

2 Amp Adjustable Positive Step-down
Integrated Switching Regulator

SLTS030B

(Revised 9/30/2000)

- 90% Efficiency
- Adjustable Output Voltage
- Internal Short Circuit Protection
- Over-Temperature Protection
- On/Off Control (Ground Off)
- Small SIP Footprint
- Wide Input Range

Switching Regulators (ISRs) designed to meet the on-board power conversion needs of battery powered or other equipment requiring high efficiency and small size. This high performance ISR family offers a unique combination of features combining 90% typical efficiency with open-collector on/off control and adjustable output voltage. Quiescent current in the shutdown mode is typically less than 100µA.

The PT6210 Series is a line of High-Performance 2 Amp, 12-Pin SIP (Single In-line Package) Integrated

Pin-Out Information

Pin	Function
1	Inhibit (30V max)
2	V _{in}
3	V _{in}
4	V _{in}
5	GND
6	GND
7	GND
8	GND
9	V _{out}
10	V _{out}
11	V _{out}
12	V _{out} Adj (5)

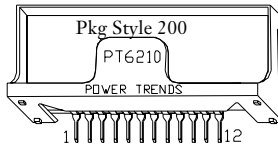
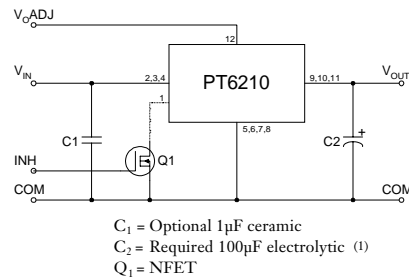
Ordering Information

- PT6211□ = +5.1 Volts
- PT6212□ = +5.0 Volts
- PT6213□ = +3.3 Volts
- PT6214□ = +12 Volts
- PT6216□ = +1.5Volts

PT Series Suffix (PT1234X)

Case/Pin Configuration	Suffix
Vertical Through-Hole	P
Horizontal Through-Hole	D
Horizontal Surface Mount	E

Standard Application



Note: Heat spreaders are not electrically connected to product.
Note: Back surface of product is conducting metal.

Specifications

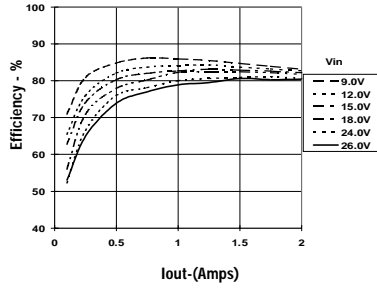
Characteristics (T _a = 25°C unless noted)	Symbols	Conditions	PT6210 SERIES			Units
			Min	Typ	Max	
Output Current	I _o	Over V _{in} range	0.1 (2)	—	2.0	A
Short Circuit Current	I _{sc}	V _{in} = V _{in min}	—	5.0	—	Apk
Input Voltage Range	V _{in}	0.1 ≤ I _o ≤ 2.0 A	V _o = 12V 9 9 9	—	30/38 (3) 30/38 (3) 26 17	V
<i>(Note: inhibit function cannot be used with V_{in} above 30V.)</i>						
Output Voltage Tolerance	ΔV _o	Over V _{in} Range, I _o = 2.0 A T _a = 0°C to +60°C	—	±1.0	±2.0	%V _o
Line Regulation	Reg _{line}	Over V _{in} range	—	±0.25	±0.5	%V _o
Load Regulation	Reg _{load}	0.1 ≤ I _o ≤ 2.0 A	—	±0.25	±0.5	%V _o
V _o Ripple/Noise	V _n	V _{in} = V _{in min}	—	±2	—	%V _o
Transient Response with C _o = 100µF	t _{tr} V _{os}	50% load change V _o over/undershoot	—	100 5.0	200 —	µSec %V _o
Efficiency	η	V _{in} = 16V, I _o = 0.5A V _{in} = 9V, I _o = 0.5 A V _{in} = 9V, I _o = 0.5 A V _{in} = 9V, I _o = 0.5 A	V _o = 12V — — —	91 89 84 72	— — — —	%
Switching Frequency	f _o	Over V _{in} and I _o ranges	V _o ≥ 3.3V V _o = 1.5V	450 400	— —	900 500 kHz
Shutdown Current	I _{sc}	V _{in} = 16V	—	100	—	µA
Quiescent Current	I _{nl}	I _o = 0A, V _{in} = 10V	—	10	—	mA
Absolute Maximum Operating Temperature Range	T _a	Over V _{in} range	—	—	+85 (4)	°C
Thermal Resistance	θ _{ja}	Free Air Convection (40-60LFM)	—	40	—	°C/W
Storage Temperature	T _s	—	—	—	+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

- Notes:**
- (1) The PT6210 Series requires a 100µF electrolytic or tantalum output capacitor for proper operation in all applications.
 - (2) The ISR will operate to no load with reduced specifications.
 - (3) Input voltage cannot exceed 30V when the inhibit function is used.
 - (4) See Thermal Derating charts.
 - (5) Consult the related application note for guidance on adjusting the output voltage.

