CY7C470
CY7C472
CY7C474

CYPRESS SEMICONDUCTOR

8K x 9 FIFO, 16K x 9 FIFO, 32K x 9 FIFO with Programmable Flags

Features

- 8K x 9, 16K x 9, and 32K x 9 FIFO buffer memory
- Asynchronous read/write
- High-speed 33.3-MHz read/write independent of depth/width
- Low operating power
  - I_{CC} (max.) = 160 mA (commercial)
  - I_{CC} (max.) = 165 mA (military)
- Programmable Almost Full/Empty flag
- Empty, Almost Empty, Half Full, Almost Full, and Full status flags
- Programmable retransmit
- Expandable in width
- 5V ± 10% supply
- TTL compatible
- Three-state outputs
- Proprietary 0.8-micron CMOS technology

Functional Description

The CYC47X FIFO series consists of high-speed, low-power, first-in first-out (FIFO) memories with programmable flags and retransmit mark. The CY7C470, CY7C472, and CY7C474 are 8K, 16K, and 32K words by 9 bits wide, respectively. They are offered in 600-mil DIP, PLCC, and LCC packages. Each FIFO memory is organized such that the data is read in the same sequential order that it was written. Three status pins—Empty/Full ($\overline{E/F}$), Programmable Almost Full/Empty ($\overline{PAFE}$), and Half Full ($\overline{HF}$)—are provided to the user. These pins are decoded to determine one of six states: Empty, Almost Empty; Less than Half Full, Greater than Half Full, Almost Full, and Full.

The read and write operations may be asynchronous; each can occur at a rate of 33.3 MHz. The write operation occurs when the write ($\overline{W}$) signal goes LOW. Read occurs when read ($\overline{R}$) goes LOW. The nine data outputs go into a high-impedance state when $\overline{R}$ is HIGH.

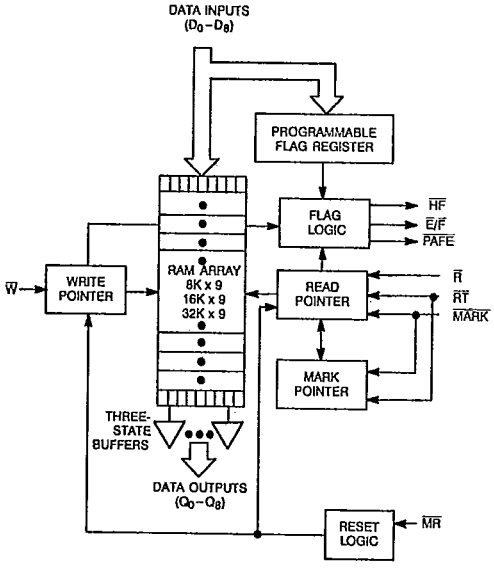
The user can store the value of the read pointer for retransmit by using the $\overline{MARK}$ pin. A LOW on the retransmit ($\overline{RT}$) input causes the FIFO to resend data by resetting the read pointer to the value stored in the mark pointer.

In the standalone and width expansion configurations, a LOW on the retransmit ($\overline{RT}$) input causes the FIFO to resend the data. With the mark feature, retransmit can start from any word in the FIFO.

The CYC47X series is fabricated using a proprietary 0.8-micron N-well CMOS technology. Input ESD protection is greater than 2001 V and latch-up is prevented by the use of reliable layout techniques, guard rings, and a substrate bias generator.

FIFOs

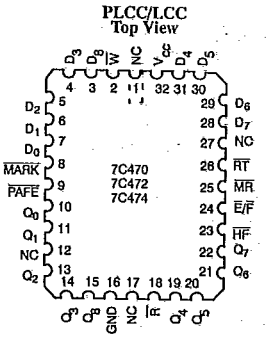
Logic Block Diagram



7C470-1

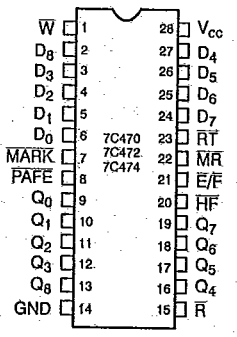
Pin Configurations

PLCC/LCC
Top View



7C470-2

DIP
Top View



7C470-3

Selection Guide

		7C470-15 7C472-15 7C474-15	7C470-20 7C472-20 7C474-20	7C470-25 7C472-25 7C474-25	7C470-40 7C472-40 7C474-40
Frequency (MHz)		33.3	28.5	28.5	20
Maximum Access Time (ns)		15	20	25	40
Maximum Operating Current (mA)	Commercial	160		145	125
	Military/Industrial		165	165	145

