

## 1-W High-Voltage Switchmode Regulator

### DESCRIPTION

The Si9105 high-voltage switchmode regulator is a monolithic BiC/DMOS integrated circuit which contains most of the components necessary to implement a high-efficiency dc/dc converter in ISDN terminals up to 3 watts. A 0.5 mA max supply current makes possible the design of a dc/dc converter with 60 % efficiency at 25 mW, therefore meeting the recommended performance under the CCITT I.430 specifications.

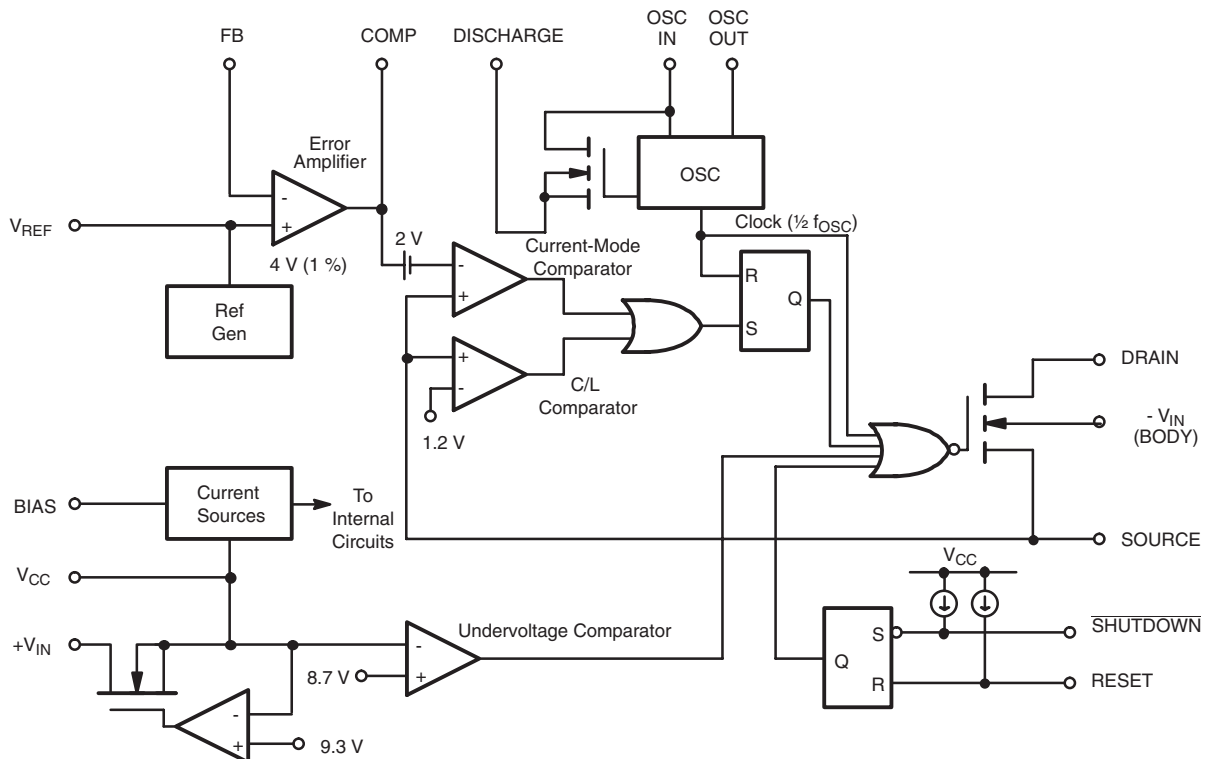
This device may be used with an appropriate transformer to implement isolated flyback power converter topologies to provide single or multiple regulated dc outputs (i.e.,  $\pm 5$  V).

The Si9105 is available in both standard and lead (Pb)-free 16-pin wide-body SOIC, 14-pin plastic DIP and 20-pin PLCC packages which are specified to operate over the industrial temperature range of - 40 °C to 85 °C.

