

## XHP™3 module with Trench/Fieldstop IGBT3 and Emitter Controlled 3 diode

### Features

- Electrical features
  - High dynamic robustness
  - Low  $V_{CEsat}$
  - Trench IGBT 3
- Mechanical features
  - Package with CTI > 600
  - Package with enhanced insulation of 10.4kV AC 10s
  - ALSiC base plate for increased thermal cycling capability
  - Extended storage temperature down to  $T_{stg} = -55^{\circ}\text{C}$
  - High creepage and clearance distances
  - Housing material compliant with the classification R23 (HL3) of the EN45545-2 “Fire protection of railway vehicles”



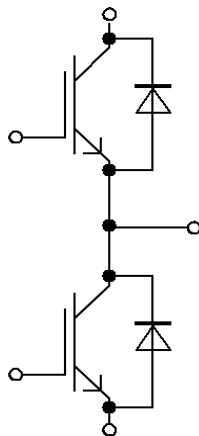
### Potential applications

- Traction drives
- Medium voltage converters

### Product validation

- Qualified for industrial applications according to the relevant tests of IEC 60747, 60749 and 60068

### Description



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## 1 Package

**Table 1 Insulation Coordination**

Parameter	Symbol	Note or test condition	Values	Unit
Isolation test voltage	$V_{ISOL}$	RMS, $f = 50$ Hz, $t = 10$ s	10.4	kV
Partial discharge extinction voltage	$V_{isol}$	RMS, $f = 50$ Hz, $Q_{PD}$ typ. 10 pC	5.1	kV
DC stability	$V_{CE(D)}$	$T_{vj}=25^{\circ}C$ , 100 Fit	3800	V
Material of module baseplate			AlSiC	
Creepage distance	$d_{Creep}$	terminal to heatsink	53.0	mm
Clearance	$d_{Clear}$	terminal to heatsink	26.0	mm
Comperative tracking index	$CTI$		> 600	

**Table 2 Characteristic Values**

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Stray inductance module	$L_{SCE}$			25		nH
Module lead resistance, terminals - chip	$R_{AA'+CC'}$	$T_C=25^{\circ}C$ , per switch		0.33		mΩ
Module lead resistance, terminals - chip	$R_{CC'+EE'}$	$T_C=25^{\circ}C$ , per switch		0.42		mΩ
Storage temperature	$T_{stg}$		-55		125	°C
Mounting torque for modul mounting	$M$	- Mounting according to valid application note M6, Screw	4.25		5.75	Nm
Terminal connection torque	$M$	- Mounting according to valid application note M3, Screw  M8, Screw	0.9		1.1	Nm
			8		10	
Weight	$G$			700		g

## 2 IGBT, Inverter

**Table 3 Maximum Rated Values**

Parameter	Symbol	Note or test condition	Values	Unit	
Collector-emitter voltage	$V_{CES}$		$T_{vj} = -50^{\circ}C$	5900	V
			$T_{vj} = 125^{\circ}C$	6500	
Continous DC collector current	$I_{CDC}$	$T_{vj\ max} = 125^{\circ}C$ $T_C = 80^{\circ}C$	225	A	

**Table 3 Maximum Rated Values (continued)**

Parameter	Symbol	Note or test condition	Values	Unit
Repetitive peak collector current	$I_{CRM}$	$t_P = 1 \text{ ms}$	450	A
Gate-emitter peak voltage	$V_{GES}$		$\pm 20$	V

**Table 4 Characteristic Values**

Parameter	Symbol	Note or test condition	Values			Unit	
			Min.	Typ.	Max.		
Collector-emitter saturation voltage	$V_{CE \text{ sat}}$	$I_C = 225 \text{ A},$ $V_{GE} = 15 \text{ V}$		$T_{vj} = 25 \text{ }^\circ\text{C}$	3.00	3.40	V
				$T_{vj} = 125 \text{ }^\circ\text{C}$	3.70	4.20	
Gate threshold voltage	$V_{GEth}$	$I_C = 33 \text{ mA},$ $V_{CE} = V_{GE},$ $T_{vj} = 25 \text{ }^\circ\text{C}$	5.40	6	6.60	V	
Gate charge	$Q_G$	$V_{GE} = \pm 15 \text{ V},$ $V_{CE} = 3600 \text{ V}$		10.5		$\mu\text{C}$	
Internal gate resistor	$R_{Gint}$	$T_{vj} = 25 \text{ }^\circ\text{C}$		0.67		$\Omega$	
Input capacitance	$C_{ies}$	$f = 100 \text{ kHz},$ $T_{vj} = 25 \text{ }^\circ\text{C},$ $V_{CE} = 25 \text{ V},$ $V_{GE} = 0 \text{ V}$		65.6		nF	
Reverse transfer capacitance	$C_{res}$	$f = 100 \text{ kHz},$ $T_{vj} = 25 \text{ }^\circ\text{C},$ $V_{CE} = 25 \text{ V},$ $V_{GE} = 0 \text{ V}$		1		nF	
Collector-emitter cut-off current	$I_{CES}$	$V_{CE} = 6500 \text{ V},$ $V_{GE} = 0 \text{ V}$	$T_{vj} = 25 \text{ }^\circ\text{C}$		5	mA	
Gate-emitter leakage current	$I_{GES}$	$V_{CE} = 0 \text{ V},$ $V_{GE} = 20 \text{ V},$ $T_{vj} = 25 \text{ }^\circ\text{C}$			400	nA	
Turn-on delay time (inductive load)	$t_{don}$	$I_C = 225 \text{ A},$ $V_{CE} = 3600 \text{ V},$ $V_{GE} = \pm 15 \text{ V},$ $R_{Gon} = 4.7 \text{ } \Omega$	$T_{vj} = 25 \text{ }^\circ\text{C}$ $T_{vj} = 125 \text{ }^\circ\text{C}$	0.240		$\mu\text{s}$	
				0.240			
Rise time (inductive load)	$t_r$	$I_C = 225 \text{ A},$ $V_{CE} = 3600 \text{ V},$ $V_{GE} = \pm 15 \text{ V},$ $R_{Gon} = 4.7 \text{ } \Omega$	$T_{vj} = 25 \text{ }^\circ\text{C}$ $T_{vj} = 125 \text{ }^\circ\text{C}$	0.070		$\mu\text{s}$	
				0.080			

