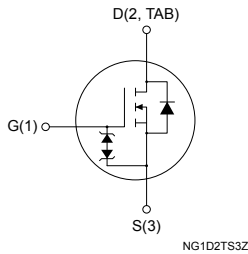
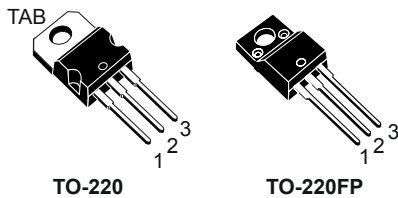


## N-channel 650 V, 1 $\Omega$ typ., 6.4 A SuperMESH Power MOSFET in a TO-220 and TO-220FP packages



### Features

Order code	$V_{DS}$	$R_{DS(on)}$ max.	$I_D$
STP9NK65Z	650 V	1.2 $\Omega$	6.4 A
STP9NK65ZFP			

- 100% avalanche tested
- Gate charge minimized
- Very low intrinsic capacitance
- Zener-protected

### Applications

- Switching applications

### Description

These high-voltage devices are Zener-protected N-channel Power MOSFETs developed using the SuperMESH technology by STMicroelectronics, an optimization of the well-established PowerMESH. In addition to a significant reduction in on-resistance, these devices are designed to ensure a high level of dv/dt capability for the most demanding applications.

#### Product status links

[STP9NK65Z](#)

[STP9NK65ZFP](#)

#### Product summary

Order code	STP9NK65Z
Marking	P9NK65Z
Package	TO-220
Packing	Tube
Order code	STP9NK65ZFP
Marking	P9NK65ZFP
Package	TO-220FP
Packing	Tube

# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

Symbol	Parameter	Value		Unit
		TO-220	TO-220FP	
$V_{DS}$	Drain-source voltage	650		V
$V_{GS}$	Gate-source voltage	±30		V
$I_D$	Drain current (continuous) at $T_C = 25\text{ °C}$	6.4	6.4 <sup>(1)</sup>	A
	Drain current (continuous) at $T_C = 100\text{ °C}$	4	4 <sup>(1)</sup>	
$I_{DM}^{(2)}$	Drain current (pulsed)	25.6	25.6 <sup>(1)</sup>	A
$P_{TOT}$	Total power dissipation at $T_C = 25\text{ °C}$	125	30	W
ESD	Gate-source human body model (C = 100 pF, R = 1.5 kΩ)	4		kV
$dv/dt^{(3)}$	Peak diode recovery voltage slope	4.5		V/ns
$V_{ISO}$	Insulation withstand voltage (RMS) from all three leads to external heat sink (t = 1 s; $T_C = 25\text{ °C}$ )	-	2.5	kV
$T_{stg}$	Storage temperature range	-55 to 150		°C
$T_J$	Operating junction temperature range			

1. Limited by maximum junction temperature.

2. Pulse width limited by safe operating area.

3.  $I_{SD} \leq 6.4\text{ A}$ ,  $di/dt \leq 200\text{ A}/\mu\text{s}$ ,  $V_{DD} = 520\text{ V}$ .

**Table 2. Thermal data**

Symbol	Parameter	Value		Unit
		TO-220	TO-220FP	
$R_{thJC}$	Thermal resistance, junction-to-case	1	4.2	°C/W
$R_{thJA}$	Thermal resistance, junction-to-ambient	62.5		°C/W

**Table 3. Avalanche characteristics**

Symbol	Parameter	Value	Unit
$I_{AR}$	Avalanche current, repetitive or not-repetitive (pulse width limited by $T_J$ max.)	6.4	A
$E_{AS}$	Single pulse avalanche energy (starting $T_J = 25\text{ °C}$ , $I_D = I_{AR}$ , $V_{DD} = 50\text{ V}$ )	200	mJ

## 2 Electrical characteristics

$T_C = 25\text{ °C}$  unless otherwise specified.

