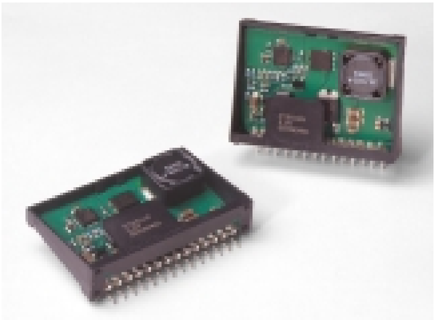
8-A 5-V/3.3-V Input Adjustable ISR with Short-Circuit protection

SLTS220 FEBRUARY 2004



Features

- 8-A Rated Output Current
- Replaces PT6500 Series
- High Efficiency (91% for PT6511)
- Small Footprint (0.75 in², Suffix 'N')
- Output On/Off Standby Control
- Output Short-Circuit Protection
- Over-Temperature Protection
- Adjustable Output Voltage
- Soft Startup
- 16-pin Mount Option (Suffixes L & F)

Description

The PT6510 series of power modules is the recommended direct replacement for the PT6500 series in existing designs. The modules have the same output current rating as the PT6500 series (8 A) and were designed to be functionally identical in as many aspects as possible. This includes the input voltage range, on/off standby control, and output voltage adjustment.

When used as a replacement, a PT6510 series part exhibits a number of performance enhancements over its PT6500 series equivalent. These include improved power dissipation and efficiency, significantly reduced inrush current, and better line and load regulation.

The modules are housed in the same 14-Pin SIP (Single In-line Package), and include the same package options.

Ordering Information

PT6511☐	=	3.3 Volts
† **PT6512☐**	=	1.5 Volts
PT6513☐	=	2.5 Volts
PT6514☐	=	3.6 Volts
† **PT6515☐**	=	1.2 Volts
† **PT6516☐**	=	1.8 Volts

† 3.3V Input Bus Capable

PT Series Suffix (PT1234x)

Case/Pin Configuration	Order Suffix	Package Code *
Vertical	N	(EED)
Horizontal	A	(EEA)
SMD	C	(EEC)
Horizontal, Top Tab	H	(EEH)
SMD, 2-Pin Tab	L	(EEL)
SMD, 2-Pin Ext Tab	F	(EEF)
Vertical, Side Tab	R	(EEE)
Horizontal, Side Tab	G	(EEG)
SMD, Side Tab	B	(EEK)

** Previously known as package styles 400/410.*

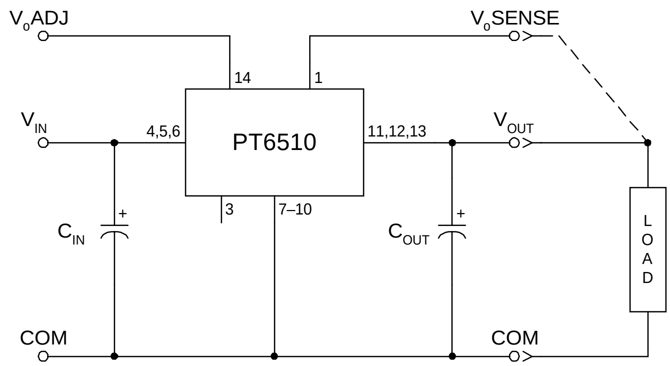
(Package availability varies with output voltage option. Reference the applicable package code drawing for the dimensions and PC board layout)

Pin-Out Information

Pin	Function
1	V_o Sense
2	Do Not Connect
3	STBY*
4	V_{in}
5	V_{in}
6	V_{in}
7	GND
8	GND
9	GND
10	GND
11	V_{out}
12	V_{out}
13	V_{out}
14	V_{out} Adjust

* *For further information, see application notes.*

Standard Application



C_{in} = Required 330 µF electrolytic capacitor.
C_{out} = Required 330 µF electrolytic capacitor.

TEXAS INSTRUMENTS

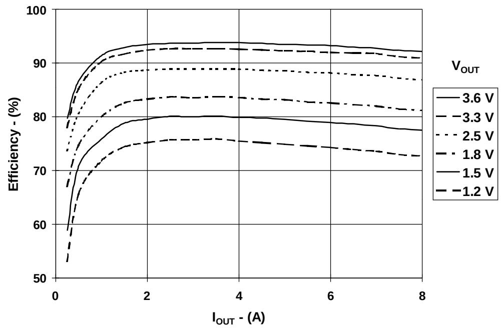
Specifications (Unless otherwise stated, T_a =25 °C, V_{in} =5 V, C_{in} =330 µF, C_{out} =330 µF, and I_o =$I_o$max)

Characteristic	Symbol	Conditions		PT6510 SERIES Min	Typ	Max	Units
Output Current	I_o	Over V_{in} range		0.1 (1)	—	8	A
Input Voltage Range	V_{in}	Over I_o Range	$V_o \geq 2.5$ V $V_o \leq 1.8$ V $V_o = 3.6$ V	4.5 (2) 3.1 (2) 4.8 (2)	— — —	6 6 6	VDC
Output Voltage Tolerance	V_o tol	T_a = –40 to +85 °C		V_o – 0.1	—	V_o + 0.1	V
Line Regulation	Reg_{line}	Over V_{in} range		±2	—	±10	mV
Load Regulation	Reg_{load}	Over I_o range		±2	—	±10	mV
Efficiency	η	I_o =3 A	V_o =3.3 V V_o =2.5 V V_o =1.8 V V_o =1.5 V V_o =1.2 V	— — — — —	92 89 83 80 75	— — — — —	%
		I_o =8 A	V_o =3.3 V V_o =2.5 V V_o =1.8 V V_o =1.5 V V_o =1.2 V	— — — — —	91 87 81 77 72	— — — — —	%
V_o Ripple (pk-pk)	V_r	20 MHz bandwidth		—	15	—	mV_{pp}
Over-Current Threshold	I_o trip	Reset, followed by auto-recovery		—	15	—	A
Transient Response	t_{tr}	1 A/µs load step, 50 % to 100 % $I_o$max		—	100	—	µs
	ΔV_{tr}	V_o over/undershoot		—	±150	—	mV
Switching Frequency	f_s	Over V_{in} and I_o range		475	550	725	kHz
On/Off Standby (Pin 3) Input High Voltage Input Low Voltage	 V_{IH} V_{IL}	Referenced to $-V_{in}$ (pin 7)		 — –0.1	 — —	 Open (3) +0.4	V
Input Low Current	I_{IL}			—	–0.5	–	mA
Standby Input Current	I_{in} stby	Pins 3 & 7 connected		—	1	5	mA
External Output Capacitance	C_{out}	See application schematic		330	—	5,000 (4)	µF
External Input Capacitance	C_{in}	See application schematic		330 (5)	—	—	µF
Operating Temperature Range	T_a	Over V_{in} range		–40	—	+85 (6)	°C
Storage Temperature	T_s	—		–40	—	+125	°C
Reliability	MTBF	Per Bellcore TR-332 50 % stress, T_a =40 °C, ground benign		6.4	—	—	10^6 Hrs
Mechanical Shock	—	Per Mil-Std-883D, method 2002.3, 1 ms, half-sine, mounted to a fixture		—	500	—	G's
Mechanical Vibration	—	Per Mil-Std-883D, method 2007.2, 20-2000 Hz		—	10	—	G's
Weight	—	Suffixes N, A, & C Suffixes R, G & B Suffix H Suffix L Suffix F		— — — — —	12.5 16.5 18.5 15.5 22	— — — — —	grams
Flammability	—	Materials meet UL 94V-0					

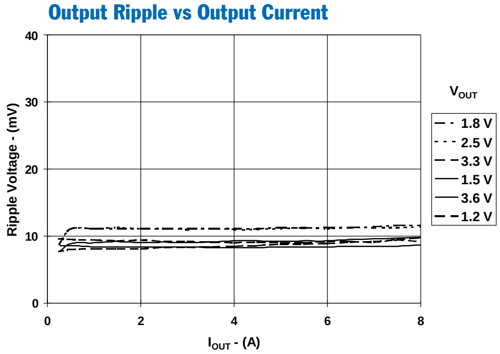
Notes: (1) *The ISR will operate at no load with reduced specifications.*
(2) *The minimum input voltage required by the part is V_{out} + 1.2 V, or 3.1 V, whichever is greater.*
(3) *The STBY* control (pin 3) has an internal pull-up and if it is left open circuit the module will operate when input power is applied. The open-circuit voltage is the input voltage, V_{in}. Refer to the application notes for other interface considerations.*
(4) *The module requires a 330 µF output capacitor for proper operation in all applications. For transient or dynamic load applications, additional output capacitance (Cout) may be necessary. The maximum allowable output capacitance is 5,000 µF.*
(5) *In addition, the input capacitance (C_{in}) must be rated for a minimum of 1.2 Arms ripple current rating. For more information consult the related application note on capacitor recommendations.*
(6) *See Safe Operating Area curves or contact the factory for the appropriate derating.*
(7) *The tab pins on the 16-pin mount package types (suffix L) must be soldered. For more information see the applicable package outline drawing.*