Maximum Ratings

Storage Temperature ..... −65°C to +150°C

Ambient Temperature with Power Applied ..... −55°C to +125°C

Supply Voltage to Ground Potential ..... −0.5V to +7.0V

DC Voltage Applied to Outputs in High Z State ..... −0.5V to +7.0V

DC Input Voltage ..... −3.0V to +7.0V

Power Dissipation 1.0W

Output Current, into Outputs (LOW) ..... 20 mA

Static Discharge Voltage ..... >2001V (per MIL-STD-883, Method 3015)

Latch-Up Current ..... >200 mA

Operating Range

Range	Ambient Temperature	V_{CC}
Commercial	0°C to +70°C	5V ± 10%
Industrial	−40°C to +85°C	5V ± 10%
Military[1]	−55°C to +125°C	5V ± 10%

Electrical Characteristics Over the Operating Range[2]

Parameter	Description	Test Conditions		7C470-15 7C472-15 7C474-15		7C470-20 7C472-20 7C474-20		7C470-25 7C472-25 7C474-25		7C470-40 7C472-40 7C474-40		Units
				Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
V_{OH}	Output HIGH Voltage	V_{CC} = Min., I_{OH} = −2.0 mA		2.4		2.4		2.4		2.4		V
V_{OL}	Output LOW Voltage	V_{CC} = Min., I_{OL} = 8.0 mA			0.4		0.4		0.4		0.4	V
V_{IH}	Input HIGH Voltage	V_{CC} = Max., I_{OUT} = 0 mA	Com'l	2.0				2.0		2.0		V
			Mil/Ind			2.2		2.2		2.2		
V_{IL}	Input LOW Voltage				0.8		0.8		0.8		0.8	V
I_{IX}	Input Leakage Current	GND ≤ V_I ≤ V_{CC}		−10	+10	−10	+10	−10	+10	−10	+10	μA
I_{OZ}	Output Leakage Current	$\overline{R} \geq V_{IH}$, GND ≤ V_O ≤ V_{CC}		−10	+10	−10	+10	−10	+10	−10	+10	μA
I_{CC}	Operating Current		Com'l[3]		160				145		125	mA
			Mil[4]/Ind				165		165		145	
I_{SB1}	Standby Current	All Inputs = V_{IH} Min.	Com'l		25				25		25	mA
			Mil/Ind				30		30		30	
I_{SB2}	Power-Down Current	All Inputs = V_{CC} − 0.2V	Com'l		20				20		20	mA
			Mil/Ind				25		25		25	
I_{OS}[5]	Output Short Circuit Current	V_{CC} = Max., V_{OUT} = GND			−90		−90		−90		−90	mA

Notes:

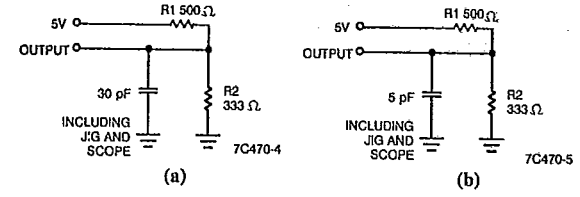
1. T_A is the "instant on" case temperature.
2. See the last page of this specification for Group A subgroup testing information.
3. I_{CC} (commercial) = 125 mA + ($\bar{f}$ − 20) • 2.5 mA/MHz for $\bar{f} \geq 20$ MHz
   where $\bar{f}$ = the larger of the write or read operating frequency.
4. I_{CC} (military) = 145 mA + ($\bar{f}$ − 20) • 2.5 mA/MHz for $\bar{f} \geq 20$ MHz
   where $\bar{f}$ = the larger of the write or read operating frequency.
5. Not more than one output should be tested at a time. Duration of the short circuit should not be more than one second.

