

## SYNCHRONOUS RECTIFIER DRIVER

### Features

- Provides constant and proper gate drive to power MOSFETs regardless of transformer output
- Minimizes loss due to power MOSFET body drain diode conduction
- Stand alone operation - no ties to primary side
- Schmitt trigger input with double pulse suppression allows operation in noisy environments
- High peak current drive capability - 4A
- High speed operation - 2MHz
- Adaptable to multiple topologies

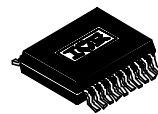
### Description

The IR1176 is a high speed CMOS controller designed to drive N-channel power MOSFETs used as synchronous rectifiers in high current, high frequency forward converters with output voltages equal or below 5VDC. Schmitt trigger inputs with double pulse suppression allow the controller to operate in noisy environments. The circuit does not require any ties to the primary side and derives its operating power directly from the secondary. The circuit functions by anticipating transformer output transitions, then turns the power MOSFETs on or off before the transitions of the transformer to minimize body drain diode conduction and reduce associated losses. Turn on/off lead time can be adjusted to accommodate a variety of power MOSFET sizes and circuit conditions. The IR1176 also provides gate drive overlap/dead-time control via external components to further minimize diode conduction by nulling effects of secondary loop and device package inductance.

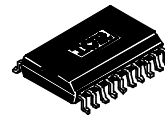
### Product Summary

$V_{dd}$	5Vdc
$I_{O+/-}$ (peak)	4A/4A
$F_{max}$	2MHz
Max lead time	500nsec

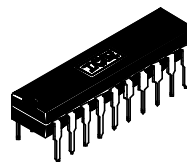
### Packages



**IR1176S**  
20 Lead Surface Mount  
(SSOP-20)



**IR1176SS**  
20 Lead SOIC (MS-013AC)



**IR1176**  
20 Lead PDIP  
(MS-001AD)

## Absolute Maximum Ratings

Absolute maximum ratings indicate sustained limits beyond which damage to the device may occur.

Symbol	Definition	Min.	Max.	Units
V <sub>DD</sub>	Supply voltage	—	7	V <sub>DC</sub>
I <sub>IN</sub>	Input clamp current	—	+/- 10	mA <sub>DC</sub>
P <sub>D</sub>	Power dissipation (SSOP-20)	—	400	mW
	(SOIC)	—	—	—
	(PDIP)	—	—	—
R <sub>thJC</sub>	Thermal resistance (SSOP-20) junction-to-case	—	28.5	°C/W
	(SOIC) junction-to-case	—	20	
	(PDIP) junction-to-case	—	28.1	
R <sub>thJA</sub>	Thermal resistance (SSOP-20) junction-to-ambient	—	90.5	
	(SOIC) junction-to-ambient	—	45	
	(PDIP) junction-to-ambient	—	62.4	
T <sub>J</sub>	Junction temperature	—	150	°C
T <sub>S</sub>	Storage temperature	-55	150	
T <sub>L</sub>	Lead temperature (soldering, 10 seconds)	—	300	

## Recommended Operating Conditions

Symbol	Definition	Min.	Typ.	Max.	Units
V <sub>DD</sub>	Supply voltage operating range	—	5	—	V <sub>DC</sub>
T <sub>A</sub>	Ambient temperature	-40	—	85	°C
Freq	Operating frequency	250	—	500	KHz
R <sub>bias</sub>	Required bias resistor (+/- 1%)	—	34.0	—	KΩ
UV	Voltage at UVSET pin	1.75	—	2.25	V <sub>DC</sub>
X <sub>IN</sub>	Maximum voltage at X1 and X2 inputs	—	—	5.6	V <sub>DC</sub>
Cd1/Cd2	Capacitance at pins DTIN1 and DTIN2	—	—	100	pF

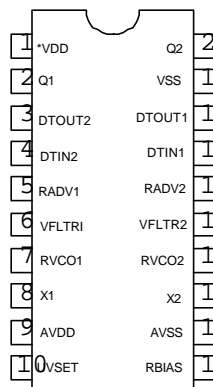
## Dynamic Electrical Characteristics

Vdd=5V, T<sub>A</sub> = 25°C, R<sub>bias</sub> = 34.0K unless otherwise specified.

