N O T I C E

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NASA

Technical Memorandum 80697

LOW POWER NASA 36 BIT TIME CODE GENERATOR

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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 microampere.

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.

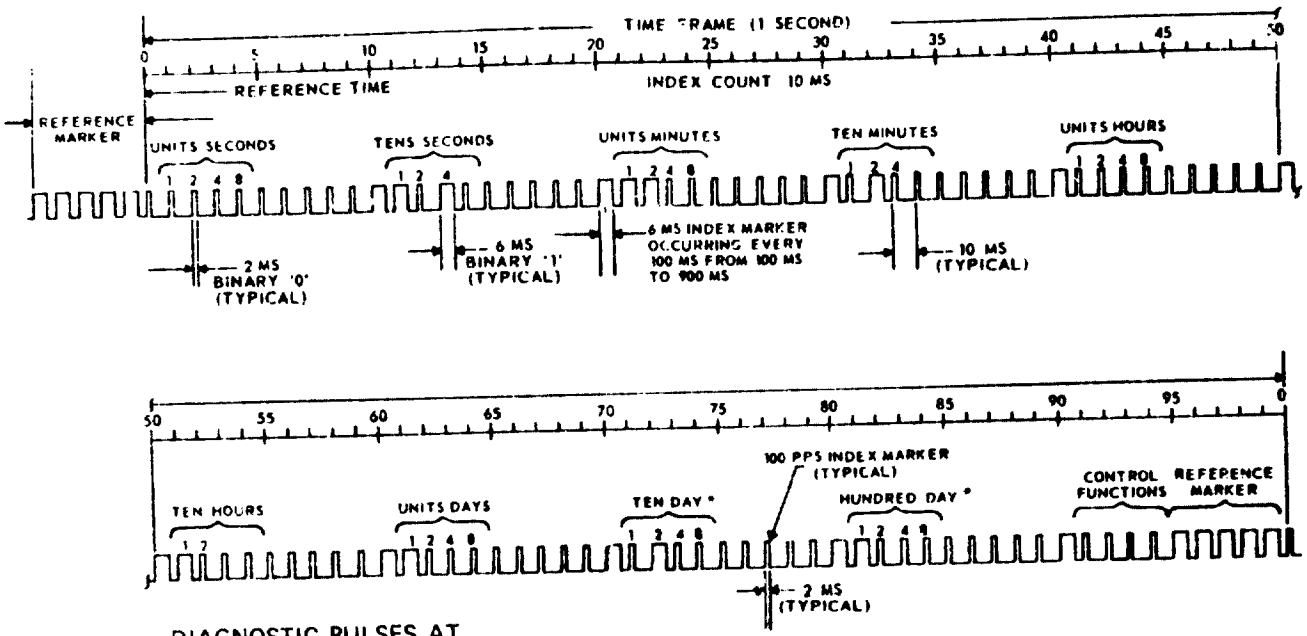
Finally, the 100Hz waveform is divided by 10 in L11 and inputted to one of the four "flag" inputs on the 1802. The 36 bit code is outputted by OR-ING the 100Hz with the "Q" output, which has the effect of widening some 2ms pulses into 6ms pulses.