Characteristic Data; V_{in} =5 V *(See Note A)*

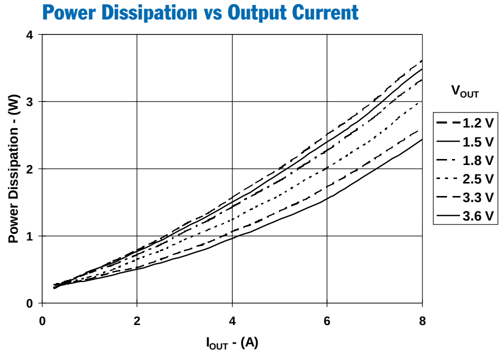
Efficiency vs Output Current



Output Ripple vs Output Current

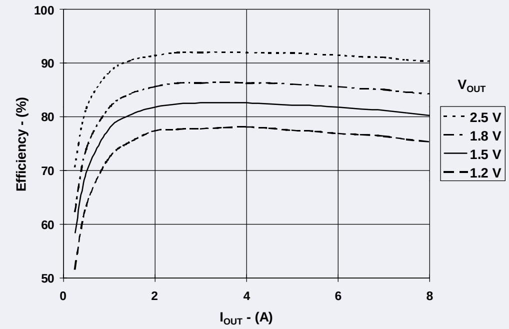


Power Dissipation vs Output Current

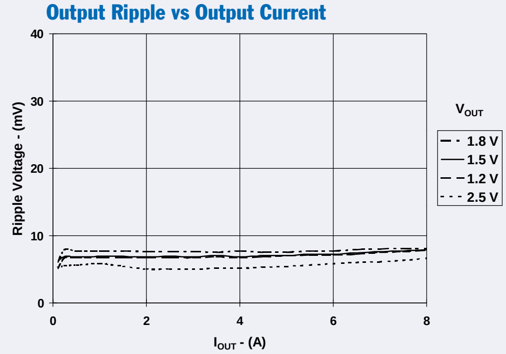


Characteristic Data; V_{in} =3.3 V *(See Note A)*

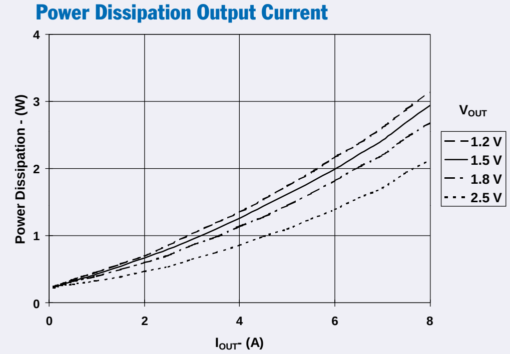
Efficiency vs Output Current



Output Ripple vs Output Current



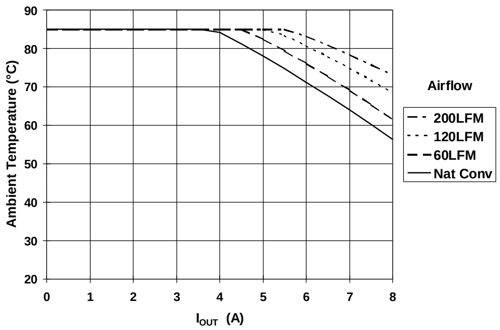
Power Dissipation Output Current



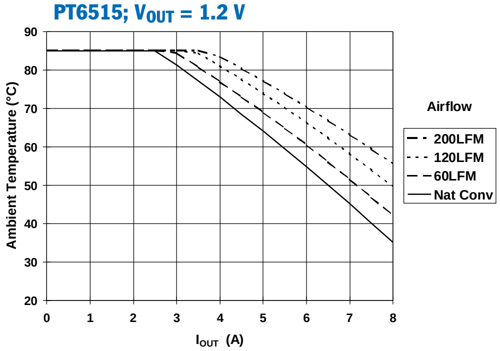
Note A: *Characteristic data has been developed from actual products tested at 25°C. This data is considered typical data for the Converter.*

Safe Operating Area; V_{in} =5 V *(See Note B)*

PT6511; V_{OUT} = 3.3 V

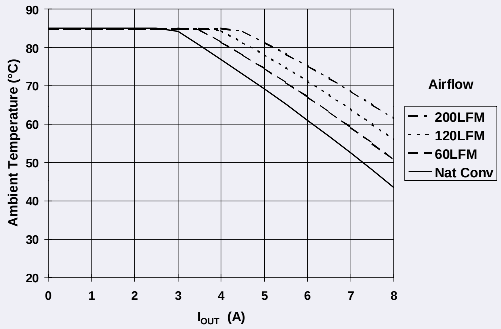


PT6515; V_{OUT} = 1.2 V



Safe Operating Area; 3.3 V *(See Note B)*

PT6515; V_{OUT} =1.2 V



Note B: *SOA curves represent the conditions at which internal components are at or below the manufacturer's maximum operating temperatures*

Using the PT6510 Series as a Replacement for the PT6500 Series in Existing Designs

Scope

The PT6510 series of power modules is the recommended plug-in replacement for PT6500 series parts. The PT6510 series uses the same single-in-line package (SIP) outlines and footprint as the PT6500 series, and was designed to be functionally identical to the PT6500. This application note highlights the differences in electrical performance between a PT6510 series replacement compared to an original PT6500 series part.

Overview

The features that the PT6510 series share with the PT6500 series includes the output current rating, thermal shutdown, and on/off standby. The input voltage range, output voltage adjustment, and output voltage options are also the same. In addition, applications that use the PT6510 series as a replacement will experience a number of performance enhancements. These include improved efficiency and power dissipation, lower in-rush current and output ripple voltage. The 'off' standby current is also significantly reduced. Table 1-1 provides a cross reference between the current PT6500 series part numbers and their equivalent PT6510 series part.

Table 1-1; PT6500 / PT6510 Series Equivalent Parts

PT6500 Series	V_{OUT}	PT6510 Series
PT6501	3.3 V	PT6511
PT6502	1.5 V	PT6512
PT6503	2.5 V	PT6513
PT6504	3.6 V	PT6514
PT6505	1.2 V	PT6515
PT6506	1.8 V	PT6516

Electrical and Functional Differences

Although the PT6510 series was designed as a drop-in replacement for PT6500 series, there are minor differences in the electrical characteristics. These are described in the following text and should be used to assess the replacement part's compatibility with the system or end product. A replacement part's compatibility with the system can be further verified with appropriate board-level tests.

On/Off Standby: The Standby input of the PT6510 series is compatible with both the logic polarity and thresholds of PT6500 series. One exception is the internal pull-up voltage, which is slightly higher on the PT6510 parts. The open-circuit voltage for the PT6510 series is the input voltage, V_{in}, versus about 1 V for the PT6500 series. This should not be a problem if the standby input is controlled with an open-drain transistor with a sufficient max-Vds rating.

Over-Current & Over-Temperature Protection:
To protect against short circuits and load impedance faults, the PT6500 employs a constant output current limit combined with over-temperature shutdown. The PT6500 will feed a limited steady-state current into a load fault. When limiting output current, the PT6500 exhibits higher power dissipation, which increases the module's operating temperature. When its internal temperature rises above the over-temperature threshold, the module will shut itself down for a few seconds. The module will then continue to periodically shut down until the load fault is removed.

The over-current protection mechanism of the PT6510 series is different. If the output current increases above the modules over-current threshold, its output voltage is momentarily turned off. It then attempts to recover by executing a soft-start power up. The module will continue in a rapid succession of shutdowns and restarts until the load fault is removed. During this period the output current is not steady state, but a series of short high-amplitude pulses (frequency <100 Hz). However, when operating into a short-circuit load fault, the average output current and power dissipation are significantly lower than under normal operation.

Power-Up Characteristic: Following the application of a valid input source, the PT6510 series modules exhibit a slightly longer time delay than the equivalent PT6500 series part. The PT6510 series has a soft-start power-up feature, which lowers the in-rush current at its input.

Figure 1-1 and Figure 1-2 show the power-up characteristics of the PT6501 and PT6511 respectively. Both modules have a 3.3-V regulated output, and rise to their regulated output voltage in a similar period. Note that the output voltage of the PT6501 begins to rise when the input voltage reaches 2.2 V, whereas the output voltage of the PT6511 doesn't begin to rise until the input voltage has reached 3.5 V.

