

Features

- Lowside Center-tapped Transformer Driver
- Automotive AEC-Q100 Grade-1 (TPM6505xQ Only)
- Low-Noise, Low EMI with Spread Spectrum and Optimized Slew Rate
- Support 2.25-V to 5.5-V Supply with 1-A Primary Side Current
- Soft-Start and Current Limit Protection
- Switching Frequency Options: 160 kHz, 400 kHz and 2200 kHz
- Synchronous Clock Input
- Device Enable Input & 1- μ A Shutdown Current
- Over Temperature Protection
- SOT23-6 Package

Applications

- Automotive Isolated Power Supply
- Isolated Power Supply for Interface Driver
- Isolated Power Supply for Industrial Application

Description

The TPM6505x/TPM6505xQ is an push-pull transformer driver family for isolated power supplies. It is an open-loop center-tapped transformer driver with voltage range from 2.25 V to 5.5 V. It is designed to optimize for EMC and noise performance.

The TPM6505x family is a simple solution for isolated power supply. The device has internal oscillator that generates switching frequency with spread spectrum on the dual output channels. It supports 160-kHz (TPM6505A), 420-kHz option (TPM6505B, TPM6505D), and 2.2 -MHz option (TPM6505C) for different EMC requirements. The interleaved dual channel low-side outputs will drive the transformer to generate isolated power supply with maximum 1-A switching current.

The TPM6505x has active-high enable input for low shutdown current. The device also supports synchronous clock input. The TPM6505xQ is qualified for automotive grade AEC-Q100 Grade 1. The TPM6505x is qualified for industrial grade.

The TPM6505x device has high efficiency, and 0.23- Ω low on-resistance $R_{ds(ON)}$ output channels. The device has built-in 1.5-A current limit and over temperature protection features to protect the system from hazardous scenarios. The TPM6505x device is available in SOT23-6 package, supporting wide ambient temperature from -40°C to 125°C .

Typical Application Circuit

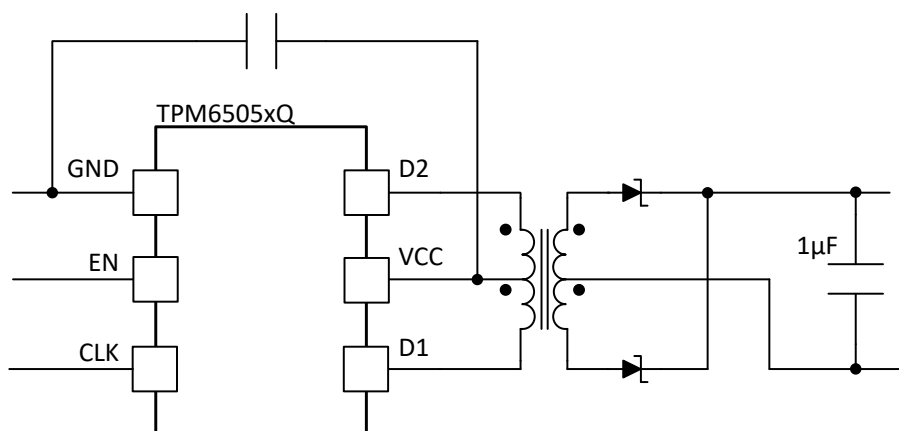


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Product Family Table

Orderable Part Number	Soft Start	Switching Frequency (kHz)	Package	Quality Grade
TPM6505AQ-S6TR-S	Yes	160	SOT23-6	Automotive
TPM6505BQ-S6TR-S	Yes	420	SOT23-6	Automotive
TPM6505CQ-S6TR-S ⁽¹⁾	Yes	2200	SOT23-6	Automotive
TPM6505DQ-S6TR-S ⁽¹⁾	No	420	SOT23-6	Automotive
TPM6505A-S6TR	Yes	160	SOT23-6	Industrial
TPM6505B-S6TR	Yes	420	SOT23-6	Industrial
TPM6505C-S6TR ⁽¹⁾	Yes	2200	SOT23-6	Industrial
TPM6505D-S6TR ⁽¹⁾	No	160	SOT23-6	Industrial

(1) Contact 3PEAK representatives for more information.

