PA5711
High Voltage LED Driver

FEATURES

- 11V to 480V Input Voltage Range.
- Over 95% Efficiency.
- Drives from 1 to hundreds of LED's in Serial and Parallel combinations.
- Constant LED Drive current.
- Linear or PWM luminance dimming control.
- Light sense and Motion detection inputs to control the LED's.
- Resistor Programmable Oscillator Frequency.
- QFN-16 RoHs Compliant Package.

APPLICATIONS

- General Illumination Displays
- Industrial and Decorative LED Lighting.
- Automotive applications.
- DC/DC or AC/DC LED driver applications.
- Constant current source.
- SMPS switching controller.
- LED back lighting.
- Security, Street and Parking garage lighting.

GENERAL DESCRIPTION

The PA5711 is a High-Efficiency LED driver with multiple dimming options that include Pulse Width Modulation (PWM), Linear dimming (LD), Motion Detection (MD) and Light sense (LS) inputs. PA5711 features a direct gate driver control through an active high enable pin. It has an internal oscillator whose frequency can be set externally through a resistor.

The PA5711 in fly-back mode can be used as a current controlled LED driver (Isolated), driving an LED load at fixed current from a few mA to over 1.4A.

The PA5711 allows the users to introduce the leading edge blanking upon their desired delay requirements, also this can be used to control the Duty cycle of the driver.

The LD pin allows the users to set the threshold beneath the pre-set 280mV, for smaller duty cycle and reduced dissipation across the CS resistors.

The PA5711 has a PWM dimming option that through an externally programmed control signal, with duty ratio 0-100% and a frequency of a few Kilo-hertz, can control the LED brightness.

