C}$, $T_{vj\text{ max}} = 175^{\circ}\text{C}$ | $I_{C\text{ nom}}$ | 450 ¹⁾ | A |
| Repetitive peak collector current | $t_P = 1\text{ ms}$ | I_{CRM} | 1320 | A |
| Total power dissipation | $T_C = 75^{\circ}\text{C}$, $T_{vj\text{ max}} = 175^{\circ}\text{C}$ | P_{tot} | 1053 ¹⁾ | W |
| Gate-emitter peak voltage | | V_{GES} | +/-20 | V |

2.2 Characteristic Values

| Parameter | Conditions | Symbol | min. typ. max. | | | Unit |
|--|--|---|----------------|---------------------|--------------------------|--------------------|
| | | | | | | |
| Collector-emitter saturation voltage | $I_C = 450\text{ A}$, $V_{GE} = 15\text{ V}$ | $V_{CE\text{ sat}}$ | | 1.10 | 1.35 | V |
| | $I_C = 450\text{ A}$, $V_{GE} = 15\text{ V}$ | | | 1.15 | | |
| | $I_C = 450\text{ A}$, $V_{GE} = 15\text{ V}$ | | | 1.15 | | |
| | $I_C = 660\text{ A}$, $V_{GE} = 15\text{ V}$ | $V_{CE\text{ sat}}$ | | 1.25 | 1.35 | V |
| | $I_C = 660\text{ A}$, $V_{GE} = 15\text{ V}$ | | | 1.25 | | |
| | $I_C = 660\text{ A}$, $V_{GE} = 15\text{ V}$ | | | 1.35 | | |
| Gate threshold voltage | $I_C = 9.60\text{ mA}$, $V_{CE} = V_{GE}$ | $V_{GE\text{ th}}$ | 4.90 | 5.80 4,10 | 6.50 | V |
| Gate charge | $V_{GE} = -8\text{ V} \dots 15\text{ V}$, $V_{CE} = 400\text{ V}$ | Q_G | | 4.40 | | μC |
| Internal gate resistor | | $R_{G\text{int}}$ | | 0.7 | | Ω |
| Input capacitance | $f = 1\text{ MHz}$, $V_{CE} = 50\text{ V}$, $V_{GE} = 0\text{ V}$ | C_{ies} | | 80.0 | | nF |
| Output capacitance | $f = 1\text{ MHz}$, $V_{CE} = 50\text{ V}$, $V_{GE} = 0\text{ V}$ | C_{oes} | | 1.00 | | nF |
| Reverse transfer capacitance | $f = 1\text{ MHz}$, $V_{CE} = 50\text{ V}$, $V_{GE} = 0\text{ V}$ | C_{res} | | 0.30 | | nF |
| Collector-emitter cut-off current | $V_{CE} = 750\text{ V}$, $V_{GE} = 0\text{ V}$ $V_{CE} = 750\text{ V}$, $V_{GE} = 0\text{ V}$ | I_{CES} | | 5 | 1.0 | mA |
| Gate-emitter leakage current | $V_{CE} = 0\text{ V}$, $V_{GE} = 20\text{ V}$ | I_{GES} | | | 400 | nA |
| Turn-on delay time, inductive load | $I_C = 450\text{ A}$, $V_{CE} = 400\text{ V}$ $V_{GE} = -8\text{ V} / +15\text{ V}$ $R_{G\text{on}} = 2.4\ \Omega$ | $t_{d\text{ on}}$ | | 0.28 | | μs |
| | | | | 0.29 | | |
| | | | | 0.30 | | |
| Rise time, inductive load | $I_C = 450\text{ A}$, $V_{CE} = 400\text{ V}$ $V_{GE} = -8\text{ V} / +15\text{ V}$ $R_{G\text{on}} = 2.4\ \Omega$ | t_r | | 0.07 | | μs |
| | | | | 0.08 | | |
| | | | | 0.08 | | |
| Turn-off delay time, inductive load | $I_C = 450\text{ A}$, $V_{CE} = 400\text{ V}$ $V_{GE} = -8\text{ V} / +15\text{ V}$ $R_{G\text{off}} = 5.1\ \Omega$ | $t_{d\text{ off}}$ | | 0.94 | | μs |
| | | | | 1.05 | | |
| | | | | 1.05 | | |
| Fall time, inductive load | $I_C = 450\text{ A}$, $V_{CE} = 400\text{ V}$ $V_{GE} = -8\text{ V} / +15\text{ V}$ $R_{G\text{off}} = 5.1\ \Omega$ | t_f | | 0.04 | | μs |
| | | | | 0.05 | | |
| | | | | 0.06 | | |
| Turn-on energy loss per pulse | $I_C = 450\text{ A}$, $V_{CE} = 400\text{ V}$, $L_S = 20\text{ nH}$ $V_{GE} = -8\text{ V} / +15\text{ V}$ $R_{G\text{on}} = 2.4\ \Omega$ $di/dt (T_{vj} 25^{\circ}\text{C}) = 5500\text{ A}/\mu\text{s}$ $di/dt (T_{vj} 150^{\circ}\text{C}) = 5000\text{ A}/\mu\text{s}$ | E_{on} | | 13.5 | | mJ |
| | | | | 17.5 | | |
| | | | | 18.0 | | |
| Turn-off energy loss per pulse | $I_C = 450\text{ A}$, $V_{CE} = 400\text{ V}$, $L_S = 20\text{ nH}$ $V_{GE} = -8\text{ V} / +15\text{ V}$ $R_{G\text{off}} = 5.1\ \Omega$ $dv/dt (T_{vj} 25^{\circ}\text{C}) = 3100\text{ V}/\mu\text{s}$ $dv/dt (T_{vj} 150^{\circ}\text{C}) = 2500\text{ V}/\mu\text{s}$ | E_{off} | | 23.5 | | mJ |
| | | | | 29.0 | | |
| | | | | 30.0 | | |
| SC data | $V_{GE} \leq 15\text{ V}$, $V_{CC} = 400\text{ V}$ $V_{CE\text{ max}} = V_{CES} - L_{SCE} \cdot di/dt$ | $t_P \leq 6\ \mu\text{s}$, $T_{vj} = 25^{\circ}\text{C}$ $t_P \leq 3\ \mu\text{s}$, $T_{vj} = 175^{\circ}\text{C}$ | I_{SC} | 4800 3900 | | A |
| Thermal resistance, junction to case | per IGBT | R_{thJC} | | 0.080 | 0.095 | K/W |
| Thermal resistance, case to heatsink | per IGBT $\lambda_{\text{Paste}} = 1\text{ W}/(\text{m}\cdot\text{K})$ / $\lambda_{\text{grease}} = 1\text{ W}/(\text{m}\cdot\text{K})$ | R_{thCH} | | 0.050 ²⁾ | | K/W |
| Temperature under switching conditions | t_{op} continuous for 10s within a period of 30s, occurrence maximum 3000 times over lifetime | $T_{vj\text{ op}}$ | -40 150 | | 150 ³⁾ 175 | $^{\circ}\text{C}$ |

