Am0026/Am0026C

5MHz Two-Phase MOS Clock Driver

Distinctive Characteristics

- 20 ns rise and fall times with 1000 pF load
- 20 V output voltage swing
- ±1.5 amps output current drive
- High speed 5 to 10 MHz depending on load
- 100% reliability assurance testing in compliance with MIL-STD-883

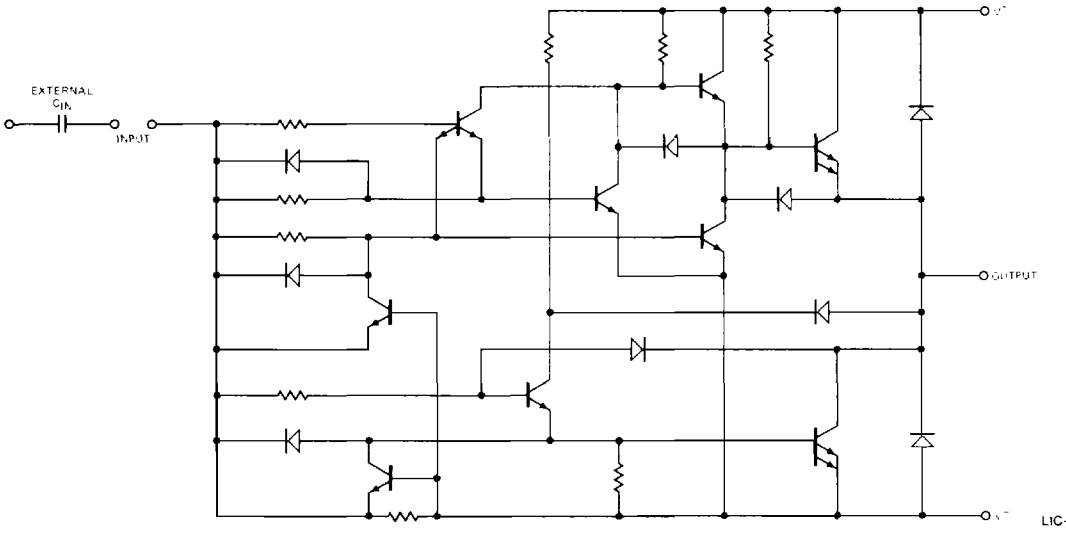
FUNCTIONAL DESCRIPTION

The Am0026 is a dual high speed MOS clock driver and interface circuit. The device is particularly suitable for driving two phase MOS circuits and can provide high speed operation even when driving into high capacitive loads. The device accepts standard TTL/DTL outputs and converts them to MOS logic levels. The output pulse width of the device is determined by the input pulse width.

The Am0026 can operate with a variety of MOS circuits. A popular application is a two-phase clock timer for driving long silicon gate shift registers such as the Am1402/3/4 series. A single clock driver is able to drive 10k bits at 5MHz. The device can also be used with standard dynamic MOS RAMS such as the 1103 to provide address and precharge drive for memories up to 8k by 16-bits.

The device is available in an 8-lead TO-5, one watt copper lead frame 8-pin mini-DIP, a one and one-half watt TO-8 package, and a 14-pin ceramic package.

SCHEMATIC DIAGRAM
(One Driver Shown)

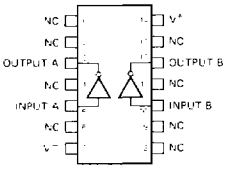


ORDERING INFORMATION

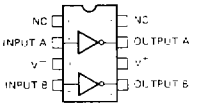
Package Type	Temperature Range	Order Number
TO-99	0°C to 70°C	MH0026CH
Mini-DIP	0°C to 70°C	MH0026CN
TO-8	0°C to 70°C	MH0026CG
Ceramic DIP	0°C to 70°C	MMH0026CL
Dice	0°C to 70°C	AM0026XC
TO-99	–55°C to +125°C	MH0026H
TO-8	–55°C to +125°C	MH0026G
Ceramic DIP	–55°C to +125°C	MMH0026L
Dice	–55°C to +125°C	AM0026XM

CONNECTION DIAGRAMS
Top Views

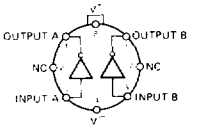
Ceramic DIP



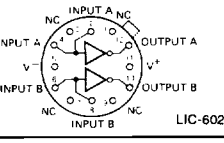
Mini DIP



TO-99



TO-8



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
$V^+ - V^-$ Differential Voltage	22 V
Input Current	100 mA
Input Voltage ($V_{IN} - V^-$)	5.5 V
Peak Output Current	1.5 A
Power Dissipation	See curves

