



# TMC2242A/TMC2242B

## Digital Half-Band Interpolating/Decimating Filter

12-bit In/16-bit Out, 60 MHz

### Features

- TMC2242A and TMC2242B are pin-compatible with TMC2242
- User selectable interpolate gain, -6 dB or 0 dB (2242B)
- 30, 40 and 60 MHz speed grades
- User selectable 2:1 decimation, 1:2 interpolation, and equal-rate filter modes
- Passband ripple  $< \pm 0.01$  dB
- Stopband rejection 59.4 dB from 0.28 to  $0.50 \times f_s$
- Cascading two TMC2242A or TMC2242B meets CCIR 601 low-pass filter requirement
- Dedicated 12-bit 2's complement input data port and 16-bit output data port with user-selectable rounding from 9 to 16 bits
- Two's complement or offset binary output format
- Built-in limiter prevents overflow

- Single +5 Volt power supply operation
- Small 44-Lead PLCC and 44-Lead MQFP

### Applications

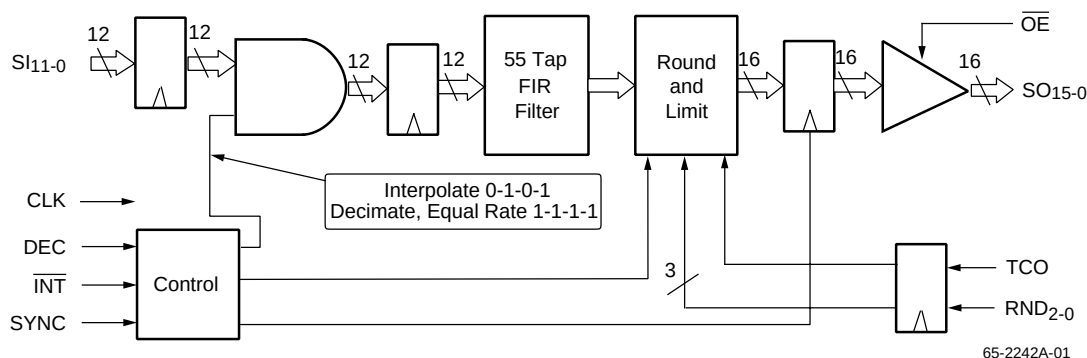
- Low-cost video filtering
- Chrominance bandwidth limiter
- Simple, inexpensive video D/A post-filters
- Reduced cost and complexity for A/D anti-aliasing filters
- High-performance digital low-pass filters
- Digital waveform reconstruction post-filtering
- Telecommunications
- Direct digital synthesis
- Radar

### Description

The TMC2242A and TMC2242B are fixed-coefficient linear-phase half-band (low-pass) digital filters. They can be used to halve or double the sampling rate of a digital signal. When used as a decimating post-filter with a double-speed oversampling A/D converter, they greatly reduce the cost and complexity of anti-aliasing filters required ahead of the A/D converter. When used as an interpolating pre-filter with a double-speed oversampling D/A converter, the TMC2242A and TMC2242B significantly reduce the design complexity and production cost of reconstruction filters used on D/A outputs.

The TMC2242A and TMC2242B user selects the mode of operation (decimate, interpolate, or equal-rate) and rounding. The TMC2242A and TMC2242B accept 12-bit 2's complement data at up to 60 MHz and output saturated (overflow-protected) 2's complement or offset binary data rounded to from 9 to 16 bits. Within the speed grade I/O limit, the output sample rate may be 1/2, 1, or 2 times the input sample rate.

### Block Diagram



## Description (continued)

The filter response is flat to within  $\pm 0.01$  dB from  $0.00$  to  $0.22 \times f_s$ , with stopband attenuation greater than 59.4 dB from  $0.28 \times f_s$  to the Nyquist frequency. The response is 6 dB down at  $0.25 \times f_s$ . Symmetric-coefficient filters such as the TMC2242A and TMC2242B have linear phase response. Full compliance with the CCIR-601 standard of 12 dB attenuation at  $0.25 \times f_s$  is achieved by cascading two parts.

The TMC2242A and TMC2242B are fabricated on an advanced submicron CMOS process. They are available in a 44-lead J-lead PLCC package. Performance is guaranteed from  $0^\circ\text{C}$  to  $70^\circ\text{C}$ .

## Functional Description

The TMC2242A and TMC2242B implement a fixed-coefficient linear-phase Finite Impulse Response (FIR) filter of 55 effective taps, with special rate-matching input and output structures to facilitate 2:1 decimation and 1:2 interpolation. The faster of either the input or output registers will operate at the guaranteed maximum clock rate (speed grade). The total internal pipeline latency from the input of an impulse to the corresponding output peak (digital group delay) is 34 cycles; the 55-value output response begins after 7 clock cycles and ends after 61 cycles.

To perform interpolation, the chip slows the effective input register clock rate to half the output rate. It internally inserts zeroes between the incoming data samples to "pad" the input data rate to match the output rate.

To perform decimation, the chip sets the output register clock rate to half of the input rate. One output is then obtained for every two inputs.

For interpolation, the user should bring SYNC HIGH for at least one clock cycle, returning it LOW with the first desired input data value. When interpolating, the chip will then continue to accept a new data input on each alternate rising edge of the clock. When decimating, the chip will present one output value for every two clock cycles. The user may leave SYNC LOW or toggle it once per rising clock edge, with equivalent performance.

The output data format is two's complement if TCO is HIGH, inverted offset binary if LOW. The user can tailor the output data word width to his/her system requirements using the Rounding control. As shown in Table 4, the output is half-LSB rounded to the resolution selected by the value of RND2-0. The asynchronous three-state output enable control simplifies connection to a data bus with other drivers.

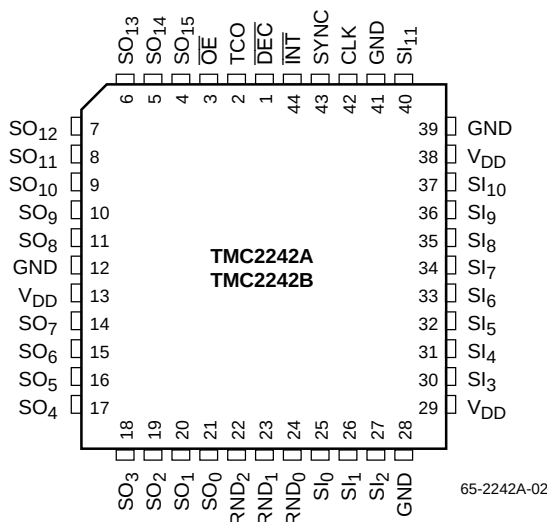
**Table 1. Operating Modes**

| DEC | INT | TMC2242A            | TMC2242B                         |
|-----|-----|---------------------|----------------------------------|
| 0   | 0   | Equal Rate          | Interpolate (0 dB)               |
| 0   | 1   | Decimate            | Decimate                         |
| 1   | 0   | Interpolate (-6 dB) | Interpolate (-6 dB) <sup>1</sup> |
| 1   | 1   | Equal Rate          | Equal Rate                       |

