

TPL5110-Q1 電力ゲーティング用 AEC-Q100 Nano-Power システム・タイマ

1 特長

- 車載アプリケーション向けに認定済み
- 下記内容で AEC-Q100 認定済み:
 - デバイス温度グレード 1: -40°C ~ 125°C の動作時 周囲温度範囲
 - デバイス HBM ESD 分類レベル 2
 - デバイス CDM ESD 分類レベル C5
- 機能安全対応
 - 機能安全システムの設計に役立つ資料を利用可能
- 消費電流: 2.5V で 35nA (標準値)
- 電源電圧: 1.8V ~ 5.5V
- 時間間隔を選択可能: 100ms ~ 7200s
- タイマ精度: 1% (標準値)
- 時間間隔を抵抗で選択可能:
- 手動での MOSFET パワーオン
- ワンショット機能
- TPL5x10Q ファミリの AEC-Q100 Nano-Power システム・タイマ:
 - **TPL5010-Q1**: ウォッチドッグ機能、プログラム可能な遅延範囲
 - **TPL5110-Q1**: MOS ドライバ、プログラム可能な遅延範囲、ワンショット機能

2 アプリケーション

- 電気自動車 (EV)
- バッテリ駆動システム
- クラッチ・アクチュエータ回路
- 車のドア・ハンドル回路
- スマート・キー
- リモート電流センサ
- 侵入者検出

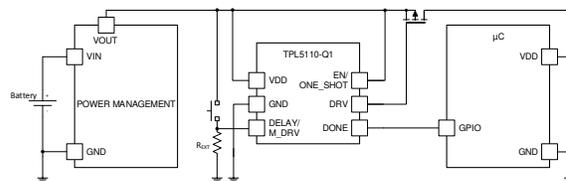
3 概要

TPL5110-Q1 Nano タイマは低消費電力で AEC-Q100 認定済みのタイマで、MOSFET ドライバが内蔵されており、デューティ・サイクル制御またはバッテリー駆動のアプリケーションでの電力ゲーティングに最適です。TPL5110-Q1 の消費電力はわずか 35nA で、スリープ時に電源ラインをイネーブルすることができ、システム全体のスタンバイ電流を劇的に減らします。この電力削減により、バッテリーを大幅に小型化できるため、環境発電やワイヤレス・センサ・アプリケーションに適しています。TPL5110-Q1 はタイミング・インターバルを 100ms ~ 7200s の範囲で選択でき、電力ゲーティング・アプリケーション用に設計されています。さらに、TPL5110-Q1 には独自のワンショット機能があり、タイマは MOSFET に 1 サイクルだけ電力を供給します。TPL5110-Q1 は 6 ピン SOT23 パッケージで供給されません。

製品情報⁽¹⁾

部品番号	パッケージ	本体サイズ (公称)
TPL5110-Q1	SOT23 (6)	3.00mm × 3.00mm

- (1) 利用可能なすべてのパッケージについては、このデータシートの末尾にある注文情報を参照してください。



アプリケーション概略回路図



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4 Revision History

Changes from Revision * (February 2017) to Revision A (September 2021)

Page

- 「特長」セクションに機能安全の箇条書き項目を追加..... **1**

Device Comparison Table

表 5-1. TPL5x10Q Family of AEC-Q100 Nano- Power System Timers

PART NUMBER	SUPPLY CURRENT (Typ)	SPECIAL FEATURES
TPL5010-Q1	35 nA	Low Power Timer
		Watchdog Function
		Programmable Delay Range
		Manual Reset
TPL5110-Q1	35 nA	Low Power Timer
		MOS-Driver
		Programmable Delay Range
		Manual Reset
		One-Shot Feature

5 Pin Configuration and Functions

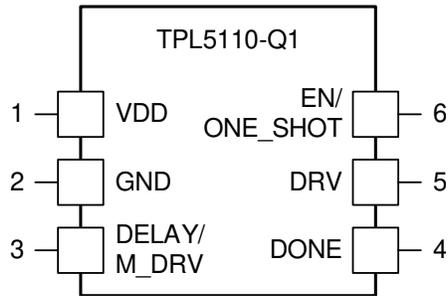


图 5-1. SOT-23 6-Lead DDC Top View

表 5-1. Pin Functions

PIN		TYPE ⁽¹⁾	DESCRIPTION	APPLICATION INFORMATION
NO.	NAME			
1	VDD	P	Supply voltage	
2	GND	G	Ground	
3	DELAY/ M_DRV	I	Time interval set and manual MOSFET Power ON	Resistance between this pin and GND is used to select the time interval. The manual MOSFET power ON switch is also connected to this pin.
4	DONE	I	Logic Input for watchdog functionality	Digital signal driven by the μ C to indicate successful processing.
5	DRV	O	Power Gating output signal generated every t_{IP}	The Gate of the MOSFET is connected to this pin. When DRV = LOW, the MOSFET is ON.
6	EN/ ONE_SHOT	I	Selector of mode of operation	When EN/ONE_SHOT = HIGH, the TPL5110-Q1 works as a TIMER. When EN/ONE_SHOT = LOW, the TPL5110-Q1 turns on the MOSFET one time for the programmed time interval. The next power on of the MOSFET is enabled by the manual power ON.

(1) G= Ground, P= Power, O= Output, I= Input.

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)⁽¹⁾

	MIN	MAX	UNIT
Supply voltage (VDD-GND)	-0.3	6.0	V
Input voltage at any pin ⁽³⁾	-0.3	VDD + 0.3	V
Input Current on any pin	-5	+5	mA
Storage temperature, T _{stg}	-65	150	°C
Junction temperature, T _J ⁽²⁾		150	°C

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) The maximum power dissipation is a function of T_J(MAX), θ_{JA}, and the ambient temperature, T_A. The maximum allowable power dissipation at any ambient temperature is P_{DMAX} = (T_J(MAX) - T_A) / θ_{JA}. All numbers apply for packages soldered directly onto a PC board.
- (3) The voltage between any two pins should not exceed 6V.

6.2 ESD Ratings

			VALUE	UNIT
V _(ESD)	Electrostatic discharge	Human Body Model, per AEC Q100-002 ⁽¹⁾	±2000	V
		Charged-device model (CDM), per AEC Q100-011	±750	

- (1) AEC Q100-002 indicates that HBM stressing shall be in accordance with ANSI/ESDA/JADEC JS-001 specification.

