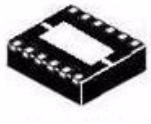
STOD02

Dual DC-DC converter for powering AMOLED display

Features

- Step-up and inverter converters
- Operating input voltage range from 2.5 V to 4.5 V
- Synchronous rectification for both DC-DC converters
- 150 mA maximum output current
- 4.6 V fixed positive output voltage
- Programmable negative voltage by S-wire from - 2.3 V to - 5.9 V
- Typical efficiency: 85 %
- Pulse skipping mode in light load condition (I_O < 10 mA)
- 1.6 MHz PWM mode control switching frequency (I_O > 10 mA)
- Enable pin for shutdown mode
- Low quiescent current: < 1 µA in shutdown mode
- Soft-start with inrush current protection
- Over temperature protection
- Temperature range: -40 °C to 85 °C
- True shutdown mode
- Fast outputs discharge circuit after shutdown
- Package: DFN 12 leads - (3 x 3 mm)



DFN12L (3 x 3 mm)

Applications

- Active matrix organic LED power supply (AMOLED)
- Mobile phones
- PDAs
- Camcorders and digital still cameras

Description

The STOD02 is a dual DC-DC converter meant to power AMOLED displays. It integrates a step up and an inverting DC-DC converter making it particularly suitable for battery operated products, where the major concern is the overall system efficiency. STOD02 works in pulse skipping mode during low load condition and in PWM-mode (at 1.6 MHz) for medium/high load condition. The high frequency allows reducing the value and number of external components just to 6 components needed. The enable pin allows turning off the device so reducing the current consumption to less that 1 µA. The negative output voltage can be programmed by an MCU through a dedicated pin which implements single-wire protocol. Soft-start with controlled inrush current limit and thermal shutdown are integrated functions of the device.

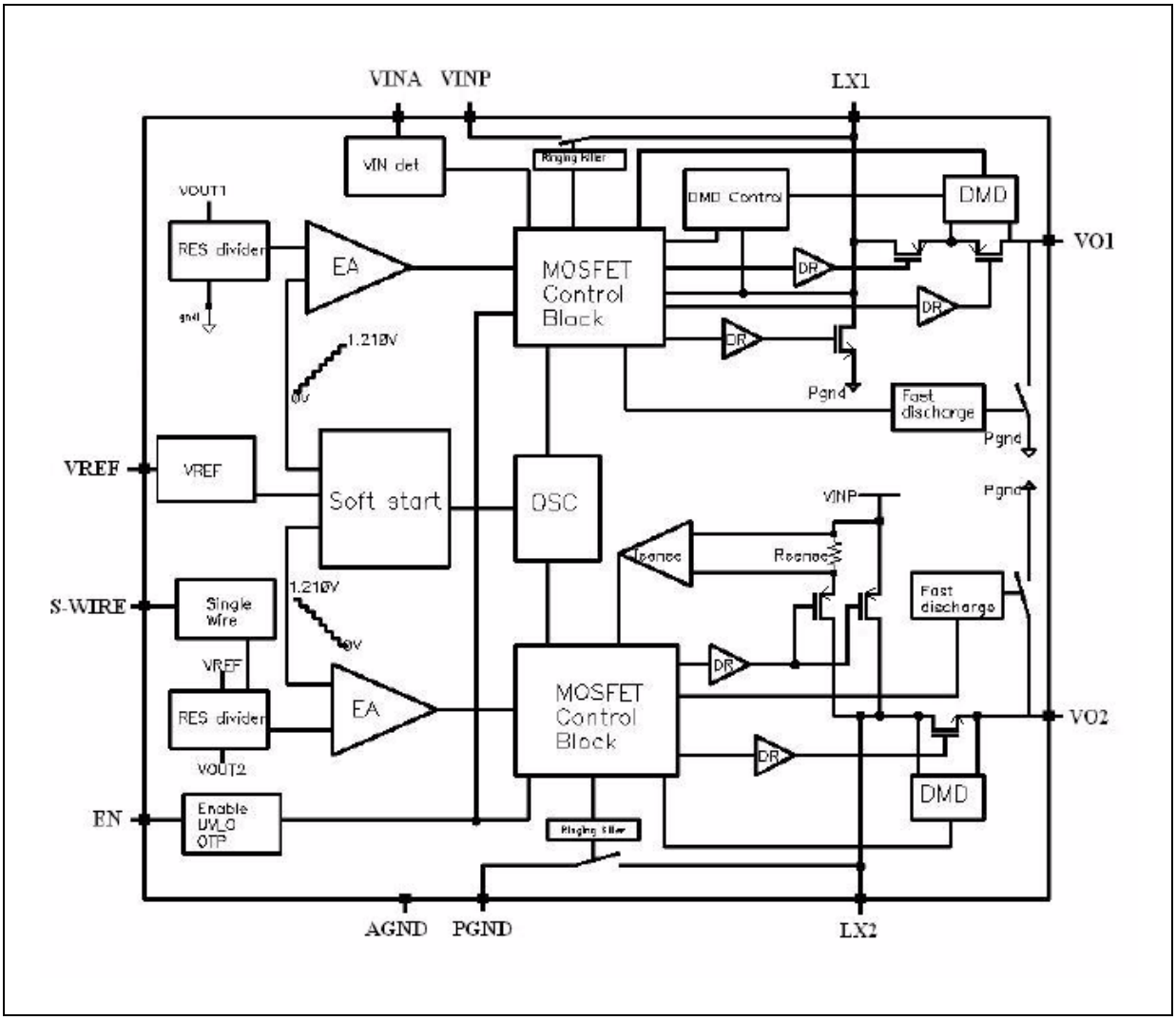
Table 1. Device summary

Order code	Package	Packaging
STOD02PUR	DFN12L (3 x 3 x 0.8 mm)	3000 parts per reel
STOD02TPUR	DFN12L (3 x 3 x 0.6 mm)	3000 parts per reel

Contents

1 Diagram

Figure 1. Block diagram



2 Pin configuration

Figure 2. Pin connections (top view)

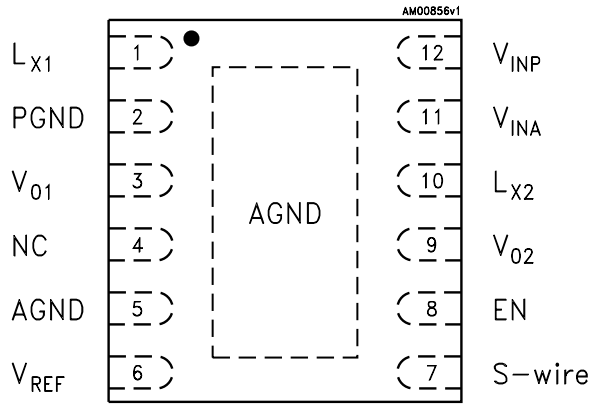


Table 2. Pin description

Pin n°	Symbol	Description
1	L_{X1}	Switching node of the step up converter
2	PGND	Power ground pin
3	V_{O1}	Step up converter output voltage
4	NC	Not connected
5	AGND	Signal ground pin. This pin must be connected to power ground pin
6	V_{REF}	External voltage reference
7	S-wire	Negative voltage setting pin, uses S-wire protocol
8	EN	Enable control pin. ON = V_I. When pulled low, the device goes in shutdown mode
9	V_{O2}	Inverting converter output voltage
10	L_{X2}	Switching node of the inverting converter
11	V_{INA}	Analog input supply voltage
12	V_{INP}	Power input supply voltage
	exposed pad	Internally connected to AGND. Exposed pad must be connected to AGND and PGND in the PCB layout in order to guarantee proper operation of the device.