**Table 4 Characteristic Values (continued)**

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Turn-off delay time (inductive load)	$t_{doff}$	$I_C = 225\text{ A},$ $V_{CE} = 3600\text{ V},$ $V_{GE} = \pm 15\text{ V},$ $R_{Goff} = 22\ \Omega$	$T_{vj} = 25\text{ °C}$ $T_{vj} = 125\text{ °C}$	6.000		$\mu\text{s}$
				6.400		
Fall time (inductive load)	$t_f$	$I_C = 225\text{ A},$ $V_{CE} = 3600\text{ V},$ $V_{GE} = \pm 15\text{ V},$ $R_{Goff} = 22\ \Omega$	$T_{vj} = 25\text{ °C}$ $T_{vj} = 125\text{ °C}$	0.950		$\mu\text{s}$
				2.000		
Turn-on energy loss per pulse	$E_{on}$	$I_C = 225\text{ A},$ $V_{CE} = 3600\text{ V},$ $L_\sigma = 85\text{ nH},$ $V_{GE} = \pm 15\text{ V},$ $R_{Gon} = 4.7\ \Omega,$ $di/dt = 2200\text{ A}/\mu\text{s}$ ( $T_{vj} = 125\text{ °C}$ )	$T_{vj} = 25\text{ °C}$ $T_{vj} = 125\text{ °C}$	1230		mJ
				1710		
Turn-off energy loss per pulse	$E_{off}$	$I_C = 225\text{ A},$ $V_{CE} = 3600\text{ V},$ $L_\sigma = 85\text{ nH},$ $V_{GE} = \pm 15\text{ V},$ $R_{Goff} = 22\ \Omega,$ $dv/dt = 2100\text{ V}/\mu\text{s}$ ( $T_{vj} = 125\text{ °C}$ )	$T_{vj} = 25\text{ °C}$ $T_{vj} = 125\text{ °C}$	875		mJ
				1170		
SC data	$I_{SC}$	$V_{GE} \leq 15\text{ V},$ $V_{CC} = 4500\text{ V},$ $V_{CEmax} = V_{CES} - L_{sCE} * di/dt$	$t_p \leq 10\ \mu\text{s},$ $T_{vj} = 125\text{ °C}$	1300		A
Thermal resistance, junction to case	$R_{thJC}$	per IGBT			0.0291	K/W
Thermal resistance, case to heatsink	$R_{thCH}$	per IGBT, $\lambda_{paste} = 1\text{ W}/(\text{m}^*\text{K}) / \lambda_{grease} = 1\text{ W}/(\text{m}^*\text{K})$			0.0213	K/W
Temperature under switching conditions	$T_{vj\ op}$			-50	125	°C

### 3 Diode, Inverter

**Table 5 Maximum Rated Values**

Parameter	Symbol	Note or test condition	Values	Unit	
Repetitive peak reverse voltage	$V_{RRM}$		$T_{vj} = -50\text{ °C}$	5900	V
			$T_{vj} = 125\text{ °C}$	6500	
Continuous DC forward current	$I_F$		225	A	
Repetitive peak forward current	$I_{FRM}$	$t_p = 1\text{ ms}$	450	A	
$I^2t$ - value	$I^2t$	$t_p = 10\text{ ms},$ $V_R = 0\text{ V}$	$T_{vj} = 125\text{ °C}$	45.2	kA <sup>2</sup> s
Maximum power dissipation	$P_{RQM}$	$T_{vj} = 125\text{ °C}$	1000	kW	
Minimum turn-on time	$t_{onmin}$		10	μs	

