

12V Electronic Fuse

Features

- 9V to 18V Input Range
- N-channel on-resistance (typ): 32mΩ
- En/Fault functions
- Output clamp voltage (typ): 15V
- Internal undervoltage lockout
- Short-circuit limit
- Overload current limit
- Controlled output voltage ramp
- Programmable soft start function
- Thermal latch (typ): 165°C
- Available in DFN10 (3x3 mm) package

Applications

- Hard disk drives
- Solid state drives (SSD)
- DVD and Blue-ray disc drivers
- Mother Board Power Management

General Description

The G5288 is an integrated, cost-effective, electronic fuse optimized for monitoring output current and input voltage. Connected in series to a 12V power-rail, it is capable of protecting the electronic circuitry on its output from overcurrent and overvoltage during output load transient and input voltage transient. If a continuous short-circuit is present on the board, when power is re-applied, G5288 initially limits the output current to a safe value to lower the power on G5288 and a thermal protection circuit is integrated as well. There is no degradation on G5288 after short-circuit/thermal protection events and it is reset either by recycling the supply voltage or using the En/Fault pin. G5288 also has a programmable delay to control turn on time.

Ordering Information

ORDER NUMBER	MARKING	TEMP. RANGE	PACKAGE (Green)
G5288QE1U	5288	-40°C~ +85°C	DFN3X3-10
G5288QE1D	5288	-40°C~ +85°C	DFN3X3-10

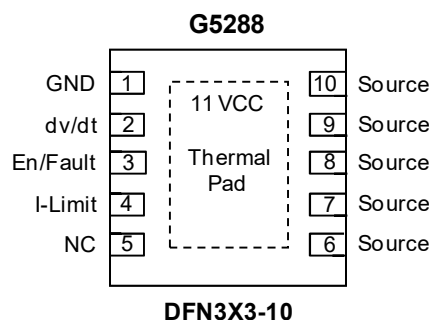
Note: QE: DFN3X3-10

1: Bonding Code

U & D: Tape & Reel

Green : Lead Free / Halogen Free

Pin Configuration



Note: Thermal Pad is the VCC Pin.

Absolute Maximum Ratings

VCC, Source, I_L Limit -0.3V to +21V
 En/Fault. -0.3V to +7V
 dv/dt -0.3V to +7V
 Thermal Resistance Junction to Ambient, (θ_{JA})
 DFN3X3-10. 53°C/W
 Continuous Power Dissipation ($T_A = +25^\circ\text{C}$)
 DFN3X3-10. 2.5W

Thermal Resistance Junction to Case, (θ_{JC})
 DFN3X3-10. 12°C/W
 Storage Temperature Range -65°C to 150°C
 Lead temperature (soldering) 10 sec. 260°C
 ESD (HBM). 2kV
 ESD (MM) 200V
 ESD (CDM) 500V

Recommended Operating Conditions

Operating junction temperature range⁽¹⁾
 -40°C to 125°C

(1) The thermal limit is set above the maximum thermal rating. It is not recommended to operate the device at temperatures greater than the maximum ratings for extended periods of time.

Note: Absolute maximum ratings are those values beyond which damage to the device may occur. Functional operation under these conditions is not implied.

Electrical Characteristics

(V_{CC} = 12V, V_{En/Fault} = 3.3V, C_I = 10μF, C_O = 47μF, T_J = 25°C.

The device is not guaranteed to function outside its operating conditions. Parameters with MIN and/or MAX limits are 100% tested at +25°C, unless otherwise specified.

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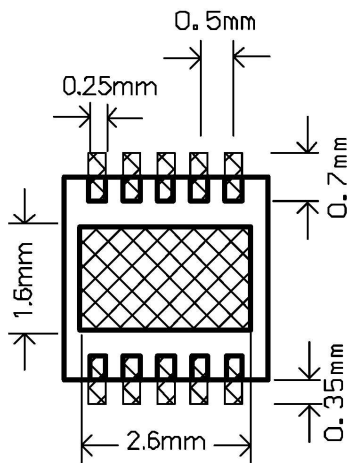
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Under/Overvoltage protection						
Output clamping voltage	V _{Clamp}	V _{CC} =18V	13.8	15	16.2	V
Under voltage lockout	V _{UVLO}	Turn-on, voltage rising	7.7	8.5	9.3	V
UVLO hysteresis	V _{Hyst}		---	0.8	---	V
Power MOSFET						
Delay time	T _{DLY}	Enabling of chip to I _D = 100mA with an 1A resistive load	---	350	---	μs
ON resistance	R _{DS_ON}	⁽¹⁾	---	32	55	mΩ
		-40°C < T _J < 125°C ⁽²⁾	---	50	---	
Off state output voltage	V _{OFF}	V _{CC} =18V, V _{GS} =0, R _L =infinite	---	190	300	mV
Continuous current	I _D	0.5in ² pad, T _A =25°C ⁽²⁾	---	3.6	---	A
		Minimum copper, T _A =80°C	---	1.7	---	
Current limit (For Kelvin Sense)						
Short-circuit current limit	I _{Short}	R _{LIMIT} = 15Ω, SOURCE < 0.5V	---	3	---	A
Hold current limit	I _{Hold}	R _{LIMIT} = 15Ω	2.75	3.44	4.25	A
Trip current limit	I _{Lim}	R _{LIMIT} = 15Ω	---	4.6	---	A
dv/dt circuit						
Output voltage ramp time	dv/dt	Enable to V _{OUT} =11.7V, No C _{dv/dt}	0.5	0.9	1.8	ms

Electrical Characteristics (Continued)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
En/Fault						
Low level input voltage	V_{IL}	Output disabled	---	---	0.5	V
Intermediate level input voltage	$V_{I(INT)}$	Thermal fault, output disabled	0.82	1.4	1.95	V
High level input voltage	V_{IH}	Output enabled	2.5	---	---	V
High state maximum voltage	$V_{I(MAX)}$		3.4	4.3	5.4	V
Low level input current (sink)	I_{IL}	$V_{En/Fault}=0V$	---	-25	-35	μA
High level leakage current for external switch	I_I	$V_{En/Fault}=3.3V$	---	---	1	μA
Maximum fan-out for fault signal		Total numbers of chips that can be connected to this pin for simultaneous shutdown	---	---	3	Units
Total device						
Bias current	I_{Bias}	Device operational	---	420	---	μA
		Shutdown	---	360	---	
Minimum operating voltage	V_{min}		---	---	7.6	V
Thermal latch						
Shutdown temperature	TSD	⁽²⁾	---	165	---	$^{\circ}C$