ELECTRICAL CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE (Unless Otherwise Noted)

Am0026C T_A = 0°C to 85°C (COM Range) $V^+ - V^-$ = 10 V to 20 V
Am0026 T_A = −55°C to +125°C (MIL Range) Unless Otherwise Specified

Parameter	Description	Test Conditions (Note 1)	Min.	Typ. (Note 2)	Max.	Units
V_{OH}	Output HIGH Voltage (Logical "0")	V^+ = +5.0 V, V^- = −12.0 V, V_{IN} = −11.6 V	4.0	4.3		Volts
		$V_{IN} - V^-$ = 0.4 V	V^+ −1.0	V^+ −0.7		
V_{OL}	Output LOW Voltage (Logical "1")	V^+ = +5.0 V, V^- = −12.0 V, V_{IN} = −9.5 V		−11.5	−11.0	Volts
		$V_{IN} - V^-$ = 2.5 V		V^- +0.5	V^- +1.0	
V_{IH}	Input HIGH Level	$V_{OUT} = V^-$ +1.0 V	2.5	1.5		Volts
V_{IL}	Input LOW Level	$V_{OUT} = V^+$ −1.0 V		0.6	0.4	Volts
I_{IL}	Input LOW Current	$V_{IN} - V^-$ = 0 V, $V_{OUT} = V^+$ −1.0 V		−0.005	−10	μA
I_{IH}	Input HIGH Current	$V_{IN} - V^-$ = 2.5 V, $V_{OUT} = V^-$ +1.0 V		10	15	mA
$I_{CC\,ON}$	"ON" Supply Current	$V^+ - V^-$ = 20 V, $V_{IN} - V^-$ = 2.5 V		30	40	mA
$I_{CC\,OFF}$	"OFF" Supply Current	$V^+ - V^-$ = 20 V, $V_{IN} - V^-$ = 0.0 V	COM'L	10	100	μA
			MIL	50	500	

Notes: 1. These specifications apply for $V^+ - V^-$ = 10 V to 20 V, C_L = 1000 pF, over the temperature range −55°C to +125°C for the Am0026 and 0°C to +85°C for the Am0026C.
2. All typical values for T_A = 25°C.

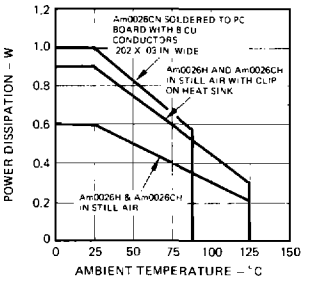
Switching Characteristics (Notes 1 and 2 Above)

Parameter	Description	Test Conditions	Min.	Typ.	Max.	Units
t_{PHL}	Turn On Delay		5.0	7.5	12	ns
t_{PLH}	Turn Off Delay		5.0	12	15	ns
t_r	Rise Time (Note 3)	$V^+ - V^-$ = 17 V, C_L = 250 pF		12		ns
		$V^+ - V^-$ = 17 V, C_L = 500 pF		15	18	
		$V^+ - V^-$ = 17 V, C_L = 1000 pF		20	35	
t_f	Fall Time (Note 3)	$V^+ - V^-$ = 17 V, C_L = 250 pF		10		ns
		$V^+ - V^-$ = 17 V, C_L = 500 pF		12	16	
		$V^+ - V^-$ = 17 V, C_L = 1000 pF		17	25	

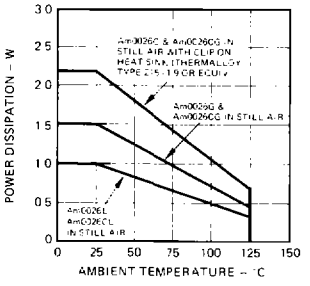
Note: 3. Rise and fall times are given for MOS logic levels; i.e., rise time is transition from logic "0" to logic "1" which is voltage fall. See switching time waveforms.

