

## Product Preview

# 3.3V/2.5V 1:14 LVCMOS PLL Clock Generator

The MPC9774 is a 3.3V or 2.5V compatible, 1:14 PLL based clock generator targeted for high performance low-skew clock distribution in mid-range to high-performance networking, computing and telecom applications. With output frequencies up to 125 MHz and output skews less than 300 ps<sup>1</sup> the device meets the needs of the most demanding clock applications.

### Features

- 1:14 PLL based low-voltage clock generator
- 2.5V or 3.3V power supply
- Internal power-on reset
- Generates clock signals up to 125 MHz
- Maximum output skew of 300 ps<sup>1</sup>
- Two LVCMOS PLL reference clock inputs
- External PLL feedback supports zero-delay capability
- Various feedback and output dividers (see application section)
- Supports up to three individual generated output clock frequencies
- Drives up to 28 clock lines
- Ambient temperature range 0°C to +85°C
- Pin and function compatible to the MPC974

### Functional Description

The MPC9774 utilizes PLL technology to frequency lock its outputs onto an input reference clock. Normal operation of the MPC9774 requires the connection of the PLL feedback output QFB to feedback input FB\_IN to close the PLL feedback path. The reference clock frequency and the divider for the feedback path determine the VCO frequency. Both must be selected to match the VCO frequency range.

The MPC9774 features frequency programmability between the three output banks outputs as well as the output to input relationships. Output frequency ratios of 1:1, 2:1, 3:1, 3:2 and 3:2:1 can be realized. Additionally, the device supports a separate configurable feedback output which allows for a wide variety of input/output frequency multiplication alternatives. The VCO\_SEL pin provides an extended PLL input reference frequency range.

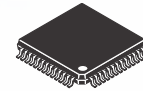
The REF\_SEL pin selects the internal crystal oscillator or the LVCMOS compatible inputs as the reference clock signal. Two alternative LVCMOS compatible clock inputs are provided for clock redundancy support. The PLL\_EN control selects the PLL bypass configuration for test and diagnosis. In this configuration, the selected input reference clock is routed directly to the output dividers bypassing the PLL. The PLL bypass is fully static and the minimum clock frequency specification and all other PLL characteristics do not apply.

The MPC9774 has an internal power-on reset.

The MPC9774 is fully 2.5V and 3.3V compatible and requires no external loop filter components. All inputs (except XTAL) accept LVCMOS signals while the outputs provide LVCMOS compatible levels with the capability to drive terminated 50 Ω transmission lines. For series terminated transmission lines, each of the MPC9774 outputs can drive one or two traces giving the devices an effective fanout of 1:12. The device is pin and function compatible to the MPC974 and is packaged in a 52-lead LQFP package.

**MPC9774**

**3.3V/2.5V 1:14 LVCMOS  
PLL CLOCK GENERATOR**



**FA SUFFIX**  
52 LEAD LQFP PACKAGE  
CASE 848D

<sup>1</sup> Final specification of this parameter is pending characterization.