PA5711 BLOCK DIAGRAM

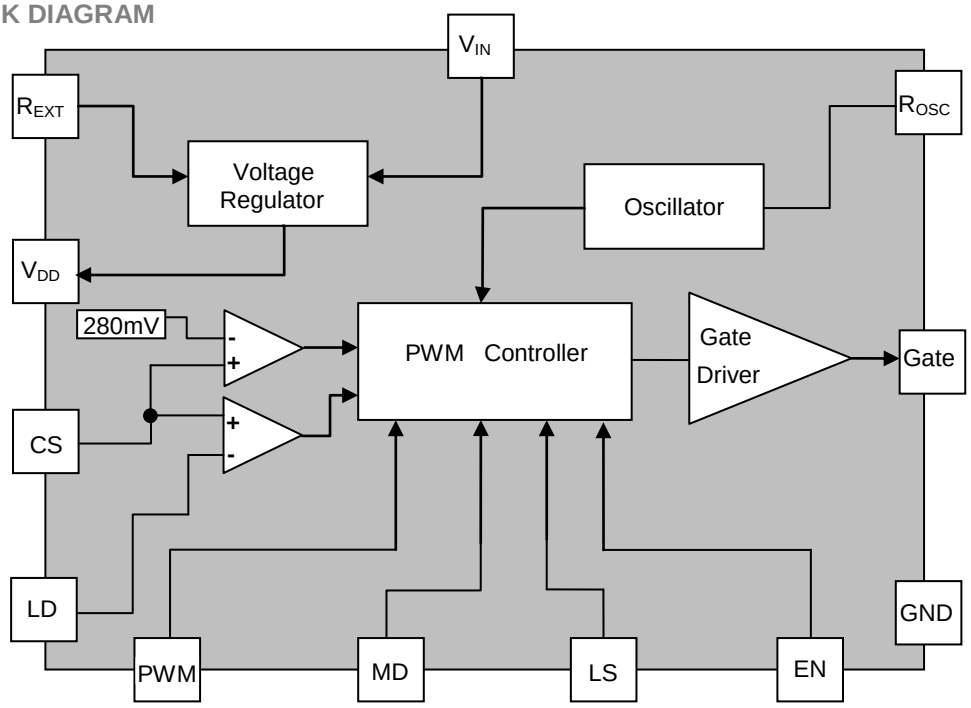


Figure 1. Block diagram

ORDERING INFORMATION

Temperature Range	Package	Part Number
-40 to 85 °C	QFN-16	PA5711-T7

1. SPECIFICATIONS

1.1 Absolute Maximum Rating

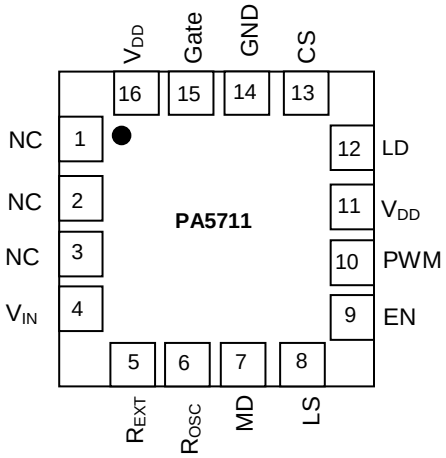
Parameter	Symbol	Max	Unit
Input Voltage	V_{IN}	-0.5 to 500	V
Input and Output voltage to GND	CS, LD, PWM, MD, EN, Gate	-0.3 to V_{DD}+0.3	V
V_{DD}, externally applied	VDD-EXT	8	V
Power Dissipation	P_D	3.45	W
Maximum Junction Temperature	T_{JMAX}	168	°C
Operating Temperature	TA	-40 to +85	°C
Junction temperature (operating)	T_J	-40 to+150	°C
Thermal Resistance Junction to Ambient	Θ_{ja}	12	°C/W
Storage Temperature	T_{STG}	-55 to +150	°C

Note: Continuous operation at or beyond these conditions may permanently damage the device.

1.2 Pin Description

PIN #	NAME	FUNCTION
1	NC	No Connect
2	NC	No Connect
3	NC	No Connect
4	V_{IN}	Supply voltage 11V- 480V
5	R_{EXT}	Pin for current limiting resistor between V_{IN} and $R_{EXT.}$
6	R_{OSC}	Resistor to ground sets the oscillator Frequency.
7	MD	Motion detection signal input; Connect to V_{DD} when unused.
8	LS	Light sense signal input; Connect to GND when unused.
9	EN	Gate driver enable. Connect to V_{DD} to enable the Gate driver output.
10	PWM	PWM input to control the Gate output. Connect to V_{DD} when unused
11	V_{DD}	5V regulated supply voltage output. Requires a storage capacitor to ground. External Voltage source can be connected to power the chip
12	LD	Linear Dimming. Used to reduce the threshold voltage lower than the internal 280mV. Connect to VDD when unused
13	CS	LED Current sense input.
14	GND	Chip Ground
15	Gate	Gate driver Output
16	V_{DD}	5V regulated supply voltage output