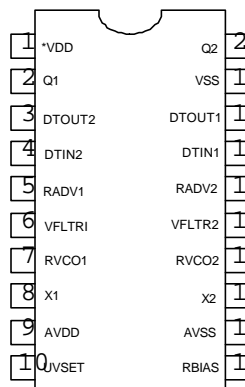
Symbol	Definition	Min.	Typ.	Max.	Units
Vdd	Supply voltage operating range	4.0	—	5.25	V <sub>DC</sub>
Iqdd	Vdd quiescent current (x1 = x2 = 0V or 5V, Iout = 0)	—	4	5	A
Freq	Operating frequency	100	—	2000	KHz
UVSET+	UVSET positive going threshold	1.10	—	1.4	V
UVSET-	UVSET negative going threshold	0.8	—	1.1	V
Vxth+	X1/X2 Input positive going threshold	—	1.4	—	V <sub>DC</sub>
Vxth-	X1/X2 Input negative going threshold	—	1.0	—	V <sub>DC</sub>
Tadv	Externally adjustable lead time (advance)	—	—	500	nsec
Td	Externally adjustable dead-time for Q1 and Q2	20	—	—	nsec
Isink (peak)	Q1,Q2 output sink current (Vdd=5.0V, pulsed, 10 usec)	—	4	—	A
Isource (peak)	Q1,Q2 output source current (Vdd=5.0V, pulsed, 10 usec)	—	4	—	
VOH	Q1, Q2 High level voltage (Iout = 20mA)	—	Vdd- 0.20	—	V
VOL	Q1, Q2 Low level voltage (Iout = 20mA)	—	0.10	—	
tio	Input to output delay (PLL bypassed, cross coupled mode)	—	20	—	nsec
tr	Gate turn-on rise time (C1=1000pf, Vdd=5V)	—	20	—	nsec
tf	Gate turn-off fall time (C1=1000pf, Vdd=5V)	—	20	—	nsec
Vtr	Cross-over voltage (Vdd=5Vdc, DTIN shorted to DTOUT, C1=1000pf) Fig. 3	—	2.5	—	V <sub>DC</sub>
Rbias	Required bias resistor (1%)	—	34.0	—	KΩ
Vbias	Voltage at Rbias pin	—	1.25	—	V <sub>DC</sub>
Tjitter	Phase-lock loop output jitter	-20	—	20	nsec
Ichgump	Charge pump output current (at VFLTR pin)	—	50	—	μA <sub>DC</sub>
Vchgump	Charge pump output voltage (at VFLTR pin)	1.3	1.5	1.7	V <sub>DC</sub>
Kvco_dc	PLL Vco DC gain (per design)	—	62	—	KHz/ Volt

## Lead Definitions and Assignments

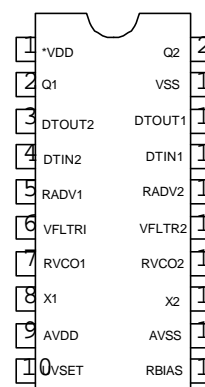
Symbol	Description
AVDD	Power - + 5 V <sub>DC</sub> to MOSFET drivers
Q1	Output - gate drive for Q1 power MOSFET
DTOUT1	Output - sets dead time for Q1 output - used with DTIN1
DTIN1	Input - sets dead time for Q1 - used with DTOUT1
RADV1	Output - sets lead time (advance) for Q1
VFLTR1	Output - PLL loop filter for Q1 output
RVCO1	Output - sets PLL center frequency for Q1 output
X1	Input - transformer input for Q1
VDD	Power - +5 Vdc for internal logic
UVSET	Input - sets UVLO+ If this pin is pulled below 1.25VDC externally, then both Q1 and Q2 outputs will be at Vss (disabled)
RBIAS	Output - connected to 34.0K +/- 1% resistor - sets operating current
AVSS	Ground for MOSFET driver supply (VDD)
X2	Input - transformer input for Q2
RVCO2	Output - sets PLL center frequency for Q2 output
VFLTR2	Output - PLL loop filter for Q2
RADV2	Output - sets lead time (advance) for Q2
DTIN2	Input - sets dead time for Q2 - used with DTOUT2
DTOUT2	Output - sets dead time for Q2 - used with DTIN2
VSS	Ground for logic supply (AVDD)
Q2	Output - gate drive for Q2 power MOSFET



