Automotive Single-Channel Ultra-Highspeed GaN Predriver

Features

- AEC-Q100 Grade-1 Qualified (TPM2015Q Only)
- 5-V Single Supply with Optimized Output Damping for Gan Reliability
- 7-A Peak Source and 5-A Sink-Drive Current
- 0.69-ns Minimum Input Pulse Width (Typical)
- Low Propagation Delay (2-ns Typical)
- Optimized Pinout for Nanosecond-pulse-width
- Fast Rise and Fall Times (0.45-ns and 0.45-ns Typical)
- ESD Protection Exceeds JESD 22 – 6-kV HBM, 1.5-kV CDM
- Available in Flip-Chip QFN2X2-10 Package

Applications

- Laser Distance Measuring System
- Automotive Lidar
- Driver Monitoring System
- GaN DC/DC Conversion System

Description

The TPM2015Q family of products are low-side single-channel ultra-highspeed gate drivers for GaN and logic-level MOSFETs. It is optimized for high-speed applications such as Lidar and high-density power convertors with enhanced low propagation delay design. The 2-mm×2-mm flip-chip QFN package of the TPM2015 minimizes parasitic inductance in the gate driver power loop and achieves state-of-the-art narrow pulse width as short as 0.69 ns. Transient suppressors ensure reliable operation with ultra-fast high-current output pulses.

Typical Application Circuit

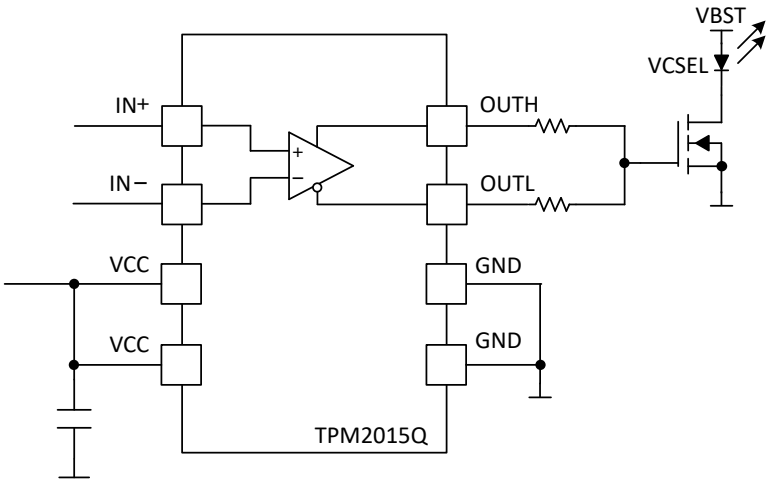


Table of Contents

Revision History

Date	Revision	Notes
2021-07-15	Rev. A.0	Initial release.

Pin Configuration and Functions

TPM2015Q
QFN2X2-10
Top View

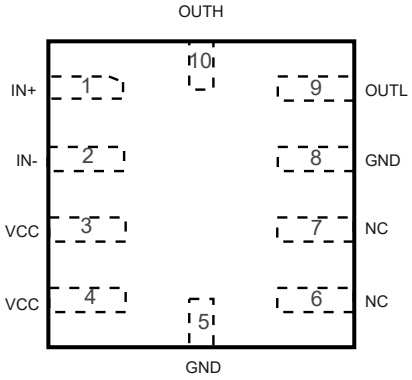


Table 1. Pin Functions: TPM2015Q

Pin No	Pin Name	I/O	Description
1	IN+	Input	Channel Positive Input, Active High
2	IN-	Input	Channel Negative Input, Active Low
3	VCC	Supply	Device Supply
4	VCC	Supply	Device Supply
5	GND	Ground	Device Ground
6	NC	NC	Not connected, recommend to tie to ground
7	NC	NC	Not connected, recommend to tie to ground
8	GND	Ground	Device Ground
9	OUTL	Output	Channel Pull-down Output
10	OUTH	Output	Channel Pull-up Output

Specifications

Absolute Maximum Ratings (1)

