

## Low Voltage PLL Clock Driver

The MPC990/991 is a 3.3V compatible, PLL based ECL/PECL clock driver. The fully differential design ensures optimum skew and PLL jitter performance. The performance of the MPC990/991 makes the device ideal for Workstation, Mainframe Computer and Telecommunication applications. The MPC990 and MPC991 devices are identical except in the interface to the reference clock for the PLL. The MPC990 offers an on-board crystal oscillator as the PLL reference while the MPC991 offers a differential ECL/PECL input for applications which need to lock to an existing clock signal. Both designs offer a secondary single-ended ECL clock for system test capabilities.

- Fully Integrated PLL
- Output Frequency Up to 400MHz
- ECL/PECL Inputs and Outputs
- Operates from a 3.3V Supply
- Output Frequency Configurable
- TQFP Packaging
- $\pm 50$ ps Cycle-to-Cycle Jitter

The MPC990/991 offers three banks of outputs which can each be programmed via the the four fsel pins of the device. There are 16 different output frequency configurations available in the device. The configurations include output ratios of 1:1, 2:1, 3:1, 3:2, 4:1, 4:3, 4:3:1 and 4:3:2. The programming table in this data sheet illustrates the various programming options. The SYNC output monitors the relationship between the Qa and Qc output banks. The output pulses per the timing diagrams in this data sheet signal the coincident edges of the two output banks. This feature is useful for non binary relationships between output frequencies (i.e., 3:2 or 4:3 relationships). The Sync\_Sel input toggles the Qd outputs between sync signals and extensions to the Qc bank of outputs.

The MPC990/991 provides a separate output for the feedback to the PLL. This allows for the feedback frequency to be programmed independently of the other outputs allowing for unique input vs output frequency relationships. The fselfB inputs provide 6 different feedback frequencies from the QFB differential output pair.

The MPC990/991 features an external differential ECL/PECL feedback to the PLL. This external feedback feature allows for the MPC991's use as a "zero" delay buffer. The propagation delay between the input reference and the output is dependent on the input reference frequency. The selection of higher reference frequencies will provide near zero delay through the device.

The PLL\_En, Ref\_Sel and the Test\_Clk input pins provide a means of bypassing the PLL and driving the output buffers directly. This allows the user to single step a design during system debug. Note that the Test\_Clk input is routed through the dividers so that depending on the programming several edges on the Test\_Clk input will be needed to get corresponding edge transitions on the outputs. The VCO\_Sel input provides a means of recentering the VCO to provide a broader range of VCO frequencies for stable PLL operation.

If the frequency select or the VCO\_Sel pins are changed during operation, a master reset signal must be applied to ensure output synchronization and phase-lock. If the VCO is driven beyond its maximum frequency, the VCO can outrun the internal dividers when the VCO\_Sel pin is low. This will also prevent the PLL from achieving lock. Again, a master reset signal will need to be applied to allow for phase-lock. The device employs a power-on reset circuit which will ensure output synchronization and PLL lock on initial power-up.