**Table 6 Characteristic Values**

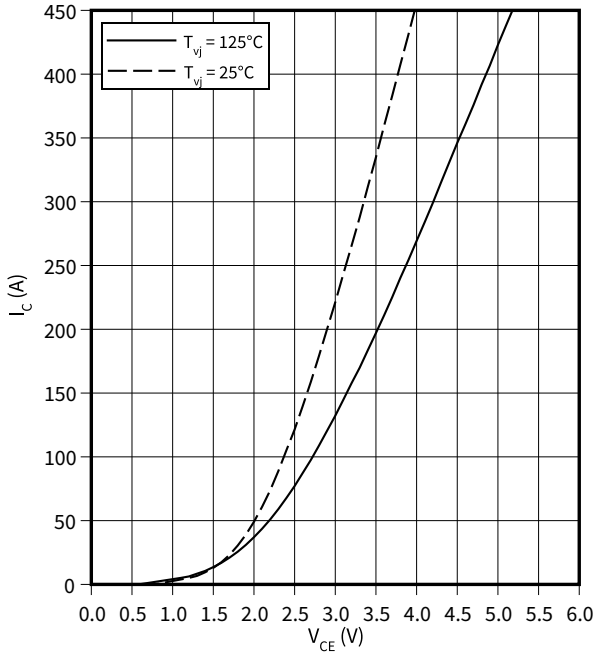
Parameter	Symbol	Note or test condition	Values			Unit	
			Min.	Typ.	Max.		
Forward voltage	$V_F$	$I_F = 225\text{ A},$ $V_{GE} = 0\text{ V}$		$T_{vj} = 25\text{ °C}$	3.10	3.55	V
				$T_{vj} = 125\text{ °C}$	2.85	3.25	
Peak reverse recovery current	$I_{RM}$	$V_R = 3600\text{ V},$ $I_F = 225\text{ A},$ $V_{GE} = -15\text{ V},$ $-di_F/dt = 2200\text{ A}/\mu\text{s}$ ( $T_{vj} = 125\text{ °C}$ )		$T_{vj} = 25\text{ °C}$	405	A	
				$T_{vj} = 125\text{ °C}$	365		
Recovered charge	$Q_r$	$V_R = 3600\text{ V},$ $I_F = 225\text{ A},$ $V_{GE} = -15\text{ V},$ $-di_F/dt = 2200\text{ A}/\mu\text{s}$ ( $T_{vj} = 125\text{ °C}$ )		$T_{vj} = 25\text{ °C}$	255	μC	
				$T_{vj} = 125\text{ °C}$	505		
Reverse recovery energy	$E_{rec}$	$V_R = 3600\text{ V},$ $I_F = 225\text{ A},$ $V_{GE} = -15\text{ V},$ $-di_F/dt = 2200\text{ A}/\mu\text{s}$ ( $T_{vj} = 125\text{ °C}$ )		$T_{vj} = 25\text{ °C}$	450	mJ	
				$T_{vj} = 125\text{ °C}$	1070		
Thermal resistance, junction to case	$R_{thJC}$	per diode			0.0513	K/W	
Thermal resistance, case to heatsink	$R_{thCH}$	per diode, $\lambda_{paste} = 1\text{ W}/(\text{m}^*\text{K}) / \lambda_{grease} = 1\text{ W}/(\text{m}^*\text{K})$			0.0242	K/W	
Temperature under switching conditions	$T_{vjop}$			-50	125	°C	