Parameter		Min	Max	Unit
VCC	Power Supply Voltage	−0.3	+6	V
OUTH, OUTL	Output Voltage Range	−0.3	VCC + 0.3	V
IN+, IN-	Input Voltage Range	−0.3	6	V
IOUTH, IOUTL	Continuous Output Channel Current	−500	+500	mA
	Pulsed Output Channel Sourcing Current OUTH (500 ns)		7	A
	Pulsed Output Channel Sinking Current OUTL (500 ns)		5	A
T_J	Operating Junction Temperature Range	−40	150	°C
T_{STG}	Storage Temperature Range	−65	150	°C
T_L	Lead Temperature (Soldering, 10 sec)		260	°C

(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.
(2) The inputs are protected by ESD protection diodes to each power supply. If the input extends more than 300 mV beyond the power supply, the input current should be limited to less than 10 mA.
(3) Power dissipation and thermal limits must be observed.

ESD, Electrostatic Discharge Protection

Parameter		Condition	Minimum Level	Unit
HBM	Human Body Model ESD	ANSI/ESDA/JEDEC JS-001，per AEC Q100-002	±6	kV
CDM	Charged Device Model ESD	ANSI/ESDA/JEDEC JS-002, per AEC Q100-011	±1.5	kV

Recommended Operating Conditions

Parameter		Min	Max	Unit
VCC	Power Supply Voltage	4.75	5.25	V
IN+, IN−	Input Voltage	0	VCC	V
VOUTH, VOUTL	Output Voltage	0	VCC	V
T_A	Operating Ambient Temperature Range	−40	125	℃

Thermal Information

Package Type	θ_{JA}	θ_{JC}	Unit
QFN2X2-10	87.54	119.32	°C/W

Electrical Characteristics

All test conditions: V_{CC} = 5 V, T_J = −40 °C to 150 °C, 1-μF capacitor between V_{CC} and GND, unless otherwise noted.

Parameter		Conditions	Min	Typ	Max	Unit
I_Q	VCC Quiescent Current	IN+ = H, IN- = L		105	200	μA
		IN+ = L, IN+ = H		105	200	
I_{OP}	VCC Operating Current	f_{SW} =30 MHz, no load, R_{OUTH} = 2 Ω, R_{OUTL} = 2 Ω		40		mA
		f_{SW} = 30 MHz, 100-pF load, R_{OUTH} = 2 Ω, R_{OUTL} = 2 Ω		51		mA
V_{UVLO_rising}	Supply Under Voltage Lock Out Rising Threshold		4	4.18	4.35	V
V_{UVLO_hys}	Supply Under Voltage Lock Out Falling Hysteresis			85		mV
T_{OTP}	Over Temperature Shutdown, turn-off			170		°C
ΔT_{OTP}	Over Temperature Hysteresis			20		°C
V_{IN_H}	Input Signal High Threshold	Input high threshold	1.7	2.15	2.6	V
V_{IN_L}	Input Signal Low Threshold	Input low threshold	1.1	1.45	1.8	V
V_{IN_HYS}	Input Hysteresis		0.38		1	V
$R_{IN\_pulldown}$	Input Pull-down Resistance		100	150	250	kΩ
C_{IN}	Input Capacitance				1.5	pF
V_{OL}	Output Low Voltage. OUTL	I_{OUTL} = 100 mA, IN+ = 0 V			36	mV
V_{CC} –V_{OH}	Output High Voltage, OUTH	I_{OUTH} = 100 mA, IN- = 5 V			50	mV
I_{OH}	Output Peak Sourcing Current	V_{OUTH} = 0 V, IN+ = 5 V		7		A
I_{OL}	Output Peak Sinking Current	V_{OUTL} = 5 V, IN- = 0 V		5		A
T_{start}	Startup Time, VDD rising above UVLO	INx = 5 V ,VDD rising above UVLO to OUTH rising		40	78	us
$T_{shut-off}$	ULVO Falling	INx = 5 V ,VDD falling below UVLO V to OUTH falling	0.7	2.5	3.5	us
$T_{pd,\ r}$	Propagation delay, turn on(1)	IN+ to OUTH, 100-pF load		2	4	ns
$T_{pd,\ f}$	Propagation delay, turn off(1)	IN- to OUTL, 100-pF load		2	4	ns
Δt_{pd}	Pulse Positive distrortion, ($t_{pd,\ f}$-$t_{pd,\ r}$)(1)			300	610	ps
t_R	Output Rise-time	0-Ω series 220-pF load		450		ps
t_F	Output Fall-time	0-Ω series 220-pF load		450		ps
t_{PW}	Minimum Input Pulse Width that changes output state	0-Ω series 220-pF load		0.69		ns