TYPICAL PERFORMANCE CHARACTERISTICS

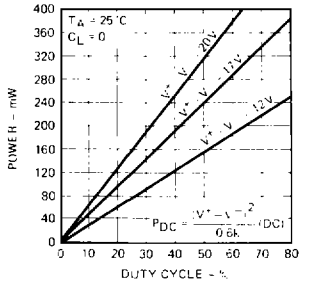
Power Ratings TO-5 & 8-Pin DIP



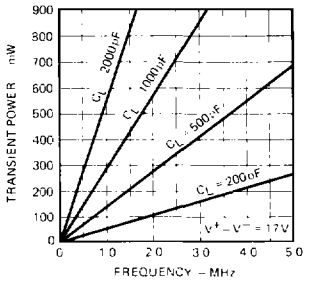
Power Rating TO-8 & 14-Pin DIP



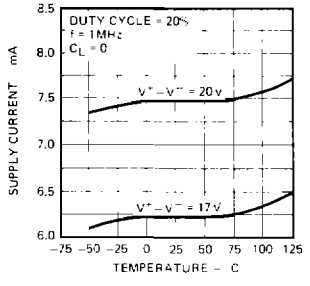
DC Power (P_{DC}) Versus Duty Cycle



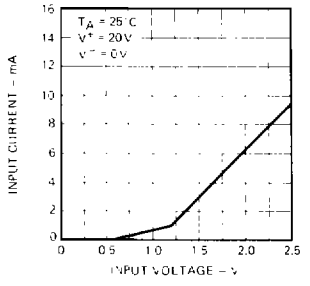
Transient Power (P_{AC}) Versus Frequency



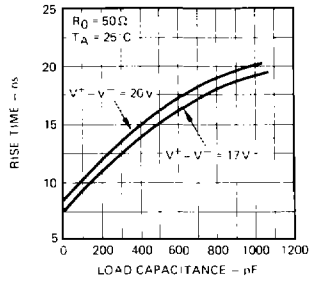
Supply Current Versus Temperature



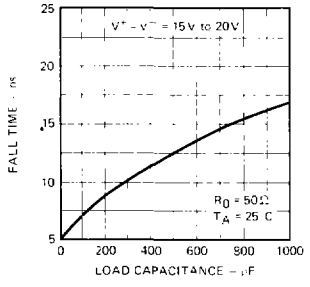
Input Current Versus Input Voltage



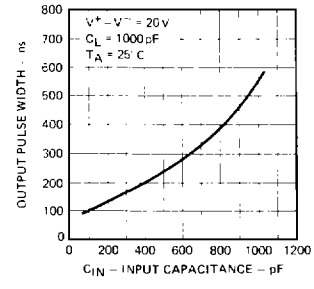
Rise Time Versus Load Capacitance



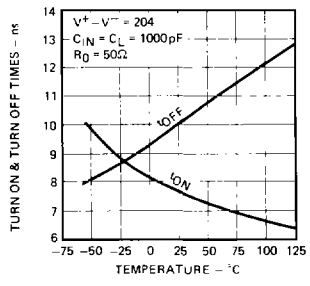
Fall Time Versus Load Capacitance



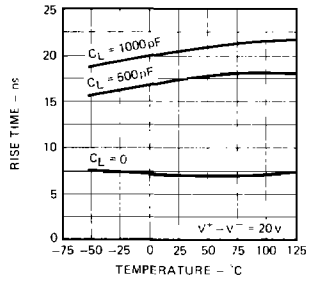
Optimum Input Capacitance Versus Output Pulse Width



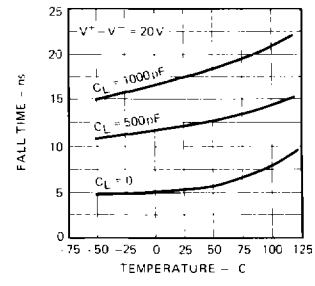
Turn-On & Turn-Off Time Versus Temperature



Rise Time Versus Temperature



Fall Time Versus Temperature



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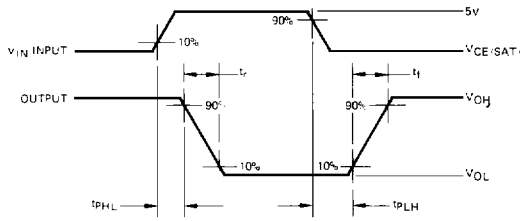
SWITCHING TIME WAVEFORMS



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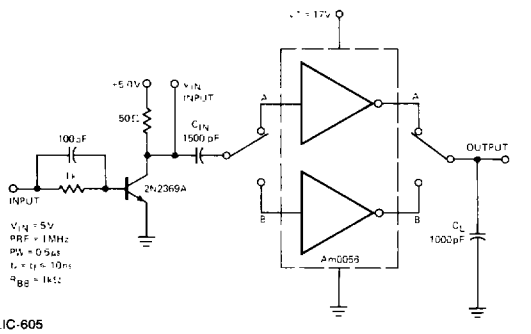
AC TEST CIRCUIT