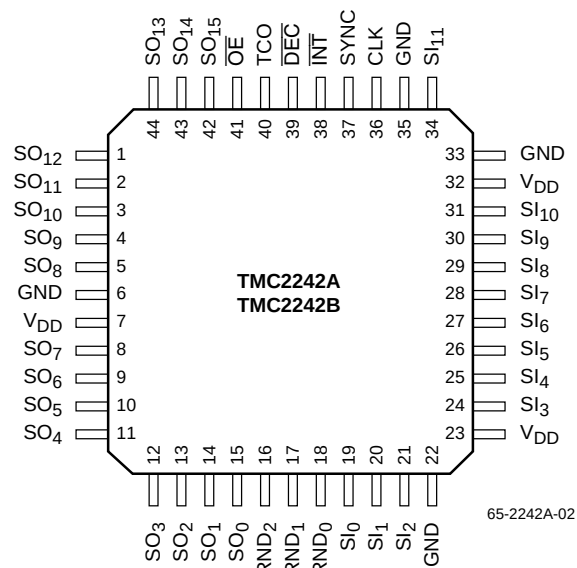
**Note:**

1. With 15-bit overflow protection. All other modes on both parts limit to 16 bits.

## Pin Assignments



**44 Lead PLCC**



**44 Lead MQFP**

## Pin Descriptions

| Pin Name        | Pin Number       |                  | Pin Function Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|-----------------|------------------|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                 | PLCC             | MQFP             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Timing Controls |                  |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| INT             | 44               | 38               | <b>Interpolate.</b> When INT is LOW and DEC is HIGH, the input data register runs at 1/2 the CLK rate and zeros are inserted in the data stream between valid input values, reducing gain by 6dB. The TMC2242A and TMC2242B interpolate and output results at the full CLK rate.                                                                                                                                                                                                                            |
| DEC             | 1                | 39               | <b>Decimate.</b> When DEC is LOW and INT is HIGH, the input data register runs at the full CLK rate. In this mode, the TMC2242A and TMC2242B decimate and output results at 1/2 the CLK rate.<br><br>When INT = DEC, the TMC2242A is in equal rate mode. When both INT and DEC are HIGH, the TMC2242B is likewise in equal-rate mode, but when both INT and DEC are LOW, the TMC2242B interpolates with unity gain.<br><br>In equal-rate mode, the input and output sample rates equal the chip clock rate. |
| SYNC            | 43               | 37               | <b>Synchronization.</b> Incoming data are synchronized by holding SYNC HIGH on CLK N–1 and LOW on CLK N when the first input data word is present on SI11-0. If DEC = INT=1 (equal rate mode), SYNC is inactive. SYNC may be held LOW until resynchronization is desired, or it may be toggled at 1/2 the CLK rate.                                                                                                                                                                                         |
| CLK             | 42               | 36               | <b>Clock.</b> The TMC2242A and TMC2242B operate from a single master clock. All internal registers, except the output register in decimation mode, are strobed on the rising edge of CLK. All timing parameters are referenced to the rising edge of CLK.                                                                                                                                                                                                                                                   |
| Data Inputs     |                  |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| SI11-0          | 40, 37-30, 27-25 | 34, 31-24, 21-19 | <b>Input Data Port.</b> A 12-bit 2's-complement input word is registered by the rising edge of CLK. In Interpolate Mode, SI11-0 is registered on every other CLK (synchronized by SYNC). SI11 is the MSB.                                                                                                                                                                                                                                                                                                   |
| Data Outputs    |                  |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| SO15-0          | 4-11, 14-21      | 42-44, 1-5, 8-15 | <b>Output Data Port.</b> A 16-bit 2's-complement output result is available after the rising edge of CLK. In Decimate Mode, SO15-0 is registered on every other CLK (synchronized by SYNC). SO15-0 is rounded according to the state of RND2-0. SO15 is the MSB.<br><br>The limiter circuitry ensures that for internal overflow, a valid full-scale output (7FFF or 8000) will be generated. With the TMC2242B in interpolate mode with -6dB gain, limits are 3FFF and C000 (TCO=1).                       |
| Output Controls |                  |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| OE              | 3                | 41               | <b>Output Enable.</b> When LOW, SO15-0 are enabled. When HIGH, SO15-0 are in a high-impedance state. OE is asynchronous with respect to CLK.                                                                                                                                                                                                                                                                                                                                                                |
| TCO             | 2                | 40               | <b>Output Format.</b> When TCO is HIGH, output data are in signed 2's-complement format. When LOW, the output is inverted offset binary.                                                                                                                                                                                                                                                                                                                                                                    |
| RND2-0          | 22-24            | 16-18            | <b>Rounding Select.</b> These inputs set the position of the effective LSB of the output result. Outputs below the rounding bit are zeroed (Table 4).                                                                                                                                                                                                                                                                                                                                                       |
| Power           |                  |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| VDD             | 13,29, 38        | 7, 23, 32        | <b>Supply Voltage.</b> +5 Volt power inputs. These should come from the same power source and be decoupled to GND.                                                                                                                                                                                                                                                                                                                                                                                          |
| GND             | 12,28, 39,41     | 6, 22, 33, 35    | <b>Ground.</b> Ground inputs should be connected to the system digital ground plane.                                                                                                                                                                                                                                                                                                                                                                                                                        |

## Absolute Maximum Ratings

(beyond which the device may be damaged)<sup>1</sup>

| Parameter                                | Conditions                            | Min  | Max                   | Units |
|------------------------------------------|---------------------------------------|------|-----------------------|-------|
| Supply Voltage                           |                                       | -0.5 | 7.0                   | V     |
| Input Voltage                            |                                       | -0.5 | V <sub>DD</sub> + 0.5 | V     |
| Output Applied Voltage <sup>2</sup>      |                                       | -0.5 | V <sub>DD</sub> + 0.5 | V     |
| Externally Forced Current <sup>3,4</sup> |                                       | -3.0 | +6.0                  | mA    |
| Short Circuit Duration                   | Single output in HIGH state to ground |      | 1                     | sec   |
| Operating Temperature (Case)             |                                       | -20  | 110                   | °C    |
| Junction Temperature                     |                                       |      | 140                   | °C    |
| Lead Soldering Temperature               | 10 seconds                            |      | 300                   | °C    |
| Storage Temperature                      |                                       | -65  | 150                   | °C    |

### Notes:

1. Functional operation under any of these conditions is NOT implied. Performance and reliability are guaranteed only if Operating Conditions are not exceeded.
2. Applied voltage must be current limited to specified range.
3. Forcing voltage must be limited to specified range.
4. Current is specified as conventional current flowing into the device.

