Linear Building Block – Quad Low-Power Op Amp with Shutdown Modes

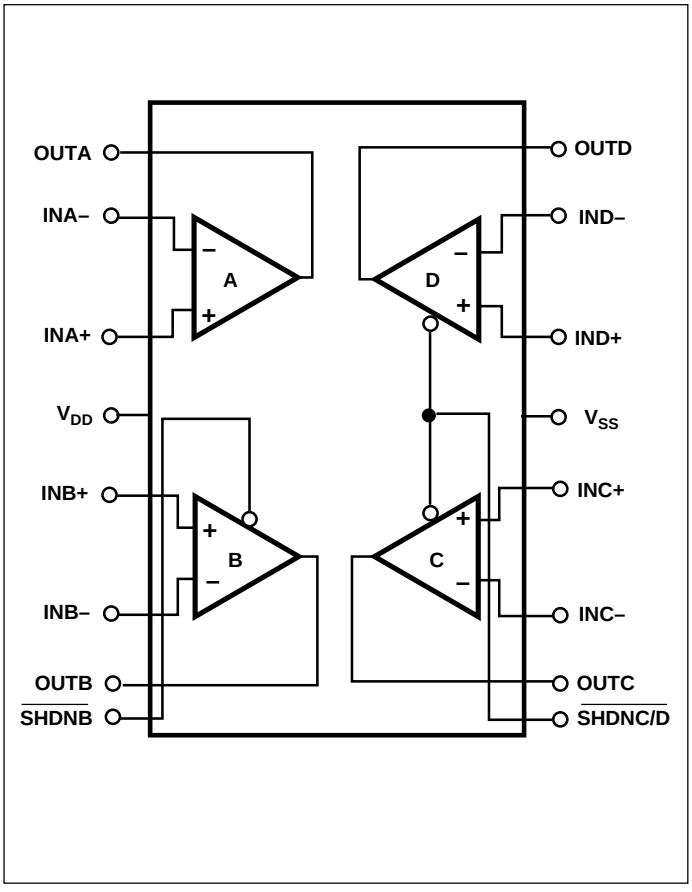
FEATURES

- **Optimized for Single-Supply Operation**
- **Small Package ..... 16-Pin QSOP**
- **Ultra Low Input Bias Current ..... Less than 100 pA**
- **Low Quiescent Current, Operating .... 20 μA (Typ.)**
  Shutdown Mode 6μA (Typ.)
- **Rail-to-Rail Inputs and Outputs**
- **Operates Down to 1.8V**
- **Can Shut Down One, Two, or Three Op Amps Using Shutdown Pins in Shutdown Mode**

APPLICATIONS

- **Power Management Circuits**
- **Battery Operated Equipment**
- **Consumer Products**

FUNCTIONAL BLOCK DIAGRAM



GENERAL DESCRIPTION

The TC1030 is a quad CMOS operational amplier designed for low power applications.

It has a typical operating supply current of 20μA which is constant over the supply voltage range of 1.8V to 5.5V.

Each op amp has rail-to-rail inputs and output which allow operation at low supply voltages with large input and output signal swings.

Two active low shutdown pins are provided. One pin disables op amp B while the other disables op amps C and D. Op amp A remains active always. When disabled the outputs of op amps B, C and D are in a high impedance state.

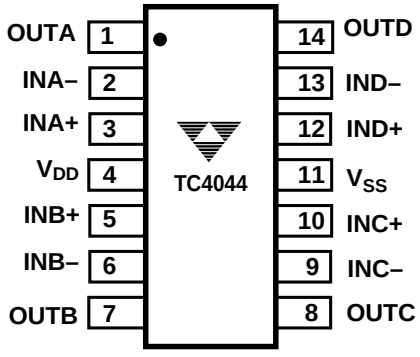
Packaged in a 16-pin QSOP, the TC1030 is ideal for battery operated applications.

