AN460
An RDS Decoder using the MC68HC05E0

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INTRODUCTION

The Radio Data System (RDS) adds a digital data capability to the FM VHF transmissions on band II (87.5 to 108 MHz). This capability is in use in the UK and several other European countries, the intention being that most of western Europe will eventually adopt it. The specification is defined in EBU Technical Document 3244 (see reference 1).

To transmit the data, a sub carrier is added at 57 KHz. This sub carrier is amplitude modulated with a shaped bi-phase coded signal. The sub carrier itself is suppressed to avoid data modulated cross-talk in phase-locked loop stereo decoders and to maintain compatibility with the German ARI system which uses the same sub carrier frequency. Information is sent in groups of four 26-bit blocks. Each group of 104 bits is one of several types containing different information. It is up to the broadcaster which features are transmitted. The only constraints are that the specified format must be adhered to and that PI, PTY and TP should always be included. Each group contains a different sub-set of the RDS features; table1 lists all currently defined RDS features.

Table 1. RDS features

Feature	Information
PI	Program identification
PTY	Program type
PS	Program service name
RT	Radiotext
CT	Clock time and date
AF	Alternative frequencies
TA	Traffic announcement
TP	Traffic program
MS	Music/speech switch
DI	Decoder identification
PIN	Programme item number
EON	Enhanced other networks
TDC	Transparent data channel
INH	In-house data

The retrieval of data is carried out by a demodulator circuit which generates clock and data signals that can be used by a microprocessor. Suitable demodulators which can perform this function include SAA7579T, TDA7330, LA2231 and RDS hybrids. The block diagram of a typical application is shown in Figure 1. The microprocessor, in this case an MC68HC05E0, decodes the RDS data using the clock and data signals from one of these demodulators and sends selected data to dot-matrix display modules.

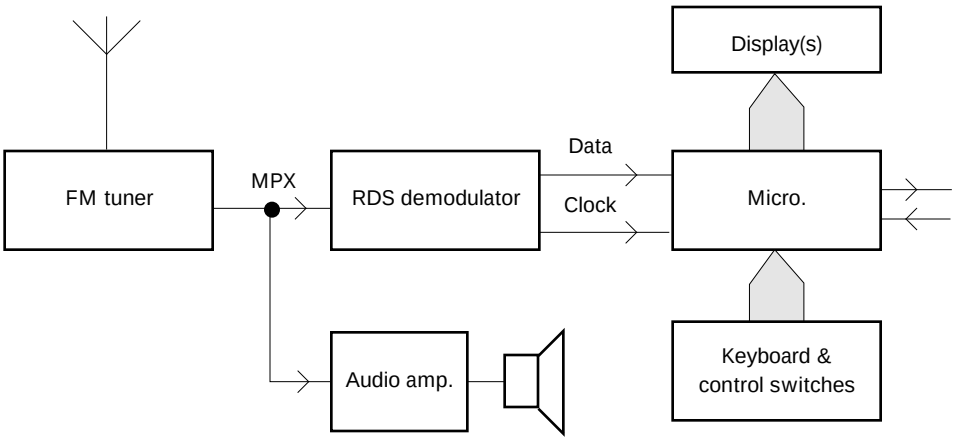

Figure 1. Typical application

This application incorporates an alarm clock which, if permanently powered, can be used to switch on the radio supplying the RDS data, at the required alarm time. There is a second alarm output intended to sound an alarm. This output is cancelled when any key is pressed, leaving the control output active. The control output could be used to switch the power supply of the radio or the audio stage. If an audio mute is used, RDS information can be updated even when the radio is "off". Alternatively the decoder can be used simply to display RDS data with its power being supplied from the radio and manually switched on and off.

RDS FEATURES

This application supports PI, PTY, PS, RT, CT, TP, TA, MS, DI, PIN and EON (see Table 1). These features facilitate permanent display of the 8-digit station name (PS) and time (CT) and, on request, can display program type (PTY), radiotext data (RT) and the status of the other RDS features. EON data can be displayed, but the retuning features associated with AF and EON are not supported as there is no capability to control the tuned frequency. In a car radio EON data would be used to switch the radio to a station which is broadcasting local traffic information and AF data to tune the radio to the strongest signal carrying the selected service.

PI is a two byte number which identifies the country, coverage area and service. It can be used by the control microprocessor but is not normally intended for display. A change in PI code causes the initialisation of all RDS data as it indicates that the radio has been retuned. This application also facilitates the display of the current PI code.

PTY is a 5-bit number which indicates the current program type. At present 16 of these types are defined. Examples include "no programme type", "Current affairs" and "Pop music", although the actual syntax which is displayed is determined by the software of the controlling microprocessor. In this example PTY can be displayed on request. Table 2 shows the display used for each PTY code.

PS is the eight character name of the station and is permanently displayed (except in the standby mode).

RT is radiotext and constitutes a string of up to 64 characters which give additional information regarding the service or programme currently being transmitted. In this application, RT is displayed on request on the 16-digit dot-matrix displays using scrolling.