**MPC990**  
**MPC991**

**LOW VOLTAGE**  
**PLL CLOCK DRIVER**



**FA SUFFIX**  
52-LEAD TQFP PACKAGE  
CASE 848D-03



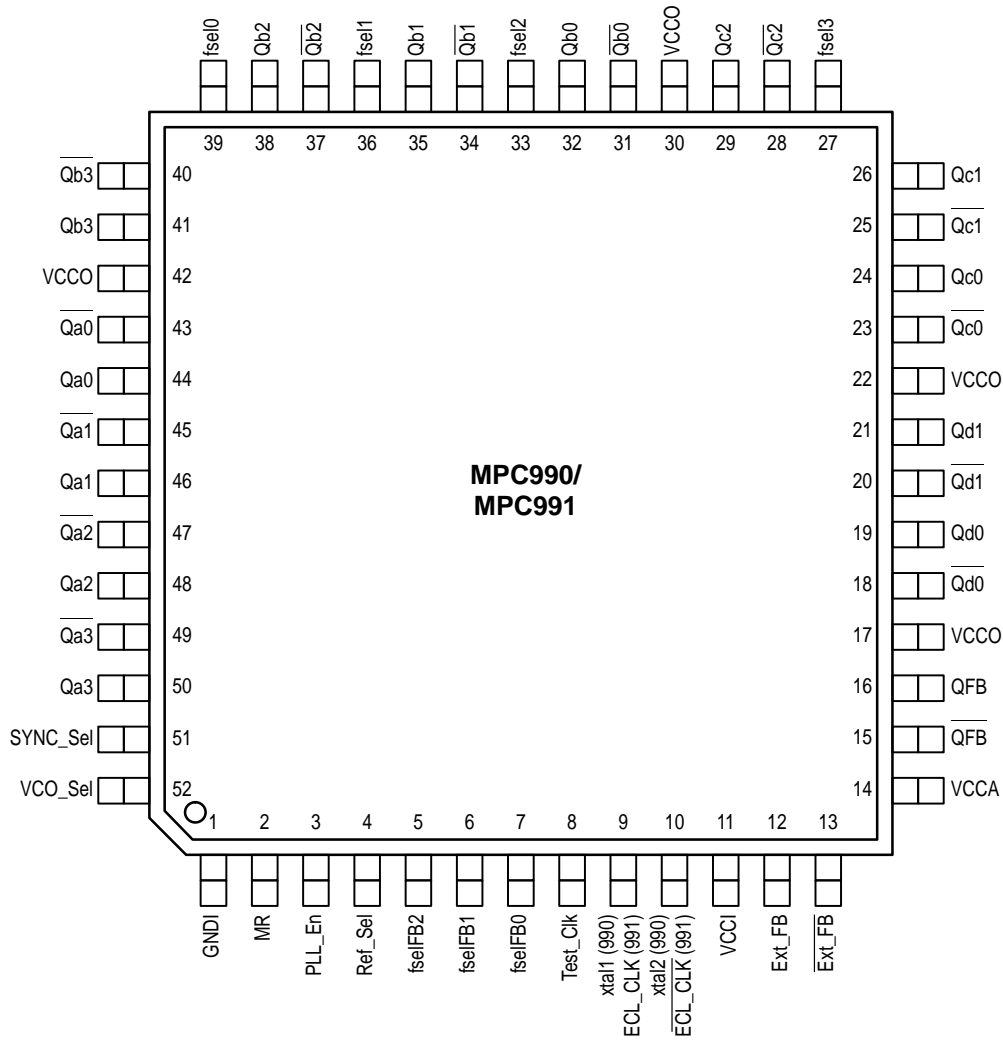


Figure 1. 52-Lead Pinout (Top View)

