

N O T I C E

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LOW POWER NASA 36 BIT TIME CODE GENERATOR

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ABSTRACT

A NASA 36 Bit Time Code Generator implemented in CMOS is described. An RCA 1802 microprocessor is used to minimize chip count. A modified 20 second format is available as an option, by changing two program steps.

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LOW POWER NASA 36 BIT TIME CODE GENERATOR

INTRODUCTION

This document describes the design and use of an all CMOS time code generator using the RCA 1802 microprocessor and Intersil's UV erasable PROM, the IM 6604. There are no adjustments; once power (4 to 11 VDC) is applied and the power-up reset clears, the unit outputs NASA 36 Bit Time Code according to the format shown in Figure 1. Current draw at 25°C is less than one milliampere.

The maximum count in the standard one-second format is 9 days, 23 hours, 59 minutes and 59 seconds. In the 20 second format, the maximum count is 9 days, 23 hours, 59 minutes and 40 seconds. In this mode, there is no unit seconds count; the tens seconds counts 00, 20, 40 00 . . .

If power is lost, the unit begins again at zero. The clock frequency is 8kHz for the 20 second format and 160kHz for the one second format, but it can be speeded up (to approximately 4MHz) for test purposes.

CIRCUITRY

Refer to Figure 2 and Figure 3. All programming is contained in the IM 6604 PROM; there is no RAM in this system. The 1802 address bus is multiplexed, so latch L31 (CD4013) is necessary to produce A8 for the 512 x 8 PROM. The falling edge of TPA (see Figure 3) accomplishes this. For the PROM read strobe, Latch S11 delays TPA one clock cycle. \overline{MRD} completes the PROM circuitry.

For the basic system timing, the clock is divided by 1600 to produce the 2ms high, 8ms low waveform that characterizes the NASA code. One 4059 counter is especially useful for this purpose since it produces a pulse one-clock-cycle wide (2ms at 500Hz input). Another 4059 could have replaced S21 and N11, but the frequency produced by N11 were necessary for other circuits.

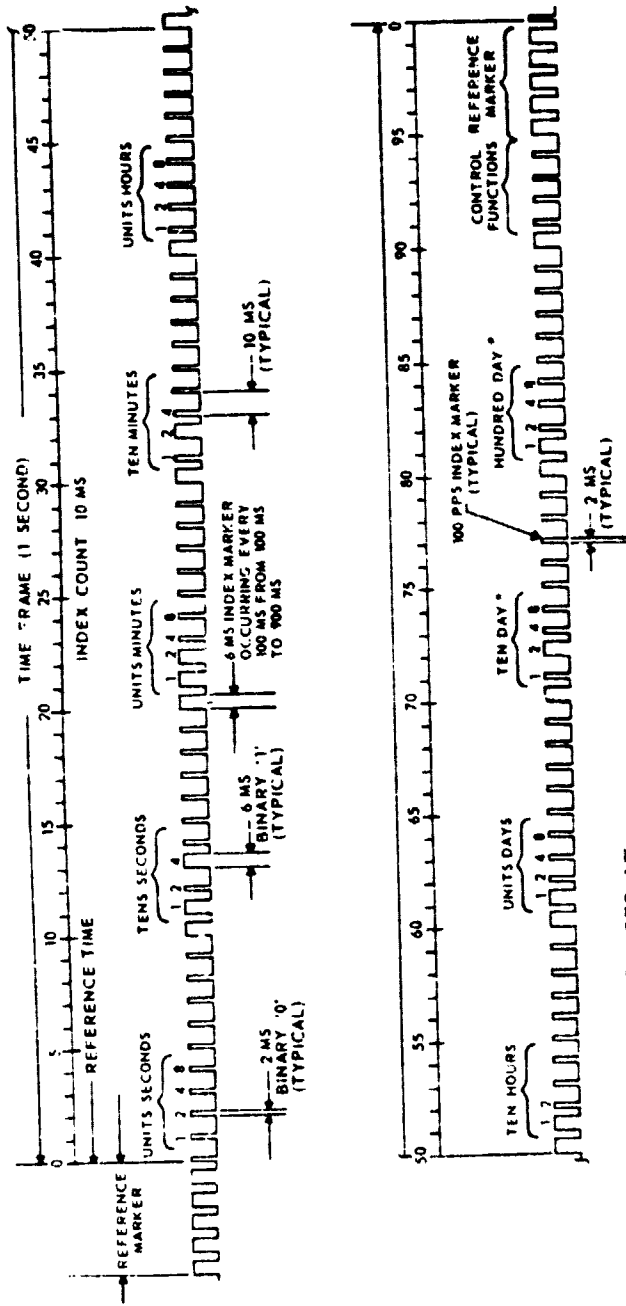
Finally, the 100Hz waveform is divided by 10 in L11 and inputted to one of the four "flag" inputs on the 1802. The 36 bit code is outputted by OR-ING the 100Hz with the "Q" output, which has the effect of widening some 2ms pulses into 6ms pulses.