Revision History

Date	Revision	Notes
2024-01-02	Rev.A.0	Initial release

Pin Configuration and Functions

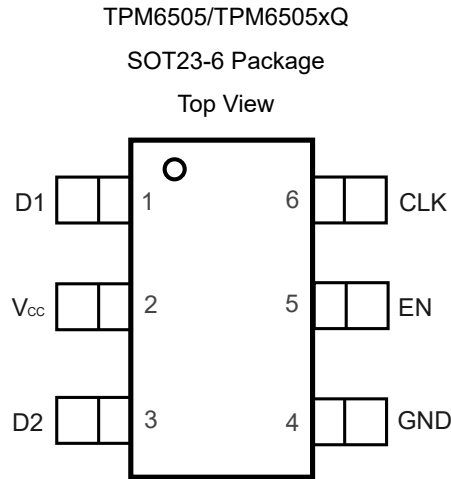


Table 1. Pin Functions: TPM6505

Pin		I/O	Description
No.	Name		
1	D1	Output	Open-drain output 1. Connect to transformer primary side 1.
2	VCC	Power	Power supply. Connect a 0.1-uF and a 10-uF low ESR capacitor.
3	D2	Output	Open-drain output 2. Connect to transformer primary side 2.
4	GND	Ground	Device ground.
5	EN	Input	Device enable with internal pull-down. High: device enabled. Low: device disabled.
6	CLK	Input	External clock input with internal pull-down. If clock is not detected, the device switches to internal clock.

Specifications

Absolute Maximum Rating

Parameter		Min	Max	Unit
V _{CC}	Supply Voltage	-0.5	6	V
V _{OUT}	D1, D2 Output Voltage	-0.5	30	V
I _{OUT}	D1, D2 Output Current		2.4	A
I _{OUT}	D1, D2 Output Current, transient pulse width < 1 μs		4	A
V _{EN}	Device Enable Voltage	-0.5	V _{CC} + 0.5	V
V _{CLK}	External Clock Voltage	-0.5	V _{CC} + 0.5	V
T _J	Maximum Junction Temperature	-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. This data was taken with the JEDEC low effective thermal conductivity test board. This data was taken with the JEDEC standard multilayer test boards.

ESD, Electrostatic Discharge Protection

Symbol	Parameter	Condition	Minimum Level	Unit
HBM	Human Body Model ESD	ANSI/ESDA/JEDEC JS-001 ⁽¹⁾	±5000	V
CDM	Charged Device Model ESD	ANSI/ESDA/JEDEC JS-002 ⁽²⁾	±1500	V

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

(2) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

Recommended Operating Conditions

Parameter		Min	Typ	Max	Unit
V _{CC}		2.25		5.5	V
I _{D1} , I _{D2}	Output Current			1	A
T _A	Ambient Temperature	-40		125	°C

Thermal Information

Package Type	θ _{JA}	θ _{JC}	Unit
SOT23-6	173.2	94.9	°C/W

Electrical Characteristics

Over full-range of recommended operating conditions, $T_A = -40\text{ }^{\circ}\text{C}$ to $125\text{ }^{\circ}\text{C}$ unless otherwise noted. All typical value are at $T_A = 25\text{ }^{\circ}\text{C}$, $V_{CC} = 5\text{ V}$, $R_L = 50\text{ }\Omega$ to V_{CC} .

Parameter		Conditions	Min	Typ	Max	Unit
Supply Voltage and Current						
I_Q	Quiescent Current	$V_{CC} = 5\text{ V}$, no load, TPM6505A		1.9	4	mA
		$V_{CC} = 5\text{ V}$, no load, TPM6505B, TPM6505D		3.6		
I_{VCC}	Supply Current	TPM6505A ($V_{CC} = 5.5$) , $R_L = 50\Omega$		1.25	2.5	mA
		TPM6505B ($V_{CC} = 5.5$) , $R_L = 50\Omega$		2.3	4	
I_{DIS}	Device disable current	$EN = 0$		0.9	1.2	μA
$V_{(UVLO_rising)}$	Under Voltage Lock Out, rising threshold			2.1	2.25	V
$V_{(UVLO_falling)}$	Under Voltage Lock Out, falling threshold		1.65	1.78		V
$V_{(UVLO_hys)}$	Under Voltage Lock out, hysteresis			0.27		V
Inputs						
$V_{TH(rising)}$	EN, CLK Rising Threshold	$V_{CC} = 5V$			$0.7 \times V_{CC}$	
$V_{TH(falling)}$	EN, CLK Falling Threshold	$V_{CC} = 5V$	$0.3 \times V_{CC}$			
$V_{TH(hys)}$	EN, CLK Hysteresis			$0.2 \times V_{CC}$		
I_{LH_EN}	Leakage Current on EN	$EN = H$		11	20	μA
I_{LH_CLK}	Leakage Current on CLK	$CLK = H$		95		μA
Output Drivers						
$f_{(SW)}$	D1, D2 Average Switching Frequency (TPM6505A)	$V_{CC} = 5V$	120	170	200	kHz
	D1, D2 Average Switching Frequency (TPM6505B, TPM6505D)	$V_{CC} = 5V$	340	440	515	
	D1, D2 Average Switching Frequency (TPM6505C)	$V_{CC} = 5V$		2200		
$f_{(SW_EXT)}$	External Switching Frequency, TPM6505A		100		600	kHz
	External Switching Frequency, TPM6505B, TPM6505D		100		1600	kHz
I_{LH_D}	D1, D2 Leakage Current	$EN = 0$		0.02	0.3	μA
t_{mm}	Average on-time Mismatch between D1 and D2			0		μs
$R_{ds(ON)}$	Output On-resistance	$V_{CC} = 4.5\text{ V}$		0.23		Ω