## 4 Characteristics diagrams

### output characteristic (typical), IGBT, Inverter

$$I_C = f(V_{CE})$$

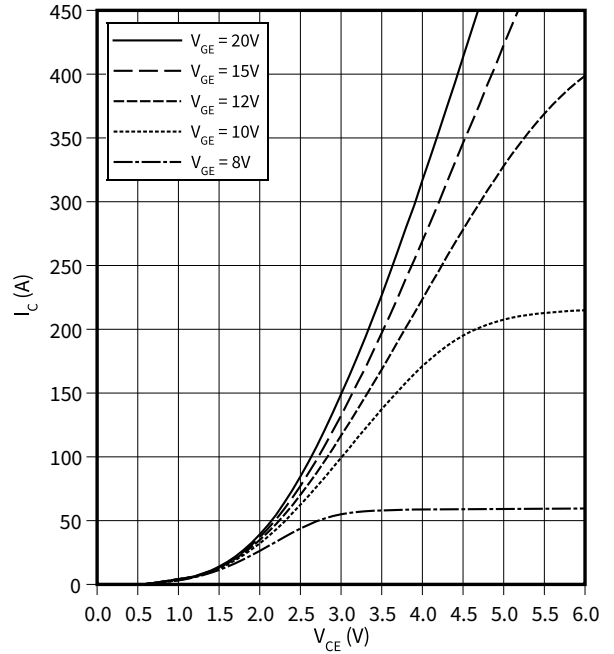
$$V_{GE} = 15 \text{ V}$$



### output characteristic (typical), IGBT, Inverter

$$I_C = f(V_{CE})$$

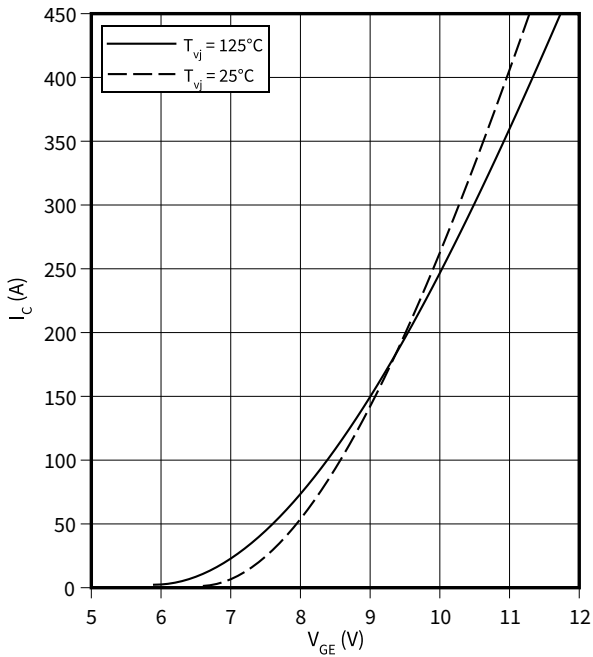
$$T_{vj} = 125 \text{ °C}$$



### transfer characteristic (typical), IGBT, Inverter

$$I_C = f(V_{GE})$$

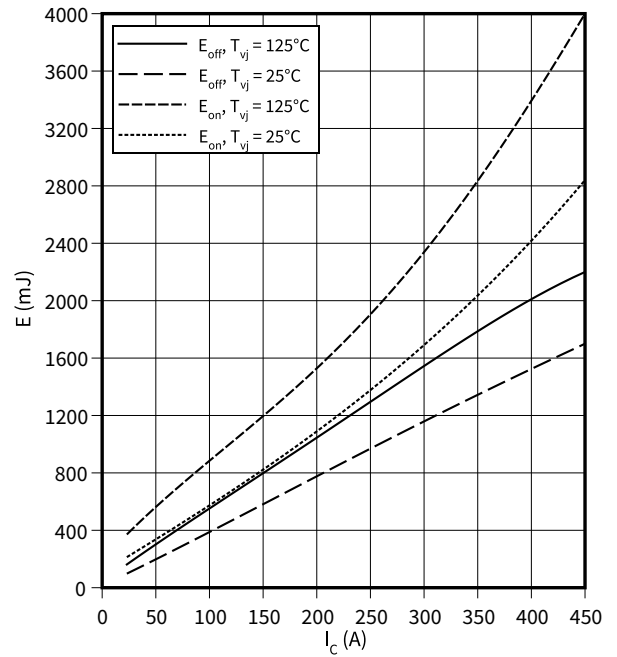
$$V_{CE} = 20 \text{ V}$$



### switching losses (typical), IGBT, Inverter

$$E = f(I_C)$$

$$R_{Goff} = 22 \text{ } \Omega, R_{Gon} = 4.7 \text{ } \Omega, V_{CE} = 3600 \text{ V}, V_{GE} = \pm 15 \text{ V}$$

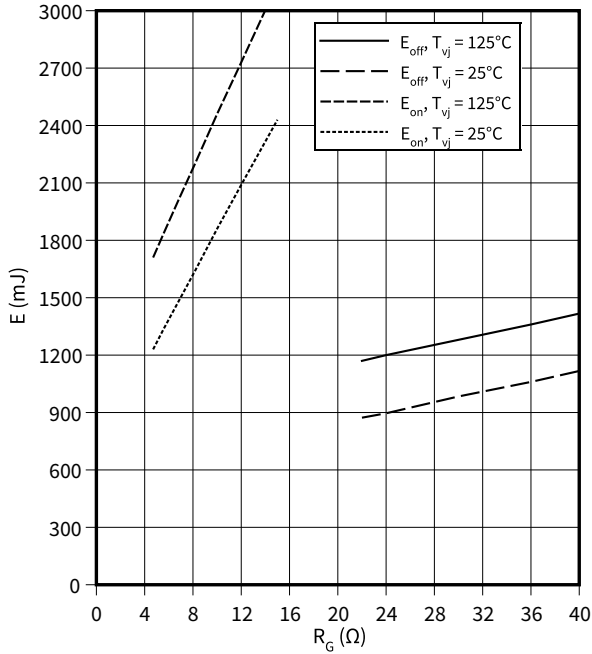


**4 Characteristics diagrams**

**switching losses (typical), IGBT, Inverter**

$E = f(R_G)$

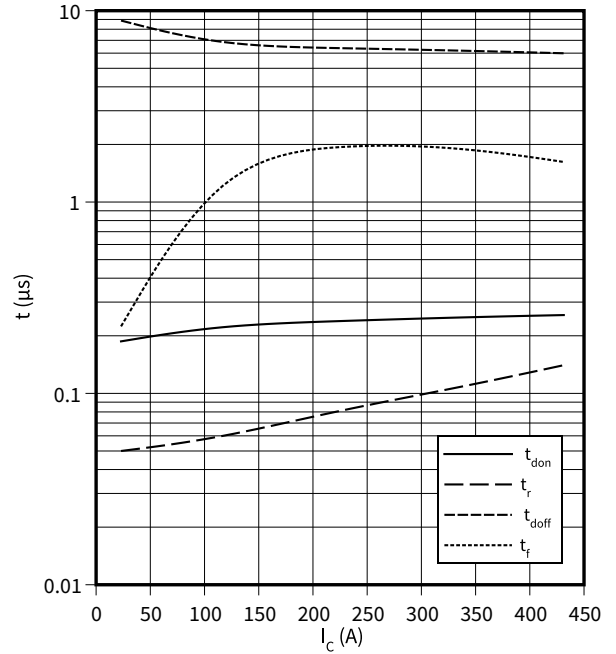
$I_C = 225 \text{ A}, V_{CE} = 3600 \text{ V}, V_{GE} = \pm 15 \text{ V}$



**switching times (typical), IGBT, Inverter**

$t = f(I_C)$

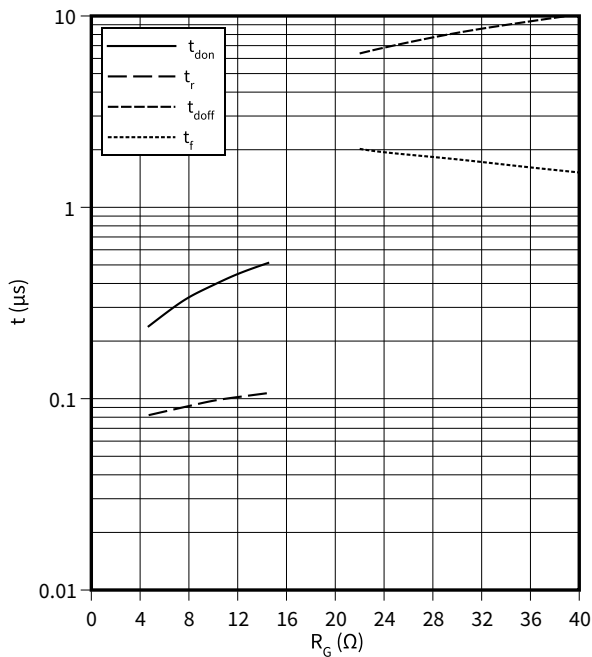
$R_{Goff} = 22 \Omega, R_{Gon} = 4.7 \Omega, V_{CE} = 3600 \text{ V}, V_{GE} = \pm 15 \text{ V}, T_{vj} = 125 \text{ }^\circ\text{C}$