## Operating Conditions

| Parameter        | Conditions                     | Min  | Nom | Max  | Units |
|------------------|--------------------------------|------|-----|------|-------|
| V <sub>DD</sub>  | Power Supply Voltage           | 4.75 | 5.0 | 5.25 | V     |
| f <sub>CLK</sub> | Clock frequency                |      |     | 30   | MHz   |
|                  | TMC2242A, B                    |      |     |      |       |
|                  | TMC2242A-1,B-1                 |      |     | 40   | MHz   |
|                  | TMC2242A-2,B-2                 |      |     | 60   | MHz   |
| t <sub>PWH</sub> | CLK pulse width, HIGH          | 6    |     |      | ns    |
| t <sub>PWL</sub> | CLK pulse width, LOW           | 6    |     |      | ns    |
| t <sub>S</sub>   | Input Data Set-up Time         | 6    |     |      | ns    |
| t <sub>H</sub>   | Input Data Hold Time           | 1    |     |      | ns    |
| V <sub>IH</sub>  | Input Voltage, Logic HIGH      | 2.0  |     |      | V     |
| V <sub>IL</sub>  | Input Voltage, Logic LOW       |      |     | 0.8  | V     |
| I <sub>OH</sub>  | Output Current, Logic HIGH     |      |     | -2.0 | mA    |
| I <sub>OL</sub>  | Output Current, Logic LOW      |      |     | 4.0  | mA    |
| T <sub>A</sub>   | Ambient Temperature, Still Air | 0    |     | 70   | °C    |

## Electrical Characteristics

| Parameter        |                                 | Conditions                                                                        | Min | Typ | Max | Units |
|------------------|---------------------------------|-----------------------------------------------------------------------------------|-----|-----|-----|-------|
| I <sub>DD</sub>  | Total Power Supply Current      | V <sub>DD</sub> = Max, C <sub>LOAD</sub> =25pF, f <sub>CLK</sub> =Max             |     |     |     |       |
|                  |                                 | TMC2242A,B                                                                        |     |     | 150 | mA    |
|                  |                                 | TMC2242A-1,B-1                                                                    |     |     | 195 | mA    |
|                  |                                 | TMC2242A-2,B-2                                                                    |     |     | 290 | mA    |
| I <sub>DDU</sub> | Power Supply Current, Unloaded  | V <sub>DD</sub> = Max, $\overline{OE}$ = HIGH, f <sub>CLK</sub> =Max              |     |     |     |       |
|                  |                                 | TMC2242A,B                                                                        |     |     | 120 | mA    |
|                  |                                 | TMC2242A-1,B-1                                                                    |     |     | 155 | mA    |
|                  |                                 | TMC2242A-2,B-2                                                                    |     |     | 230 | mA    |
| I <sub>DDQ</sub> | Power Supply Current, Quiescent | V <sub>DD</sub> = Max, CLK = LOW                                                  |     |     | 5   | mA    |
| C <sub>PIN</sub> | I/O Pin Capacitance             |                                                                                   |     | 5   |     | pF    |
| I <sub>IH</sub>  | Input Current, HIGH             | V <sub>DD</sub> = Max, V <sub>IN</sub> = V <sub>DD</sub>                          |     |     | ±10 | μA    |
| I <sub>IL</sub>  | Input Current, LOW              | V <sub>DD</sub> = Max, V <sub>IN</sub> = 0 V                                      |     |     | ±10 | μA    |
| I <sub>OZH</sub> | Leakage Current, HIGH           | $\overline{OE}$ = HIGH, V <sub>OUT</sub> = V <sub>DD</sub>                        |     |     | ±10 | μA    |
| I <sub>OZL</sub> | Leakage Current, LOW            | $\overline{OE}$ = HIGH, V <sub>OUT</sub> = 0 V                                    |     |     | ±10 | μA    |
| I <sub>OS</sub>  | Short-Circuit Current           | V <sub>DD</sub> = Max, Output = HIGH, one pin to ground, one second duration max. | -20 |     | -80 | mA    |
| V <sub>OH</sub>  | Output Voltage, HIGH            | SO15-0, I <sub>OH</sub> = Max                                                     | 2.4 |     |     | V     |
| V <sub>OL</sub>  | Output Voltage, LOW             | SO15-0, I <sub>OL</sub> = Max                                                     |     |     | 0.4 | V     |

## Switching Characteristics

| Parameter        |                     | Conditions                | Min | Typ | Max | Units |
|------------------|---------------------|---------------------------|-----|-----|-----|-------|
| t <sub>DO</sub>  | Output Delay Time   | C <sub>LOAD</sub> = 25 pF |     |     | 15  | ns    |
| t <sub>HO</sub>  | Output Hold Time    | C <sub>LOAD</sub> = 25 pF | 2.5 |     |     | ns    |
| t <sub>ENA</sub> | Output Enable Time  | C <sub>LOAD</sub> = 0 pF  |     |     | 12  | ns    |
| t <sub>DIS</sub> | Output Disable Time | C <sub>LOAD</sub> = 0 pF  |     |     | 12  | ns    |

Table 2. Impulse Response

| Hex  | Decimal Equivalent |             |
|------|--------------------|-------------|
| FFF2 | -0.000875473       | start & end |
| 0000 | 0.0                |             |
| 0017 | 0.001390457        |             |
| 0000 | 0.0                |             |
| FFDB | -0.002265930       |             |
| 0000 | 0.0                |             |
| 0039 | 0.003501892        |             |
| 0000 | 0.0                |             |
| FFA8 | -0.006366836       |             |
| 0000 | 0.0                |             |
| 007D | 0.007621765        |             |
| 0000 | 0.0                |             |
| FF51 | -0.01071167        |             |
| 0000 | 0.0                |             |
| 00F3 | 0.01483154         |             |
| 0000 | 0.0                |             |
| FEB5 | -0.02018738        |             |
| 0000 | 0.0                |             |
| 01CA | 0.02796364         |             |
| 0000 | 0.0                |             |
| FD79 | -0.03949928        |             |
| 0000 | 0.0                |             |
| 03CD | 0.05937767         |             |
| 0000 | 0.0                |             |
| F95E | -0.1036148         |             |
| 0000 | 0.0                |             |
| 145B | 0.3180542          |             |
| 2010 | 0.5009766          | center      |