Automotive Grade 1-A Transformer Driver

Parameter		Conditions	Min	Typ	Max	Unit
		VCC = 2.8 V		0.26		
		VCC = 2.25 V		0.3		
V _(SLEW)	Voltage Slew Rates on D1 and D2 for TPM6505A			48		V/μs
	Voltage Slew Rates on D1 and D2 for TPM6505B , TPM6505D			152		
	Voltage Slew Rates on D1 and D2 for TPM6505C			420		
I _(SLEW)	Voltage Slew Rates on D1 and D2 for TPM6505A			11		A/μs
	Voltage Slew Rates on D1 and D2 for TPM6505B, TPM6505D			41		
	Voltage Slew Rates on D1 and D2 for TPM6505C			42		
Protection						
I _{LIMIT}	Output Current Limit	Steady state current	1.2	1.5	2.4	A
T _{SD}	Thermal Shutdown Threshold		150	165	180	°C
T _{SD_HYS}	Thermal Shutdown Threshold Hysteresis			18		°C
Timing						
t _{DEAD}	Deadtime between D1 and D2	TPM6505A, 160 kHz		50		ns
		TPM6505B, TPM6505D, 420 kHz		50		ns
		TPM6505C, 2.2 MHz		50		ns
t _{ss}	Softstart Time TPM6505A		1.2	3.3	7	ms
	Softstart Time TPM6505B			4.2	7	ms
t _{ssdelay}	Softstart Time Delay TPM6505A		4.7	7.3	13	ms
	Softstart Time Delay TPM6505B		4.7	8.3	13	ms
t _{UVLO_delay}	Power up Delay Time			60		μs

Typical Performance Characteristics

All test conditions: $V_{IN} = 5\text{ V}$, $T_A = 25^\circ\text{C}$, unless otherwise noted.

