TMC3003

Triple Video D/A Converter

10 bit, 80 Msps

Features

- 10-bit resolution
- 80, 50, and 30 megapixels per second
- Sync and blank controls
- Sync on green D/A output
- 1.0V p-p video into 37.5Ω or 75Ω load
- Enhancement of ADV7122
  - Internal bandgap voltage reference
  - Double-buffered data for low distortion
- TTL-compatible inputs
- Low glitch energy
- Single +5 Volt power supply

Applications

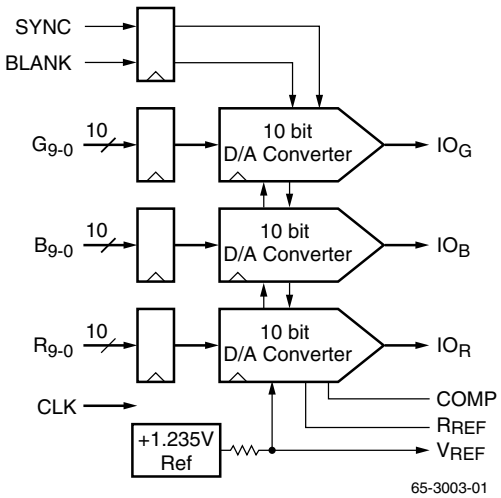
- Video signal conversion
  - RGB
  - YC_BC_R
  - Composite, Y, C
- Multimedia systems
- Image processing
- True-color graphics systems (1 billion colors)
- Broadcast television equipment
- High-Definition Television (HDTV) equipment
- Direct digital synthesis

Description

The TMC3003 is a high-speed triple 10-bit D/A converter especially suited for video and graphics applications. It offers 10-bit resolution, TTL-compatible inputs, low power consumption, and requires only a single +5 Volt power supply. It has single-ended current outputs, $\overline{SYNC}$ and $\overline{BLANK}$ control inputs, and a separate current source for adding sync pulses to the Green D/A converter output. It is ideal for generating analog RGB from digital RGB and driving computer display and video monitors. Three speed grades are available: 30, 50, and 80 Msps.

The TMC3003 triple D/A converter is available in a 44-lead plastic J-leaded PLCC and 48-Lead quad flatpack (LQFP). It is fabricated on a sub-micron CMOS process with performance guaranteed from 0°C to 70°C.

Block Diagram



Functional Description

The TMC3003 is a low-cost triple 10-bit CMOS D/A converter designed to directly drive computer CRT displays and video transmission lines at pixel rates of up to 80 Msps. It comprises three identical 10-bit D/A converters with registered data inputs, common clock, and internal voltage reference. An independent current source allows sync to be added to the green D/A converter output.

Digital Inputs

All digital inputs are TTL-compatible. Data are registered on the rising edge of the CLK signal. The analog output changes t_{DO} after the rising edge of CLK. There is one stage of pipeline delay on the chip. The guaranteed clock rates of the TMC3003 are 80, 50, and 30 MHz.

$\overline{\text{SYNC}}$ and $\overline{\text{BLANK}}$

$\overline{\text{SYNC}}$ and $\overline{\text{BLANK}}$ inputs control the output level (Figure 1 and Table 1) of the D/A converters during CRT retrace intervals. $\overline{\text{BLANK}}$ forces the D/A outputs to the blanking level while $\overline{\text{SYNC}}$ turns off a separate current source which is connected to the green D/A converter. This connection adds a 40 IRE sync pulse to the D/A output and brings that D/A output to 0.0 Volts during the sync tip. $\overline{\text{SYNC}}$ and $\overline{\text{BLANK}}$ are registered on the rising edge of CLK.

$\overline{\text{BLANK}}$ gates the D/A inputs and sets the pedestal voltage. If $\overline{\text{BLANK}}$ = HIGH, the D/A inputs are added to a pedestal which offsets the current output. If $\overline{\text{BLANK}}$ = LOW, data inputs and the pedestal are disabled.

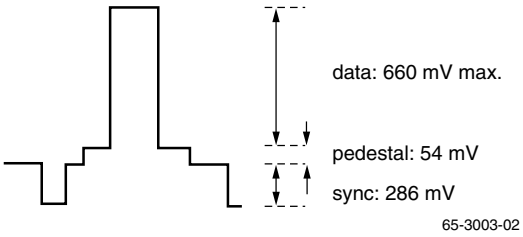


Figure 1. Nominal Output Levels

D/A Outputs

Each D/A output is a current source. To obtain a voltage output a resistor must be connected to ground. Output voltage of the D/A converters depends upon this resistor, the reference voltage, and the value of the gain-setting resistor connected between R_{REF} and GND.