3 Maximum ratings

Table 3. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{INA}, V_{INP}	DC supply voltage	-0.3 to 6	V
EN,S-wire	Enable pin, S-wire pin	-0.3 to 6	V
IL_{X2}	Inverting converter's switching current	Internally limited	A
L_{X2}	Inverting converter switching node	-10 to V_{INP}+0.3	V
V_{O2}	Inverting converter output voltage	-10 to GND+0.3	V
V_{O1}	Step-up converter output voltage	-0.3 to 6	V
L_{X1}	Step-up converter switching node	-0.3 to V_{O1}+0.3	V
IL_{X1}	Step up converter's switching current	Internally limited	A
V_{REF}	Reference voltage	-0.3 to 3	V
P_D	Power dissipation	Internally limited	mW
T_{st}	Storage temperature range	-65 to 150	°C
T_J	Maximum junction temperature	150	°C
ESD	ESD protection HBM	2	kV

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

Table 4. Thermal data

Symbol	Parameter	Value	Unit
R_{thJA}	Thermal resistance junction-ambient referred to FR-4 PCB	49.1	°C/W
R_{thJC}	Thermal resistance junction-case	4.216	°C/W

4 Application

Figure 3. Typical application circuit

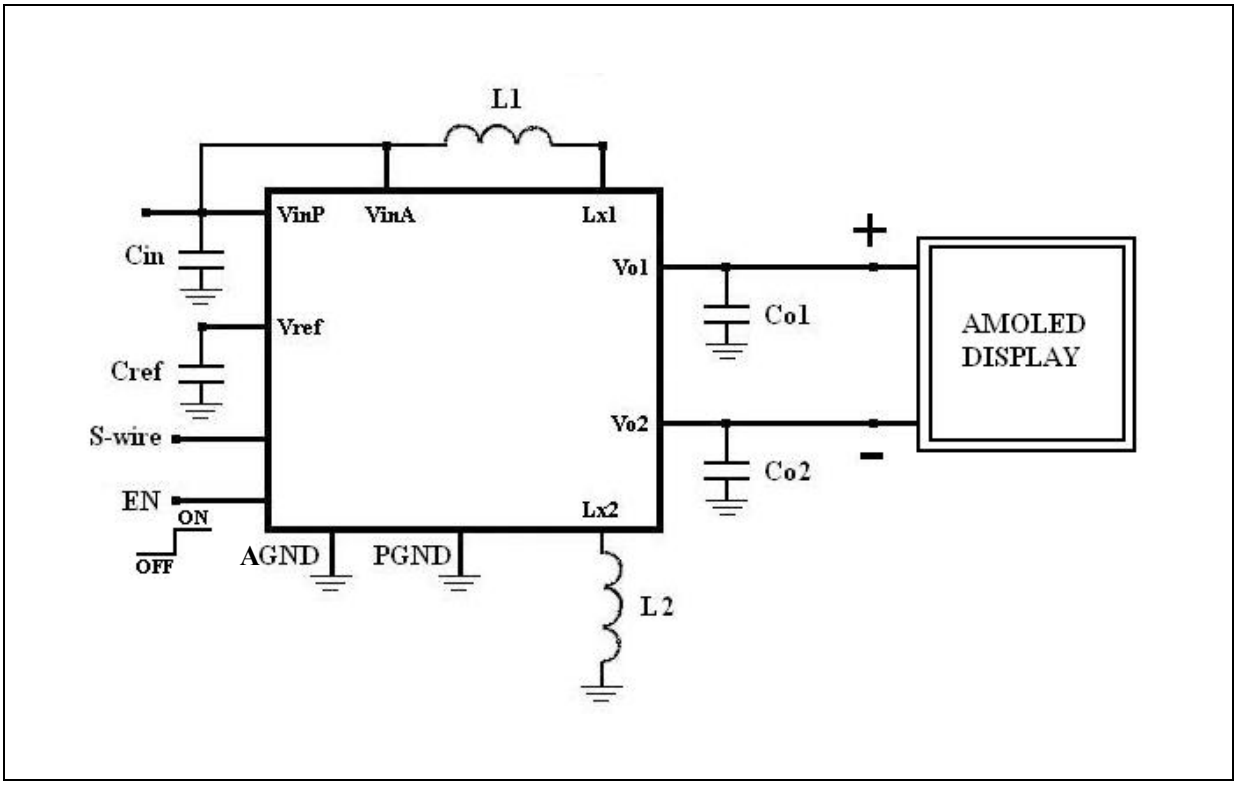


Table 5. Typical external components

Symbol	Parameter	Min.	Typ.	Max.	Unit
L_1	Inductor		4.7		µH
L_2	Inductor		4.7		µH
C_{IN}	Ceramic capacitor SMD		4.7		µF
C_{01}, C_{02}	Ceramic capacitor SMD		4.7		µF
C_{ref}	Ceramic capacitor SMD		1		µF

5 Electrical characteristics

T_J = 25 °C, V_{INA} = V_{INP} = 3.7 V, $I_{O1,2}$ = 30 mA, C_I = 4.7 µF, $C_{O1,2}$ = 4.7 µF, C_{REF} = 1 µF, L1 = 4.7 µH, L2 = 4.7 µH, V_{EN} = V_{INA} = V_{INP}, V_{O1} = 4.6 V, V_{O2}= -4.9 V unless otherwise specified.

Table 6. Electrical characteristics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
General section						
V_{IN}	Operating input voltage range	V_{O1}=4.6V, T_J = -40 to 85°C	2.5		4.5	V
UVLO_H	Under voltage lockout HIGH	V_{INA} rising, T_J = -40 to 85°C		2.40	2.50	V
UVLO_L	Under voltage lockout LOW	V_{INA} falling, T_J = -40 to 85°C	2.30	2.35		V
I_V_I	Input current	No Load condition (I_V_I = I_{INA} + I_{INP})		1	1.5	mA
I_S	Shutdown current	V_{EN} = GND, (I_S = I_{INA} + I_{INP})			1	µA
V_{EN} H	Enable high threshold	V_{INA}= 2.5V to 4.5V, T_J = -40 to 85°C	1.2			V
V_{EN} L	Enable low threshold	V_{INA}= 2.5V to 4.5V, T_J = -40 to 85°C			0.4	
I_{EN}	Enable input current	V_{EN} = V_I			1	µA
F_{SW}	Frequency	PWM mode, T_J = -40 to 85°C	1.35	1.6	1.85	MHz
$D1_{MAX}$	Step-up maximum duty cycle			90		%
$D2_{MAX}$	Inverting maximum duty cycle			90		%
ν	Total system efficiency	$I_{O1,2}$=10 to 30mA, V_{O1}=4.6V, V_{O2}=-4.9V		80		%
		$I_{O1,2}$=30 to 150mA, V_{O1}=4.6V, V_{O2}=-4.9V		85		
V_{REF}	Voltage reference	I_{REF}=10µA	1.196	1.209	1.222	V
I_{REF}	Voltage reference current capability	At V_{REF} = V_{REF} – 1.5%	100			µA
Step-up converter section						
V_{O1}	Line/Load maximum output voltage variation	V_{INA}=2.5V to 4.5V, I_{O1}=5mA to 100mA	4.55	4.6	4.65	V
$\Delta V_{O1\ SL}$	Static line regulation (1)	V_{INA}=2.5V to 4.5V, I_{O1}=5mA, I_{O2} no load; T_J=-40°C to 85°C		0.5		%
		V_{INA}=2.5V to 4.5V, I_{O1}=100mA, I_{O2} no load, T_J=-40°C to 85°C		0.5		
$\Delta V_{O1\ LT}$	Line transient	V_{INA}=3.5V to 3.0V, I_{O1}=100mA T_J=-40°C to 85°C, T_R=T_F=50µs output voltage variation with respect to nominal V_{O1}		-12		mV