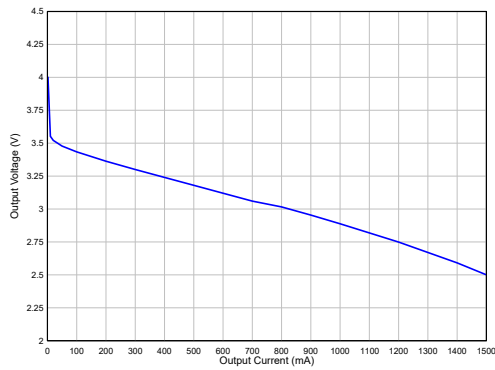


Figure 1. Output Voltage vs. Load Current

$V_{OUT} = 3.3\text{ V}$

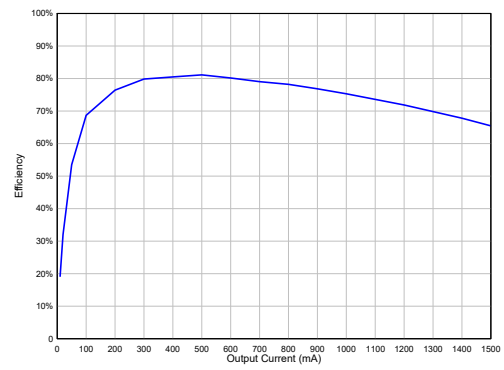


Figure 2. Efficiency vs. Load Current

$V_{OUT} = 3.3\text{ V}$

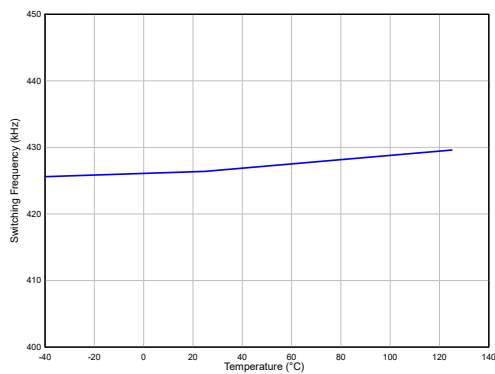


Figure 3. Switching Frequency vs. Temperature

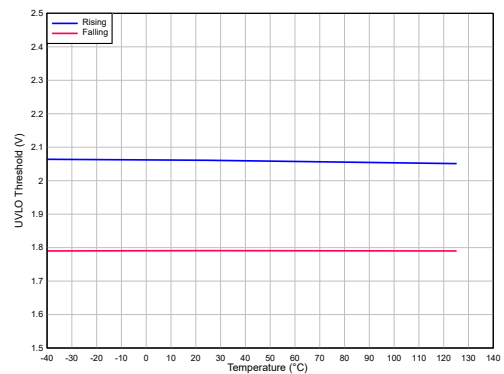


Figure 4. Under-voltage Threshold vs. Temperature

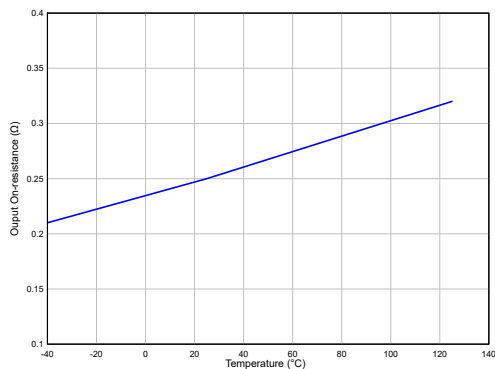


Figure 5. On-resistance vs. Temperature

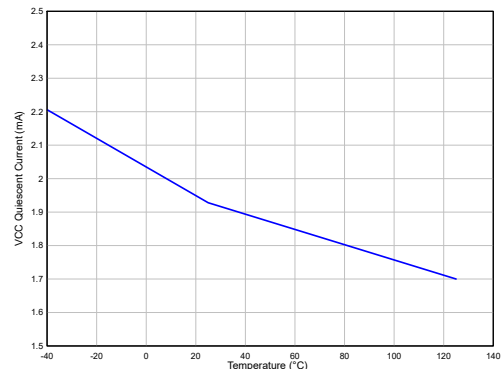
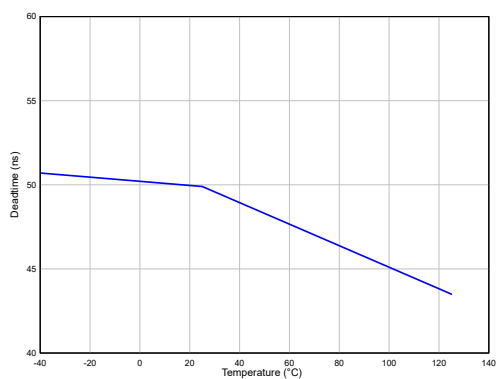
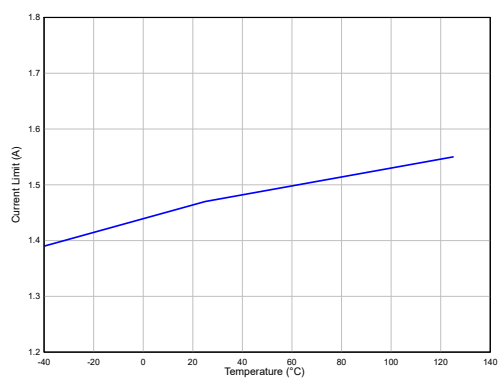
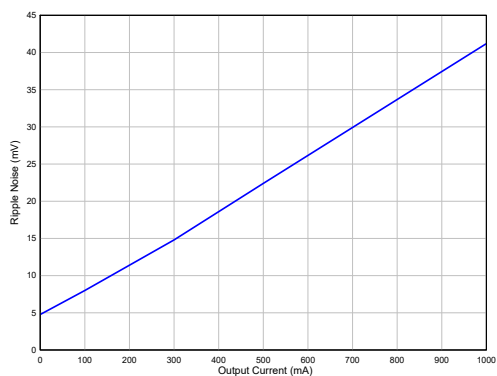


