

10-Bit high-speed multiplying D/A converter

MC3410, MC3410C

DESCRIPTION

The MC3410 series are 10-bit Multiplying Digital-to-Analog Converters. They are capable of high-speed performance, and are used as general-purpose building blocks in cost-effective D/A systems.

The Philips Semiconductors design provides complete 10-bit accuracy without laser trimming, and guaranteed monotonicity over temperature. Segmented current sources, in conjunction with an R-2R DAC provides the binary weighted currents. The output buffer amplifier and voltage reference have been omitted to allow greater speed, lower cost, and maximum user flexibility.

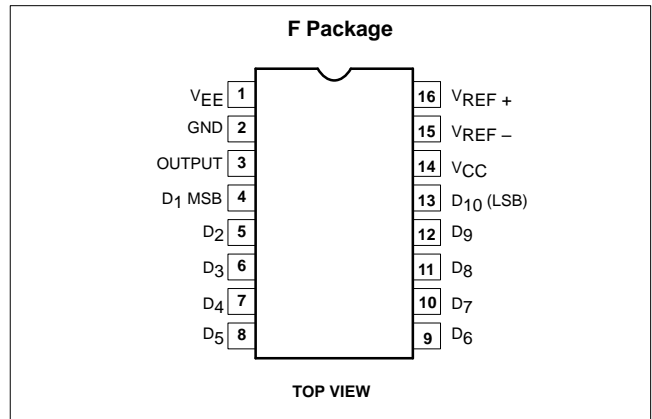
FEATURES

- 10-bit resolution and accuracy ($\pm 0.05\%$)
- Guaranteed monotonicity over temperature
- Fast settling time—250ns typical
- Digital inputs are TTL and CMOS compatible
- Wide output voltage compliance range
- High-speed multiplying input slew rate—20mA/ μ s
- Reference amplifier internally-compensated
- Standard supply voltages +5V and -15V

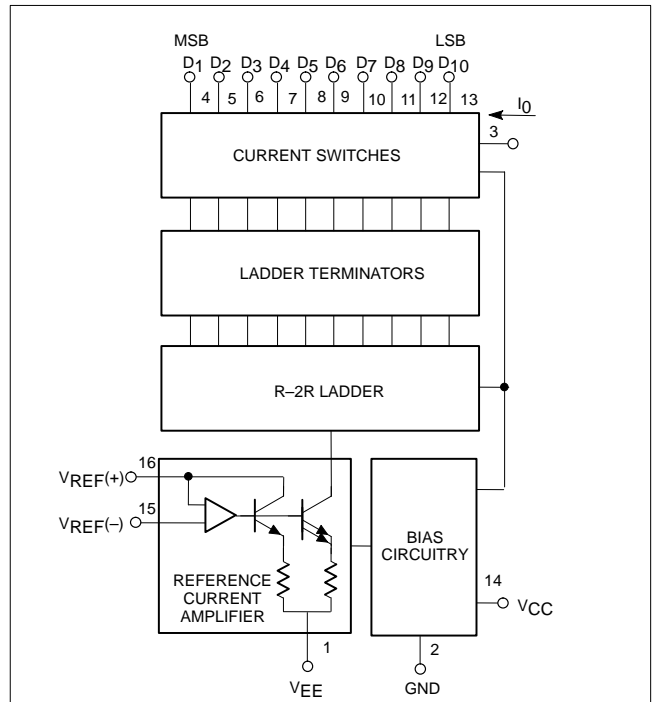
APPLICATIONS

- Successive approximation A/D converters
- High-speed, automatic test equipment
- High-speed modems
- Waveform generators
- CRT displays
- Strip CHART and X-Y plotters
- Programmable power supplies
- Programmable gain and attenuation

PIN CONFIGURATION



BLOCK DIAGRAM



ORDERING INFORMATION

DESCRIPTION	TEMPERATURE RANGE	ORDER CODE	DWG #
16-Pin Ceramic Dual In-Line Package (CERDIP)	0 to +70°C	MC3410F	0582B
16-Pin Ceramic Dual In-Line Package (CERDIP)	0 to +70°C	MC3410CF	0582B