1.3 Pin Configuration



Top view of the PA5711

1.4 Electrical Specifications

Parameter	Symbol	Min	Typical*	Max	Units	Conditions
Input DC Voltage Range	V_{INDC}	11		480	V	DC input Voltage into the V_{IN} pin
Shut-Down Mode Supply Current	I_{INsd}		1.3	1.87	mA	EN to GND V_{DD}=5 R_{OSC} = 1MΩ
Internal DC Voltage Regulator	V_{DD}		5		V	V_{IN}=15~450V, $I_{DD(ext)}$=0, Gate output open
Maximum Voltage to V_{DD} Pin	V_{DDmax}			7	V	External voltage applied to V_{DD} pin
V_{DD} Current Available for External Circuitry	$I_{DD(ext)}$			1.0	mA	Limited by package power dissipation
PWM Pull-Down Resistance	R_{EN}	55	70	72	kΩ	V_{PWM} = 5V
Current Sense Threshold Voltage	$V_{CS(high)}$	272	280	304	mV	T=25° C
GATE High Output Voltage	$V_{GATE(high)}$	V_{DD}-0.2		V_{DD}	V	I_{OUT}=10mA VIN =20V
GATE Low Output Voltage	$V_{GATE(low)}$	0		0.2	V	I_{OUT}=-10mA VIN =20V
Oscillator Frequency	f_{OSC}	196	200	204	kHz	R_{OSC} = 150 kΩ
		32	34	35	kHz	R_{OSC} = 1 MΩ
Oscillator PWM Duty Cycle	D	0		100	%	External voltage provided to PWM
Linear Dimming Voltage Range	V_{LD}	0		250	mV	External voltage provided to the LD pin.
Delay from CS Trip to gate low	t_{DELAY}		22.9	24.8	nS	
GATE Output Rise Time	t_{RISE}		25		nS	
GATE Output Fall Time	t_{FALL}		20		nS	
Quiescent current	I_Q	1.4	1.5	1.6	mA	No load, V_{DD}=5
Pin LS input low	$V_{LS(lo)}$			635	mV	V_{DD}=5
Pin LS input high	$V_{LS(hi)}$	630			mV	V_{DD}=5
Pin EN input low	$V_{EN(lo)}$			2.28	mV	V_{DD}=5
Pin EN input high	$V_{EN(hi)}$	2.85			mV	V_{DD}=5
Pin MD input low	$V_{MD(lo)}$			2.38	mV	V_{DD}=5
Pin MD input high	$V_{MD(hi)}$	2.55			mV	V_{DD}=5
Pin PWM input low	$V_{PWM(lo)}$			2.24	mV	V_{DD}=5
Pin PWM input high	$V_{PWM(hi)}$	2.66			mV	V_{DD}=5