Input = 0, 0, 0, ..., 0, 400h, 0, ..., 0, 0, 0

INT = DEC = TCO = 1

Table 3. Step Response

| Input | INT=1<br>DEC=1<br>TCO=0 | INT=1<br>DEC=1<br>TCO=1 | INT=0<br>DEC=1<br>TCO=1 | INT=1<br>DEC=0<br>TCO=1 |              |
|-------|-------------------------|-------------------------|-------------------------|-------------------------|--------------|
| 400   | xx                      | xx                      | xx                      | xx                      |              |
| 400   | xx                      | xx                      | xx                      | xx                      |              |
| ...   | ...                     | ...                     | ...                     | ...                     |              |
| 400   | 3FE7                    | 4018                    | 2008                    | 4018                    | DC Gain      |
| 400   | 3FE7                    | 4018                    | 2010                    | 4018                    |              |
| 000   | 3FE7                    | 4018                    | 2008                    | 4018                    |              |
| ...   | ...                     | ...                     | ...                     | ...                     |              |
| 000   | 3B90                    | 446F                    | 245F                    | 446F                    | Max Ringing  |
| 000   | 3B90                    | 446F                    | 2010                    | 446F                    |              |
| 000   | 4FEB                    | 3014                    | 1004                    | 1004                    |              |
| 000   | 6FFB                    | 1004                    | 0000                    | 1004                    |              |
| 000   | 8456                    | FBA9                    | FBA9                    | FBA9                    | Min Ringing  |
| ...   | ...                     | ...                     | ...                     | ...                     |              |
| 000   | 7FFF                    | 0000                    | 0000                    | 0000                    | Steady State |

Table 4a. Input Data Format

|        |          |          |     |           |           |
|--------|----------|----------|-----|-----------|-----------|
| $-2^0$ | $2^{-1}$ | $2^{-2}$ | ... | $2^{-10}$ | $2^{-11}$ |
|--------|----------|----------|-----|-----------|-----------|

**Table 4b. Output Data Formats and Bit Weighting for TCO = 1****Interpolation Mode** (TMC2242A and TMC2242B when  $\overline{\text{INT}} = 0$  and  $\overline{\text{DEC}} = 1$ )

|        |       |          |     |       |          |          |          |           |           |           |           |           |
|--------|-------|----------|-----|-------|----------|----------|----------|-----------|-----------|-----------|-----------|-----------|
| $-2^1$ | $2^0$ | $2^{-1}$ | ... | $2^6$ | $2^{-7}$ | $2^{-8}$ | $2^{-9}$ | $2^{-10}$ | $2^{-11}$ | $2^{-12}$ | $2^{-13}$ | $2^{-14}$ |
|--------|-------|----------|-----|-------|----------|----------|----------|-----------|-----------|-----------|-----------|-----------|

**Decimation, Equal Rate Modes** (and TMC2242B in unity gain interpolate mode with  $\overline{\text{INT}} = \overline{\text{DEC}} = 0$ )

|        |          |          |     |          |          |          |           |           |           |           |           |           |
|--------|----------|----------|-----|----------|----------|----------|-----------|-----------|-----------|-----------|-----------|-----------|
| $-2^0$ | $2^{-1}$ | $2^{-2}$ | ... | $2^{-7}$ | $2^{-8}$ | $2^{-9}$ | $2^{-10}$ | $2^{-11}$ | $2^{-12}$ | $2^{-13}$ | $2^{-14}$ | $2^{-15}$ |
|--------|----------|----------|-----|----------|----------|----------|-----------|-----------|-----------|-----------|-----------|-----------|

**Rounded LSBs as a function of RND2-0**

|      |      |              |      |      |      |      |      |      |      |      |  | RND2-0 |
|------|------|--------------|------|------|------|------|------|------|------|------|--|--------|
| SO15 | SO14 | SO13 ... SO8 | SO7  | SO6  | SO5  | SO4  | SO3  | SO2  | SO1  | SO0r |  | 000    |
| SO15 | SO14 | SO13 ... SO8 | SO7  | SO6  | SO5  | SO4  | SO3  | SO2  | SO1r | 0    |  | 001    |
| SO15 | SO14 | SO13 ... SO8 | SO7  | SO6  | SO5  | SO4  | SO3  | SO2r | 0    | 0    |  | 010    |
| SO15 | SO14 | SO13 ... SO8 | SO7  | SO6  | SO5  | SO4  | SO3r | 0    | 0    | 0    |  | 011    |
| SO15 | SO14 | SO13 ... SO8 | SO7  | SO6  | SO5  | SO4r | 0    | 0    | 0    | 0    |  | 100    |
| SO15 | SO14 | SO13 ... SO8 | SO7  | SO6  | SO5r | 0    | 0    | 0    | 0    | 0    |  | 101    |
| SO15 | SO14 | SO13 ... SO8 | SO7  | SO6r | 0    | 0    | 0    | 0    | 0    | 0    |  | 110    |
| SO15 | SO14 | SO13 ... SO8 | SO7r | 0    | 0    | 0    | 0    | 0    | 0    | 0    |  | 111    |

**Notes:**

1. A leading minus sign denotes the two's complement sign bit.
2. When TCO=0, the most significant bit of the output is positive instead of negative.
3. In all operating modes except  $\overline{\text{INT}} = 0$  and  $\overline{\text{DEC}} = 1$ , the gain is approximately unity. When  $\overline{\text{INT}} = 0$  and  $\overline{\text{DEC}} = 1$ , the output gain is -6 dB.
4. The "r" indicates that the trailing significant output bit has been rounded to the nearest 1/2 LSB. (Internally, the chip adds 1 to the next lower bit, to allow the user to obtain a properly rounded output)

**Table 5. TMC2242A Steady-State Output Values and Limiter Triggers (L) versus Input Data**

| Input | $\overline{\text{INT}} = 1$ or $\overline{\text{DEC}} = 0$ |          | $\overline{\text{INT}} = 0$ and $\overline{\text{DEC}} = 1$ |             | Interpretation |
|-------|------------------------------------------------------------|----------|-------------------------------------------------------------|-------------|----------------|
|       | TCO = 0                                                    | TCO = 1  | TCO = 0                                                     | TCO = 1     |                |
| 7FF   | 0000 (L)                                                   | 7FFF (L) | 3FF7 / 3FE7                                                 | 4008 / 4018 | + full-scale   |
| 400   | 3FE7                                                       | 4018     | 5FF7 / 5FEF                                                 | 2008 / 2010 | +1/2 scale     |
| 001   | 7FEF                                                       | 0010     | 7FF7                                                        | 0008        | +1 LSB         |
| 000   | 7FFF                                                       | 0000     | 7FFF                                                        | 0000        | Zero           |
| FFF   | 800F                                                       | FFF0     | 8007                                                        | FFF8        | -1 LSB         |
| C00   | C017                                                       | BFE8     | A007 / A00F                                                 | DFF8 / DFF0 | -1/2 scale     |
| 801   | FFFF (L)                                                   | 8000 (L) | C007 / C017                                                 | BFF8 / BFE8 | - full-scale   |