Normally, a source termination resistor of 75 Ohms is connected between the D/A current output pin and GND near the D/A converter. A 75 Ohm coaxial cable may then be connected with another 75 Ohm termination resistor at the far end of the cable. This "double termination" presents the D/A converter with a net resistive load of 37.5 Ohms.

The TMC3003 may also be operated with a single 75 Ohm terminating resistor. To lower the output voltage swing to the desired range, the value of the resistor on R_{REF} should be increased.

Voltage Reference

The TMC3003 has an internal bandgap voltage reference of +1.235 Volts. An external voltage reference may be connected to the V_{REF} pin, overriding the internal voltage reference. All three D/A converters are driven from the same reference.

A 0.1μF capacitor must be connected between the COMP pin and V_{DD} to stabilize internal bias circuitry and ensure low-noise operation.

Power and Ground

The TMC3003 D/A converter requires a single +5.0 Volt power supply. The analog (V_{DD}) power supply voltage should be decoupled to GND to reduce power supply induced noise. 0.1μF decoupling capacitors should be placed as close as possible to the power pins.

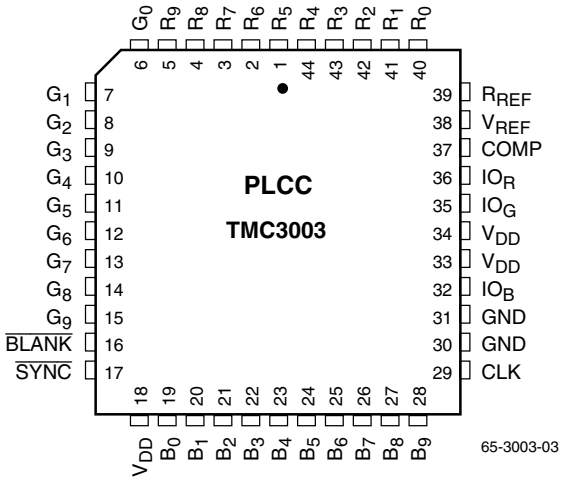
The high slew-rate of digital data makes capacitive coupling to the outputs of any D/A converter a potential problem. Since the digital signals contain high-frequency components of the CLK signal, as well as the video output signal, the resulting data feedthrough often looks like harmonic distortion or reduced signal-to-noise performance. All ground pins should be connected to a common solid ground plane for best performance.

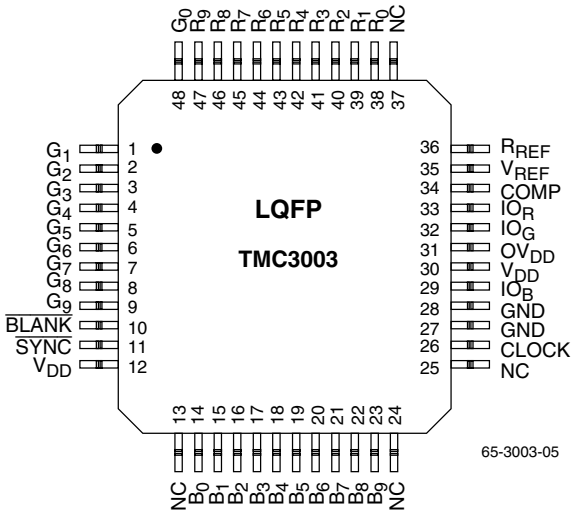
Table 1. Output Voltage versus Input Code, $\overline{SYNC}$, and $\overline{BLANK}$

V_{REF} = 1.235 V, R_{REF} = 590 Ω, R_L = 37.5 Ω

RGB_{9-0} (MSB...LSB)	Red and Blue D/As			Green D/A		
	$\overline{SYNC}$	$\overline{BLANK}$	V_{OUT}	$\overline{SYNC}$	$\overline{BLANK}$	V_{OUT}
11 1111 1111	X	1	0.7140	1	1	1.0000
11 1111 1110	X	1	0.7134	1	1	0.9994
11 1111 1101	X	1	0.7127	1	1	0.9987
•	•	•	•	•	•	•
•	•	•	•	•	•	•
10 0000 0000	X	1	0.3843	1	1	0.6703
01 1111 1111	X	1	0.3837	1	1	0.6697
•	•	•	•	•	•	•
•	•	•	•	•	•	•
00 0000 0010	X	1	0.0553	1	1	0.3413
00 0000 0001	X	1	0.0546	1	1	0.3406
00 0000 0000	X	1	0.0540	1	1	0.3400
xx xxxx xxxx	X	0	0.0000	1	0	0.2860
xx xxxx xxxx	X	0	0.0000	0	0	0.0000