**Typical values should not be used for specification limits. TA=25°C unless otherwise specified*

2. FUNCTIONAL DESCRIPTION

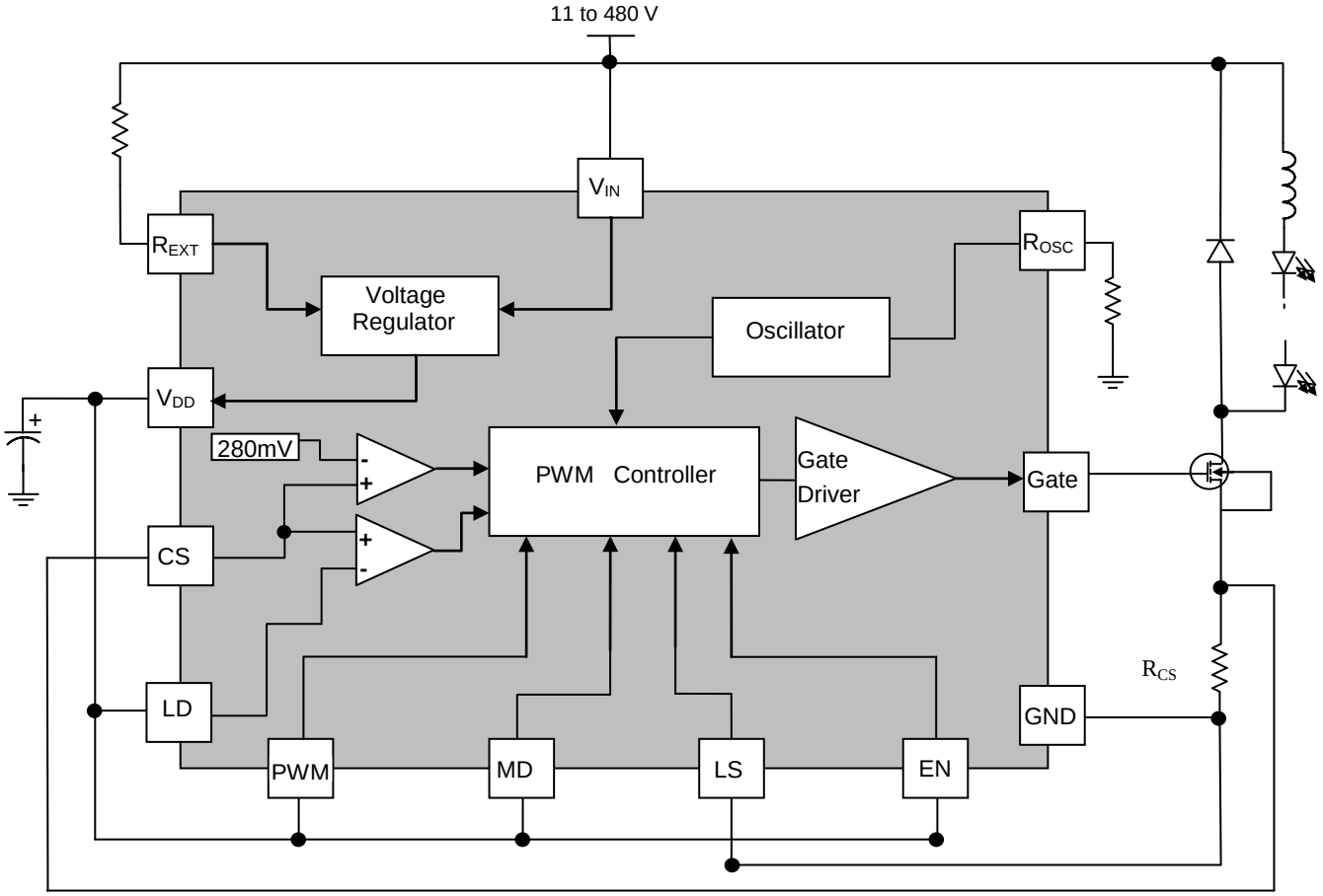


Figure 2. A typical Application Circuit

2.1 Overview

The PA5711 is a high efficiency, low cost, off-line LED driver with multiple inputs for controlling the LED under various environmental conditions. The PA5711 driver utilizes a high voltage process for a broad input voltage range. This flexibility allows for wide range of operation from 11V to 480V DC. This enables the PA5711 to drive the applications such as decorative lighting, signage and RGB back lighting.

The PA5711 in the buck topology (as shown above in Fig.2) is a common choice to use the controller in non isolated LED lighting. The PA5711 can drive multiple LED's in a string or in parallel. This set up provides a good efficiency and constant current drive with minimal external components.

The LED's can be dimmed using voltage 0-250mV on the LD pin or by a low frequency on the PWM.

To save energy by turning the LED's off, the LED's can also be controlled via external signals to MD, LS, and EN pins. The sense resistor at CS controls the peak current thru the LED string.

2.2 LED DRIVER - THEORY OF OPERATION

The gates of PWM, EN, MD, and LD are enabled when they are connected to the VDD pin. The LS must be connected to GND. In such a configuration the LED current is solely controlled by the CS resistor. Each positive edge of the oscillator turns the Gate driver output high, turning on the external MOSFET. This ramps the Inductor current and increases the voltage drop across the CS resistor. When this drop exceeds V_{CS}, the gate driver output is low. This turns off the MOSFET decaying the inductor current until the next positive edge of the clock cycle.

The current threshold limit is set by comparing the voltage developed across R_{CS} to V_{CS}, which is 280mV for the PA5711.This default threshold level can be reduced applying a voltage lower than V_{CS} at the LD pin. The lower of these two thresholds limits the peak current in the inductor.

2.2.1 Voltage Regulator

The PA5711 has an internal voltage regulator that can regulate 11V to 480V input voltage, with an appropriate current limiting resistor at R_{EXT}, down to 5V. The V_{DD} pin needs to have a holding cap of 22µF to provide filtering against bounces and a 0.1µF to by pass any high frequency switching noise. The PA5711 V_{DD} pin can supply 1mA for external circuitry.

The internal voltage regulator can be bypassed by providing a voltage higher than internal V_{DD}. This feature reduces the power dissipation and can be implemented in an application where an auxiliary supply can power to the PA5711.