**IR1176S**  
(SSOP-20)



**IR1176SS**  
SOIC (wide body)



**IR1176**  
PDIP

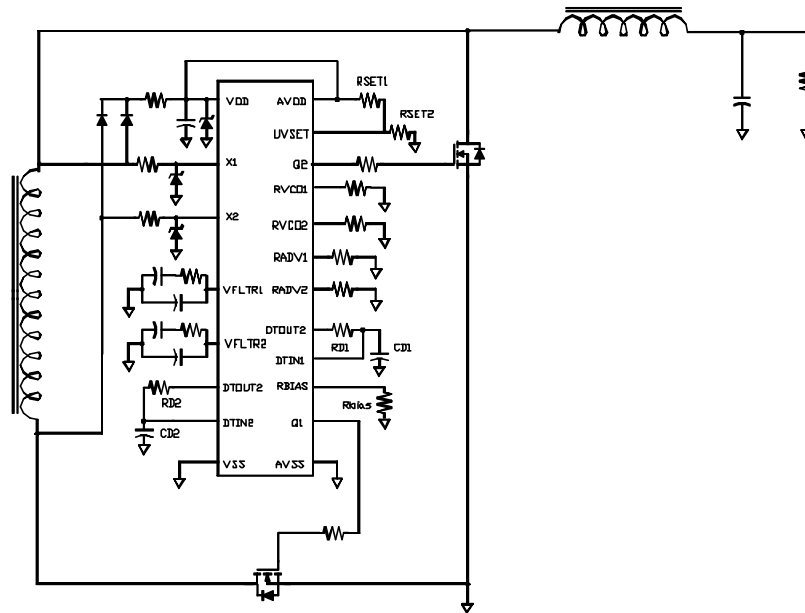


Fig. 1 Typical application circuit when supply  $V_{out} < 5.0 \text{ V}_{DC}$

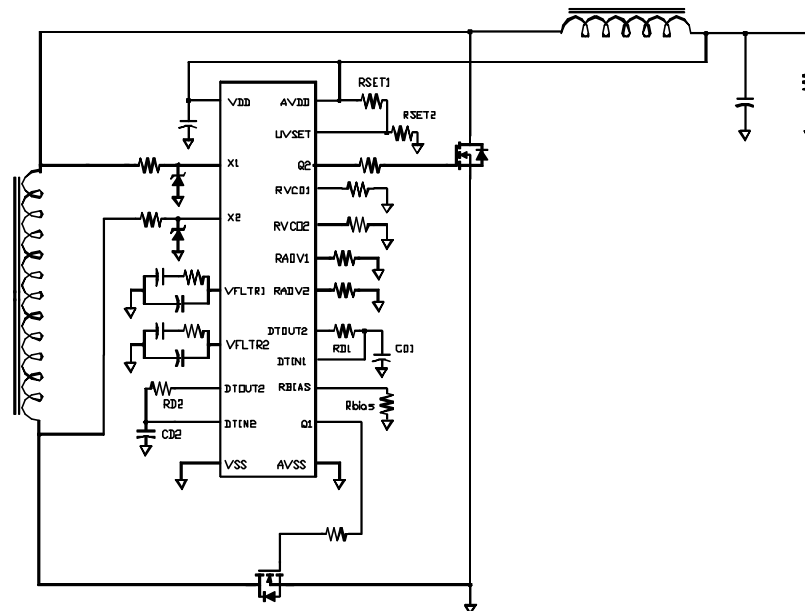
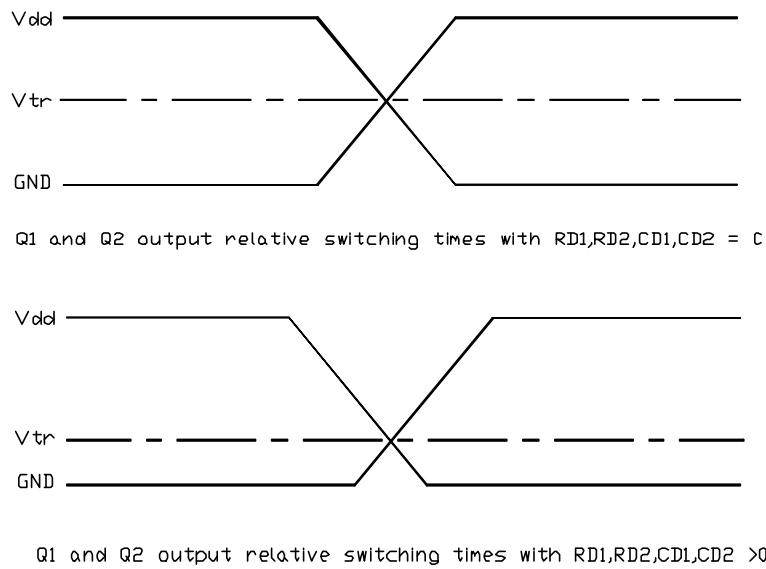