 1. Pulse test: Pulse width = 300 μs , Duty cycle = 2%

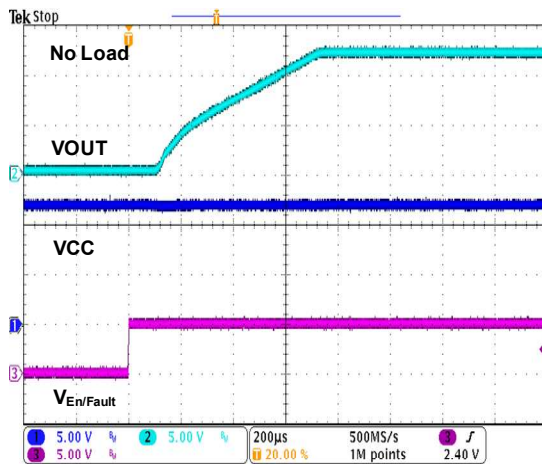
2. Guaranteed by design, but not tested in production

Minimum Footprint PCB Layout Section
DFN3X3-10


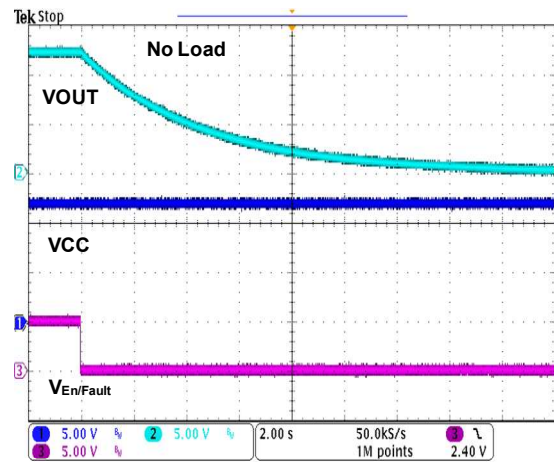
Typical Performance Characteristics

$V_{CC}=12V$, $V_{En/Fault}=5V$, $R_{LIMIT}=15\Omega$, $C_L=47\mu F$, $C_{dv}/dt=open$, Direct Sense, $T_A=T_J=25^\circ C$.