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MC3410,
MC3410C**ABSOLUTE MAXIMUM RATINGS** $T_A = +25^\circ\text{C}$ unless otherwise noted

SYMBOL	PARAMETER	RATING	UNIT
V_{CC}	Power supply	+7.0	V_{DC}
V_{EE}		-18	V_{DC}
V_I	Digital input voltage	+15	V_{DC}
V_O	Applied output voltage	0.5, -5.0	V_{DC}
$I_{REF(16)}$	Reference current	2.5	mA
V_{REF}	Reference amplifier inputs	V_{CC}, V_{EE}	V_{DC}
$V_{REF(D)}$	Reference amplifier differential inputs	0.7	V_{DC}
T_A	Operating ambient temperature range MC3410, 3410C	0 to +70	$^\circ\text{C}$
T_J	Junction temperature, ceramic package	+150	$^\circ\text{C}$
P_D	Maximum power dissipation, $T_A = 25^\circ\text{C}$ (still-air) ¹ F package	1190	mW

NOTES:

- Derate above 25°C , at the following rates:
F package at $9.5\text{mW}/^\circ\text{C}$

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ELECTRICAL CHARACTERISTICS

$V_{CC}=+5.0VDC$, $V_{EE}=-15DC$, $\frac{V_{REF}}{R_{16}}=2.0mA$, all digital inputs at high logic level. MC3410 Series: $T_A=0^{\circ}C$ to $+70^{\circ}C$, unless otherwise noted.

SYMBOL	PARAMETER	TEST CONDI- TIONS	MC3410			MC3410C			UNIT
			Min	Typ	Max	Min	Typ	Max	
E_r	Relative accuracy (error relative to full-scale I_O)	$T_A=25^{\circ}C$			± 0.05			± 0.1	%
					1/4			1/2	LSB
TCE_r	Relative accuracy drift (relative to full-scale I_O)			2.5			2.5		ppm/ $^{\circ}C$
	Monotonicity	Over temperature	10			10			Bits
t_s	Settling time to within \pm LSB (all bits LOW-to-HIGH)	$T_A=25^{\circ}C$		250			250		ns
t_{PLH} t_{PHL}	Propagation delay time	$T_A=25^{\circ}C$		35 20			35 20		ns
TCl_O	Output full scale current drift				60			70	ppm/ $^{\circ}C$
V_{IH}	Digital input logic levels (all bits) HIGH-level, Logic "1" LOW-level, Logic "0"		2.0		0.8	2.0		0.8	V_{DC}
I_{IH} I_{IL}	Digital input current (all bits) HIGH-level, $V_{IH}=5.5V$ LOW-level, $V_{IL}=0.8V$			-0.05	+0.04 -0.4		-0.05	+0.04 -0.4	mA
$I_{REF(15)}$	Reference input bias current (Pin 15)			-1.0	-5.0		-1.0	-5.0	μA
I_{OR}	Output current range			4.0	5.0		4.0	5.0	mA
I_{OH}	Output current (all bits high)	$V_{REF}=2.000V$, $R_{16}=1000\Omega$	3.8	3.996	4.2	3.8	3.996	4.2	mA
I_{OL}	Output current (all bits low)	$T_A=25^{\circ}C$		0	2.0		0	4.0	μA
V_O	Output voltage compliance	$T_A=25^{\circ}C$			-2.5 +0.2			-2.5 +0.2	V_{DC}
$SR I_{REF}$	Reference amplifier slew rate			20			20		mA/ μs
$ST I_{REF}$	Reference amplifier settling time	0 to 4.0mA, $\pm 0.1\%$		2.0			2.0		μs
$PSRR(-)$	Output current power supply sensitivity			0.003	0.01		0.003	0.02	%/%
C_O	Output capacitance	$V_O=0$		25			25		pF
C_I	Digital input capacitance (all bits high)			4.0			4.0		pF
I_{CC} I_{EE}	Power supply current (all bits low)			-11.4	+18 -20		-11.4	+18 -20	mA
V_{CC} V_{EE}	Power supply voltage range	$T_A=25^{\circ}C$	+4.75 -14.25	+5.0 -15	+5.25 -15.75	+4.75 -14.25	+5.0 -15	+5.25 -15.75	V_{DC}
	Power consumption (all bits low) (all bits high)			220 200	380		220 200	380	mW