Figure 6. Quiescent Current vs. Temperature


Figure 7. Deadtime vs. Temperature

Figure 8. Current Limit Threshold vs. Temperature

Figure 9. Output Ripple Noise vs. Output Current

Detailed Description

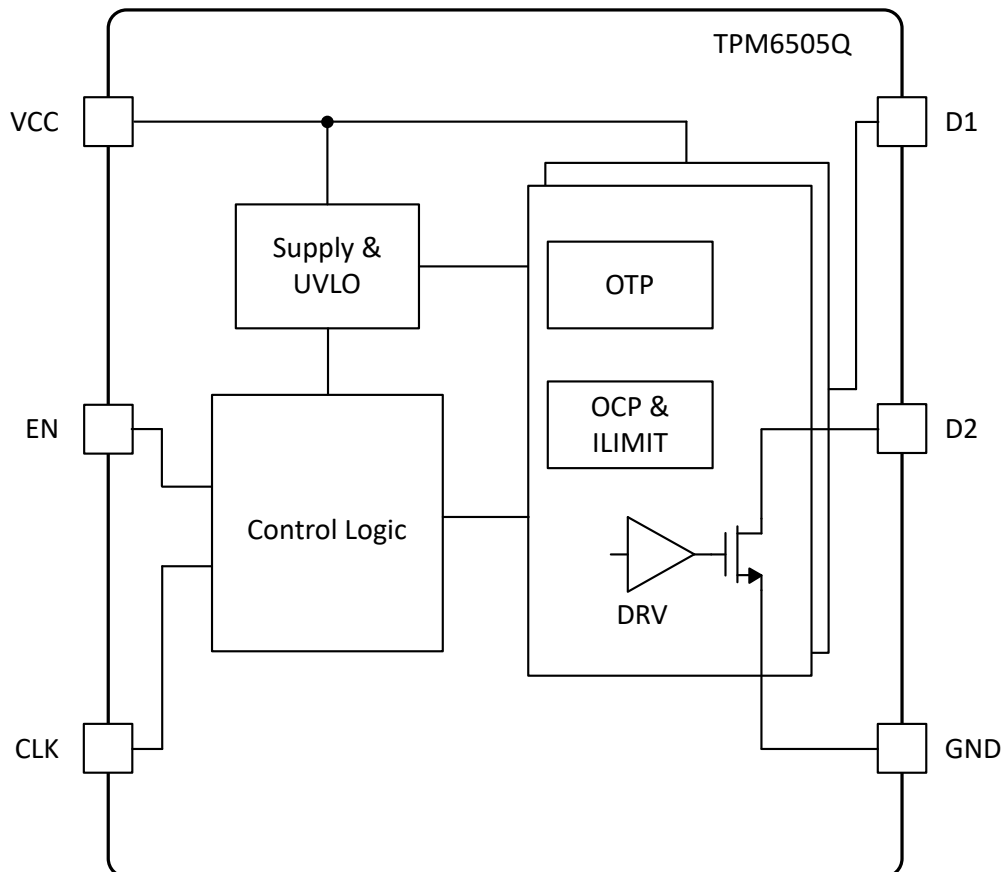
Overview

The TPM6505x/TPM6505xQ is a push-pull transformer driver designed for isolated power supply. The TPM6505xQ is automotive grade with AEC-Q100 Grade 1. The device has two complementary low-side MOSFETs to drive a center-tapped transformer to generate isolated power supply.

The two output channels drives with a deadtime in between to avoid shorting out both of the primary side inputs. At the secondary side, two rectification diodes are needed to rectify output voltage. The device family supports both 160-kHz (TPM6505A), 420-kHz (TPM6505B, TPM6505D) and 2200-kHz (TPM6505C) switching frequency with spread spectrum to reduce electro-magnetic emissions.

The device supports both internal oscillator mode and external clock mode for frequency synchronization. Device enable feature allows the device in sleep mode.

The device has soft-start, current limit protection and over temperature protection features to protect the device from hazardous scenarios.

Functional Block Diagram**Figure 10. Functional Block Diagram**

Feature Description

Push-pull Converter

Push-pull converter utilizes a center-tapped to transfer power from primary side to secondary side.

The dual low-side switches Q1 and Q2 are connected to inputs of the transformer's primary side. Q1 and Q2 drives half of the transformer coil complementarily. When Q1 is driving, current flows from the center-tap to D1, through Q1 to GND. With the other half of the transformer floating, the device generates $2 \times V_{IN}$ at the open end of D2. When Q2 is driving, current flows from the center-tap to D2, through Q2 to GND. With the other half of the transformer floating, the device generates $2 \times V_{IN}$ at the open end of D1.

Switching Frequency Selection

Part Number	SoftStart	Frequency (kHz)
TPM6505A / TPM6505AQ	Yes	160
TPM6505B / TPM6505BQ	Yes	420
TPM6505C / TPM6505CQ	Yes	2200
TPM6505D / TPM6505DQ	No	420

The TPM6505x provides 4 options for different EMC performance and switching frequency considerations. In general, 160kHz and 420kHz provides high efficiency power conversion while 2200kHz could help shrink board size. Both of them are designed for high electro-magnetic compliance performance.

Soft start

The TPM6505A/B/C devices support soft-start feature by limiting output current. When the device starts up either by powering up or EN rising edge, the output stops switching for 4 ms and then slowly ramps up output current limit. The soft start feature can prevent in-rush current upon starting up and protect transformer accordingly.

Current Limit

The TPM6505x devices support current limit feature by clamping output current to I_{limit} . When the output current increases close to the threshold current, the output gate drive voltage will be clamped and output on-resistance will increase accordingly. With current limit, the device can help protect isolated power transformer from over current. However, the excessive thermal dissipation needs to be considered and can lead to over temperature protection. It is also noted that during over load conditions, the current limit will have over shoot current higher than expected clamp current. 3PEAK recommends to limit coil current below 1 A and use 1- μ F output capacitance.