6.3 Recommended Operating Ratings

over operating free-air temperature range (unless otherwise noted)

	MIN	MAX	UNIT
Supply Voltage (VDD-GND)	1.8	5.5	V
Temperature Range	-40	125	°C

6.4 Thermal Information

THERMAL METRIC ⁽¹⁾		TPL5110-Q1	UNIT
		SOT-23	
		6 PINS	
R _{θJA}	Junction-to-ambient thermal resistance	163	°C/W
R _{θJC(top)}	Junction-to-case (top) thermal resistance	26	°C/W
R _{θJB}	Junction-to-board thermal resistance	57	°C/W
Ψ _{JT}	Junction-to-top characterization parameter	7.5	°C/W
Ψ _{JB}	Junction-to-board characterization parameter	57	°C/W

- (1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

6.5 Electrical Characteristics

Specifications are for $T_A = 25^\circ\text{C}$, $V_{DD-GND} = 2.5\text{ V}$, unless otherwise stated.⁽¹⁾

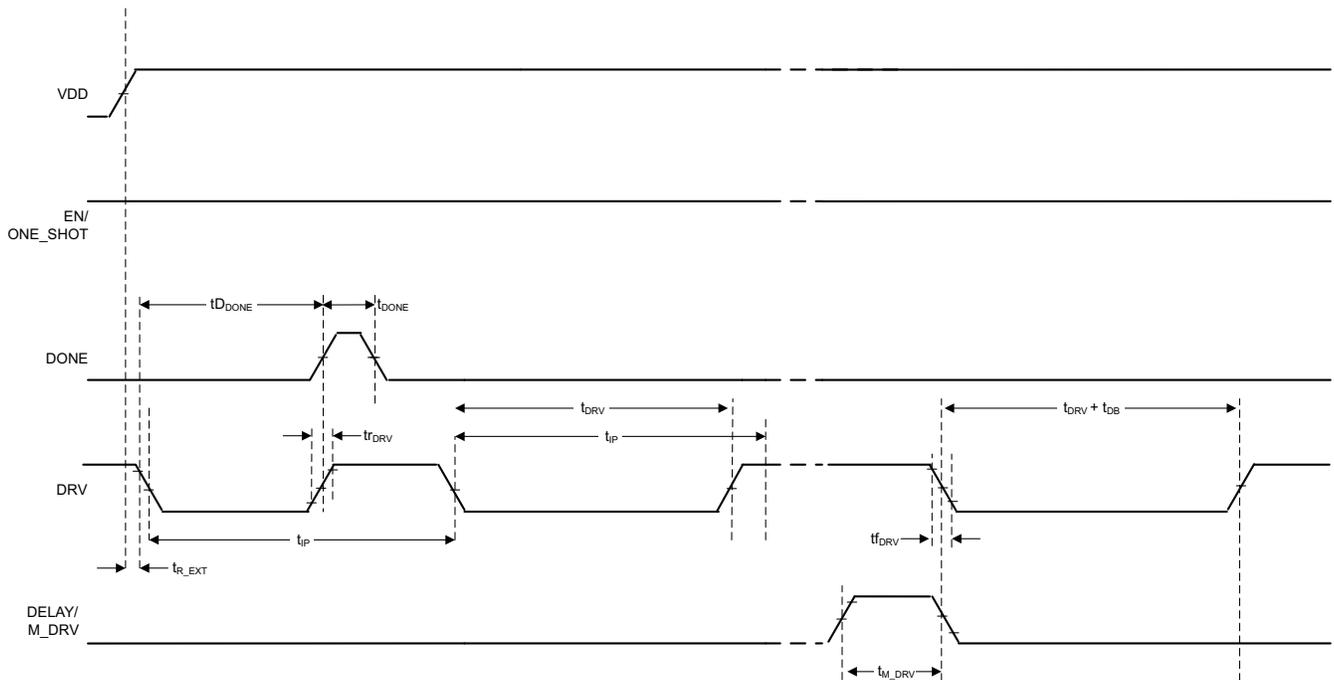
	PARAMETER	TEST CONDITIONS	MIN ⁽²⁾	TYP ⁽³⁾	MAX ⁽²⁾	UNIT
POWER SUPPLY						
IDD	Supply current ⁽⁴⁾	Operation mode		35	50	nA
		Digital conversion of external resistance (Rext)		200	400	μA
TIMER						
t _{IP}	Time interval Period ⁽⁵⁾	1650 selectable Time intervals	Min time interval	100		ms
			Max time interval	7200		s
	Time interval Setting Accuracy ⁽⁷⁾	Excluding the precision of Rext	±0.6%			
	Time interval Setting Accuracy over supply voltage	$1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	±25			ppm/V
t _{OSC}	Oscillator Accuracy		-0.5%		0.5%	
	Oscillator Accuracy over temperature ⁽⁵⁾	$-40^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$		150		ppm/°C
	Oscillator Accuracy over supply voltage ⁽⁵⁾	$1.8\text{ V} \leq V_{DD} \leq 5.5\text{ V}$		±0.4		%/V
	Oscillator Accuracy over life time ⁽⁶⁾			±0.24%		
t _{DONE}	Minimum DONE Pulse width ⁽⁵⁾			100		ns
t _{DRV}	DRV Pulse width	DONE signal not received		t _{IP} -50ms		
t _{Rext}	Time to convert Rext ⁽⁵⁾			100		ms
DIGITAL LOGIC LEVELS						
VIH	Minimum Logic High Threshold DONE pin			0.7xVDD		V
VIL	Maximum Logic Low Threshold DONE pin			0.3xVDD		V
VOH	Logic output High Level DRV pin	I _{out} = 100 μA		VDD-0.3		V
		I _{out} = 1 mA		VDD-0.7		V
VOL	Logic output Low Level DRV pin	I _{out} = -100 μA			0.3	V
		I _{out} = -1 mA			0.7	V
VIH _{M_DRV}	Minimum Logic High Threshold DELAY/M_DRV pin ⁽⁵⁾			1.5		V

- Electrical Characteristics Table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device such that $T_J = T_A$. No specification of parametric performance is indicated in the electrical tables under conditions of internal self-heating where $T_J > T_A$. Absolute Maximum Ratings indicate junction temperature limits beyond which the device may be permanently degraded, either mechanically or electrically.
- Limits are specified by testing, design, or statistical analysis at 25°C . Limits over the operating temperature range are specified through correlations using statistical quality control (SQC) method.
- Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration. The typical values are not tested and are not specified on shipped production material.
- The supply current excludes load and pull-up resistor current. Input pins are at GND or VDD.
- This parameter is specified by design and/or characterization and is not tested in production.
- Operational life time test procedure equivalent to 10 years.
- The accuracy for time interval settings below 1second is $\pm 100\text{ms}$.

6.6 Timing Requirements

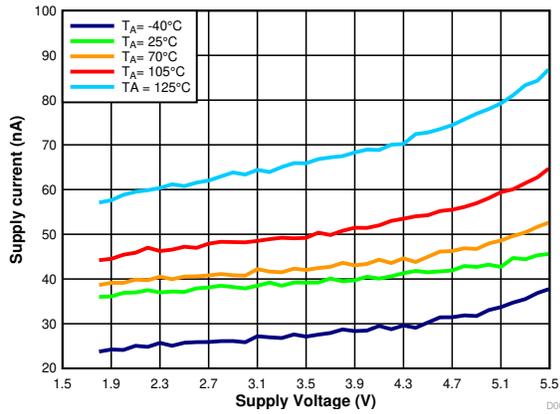
			MIN ⁽³⁾	NOM ⁽⁴⁾	MAX ⁽³⁾	UNIT
$t_{r_{DRV}}$	Rise Time DRV ⁽²⁾	Capacitive load 50 pF		50		ns
$t_{f_{DRV}}$	Fall Time DRV ⁽²⁾	Capacitive load 50 pF		50		ns
$t_{D_{DONE}}$	DONE to DRV delay	Min delay ⁽¹⁾		100		ns
		Max delay ⁽¹⁾		t_{DRV}		
t_{M_DRV}	Minimum Valid manual MOSFET Power ON	Observation time 30ms		20		ms
t_{DB}	De-bounce manual MOSFET Power ON			20		ms

- (1) from DRV falling edge.
- (2) This parameter is specified by design and/or characterization and is not tested in production.
- (3) Limits are specified by testing, design, or statistical analysis at 25°C. Limits over the operating temperature range are specified through correlations using statistical quality control (SQC) method.
- (4) Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration. The typical values are not tested and are not specified on shipped production material.