### FEATURES

- CCITT Compatible
- Current-Mode Control
- Low Power Consumption (less than 5 mW)
- 10 to 120 V Input Range
- 200 V, 250 mA MOSFET
- Internal Start-Up Circuit
- Current-Mode Control
- $\overline{\text{SHUTDOWN}}$  and RESET

### FUNCTIONAL BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS			
Parameter		Limit	Unit
<b>Voltages Referenced to - V<sub>IN</sub> (V<sub>CC</sub> &lt; + V<sub>IN</sub> + 0.3 V)</b>			
V <sub>CC</sub>		15	V
+V <sub>IN</sub>		120	
V <sub>DS</sub>		200	
I <sub>D</sub> (Peak) (300 μs pulse, 2 % duty cycle)		2	A
I <sub>D</sub> (rms)		250	mA
Logic Inputs (RESET, SHUTDOWN, OSC IN)		- 0.3 V to V <sub>CC</sub> + 0.3 V	V
Linear Inputs (FEEDBACK, SOURCE)		- 0.3 V to 7 V	
HV Pre-Regulator Input Current (continuous)		5	mA
Storage Temperature		- 65 to 125	°C
Operating Temperature		- 40 to 85	
Junction Temperature (T <sub>J</sub> )		150	
Power Dissipation (Package) <sup>a</sup>	14-Pin Plastic DIP (J Suffix) <sup>b</sup>	750	mW
	16-Pin Plastic Wide-Body SOIC (W Suffix) <sup>c</sup>	900	
	20-Pin PLCC (N Suffix) <sup>d</sup>	1400	
Thermal Impedance (θ <sub>JA</sub> )	14-Pin Plastic DIP	167	°C/W
	16-Pin Plastic Wide-Body SOIC	140	
	20-Pin PLCC	90	

## Notes:

a. Device Mounted with all leads soldered or welded to PC board.

b. Derate 6 mW/°C above 25 °C.

c. Derate 7.2 mW/°C above 25 °C.

d. Derate 11.2 mW/°C above 25 °C.

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

RECOMMENDED OPERATING RANGE			
Parameter		Limit	Unit
<b>Voltages Referenced to - V<sub>IN</sub></b>			
V <sub>CC</sub>		10 to 13.5	V
+ V <sub>IN</sub>		10 to 120	
f <sub>OSC</sub>		40 kHz to 1 MHz	
R <sub>OSC</sub>		25 kΩ to 1 MΩ	
Linear Inputs		0 to V <sub>CC</sub> - 3 V	V
Digital Inputs		0 to V <sub>CC</sub>	

SPECIFICATIONS <sup>a</sup>							
Parameter	Symbol	Test Conditions Unless Otherwise Specified DISCHARGE = - V <sub>IN</sub> = 0 V V <sub>CC</sub> = 10 V, + V <sub>IN</sub> = 48 V R <sub>BIAS</sub> = 820 kΩ, R <sub>OSC</sub> = 910 kΩ	Limits				Unit
			Temp <sup>b</sup>	Min <sup>c</sup>	Typ <sup>d</sup>	Max <sup>c</sup>	
<b>Reference</b>							
Output Voltage	V <sub>R</sub>	OSC IN = - V <sub>IN</sub> (OSC Disabled) R <sub>L</sub> = 10 MΩ	Room	3.92	4.00	4.08	V
Output Impedance <sup>e</sup>	Z <sub>OUT</sub>	OSC IN = - V <sub>IN</sub>	Room	15	300	45	kΩ
Short Circuit Current	I <sub>SREF</sub>	OSC IN = - V <sub>IN</sub> , V <sub>REF</sub> = - V <sub>IN</sub>	Room	70	100	130	μA
Temperature Stability <sup>e</sup>	T <sub>REF</sub>	OSC IN = - V <sub>IN</sub>	Full		0.25	1.0	mV/°C
Long Term Stability <sup>e</sup>		t = 1000 h, T <sub>A</sub> = 125 °C	Room		5.00	25.00	mV
<b>Oscillator</b>							
Maximum Frequency <sup>e</sup>	f <sub>MAX</sub>	R <sub>OSC</sub> = 0	Room	1	3		MHz
Initial Accuracy	f <sub>OSC</sub>	See Note e	Room	32	40	48	kHz
Voltage Stability	Δf/f	Δf/f = f(13.5 V) - f(9.5 V)/f(9.5 V)	Room		10	15	%
Temperature Coefficient <sup>e</sup>	T <sub>OSC</sub>		Full		200	500	ppm/°C



