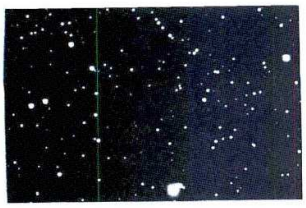


ASTRONOMY
ASTROPHYSICS SPECIAL

A KIM-1 SIDEREAL/SOLAR CLOCK

by John O. Bumgarner

This program includes both major and minor timing loops and can be tuned to run accurately with a wide range of clock frequencies. This program will also fit nicely into the KIM-1 scratch pad area.

Adjusting the clock rate by time fillers is an example of "fixing it in the software" rather than electronically adjusting the crystal clock rate. The fillers at locations 0216 and 0218 provide a 4 μsec. to 12 μsec. range of delays depending on the instructions loaded here. A 1 μsec. change in this delay results in about 19.82 seconds per day change in the clock rate. Inspection of the *MCS 650X Instruction Set Summary Card* shows several 2-byte instructions with execution times of from 2 μsec. to 6 μsec. The instructions chosen should not modify the time stored at locations 0020, 0021, 0022, the X register or the decimal mode bit.

The minor timing loop has the delay formula

Delay = 6 + 5(N-1) + V μsec. where
6 = 2 + 4, 2 μsec. for the load X,
4 μsec. for the loop without a branch
5 = loop time with a branch, μsec.
N = loop count, $01 to $FF or $00
V = variable time filler 2 μsec. to 6 μsec.

The delay introduced by this timing loop will vary from 8 μsec. (N = 1, V = 2 μsec.) to 1282 μsec. (N = 255, V = 6 μsec.). The loop will go 1287 μsec. if N = 00 since X is decremented to 255 before testing.

An example: Suppose you determine that your KIM-1 is running 10.63 seconds/day fast by observing it against a time standard such as WWV. Patient observation over several weeks will be necessary if the KIM-1 is close to the desired rate. The number of microseconds to delay per second is:

$$\frac{10.63 \times 10^6}{60 \times 60 \times 24} = \frac{10630000}{86400} = 123.03 \text{ or } 123\ \mu\text{sec. per second}$$

The loop parameters are found this way:

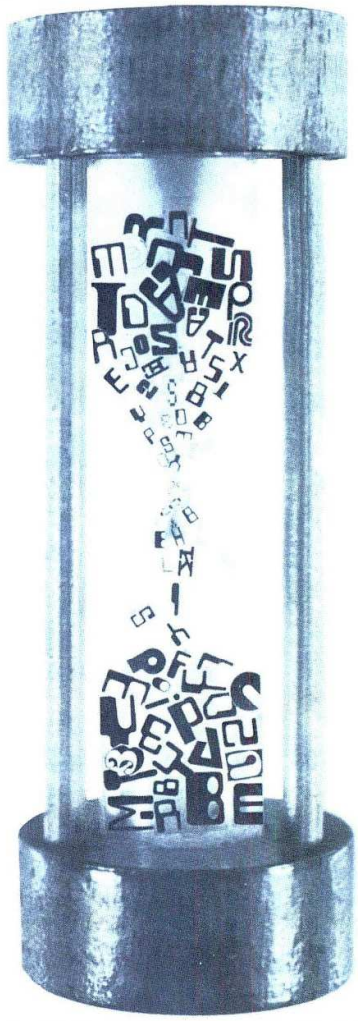
$123 - 6 = 117$ (the fixed delay amount)

$\frac{117}{5} = 23.4$ (23 loops plus 0.4 x 5 = 2 μsec. more),

$23_{10} = 17_{16}$.

The loop parameters would be $17 at location 021E and the filler would be 2 μsec. — say a LDY immediate instruction. By choosing the loop count and filler appropriately any delay in the range of the loop can be achieved to the nearest microsecond. A change of one microsecond in this loop will result in a change in the clock rate of 0.0864 seconds per day or about 30 seconds per year.

The KIM-1 programmable internal timers could be used for both the major and minor delays but require "watching" the timer or the wiring of the interrupt lines on the KIM-1 and are not so simple to tune as the delay loops.



The crystal clock rate can be accurately adjusted to the nearest microsecond by "fixing" it in the KIM-1 software fillers.