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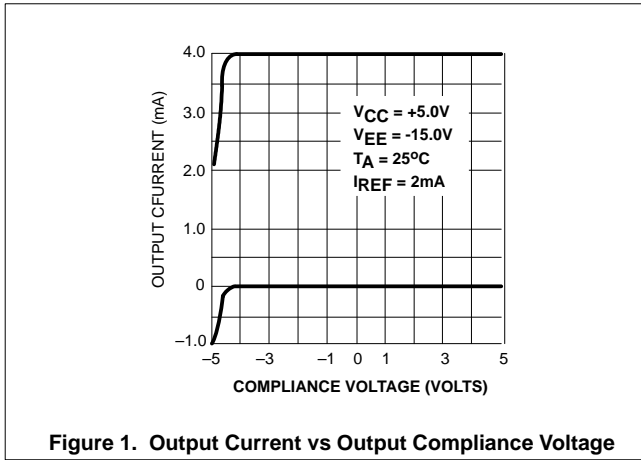


Figure 1. Output Current vs Output Compliance Voltage

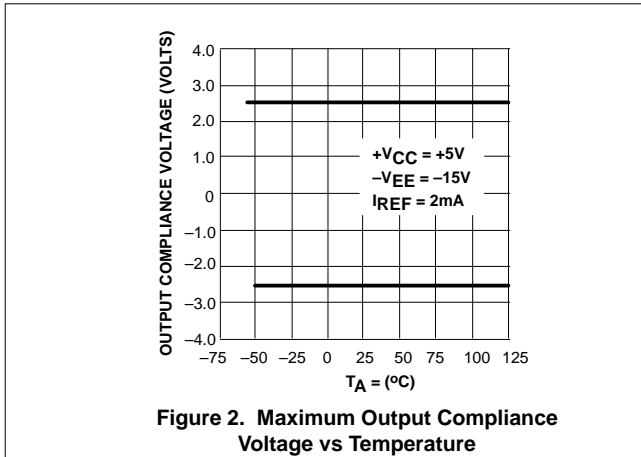


Figure 2. Maximum Output Compliance Voltage vs Temperature

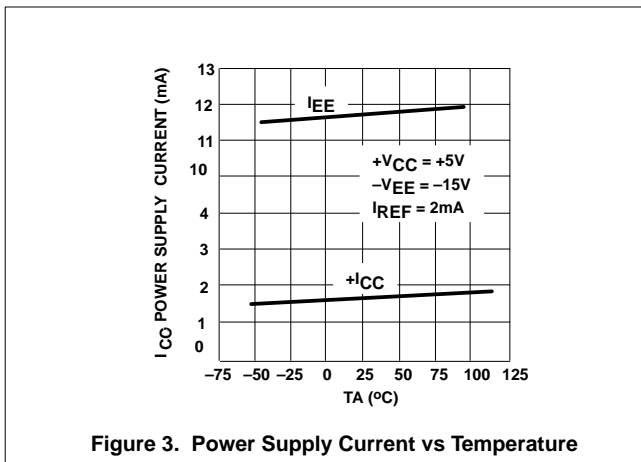


Figure 3. Power Supply Current vs Temperature

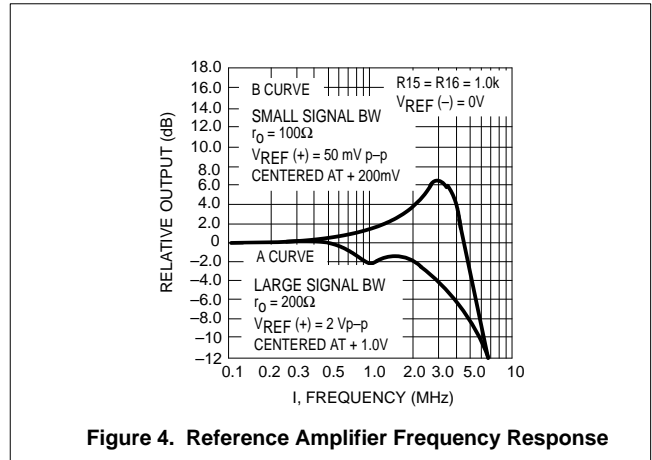


Figure 4. Reference Amplifier Frequency Response

CIRCUIT DESCRIPTION