FUNCTION TABLE 1

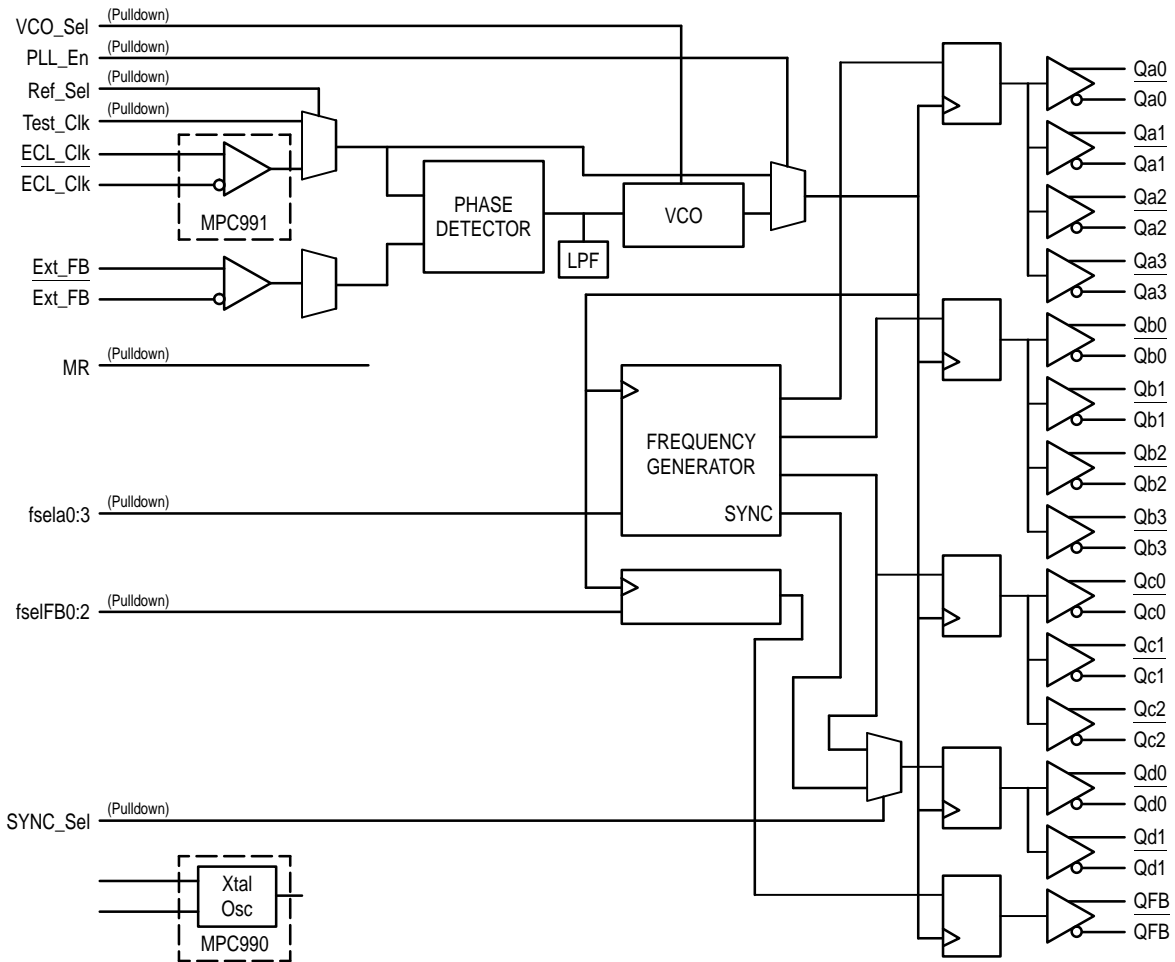
INPUTS				OUTPUTS		
fsel3	fsel2	fsel1	fsel0	Qa	Qb	Qc
0	0	0	0	+2	+2	+2
0	0	0	1	+2	+2	+4
0	0	1	0	+2	+4	+4
0	0	1	1	+2	+2	+6
0	1	0	0	+2	+6	+6
0	1	0	1	+2	+4	+6
0	1	1	0	+2	+4	+8
0	1	1	1	+2	+6	+8
1	0	0	0	+2	+2	+8
1	0	0	1	+2	+8	+8
1	0	1	0	+4	+4	+6
1	0	1	1	+4	+6	+6
1	1	0	0	+4	+6	+8
1	1	0	1	+6	+6	+8
1	1	1	0	+6	+8	+8
1	1	1	1	+8	+8	+8

FUNCTION TABLE 2

fselFB2	fselFB1	fselFB0	QFB
0	0	0	+2
0	0	1	+4
0	1	0	+6
0	1	1	+8
1	0	0	+8
1	0	1	+16
1	1	0	+24
1	1	1	+32

FUNCTION TABLE 3

Control Pin	Logic '0'	Logic '1'
PLL_En	Enable PLL	Bypass PLL
VCO_Sel	fVCO	fVCO/2
Ref_Sel	xtal or ECL/PECL	Test_Clk
MR	—	Reset Outputs
SYNC_Sel	SYNC Outputs	Match Qc Outputs



NOTE: ECL\_Clk, Ext\_FB have internal pulldowns, while ECL\_Clk, Ext\_FB have external pullups to ensure stability under open input conditions.