Over Temperature Protection

The TPM6505xQ devices support over temperature protection. When device junction temperature rises above the protection threshold, the device will turn off outputs to protect the device from over temperature damage. When the junction temperature falls below the falling threshold, the device will resume operation with soft-start.

Spread Spectrum

The TPM6505x has spread spectrum clocks to enhance electro-magnetic performance by modulating its internal clock frequency. The emission energy is spread across a wider band of frequency instead of a narrow band peak. The spread spectrum feature greatly improves EMC performances.

External Clock Mode

The TPM6505x device has external clock mode with CLK input to synchronize with external frequency. The CLK rising edge will be used as trigger and frequency is divided by two as switching clock frequency.

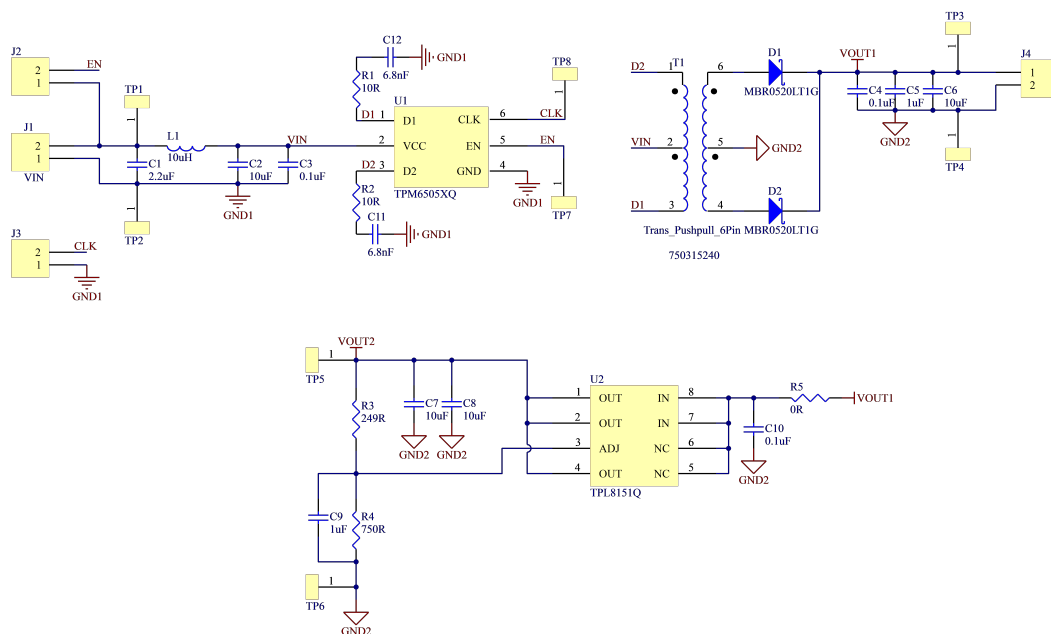
Application and Implementation

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

The TPM6505xQ is a simple solution for push-pull isolated power supply.