**Table 4. On/off states**

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source Breakdown voltage	$I_D = 1\text{ mA}$ , $V_{GS} = 0\text{ V}$	650	-	-	V
$I_{DSS}$	Zero gate voltage drain current	$V_{GS} = 0\text{ V}$ , $V_{DS} = 650\text{ V}$	-	-	1	$\mu\text{A}$
		$V_{GS} = 0\text{ V}$ , $V_{DS} = 650\text{ V}$ , $T_C = 125\text{ °C}^{(1)}$	-	-	50	
$I_{GSS}$	Gate-body leakage current	$V_{DS} = 0\text{ V}$ , $V_{GS} = \pm 20\text{ V}$	-	-	$\pm 10$	$\mu\text{A}$
$V_{GS(th)}$	Gate threshold voltage	$V_{DS} = V_{GS}$ , $I_D = 100\text{ }\mu\text{A}$	3	3.75	4.5	V
$R_{DS(on)}$	Static drain-source on-resistance	$V_{GS} = 10\text{ V}$ , $I_D = 3.2\text{ A}$	-	1	1.2	$\Omega$

1. Specified by design, not tested in production.

**Table 5. Dynamic**

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
$C_{iss}$	Input capacitance	$V_{DS} = 25\text{ V}$ , $f = 1\text{ MHz}$ , $V_{GS} = 0\text{ V}$	-	1145	-	pF
$C_{oss}$	Output capacitance		-	130	-	pF
$C_{riss}$	Reverse transfer capacitance		-	28	-	pF
$C_{oss\ eq.}^{(1)}$	Equivalent output capacitance	$V_{DS} = 0\text{ to }400\text{ V}$ , $V_{GS} = 0\text{ V}$	-	55	-	pF
$Q_g$	Total gate charge	$V_{DD} = 520\text{ V}$ , $I_D = 6.4\text{ A}$ , $V_{GS} = 0\text{ to }10\text{ V}$ (see the Figure 16. Test circuit for gate charge behavior)	-	41	-	nC
$Q_{gs}$	Gate-source charge		-	7.5	-	nC
$Q_{gd}$	Gate-drain charge		-	22	-	nC

1.  $C_{oss\ eq.}$  is defined as a constant equivalent capacitance giving the same charging time as  $C_{oss}$  when  $V_{DS}$  increases from 0 to 80%  $V_{DSS}$ .

**Table 6. Switching times**

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$V_{DD} = 325\text{ V}$ , $I_D = 3.2\text{ A}$ , $R_G = 4.7\text{ }\Omega$ , $V_{GS} = 10\text{ V}$	-	20	-	ns
$t_r$	Rise time		-	12	-	ns
$t_{d(off)}$	Turn-off delay time	(see the Figure 15. Test circuit for resistive load switching times and Figure 20. Switching time waveform)	-	45	-	ns
$t_f$	Fall time		-	15	-	ns

**Table 7. Source drain diode**

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-drain current		-	-	6.4	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)		-	-	25.6	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 6.4 \text{ A}, V_{GS} = 0 \text{ V}$	-	-	1.6	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 6.4 \text{ A}, di/dt = 100 \text{ A}/\mu\text{s},$	-	400	-	ns
$Q_{rr}$	Reverse recovery charge	$V_{DD} = 50 \text{ V}, T_J = 150 \text{ }^\circ\text{C}$	-	2.6	-	$\mu\text{C}$
$I_{RRM}$	Reverse recovery current	(see the Figure 17. Test circuit for inductive load switching and diode recovery times)	-	13	-	A