The MC3410 consists of four segment current sources which generate the two most significant bits (MSBs), and an R-2R DAC implemented with ion-implanted resistors for scaling the remaining eight least significant bits (LSBs) (See Figure 5). This approach provides complete 10-bit accuracy without trimming.

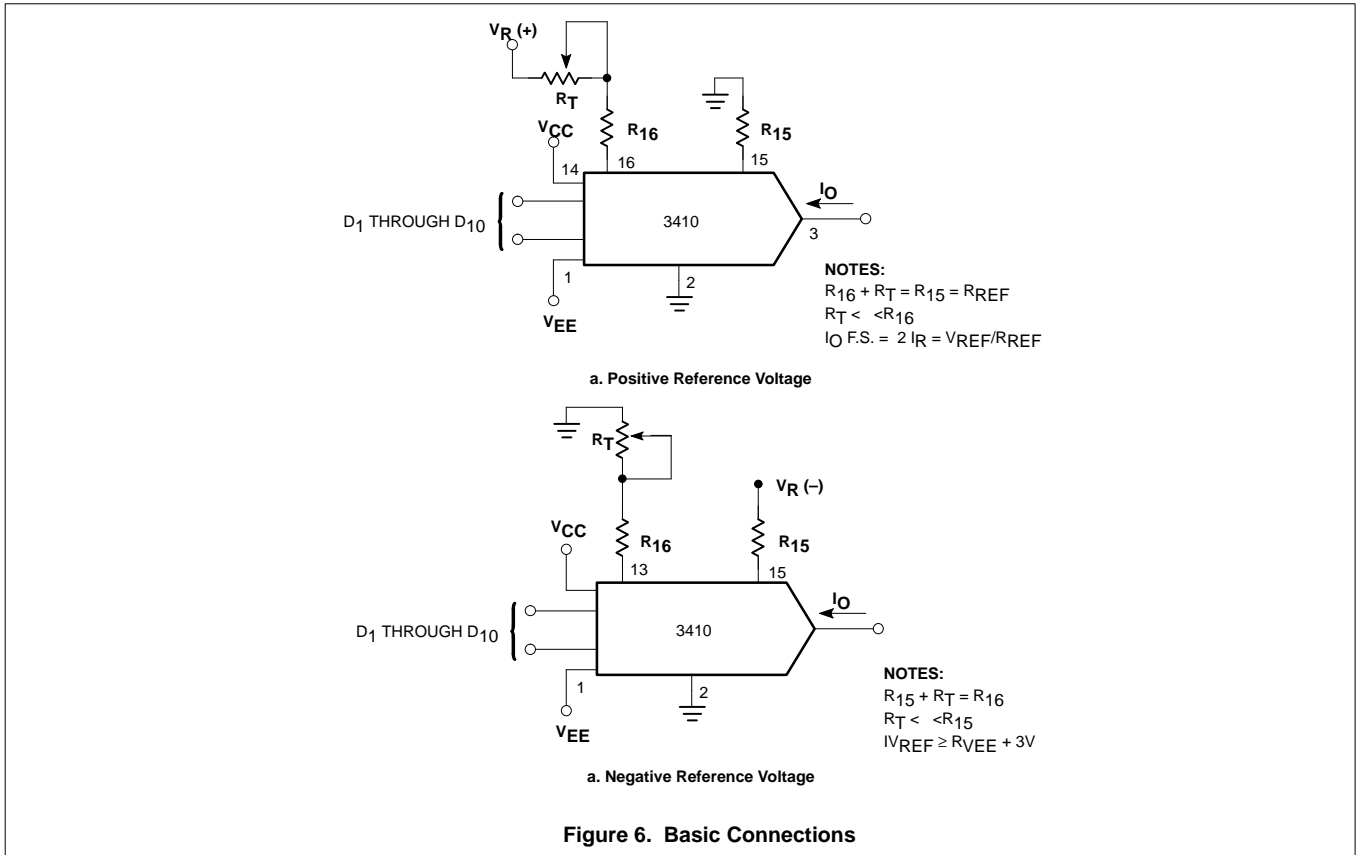
The individual bit currents are switched ON or OFF by fully differential current switches. The switches use current steering for speed.

