LOW-POWER MONOSTABLE/ ASTABLE MULTIVIBRATOR

GENERAL DESCRIPTION

The MMC 4047 is a monolithic integrated circuit processed in standard Al-gate CMOS technology available in 14 lead dual in-line package. The MMC 4047 consists of a gatable astable multivibrator with logic techniques incorporated to permit positive or negative edge-triggered monostable multivibrator action with retriggering and external counting options. Inputs include +TRIGGER,-TRIGGER, ASTABLE, $\overline{\text{ASTABLE}}$, RETRIGGER and EXTERNAL RESET. Buffered outputs are Q,$\overline{Q}$ and OSCILLATOR. In all modes of operation, an external capacitor must be connected between C-Timing and C-Common terminals, and an external resistor must be connected between the R-Timing and RC-Common terminals.

FEATURES

- Low-power consumption: special CMOS oscillator configuration
- Monostable (one-shot) or astable (free-runing) operation
- True and complemented buffered outputs
- Only one external R and C required
- Buffered inputs

ABSOLUTE MAXIMUM RATINGS

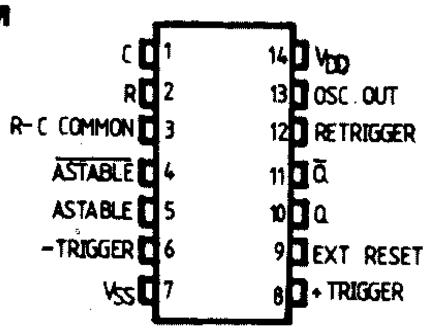
V_{DD}*	Supply voltage: G and H types	-0.5 to	20	V
	E and F types	-0.5 to	18	V
V_i	Input voltage	-0.5 to	V_{DD}+0.5	V
I_I	DC input current (any one input)		±10	mA
P_{tot}	Total power dissipation (per package)		200	mW
	Dissipation per output transistor for T_A = full package-temperature range		100	mW
T_A	Operating temperature: G and H types	-55 to	125	°C
	E and F types	-40 to	85	°C
T_{stg}	Storage temperature	-65 to	150	°C