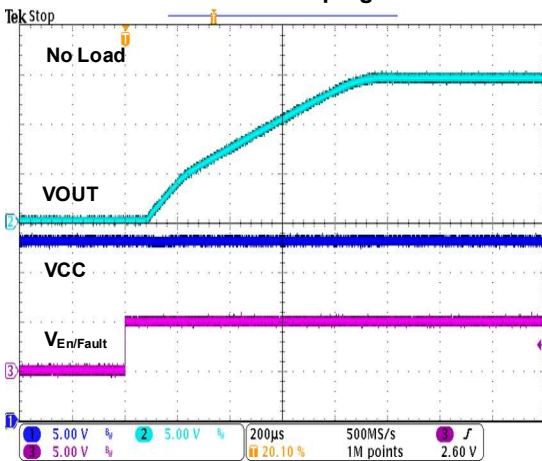
Startup through Enable



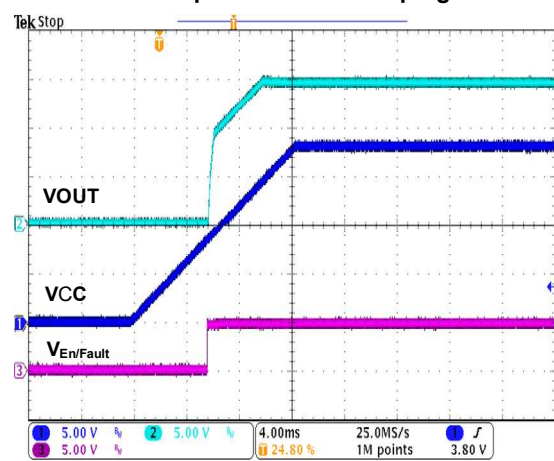
Startdown through Enable



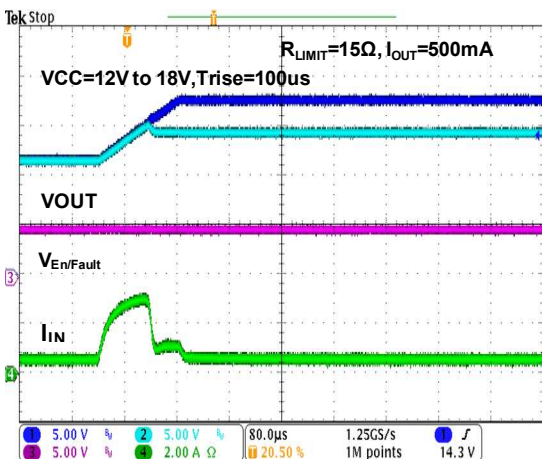
VOUT Clamping



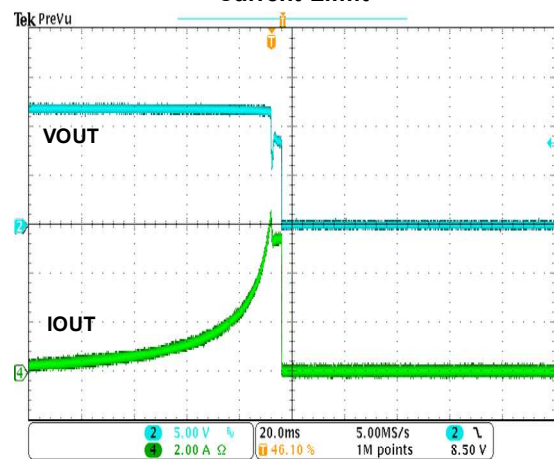
Startup into VOUT Clamping



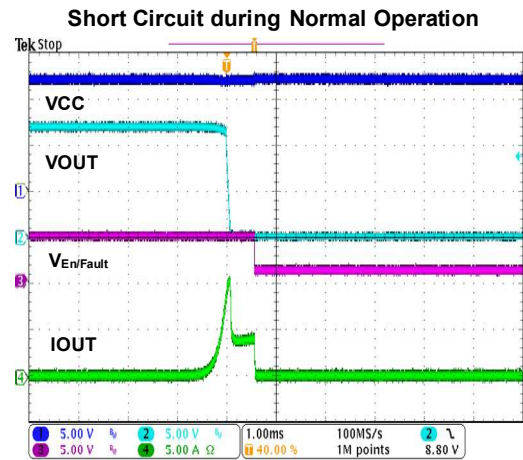
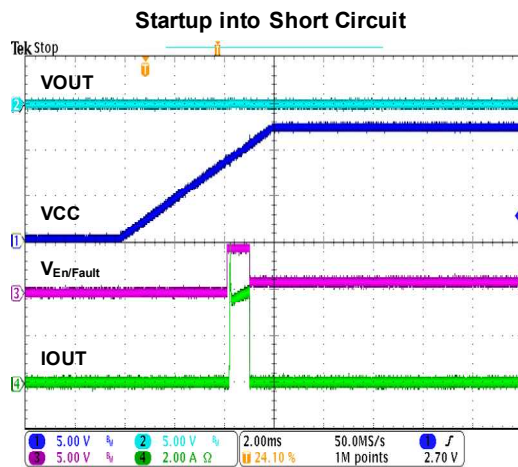
Line Transient



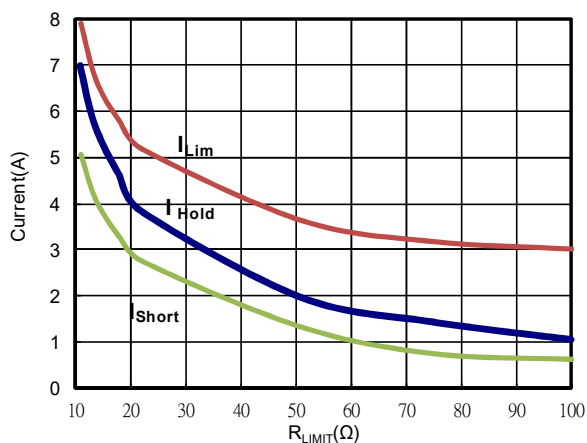
Current Limit



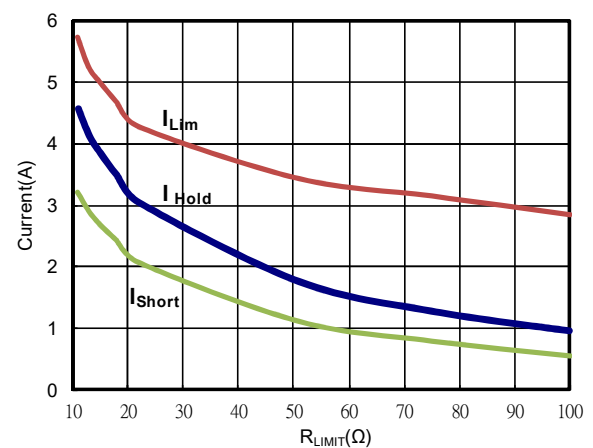
Typical Performance Characteristics (continued)



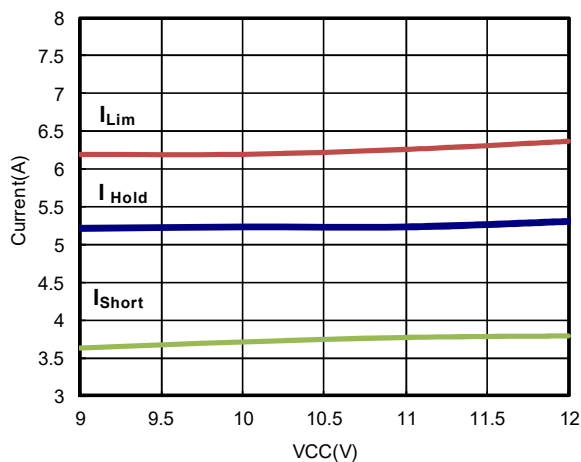
Trip Current, Hold Current, and Short Current vs. R_{LIMIT} Direct Sense $V_{CC}=12V$



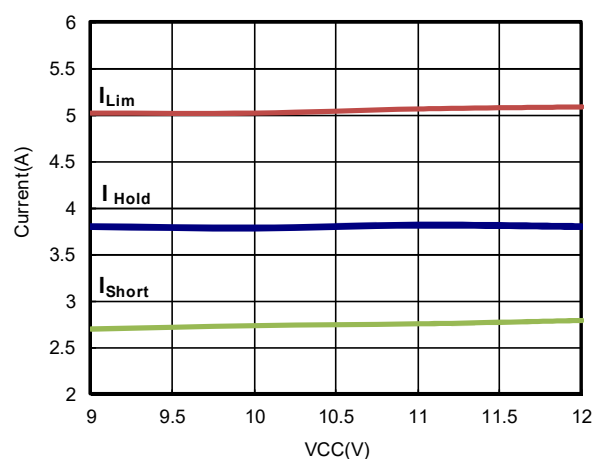
Trip Current, Hold Current, and Short Current vs. R_{LIMIT} Kelvin Sense $V_{CC}=12V$



Trip Current, Hold Current, and Short Current vs. V_{CC} Direct Sense $R_{LIMIT}=15\Omega$

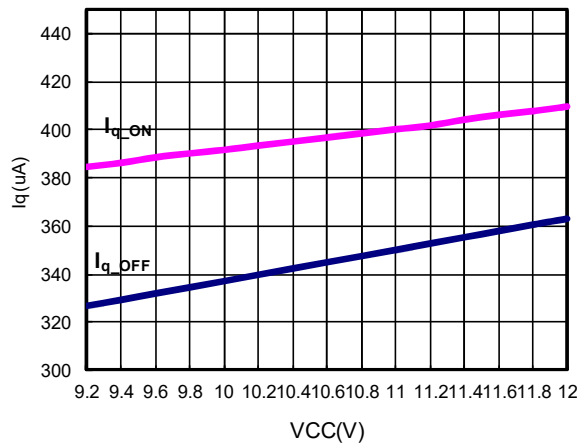


Trip Current, Hold Current, and Short Current vs. V_{CC} Kelvin Sense $R_{LIMIT}=15\Omega$