Fig. 2 Typical application circuit when supply  $V_{out} = 5.0 \text{ V}_{DC}$



**Fig. 3 Gate drive characteristics and definitions**

## Phase Lock Loop Design Equations:

1 - Resistor to set VCO Center Frequency:

$$R_{vco} (K\Omega) = [1E2 \times V_{chgpump}(V_{DC}) / f_{vco}(KHz)] \times K_{vco\_dc}(KHz/Volt)$$

Example (A): Choose  $V_{chgpump} = 1.5V$ , desired frequency ( $f_{vco}$ ) = 300KHz

$$R_{vco} = [1E2 \times 1.5 / 300] \times 62 \text{ Hz} = 31 K\Omega$$

2 - Small Signal gain for VCO:

$$K_{vco\_ac} (KHz/Volt) = 1E2 \times K_{vco\_dc} (KHz/Volt) / R_{vco}(K\Omega)$$

Example (B): Choosing same conditions as in example A:

$$K_{vco\_ac} = 1E2 \times 62 / 31 = 200 KHz/volt$$

3 -PLL Natural frequency:

$$\omega_n = 2\pi f_n(\text{KHz}) = \frac{1}{C(\text{nF})} \sqrt{\frac{I_{\text{chpump}}(\mu\text{A}) \times K_{\text{vco\_ac}}(\text{KHz/V})}{C(\text{nF})}}$$

Choose  $C_f$  such that  $C_f = C/16$

4 -PLL Damping factor calculations:

$$P = \frac{1}{\zeta^2 - 3} \times R_f(\text{K}\Omega) \times C(\text{nF}) \times f_n(\text{KHz})$$

Typical value for P is 0.707. (Critically damped)

5 -Advance timing:

$$T_{\text{adv}}(\text{nsec}) = R_{\text{ADV}}(\text{K}\Omega) \times 10 + 6$$

Where  $R_{\text{ADV}}$  is resistance from  $R_{\text{ADV1}}$  or  $R_{\text{ADV2}}$  to ground.

Example C:  $R_{\text{ADV}} = 10\text{K}\Omega$  will result in  $T_{\text{adv}} = 10 \times 10 + 6 = 106\text{ nsec}$ .

6-Dead time calculations:

$$T_d(\text{nsec}) = 0.69 \times C_{\text{dt}}(\text{pF}) \times (R_{\text{dt}}(\text{K}\Omega) + 0.15) \text{ (For } V_{\text{dd}} = 5\text{V)}$$

Where  $R_{\text{dt}}$  is resistance between pins  $\text{DTIN1}$  and  $\text{DTOUT1}$  or  $\text{DTIN2}$  and  $\text{DTOUT2}$ .  $C_{\text{dt}}$  is capacitance from  $\text{DTIN1}$  or  $\text{DTIN2}$  to ground.

Example D:  $R_{\text{d}} = 2\text{K}\Omega$  and  $C_{\text{dt}} = 100\text{pF}$  will result in  $T_d = 148.35\text{nsec}$ .

