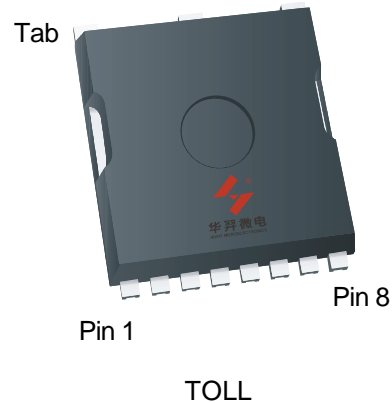


## N-Channel Enhancement Mode MOSFET

## Feature

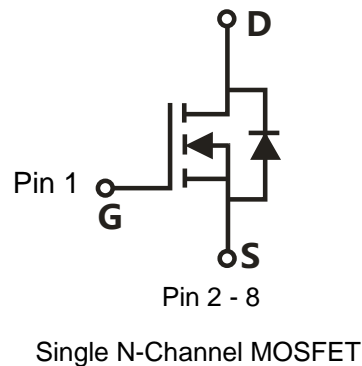
- 135V/220A  
 $R_{DS(ON)} = 3.5 \text{ m}\Omega(\text{typ.}) @ V_{GS} = 10\text{V}$
- 100% Avalanche Tested
- 100% DVDS
- Reliable and Rugged
- Halogen Free and Green Devices Available  
(RoHS Compliant)

## Pin Description




## Applications

- Switching application
- DC-DC
- Li-battery protection
- Motor control



## Ordering and Marking Information

 HYG 040N13NS XYMXXXXX	Package Code TA: TOLL  Date Code XYMXXXXX
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Note: HUAYI halogen free products contain molding compounds and 100% matte tin plate Termination finish; which are fully compliant with RoHS. HUAYI halogen free products meet or exceed the halogen free requirements of IPC/JEDEC J-STD-020 for MSL classification at halogen free peak reflow temperature. HUAYI defines "Green" to mean halogen free (RoHS compliant) and halogen free (Br or Cl does not exceed 900ppm by weight in homogeneous material and total of Br and Cl does not exceed 1500ppm by weight).

HUAYI reserves the right to make changes, corrections, enhancements, modifications, and improvements to this product and/or to this document at any time without notice.

## Absolute Maximum Ratings

Symbol	Parameter		Rating	Unit
Common Ratings (T <sub>C</sub> =25°C Unless Otherwise Noted)				
V <sub>DSS</sub>	Drain-Source Voltage		135	V
V <sub>GSS</sub>	Gate-Source Voltage		±20	V
T <sub>J</sub>	Junction Temperature Range		-55 to 175	°C
T <sub>STG</sub>	Storage Temperature Range			°C
I <sub>S</sub>	Source Current-Continuous(Body Diode)	T <sub>C</sub> =25°C	220	A
Mounted on Large Heat Sink				
I <sub>DM</sub>	Pulsed Drain Current *	T <sub>C</sub> =25°C	750	A
I <sub>D</sub>	Continuous Drain Current	T <sub>C</sub> =25°C	220	A
		T <sub>C</sub> =100°C	156	A
P <sub>D</sub>	Maximum Power Dissipation	T <sub>C</sub> =25°C	429	W
		T <sub>C</sub> =100°C	214	W
R <sub>θJC</sub>	Thermal Resistance, Junction-to-Case		0.35	°C/W
R <sub>θJA</sub>	Thermal Resistance, Junction-to-Ambient **		45	°C/W
E <sub>AS</sub>	Single Pulsed-Avalanche Energy ***	L=0.3mH	1309	mJ

Note: \* Repetitive rating; pulse width limited by max.junction temperature.

\*\* Surface mounted on 1in2 FR-4 board.

\*\*\* Limited by  $T_{\text{Jmax}}$ , starting  $T_J=25^{\circ}\text{C}$ ,  $L=0.3\text{mH}$ ,  $R_G=25\Omega$ ,  $V_{\text{GS}}=10\text{V}$ .

