20A Fully Integrated Synchronous Boost Converter

DESCRIPTION

The MT5083 is a high efficiency fully integrated synchronous Boost converter with built-in main switch and synchronous switch. The device has 20A switch peak current capability and provides output voltage up to 30V. Synchronous rectification increases efficiency, reduces power losses and eases thermal requirements, allowing the MT5083 to be used in high power step-up applications. The 3V to 30V input voltage range supports a wide range of battery and AC powered inputs. The 70μA no load quiescent current extends operating run time in battery-powered systems. The operating frequency can be externally set for a 50kHz to 1MHz range, as for operation mode:

▪Mode pin: Low is automatic PSM/PWM mode.

▪Mode pin: High is Forced PWM mode.

The MT5083 implements a programmable soft-start function, an adjustable cycle by cycle switching peak current limit function and thermal shutdown protection. The MT5083 is available in a small 22 pin 4mm×4mm QFN package.

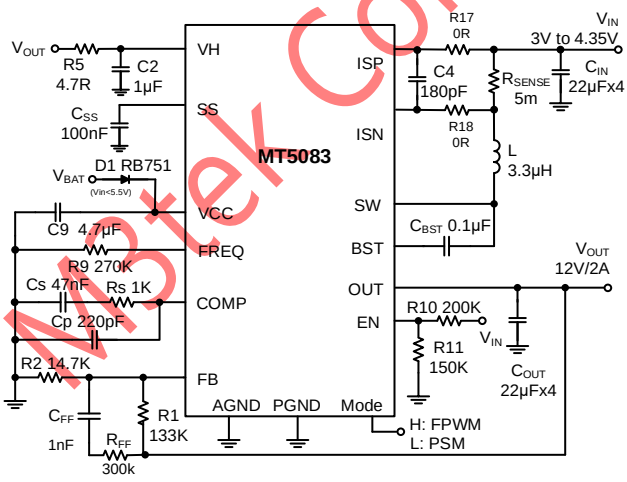
FEATURES

- MT5083: 3V to 30V Input Range
  3V to 30V Output Voltage
  Integrated 30V Rating 12mΩ Main and Synchronous Power Switches with 20A Peak Current Capability
- Adjustable Input UVLO through EN pin
- Low Quiescent Current 70μA
- Low Shutdown Supply Current 3.5μA
- Resistor or Inductor DCR Current Sensing
- Adjustable Frequency from 50kHz to 1MHz
- Programmable Soft-start
- Programmable Mode
  High: FPWM; Low: PSM/PWM
- Cycle-by-Cycle Current Limit
- Thermal Shutdown
- QFN4×4_22L Packages
- Pb-Free ROHS compliant

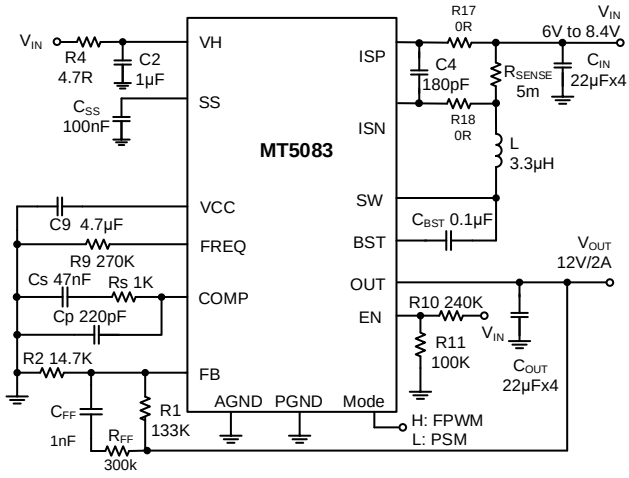
APPLICATIONS

- USB TypeC-PD and Thunderbolt Port for PCs
- Industrial Battery Powered POS Terminals
- Quick Charge Power Banks
- Electronic Cigarette
- Hi Power Bluetooth Speaker