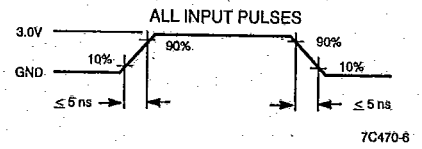
Capacitance[6]

Parameters	Description	Test Conditions	Max.	Units
C_{IN}	Input Capacitance	$T_A = 25°C$, f = 1 MHz, $V_{CC} = 4.5V$	5	pF
C_{OUT}	Output Capacitance		7	pF

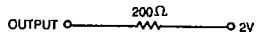
AC Test Loads and Waveforms

T-46-35





Equivalent to: THÉVENIN EQUIVALENT



FIFOs

Switching Characteristics Over the Operating Range[7,8]

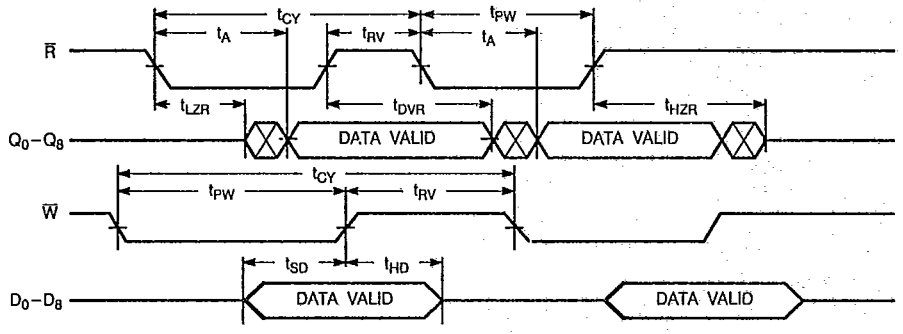
Parameters	Description	7C470–15 7C472–15 7C474–15		7C470–20 7C472–20 7C474–20		7C470–25 7C472–25 7C474–25		7C470–40 7C472–40 7C474–40		Units
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
t_{CY}	Cycle Time	30		35		35		50		ns
t_A	Access Time		15		20		25		40	ns
t_{RV}	Recovery Time	15		15		10		10		ns
t_{PW}	Pulse Width	15		20		25		40		ns
t_{LZR}	Read LOW to Low Z	3		3		3		3		ns
t_{DVR}[9]	Read HIGH to Data Valid	3		3		3		3		ns
t_{HZR}[9]	Read HIGH to High Z		15		15		18		25	ns
t_{HWZ}	Write HIGH to Low Z	5		5		5		5		ns
t_{SD}	Data Set-Up Time	11		12		15		20		ns
t_{HD}	Data Hold Time	0		0		0		0		ns
t_{EFD}	$\overline{E}/\overline{F}$ Delay		15		20		25		40	ns
t_{EFL}	$\overline{MR}$ to $\overline{E}/\overline{F}$ LOW		30		35		35		50	ns
t_{HFD}	$\overline{HF}$ Delay		30		35		35		50	ns
t_{AFED}	$\overline{PAFE}$ Delay		30		35		35		50	ns
t_{RAE}	Effective Read from Write HIGH	15		20		25		40		ns
t_{WAF}	Effective Write from Read HIGH	15		20		25		40		ns

Notes:

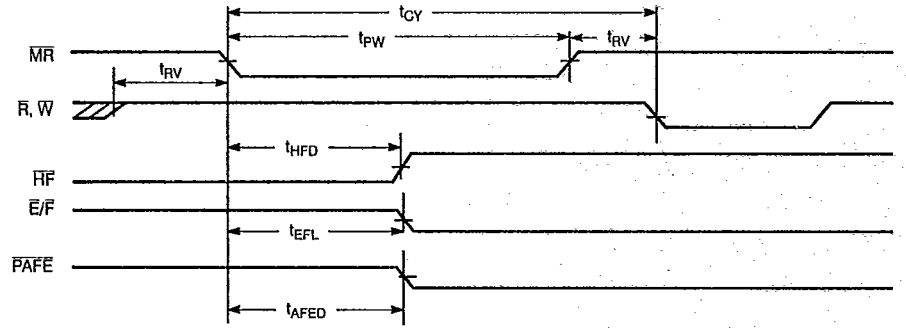
6. Tested initially and after any design or process changes that may affect these parameters.
7. Test conditions assume signal transmission time of 5 ns or less, timing reference levels of 1.5V and output loading of the specified I_{OL}/I_{OH} and 30 pF load capacitance, as in part (a) of AC Test Load and Waveforms, unless otherwise specified.
8. See the last page of this specification for Group A subgroup testing information.
9. t_{HZR} and t_{DVR} use capacitance loading as in part (b) of AC Test Loads. t_{HZR} transition is measured at +500 mV from V_{OL} and − 500 mV from V_{OH}. t_{DVR} transition is measured at the 1.5V level. t_{HWZ} and t_{LZR} transition is measured at ±100 mV from the steady state.