Pin Assignments





Pin Descriptions

Pin Name	Pin Number PLCC	Pin Number LQFP	Value	Description
Clock and Pixel I/O				
CLK	29	26	TTL	**Clock.** The clock input is TTL-compatible and all pixel data is registered on the rising edge of CLK. It is recommended that CLK be driven by a dedicated TTL buffer to avoid reflection induced jitter, overshoot, and undershoot.
R_{9-0}	5, 4, 3, 2, 1, 44, 43, 42, 41, 40	47, 46, 45, 44, 43, 42, 41, 40, 39, 38, 37	TTL	**Red pixel data inputs.** The Red digital input is TTL-compatible and registered on the rising edge of CLK.
G_{9-0}	15, 14, 13, 12, 11, 10, 9, 8, 7, 6	48, 9, 8, 7, 6, 5, 4, 3, 2, 1	TTL	**Green pixel data inputs.** The Green digital input is TTL-compatible and registered on the rising edge of CLK.
B_{9-0}	28, 27, 26, 25, 24, 23, 22, 21, 20, 19	23, 22, 21, 20, 19, 18, 17, 16, 15, 14	TTL	**Blue pixel data inputs.** The Blue digital input is TTL-compatible and registered on the rising edge of CLK.
Controls				
$\overline{SYNC}$	17	11	TTL	**Sync pulse Input.** Bringing $\overline{SYNC}$ LOW, turns off a 40 IRE (7.62 mA) current source which forms a sync pulse on the Green D/A converter output. $\overline{SYNC}$ is registered on the rising edge of CLK along with pixel data and has the same pipeline latency as $\overline{BLANK}$ and pixel data. $\overline{SYNC}$ does not override any other data and should be used only during the blanking interval. Since this is a single-supply D/A and all signals are positive-going, sync is added to the bottom of the Green D/A range. So turning SYNC OFF means turning the current source ON. When a sync pulse is desired, the current source is turned OFF. If the system does not require sync pulses from the Green D/A converter, $\overline{SYNC}$ should be connected to GND.
$\overline{BLANK}$	16	10	TTL	**Blanking Input.** When $\overline{BLANK}$ is LOW, pixel inputs are ignored and the D/A converter outputs are driven to the blanking level. $\overline{BLANK}$ is registered on the rising edge of CLK and has the same pipeline latency as $\overline{SYNC}$.
Video Outputs				
IO_R	36	33	0.714 Vp-p	**Red D/A output.** The current source outputs of the D/A converters are capable of driving RS-343A/SMPTE-170M compatible levels into doubly-terminated 75 Ohm lines.
IO_G	35	32	1 V p-p	**Green D/A output.** The current source outputs of the D/A converters are capable of driving RS-343A/SMPTE-170M compatible levels into doubly-terminated 75 Ohm lines. Sync pulses may be added to the Green D/A output.
IO_B	32	29	0.714 Vp-p	**Blue D/A output.** The current source outputs of the D/A converters are capable of driving RS-343A/SMPTE-170M compatible levels into doubly-terminated 75 Ohm lines.

Pin Descriptions (continued)

Pin Name	Pin Number PLCC	Pin Number LQFP	Value	Description
Voltage Reference				
V_{REF}	38	35	+1.235 V	**Voltage Reference output/input.** An internal voltage source of +1.235 Volts is output on this pin. An external +1.235 Volt reference may be applied here which overrides the internal reference. Decoupling V_{REF} to GND with a 0.1µF ceramic capacitor is required.
R_{REF}	39	36	560 Ω	**Current-setting resistor.** The full-scale output current of each D/A converter is determined by the value of the resistor connected between R_{REF} and GND. The nominal value for R_{REF} is found from: $R_{REF} = 9.1(V_{REF}/I_{FS})$ where I_{FS} is the full-scale (white) output current (in amps) from the D/A converter (without sync). Sync is 0.4 * I_{FS}. D/A full-scale (white) current may also be calculated from: $I_{FS} = V_{FS}/ R_L$ Where V_{FS} is the white voltage level and R_L is the total resistive load (in ohms) on each D/A converter. V_{FS} is the blank to full-scale voltage.
COMP	37	34	0.1 µF	**Compensation capacitor.** A 0.1 µF ceramic capacitor must be connected between COMP and V_{DD} to stabilize internal bias circuitry.
Power and Ground				
V_{DD}	18, 33, 34	12, 30, 31	+5 V	Power supply
GND	30, 31	27, 28	0.0 V	Ground