ORDERING INFORMATION

Part No.	Package	Temp. Range
TC1030EQR	16-Pin QSOP	– 40°C to +85°C

TC1043EV Evaluation Kit for Linear Building Block Family

PIN CONFIGURATION (QSOP)



14-Pin SOIC

TC1030

ABSOLUTE MAXIMUM RATINGS*

Supply Voltage 6.0V
Voltage on Any Pin: (With Respect to Supplies)
..... (V_{SS} – 0.3V) to (V_{DD} +0.3V)
Operating Temperature Range: ..... – 40°C to + 85°C
Storage Temperature Range ..... – 55°C to +150°C
Lead Temperature (Soldering, 10 sec) ..... +260°C

* Static-sensitive device. Unused devices must be stored in conductive material. Protect devices from static discharge and static fields. Stresses above 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 above 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.

ELECTRICAL CHARACTERISTICS: Typical values apply at 25°C, V_{DD} = 3.0V; T_A = –40°C to +85°C, V_{DD} = 1.8V to 5.5V, unless otherwise specified.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_{DD}	Supply Voltage		1.8	—	5.5	V
Shutdown Inputs						
V_{IH}	Input High Threshold		80% V_{DD}	—	—	V
V_{IL}	Input Low Threshold		—	—	20% V_{DD}	V
I_{SI}	Shutdown Input Current, $\overline{SHDNB}$ or $\overline{SHDNC/D}$		—	—	±100	nA
Op Amps						
I_Q	Supply Current, Operating	All Outputs Open, $\overline{SHDNB}$ = V_{DD}, $\overline{SHDNC/D}$ = V_{DD}	—	20	32	µA
I_{SHDN}	Supply Current Shutdown Mode	$\overline{SHDNB}$ = V_{SS} $\overline{SHDNC/D}$ = V_{SS}	—	6	10	µA
R_{OUT}(SD)	Output Resistance in Shutdown	$\overline{SHDNB}$ = V_{SS}, $\overline{SHDNC/D}$ = V_{SS}	20	—	—	MΩ
C_{OUT}(SD)	Output Capacitance in Shutdown	$\overline{SHDNB}$ = V_{SS}, $\overline{SHDNC/D}$ = V_{SS}	—	—	5	pF
T_{SEL}	Select Time (V_{OUT} from $\overline{SHDNB}$, $\overline{SHDNC/D}$ = V_{IH})	R_L =10KΩ to V_{SS}	—	15	—	µsec
T_{DESEL}	Deselect Time (V_{OUT} from $\overline{SHDNB}$, $\overline{SHDNC/D}$ = V_{IL})	R_L =10KΩ to V_{SS}	—	20	—	nsec
A_{VOL}	Large Signal Voltage Gain	R_O = 10 KΩ, V_{DD} = 5V	—	100	—	V/mV
GBWP	Gain-Bandwidth Product	V_{DD} = 1.8 to 5.5V; V_O = V_{DD} to V_{SS}	—	90	—	KHz
V_{ICMR}	Common Mode Input Voltage Range		V_{SS} – 0.2	—	V_{DD} + 0.2	V
V_{OS}	Input Offset Voltage	V_{DD} = 3V, V_{CM} = 1.5V, T_A = 25°C, T_A = –40°C to 85°C		±100 ±0.3	±500 ±1.5	µV mV
I_B	Input Bias Current	T_A = 25°C; V_{CM} = V_{DD} to V_{SS}	–100	50	100	pA
$V_{OS\ (DRIFT)}$	Average Input Offset Voltage Drift	V_{DD} = 3V; V_{CM} = 1.5V	—	4	—	µV/°C
SR	Slew Rate	C_L = 100 pF, R_L = 1 MΩ to GND, Gain = 1 V_{IN} = V_{SS} to V_{DD}	—	35	—	mV/µsec
V_{OUT}	Output Signal Swing	R_L = 10 KΩ	V_{SS} + 0.05	—	V_{DD} – 0.05	V
CMRR	Common Mode Rejection Ratio	T_A = 25°C; V_{DD} = 5V; V_{CM} = V_{DD} to V_{SS}	70	—	—	dB
PSRR	Power Supply Rejection Ratio	T_A = 25°C; V_{CM} = V_{SS}; V_{DD} = 1.8V to 5V	80	—	—	dB