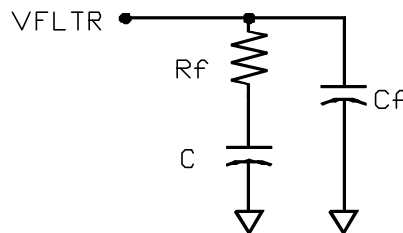


Fig. 4 PLL loop filter component definitions

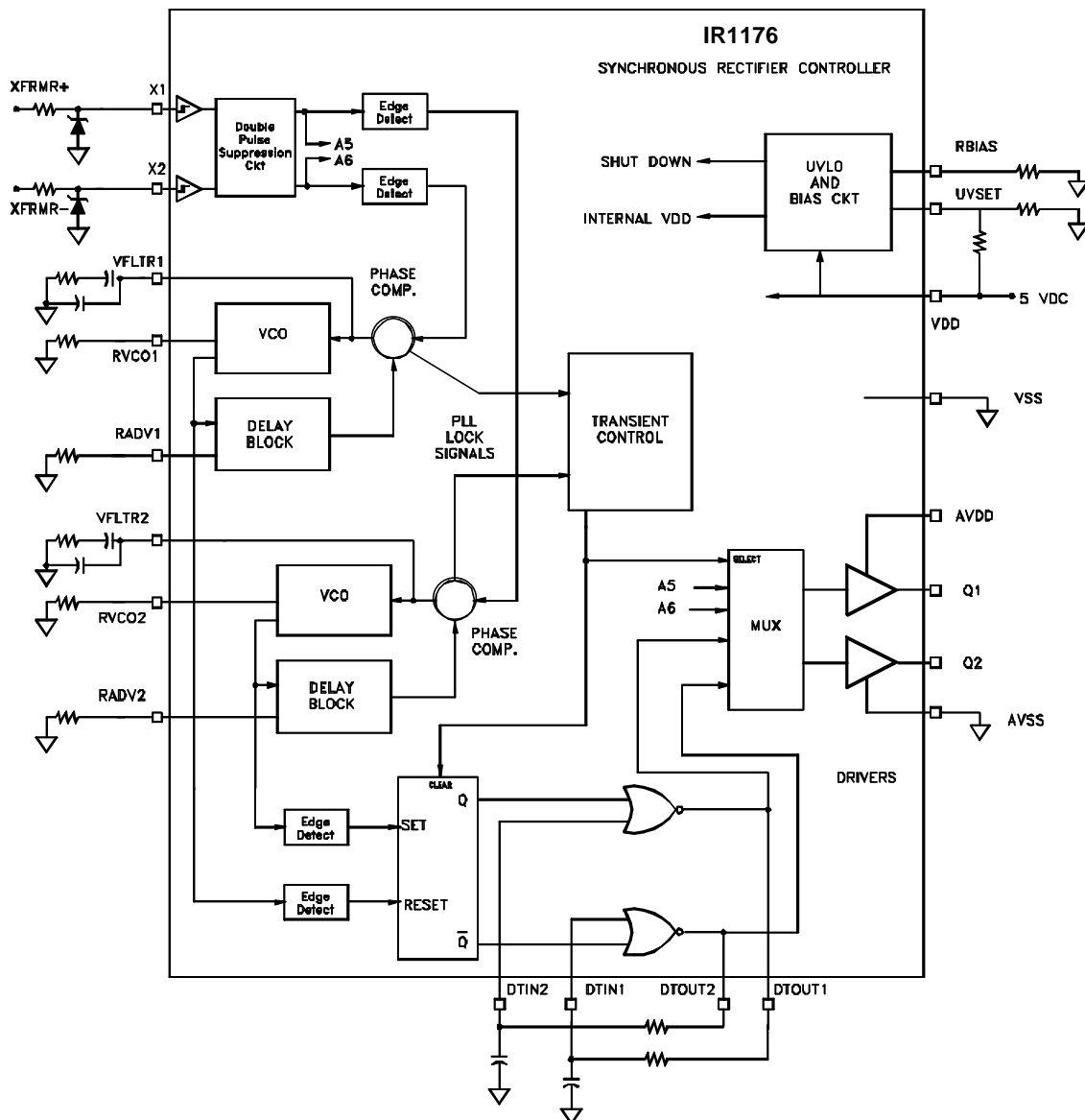
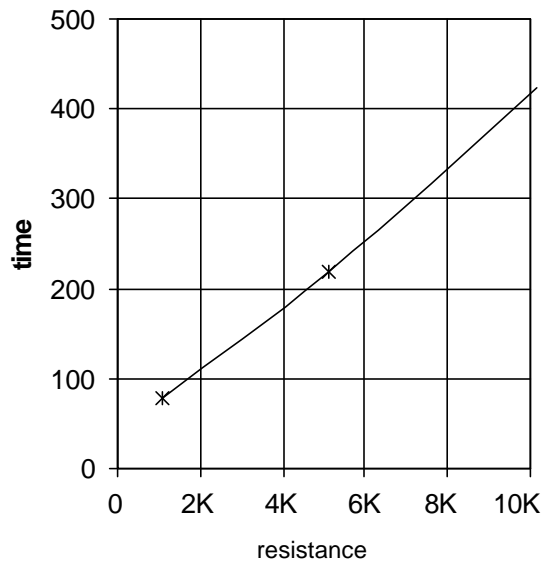
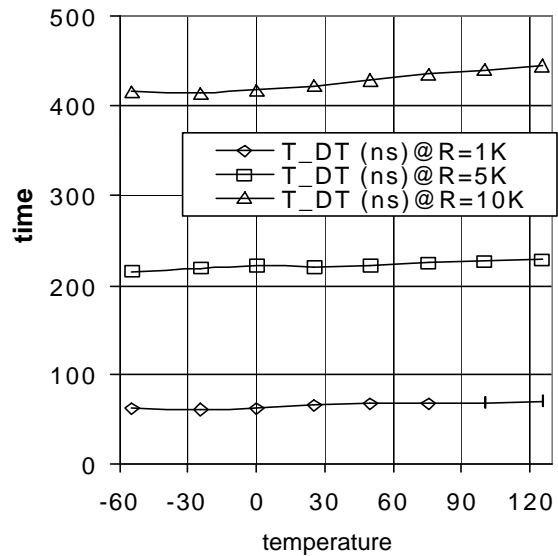