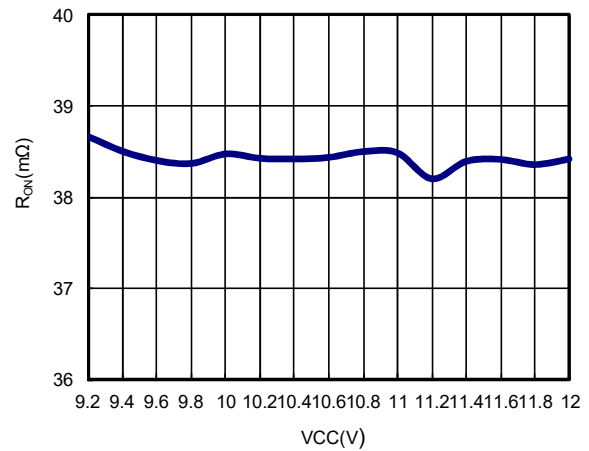


Typical Performance Characteristics (continued)

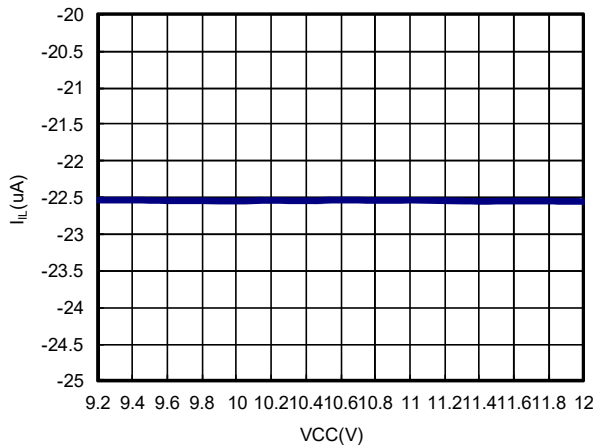
I_q (ON) & I_q (OFF) vs. VCC



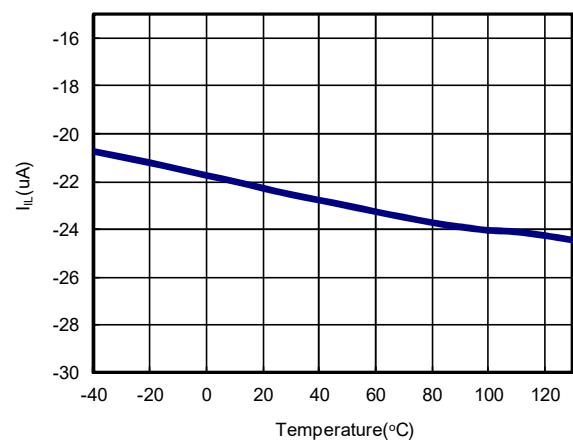
$R_{DS(on)}$ vs. VCC



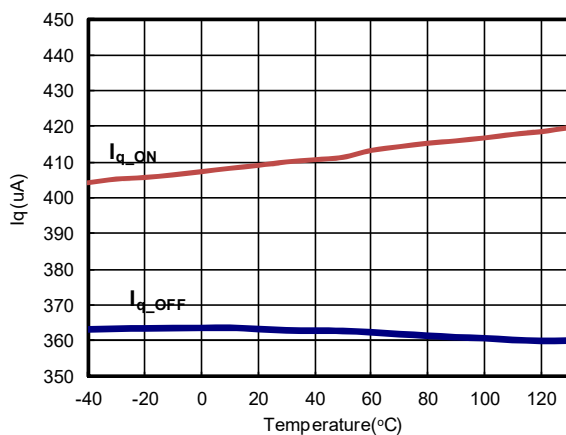
I_{IL} vs. VCC



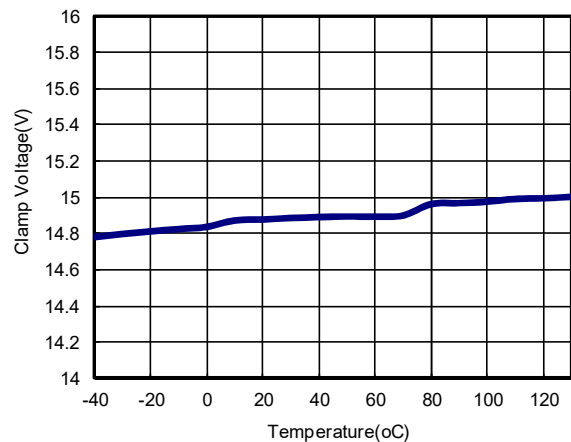
I_{IL} vs. Temperature



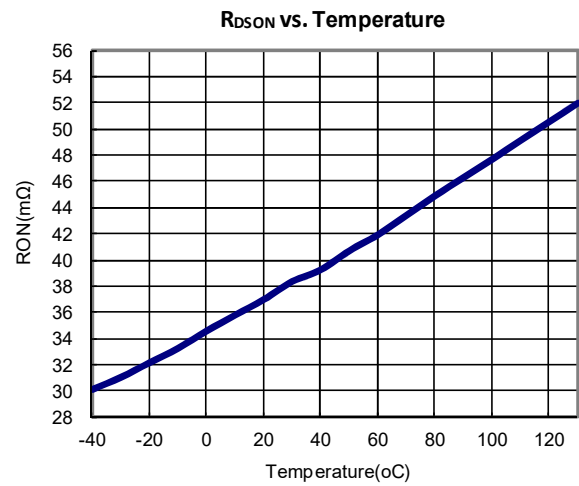
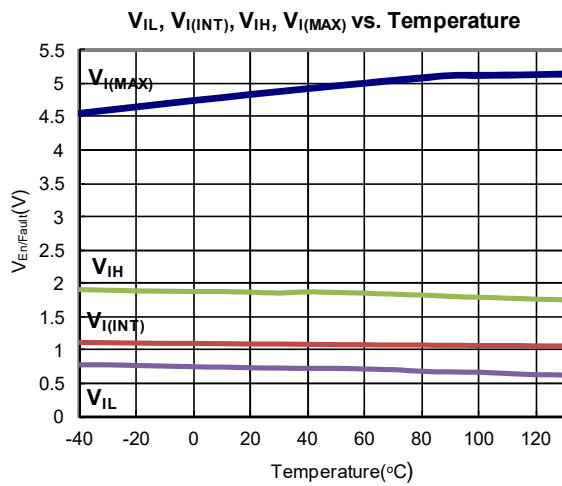
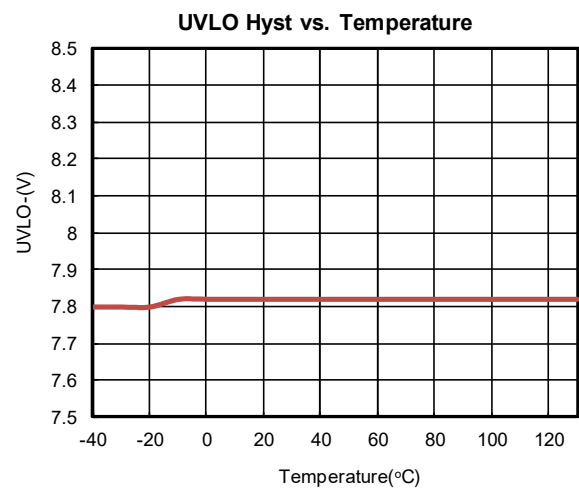
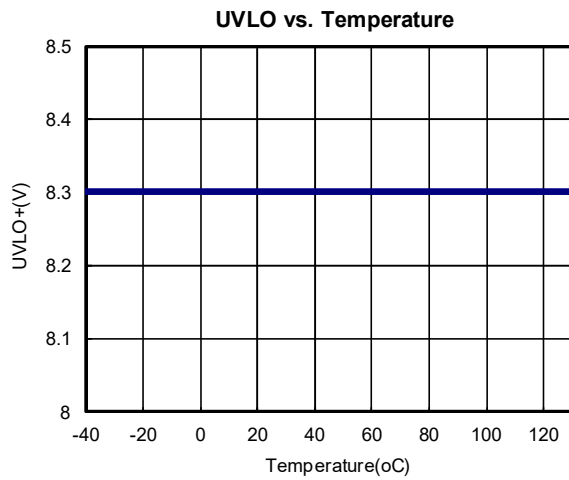
I_q (ON) & I_q (OFF) vs. Temperature
VCC=12V