ELECTRICAL CHARACTERISTICS (CON'T): Typical values apply at 25°C, V_{DD} = 3.0V; T_A = –40°C to +85°C, V_{DD} = 1.8V to 5.5V, unless otherwise specified.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
I_{SRC}	Output Source Current	$V_{IN}+ = V_{DD}$, $V_{IN}– = V_{SS}$ Output Shorted to V_{SS} V_{DD} = 1.8V; Gain = 1	3	—	—	mA
I_{SINK}	DC Output Sink Current	$V_{IN}+ = V_{SS}$, $V_{IN}– = V_{DD}$ Output Shorted to V_{DD} V_{DD} = 1.8V; Gain = 1	4	—	—	mA
en	Input Noise Voltage	0.1 Hz to 10 Hz	—	10	—	µVpp
	Input Noise Density	1 KHz	—	125	—	nV/√Hz

DETAILED DESCRIPTION

The TC1030 is one of a series of very low-power, Linear Building Block products targeted at low-voltage, single-supply applications. The TC1030 minimum operating voltage is 1.8V, and maximum supply current is only 32 µA (fully enabled). It combines four op amps in a single package.

Microchip's op amps are internally compensated to be unity-gain stable and have a typical gain-bandwidth product of 90 KHz with typical slew rates of 35 V/msec.

The amplifier's input range extends beyond both supplies by 200mV and the outputs will swing to within several millivolts of the supplies depending on the load current being driven.

Two shutdown mode pins are incorporated for easy adaptation to system power management schemes. In this state, the shutdown pins allow the user to power on one, two, three, or all four op amps (see Table 1 on next page). Pin $\overline{\text{SHDNB}}$ can be used to disable op amp B and pin $\overline{\text{SHDNC/D}}$ to disable op amps C and D. Op amp A is always powered on regardless of the states of the shutdown pins. When both shutdown pins are low, the total quiescent current of the TC1030 is only 6 µA, typical.

Input offset voltage is 500µV max at 25°C with an input bias current of less than 100pA. This makes the TC1030 extremely suitable for precision, low power applications.

TYPICAL APPLICATIONS

The TC1030 lends itself to a wide variety of applications, particularly in battery-powered systems. It typically finds application in power management, process supervisory, and interface circuitry.

Voice Band Receive Filter

The majority of spectral energy for human voices is found to be in a 2.7 KHz frequency band from 300 Hz to 3 KHz. To properly recover a voice signal in applications such as radios, cellular phones, and voice pagers a low-power bandpass filter that is matched to the human voice spectrum can be implemented using Microchip's CMOS op amps. Figure 1 shows a unity gain multi-pole Butterworth filter with ripple less than 0.15 dB in the human voice band. The lower 3 dB cut-off frequency is 70 Hz (single order response) while the upper cut-off frequency is 3.5KHz (fourth order response).

Supervisory Audio Tone (SAT) Filter for Cellular

Supervisory Audio Tones (SAT) provide a reliable transmission path between cellular subscriber units and base stations. The SAT tone functions much like the current/voltage used in land line telephone systems to indicate that a phone is off the hook. The SAT tone may be one of three frequencies: 5970, 6000, or 6030 Hz. A loss of SAT implies that channel conditions are impaired and if SAT is interrupted for more than 5 seconds a cellular call is terminated.

Figure 2 shows a high Q (30) second order SAT detection bandpass filter using Microchip's CMOS op amp architecture. This circuit nulls all frequencies except the three SAT tones of interest.

EVALUATION KIT

The TC1043EV consists of a four-inch by six-inch prewired application circuit board. Pre-configured circuits include a pulse width modulator, wake-up timer, function generator, and others. On-board current meter terminals, voltage regulator, and a user-prototyping area speed circuit development. Please contact your local Microchip Semiconductor representative for more information.