Equivalent Circuits

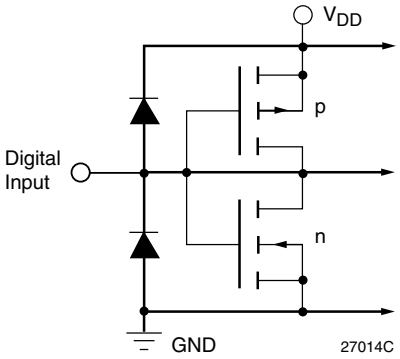


Figure 2. Equivalent Digital Input Circuit

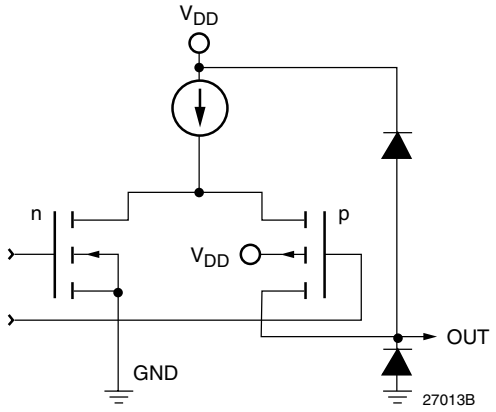


Figure 3. Equivalent Analog Output Circuit

Equivalent Circuits (continued)

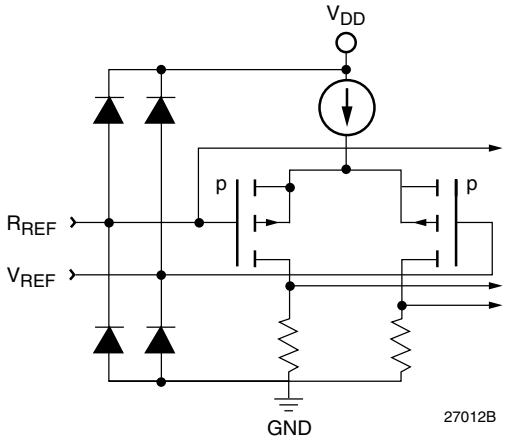


Figure 4. Equivalent Analog Input Circuit

Absolute Maximum Ratings (beyond which the device may be damaged)[1]

Parameter	Min	Typ	Max	Unit
Power Supply Voltage				
V_{DD} (Measured to GND)	-0.5		7.0	V
Inputs				
Applied Voltage (measured to GND)[2]	-0.5		V_{DD} + 0.5	V
Forced Current[3,4]	-10.0		10.0	mA
Outputs				
Applied Voltage (measured to GND)[2]	-0.5		V_{DD} + 0.5	V
Forced Current[3,4]	-60.0		60.0	mA
Short Circuit Duration (single output in HIGH state to ground)			infinite	second
Temperature				
Operating, Ambient	-20		110	°C
Junction			150	°C
Lead Soldering (10 seconds)			300	°C
Vapor Phase Soldering (1 minute)			220	°C
Storage	-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			Min	Nom	Max	Units
V_{DD}	Power Supply Voltage		4.75	5.0	5.25	V
f_S	Conversion Rate	TMC3003-30			30	Msps
		TMC3003-50			50	Msps
		TMC3003-80			80	Msps
t_{PWH}	CLK Pulsewidth, HIGH		4			ns
t_{PWL}	CLK Pulsewidth, LOW		4			ns
t_s	Input Data Setup Time		3			ns
t_h	Input Date Hold Time		2			ns
V_{REF}	Reference Voltage, External		1.0	1.235	1.5	V
C_C	Compensation Capacitor			0.1		µF
R_L	Output Load			37.5		Ω
V_{IH}	Input Voltage, Logic HIGH		2.0		V_{DD}	V
V_{IL}	Input Voltage, Logic LOW		GND		0.8	V
T_A	Ambient Temperature, Still Air		0		70	°C