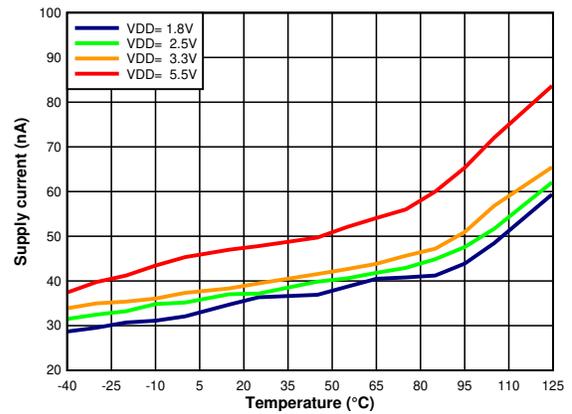


6-1. TPL5110-Q1 Timing

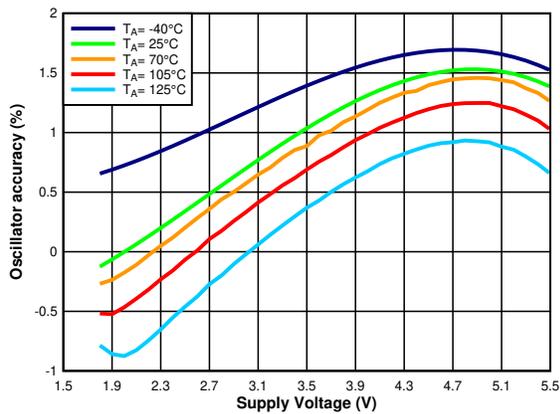
6.7 Typical Characteristics



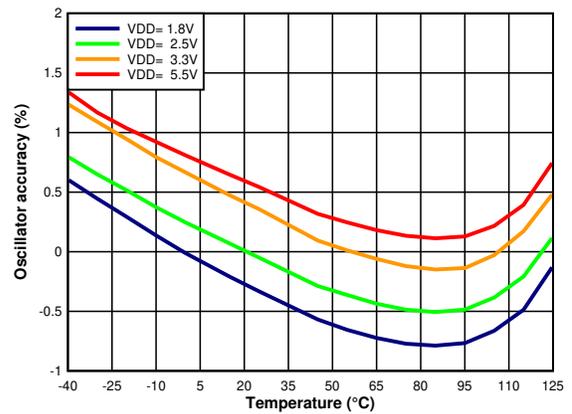
6-2. I_{DD} vs. V_{DD}



6-3. I_{DD} vs. Temperature

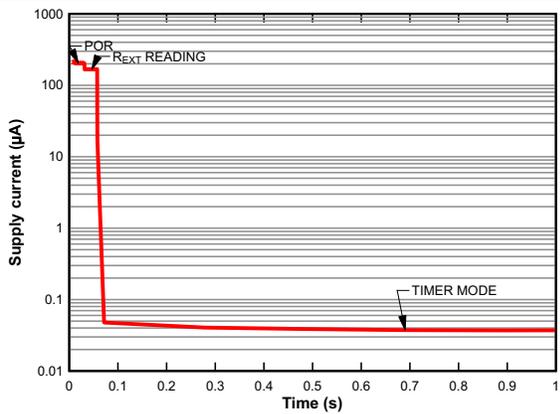


6-4. Oscillator Accuracy vs. V_{DD}

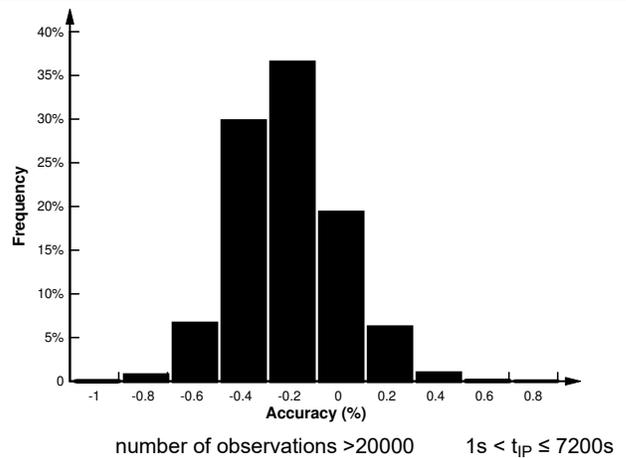


6-5. Oscillator Accuracy vs. Temperature

A.



6-6. I_{DD} vs. Time



6-7. Time Interval Setting Accuracy

7 Detailed Description

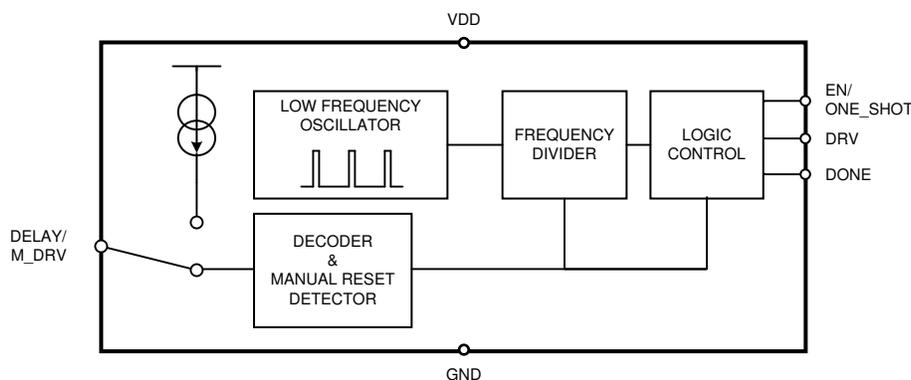
7.1 Overview

The TPL5110-Q1 is a timer with power gating feature. It is ideal for use in power-cycled applications and provides selectable timing from 100ms to 7200s.

Once configured in timer mode (EN/ONE_SHOT= HIGH) the TPL5110-Q1 periodically sends out a DRV signal to a MOSFET to turn on the μC . If the μC replies with a DONE signal within the programmed time interval (t_{DRV}) the TPL5110-Q1 turns off the μC , otherwise the TPL5110-Q1 keeps the μC in the on state for a time equal to t_{DRV} .

The TPL5110-Q1 can work also in a one-shot mode (EN/ONE_SHOT= LOW). In this mode the DRV signal is sent out just one time at the power on of the TPL5110-Q1 to turn on the μC . If the μC replies with a DONE signal within the programmed time interval (t_{DRV}) the TPL5110-Q1 turns off the μC , otherwise the TPL5110-Q1 keeps the μC in the on state for a time equal to t_{DRV} .

7.2 Functional Block Diagram



7.3 Feature Description

The TPL5110-Q1 implements a periodical power gating feature or one shot power gating according to the EN/ONE_SHOT voltage. A manual MOSFET Power ON function is realized by momentarily pulling the DELAY/M_DRV pin to VDD.