Switching Waveforms

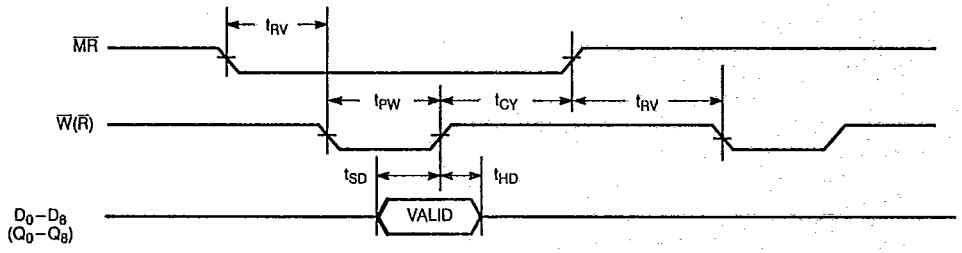
Asynchronous Read and Write



Master Reset (No Write to Programmable Flag Register)



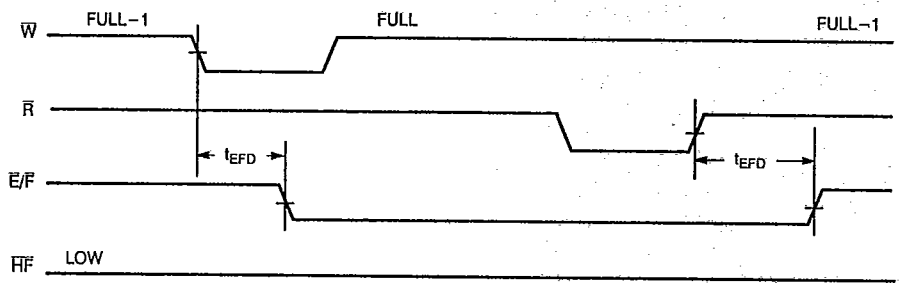
Master Reset (Write to Programmable Flag Register)[10]



Note:
10. Waveform labels in parentheses pertain to writing the programmable flag register from the output port (Q_0 – Q_8).

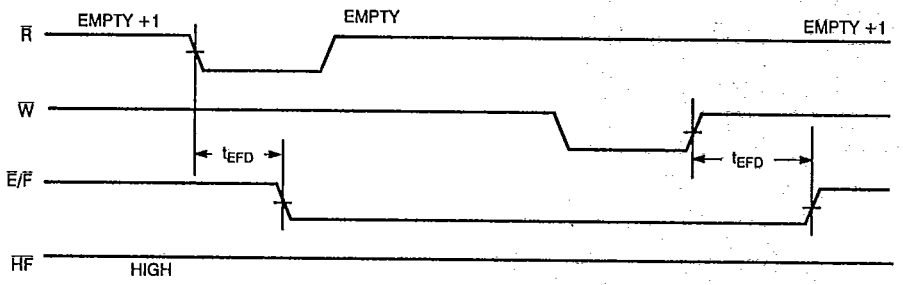
Switching Waveforms (continued)

$\overline{E}/\overline{F}$ Flag (Last Write to First Read Full Flag)



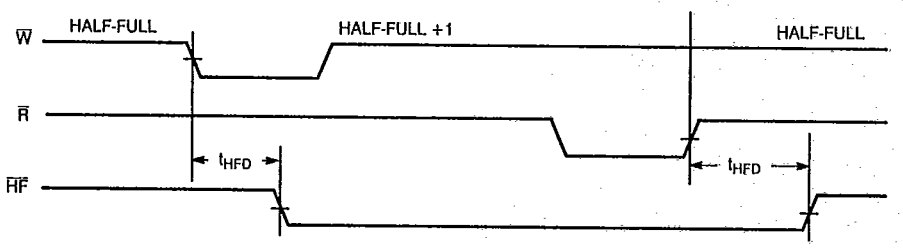
7C470-10

$\overline{E}/\overline{F}$ Flag (Last Read to First Write Empty Flag)