The reset circuitry must delay CPU operation until the 4059 (N21) has had at least 3 input cycles. (It is being used in the "master preset mode"; see RCA databook SSD-250.) This time is 6ms for the standard format and 120ms for the 20 second format.

For diagnostic purposes, the state code line (pin 6) outputs a square wave with high = fetch and low = execute each machine cycle. See the Table in Figure 1 for additional pulses.

PROGRAMMING

The 6604 programming follows on the next six pages. Finally, Figure 4 gives register usage and flow charts.



DIAGNOSTIC PULSES AT

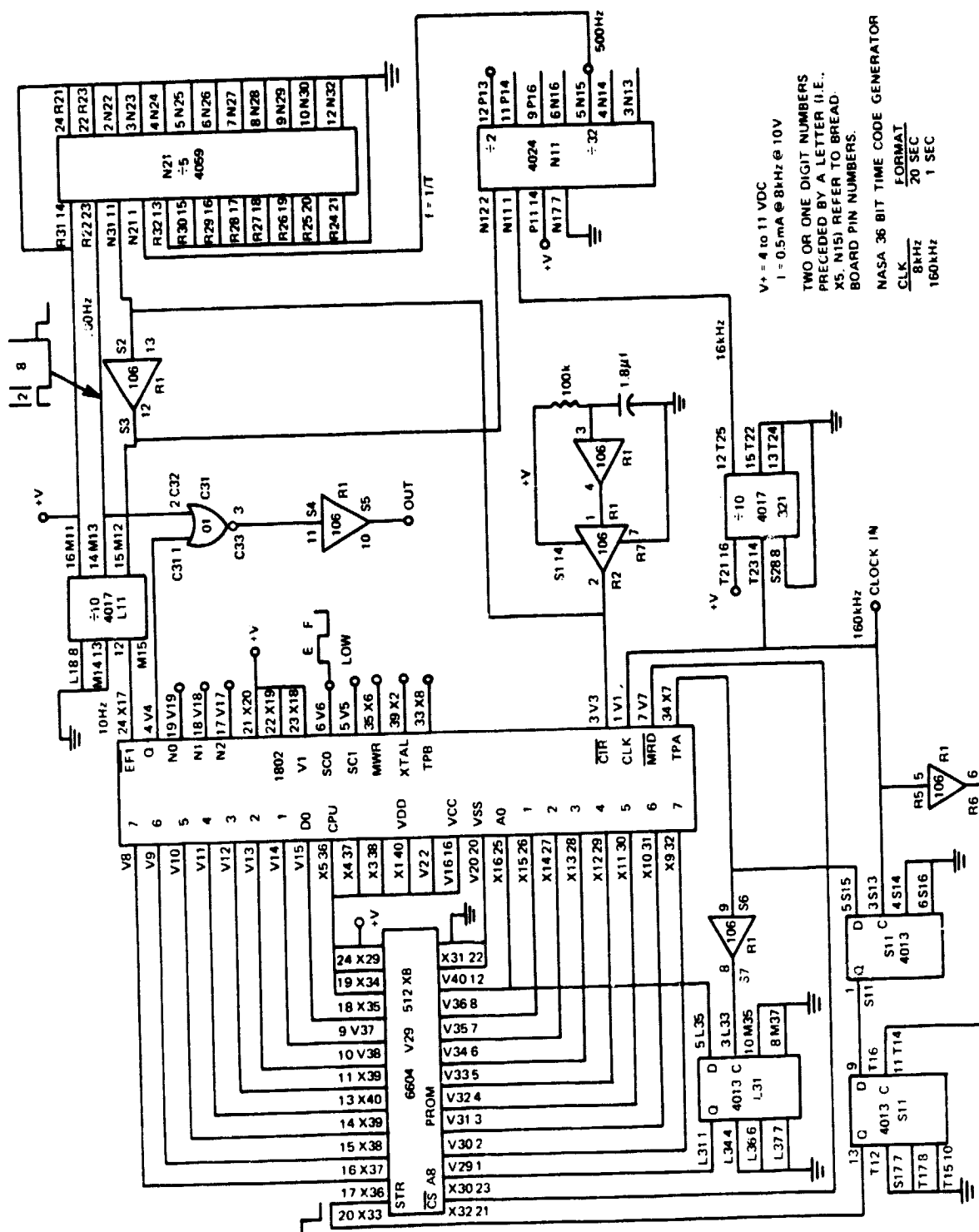
	CPU PIN	OCCURS APPROX. AT
N ₀	19	000 MS
N ₁	18	EVERY 100 MS
N ₂	17	8 TIMES BETWEEN 840 MS & 900 MS