7.3.1 DRV

The gate of the MOSFET is connected to the DRV pin. When DRV= LOW, the MOSFET is turned ON. The pulse generated at DRV is equal to the selected time interval period, minus 50ms. It is shorter in the case of a DONE signal received from the μC . If the DONE signal is not received within the programmed time interval (minus 50ms), the DRV signal will be high for the last 50ms of the time interval in order to turn off the MOSFET before the next cycle starts.

The default value (after resistance reading) is HIGH. The signal is sent out from the TPL5110-Q1 when the programmed time interval starts. When the DRV is LOW, the manual power ON signal is ignored.

7.3.2 DONE

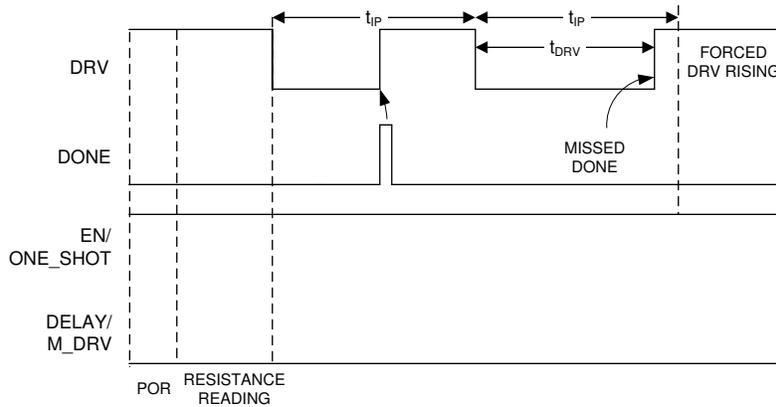
The DONE pin is driven by a μC to signal that the μC is working properly. The TPL5110-Q1 recognizes a valid DONE signal as a low to high transition; if two or more DONE signals are received within the time interval, only the first DONE signal is processed. The minimum DONE signal pulse length is 100ns. When the TPL5110-Q1 receives the DONE signal it asserts DRV logic HIGH.

7.4 Device Functional Modes

7.4.1 Start-Up

During start-up, after POR, the TPL5110-Q1 executes a one-time measurement of the resistance attached to the DELAY/M_DRV pin in order to determine the desired time interval for DRV. This measurement interval is $t_{\text{R_EXT}}$. During this measurement a constant current is temporarily flowing into R_{EXT} .

Once the reading of the external resistance is completed the TPL5110-Q1 enters automatically in one of the 2 modes according to the EN/ONE_SHOT value. The EN/ONE_SHOT pin must be hard wired to GND or VDD according to the required mode of operation.



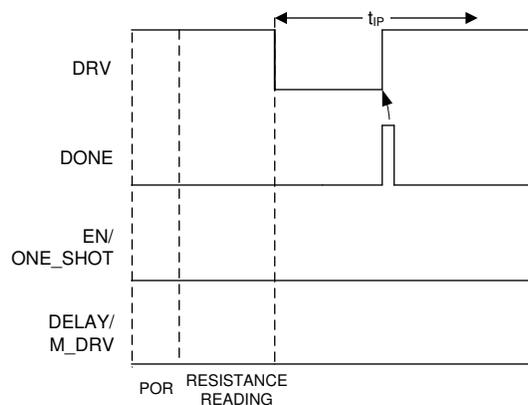
7-1. Start-Up - Timer Mode

7.4.2 Timer Mode

During timer mode (EN/ONE_SHOT = HIGH), the TPL5110-Q1 asserts periodic DRV pulses according to the programmed time interval. The length of the DRV pulses is set by the receiving of a DONE pulse from the uC. See 7-1.

7.4.3 One-Shot Mode

During one-shot mode (EN/ONE_SHOT = LOW), the TPL5110-Q1 generates just one pulse at the DRV pin which lasts according to the programmed time interval. In one-shot mode, other DRV pulses can be triggered using the DELAY/M_DRV pin. If a valid manual power ON occurs when EN/ONE_SHOT is LOW, the TPL5110-Q1 generates just one pulse at the DRV pin. The duration of the pulse is set by the programmed time interval. Also in this case, if a DONE signal is received within the programmed time interval (minus 50ms), the MOSFET connected to the DRV pin is turned off. See 7-2 and 7-3.



7-2. Start-Up One-Shot Mode, (DONE Received Within t_{IP})

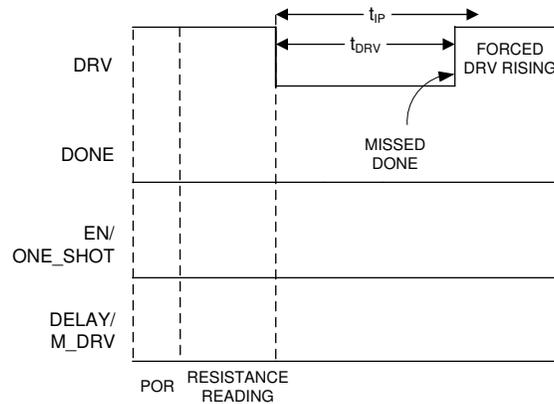


图 7-3. Start-Up One-Shot Mode, (No DONE Received Within t_{IP})

7.5 Programming

7.5.1 Configuring the Time Interval with the DELAY/M_DRV Pin

The time interval between 2 adjacent DRV pulses (falling edges, in timer mode) is selectable through an external resistance (R_{EXT}) between the DELAY/M_DRV pin and ground. The resistance (R_{EXT}) must be in the range between 500Ω and $170k\Omega$. At least a 1% precision resistance is recommended. See section [セクション 7.5.3](#) on how to set the time interval using R_{EXT} .

7.5.2 Manual MOSFET Power ON Applied to the DELAY/M_DRV Pin

If VDD is connected to the DELAY/M_DRV pin, the TPL5110-Q1 recognizes this as a manual MOSFET Power ON condition. In this case the time interval is not set. If the manual MOSFET Power ON is asserted during the POR or during the reading procedure, the reading procedure is aborted and is re-started as soon as the manual MOSFET Power ON switch is released. A pulse on the DELAY/M_DRV pin is recognized as a valid manual MOSFET Power ON only if it lasts at least 20ms (observation time is 30ms). The manual MOSFET Power ON may be implemented using a switch (momentary mechanical action).

If the DRV is already LOW (MOSFET ON) the manual MOSFET Power ON is ignored.

