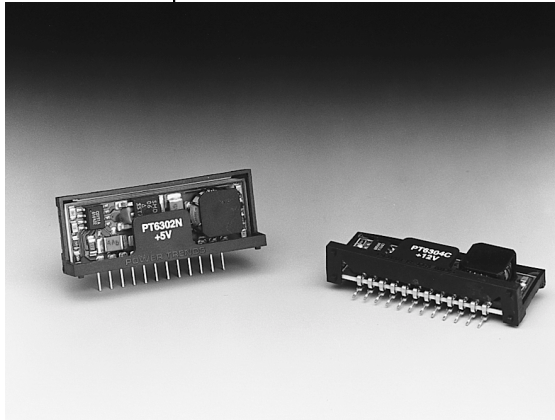


# PT6220 Series

2 AMP ADJUSTABLE LOW VOLTAGE INPUT INTEGRATED SWITCHING REGULATOR

SLTS082  
(Revised 8/7/98)

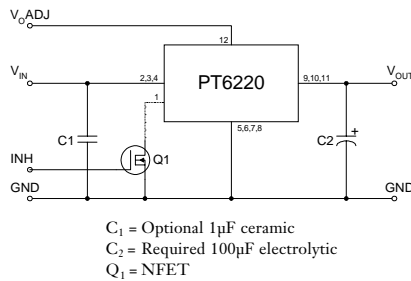


- Low Voltage Input (7V)
- 89% Efficiency
- Adjustable Output Voltage
- Internal Short Circuit Protection
- Over-Temperature Protection
- On/Off Control (Ground Off)

The PT6220 series is a low voltage input (typically 7V) version of Power Trends' high-performance 2A, 12 pin SIP Integrated Switching

Regulators (ISRs). These ISRs are designed with premium low threshold FETs for those applications requiring very low input/output voltage differentials such as battery powered equipment. This high-performance ISR family offers a unique combination of features combining 89% typical efficiency with open-collector on/off control and adjustable output voltage. Quiescent current in the shutdown mode is less than 100µA.

### Standard Application



### Pin-Out Information

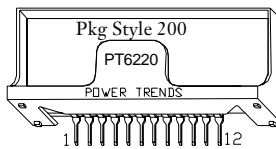
Pin	Function
1	Inhibit (30V max)
2	V <sub>in</sub>
3	V <sub>in</sub>
4	V <sub>in</sub>
5	GND
6	GND
7	GND
8	GND
9	V <sub>out</sub>
10	V <sub>out</sub>
11	V <sub>out</sub>
12	V <sub>out</sub> Adj

### Ordering Information

PT6222□ = +5.0 Volts  
PT6223□ = +3.3 Volts

### PT Series Suffix (PT1234X)

Case/Pin Configuration	Suffix
Vertical Through-Hole	N
Horizontal Through-Hole	A
Horizontal Surface Mount	C