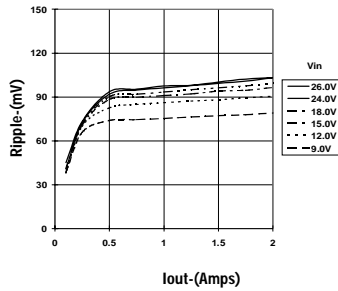
2 Amp Adjustable Positive Step-down Integrated Switching Regulator

PT6213, 3.3 VDC (See Note A)

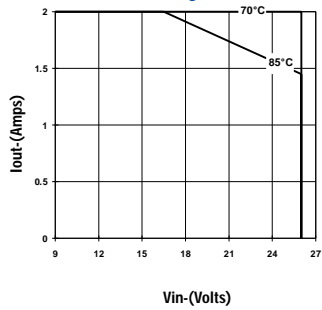
Efficiency vs Output Current



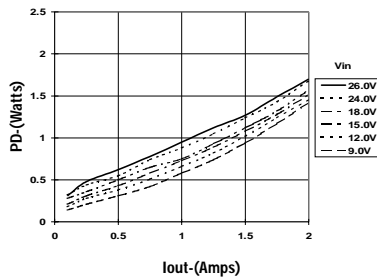
Ripple vs Output Current



Thermal Derating (Ta) (See Note B)

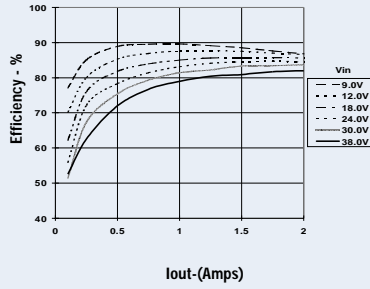


Power Dissipation vs Output Current

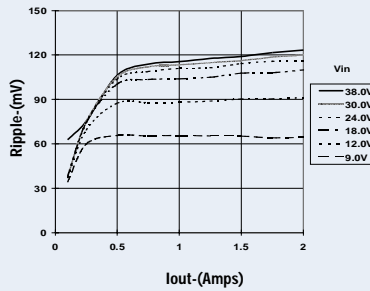


PT6212, 5.0 VDC (See Note A)

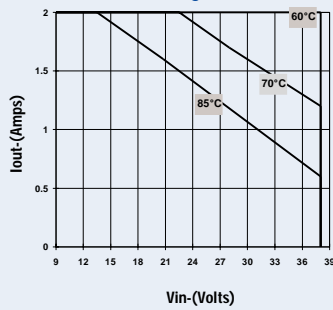
Efficiency vs Output Current



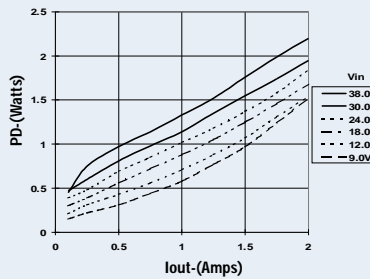
Ripple vs Output Current



Thermal Derating (Ta) (See Note B)

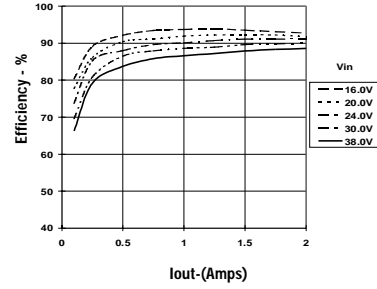


Power Dissipation vs Output Current

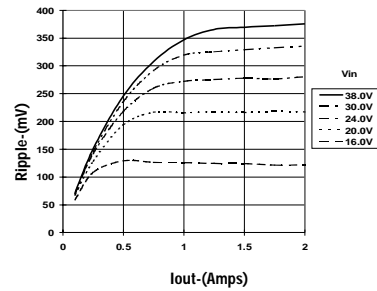


PT6214, 12.0 VDC (See Note A)