1. Guaranted by design

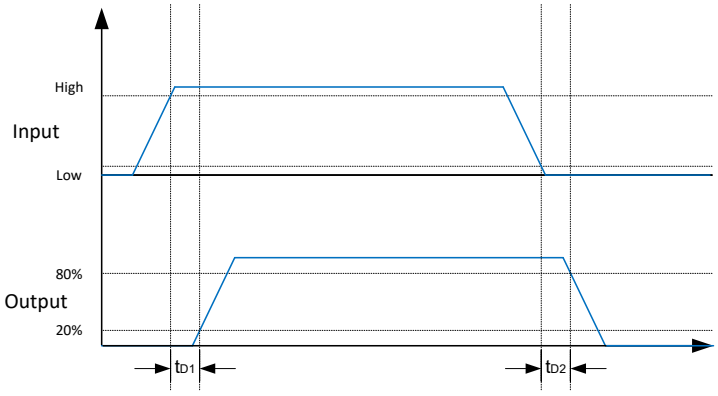


Figure 1. Input Timing Diagram

Typical Performance Characteristics

All test conditions: V_{OUT} = 5 V, T_A = +25°C, unless otherwise noted.

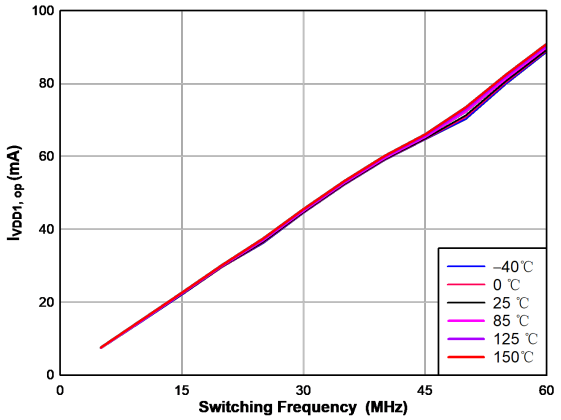


Figure 2. Operating Current vs Temperature

2 Ω in series with 100-pF Load

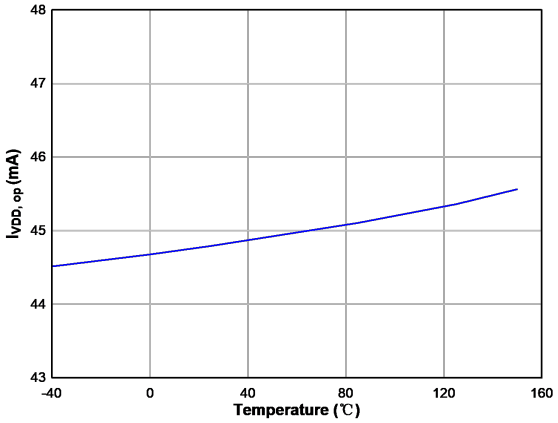


Figure 3. Operating Current vs Temperature

2Ω in series with 100pF Load, frequency = 30 MHz

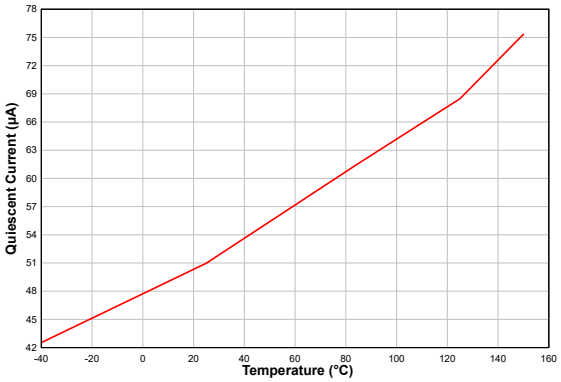


Figure 4. Quiescent current vs Temperature

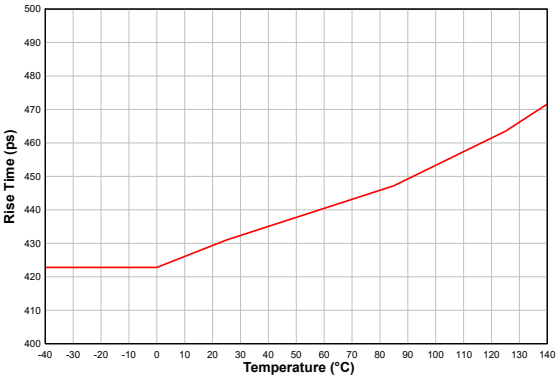


Figure 5. Rise time vs Temperature

load = 1.8 nC

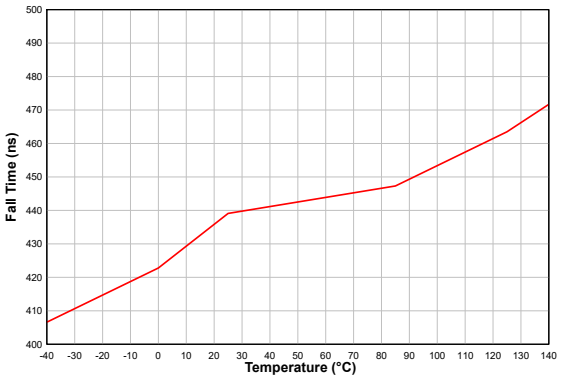


Figure 6. Fall time vs Temperature

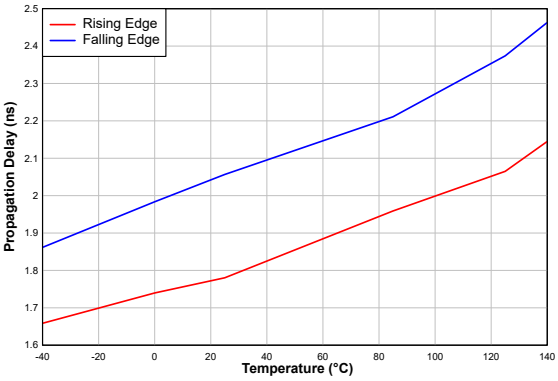


Figure 7. Propagation Delay vs Temperature