# MPC9774

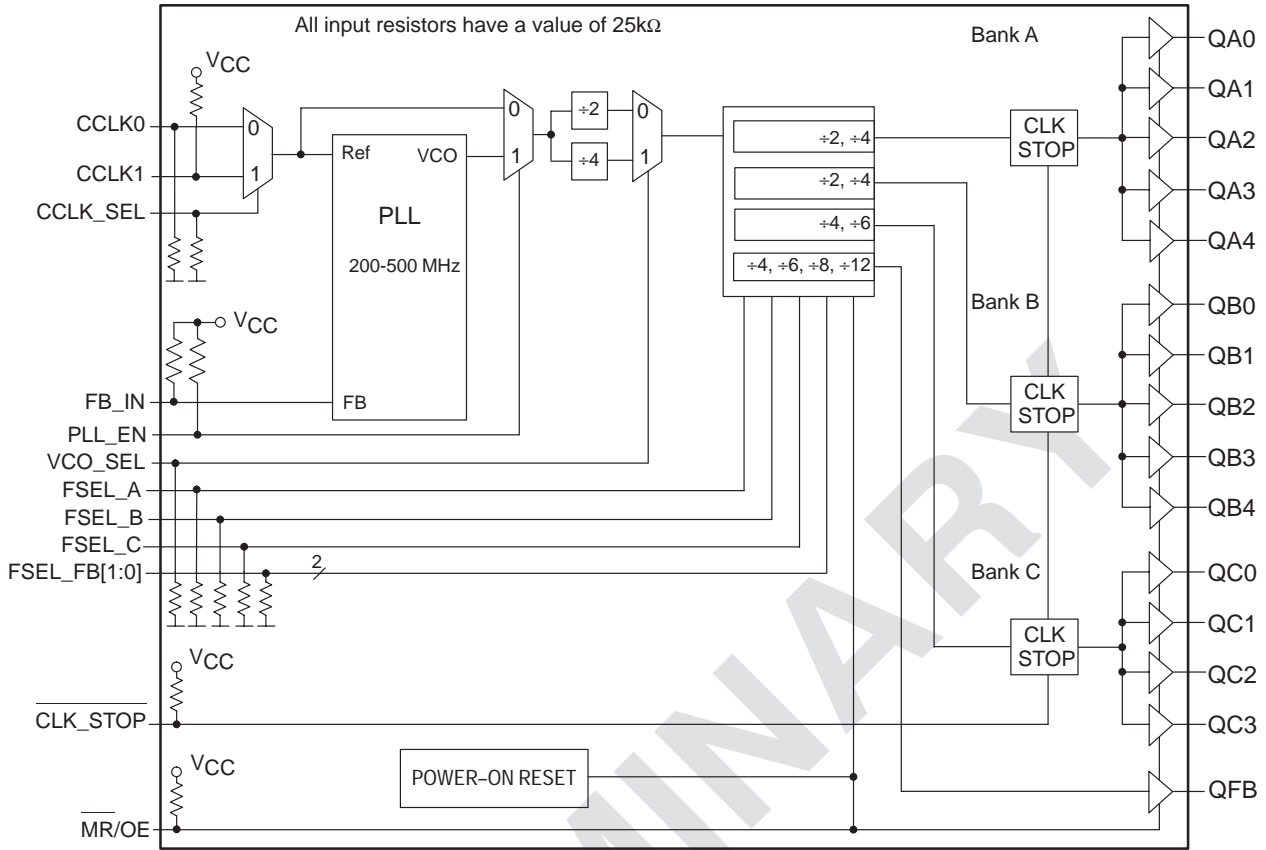


Figure 1. MPC9774 Logic Diagram

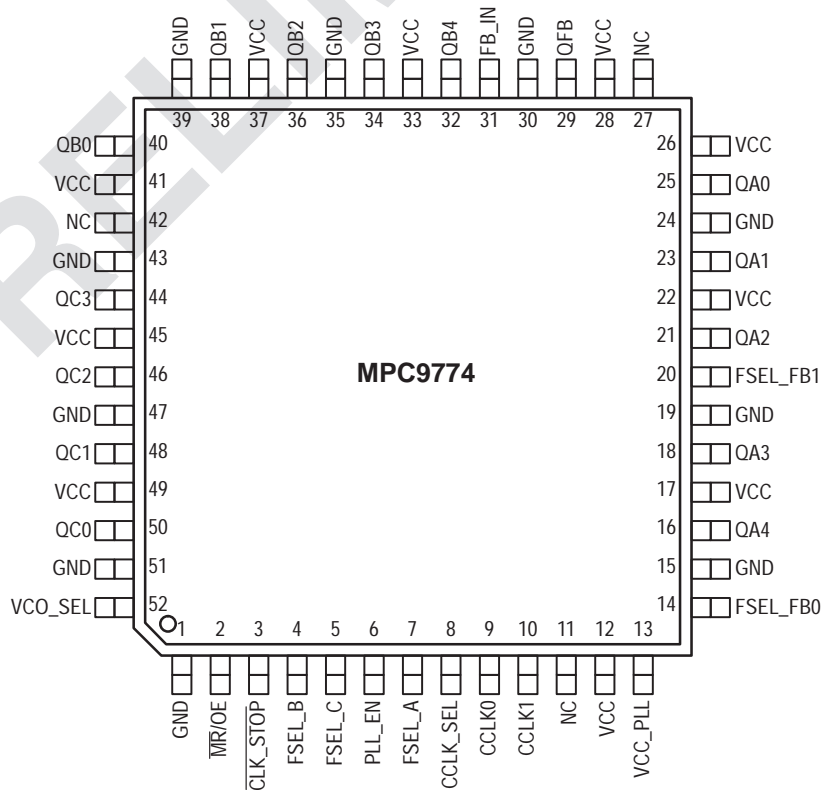


Figure 2. MPC9774 52-Lead Package Pinout (Top View)

**Table 1. PIN CONFIGURATION**

Pin	I/O	Type	Function
CCLK0	Input	LVC MOS	PLL reference clock
CCLK1	Input	LVC MOS	Alternative PLL reference clock
FB_IN	Input	LVC MOS	PLL feedback signal input, connect to QFB
CCLK_SEL	Input	LVC MOS	LVC MOS clock reference select
VCO_SEL	Input	LVC MOS	VCO operating frequency select
PLL_EN	Input	LVC MOS	PLL enable/PLL bypass mode select
MR/OE	Input	LVC MOS	Output enable/disable (high-impedance tristate) and device reset
CLK_STOP	Input	LVC MOS	Output enable/clock stop (logic low state)
FSEL_A	Input	LVC MOS	Frequency divider select for bank A outputs
FSEL_B	Input	LVC MOS	Frequency divider select for bank B outputs
FSEL_C	Input	LVC MOS	Frequency divider select for bank C outputs
FSEL_FB[1:0]	Input	LVC MOS	Frequency divider select for the QFB output
QA[4:0]	Output	LVC MOS	Clock outputs (Bank A)
QB[4:0]	Output	LVC MOS	Clock outputs (Bank B)
QC[3:0]	Output	LVC MOS	Clock outputs (Bank C)
QFB	Output	LVC MOS	PLL feedback output. Connect to FB_IN.
GND	Supply	Ground	Negative power supply
VCC_PLL	Supply	VCC	PLL positive power supply (analog power supply). It is recommended to use an external RC filter for the analog power supply pin VCC_PLL. Please see applications section for details.
VCC	Supply	VCC	Positive power supply for I/O and core. All VCC pins must be connected to the positive power supply for correct operation

**Table 2. Function Table (MPC9774 configuration controls)**

Control	Default	0	1
CCLK_SEL	0	Selects CCLK0 as PLL reference signal input	Selects CCLK1 as PLL reference signal input
VCO_SEL	0	Selects VCO ÷ 2. The VCO frequency is scaled by a factor of 2 (high input frequency range)	Selects VCO ÷ 4. The VCO frequency is scaled by a factor of 4 (low input frequency range).
PLL_EN	1	Test mode with the PLL bypassed. The reference clock is substituted for the internal VCO output. MPC9774 is fully static and no minimum frequency limit applies. All PLL related AC characteristics are not applicable.	Normal operation mode with PLL enabled.
CLK_STOP	1	QA, QB and QC outputs disabled in logic low state. QFB is not affected by CLK_STOP. CLK_STOP deassertion may cause the initial output clock pulse to be distorted.	Outputs enabled (active)
MR/OE	1	Outputs disabled (high-impedance state) and reset of the device. During reset/output disable the PLL feedback loop is open and the internal VCO is tied to its lowest frequency. The MPC9774 requires reset after any loss of PLL lock. Loss of PLL lock may occur when the external feedback path is interrupted. The length of the reset pulse should be greater than one reference clock cycle (CCLKx). The device is reset by the internal power-on reset (POR) circuitry during power-up.	Outputs enabled (active)
VCO_SEL, FSEL_A, FSEL_B, FSEL_C and FSEL_FB[1:0] control the operating PLL frequency range and input/output frequency ratios. See Table 3 and Table 4 for the device frequency configuration.			