SPECIFICATIONS <sup>a</sup>							
Parameter	Symbol	Test Conditions Unless Otherwise Specified DISCHARGE = - V <sub>IN</sub> = 0 V V <sub>CC</sub> = 10 V, + V <sub>IN</sub> = 48 V R <sub>BIAS</sub> = 820 kΩ, R <sub>OSC</sub> = 910 kΩ	Limits				Unit
			Temp <sup>b</sup>	Min <sup>c</sup>	Typ <sup>d</sup>	Max <sup>c</sup>	
<b>Error Amplifier</b>							
Feedback Input Voltage	V <sub>FB</sub>	FB Tied to COMP OSC IN = - V <sub>IN</sub> (OSC Disabled)	Room	3.96	4	4.04	V
Input BIAS Current	I <sub>FB</sub>	OSC IN = - V <sub>IN</sub> , V <sub>FB</sub> = 4 V	Room		25	500	nA
Open Loop Voltage Gain <sup>e</sup>	A <sub>VOL</sub>	OSC IN = - V <sub>IN</sub> (OSC Disabled)	Room	60	80		dB
Input OFFSET Voltage	V <sub>OS</sub>	OSC IN = - V <sub>IN</sub>	Room		± 15	± 40	mV
Unity Gain Bandwidth <sup>e</sup>	BW		Room	0.5	0.8		MHz
Dynamic Output Impedance	Z <sub>OUT</sub>		Room		1		kΩ
Output Current	I <sub>OUT</sub>	Source (V <sub>FB</sub> = 3.4 V)	Room		- 1.2	- 0.32	mA
		Sink (V <sub>FB</sub> = 4.5 V)	Room	0.05	0.08		
Power Supply Rejection	PSRR	10 V ≤ V <sub>CC</sub> ≤ 13.5 V	Room		70		dB
<b>Current Limit</b>							
Threshold Voltage	V <sub>SOURCE</sub>	R <sub>L</sub> = 100 Ω from DRAIN to V <sub>CC</sub> V <sub>FB</sub> = 0 V	Room	0.8	1.0	1.2	V
Delay to Output <sup>e</sup>	t <sub>d</sub>	R <sub>L</sub> = 100 Ω from DRAIN to V <sub>CC</sub> V <sub>SOURCE</sub> = 1.5 V, See Figure 1	Room		200	300	ns
Input Voltage	+ V <sub>IN</sub>	I <sub>IN</sub> = 10 μA	Room	120			V
Input Leakage Current	+ I <sub>IN</sub>	V <sub>CC</sub> ≥ 10 V	Room			10	μA
Pre-Regulator Start-Up Current	I <sub>START</sub>	Pulse Width ≤ 300 μs, V <sub>CC</sub> = 7 V	Room	8	15		mA
V <sub>CC</sub> Pre-Regulator Turn-Off Threshold Voltage	V <sub>REG</sub>	I <sub>PRE-REGULATOR</sub> = 10 μA	Room	7.5	9.3	9.7	V
Undervoltage Lockout	V <sub>UVLO</sub>	R <sub>L</sub> = 100 Ω from DRAIN to V <sub>CC</sub> See Detailed Description	Room	7.0	8.7	9.2	
V <sub>REG</sub> - V <sub>UVLO</sub>	V <sub>DELTA</sub>		Room	0.25	0.5		
<b>Supply</b>							
Supply Current	I <sub>CC</sub>		Room		0.35	0.5	mA
Bias Current	I <sub>BIAS</sub>		Room		7.5		μA
SHUTDOWN Delay	t <sub>SD</sub>	V <sub>SOURCE</sub> = - V <sub>IN</sub> , See Figure 2	Room		50	100	ns
SHUTDOWN Pulse Width	t <sub>SW</sub>	See Figure 3	Room	50			
RESET Pulse Width	t <sub>RW</sub>		Room	50			
Latching Pulse Width SHUTDOWN and RESET Low	t <sub>LW</sub>		Room	25			
Input Low Voltage	V <sub>IL</sub>		Room			2.0	V
Input High Voltage	V <sub>IH</sub>		Room	8.0			
Input Current Input Voltage High	I <sub>IH</sub>	V <sub>IN</sub> = 10 V	Room		1	5	μA
Input Current Input Voltage Low	I <sub>IL</sub>	V <sub>IN</sub> = 0 V	Room	- 35	- 25		
<b>MOSFET Switch</b>							
Breakdown Voltage	V <sub>(BR)DSS</sub>	I <sub>DRAIN</sub> = 100 μA	Full	200	220		V
Drain-Source On Resistance <sup>g</sup>	r <sub>DS(on)</sub>	I <sub>DRAIN</sub> = 100 mA	Room		5	7	Ω
Drain Off Leakage Current	I <sub>DSS</sub>	V <sub>DRAIN</sub> = 100 V	Room			10	μA
Drain Capacitance	C <sub>DS</sub>		Room		35		pF

Notes:

- a. Refer to PROCESS OPTION FLOWCHART for additional information.
- b. Room = 25 °C, Full = as determined by the operating temperature suffix.
- c. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum, is used in this data sheet.
- d. Typical values are for DESIGN AID ONLY, not guaranteed nor subject to production testing.
- e. Guaranteed by design, not subject to production test.
- f. C<sub>STRAY</sub> Pin 8 = ≤ 5 pF.
- g. Temperature coefficient of r<sub>DS(on)</sub> is 0.75 % per °C, typical.