### Specifications

Characteristics (T <sub>a</sub> = 25°C unless noted)	Symbols	Conditions	PT6220 SERIES			Units
			Min	Typ	Max	
Output Current	I <sub>o</sub>	Over V <sub>in</sub> range	0.1*	—	2.0	A
Short Circuit Current	I <sub>sc</sub>	V <sub>in</sub> = V <sub>in</sub> min	—	5.0	—	Apk
Input Voltage Range (Note: inhibit function cannot be used with V <sub>in</sub> above 30V)	V <sub>in</sub>	0.1 ≤ I <sub>o</sub> ≤ 2.0 A	7	—	26	V
			7	—	30/38**	V
Output Voltage Tolerance	ΔV <sub>o</sub>	Over V <sub>in</sub> Range, I <sub>o</sub> = 2.0 A T <sub>a</sub> = 0°C to +60°C	—	±1.0	±2.0	%V <sub>o</sub>
Line Regulation	Reg <sub>line</sub>	Over V <sub>in</sub> range	—	±0.25	±0.5	%V <sub>o</sub>
Load Regulation	Reg <sub>load</sub>	0.1 ≤ I <sub>o</sub> ≤ 2.0 A	—	±0.25	±0.5	%V <sub>o</sub>
V <sub>o</sub> Ripple/Noise	V <sub>n</sub>	V <sub>in</sub> = V <sub>in</sub> min	—	±2	—	%V <sub>o</sub>
Transient Response with C <sub>o</sub> = 100µF	t <sub>tr</sub> V <sub>os</sub>	50% load change V <sub>o</sub> over/undershoot	—	100 5.0	200	µSec %V <sub>o</sub>
Efficiency	η	V <sub>in</sub> = 9V, I <sub>o</sub> = 0.5 A V <sub>in</sub> = 9V, I <sub>o</sub> = 0.5 A	—	84 89	—	% %
		V <sub>o</sub> = 3.3V V <sub>o</sub> = 5V	—	—	—	—
Switching Frequency	f <sub>o</sub>	Over V <sub>in</sub> and I <sub>o</sub> ranges	450	—	900	kHz
Shutdown Current	I <sub>sc</sub>	V <sub>in</sub> = 16V	—	100	—	µA
Quiescent Current	I <sub>nl</sub>	I <sub>o</sub> = 0A, V <sub>in</sub> = 10V	—	10	—	mA
Output Voltage Adjustment Range	V <sub>o</sub>	Below V <sub>o</sub> Above V <sub>o</sub>	See Application Notes.			
Absolute Maximum Operating Temperature Range	T <sub>a</sub>		-40	—	+85	°C
Recommended Operating	T <sub>a</sub>	Free Air Convection, (40-60LFM)	-40	—	+85***	°C
Thermal Resistance	θ <sub>ja</sub>	Free Air Convection (40-60LFM)	—	40	—	°C/W
Storage Temperature	T <sub>s</sub>	—	-40	—	+125	°C
Mechanical Shock	—	Per Mil-STD-883D, Method 2002.3, 1 msec, Half Sine, mounted to a fixture	—	500	—	G's
Mechanical Vibration	—	Per Mil-STD-883D, Method 2007.2, 20-2000 Hz, Soldered in a PC board	—	10	—	G's
Weight	—	—	—	6	—	grams

\* ISR will operate to no load with reduced specifications.

\*\* Input voltage cannot exceed 30V when the inhibit function is used. \*\*\* See Thermal Derating chart

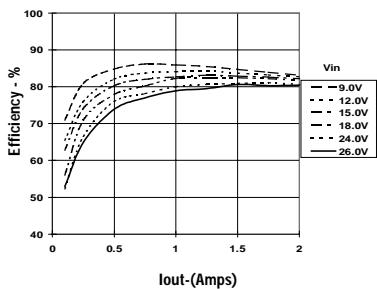
Note: The PT6220 Series requires a 100µF electrolytic or tantalum output capacitor for proper operation in all applications.

CHARACTERISTIC DATA

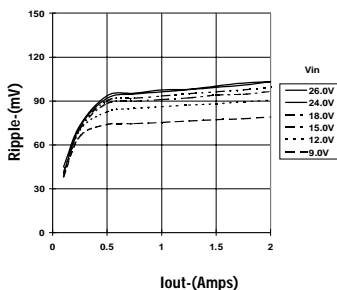
PT6220 Series

PT6223, 3.3 VDC (See Note 1)

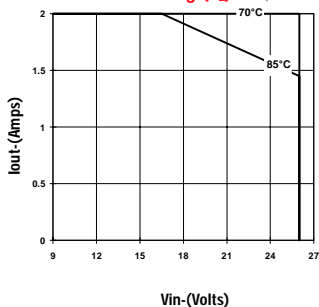
Efficiency vs Output Current



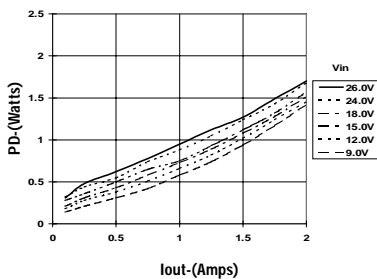
Ripple vs Output Current



Thermal Derating ( $T_a$ ) (See Note 2)

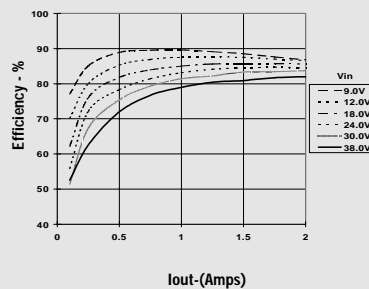


Power Dissipation vs Output Current

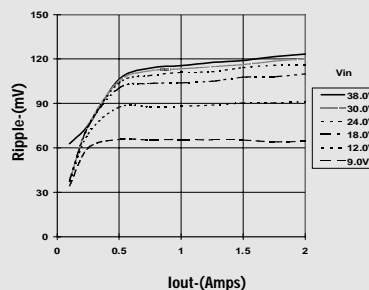


PT6222, 5.0 VDC (See Note 1)