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

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

NASA 36 BIT TIME CODE
Reference IRIG Document 104-59

*NOT GENERATED AS PRESENTLY CONFIGURED

Figure 1. NASA 36 Bit Time Code

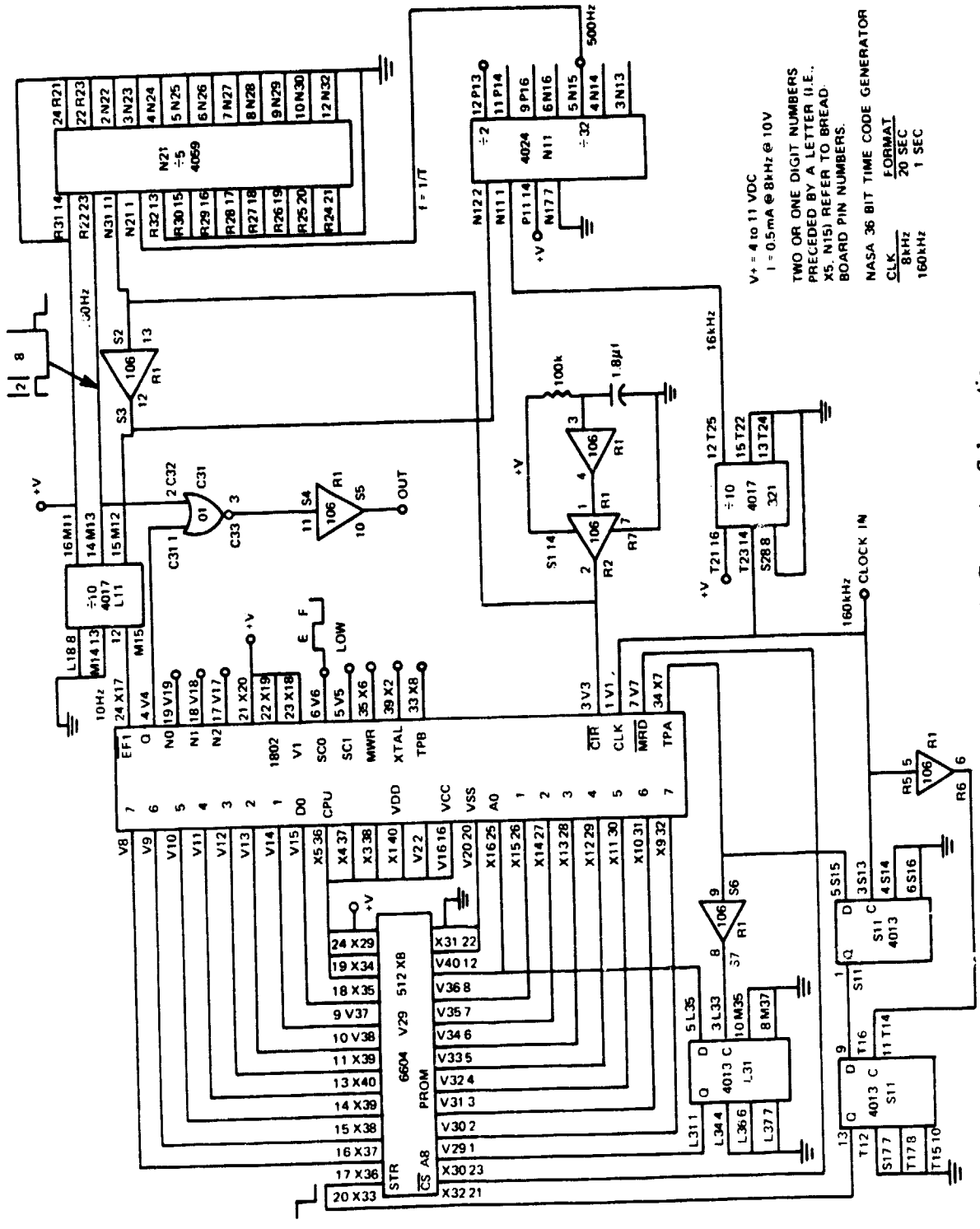


Figure 2. Time Code Generator Schematic

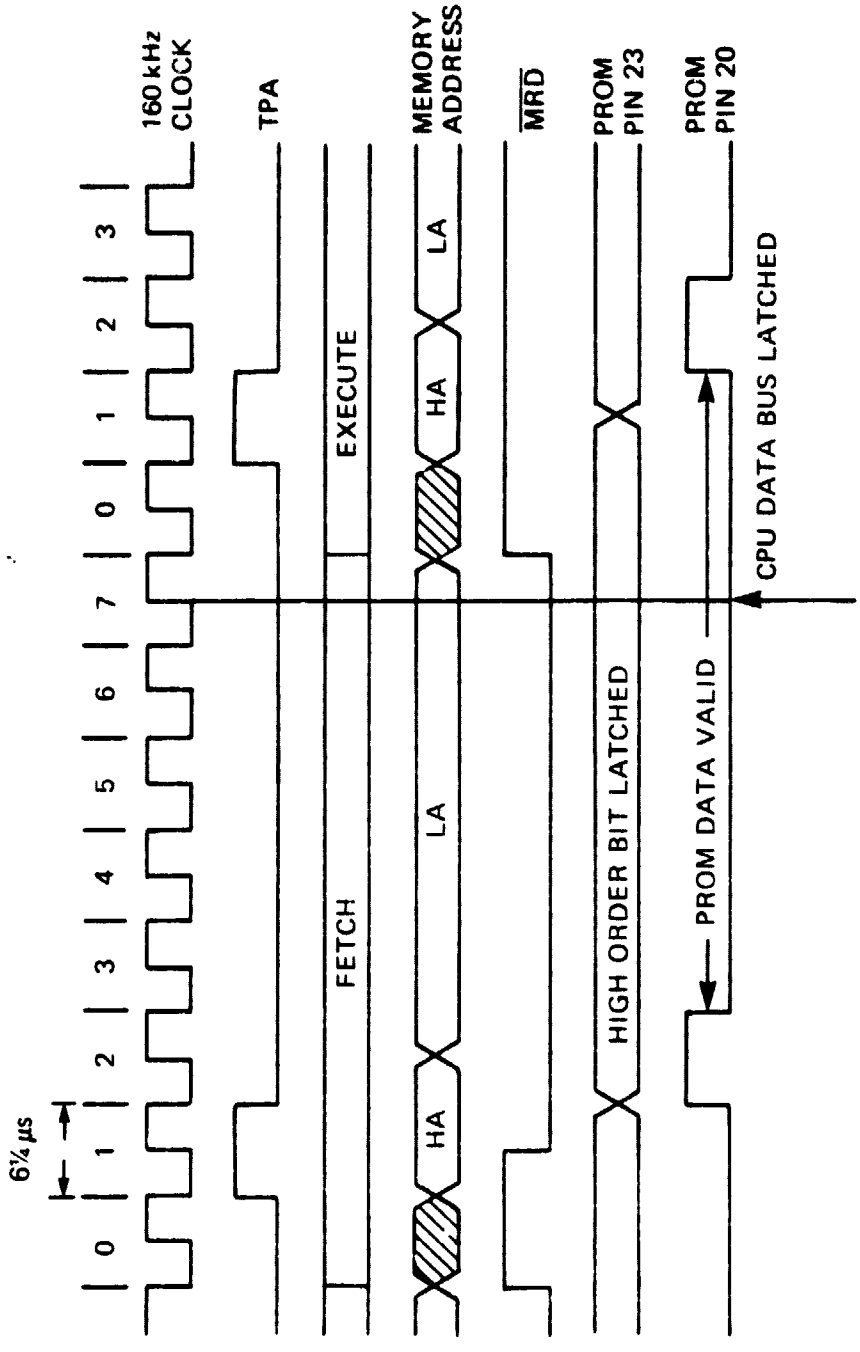


Figure 3. Timing

Program–IM 6604

NASA 36 Bit Time Code – 160kHz Clock

```
000 90   GHI R0   ZERO 2,4,5,6,9
  1 B2   PHI 2    HIGH ORDER BITS
  2 B4   PHI 4
  3 B5   PHI 5
  4 B6   PHI 6
  5 A9   PLO 9    (U.S.)
  6 F8   LDI   30 → R2.0
  7 30
  8 A2   PLO 2
  9 F8   LDI   D7 → R4.0
  A D7
  B A4   PLO 4
  C F8   LDI   BB → R5.0
  D BB
  E A5   PLO 5
  F F8   LDI   78 → R6.0
010 78
  1 A6   PLO 6
  2 F8   LDI   01 → RA.0
  3 01         01 → RB.0
  4 AA   PLO A   (T.S.)
  5 AB   PLO B   (U.M.)
  6 78   SAV   (USED AS NO-OP)