NASA 36 BIT TIME CODE
Reference IRIG Document 104-59

Time of Reference Marker is: 121 days, 10 hours, 23 minutes, 50 seconds.

*NOT GENERATED AS PRESENTLY CONFIGURED

Figure 1. NASA 36 Bit Time Code



$V^+ = 4 \text{ to } 11 \text{ VDC}$
 $I = 0.5 \text{ mA @ } 8 \text{ kHz @ } 10 \text{ V}$
 TWO OR ONE DIGIT NUMBERS
 PRECEDED BY A LETTER (I.E.,
 X5, N15) REFER TO BREAD-
 BOARD PIN NUMBERS.
 NASA 36 BIT TIME CODE GENERATOR
 CLK 8KHZ
 FORMAT 20 SEC
 160KHZ 1 SEC

Figure 2. Time Code Generator Schematic

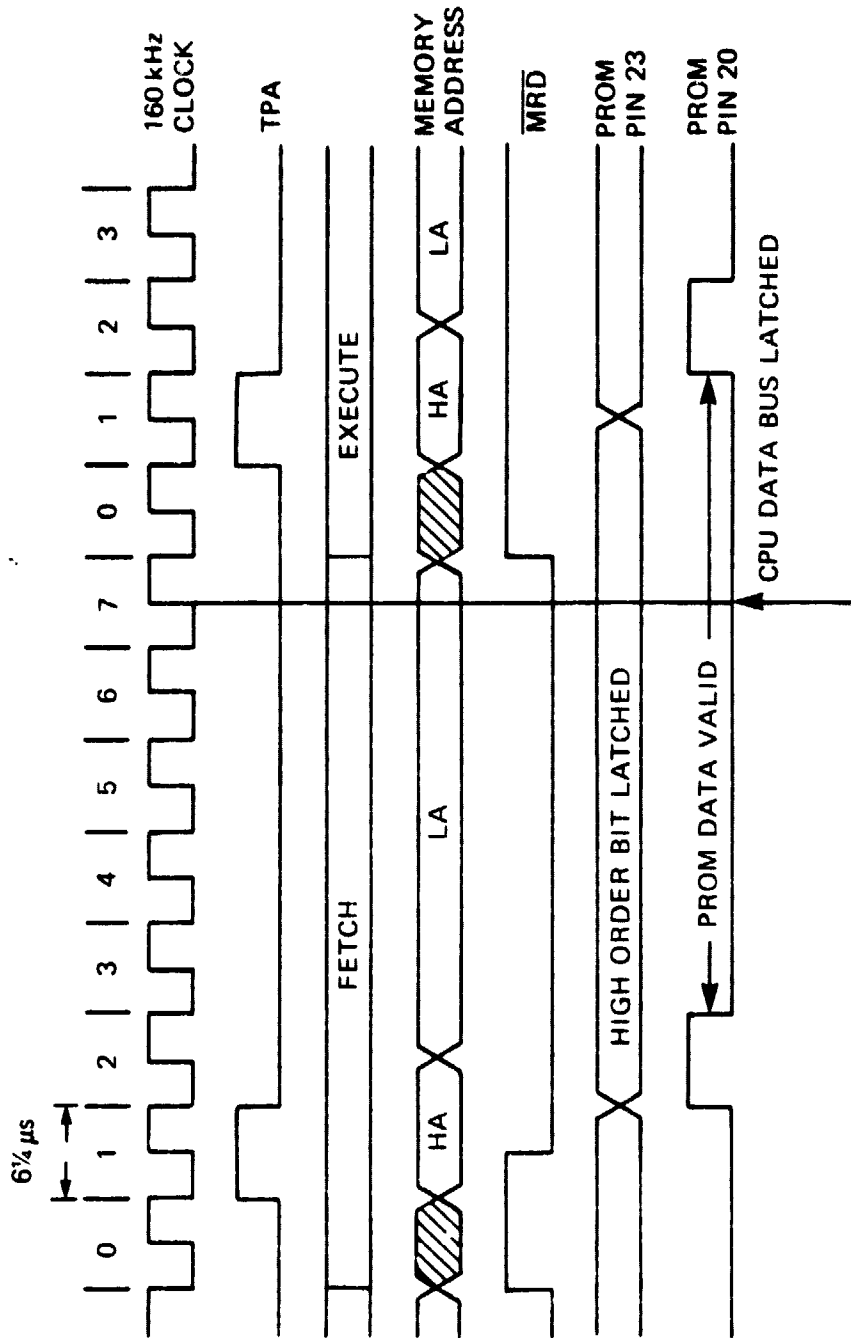


Figure 3. Timing

Program-IM 6604

NASA 36 Bit Time Code - 160kHz Clock

000	90	GHI R0	ZERO 2,4,5,6,9	8	
1	B2	PHI 2	HIGH ORDER BITS	9	
2	B4	PHI 4		A	
3	B5	PHI 5		B	
4	B6	PHI 6		C	
5	A9	PLO 9	(U.S.)	D	
6	F8	LDI	30 → R2.0	E	
7	30			F	D0 SEP 0
8	A2	PLO 2		030	7B SEQ (SEP 2) INDEX MARK
9	F8	LDI	D7 → R4.0	1	F8 LDI AT 800ms
A	D7			2	11
B	A4	PLO 4		3	A7 PLO 7
C	F8	LDI	BB → R5.0	4	62 OUT 2
D	BB			5	27 DEC 7
E	A5	PLO 5		6	87 GLO 7
F	F8	LDI	78 → R6.0	7	3A BNZ
010	78			8	35
1	A6	PLO 6		9	7A REQ
2	F8	LDI	01 → RA.0	A	3C BNI
3	01		01 → RB.0	B	3E
4	AA	PLO A	(T.S.)	C	30 BR
5	AB	PLO B	(U.M.)	D	3A
6	78	SAV	(USED AS NO-OP)	E	C0 LBR 30 BR
7	78			F	01 46
8	78			040	1F MODIFICATION FOR
