Am8224

Clock Generator and Driver for 8080A Compatible Microprocessors

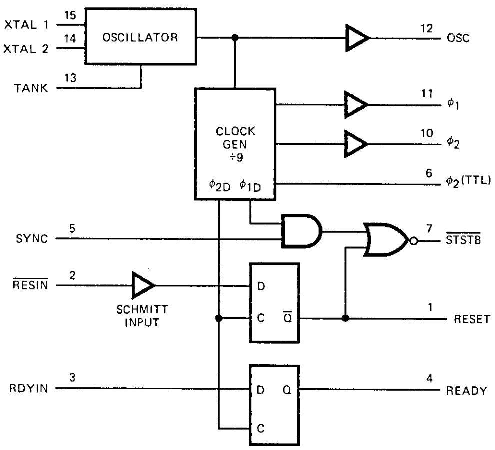
Distinctive Characteristics

- Single chip clock generator/driver for 8080A compatible CPU
- Power-up reset for CPU
- Ready synchronizing flip-flop
- Status strobe signal
- Oscillator output for external system timing
- Am8224-4 version available for use with 1μsec instruction cycle of Am9080A-4
- Available for operation over both commercial and military temperature ranges
- Crystal controlled for stable system operation
- Reduces system package count
- Advanced Schottky processing
- 100% reliability assurance testing in compliance with MIL-STD-883

FUNCTIONAL DESCRIPTION

The Am8224 is a single chip Clock Generator/Driver for the Am9080A and 8080A CPU. It contains a crystal-controlled oscillator, a "divide by nine" counter, two high-level drivers and several auxiliary logic functions, including a power-up reset, status strobe and synchronization of ready. Also provided are TTL compatible oscillator and ϕ_2 outputs for external system timing. The Am8224 provides the designer with a significant reduction of packages used to generate clocks and timing for the Am9080A or 8080A for both commercial and military temperature range applications. A high speed version, the Am8224-4, is available for use with the high speed Am9080A-4.

LOGIC DIAGRAM



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PIN DEFINITION

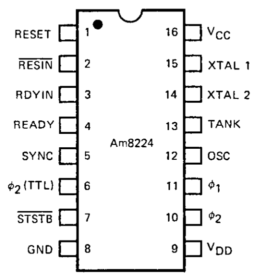
XTAL 1	CONNECTIONS FOR CRYSTAL
XTAL 2	
TANK	USED WITH OVERTONE XTAL
OSC	OSCILLATOR OUTPUT
ϕ_2(TTL)	ϕ_2 CLK (TTL LEVEL)
V_{CC}	+5.0V
V_{DD}	+12V
GND	0V
$\overline{\text{RESIN}}$	RESET INPUT
RESET	RESET OUTPUT
RDYIN	READY INPUT
READY	READY OUTPUT
SYNC	SYNC INPUT
$\overline{\text{STSTB}}$	STATUS STB (ACTIVE LOW)
ϕ_1	Am9080A/8080A CLOCKS
ϕ_2	

ORDERING INFORMATION

Package Type	Temperature Range	Order Number
Hermetic DIP	–55°C to +125°C	AM8224DM
Hermetic DIP	0°C to +70°C	D8224
Molded DIP	0°C to +70°C	AM8224PC
Dice	0°C to +70°C	AM8224XC
Hermetic DIP	0°C to +70°C	AM8224-4DC*

* For use with Am9080A-4 with clock period between 250ns and 320ns.

CONNECTION DIAGRAM
Top View



Note: Pin 1 is marked for orientation.

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MAXIMUM RATINGS (Above which the useful life may be impaired)

Storage Temperature	−65°C to +150°C
Temperature (Ambient) Under Bias	−55°C to +125°C
Supply Voltage to Ground Potential	
V_{CC}	7.5V
V_{DD}	15V
Maximum Output Current ϕ_1 and ϕ_2 (Note 1)	100mA

ELECTRICAL CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE

The Following Conditions Apply Unless Otherwise Noted:

Am8224XC, Am8224-4XC (COM'L)	T_A = 0°C to +70°C	V_{CC} = 5.0V ± 5%	V_{DD} = 12V ± 5%
Am8224XC (MIL)	T_A = −55°C to +125°C	V_{CC} = 5.0V ± 10%	V_{DD} = 12V ± 10%