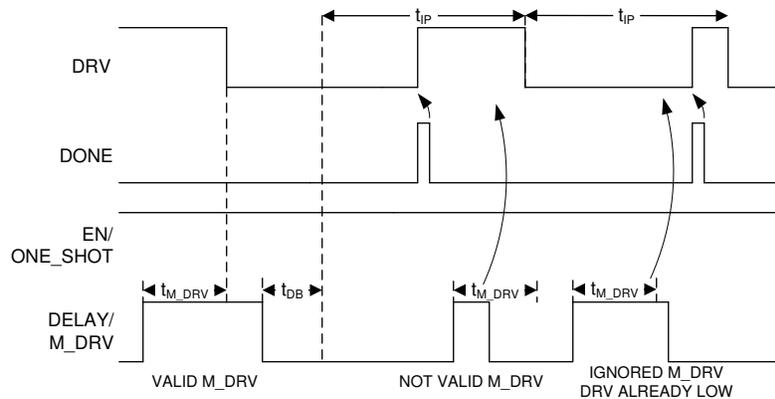


图 7-4. Manual MOSFET Power ON in Timer Mode

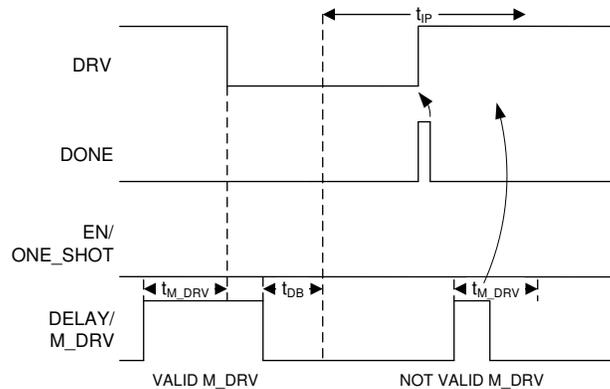


Figure 7-5. Manual MOSFET Power ON in One-Shot Mode

7.5.2.1 DELAY/M_DRV

A resistance in the range between 500Ω and 170kΩ must be connected to the DELAY/M_DRV pin in order to select a valid time interval. At the POR and during the reading of the resistance, the DELAY/M_DRV is connected to an analog signal chain through a mux. After the reading of the resistance, the analog circuit is switched off and the DELAY/M_DRV is connected to a digital circuit.

In this state, a logic HIGH applied to the DELAY/M_DRV pin is interpreted by the TPL5110-Q1 as a manual power ON. The manual power ON detection is provided with a de-bounce feature (on both edges) which makes the TPL5110-Q1 insensitive to the glitches on the DELAY/M_DRV.

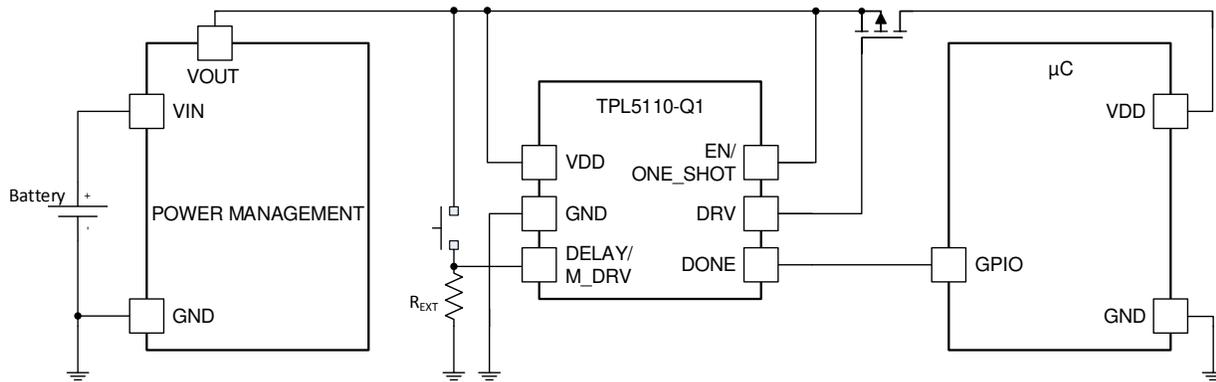
The M_DRV must stay high for at least 20ms to be valid. Once a valid signal at DELAY/M_DRV is understood as a manual power on, the DRV signal will be asserted in the next 10ms. Its duration will be according to the programmed time interval (minus 50ms), or less if the DONE is received.

A manual power ON signal resets all the counters. The counters will restart as soon as a valid manual power ON signal is recognized and the signal at DELAY/M_DRV pin is asserted LOW. Due to the asynchronous nature of the manual power ON signal and its arbitrary duration, the LOW status of the DRV signal may be affected by an uncertainty of about ±5ms.

An extended assertion of a logic HIGH at the DELAY/M_DRV pin will turn on the MOSFET for a time longer than the programmed time interval. DONE signals received while the DELAY/M_DRV is HIGH are ignored. If the DRV is already LOW (MOSFET ON) the manual power ON is ignored.

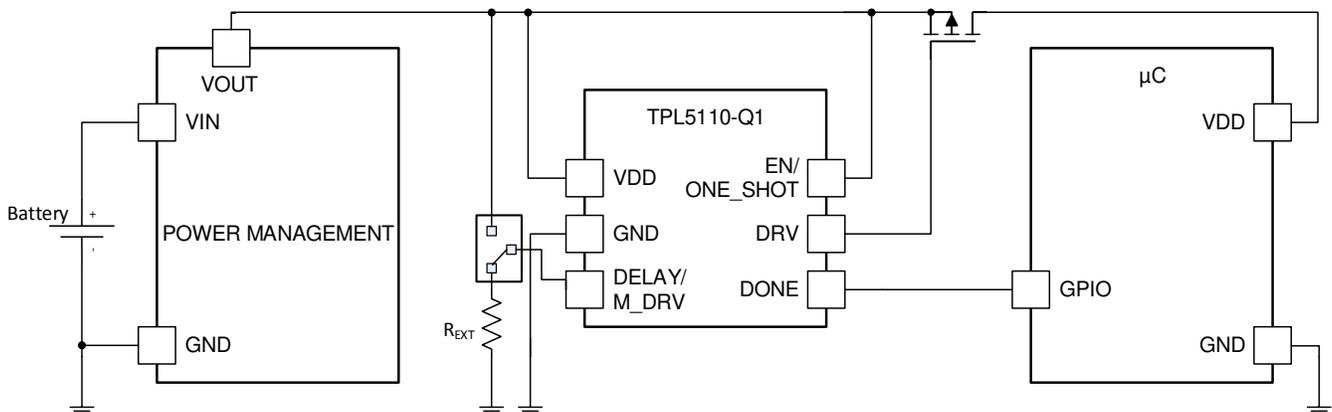
7.5.2.2 Circuitry

The manual Power ON may be implemented using a switch (momentary mechanical action). The TPL5110-Q1 offers 2 possible approaches according to the power consumption constraints of the application.



7-6. Manual MOSFET Power ON with SPST Switch

For use cases that do not require the lowest power consumption, using a single pole single throw switch may offer a lower cost solution. The DELAY/M_DRV pin may be directly connected to VDD with R_{EXT} in the circuit. The current drawn from the supply voltage during the manual power ON is given by VDD/R_{EXT} .



7-7. Manual MOSFET Power ON with SPDT Switch

The manual MOSFET Power ON function may also be asserted by switching DELAY/M_DRV from R_{EXT} to VDD using a single pole double throw switch, which will provide a lower power solution for the manual power ON, because no current flows.

7.5.3 Selection of the External Resistance

In order to set the time interval, the external resistance R_{EXT} is selected according the following formula:

$$R_{EXT} = 100 \left(\frac{-b + \sqrt{b^2 - 4a(c - 100T)}}{2a} \right) \quad (1)$$

Where:

- **T** is the desired time interval in seconds.
- **R_{EXT}** is the resistance value to use in Ω .
- **a,b,c** are coefficients depending on the range of the time interval.