**TIMING WAVEFORMS**

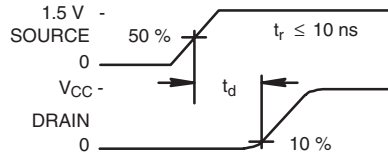


Figure 1.

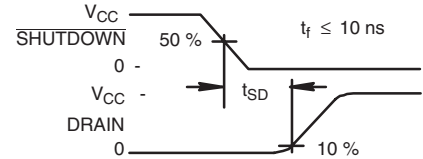


Figure 2.

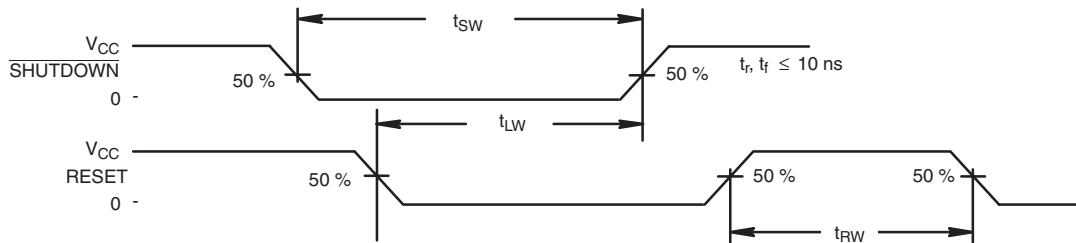


Figure 3.

**TYPICAL CHARACTERISTICS**

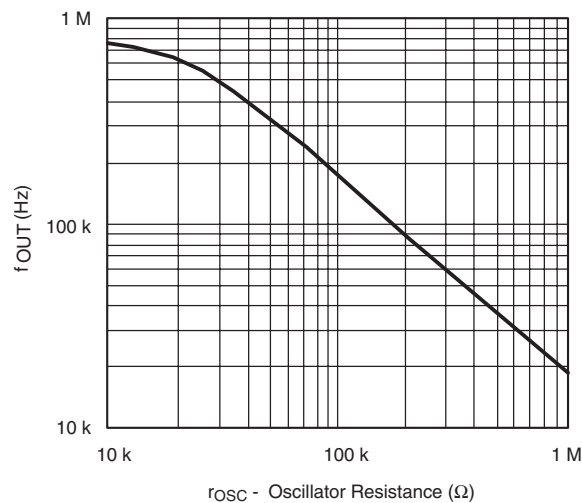
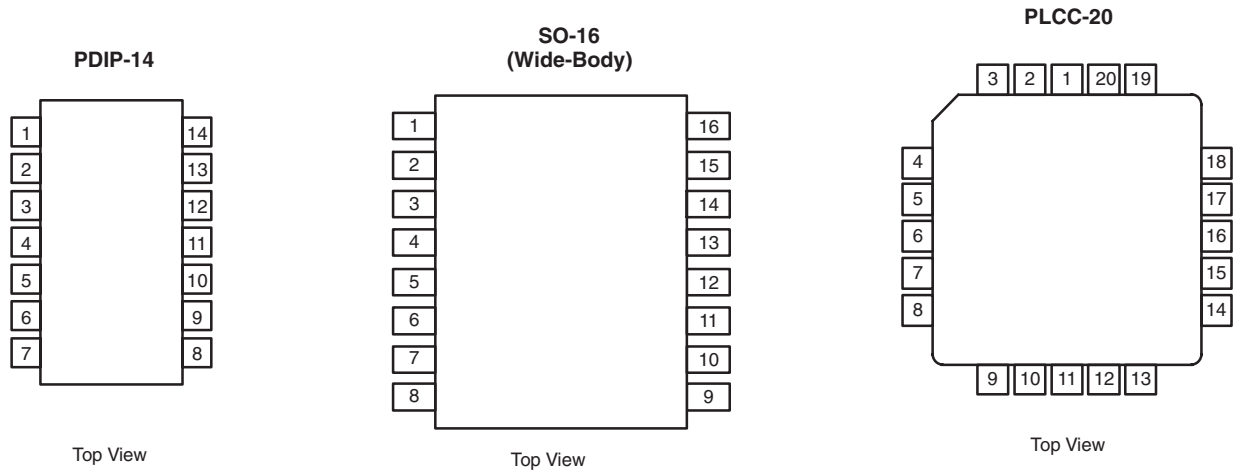