Table 6. Electrical characteristics (continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
ΔV_{O1}	Static load regulation (2)	I_{O1}=5 to 100mA, I_{O2} no load, V_{INA}=2.5V; T_J=-40°C to 85°C		+ 1		%
		I_{O1}=5 to 100mA, I_{O2} no load, V_{INA}=4.5V; T_J=-40°C to 85°C		+ 1		
ΔV_{O1t}	Load transient regulation	I_{O1}=3 to 30mA and I_{O1}=30 to 3mA, T_R=T_F=30µs, output voltage variation with respect to nominal V_{O1}		±30		mV
		I_{O1}=10 to 100mA and I_{O1}=100 to 10mA, T_R=T_F=30µs, output voltage variation with respect to nominal V_{O1}		±35		
ΔV_{O1}	Ripple output voltage range (peak to peak)	I_{O1}=5 to 100mA; 0.5Vpp pulse signal applied to V_I at 200Hz; TDMA Noise			20	mV
I_{O1}	Maximum Step-up output current	V_I=2.9V to 5.5V	150			mA
I-L_{1MAX}	I_{peak} current	V_{o1} below 10% of nominal value	0.9			A
R_{DSON}P1		T_J = -40 to 85°C		0.8	1.0	Ω
R_{DSON}N1		T_J = -40 to 85°C		0.5	1.0	Ω
Inverting converter section						
V_{O2}	Output negative voltage range	10 different values set by S-wire pin (see *Table 9*)	-2.3		-5.9	V
V_{O2} def.	V_{O2} default value	Default output voltage	-4.80	-4.9	-5.00	V
V_{O2} Toll.	V_{O2} tolerance	Output voltage variation with respect to nominal V_O selected		±2		%
ΔV_{O2}	Static line regulation (3)	V_{INA}=2.5V to 4.5V, I_{O2}=5mA, I_{O1} no load; T_J=-40°C to 85°C		+ 1		%
		V_{INA}=2.5V to 4.5V, I_{O2}=100mA, I_{O1} no load, T_J=-40°C to 85°C		+ 1		%
$\Delta V_{O1\ LT}$	Line transient	V_{INA}=3.5V to 3.0V, I_{O2}=100mA T_J=-40°C to 85°C, T_R=T_F=50µs output voltage variation with respect to nominal V_{O2}		+30		mV
ΔV_{O2}	Static load regulation (4)	I_{O2}=5 to 100mA, I_{O1} no load, V_{INA}=2.5V; T_J=-40°C to 85°C		+ 1		%
		I_{O2}=5 to 100mA, I_{O1} no load, V_{INA}=4.5V; T_J=-40°C to 85°C		+ 1		
ΔV_{O2t}	Load transient regulation	I_{O2}=3 to 30mA and I_{O2}=30 to 3mA, T_R=T_F=30µs, output voltage variation with respect to nominal V_{O2}		±40	±80	mV
ΔV_{O2e}	Load transient regulation HC	I_{O2}=10 to 100mA and I_{O2}=100 to 10mA, T_R=T_F=30µs		±30	±50	mV

Table 6. Electrical characteristics (continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
ΔV_{O2}	Ripple output voltage range	I_{O2}=5 to 100mA 0.5Vpp pulse signal applied to V_I at 200Hz; TDMA Noise			25	mV
I_{O2s}	Maximum inverting output current	V_{INA}=2.5V to 2.9V			-120	mA
I_{O2}	Maximum inverting output current	V_{INA}=2.9V to 4.5V			-150	mA
$I\text{-}L_{2MAX}$	I_{peak} current	V_{O2} below 10% of value set by S-wire		-1.2	-1.1	A
$R_{DSON}P2$		T_J = -40 to 85°C		0.4	2.0	Ω
$R_{DSON}N2$		T_J = -40 to 85°C		0.4	1.0	Ω
Thermal shutdown						
OTP	Over temperature protection			140		°C
OTP_{HYST}	Over temperature protection hysteresis			15		°C
Discharge resistor						
R_{DIS}	Discharge resistor value			600		Ω
T_{DIS}	Discharge time			6		ms

1. $[(V_{O1MAX} - V_{O1MIN}) / (V_{O1}$ at 25°C and V_{INA} = 2.5 V)] x 100
2. $[(V_{O1MAX} - V_{O1MIN}) / (V_{O1}$ at 25°C and I_{O1} = 5 mA)] x 100
3. $[(V_{O2MAX} - V_{O2MIN}) / (V_{O2}$ at 25°C and V_{INA} = 2.5 V)] x 100
4. $[(V_{O2MAX} - V_{O2MIN}) / (V_{O2}$ at 25°C and I_{O2} = 5 mA)] x 100