## Electrical Characteristics ( $T_C=25^{\circ}\text{C}$ Unless Otherwise Noted)

Symbol	Parameter	Test Conditions	HYG040N13NS1			Unit
			Min.	Typ.	Max.	
Static Characteristics						
BV <sub>DSS</sub>	Drain-Source Breakdown Voltage	V <sub>GS</sub> =0V, I <sub>DS</sub> =250μA	135	150	-	V
I <sub>DSS</sub>	Drain-to-Source Leakage Current	V <sub>DS</sub> =135V, V <sub>GS</sub> =0V	-	-	1	μA
			T <sub>J</sub> =125°C	-	-	50
V <sub>GS(th)</sub>	Gate Threshold Voltage	V <sub>DS</sub> =V <sub>GS</sub> , I <sub>DS</sub> =250μA	2.0	3.1	4.0	V
I <sub>GSS</sub>	Gate-Source Leakage Current	V <sub>GS</sub> =±20V, V <sub>DS</sub> =0V	-	-	±100	nA
R <sub>DS(ON)</sub>	Drain-Source On-State Resistance	V <sub>GS</sub> =10V, I <sub>DS</sub> =50A	-	3.5	4.2	mΩ
Diode Characteristics						
V <sub>SD</sub>	Diode Forward Voltage	I <sub>SD</sub> =50A, V <sub>GS</sub> =0V	-	0.81	1.3	V
t <sub>rr</sub>	Reverse Recovery Time	I <sub>SD</sub> =50A, dI <sub>SD</sub> /dt=100A/μs	-	118	-	ns
Q <sub>rr</sub>	Reverse Recovery Charge		-	510	-	nC

**Electrical Characteristics (Cont.)** ( $T_C = 25^\circ\text{C}$  Unless Otherwise Noted)

Symbol	Parameter	Test Conditions	HYG040N13NS1			Unit
			Min.	Typ.	Max.	
Dynamic Characteristics						
R <sub>G</sub>	Gate Resistance	V <sub>GS</sub> =0V, V <sub>DS</sub> =0V, f=500KHz	-	1.8	-	Ω
C <sub>iss</sub>	Input Capacitance	V <sub>GS</sub> =0V, V <sub>DS</sub> =25V, f=500KHz	-	8696	-	pF
C <sub>oss</sub>	Output Capacitance		-	3940	-	
C <sub>rss</sub>	Reverse Transfer Capacitance		-	121	-	
t <sub>d(ON)</sub>	Turn-on Delay Time	V <sub>DD</sub> =68V, R <sub>G</sub> =4Ω, I <sub>DS</sub> =50A, V <sub>GS</sub> =10V	-	39	-	ns
t <sub>r</sub>	Turn-on Rise Time		-	98	-	
t <sub>d(OFF)</sub>	Turn-off Delay Time		-	85	-	
t <sub>f</sub>	Turn-off Fall Time		-	100	-	
Gate Charge Characteristics						
Q <sub>g</sub>	Total Gate Charge(V <sub>GS</sub> =10V)	V <sub>DS</sub> =108V, I <sub>DS</sub> =50A	-	127	-	nC
Q <sub>gs</sub>	Gate-Source Charge		-	46	-	
Q <sub>gd</sub>	Gate-Drain Charge		-	24	-	
V <sub>plateau</sub>	Gate plateau voltage		-	5.2	-	V