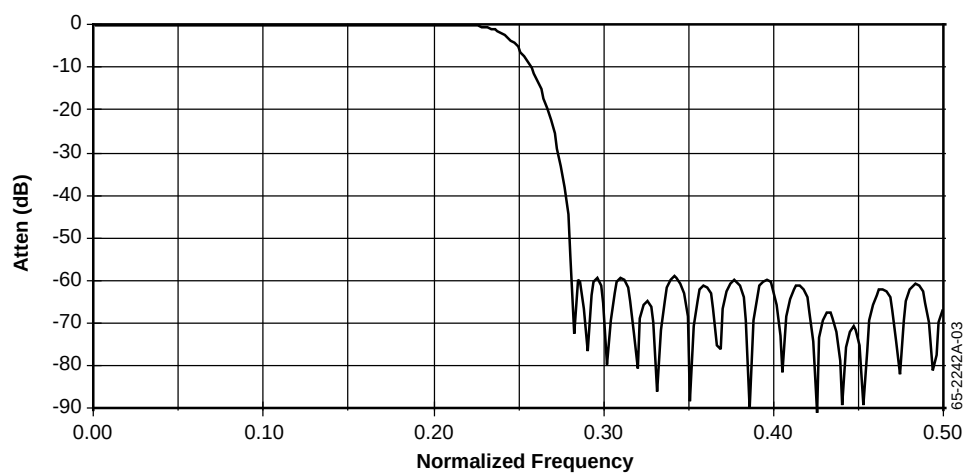
**Table 6. TMC2242B Steady-State Output Values and Limiter Triggers (L) versus Input Data Interpolation Modes**

| Input | $\overline{\text{INT}} = 0$ and $\overline{\text{DEC}} = 0$ |             | $\overline{\text{INT}} = 0$ and $\overline{\text{DEC}} = 1$ |             | Interpretation |
|-------|-------------------------------------------------------------|-------------|-------------------------------------------------------------|-------------|----------------|
|       | TCO = 0                                                     | TCO = 1     | TCO = 0                                                     | TCO = 1     |                |
| 7FF   | 0000 (L)                                                    | 7FFF (L)    | 4000 (L)                                                    | 3FFF (L)    | + full-scale   |
| 400   | 3FEF / 3FDF                                                 | 4010 / 4020 | 5FF7 / 5FEF                                                 | 2008 / 2010 | +1/2 scale     |
| 001   | 7FEF                                                        | 0010        | 7FF7                                                        | 0008        | +1 LSB         |
| 000   | 7FFF                                                        | 0000        | 7FFF                                                        | 0000        | Zero           |
| FFF   | 800F                                                        | FFF0        | 8007                                                        | FFF8        | -1 LSB         |
| C00   | C00F / C01F                                                 | BFF0 / BFE0 | A007 / A00F                                                 | DFF8 / DFF0 | -1/2 scale     |
| 801   | FFFF                                                        | 8000 (L)    | BFFF                                                        | C000 (L)    | - full-scale   |

#### Decimation and Equal-Rate Modes

| Input | $\overline{\text{INT}} = 1$ |          | Interpretation |
|-------|-----------------------------|----------|----------------|
|       | TCO = 0                     | TCO = 1  |                |
| 7FF   | 0000 (L)                    | 7FFF (L) | + full-scale   |
| 400   | 3FE7                        | 4018     | +1/2 scale     |
| 001   | 7FEF                        | 0010     | +1 LSB         |
| 000   | 7FFF                        | 0000     | Zero           |
| FFF   | 800F                        | FFF0     | -1 LSB         |
| C00   | C017                        | BFE8     | -1/2 scale     |
| 801   | FFFF (L)                    | 8000 (L) | - full-scale   |

## Performance Curves



**Figure 1. Frequency Response**



Performance Curves (continued)