6 S-wire protocol

Figure 4. S-wire protocol

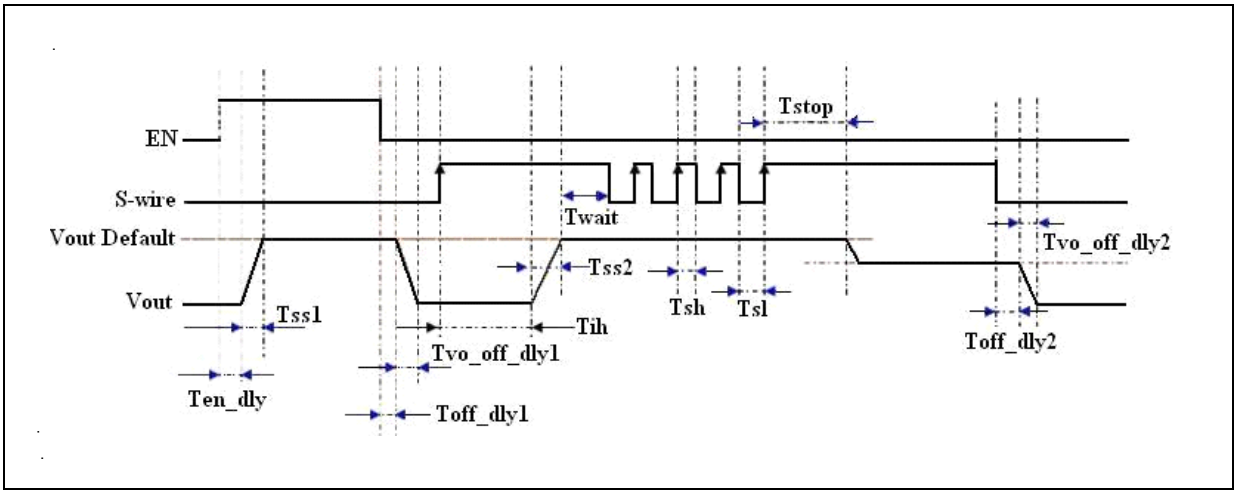


Table 7. Time

Rating	Symbol	Min.	Typ.	Max.	Unit
Enable high delay time	Ten_dly		300		µs
Soft-start delay	Tss1		2		ms
Turn-off delay	Toff_dly1		50		µs
V_O turn-off delay	Tvo_off_dly1		12		ms
S-Wire initial time	Tih		300	400	µs
Soft-start time by S-wire enable	Tss2		2	3	ms
S-Wire High	Tsh	2	20	45	µs
S-Wire Low	Tsl	2	20	75	µs
S-Wire signal stop indicate time	Tstop	300		400	µs
V_O turn-off delay by S-Wire	Tvo_off_dly2		12	related to load	ms
Twait after data	Twait		0	10	µs
S-Wire turn-off detection time	Toff_dly2	300		400	µs

Figure 5. Waveform

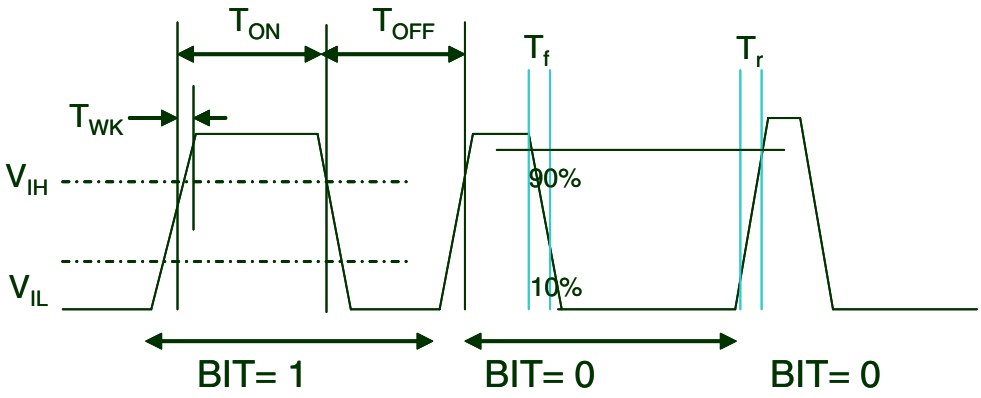


Table 8. Time

Rating	Symbol	Min.	Typ.	Max.	Unit
Rising input high threshold voltage level	V_{IH}	1.2		V_{INA}	V
Falling input high threshold voltage level	V_{IL}	0		0.6	V
Pull down resistor	R_{S-WIRE}		150		kΩ
Wake up delay	T_{WK}			1	µs
S-Wire rising time	T_r			200	ns
S-Wire falling time	T_f			200	ns
Clocked s-wire high	T_{ON}	2		45	µs
S-wire low	T_{OFF}	2		75	µs
Input S-Wire frequency	F_{S-WIRE}			400	kHz

Table 9. Inverting output voltages

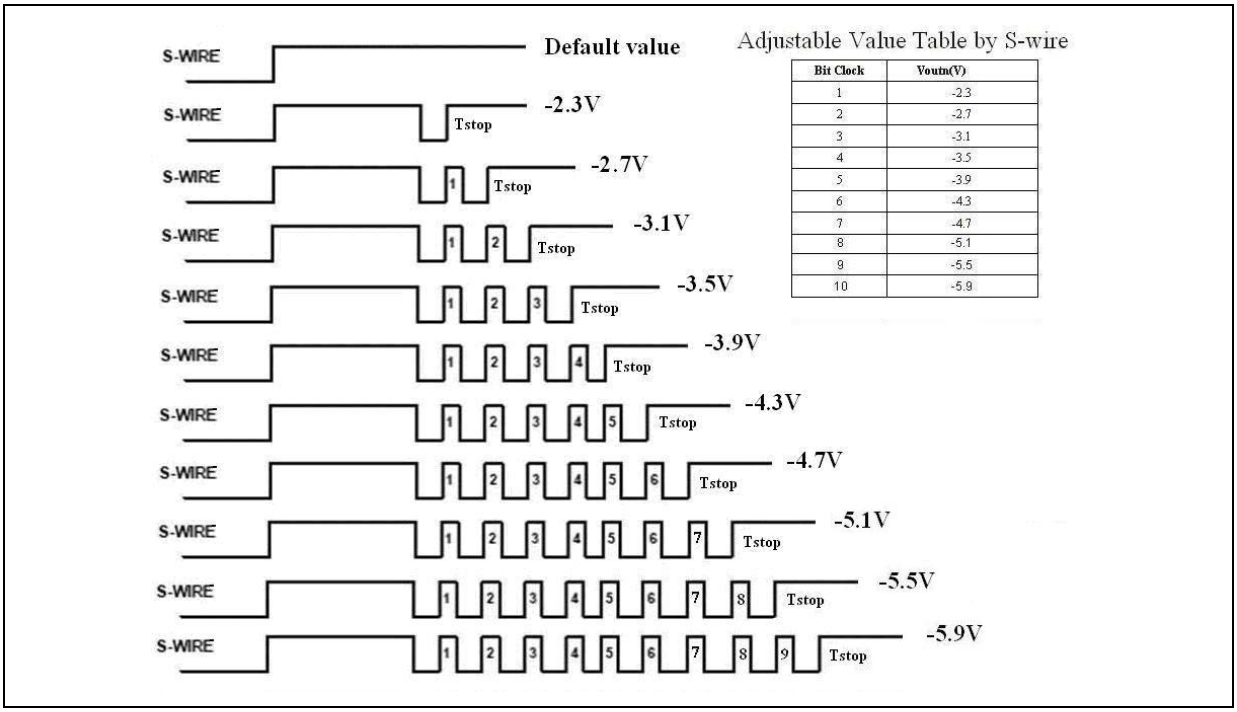
Bit clock	V_{O2} (V)
1	-2.3
2	-2.7
3	-3.1
4	-3.5
5	-3.9
6	-4.3
7	-4.7
8	-5.1
9	-5.5
10	-5.9

Table 10. Enable and s-wire pin settings

Enable	S-wire	Action
0	0	Device off
0	1	Output set by S-Wire
1	0	Default value output (- 4.9 V)
1	1	Default value output (- 4.9 V)

Note: Enable pin must be set to GND while using S-wire function.