9	AF	PLO F	01 → RF.0 (U.D.)	1	34 B1 20 SECOND FORMAT
A	F8	LDI	01 → R8.0	2	2F NO UNIT SECONDS
B	01			3	30 BR 8kHz CLOCK
C	A8	PLO 8		4	41
D	E1	SEX 1	X = 1	5	
E	F8	LDI	01 → RC.0	6	8A GLO A 046 THRU 04D ONLY
F	01			7	76 RSHR USED FOR 20
020	AC	PLO C	(T.M.)	8	AA PLO A SECOND FORMAT
1	AE	PLO E	01 → RE.0 (T.H.)	9	1A INC A
2	F8	LDI	01 → RD.0	A	1A INC A
3	01			B	C0 LBR
4	AD	PLO D	(U.H.)	C	01
5	30	BR		D	37
6	55			E	
7				F	

Program-IM 6604 (Continued)

050				8 62	OUT 2 (SEP 6) OUTPUT
	1	34	BI	9 F6	SHR SUBROUTINE
	2	55		A BF	PHI F
	3	30	BR	B 3B	BNF
	4	51		C 7F	
	5	61	OUT 1 MAIN PROGRAM	D 30	BR
	6	89	GLO 9 U.S. 000ms	E 82	
	7	D6	SEP 6	F 78	
	8	8A	GLO A T.S. 100ms	080 30	BR
	9	D6	SEP 6	1 83	
	A	8B	GLO B U.M. 200ms	2 7B	SEQ
	B	D6	SEP 6	3 F8	LDI
	C	8C	GLO C T.M. 300ms	4 10	
	D	D6	SEP 6	5 A7	PLO 7
	E	8D	GLO D U.H. 400ms	6 78	
	F	D6	SEP 6	7 27	DEC 7
060	8E	GLO E	T.H. 500ms	8 87	GLO 7
	1	D6	SEP 6	9 3A	BNZ
	2	8F	GLO F U.O. 600ms	A 87	
	3	D6	SEP 6	B 7A	REQ
	4	D5	SEP 5 700ms	C F8	LDI
	5	78		D 0C	
	6	D2	SEP 2 800ms	E A7	PLO 7
	7	78		F 78	
	8	D4	SEP 4 REF. 900ms	090 27	DEC 7
	9	30	BR	1 87	GLO 7
	A	51		2 3A	BNZ
	B			3 90	
	C			4 28	DEC 8
	D			5 88	GLO 8
	E			6 32	BZ
	F			7 A5	
070				8 9F	GHI F
	1			9 30	BR
	2			A 79	
	3			B	
	4			C	
	5			D	
	6			E	
	7	D0		F	