Note: \*Pulse test, pulse width  $\leq 300\mu\text{s}$ , duty cycle  $\leq 2\%$

## Typical Operating Characteristics

Figure 1: Power Dissipation

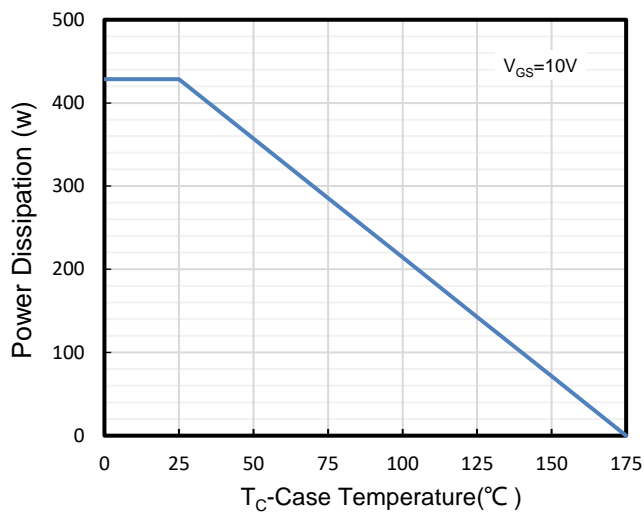


Figure 2: Drain Current

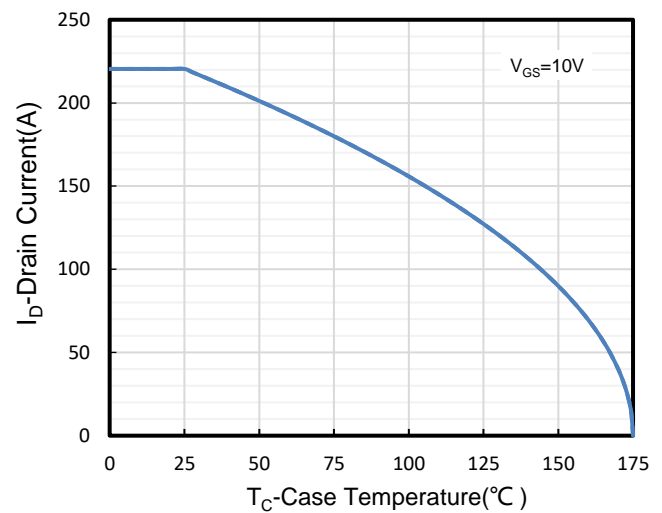


Figure 3: Safe Operation Area