Figure 1-1 PT6501 Power-Up Characteristics

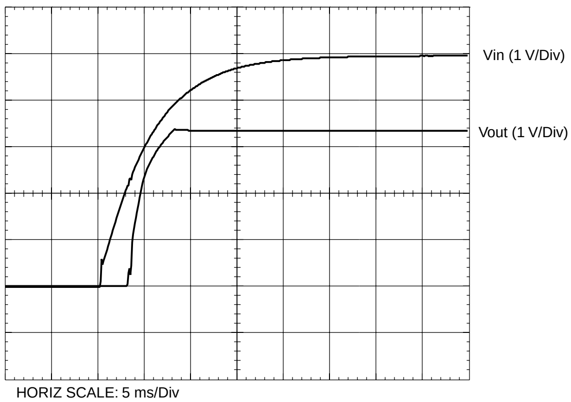
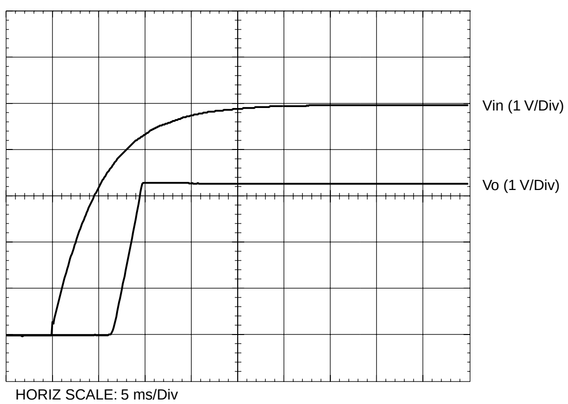


Figure 1-2; PT6511 Power-Up Characterstic



Conclusion

The differences in electrical performance between the PT6500 series and the PT6510 series are small. This should result in only a few, if any, compatibility issues when a PT6510 series part is used to replace a PT6500 series part in an existing application. In most cases, the use of a PT6510 part will improve the performance of the end product over the original PT6500. The performance differences are described to help customers work through any compatibility issues, and thereby minimize the impact to their end products. For additional information and questions call Texas Instrument's product information center (PIC) and request application assistance for plug-in power products.

Capacitor Recommendations for the PT6510 Series of Integrated Switching Regulators

Input Capacitors:

The recommended input capacitance is determined by 330 µF minimum value (300 µF for Oscon or low-ESR tantalum types), and 1 A minimum ripple current rating. Ripple current and less than 100 mΩ equivalent series resistance (ESR) are the major parameters, along with temperature, when selecting an input capacitor. Tantalum capacitors have a recommended minimum voltage rating of twice 2× (max. DC voltage + AC ripple). This is standard practice to insure reliability.

Output Capacitors:

The ESR of the required output capacitor must not be greater than 150 mΩ. Electrolytic capacitors have poor ripple performance at frequencies greater than 400 kHz but excellent low-frequency transient response. Above the ripple frequency, ceramic capacitors are necessary to improve the transient response and reduce any high frequency noise components apparent during higher current excursions. Preferred low-ESR type capacitor part numbers are identified in Table 2-1.

Tantalum Capacitors

Tantalum type capacitors may be used for the output but only the AVX TPS, Sprague 593D/594/595, or Kemet T495/T510 series. These capacitors are recommended over many other tantalum types due to their higher rated surge, power dissipation, and ripple current capability. As a caution the TAJ series by AVX is not recommended. This series has considerably higher ESR, reduced power dissipation, and lower ripple current capability. The TAJ series is less reliable than the AVX TPS series when determining power dissipation capability. Tantalum or Oscon types are recommended for applications where ambient temperatures fall below 0 °C.

Capacitor Table

Table 2-1 identifies the characteristics of capacitors from a number of vendors with acceptable ESR and ripple current (rms) ratings. The number of capacitors required at both the input and output buses is identified for each capacitor type.

This is not an extensive capacitor list. Capacitors from other vendors are available with comparable specifications. Those listed are for guidance. The RMS ripple current rating and ESR (at 100 kHz) are critical parameters necessary to insure both optimum regulator performance and long capacitor life.

Table 2-1: Suggested Input/Output Capacitors

Capacitor Vendor/ Component Series	Capacitor Characteristics					Quantity		
	Working Voltage	Value (µF)	Max. ESR at 100 kHz	Max. Ripple Current at 85 °C (Irms)	Physical Size (mm)	Input Bus	Output Bus	Vendor Number
Panasonic FC	25 V 35 V 35 V	560 µF 390 µF 330 µF	0.0065 Ω 0.065 Ω 0.117 Ω	1205 mA 1205 mA 555 mA	12.5x15 12.5x15 8x11.5	1 2 N/R	1 1 1	EEUFC1E561S EEUFC1V391S EEUFC1C331
United Chemi-Con LXV/FS/ LXZ	16 V 35 V 10 V 20 V	330 µF 470 µF 330 µF 150 µF	0.120 Ω 0.052 Ω 0.025 Ω 0.030 ÷2 Ω	555 mA 122 0mA 3500 mA 3200 mA	8x12 10x20 10x10.5 10x10.5	N/R 1 1 2	1 1 1 2	LXZ16VB331M8X12LL LXZ35VB471M10X20LL 10FS330M 20FS150M
Nichicon PL/ PM	35 V 35 V 50 V	560 µF 330 µF 470 µF	0.048 Ω 0.065 ÷2 Ω 0.046 Ω	1360 mA 1020 mA 1470 mA	16x15 12.5x15 18x15	1 1 1	1 1 1	UPL1V561MHH6 UPL1V331MHH6 UPM1H4711MHH6
Panasonic FC (Surface Mtg)	10 V 35 V 16 V	1000 µF 330 µF 330 µF	0.043 Ω 0.065 Ω 0.150 Ω	1205 mA 1205 mA 670 mA	12x16.5 12.5x16 10x10.2	1 1 N/R	1 1 1	EEVFC1A102LQ EEVFC1V331LQ EEVFC1C331P
Oscon- SS SV	10 V 10 V 20 V	330 µF 330 µF 150 µF	0.025 Ω 0.025 Ω 0.024 ÷2 Ω	>3500 mA >3800 mA 3600 mA	10.0x10.5 10.3x10.3 10.3x10.3	1 1 2	1 1 2	10SS330M 10SV330M 20SV150M SV= Surface Mount
AVX Tantalum TPS	10 V 10 V 10 V	330 µF 330 µF 220 µF	0.100 ÷2 Ω 0.100 ÷2 Ω 0.095 Ω	>2500 mA >3000 mA >2000 mA	7.3Lx 4.3Wx 4.1H	2 2 2	1 1 2	TPSV337M010R0100 TPSV337M010R0060 TPSV227M0105R0100
Kemet T510/ T495	10 V 10 V	330 µF 220 µF	0.033 Ω 0.07 Ω ÷2 =0.035 Ω	1400 mA >2000 mA	7.3Lx5.7W x 4.0H	2 2	1 2	T510X337M010AS T495X227M010AS
Sprague 594D	10 V 10 V	330 µF 220 µF	0.045 Ω 0.065 Ω	2350 mA >2000 mA	7.3Lx 6.0Wx 4.1H	2 2	1 2	4D337X0010R2T 594D227X0010D2T

N/R –Not recommended. The ripple current rating and ESR does not meet the requirements.

Using the Standby Function of the PT6510 Series of Integrated Switching Regulators

The PT6510 series of power modules incorporate a *Standby* function. This may be used in applications that require power-up/shutdown sequencing, and wherever there is a requirement for the output status of the module to be controlled by external circuitry.

The standby function is provided by the *STBY** control, pin 3. If pin 3 is left open-circuit [1] the regulator operates normally, and provides a regulated output whenever a valid supply voltage is present at applied to V_{in} (pins 4-6) with respect to GND (pins 7–10). Applying a ground signal to pin 3 disables the regulator's output and reduces the input current to about 1 mA [4]. The standby control may also be used to hold off the regulator output during the period that input power is applied.

Pin 3 is ideally controlled with an open-drain discrete transistor [1] (See Figure 3-1). It may also be driven directly from a dedicated TTL [3] compatible gate. Table 3-1 gives the circuit parameters for the control of this input.

Table 3-1 Standby Control Requirements [2]

Parameter	Min	Typ	Max
Input Low (V_{IL})	–0.1 V		0.4 V
Input High (V_{IH})	2 V		V_{in}
Input Low Current (I_{IL})		–0.4 mA	

Notes:

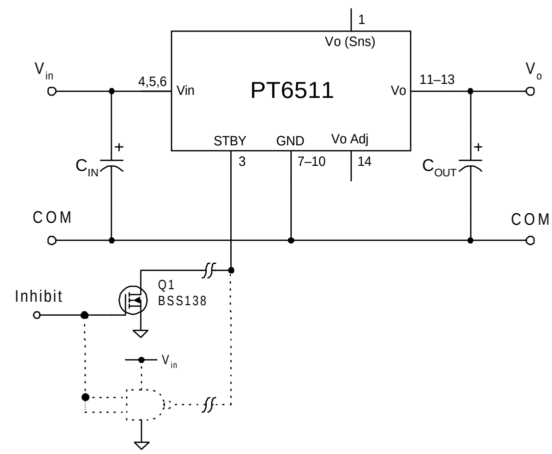
1 The standby control input is ideally controlled using an open-drain discrete transistor. An external pull-up resistor is not necessary. The open-circuit voltage of the STBY* pin is the input voltage, V_{in}.