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APPLICATION INFORMATION

POWER DISSIPATION

The total average power dissipation of the Am0026 is the sum of the DC power and AC transient power. This total must be less than the given package power rating.

$$P_{DISS} = P_{AC} + P_{DC} \leqslant P_{MAX.}$$

With the device dissipating only 2 mW when the output is at a HIGH voltage (MOS logic "0"), the dominant factor in average DC power is the duty cycle or fraction of the time the output is at a LOW voltage level (MOS logic "1"). For the shift register driving where the duty cycle is less than 25%, P_{DC} is usually negligible. For RAM address line driver applications P_{DC} dominates since duty cycle can exceed 50%.

DC Power per driver:

DC power is given by,

$$P_{DC} = (V^+ - V^-) \times I_{S(LOW)} \times \text{Duty Cycle}$$

where $I_{S(LOW)}$ is $I_{SUPPLY(ON)}$ at $(V^+ - V^-)$

$$I_{SUPPLY(ON)} \text{ is } 40\,mA \times \frac{(V^+ - V^-)}{20\,V} \text{ worst case}$$

$$\text{or } 30\,mA \times \frac{(V^+ - V^-)}{20\,V} \text{ typically}$$

AC transient power per driver:

AC transient power is given by,

$$P_{AC} = (V^+ - V^-)^2 \times C_L \times f \times 10^{-3} \text{ in mW}$$

where f = frequency of operation in MHz and C_L = load capacitance including all strays and wiring in pF.

PACKAGE SELECTION

Power ratings are based on a maximum junction rating of 175°C. The following guidelines are suggested for package selection. Graphs shown in the Performance Curves illustrate derating for various operating temperatures.

TO-5 ("H") Package: Rated at 600 mW in still air (derate at 4.0 mW/°C above 25°C) and rated at 900 mW with clip-on heat sink (derate at 6.0 mW/°C above 25°C). This popular hermetic package is recommended for small systems. Low cost (about 10¢) clip-on-heat sink increases driving power dissipation capability by 50%.

8-pin ("N") Molded Mini-DIP: Rated at 600 mW still air (derate at 4.0 mW/°C above 25°C) and rated at 1.0 watt soldered to PC board (derate at 6.6 mW/°C). Constructed with a special copper lead frame, this package is recommended for medium size commercial systems particularly where automatic insertion is used. (Please note for prototype work, that this package is only rated at 600 mW when mounted in a socket and not one watt until it is soldered down.)

$$C_L \text{ (max.)} = \frac{10^3}{n} \frac{(P_{max.} \text{ Req} - 10^3 n (V^+ - V^-)^2 \text{ Duty Cycle})}{\text{Req } (V^+ - V^-)^2 \times f}$$

where n is the number of drivers used in the package.

$P_{max.}$ is the package power rating in milliwatts for given package, heat sink, and maximum ambient temperature.

Req is the equivalent resistance $(V^+ - V^-)/I_{S(LOW)} = 500\,\Omega$ (worst case over temperature or 600 Ω (typically).

Duty cycle is the fraction of the time that the output signal is in the LOW state.

f is the input signal frequency in MHz.

$C_{L(max.)}$ is the maximum load capacitance per driver in picofarads which can be driven without exceeding device power limits.

When used as a non-overlapping two phase driver with each side operating at the same frequency and duty cycle, and with $(V^+ - V^-)$ -17 V, the above equation simplifies to

$$C_L = \frac{10^3}{f}\left[\frac{P_{max.}}{578} - \text{Duty Cycle}\right]$$

Table I gives maximum drive capability for various system conditions using the above equation.

PULSE WIDTH CONTROL

The Am0026 is intended for applications in which the input pulse width sets the output pulse width; i.e., the output pulse width is logically controlled by the input pulse. The output pulse width is given by:

$$(PW)_{OUT} = (PW)_{IN} + t_f = PW_{IN} + 25\,ns$$

Two external input coupling capacitors are required to perform the level translation between TTL/DTL and MOS logic levels. Selection of the capacitor size is determined by the desired output pulse width. Minimum delay and optimum performance is attained when the voltage at the input of the Am0026 discharges to just above the devices threshold (about 1.5 V). If the input is allowed to discharge below the threshold, t_r and t_f will be degraded. The graph in the Performance Curves shows optimum values for C_{IN} versus desired output pulse width. The value for C_{IN} may be roughly predicted by:

$$C_{IN} = (2 \times 10^{-3})\ (PW)_{OUT}$$

For an output pulse width of 500 ns, the optimum value for C_{IN} is:

$$C_{IN} = (2 \times 10^{-3})\ (500 \times 10^{-9}) = 1000\,pF$$

RISE AND FALL TIME CONSIDERATIONS (Note 3)