Figure 4. Output Switching Frequency vs. Oscillator Resistance

**PIN CONFIGURATIONS**



<b>PIN DESCRIPTION</b>			
Function	Pin Number		
	14-Pin Plastic DIP	16-Pin SOIC	20-Pin PLCC
SOURCE	4	1	7
- V <sub>IN</sub>	5	2	8
V <sub>CC</sub>	6	4	9
OSC <sub>OUT</sub>	7	5	10
OSC <sub>IN</sub>	8	6	11
DISCHARGE	9	7	12
V <sub>REF</sub>	10	8	14
SHUTDOWN	11	9	16
RESET	12	10	17
COMP	13	11	18
FB	14	12	20
BIAS	1	13	2
+ V <sub>IN</sub>	2	14	3
DRAIN	3	16	5
NC		3, 15	1, 4, 6, 13, 15, 19

<b>ORDERING INFORMATION</b>			
Standard Part Number	Lead (Pb)-free Part Number	Temperature Range	Package
Si9105DJ02	Si9105DJ02-E3	- 40 to 85 °C	PDIP-14
Si9105DW			SOIC-16 (WB)
Si9105DW-T1 (With Tape and Reel)	Si9105DW-T1-E3 (With Tape and Reel)		
Si9105DN02	Si9105DN02-E3		PLCC-20
Si9105DN02-T1 (With Tape and Reel)	Si9105DN02-T1-E3 (With Tape and Reel)		

## DETAILED DESCRIPTION

### Pre-Regulator/Start-Up Section

Due to the low quiescent current requirement of the Si9105 control circuitry, bias power can be supplied from the unregulated input power source, from an external regulated low-voltage supply, or from an auxiliary "bootstrap" winding on the output inductor or transformer.

When power is first applied during start-up,  $+V_{IN}$  will draw a constant current. The magnitude of this current is determined by a high-voltage depletion MOSFET device which is connected between  $+V_{IN}$  and  $V_{CC}$ . This start-up circuitry provides initial power to the IC by charging an external bypass capacitance connected to the  $V_{CC}$  pin. The constant current is disabled when  $V_{CC}$  exceeds 9.3 V. If  $V_{CC}$  is not forced to exceed the 9.3 V threshold, then  $V_{CC}$  will be regulated to a nominal value of 9.3 V by the pre-regulator circuit.

As the supply voltage rises toward the normal operating conditions, an internal undervoltage (UV) lockout circuit keeps the output MOSFET disabled until  $V_{CC}$  exceeds the undervoltage lockout threshold (typically 8.7 V). This guarantees that the control logic will be functioning properly and that sufficient gate drive voltage is available before the MOSFET turns on. The design of the IC is such that the undervoltage lockout threshold will not exceed the pre-regulator turn-off voltage. Power dissipation can be minimized by providing an external power source to  $V_{CC}$  such that the constant current source is always disabled.

### BIAS

To properly set the bias for the Si9105, a 820 k $\Omega$  resistor should be tied from BIAS to  $-V_{IN}$ . This determines the magnitude of bias current in all of the analog sections and the pull-up current for the  $\overline{\text{SHUTDOWN}}$  and RESET pins. The current flowing in the bias resistor is nominally 7.5  $\mu\text{A}$ .

### Reference Section

The reference section of the Si9105 consists of a temperature compensated buried zener and trimmable divider network.

The output of the reference section is connected internally to the non-inverting input of the error amplifier. Nominal reference output voltage is 4 V. The trimming procedure that is used on the Si9105 brings the output of the error amplifier (which is configured for unity gain during trimming) to within  $\pm 1\%$  of 4 V. This automatically compensates for the input offset voltage in the error amplifier.

The output impedance of the reference section has been purposely made high so that a low impedance external voltage source can be used to override the internal voltage source, if desired, without otherwise altering the performance of the device.

### Error Amplifier

Closed-loop regulation is provided by the error amplifier, whose 1 k $\Omega$  dynamic output impedance enables it to be used with feedback compensation (unlike transconductance amplifiers). A MOS differential input stage provides for low input current. The noninverting input to the error amplifier ( $V_{REF}$ ) is internally connected to the output of the reference supply and should be bypassed with a small capacitor to ground.