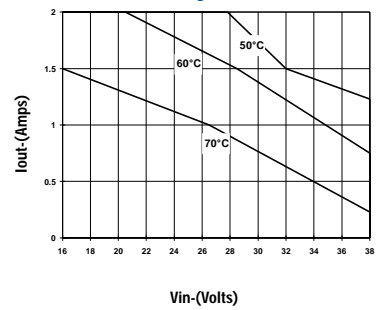
Efficiency vs Output Current



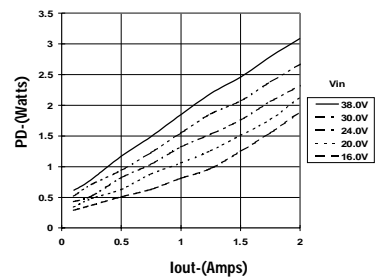
Ripple vs Output Current



Thermal Derating (Ta) (See Note B)



Power Dissipation vs Output Current



Note A: The characteristic data listed in the above graphs has been developed from actual products tested at 25°C. This data is considered typical data for the ISR.

Note B: Thermal derating graphs are developed in free air convection cooling of 40-60 LFM. (See Thermal Application Notes).

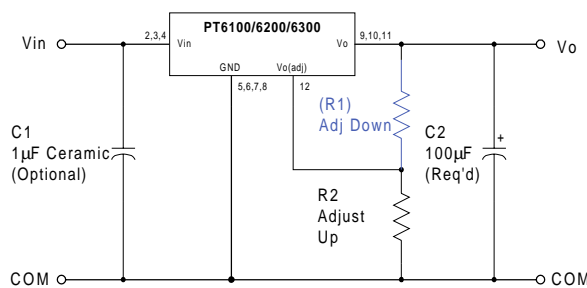
Adjusting the Output Voltage of Power Trends' Wide Input Range Bus ISRs

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}).

Figure 1



The values of (R1) [adjust down], and R2 [adjust up], can also be calculated using the following formulas. Refer to Figure 1 and Table 2 for both the placement and value of the required resistor; either (R1) or R2 as appropriate.

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

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

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					
1A dc Rated		PT6102	PT6101		PT6103
2A dc Rated	PT6216	PT6213		PT6212	PT6214
3A dc Rated	PT6314	PT6303		PT6302	PT6304
V_o (nom)	1.5	3.3	5.0	5.0	12.0
V_a (min)	1.3	1.8	1.88	2.18	2.43
V_a (max)	1.9	6.07	11.25	8.5	22.12
R_o (k Ω)	8.25	66.5	150.0	90.9	243.0

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.
3. 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. The limits are model dependant.

PT6216/PT6314:

$$V_{in} (\text{max}) = (10 \times V_a)V \text{ or } 17V, \text{ whichever is less.}$$

$$V_{in} (\text{min}) = 9.0V$$

All other models:

$$V_{in} (\text{max}) = (8 \times V_a)V \text{ or as specified.}$$

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

PT6100/6210/6300 Series

Table 2

ISR ADJUSTMENT RESISTOR VALUES

1Adc Rated		PT6102	PT6101		PT6103
2Adc Rated	PT6216	PT6213		PT6212	PT6214
3Adc Rated	PT6314	PT6303		PT6302	PT6304
V ₀ (nom)	1.5	3.3	5.0	5.0	12.0
V _a (req.d)					
1.3	(2.1kΩ)				
1.4	(12.4kΩ)				
1.5					
1.6	103.0kΩ				
1.7	51.6kΩ				
1.8	34.4kΩ	(24.4)kΩ			
1.9	25.8kΩ	(30.9)kΩ	(31.5)kΩ		
2.0		(38.4)kΩ	(37.5)kΩ		
2.1		(47.1)kΩ	(44.0)kΩ		
2.2		(57.4)kΩ	(50.9)kΩ	(30.8)kΩ	
2.3		(69.8)kΩ	(58.3)kΩ	(35.4)kΩ	
2.4		(85.0)kΩ	(66.3)kΩ	(40.2)kΩ	
2.5		(104.0)kΩ	(75.0)kΩ	(45.5)kΩ	(32.0)kΩ
2.6		(128.0)kΩ	(84.4)kΩ	(51.1)kΩ	(34.9)kΩ
2.7		(161.0)kΩ	(94.6)kΩ	(57.3)kΩ	(37.9)kΩ
2.8		(206.0)kΩ	(106.0)kΩ	(64.0)kΩ	(40.9)kΩ
2.9		(274.0)kΩ	(118.0)kΩ	(71.4)kΩ	(44.1)kΩ
3.0		(388.0)kΩ	(131.0)kΩ	(79.5)kΩ	(47.3)kΩ
3.1		(615.0)kΩ	(146.0)kΩ	(88.5)kΩ	(50.5)kΩ
3.2		(1300.0)kΩ	(163.0)kΩ	(98.5)kΩ	(53.8)kΩ
3.3		(181.0)kΩ	(110.0)kΩ	(57.3)kΩ	
3.4		831.0kΩ	(202.0)kΩ	(122.0)kΩ	(60.8)kΩ
3.5		416.0kΩ	(225.0)kΩ	(136.0)kΩ	(64.3)kΩ
3.6		227.0kΩ	(252.0)kΩ	(153.0)kΩ	(68.0)kΩ
3.7		208.0kΩ	(283.0)kΩ	(171.0)kΩ	(71.7)kΩ
3.8		166.0kΩ	(319.0)kΩ	(193.0)kΩ	(75.6)kΩ
3.9		139.0kΩ	(361.0)kΩ	(219.0)kΩ	(79.5)kΩ
4.0		119.0kΩ	(413.0)kΩ	(250.0)kΩ	(83.5)kΩ
4.1		104.0kΩ	(475.0)kΩ	(288.0)kΩ	(87.7)kΩ
4.2		92.4kΩ	(533.0)kΩ	(335.0)kΩ	(91.9)kΩ
4.3		83.1kΩ	(654.0)kΩ	(396.0)kΩ	(96.3)kΩ
4.4		75.6kΩ	(788.0)kΩ	(477.0)kΩ	(101.0)kΩ
4.5		69.3kΩ	(975.0)kΩ	(591.0)kΩ	(105.0)kΩ
4.6		63.9kΩ	(1260.0)kΩ	(761.0)kΩ	(110.0)kΩ
4.7		59.4kΩ	(1730.0)kΩ	(1050.0)kΩ	(115.0)kΩ
4.8		55.4kΩ		(1610.0)kΩ	(120.0)kΩ
4.9		52.0kΩ			(125.0)kΩ
5.0		48.9kΩ			(130.0)kΩ
5.1		46.2kΩ	1880.0kΩ	1140.0kΩ	(136.0)kΩ
5.2		43.8kΩ	937.0kΩ	568.0kΩ	(141.0)kΩ
5.3		41.6kΩ	625.0kΩ	379.0kΩ	(147.0)kΩ
5.4		39.6kΩ	469.0kΩ	284.0kΩ	(153.0)kΩ
5.5		37.8kΩ	375.0kΩ	227.0kΩ	(159.0)kΩ
5.6		36.1kΩ	313.0kΩ	189.0kΩ	(165.0)kΩ
5.7		34.6kΩ	268.0kΩ	162.0kΩ	(172.0)kΩ
5.8		33.3kΩ	234.0kΩ	142.0kΩ	(178.0)kΩ
5.9		32.0kΩ	208.0kΩ	126.0kΩ	(185.0)kΩ
6.0		30.8kΩ	188.0kΩ	114.0kΩ	(192.0)kΩ

ISR ADJUSTMENT RESISTOR VALUES (Cont)

1Adc Rated	PT6101		PT6103
2Adc Rated		PT6212	PT6214
3Adc Rated		PT6302	PT6304
V ₀ (nom)	5.0	5.0	12.0
V _a (req.d)			
6.2	156.0kΩ	94.7kΩ	(207.0)kΩ
6.4	134.0kΩ	81.2kΩ	(223.0)kΩ
6.6	117.0kΩ	71.0kΩ	(241.0)kΩ
6.8	104.0kΩ	63.1kΩ	(259.0)kΩ
7.0	93.8kΩ	56.8kΩ	(279.0)kΩ
7.2	85.2kΩ	51.6kΩ	(301.0)kΩ
7.4	78.1kΩ	47.3kΩ	(325.0)kΩ
7.6	72.1kΩ	43.7kΩ	(351.0)kΩ
7.8	67.0kΩ	40.6kΩ	(379.0)kΩ
8.0	62.5kΩ	37.9kΩ	(410.0)kΩ
8.2	58.6kΩ	35.5kΩ	(444.0)kΩ
8.4	55.1kΩ	33.4kΩ	(483.0)kΩ
8.6	52.1kΩ		(525.0)kΩ
8.8	49.3kΩ		(573.0)kΩ
9.0	46.9kΩ		(628.0)kΩ
9.5	41.7kΩ		(802.0)kΩ
10.0	37.5kΩ		(1060.0)kΩ
10.5	34.1kΩ		(1500.0)kΩ
11.0	31.3kΩ		
11.5			
12.0			
12.5			608.0kΩ
13.0			304.0kΩ
13.5			203.0kΩ
14.0			152.0kΩ
14.5			122.0kΩ
15.0			101.0kΩ
15.5			86.8kΩ
16.0			75.9kΩ
16.5			67.5kΩ
17.0			60.8kΩ
17.5			55.2kΩ
18.0			50.6kΩ
18.5			46.7kΩ
19.0			43.4kΩ
19.5			40.5kΩ
20.0			38.0kΩ
20.5			35.7kΩ
21.5			33.8kΩ
21.5			32.0kΩ
22.0			30.4kΩ