SIDEREAL/SOLAR CLOCK PROGRAM FOR KIM-1

HEX ADDR	CODE	LABEL			COMMENTS	
0200	A2E9	L1	LDX	$E9	Load X with timing loop count, Note 1.	
2	d8		CLD		Clear decimal mode.	
3	A520	L2	LDA	HR	Move time to display area. Note 2	major timing loop
5	85Fb		STA	Fb		
7	A521		LDA	MI		
9	85FA		STA	FA		
b	A522		LDA	SE		
d	85F9		STA	F9		
020F	8623		STX	T1	Save loop count. Note 2	
0211	20 1F 1F		JSR	SCANDS	Jump to KIM-1 display subroutine.	
4	A623		LDX	T1	restore loop count.	
6	A100		LDA	(0,X)	Note 3.	
8	A100		LDA	(0,X)		
A	CA		DEX		decrement loop count.	
b	d0E6		BNE	L2	Branch to loop head if X ≠ 0.	
d	A216		LDX	$90	Load X with timing loop count. Note 6.	
021F	CA		DEX		Decrement loop count.	minor timing loop
0220	d0Fd		BNE	*-1	If X ≠ 0, go back one line.	
2	b500		LDA	0,X	>Note 4.	
4	F8		SED		Set decimal mode for arithmetic.	establish & clean environment
5	18		CLC		Clear carry bit.	
6	A522		LDA	SE	Pick up seconds count.	
8	6901		ADC	$01	Add one to it.	
A	8522		STA	SE	Put it back.	
C	C960		CMP	$60	Compare seconds count to sixty.	
023E	d0d0		BNE	L1	If seconds not equal to sixty, to to the start. Note 5.	
0	8622		STX	SE	Set seconds count to zero (X is zero here).	
2	A521		LDA	MI	Pick up minutes count.	
4	6900		ADC	$00	Add one to it (the CMP at 022C set the carry bit on equal).	
6	8521		STA	MI	Put it back.	
0238	C960		CMP	$60	Compare seconds count to sixty.	
A	d0C4		BNE	L1	If minutes not equal to sixty, go to start.	
C	8621		STX	MI	Set minutes to zero.	
023E	A520		LDA	HR	Pick up the hours count.	
0240	6900		ADC	$00	Add one to it.	
2	8520		STA	HR	Put it back.	
4	C924		CMP	$24	Compare hours to 24. Note 6.	
6	d0b8		BNE	L1	If hours not equal to 24, go to the start.	
8	8620		STX	HR	Set hours to zero.	
024A	F064		BEQ	L1	Go to start.	
			END	@0200		

NOTES:

1. For regular time rate (UT or solar rate) load $EA instead of $E9.
2. Zero page locations used: 0020 for seconds, 0021 for minutes, 0022 for hours and 0023 temporary.
3. These two instructions are timing fillers. The two above are a 12μsec delay for sidereal time. For solar time my KIM-1 needs a delay of 8μsec and I use E6 23 A523 (INC T1, LDA T1) here.
4. This instruction is a time filler. It will probably be different in your KIM-1 for sidereal or solar rate, see text.
5. The compare instruction just before this branch sets the carry bit on equal compare. Therefore when seconds equal sixty the branch is not taken and adding zero later results in adding one due to the carry.
6. For solar time on my KIM-1 this constant is $16 instead of $90.
7. For 12 hour clock use the following code:

0244	C913		CMP	$13	Compare hours to thirteen.
6	dob8		BNE	L1	If hours not equal to thirteen, go to the start.
8	E8		INX		increment X. X is not $01.
9	8620		STX	HR	Store X in hours.
024b	Fob3		BNE	L1	Go to start.
			END	@0200	