An on-chip high-slew reference current amplifier drives the R-2R ladder and segment decoder. The currents are scaled in such a way that, with all bits on, the maximum output current is two times 1023/1024 of the reference amplifier current, or nominally 3.996mA for a 2.000mA reference input current. The reference amplifier allows the user to provide a voltage input. Out-board resistor R₁₆ (see Figure 6) converts this voltage to a usable current. A current mirror doubles this reference current and feeds it to the segment decoder and resistor ladder. Thus, for a reference voltage of 2.0V and a 1kΩ resistor tied to Pin 16, the full-scale current is approximately 4.0mA. This relationship will remain regardless of the reference voltage polarity.

Connections for a positive reference voltage are shown in Figure 6a. For negative reference voltage inputs, or for bipolar reference voltage inputs in the multiplying mode, R₁₅ can be tied to a negative voltage corresponding to the minimum input level. For a negative reference input, R₁₆ should be grounded (Figure 6b). In addition, the negative voltage reference must be at least 3V above the V_{EE} supply voltage for best operation. Bipolar input signals may be handled by connecting R₁₆ to a positive voltage equal to the peak positive input level at Pin 15.

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MONOTONICITY

The MC3410 and MC3410C are guaranteed monotonic over temperature. This means that for every increase in the input digital code, the output current either remains the same or increases but never decreases. In the multiplying mode, where reference input current will vary, monotonicity can be assured if the reference current remains above 0.5mA.

SETTLING TIME

The worst-case switching condition occurs when all bits are switched "on," which corresponds to a low-to-high transition for all bits. This time is typically 250ns for the output to settle to within $\pm 1/2\text{LSB}$ for 10-bit accuracy, and 200ns for 8-bit accuracy. The turn-off time is typically 120ns. These times apply when the output swing is limited to a small ($<0.7V$) swing and the external output capacitance is under 25pF.

The major carry (MSB off-to-on, all others on-to-off) settles in approximately the same time as when all bits are switched off-to-on.