2. To ensure the regulator output is disabled, the control pin must be pulled to less than 0.4 Vdc with a low-level 0.5-mA sink to ground.

3. The STBY* input is also compatible with a differential output from standard TTL logic, providing the IC shares the same supply voltage as the module.

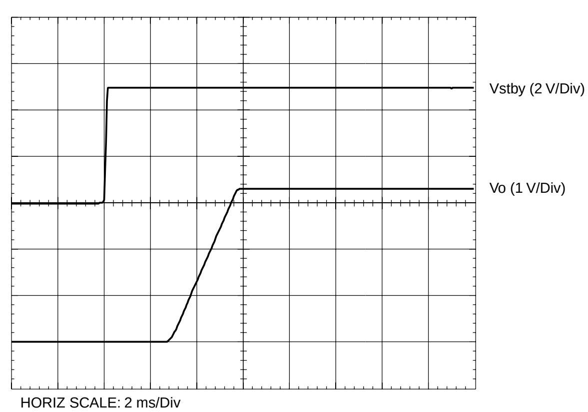
4. When the regulator output is disabled the current drawn from the input source is typically reduced to about 1 mA.

Figure 3-1



Turn-On Time: In the circuit of Figure 3-1, turning Q_1 on applies a low voltage to the STBY control (pin 3) and disables the regulator ouput. Correspondingly, turning Q_1 off removes the low-voltage signal and enables the output. Once enabled, the output will typically experience a 10–15 ms delay followed by a predictable ramp-up of voltage. The regulator should provide a fully regulated output voltage within 40 ms. The waveform of Figure 3-2 shows the output voltage and input current waveforms of a PT6511 (3.3 V) following the turn-off of Q_1. The turn off of Q_1 corresponds to the rise in Vstby. The waveforms were measured with a 5 Vdc input voltage, and 4.5 A resistive load.

Figure 3-2



Adjusting the Output Voltage of the PT6510 5V/3.3V Bus Converters

The output voltage of the PT6510 series switching regulators may be adjusted higher or lower than the factory trimmed pre-set voltage with the addition of a single external resistor. Table 4-1 gives the allowable adjustment range for each model in the series as V_a (min) and V_a (max).

Adjust Up: An increase in the output voltage is obtained by adding a resistor R_2, between *V_o Adjust* (pin 14) and *GND* (pins 7-10).

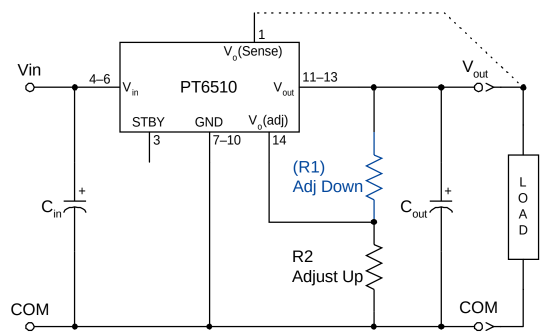
Adjust Down: Add a resistor (R_1), between *V_o Adjust* (pin 14) and *V_{out}* (pins 11-13).

Refer to Figure 4-1 and Table 4-2 for both the placement and value of the required resistor, either (R_1) or R_2 as appropriate.

Notes:

1. Use only a single 1 % resistor in either the (R_1) or R_2 location. Place the resistor as close to the ISR as possible.
2. Never connect capacitors from *V_o Adjust* to either *GND*, V_{out}, or the *V_o Sense* pin. Any capacitance added to the *V_o Adjust* pin will affect the stability of the ISR.
3. If the remote sense feature is used, connecting the resistor (R_1) between *V_o Adjust* (pin 14) and *V_o Sense* (pin 1) can benefit load regulation.
4. The minimum input voltage required by the part is V_{out} + 1.2 or V_{in}(min) from Table 4-1, whichever is higher.

Figure 4-1



The values of (R_1) [adjust down], and R_2 [adjust up], can also be calculated using the following formulae.

$$(R_1) = \frac{R_o (V_a - 1.0)}{(V_o - V_a)} - R_s \quad k\Omega$$

$$R_2 = \frac{R_o}{V_a - V_o} - R_s \quad k\Omega$$

Where: V_o = Original output voltage
V_a = Adjusted output voltage
R_o = The resistance value in Table 4-1
R_s = The series resistance from Table 4-1

Table 4-1

PT6510 ADJUSTMENT AND FORMULA PARAMETERS

Series Pt #	PT6515	PT6512	PT6516	PT6513	PT6511	PT6514
V_o (nom)	1.2	1.5	1.8	2.5	3.3	3.6
V_a (min)	1.14	1.27	1.4	1.8	2.25	2.5
V_a (max)	2.35	2.65	2.95	3.5	4.2	4.3
R_o (kΩ)	2.49	2.49	2.49	4.99	12.1	10
R_s (kΩ)	2	2	2	4.22	12.1	12.1
V_{in}(min)	3.1	3.1	3.1	4.5	4.5	4.5