Program-IM 6604 (Continued)

0A0		8 78
1		9 78
2		A 78
3		B 3C BNI
4		C CF
5	3C BNI OUTPUT SUBROUTINE	D 30 BR
6	9A CONTINUED	E CB
7	30 BR	F 34 B1
8	A5	ODO BA
9	F8 LDI	1 30 BR
A	06	2 CF
B	A8 PLO 8	3
C	34 B1	4
D	77	5
E	30 BR	6 D0 SEP 0
F	AC	7 F8 LDI (SEP 4) REFERENCE
0B0		8 05 MARK ROUTINE
1		9 A3 PLO 3(900ms)
2		A 62 OUT 2
3		B 7B SEQ
4		C F8 LDI
5		D 09
6		E A7 PLO 7
7		F 78
8		OEO 78
9		1 27 DEC 7
A	D0 SEP 0	2 87 GLO 7
B	7B SEQ (SEP 5) INDEX MARK	3 78
C	F8 LDI AT 700ms	4 78
D	0A	5 3A BNZ
E	A7 PLO 7	6 E1
F	62 OUT 2	7 7A REQ
0C0	78	8 3C BNI
1	27 DEC 7	9 EC
2	87 GLO 7	A 30 BR
3	78	B E8
4	78	C 7B SEQ
5	3A BNZ	D F8 LDI
6	C1	E 0B
7	7A REQ	F A7 PLO 7

Program--IM 6604 (Continued)

0F0 27	DEC 7	8	
1 87	GLO 7	9	
2 78		A	
3 78		B	
4 3A	BNZ	C	
5 F0		D	
6 7A	REQ	E	
7 23	DEC 3	F 64	OUT 4
8 83	GLO 3	120 89	GLO 9
9 CA	LBNZ	1 76	RSHR
A 01		2 A9	PLO 9
B 05		3 19	INC 9
C 30	BR	4 89	GLO 9
D D6		5 FD	SDI U.S.
E		6 0A	
F		7 32	BZ
100		8 2F	
1		9 89	GLO 9
2		A FE	SHL
3		B A9	PLO 9
4		C C0	LBR
5 F8	LDI REFERENCE MARK	D 00	
6 06	ROUTINE CONTINUED	E 41	
7 A7	PLO 7	F 78	
8 78		130 FE	SHL
9 78		1 A9	PLO 9
A 78		2 64	OUT 4
B 78		3 8A	GLO A
C 27	DEC 7	4 76	RSHR
D 87	GLO 7	5 AA	PLO A
E 78		6 1A	INC A
F 78		7 8A	GLO A
110 3A	BNZ	8 FD	SDI
1 0C		9 06	
2 C0	LBR	A 32	BZ
3 00		B 41	
4 EC		C 8A	GLO A
5		D 7E	RSHL
6		E AA	PLO A
7		F 30	BR

COUNT ROUTINE
CALLED FROM 03E

T.S. CALLED
FROM 04B

Program-IM 6604 (Continued)

140	2C			8	64	OUT 4	COUNT ROUTINE
	1	7E	RSHL	9	8C	GLO C	CONTINUED
	2	AA	PLO A	A	76	RSHR	
	3	30	BR	B	AC	PLO C	
	4	4A		C	1C	INC C	
	5			D	8C	GLO C	
	6			E	FD	SDI	
	7			F	06		T.M.
	8			170	32	BZ	
	9			1	77		
	A	64	OUT 4	2	8C	GLO C	
	B	8B	GLO B	3	7E	RSHL	
	C	76	RSHR	4	AC	PLO C	
	D	AB	PLO B	5	30	BR	
	E	1B	INC B	6	2C		
	F	8B	GLO B	7	7E	RSHL	
150	FD	SDI		8	AC	PLO C	
	1	0A		9	64	OUT 4	
	2	32	BZ	A	8D	GLO D	U.H.
	3	59		B	76	RSHR	
	4	8B	GLO B	C	AD	PLO D	
	5	7E	RSHL	D	1D	INC D	
	6	AB	PLO B	E	8E	GLO E	
	7	30	BR	F	F6	SHR	
	8	2C		180	FD	SDI	
	9	7E	RSHL	1	02		
	A	AB	PLO B	2	32	BZ	
	B	30	BR	3	A6		
	C	68		4	64	OUT 4	
	D			5	30	BR	
	E			6	90		
	F			7			
160				8			
	1			9			
	2			A			
	3			B			
	4			C			
	5			D			
	6			E			
	7			F			