Figure 2. MPC990/991 Logic Diagram

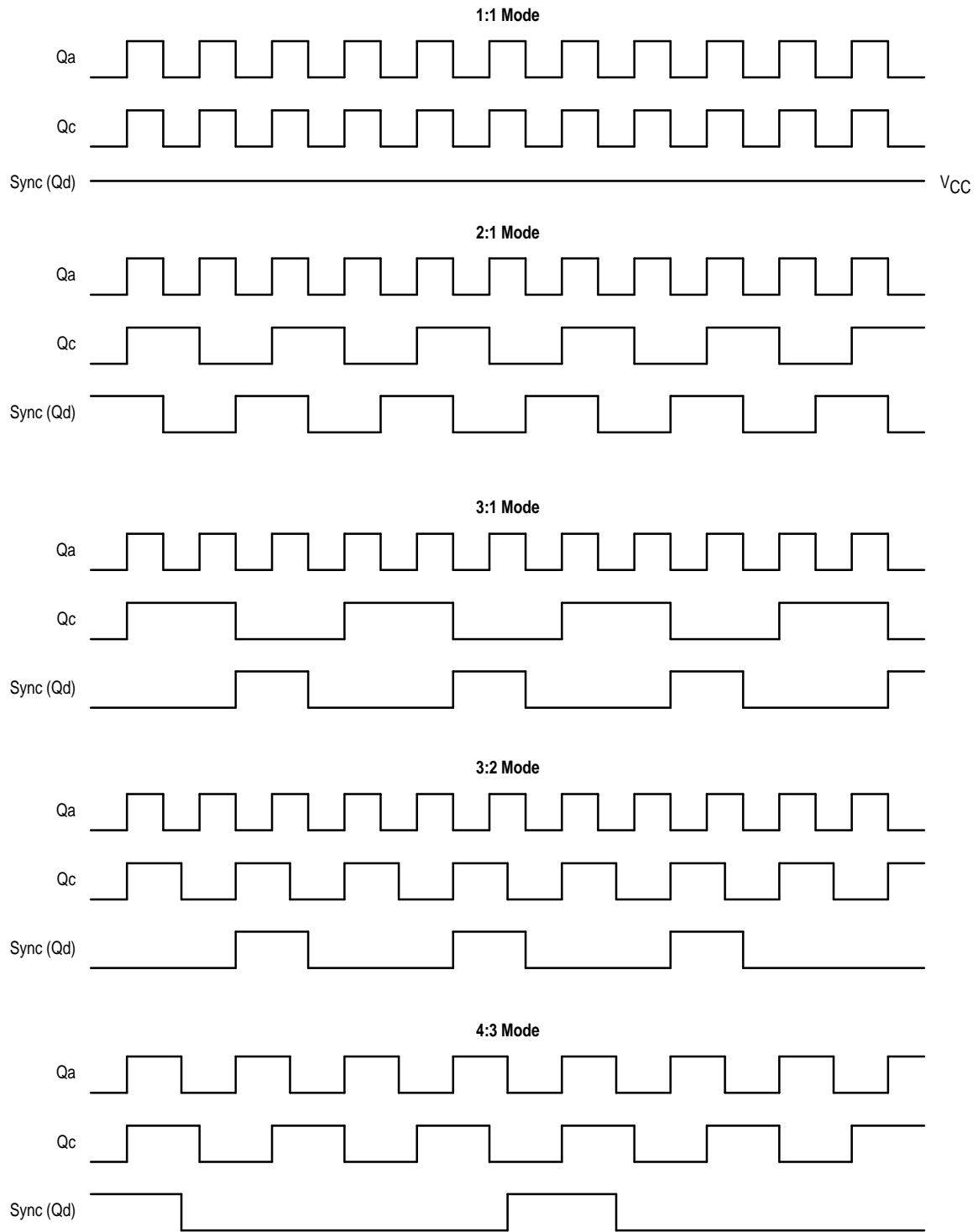


Figure 3. Timing Diagrams

**ECL DC CHARACTERISTICS** ( $T_A = 0^\circ$  to  $70^\circ\text{C}$ ,  $V_{CCA} = V_{CCI} = V_{CCO} = 0\text{V}$ ,  $GNDI = -3.3\text{V} \pm 5\%$ , Note 1.)

Symbol	Characteristic	0°C			25°C			70°C			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
$V_{OH}$	Output HIGH Voltage	-1.3		-0.7	-1.3	-1.0	-0.7	-1.3		-0.7	V
$V_{OL}$	Output LOW Voltage	-2.0		-1.4	-2.0	-1.7	-1.4	-2.0		-1.4	V
$V_{IH}$	Input HIGH Voltage	-1.1		-0.9	-1.1		-0.9	-1.1		-0.9	V
$V_{IL}$	Input LOW Voltage	-1.8		-1.5	-1.8		-1.5	-1.8		-1.5	V
$V_{PP}$	Minimum Input Swing	500			500			500			mV
$V_{CMR}$	Common Mode Range	$V_{CC}$ -1.3V		$V_{CC}$ -0.5V	$V_{CC}$ -1.3V		$V_{CC}$ -0.5V	$V_{CC}$ -1.3V		$V_{CC}$ -0.5V	V
$I_{IH}$	Input HIGH Current			150			150			150	$\mu\text{A}$
$I_{GNDI}$	Power Supply Current		200	240		200	240		200	240	mA

1. Refer to Motorola Application Note AN1545/D "Thermal Data for MPC Clock Drivers" for thermal management guidelines.

**PECL DC CHARACTERISTICS** ( $T_A = 0^\circ$  to  $70^\circ\text{C}$ ,  $V_{CCA} = V_{CCI} = V_{CCO} = 3.3\text{V} \pm 5\%$ ,  $GNDI = 0\text{V}$ , Note 2.)