8. To run, load the time, HR:MI:SE, in 20 to 22 on page zero and GO at address 0200.

ASTRONOMY
ASTROPHYSICS SPECIAL

LOCAL SIDEREAL TIME & DATE

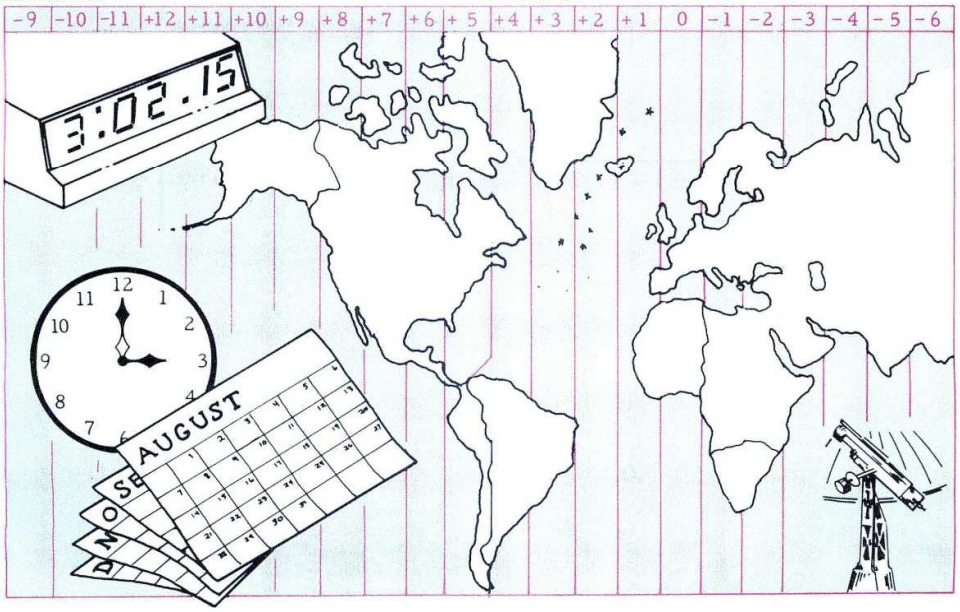
by James J. Brennan

DESCRIPTION

The following BASIC application program calculates the Greenwich Mean Time (GMT), Greenwich Sidereal Time (GST), Greenwich Sidereal Date (GSD), Julian Date (JD), corrected Local Mean Time (LMT), and Local Sidereal Time (LST).