Parameters	Description	Test Conditions		Min.	Typ. (Note 2)	Max.	Units
I_F	Input Current Loading	V_F = 0.45V				−0.25	mA
I_R	Input Leakage Current	V_R = 5.25V				10	μA
V_C	Input Forward Clamp Voltage	I_C = −5.0mA	COM'L			−1.0	Volts
			MIL			−1.2	
V_{IL}	Input LOW Voltage	V_{CC} = 5.0V				0.8	Volts
V_{IH}	Input HIGH Voltage	Reset input	COM'L	2.6	2.2		Volts
			MIL	2.8	2.2		
		All other inputs		2.0			
V_{IH}-V_{IL}	$\overline{\text{RESIN}}$ Input Hysteresis	V_{CC} = 5.0V		0.25	0.5		Volts
V_{OL}	Output LOW Voltage	(ϕ_1, ϕ_2), Ready, Reset, $\overline{\text{STSTB}}$ I_{OL} = 2.5mA				0.45	Volts
		All other inputs I_{OL} = 15mA				0.45	
V_{OH}	Output HIGH Voltage	ϕ_1, ϕ_2; I_{OH} = −100μA	COM'L	9.4	11		Volts
			MIL	V_{DD} −1.6V	V_{DD} −1.0V		
		READY, RESET; I_{OH} = −100μA	COM'L	3.6	4.0		
			MIL	3.35	4.0		
		All other outputs; I_{OH} = −1.0mA		2.4	3.0		
I_{SC}	Output Short Circuit Current (All Low Voltage Outputs Only)	V_O = 0V, V_{CC} = 5.0V		−10		−60	mA
I_{CC}	Power Supply Current	V_{CC} = MAX. (Note 3)			70	115	mA
I_{DD}	Power Supply Current	V_{DD} = MAX.			5.0	12	mA

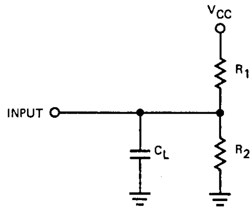
Notes: 1. Caution: ϕ_1 and ϕ_2 outputs do not have short circuit protection.
2. Typical limits are at V_{CC} = 5.0V, V_{DD} = 12V, 25°C ambient and maximum loading.
3. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.

CRYSTAL REQUIREMENTS

Tolerance: .005% at 0°C - 70°C
Resonance: Series (Fundamental)*
Load Capacitance: 20-35pF
Equivalent Resistance: 75-20 ohms
Power Dissipation (Min): 4mW

*With frequency in excess of 18MHz use 3rd overtone XTALs and tank circuit.

TEST CIRCUIT



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AC CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE

Parameters	Description	Test Conditions	Am8224XM Min.	Am8224XM Typ.	Am8224XM Max.	Am8224XC Min.	Am8224XC Typ.	Am8224XC Max.	Am8224-4XC (Note 2) Min.	Am8224-4XC (Note 2) Typ.	Am8224-4XC (Note 2) Max.	Units
$t_{\phi 1}$	ϕ_1 Pulse Width	C_L = 20pF to 50pF	$\frac{2t_{CY}}{9}$ −23ns			$\frac{2t_{CY}}{9}$ −20ns			45			
$t_{\phi 2}$	ϕ_2 Pulse Width		$\frac{5t_{CY}}{9}$ −35ns			$\frac{5t_{CY}}{9}$ −35ns			110			
t_{D1}	ϕ_1 to ϕ_2 Delay		0			0			0			
t_{D2}	ϕ_2 to ϕ_1 Delay		$\frac{2t_{CY}}{9}$ −17ns			$\frac{2t_{CY}}{9}$ −14ns			35			ns
t_{D3}	ϕ_1 to ϕ_2 Delay		$\frac{2t_{CY}}{9}$		$\frac{2t_{CY}}{9}$ +22ns	$\frac{2t_{CY}}{9}$		$\frac{2t_{CY}}{9}$ +20ns	55		76	
t_r	ϕ_1 and ϕ_2 Rise Time				20			20			20	
t_f	ϕ_1 and ϕ_2 Fall Time				20			20			20	
$t_{D\phi 2}$	ϕ_2 to ϕ_2(TTL) Delay	ϕ_2(TTL), C_L = 30pF, R_1 = 300Ω, R_2 = 600Ω	−5.0		15	−5.0		15	−5.0		15	ns
t_{DSS}	ϕ_2 to $\overline{STSTB}$ Delay	$\overline{STSTB}$, C_L = 15pF, R_1 = 2.0kΩ, R_2 = 4.0kΩ	$\frac{6t_{CY}}{9}$ −33ns		$\frac{6t_{CY}}{9}$	$\frac{6t_{CY}}{9}$ −30ns		$\frac{6t_{CY}}{9}$	137		167	
t_{PW}	$\overline{STSTB}$ Pulse Width		$\frac{t_{CY}}{9}$ −18ns			$\frac{t_{CY}}{9}$ −15ns			18			ns
t_{DRS}	RDYIN Set-up Time to Status Strobe		50ns − $\frac{4t_{CY}}{9}$			50ns − $\frac{4t_{CY}}{9}$			−61			
t_{DRH}	RDYIN Hold Time After STSTB		$\frac{4t_{CY}}{9}$			$\frac{4t_{CY}}{9}$			111			
t_{DR}	RDYIN or RESIN to ϕ_2 Delay	Ready and Reset C_L = 10pF, R_1 = 2.0kΩ, R_2 = 4.0kΩ	$\frac{4t_{CY}}{9}$ −25ns			$\frac{4t_{CY}}{9}$ −25ns			86			ns
t_{CLK}	CLK Period			$\frac{t_{CY}}{9}$			$\frac{t_{CY}}{9}$			28		
$f_{Max.}$	Maximum Oscillating Frequency		27			28.12			36			MHz
C_{in}	Input Capacitance	V_{CC} = 5.0V, V_{DD} = 12V, V_{BIAS} = 2.5V, f = 1.0MHz			8.0			8.0			8.0	pF