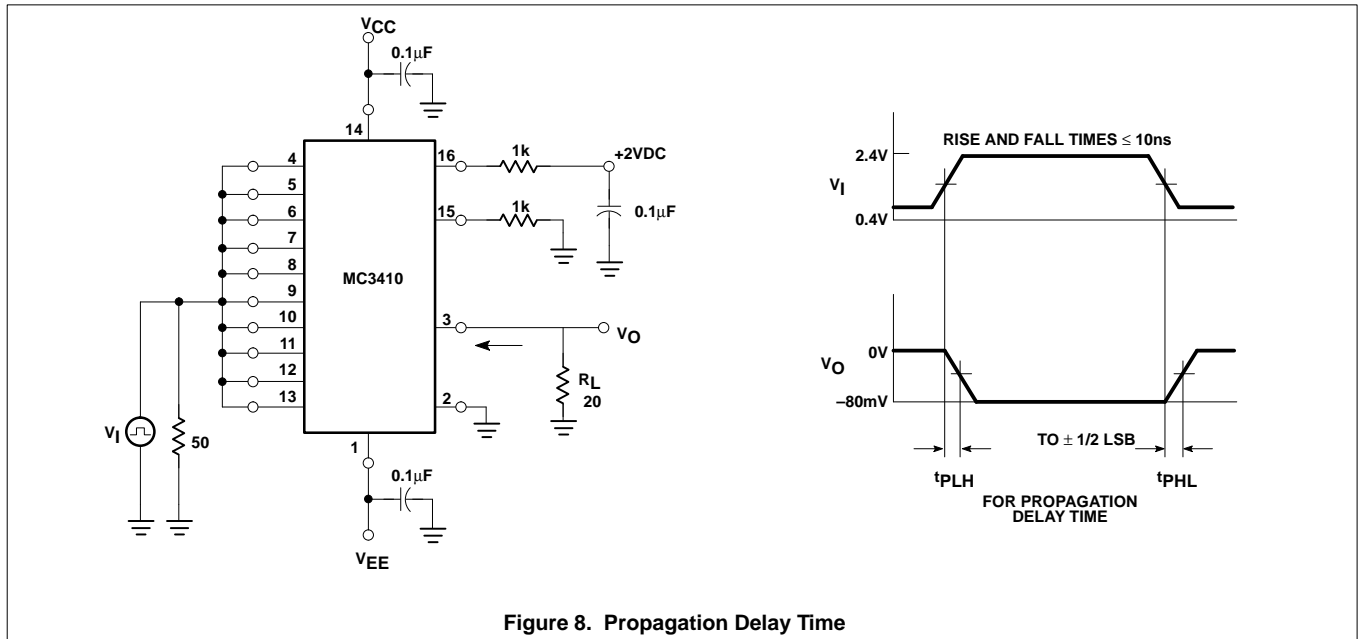
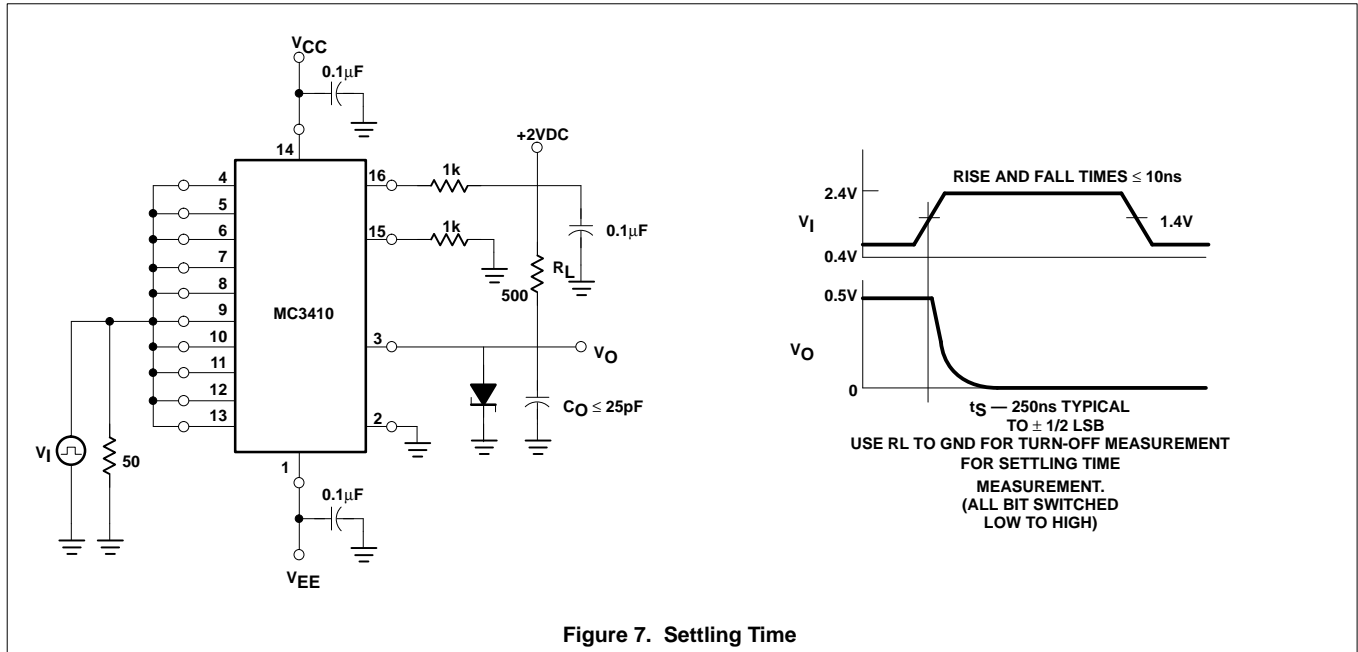
If a load resistor of 625 Ω is connected to ground, allowing the output to swing to -2.5V, the settling time increases to 1.5 μ s.