Program -IM 6604 (Continued)

190	8D	GLO D	COUNT ROUTINE	8			
1	FD	SDI	CONTINUED	9			
2	0A			A			
3	32	BZ		B			
4	9A			C			
5	8D	GLO D	U.H.	D			
6	7E	RSHL		E			
7	AD	PLO D		F			
8	30	BR			1C0	8F	GLO F
9	2C				1	76	RSHR
A	7E	RSHL			2	AF	PLO F
B	AD	PLO D			3	1F	INC F
C	64	OUT 4			4	8F	GLO F
D	8E	GLO E			5	FD	SDI
E	76	RSHR			6	0A	
F	AE	PLO E			7	32	BZ U.D.
1A0	1E	INC E	T.H.		8	CE	
1	8E	GLO E			9	8F	GLO F
2	7E	RSHL			A	7E	RSHL
3	AE	PLO E			B	AF	PLO F
4	30	BR			C	30	BR
5	2C				D	2C	
6	8D	GLO D			E	7E	RSHL
7	FD	SDI			F	AF	PLO F
8	04				1D0	30	BR
9	32	BZ			1	2C	
A	B0				2		
B	8D	GLO D			3		
C	7E	RSHL			4		
D	AD	PLO D			5		
E	30	BR			6		
F	2C				7		
1E0	7E	RSHL			8		
1	AD	PLO D			9		
2	AF	PLO E			A		
3	64	OUT 4			B		
4	30	BR			C		
5	C0				D		
6					E		
7					F		

1802 REGISTER USAGE

HIGH BYTE		LOW BYTE	
R0.1	PROGRAM COUNTER	R0.0	PROGRAM COUNTER
1.1		1.0	DIAGNOSTIC OUT
2.1	00	2.0	INDEX MARK AT 800MS (030)
3.1		3.0	REFERENCE MARK COUNTER
4.1	00	4.0	REFERENCE MARK AT 900MS (0D7)
5.1	00	5.0	INDEX MARK AT 700MS (08B)
6.1	00	6.0	OUTPUT SUBROUTINE (07B)
7.1		7.0	DELAY COUNTER
8.1		8.0	DATA COUNTER FOR OUTPUT SUBROUTINE
9.1		9.0	U.S. COUNT
A.1		A.0	T.S. COUNT
B.1		B.0	U.M. COUNT
C.1		C.0	T.M. COUNT
D.1		D.0	U.H. COUNT
E.1		E.0	T.H. COUNT
F.1	TEMPORARY STORAGE FOR OUTPUT ROUTINE	F.0	U.D. COUNT