Electrical Characteristics

Parameter		Conditions[3]	Min	Typ[1]	Max	Units
I_{DD}	Power Supply Current[2]	V_{DD} = Max				
		TMC3003-30			100	mA
		TMC3003-50			100	
		TMC3003-80			125	
PD	Total Power Dissipation[2]	V_{DD} = Max				
		TMC3003-30			525	mW
		TMC3003-50			525	
		TMC3003-80			655	
R_O	Output Resistance			100		kΩ
C_O	Output Capacitance	I_{OUT} = 0mA			30	pF
I_{IH}	Input Current, HIGH	V_{DD} = Max, V_{IN} = 2.4V			-1	µA
I_{IL}	Input Current, LOW	V_{DD} = Max, V_{IN} = 0.4V			1	µA
I_{REF}	V_{REF} Input Bias Current			0	±100	µA
V_{REF}	Reference Voltage Output			1.235		V
V_{OC}	Output Compliance	Referred to V_{DD}	-0.4	0	+1.5	V
C_{DI}	Digital Input Capacitance			4	10	pF

Notes:

1. Values shown in Typ column are typical for V_{DD} = +5V and T_A = 25°C.
2. Minimum/Maximum values with V_{DD} = Max and T_A = Min.
3. V_{REF} = 1.235V, R_{LOAD} = 37.5Ω, R_{REF} = 540Ω

Switching Characteristics

Parameter		Conditions[2]	Min	Typ[1]	Max	Units
t_D	Clock to Output Delay	V_{DD} = Min		10	15	ns
t_{SKEW}	Output Skew			1	2	ns
t_R	Output Risetime	10% to 90% of Full Scale		2	3	ns
t_F	Output Falltime	90% to 10% of Full Scale		2	3	ns
t_{SET}	Output Settling Time	to 3%/FS		15		ns

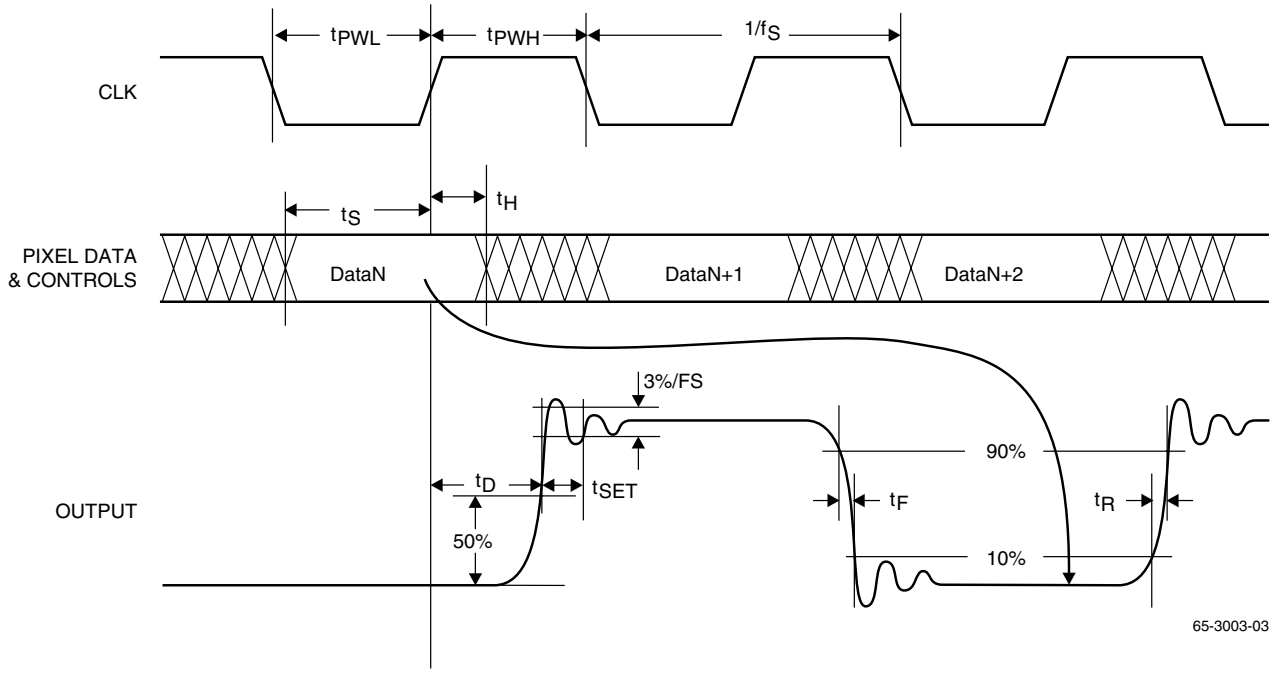
Notes:
1. Values shown in Typ column are typical for V_{DD} = +5V and T_A = 25°C.
2. V_{REF} = 1.235V, R_{LOAD} = 37.5Ω, R_{REF} = 590Ω.