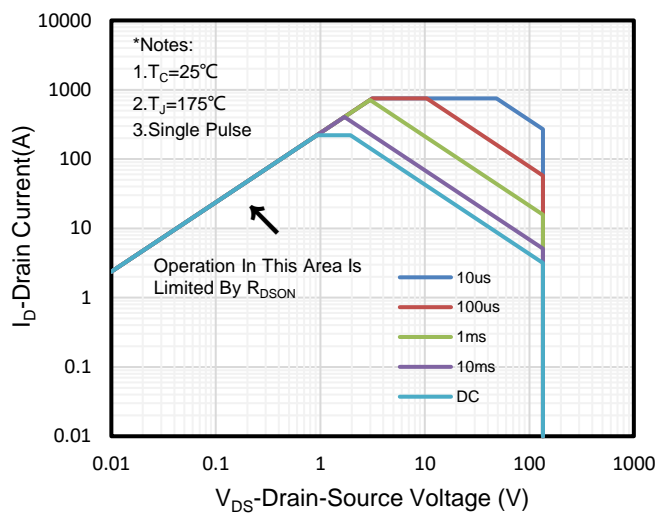


Figure 4: Thermal Transient Impedance

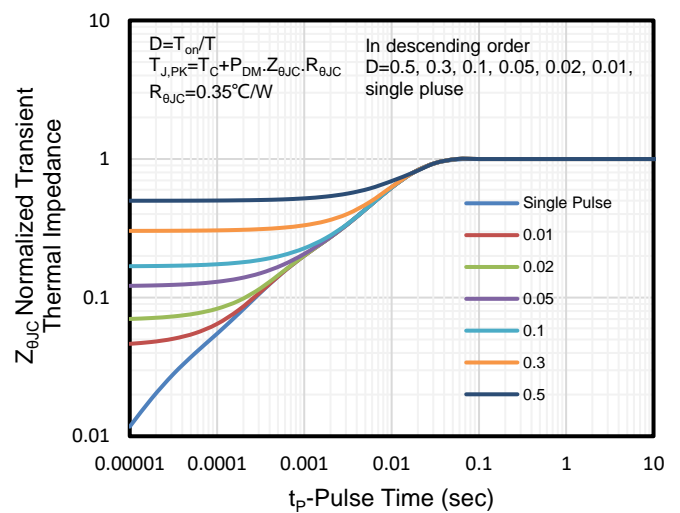


Figure 5: Output Characteristics

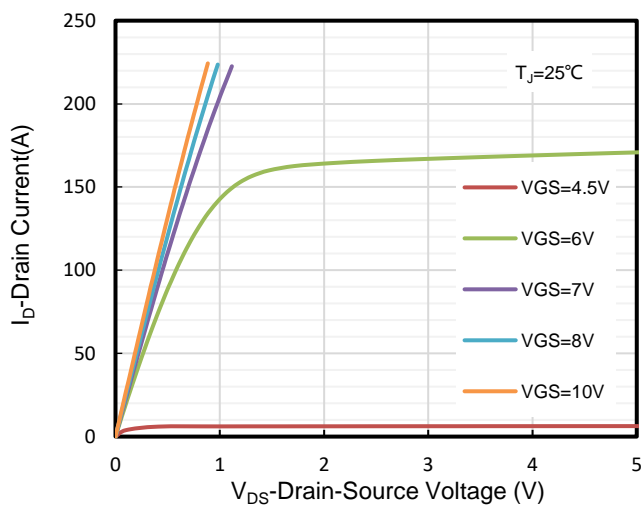
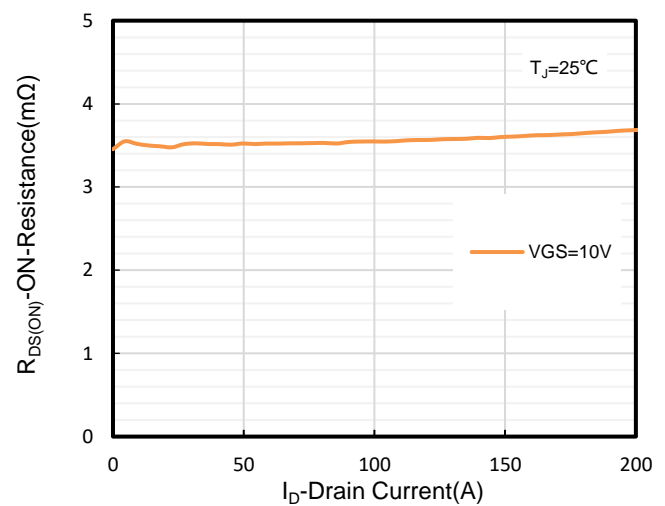
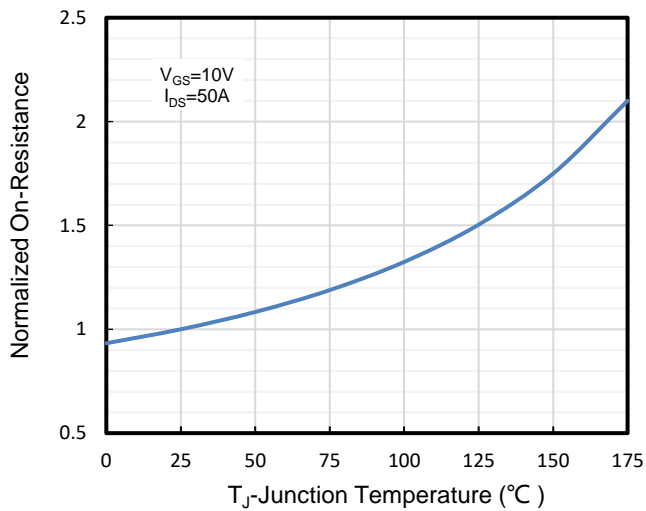