**Table 3. Function Table (Output Dividers Bank A, B, and C)**

VCO_SEL	FSEL_A	QA[4:0]	VCO_SEL	FSEL_B	QB[4:0]	VCO_SEL	FSEL_C	QC[3:0]
0	0	VCO ÷ 4	0	0	VCO ÷ 4	0	0	VCO ÷ 8
0	1	VCO ÷ 8	0	1	VCO ÷ 8	0	1	VCO ÷ 12
1	0	VCO ÷ 8	1	0	VCO ÷ 8	1	0	VCO ÷ 16
1	1	VCO ÷ 16	1	1	VCO ÷ 16	1	1	VCO ÷ 24

**Table 4. Function Table (QFB)**

VCO_SEL	FSEL_B1	FSEL_B0	QFB
0	0	0	VCO ÷ 8
0	0	1	VCO ÷ 16
0	1	0	VCO ÷ 12
0	1	1	VCO ÷ 24
1	0	0	VCO ÷ 16
1	0	1	VCO ÷ 32
1	1	0	VCO ÷ 24
1	1	1	VCO ÷ 48

PRELIMINARY

**Table 5. General Specifications**

Symbol	Characteristics	Min	Typ	Max	Unit	Condition
V <sub>TT</sub>	Output termination voltage		V <sub>CC</sub> ÷ 2		V	
MM	ESD protection (Machine model)	200			V	
HBM	ESD protection (Human body model)	2000			V	
LU	Latch-up immunity	200			mA	
C <sub>PD</sub>	Power dissipation capacitance		12		pF	Per output
C <sub>IN</sub>	Input capacitance		4.0		pF	Inputs

**Table 6. Absolute Maximum Ratings<sup>a</sup>**

Symbol	Characteristics	Min	Max	Unit	Condition <sup>5</sup>
V <sub>CC</sub>	Supply Voltage	-0.3	3.6	V	
V <sub>IN</sub>	DC Input Voltage	-0.3	V <sub>CC</sub> + 0.3	V	
V <sub>OUT</sub>	DC Output Voltage	-0.3	V <sub>CC</sub> + 0.3	V	
I <sub>IN</sub>	DC Input Current		±20	mA	
I <sub>OUT</sub>	DC Output Current		±50	mA	
T <sub>S</sub>	Storage temperature	-65	125	°C	

- a. Absolute maximum continuous ratings are those maximum values beyond which damage to the device may occur. Exposure to these conditions or conditions beyond those indicated may adversely affect device reliability. Functional operation at absolute-maximum-rated conditions is not implied.

**Table 7. DC Characteristics** (V<sub>CC</sub> = 3.3V ± 5%, T<sub>A</sub> = 0°C to +85°C)

Symbol	Characteristics	Min	Typ	Max	Unit	Condition
V <sub>CC_PLL</sub>	PLL supply voltage	2.325		V <sub>CC</sub>	V	LVC MOS
V <sub>IH</sub>	Input high voltage	2.0		V <sub>CC</sub> + 0.3	V	LVC MOS
V <sub>IL</sub>	Input low voltage			0.8	V	LVC MOS
V <sub>OH</sub>	Output High Voltage	2.4			V	I <sub>OH</sub> = -24 mA <sup>a</sup>
V <sub>OL</sub>	Output Low Voltage			0.55 0.30	V V	I <sub>OL</sub> = 24 mA I <sub>OL</sub> = 12 mA
Z <sub>OUT</sub>	Output impedance		14 - 17		Ω	
I <sub>IN</sub>	Input Current <sup>b</sup>			±200	μA	V <sub>IN</sub> = V <sub>CC</sub> or GND
I <sub>CC_PLL</sub>	Maximum PLL Supply Current		3.0	5.0	mA	V <sub>CC_PLL</sub> Pin
I <sub>CCQ</sub>	Maximum Quiescent Supply Current			1.0	mA	All V <sub>CC</sub> Pins

- a. The MPC9774 is capable of driving 50Ω transmission lines on the incident edge. Each output drives one 50Ω parallel terminated transmission line to a termination voltage of V<sub>TT</sub>. Alternatively, the device drives up to two 50Ω series terminated transmission lines.
- b. Inputs have pull-down or pull-up resistors affecting the input current.