Extra care must be taken in board layout as this is usually the dominant factor in satisfactory test results when measuring settling time. Short leads, 100 μ F supply bypassing, and minimum scope lead length are all necessary.

A typical test setup for measuring settling time is shown in Figure 7. The same setup for the most part can be used to measure the slew rate of the reference amplifier (Figure 9) by tying all data bits high, pulsing the voltage reference input between 0 and 2V, and using a 500 Ω load resistor R_L .

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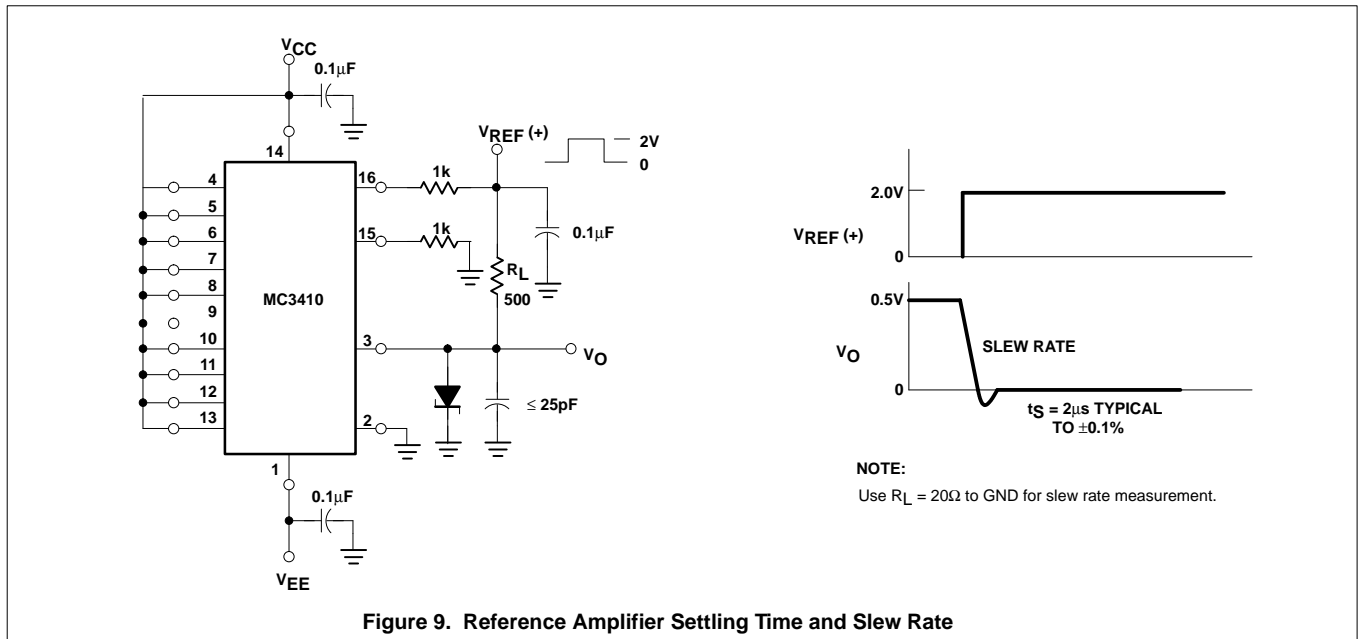