* All voltage values are referred to V_{SS} pin voltage

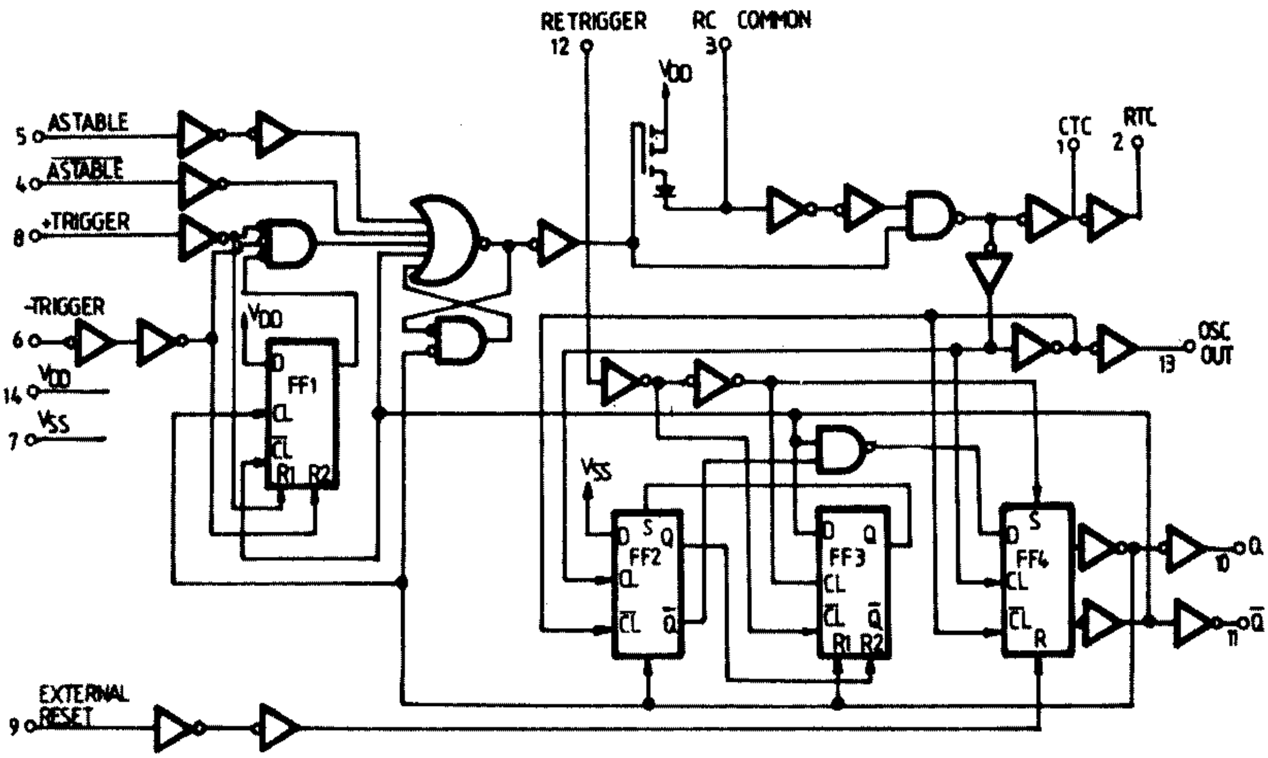
RECOMMENDED OPERATING CONDITIONS

V_{DD}*	Supply voltage: G and H types	3 to	18	V
	E and F types	3 to	15	V
V_i	Imput voltage	0 to	V_{DD}	V
T_A	Operating temperature: G and H types	-55 to	125	°C
	E and F types	-40 to	85	°C

CONNECTION DIAGRAM



LOGIC DIAGRAM



FUNCTIONAL TERMINAL CONNECTIONS

FUNCTION*	TERMINAL CONNECTIONS			OUTPUT PULSE FROM	OUTPUT PERIOD OR PULSE WIDTH
	TO V_{DD}	TO V_{SS}	INPUT PULSE TO		
Astable multivibrator:					
Free running	4, 5, 6, 14	7, 8, 9, 12	—	10,11, 13	t_A(10, 11)=4.40 RC
True gating	4, 6, 14	7, 8, 9, 12	5	10, 11, 13	tA(13)=2.20 RC
Complement gating	6, 14	5, 7, 8, 9, 12	4	10, 11, 13	
Monostable multivibrator:					
Positive-edge trigger	4, 14	5, 6, 7, 9, 12	8	10, 11	
Negative-edge trigger	4, 8, 14	5, 7, 9, 12	6	10, 11	
Retriggerable	4, 14	5, 6, 7, 9	8, 12	10, 11	t_M(10, 11)=2.48 RC
External countdown**	14	5, 6, 7, 8, 9, 12	—	10, 11	

* In all cases external capacitor and resistor between pins 1, 2 and 3 (see logic diagrams)
** Input pulse to reset of external counting chip.
External counting chip output to pin 4

STATIC ELECTRICAL CHARACTERISTICS

(over recommended operating conditions)