Table 2. PTY Types

PTY	Display
0	No program type
1	News
2	Current affairs
3	Information
4	Sport
5	Education
6	Drama
7	Culture
8	Science
9	Varied
10	Pop music
11	Rock music
12	Easy listening
13	Light classics
14	Serious classics
15	Other music
16-31	No program type

The data often contains extra spaces to centre the text on a 2x32 character display. As this is not suitable for a 16-character scrolling display the software reduces all sequences of two or more spaces to a single space.

CT data is transmitted every minute on the minute and provides a very accurate clock, traceable to national standards. The (Modified Julian) date and local time variation are also transmitted. Time is permanently displayed. In standby mode (see below) the date is displayed instead of the PS name. The MJD number, which is the form in which the date is received, can also be displayed. The microprocessor converts this number into day-of-week, day-of-month, month and year.

AF would be used by a car radio to retune to the strongest signal carrying the selected service. AF data, along with TDC and INH, is not used in this application.

TA and TP are flags. TP is set if the transmitter normally carries traffic information and TA is set if a traffic announcement is in progress. The combination, TA=1 and TP=0, is used to indicate that EON data is being used to supply information on other networks including traffic announcements. The status of these flags can be displayed and the combination, TA=TP=1, is brought out to a pin and can be used to control a LED or external hardware. An example of this could be to demute the radio or switch from cassette when a traffic announcement is taking place.

MS is a single bit indicating either music or speech and is intended to be used to make a tone or volume adjustment to a radio's audio stage. The MS bit is displayed on request.

Decoder information (DI) constitutes four bits indicating the type of transmission (mono, stereo, binaural, etc.). It is not currently in use in the UK but can be displayed as a number between 0 and 15.

Programme item number or PIN is used to identify the programme currently being broadcast. The format is a 2-byte number which includes the scheduled time and date (day-of-month) of the start of the programme. It can be displayed as four hexadecimal digits or fully decoded to day-of-month and time.

EON (Enhanced Other Networks) replaces the older ON format. If type 14 groups are used to provide EON data then type 3 groups (ON) will not be used (Table 6 shows the currently defined group types). Type 14A groups are used to send information about other networks. The PS name and principal frequency of up to 11 other networks can be displayed. Type 14B groups are intended to be used to switch to traffic announcements in a radio in which the microprocessor can control the tuned frequency.

DECODING

Each 26-bit block contains 16 bits of data and 10 extra bits which are used for synchronisation and error detection. There are no gaps between blocks or groups, the synchronisation being done by looking for specific checkwords in the incoming data. In order to look for a checkword a stream of 26 consecutive data bits has to be multiplied by the fixed 10x26 matrix shown in Figure 2.

The result of this multiplication is a 10-bit word which is compared with allowed values. There are 5 of these 10-bit “syndromes”, one for each of the blocks 1, 2 and 4 and two for block 3 (see Table 3). The alternative syndrome for block 3 is used in the B version of a group. In this version the PI code is sent in block 3, replacing what would be sent in the A version of the same group type. This is done to increase the frequency of sending the PI code so that it can be acquired more quickly.

```
10 0000 0000  ($02,$00)
01 0000 0000  ($01,$00)
00 1000 0000  ($00,$80)
00 0100 0000  ($00,$40)
00 0010 0000  ($00,$20)
00 0001 0000  ($00,$10)
00 0000 1000  ($00,$08)
00 0000 0100  ($00,$04)
00 0000 0010  ($00,$02)
00 0000 0001  ($00,$01)
10 1101 1100  ($02,$DC)
01 0110 1110  ($01,$6E)
00 1011 0111  ($00,$B7)
10 1000 0111  ($02,$87)
11 1001 1111  ($03,$9F)
11 0001 0011  ($03,$13)
11 0101 0101  ($03,$55)
11 0111 0110  ($03,$76)
01 1011 1011  ($01,$BB)
10 0000 0001  ($02,$01)
11 1101 1100  ($03,$DC)
01 1110 1110  ($01,$EE)
00 1111 0111  ($00,$F7)
10 1010 0111  ($02,$A7)
11 1000 1111  ($03,$8F)
11 0001 1011  ($03,$1B)
```

Figure 2. 10x26 decoding matrix

Table 3. Syndromes

Block	Syndrome	Binary	Hex
1	A	11 1101 1000	$03,$D8
2	B	11 1101 0100	$03,$D4
3	C	10 0101 1100	$02,$5C
	C'	11 1100 1100	$03,$CC
4	D	01 0101 1000	$01,$58

This syndrome test has to take place after each bit is received. The test inspects the last 26 bits received, until a valid syndrome is found. In this application, only syndrome A is accepted during the bit-by-bit syndrome check and the data is used only after four valid syndromes have been acquired. A more complex algorithm could allow all syndromes to be accepted during initial synchronisation and require less than four valid syndromes before the data is used. This can reduce the time taken to acquire the PI code, which is also included in block 3 of type B groups, but increases the likelihood that random data, giving a valid syndrome, will be used in error. The bit rate is 1187.5 Hz so the control microprocessor has a lot to do during this initial synchronisation. Once the first valid syndrome has been found, subsequent syndrome checks need be done only after the next 26 bits have been received, as this is when the next valid syndrome would be expected. If it is not found, then the bit-by-bit synchronisation check is re-started. Once consecutive A, B, C (or C') and D syndromes have been detected, a complete group has been acquired and the data can be used.