The total input current from the V_{IN} supply is a sum of the quiescent current of the PA5711, which is about 1.87mA and the gate driver current. The gate driver current is dependent on the gate charge of the external MOSFET and switching frequency.

This input current approximation can be done by using the following equation:

$I_{IN} \approx 1.87mA + (Q_{GATE} * f_s)$

Where Q_{GATE} is the total gate charge of the External MOSFET.

R_{EXT} in kΩ	V_{IN} Range in volts
10	11 - 50
20	30 - 100
100	75 - 200
330	175 - 300
560	290 - 400
750	400 - 480

An indicative table to choose the approximate value of R_{EXT} depending on V_{IN}

2.2.2 Current Sense Resistor

The peak LED current is set by the external sense resistor connected from the CS pin to ground. The value of this resistor is determined by the average LED current, the inductor ripple current and the internal threshold voltage. The inductor is selected to keep the inductor ripple current less than 30% of the average LED current.The dissipation across this resistor is given by the formula :

$P = R_{CS} * I_{LED}^2$

It is a safe practice to select the resistor with atleast twice the power rating that is calculated.

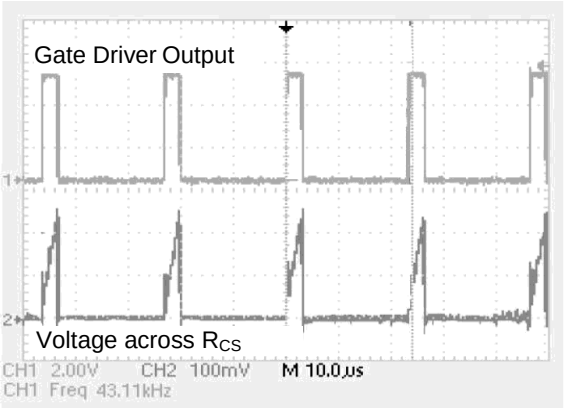


Figure 3. PA5711 Waveforms

2.2.3 Current Sense Blanking

The PA5711 has no internal current sense blanking circuit. This allows the user to choose and introduce the right time delay that fits the application. The user can add a RC delay network on the CS path i.e. between the R_{CS} and the CS pin. A time delay approximation can be made using :

$$\tau = 5*R*C$$

Where R and C are the delay elements

2.2.4 Enable / Disable

The Enable pin (EN) of the PA5711 is active high. If this pin is grounded then the Driver is disabled and chip will consume minimal current. The Gate driver is disabled and the LED's cannot be driven during this period. For normal operation the Enable pin must be connected high.

2.2.5 Linear Dimming

The PA5711 comes with a linear dimming function which is one of the four different ways the LED can be controlled. While V_{CS} is the maximum threshold against which the current sense resistor voltage drop is compared against, the LD pin can be used to reduce this threshold. An external resistive divider setup will allow the user to adjust the LED light intensity.

The R_{CS} voltage drop is compared against the lower of these two voltages. Hence decreasing the voltage provided at LD below 250mV would reduce the intensity of the LED light. This allows the user to choose from available resistors rather than calculating the resistor value in accordance with the internal threshold.

Since a voltage lower than the internal threshold can enable linear dimming it is advisable to connect LD to V_{DD} when linear dimming is not required.

A soft start function can be implemented on the PA5711 by using RC network to slowly ramp the voltage applied to the LD pin from GND potential to over 300mV, at which the V_{CS} overrides the Linear Dimming Function.

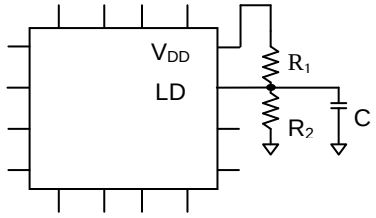


Figure 4. Soft-Start RC arrangement

The LD pin can also be used as a feed back to the chip, especially in an isolated driver application, a feedback from the isolated portion can be applied to the LD pin to achieve greater control over the calculate current drive.