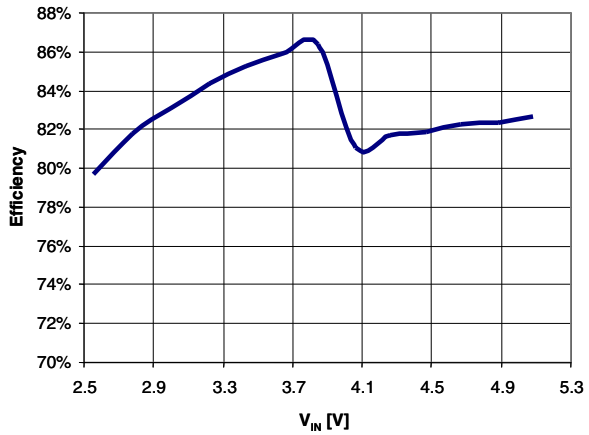
Figure 6. Single wire programming



7 Typical performance characteristics

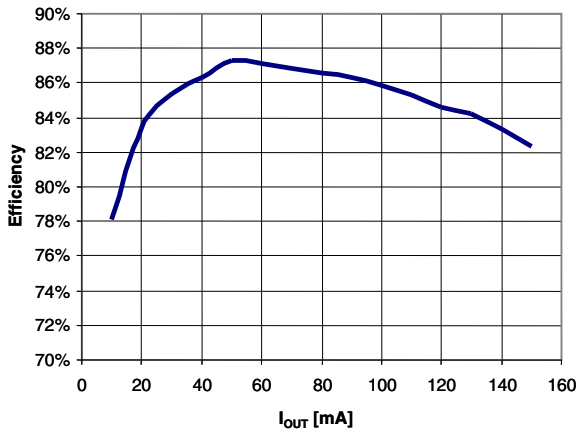
$C_I = C_{O1,2} = 4.7\ \mu F$, $C_{REF} = 1\ \mu F$, $L_1 = L_2 = 4.7\ \mu H$, $T_J = 25\ °C$

Figure 7. Efficiency vs. input voltage



Efficiency values are measured using MARUWA CXFU0208-4R7 (0.44 Ω DC resistance)

Figure 8. Efficiency vs. output current



Efficiency values are measured using MARUWA CXFU0208-4R7 (0.44 Ω DC resistance)

Figure 9. Step-up inductor peak current vs. input voltage

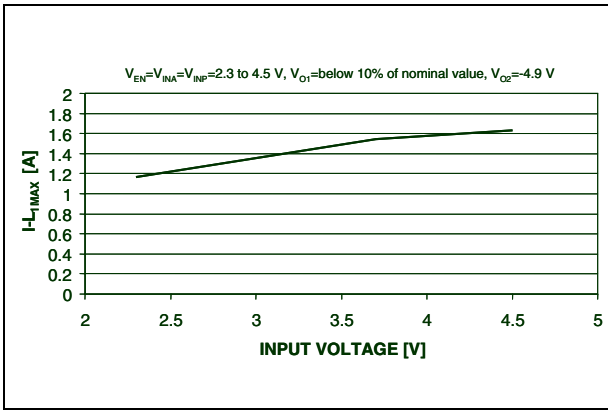


Figure 10. Inverting inductor peak current vs. input voltage

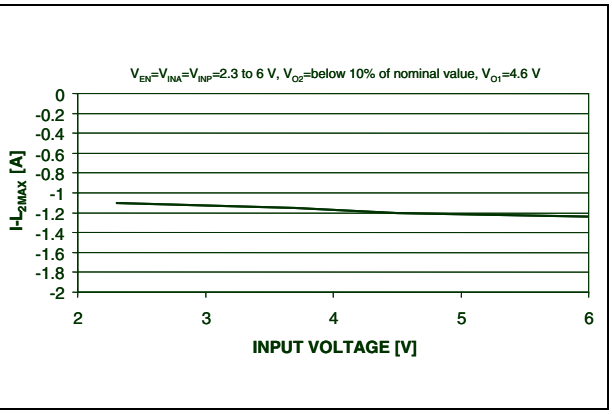


Figure 11. PWM step-up frequency vs. temperature

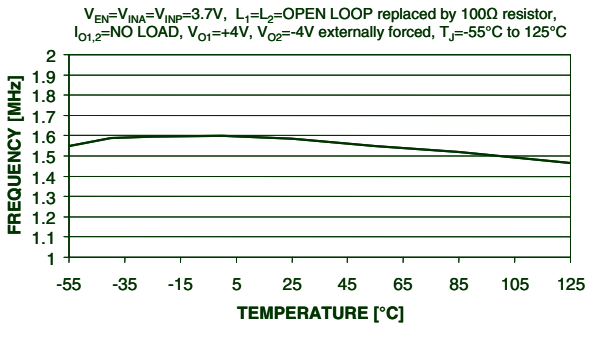


Figure 12. PWM inverting frequency vs. temperature

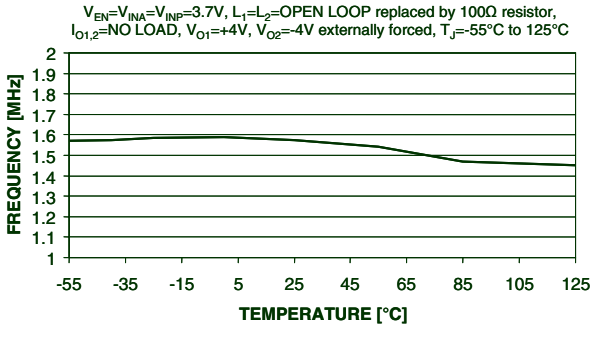
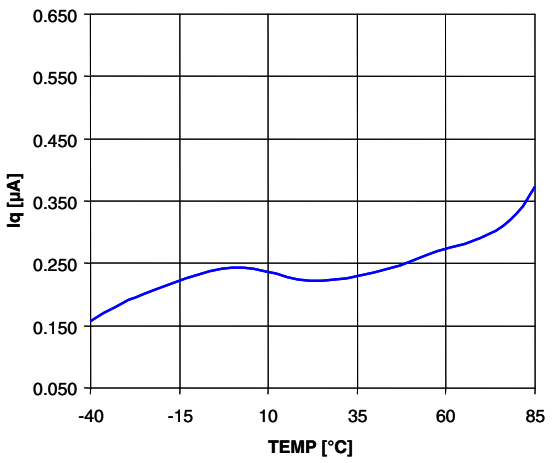
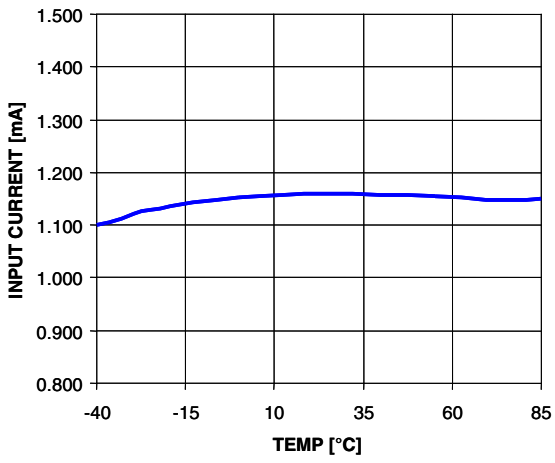