**switching times (typical), IGBT, Inverter**

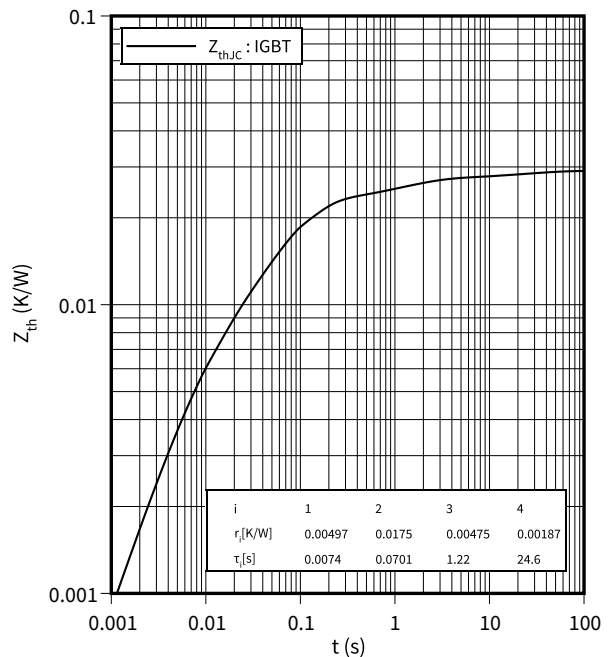
$t = f(R_G)$

$I_C = 225 \text{ A}, V_{CE} = 3600 \text{ V}, V_{GE} = \pm 15 \text{ V}, T_{vj} = 125 \text{ }^\circ\text{C}$



**transient thermal impedance, IGBT, Inverter**

$Z_{th} = f(t)$



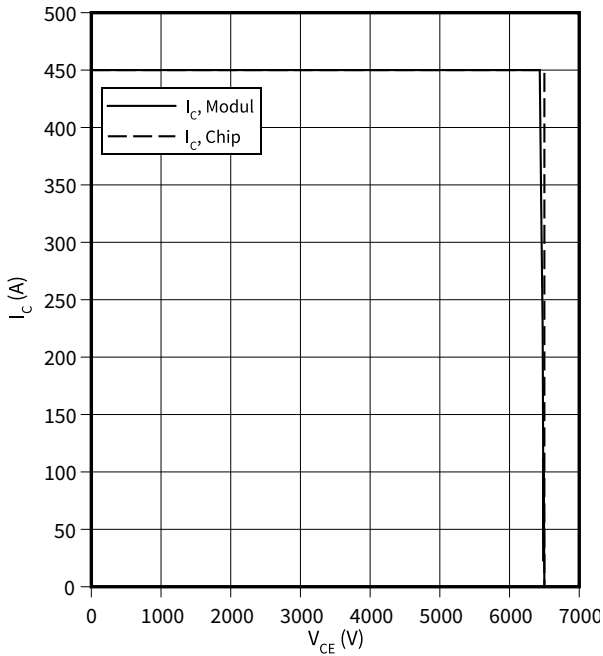


4 Characteristics diagrams

**reverse bias safe operating area (RBSOA), IGBT, Inverter**

$I_C = f(V_{CE})$

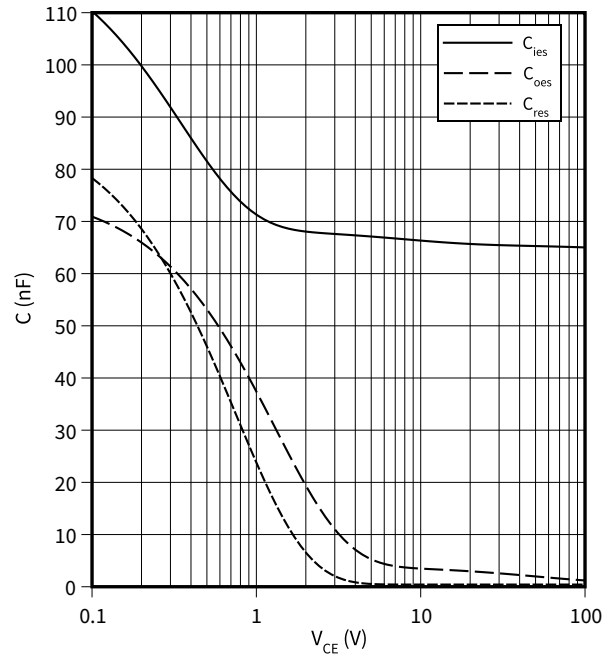
$R_{Goff} = 22 \Omega$ ,  $V_{GE} = \pm 15 \text{ V}$ ,  $T_{vj} = 125 \text{ }^\circ\text{C}$