load = 1.8 nC	load = 1.8 nC

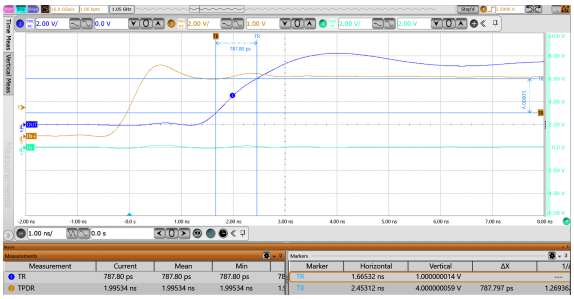
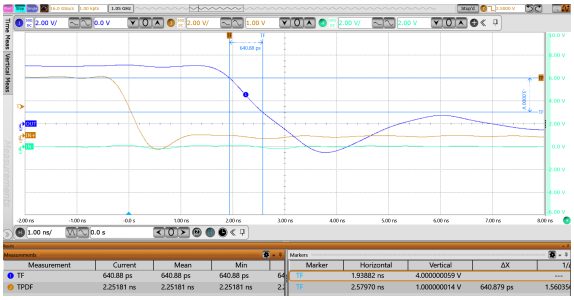

	

Figure 8. Rising Edge	**Figure 9. Falling Edge**
CH1: Input; CH2: GaN Transistor Gate	CH1: Input; CH2: GaN Transistor Gate

Detailed Description

Overview

The TPM20215Q family of products are low-side single-channel ultra-highspeed gate drivers for GaN and logic-level MOSFETs. It is optimized for high-speed applications such as Lidar and high-density power convertors with enhanced low propagation delay design. The 2-mm×2-mm flip-chip QFN package of the TPM2015 minimizes parasitic inductance in the gate driver power loop and achieves state-of-the-art narrow pulse width as short as 0.69 ns. Transient suppressors ensure reliable operation with ultra-fast high-current output pulses.