Four bits in block 2 determine the group type. Block 2 also contains TP and PTY data. The use of the other bits in blocks 2, 3 and 4 depends upon the group type while block 1 always contains the PI code. Table 7 shows the structures of the group types which are handled in this application.

CIRCUIT

Figure 3. shows the circuit diagram. As different demodulator devices can be used, the circuitry for the demodulator is not shown. The clock from the demodulator interrupts the microprocessor on each positive edge. At this time a data bit is available and is read on bit 2 of port B. Both an LCD and a VFD module are shown but normally only one will be used. If the LCD module is not connected, a pull-down resistor should be connected to bit 7 of port C, as the microprocessor uses this bit to check that the controller in the module is ready to receive a command. If this bit is left open circuit, it may cause the software to hang up. Alternatively the LCD drive software could be removed, allowing the use of port C for other purposes.

With more I/O available, additions to the software would allow access to the other control bits intended for controlling external hardware. These include the MS bit, DI data (4 bits) and PIN (match with current time and date). They could be brought out to port pins in a manner similar to that used for the TA=TP=1 signal. The unused port A and D pins could also be used for this purpose but in this application they were used during debug by the E0BUG monitor (reference 2). The application could make use of the port A and D pins, if debugging was done on a development system which did not have this limitation.

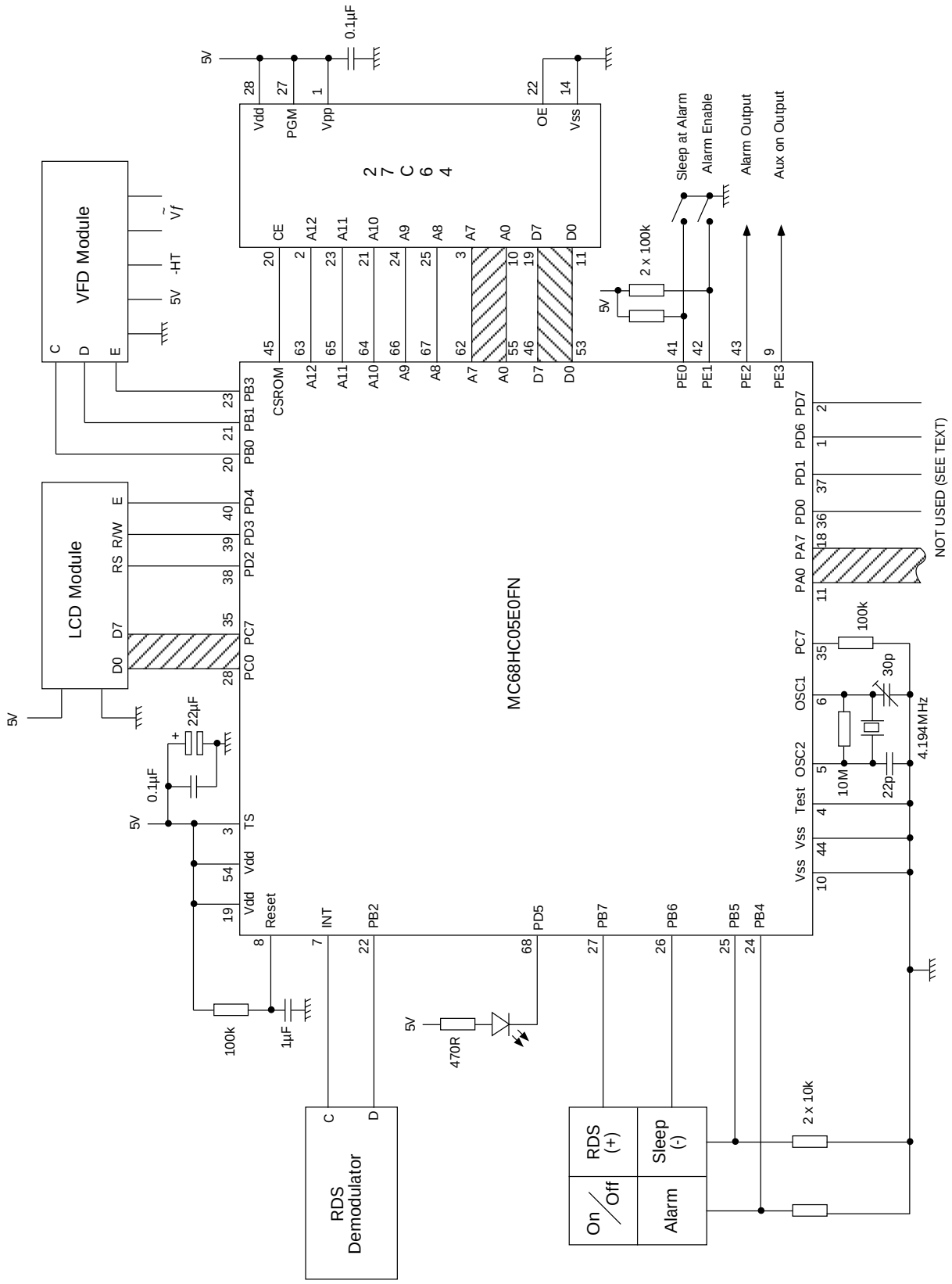

Figure 3. Circuit diagram

SOFTWARE

The complete software is listed. The reset routine (START) sets up the I/O ports including the enabling of some of the special functions available on port D. These signals (A15, A14, R/W and the P02 clock) were used during debug. The pins are not used in the final application. This also applies to all the port A pins which are configured as outputs. External interrupts are enabled on positive edges so that the RDS clock can interrupt the microprocessor when each data bit is available. Timer B runs as a real-time clock with interrupts every 125 ms. Correct operation of this clock in the absence of an RDS signal requires that a 4.194 MHz crystal be used (the trimmer on pin 6 should be adjusted for accurate timekeeping). Timer A's pre-scaler is set up to divide by 64; this causes the idle loop to cycle at 64Hz. The reset routine also initialises the LCD module (the display shows Mon 0 inv 00:00 until a valid group 4A is received), clears the RAM and calls a subroutine (INITD) to initialise the RAM locations used for displaying data.

Lines 114-118 and 193-208 are commented out as they are only relevant when de-bugging using the E0BUG monitor (reference 2).

The idle loop (IDLE) regularly checks the local keyboard for a keypress, compares the current time with the alarm time and performs other time-dependent functions related to the display modules and the sleep timer.