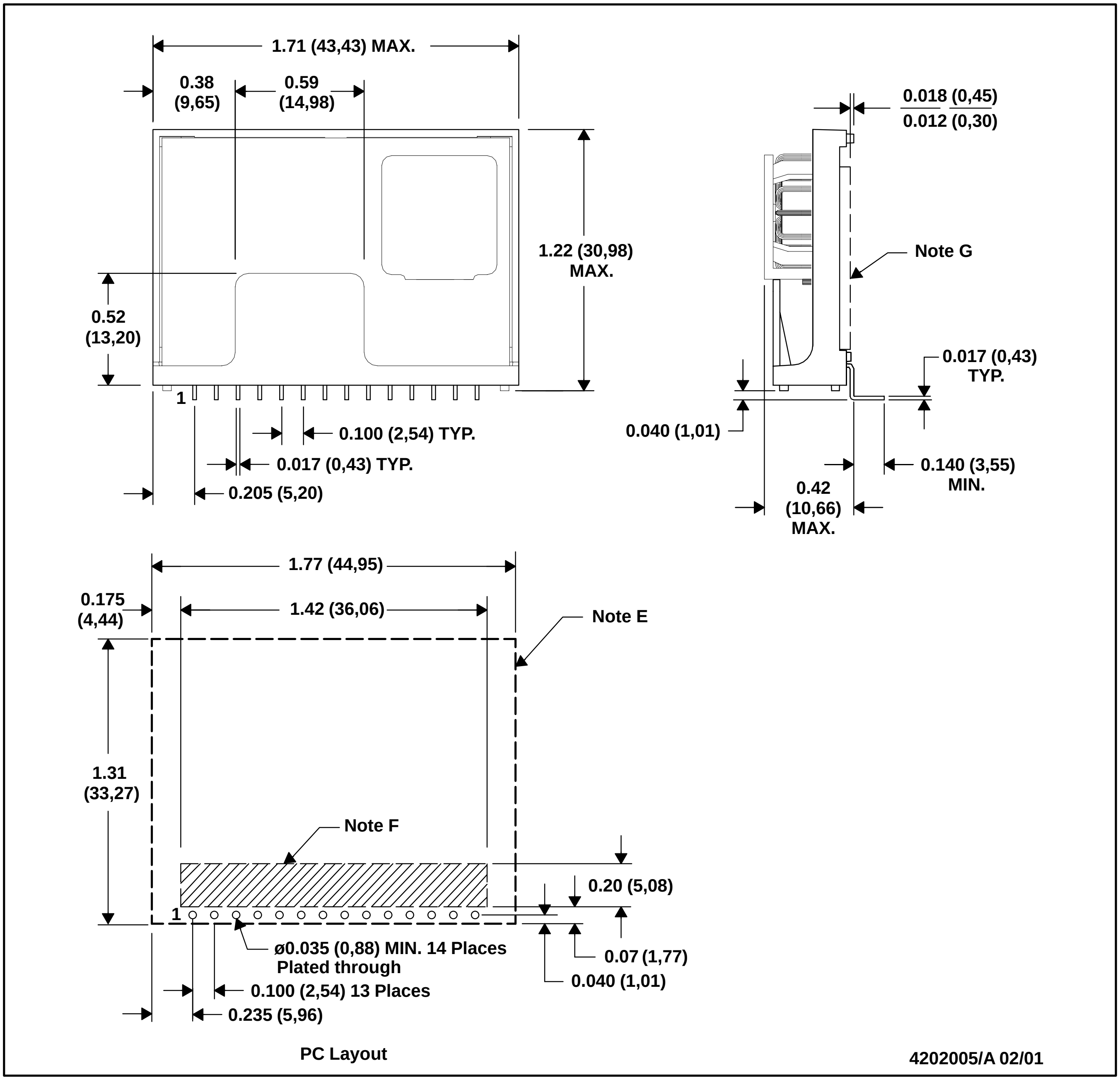
Table 4-2

PT6500 ADJUSTMENT RESISTOR VALUES

Series Pt #	PT6515	PT6512	PT6516	PT6513	PT6511	PT6514
V_o (nom)	1.2 V	1.5 V	1.8 V	2.5 V	3.3 V	3.6 V
V_a (req'd)						
1.15	(5.5) kΩ					
1.2						
1.25	47.8 kΩ					
1.3	22.9 kΩ	(1.7) kΩ				
1.35	14.6 kΩ	(3.8) kΩ				
1.4	10.5 kΩ	(8.0) kΩ	(0.5) kΩ			
1.45	8.0 kΩ	(20.4) kΩ	(1.2) kΩ			
1.5	6.3 kΩ		(2.2) kΩ			
1.55	5.1 kΩ	47.8 kΩ	(3.5) kΩ			
1.6	4.2 kΩ	22.9 kΩ	(5.5) kΩ			
1.65	3.5 kΩ	14.6 kΩ	(8.8) kΩ			
1.7	3.0 kΩ	10.5 kΩ	(15.4) kΩ			
1.75	2.5 kΩ	8.0 kΩ	(35.4) kΩ			
1.8	2.2 kΩ	6.3 kΩ		(1.5) kΩ		
1.85	1.8 kΩ	5.1 kΩ	47.8 kΩ	(2.3) kΩ		
1.9	1.6 kΩ	4.2 kΩ	22.9 kΩ	(3.3) kΩ		
1.95	1.3 kΩ	3.5 kΩ	14.6 kΩ	(4.4) kΩ		
2.0	1.1 kΩ	3.0 kΩ	10.5 kΩ	(5.8) kΩ		
2.05	0.9 kΩ	2.5 kΩ	8.0 kΩ	(7.4) kΩ		
2.1	0.8 kΩ	2.2 kΩ	6.3 kΩ	(9.5) kΩ		
2.15	0.6 kΩ	1.8 kΩ	5.1 kΩ	(12.2) kΩ		
2.2	0.5 kΩ	1.6 kΩ	4.2 kΩ	(15.7) kΩ		
2.25	0.4 kΩ	1.3 kΩ	3.5 kΩ	(20.7) kΩ	(2.3) kΩ	
2.3	0.3 kΩ	1.1 kΩ	3.0 kΩ	(28.2) kΩ	(3.6) kΩ	
2.35	0.2 kΩ	0.9 kΩ	2.5 kΩ	(40.7) kΩ	(5.1) kΩ	
2.4		0.8 kΩ	2.2 kΩ	(65.6) kΩ	(6.7) kΩ	
2.45		0.6 kΩ	1.8 kΩ	(140.0) kΩ	(8.5) kΩ	
2.5		0.5 kΩ	1.6 kΩ		(10.6) kΩ	(1.5) kΩ
2.55		0.4 kΩ	1.3 kΩ	95.6 kΩ	(12.9) kΩ	(2.7) kΩ
2.6		0.3 kΩ	1.1 kΩ	45.7 kΩ	(15.6) kΩ	(3.9) kΩ
2.65		0.2 kΩ	6.9 kΩ	29.0 kΩ	(18.6) kΩ	(5.3) kΩ
2.7			0.8 kΩ	20.7 kΩ	(22.2) kΩ	(6.8) kΩ
2.75			0.6 kΩ	15.7 kΩ	(26.4) kΩ	(8.5) kΩ
2.8			0.5 kΩ	12.4 kΩ	(31.5) kΩ	(10.4) kΩ
2.85			0.4 kΩ	10.0 kΩ	(37.6) kΩ	(12.6) kΩ
2.9			0.3 kΩ	8.3 kΩ	(45.4) kΩ	(15.0) kΩ
2.95			0.2 kΩ	0.9 kΩ	(55.3) kΩ	(17.9) kΩ
3.0				5.8 kΩ	(68.6) kΩ	(21.2) kΩ
3.1				4.1 kΩ	(115.0) kΩ	(29.9) kΩ
3.2				2.9 kΩ	(254.0) kΩ	(42.9) kΩ
3.3				2.0 kΩ		(64.6) kΩ
3.4				1.3 kΩ	109.0 kΩ	(108.0) kΩ
3.5				0.8 kΩ	48.4 kΩ	(238.0) kΩ
3.6					28.2 kΩ	
3.7					18.2 kΩ	87.9 kΩ
3.8					12.1 kΩ	37.9 kΩ
3.9			4/. V_{out} >3.8 Vdc requires V_{in} >5 Vdc !		8.1 kΩ	21.2 kΩ
4.0					5.2 kΩ	12.9 kΩ
4.1					3.0 kΩ	7.9 kΩ
4.2					1.3 kΩ	4.6 kΩ
4.3						2.2 kΩ