V_{Clamp} vs. Temperature
VCC=18V



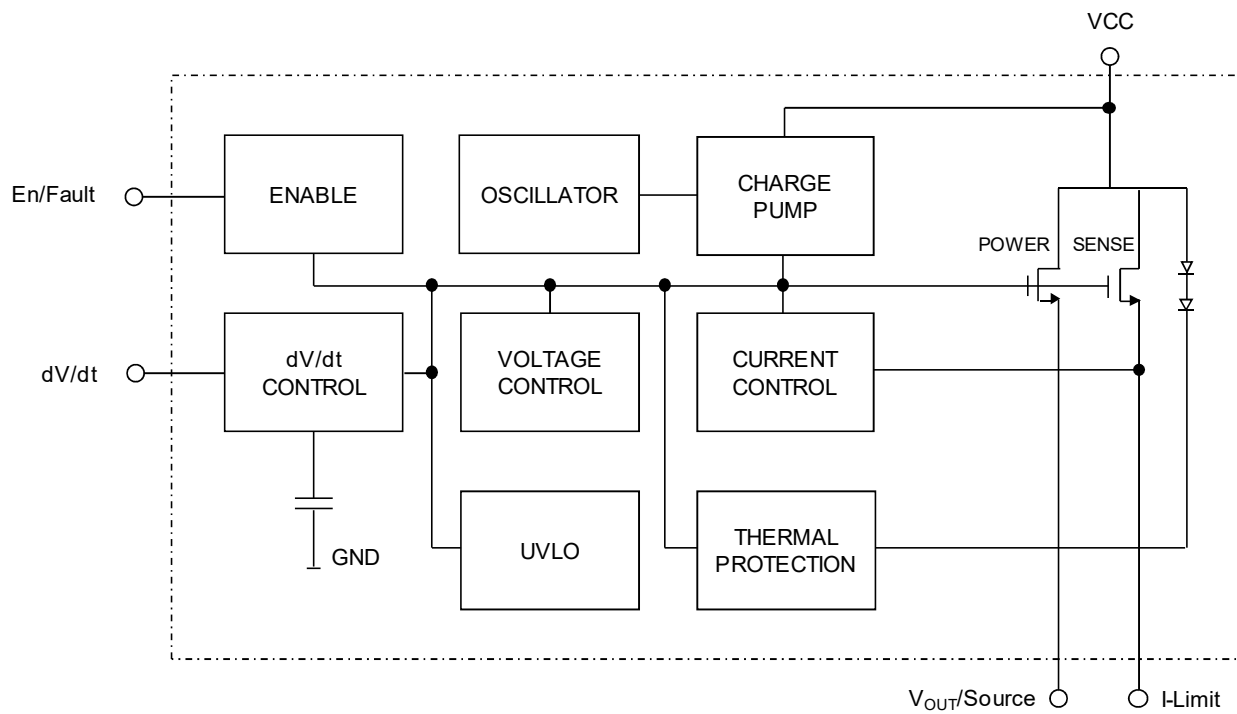
Typical Performance Characteristics (continued)