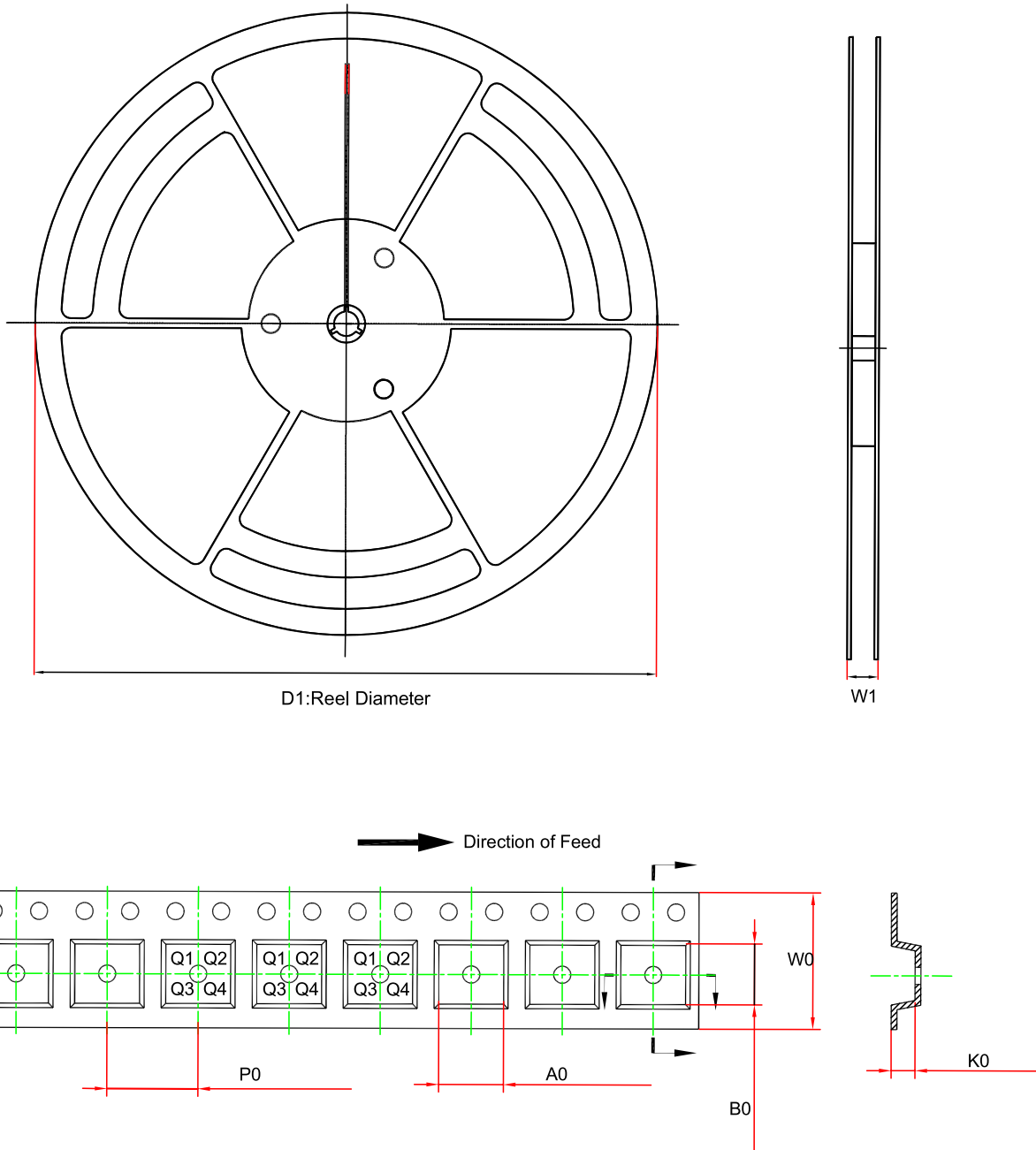


PN.	Description	Quantity	Manufacturer
C1	2.2uF/25V, 0805	1	Murata
L1	10uH, 1210	1	Murata
C2, C6, C7, C8	10uF/25V, 0805	1	Murata
C5,C9	1uF/25V, 0805	1	Murata
C3, C4, C10	0.1uF/25V, 0603	2	Murata
C11, C12	6.8nF/25V, 0603	2	Murata
R1, R2	10R/0805	2	Murata
R3	249R/0603	1	Murata
R4	750R/0603	1	Murata
R5	0R/0805	1	Murata
U1	TPM6505AQ	1	3PEAK
U2	TPL8151Q	1	3PEAK
D1, D2	1N5819HW	2	On-semi

Automotive Grade 1-A Transformer Driver

PN.	Description	Quantity	Manufacturer
T1	750315240, 1:1.1	1	Wurth
J1, J2, J3, J4	1*2pin, 100mil	4	-
TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8	connector	8	-