TYPICAL APPLICATIONS



1-Cell Application



2-Cell Application

For example: Build 5V nominal output voltage from the minimum 3V input supply voltage. Select switching frequency 600kHz. Choose output capacitor to get less than 50mV ripple (1% of V_{OUT}) at maximum 4Amp output current. The minimum output capacitor is 53µF required to limit the output voltage ripple.

$$C_{OUT} \geq \frac{I_{OUT\max} \times D_{\max}}{\Delta V_{OUT} \times f_{OSC}} = \frac{4A \times \frac{5V-3V}{5V}}{5V \times 1\% \times 600kHz} = 53\mu F$$

Multiple capacitors placed in parallel may be needed to meet the ESR and RMS current handling requirements. Ceramic capacitors have excellent low ESR characteristics but can have a DC Bias effect, which will have a strong influence on the final effective capacitance. Capacitance deratings for aging,temperature and dc bias increase the minimum value required. The voltage rating must be greater than theoutput voltage with some tolerance for output voltage ripple and overshoot in transient conditions. For thisexample 4 x 22µF, 25V ceramic capacitors with 5 mΩof ESR are used. The 40% derated capacitance is52.8µF, approximately equal to the calculated minimum.

Setting Output Voltage

The MT5083 output voltage is set by an external feedback resistor divider carefully placed across the output, as shown in Figure 6. Great care should be taken to route the VFB line away from noise sources, such as the inductor or the SW line. Also, keep the FB trace as short as possible to avoid noise pickup. The typical value of the voltage on the FB pin is 1.203V. The maximum allowed value for the output voltage is 30V. Choose the bottom resistor R_{FB_BOT} in the 2kΩ~200kΩ range to set the divider current at 6µA or higher. Typically select R_{FB_BOT}=100kΩ. The value of top resistor R_{FB_TOP}, depending on the needed output voltage V_{OUT}, can be calculated usingEquation 10:

$$R_{FB\_TOP} = R_{FB\_BOT} \times \left(\frac{V_{OUT}}{V_{FB}} - 1 \right) = 100k\Omega \times \left(\frac{V_{OUT}}{1.203V} - 1 \right) \quad \text{(Equation 10)}$$

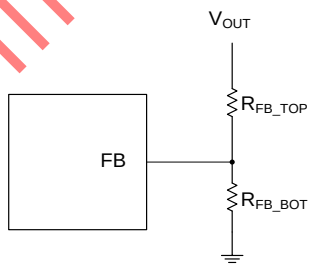


Figure 6. Output Voltage Setting

The Control Loop Compensation

The series R_C-C_C filter at COMP pin sets the dominant pole-zero loop compensation. The resistor R_C in series with a capacitor C_C creates a compensating zero. A capacitor C_{C1}in parallel to these two components can be added to form a compensating pole. In a step-up topology, the maximum crossover frequency is typically limited by the right-half plane zero (RHPZ). The compensation design should be done at the minimum input voltage and full load when the RHPZ is at the lowest frequency. The crossover frequency should also be limited to less than1/4 of the RHPZ frequency.

Table 1. Gives R_C, C_C and C_{C1}values for certain inductors, input and output voltages providing a very stable system. For a faster response time, a higher R_C value can be used to enlarge the bandwidth, as well as a slightly lower value of C_C to keep enough phase margin. These adjustments should be performed in parallel with the load transient response monitoring of MT5083.