表 7-1. Coefficients for 式 1

SET	Time Interval Range (s)	a	b	c
1	1 < T ≤ 5	0.2253	-20.7654	570.5679
2	5 < T ≤ 10	-0.1284	46.9861	-2651.8889
3	10 < T ≤ 100	0.1972	-19.3450	692.1201
4	100 < T ≤ 1000	0.2617	-56.2407	5957.7934
5	T > 1000	0.3177	-136.2571	34522.4680

EXAMPLE

Required time interval: 8s

The coefficient set to be selected is the number 2. The formula becomes

$$R_{EXT} = 100 \left(\frac{46.9861 - \sqrt{46.9861^2 + 4 * 0.1284 (-2651.8889 - 100 * 8)}}{2 * 0.1284} \right) \quad (2)$$

The resistance value is 10.18 kΩ.

The following Look-Up-Tables contain example values of t_{IP} and their corresponding value of R_{EXT} .

表 7-2. First 9 Time Intervals

t_{IP} (ms)	Resistance (Ω)	Closest real value (Ω)	Parallel of two 1% tolerance resistors, (kΩ)
100	500	500	1.0 // 1.0
200	1000	1000	-
300	1500	1500	2.43 // 3.92
400	2000	2000	-
500	2500	2500	4.42 // 5.76
600	3000	3000	5.36 // 6.81
700	3500	3500	4.75 // 13.5
800	4000	4000	6.19 // 11.3
900	4500	4501	6.19 // 16.5

表 7-3. Most Common Time Intervals Between 1s to 2h

t_{IP}	Calculated Resistance (kΩ)	Closest Real Value (kΩ)	Parallel of Two 1% Tolerance Resistors, (kΩ)
1s	5.20	5.202	7.15 // 19.1
2s	6.79	6.788	12.4 // 15.0
3s	7.64	7.628	12.7 // 19.1
4s	8.30	8.306	14.7 // 19.1
5s	8.85	8.852	16.5 // 19.1
6s	9.27	9.223	18.2 // 18.7
7s	9.71	9.673	19.1 // 19.6
8s	10.18	10.180	11.5 // 8.87
9s	10.68	10.68	17.8 // 26.7
10s	11.20	11.199	15.0 // 44.2
20s	14.41	14.405	16.9 // 97.6
30s	16.78	16.778	32.4 // 34.8
40s	18.75	18.748	22.6 // 110.0

表 7-3. Most Common Time Intervals Between 1s to 2h (continued)

t_{IP}	Calculated Resistance (k Ω)	Closest Real Value (k Ω)	Parallel of Two 1% Tolerance Resistors, (k Ω)
50s	20.047	20.047	28.7 // 66.5
1min	22.02	22.021	40.2 // 48.7
2min	29.35	29.349	35.7 // 165.0
3min	34.73	34.729	63.4 // 76.8
4min	39.11	39.097	63.4 // 102.0
5min	42.90	42.887	54.9 // 196.0
6min	46.29	46.301	75.0 // 121.0
7min	49.38	49.392	97.6 // 100.0
8min	52.24	52.224	88.7 // 127.0
9min	54.92	54.902	86.6 // 150.0
10min	57.44	57.437	107.0 // 124.0
20min	77.57	77.579	140.0 // 174.0
30min	92.43	92.233	182.0 // 187.0
40min	104.67	104.625	130.0 // 536.00
50min	115.33	115.331	150.0 // 499.00
1h	124.91	124.856	221.0 // 287.00
1h30min	149.39	149.398	165.0 // 1580.0
2h	170.00	170.00	340.0 // 340.0

7.5.4 Quantization Error

The TPL5110-Q1 can generate 1650 discrete timer intervals in the range of 100ms to 7200s. The first 9 intervals are multiples of 100ms. The remaining 1641 intervals cover the range between 1s to 7200s. Because they are discrete intervals, there is a quantization error associated with each value.

The quantization error can be evaluated according to the following formula:

$$Err = 100 \frac{(T_{DESIRED} - T_{ADC})}{T_{DESIRED}} \quad (3)$$

Where:

$$T_{ADC} = INT \left[\frac{1}{100} \left(a \frac{R_D^2}{100} + b \frac{R_D}{100} + c \right) \right] \quad (4)$$

$$R_D = INT \left[\frac{R_{EXT}}{100} \right] \quad (5)$$

R_{EXT} is the resistance calculated with 式 1 and a,b,c are the coefficients of the equation listed in 表 7-1.

7.5.5 Error Due to Real External Resistance

R_{EXT} is a theoretical value and may not be available in standard commercial resistor values. It is possible to closely approach the theoretical R_{EXT} using two or more standard values in parallel. However, standard values are characterized by a certain tolerance. This tolerance will affect the accuracy of the time interval.

The accuracy can be evaluated using the following procedure:

1. Evaluate the min and max values of R_{EXT} (R_{EXT_MIN} , R_{EXT_MAX} with 式 1 using the selected commercial resistance values and their tolerances.
2. Evaluate the time intervals ($T_{ADC_MIN}[R_{EXT_MIN}]$, $T_{ADC_MAX}[R_{EXT_MAX}]$) with 式 4.

3. Find the errors using 式 3 with T_{ADC_MIN} , T_{ADC_MAX} .

The results of the formula indicate the accuracy of the time interval.

The example below illustrates the procedure.

- Desired time interval , $T_{desired} = 600s$,
- Required R_{EXT} , from 式 1, $R_{EXT} = 57.44k\Omega$.

From 表 7-3, R_{EXT} can be built with a parallel combination of two commercial values with 1% tolerance: $R1=107k\Omega$, $R2=124k\Omega$. The uncertainty of the equivalent parallel resistance can be found using:

$$uR_{//} = R_{//} \sqrt{\left(\frac{u_{R1}}{R1}\right)^2 + \left(\frac{u_{R2}}{R2}\right)^2} \quad (6)$$

Where uR_n ($n=1,2$) represent the uncertainty of a resistance,

$$u_{R_n} = R_n \frac{Tolerance}{\sqrt{3}} \quad (7)$$

The uncertainty of the parallel resistance is 0.82%, meaning the value of R_{EXT} may range between $R_{EXT_MIN} = 56.96 k\Omega$ and $R_{EXT_MAX} = 57.90 k\Omega$.

Using these value of R_{EXT} , the digitized timer intervals calculated with 式 4 are respectively $T_{ADC_MIN} = 586.85 s$ and $T_{ADC_MAX} = 611.3 s$, giving an error range of -1.88% / +2.19%. The asymmetry of the error range is due to the quadratic transfer function of the resistance digitizer.

8 Application and Implementation

Note

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8.1 Application Information

In battery powered applications one design constraint is the need for low current consumption. The TPL5110-Q1 is suitable in applications where there is a need to monitor environmental conditions at a fixed time interval. Often in these applications a watchdog or other internal timer in a μC is used to implement a wakeup function. Typically, the power consumption of these functions is not optimized. Using the TPL5110-Q1 to implement a periodical power gating of the μC or of the entire system the current consumption will be only tens of nA.

8.2 Typical Application

The TPL5110-Q1 can be used in environment sensor nodes such as humidity and temperature sensor node. The sensor node has to measure the humidity and the temperature and transmit the data through a low power RF micro such as the CC2531. Since the temperature and the humidity in home application do not change so fast, the measurement and the transmission of the data can be done at very low rate, such as every 30 seconds. The RF micro should spend most of the time in counting the elapsed time, but using the TPL5110-Q1 it is possible to complete turn off the RF micro and extend the battery life. The TPL5110-Q1 will turn on the RF micro when the programmed time interval elapses or for debug purpose with the manual MOSFET Power ON switch.