PROGRAM

```
10 PRINT
40 PRINT"                    ASTRON 2
50 PRINT"A PROGRAM TO DO ASTRONOMICAL COMPUTATIONS FOR YOU
60 PRINT
70 REM INITIALIZE THE PROGRAM
80 GOSUB 1000
90 REM GET THE REQUIRED INFORMATION FOR THE CALCULATIONS
100 GOSUB 2000
110 REM CALCULATE THE NUMBER OF ELAPSED DAYS FROM THE BASE
120 REM DATE TO THE DATE IN QUESTION
130 GOSUB 3000
140 REM CALCULATE THE JULIAN DATE (AT 0 HRS U.T.) FOR
150 REM THE DATE IN QUESTION. (AT GREENWITCH LONGITUDE)
160 GOSUB 4000
170 REM CALCULATE THE SIDEREAL DAY
180 GOSUB 5000
190 REM CALCULATE THE GREENWITCH SIDEREAL TIME
200 GOSUB 6000
210 REM CALCULATE THE GREENWITCH MEAN TIME GIVEN THE LOCAL
220 REM CIVIL TIME AND TIME ZONE
230 GOSUB 7000
240 REM CONVERT THE GREENWITCH SIDEREAL TIME ACCOUNT FOR THE ACTUAL GMT
250 GOSUB 8000
260 REM CONVERT GMT TO LMT
270 GOSUB 9000
280 REM CONVERT GMT TO LOCAL SIDEREAL TIME
290 GOSUB 10000
899 REM PRINT OUT THE DATA THAT WAS CONPUTED
900 GOSUB 20000
1000 REM INITIALIZATION SUBROUTINE
1001 DEFDBL A-H
1002 DEFDBL J-Z
1799 C=.0666667#:REM 1"LONGITUDE= C SECONDS OF SOLAR TIME
1800 C1=76
1810 C2=1.0027379093#
1820 C3=.9972695664#
1830 C4=244
1840 C5=3000.5
1845 C5A=2443000.5#
1850 C6=244
1860 C7=9690
1861 C7A=2.44969E+06
1870 C8=8
1880 C9=10
1890 C10=76
1900 DS=86400!
1905 DX=86636.55536#
1910 HS=3600
```



```
1920 MS=60
1930 S=S
1940 SX=2449690#
1999 RETURN
2000 REM SUBROUTINE TO GET THE REQUIRED INFORMATION
2010 PRINT"ENTER THE MONTH,DAY,AND THE LAST TWO NUMBERS OF THE
2020 PRINT"YEAR IN QUESTION.  DONT FORGET THE COMMAS!
2030 PRINT"WHAT IS THE DATE";:INPUT M,D,Y
2040 PRINT:PRINT"ENTER THE LOCAL CIVIL TIME HOUR,MINUTE,AND
2050 PRINT"SECOND (DON'T FORGET THE COMMAS)! WHAT IS THE LOCAL
2060 PRINT"CIVIL TIME";:INPUT CH,CM,CS
2062 PRINT:PRINT"WHAT IS THE CIVIL TIME ZONE (PST OR PDT)";
2063 INPUT CZ$
2070 PRINT:PRINT"ENTER THE DEGREES, SECONDS, AND MINUTES
2080 PRINT"OF LONGITUDE OF THE PLACE IN QUESTION
2090 PRINT" (AGAIN, DONT FORGET THE COMMAS!)
2100 PRINT"WHAT IS THE LONGITUDE";:INPUT DL,ML,SL
2999 RETURN
3000 REM ROUTINE TO CALCULATE THE NULMBER OF ELAPSED DAYS
3010 REM FROM THE BASE DATE TO THE DATE IN QUESTION
3020 DIM T(13)
3060 DATA 31,28,31,30,31,30,31,31,30,31,30,31
3090 D3=0
3100 IF C8>2 THEN 3130
3115 IF INT(C10/4)-(C10/4)<>0 THEN 3130
3120 D3=1
3130 FOR I=1 TO 12
3140 READ T(I)
3160 NEXT I
3170 D3=T(C8)-C9+D3
3200 FOR I=C8+1 TO 12
3210 D3=T(I)+D3
3220 NEXT I
3260 Y3=C10
3265 Y3=Y3+1
3280 IF Y3>=Y THEN 3370
3310 IF INT(Y3/4)-(Y3/4)=0 THEN 3340
3315 D3=D3+365
3325 GOTO 3225
3340 D3=D3+366
3350 GOTO 3265
3370 IF M<=2 THEN 3400
3380 IF INT(Y/4)-(Y/4)<>0 THEN 3400
3390 D3=D3+1
3400 FOR I=1 TO M-1
3410 D3=T(I)+D3
3420 NEXT I
3430 D3=D+D3
3440 IF C10=Y THEN D3=D3-366
3445 IF M<=2 THEN D3=D3-31
3999 RETURN
4000 REM ROUTINE TO CALCULATE THE JULIAN DATE
4010 REM THE JULIAN DATE FOR THE BASE DATE OF