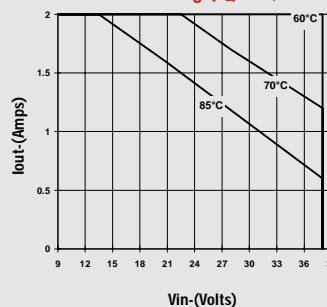
Efficiency vs Output Current



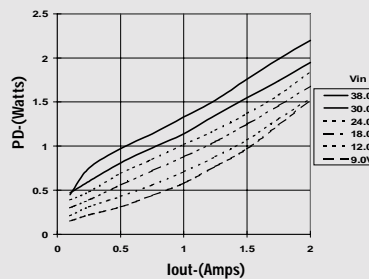
Ripple vs Output Current



Thermal Derating ( $T_a$ ) (See Note 2)



Power Dissipation vs Output Current



Note 1: All data listed in the above graphs, except for derating data, has been developed from actual products tested at 25°C. This data is considered typical data for the ISR.  
 Note 2: Thermal derating graphs are developed in free air convection cooling of 40-60 LFM. (See Thermal Application Notes).

[More Application Notes](#)

### Adjusting the Output Voltage of Power Trends' Wide Input Range Bus ISRs

The output voltage of the Power Trends' Wide Input Range Series ISRs may be adjusted higher or lower than the factory trimmed pre-set voltage with the addition of a single external resistor. Table 1 accordingly gives the allowable adjustment range for each model for either series as  $V_a$  (min) and  $V_a$  (max).

**Adjust Up:** An increase in the output voltage is obtained by adding a resistor R2, between pin 12 ( $V_o$  adjust) and pins 5-8 (GND).

**Adjust Down:** Add a resistor (R1), between pin 12 ( $V_o$  adjust) and pins 9-11( $V_{out}$ ).

Refer to Figure 1 and Table 2 for both the placement and value of the required resistor; either (R1) or R2 as appropriate.

**Notes:**

1. Use only a single 1% resistor in either the (R1) or R2 location. Place the resistor as close to the ISR as possible.
2. Never connect capacitors from  $V_o$  adjust to either GND or  $V_{out}$ . Any capacitance added to the  $V_o$  adjust pin will affect the stability of the ISR.
4. Adjustments to the output voltage may place additional limits on the maximum and minimum input voltage for the part. The revised maximum and minimum input voltage limits must comply with the following requirements. Note that the minimum input voltage limits are also model dependant.

$$V_{in}(\max) = (8 \times V_a)V \text{ or } *30/38V, \text{ whichever is less.}$$

*\*Limit is 30V when inhibit function is active.*

**PT6x0x/PT6x1x series:**

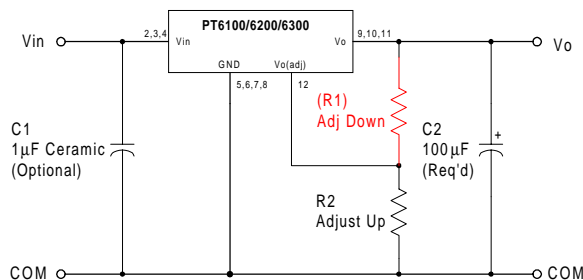
$$V_{in}(\min) = (V_a + 4)V \text{ or } 9V, \text{ whichever is greater.}$$

**PT6x2x series:**

$$V_o < 10V; \quad V_{in}(\min) = (V_a + 2.0)V \text{ or } 7.0V, \text{ whichever is greater.}$$

$$V_o \geq 10V; \quad V_{in}(\min) = (V_a + 2.5)V$$

Figure 1



The values of (R1) [adjust down], and R2 [adjust up], can also be calculated using the following formulae.

$$(R1) = \frac{R_o (V_a - 1.25)}{V_o - V_a} \quad k\Omega$$

$$R2 = \frac{1.25 R_o}{V_a - V_o} \quad k\Omega$$

Where:  $V_o$  = Original output voltage  
 $V_a$  = Adjusted output voltage  
 $R_o$  = The resistance value from Table 1

Table 1

ISR ADJUSTMENT RANGE AND FORMULA PARAMETERS				
	PT6102	PT6101		PT6103
1Adc Rated	PT6122	PT6121		
	PT6213		PT6212	PT6214
2Adc Rated	PT6223		PT6222	
	PT6303		PT6302	PT6304
3Adc Rated	PT6323		PT6322	
	$V_o$ (nom)	3.3	5.0	5.0
$V_a$ (min)	1.89	1.88	2.18	2.43
$V_a$ (max)	6.07	11.25	8.5	22.12
$R_o$ (k $\Omega$ )	66.5	150.0	90.9	243.0