Figure 6: Drain-Source On Resistance

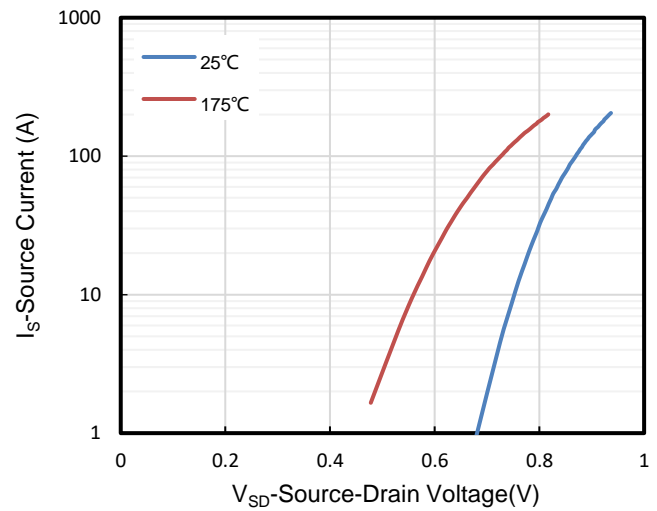


## Typical Operating Characteristics(Cont.)

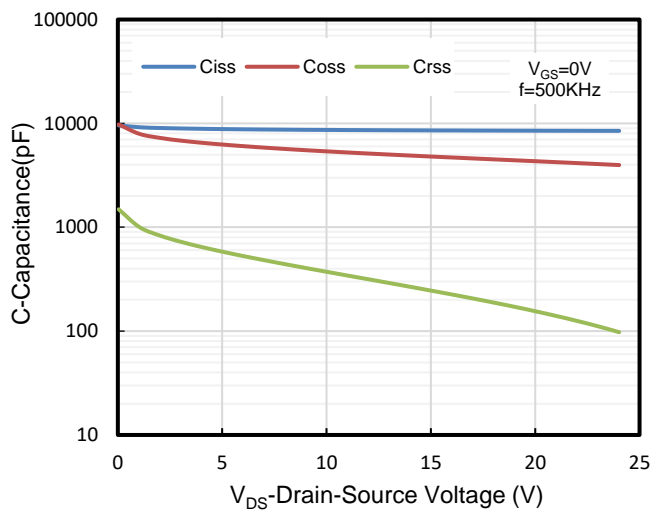
**Figure 7: On-Resistance vs. Temperature**



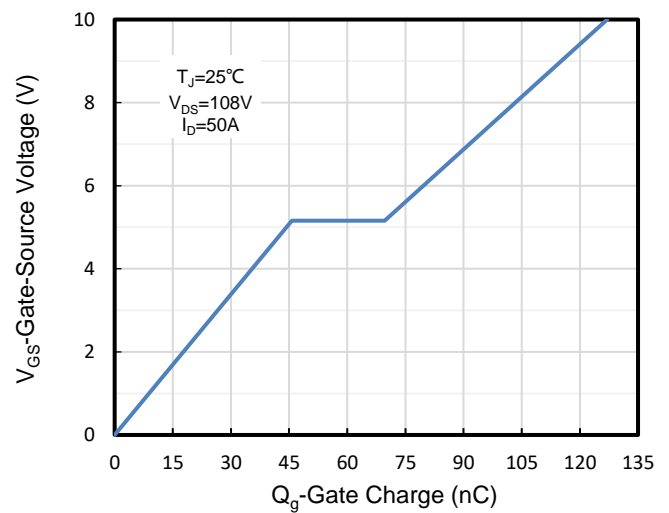
**Figure 8: Source-Drain Diode Forward**



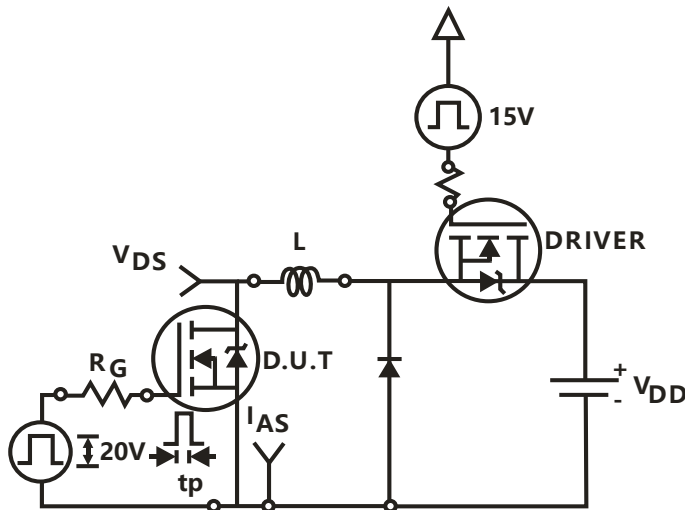
**Figure 9: Capacitance Characteristics**



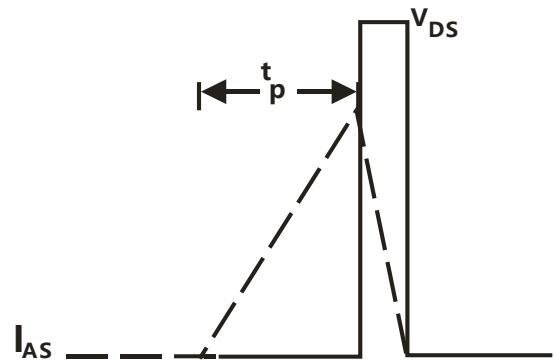
**Figure 10: Gate Charge Characteristics**