# MPC9774

**Table 8. AC Characteristics** ( $V_{CC} = 3.3V \pm 5\%$ ,  $T_A = 0^\circ C$  to  $+ 85^\circ C$ )<sup>a b</sup>

Symbol	Characteristics	Min	Typ	Max	Unit	Condition	
$f_{ref}$	Input reference frequency	+8 feedback	25.0		62.5	MHz	PLL locked
		+12 feedback	16.6		41.6	MHz	
		+16 feedback	12.5		31.25	MHz	
		+24 feedback	8.33		20.83	MHz	
		+32 feedback	6.25		15.625	MHz	
		+48 feedback	4.16		10.41	MHz	
	Input reference frequency in PLL bypass mode <sup>c</sup>			TBD	MHz	PLL bypass	
$f_{VCO}$	VCO frequency range <sup>d</sup>	200		500	MHz		
$f_{MAX}$	Output Frequency	+4 output	50.0		125.0	MHz	PLL locked
		+8 output	25.0		62.5	MHz	
		+12 output	16.6		41.6	MHz	
		+16 output	12.5		31.25	MHz	
		+24 output	8.33		20.83	MHz	
$f_{refDC}$	Reference Input Duty Cycle	40		60	%		
$t_r, t_f$	CCLKx Input Rise/Fall Time			1.0	ns	0.8 to 2.0V	
$t(\emptyset)$	Propagation Delay (static phase offset) CCLKx or FB_IN		$\pm 150$		ps	PLL locked	
$t_{sk(O)}$	Output-to-output Skew <sup>e</sup>			300	ps		
DC	Output duty cycle	45	50	55	%		
$t_r, t_f$	Output Rise/Fall Time	0.1		1.0	ns	0.55 to 2.4V	
$t_{PLZ, HZ}$	Output Disable Time			8	ns		
$t_{PZL, LZ}$	Output Enable Time			8	ns		
$t_{JIT(CC)}$	Cycle-to-cycle jitter	RMS (1 $\sigma$ ) <sup>f</sup>	TBD		ps		
$t_{JIT(PER)}$	Period Jitter	RMS (1 $\sigma$ )	TBD		ps		
$t_{JIT(\emptyset)}$	I/O Phase Jitter	RMS (1 $\sigma$ )	TBD		ps		
BW	PLL closed loop bandwidth <sup>g</sup>				kHz		
$t_{LOCK}$	Maximum PLL Lock Time		10		ms		

a All AC characteristics are design targets and subject to change upon device characterization.

b AC characteristics apply for parallel output termination of  $50\Omega$  to  $V_{TT}$ .

c In bypass mode, the MPC9774 divides the input reference clock.

d The input reference frequency must match the VCO lock range divided by the total feedback divider ratio:  $f_{ref} = f_{VCO} \div (M \cdot VCO\_SEL)$ .

e See application section for part-to-part skew calculation.

f See application section for a jitter calculation for other confidence factors than 1  $\sigma$ .

g -3 dB point of PLL transfer characteristics.

**Table 9. DC Characteristics** ( $V_{CC} = 2.5V \pm 5\%$ ,  $T_A = 0^\circ C$  to  $+85^\circ C$ )

Symbol	Characteristics	Min	Typ	Max	Unit	Condition
$V_{CC\_PLL}$	PLL supply voltage	2.325		$V_{CC}$	V	LVC MOS
$V_{IH}$	Input high voltage	1.7		$V_{CC} + 0.3$	V	LVC MOS
$V_{IL}$	Input low voltage	-0.3		0.7	V	LVC MOS
$V_{OH}$	Output High Voltage	1.8			V	$I_{OH} = -15\text{ mA}^a$
$V_{OL}$	Output Low Voltage			0.6	V	$I_{OL} = 15\text{ mA}$
$Z_{OUT}$	Output impedance		17 - 20		$\Omega$	
$I_{IN}$	Input Current <sup>b</sup>			$\pm 200$	$\mu A$	$V_{IN} = V_{CC}$ or GND
$I_{CC\_PLL}$	Maximum PLL Supply Current		2.0	5.0	mA	$V_{CCA}$ Pin
$I_{CC}$	Maximum Quiescent Supply Current			1.0	mA	All $V_{CC}$ Pins

- a. The MPC9774 is capable of driving  $50\Omega$  transmission lines on the incident edge. Each output drives one  $50\Omega$  parallel terminated transmission line to a termination voltage of  $V_{TT}$ . Alternatively, the device drives up to two  $50\Omega$  series terminated transmission lines per output.
- b. Inputs have pull-down or pull-up resistors affecting the input current.

**Table 10. AC Characteristics** ( $V_{CC} = 2.5V \pm 5\%$ ,  $T_A = 0^\circ C$  to  $+85^\circ C$ )<sup>a b</sup>

Symbol	Characteristics	Min	Typ	Max	Unit	Condition	
$f_{ref}$	Input reference frequency	+8 feedback	25.0		50.0	MHz	PLL locked
		+12 feedback	16.6		33.3	MHz	
		+16 feedback	12.5		25.0	MHz	
		+24 feedback	8.33		16.6	MHz	
		+32 feedback	6.25		12.5	MHz	
		+48 feedback	4.16		8.3	MHz	
	Input reference frequency in PLL bypass mode <sup>c</sup>			TBD	MHz	PLL bypass	
$f_{VCO}$	VCO frequency range <sup>d</sup>	200		400	MHz		
$f_{MAX}$	Output Frequency	+4 output	50.0		100.0	MHz	PLL locked
		+8 output	25.0		50.0	MHz	
		+12 output	16.6		33.3	MHz	
		+16 output	12.5		25.0	MHz	
		+24 output	8.33		16.6	MHz	
$f_{refDC}$	Reference Input Duty Cycle	40		60	%		
$t_r, t_f$	CCLKx Input Rise/Fall Time			1	ns	0.7 to 1.7V	
$t(\varnothing)$	Propagation Delay (static phase offset) CCLKx or PCLK to FB_IN		$\pm 150$		ps	PLL locked	
$t_{sk(O)}$	Output-to-output Skew <sup>e</sup>			300	ps		
DC	Output duty cycle	45	50	55	%		
$t_r, t_f$	Output Rise/Fall Time	0.1		1.0	ns	0.6 to 1.8V	
$t_{PLZ, HZ}$	Output Disable Time			10	ns		
$t_{PZL, LZ}$	Output Enable Time			10	ns		
$t_{JIT(CC)}$	Cycle-to-cycle jitter	RMS (1 $\sigma$ ) <sup>f</sup>	TBD		ps		
$t_{JIT(PER)}$	Period Jitter	RMS (1 $\sigma$ )	TBD		ps		
$t_{JIT(\varnothing)}$	I/O Phase Jitter	RMS (1 $\sigma$ )	TBD		ps		
BW	PLL closed loop bandwidth <sup>g</sup>			TBD	kHz		
$t_{LOCK}$	Maximum PLL Lock Time		10		ms		