1. Pulse width is limited by safe operating area.
2. Pulsed: pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%.

## 2.1 Electrical characteristics curves

Figure 1. Safe operating area for TO-220

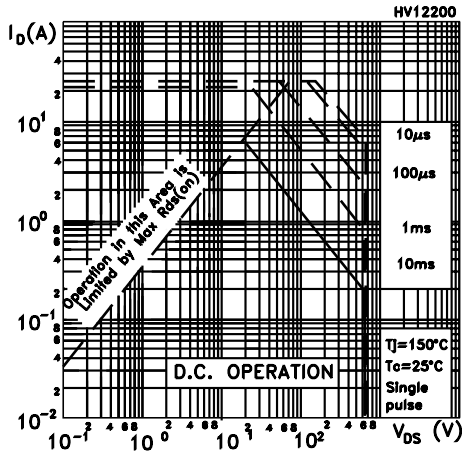


Figure 2. Normalized transient thermal impedance for TO-220

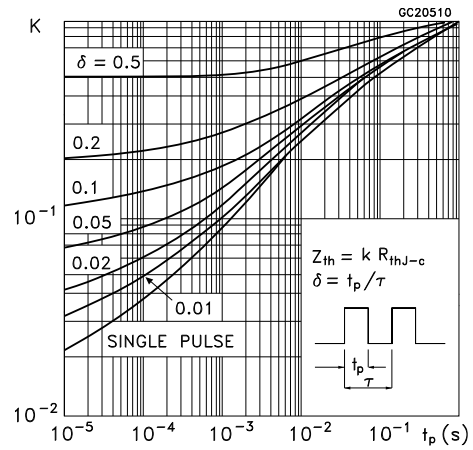


Figure 3. Safe operating area for TO-220FP

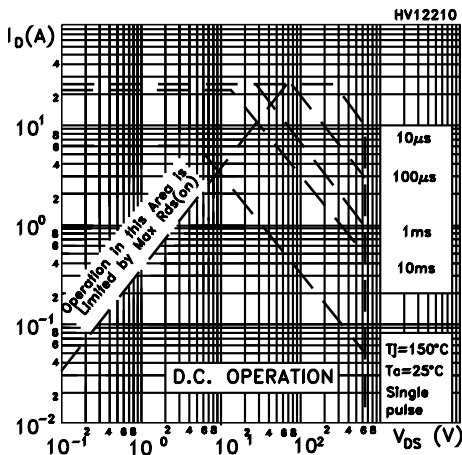


Figure 4. Normalized transient thermal impedance for TO-220FP