7C470-11

Half Full Flag

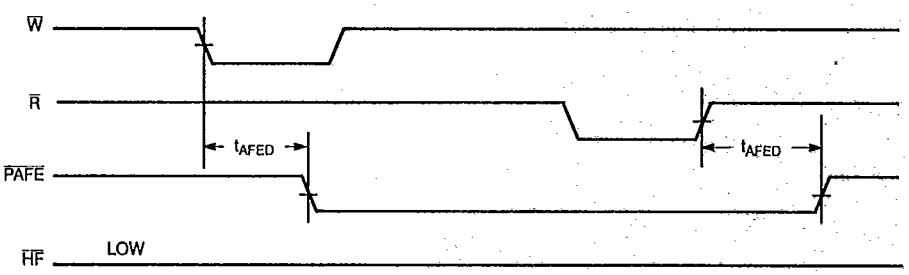


7C470-12

5 FIFOs

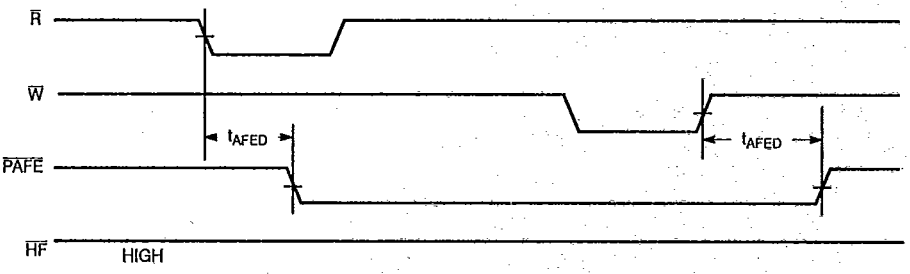
Switching Waveforms (continued)

$\overline{PAFE}$ Flag (Almost Full)



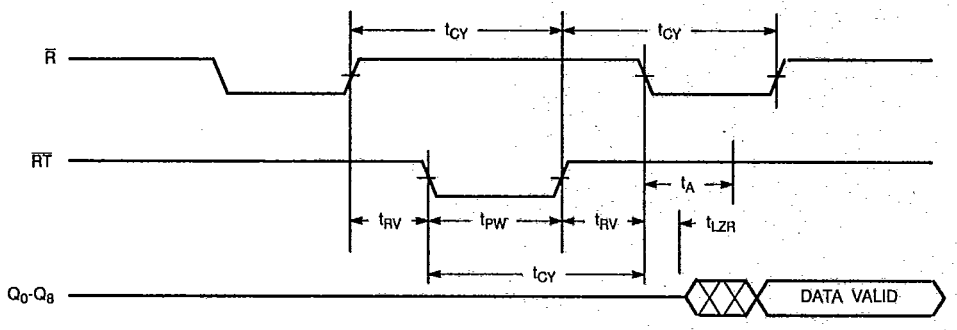
7C470-13

$\overline{PAFE}$ Flag (Almost Empty)



7C470-14

Retransmit

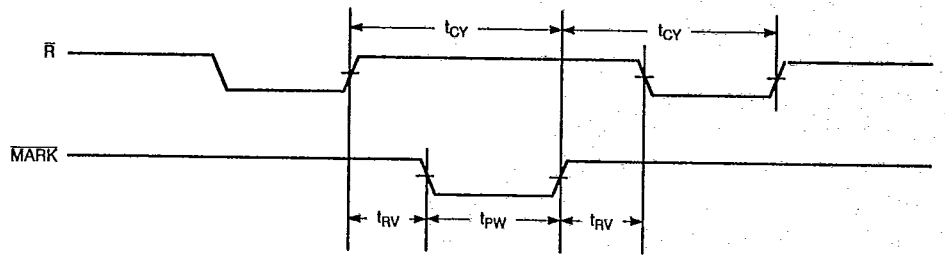


7C470-15

Switching Waveforms (continued)