  7 78
  8 78
  9 AF   PLO F   01 → RF.0 (U.D.)
  A F8   LDI   01 → R8.0
  B 01
  C A8   PLO 8
  D E1   SEX 1   X = 1
  E F8   LDI   01 → RC.0
  F 01
020 AC   PLO C   (T.M.)
  1 AE   PLO E   01 → RE.0 (T.H.)
  2 F8   LDI   01 → RD.0
  3 01
  4 AD   PLO D   (U.H.)
  5 30   BR
  6 55
  7
  8
  9
  A
  B
  C
  D
  E
  F D0   SEP 0
030 7B   SEQ   (SEP 2) INDEX MARK
  1 F8   LDI   AT 800ms
  2 11
  3 A7   PLO 7
  4 62   OUT 2
  5 27   DEC 7
  6 87   GLO 7
  7 3A   BNZ
  8 35
  9 7A   REQ
  A 3C   BN1
  B 3E
  C 30   BR
  D 3A
  E C0   LBR  |  30 BR
  F 01        |  46
040 1F        |  MODIFICATION FOR
  1 34   B1   |  20 SECOND FORMAT
  2 2F        |  NO UNIT SECONDS
  3 30   BR   |  8kHz CLOCK
  4 41        |
  5
  6 8A   GLO A   046 THRU 04D ONLY
  7 76   RSHR    USED FOR 20
  8 AA   PLO A   SECOND FORMAT
  9 1A   INC A
  A 1A   INC A
  B C0   LBR
  C 01
  D 37
  E
  F
```