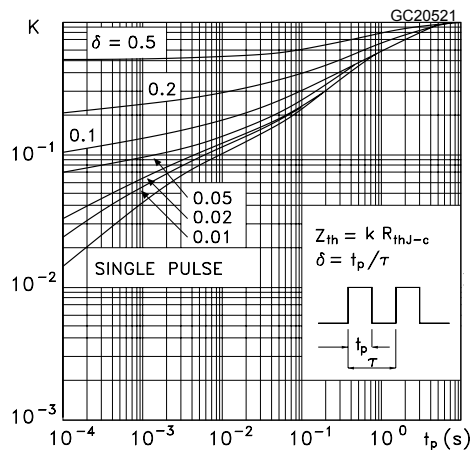


Figure 5. Typical output characteristics

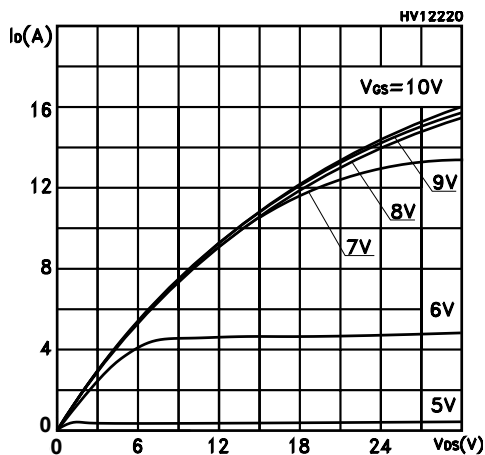


Figure 6. Typical transfer characteristics

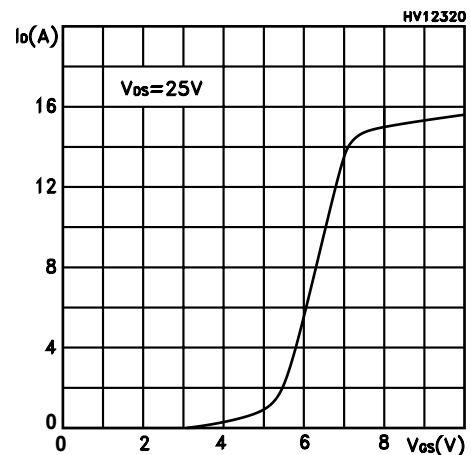


Figure 7. Typical static drain-source on-resistance

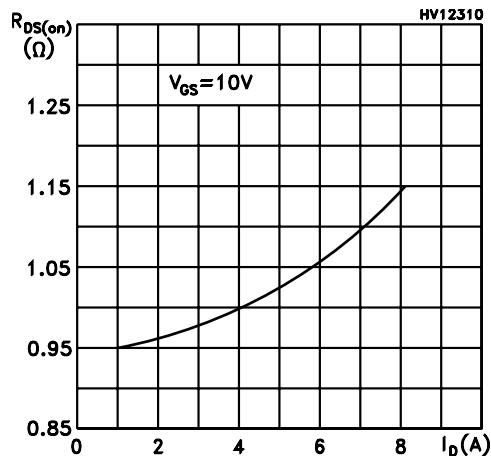


Figure 8. Typical gate charge characteristics

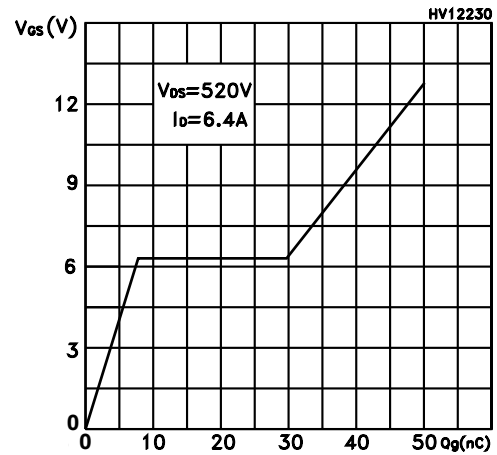


Figure 9. Typical capacitance variations

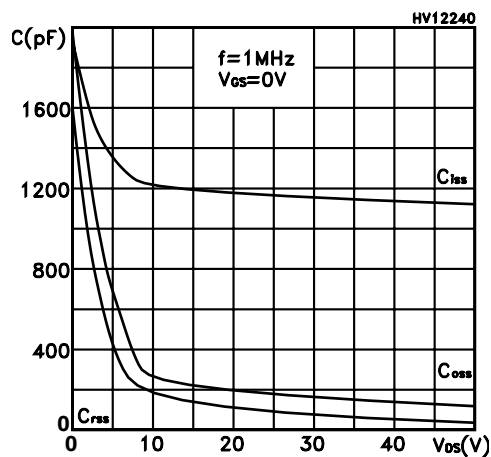


Figure 10. Normalized gate threshold vs temperature