Symbol	Characteristic	0°C			25°C			70°C			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
$V_{OH}$	Output HIGH Voltage (Note 3.)	2.0		2.6	2.0	2.3	2.6	2.3		2.6	V
$V_{OL}$	Output LOW Voltage (Note 3.)	1.3		1.9	1.3	1.6	1.9	1.3		1.9	V
$V_{IH}$	Input HIGH Voltage (Note 3.)	2.2		2.4	2.2		2.4	2.2		2.4	V
$V_{IL}$	Input LOW Voltage (Note 3.)	1.5		1.8	1.5		1.8	1.5		1.8	V
$V_{PP}$	Minimum Input Swing	500			500			500			mV
$V_{CMR}$	Common Mode Range	$V_{CC}$ -1.3V		$V_{CC}$ -0.5V	$V_{CC}$ -1.3V		$V_{CC}$ -0.5V	$V_{CC}$ -1.3V		$V_{CC}$ -0.5V	V
$I_{IH}$	Input HIGH Current			150			150			150	$\mu\text{A}$
$I_{GNDI}$	Power Supply Current		200	240		200	240		200	240	mA

2. Refer to Motorola Application Note AN1545/D "Thermal Data for MPC Clock Drivers" for thermal management guidelines.

3. These values are for  $V_{CC} = 3.3\text{V}$ . Level Specifications will vary 1:1 with  $V_{CC}$ .

**AC CHARACTERISTICS** ( $T_A = 0^\circ$  to  $70^\circ\text{C}$ ,  $V_{CCA} = V_{CCI} = V_{CCO} = 3.3\text{V} \pm 5\%$ , Termination of  $50\Omega$  to  $V_{CC} - 2.0\text{V}$ )

Symbol	Characteristic	Min	Typ	Max	Unit	Condition
$f_{xtal}$	Crystal Oscillator Frequency	10		25	MHz	
$t_r, t_f$	Output Rise/Fall Time	0.2		1.0	ns	20% to 80%
$t_{pw}$	Output Duty Cycle	47.5	50	52.5	%	
$t_{os}$	Output-to-Output Skew		150 250	250 350	ps	Same Frequency Different Frequencies
$f_{VCO}$	PLL VCO Lock Range	$V_{CO\_Sel} = '0'$ $V_{CO\_Sel} = '1'$	400 200		800 400	MHz FB $\pm 8$ to $\pm 32$ (Note 4.) FB $\pm 4$ to $\pm 32$
$t_{pd}$	Ref to Feedback Offset	75	250	425	ps	$f_{ref} = 50\text{MHz}$ (Note 5.)
$f_{max}$	Maximum Output Frequency			400 200 133 100	MHz	Qa,Qb,Qc ( $\pm 2$ ) Qa,Qb,Qc ( $\pm 4$ ) Qa,Qb,Qc ( $\pm 6$ ) Qa,Qb,Qc ( $\pm 8$ )
$t_{jitter}$	Cycle-to-Cycle Jitter (Peak-to-Peak)		$\pm 50$		ps	
$t_{lock}$	Maximum PLL Lock Time			10	ms	

4. With  $V_{CO\_Sel} = '0'$ , the PLL will be unstable with a  $\pm 2$ ,  $\pm 4$  or  $\pm 6$  feedback ratio. With  $V_{CO\_Sel} = '1'$ , the PLL will be unstable with a  $\pm 2$  feedback ratio.

5.  $t_{pd}$  is specified for 50MHz input reference FB  $\pm 8$ . The window will shrink/grow proportionally from the minimum limit with shorter/longer input reference periods. The  $t_{pd}$  does not include jitter.