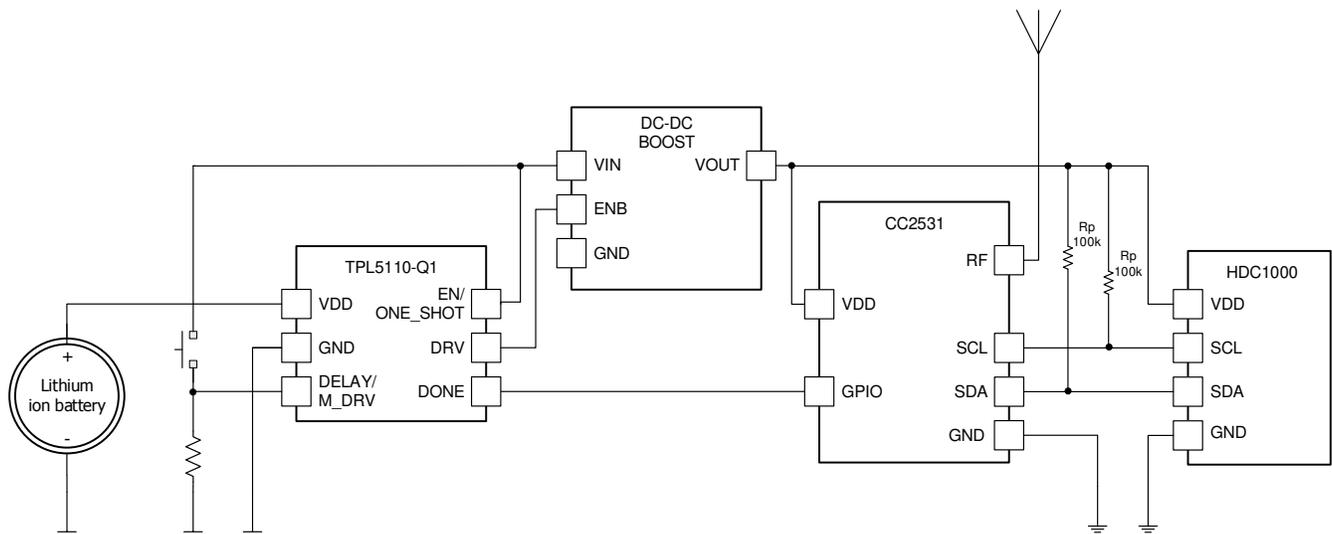


図 8-1. Sensor Node

8.2.1 Design Requirements

The Design is driven by the low current consumption constraint. The data are usually acquired on a rate which is in the range between 30s and 60s. The highest necessity is the maximization of the battery life. The TPL5110-Q1 helps achieve this goal because it allows turning off the RF micro.

8.2.2 Detailed Design Procedure

When the focal constraint is the battery life, the selection of a low power voltage regulator and low leakage MOSFET to power gate the μC is mandatory. The first step in the design is the calculation of the power consumption of each device in the different mode of operations. An example is the HDC1000, in measurement mode the RF micro is in normal operation and transmission. The different modes offer the possibility to select the appropriate time interval which respect the application constraint and maximize the life of the battery.

8.2.3 Application Curve

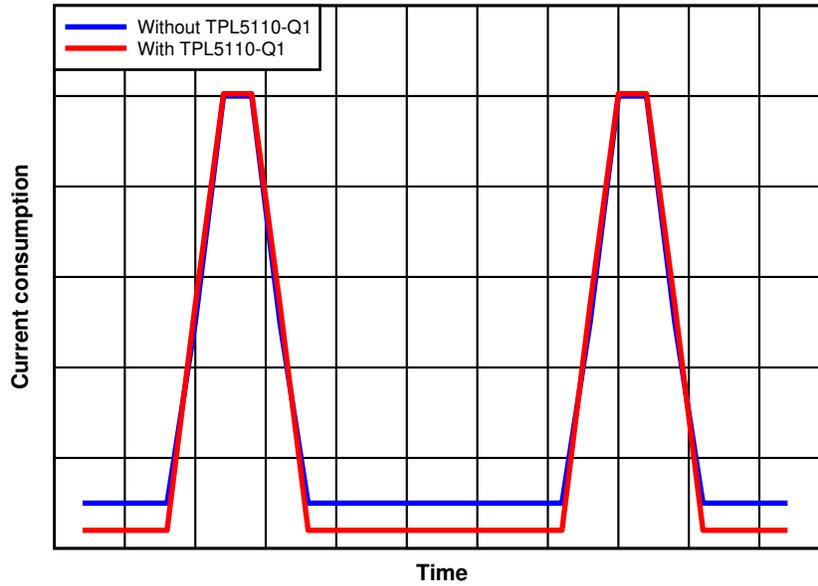


图 8-2. Effect of TPL5110-Q1 on Current Consumption

9 Power Supply Recommendations

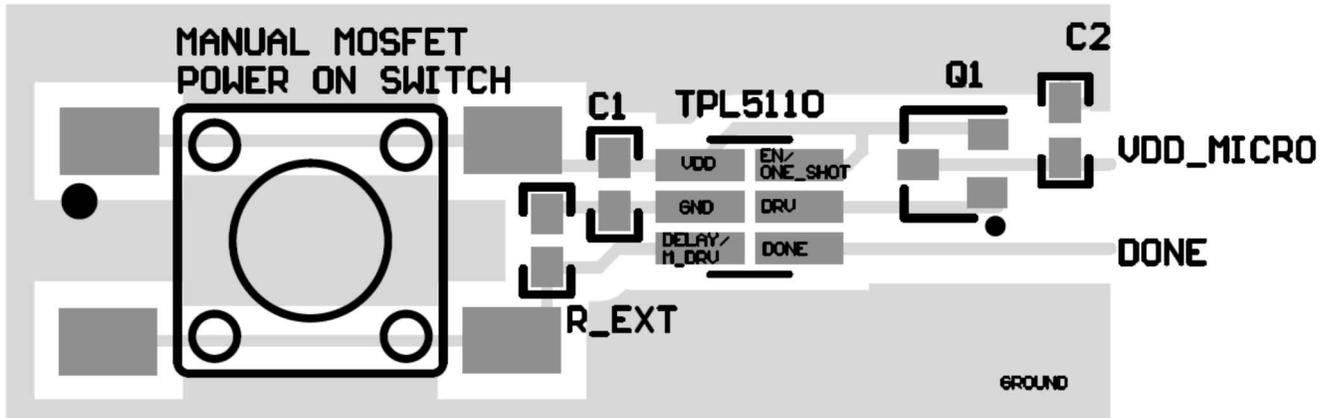
The TPL5110-Q1 requires a voltage supply within 1.8 V and 5.5 V. A multilayer ceramic bypass X7R capacitor of 0.1 μ F between VDD and GND pin is recommended.

10 Layout

10.1 Layout Guidelines

The DELAY/M_DRV pin is sensitive to parasitic capacitance. It is suggested that the traces connecting the resistance on this pin to GROUND be kept as short as possible to minimize parasitic capacitance. This capacitance can affect the initial set up of the time interval. Signal integrity on the DRV pin is also improved by keeping the trace length between the TPL5110-Q1 and the gate of the MOSFET short to reduce the parasitic capacitance. The EN/ONE_SHOT needs to be tied to GND or VDD with short traces.