Figure 13. Quiescent current vs. temperature



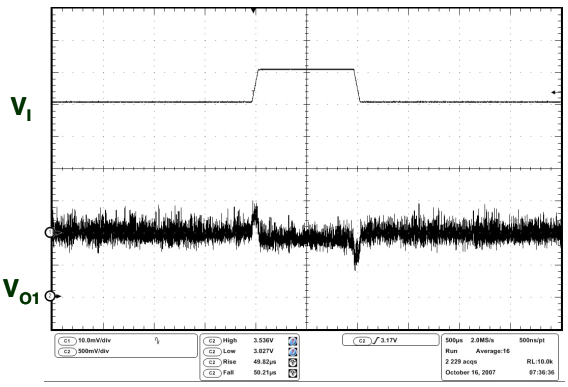
V_{EN}=GND, V_{INA}=V_{INP}=3.7V

Figure 14. Input current vs. temperature



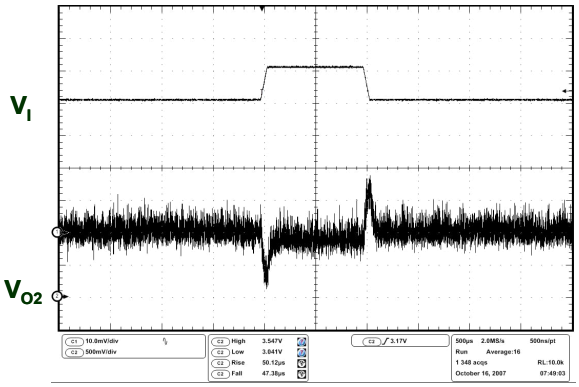
V_{EN}=V_{INA}=V_{INP}=3.7V, I_{O1}=I_{O2}=NO LOAD, V_{O1}=4.6V, V_{O2}=-4.9V

Figure 15. Step-up line transient regulation



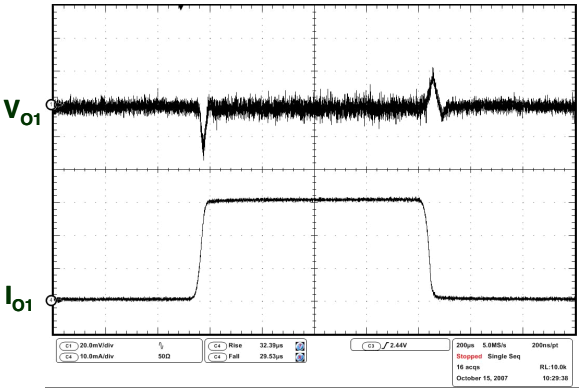
V_{EN}=V_{INA}=V_{INP}=3.5V to 3V, I_{O1}=100mA, I_{O2}=NO LOAD, V_{O1}=4.6V, V_{O2}=-4.9V, T_R=T_F=50µs

Figure 16. Inverting line transient regulation



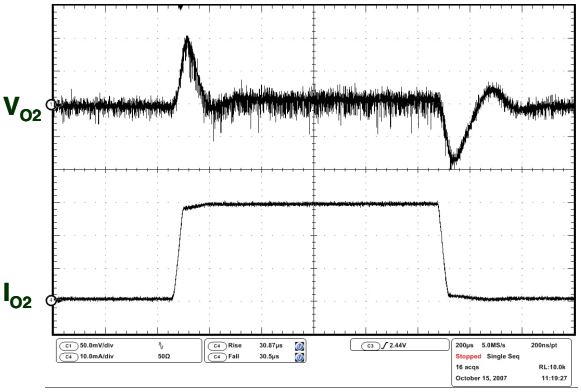
V_{EN}=V_{INA}=V_{INP}=3.5V to 3V, I_{O1}=NO LOAD, I_{O2}=100mA, V_{O1}=4.6V, V_{O2}=-4.9V, T_R=T_F=50µs

Figure 17. Step-up load transient regulation



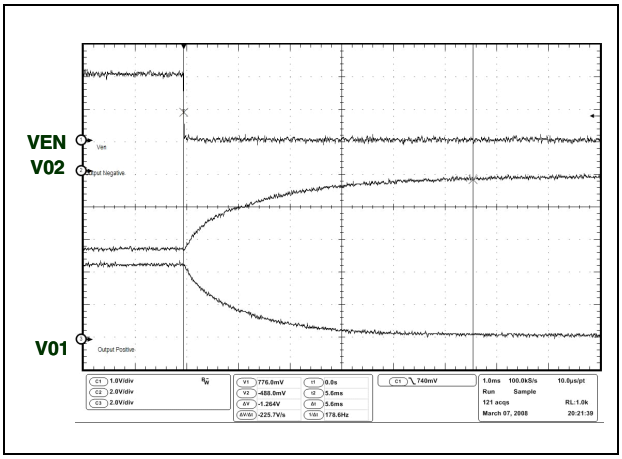
V_{EN}=V_{INA}=V_{INP}=3.7V, I_{O1}=3 to 30mA & I_{O1}=30 to 3mA, V_{O1}=4.6V, V_{O2}=-4.9V, I_{O2}=NO LOAD, T_R=T_F=30µs

Figure 18. Inverting load transient regulation



V_{EN}=V_{INA}=V_{INP}=3.7V, I_{O2}=3 to 30mA & I_{O2}=30 to 3mA, V_{O1}=4.6V, V_{O2}=-4.9V, I_{O1}=NO LOAD, T_R=T_F=30µs

Figure 19. Fast discharge



8 Demonstration board

Figure 20. Suggested demonstration board schematic (top layer view)

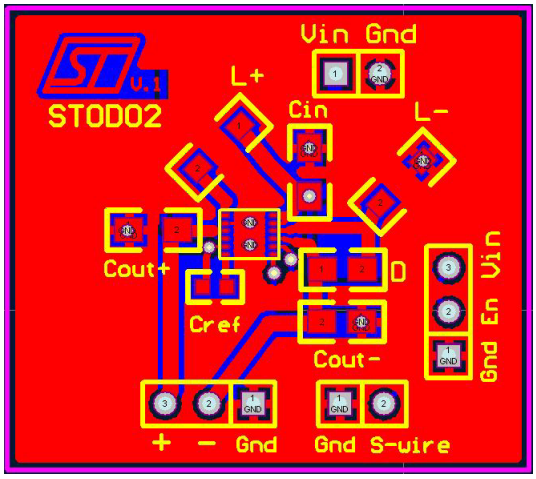
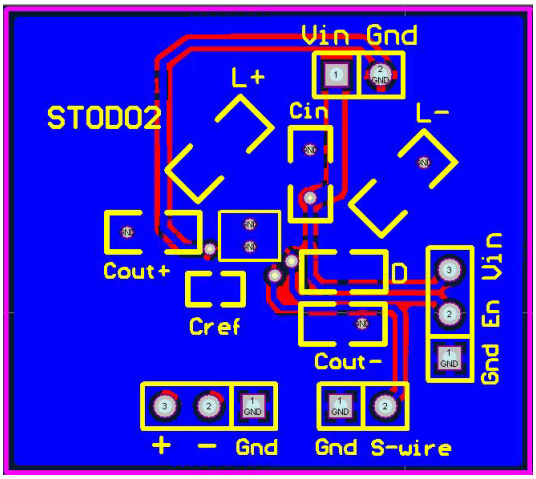


Figure 21. Suggested demonstration board schematic (bottom layer view)