Fig. 5 IR1176 Block Diagram

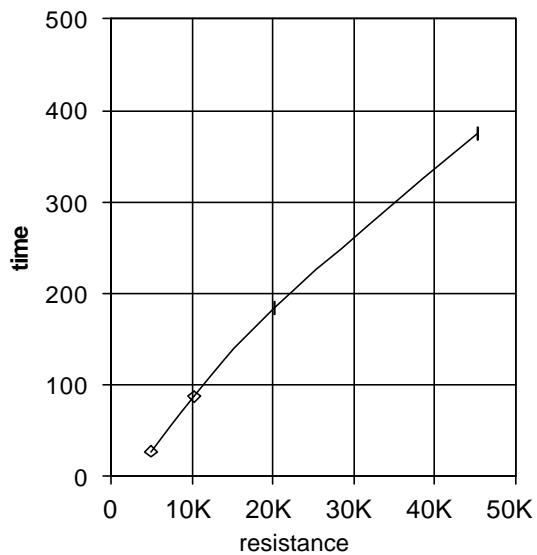




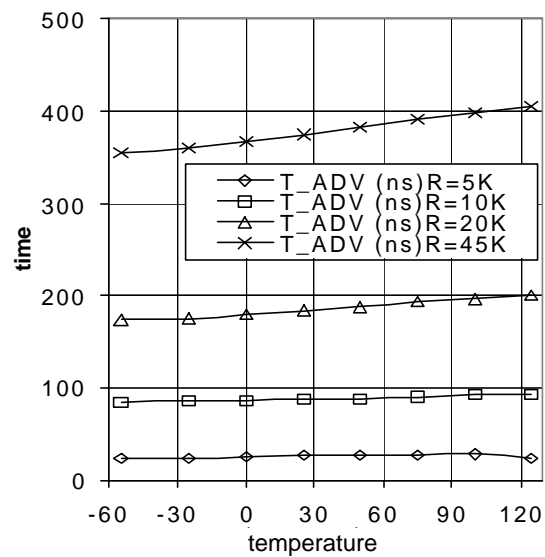
Response at 25°C  
T\_DT vs R\_DT, C = 100pF