Table 2

ISR ADJUSTMENT RESISTOR VALUES

1Adc Rated	PT6102	PT6101		PT6103
2Adc Rated	PT6213	PT6211	PT6212	PT6214
3Adc Rated	PT6303		PT6302	PT6304
$V_o$ (nom)	3.3	5.0	5.0	12.0
$V_a$ (req.d)				
1.9	(30.9)k $\Omega$	(31.5)k $\Omega$		
2.0	(38.4)k $\Omega$	(37.5)k $\Omega$		
2.1	(47.1)k $\Omega$	(44.0)k $\Omega$		
2.2	(57.4)k $\Omega$	(50.9)k $\Omega$	(30.8)k $\Omega$	
2.3	(69.8)k $\Omega$	(58.3)k $\Omega$	(35.4)k $\Omega$	
2.4	(85.0)k $\Omega$	(66.3)k $\Omega$	(40.2)k $\Omega$	
2.5	(104.0)k $\Omega$	(75.0)k $\Omega$	(45.5)k $\Omega$	(32.0)k $\Omega$
2.6	(128.0)k $\Omega$	(84.4)k $\Omega$	(51.1)k $\Omega$	(34.9)k $\Omega$
2.7	(161.0)k $\Omega$	(94.6)k $\Omega$	(57.3)k $\Omega$	(37.9)k $\Omega$
2.8	(206.0)k $\Omega$	(106.0)k $\Omega$	(64.0)k $\Omega$	(40.9)k $\Omega$
2.9	(274.0)k $\Omega$	(118.0)k $\Omega$	(71.4)k $\Omega$	(44.1)k $\Omega$
3.0	(388.0)k $\Omega$	(131.0)k $\Omega$	(79.5)k $\Omega$	(47.3)k $\Omega$
3.1	(615.0)k $\Omega$	(146.0)k $\Omega$	(88.5)k $\Omega$	(50.5)k $\Omega$
3.2	(1300.0)k $\Omega$	(163.0)k $\Omega$	(98.5)k $\Omega$	(53.8)k $\Omega$
3.3		(181.0)k $\Omega$	(110.0)k $\Omega$	(57.3)k $\Omega$
3.4	831.0k $\Omega$	(202.0)k $\Omega$	(122.0)k $\Omega$	(60.8)k $\Omega$
3.5	416.0k $\Omega$	(225.0)k $\Omega$	(136.0)k $\Omega$	(64.3)k $\Omega$
3.6	227.0k $\Omega$	(252.0)k $\Omega$	(153.0)k $\Omega$	(68.0)k $\Omega$
3.7	208.0k $\Omega$	(283.0)k $\Omega$	(171.0)k $\Omega$	(71.7)k $\Omega$
3.8	166.0k $\Omega$	(319.0)k $\Omega$	(193.0)k $\Omega$	(75.6)k $\Omega$
3.9	139.0k $\Omega$	(361.0)k $\Omega$	(219.0)k $\Omega$	(79.5)k $\Omega$
4.0	119.0k $\Omega$	(413.0)k $\Omega$	(250.0)k $\Omega$	(83.5)k $\Omega$
4.1	104.0k $\Omega$	(475.0)k $\Omega$	(288.0)k $\Omega$	(87.7)k $\Omega$
4.2	92.4k $\Omega$	(533.0)k $\Omega$	(335.0)k $\Omega$	(91.9)k $\Omega$
4.3	83.1k $\Omega$	(654.0)k $\Omega$	(396.0)k $\Omega$	(96.3)k $\Omega$
4.4	75.6k $\Omega$	(788.0)k $\Omega$	(477.0)k $\Omega$	(101.0)k $\Omega$
4.5	69.3k $\Omega$	(975.0)k $\Omega$	(591.0)k $\Omega$	(105.0)k $\Omega$
4.6	63.9k $\Omega$	(1260.0)k $\Omega$	(761.0)k $\Omega$	(110.0)k $\Omega$
4.7	59.4k $\Omega$	(1730.0)k $\Omega$	(1050.0)k $\Omega$	(115.0)k $\Omega$
4.8	55.4k $\Omega$		(1610.0)k $\Omega$	(120.0)k $\Omega$
4.9	52.0k $\Omega$			(125.0)k $\Omega$
5.0	48.9k $\Omega$			(130.0)k $\Omega$
5.1	46.2k $\Omega$	1880.0k $\Omega$	1140.0k $\Omega$	(136.0)k $\Omega$
5.2	43.8k $\Omega$	937.0k $\Omega$	568.0k $\Omega$	(141.0)k $\Omega$
5.3	41.6k $\Omega$	625.0k $\Omega$	379.0k $\Omega$	(147.0)k $\Omega$
5.4	39.6k $\Omega$	469.0k $\Omega$	284.0k $\Omega$	(153.0)k $\Omega$
5.5	37.8k $\Omega$	375.0k $\Omega$	227.0k $\Omega$	(159.0)k $\Omega$
5.6	36.1k $\Omega$	313.0k $\Omega$	189.0k $\Omega$	(165.0)k $\Omega$
5.7	34.6k $\Omega$	268.0k $\Omega$	162.0k $\Omega$	(172.0)k $\Omega$
5.8	33.3k $\Omega$	234.0k $\Omega$	142.0k $\Omega$	(178.0)k $\Omega$
5.9	32.0k $\Omega$	208.0k $\Omega$	126.0k $\Omega$	(185.0)k $\Omega$
6.0	30.8k $\Omega$	188.0k $\Omega$	114.0k $\Omega$	(192.0)k $\Omega$