**PLL INPUT REFERENCE CHARACTERISTICS** ( $T_A = 0$  to  $70^\circ\text{C}$ )

Symbol	Characteristic	Min	Max	Unit	Condition
$t_r, t_f$	TCLK Input Rise/Falls		3.0	ns	
$f_{ref}$	Reference Input Frequency	Note 6.	Note 6.	MHz	
$f_{refDC}$	Reference Input Duty Cycle	25	75	%	

6. Maximum and minimum input reference frequencies are limited by the VCO lock range and the feedback divider.

**APPLICATIONS INFORMATION****Using the On-Board Crystal Oscillator**

The MPC990 features an on-board crystal oscillator to allow for seed clock generation as well as final distribution. The on-board oscillator is completely self contained so that the only external component required is the crystal. As the oscillator is somewhat sensitive to loading on its inputs the user is advised to mount the crystal as close to the MPC990 as possible to avoid any board level parasitics. To facilitate co-location surface mount crystals are recommended, but not required.

The oscillator circuit is a series resonant circuit as opposed to the more common parallel resonant circuit, this eliminates the need for large on-board capacitors. Because the design is a series resonant design for the optimum frequency accuracy a series resonant crystal should be used (see specification table below). Unfortunately most of the shelf crystals are characterized in a parallel resonant mode. However a parallel resonant crystal is physically no different than a series resonant crystal, a parallel resonant crystal is simply a crystal which has been characterized in its parallel resonant mode. Therefore in the majority of cases a parallel specified crystal can be used with the MPC990 with just a minor frequency error due to the actual series resonant frequency of the parallel resonant specified crystal. Typically a parallel specified crystal used in a series resonant mode will exhibit an oscillatory frequency a few hundred ppm lower than the specified value. For most processor implementations a few hundred ppm translates into kHz inaccuracies, a level which does not represent a major issue.

The MPC990 is a clock driver which was designed to generate outputs with programmable frequency relationships and not a synthesizer with a fixed input frequency. As a result the crystal input frequency is a function of the desired output frequency. For a design which utilizes the external feedback to the PLL the selection of the crystal frequency is straight forward; simply chose a crystal which is equal in frequency to the fed back signal.

**Table 1. Crystal Specifications**

Parameter	Value
Crystal Cut	Fundamental at Cut
Resonance	Series Resonance*
Frequency Tolerance	$\pm 75\text{ppm}$ at $25^\circ\text{C}$
Frequency/Temperature Stability	$\pm 150\text{ppm}$ 0 to $70^\circ\text{C}$
Operating Range	0 to $70^\circ\text{C}$
Shunt Capacitance	5–7pF
Equivalent Series Resistance (ESR)	50 to $80\Omega$ Max
Correlation Drive Level	100 $\mu\text{W}$
Aging	5ppm/Yr (First 3 Years)

\* See accompanying text for series versus parallel resonant discussion.

**Power Supply Filtering**

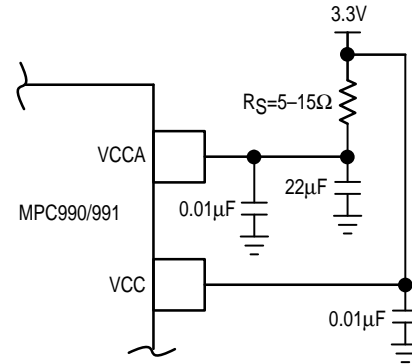
The MPC990/991 is a mixed analog/digital product and as such it exhibits some sensitivities that would not necessarily be seen on a fully digital product. Analog circuitry is naturally susceptible to random noise, especially if this noise is seen on the power supply pins. The MPC990/991 provides separate power supplies for the output buffers ( $V_{CCO}$ ) and the internal PLL ( $V_{CCA}$ ) of the device. The purpose of this design technique is to try and isolate the high switching noise digital outputs from the relatively sensitive internal analog phase-locked loop. In a controlled environment such as an evaluation board this level of isolation is sufficient. However, in a digital system environment where it is more difficult to minimize noise on the power supplies a second level of isolation may be required. The simplest form of isolation is a power supply filter on the  $V_{CCA}$  pin for the MPC990/991.