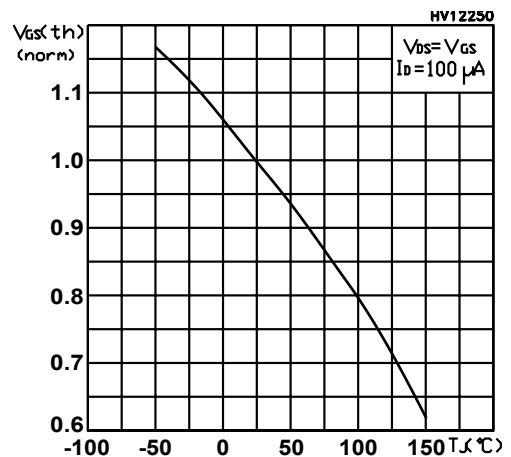


Figure 11. Normalized on-resistance vs temperature

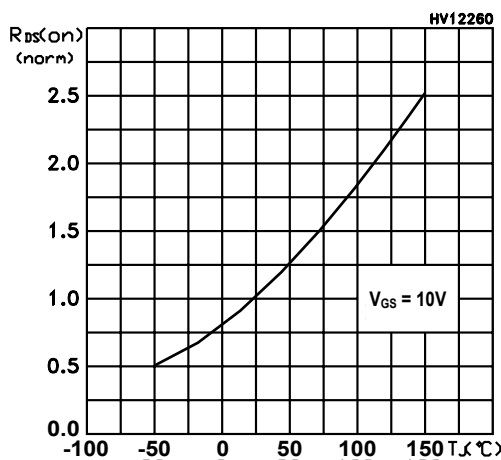


Figure 12. Typical reverse diode forward characteristics

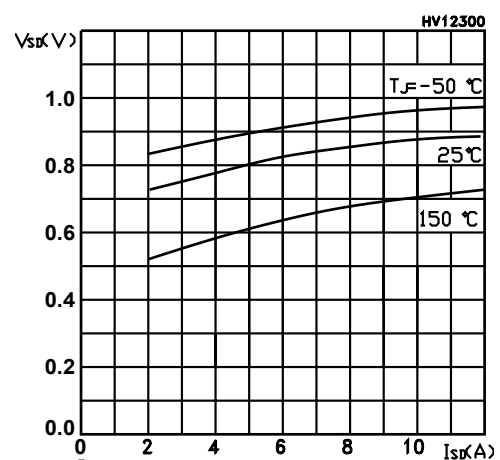


Figure 13. Normalized breakdown voltage vs temperature

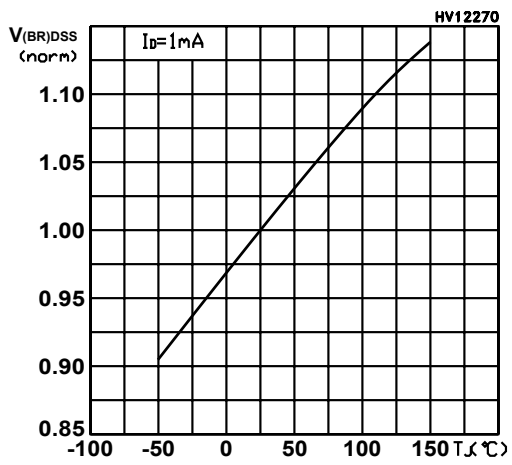
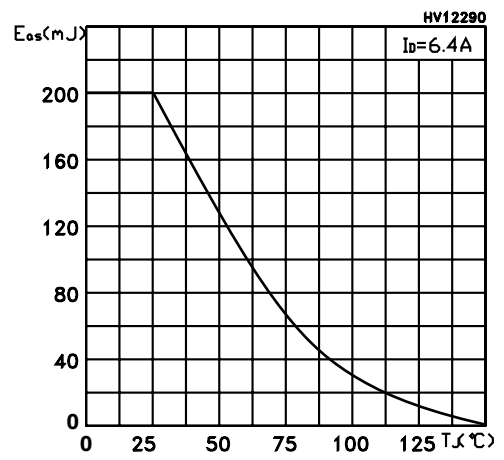
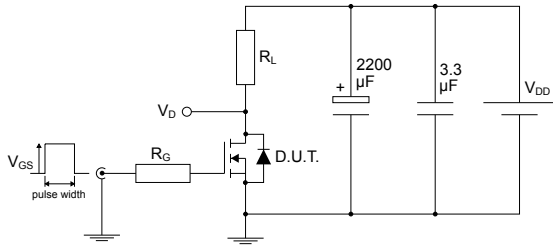


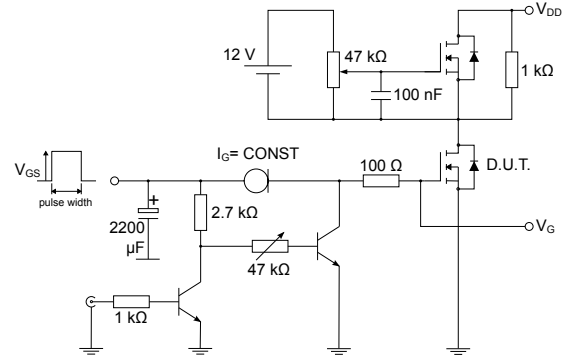
Figure 14. Maximum avalanche energy vs temperature