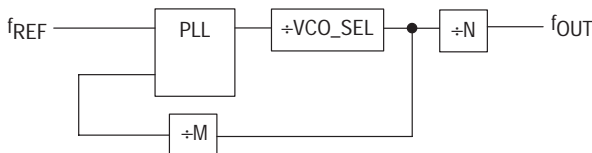
- a. All AC characteristics are design targets and subject to change upon device characterization.
- b. AC characteristics apply for parallel output termination of  $50\Omega$  to  $V_{TT}$ .
- c. In bypass mode, the MPC9774 divides the input reference clock.
- d. The input reference frequency must match the VCO lock range divided by the total feedback divider ratio:  $f_{ref} = f_{VCO} \div (M \cdot VCO\_SEL)$ .
- e. See application section for part-to-part skew calculation.
- f. See application section for a jitter calculation for other confidence factors than 1  $\sigma$ .
- g. -3 dB point of PLL transfer characteristics.

APPLICATIONS INFORMATION

MPC9774 Configurations

Configuring the MPC9774 amounts to properly configuring the internal dividers to produce the desired output frequencies. The output frequency can be represented by this formula:

$$f_{OUT} = f_{REF} \cdot M \div N$$



where  $f_{REF}$  is the reference frequency of the selected input clock source (CCLK0 or CCLK1), M is the PLL feedback divider and N is a output divider. M is configured by the FSEL\_FB[0:1] and N is individually configured for each output bank by the FSEL\_A, FSEL\_B and FSEL\_C inputs.

The reference frequency  $f_{REF}$  and the selection of the feedback-divider M is limited by the specified VCO frequency range.  $f_{REF}$  and M must be configured to match the VCO frequency range of 200 to 500<sup>1</sup> MHz ( $V_{CC} = 3.3V$ ) in order to achieve stable PLL operation:

$$f_{VCO,MIN} \leq (f_{REF} \cdot VCO\_SEL \cdot M) \leq f_{VCO,MAX}$$

The PLL post-divider VCO\_SEL is either a divide-by-two or a divide-by-four and can be used to situate the VCO into the specified frequency range. This divider is controlled by

the VCO\_SEL pin. VCO\_SEL effectively extends the usable input frequency range while it has no effect on the output to reference frequency ratio. The output frequency for each bank can be derived from the VCO frequency and the output divider:

$$f_{QA[4:0]} = f_{VCO} \div (VCO\_SEL \cdot N_A)$$

$$f_{QB[4:0]} = f_{VCO} \div (VCO\_SEL \cdot N_B)$$

$$f_{QC[3:0]} = f_{VCO} \div (VCO\_SEL \cdot N_C)$$

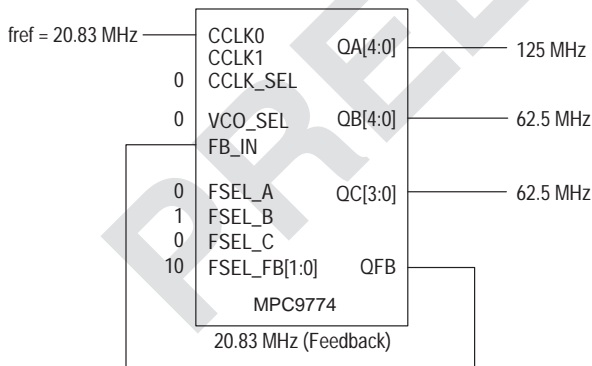
Table 11. MPC9774 Divider

Divider	Function	VCO_SEL	Values
M	PLL feedback FSEL_FB[0:2]	+2	8, 12, 16, 24
		+4	16, 24, 32, 48
N <sub>A</sub>	Bank A Output Divider FSEL_A	+2	4, 8
		+4	8, 16
N <sub>B</sub>	Bank B Output Divider FSEL_B	+2	4, 8
		+4	8, 16
N <sub>C</sub>	Bank C Output Divider FSEL_C	+2	8, 12
		+4	16, 24

1. The VCO frequency range for 2.5V operation is specified from 200 to 400 MHz.

Table 11 shows the various PLL feedback and output dividers. The output dividers for the three output banks allow the user to configure the outputs into 1:1, 2:1, 3:2 and 3:2:1 frequency ratios. Figure 3 and Figure 4 display example configurations for the MPC9774:

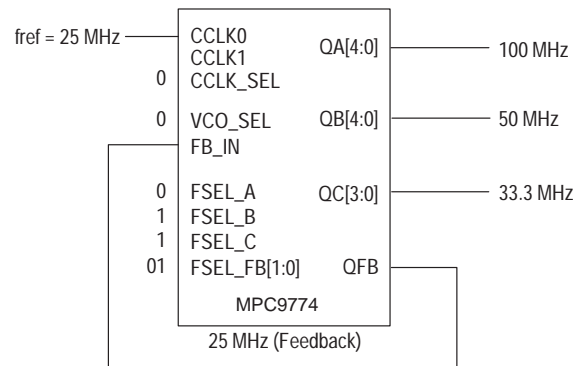
Figure 3. Example Configuration



MPC9774 example configuration (feedback of QFB = 20.83 MHz, VCO\_SEL = +2, M = 12, N<sub>A</sub> = 2, N<sub>B</sub> = 4, N<sub>C</sub> = 4,  $f_{VCO}$  = 500 MHz).