2.2.6 PWM dimming

Pulse Width Modulation dimming or PWM dimming can be implemented on the PA5711 by using a low frequency Square wave signal to drive the PWM pin. The square wave frequency can be in the range of a few hundred hertz. In this setup the PWM wave will be directly driving the output of the Gate driver.

PWM signals can be generated using a Microcontroller or Pulse generators. The duty cycle of the input PWM is directly proportional to the intensity of LED light. If the PWM input is driven low the LED's are turned off.

2.2.7 Light sense

The PA5711 has a Light sense input to accept signal from an external light sensor. The LED's are turned on/off dependent on the signal from the Light sensors. This pin must be connected to ground if not used.

2.2.8 Motion Detection

The PA5711 has a motion detection input. An external motion detector can drive this pin to turn the LED's on/off. This pin needs to be connected to VDD when not used.

2.2.9 Gate Driver

The PA5711 can drive external MOSFETs with a gate capacitance of up to 600pF.

2.2.10 Oscillator

The PA5711 operates at a constant frequency. The external resistor R_{osc} determines the oscillator frequency. The inductor size, total chip power dissipation and filter capacitors are the basis on which the switching frequency is decided.

The internal oscillator has a 20% frequency accuracy. In a non-isolated mode the driver switching frequency is between 30 kHz and 200kHz. This large operating range gives the designer a reasonable compromise between switching frequency and inductor size.

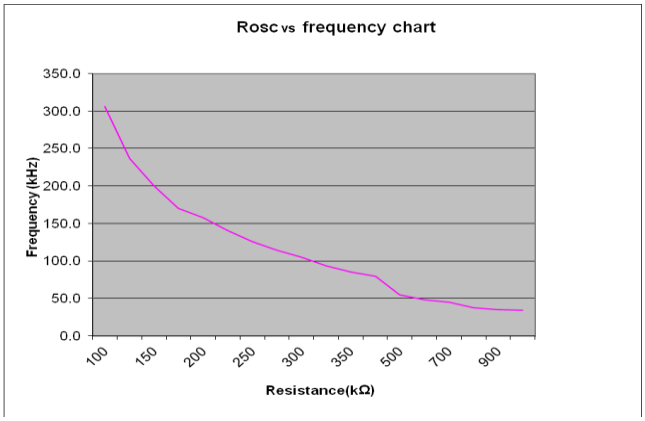


Figure 5. Frequency variation across R_{OSC}

2.2.11 Inductor design

The LED ripple current along with factors such as Maximum T_{ON}, Minimum input voltage and total forward voltage drop across the LED's (V_F) at the desired average LED current decide the value of the inductor. The minimum voltage is dependent on the specific application and the Maximum T_{ON} is determined by the duty cycle and the switching frequency.

The maximum duty cycle - D_{max} is given by :

$$D_{max} = \frac{V_{LEDstring}}{V_{in}}$$

Where

$V_{LEDstring}$ is the desired forward voltage drop across LED string at the designed LED current

V_{in} is the minimum input voltage

The maximum duty cycle must be maintained below 50% to maintain open loop stability and sub harmonic oscillations.

The Maximum ON-time can be calculated as follows:

$$t_{ONmax} = \frac{D_{max}}{f_s}$$

Where
f_s is the switching frequency

The size of the inductor can be calculated using the equation :

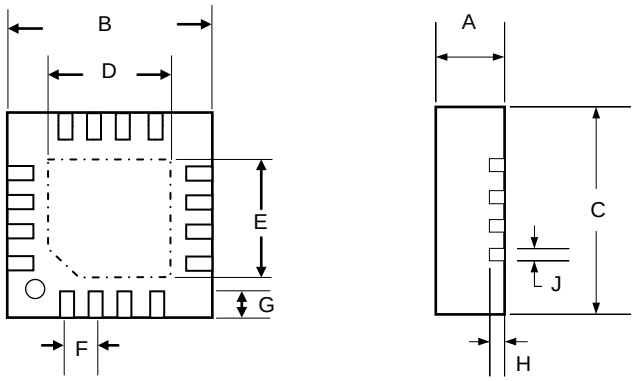
$$L_{min} = \frac{t_{ONmax} * (V_{in} - V_{LEDstring})}{I_{LED} * \gamma}$$