Figure 9. Reference Amplifier Settling Time and Slew Rate

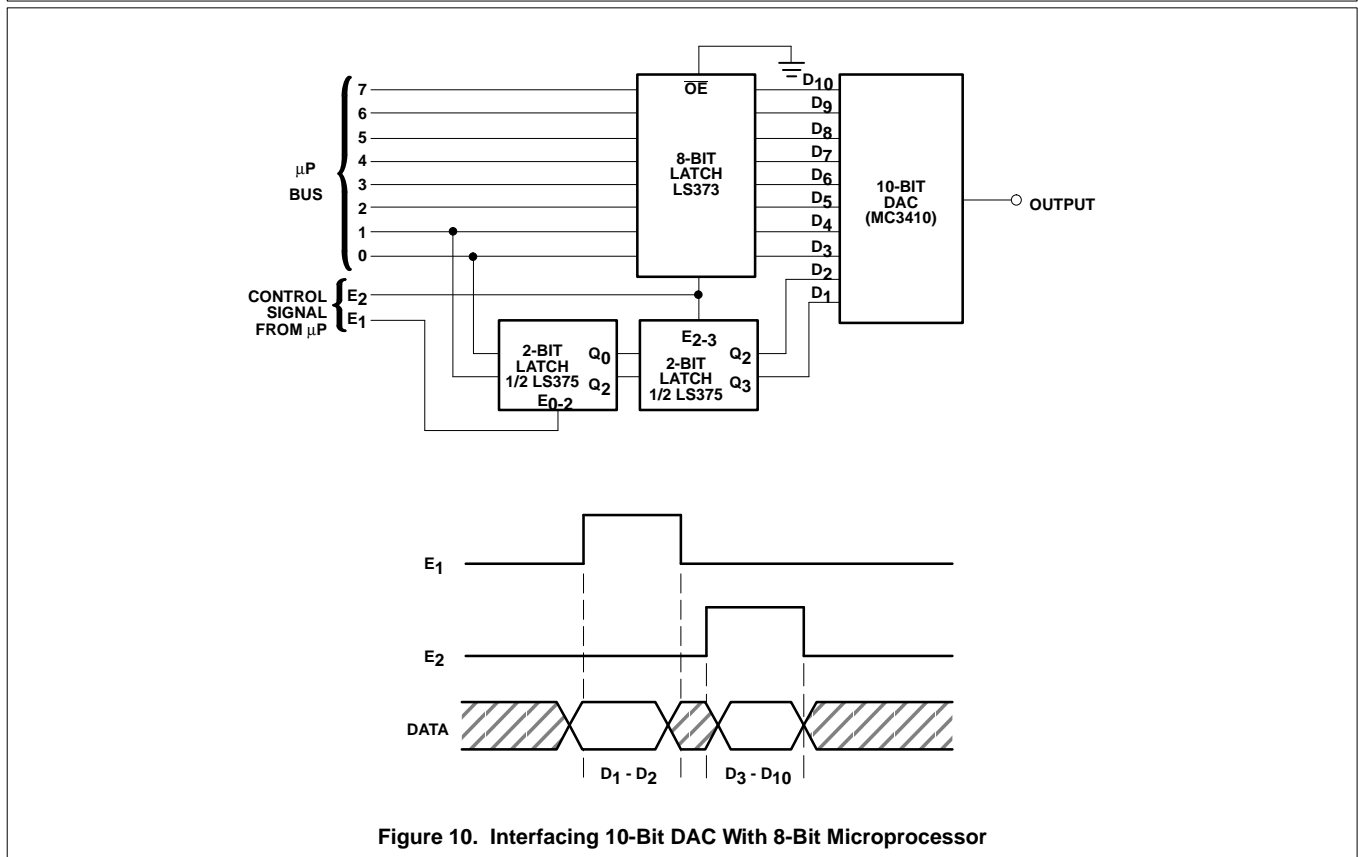


Figure 10. Interfacing 10-Bit DAC With 8-Bit Microprocessor