System Performance Characteristics

Parameter		Conditions[2]	Min	Typ[1]	Max	Units
E_{LI}	Integral Linearity Error	V_{DD}, V_{REF} = Nom		±0.1	±0.25	%/FS
E_{LD}	Differential Linearity Error	V_{DD}, V_{REF} = Nom		±0.1	±0.25	%/FS
E_{DM}	DAC to DAC Matching	V_{DD}, V_{REF} = Nom		3	10	%
E_G	Absolute Gain Error	V_{DD}, V_{REF} = Nom			—	%/FS
TC_E	Gain Error Tempco	V_{DD}, V_{REF} = Nom		—		PPM/°C
V_{OF}	Output Offset Current	V_{DD} = Max, R, G, B = 000h			20	mA
PSR	Power Supply Rejection				0.05	%/%

Notes:
1. Values shown in Typ column are typical for V_{DD} = +5V and T_A = 25°C.
2. V_{REF} = 1.235V, R_{LOAD} = 37.5Ω, R_{REF} = 590Ω.

Timing Diagram



Applications Discussion

Figure 4 illustrates a typical TMC3003 interface circuit. In this example, an optional 1.2 Volt bandgap reference is connected to the V_{REF} output, overriding the internal voltage reference source.

Grounding

It is important that the TMC3003 power supply is well-regulated and free of high-frequency noise. Careful power supply decoupling will ensure the highest quality video signals at the output of the circuit. The TMC3003 has separate analog and digital circuits. To keep digital system noise from the D/A converter, it is recommended that power supply voltages (V_{DD}) come from the system analog power source and all ground connections (GND) be made to the analog ground plane. Power supply pins should be individually decoupled at the pin.

Printed Circuit Board Layout

Designing with high-performance mixed-signal circuits demands printed circuits with ground planes. Overall system performance is strongly influenced by the board layout. Capacitive coupling from digital to analog circuits may result in poor D/A conversion. Consider the following suggestions when doing the layout:

1. Keep the critical analog traces (V_{REF}, I_{REF}, COMP, IO_R, IO_G, IO_B) as short as possible and as far as possible from all digital signals. The TMC3003 should be located near the board edge, close to the analog output connectors.

2. The power plane for the TMC3003 should be separate from that which supplies the digital circuitry. A single power plane should be used for all of the V_{DD} pins. If the power supply for the TMC3003 is the same as that of the system's digital circuitry, power to the TMC3003 should be decoupled with 0.1μF and 0.01μF capacitors and isolated with a ferrite bead.

3. The ground plane should be solid, not cross-hatched. Connections to the ground plane should have very short leads.

4. If the digital power supply has a dedicated power plane layer, it should not be placed under the TMC3003, the voltage reference, or the analog outputs. Capacitive coupling of digital power supply noise from this layer to the TMC3003 and its related analog circuitry can have an adverse effect on performance.

5. CLK should be handled carefully. Jitter and noise on this clock will degrade performance. Terminate the clock line carefully to eliminate overshoot and ringing.

Related Products

- TMC3503 Triple 8-bit 80 Msps D/A Converters
- TMC1175A 40 Msps CMOS 8-bit A/D Converter
- TMC1275 40 Msps CMOS 8-bit A/D Converter
- TMC22091, TMC22191 Digital Video Encoders
- TMC2242A/TMC2243/TMC2246A Video Filters
- TMC2249A Digital Mixer
- TMC2250A Matrix Multiplier
- TMC2272A Colorspace Converter
- TMC2302 Image Manipulation Sequencer
- TMC2340A Digital Synthesizer
- TMC2081 Digital Video Mixer