The Am0026's peak output current is limited to 1.5 A. The peak current limitation restricts the maximum load capacitance which the device is capable of driving and is given by:

$$I = C_L \frac{dv}{dt} \leqslant 1.5\ A$$

The rise time, t_r, for various loads may be predicted by:

$$t_r = (\Delta V)\ \ (250 \times 10^{-12} + C_L)$$

Where: ΔV = the change in voltage across C_L

$$\cong V^+ - V^-$$

C_L = *The load capacitance*

for $V^+ - V^- = 20\,V$, $C_L = 1000\,pF$, t_r is:

$$t_r \cong (20\ V)\ \ (250 \times 10^{-12} + 1000 \times 10^{-12})$$

$$= 25\ ns$$

For small values of C_L, the equation above predicts optimistic values for t_r. The graph in the performance curves shows typical rise times for various load capacitances.

The output fall time (see Graph) may be predicted by:

$$t_f \cong 2.2\ R \left(C_S + \frac{C_L}{h_{FE} + 1} \right)$$

CLOCK OVERSHOOT

The output waveform of the Am0026 can overshoot. The overshoot is due to finite inductance of the clock lines. It occurs on the negative going edge when Q_7 saturates, and on the positive edge when Q_3 turns OFF as the output goes through $V^+ - V_{be}$. The problem can be eliminated by placing a small series resistor in the output of the Am0026. The critical valve for $R_S = 2\sqrt{L/C_L}$ where L is the self-inductance of the clock line. In practice, determination of a value for L is rather difficult. However, R_S is readily determined emperically, and values typically range between 10 and 51Ω. R_S does reduce rise and fall times as given by:

$$t_r = t_r \cong 2.2 R_S\ C_L$$

CLOCK LINE CROSS TALK

At the system level, voltage spikes from ϕ_1 may be transmitted to ϕ_2 (and vice-versa) during the transition of ϕ_1 to MOS logic "1". The spike is due to mutual capacitance between clock lines and is, in general, aggravated by long clock lines when numerous registers are being driven. Transistors Q_3 and Q_4 *on the* ϕ_2 *side of the Am0026 are essentially "OFF" when* ϕ_2 is in the MOS logic "0" state since only micro-amperes are drawn from the device. When the spike is coupled to ϕ_2, the output has to drop at least $2\,V_{BE}$ before Q_3 and Q_4 come on and pull the output back to V^+. A simple method for eliminating or minimizing this effect is to add bleed resistors between the Am0026 outputs and ground causing a current of a few milliamps to flow in Q_4. When a spike is coupled to the clock line Q_4 is already "ON" with a finite h_{fe}. The spike is quickly clamped by Q_4. Values for R depend on layout and the number of registers being driven and vary typically between 2 k and 10 kΩ.

POWER SUPPLY DECOUPLING

Adequate power supply decoupling is necessary for satisfactory operation. Decoupling of V^+ to V^- supply lines with at least 0.1 μF noninductive capacitors as close as possible to each Am0026 is strongly recommended. This decoupling is necessary because otherwise 1.5 ampere currents flow during logic transition in order to rapidly charge clock lines.

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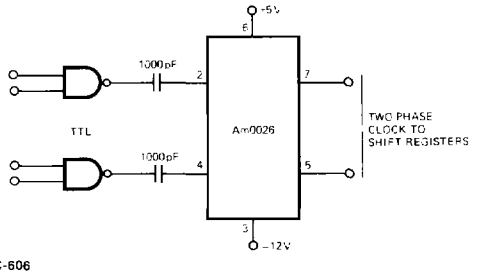
TABLE I – WORST CASE MAXIMUM DRIVE CAPABILITY FOR Am0026*

Package Type		TO-8 with Heat Sink		TO-8 Free Air		Mini-DIP Soldered Down		TO-5 and Mini-DIP Free Air		14-Pin DIP Soldered Down
Max. Operating Frequency	Max. Ambient Temp. / Duty Cycle	60°C	85°C	60°C	85°C	60°C	85°C	60°C	85°C	70°C
100kHz	5%	30k	24k	19k	15k	13k	10k	7.5k	5.1k	11k
500kHz	10%	6.5k	5.1k	4.1k	3.2k	2.5k	1.9k	1.4k	1.1k	2k
1MHz	20%	2.9k	2.2k	1.8k	1.4k	1.1k	840	600	420	860
2MHz	25%	1.4k	1.1k	850	650	540	400	280	190	390
5MHz	25%	620	470	380	290	220	160	110	75	165
10MHz	25%	280	220	170	130	110	79	55	37	90