Table 1. Recommended Compensation Network Values

Application	I_{OUT_MAX}	F_{SW}	Inductor	R_{SENSE}	C_{IN}	C_{OUT}	R_C	C_C and C_{C1}
1-Cell step-up to 5V Vin Range: 3V~4.35V	5A	250kHz	3.3μH ISAT=14.5A	5mΩ	4*22μF 16V	4*22μF 16V	1kΩ	C_C=47nF C_{C1}=220pF
1-Cell step-up to 9V Vin Range: 3V~4.35V	3A	250kHz	3.3μH ISAT=14.5A	5mΩ	4*22μF 25V	4*22μF 25V	1kΩ	C_C=47nF C_{C1}=220pF
1-Cell step-up to 12V Vin Range: 3V~4.35V	2A	250kHz	3.3μH ISAT=14.5A	5mΩ	4*22μF 25V	4*22μF 25V	1kΩ	C_C=47nF C_{C1}=220pF
2-Cell step-up to 12V Vin Range: 6V~8.4V	2A	250kHz	3.3μH ISAT=14.5A	5mΩ	4*22μF 25V	4*22μF 25V	1kΩ	CC=47nF C_{C1}=220pF

Thermal information

Implementation of integrated circuits in low-profile and fine-pitch surface-mount packages typically requires special attention to power dissipation. Many system-dependent issues such as thermal coupling, airflow, added heat sinks and convection surfaces, and the presence of other heat-generating components affect the power-dissipation limits of a given component.

Three basic approaches for enhancing thermal performance are listed below:

- Improve the power dissipation capability of the PCB design
- Improve the thermal coupling of the component to the PCB
- Introducing airflow in the system

The maximum junction temperature (T_J) of the MT5083 devices is 160°C and worse case won't excess 145°C, The thermal resistance of the 20-pin QFN package is θ_{JA}= 50°C/W, if the Exposed PAD is soldered. Specified regulator operation is assured to a maximum ambient temperature T_A of +85°C. Therefore, the maximum power dissipation for the 20-pin QFN package it is about 1W.More power can be dissipated if the maximum ambient temperature of the application is lower.

$$P_{D(MAX)} = \frac{T_{J(MAX)} - T_A}{R_{\theta JA}} = \frac{145°C - 85°C}{50°C/W} = 1.2W$$

PCB Layout Recommendation

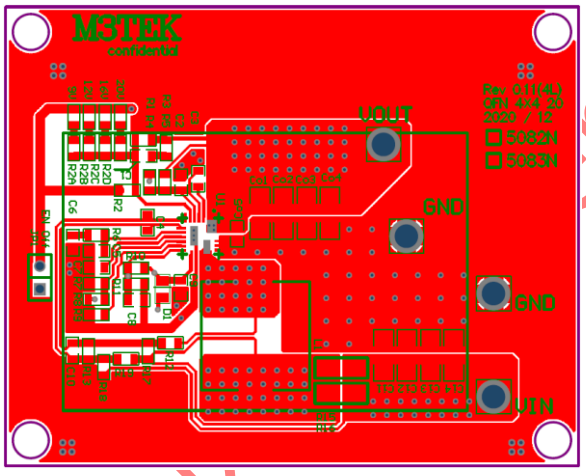
For designing the MT5083 a boost power supply, especially those operating at high output voltage and current application, PCB layout is a very important in design step. To prevent radiation of high frequency noise (for example,

EMI), proper layout of the high-frequency switching path is essential. Minimize the length and area of all traces connected to the SW pin to reducing the high frequency noise of coupling to GND plane to cause EMI or power system unstable.

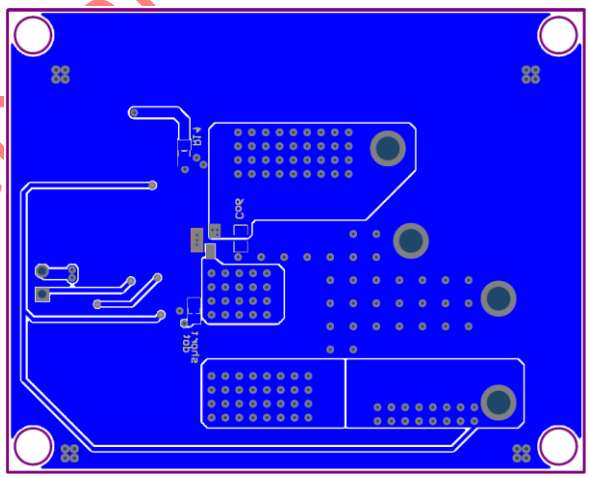
Check the following layout rules:

1. Put the input capacitors GND, output capacitors GND and the PGND of MT5083 in the same of power plane to reduce impedance to avoid EMI and increase efficiency of power system.
2. The GND and PGND kept separate and used dot short skill to avoid noise coupling to GND to cause power system unstable as MT5083 EV board PCB design.
3. ISP and ISN trace routing like a differential pail to shielding each other to filter the common mode noise. And far away the SW trace to avoid to be coupled that will cause the current limit protection circuit fault. Ensure accurate current sensing with Kelvin connections at the sense resistor or the DCR of inductor.
4. Keep the switching node (SW and PGND) and boost node (BST) away from sensitive small-signal nodes.

MT5083 QFN4x4-22L



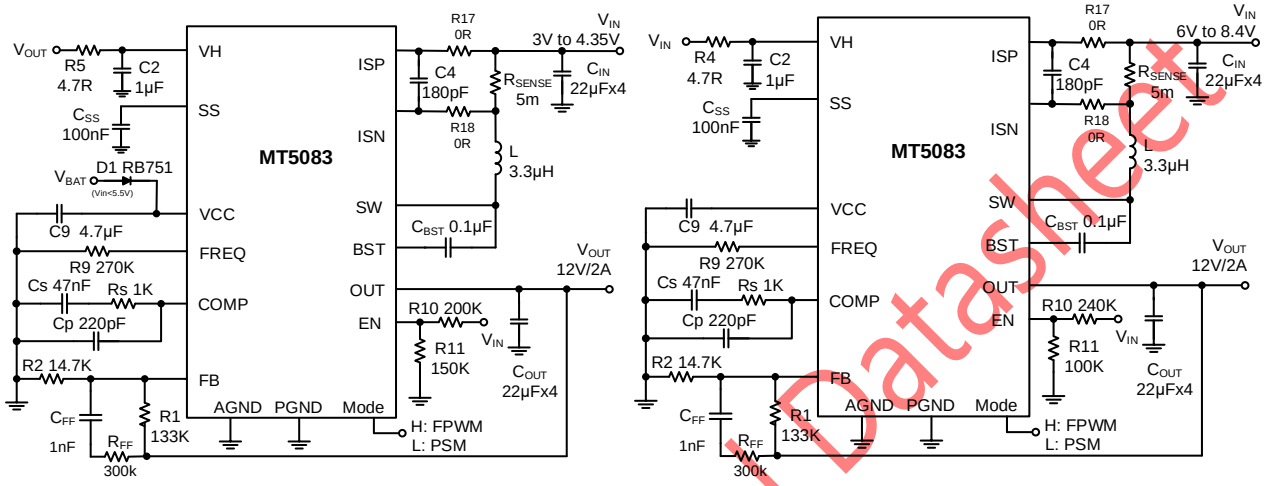
Top Layer



Bottom Layer

MT5083 Application Schematic

Current Sensing Resistor:



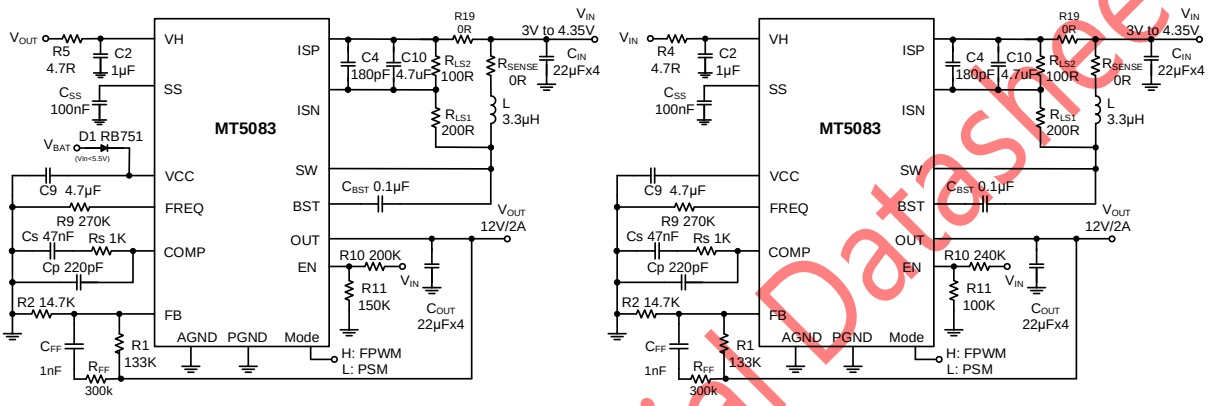
1-Cell Application 2-Cell Application

Application EVB BOM List

Qty	Ref	Value		Description	Package
4	C_{IN}	22uF		Ceramic Capacitor, 35V, X5R	1206
4	C_{OUT}	22uF		Ceramic Capacitor, 35V, X5R	1206
1	L	3.3µH		Inductor, 3.3µH DCR=9mΩ,744314330 R sense ,5mΩ, PA1206FRE470R005L	SMD
1	R1	133kΩ		Resistor, ±1%	0603
1	R2	Vout=5V	42.2kΩ	Resistor, ±1%	0603
		Vout=9V	20.5kΩ		
		Vout=12V	14.7kΩ		
		Vout=20V	8.45kΩ		
1	R3(R_{FF})	300kΩ		Resistor, ±1%	0603
1	R5($V_{BAT<5.5V}$ VH connect Vout)	4.7Ω		Resistor, ±1%	0603
1	R4($V_{BAT>5.5V}$ VH connect V_{BAT})	4.7Ω		Resistor, ±1%	0603
1	R6(Rs)	1kΩ		Resistor, ±1%	0603
1	R10($V_{BAT<5.5V}$)	200 kΩ		Resistor, ±51%	0603
1	R11($V_{BAT<5.5V}$)	150 kΩ		Resistor, ±5%	0603
1	R10($V_{BAT>5.5V}$)	240kΩ		Resistor, ±1%	0603
1	R11($V_{BAT>5.5V}$)	100kΩ		Resistor, ±1%	0603
1	R9	270kΩ		Resistor, ±1%	0603
2	R17,R18	0Ω		Resistor, ±1%	0603
1	R15(R_{SENSE})	5mΩ		Resistor, ±1%	1206
1	C2	1uF		Ceramic Capacitor, 50V, X5R	0603
1	C4	180pF		Ceramic Capacitor, 50V, X5R	0603
1	C9	4.7uF		Ceramic Capacitor, 10V, X5R	0603

1	C1(C_{FF})	1nF	Ceramic Capacitor, 10V, X5R	0603
2	C3(C_{BST}),C7(Css)	0.1uF	Ceramic Capacitor, 50V, X5R	0603
1	C5(Cp)	220pF	Ceramic Capacitor, 10V, X5R	0603
1	C6(Cs)	47nF	Ceramic Capacitor, 10V, X5R	0603
1	D1($V_{BAT<5.5V}$)	RB751	Diode, RB751	
0	D1($V_{BAT>5.5V}$)	NC	Diode, RB751	
1	Power IC	MT5083	Boost DC/DC Converter	QFN4x4_20L

Current Sensing DCR of Inductor:



1-Cell Application **2-Cell Application**

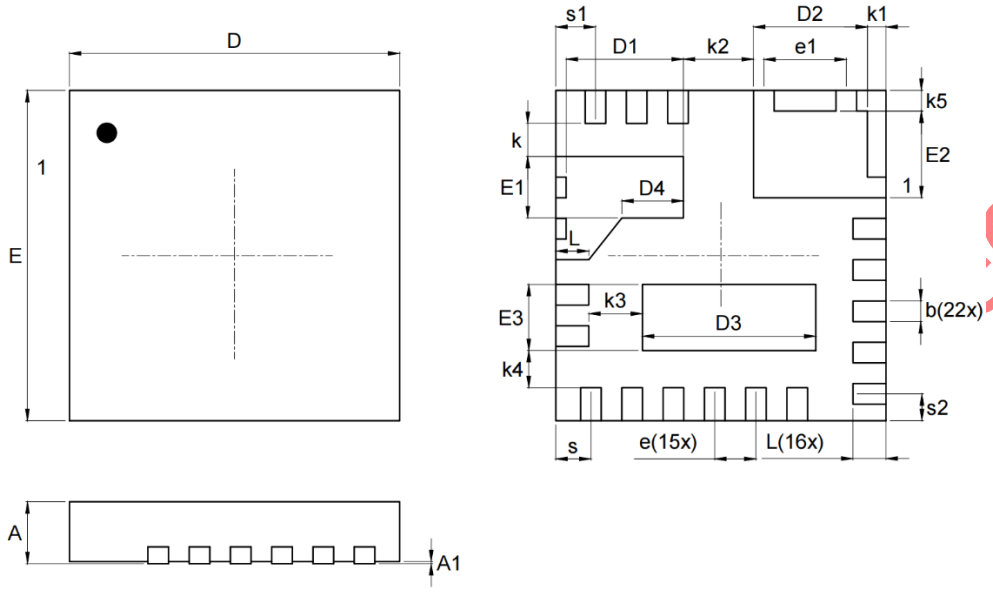
Application EVB BOM List

Qty	Ref	Value		Description	Package
4	C_{IN}	22uF		Ceramic Capacitor, 35V, X5R	1206
4	C_{OUT}	22uF		Ceramic Capacitor, 35V, X5R	1206
1	L	3.3μH		Inductor, 3.3μH DCR=9mΩ,744314330 R sense ,5mΩ, PA1206FRE470R005L	SMD
1	R1	133kΩ		Resistor, ±1%	0603
1	R2	Vout=5V	42.2kΩ	Resistor, ±1%	0603
		Vout=9V	20.5kΩ		
		Vout=12V	14.7kΩ		
		Vout=20V	8.45kΩ		
1	R3(R_{FF})	300kΩ		Resistor, ±1%	0603
1	R5($V_{BAT<5.5V}$ VH connect Vout)	4.7Ω		Resistor, ±1%	0603
1	R4($V_{BAT>5.5V}$ VH connect V_{BAT})	4.7Ω		Resistor, ±1%	0603
1	R6(Rs)	1kΩ		Resistor, ±1%	0603
1	R10($V_{BAT<5.5V}$)	200 kΩ		Resistor, ±51%	0603
1	R11($V_{BAT<5.5V}$)	150 kΩ		Resistor, ±5%	0603
1	R10($V_{BAT>5.5V}$)	240kΩ		Resistor, ±1%	0603
1	R11($V_{BAT>5.5V}$)	100kΩ		Resistor, ±1%	0603
1	R9	270kΩ		Resistor, ±1%	0603
1	R19	0Ω		Resistor, ±1%	0603
1	R15(R_{SENSE})	0Ω		Resistor, ±1%	1206
1	R12(R_{LS1})	200Ω		Resistor, ±1%	0603
1	R13(R_{LS2})	100Ω		Resistor, ±1%	0603
1	C10	4.7uF		Ceramic Capacitor, 25V, X5R	0603
1	C2	1uF		Ceramic Capacitor, 50V, X5R	0603

1	C4	180pF	Ceramic Capacitor, 50V, X5R	0603
1	C9	4.7uF	Ceramic Capacitor, 10V, X5R	0603
1	C1(C_{FF})	1nF	Ceramic Capacitor, 10V, X5R	0603
2	C3(C_{BST}),C7(Css)	0.1uF	Ceramic Capacitor, 50V, X5R	0603
1	C5(Cp)	220pF	Ceramic Capacitor, 10V, X5R	0603
1	C6(Cs)	47nF	Ceramic Capacitor, 10V, X5R	0603
1	D1($V_{BAT<5.5V}$)	RB751	Diode, RB751	
0	D1($V_{BAT>5.5V}$)	NC	Diode, RB751	
1	Power IC	MT5083	Boost DC/DC Converter	QFN4x4_20L