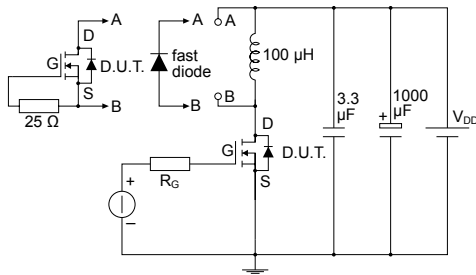
### 3 Test circuits

**Figure 15. Test circuit for resistive load switching times**


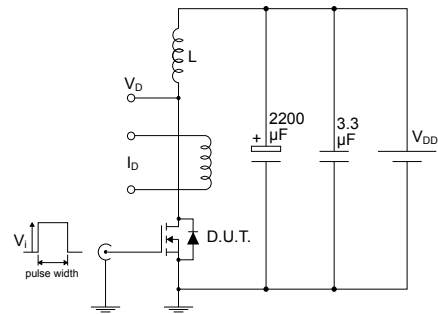
AM01468v1

**Figure 16. Test circuit for gate charge behavior**


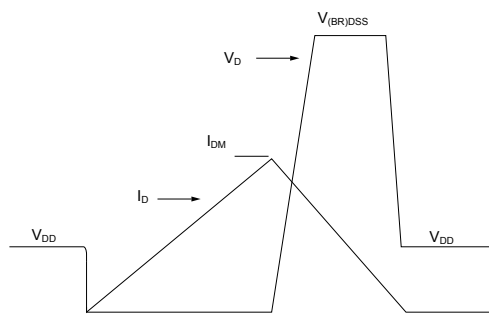
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**Figure 17. Test circuit for inductive load switching and diode recovery times**