**capacity characteristic (typical), IGBT, Inverter**

$C = f(V_{CE})$

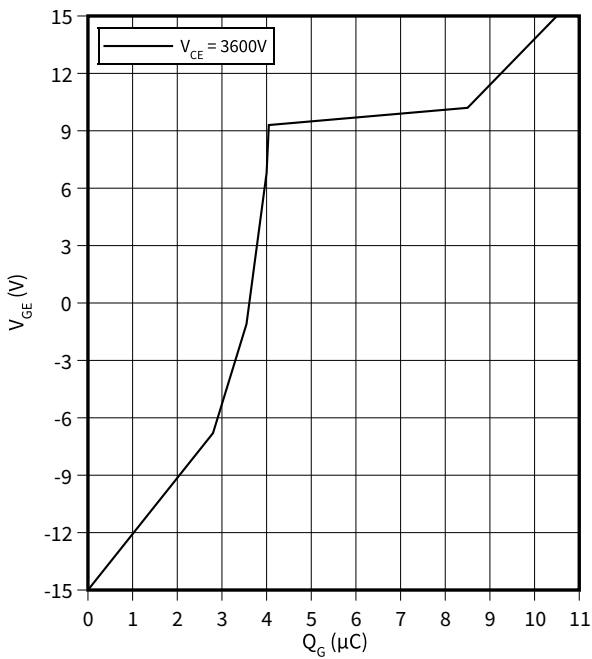
$f = 100 \text{ kHz}$ ,  $V_{GE} = 0 \text{ V}$ ,  $T_{vj} = 25 \text{ }^\circ\text{C}$