Program–1M 6604 (Continued)

```
050
  1  34  B1
  2  55
  3  30  BR
  4  51
  5  61  OUT 1   MAIN PROGRAM
  6  89  GLO 9   U.S.  000ms
  7  D6  SEP 6
  8  8A  GLO A   T.S.  100ms
  9  D6  SEP 6
  A  8B  GLO B   U.M.  200ms
  B  D6  SEP 6
  C  8C  GLO C   T.M.  300ms
  D  D6  SEP 6
  E  8D  GLO D   U.H.  400ms
  F  D6  SEP 6
060  8E  GLO E   T.H.  500ms
  1  D6  SEP 6
  2  8F  GLO F   U.O.  600ms
  3  D6  SEP 6
  4  D5  SEP 5   700ms
  5  78
  6  D2  SEP 2   800ms
  7  78
  8  D4  SEP 4   REF.  900ms
  9  30  BR
  A  51
  B
  C
  D
  E
  F
070
  1
  2
  3
  4
  5
  6
  7  D0
  8  62  OUT 2   (SEP 6) OUTPUT
  9  F6  SHR SUBROUTINE
  A  BF  PHI F
  B  3B  BNF
  C  7F
  D  30  BR
  E  82
  F  78
080  30  BR
  1  83
  2  7B  SEQ
  3  F8  LDI
  4  10
  5  A7  PLO 7
  6  78
  7  27  DEC 7
  8  87  GLO 7
  9  3A  BNZ
  A  87
  B  7A  REQ
  C  F8  LDI
  D  0C
  E  A7  PLO 7
  F  78
090  27  DEC 7
  1  87  GLO 7
  2  3A  BNZ
  3  90
  4  28  DEC 8
  5  88  GLO 8
  6  32  BZ
  7  A5
  8  9F  GHI F
  9  30  BR
  A  79
  B
  C
  D
  E
  F
```

Program–IM 6604 (Continued)

```
0A0
  1
  2
  3
  4
  5  3C  BN1   OUTPUT SUBROUTINE
  6  9A        CONTINUED
  7  30  BR
  8  A5
  9  F8  LDI
  A  06
  B  A8  PLO 8
  C  34  B1
  D  77
  E  30  BR
  F  AC
0B0
  1
  2
  3
  4
  5
  6
  7
  8
  9
  A  D0  SEP 0
  B  7B  SEQ   (SEP 5) INDEX MARK
  C  F8  LDI   AT 700ms
  D  0A
  E  A7  PLO 7
  F  62  OUT 2
0C0  78
  1  27  DEC 7
  2  87  GLO 7
  3  78
  4  78
  5  3A  BNZ
  6  C1
  7  7A  REQ
  8  78
  9  78
  A  78
  B  3C  BN1
  C  CF
  D  30  BR
  E  CB
  F  34  B1
0D0  BA
  1  30  BR
  2  CF
  3
  4
  5
  6  D0  SEP 0
  7  F8  LDI   (SEP 4) REFERENCE
  8  05        MARK ROUTINE
  9  A3  PLO 3 (900ms)
  A  62  OUT 2
  B  7B  SEQ
  C  F8  LDI
  D  09
  E  A7  PLO 7
  F  78
0E0  78
  1  27  DEC 7
  2  87  GLO 7
  3  78
  4  78
  5  3A  BNZ
  6  E1
  7  7A  REQ
  8  3C  BN1
  9  EC
  A  30  BR
  B  E8
  C  7B  SEQ
  D  F8  LDI
  E  0B
  F  A7  PLO 7
```