Frequency range	Min	Max
Input	8.33 MHz	20.83 MHz
QA outputs	50 MHz	125 MHz
QB outputs	25 MHz	62.5 MHz
QC outputs	25 MHz	62.5 MHz

Figure 4. Example Configuration



MPC9774 example configuration (feedback of QFB = 25 MHz, VCO\_SEL = +2, M = 8, N<sub>A</sub> = 2, N<sub>B</sub> = 4, N<sub>C</sub> = 6,  $f_{VCO}$  = 400 MHz).

Frequency range	Min	Max
Input	20 MHz	48 MHz
QA outputs	50 MHz	120 MHz
QB outputs	50 MHz	120 MHz
QC outputs	100 MHz	200 MHz



**Using the MPC9774 in zero-delay applications**

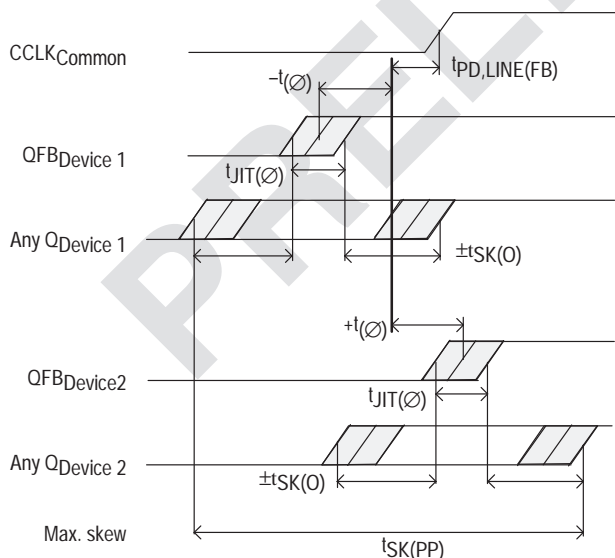
Nested clock trees are typical applications for the MPC9774. Designs using the MPC9774 as LVCMOS PLL fanout buffer with zero insertion delay will show significantly lower clock skew than clock distributions developed from CMOS fanout buffers. The external feedback of the MPC9774 clock driver allows for its use as a zero delay buffer. The PLL aligns the feedback clock output edge with the clock input reference edge resulting a near zero delay through the device (the propagation delay through the device is virtually eliminated). The maximum insertion delay of the device in zero-delay applications is measured between the reference clock input and any output. This effective delay consists of the static phase offset, I/O jitter (phase or long-term jitter), feedback path delay and the output-to-output skew error relative to the feedback output.

**Calculation of part-to-part skew**

The MPC9774 zero delay buffer supports applications where critical clock signal timing can be maintained across several devices. If the reference clock inputs of two or more MPC9774 are connected together, the maximum overall timing uncertainty from the common CCLK input to any output is:

$$t_{SK(PP)} = t_{(\varnothing)} + t_{SK(O)} + t_{PD, LINE(FB)} + t_{JIT(\varnothing)} \cdot CF$$

This maximum timing uncertainty consist of 4 components: static phase offset, output skew, feedback board trace delay and I/O (phase) jitter:



**Figure 5. MPC9774 max. device-to-device skew**

Due to the statistical nature of I/O jitter a rms value ( $1 \sigma$ ) is specified. I/O jitter numbers for other confidence factors (CF) can be derived from Table 12.

**Table 12. MPC9774 Divider**

CF	Probability of clock edge within the distribution
$\pm 1\sigma$	0.68268948
$\pm 2\sigma$	0.95449988
$\pm 3\sigma$	0.99730007
$\pm 4\sigma$	0.99993663
$\pm 5\sigma$	0.99999943
$\pm 6\sigma$	0.99999999

The feedback trace delay is determined by the board layout and can be used to fine-tune the effective delay through each device. In the following example calculation a I/O jitter confidence factor of 99.7% ( $\pm 3\sigma$ ) is assumed, resulting in a worst case timing uncertainty from input to any output of  $-495 \text{ ps}$  to  $495 \text{ ps}^2$  relative to CCLK:

$$t_{SK(PP)} = [-300\text{ps}...300\text{ps}] + [-150\text{ps}...150\text{ps}] + [(15\text{ps} \cdot -3)...(15\text{ps} \cdot 3)] + t_{PD, LINE(FB)}$$

$$t_{SK(PP)} = [-495\text{ps}...495\text{ps}] + t_{PD, LINE(FB)}$$

Due to the frequency dependence of the I/O jitter, Figure 6 can be used for a more precise timing performance analysis.

**TBD.**

See MPC961C application section for an example I/O jitter characteristic

**Figure 6.**

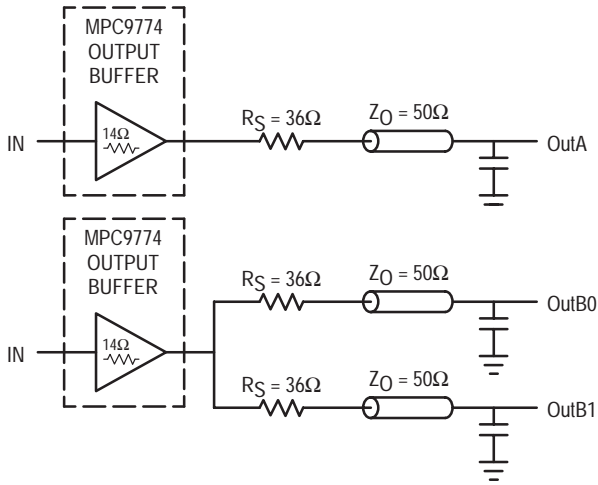
2. Final skew data pending specification

**Driving Transmission Lines**

The MPC9774 clock driver was designed to drive high speed signals in a terminated transmission line environment. To provide the optimum flexibility to the user the output drivers were designed to exhibit the lowest impedance possible. With an output impedance of less than  $20\Omega$  the drivers can drive either parallel or series terminated transmission lines. For more information on transmission lines the reader is referred to Motorola application note AN1091. In most high performance clock networks point-to-point distribution of signals is the method of choice. In a point-to-point scheme either series terminated or parallel terminated transmission lines can be used. The parallel technique terminates the signal at the end of the line with a  $50\Omega$  resistance to  $V_{CC} + 2$ .