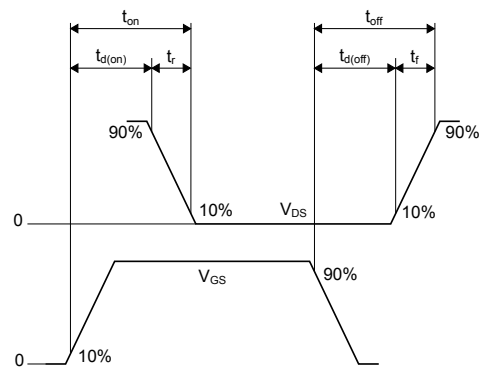
AM01470v1

**Figure 18. Unclamped inductive load test circuit**


AM01471v1

**Figure 19. Unclamped inductive waveform**


AM01472v1

**Figure 20. Switching time waveform**


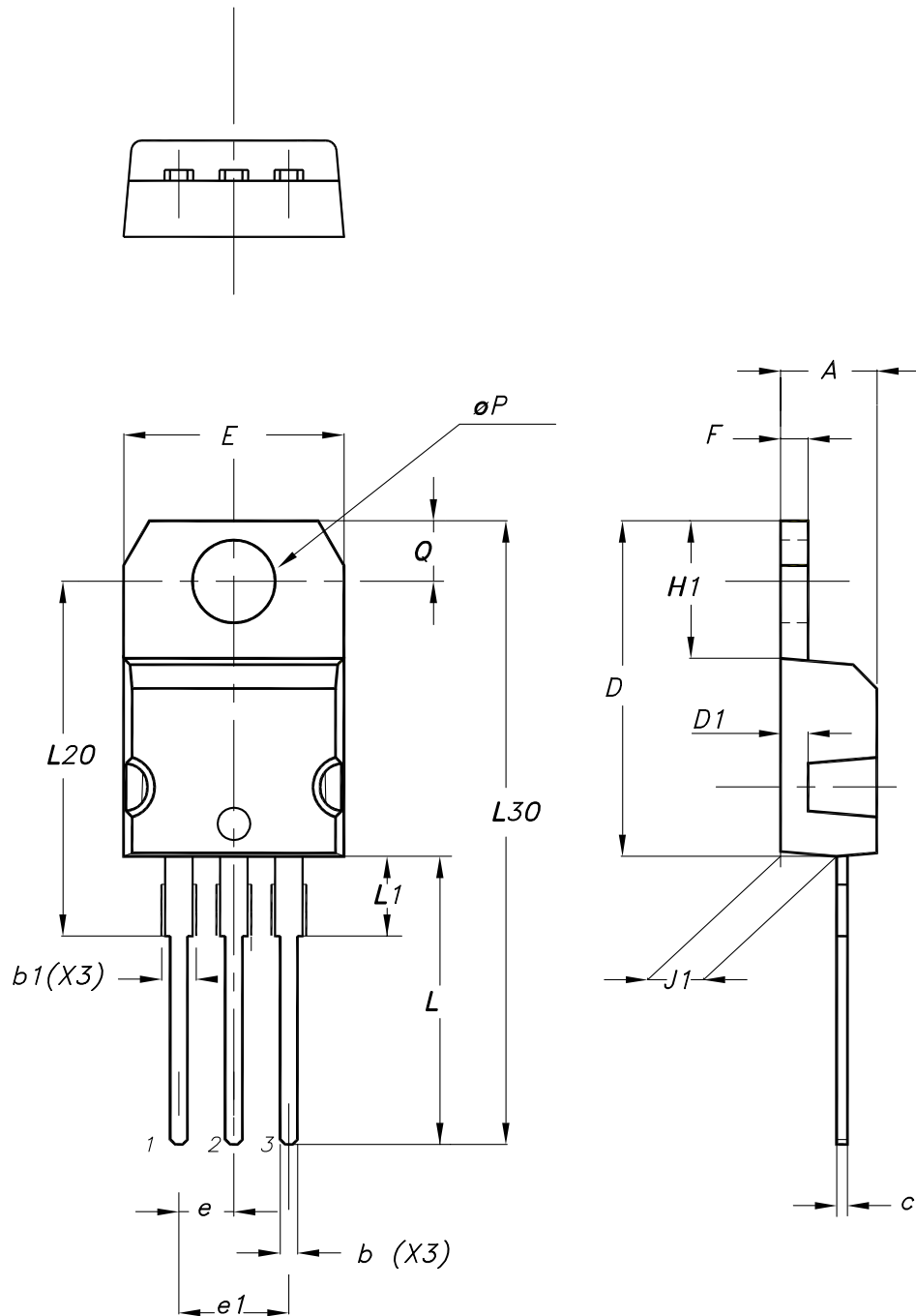
AM01473v1

## 4 Package information

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](http://www.st.com). ECOPACK is an ST trademark.