TC1030

Table 1. TC1030 Shutdown Power Control Logic

$\overline{SHDNC/D}$	$\overline{SHDNB}$	Op Amps Enabled	Op Amps Disabled	Max. Device Supply Current
V_{IL}	V_{IL}	A	B,C,D	10 µA
V_{IL}	V_{IH}	A, B	C, D	16 µA
V_{IH}	V_{IL}	A, C, D	B	24µA
V_{IH}	V_{IH}	A, B, C, D	None	32µA

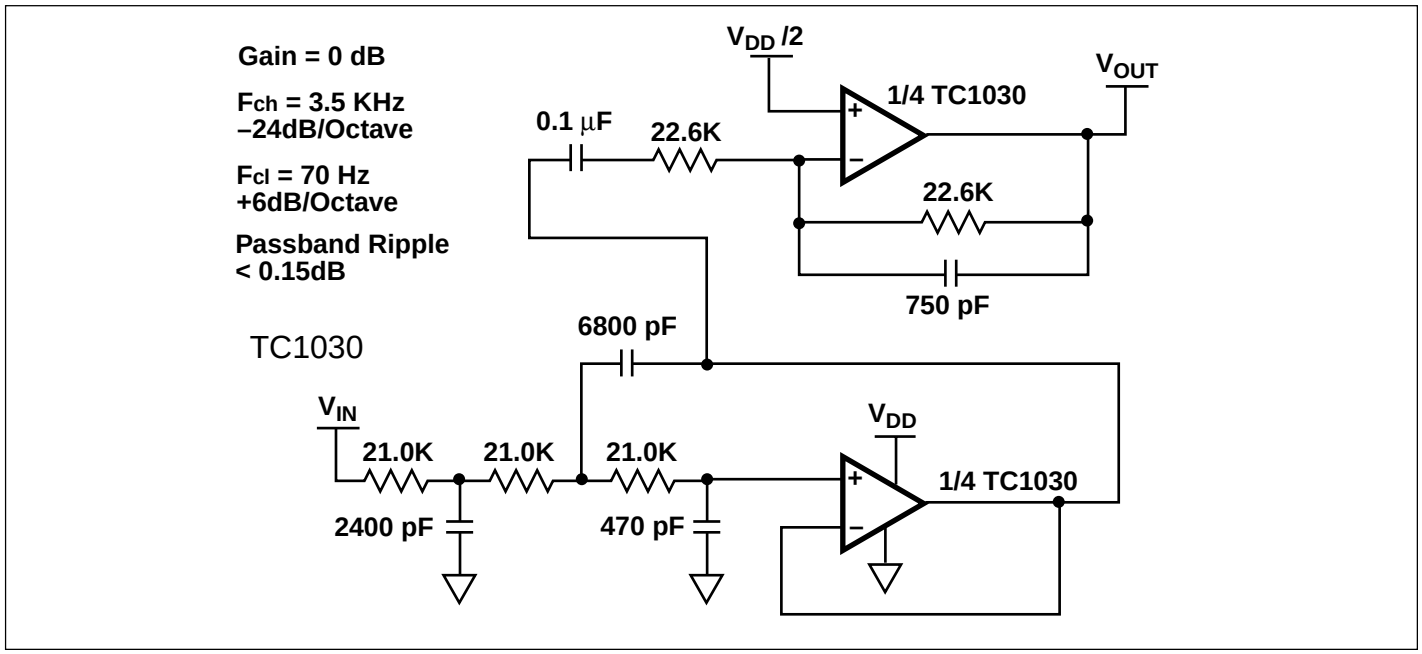


Figure 1. Multi-Pole Butterworth Voice Band Receiver Filter

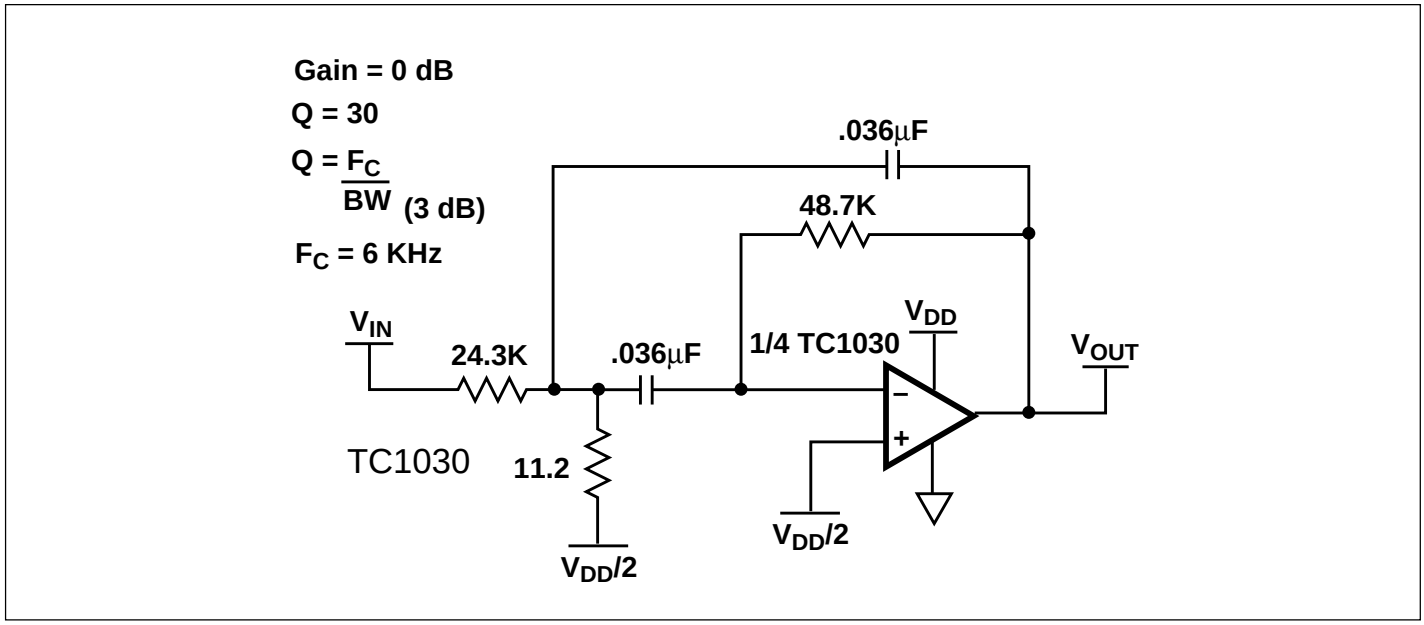
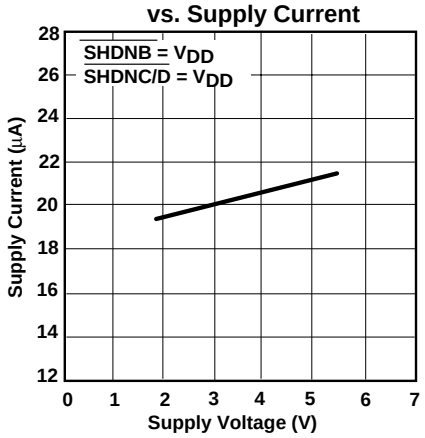


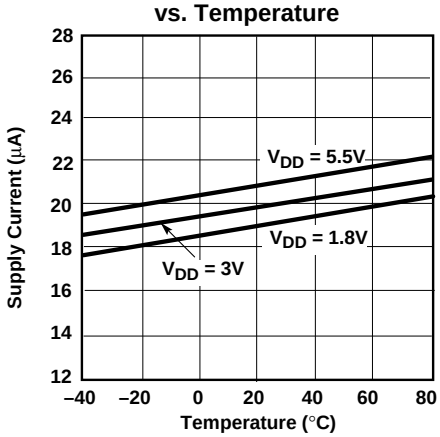
Figure 2. Second Order SAT Bandpass Filter