### Oscillator Section

The oscillator consists of a ring of CMOS inverters, capacitors, and a capacitor discharge switch. Frequency is set by an external resistor between the OSC IN and OSC OUT pins. (See Typical Characteristics graph of resistor value vs. frequency.) The DISCHARGE pin should be tied to  $-V_{IN}$  for normal internal oscillator operation. A frequency divider in the logic section limits switch duty cycle to a maximum of 50% by locking the switching frequency to one half of the oscillator frequency.

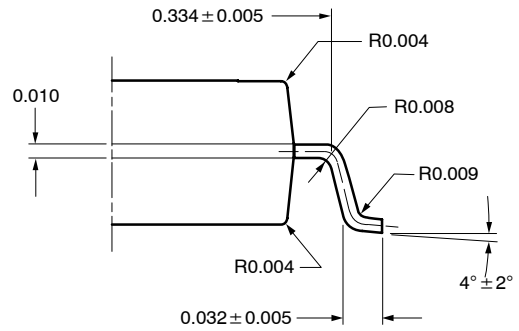
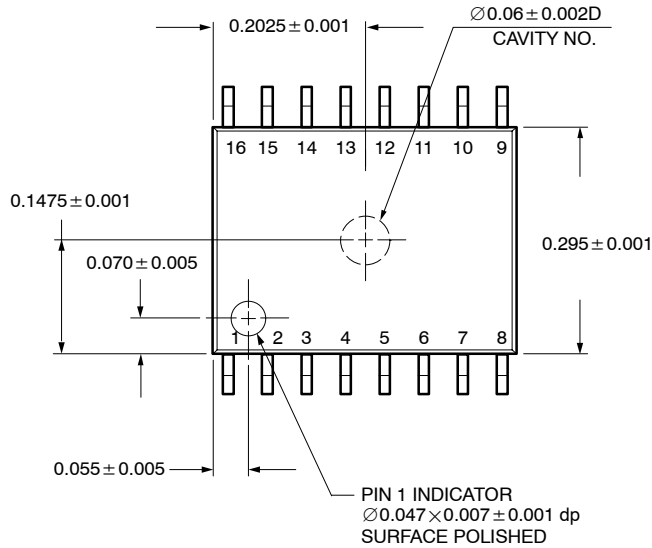
Remote synchronization can be accomplished by capacitive coupling of a synchronization pulse into the OSC IN terminal. For a 5 V pulse amplitude and 0.5  $\mu\text{s}$  pulse width, typical values would be 100 pF in series with 3 k $\Omega$  to OSC IN.



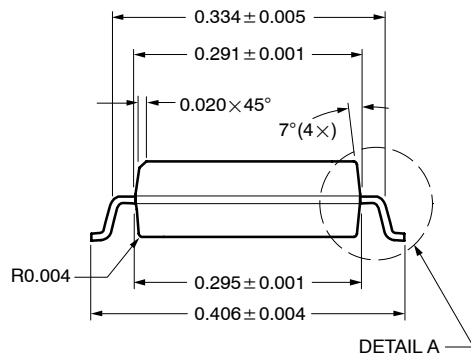
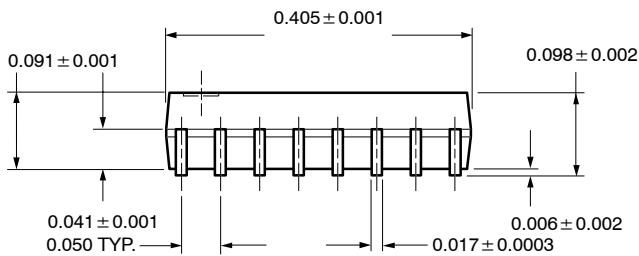