PACKAGING INFORMATION

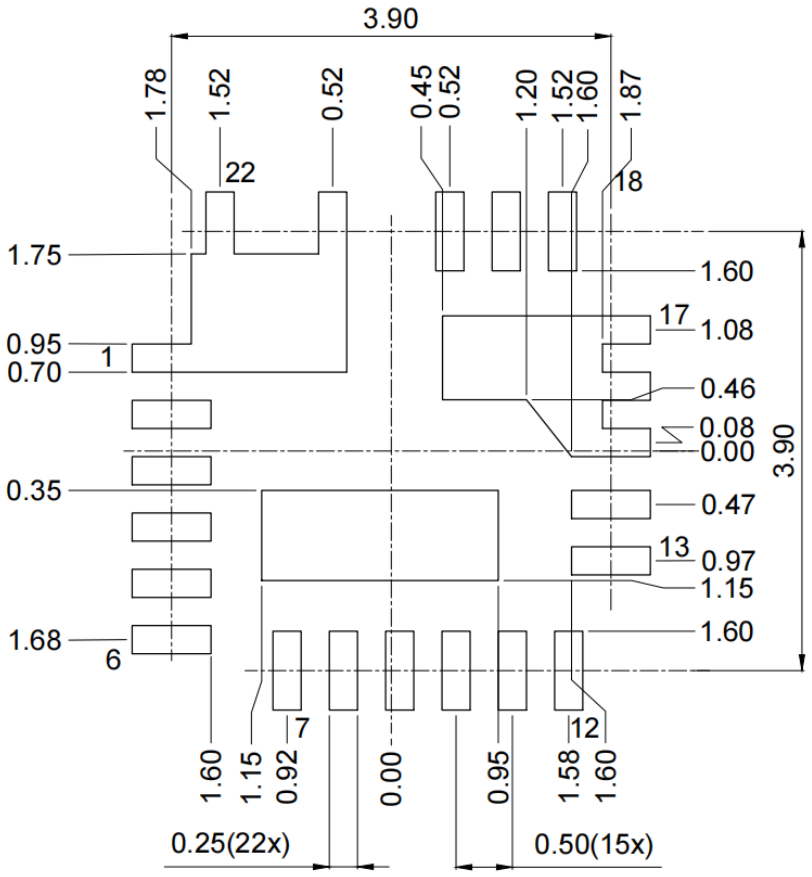
QFN4x4_22L PACKAGE OUTLINE DIMENSIONS



SYMBOLS	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	0.70	0.80	0.028	0.031
A1	0.00	0.05	0.000	0.002
b	0.20	0.30	0.008	0.012
D	3.90	4.10	0.154	0.161
E	3.90	4.10	0.154	0.161
D1	1.37	1.47	0.054	0.058
D2	1.33	1.43	0.052	0.056
D3	2.05	2.15	0.081	0.085
D4	0.73	0.76	0.029	0.030
E1	0.69	0.80	0.027	0.031
E2	1.00	1.10	0.039	0.043
E3	0.75	0.85	0.030	0.033
k	0.35	0.45	0.014	0.018
k1	0.18	0.28	0.007	0.011
k2	0.80	0.90	0.031	0.035
k3	0.60	0.70	0.024	0.028
k4	0.40	0.50	0.016	0.020
k5	0.20	0.30	0.008	0.012
L	0.30	0.50	0.012	0.020
s	0.43 BSC		0.017 BSC	
s1	0.48 BSC		0.019 BSC	
s2	0.33 BSC		0.013 BSC	
e	0.50 BSC		0.020 BSC	
e1	1.00 BSC		0.039 BSC	

LAND PATTERN INFORMATION

QFN4x4_22L



Note:

- Dimensions in mm.
- For reference only.