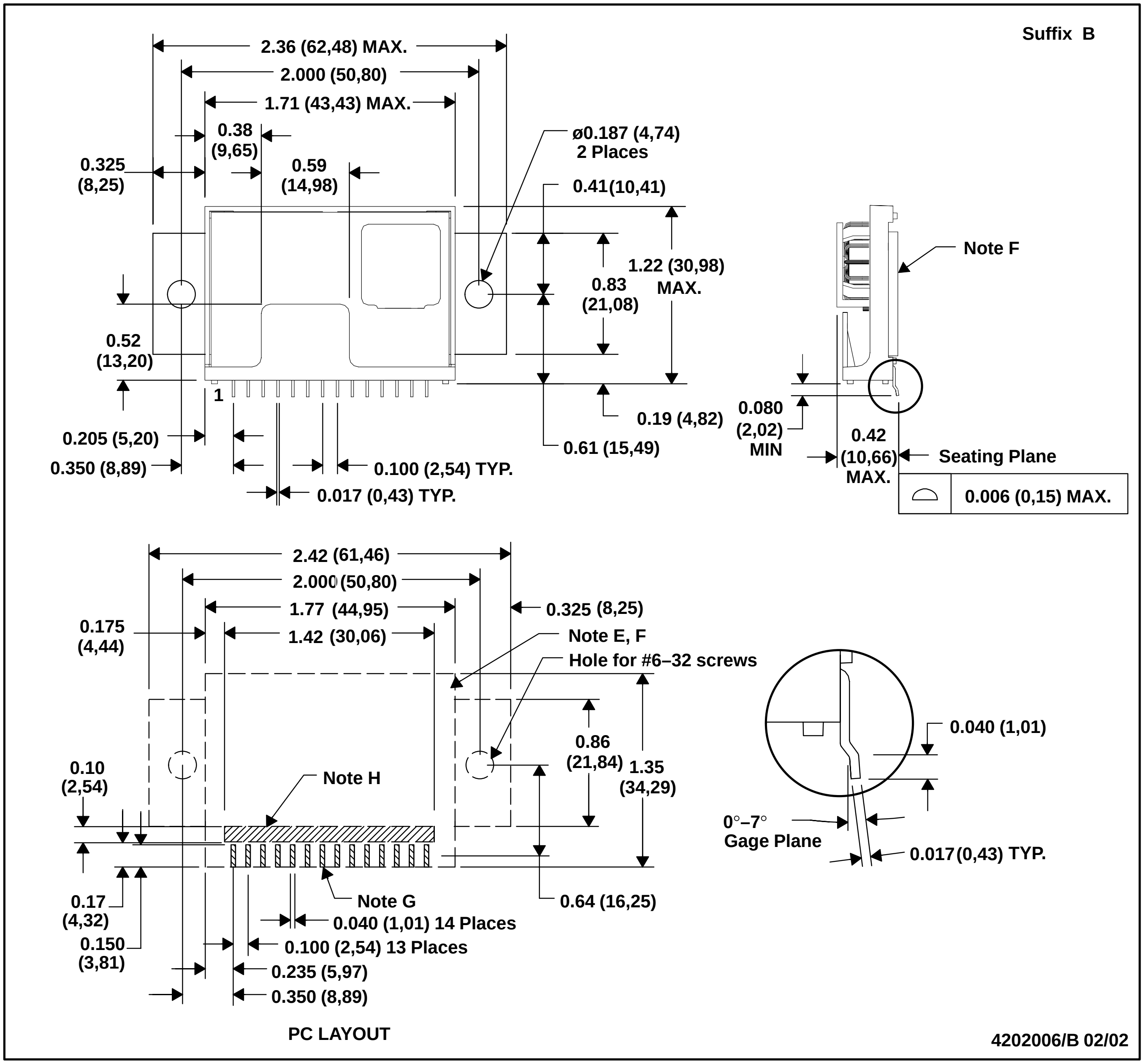
R1 = (Blue)   R2 = Black

EEA (R–PSIP–T14) **PLASTIC SINGLE-IN-LINE MODULE**



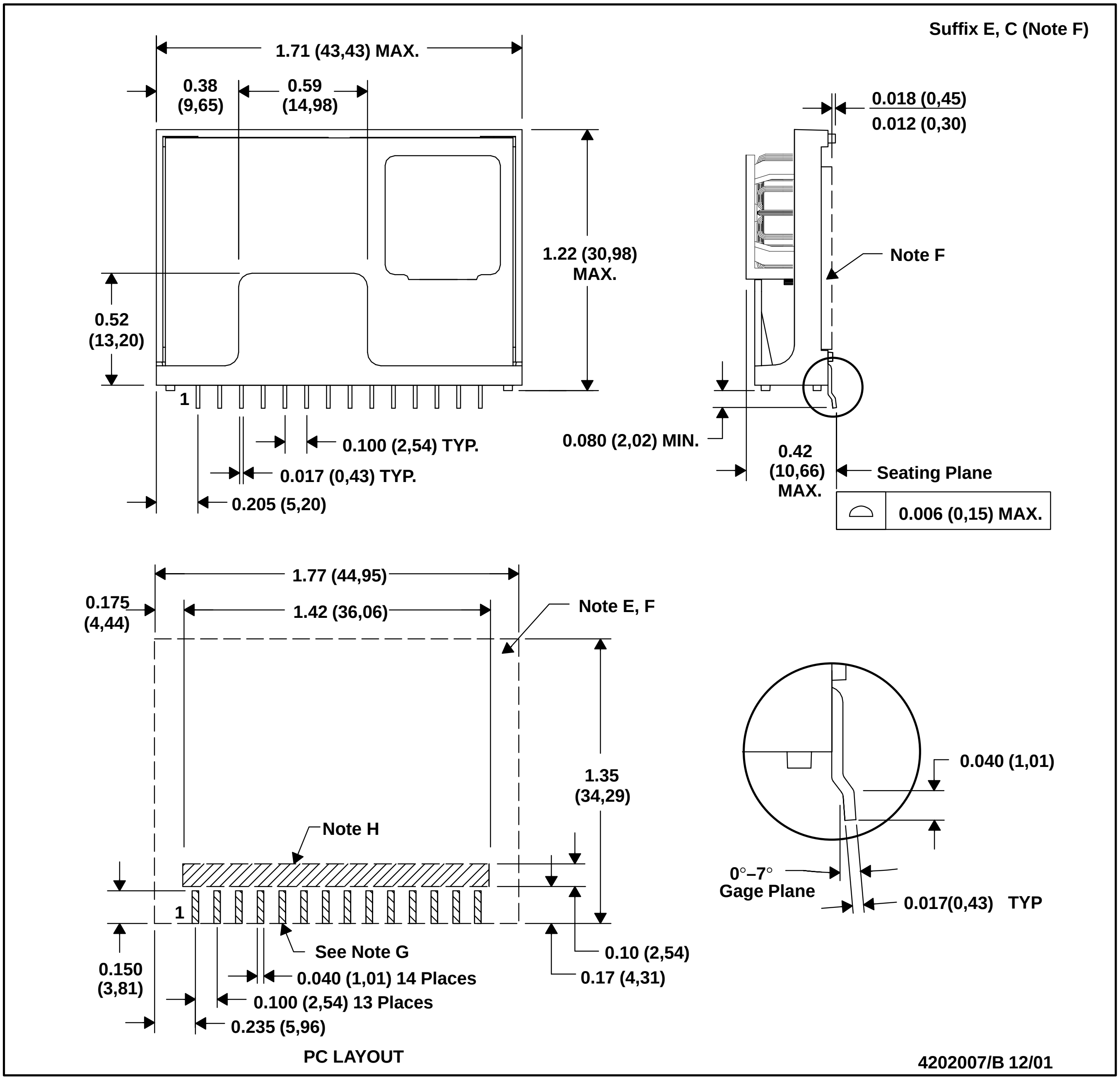
NOTES:
- A. All linear dimensions are in inches (mm).
- B. This drawing is subject to change without notice.
- C. 2-place decimals are ± 0.030 (± 0, 76 mm).
- D. 3-place decimals are ± 0.010 (± 0, 25 mm).
- E. Recommended mechanical keep-out area.
- F. No copper, power or signal traces in this area.
- G. D-suffix parts include a metal heat spreader. No signal traces are allowed under the heat spreader area. A solid copper island is recommended, which may be grounded. A-suffix does not include a metal heat spreader.

EEK (R–PSIP–G14) **PLASTIC SINGLE-IN-LINE MODULE**



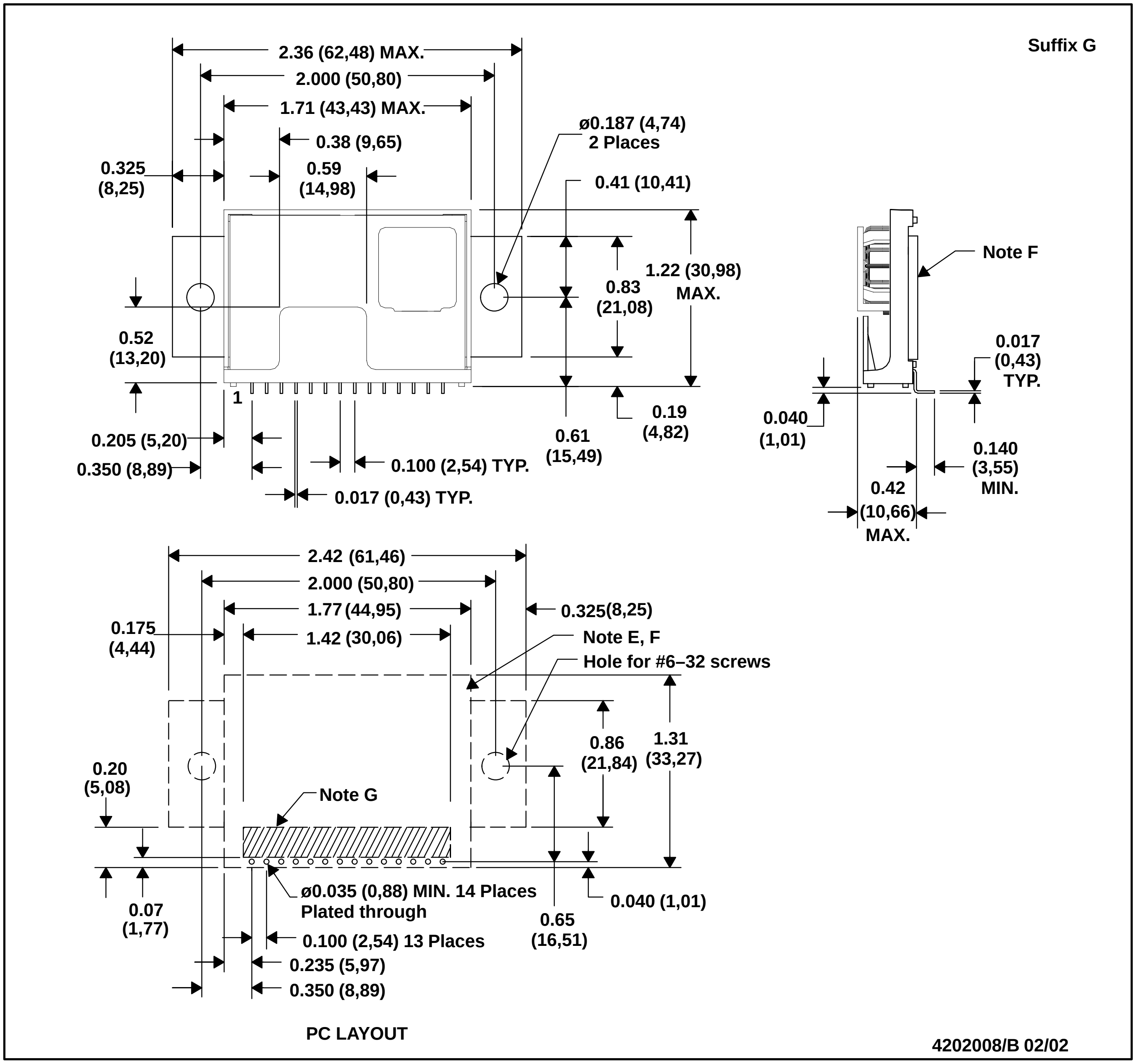
NOTES:
- A. All linear dimensions are in inches (mm).
- B. This drawing is subject to change without notice.
- C. 2–place decimals are ± 0.030 (± 0, 76 mm).
- D. 3–place decimals are ± 0.010 (± 0, 25 mm).
- E. Recommended mechanical keep-out area.
- F. The metal tab is isolated but electrically conductive. No signal traces are allowed under the metal tab area. A solid copper island is recommended, which may be grounded.
- G. Power pin connections should utilize two or more vias per input, ground and output pin.
- H. No copper, power or signal traces in this area.