**SOIC (WIDE-BODY): 16-LEAD (POWER IC ONLY)**

ECN: S-40079—Rev. A, 02-Feb-04  
DWG: 5910



DETAIL A



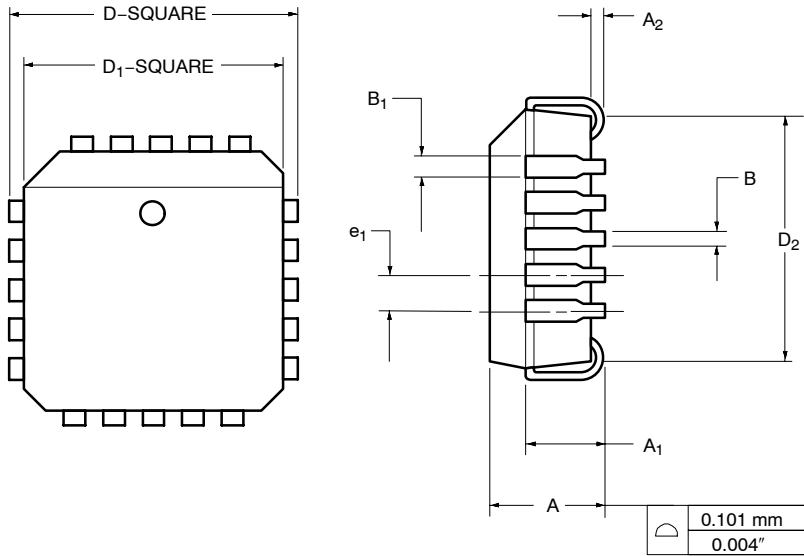
DETAIL A

All Dimensions In Inches





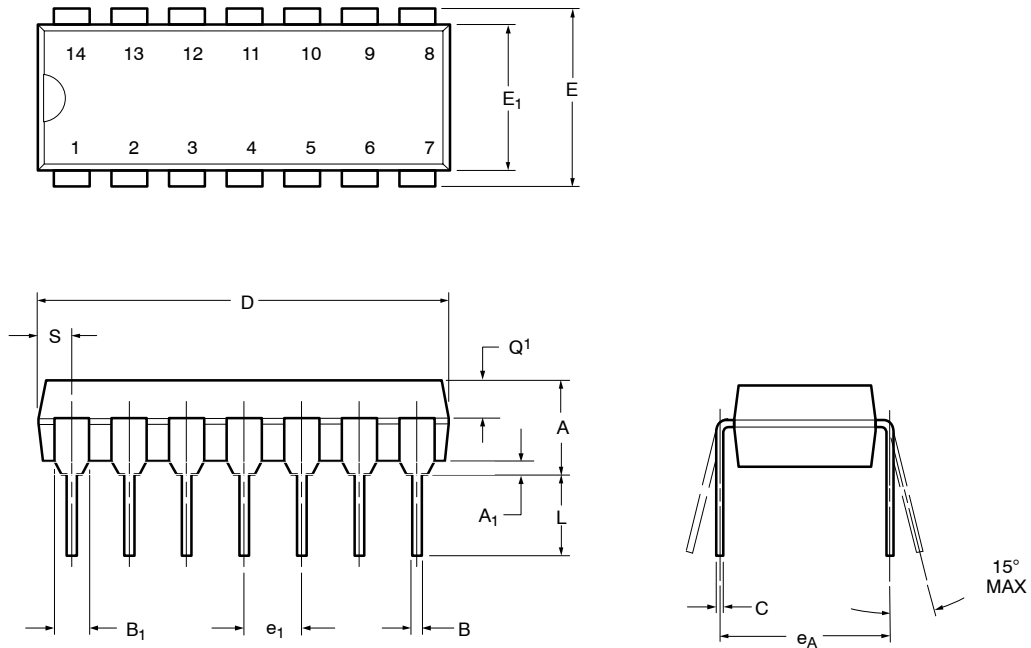
**PLCC: 20-LEAD (POWER IC ONLY)**



Dim	MILLIMETERS		INCHES	
	Min	Max	Min	Max
<b>A</b>	4.20	4.57	0.165	0.180
<b>A<sub>1</sub></b>	2.29	3.04	0.090	0.120
<b>A<sub>2</sub></b>	0.51	-	0.020	-
<b>B</b>	0.331	0.553	0.013	0.021
<b>B<sub>1</sub></b>	0.661	0.812	0.026	0.032
<b>D</b>	9.78	10.03	0.385	0.395
<b>D<sub>1</sub></b>	8.890	9.042	0.350	0.356
<b>D<sub>2</sub></b>	7.37	8.38	0.290	0.330
<b>e<sub>1</sub></b>	1.27 BSC		0.050 BSC	