R1 = (Red) R2 = Black

ISR ADJUSTMENT RESISTOR VALUES (Cont)

1Adc Rated	PT6101		PT6103
2Adc Rated	PT6211	PT6212	PT6214
3Adc Rated		PT6302	PT6304
$V_o$ (nom)	5.0	5.0	12.0
$V_a$ (req.d)			
6.2	156.0k $\Omega$	94.7k $\Omega$	(207.0)k $\Omega$
6.4	134.0k $\Omega$	81.2k $\Omega$	(223.0)k $\Omega$
6.6	117.0k $\Omega$	71.0k $\Omega$	(241.0)k $\Omega$
6.8	104.0k $\Omega$	63.1k $\Omega$	(259.0)k $\Omega$
7.0	93.8k $\Omega$	56.8k $\Omega$	(279.0)k $\Omega$
7.2	85.2k $\Omega$	51.6k $\Omega$	(301.0)k $\Omega$
7.4	78.1k $\Omega$	47.3k $\Omega$	(325.0)k $\Omega$
7.6	72.1k $\Omega$	43.7k $\Omega$	(351.0)k $\Omega$
7.8	67.0k $\Omega$	40.6k $\Omega$	(379.0)k $\Omega$
8.0	62.5k $\Omega$	37.9k $\Omega$	(410.0)k $\Omega$
8.2	58.6k $\Omega$	35.5k $\Omega$	(444.0)k $\Omega$
8.4	55.1k $\Omega$	33.4k $\Omega$	(483.0)k $\Omega$
8.6	52.1k $\Omega$		(525.0)k $\Omega$
8.8	49.3k $\Omega$		(573.0)k $\Omega$
9.0	46.9k $\Omega$		(628.0)k $\Omega$
9.5	41.7k $\Omega$		(802.0)k $\Omega$
10.0	37.5k $\Omega$		(1060.0)k $\Omega$
10.5	34.1k $\Omega$		(1500.0)k $\Omega$
11.0	31.3k $\Omega$		
11.5			
12.0			
12.5			608.0k $\Omega$
13.0			304.0k $\Omega$
13.5			203.0k $\Omega$
14.0			152.0k $\Omega$
14.5			122.0k $\Omega$
15.0			101.0k $\Omega$
15.5			86.8k $\Omega$
16.0			75.9k $\Omega$
16.5			67.5k $\Omega$
17.0			60.8k $\Omega$
17.5			55.2k $\Omega$
18.0			50.6k $\Omega$
18.5			46.7k $\Omega$
19.0			43.4k $\Omega$
19.5			40.5k $\Omega$
20.0			38.0k $\Omega$
20.5			35.7k $\Omega$
21.5			33.8k $\Omega$
21.5			32.0k $\Omega$
22.0			30.4k $\Omega$

[More Application Notes](#)

## Using the Inhibit Function on Power Trends' Wide Input Range Bus ISRs

For applications requiring output voltage On/Off control, the 12pin ISR products incorporate an inhibit function. The function has uses in areas such as battery conservation, power-up sequencing, or any other application where the regulated output from the module is required to be switched off. The On/Off function is provided by the *Inhibit* control, pin 1.