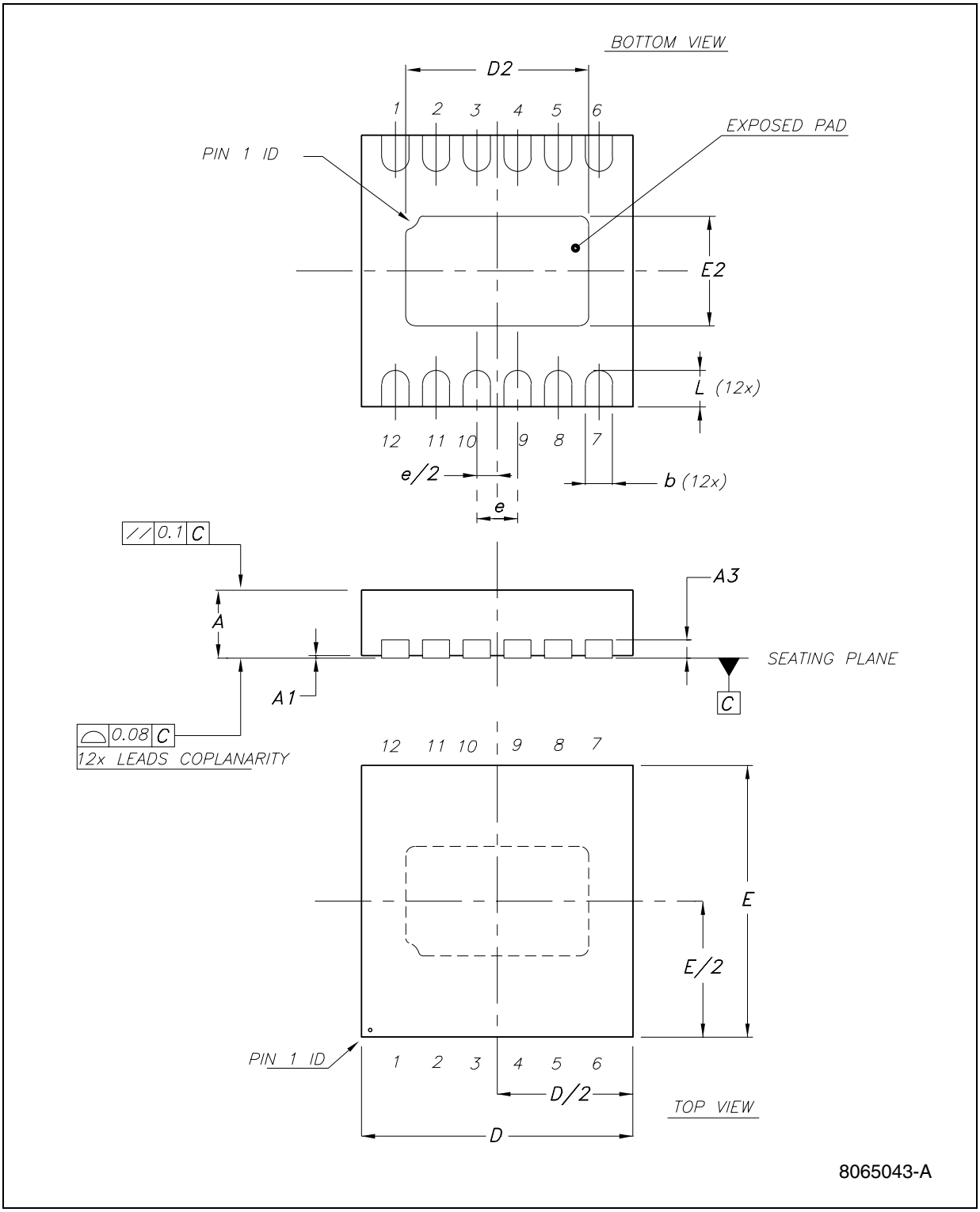
9 Package mechanical data

In order 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*. ECOPACK® is an ST trademark.

Table 11. DFN12L (3 x 3 x 0.8 mm) mechanical data

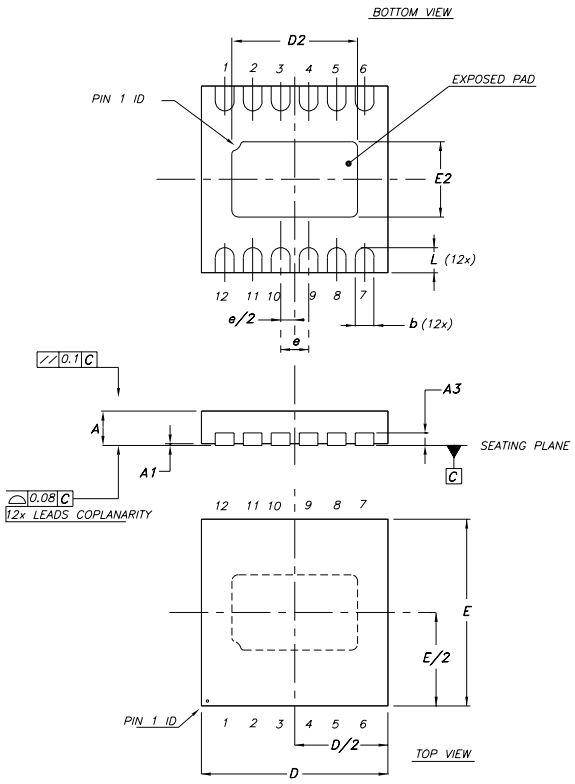
Dim.	mm.		
	Min.	Typ.	Max.
A	0.70	0.75	0.80
A1	0	0.02	0.05
A3		0.20	
b	0.18	0.25	0.30
D	2.85	3	3.15
D2	1.87	2.02	2.12
E	2.85	3	3.15
E2	1.06	1.21	1.31
e		0.45	
L	0.30	0.40	0.50

Figure 22. Drawing dimension DFN12L (3 x 3 x 0.8 mm)