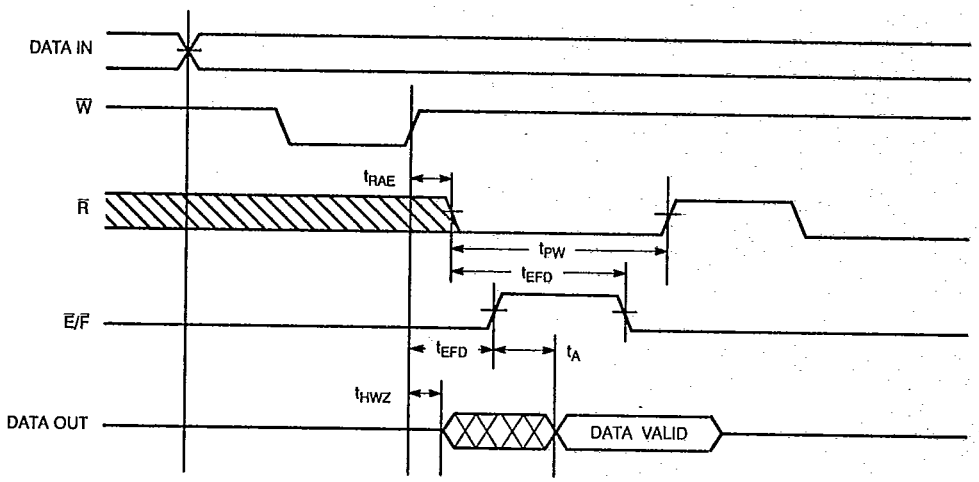
T-46-35

Mark



7C470-16

Empty Flag and Empty Boundary

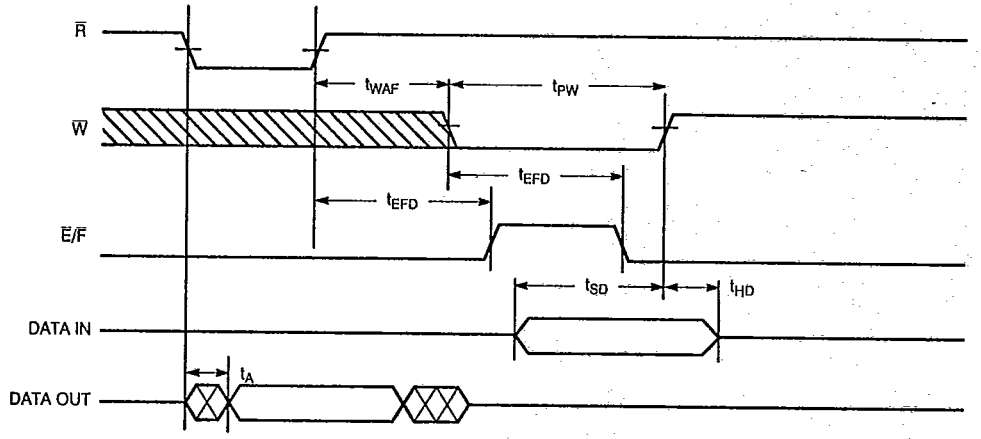


7C470-17

5 FIFOs

Switching Waveforms (continued)

Full Flag and Full Boundary



7C470-18

Architecture

The CY7C470, CY7C472, and CY7C474 FIFOs consist of an array of 8,192, 16,384, and 32,768 words of 9 bits each, respectively. The control consists of a read pointer, a write pointer, a retransmit pointer, control signals (i.e., write, read, mark, retransmit, and master reset), and flags (i.e., Empty/Full, Half Full, and Programmable Almost Full/Empty).

Resetting the FIFO

Upon power up, the FIFO must be reset with a master reset ($\overline{MR}$) cycle. This causes the FIFO to enter the empty condition signified by the Empty flag ($\overline{E/F}$) being LOW, and both the Programmable Almost Full/Empty flag ($\overline{PAFE}$) and Half Full flag ($\overline{HF}$) being HIGH. The read pointer, write pointer, and retransmit pointer are reset to zero. For a valid reset, read ($\overline{R}$) and write ($\overline{W}$) must be HIGH t_{RPW}/t_{WPW} before the falling edge and t_{RMR} after the rising edge of $\overline{MR}$.

Writing Data to the FIFO

Data can be written to the FIFO when it is not FULL[11]. A falling edge of $\overline{W}$ initiates a write cycle. Data appearing at the inputs (D_0–D_8) t_{SD} before and t_{HD} after the rising edge of $\overline{W}$ will be stored sequentially in the FIFO.

Reading Data from the FIFO

Data can be read from the FIFO when it is not empty[12]. A falling edge of $\overline{R}$ initiates a read cycle. Data outputs (Q_0–Q_8) are in a high-impedance condition when the FIFO is empty and between read operations ($\overline{R}$ HIGH). The falling edge of $\overline{R}$ during the last read cycle before the empty condition triggers a high-to-low transition of $\overline{E/F}$, prohibiting any further read operations until t_{RFF} after a valid write.