*Note Values in pF and assume both sides in use as non-overlapping 2 phase driver, each side operating at same frequency and duty cycle with $(V^+ - V^-) = 17\,V$

TYPICAL APPLICATIONS

AC Coupled MOS Clock Driver



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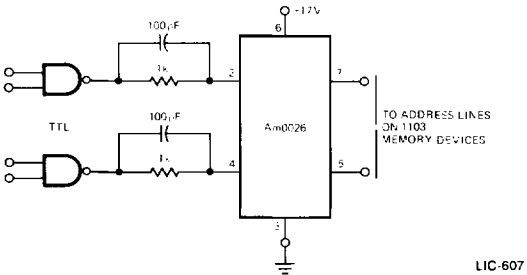
DC Coupled RAM Memory Address or Precharge Driver (Positive Supply Only)



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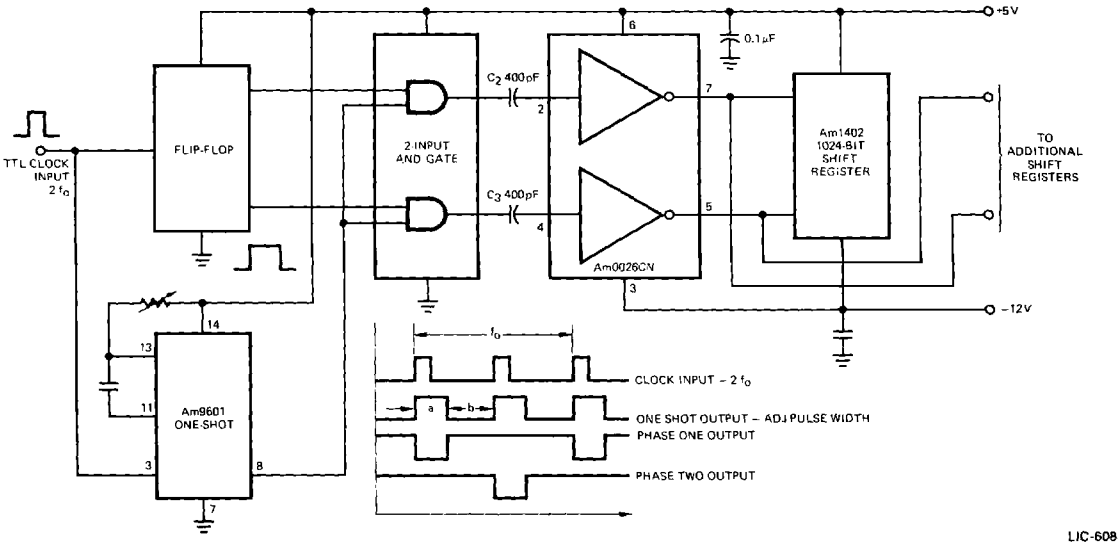
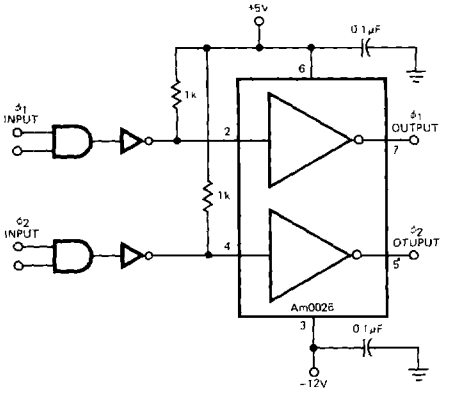
TYPICAL APPLICATIONS (Cont.)

Logically Controlled AC Coupled Clock Driver



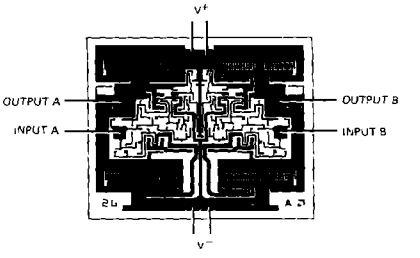
LIC-608

DC Coupled MOS Clock Driver



LIC-609

Metallization and Pad Layout



DIE SIZE 0.063" X 0.078"