The keyboard software (KBD) scans the 4-key matrix for a keypress every 16ms. If the same key is held pressed for 3 successive scans, it acts on this key function by calling the relevant subroutine (ALARM, ONOFF, SLEEP or RDS). This software also controls the repeat rate of the SLEEP and RDS keys. This rate is set at 6Hz (after an initial 750ms delay) when the keys are used to change the alarm time and 1Hz for their normal function. The other keys do not repeat if held down. Table 4 shows the functions available in each mode.

Table 4. Key functions

<table>
<tr><th rowspan="2">MODE</th><th colspan="4">KEY</th></tr>
<tr><th>On/Off</th><th>Sleep</th><th>Alarm</th><th>RDS</th></tr>
<tr><td>Standby (Off)</td><td>mode normal (On)</td><td rowspan="4">mode sleep (On)</td><td rowspan="2">mode alarm</td><td>—</td></tr>
<tr><td>Normal (On)</td><td rowspan="2">mode stndby (Off)</td><td rowspan="3">RT
PTY
PI
TA/TP
PIN(h)
PIN(d)
MJD
MS/DI
EON 1
:
:
EON 11</td></tr>
<tr><td>Alarm OFF</td><td>mode alarm ON</td></tr>
<tr><td>Alarm ON</td><td>mode alarm set-up</td><td rowspan="2">mode alarm OFF</td></tr>
<tr><td>Alarm SET UP</td><td>toggle hr/min</td><td>dec. hr/min</td><td>inc. hr/min</td></tr>
</table>

The On/Off key uses the subroutine ONOFF to toggle between ON and standby. A port pin (3,PORTE) can be used to control the power to the VHF radio and/or other external hardware. In standby mode, with the alarm disabled, the time and date are displayed. If the alarm is enabled, the alarm time is displayed. In the ON mode the time is displayed along with the current RDS PS-name. Table 5 shows these display formats.

Table 5. Display formats

Display mode		Format
Standby (Off)	Alarm off	Thu 30 Apr 18:05
	Alarm off, no CT	Mon 0 inv 0:00
	Alarm on	0659 ALARM 18:05
Normal (On)	With RDS PS name	BBC R4 18:05
	Without RDS	–------- 18:05
Alarm	Alarm off	Alarm – OFF
	Alarm on	Alarm – 6:59
Sleep		Sleep 60 min.
RDS	RT	BBC Radio 4 ....
	PTY	News
	PI	PI code – C204
	TA & TP	TP – 0 TA – 1
	PIN(hex)	PIN no. – F480
	PIN(decod)	30th at 18:00
	MJD	MJ day – 48742
	MS & DI	M/S M DI 15
	EON 1	BBC R3 92.10
	2	BBC R.Sc 103.60
	3	BBC Nwcl 96.00
	4	BBC Scot 94.30
	5	BBC Mtme 92.50
	6	BBC Twed 93.50
	7	BBC R5 909kHz
	8	BBC Eng. 100.00
	9	BBC R1 99.50
	10	BBC R2 89.90
	11	–-------

The Alarm key calls the subroutine ALARM which displays the current alarm status. A second press changes the alarm armed status. When the alarm is armed, the alarm time is displayed. In this mode the On/Off key can be used to select either hours or minutes (indicated by flashing) and the Sleep and RDS keys used to increment and decrement the settings. If the alarm has triggered then the first press of any key cancels it. The alarm display has one of the two alarm formats shown in Table 5 according to whether or not the alarm is armed. As all the keys have a special function in the alarm mode the only way to exit this mode is to wait for a timeout. If no keys are pressed for 5 seconds, the mode returns to normal.