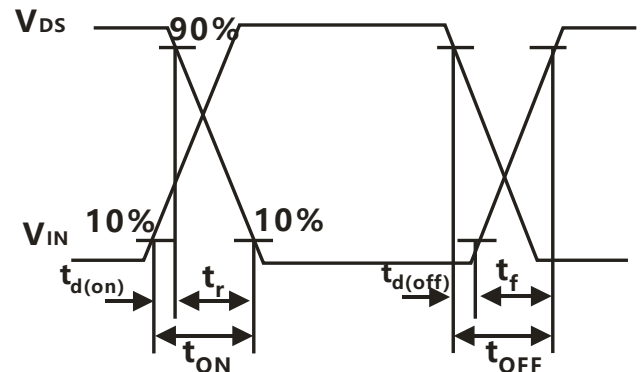
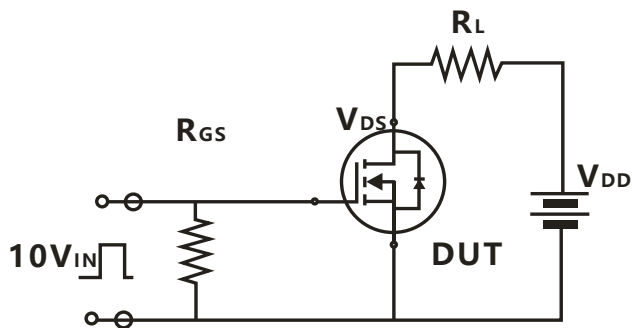
## Avalanche Test Circuit



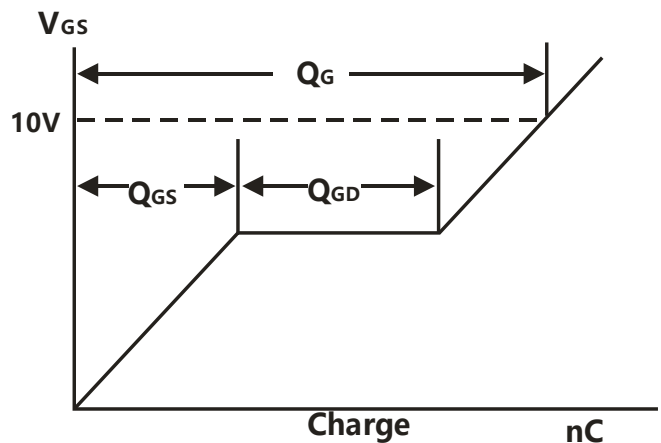
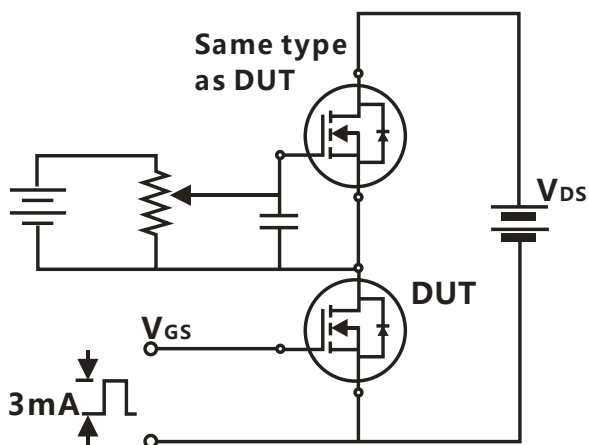
$$E_{AS} = \frac{1}{2} L I_{AS}^2$$