¹⁾ Verified by characterization / design not by test.

²⁾ cooler alpha = 1500 W/(m²K); $R_{thHF_typ} = 0,06\text{ K/W}$

³⁾ For $T_{vj\text{ op}} > 150^{\circ}\text{C}$: Baseplate temperature has to be limited to 125 $^{\circ}\text{C}$.

3 Diode, Inverter

3.1 Maximum Rated Values

| Parameter | Conditions | Symbol | Value | Unit |
|---------------------------------|--|-----------|-------------------|--|
| Repetitive peak reverse voltage | $T_{vj} = 25^{\circ}\text{C}$ | V_{RRM} | 750 | V |
| Implemented forward current | | I_{FN} | 660 | A |
| Continuous DC forward current | | I_F | 450 ¹⁾ | A |
| Repetitive peak forward current | $t_p = 1 \text{ ms}$ | I_{FRM} | 1320 | A |
| I^2t - value | $V_R = 0 \text{ V}, t_p = 10 \text{ ms}, T_{vj} = 150^{\circ}\text{C}$ $V_R = 0 \text{ V}, t_p = 10 \text{ ms}, T_{vj} = 175^{\circ}\text{C}$ | I^2t | 19000 16000 | A^2s A^2s |

3.2 Characteristic Values

| Parameter | Conditions | Symbol | min. typ. max. | | | Unit |
|--|---|-------------|----------------|---------------------|-------|--|
| | | | | | | |
| Forward voltage | $I_F = 450 \text{ A}, V_{GE} = 0 \text{ V}$ | V_F | | 1.45 | 1.65 | V |
| | $I_F = 450 \text{ A}, V_{GE} = 0 \text{ V}$ | | | 1.30 | | |
| | $I_F = 450 \text{ A}, V_{GE} = 0 \text{ V}$ | | | 1.25 | | |
| | $I_F = 660 \text{ A}, V_{GE} = 0 \text{ V}$ | | | 1.60 | | |
| Peak reverse recovery current | $I_F = 450 \text{ A}, -di_F/dt = 5000 \text{ A}/\mu\text{s} (T_{vj} = 150^{\circ}\text{C})$ | I_{RM} | | 250 | | A |
| | $V_R = 400 \text{ V}$ $V_{GE} = -8 \text{ V}$ | | | 350 370 | | |
| Recovered charge | $I_F = 450 \text{ A}, -di_F/dt = 5000 \text{ A}/\mu\text{s} (T_{vj} = 150^{\circ}\text{C})$ | Q_r | | 20.0 | | μC |
| | $V_R = 400 \text{ V}$ $V_{GE} = -8 \text{ V}$ | | | 40.0 45.0 | | |
| Reverse recovery energy | $I_F = 450 \text{ A}, -di_F/dt = 5000 \text{ A}/\mu\text{s} (T_{vj} = 150^{\circ}\text{C})$ | E_{rec} | | 7.00 | | mJ |
| | $V_R = 400 \text{ V}$ $V_{GE} = -8 \text{ V}$ | | | 13.0 15.0 | | |
| Thermal resistance, junction to case | per diode | R_{thJC} | | 0.125 | 0.150 | K/W |
| Thermal resistance, case to heatsink | per diode $\lambda_{Paste} = 1 \text{ W}/(\text{m}\cdot\text{K}) / \lambda_{grease} = 1 \text{ W}/(\text{m}\cdot\text{K})$ | R_{thCH} | | 0.050 ²⁾ | | K/W |
| Temperature under switching conditions | t_{op} continuous for 10s within a period of 30s, occurrence maximum 3000 times over lifetime | $T_{vj op}$ | | -40 150 | | 150 ³⁾ 175 $^{\circ}\text{C}$ |

4 NTC-Thermistor

| Parameter | Conditions | Symbol | min. typ. max. | | | Unit |
|-------------------|--|--------------|----------------|------|------|------------------|
| | | | | | | |
| Rated resistance | $T_C = 25^{\circ}\text{C}$ | R_{25} | | 5.00 | | $\text{k}\Omega$ |
| Deviation of R100 | $T_C = 100^{\circ}\text{C}, R_{100} = 493 \Omega$ | $\Delta R/R$ | 5 | | 5 | % |
| Power dissipation | $T_C = 25^{\circ}\text{C}$ | P_{25} | | | 20.0 | mW |
| B-value | $R_2 = R_{25} \exp [B_{25/50}(1/T_2 - 1/(298,15 \text{ K}))]$ | $B_{25/50}$ | | 3375 | | K |
| B-value | $R_2 = R_{25} \exp [B_{25/80}(1/T_2 - 1/(298,15 \text{ K}))]$ | $B_{25/80}$ | | 3411 | | K |
| B-value | $R_2 = R_{25} \exp [B_{25/100}(1/T_2 - 1/(298,15 \text{ K}))]$ | $B_{25/100}$ | | 3433 | | K |

Specification according to the valid application note.