This technique draws a fairly high level of DC current and thus only a single terminated line can be driven by each output of the MPC9774 clock driver. For the series terminated case however there is no DC current draw, thus the outputs can drive multiple series terminated lines. Figure 7 "Single versus Dual Transmission Lines" illustrates an output driving a single series terminated line versus two series terminated lines in parallel. When taken to its extreme the fanout of the MPC9774 clock driver is effectively doubled due to its capability to drive multiple lines.

# MPC9774



**Figure 7. Single versus Dual Transmission Lines**

The waveform plots in Figure 8 “Single versus Dual Line Termination Waveforms” show the simulation results of an output driving a single line versus two lines. In both cases the drive capability of the MPC9774 output buffer is more than sufficient to drive 50Ω transmission lines on the incident edge. Note from the delay measurements in the simulations a delta of only 43ps exists between the two differently loaded outputs. This suggests that the dual line driving need not be used exclusively to maintain the tight output-to-output skew of the MPC9774. The output waveform in Figure 8 “Single versus Dual Line Termination Waveforms” shows a step in the waveform, this step is caused by the impedance mismatch seen looking into the driver. The parallel combination of the 36Ω series resistor plus the output impedance does not match the parallel combination of the line impedances. The voltage wave launched down the two lines will equal:

$$V_L = V_S ( Z_0 \div (R_S + R_0 + Z_0))$$

$$Z_0 = 50\Omega \parallel 50\Omega$$

$$R_S = 36\Omega \parallel 36\Omega$$

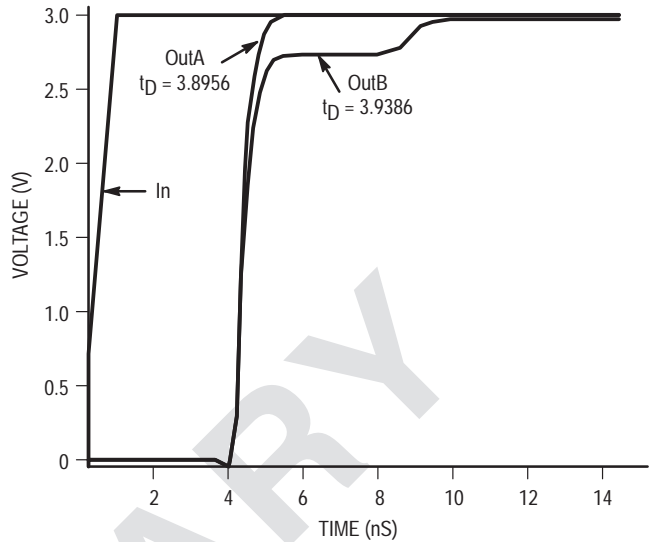
$$R_0 = 14\Omega$$

$$V_L = 3.0 ( 25 \div (18 + 17 + 25))$$

$$= 1.31V$$

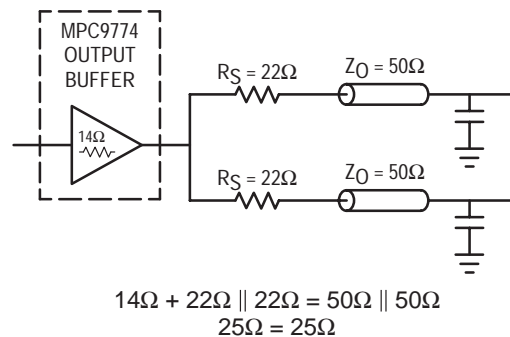
At the load end the voltage will double, due to the near unity reflection coefficient, to 2.6V. It will then increment

towards the quiescent 3.0V in steps separated by one round trip delay (in this case 4.0ns).



**Figure 8. Single versus Dual Waveforms**

Since this step is well above the threshold region it will not cause any false clock triggering, however designers may be uncomfortable with unwanted reflections on the line. To better match the impedances when driving multiple lines the situation in Figure 9 “Optimized Dual Line Termination” should be used. In this case the series terminating resistors are reduced such that when the parallel combination is added to the output buffer impedance the line impedance is perfectly matched.



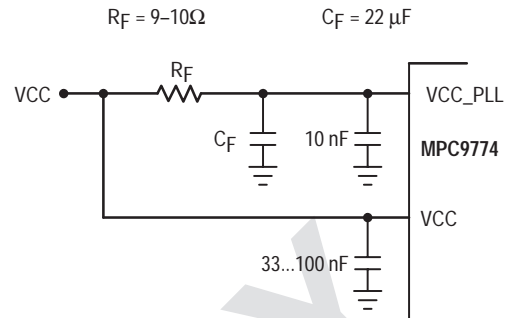
**Figure 9. Optimized Dual Line Termination**

### Power Supply Filtering

The MPC9774 is a mixed analog/digital product. Its analog circuitry is naturally susceptible to random noise, especially if this noise is seen on the power supply pins. Random noise on the VCC\_PLL power supply impacts the device characteristics, for instance I/O jitter. The MPC9774 provides separate power supplies for the output buffers (VCC) and the phase-locked loop (VCC\_PLL) of the device. The purpose of this design technique is to isolate the high switching noise digital outputs from the relatively sensitive internal analog phase-locked loop. 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 simple but effective form of isolation is a power supply filter on the VCC\_PLL pin for the MPC9774. Figure 10 illustrates a typical power supply filter scheme. The MPC9774 frequency and phase stability is most susceptible to noise with spectral content in the 100 kHz to 20 MHz 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 across the series filter resistor  $R_F$ . From the data sheet the  $I_{CC\_PLL}$  current (the current sourced through the VCC\_PLL pin) is typically 3 mA (5 mA maximum), assuming that a minimum of 2.325V ( $V_{CC} = 3.3V$  or  $V_{CC} = 2.5V$ ) must be maintained on the VCC\_PLL pin. The resistor  $R_F$  shown in MPC9774 must have a resistance of 9-10 $\Omega$  ( $V_{CC} = 2.5V$ ) to meet the voltage drop criteria.