The Sleep key controls the sleep timer. If the decoder is in the standby mode the first press of Sleep switches it on and initialises the sleep time to 60 minutes. When the sleep timer is running, this is indicated by a flashing decimal point in the right-most character of the display modules. Subsequent presses of the Sleep key decrement the time remaining by 5 minutes. When the sleep time has elapsed, the decoder returns to standby. In the alarm set-up mode this key decrements the alarm time.

The RDS key uses subroutine RDS to step through the various RDS data which can be displayed. Holding down this key steps through the displays at 1Hz. The displays are RT (scrolling), PTY, PI, TA/TP, PIN (hex), PIN (decoded), MJD, MS/DI and EON (11 networks) as shown in Table 5. In the alarm set-up mode this key increments the alarm time.

The timer interrupt routine (TINTB) updates the RT scrolling pointers (DISP1 and DISP2). These pointers are incremented regularly whether or not an RT display is active. In this way, the software can be easily converted to using a 2-line LCD module in which the top line is the normal display of PS-name and time and the lower line a permanent display of scrolling RT. The timer interrupt also decrements the sleep timer and updates the RAM locations used to store hours, minutes, seconds and eighth-seconds. All RDS data (except date and time) is cleared by this routine if no valid RDS data is detected for a period of 10 seconds.

SYNDROME AND CONFIDENCE

Hardware interrupts are vectored to jump to SDATA where serial data is received from the RDS demodulator. The clock edge causes an interrupt and the first instruction reads the data into the carry bit of the condition code register. The bit is shifted into a 4-byte RAM register and the matrix multiplication performed. The state of flag 0,STAT2, determines if the multiplication is to take place after every bit or only after all 26 bits have arrived. The multiplication is performed using two EOR instructions for every bit (two are required as the 10-bit syndrome requires two bytes). As the top of the matrix (see Figure 2.) is the unity matrix, the first 10 bits are transferred directly into the syndrome RAM locations (SYN). This, the omission of any EOR #$00 instructions, the reordering of the bits and the use of the index register for temporary storage help to reduce the length of inline code in this routine. The routine could be shortened by using a loop but this would incur an unacceptable penalty in execution time. Microprocessors with two accumulators would find this task a lot simpler and quicker but an MC68HC05E0, at half its maximum speed, can easily perform the calculation in the required time.

After the multiplication has been performed the resultant 10-bit number is compared with the allowed syndromes (see Table 3). The variable LEV records the current block level. It is initially zero but incremented each time a valid syndrome is found. When it is zero only syndrome A is accepted, if this is found then syndrome B is expected 26 bits later so when LEV is one only syndrome B is accepted. If an invalid syndrome is found LEV is cleared, the syndrome confidence level CONF is decremented and the interrupt ended.

When a valid syndrome is found, CONF in increased by 4 and the 16 data bits saved in the relevant bytes of TMPGRP. If the valid syndrome is type D then a complete group has been received and all 8 bytes are transferred to the 8 RAM locations at GROUP. This double buffer means that the data in GROUP can be used while interrupts are overwriting TMPGRP with new data.

The confidence level CONF is used to decide what should be done if the data becomes unreliable due to a poor RF input to the receiver. When the first valid syndrome is found it is initialised to 42. Subsequent valid syndromes increment it by four and invalid ones decrement it by 1. If CONF falls below 41, then it is assumed that synchronisation has been lost and a bit-by-bit re-synchronisation is carried out. If it falls below 10, the signal is deemed unacceptable and the displays are re-initialised. The confidence level is not incremented by the detection of a valid syndrome if it is higher than 56.

GROUPS HANDLED

If a complete group has been received the data can be processed. The buffering used would allow this to be done outside the interrupt but in this case there is sufficient time to do it within the interrupt. The PI code is checked to see if it has changed. If it has changed the displays are initialised. In an application using the AF capability of RDS, more use would be made of the PI code.

Next PTY and TP are updated and the group type identified. Group types 0A, 0B, 1A, 1B, 2A, 4A, 14A and 15B are handled. Table 6 shows the type of information contained in each group and Table 7 shows the detailed structure of the groups actually used.

Table 6. RDS Groups

Group	Features
All	PI, PTY, TP
0	TA, DI, MS, PS, AF
1	PIN
2	RT
3	ON (replaced by EON)
4A	CT
5	TDC
6	INH
14	EON
15B	TA, DI, MS

Group 0 & 15B

As AF data is not handled, there is no difference in the treatment of groups 0A and 0B. PS data is extracted and placed in RAM according to the address bits in block 2 (see Table 7). TA, DI and MS data are then read, DI is sent a single bit at a time and uses the same address bits as the PS name to determine which of the four bits is being updated. Groups of type 15B also contains all this switching information. They are used to increase the repetition rate of this data but contain no PS or AF information.