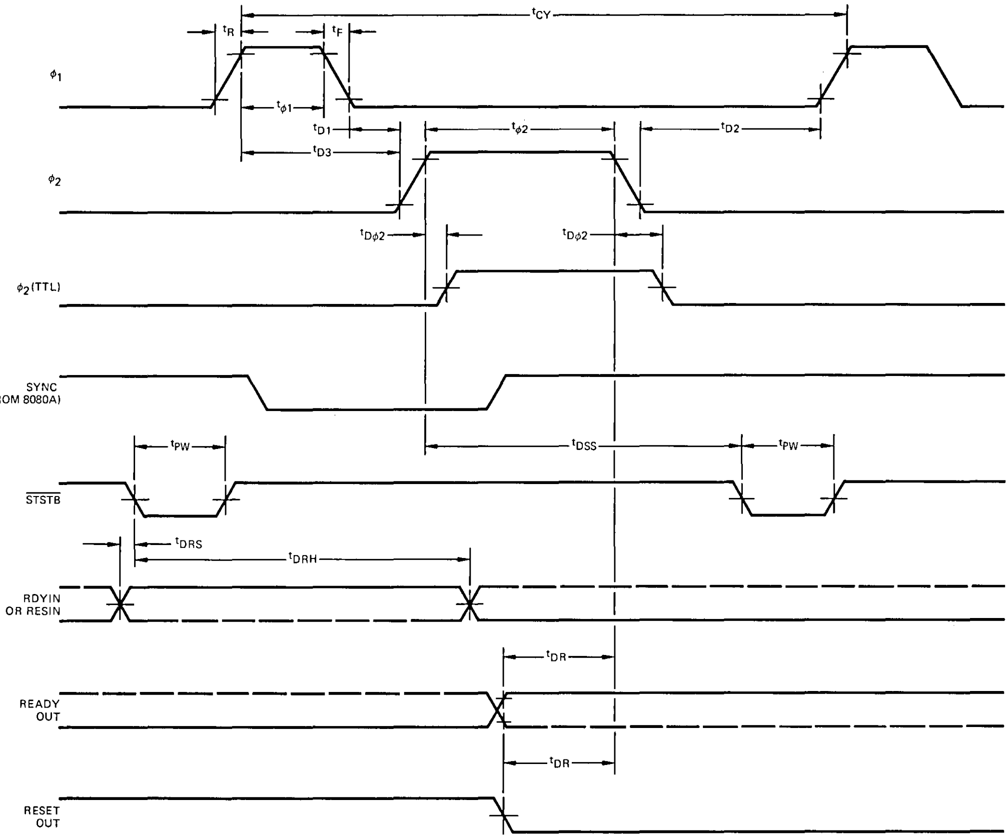
AC CHARACTERISTICS (For t_{CY} = 488.28ns)