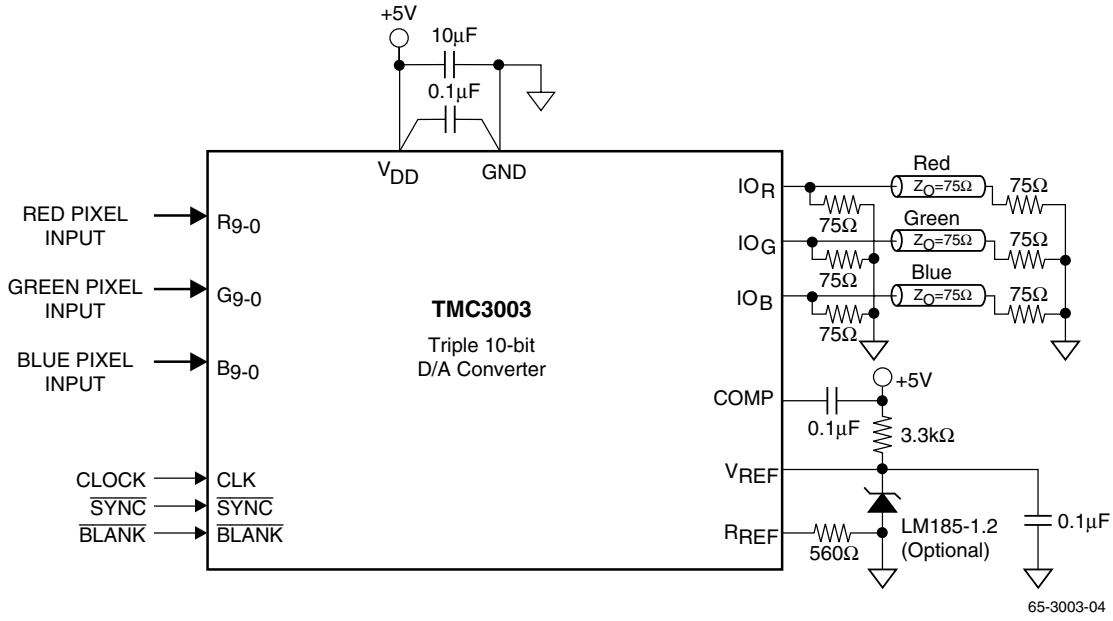


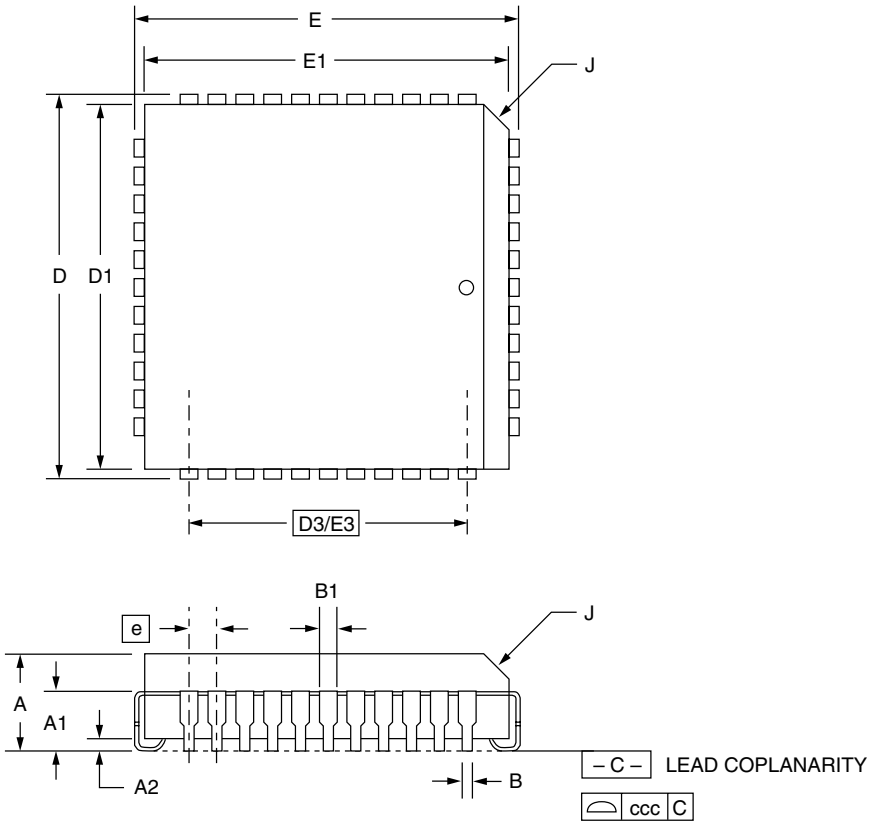
Figure 4. Typical Interface Circuit

Mechanical Dimensions – 44-Lead 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)