EEC (R–PSIP–G14) PLASTIC SINGLE-IN-LINE MODULE



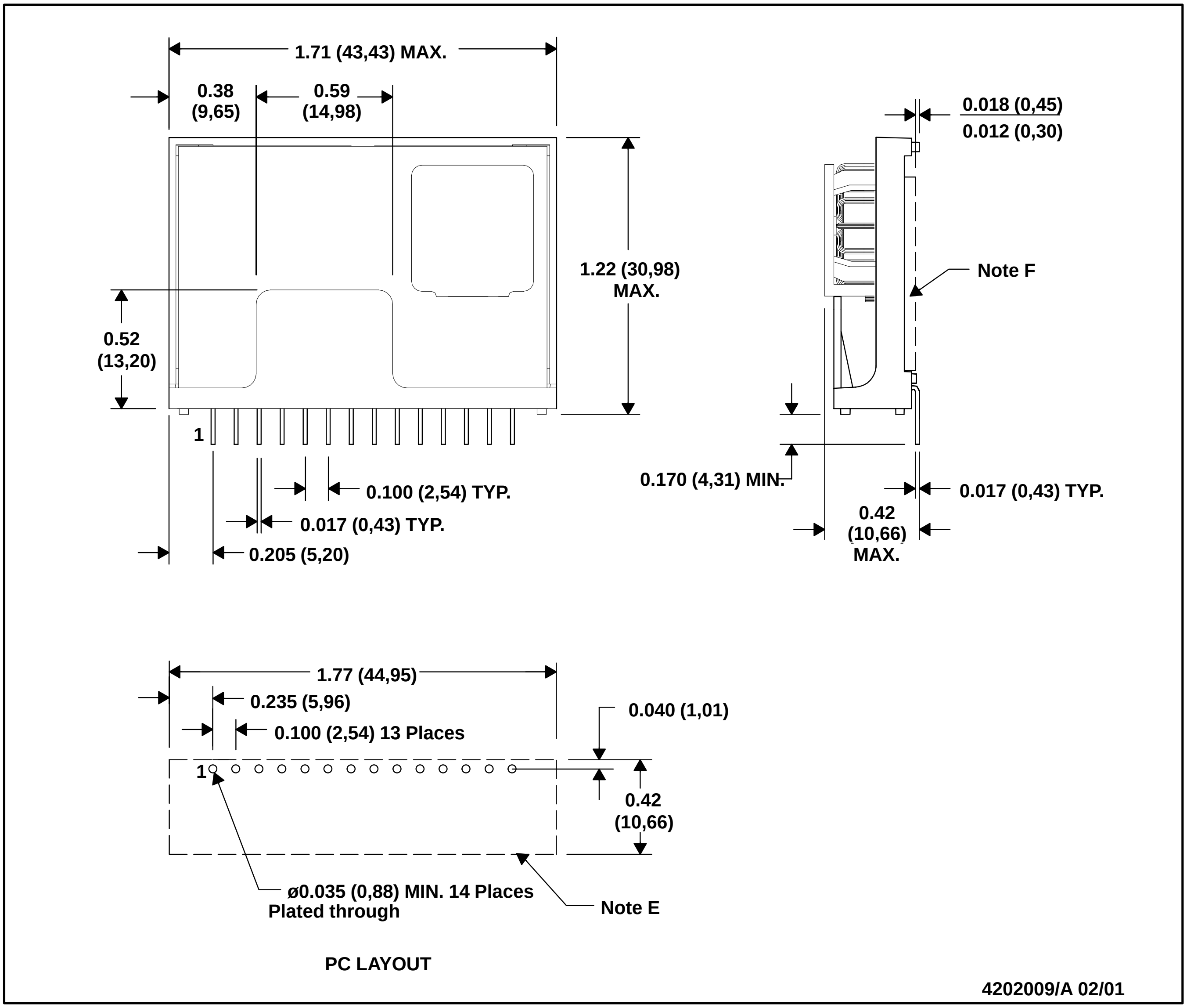
NOTES:
- A. All linear dimensions are in inches (mm).
- B. This drawing is subject to change without notice.
- C. 2–place decimals are ± 0.030 (± 0, 76 mm).
- D. 3–place decimals are ± 0.010 (± 0, 25 mm).
- E. Recommended mechanical keep-out area.
- F. E-suffix parts include a metal heat spreader. No signal traces are allowed under the heat spreader area. A solid copper island is recommended, which may be grounded. C-suffix does not include a metal heat spreader.
- G. Power pin connections should utilize two or more vias per input, ground and output pin.
- H. No copper, power or signal traces in this area.

EEG (R–PSIP–T14) **PLASTIC SINGLE-IN-LINE MODULE**



NOTES: A. All linear dimensions are in inches (mm).
B. This drawing is subject to change without notice.
C. 2-place decimals are ± 0.030 (± 0,76 mm).
D. 3-place decimals are ± 0.010 (± 0,25 mm).
E. Recommended mechanical keep-out area.
F. The metal tab is isolated but electrically conductive.
No signal traces are allowed under the metal tab area.
A solid copper island is recommended, which may be grounded.
G. No copper, power or signal traces in this area.

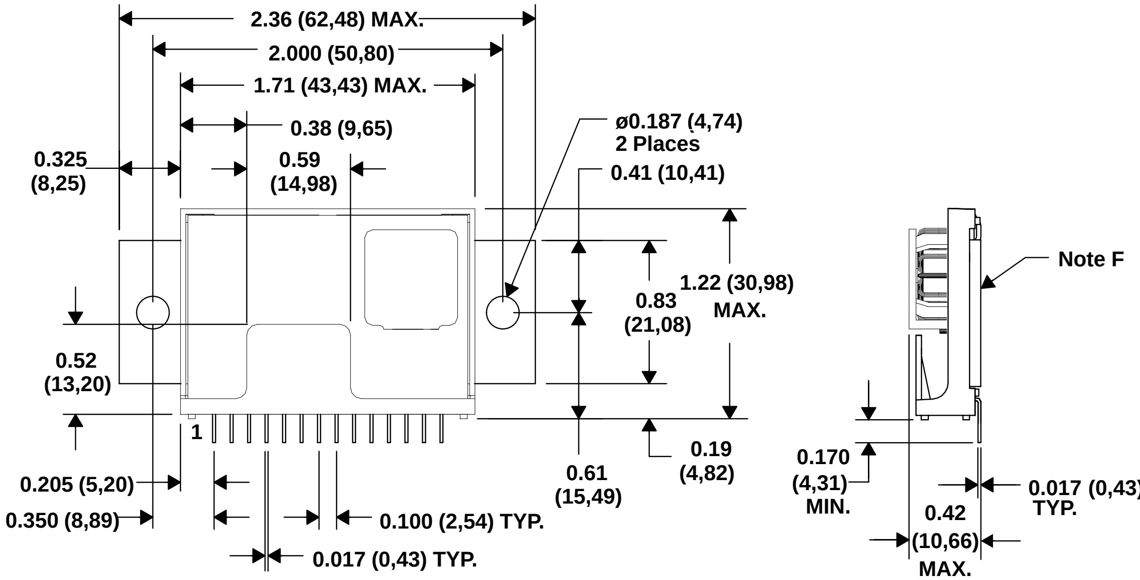
EED (R–PSIP–T14) **PLASTIC SINGLE-IN-LINE MODULE**

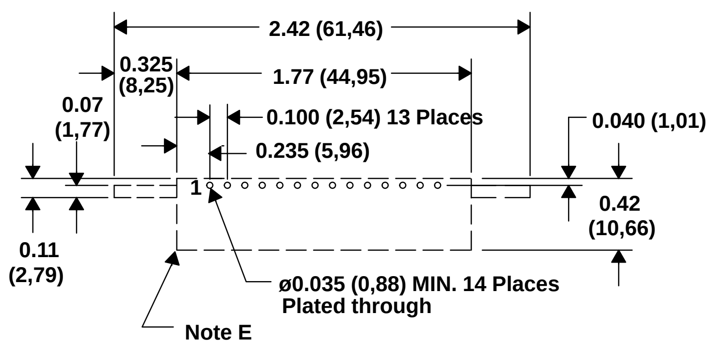


NOTES:
- A. All linear dimensions are in inches (mm).
- B. This drawing is subject to change without notice.
- C. 2-place decimals are ± 0.030 (± 0,76 mm).
- D. 3-place decimals are ± 0.010 (± 0,25 mm).
- E. Recommended mechanical keep-out area.
- F. P-suffix parts include a metal heat spreader. The heat spreader is isolated but electrically conductive, it can be grounded. N-suffix does not include a metal heat spreader.