## Switching Time Test Circuit



## Gate Charge Test Circuit



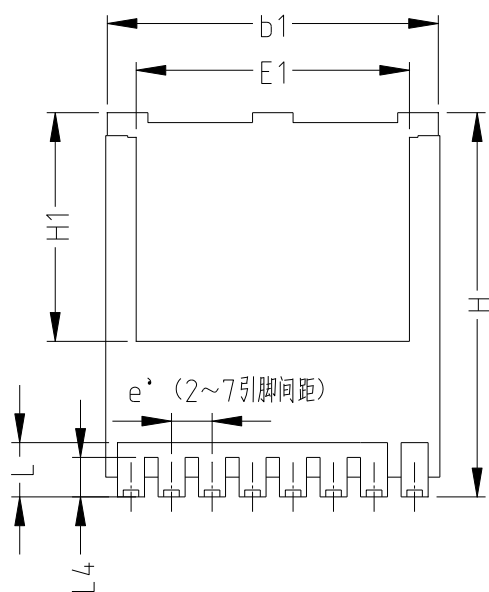
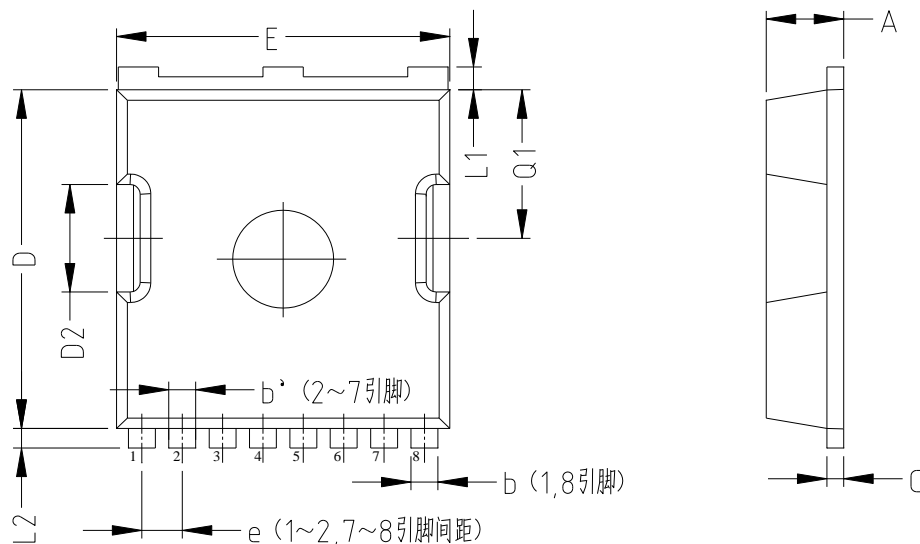
# HYG040N13NS1TA