Program--1M 6604 (Continued

```
0F0  27  DEC 7
  1  87  GLO 7
  2  78
  3  78
  4  3A  BNZ
  5  F0
  6  7A  REQ
  7  23  DEC 3
  8  83  GLO 3
  9  CA  LBNZ
  A  01
  B  05
  C  30  BR
  D  D6
  E
  F
100
  1
  2
  3
  4
  5  F8  LDI   REFERENCE MARK
  6  06        ROUTINE CONTINUED
  7  A7  PLO 7
  8  78
  9  78
  A  78
  B  78
  C  27  DEC 7
  D  87  GLO 7
  E  78
  F  78
110  3A  BNZ
  1  0C
  2  C0  LBR
  3  00
  4  EC
  5
  6
  7
  8
  9
  A
  B
  C
  D
  E              COUNT ROUTINE
  F  64  OUT 4   CALLED FROM 03E
120  89  GLO 9
  1  76  RSHR
  2  A9  PLO 9
  3  19  INC 9
  4  89  GLO 9
  5  FD  SDI   U.S.
  6  0A
  7  32  BZ
  8  2F
  9  89  GLO 9
  A  FE  SHL
  B  A9  PLO 9
  C  C0  LBR
  D  00
  E  41
  F  78
130  FE  SHL
  1  A9  PLO 9
  2  64  OUT 4
  3  8A  GLO A
  4  76  RSHR
  5  AA  PLO A
  6  1A  INC A
  7  8A  GLO A   T.S. CALLED
  8  FD  SDI     FROM 04B
  9  06
  A  32  BZ
  B  41
  C  8A  GLO A
  D  7E  RSHL
  E  AA  PLO A
  F  30  BR
```

Program–IM 6604 (Continued)

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

Program--1M 6604 (Continued)

190	8D	GLO D	COUNT ROUTINE
1	FD	SDI	CONTINUED
2	0A		
3	32	BZ	
4	9A		
5	8D	GLO D	U.H.
6	7E	RSHL	
7	AD	PLO D	
8	30	BR	
9	2C		
A	7E	RSHL	
B	AD	PLO D	
C	64	OUT 4	
D	8E	GLO E	
E	76	RSHR	
F	AE	PLO E	
1A0	1E	INC E	T.H.
1	8E	GLO E	
2	7E	RSHL	
3	AE	PLO E	
4	30	BR	
5	2C		
6	8D	GLO D	
7	FD	SDI	
8	04		
9	32	BZ	
A	B0		
B	8D	GLO D	
C	7E	RSHL	
D	AD	PLO D	
E	30	BR	
F	2C		
1B0	7E	RSHL	
1	AD	PLO D	
2	AE	PLO E	
3	64	OUT 4	
4	30	BR	
5	C0		
6			
7			
8			
9			
A			
B			
C			
D			
E			
F			
1C0	8F	GLO F	COUNT ROUTINE
1	76	RSHR	CONCLUDED
2	AF	PLO F	
3	1F	INC F	
4	8F	GLO F	
5	FD	SDI	
6	0A		
7	32	BZ	U.D.
8	CE		
9	8F	GLO F	
A	7E	RSHL	
B	AF	PLO F	
C	30	BR	
D	2C		
E	7E	RSHL	
F	AF	PLO F	
1D0	30	BR	
1	2C		
2			
3			
4			
5			
6			
7			
8			
9			
A			
B			
C			
D			
E			
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 (088)
6.1	00	6.0	OUTPUT SUBROUTINE (078)
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