Retransmit

The retransmit feature is beneficial when transferring packets of data. It enables the receipt of data to be acknowledged by the receiver and resent if necessary. Retransmission can start from anywhere in the FIFO and be repeated without limitation.

The retransmit methodology is as follows: mark the current value of the read pointer, after an error in subsequent read operations return to that location and resume reading. This effectively resends all of the data from the mark point. When $\overline{MARK}$ is LOW, the current value of the read pointer is stored. This operation marks the beginning of the packet to be resent. When $\overline{RT}$ is LOW, the read pointer is updated with the mark location. During each subsequent read cycle, data is read and the read pointer incremented.

Care must be taken when using the retransmit feature. Use the mark function such that the write pointer does not pass the mark pointer, because further write operations will overwrite data.

Programmable Almost Full/Empty Flag

The CY7C470/2/4 offer a variable offset for the Almost Empty and the Almost Full condition. The offset is loaded into the programmable flag register (PFR) during a master reset cycle. While $\overline{MR}$ is LOW, the PFR can be loaded from Q_8–Q_0 by pulsing $\overline{R}$ LOW or from D_8–D_0 by pulsing $\overline{W}$ LOW. The offset options are listed in *Table 2*. See *Table 1* for a description of the six FIFO states. If the PFR is not loaded during master reset ($\overline{R}$ and $\overline{W}$ HIGH) the default offset will be 256 words from Full and Empty.

Notes:

11. When the FIFO is less than half full, the flags make a LOW-to-HIGH transition on the rising edge of $\overline{W}$ and make the HIGH-to-LOW transition on the falling edge of $\overline{R}$. If the FIFO is more than half full, the flags make the LOW-to-HIGH transition on the rising edge of $\overline{R}$ and HIGH-to-LOW transition on the falling edge of $\overline{W}$.
12. Full and empty states can be decoded from the Half-Full ($\overline{HF}$) and Empty/Full ($\overline{E/F}$) flags.

T-46-35

Table 1. Flag Truth Table[13]

$\overline{HF}$	$\overline{E/F}$	$\overline{PAFE}$	State	CY77C470 (8K x 9) Number of Words in FIFO	CY77C472 (16K x 9) Number of Words in FIFO	CY77C474 (32K x 9) Number of Words in FIFO
1	0	0	Empty	0	0	0
1	1	0	Almost Empty	1 → P	1 → P	1 → P
1	1	1	Less than Half Full	P + 1 → 4096	P + 1 → 8192	P + 1 → 16384
0	1	1	Greater than Half Full	4097 → 8190 − P	8193 → 16382 − P	16385 → 32766 − P
0	1	0	Almost Full	8191 − P → 8191	16383 − P → 16383	32767 − P → 32767
0	0	0	Full	8192	16384	32768

Table 2. Programmable Almost Full/Empty Empty Options[14]

D3	D2	D1	D0	PAFE Active when:	P
0	0	0	0	256 or less locations from Empty/Full (default)	256
0	0	0	1	16 or less locations from Empty/Full	16
0	0	1	0	32 or less locations from Empty/Full	32
0	0	1	1	64 or less locations from Empty/Full	64
0	1	0	0	128 or less locations from Empty/Full	128
0	1	0	1	256 or less locations from Empty/Full (default)	256
0	1	1	0	512 or less locations from Empty/Full	512
0	1	1	1	1024 or less locations from Empty/Full	1024
1	0	0	0	2048 or less locations from Empty/Full	2048
1	0	0	1	4098 or less locations from Empty/Full[15]	4098
1	0	1	0	8192 or less locations from Empty/Full[16]	8192

Notes:
13. See *Table 2* for P values.
14. Almost flags default to 256 locations from Empty/Full.
15. Only for CY7C472 and CY7C474.
16. Only for CY7C470.