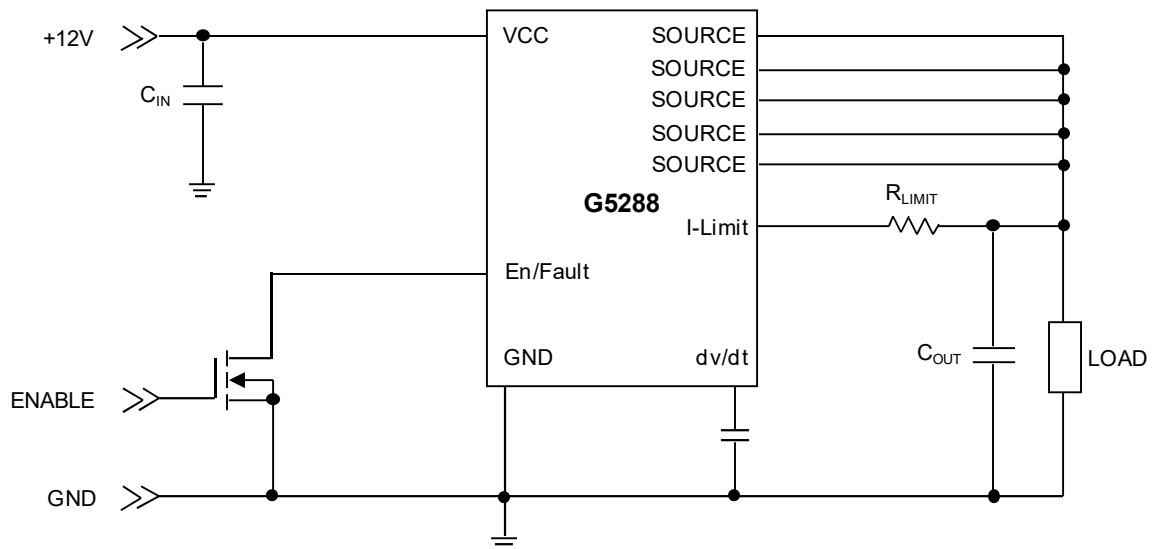
Pin Description

PIN	NAME	FUNCTION
1	GND	Ground pin
2	dv/dt	The internal dv/dt circuit controls the slew rate of the output voltage at turn-on. The internal capacitor allows a ramp-up time of around 1ms. An external capacitor can be added to this pin to increase the ramp time. If an additional capacitor is not required, this pin should be left open.
3	En/Fault	The En/Fault pin is a tri-state, bi-directional interface. During normal operation the pin must be left floating, or it can be used to disable the output of the device by pulling it to ground using an open drain or open collector device. If a thermal fault occurs, the voltage on this pin goes into an intermediate state to signal a monitor circuit that the device is in thermal shutdown. It can be connected to another device of this family to cause a simultaneous shutdown during thermal events.
4	I-Limit	A resistor between this pin and the Source pin sets the overload and short-circuit current limit levels.
5	NC	Not connected
6~10	Source	Connected to the source of the internal power MOSFET and to the output terminal of the fuse
11	VCC	Exposed pad. Positive input voltage must be connected to VCC.

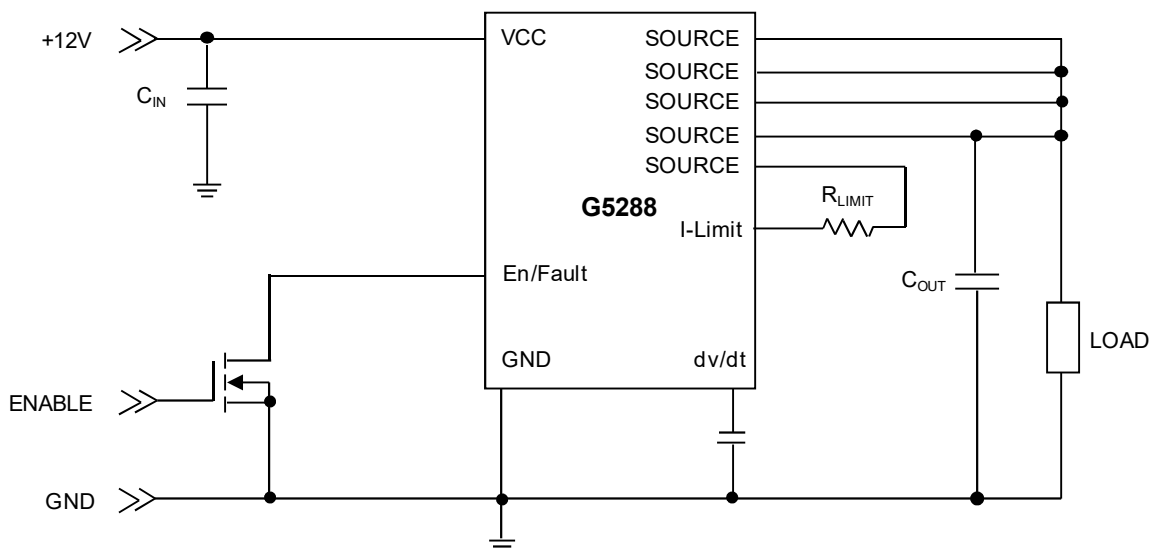
Block Diagram



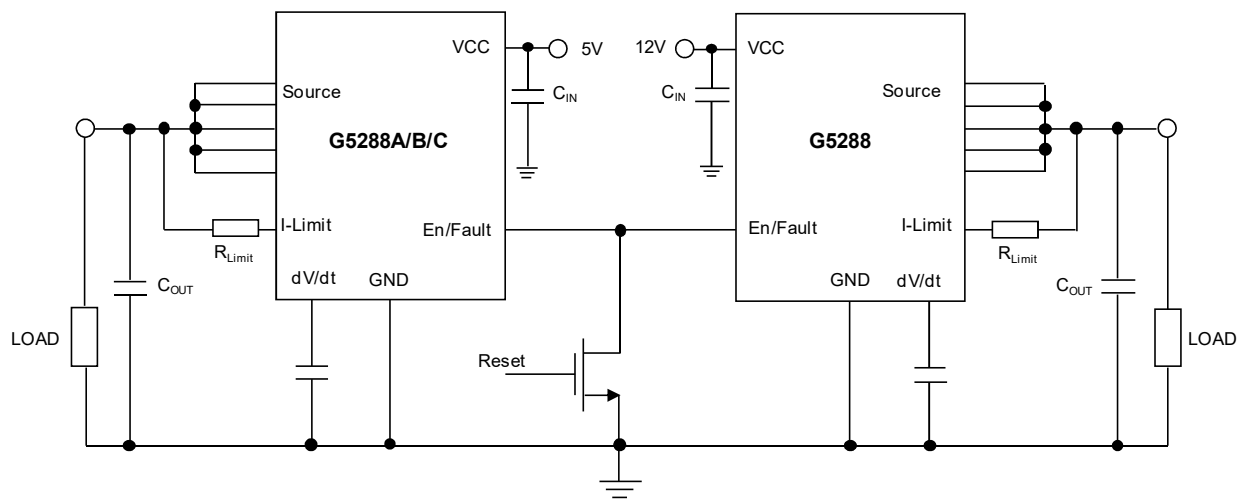
Typical application



Application Circuit with Direct Sense



Application Circuit with Kelvin Sense



Typical HDD Application Circuit

Operating modes

Turn-on

When the input voltage is applied, the En/Fault pin goes up to the high state, enabling the internal control circuit. After an initial delay time of typically 350 μ s, the output voltage is supplied with a slope defined by the internal dv/dt circuit. If no additional capacitor is connected to dv/dt pin, the total time from the Enable signal going high and the output voltage reaching the nominal value is around 1 ms (Fig. 1)

Normal operating condition

The G5288 buffers the circuitry on its output with the same voltage shown at its input, with a small voltage drop due to the N-channel MOSFET resistance.