## Device Per Unit

Package Type	Unit	Quantity
TOLL	Reel	1200

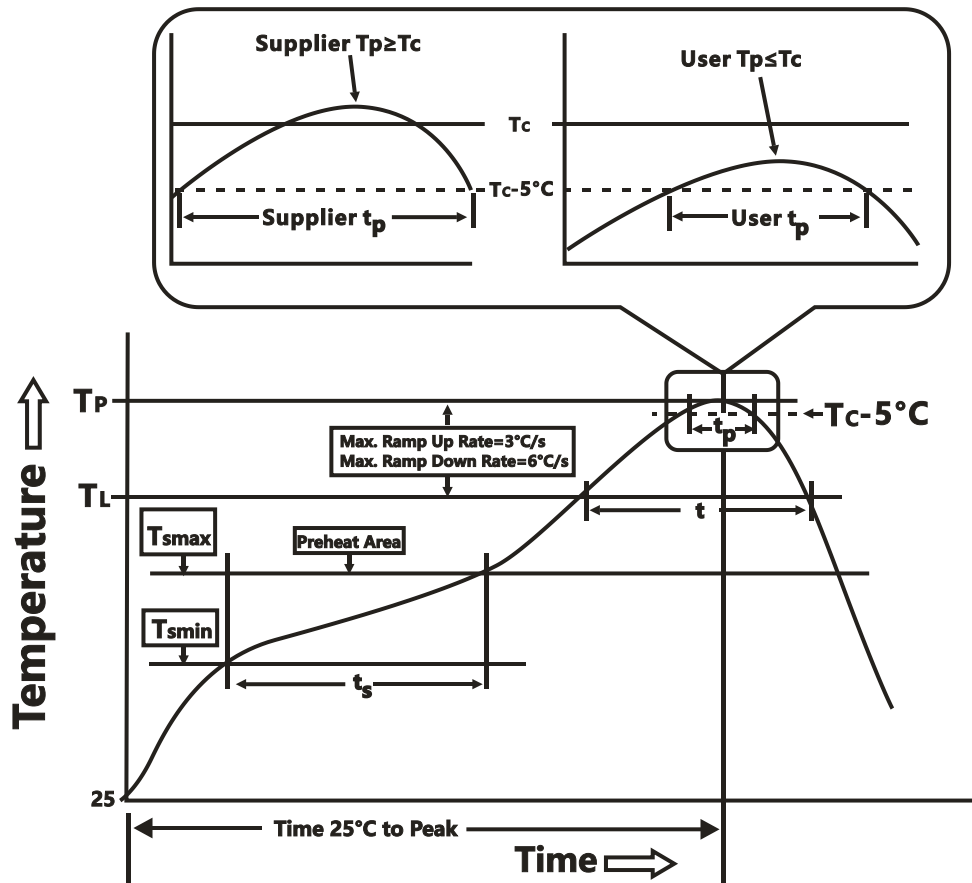
## Package Information

TOLL



COMMON DIMENSIONS			
SYMBOL	mm		
	MIN	NOM	MAX
A	2.15	2.3	2.45
b	0.7	0.75	0.85
b'	0.65	0.7	0.8
b1	9.65	9.8	9.95
C	0.45	0.5	0.6
D	10.18	10.38	10.58
D2	3.15	3.3	3.45
E	9.7	9.9	10.1
E1	7.95	8.1	8.25
e	BSC 1.225		
e'	BSC 1.20		
Q1	4.40	4.55	4.70
H	11.48	11.68	11.88
H1	6.80	6.95	7.10
L	1.60	1.80	2.00
L1	0.50	0.70	0.90
L2	0.48	0.60	0.72
L4	1.00	1.15	1.30

## Classification Profile



## Classification Reflow Profiles

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
<b>Preheat &amp; Soak</b>		
Temperature min ( $T_{smin}$ )	100 °C	150 °C
Temperature max ( $T_{smax}$ )	150 °C	200 °C
Time ( $T_{smin}$ to $T_{smax}$ ) ( $t_s$ )	60-120 seconds	60-120 seconds
Average ramp-up rate ( $T_{smax}$ to $T_P$ )	3 °C/second max.	3°C/second max.
Liquidous temperature ( $T_L$ )	183 °C	217 °C
Time at liquidous ( $t_L$ )	60-150 seconds	60-150 seconds
Peak package body Temperature ( $T_P$ )*	See Classification Temp in table1	See Classification Temp in table2
Time ( $t_p$ )** within 5°C of the specified classification temperature ( $T_C$ )	20** seconds	30** seconds
Average ramp-down rate ( $T_P$ to $T_{smax}$ )	6 °C/second max.	6 °C/second max.
Time 25°C to peak temperature	6 minutes max.	8 minutes max.
* Tolerance for peak profile Temperature ( $T_P$ ) is defined as a supplier minimum and a user maximum.		
** Tolerance for time at peak profile temperature ( $t_p$ ) is defined as a supplier minimum and a user maximum.		



Table 1. SnPb Eutectic Process – Classification Temperatures ( $T_C$ )

Package	Volume mm <sup>3</sup>	Volume mm <sup>3</sup>
Thickness	<350	≥350
<2.5 mm	235 °C	220 °C
≥2.5 mm	220 °C	220 °C

Table 2. Pb-free Process – Classification Temperatures ( $T_C$ )

Package	Volume mm <sup>3</sup>	Volume mm <sup>3</sup>	Volume mm <sup>3</sup>
Thickness	<350	350-2000	≥2000
<1.6 mm	260 °C	260 °C	260 °C
1.6 mm – 2.5 mm	260 °C	250 °C	245 °C
≥2.5 mm	250 °C	245 °C	245 °C

## Reliability Test Program

Test item	Method	Description
SOLDERABILITY	JESD-22, B102	5 Sec, 245°C
HTRB	JESD-22, A108	168/500/1000 Hrs, Bias @ 150°C
HTGB	JESD-22, A108	168/500/1000 Hrs, $V_{GS}$ 100% @ 150°C
PCT	JESD-22, A102	96 Hrs, 100%RH, 2atm, 121°C
TCT	JESD-22, A104	250/500/1000 Cycles, -55°C~150°C

## Customer Service

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