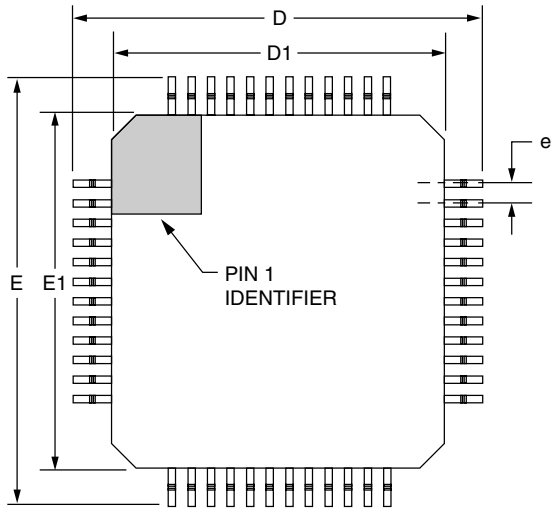


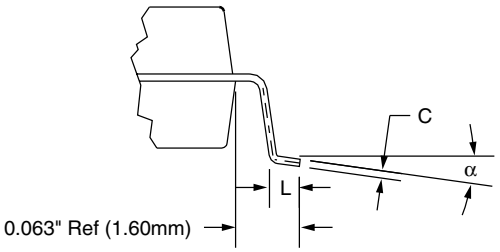
Mechanical Dimensions – 48-Lead LQFP Package

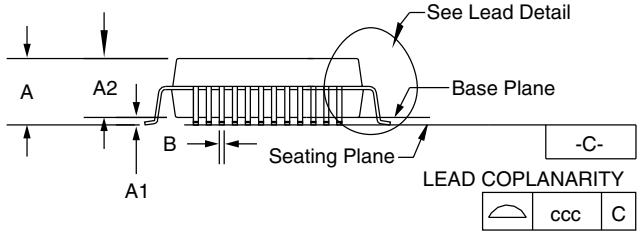
Symbol	Inches		Millimeters		Notes
	Min.	Max.	Min.	Max.	
A	.055	.063	1.40	1.60	
A1	.001	.005	.05	.15	
A2	.053	.057	1.35	1.45	
B	.006	.010	.17	.27	7
D/E	.346	.362	8.8	9.2	8
D1/E1	.268	.284	6.8	7.2	2
e	.019 BSC		.50 BSC		
L	.017	.029	.45	.75	6
N	48		48		4
ND	12		12		5
α	0°	7°	0°	7°	
ccc	.004		0.08		

Notes:

1. All dimensions and tolerances conform to ANSI Y14.5M-1982.
2. Dimensions "D1" and "E1" do not include mold protrusion. Allowable protrusion is 0.25mm per side. D1 and E1 are maximum plastic body size dimensions including mold mismatch.
3. Pin 1 identifier is optional.
4. Dimension ND: 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. Dimension "B" does not include dambar protrusion. Allowable dambar protrusion shall not cause the lead width to exceed the maximum B dimension by more than 0.08mm. Dambar can not be located on the lower radius or the foot. Minimum space between protrusion and an adjacent lead is 0.07mm for 0.4mm and 0.5mm pitch packages.
8. To be determined at seating place —C—







Ordering Information

Product Number	Conversion Rate (Msps)	Temperature Range	Screening	Package	Package Marking
TMC3003R2C30	30 Msps	T_A = 0°C to 70°C	Commercial	44-Lead PLCC	3003R2C30
TMC3003R2C50	50 Msps	T_A = 0°C to 70°C	Commercial	44-Lead PLCC	3003R2C50
TMC3003R2C80	80 Msps	T_A = 0°C to 70°C	Commercial	44-Lead PLCC	3003R2C80
TMC3003KRC30	30 Msps	T_A = 0°C to 70°C	Commercial	48-Lead LQFP	3003KRC30
TMC3003KRC50	50 Msps	T_A = 0°C to 70°C	Commercial	48-Lead LQFP	3003KRC50
TMC3003KRC80	80 Msps	T_A = 0°C to 70°C	Commercial	48-Lead LQFP	3003KRC80

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