Output voltage clamp

This internal protection circuit clamps the output voltage to a maximum safe value, typically 15 V, if the input voltage exceeds this threshold.

Current limiting

When an overload event occurs, the current limiting circuit reduces the conductivity of the power MOSFET, in order to clamp the output current at the value selected externally by means of the limiting resistor R_{LIMIT} . There are two methods to set up the application circuit for the G5288 as shown in typical application section.

Direct sense: connecting R_{LIMIT} between the current limit pin (I-limit) and the load. The resistance has an influence on the current limit value for a given resistor and may vary slightly depending on the impedance between the R_{LIMIT} and the source pins. The R_{DS_ON} of G5288 will be slightly lower in the method since all five source pins are connected in parallel.

Rough formulas for current limiting in direct sense method are shown below:

For trip current,

$$I_{Lim} = \frac{60}{R_{LIMIT}} + 2.4(A)$$

For hold current,

$$I_{Hold} = \frac{75}{R_{LIMIT}} + 0.35(A)$$

Where R_{LIMIT} is expressed in Ohm.

Kelvin sense: using one of the source pins as the connection for R_{LIMIT} . This connection senses the voltage on the die and therefore any bond wire resistance and external impedance on the board have no effect on the current limit value. In this method, the R_{DS_ON} is slightly increased relative to the direct sense

method since only four of the source pins are used. The tables as shown below list the examples of current limit values of the resistor value for both Kelvin sense and direct sense.

Thermal shutdown

If the device temperature exceeds the thermal latch threshold, typically 165 $^{\circ}$ C, the thermal shutdown circuitry turns the power MOSFET off, thus disconnecting the load. The En/Fault pin of the device is automatically set at an intermediate voltage, in order to signal the over temperature event. In this condition, G5288 can be reset either by cycling the supply voltage or by pulling down the En/Fault pin below the V_{IL} threshold and then releasing it.

Cdv/dt calculation

Connecting a capacitor between the dv/dt pin and GND allows the modification of the output voltage ramp-up time. Given the desired time interval Δt during which the output voltage goes from zero to its maximum value, the capacitance to be added on the dv/dt pin can be calculated using the following theoretical formula:

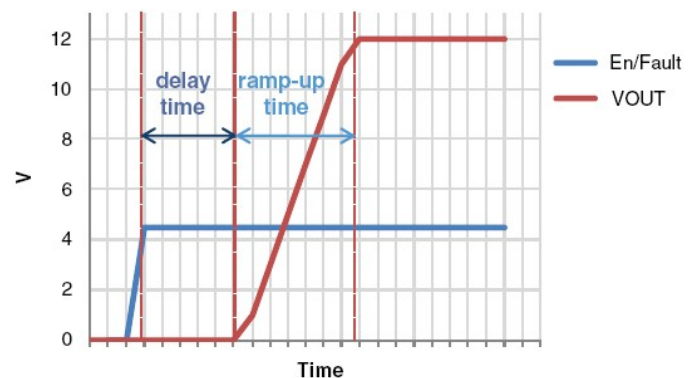
Equation 1

$$t_{slew} = 24 \times 10^6 \times (50pF + C_{dv/dt})$$

$$C_{dv/dt} = \frac{t_{slew}}{24 \times 10^6} - 50pF$$

Where Cdv/dt is expressed in Farads and the time in seconds.

Fig. 1 Delay time and VOUT ramp-up time



En/Fault pin

The En/Fault pin has the dual function of controlling the output of the device and, at the same time, of providing information about the device status to the application.

When it is used as a standard Enable pin, it should be connected to an external open-drain or open-collector device. In this case, when it is pulled at low logic level, it turns the output of the E-Fuse off.

If this pin is left floating, since it has internal pull-up circuitry, the output of G5288 is hold ON, in normal operating conditions.

In case of thermal fault, the pin is pulled to an intermediate state (Fig. 2). This signal can be provided to a monitor circuit, informing it that a thermal shutdown has occurred, or it can be directly connected to the En/Fault pins of other devices on the same application in order to achieve a simultaneous enable/disable feature.

When a thermal fault occurs, the device can be reset either by cycling the supply voltage or by pulling down the En/Fault pin below the V_{IL} threshold and then releasing it.

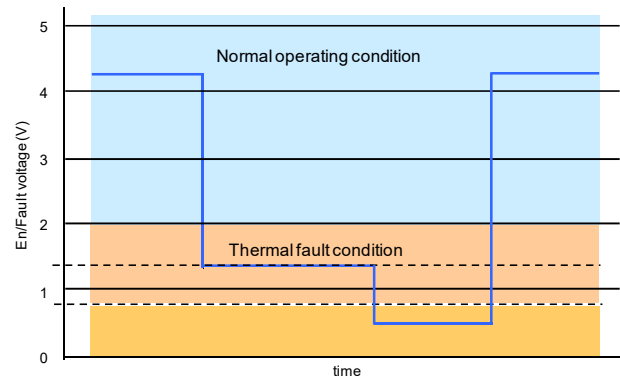


Fig. 2 En/Fault pin status

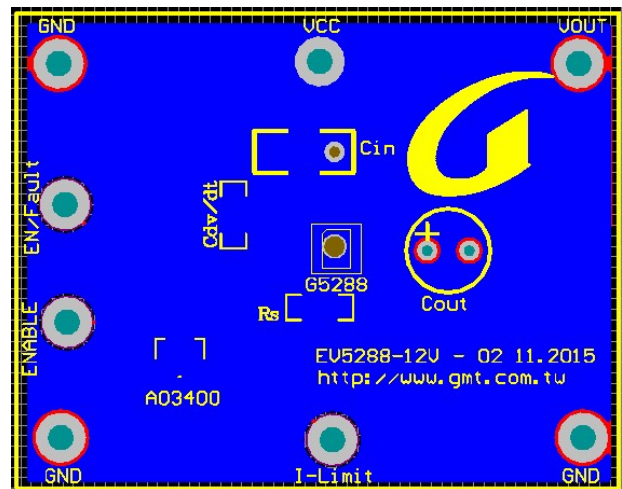
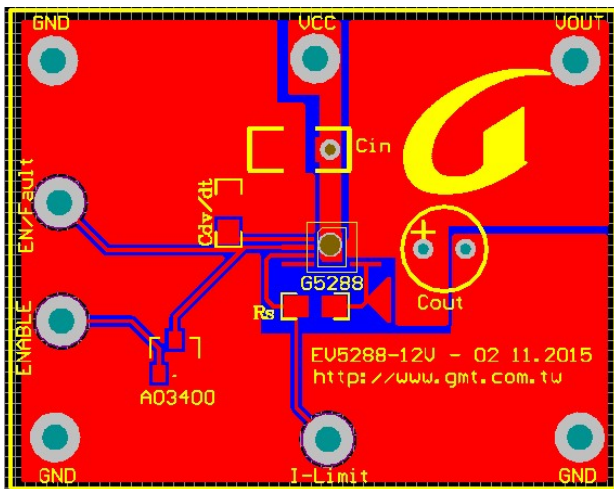
Table1: Current Limit vs. Current Limit Resistor (VCC=12V, Kelvin Sense)