The ISR functions normally with pin 1 open-circuit, providing a regulated output whenever a valid source voltage is applied to  $V_{in}$ , (pins 2, 3, & 4). When a low-level<sup>2</sup> ground signal is applied to pin 1 the regulator output is disabled, and the input current to the ISR is reduced to about 100 $\mu$ A<sup>3</sup>.

Figure 1 shows an application schematic, which details the typical use of the inhibit function. Note the discrete transistor, Q1. The inhibit control has its own internal pull-up with a maximum open-circuit voltage of 8.3VDC. Only devices with a true open-collector or open-drain output can be used to control this pin. A discrete bipolar transistor or MOSFET is recommended.

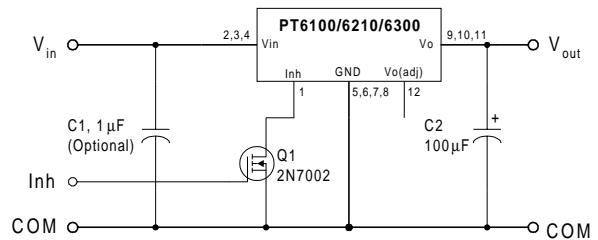
### Notes:

1. The inhibit control logic is similar for all Power Trends' modules, but the flexibility and threshold tolerances will be different. For specific information on the inhibit function of other ISR models, consult the applicable application note.
2. Use only a true open-collector device (preferably a discrete transistor) for the inhibit input. **Do Not** use a pull-up resistor, or drive the input directly from the output of a TTL or other logic gate. To disable the output voltage, the control pin should be pulled low to less than +1.5VDC.
3. The following equation may be used to determine the approximate current drawn from the input supply at  $V_{in}$ , and through Q1 when the inhibit is active.

$$I_{stby} = V_{in} \div 155k\Omega \pm 20\%$$

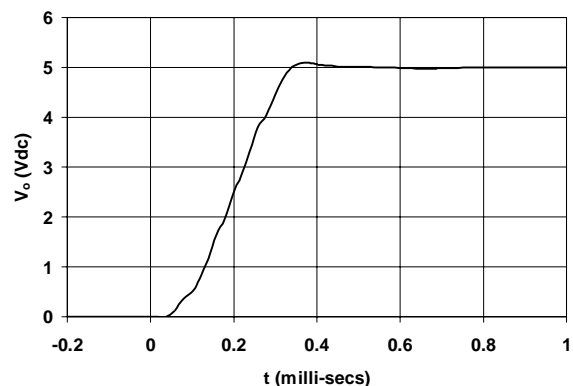
4. When the inhibit control pin is active, i.e. pulled low, the maximum input voltage is limited to +30Vdc.
5. Do not control the inhibit input with an external DC voltage. This will lead to erratic operation of the ISR and may over-stress the regulator.
6. Avoid capacitance greater than 500pF at the Inhibit control pin. Excessive capacitance at this pin will cause the ISR to produce a pulse on the output voltage bus at turn-on.
7. Keep the On/Off transition to less than 10 $\mu$ s. This prevents erratic operation of the ISR, which can cause a momentary high output voltage.

Figure 1



**Turn-On Time:** The output of the ISR is enabled automatically when external power is applied to the input. The *Inhibit* control pin is pulled high by its internal pull-up resistor. The ISR produces a fully regulated output voltage within 1-msec of either the release of the Inhibit control pin, or the application of power. The actual turn-on time will vary with the input voltage, output load, and the total amount of capacitance connected to the output. Using the circuit of Figure 1, Figure 2 shows the typical rise in output voltage for the PT6101 following the turn-off of Q1 at time  $t=0$ . The waveform was measured with a 9Vdc input voltage, and 5-Ohm resistive load.

Figure 2



**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/ Ball Finish	MSL Peak Temp <sup>(3)</sup>	Samples (Requires Login)
PT6222A	NRND	SIP MODULE	EBA	12	12	Pb-Free (RoHS)	Call TI	N / A for Pkg Type	
PT6222C	NRND	SIP MODULE	EBC	12		TBD	Call TI	Call TI	
PT6222H	OBSOLETE	SIP MODULE	EBH	12		TBD	Call TI	Call TI	
PT6222J	OBSOLETE	SIP MODULE	EBJ	12		TBD	Call TI	Call TI	
PT6222S	OBSOLETE	SIP MODULE	EBF	12		TBD	Call TI	Call TI	
PT6223H	OBSOLETE	SIP MODULE	EBH	12		TBD	Call TI	Call TI	

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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