¹⁾ Verified by characterization / design not by test.

²⁾ cooler alpha = 1500 W/(m²K); $R_{thHF_typ} = 0,06 \text{ K/W}$

³⁾ For $T_{vjop} > 150^{\circ}\text{C}$: Baseplate temperature has to be limited to 125°C.

5 Module

| Parameter | Conditions | Symbol | Value | | | Unit |
|--|--|--------------|--|------|--------------------------|------|
| Isolation test voltage | RMS, f = 0 Hz, t = 1 sec | V_{ISOL} | 4.2 | | | kV |
| Maximum RMS module terminal current | $T_F = 75^\circ\text{C}$, $T_{Ct} = 105^\circ\text{C}$ $T_C = 85^\circ\text{C}$, $T_{Ct} = 105^\circ\text{C}$ | I_{RMS} | 500 500 | | | A |
| Material of module baseplate | | | Cu+Ni ¹⁾ | | | |
| Internal isolation | basic insulation (class 1, IEC 61140) | | Al ₂ O ₃ ²⁾ | | | |
| Creepage distance | terminal to heatsink terminal to terminal | d_{Creep} | 9.0 | | | mm |
| | | | 9.0 | | | |
| Clearance | terminal to heatsink terminal to terminal | d_{Clear} | 4.5 | | | mm |
| | | | 4.5 | | | |
| Comperative tracking index | | CTI | > 200 | | | |
| | | | | | | |
| Maximum pressure in cooling circuit | $T_{baseplate} < 40^\circ\text{C}$ $T_{baseplate} > 40^\circ\text{C}$ (relative pressure) | p | min. | typ. | max. | bar |
| | | | | | 3.0 ³⁾ 2.5 | |
| Stray inductance module | | L_{sCE} | 8.0 | | | nH |
| Module lead resistance, terminals - chip | $T_C = 25^\circ\text{C}$, per switch | $R_{CC+EE'}$ | 0.75 | | | mΩ |
| Storage temperature | | T_{stg} | -40 | 125 | | °C |
| Mounting torque for modul mounting | Screw M4 baseplate to heatsink Screw EJOT Delta PCB to frame | M | 1.80 | 2.00 | 2.20 | Nm |
| | | | 0.45 | 0.50 | 0.55 ⁴⁾ | |
| Weight | | G | 600 | | | g |

¹⁾ Ni plated Cu baseplate.

²⁾ Improved Al₂O₃ ceramic.

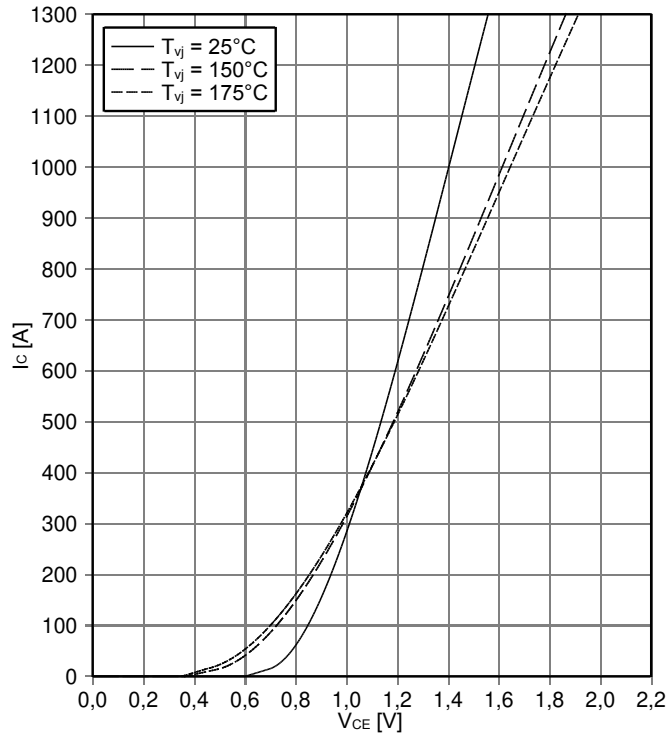
³⁾ According to application note AN-HPD-ASSEMBLY

⁴⁾ EJOT Delta PT WN 5451 30x10. Effective mounting torque according to application note AN-HPD-ASSEMBLY

6 Characteristics Diagrams

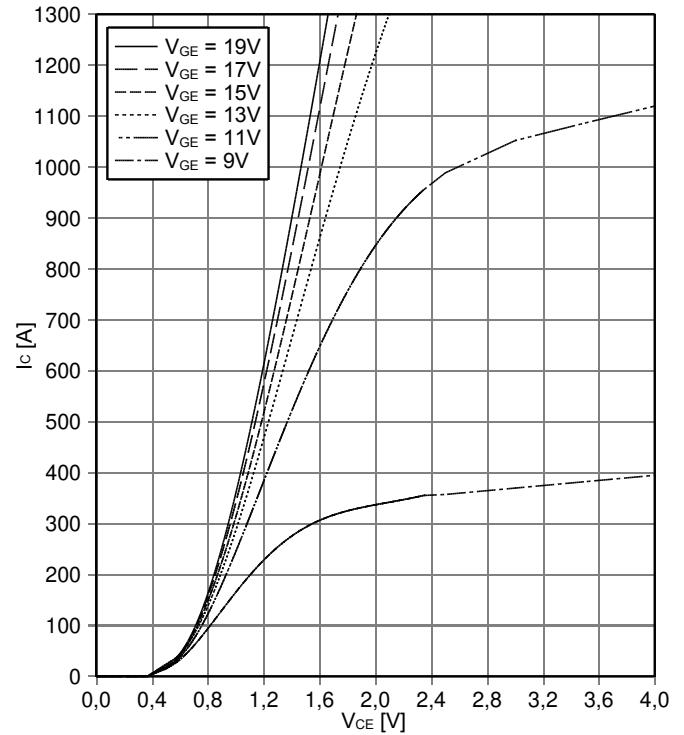
output characteristic IGBT, Inverter (typical)