R1 = (Blue) R2 = Black

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 Pin 1 (*Inhibit*) control.

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-level² ground signal is applied to Pin 1, the regulator output will be disabled.

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.

Equation 1 may be used to determine the approximate current drawn by Q1 when the inhibit is active.

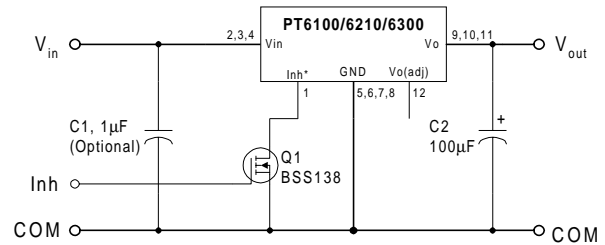
Equation 1

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

Notes:

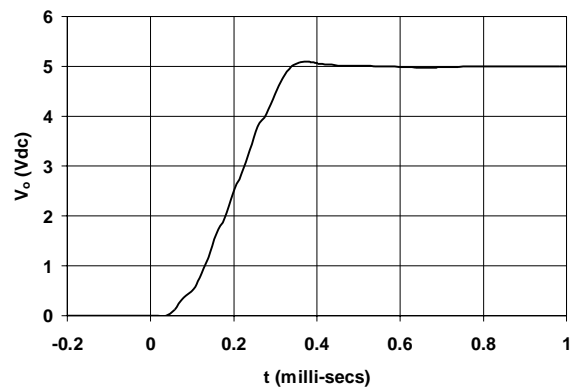
1. The Inhibit control logic is similar for all Power Trends' modules, but the flexibility and threshold tolerances will be different. For specific information on the inhibit function of other ISR models, consult the applicable application note.
2. Use only a true open-collector device (preferably a 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. When the Inhibit control pin is active, i.e. pulled low, the maximum allowed input voltage is limited to +30Vdc.
4. 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.
5. 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.
6. Keep the On/Off transition to less than 10 μ 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 ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
PT6211P	NRND	SIP MOD ULE	EBD	12	12	Pb-Free (RoHS)	Call TI	N / A for Pkg Type
PT6212D	NRND	SIP MOD ULE	EBA	12	12	Pb-Free (RoHS)	Call TI	N / A for Pkg Type
PT6212E	NRND	SIP MOD ULE	EBC	12	12	Pb-Free (RoHS)	Call TI	Level-1-215C-UNLIM
PT6212P	NRND	SIP MOD ULE	EBD	12	12	Pb-Free (RoHS)	Call TI	N / A for Pkg Type
PT6213D	NRND	SIP MOD ULE	EBA	12	12	Pb-Free (RoHS)	Call TI	N / A for Pkg Type
PT6213E	NRND	SIP MOD ULE	EBC	12	12	Pb-Free (RoHS)	Call TI	Level-1-215C-UNLIM
PT6213P	NRND	SIP MOD ULE	EBD	12	12	Pb-Free (RoHS)	Call TI	N / A for Pkg Type
PT6214D	NRND	SIP MOD ULE	EBA	12	12	Pb-Free (RoHS)	Call TI	N / A for Pkg Type
PT6214E	NRND	SIP MOD ULE	EBC	12	12	Pb-Free (RoHS)	Call TI	Level-1-215C-UNLIM
PT6214P	NRND	SIP MOD ULE	EBD	12	12	Pb-Free (RoHS)	Call TI	N / A for Pkg Type
PT6216E	NRND	SIP MOD ULE	EBC	12	12	Pb-Free (RoHS)	Call TI	Level-1-215C-UNLIM
PT6216P	NRND	SIP MOD ULE	EBD	12	12	Pb-Free (RoHS)	Call TI	N / A for Pkg Type

⁽¹⁾ 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.

⁽²⁾ 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)

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

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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
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