Group 1

Group types 1A and 1B contain the same data except for the repetition of the PI code in type 1B. The PIN data is recovered and saved in RAM. This is intended for future use to control external hardware, for example a tape recorder. This would facilitate the unattended recording of a pre-selected program. At present this application simply allows the display of PIN data both in its raw hexadecimal form and fully decoded to day-of-month and time. Full use of PIN data would require continuously comparing the PIN day-of-month and time with the current day-of-month and time enabling an I/O pin to be switched when there is a match.

Group 2A

RT data from blocks 3 and 4 is written to RAM according to the address included in block 2. There are four address bits and four ASCII encoded bytes giving the possibility of 64 characters. If the Text A/B flag changes state, the RT area in RAM is cleared, indicating that the message has changed. Group 2B is not handled as it is rarely, if ever, used.

Group 4A

Two of the more complex tasks to be performed are required by the CT calculations for group 4A. These are for the local time difference and the conversion of the MJD number into a recognisable date.

The broadcast time is Universal Coordinated Time (UTC), effectively the same as GMT. Time differences from UTC, including summer (daylight saving) time, are sent as an offset of up to +/- 12 hours in half-hour increments.

The software includes 4-function, 9-digit integral BCD arithmetic which is used to decode the date from the MJD number using the formulae:

Y' = int[(MJD-15078.2)/365.25]

M' = int[(MJD-14956.1-int{Y'x365.25})/30.6001]

Day = MJD-14956-int(Y'x365.25)-int(M'x30.6001)

If M'=14 or M'=15,
then K=1;
else K=0

Year = Y'+K

Month = M'-1-12K

Group 14A

This group contains EON data. A large amount of information can be sent using this group, and it can take up to two minutes for all the data to arrive after the radio has been retuned. This application saves the PI code, PS name and principal frequency of up to 11 networks although more networks, each with many frequencies, and other data (e.g. PTY(ON), PIN(ON), TA(ON) etc.) may be sent. Table 5 shows the format of the EON display. All the information shown is real data from the Black Hill transmitter in central Scotland.

Displays

The software drives both a parallel LCD module (based on an HD44780 driver with or without an HD44100) and a serial VFD module (based on an MSC7128 driver) to give a choice of display types. The displays show the same data (within the limitations of their character ROMs).

The display routine (MOD) is executed in the idle loop if flag 3,STAT2 is set. It is set every 125ms by timer B interrupts. If flag 4,STAT2 is set, the display is initialised, indicating no valid RDS data. The LCD module is then updated with new data. Each time anything is written to the module, the subroutine WAIT is used before the write is executed; this checks that the controller in the module is not busy. This is indicated by a low on bit 7, so bit 7 on port C should have a pull-down resistor to satisfy this condition if an LCD module is not being used.

Table 7.

	Block 1		Block 2		Block 3		Block 4	
Group 0 and 15B	PI code	chck A	bit(s) use 15–12 : group no. 11 : group type 10 : TP flag 9–5 : PTY code 4 : TA flag 3 : M/S bit 2 : DI bit 1–0 : PS/DI address	chck B	AF (PI code in type 0B and 15B)	chck C or C'	PS name (as block 2 for 15B)	chck D
Group 1	PI code	chck A	15–12 : 0001 11 : group type 10 : TP flag 9–5 : PTY code 4–0 : not used	chck B	not used (PI code in type 1B)	chck C or C'	PIN data 15–11 : day-of-month 10–6 : hour 5–0 : minute	chck D
Group 2A	PI code	chck A	15–12 : 0010 11 : 0 10 : TP flag 9–5 : PTY code 4 : text A/B flag 3–0 : text address	chck B	RT 2 ASCII characters	chck C	RT 2 ASCII characters	chck D
Group 4A	PI code	chck A	15–12 : 0100 11 : 0 10 : TP flag 9–5 : PTY code 4–2 : not used 1–0 : MJD (16–15)	chck B	CT 15–1 : MJD (14–0) 0 : hour (4)	chck C	CT 15–12 : hour (3–0) 11–6 : minute (5–0) 5 : offset sense 4–0 : offset (4–0)	chck D
Group 14A	PI code	chck A	15–12 : 1110 11 : 0 10 : TP flag 9–5 : PTY code 4 : TP (On) flag 3–0 : usage code	chck B	EON information code: 0–3 : PS 4 : AF 5–9 : AF (map) 10–11 : not used 12–15 : not imp.	chck C	PI (On)	chck D

The listing is shown for use with a divide by 8 multiplexing LCD module. This module will normally contain an HD44780 and an HD44100.

If a divide by 16 module (HD44780 only) is to be used then line 1294 should be replaced by line 1293 and line 1371 commented out to include the execution of the code on lines 1379 to 1392.