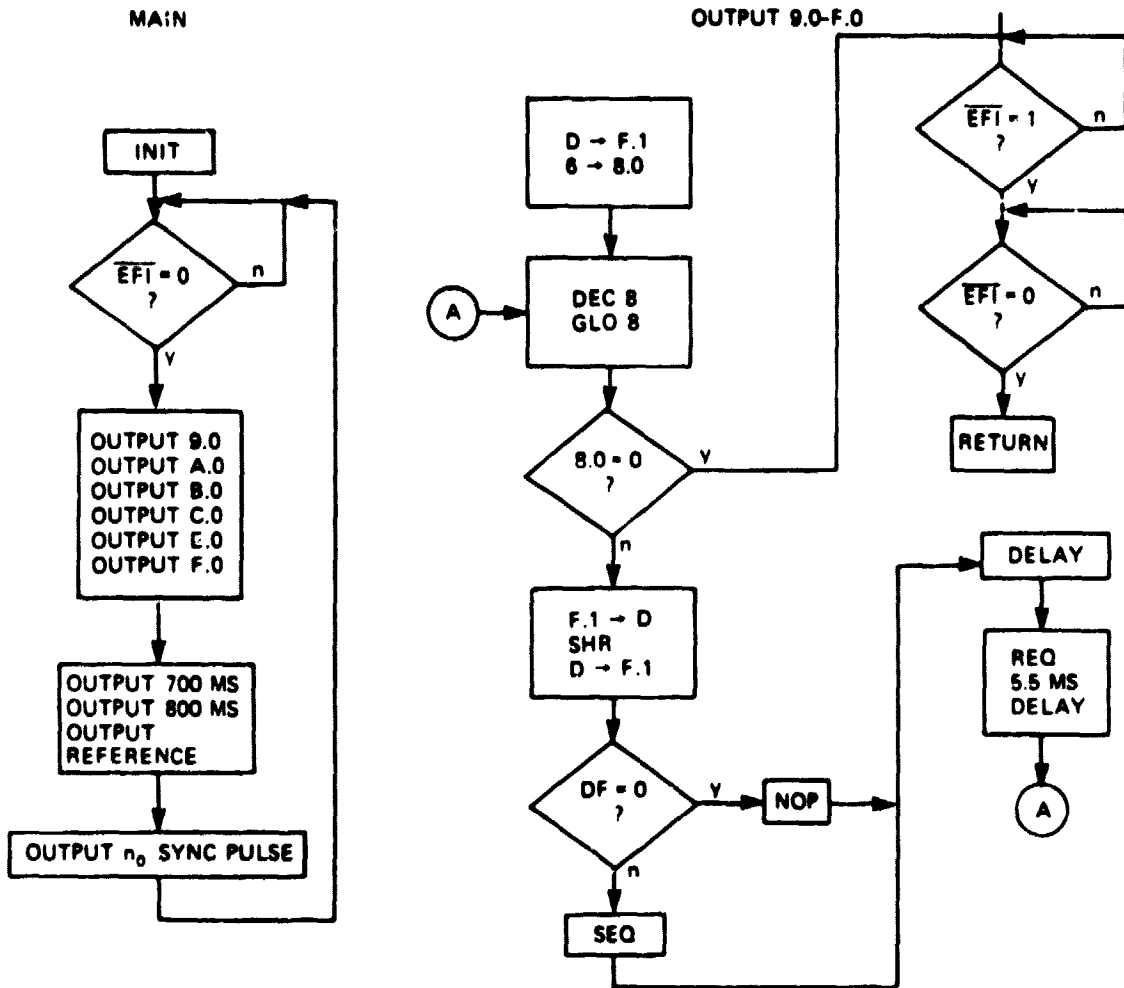


Figure 4a. Flow Charts

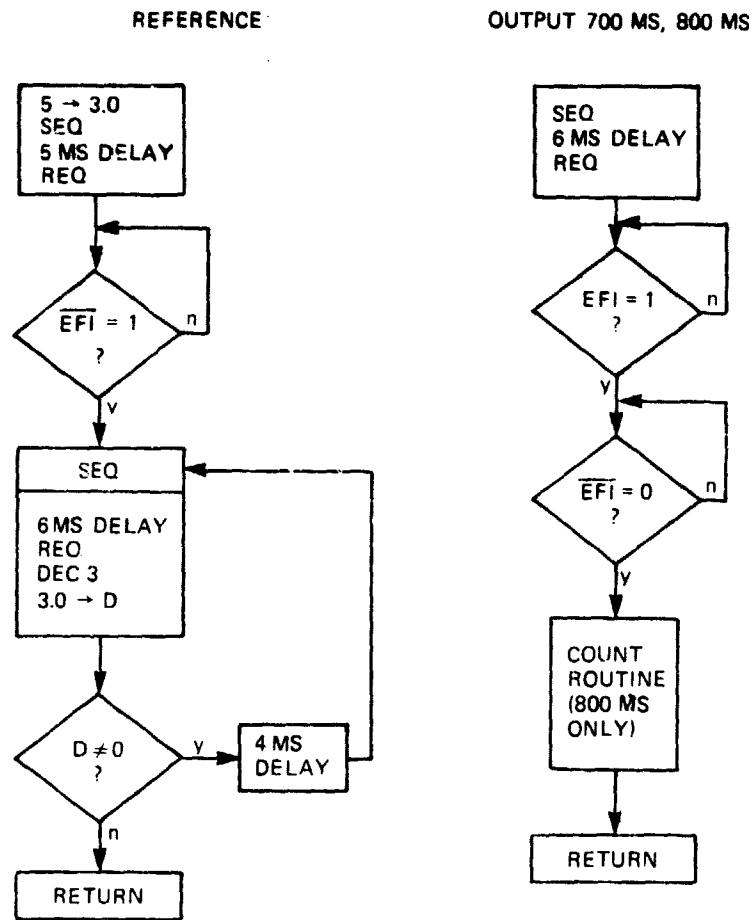