TYPICAL CHARACTERISTICS CURVES

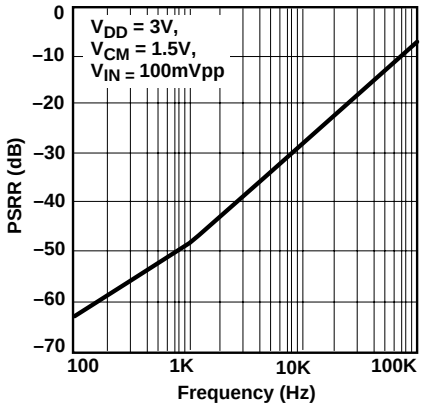
Op-Amp Supply Voltage vs. Supply Current



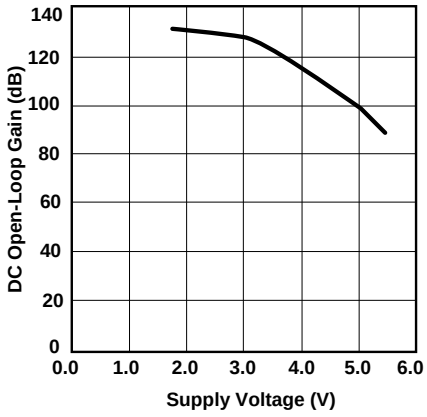
Op-Amp Supply Current vs. Temperature



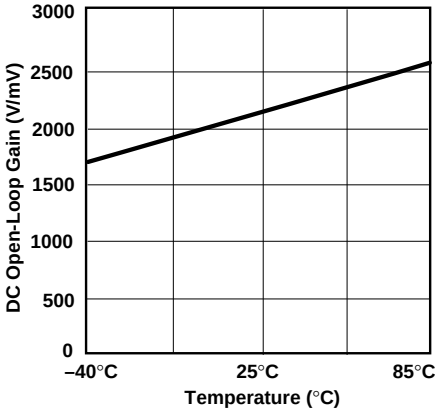
Op-Amp Power Supply Rejection Ratio(PSRR) vs. Frequency



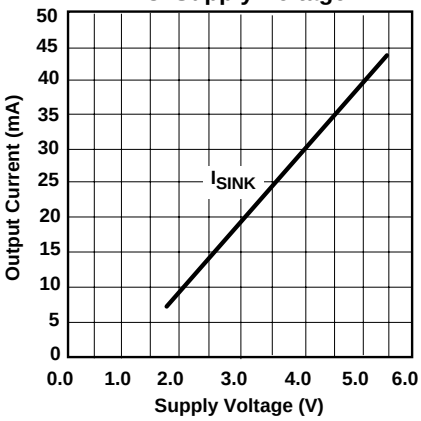
Op-Amp DC Open-Loop Gain vs. Supply Voltage



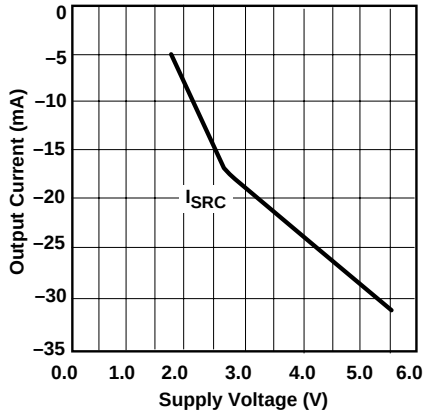
Op-Amp DC Open-Loop Gain vs. Temperature



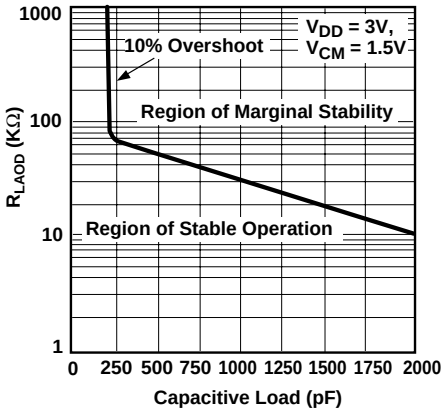
Op-Amp Short-Circuit Current vs. Supply Voltage