### 4.1 TO-220 type A package information

Figure 21. TO-220 type A package outline



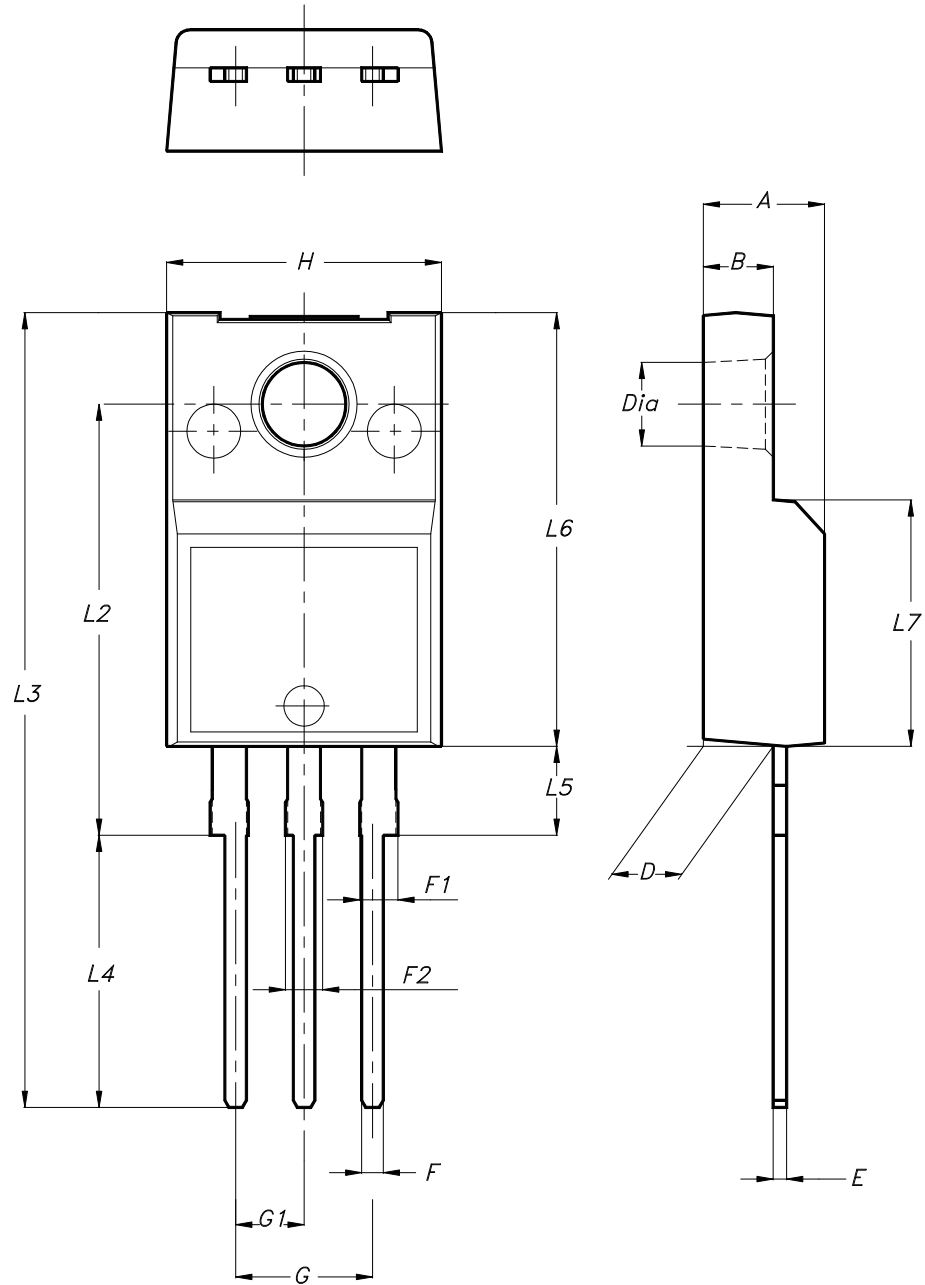
0015988\_typeA\_Rev\_24

Table 8. TO-220 type A package mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	4.40		4.60
b	0.61		0.88
b1	1.14		1.55
c	0.48		0.70
D	15.25		15.75
D1		1.27	
E	10.00		10.40
e	2.40		2.70
e1	4.95		5.15
F	1.23		1.32
H1	6.20		6.60
J1	2.40		2.72
L	13.00		14.00
L1	3.50		3.93
L20		16.40	
L30		28.90	
øP	3.75		3.85
Q	2.65		2.95
Slug flatness		0.03	0.10

## 4.2 TO-220FP type B package information

Figure 22. TO-220FP type B package outline



7012510\_B\_rev.14

Table 9. TO-220FP type B package mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A	4.40		4.60
B	2.50		2.70
D	2.50		2.75
E	0.45		0.70
F	0.75		1.00
F1	1.15		1.70
F2	1.15		1.70
G	4.95		5.20
G1	2.40		2.70
H	10.00		10.40
L2		16.00	
L3	28.60		30.60
L4	9.80		10.60
L5	2.90		3.60
L6	15.90		16.40
L7	9.00		9.30
Dia	3.00		3.20

## Revision history

**Table 10. Document revision history**

Date	Version	Changes
11-Sep-2006	2	Complete version.
19-Dec-2007	3	The document has been reformatted.
26-Jan-2012	4	Modified: <i>Features</i> in cover page. Updated: <i>Section 4: Package mechanical data</i> . Minor text changes.
10-Feb-2026	5	Updated <a href="#">Section 4: Package information</a> . Minor text changes.



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