ECN: S-40081—Rev. A, 02-Feb-04  
DWG: 5917

### PDIP: 14-LEAD (POWER IC ONLY)



Dim	MILLIMETERS		INCHES	
	Min	Max	Min	Max
<b>A</b>	3.81	5.08	0.150	0.200
<b>A<sub>1</sub></b>	0.38	1.27	0.015	0.050
<b>B</b>	0.38	0.51	0.015	0.020
<b>B<sub>1</sub></b>	0.89	1.65	0.035	0.065
<b>C</b>	0.20	0.30	0.008	0.012
<b>D</b>	17.27	19.30	0.680	0.760
<b>E</b>	7.62	8.26	0.300	0.325
<b>E<sub>1</sub></b>	5.59	7.11	0.220	0.280
<b>e<sub>1</sub></b>	2.29	2.79	0.090	0.110
<b>e<sub>A</sub></b>	7.37	7.87	0.290	0.310
<b>L</b>	2.79	3.81	0.110	0.150
<b>Q<sub>1</sub></b>	1.27	2.03	0.050	0.080
<b>S</b>	1.02	2.03	0.040	0.080

ECN: S-40081—Rev. A, 02-Feb-04  
DWG: 5919



## Disclaimer

ALL PRODUCT, PRODUCT SPECIFICATIONS AND DATA ARE SUBJECT TO CHANGE WITHOUT NOTICE TO IMPROVE RELIABILITY, FUNCTION OR DESIGN OR OTHERWISE.

Vishay Intertechnology, Inc., its affiliates, agents, and employees, and all persons acting on its or their behalf (collectively, "Vishay"), disclaim any and all liability for any errors, inaccuracies or incompleteness contained in any datasheet or in any other disclosure relating to any product.

Vishay makes no warranty, representation or guarantee regarding the suitability of the products for any particular purpose or the continuing production of any product. To the maximum extent permitted by applicable law, Vishay disclaims (i) any and all liability arising out of the application or use of any product, (ii) any and all liability, including without limitation special, consequential or incidental damages, and (iii) any and all implied warranties, including warranties of fitness for particular purpose, non-infringement and merchantability.

Statements regarding the suitability of products for certain types of applications are based on Vishay's knowledge of typical requirements that are often placed on Vishay products in generic applications. Such statements are not binding statements about the suitability of products for a particular application. It is the customer's responsibility to validate that a particular product with the properties described in the product specification is suitable for use in a particular application. Parameters provided in datasheets and/or specifications may vary in different applications and performance may vary over time. All operating parameters, including typical parameters, must be validated for each customer application by the customer's technical experts. Product specifications do not expand or otherwise modify Vishay's terms and conditions of purchase, including but not limited to the warranty expressed therein.

Except as expressly indicated in writing, Vishay products are not designed for use in medical, life-saving, or life-sustaining applications or for any other application in which the failure of the Vishay product could result in personal injury or death. Customers using or selling Vishay products not expressly indicated for use in such applications do so at their own risk and agree to fully indemnify and hold Vishay and its distributors harmless from and against any and all claims, liabilities, expenses and damages arising or resulting in connection with such use or sale, including attorneys fees, even if such claim alleges that Vishay or its distributor was negligent regarding the design or manufacture of the part. Please contact authorized Vishay personnel to obtain written terms and conditions regarding products designed for such applications.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted by this document or by any conduct of Vishay. Product names and markings noted herein may be trademarks of their respective owners.



Компания «ЭлектроПласт» предлагает заключение долгосрочных отношений при поставках импортных электронных компонентов на взаимовыгодных условиях!

Наши преимущества:

- Оперативные поставки широкого спектра электронных компонентов отечественного и импортного производства напрямую от производителей и с крупнейших мировых складов;
- Поставка более 17-ти миллионов наименований электронных компонентов;
- Поставка сложных, дефицитных, либо снятых с производства позиций;
- Оперативные сроки поставки под заказ (от 5 рабочих дней);
- Экспресс доставка в любую точку России;
- Техническая поддержка проекта, помощь в подборе аналогов, поставка прототипов;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- Лицензия ФСБ на осуществление работ с использованием сведений, составляющих государственную тайну;
- Поставка специализированных компонентов (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Aeroflex, Peregrine, Syfer, Eurofarad, Texas Instrument, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

Помимо этого, одним из направлений компании «ЭлектроПласт» является направление «Источники питания». Мы предлагаем Вам помощь Конструкторского отдела:

- Подбор оптимального решения, техническое обоснование при выборе компонента;
- Подбор аналогов;
- Консультации по применению компонента;
- Поставка образцов и прототипов;
- Техническая поддержка проекта;
- Защита от снятия компонента с производства.



#### Как с нами связаться

**Телефон:** 8 (812) 309 58 32 (многоканальный)

**Факс:** 8 (812) 320-02-42

**Электронная почта:** [org@eplast1.ru](mailto:org@eplast1.ru)

**Адрес:** 198099, г. Санкт-Петербург, ул. Калинина, дом 2, корпус 4, литера А.