4020 REM AUGUST 10, 1976 IS 2,443,000.5
4030 REM AT 0 HRS U.T. AT GREENWITCH
4050 JD=C5A+D3
4999 RETURN
5000 REM ROUTINE TO CALCULATE THE SIDEREAL DATE IN TOTAL SECONDS
5010 REM AT 0 HRS U.T. ON THE DATE IN QUESTION
5030 REM SD=2449690.0 ON AUG 10 1976
5060 ST=SX * DS
5090 SY=ST+D3*DX
5999 RETURN
6000 REM ROUTINE TO CALCULATE THE GREENWITCH SIDEREAL TIME
6010 REM THE GST AT 0 HRS U.T. ON THE BASE DATE OF
6020 REM AUG 10,1976 WAS 21 HOURS, 14 MINUTES, 23.155 SEC.
6030 REM (MEAN SIDEREAL TIME)
6050 SZ=SY+(21*HS+14*MS+23.155)
6999 RETURN
7000 REM CALCULATE THE ACTUAL GREENWICH MEAN TIME FOR THE
7010 REM CIVIL TIME ENTERED
7030 CT=CH*HS+CM*MS+CS
7040 IF CT=>24*HS THEN 7500
7080 IF CZ$<>"PST" THEN 7600
7090 IF CZ$="PST" THEN GT=CT+8*HS: REM ADD 8 HOURS
7100 IF CZ$="PDT" THEN GT=CT+7*HS: REM ADD 7 HOURS
7130 GH=INT(GT/HS)
7140 GR=GT-(GH*HS)
7150 GM=INT(GR/MS)
7160 GR=GR-(GM*MS)
7170 GS=GR
7499 RETURN
7500 PRINT"THERE WAS AN ERROR IN THE CIVIL TIME THAT YOU ENTERED
7510 PRINT"PLEASE RE-ENTER THE LOCAL TIME IN HRS,MIN,SEC
7520 PRINT"WHAT IS THE CIVIL TIME";:INPUT CH,CM,CS:GOTO 7000
7600 IF CZ$="PDT"THEN 7100 ELSE 7610
7610 PRINT:PRINT:PRINT" RE-ENTER THE TIME ZONE.  IT CAN ONLY BE PST
7620 PRINT" OR PDT.  WHICH IS IT";:INPUT CZ$:GOTO 7080
8000 REM CONVERT GREENWITCH SIDEREAL TO ACCOUNT FOR THE
8010 REM ACTUAL GMT
8020 SZ=SZ+GS
8040 SD=INT(SZ/DS):SR=SZ-(SD*DS):SH=INT(SR/HS):SR=SR-(SH*HS)
8050 SM=INT(SR/MS):SR=SR-(SM*MS):SS=SR
8999 RETURN
9000 REM CONVERT GMT TO LMT
9020 TL=DL*HS+ML*MS+SL
9040 TZ=TL*C
9060 LT=GT-TZ
9080 LH=INT(LT/HS)
9090 LR=LT-(LH*HS)
9100 LM=INT(LR/MS)
9110 LR=LR-(LM*MS)
9120 LS=LR
9999 RETURN
10000 REM ROUTINE TO CONVERT GMT TO LOCAL SIDEREAL TIME
10080 W1=SZ-(TZ*1.0027379093#)
10090 W2=INT(W1/DS):REM DAYS
10100 W6=W1-(W2*DS):REM SEC REMAINING
10110 W3=INT(W6/HS):REM HOURS
10120 W6=W6-(W3*HS):REM SEC REMAINING
10130 W4=INT(W6/MS):REM MIN
10140 W6=W6-(W4*MS):REM SEC REMAINING
10150 W5=W6:REM SECONDS OF LOCAL SIDEREAL TIME
20000 REM ROUTINE TO PRINT OUT THE DATA COMPUTED
20010 PRINT:PRINT:PRINT
20020 PRINT"FOR THE CIVIL DATE ";M;D;Y
20030 PRINT"AND THE CIVIL TIME "CH;CM;CS;CZ$
20040 PRINT:PRINT"AT A LONGITUDE OF ";DL;ML;SL
20050 PRINT:PRINT"THE FOLLOWING INFORMATION APPLIES:"
20058 IF GH<0 THEN GH=GH+24
20059 IF GH=>24 THEN GH=GH-24
20060 PRINT:PRINT:PRINT"THE GREENWICH MEAN TIME (OR U.T.) IS "GH;GM;GS
20068 IF SH<0 THEN SH=SH+24
20069 IF SH=>24 THEN SH=SH-24
20070 PRINT:PRINT"THE GREENWICH SIDEREAL TIME IS ";SH;SM;INT(SS)
20080 PRINT:PRINT"THE GREENWITCH SIDEREAL DATE IS ";SD
20095 PRINT:PRINT"THE JULIAN DAY IS ";JD
20098 IF LH<0 THEN LH=LH+24
20099 IF LH=>24 THEN LH=LH-24
20100 PRINT:PRINT"THE LOCAL MEAN TIME (CORRECTED FOR
20110 PRINT"LONGITUDE"; DL;ML;SL ")  IS ";LH;LM;INT(LS)
20120 PRINT:PRINT"THE LOCAL SIDEREAL DAY IS";W2
20129 IF W3<0 THEN W3=W3+24