Temperature Response  
T\_DT vs R\_DT, C = 100pF

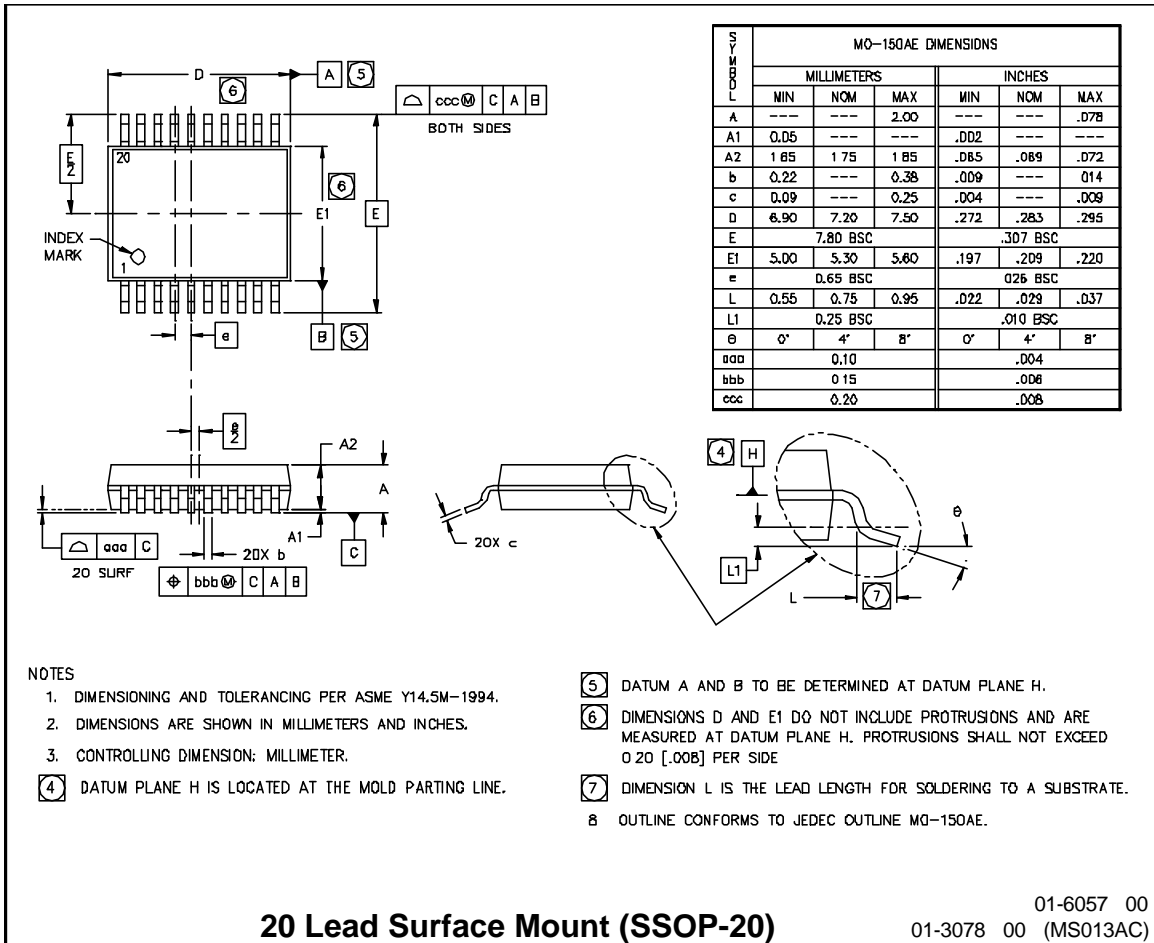


Response at 25°C  
T\_ADV vs R\_ADV

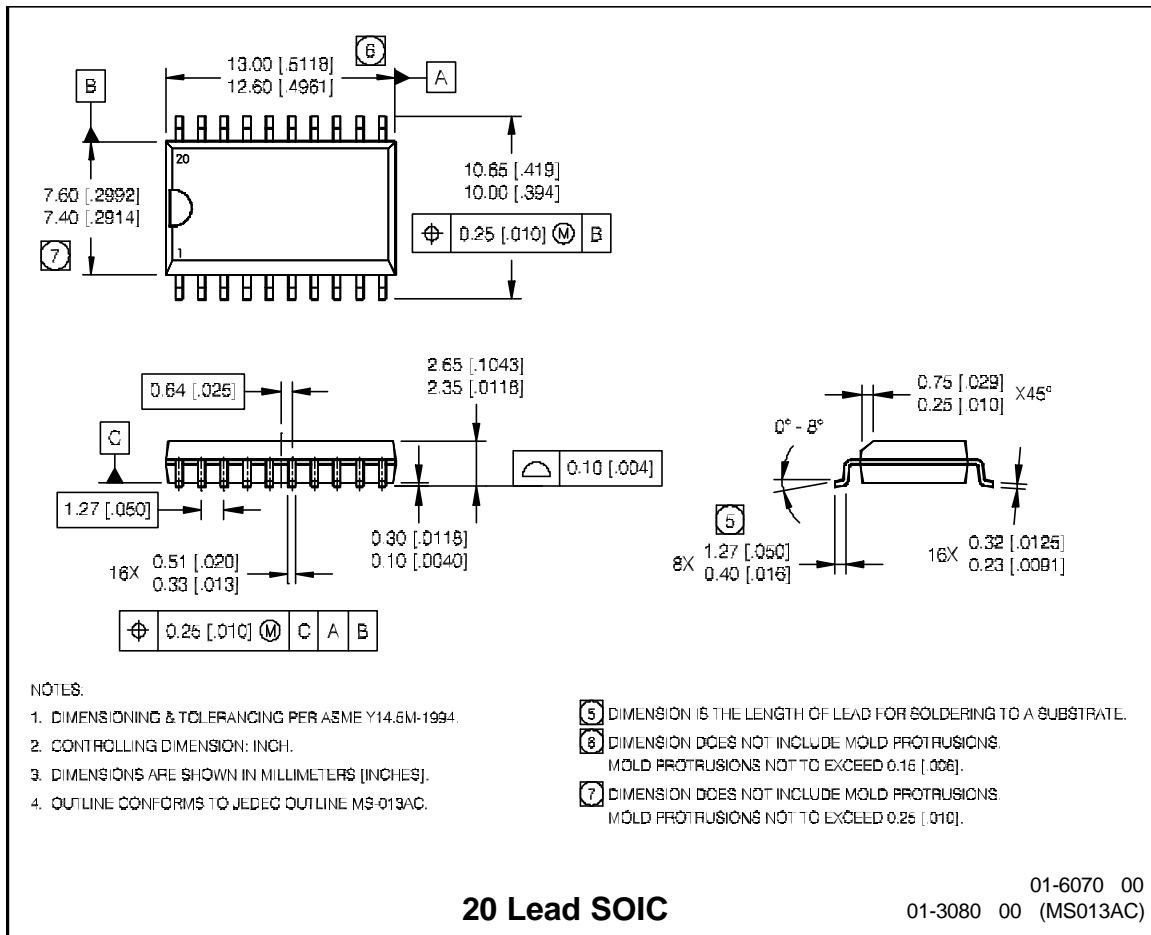