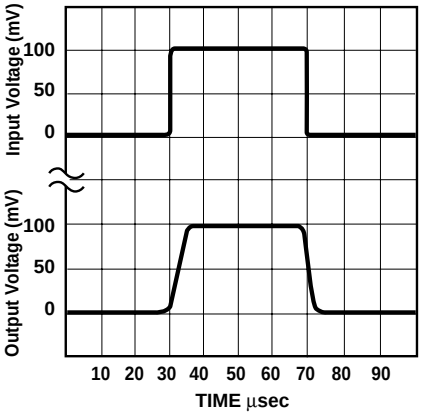
Op-Amp Short-Circuit Current vs. Supply Voltage



Op-Amp Load Resistance vs. Load Capacitance

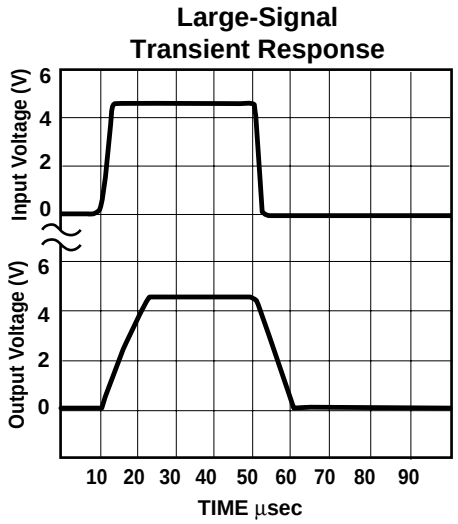


Op-Amp Small-Signal Transient Response



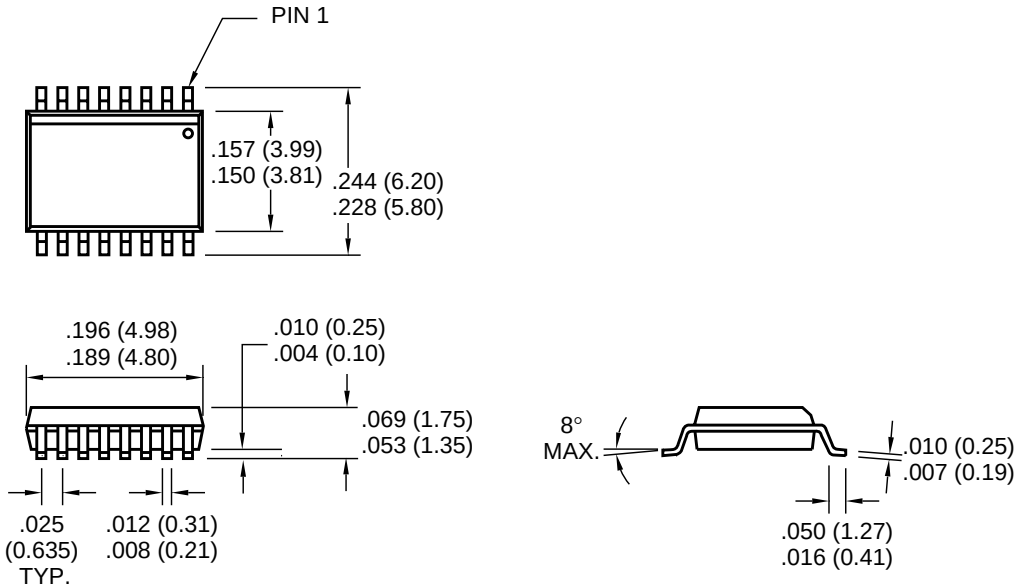
TC1030

TYPICAL CHARACTERISTICS CURVE



PACKAGE DIMENSIONS

16-Pin QSOP (Narrow)



Dimensions: inches (mm)

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