20130 PRINT:PRINT"THE LOCAL SIDEREAL TIME IS ";W3;W4;INT(W5)
OK

1000 REM INITIALIZATION ROUTINE
1001 REM THE FOLLOWING REMARKS STATEMENTS CONTAIN THE
1002 REM BASIC ASTRONOMICAL TIMEKEEPING INFORMATION
1003 REM USED IN THIS PROGRAM (FOR INFORMATION ONLY)
1010 REM GST=GREENWITCH SIDEREAL TIME
1020 REM GMT=GREENWITCH MEAN TIME
1030 REM UT=UNIVERSAL TIME (ANOTHER NAME FOR GMT)
1040 REM LMT=LOCAL MEAN TIME
1050 REM LCT=LOCAL CIVIL TIME
1060 REM LST=LOCAL SIDERIAL TIME
1070 REM GHA=GREENWITCH HOUR ANGLE
1080 REM LHA=LOCAL HOUR ANGLE
1090 REM RA=RIGHT ASCENSION
1100 REM LST=RA (AT UPPER TRANSIT)
1110 REM LST=RA+LHA
1120 REM LHA=LST-RA
1130 REM LST=LHA ARIES
1140 REM GST=GHA ARIES
1150 REM GST=LST+WEST LONGITUDE CONVERTED TO TIME
1160 REM GST=LST-EAST LONGITUDE CONVERTED TO TIME
1170 REM GMT=LMT+WEST LONGITUDE CONVERTED TO TIME
1180 REM GMT=LMT-EAST LONGITUDE CONVERTED TO TIME
1190 REM 1" LONGITUDE= 0.666667 SECONDS OF SOLAR TIME
1200 REM 1' LONGITUDE= 4 SECONDS OF SOLAR TIME
1210 REM 1 DEGREE LONGITUDE= 4 MINUTES OF SOLAR TIME
1220 REM 15 DEGREES LONGITUDE= 1 HOUR OF SOLAR TIME
1230 REM 24 HOURS OF SIDEREAL TIME IS EQUAL TO
1240 REM 23 HOURS,56 MIN, 04.1 SEC OF SOLAR TIME
1250 REM
1260 REM 24 HOURS OF MEAN SOLAR TIME IS EQUAL TO
1270 REM 24 HOURS, 03 MIN, 56.6 SEC OF SIDEREAL TIME
1280 REM
1290 REM FOR EACH 1 HOUR OF SIDEREAL TIME, 1 HOUR OF
1300 REM MEAN SOLAR TIME IS 9.83 SEC SHORTER
1310 REM
1320 REM FOR EACH 1 HOUR OF MEAN SOLAR TIME, 1 HOUR OF
1330 REM SIDEREAL TIME IS 9.87 SECOND LONGER
1340 REM
1350 REM 1 SOLAR SECOND=1.00273791 SIDEREAL SECONDS
1360 REM 1 SIDEREAL SECOND=0.997270 SOLAR SECOND
1370 REM FIRST POINT OF ARIES IS ABOUT MARCH 21
1380 REM SUMMER SOLSTICE IS ABOUT JUNE 22
1390 REM AUTUMNAL EQUINOX IS ABOUT SEPT 23
1400 REM WINTER SOLSTICE IS ABOUT DEC 22
1410 REM FPA TO FPA IS 365 DAYS,05 HOURS,48 MIN,46 SEC
1420 REM AND IS CALLED THE TROPICAL YEAR
OK

RUN

                    ASTRON 2
A PROGRAM TO DO ASTRONOMICAL COMPUTATIONS FOR YOU

ENTER THE MONTH,DAY,AND THE LAST TWO NUMBERS OF THE
YEAR IN QUESTION.  DONT FORGET THE COMMAS!
WHAT IS THE DATE? 7,9,77

ENTER THE LOCAL CIVIL TIME HOUR,MINUTE,AND
SECOND (DON'T FORGET THE COMMAS)! WHAT IS THE LOCAL
CIVIL TIME? 11,45,30

WHAT IS THE CIVIL TIME ZONE (PST OR PDT)? PDT

ENTER THE DEGREES, SECONDS, AND MINUTES
OF LONGITUDE OF THE PLACE IN QUESTION
 (AGAIN, DONT FORGET THE COMMAS!)
WHAT IS THE LONGITUDE? 121,07,30


FOR THE CIVIL DATE  7  9  77
AND THE CIVIL TIME  11  45  30 PDT

AT A LONGITUDE OF  121  7  30

THE FOLLOWING INFORMATION APPLIES:


THE GREENWICH MEAN TIME (OR U.T.) IS  18  45  30

THE GREENWICH SIDEREAL TIME IS  19  7  46

THE GREENWITCH SIDEREAL DATE IS  2450024

THE JULIAN DAY IS  2443333.5

THE LOCAL MEAN TIME (CORRECTED FOR
LONGITUDE 121  7  30 )  IS  10  40  59

THE LOCAL SIDEREAL DAY IS 2450024

THE LOCAL SIDEREAL TIME IS  11  1  56
OK
```