Figure 4 illustrates a typical power supply filter scheme. The MPC990/991 is most susceptible to noise with spectral content in the 1KHz to 1MHz range. Therefore the filter

should be designed to target this range. The key parameter that needs to be met in the final filter design is the DC voltage drop that will be seen between the  $V_{CC}$  supply and the  $V_{CCA}$  pin of the MPC990/991. From the data sheet the  $I_{VCCA}$  current (the current sourced through the  $V_{CCA}$  pin) is typically 15mA (20mA maximum), assuming that a minimum of 3.0V must be maintained on the  $V_{CCA}$  pin very little DC voltage drop can be tolerated when a 3.3V  $V_{CC}$  supply is used. The resistor shown in Figure 4 must have a resistance of 5–15 $\Omega$  to meet the voltage drop criteria. The RC filter pictured will provide a broadband filter with approximately 100:1 attenuation for noise whose spectral content is above 20KHz. As the noise frequency crosses the series resonant point of an individual capacitor it's overall impedance begins to look inductive and thus increases with increasing frequency. The parallel capacitor combination shown ensures that a low impedance path to ground exists for frequencies well above the bandwidth of the PLL.

Although the MPC990/991 has several design features to minimize the susceptibility to power supply noise (isolated power and grounds and fully differential PLL) there still may

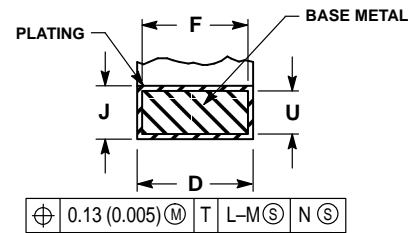
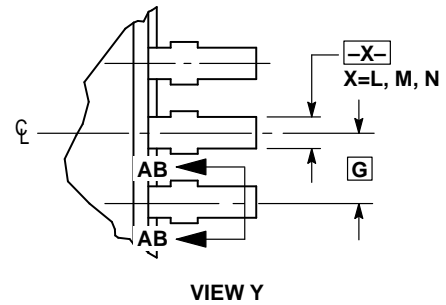
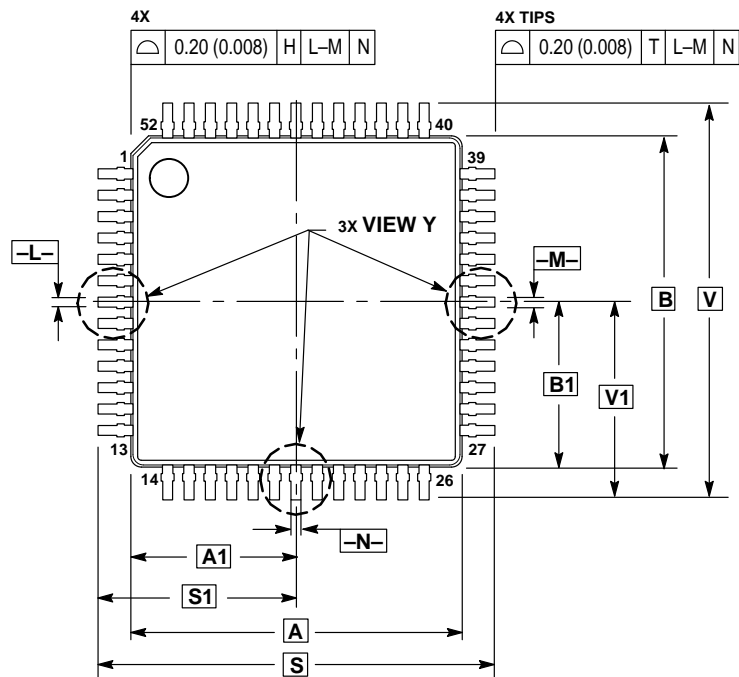
be applications in which overall performance is being degraded due to system power supply noise. The power supply filter schemes discussed in this section should be adequate to eliminate power supply noise related problems in most designs.