$R_{LIMIT}(\Omega)$	11	13	15	18	22	51	75	100
Trip Current (A)	5.72	5.24	5	4.68	4.28	3.44	3.16	2.86
Hold Current (A)	4.56	4.12	3.84	3.48	3.04	1.76	1.28	0.96

Table2: Current Limit vs. Current Limit Resistor (VCC=12V, Direct Sense)

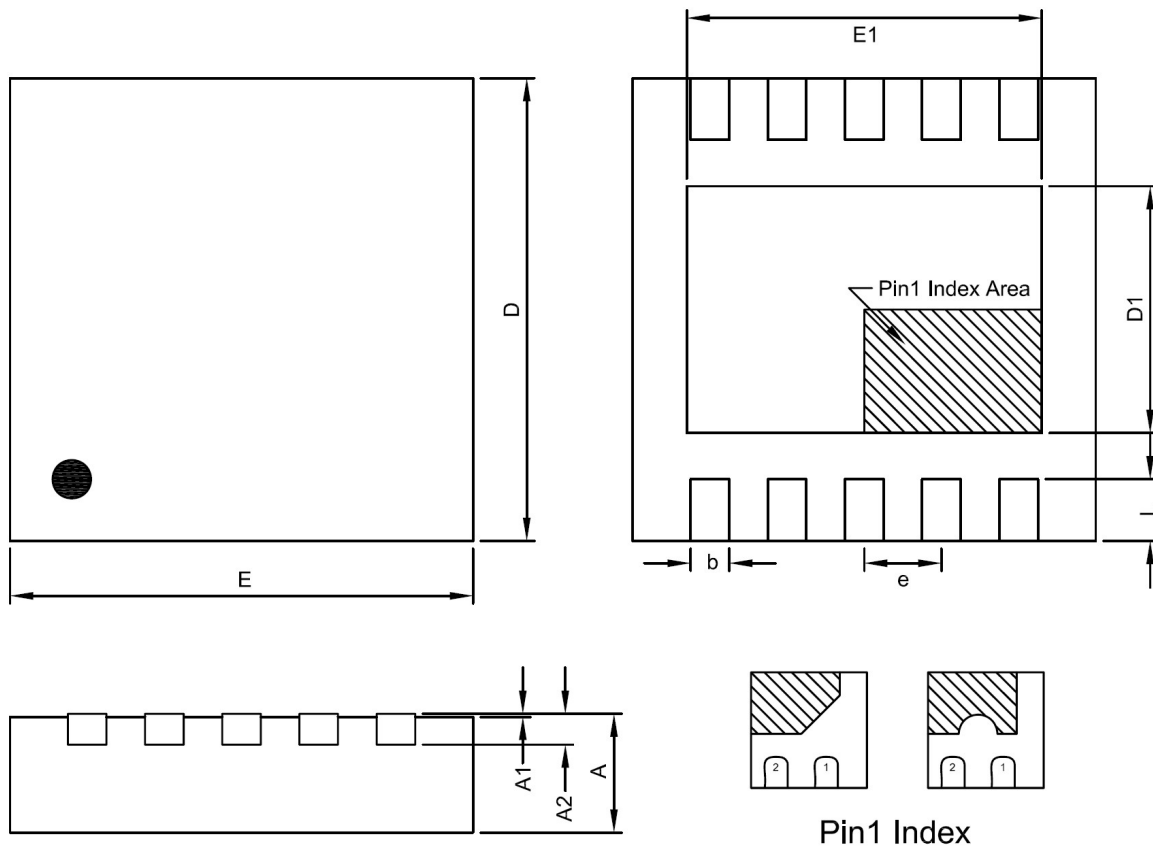
$R_{LIMIT}(\Omega)$	11	13	15	18	22	51	75	100
Trip Current (A)	7.92	6.96	6.36	5.8	5.2	3.64	3.18	3.02
Hold Current (A)	7	5.96	5.32	4.64	3.84	1.96	1.42	1.04

EV Board PCB Layout Section



DFN3X3-10 PCB	Information
Board Material	FR4
Size	36.3mm×28.7mm
Board Thickness	1.6mm
Layers	2
Copper Thickness	2 oz.

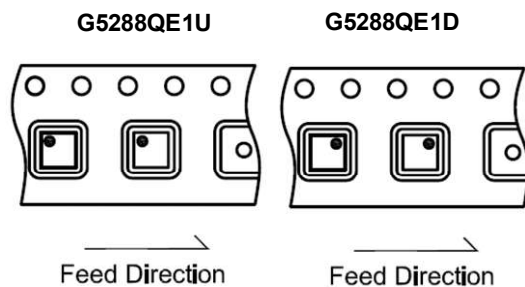
Package Information



DFN3X3-10 Package

Symbol	DIMENSION IN MM			DIMENSION IN INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.80	0.90	1.00	0.0315	0.0354	0.0394
A1	0.00	---	0.05	0.0000	---	0.0020
A2	0.20 REF			0.0079 REF		
D	2.95	3.00	3.05	0.1161	0.1181	0.1201
E	2.95	3.00	3.05	0.1161	0.1181	0.1201
D1	1.50	1.60	1.75	0.0591	0.0630	0.0689
E1	2.20	2.60	2.70	0.0866	0.1024	0.1063
b	0.18	0.25	0.30	0.0071	0.0098	0.0118
e	0.50 BSC			0.0197 BSC		
L	0.30	0.40	0.50	0.0118	0.0157	0.0197

Taping Specification



PACKAGE	Q'TY/REEL
DFN3X3-10	3,000 ea

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