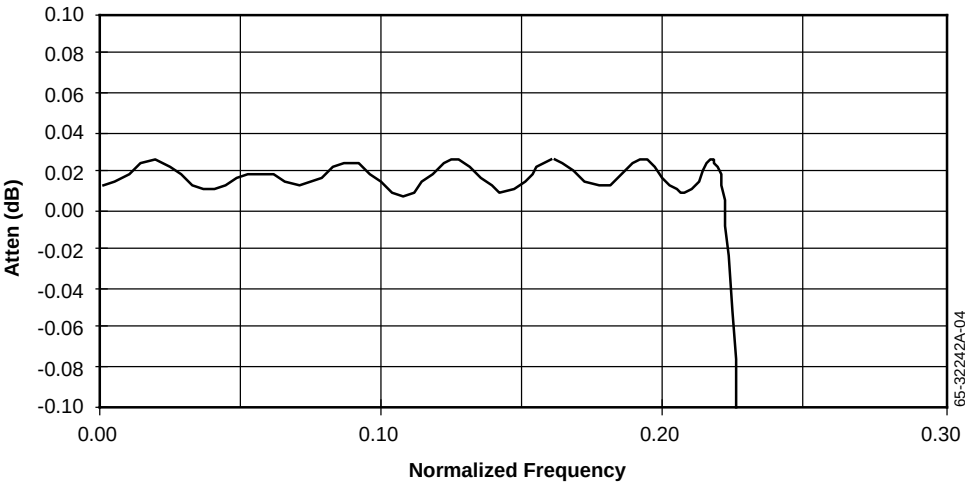


Figure 2. Passband Ripple Response

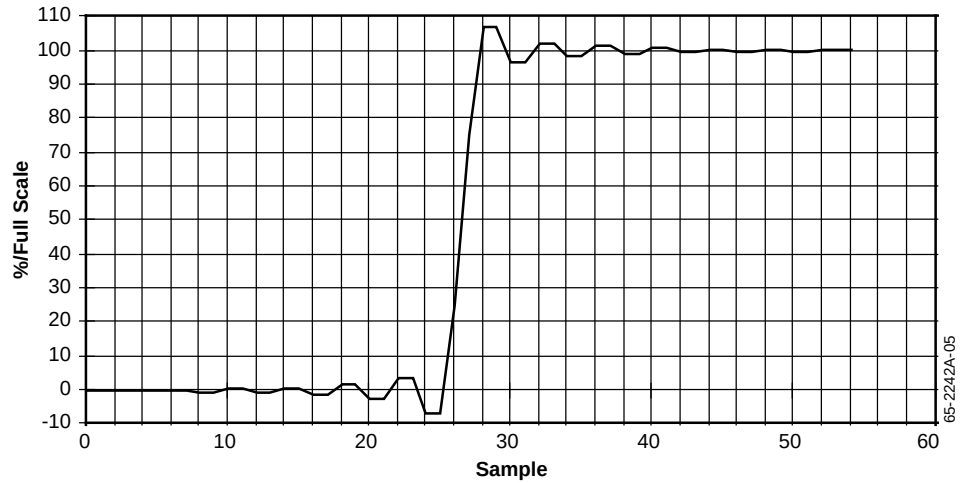


Figure 3. Step Response

Equivalent Circuits

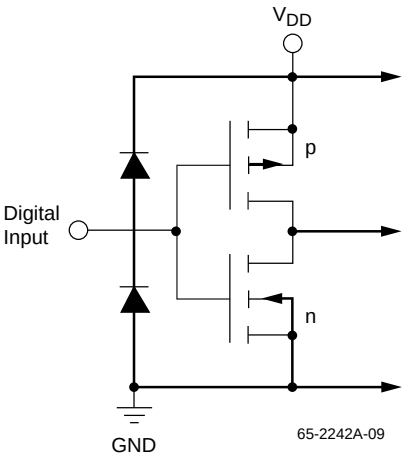


Figure 7. Equivalent Digital Input Circuit

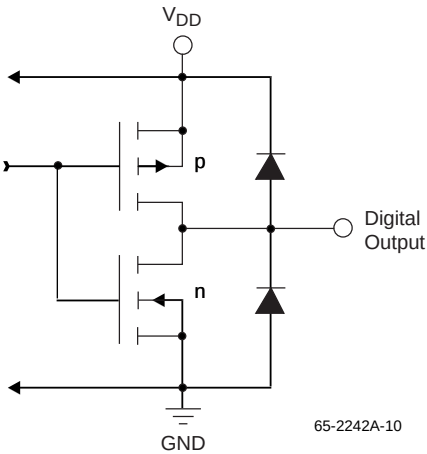
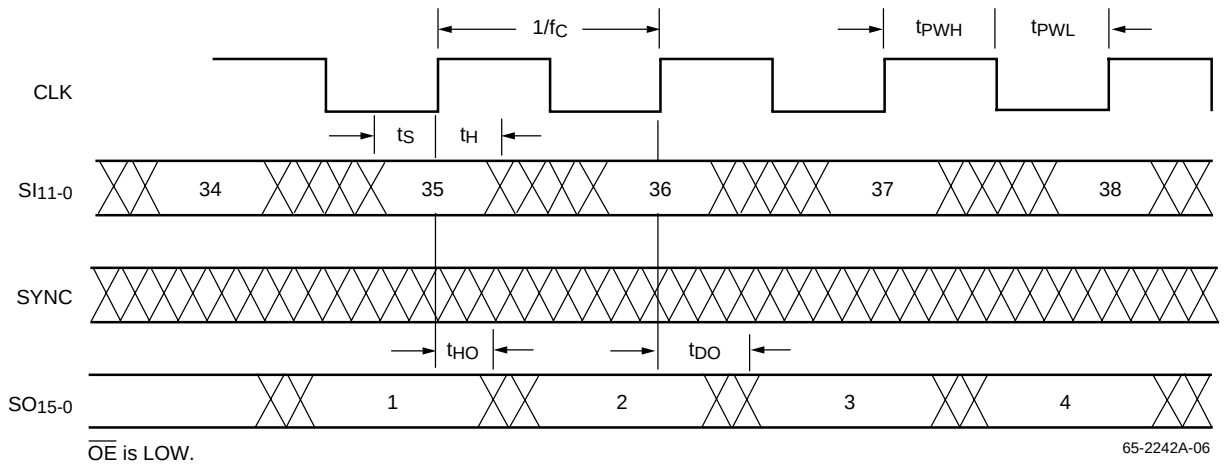


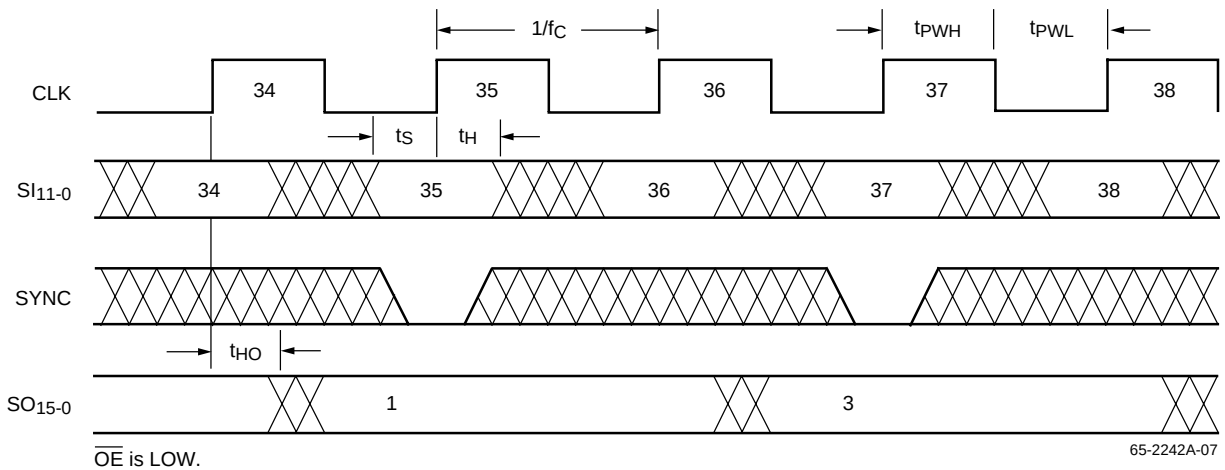
Figure 8. Equivalent Digital Output Circuit