**gate charge characteristic (typical), IGBT, Inverter**

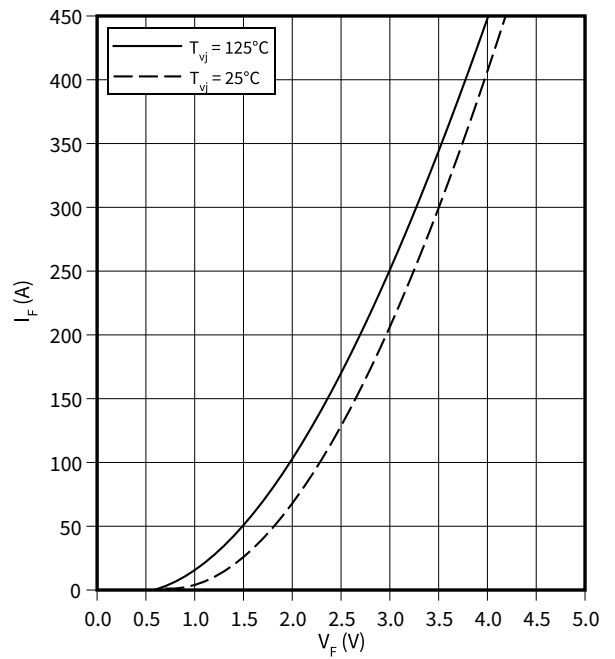
$V_{GE} = f(Q_G)$

$I_C = 225 \text{ A}$ ,  $T_{vj} = 25 \text{ }^\circ\text{C}$



**forward characteristic (typical), Diode, Inverter**

$I_F = f(V_F)$

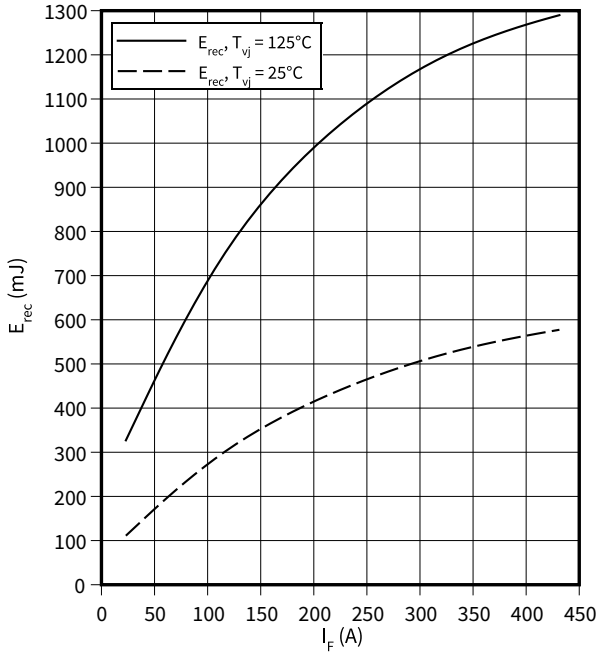


**4 Characteristics diagrams**

**switching losses (typical), Diode, Inverter**

$E_{rec} = f(I_F)$

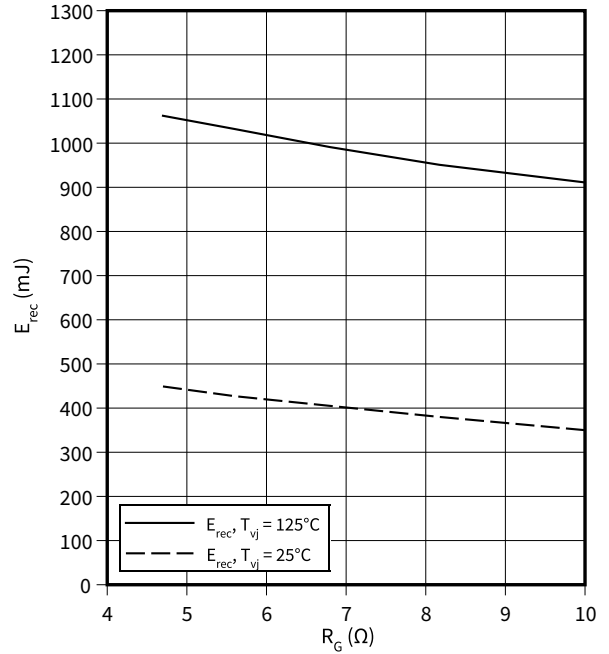
$R_{Gon} = 4.7 \Omega, V_{CE} = 3600 V$



**switching losses (typical), Diode, Inverter**

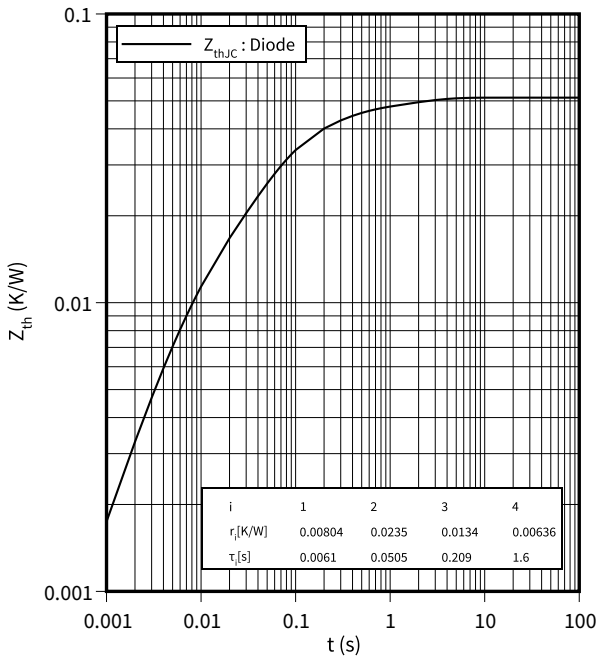
$E_{rec} = f(R_G)$

$V_{CE} = 3600 V, I_F = 225 A$



**transient thermal impedance , Diode, Inverter**

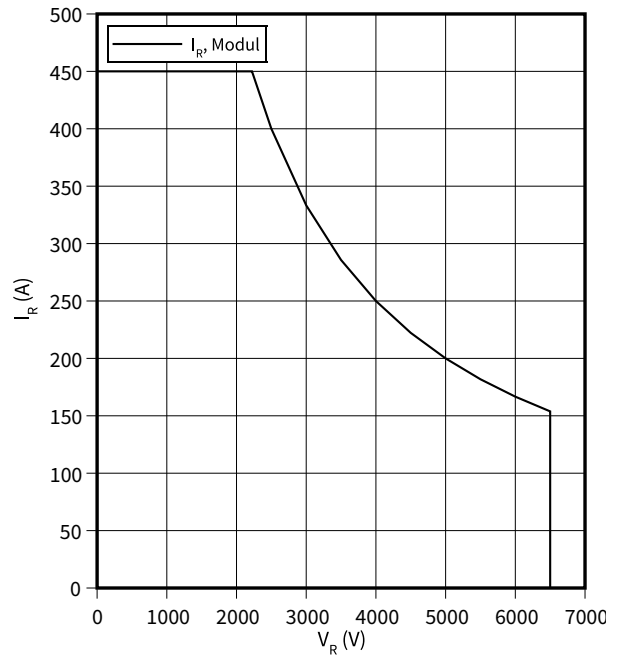
$Z_{th} = f(t)$



**safe operation area (SOA), Diode, Inverter**

$I_R = f(V_R)$