Functional Block Diagram

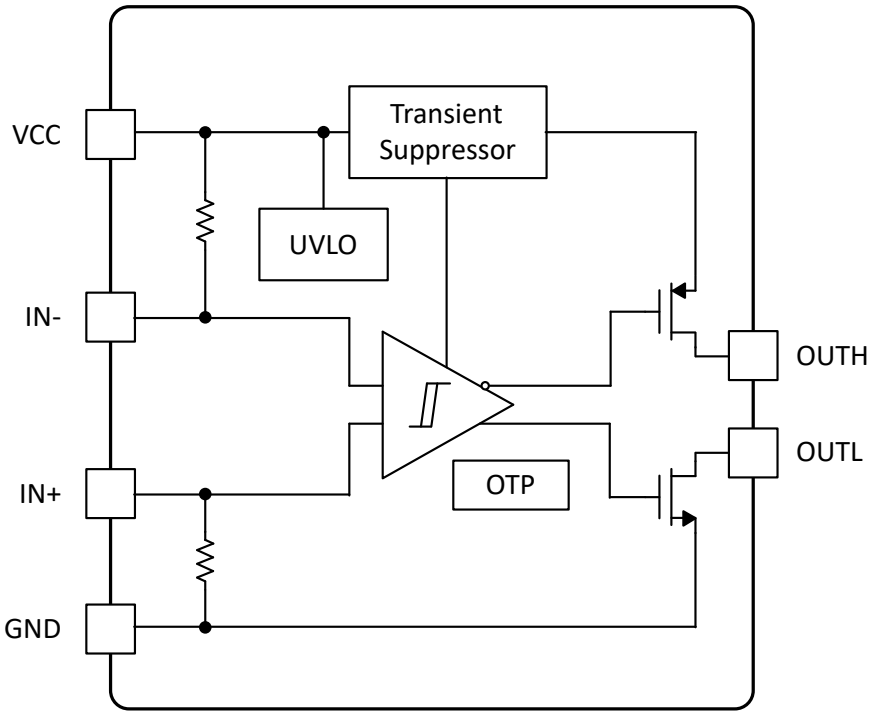


Figure 10. Functional Block Diagram

Feature Description

Supply and Under-Voltage-Lock-Out (UVLO)

The device has under-voltage-lock-out (UVLO) monitors. When supply voltage is above its rising threshold, the outputs are functional. When supply voltage is below its falling threshold, the device pulls OUTL to GND. A short deglitch timer is inserted to avoid oscillations on power supply.

Due to ultra-fast turn-on speed, channel output may drain high current on supply nodes within nanoseconds. 3PEAK recommends placing 3-terminal capacitors close to device supply pins as low as possible. Parasitic inductance may prevent external capacitors from supplying current in such a short time. The TPM2015Q has built in transient suppressor circuitry to avoid sudden drop which may trigger UVLO and cause output malfunction.

Channel Input and Output

The channel inputs are connected to a low-latency Schmitt trigger. It can cut propagation delay without additional gates. The inputs are pulled low via internal resistors.

The TPM2015 provides outputs with split pull-up and pull-down paths. The split outputs allow users to independently configure pull-up and pull-down slew-rate via external resistors. The maximum output sink/source current is +7 A / −5 A. Configuring slew rates may reduce ringing on GaN gate node due to parasitic inductance/capacitance, thus it can improve reliability of GaN transistors.

Over-Temperature Protection (OTP)

The TPM2015Q provides over temperature protection function to disable channel. When the junction temperature rises above the rising threshold, the channel outputs are disabled; when the junction temperature falls below the falling threshold, the channel outputs are enabled.