Figure 4b. Flow Charts, Continued

COUNT ROUTINE

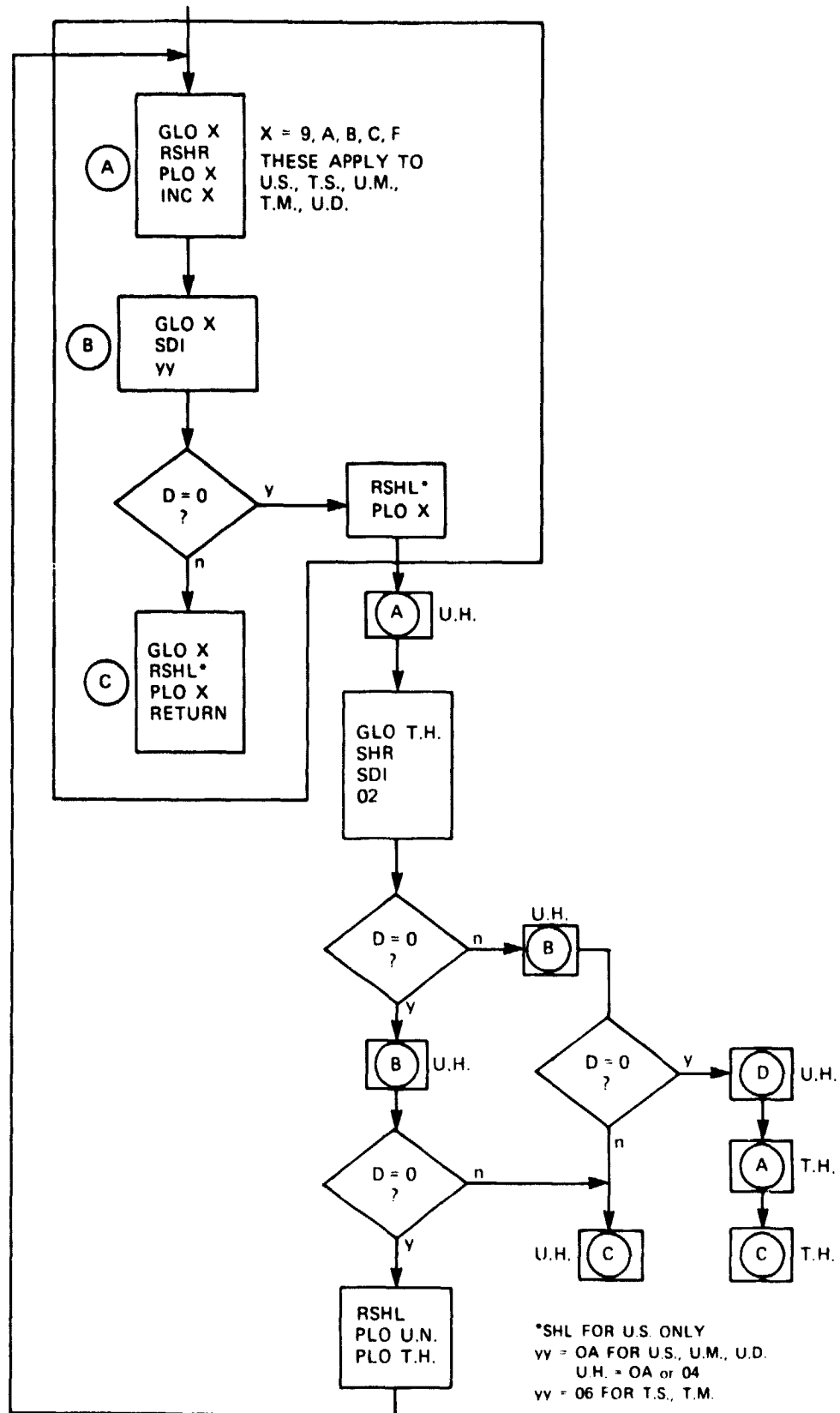


Figure 4c. Flow Charts, Concluded