Parameter			Test conditions V_I (V)	V_O (V)	$\|I_O\|$ (µA)	V_{DD} (V)	T_{LOW}* min.	T_{LOW}* max.	25°C min.	25°C typ	25°C max.	T_{HIGH}* min.	T_{HIGH}* max.	Unit
I_L	Quiescent current	G, H types	0/ 5			5		1		0.02	1		30	µA
			0/10			10		2		0.02	2		60	
			0/15			15		4		0.02	4		120	
			0/20			20		20		0.04	20		600	
		E, F types	0/ 5			5		4		0.02	4		30	
			0/10			10		8		0.02	8		60	
			0/15			15		16		0.02	16		120	
V_{OH}	Output high voltage		0/ 5		< 1	5	4.95		4.95			4.95		V
			0/10		< 1	10	9.95		9.95			9.95		
			0/15		< 1	15	14.95		14.95			14.95		
V_{OL}	Output low voltage		5 /0		< 1	5		0.05			0.05		0.05	V
			10/0		< 1	10		0.05			0.05		0.05	
			15/0		< 1	15		0.05			0.05		0.05	
V_{IH}	Input high voltage			0.5/4.5	< 1	5	3.5		3.5			3.5		V
				1/9	< 1	10	7		7			7		
				1.5/13.5	< 1	15	11		11			11		
V_{IL}	Input low voltage			4.5/0.5	< 1	5		1.5			1.5		1.5	V
				9/1	< 1	10		3			3		3	
				13.5/1.5	< 1	15		4			4		4	
I_{OH}	Output drive current	G, H types	0/ 5	2.5		5	−2		−1.6	−3.2		−1.15		mA
			0/ 5	4.6		5	−0.64		−0.51	−1		−0.36		
			0/10	9.5		10	−1.6		−1.3	−2.6		−0.9		
			0/15	13.5		15	−4.2		−3.4	−6.8		−2.4		
		E, F types	0/ 5	2.5		5	−1.53		−1.36	−3.2		−1.1		
			0/ 5	4.6		5	−0.52		−0.44	−1		−0.36		
			0/10	9.5		10	−1.3		−1.1	−2.6		−0.9		
			0/15	13.5		15	−3.6		−3.0	−6.8		−2.4		
I_{OL}	Output sink current	G, H types	0/ 5	0.4		5	0.64		0.51	1		0.36		mA
			0/10	0.5		10	1.6		1.3	2.6		0.9		
			0/15	1.5		15	4.2		3.4	6.8		2.4		
		E, F types	0/ 5	0.4		5	0.52		0.44	1		0.36		
			0/10	0.5		10	1.3		1.1	2.6		0.9		
			0/15	1.5		15	3.6		3.0	6.8		2.4		
I_{IH}, I_{IL}	Input leakage current	G, H types	0/18	Any input		18		±0.1		$\pm10^{-5}$	±0.1		±1	µA
		E, F types	0/15			15		±0.3		$\pm10^{-5}$	±0.3		±1	
C_I	Input capacitance			Any input						5	7.5			pF

* T_{LOW} = −55°C for G, H devices; −40°C for E, F devices.
* T_{HIGH} = +125°C for G, H devices; +85°C for E, F devices.

The Noise Margin for both "1" and "0" level is:

1 V min. with V_{DD} = 5 V
2 V min. with V_{DD} = 10 V
2.5 V min. with V_{DD} = 15 V

DYNAMIC ELECTRICAL CHARACTERISTICS

(T_A = 25°C, C_L = 15 pF, R_L = 200 kohm, typical temperature coefficient for all V_{DD} values is 0.3%/°C, all input rise and fall times = 20 ns)

PARAMETER			TEST CONDITIONS V_{DD} (V)	VALUES min.	VALUES typ.	VALUES max	UNIT
t_{PLH}, t_{PHL}	Propagation delay time	Astable, $\overline{Astable}$ to osc. out	5 10 15		200 100 80	400 200 160	ns
		Astable, $\overline{Astable}$ to Q, $\overline{Q}$	5 10 15		350 175 125	700 350 250	ns
		+ or − Trigger to Q, $\overline{Q}$	5 10 15		500 225 150	1000 450 300	ns
		Retrigger to Q, $\overline{Q}$	5 10 15		300 150 100	600 300 200	ns
		External Reset to Q, $\overline{Q}$	5 10 15		250 100 70	500 200 140	ns
t_{THL}, t_{TLH}	Transition time osc. out Q, $\overline{Q}$		5 10 15		100 50 40	200 100 80	ns
t_W	Input pulse width:	+Trigger, −Trigger	5 10 15		200 80 50	400 160 100	ns
		Reset	5 10 15		100 50 30	200 100 60	ns
		Retrigger	5 10 15		300 115 75	600 230 150	ns
t_r, t_f	Input rise and fall time All inputs		5 10 15	Unlimited			µs
	Q or $\overline{Q}$ deviation from 50% Duty factor		5 10 15		±0.5 ±0.5 ±0.1	±1 ±1 ±0.5	%

APPLICATION INFORMATION

1 - Circuit description

Astable operation is enabled by a high level on the ASTABLE input. The period of the square wave at the Q and $\overline{Q}$ Outputs in this mode of operation is a function of the external components employed. „True" input pulses on the ASTABLE input or „Complement" pulses on the $\overline{ASTABLE}$ input alow the circuit to be used as a gatable multivibrator. The OSCILLATOR output period will be half of the Q terminal output in the astable mode However, a 50% duty cycle is not guaranteed at this output. In the monostable mode, positive-edge triggering is accomplished by application of a leading-edge pulse to the +TRIGER input and a low level to the −TRIGGER input. For negative-edge triggering, a trailing-edge pulse is applied to the −TRIGGER and a high level is applied to the +TRIGGER. Input pulses may be of any duration relative to the output pulse.