DFN12L (3 x 3 x 0.6 mm) mechanical data

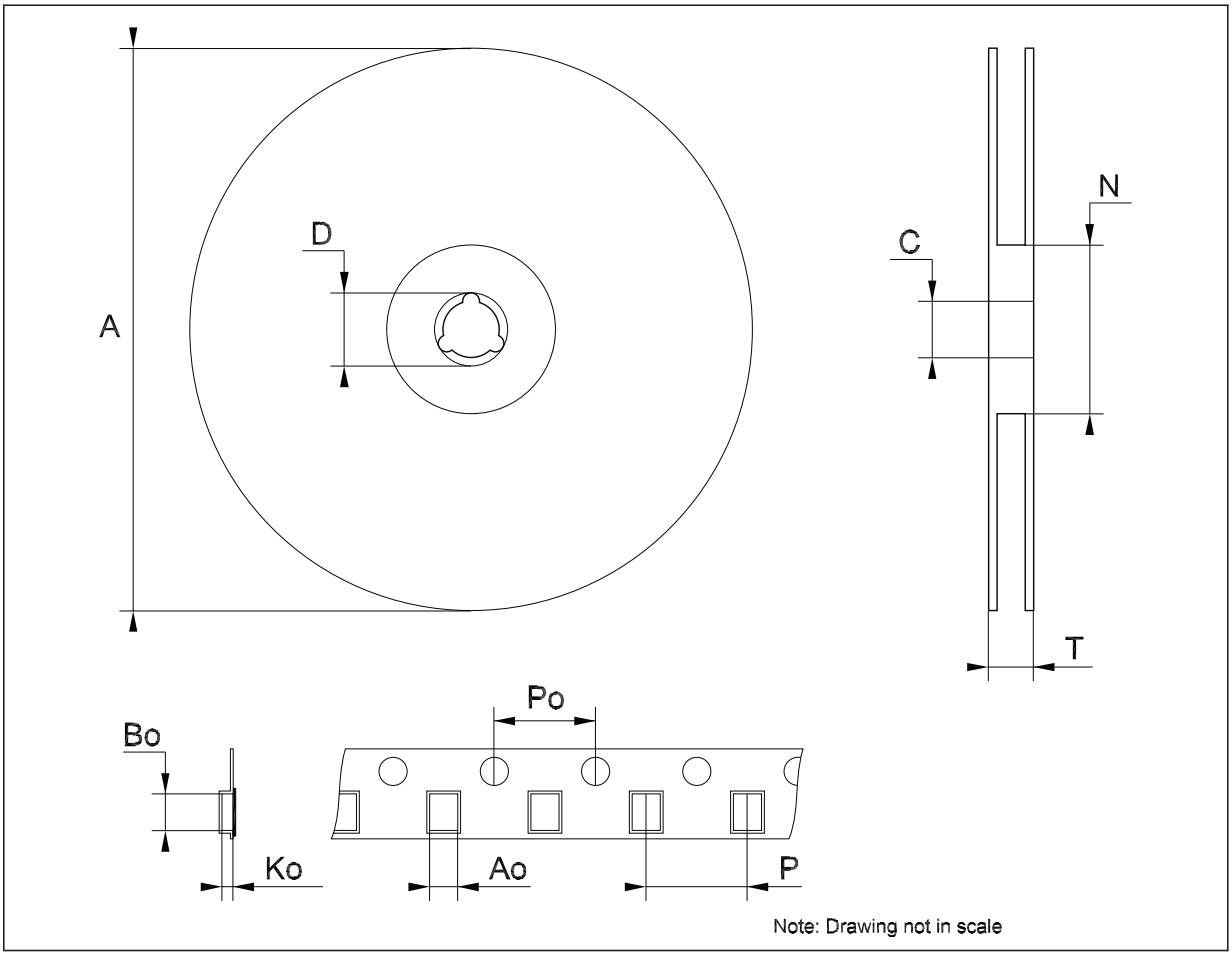
Dim.	mm.			inch.		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	0.51	0.55	0.60	0.020	0.022	0.024
A1	0	0.02	0.05	0	0.001	0.002
A3		0.20			0.008	
b	0.18	0.25	0.30	0.007	0.010	0.012
D	2.85	3	3.15	0.112	0.118	0.124
D2	1.87	2.02	2.12	0.074	0.080	0.083
E	2.85	3	3.15	0.112	0.118	0.124
E2	1.06	1.21	1.31	0.042	0.048	0.052
e		0.45			0.018	
L	0.30	0.40	0.50	0.012	0.016	0.020



8085116/A

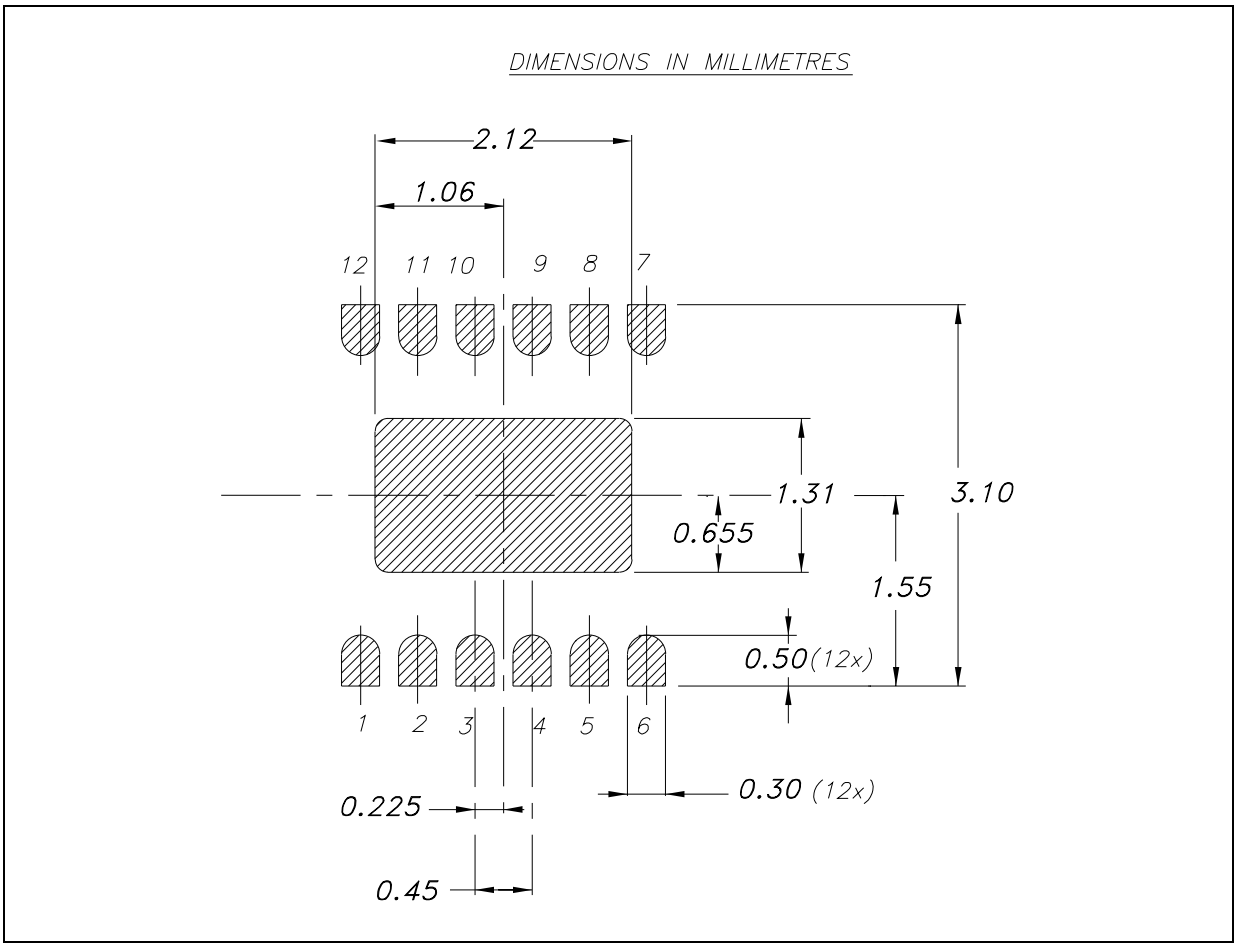
Tape & reel QFNxx/DFNxx (3x3) mechanical data

DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A			330			12.992
C	12.8		13.2	0.504		0.519
D	20.2			0.795		
N	99		101	3.898		3.976
T			14.4			0.567
Ao		3.3			0.130	
Bo		3.3			0.130	
Ko		1.1			0.043	
Po		4			0.157	
P		8			0.315	



Note: Drawing not in scale

Figure 23. DFN12L (3 x 3 mm) footprint recommended data



10 Revision history

Table 12. Document revision history

Date	Revision	Changes
05-Dec-2008	1	Initial release.
15-Dec-2008	2	Added: pin description exposed pad *Table 2 on page 4*.
30-Jun-2009	3	Modified: *Table 2 on page 4*.

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