Application and Implementation

> Note
>
> Information in the following application sections is not part of the 3PEAK's component specification and 3PEAK does not warrant its accuracy or completeness. 3PEAK's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

Application Information

In modern Time-of-Flight (ToF) LiDAR system, it is necessary to ensure a narrow laser pulse. Gallium nitride (GaN) transistors are widely used in the industry due to its high switching frequency. As depicted in the schematic below, it is required to keep gate driver output loop as small as possible to minimize parasitic inductance.

Typical Application

Figure 11 shows the typical application schematic.

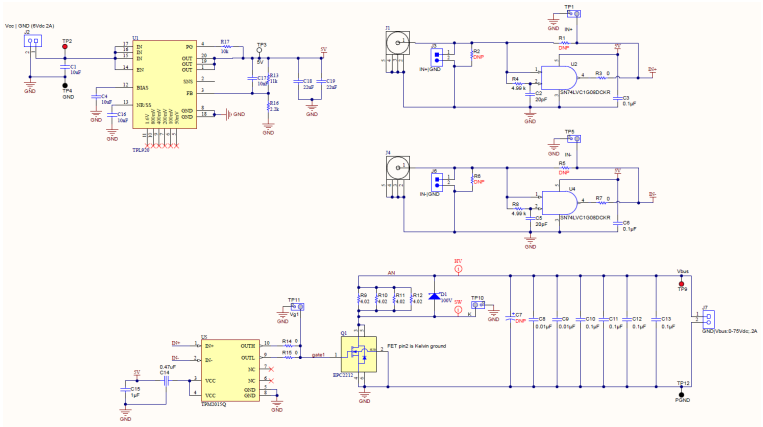
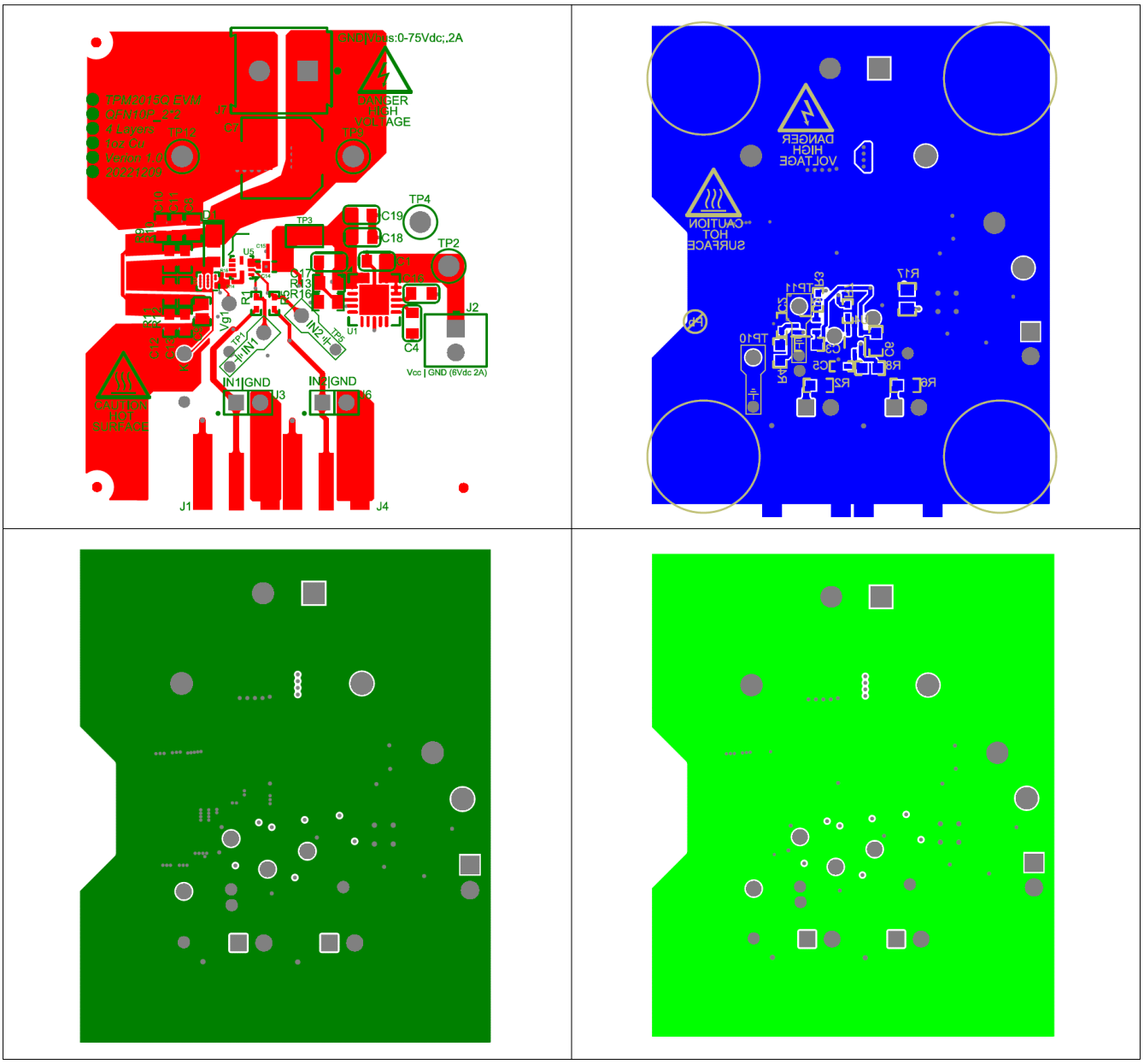
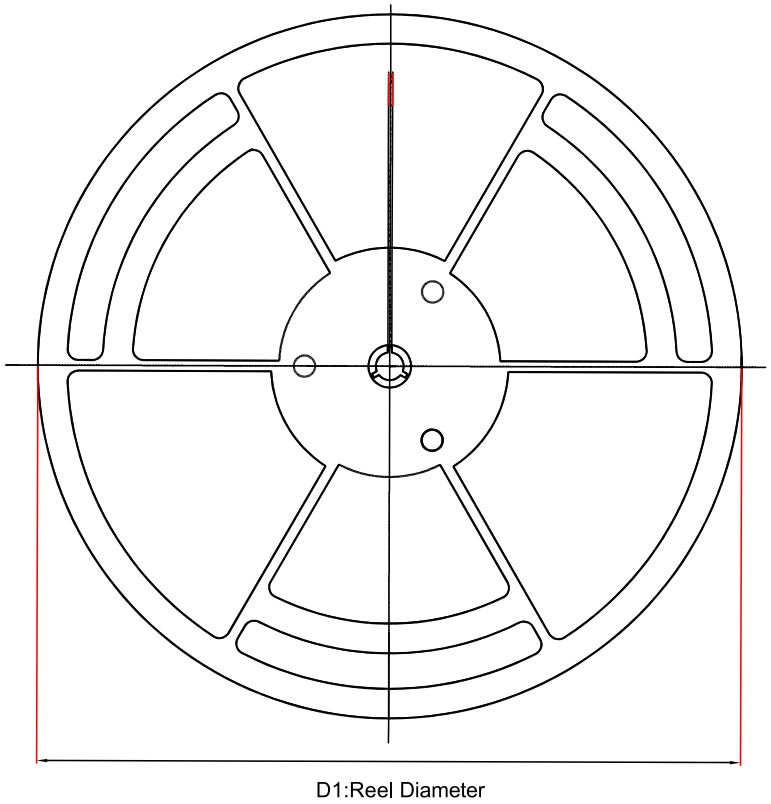
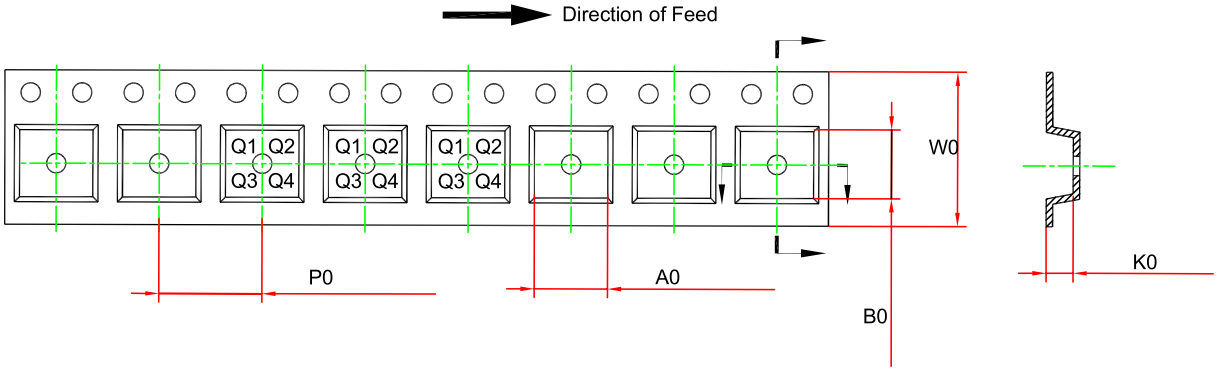