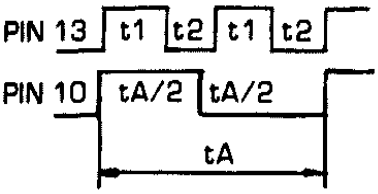
The multivibrator can be retriggered (on the leading edge only) by applying a common pulse to both the RETRIGGER and +TRIGGER inputs. In this mode the output pulse remains high as long as the input pulse period is shorter than the period determined by the RC components. An external countdown option can be implemented by coupling „Q" to an external „N" counter and resetting the counter with the trigger pulse. The

counter output pulse is fed back to the $\overline{\text{ASTABLE}}$ input and has a duration equal to N times the period of the multivibrator. A high level on the EXTERNAL RESET input assures no output pulse during an „ON" power condition. This input can also be activated to terminte the output pulse at any time. In the monostable mode, high-level or power-on reset pulse, must be applied to the EXTERNAL RESET whenever V_{DD} is applied.

2 - Astable Mode

The following anlysis presents worst-case variations from unit-to-unit as a function of transfer-voltage (V_{TR}) shift (33%—67% V_{DD}) for free-running (astable) operation.

Astable mode waveforms



$$t1 = -RC \ln \frac{V_{TR}}{V_{DD} + V_{TR}}$$

$$t2 = -RC \ln \frac{V_{DD} - V_{TR}}{2V_{DD} - V_{TR}}$$

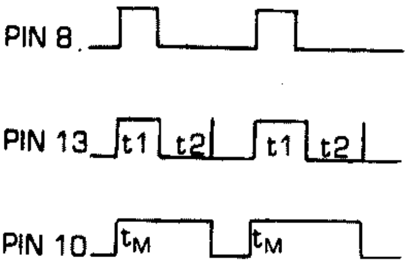
$$t_A = 2(t1 + t2) = -2RC \ln \frac{(V_{TR})(V_{DD} - V_{TR})}{(V_{DD} - V_{TR})(2V_{DD} - V_{TR})}$$

Typ: $V_{TR} = 0.5\ V_{DD}$ $t_A = 4.40\ RC$
Min: $V_{TR} = 0.33\ V_{DD}$ $t_A = 4.62\ RC$
Max: $V_{TR} = 0.67\ V_{DD}$ $t_A = 4.62\ RC$
thus if $t_A = 4.40\ RC$ is used, the maximum variation will be (+5.0%, − 0.0%) In addition to variations from unit-to-unit, the astable period may vary as a function of frequency with respect to V_{DD} and temperature.

3 - Monostable Mode

The following analysis presents worst-case variations from unit-to-unit as a function of transfer-voltage (V_{TR}) shift (33%—67% V_{DD}) for one-shot (monostable) operation.

Monostable waveforms



$$t1 = -RC \ln \frac{V_{TR}}{V_{DD} + V_{DD}}$$

$$t2 = -RC \ln \frac{V_{DD} - V_{TR}}{2V_{DD} - V_{TR}}$$

$$tM = (t1 + t2) = -RC \ln \frac{(V_{TR})(V_{DD} - V_{TR})}{(2V_{DD} - V_{TR})(2V_{DD})}$$

where t_M = monostable mode pulse width. Values for t_M are as follows:
Typ: $V_{TR} = 0.5\ V_{DD}$ $t_M = 2.48\ RC$
Min: $V_{TR} = 0.33\ V_{DD}$ $t_M = 2.71\ RC$
Max: $V_{TR} = 0.67\ V_{DD}$ $t_M = 2.48\ RC$
Thus if $t_M = 2.48\ RC$ is used, the maximum variation will be (+9.3% − 0.0%)