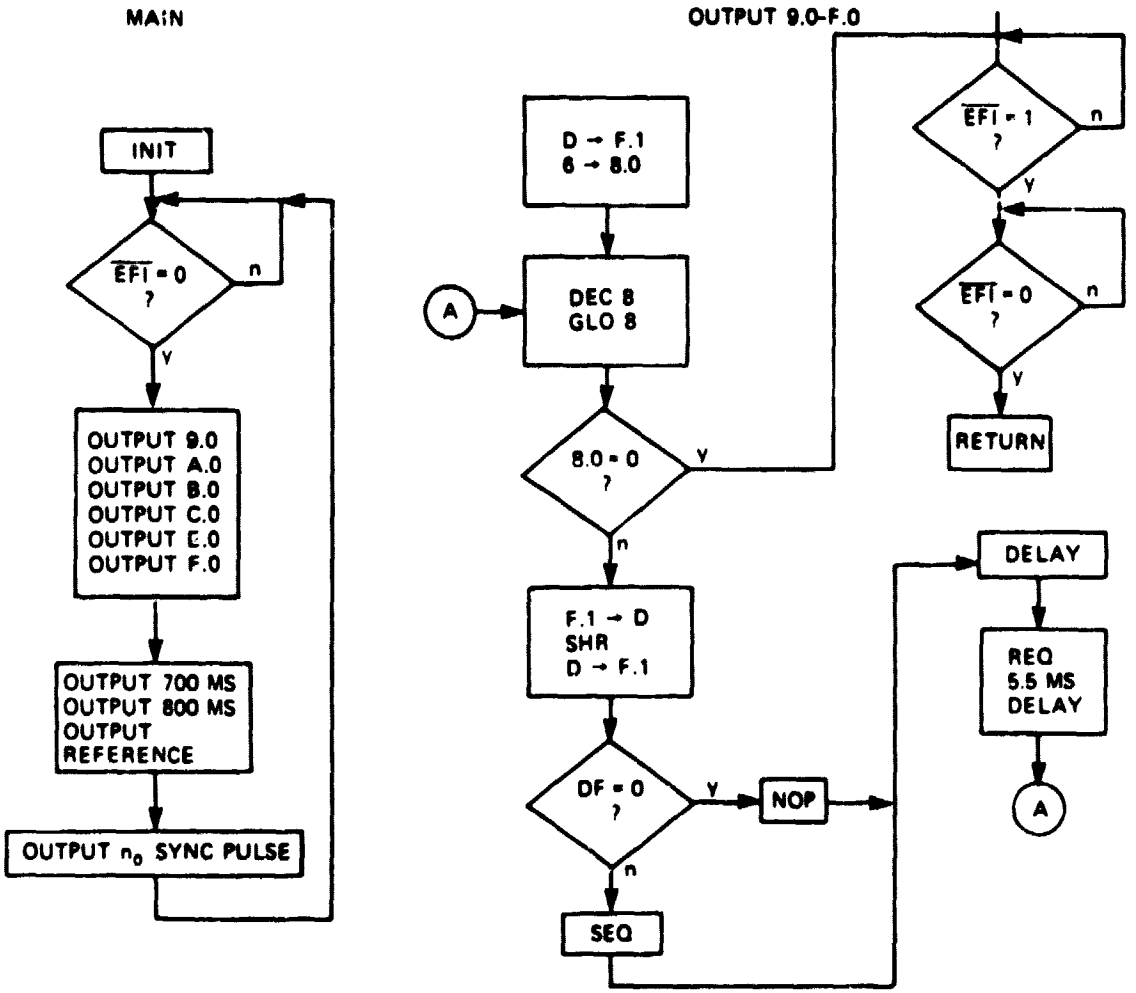


Figure 4a. Flow Charts

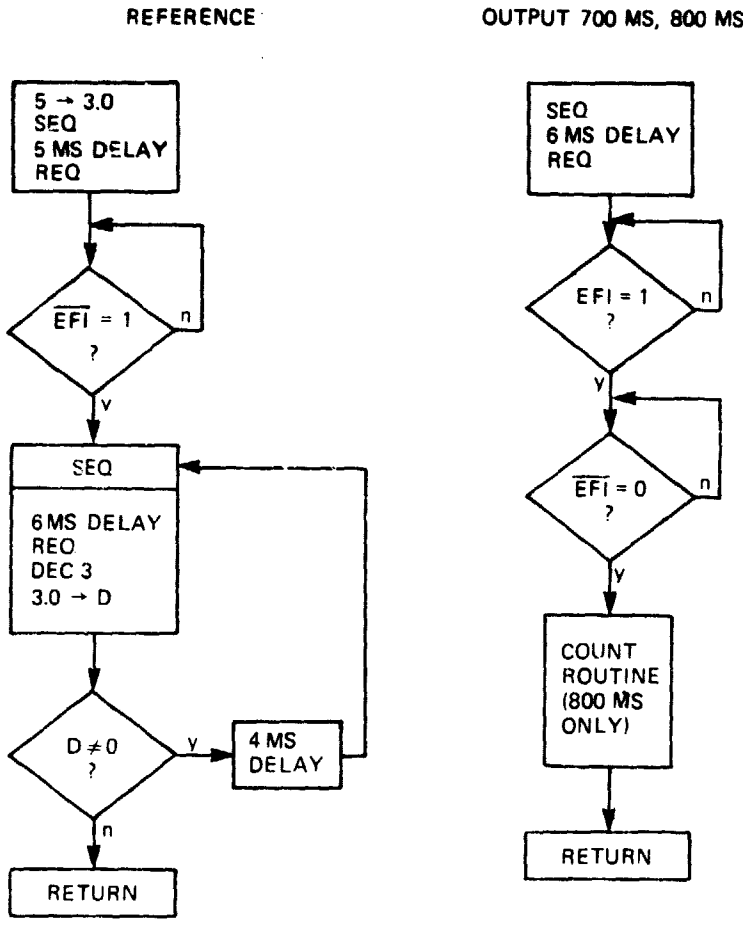