$I_C = f(V_{CE})$
 $V_{GE} = 15\text{ V}$



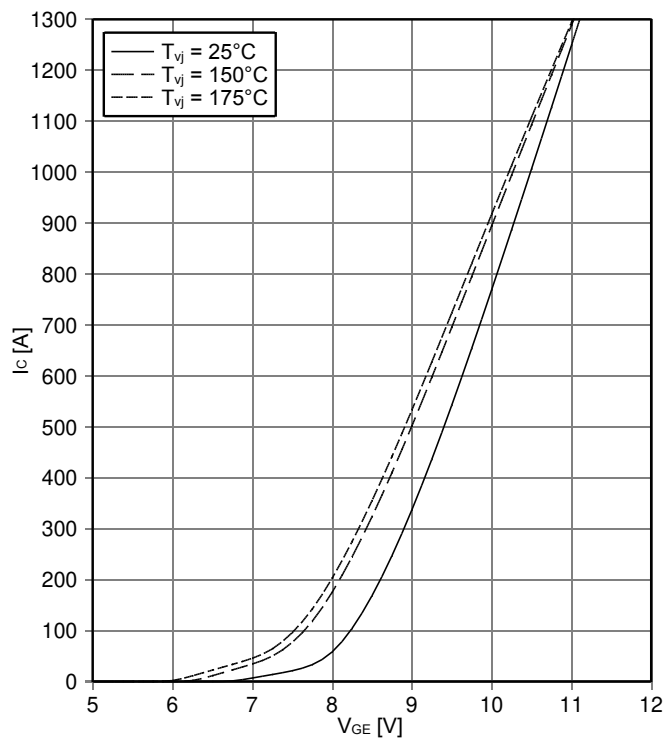
output characteristic IGBT, Inverter (typical)

$I_C = f(V_{CE})$
 $T_{vj} = 150^\circ\text{C}$



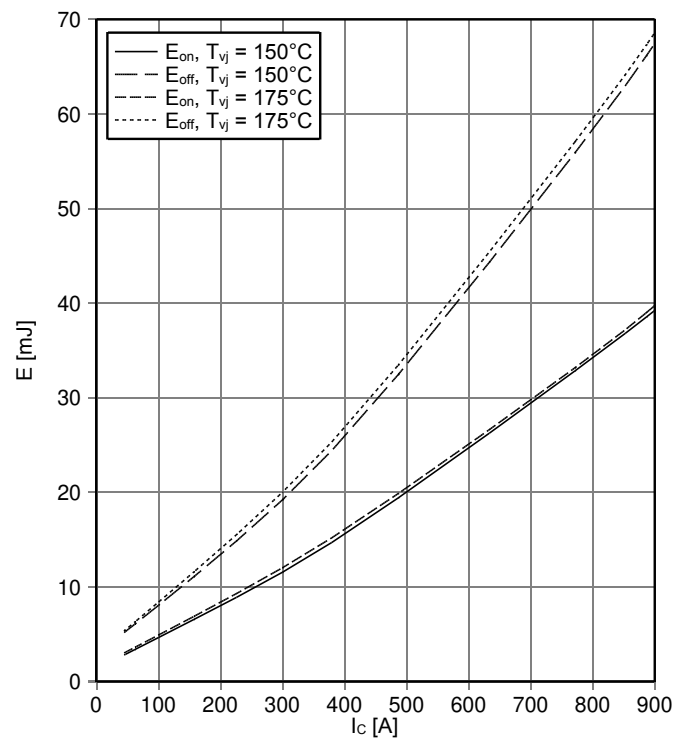
transfer characteristic IGBT, Inverter (typical)

$I_C = f(V_{GE})$
 $V_{CE} = 20\text{ V}$



switching losses IGBT, Inverter (typical)

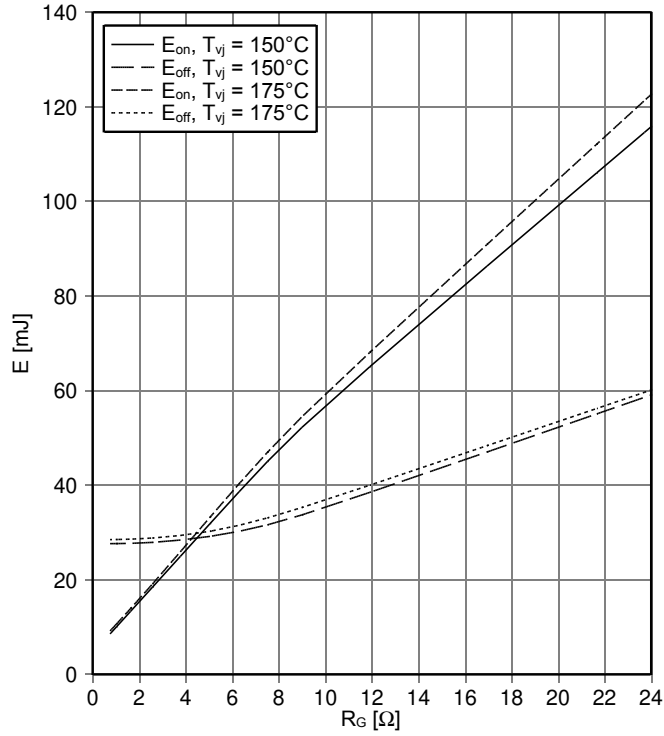
$E_{on} = f(I_C)$, $E_{off} = f(I_C)$
 $V_{GE} = +15\text{ V} / -8\text{ V}$, $R_{Gon} = 2.4\ \Omega$, $R_{Goff} = 5.1\ \Omega$, $V_{CE} = 400\text{ V}$



switching losses IGBT, Inverter (typical)