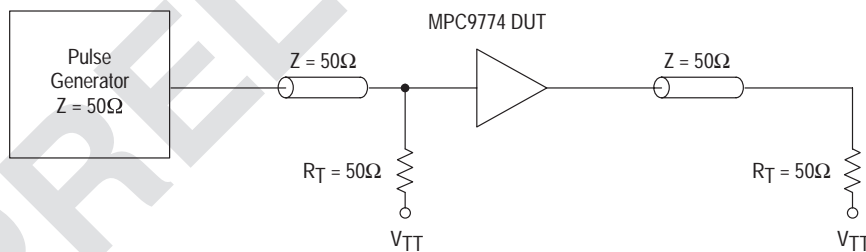
The minimum values for  $R_F$  and the filter capacitor  $C_F$  are defined by the required filter characteristics: the RC filter should provide an attenuation greater than 40 dB for noise

whose spectral content is above 100 kHz. In the example RC filter shown in MPC9774, the filter cut-off frequency is around 3-5 kHz and the noise attenuation at 100 kHz is better than 42 dB.

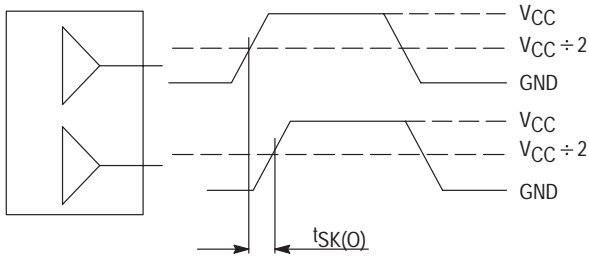


**Figure 10. VCC Power Supply Filter**

As the noise frequency crosses the series resonant point of an individual capacitor its 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 MPC9774 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.

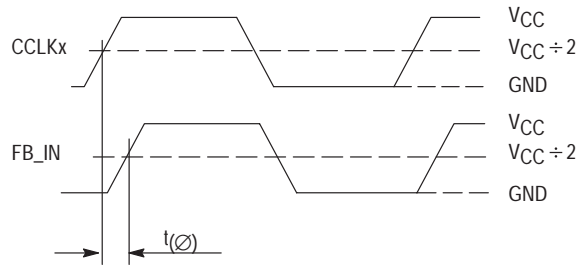


**Figure 11. CCLK MPC9774 AC test reference for  $V_{CC} = 3.3V$  and  $V_{CC} = 2.5V$**

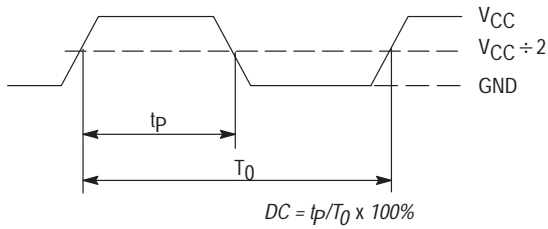


The pin-to-pin skew is defined as the worst case difference in propagation delay between any similar delay path within a single device

**Figure 12. Output-to-output Skew  $t_{SK(O)}$**

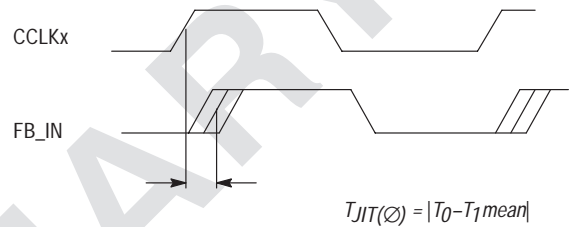


**Figure 13. Propagation delay ( $t(\phi)$ , static phase offset) test reference**



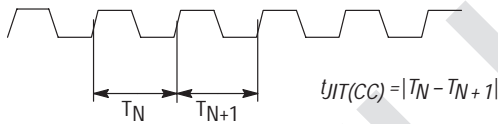
The time from the PLL controlled edge to the non controlled edge, divided by the time between PLL controlled edges, expressed as a percentage

**Figure 14. Output Duty Cycle (DC)**



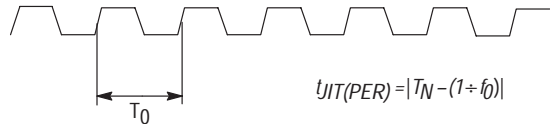
The deviation in  $t_0$  for a controlled edge with respect to a  $t_0$  mean in a random sample of cycles

**Figure 15. I/O Jitter**



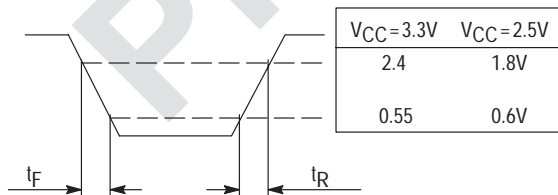
The variation in cycle time of a signal between adjacent cycles, over a random sample of adjacent cycle pairs

**Figure 16. Cycle-to-cycle Jitter**



The deviation in cycle time of a signal with respect to the ideal period over a random sample of cycles

**Figure 17. Period Jitter**



**Figure 18. Output Transition Time Test Reference**




MPC9774

## NOTES

**NOTES**

MPC9774

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