**Figure 4. Power Supply Filter**

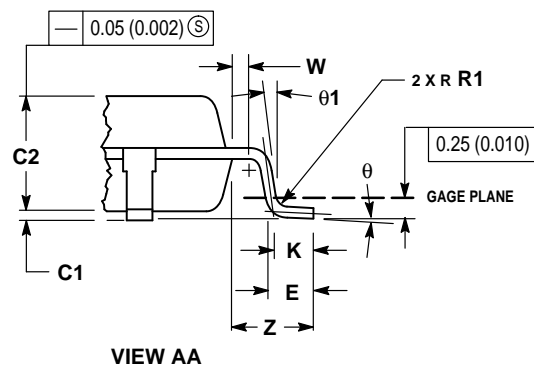
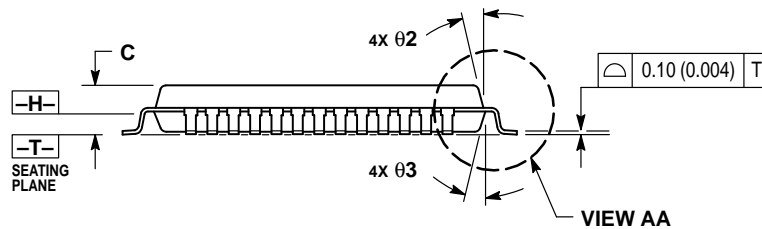
OUTLINE DIMENSIONS

FA SUFFIX  
TQFP PACKAGE  
CASE 848D-03  
ISSUE C




NOTES:

- DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
- CONTROLLING DIMENSION: MILLIMETER.
- DATUM PLANE -H- IS LOCATED AT BOTTOM OF LEAD AND IS COINCIDENT WITH THE LEAD WHERE THE LEAD EXITS THE PLASTIC BODY AT THE BOTTOM OF THE PARTING LINE.
- DATUMS -L-, -M- AND -N- TO BE DETERMINED AT DATUM PLANE -H-.
- DIMENSIONS S AND V TO BE DETERMINED AT SEATING PLANE -T-.
- DIMENSIONS A AND B DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS 0.25 (0.010) PER SIDE. DIMENSIONS A AND B DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE -H-.
- DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. DAMBAR PROTRUSION SHALL NOT CAUSE THE LEAD WIDTH TO EXCEED 0.46 (0.018). MINIMUM SPACE BETWEEN PROTRUSION AND ADJACENT LEAD OR PROTRUSION 0.07 (0.003).



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.00	BSC	0.394	BSC
A1	5.00	BSC	0.197	BSC
B	10.00	BSC	0.394	BSC
B1	5.00	BSC	0.197	BSC
C	—	1.70	—	0.067
C1	0.05	0.20	0.002	0.008
C2	1.30	1.50	0.051	0.059
D	0.20	0.40	0.008	0.016
E	0.45	0.75	0.018	0.030
F	0.22	0.35	0.009	0.014
G	0.65	BSC	0.026	BSC
J	0.07	0.20	0.003	0.008
K	0.50	REF	0.020	REF
R1	0.08	0.20	0.003	0.008
S	12.00	BSC	0.472	BSC
S1	6.00	BSC	0.236	BSC
U	0.09	0.16	0.004	0.006
V	12.00	BSC	0.472	BSC
V1	6.00	BSC	0.236	BSC
W	0.20	REF	0.008	REF
Z	1.00	REF	0.039	REF
$\theta$	0°	7°	0°	7°
$\theta 1$	0°	—	0°	—
$\theta 2$	12°	REF	12°	REF
$\theta 3$	5°	13°	5°	13°



Motorola reserves the right to make changes without further notice to any products herein. Motorola makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does Motorola assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. "Typical" parameters which may be provided in Motorola data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. Motorola does not convey any license under its patent rights nor the rights of others. Motorola products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the Motorola product could create a situation where personal injury or death may occur. Should Buyer purchase or use Motorola products for any such unintended or unauthorized application, Buyer shall indemnify and hold Motorola and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that Motorola was negligent regarding the design or manufacture of the part. Motorola and  are registered trademarks of Motorola, Inc. Motorola, Inc. is an Equal Opportunity/Affirmative Action Employer.

**How to reach us:**

**USA/EUROPE/Locations Not Listed:** Motorola Literature Distribution;  
P.O. Box 5405; Denver, Colorado 80217. 303-675-2140 or 1-800-441-2447

**Mfax™:** RMFAX0@email.sps.mot.com – TOUCHTONE 602-244-6609  
**INTERNET:** <http://www.mot.com/sps/>

**JAPAN:** Nippon Motorola Ltd.; Tatsumi-SPD-JLDC, 6F Seibu-Butsuryu-Center,  
3-14-2 Tatsumi Koto-Ku, Tokyo 135, Japan. 81-3-3521-8315

**ASIA/PACIFIC:** Motorola Semiconductors H.K. Ltd.; 8B Tai Ping Industrial Park,  
51 Ting Kok Road, Tai Po, N.T., Hong Kong. 852-26629298