T_A = 0°C to +70°C V_{CC} = +5.0V ±5% V_{DD} = +12V ±5%

Parameters	Description	Test Conditions	Min.	Typ.	Max.	Units
$t_{\phi 1}$	ϕ_1 Pulse Width	ϕ_1 and ϕ_2 Loaded C_L = 20 to 50pF	89			ns
$t_{\phi 2}$	ϕ_2 Pulse Width		236			ns
t_{D1}	Delay ϕ_1 to ϕ_2		0			ns
t_{D2}	Delay ϕ_2 to ϕ_1		95			ns
t_{D3}	Delay ϕ_1 to ϕ_2 Leading Edges		109		129	ns
t_r	Output Rise Time				20	ns
t_f	Output Fall Time				20	ns
t_{DSS}	ϕ_2 to $\overline{STSTB}$ Delay		296		326	ns
$t_{D\phi 2}$	ϕ_2 to ϕ_2 (TTL) Delay		−5.0		15	ns
t_{PW}	Status Strobe Pulse Width		40			ns
t_{DRS}	RDYIN Set-up Time to $\overline{STSTB}$	Ready and Reset Loaded C_L = 20 to 50pF R_1 = 2.0kΩ, R_2 = 4.0kΩ	−167			ns
t_{DRH}	RDYIN Hold Time After $\overline{STSTB}$		217			ns
t_{DR}	Ready or Reset to ϕ_2 Delay		192			ns
FREQ	Oscillator Frequency				18.432	MHz

Notes: 1. All measurements referenced to 1.5V unless specified otherwise.
2. Am8224-4 parameter limits are given for t_{CY} = 250ns or an oscillating frequency of 36MHz. Between 28.12MHz and 36MHz min. and max. limits should be ratioed between the calculated Am8224XC limits at 28.12MHz and the given 36MHz parameter limits.

SWITCHING WAVEFORMS



Voltage measurement points: ϕ_1, ϕ_2 Logic "0" = 1.0V, Logic "1" = 8.0V.
All other signals measured at 1.5V.

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Oscillator

The oscillator circuit derives its basic operating frequency from an external, series resonant, fundamental mode crystal. Two inputs are provided for the crystal connections (XTAL1, XTAL2).

The selection of the external crystal frequency depends mainly on the speed at which the CPU is to be run. Basically, the oscillator operates at 9 times the desired processor speed.

The formula to determine the crystal frequency is:

$$f(XTAL) = \frac{1}{t_{CY}} \text{ times } 9$$

When using crystals above 10MHz a small amount of frequency "trimming" is necessary to produce the desired frequency. The addition of a selected capacitance (20pF – 30pF) in series with the crystal will accomplish this function.

Another input to the oscillator is TANK. This input allows the use overtone mode crystals. This type of crystal generally has a much lower output at its rated frequency and has a tendency to oscillate at its fundamental.

To avoid the unwanted oscillation and increase the desired frequency output it is necessary to provide a parallel tuned resonant circuit of low impedance. The external LC network is connected to the TANK input and is AC coupled. See typical application with Am8228 and Am9080A in Figure 2.

The formula for the LC network is:

$$F = \frac{1}{2\pi \sqrt{LC}}$$

The output of the oscillator is buffered and brought out on OSC (pin 12) so that other system timing signals can be derived from this stable, crystal-controlled source.

Clock Generator

The Clock Generator consists of a synchronous "divide by nine" counter and the associated decode gating to create the waveforms of the two clocks and auxiliary timing signals.

The waveforms generated by the decode gating follow a simple 2-5-2 digital pattern. See Figure 2. The clocks generated; ϕ_1 and ϕ_2, can best be thought of as consisting of "units" based on the oscillator frequency. Assume that one "unit" equals the period of the oscillator frequency. By multiplying the number of "units" that are contained in a pulse width or delay, times the period of the oscillator frequency, the approximate time in nanoseconds can be derived.

The outputs of the clock generator are connected to two high level drivers for direct interface to the CPU. A TTL level phase 2 is also brought out ϕ_2 (TTL) for external timing purposes. It is especially useful in DMA dependent activities. This signal is used to gate the requesting device onto the bus once the CPU issues the Hold Acknowledgement (HLDA).