The different display formats are selected by checking the various flags and the relevant routine executed. The normal display permanently shows PS name and time. As the locations in RAM used for hours and minutes contain binary numbers they are converted to BCD before being written to the relevant bytes in DISP. Once all 16 bytes in DISP have been loaded, a loop is used to send the data to the LCD module.

The VFD routine sends the same data as is shown on the LCD module to the serial VFD module. The display driver used has a different character set from the standard ASCII set used by the LCD module. The table VTAB is used to convert ASCII data into the required character in the VFD module. The small table INITF is used to send the required initialisation bytes to the VFD module. This module does not require a busy check but does require a delay between successive bytes. This is satisfied by the wait loop within the serial output loop VFDF.

Alarm functions

The alarm time can be entered as described above. If the alarm is enabled (alarm time displayed on first press of the ALARM key, and permanently displayed in standby mode) then, at the alarm time, the auxiliary control line will go high. This can be used to control external hardware, for example to switch on the VHF radio supplying the RDS data. If the auxiliary line is already high (decoder fully on or on via the sleep timer), then it simply stays high. The operation of the sleep timer is not affected if bit 0 of port E is high. If this I/O line is low at the alarm time, then the sleep timer is activated for an hour. This takes place whether the decoder was previously on, off, or running the sleep timer, and has the effect of switching the auxiliary line low an hour after the alarm time, regardless of its condition prior to the alarm.

At the alarm time the alarm output will also be activated (active low) as long as it is enabled by bit 1 of port E being held low. This is intended to drive an alarm sounder. When this output is active, a press of any key cancels it until the next alarm. This cancellation does not affect the auxiliary output.