Ordering Information

T-46-35

Speed (ns)	Ordering Code	Package Type	Operating Range
15	CY77C470-15DC	D16	Commercial
	CY77C470-15JC	J65	
	CY77C470-15LC	L55	
	CY77C470-15PC	P15	
	CY77C470-15DI	D16	Industrial
	CY77C470-15JI	J65	
	CY77C470-15PI	P15	
20	CY77C470-20DMB	D16	Military
	CY77C470-20LMB	L55	
25	CY77C470-25DC	D16	Commercial
	CY77C470-25JC	J65	
	CY77C470-25LC	L55	
	CY77C470-25PC	P15	
	CY77C470-25DI	D16	Industrial
	CY77C470-25JI	J65	
	CY77C470-25PI	P15	
	CY77C470-25DMB	D16	Military
	CY77C470-25LMB	L55	
40	CY77C470-40DC	D16	Commercial
	CY77C470-40JC	J65	
	CY77C470-40LC	L55	
	CY77C470-40PC	P15	
	CY77C470-40DI	D16	Industrial
	CY77C470-40JI	J65	
	CY77C470-40PI	P15	
	CY77C470-40DMB	D16	Military
	CY77C470-40LMB	L55	

Speed (ns)	Ordering Code	Package Type	Operating Range
15	CY77C472-15DC	D16	Commercial
	CY77C472-15JC	J65	
	CY77C472-15LC	L55	
	CY77C472-15PC	P15	
	CY77C472-15DI	D16	Industrial
	CY77C472-15JI	J65	
	CY77C472-15PI	P15	
20	CY77C472-20DMB	D16	Military
	CY77C472-20LMB	L55	
25	CY77C472-25DC	D16	Commercial
	CY77C472-25JC	J65	
	CY77C472-25LC	L55	
	CY77C472-25PC	P15	
	CY77C472-25DI	D16	Industrial
	CY77C472-25JI	J65	
	CY77C472-25PI	P15	
	CY77C472-25DMB	D16	Military
	CY77C472-25LMB	L55	
40	CY77C472-40DC	D16	Commercial
	CY77C472-40JC	J65	
	CY77C472-40LC	L55	
	CY77C472-40PC	P15	
	CY77C472-40DI	D16	Industrial
	CY77C472-40JI	J65	
	CY77C472-40PI	P15	
	CY77C472-40DMB	D16	Military
	CY77C472-40LMB	L55	

Ordering Information (continued)

Speed (ns)	Ordering Code	Package Type	Operating Range
15	CY77C474-15DC	D16	Commercial
	CY77C474-15JC	J65	
	CY77C474-15LC	L55	
	CY77C474-15PC	P15	
	CY77C474-15DI	D16	Industrial
	CY77C474-15JI	J65	
	CY77C474-15PI	P15	
20	CY77C474-20DMB	D16	Military
	CY77C474-20LMB	L55	
25	CY77C474-25DC	D16	Commercial
	CY77C474-25JC	J65	
	CY77C474-25LC	L55	
	CY77C474-25PC	P15	
	CY77C474-25DI	D16	Industrial
	CY77C474-25JI	J65	
	CY77C474-25PI	P15	
	CY77C474-25DMB	D16	Military
	CY77C474-25LMB	L55	
40	CY77C474-40DC	D16	Commercial
	CY77C474-40JC	J65	
	CY77C474-40LC	L55	
	CY77C474-40PC	P15	
	CY77C474-40DI	D16	Industrial
	CY77C474-40JI	J65	
	CY77C474-40PI	P15	
	CY77C474-40DMB	D16	Military
	CY77C474-40LMB	L55	

MILITARY SPECIFICATIONS

Group A Subgroup Testing

T-46-35

DC Characteristics

Parameters	Subgroups
V_{OH}	1, 2, 3
V_{OL}	1, 2, 3
V_{IH}	1, 2, 3
V_{IL} Max.	1, 2, 3
I_{IX}	1, 2, 3
I_{OS}	1, 2, 3
I_{CC}	1, 2, 3

Switching Characteristics

Parameters	Subgroups
t_{CY}	9, 10, 11
t_A	9, 10, 11
t_{RV}	9, 10, 11
t_{PW}	9, 10, 11
t_{LZR}	9, 10, 11
t_{DVR}	9, 10, 11
t_{HZR}	9, 10, 11
t_{HWZ}	9, 10, 11
t_{SD}	9, 10, 11
t_{HD}	9, 10, 11
t_{EFD}	9, 10, 11
t_{HFD}	9, 10, 11
t_{AFED}	9, 10, 11
t_{RAE}	9, 10, 11
t_{WAF}	9, 10, 11

Document #: 38–00142–B