$E_{on} = f(R_G), E_{off} = f(R_G)$

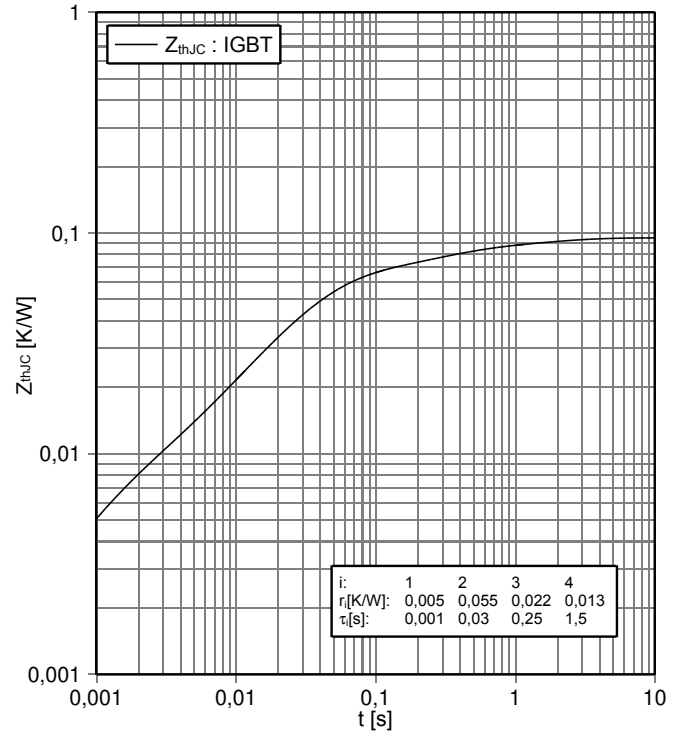
$V_{GE} = +15V / -8V, I_C = 450 A, V_{CE} = 400 V$



transient thermal impedance IGBT, Inverter

$Z_{thJC} = f(t)$

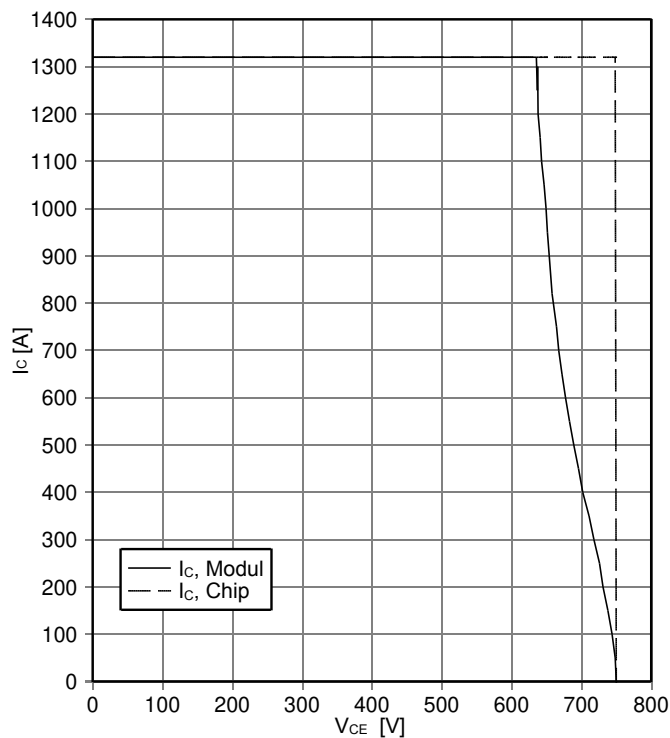
thermal grease 1W/(m²K), cooler alpha = 1500 W/(m²K)



reverse bias safe operating area IGBT, Inverter (RBSOA)

$I_C = f(V_{CE})$

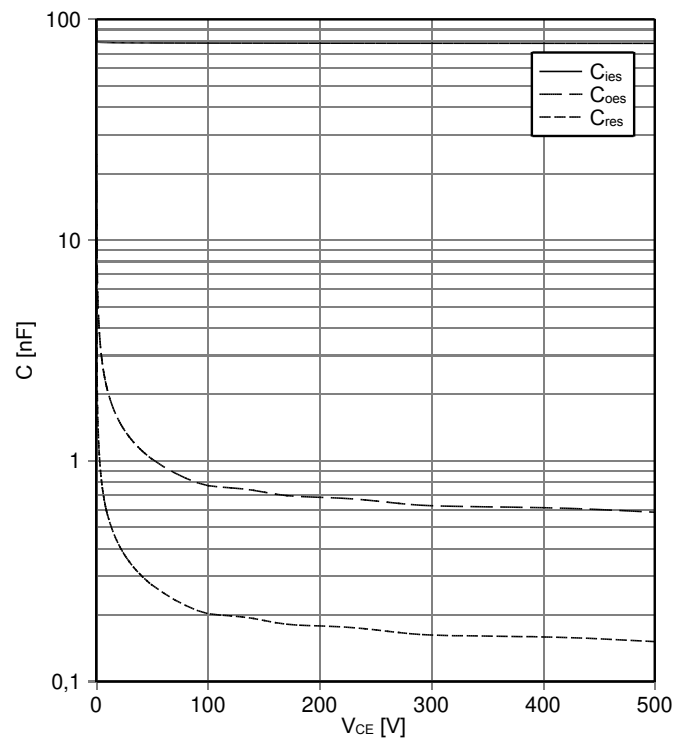
$V_{GE} = +15V / -8V, R_{Goff} = 5,1 \Omega, T_{vj} = 175^\circ C$



capacity characteristic IGBT, Inverter (typical)