10.2 Layout Example



10-1. Layout

11 Device and Documentation Support

11.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](https://www.ti.com). Click on *Subscribe to updates* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

11.2 サポート・リソース

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This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

11.5 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
TPL5110QDDCRQ1	Active	Production	SOT-23-THIN (DDC) 6	3000 LARGE T&R	Yes	NIPDAU SN	Level-1-260C-UNLIM	-40 to 125	13ZX
TPL5110QDDCRQ1.A	Active	Production	SOT-23-THIN (DDC) 6	3000 LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 125	13ZX
TPL5110QDDCTQ1	Active	Production	SOT-23-THIN (DDC) 6	250 SMALL T&R	Yes	NIPDAU SN	Level-1-260C-UNLIM	-40 to 125	13ZX
TPL5110QDDCTQ1.A	Active	Production	SOT-23-THIN (DDC) 6	250 SMALL T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 125	13ZX

(1) **Status:** For more details on status, see our [product life cycle](#).

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "-" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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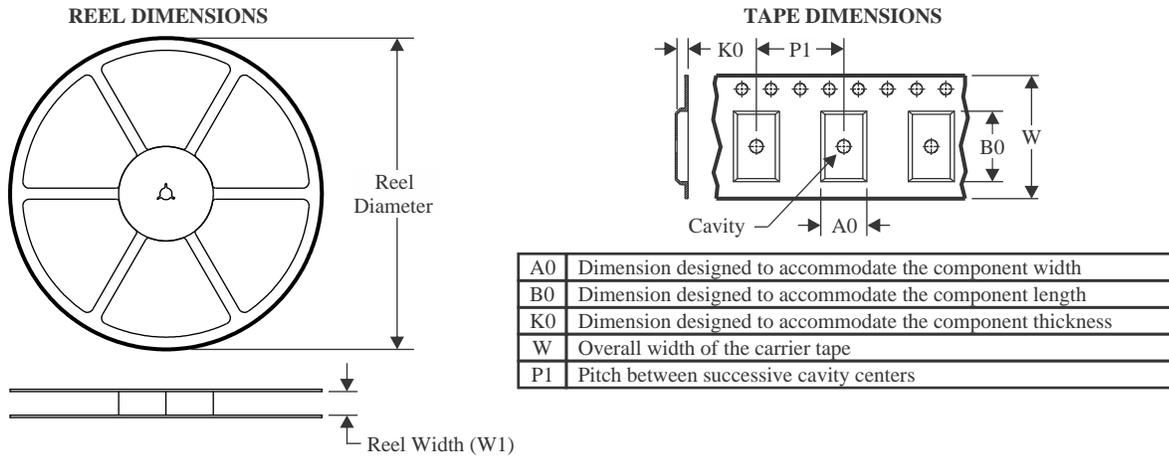
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

OTHER QUALIFIED VERSIONS OF TPL5110-Q1 :

- Catalog : [TPL5110](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

TAPE AND REEL INFORMATION

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TPL5110QDDCRQ1	SOT-23-THIN	DDC	6	3000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
TPL5110QDDCTQ1	SOT-23-THIN	DDC	6	250	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

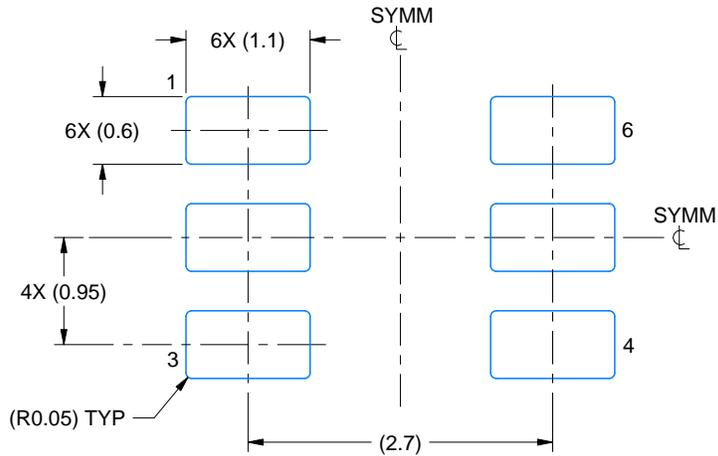
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPL5110QDDCRQ1	SOT-23-THIN	DDC	6	3000	208.0	191.0	35.0
TPL5110QDDCTQ1	SOT-23-THIN	DDC	6	250	208.0	191.0	35.0

EXAMPLE BOARD LAYOUT

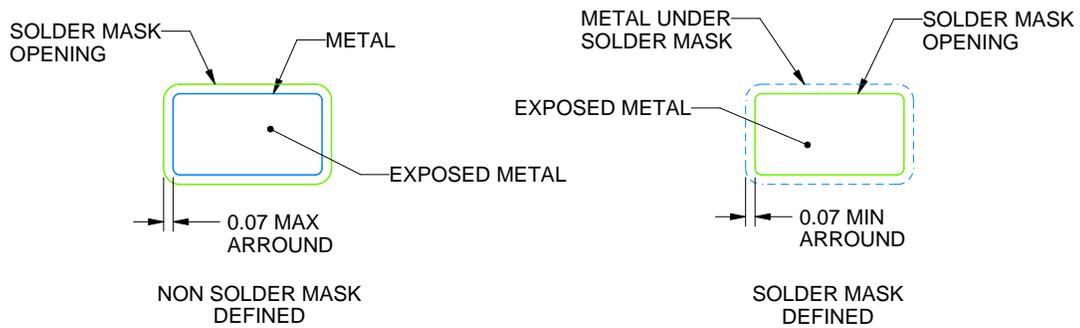
DDC0006A

SOT-23 - 1.1 max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE
EXPLODED METAL SHOWN
SCALE:15X



SOLDEMASK DETAILS

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NOTES: (continued)

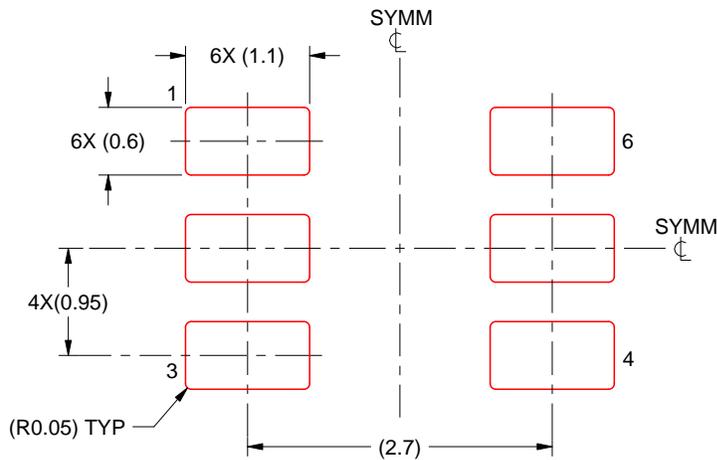
- 4. Publication IPC-7351 may have alternate designs.
- 5. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

DDC0006A

SOT-23 - 1.1 max height

SMALL OUTLINE TRANSISTOR



SOLDER PASTE EXAMPLE
BASED ON 0.125 THICK STENCIL
SCALE:15X

4214841/E 08/2024

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
7. Board assembly site may have different recommendations for stencil design.

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