Figure 4b. Flow Charts, Continued

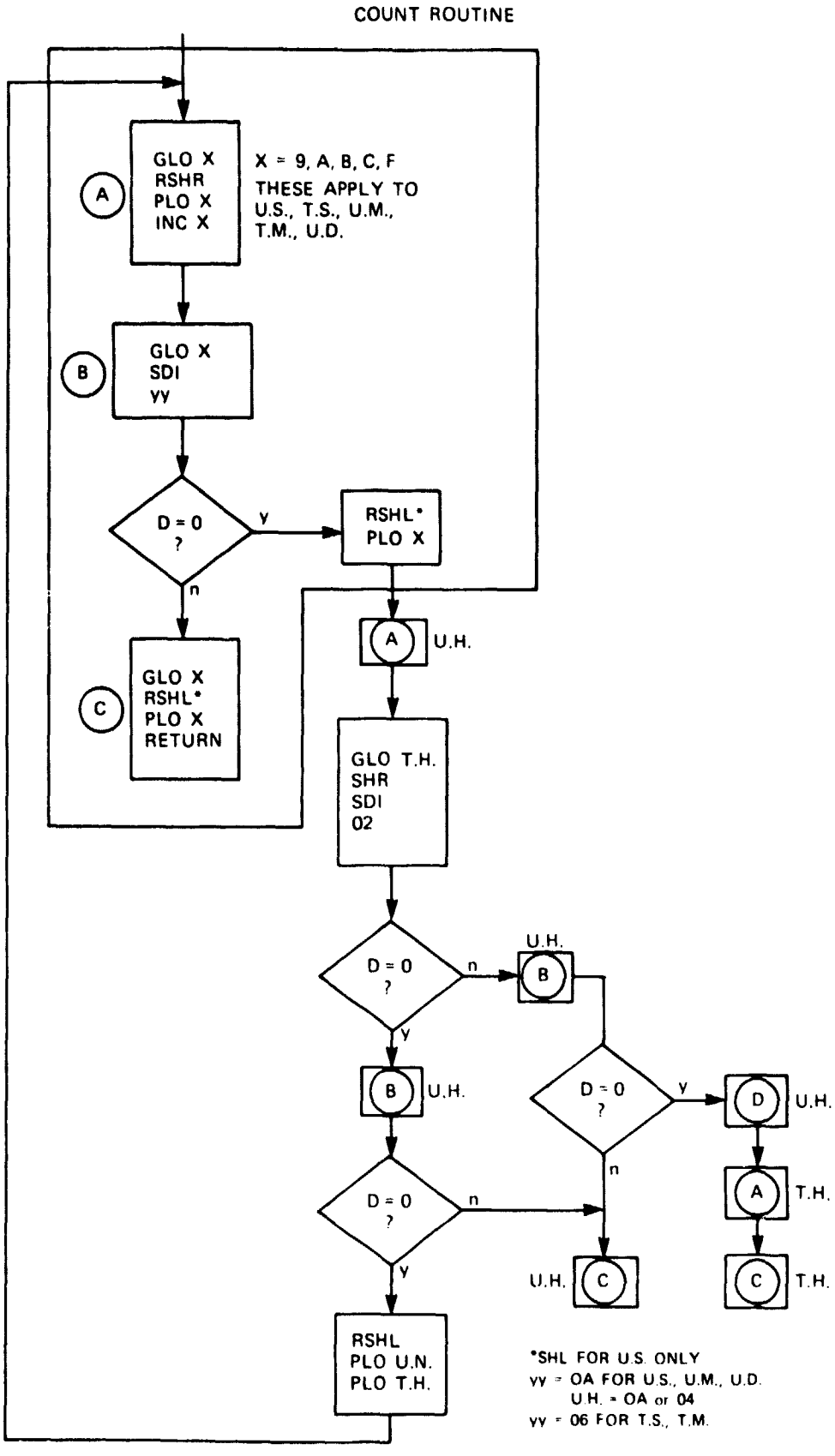


Figure 4c. Flow Charts, Concluded