EEE (R–PSIP–T14) **PLASTIC SINGLE-IN-LINE MODULE**

Suffix R



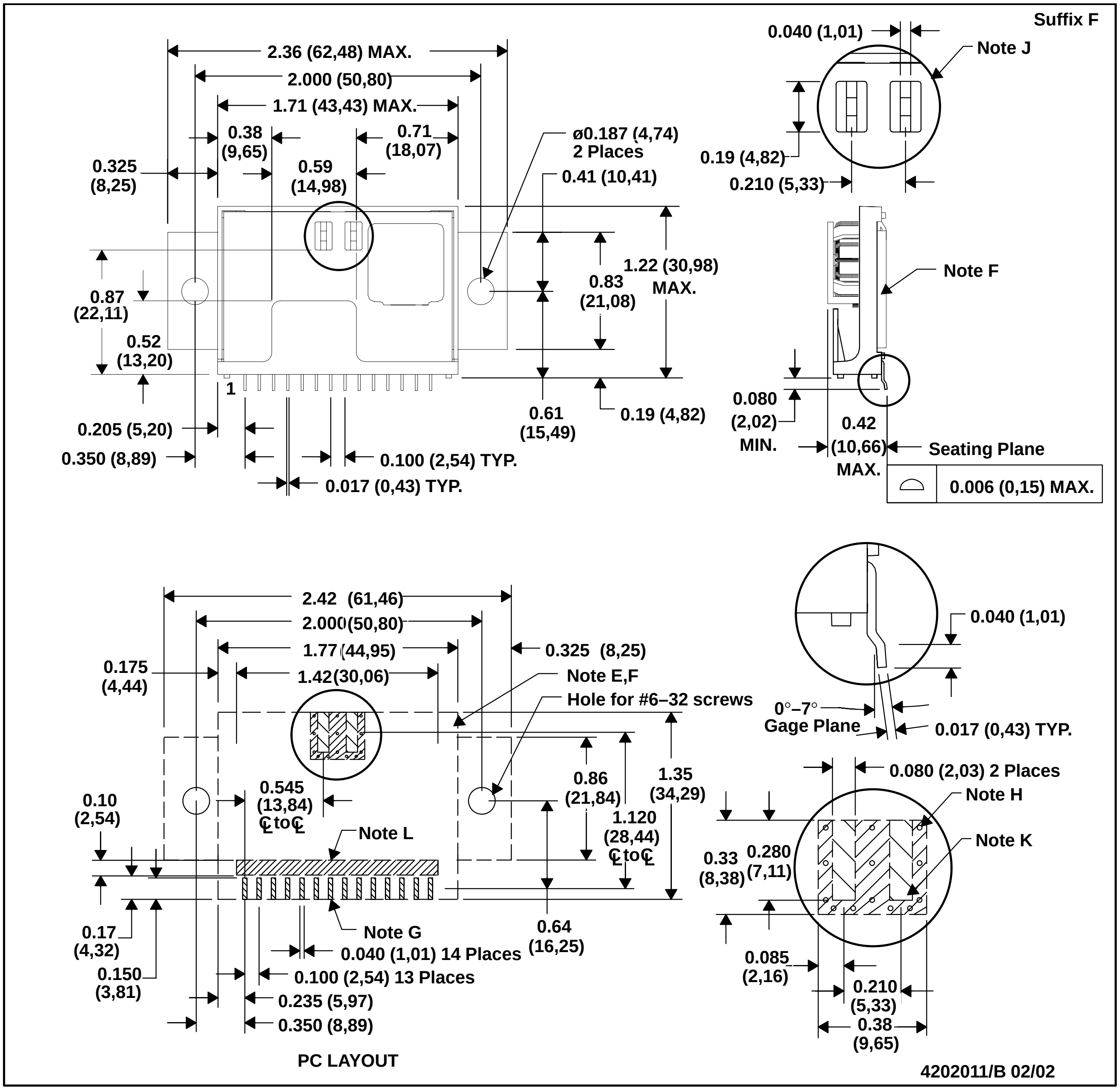


PC LAYOUT

4202010/B 02/02

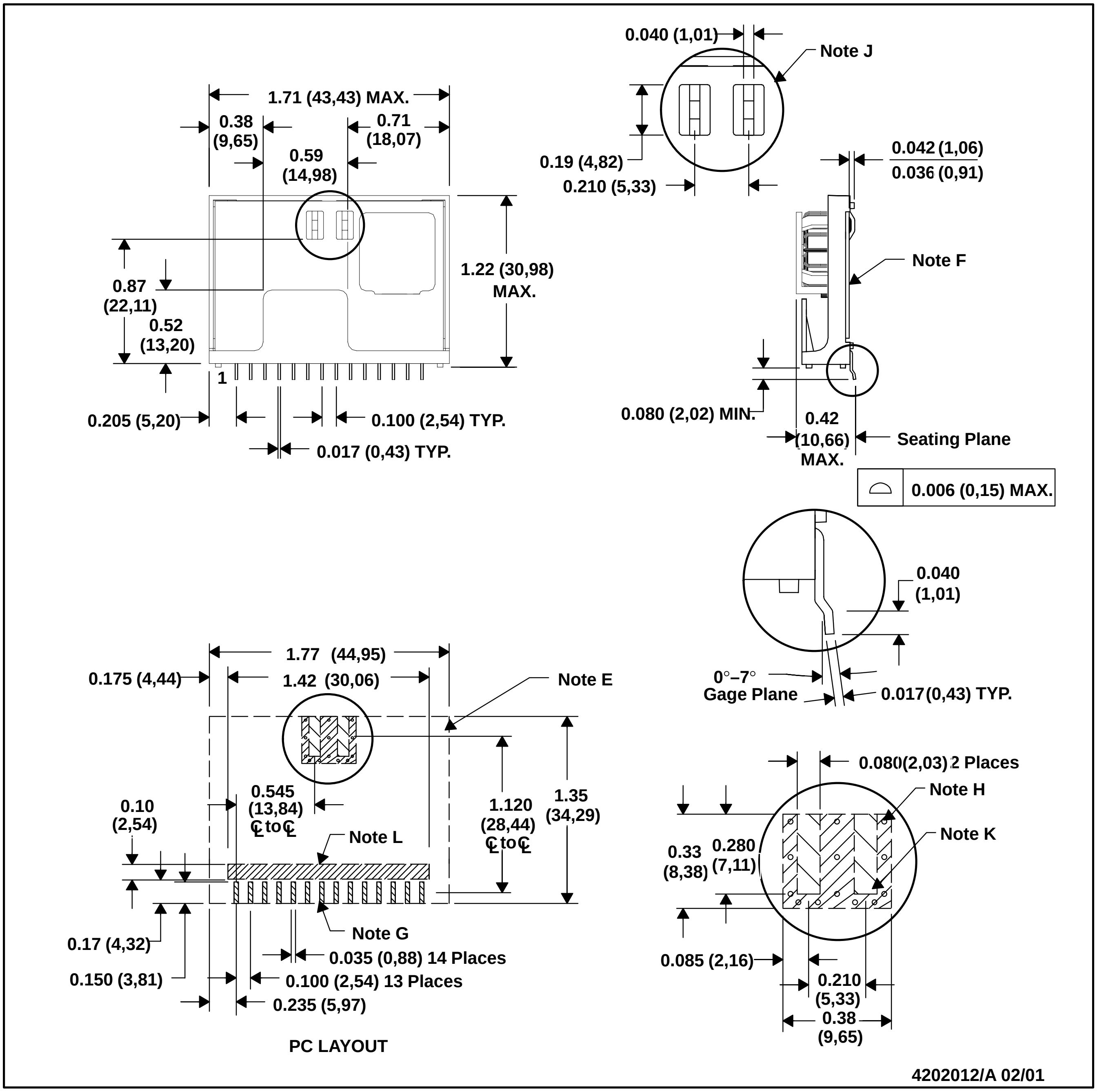
NOTES:
- A. All linear dimensions are in inches (mm).
- B. This drawing is subject to change without notice.
- C. 2-place decimals are ± 0.030 (± 0, 76 mm).
- D. 3-place decimals are ± 0.010 (± 0, 25 mm).
- E. Recommended mechanical keep-out area.
- F. The metal tab is isolated but electrically conductive, it can be grounded.

EEF (R–PSIP–G14) **PLASTIC SINGLE-IN-LINE MODULE**



NOTES:
- A. All linear dimensions are in inches (mm).
- B. This drawing is subject to change without notice.
- C. 2-place decimals are ± 0.030 (± 0, 76 mm).
- D. 3–place decimal are ± 0.010 (± 0, 25 mm).
- E. Recommended mechanical keep-out area.
- F. The metal tab is isolated but electrically conductive. No signal traces are allowed under the metal tab area. A solid copper island is recommended, which may be grounded.
- G. Power pin connections should utilize two or more vias per input, ground and output pin.
- H. Minimum copper land area required for solder tab. Vias are recommended to improve copper adhesion or connect land to other ground area.
- J. Underside solder tabs detail.
- K. Solder mask openings to copper island for solder joints to mechanical pins.
- L. No copper, power or signal traces in this area.

EEL (R–PSIP–G14) **PLASTIC SINGLE-IN-LINE MODULE**



NOTES:
- A. All linear dimensions are in inches (mm).
- B. This drawing is subject to change without notice.
- C. 2–place decimals are ± 0.030 (± 0,76 mm).
- D. 3–place decimals are ± 0.010 (± 0,25 mm).
- E. Recommended mechanical keep-out area.
- F. The metal tab is isolated but electrically conductive. No signal traces are allowed under the metal tab area. A solid copper island is recommended, which may be grounded.
- G. Power pin connections should utilize two or more vias per input, ground and output pin.
- H. Minimum copper land area required for solder tab. Vias are recommended to improve copper adhesion or connect land to other ground area.
- J. Underside solder tabs detail
- K. Solder mask openings to copper island for solder joints to mechanical pins.
- L. No copper, power or signal traces in this area.

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