## Timing Diagrams

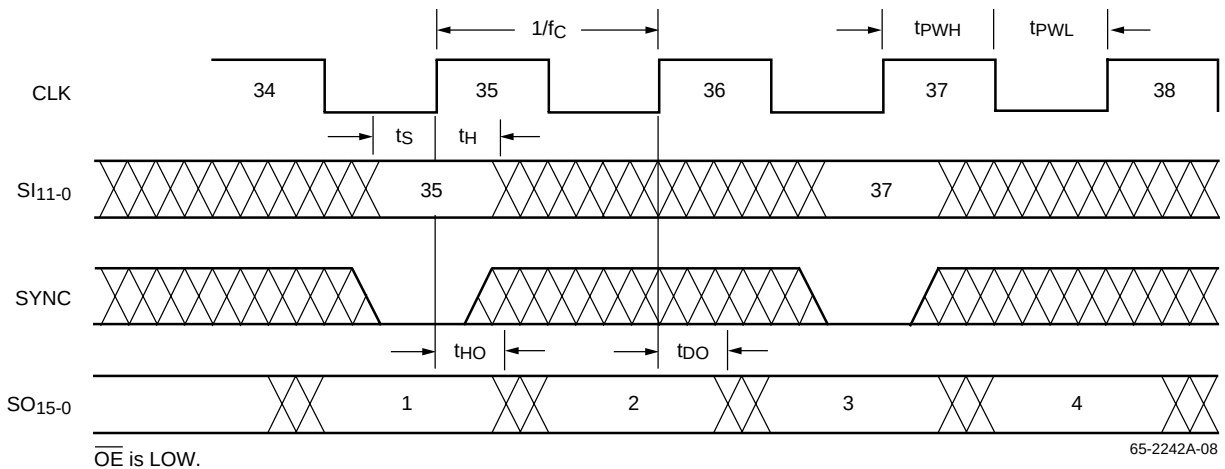


**Note:** Values at SO15-0 are impulse response centers (peaks) corresponding to same-numbered inputs.

**Figure 4. Equal Rate Mode**



**Figure 5. Decimate Mode**



**Figure 6. Interpolate Mode**

## Timing Diagrams (continued)

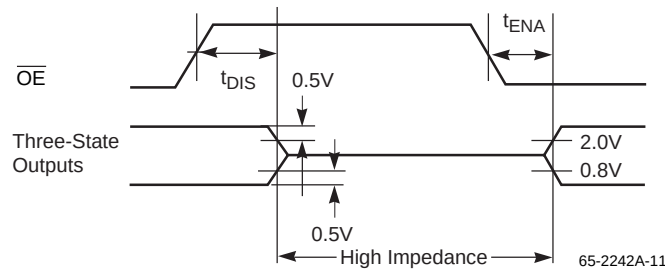


Figure 9. Threshold Levels for Three State Measurements

## Applications Discussion

The TMC2242A and TMC2242B are well-suited for filtering digitized composite NTSC or PAL video. In Figure 10, the TMC1175A 8-bit video A/D converter outputs, D7-0, are connected to the TMC2242B inputs, SI<sub>11-4</sub>, respectively (grounding SI<sub>3-0</sub>). The RND2-0 controls are set to 111 for a 9-bit rounded decimated output on SO<sub>15-7</sub>.

In Figure 11, the TMC2242B drives a fast D/A converter to reconstruct analog composite video. The TMC3003 10-bit digital-to-analog converter inputs, D9-0 are connected to the TMC2242B outputs SO<sub>15-6</sub>, respectively. The TMC2242B RND2-0 controls are set to 110 for rounded 10-bit interpolation operation.

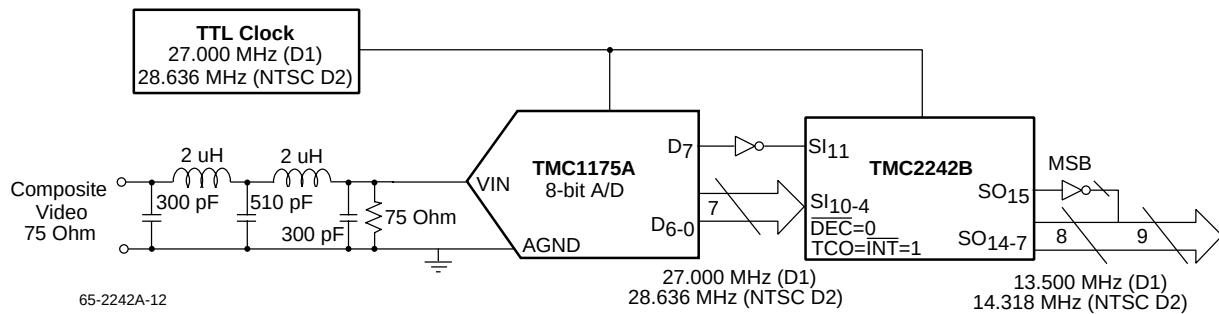
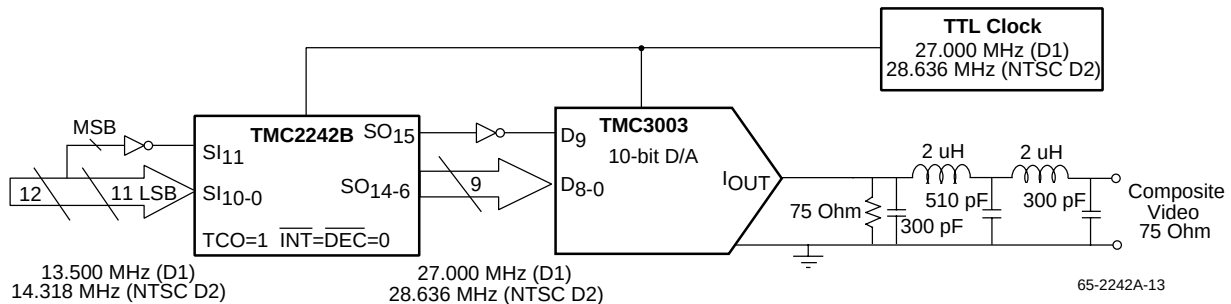