Temperature Response  
T\_ADV vs R\_ADV

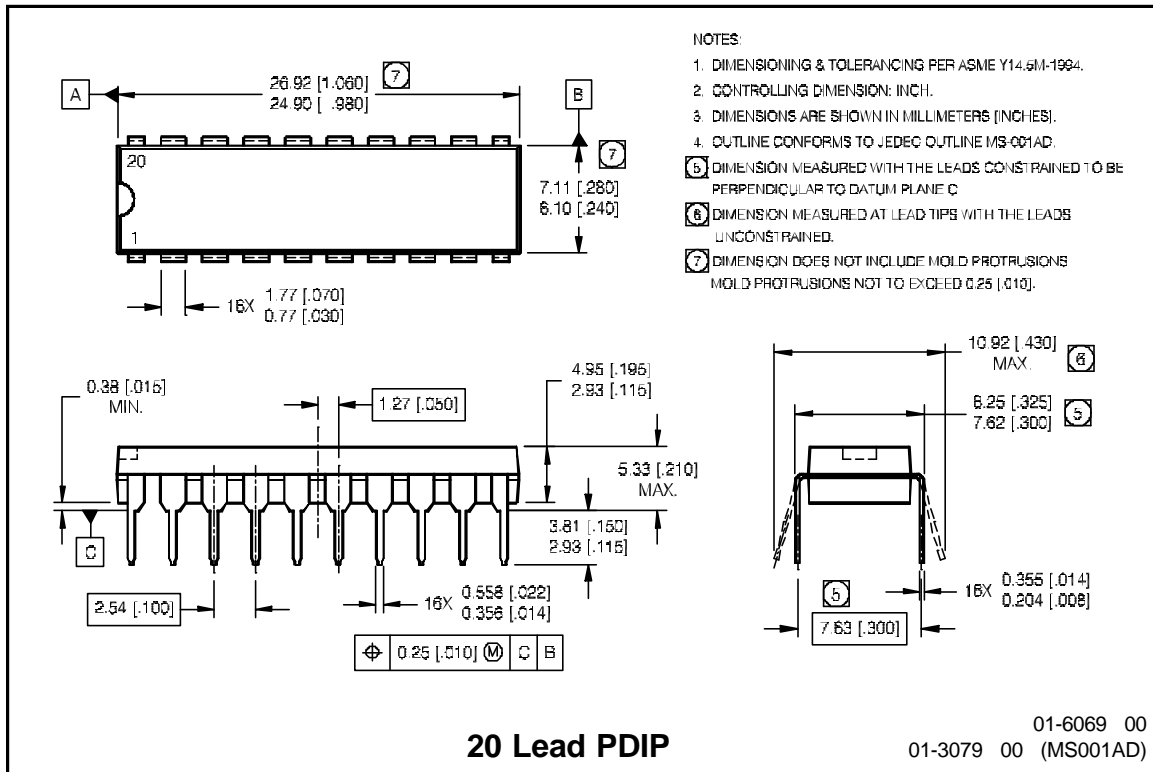
## Case Outline



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