Several other signals are also generated internally so that optimum timing of the auxiliary flip-flops and status strobe ($\overline{STSTB}$) is achieved.

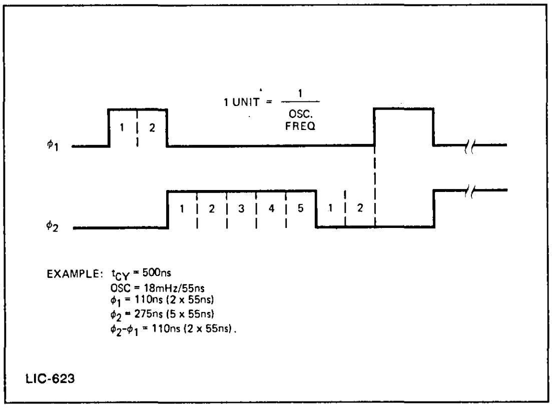

Figure 1. Clock Generator Waveforms.

$\overline{STSTB}$ (Status Strobe)

At the beginning of each machine cycle the CPU issues status information on its data bus. This information tells what type of action will take place during that machine cycle. By bringing in the SYNC signal from the CPU, and gating it with an internal timing signal (ϕ_{1A}), an active low strobe can be derived that occurs at the start of each machine cycle at the earliest possible moment that status data is stable on the bus. The $\overline{STSTB}$ signal connects directly to the Am8228 System Controller.

The power-on Reset also generates $\overline{STSTB}$, but of course, for a longer period of time. This feature allows the Am8228 to be automatically reset without additional pins devoted for this function.

Power-On Reset and Ready Flip-Flops

A common function in microcomputer systems is the generation of an automatic system reset and start-up upon initial power-on. The Am8224 has a built-in feature to accomplish this feature.

An external RC network is connected to the $\overline{RESIN}$ input. The slow transition of the power supply rise is sensed by an internal Schmitt Trigger. This circuit converts the slow transition into a clean, fast edge when its input level reaches a predetermined value. The output of the Schmitt Trigger is connected to a "D" type flip-flop that is clocked with ϕ_{2D} (an internal timing signal). The flip-flop is synchronously reset and an active high level that complies with the microprocessor input spec is generated. For manual switch type system Reset circuits, an active low switch closing can be connected to the RESIN input in addition to the power-on RC network.

The READY input to the CPU has certain timing specifications such as "set-up and hold" thus, an external synchronizing flip-flop is required. The Am8224 has this feature built-in. The RDYIN input presents the asynchronous "wait request" to the "D" type flip-flop. By clocking the flip-flop with ϕ_{2D}, a synchronized READY signal at the correct input level, can be connected directly to the CPU.

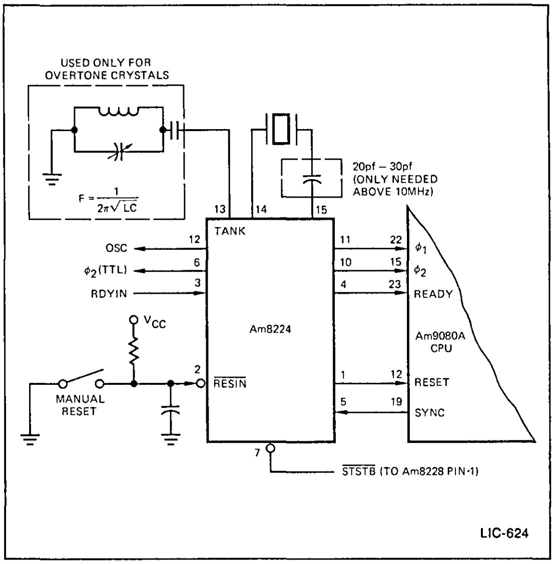

Figure 2. Typical Application with Am8224 and Am9080A.