Tape and Reel Information

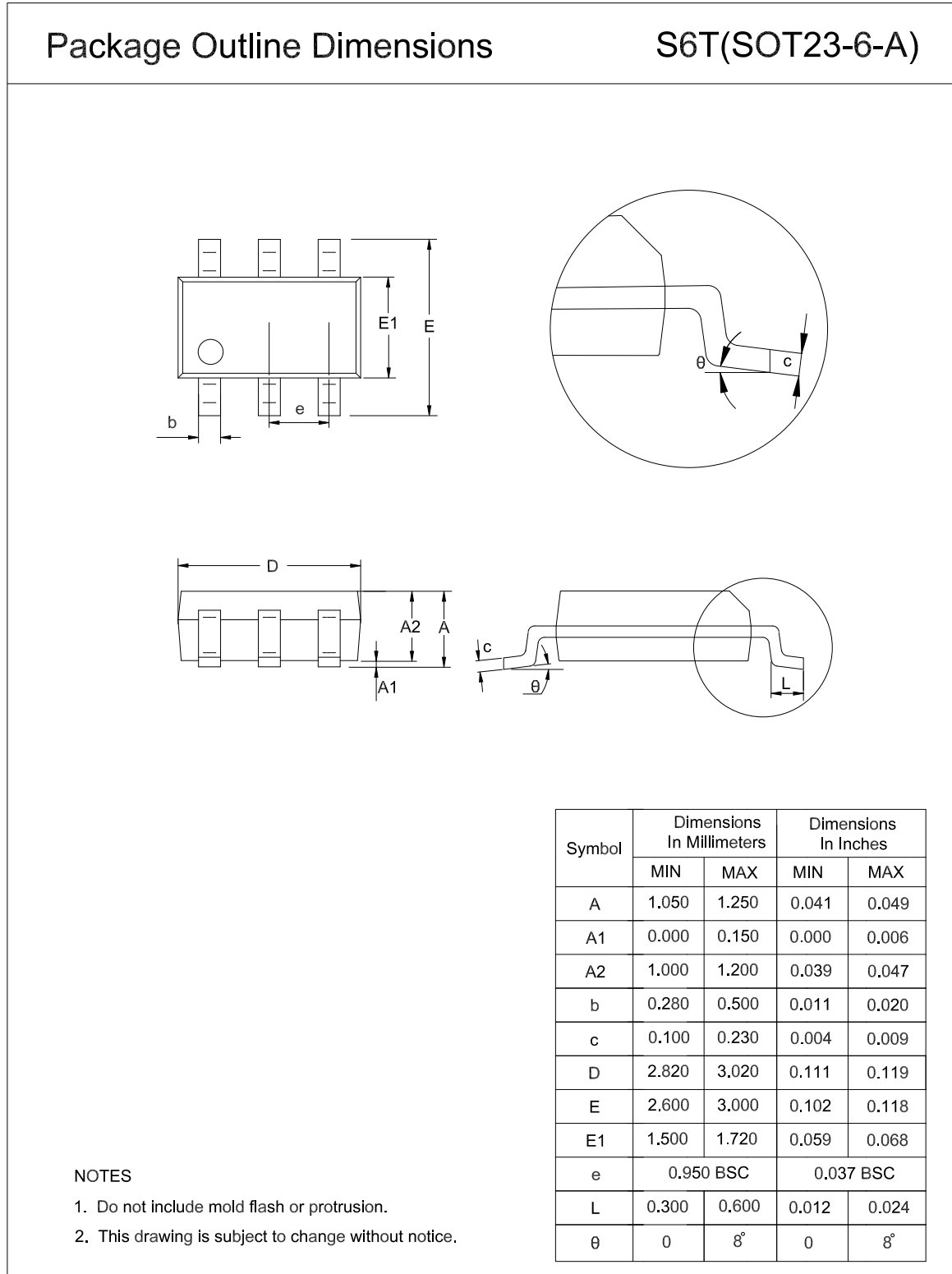


Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPM6505AQ-S6TR-S	SOT23-6	180	12.0	3.3	3.2	1.4	4.0	8.0	Q3
TPM6505BQ-S6TR-S	SOT23-6	180	12.0	3.3	3.2	1.4	4.0	8.0	Q3
TPM6505CQ-S6TR-S	SOT23-6	180	12.0	3.3	3.2	1.4	4.0	8.0	Q3

Automotive Grade 1-A Transformer Driver

Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPM6505DQ-S6TR-S	SOT23-6	180	12.0	3.3	3.2	1.4	4.0	8.0	Q3
TPM6505A-S6TR	SOT23-6	180	12.0	3.3	3.2	1.4	4.0	8.0	Q3
TPM6505B-S6TR	SOT23-6	180	12.0	3.3	3.2	1.4	4.0	8.0	Q3
TPM6505C-S6TR	SOT23-6	180	12.0	3.3	3.2	1.4	4.0	8.0	Q3
TPM6505D-S6TR	SOT23-6	180	12.0	3.3	3.2	1.4	4.0	8.0	Q3

Package Outline Dimensions

SOT23-6


Order Information

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPM6505AQ-S6TR-S	-40 to 125°C	SOT23-6	55A	1	Tape and Reel, 3000	Green
TPM6505BQ-S6TR-S	-40 to 125°C	SOT23-6	55B	1	Tape and Reel, 3000	Green
TPM6505CQ-S6TR-S ⁽¹⁾	-40 to 125°C	SOT23-6	55C	1	Tape and Reel, 3000	Green
TPM6505DQ-S6TR-S ⁽¹⁾	-40 to 125°C	SOT23-6	55D	1	Tape and Reel, 3000	Green
TPM6505A-S6TR	-40 to 125°C	SOT23-6	55A	1	Tape and Reel, 3000	Green
TPM6505B-S6TR	-40 to 125°C	SOT23-6	55B	1	Tape and Reel, 3000	Green
TPM6505C-S6TR ⁽¹⁾	-40 to 125°C	SOT23-6	55C	1	Tape and Reel, 3000	Green
TPM6505D-S6TR ⁽¹⁾	-40 to 125°C	SOT23-6	55D	1	Tape and Reel, 3000	Green

(1) For future products, contact the 3PEAK factory for more information and samples.

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

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