Figure 10. Decimating Oversampled Video With a Low Cost 8-bit A/D



**Note:** Data buses are unsigned binarys; TMC2242 input is two's complement.

Figure 11. Interpolating Digital Video Signals before Reconstruction

**Notes:**

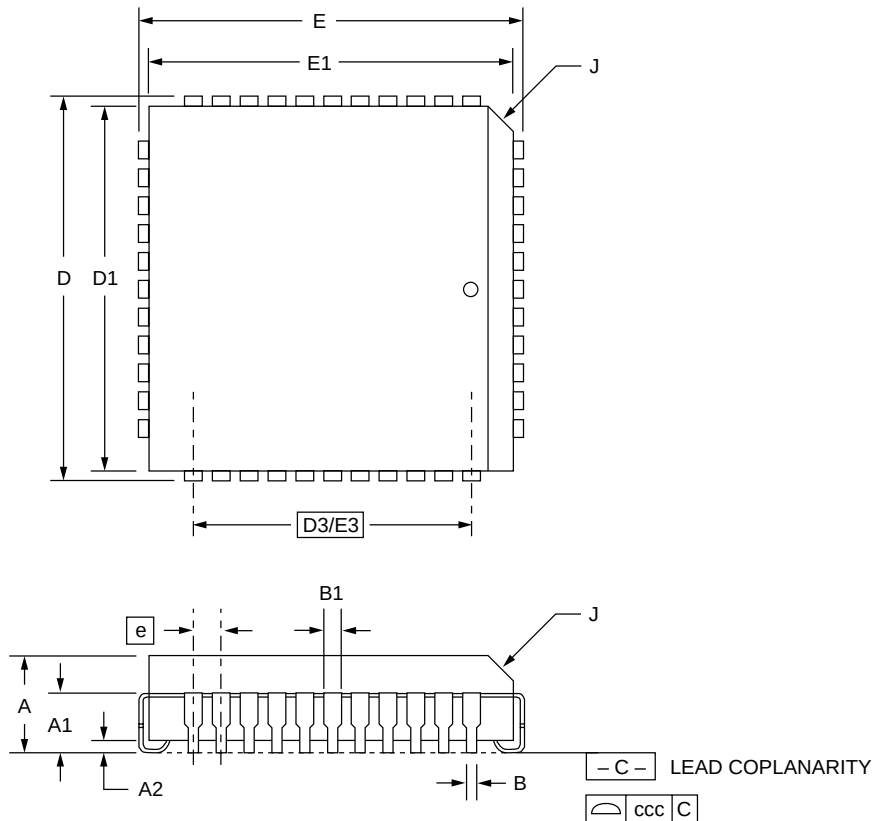
**Notes:**

## Mechanical Dimensions – 44-Pin PLCC Package

| Symbol | Inches   |      | Millimeters |       | Notes |
|--------|----------|------|-------------|-------|-------|
|        | Min.     | Max. | Min.        | Max.  |       |
| A      | .165     | .180 | 4.19        | 4.57  |       |
| A1     | .090     | .120 | 2.29        | 3.05  |       |
| A2     | .020     | —    | .51         | —     |       |
| B      | .013     | .021 | .33         | .53   |       |
| B1     | .026     | .032 | .66         | .81   |       |
| D/E    | .685     | .695 | 17.40       | 17.65 |       |
| D1/E1  | .650     | .656 | 16.51       | 16.66 | 3     |
| D3/E3  | .500 BSC |      | 12.7 BSC    |       |       |
| e      | .050 BSC |      | 1.27 BSC    |       |       |
| J      | .042     | .056 | 1.07        | 1.42  | 2     |
| ND/NE  | 11       |      | 11          |       |       |
| N      | 44       |      | 44          |       |       |
| ccc    | —        | .004 | —           | 0.10  |       |

### Notes:

1. All dimensions and tolerances conform to ANSI Y14.5M-1982
2. Corner and edge chamfer (J) = 45°
3. Dimension D1 and E1 do not include mold protrusion. Allowable protrusion is .101" (.25mm)

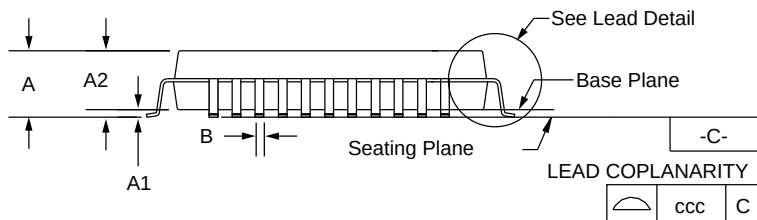
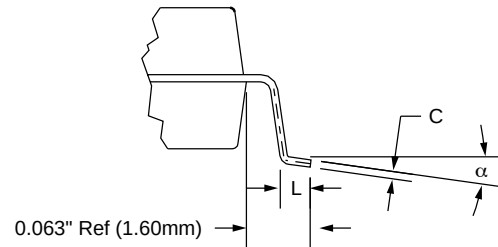
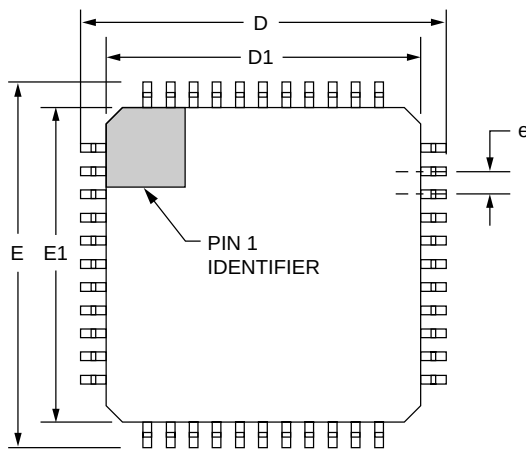


## Mechanical Dimensions – 44-Lead MQFP Package

| Symbol   | Inches   |      | Millimeters |       | Notes |
|----------|----------|------|-------------|-------|-------|
|          | Min.     | Max. | Min.        | Max.  |       |
| A        | .077     | .093 | 1.95        | 2.35  |       |
| A1       | .000     | .010 | .00         | .25   |       |
| A2       | .077     | .083 | 1.95        | 2.11  |       |
| B        | .012     | .018 | .30         | .46   | 7     |
| C        | .005     | .009 | .13         | .23   |       |
| D/E      | .510     | .530 | 12.95       | 13.45 |       |
| D1/E1    | .390     | .398 | 9.90        | 10.10 | 2     |
| e        | .032 BSC |      | .81 BSC     |       |       |
| L        | .026     | .037 | .66         | .94   | 6     |
| N        | 44       |      | 44          |       | 4     |
| ND       | 11       |      | 11          |       | 5     |
| $\alpha$ | 0°       | 7°   | 0°          | 7°    |       |
| ccc      | —        | .004 | —           | 0.10  |       |

### Notes:

1. All dimensions and tolerances conform to ANSI Y14.5M-1982.
2. Dimensions "D1" and "E1" do not include mold protrusion.
3. Pin 1 identifier is optional.
4. Dimension N: number of terminals.
5. Dimension ND: Number of terminals per package edge.
6. "L" is the length of terminal for soldering to a substrate.
7. "B" includes lead finish thickness.



## Ordering Information

| Product Number | Temperature Range | Speed Grade | Screening  | Package      | Package Marking |
|----------------|-------------------|-------------|------------|--------------|-----------------|
| TMC2242AR2C    | 0°C to 70°C       | 30 MHz      | Commercial | 44-Lead PLCC | 2242AR2C        |
| TMC2242AR2C1   | 0°C to 70°C       | 40 MHz      | Commercial | 44-Lead PLCC | 2242AR2C1       |
| TMC2242AR2C2   | 0°C to 70°C       | 60 MHz      | Commercial | 44-Lead PLCC | 2242AR2C2       |
| TMC2242BR2C    | 0°C to 70°C       | 30 MHz      | Commercial | 44-Lead PLCC | 2242BR2C        |
| TMC2242BR2C1   | 0°C to 70°C       | 40 MHz      | Commercial | 44-Lead PLCC | 2242BR2C1       |
| TMC2242BR2C2   | 0°C to 70°C       | 60 MHz      | Commercial | 44-Lead PLCC | 2242BR2C2       |
| TMC2242AKTC    | 0°C to 70°C       | 30 MHz      | Commercial | 44-Lead MQFP | 2242AKTC        |
| TMC2242AKTC1   | 0°C to 70°C       | 40 MHz      | Commercial | 44-Lead MQFP | 2242AKTC1       |
| TMC2242AKTC2   | 0°C to 70°C       | 60 MHz      | Commercial | 44-Lead MQFP | 2242AKTC2       |
| TMC2242BKTC    | 0°C to 70°C       | 30 MHz      | Commercial | 44-Lead MQFP | 2242BKTC        |
| TMC2242BKTC1   | 0°C to 70°C       | 40 MHz      | Commercial | 44-Lead MQFP | 2242BKTC1       |
| TMC2242BKTC2   | 0°C to 70°C       | 60 MHz      | Commercial | 44-Lead MQFP | 2242BKTC2       |

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