APPLICATION PRECAUTIONS WHEN USING Am8224 UP TO 36MHz

Usage with Third Harmonic Crystal or Am9080A-4

The use of the Am8224 with a third harmonic crystal requires a minor modification to the external circuitry associated with the Am8224. The changes are as follows:

– Series capacitor in conjunction with the xtal
– Adding a tuned circuit in the "tank" lead
– Tuning of circuit to proper frequency

It is necessary to maintain the crystal activity to a proper level if an xtal controlled circuit is to operate properly. A 20-30pfd capacitor placed in series will help achieve this level in third overtone crystal, while helping to suppress the fundamental mode. The Am8224 has an auxiliary port provided to allow for a tuned circuit. This tuned circuit eliminates the tendency of the circuit to oscillate at the crystal's fundamental. The tank or tuned circuit must have the following properties:

1. It must be parallel resonant at the crystal frequency (third order).
2. The off resonance impedance must be low enough to spoil the AC gain of the Am8224.
3. The circuit must be DC decoupled (or returned to V_{CC}) at a low impedance (substantially below 100Ω).

All frequency determining components must be in close proximity to the Am8224. Insert crystal and tune tank for best waveform at Pin 12 (OSC). If counter is available, adjust for match of crystal marking. The circuit in Figure 3 will accomplish the above result for the 36MHz range.

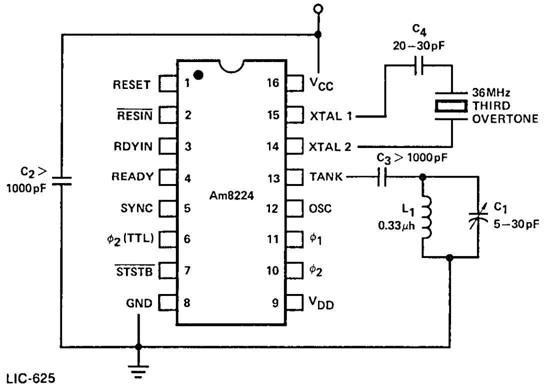

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Figure 3.

C_1 = E.F. Johnson
275-0430-005
5-30pF Trimmer or Equiv.

L_1 = J.W. Miller Inductor
9230-08

V_{CC} Ground

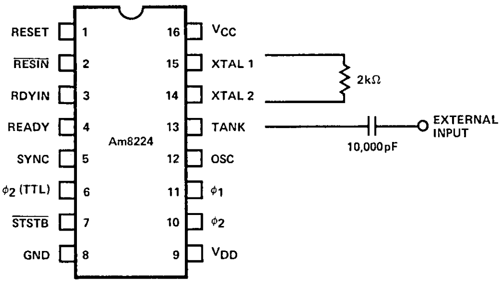
Due to the nature of our device (fast switching, higher voltage) it is necessary to provide a bypass capacitor from V_{CC} to ground in the immediate proximity of the Am8224. This insures proper operation of the device while reducing noise spiking on adjacent circuits.

Resin Bypass

The use of a high impedance capacitor for timing R-C, and/or timing components remotely located from the Am8224 device may cause a disturbance to occur during the linear transition region. The capacitor for this function should be of the ceramic type and a value of 1000pF or greater.

This can be cured by placing a >1000pfd ceramic capacitor from Resin (Pin 2) to Ground (Pin 8) in the immediate proximity of the device. This will allow the timing R-C to be placed at will.

APPLICATIONS



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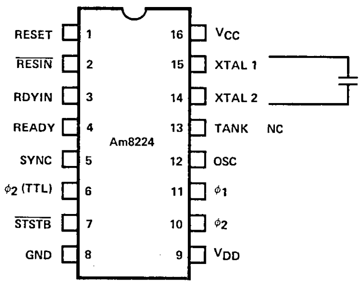
The Am8224 can be driven from an external source of frequency by connecting as shown and driven with approximately 500mV over a wide frequency range.



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The Am8224 can oscillate without a xtal by placing a small value capacitor (10→200pF) in place of a crystal.

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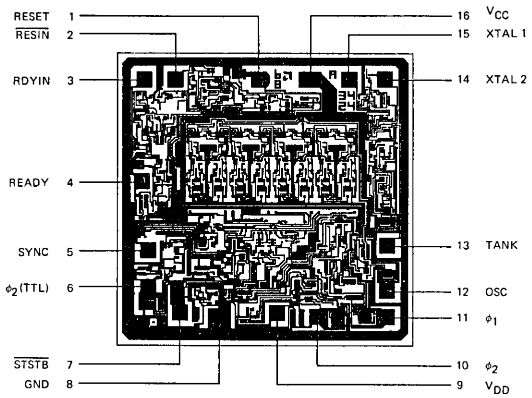
Metallization and Pad Layout



DIE SIZE 0.085" X 0.084"