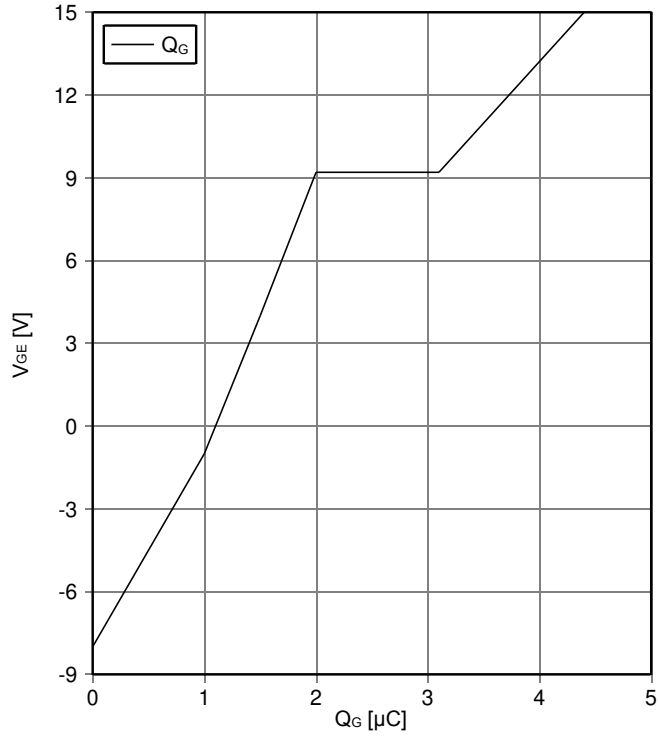
$C = f(V_{CE})$

$V_{GE} = 0 V, T_{vj} = 25^\circ C, f = 1 MHz$



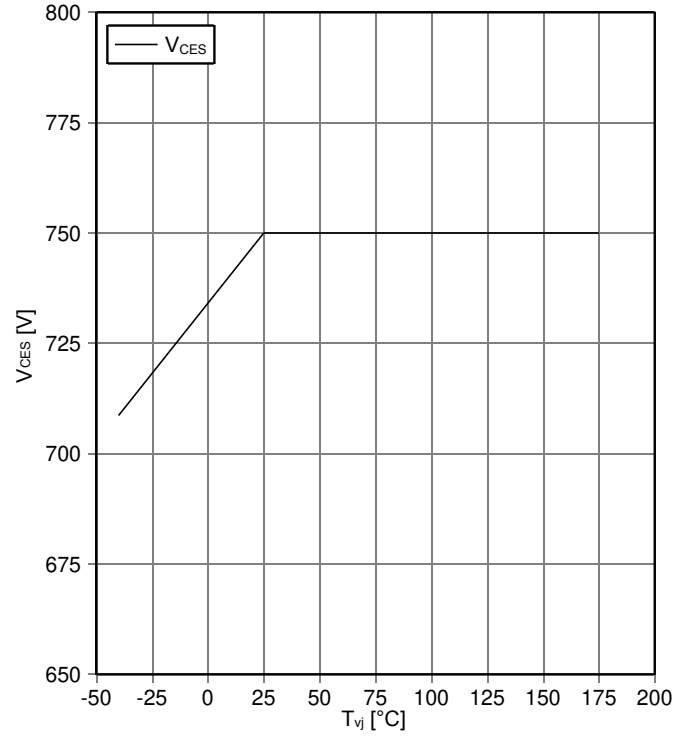
gate charge characteristic IGBT, Inverter (typical)

$V_{GE} = f(Q_G)$
 $V_{CE} = 400\text{ V}$, $I_C = 450\text{ A}$, $T_{vj} = 25^\circ\text{C}$



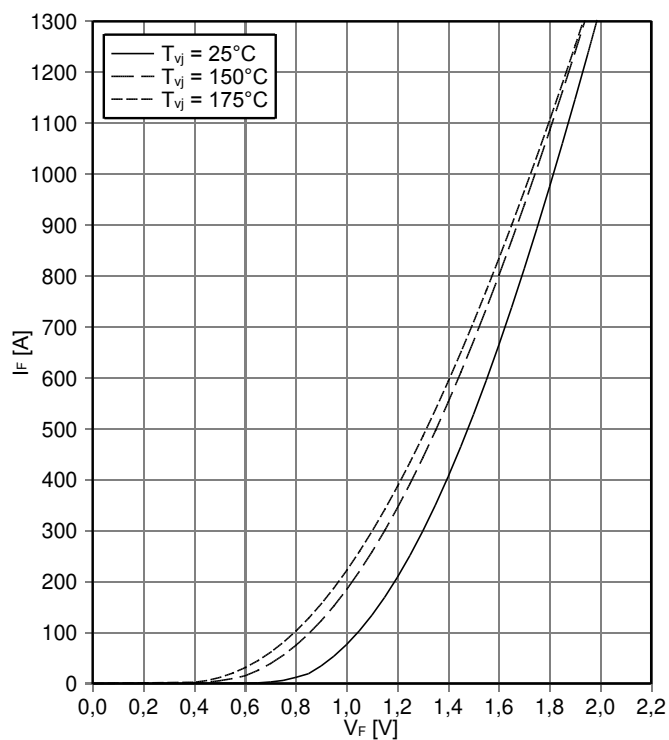
maximum allowed collector-emitter voltage