Figure 11. Typical TOF Lidar Application Schematic


TPM2015Q EVM
QFN10P_2*2
4 Layers
1oz Cu
Vertion 1.0
2022/12/09
GND|Vbus:0-75Vdc;,2A
DANGER
HIGH
VOLTAGE
CAUTION
HOT
SURFACE
TP4
TP2
J2
C4
Vcc | GND (6Vdc 2A)
IN1|GND
IN2|GND
J1
J4

Tape and Reel Information



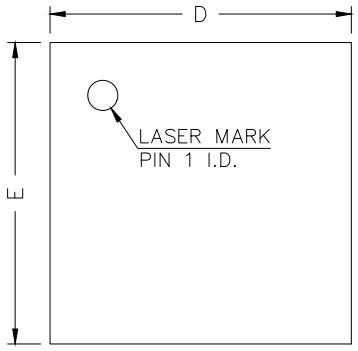


Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPM2015Q-FC1R-S	QFN2X2-10	180	12.0	2.3	2.3	1.0	4	8	Q1
TPM2015-FC1R	QFN2X2-10	180	12.0	2.3	2.3	1.0	4	8	Q1

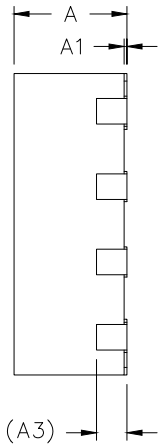
Package Outline Dimensions

QFN2X2-10

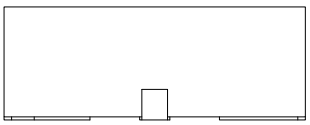
Package Outline Dimensions FC1(QFN2X2-10-A)



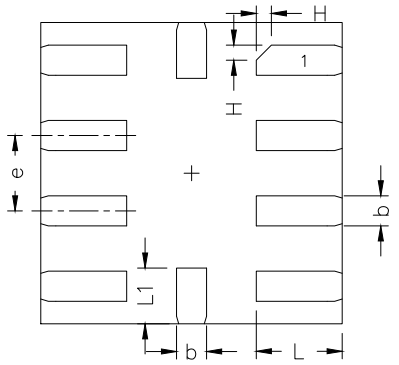
TOP VIEW



SIDE VIEW



SIDE VIEW



BOTTOM VIEW

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
b	0.150	0.250	0.006	0.010
A3	0.203 REF		0.008 REF	
D	1.900	2.100	0.075	0.083
E	1.900	2.100	0.075	0.083
e	0.500 BSC		0.020 BSC	
H	0.100 REF		0.004 REF	
L	0.470	0.670	0.019	0.026
L1	0.270	0.470	0.011	0.019

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

Order Information

Order Number	Operating Ambient Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPM2015Q-FC1R-S	–40 °C to 125 °C	QFN2X2-10	Q15	MSL3	3000	Green
TPM2015-FC1R	–40 °C to 125 °C	QFN2X2-10	Q15	MSL3	3000	Green

(1) The ambient temperature indicates device operation condition range. Application thermal behavior needs to be taken care of when operating in high temperature scenarios.

Green: 3PEAK defines "Green" to mean RoHS compatible and free of halogen substances.

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