Where
γ is the inductor ripple

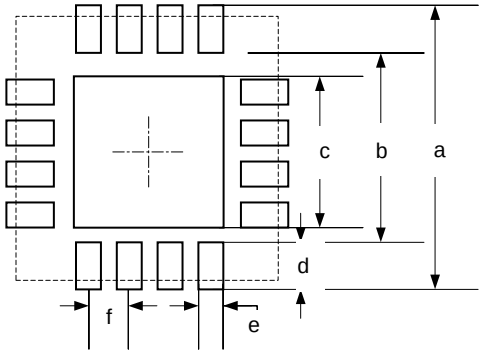
The peak inductor current is given by :

$$I_{Lmax} = I_{LED} * [1 + \frac{\gamma}{2}]$$

3. QFN-16 PACKAGE DIMENSIONS AND LAYOUT



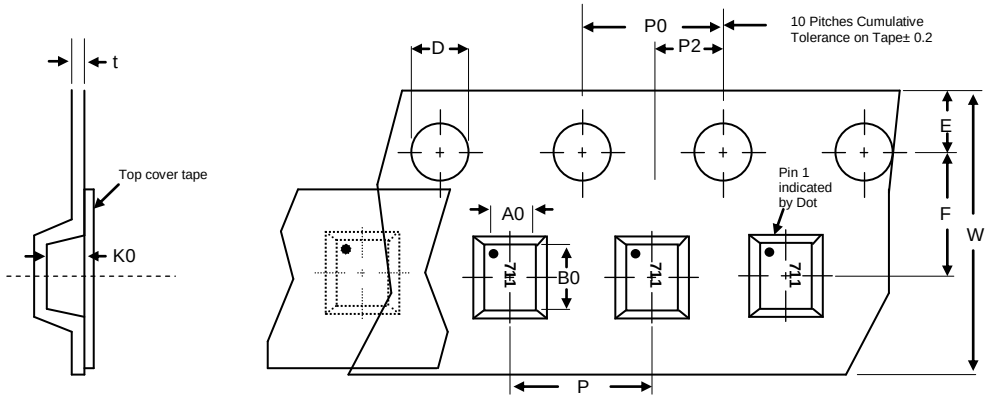
QFN-16 Dimensions						
	Min		Typical		Max	
	mm	in	mm	in	mm	in
A	0.70	0.028	0.75	0.030	0.8	0.031
B	3.925	0.155	4.00	0.157	4.075	0.160
C	3.925	0.155	4.00	0.157	4.075	0.160
D	2.25	0.089	2.30	0.091	2.35	0.093
E	2.25	0.089	2.30	0.091	2.35	0.093
F			0.65	0.026		0.000
G	0.35	0.014	0.55	0.022	0.75	0.030
H			0.20	0.008		0.000
J	0.25	0.010	0.30	0.012	0.35	0.014



	QFN-16 Pad Layout					
	Min		Typical		Max	
	mm	in	mm	in	mm	in
a	4.30	0.169	4.35	0.171	4.40	0.173
b	2.85	0.112	2.90	0.114	2.95	0.116
c	2.10	0.083	2.15	0.085	2.20	0.0866
d	0.67	0.026	0.72	0.028	0.77	0.030
e	0.25	0.010	0.30	0.012	0.35	0.014
f			0.65	0.026		

Tape and Reel Specifications

Reel Dia	A0	B0	K0	D	E	F	W	P0	P2	P	t-max
178 (7")	4.1±0.05	4.1±0.05	0.80±0.05	1.50±0.10	1.75±0.10	3.50±0.05	12.00±0.30	4.00±0.10	2.00±0.05	4.00±0.10	0.25



NOT FOR USE IN LIFE SUPPORT SYSTEMS