$V_{CES} = f(T_{vj})$, verified by characterization / design not by test
 $I_{CES} = 1\text{ mA}$ for $T_{vj} \leq 25^\circ\text{C}$; $I_{CES} = 30\text{ mA}$ for $T_{vj} > 25^\circ\text{C}$



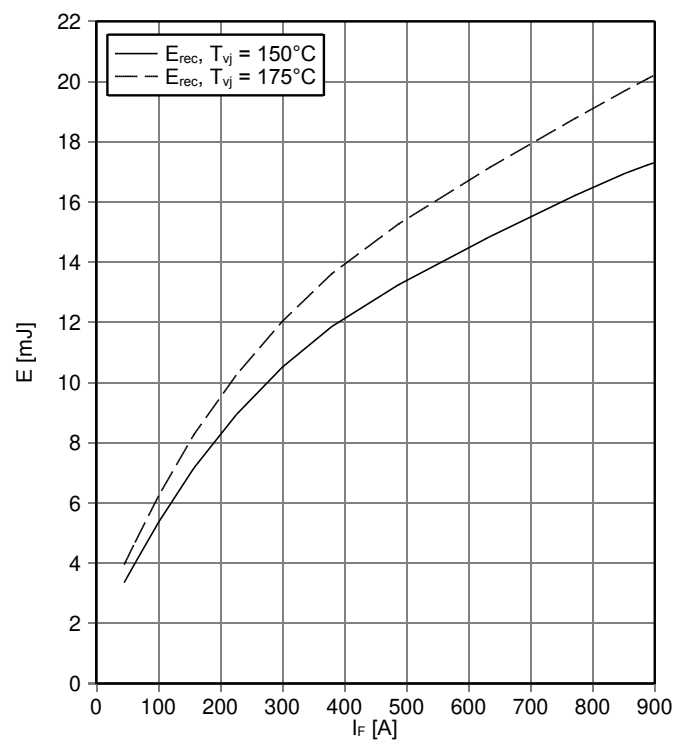
forward characteristic of Diode, Inverter (typical)

$I_F = f(V_F)$



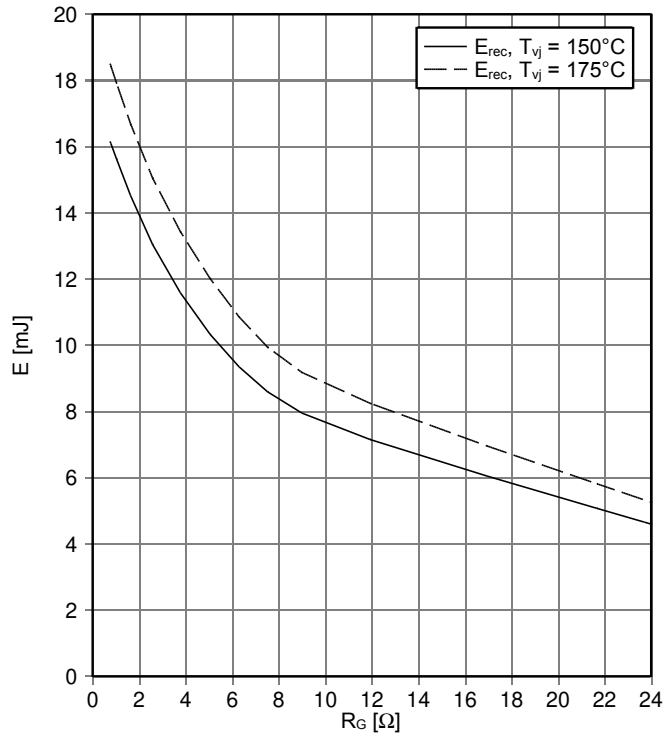
switching losses Diode, Inverter (typical)

$E_{rec} = f(I_F)$,
 $R_{Gon} = 2.4\ \Omega$, $V_{CE} = 400\text{ V}$



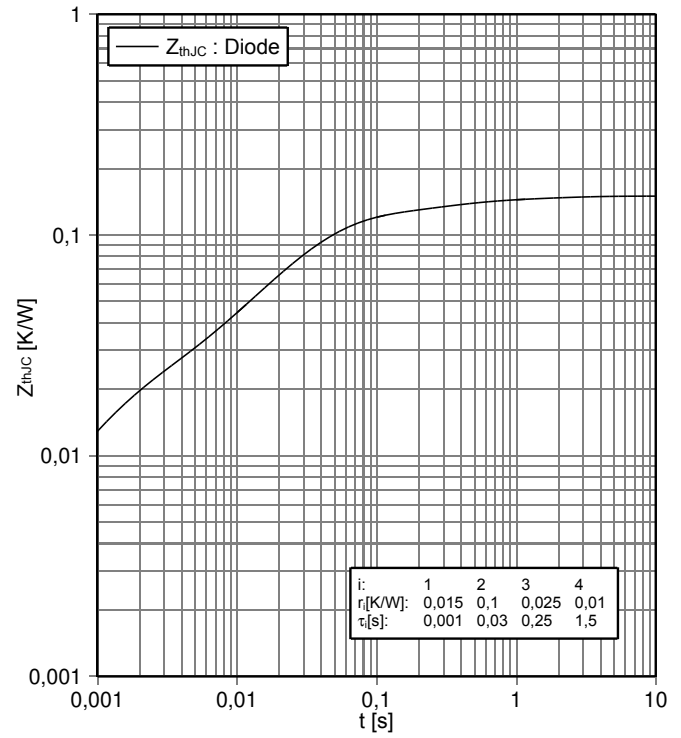
switching losses Diode, Inverter (typical)