$T_{vj} = 125^\circ C$



## 5 Circuit diagram

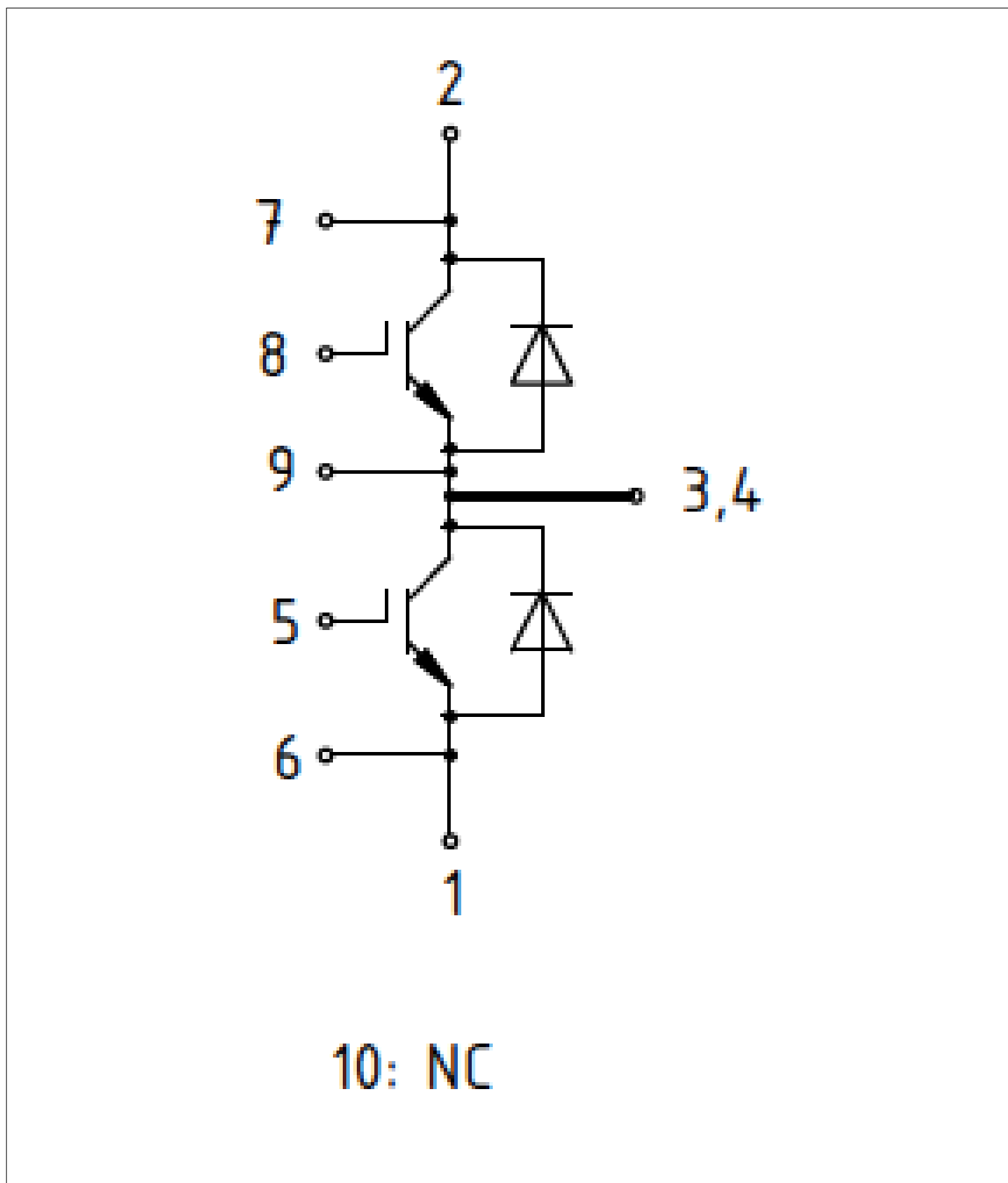


Figure 2

## 6 Package outlines

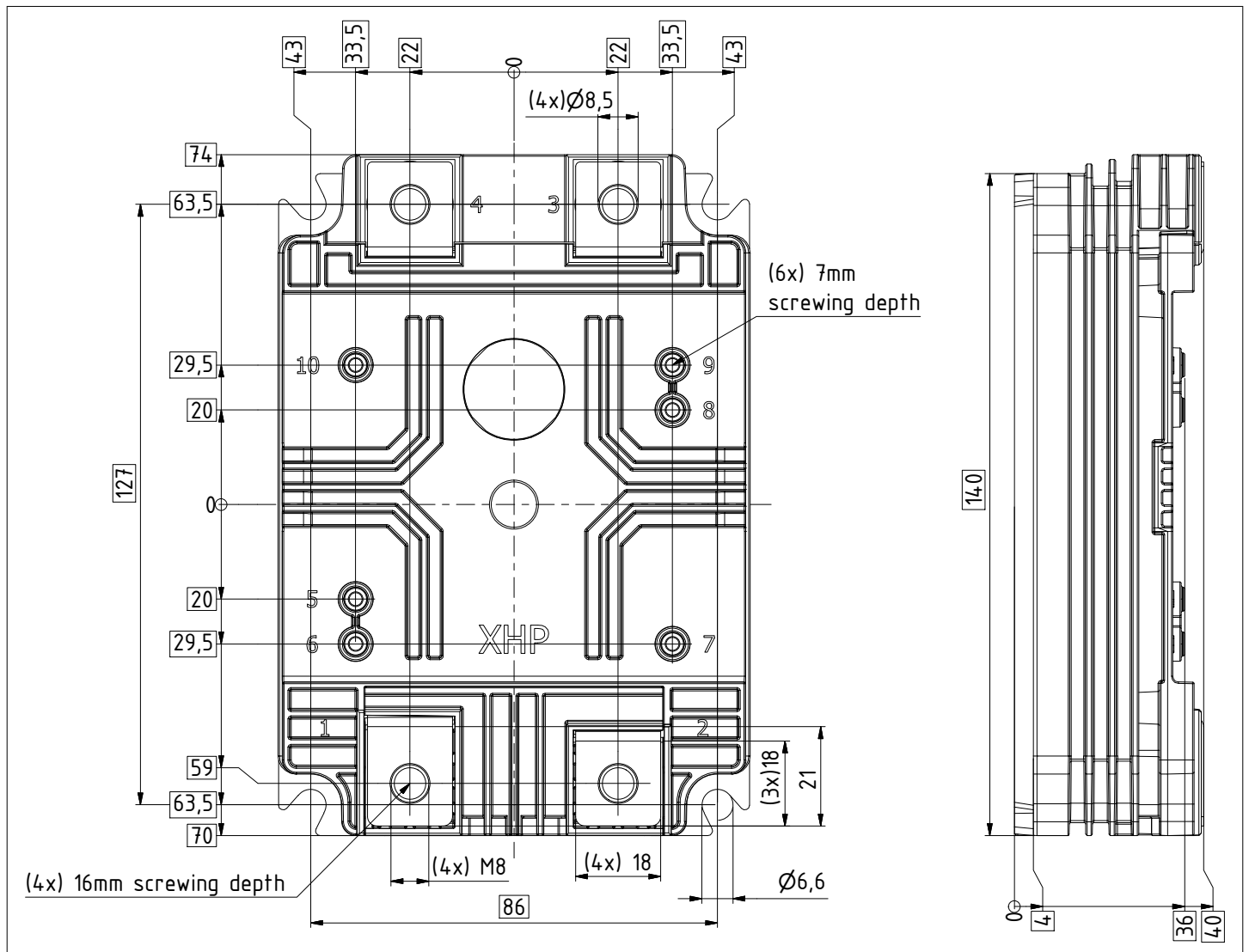




Figure 3

## 7 Module label code

Module label code			
Code format	Data Matrix	Barcode Code128	
Encoding	ASCII text	Code Set A	
Symbol size	16x16	23 digits	
Standard	IEC24720 and IEC16022	IEC8859-1	
Code content	<i>Content</i>	<i>Digit</i>	<i>Example</i>
	Module serial number	1 - 5	71549
	Module material number	6 - 11	142846
	Production order number	12 - 19	55054991
	Date code (production year)	20 - 21	15
	Date code (production week)	22 - 23	30
Example	 		
	71549142846550549911530		71549142846550549911530

**Figure 4**

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