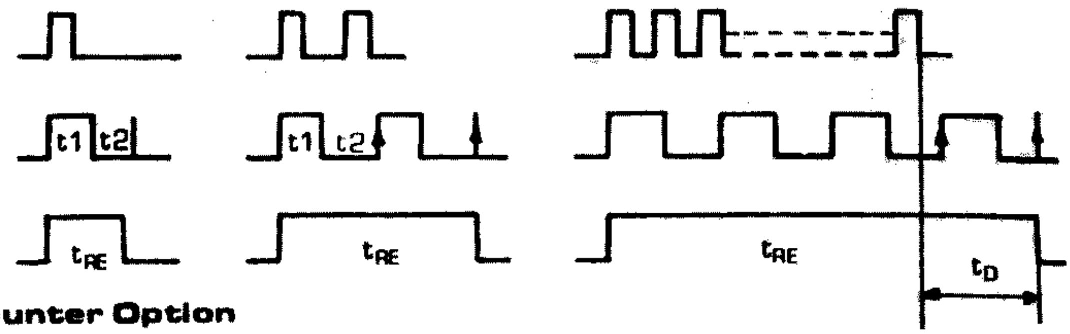
Note: In the astable mode the first positive half cycle has a duration of T_M; succeding durations are $t_A/2$. In addition to variations from unit-to-unit, the monostable pulse width may vary as a function of frequency with respect to V_{DD} and temperature.

4 - Retrigger mode

The MMC 4047 can be used in the retrigger mode to extend the output-pulse duration, or to compare the frequency of an input signal with that of the internal oscillator. In the retrigger mode the input pulse is applied to terminals 8 and 12, and the output is taken from terminal 10 or 11. As shown in Fig. A normal monostable action is obtained when one retrigger pulse is applied. For two input pulses, $t_{RE} = t_{11} + t_1 + 2t_2$.

For more than two pulses, t_{RE}(Q OUTPUT) terminates at some variable time t_D after the termination of the last retrigger pulse. t_D is variable because t_{RE}(Q OUTPUT) terminates after the second positive edge of the oscillator output appears at flip-flop 4 (see logic diagram).

Fig. A' Retrigger-mode waveforms



5-External Counter Option

Time t_M can be extended by any amount with the use of external counting circuitry. Advantages include digitally controlled pulse duration small timing capacitors for long time periods and extremely fast recovery time.
A typical implementation is shown in Fig. B. The pulse duration at the output is

$$t_{ext} = (N-1)t_A + (t_M + t_A/2)$$

where t_{ext} = pulse duration of the circuitry, and N is the number of counts used.

6-Power Consumption

In the standby mode (Monostable or Astable), power dissipation will be a function of leakage current in the circuit, as shown in the static electrical characteristics. For dynamic operation, the power needed to charge the external timing capacitor C is given by the following formula:
Astable Mode: $P = 2CV^2f$. (Output at Pin 13)
$P = 4CV^2f$. (Output at Pin 10 and 11)
Monostable Mode: $P = (1/T)(2.9\ CV^2)$ (Duty Cycle). (Output at Pin 10 and 11) The circuit is designed so that most of the total power is consumed in the external components. In practice, the lower the values of frequency and voltage used, the closer the actual power dissipation will be to the calculated value.
Because the power dissipation does not depend on R, a design for minimum power dissipation would be a small value of C. The value of R would depend on the desired period (within the limitations discussed above).

7 - Timing-component limitations

The capacitor used in the circuit should be non-polarized and have low leakage (i.e. the parallel resistance of the capacitor should be an order of magnitude greater than the external resistor used). There is no upper or lower limit for either R or C value to maintain oscillation. However, in consideration of accuracy, C must be much larger than the inherent stray capacitance in the system (unless this capacitance can be measured and taken into account). R must be much larger than the CMOS "ON" resistance in series with it, which typically is hundreds of ohms. In addition, with very large values of R, some short-term instability with respect to time may be noted.
The rectomended values for these components to maintain agreement with previously calculated formulas without trimming should be:
C ≥ 100 pF, up to any practical value, for astable modes;
C ≥ 1000 pF, up to any practical value, for monostable modes. 10k ≤ R ≤ 1M.

Fig. B' Implementation of external counter option