$E_{rec} = f(R_G)$,
 $I_F = 450\text{ A}$, $V_{CE} = 400\text{ V}$



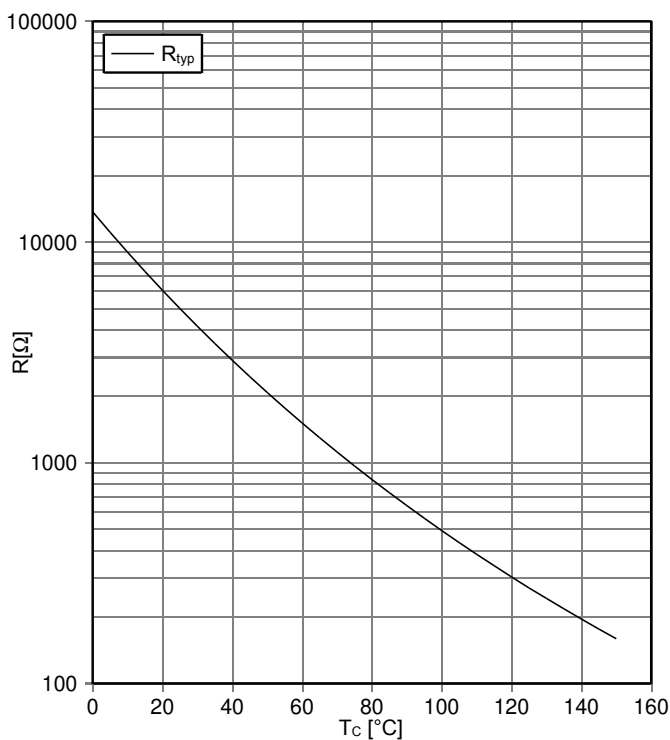
transient thermal impedance Diode, Inverter

$Z_{thJC} = f(t)$
thermal grease $1\text{ W}/(\text{m}^2\text{K})$, cooler $\alpha = 1500\text{ W}/(\text{m}^2\text{K})$

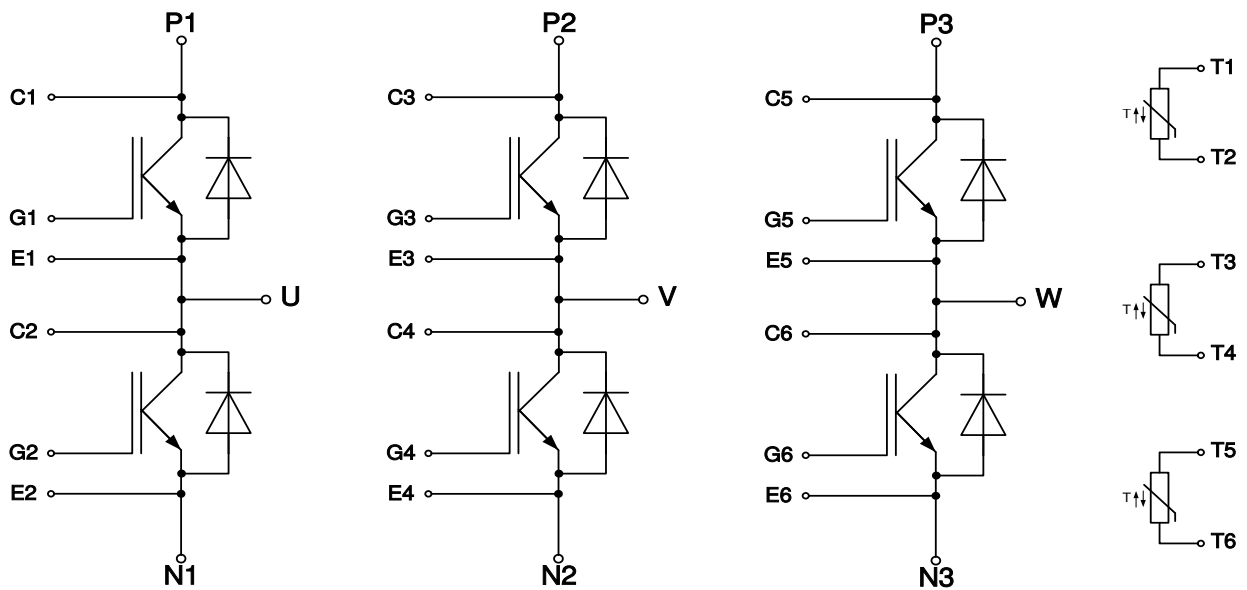


NTC-Thermistor-temperature characteristic (typical)

$R = f(T)$




7 Circuit diagram




9 Label Codes

9.1 Module Code

| | | | |
|--------------|--|---|--|
| Code Format | Data Matrix | | |
| Encoding | ASCII Text | | |
| Symbol Size | 16x16 | | |
| Standard | IEC24720 and IEC16022 | | |
| Code Content | Content Module Serial Number Module Material Number Production Order Number Datecode (Production Year) Datecode (Production Week) | Digit 1 - 5 6 - 11 12 - 19 20 - 21 22 - 23 | Example (below) 71549 142846 55054991 15 30 |
| Example |  71549142846550549911530 | | |

9.2 Packing Code

| | | | | |
|--------------|--|---------------------------------------|--|---|
| Code Format | Code128 | | | |
| Encoding | Code Set A | | | |
| Symbol Size | 34 digits | | | |
| Standard | IEC8859-1 | | | |
| Code Content | Content Backend Construction Number Production Lot Number Serial Number Date Code Box Quantity | Identifier X 1T S 9D Q | Digit 2 - 9 12 - 19 21 - 25 28 - 31 33 - 34 | Example (below) 95056609 2X0003E0 754389 1139 15 |
| Example |  X950566091T2X0003E0S754389D1139Q15 | | | |

Revision History

Major changes since previous revision

| Revision History | | |
|------------------|------------|---|
| Reference | Date | Description |
| V2.0 | 2018-03-07 | - |
| V2.1 | 2018-11-28 | Correction of pin designation in package outlines |
| V3.0 | 2019-05-20 | - |

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