REFERENCES

1 EBU Technical Document 3244, Specifications of the Radio Data System RDS for VHF/FM Sound Broadcasting.

2 AN459, A Monitor for the MC68HC05E0.

APPENDIX (listing) follows

```
0001                    ************************************************
0002                    *                                              *
0003                    *                HC05E0 RDS Decoder.           *
0004                    *                                              *
0005                    *     P. Topping           29th February '92   *
0006                    *                                              *
0007                    ************************************************
0008
0009 0000               PORTA    EQU     $00             PORT A ADDRESS
0010 0001               PORTB    EQU     $01               "  B    "
0011 0002               PORTC    EQU     $02               "  C    "
0012 0003               PORTD    EQU     $03               "  D    "
0013 0004               PORTE    EQU     $04               "  E    "
0014 0005               PORTAD   EQU     $05             PORT A DATA DIRECTION REG.
0015 0006               PORTBD   EQU     $06               "  B  "       "      "
0016 0007               PORTCD   EQU     $07               "  C  "       "      "
0017 0008               PORTDD   EQU     $08               "  D  "       "      "
0018 0009               PORTED   EQU     $09               "  E  "       "      "
0019 000a               TAP      EQU     $0A             TIMER A PRE-SCALLER
0020 000b               TBS      EQU     $0B             TIMER B SCALLER
0021 000c               TCR      EQU     $0C             TIMER CONTROL REGISTER
0022 000e               ICR      EQU     $0E             INTERRUPT CONTROL REGISTER
0023 0012               PORTDSF  EQU     $12             PORTD SPECIAL FUNCTIONS
0024
0025 0009               ND       EQU     9               No. BCD DIGITS
0026
0027 0030                        ORG     $0030
0028
0029 0030               Q        RMB     9               BCD WORKING NUMBERS
0030 0039               TMQ      RMB     9               SCRATCH
0031 0042               P        RMB     9               WORKING NUMBER 2
0032 004b               TMP      RMB     9               MULT. OVER. OR DIV. REMAINDER
0033 0054               R        RMB     9               WORKING NUMBER 3
0034 005d               MJD      RMB     9               MODIFIED JULIAN DAY NUMBER
0035 0066               YR       RMB     9               YEAR
0036 006f               MNTH     RMB     2               MONTH
0037 0071               DOM      RMB     2               DATE
0038 0073               DOW      RMB     1               DAY OF WEEK
0039 0074               BMJD     RMB     3               BINARY MJD
0040 0077               DIST     RMB     1               DISPLAY TRANSIENT TIMEOUT COUNTER
0041 0078               SLEPT    RMB     1               SLEEP TIMER MINUTES COUNTER
0042 0079               RDSTO    RMB     1               RDS TIMEOUT COUNTER
0043 007a               DAT      RMB     4               SERIAL DATA BUFFER
0044 007e               TMPGRP   RMB     8               TEMPORARY GROUP DATA
0045 0086               GROUP    RMB     8               COMPLETE GROUP DATA
0046 008e               PTY      RMB     1               PROGRAM-TYPE CODE (CURRENT)
0047 008f               PI       RMB     2               PROGRAM IDENTIFICATION CODE
0048 0091               PIN      RMB     2               PROGRAM ITEM NUMBER
0049 0093               LEV      RMB     1               VALID BLOCK LEVEL
0050 0094               BIT      RMB     1               BIT LEVEL
0051 0095               ITMP1    RMB     1               TEMP BYTE FOR USE IN IRQ
0052 0096               SYN      RMB     2               SYNDROME
0053 0098               CONF     RMB     1               SYNDROME CONFIDENCE
0054 0099               TH8      RMB     1               TICS (EIGHTHS OF SECONDS)
0055 009a               SEC      RMB     1               SECONDS
0056 009b               MIN      RMB     1               MINUTES
0057 009c               OUR      RMB     1               HOURS
0058 009d               AMIN     RMB     1               ALARM MINUTES
0059 009e               AOUR     RMB     1               ALARM HOURS
0060 009f               DISP1    RMB     1               RT DISPLAY POINTER #1
0061 00a0               DISP2    RMB     1               RT DISPLAY POINTER #2
0062 00a1               W1       RMB     1               W
0063 00a2               W2       RMB     1               O
0064 00a3               W3       RMB     1               R
0065 00a4               W4       RMB     1               K
0066 00a5               W5       RMB     1               I
0067 00a6               W6       RMB     1               N
0068 00a7               W7       RMB     1               G
0069 00a8               W8       RMB     1
0070 00a9               KEY      RMB     1               CODE OF PRESSED KEY
0071 00aa               KOUNT    RMB     1               KEYBOARD COUNTER
0072 00ab               CARRY    RMB     1               BCD CARRY
0073 00ac               COUNT    RMB     1               LOOP COUNTER
0074 00ad               NUM1     RMB     1               1ST No. POINTER (ADD & SUBTRACT)
0075 00ae               NUM2     RMB     1               2ND No. POINTER (ADD & SUBTRACT)
0076 00af               RTDIS    RMB     1               RDS DISPLAY TYPE
0077 00b0               DI       RMB     1               DECODER IDENTIFICATION
0078 00b1               DISP     RMB     16              LCD MODULE BUFFER
0079 00c1               PSN      RMB     8               PS NAME
0080
0081 00c9               STAT2    RMB     1               0: VALID SYNDROME
0082                    *                                1: VALID GROUP
0083                    *                                2: RT DISPLAY
0084                    *                                3: UPDATE DISPLAY
0085                    *                                4: CLEAR DISPLAY
0086                    *                                5: SPACE FLAG
0087 00ca               STAT3    RMB     1               0: M/S, 0: M, 1: S
0088                    *                                1: TEXTA/TEXTB BIT (RT)
0089                    *                                2: TA FLAG
0090                    *                                3: TP FLAG
0091                    *                                4: KEY REPEATING
0092                    *                                5: KEY FUNCTION PERFORMED
0093                    *                                6: UPDATE DATE
0094 00cb               STAT4    RMB     1               0: DISPLAY TRANSIENT
0095                    *                                1: SLEEP TIMER RUNNING
0096                    *                                2: SLEEP DISPLAY
0097                    *                                3: ALARM DISPLAY
0098                    *                                4: ALARM ARMED
0099                    *                                5: ALARM SET-UP
0100                    *                                6: ALARM HOURS (SET-UP)
0101                    *                                7: RDS DISPLAYS
0102
0103 00cc                        RMB     33              not used
0104 00ed               STACK    RMB     18              19 BYTES USED (1 INTERRUPT
0105 00ff               SP       RMB     1               AND 7 NESTED SUBROUTINES)
0106
0107 0100                        ORG     $0100
0108
0109 0100               RT       RMB     69              RADIOTEXT
0110 0145               EON      RMB     176             EON DATA (MAX: 11 NETWORKS)
```

```
0112 e000                       ORG     $E000
0113
0114                    *STRST   JMP     START          RESET VECTOR               ($0400 DURING DE-BUG)
0115                    *IRQ     JMP     SDATA          IRQ                        ($0403 DURING DE-BUG)
0116                    *TIMERA  JMP     START          TIMER A INTERRUPT (NOT USED, $0406 DURING DE-BUG)
0117                    *TIMERB  JMP     TINTB          TIMER B INTERRUPT          ($0409 DURING DE-BUG)
0118                    *SERINT  JMP     START          SERIAL INTERRUPT  (NOT USED, $040C DURING DE-BUG)
0119
0120                    ************************************************
0121                    *                                              *
0122                    *       Reset routine - setup ports.           *
0123                    *                                              *
0124                    ************************************************
0125
0126 e000 a6 c3         START   LDA     #$C3           ENABLE PORTD SPECIAL FUNCTIONS
0127 e002 b7 12                 STA     PORTDSF        P02, R/W, A14 & A15 (0,1,6,7)
0128 e004 a6 45                 LDA     #$45           ENABLE POSITIVE EDGE/LEVEL
0129 e006 b7 0e                 STA     ICR            INTERRUPTS
0130 e008 a6 01                 LDA     #1             TIMER B SCALER: /2
0131 e00a b7 0b                 STA     TBS            125 mS INTERRUPTS (4.194 MHz XTAL)
0132 e00c a6 3f                 LDA     #63            TIMER A PRE-SCALER: /64
0133 e00e b7 0a                 STA     TAP            64Hz IDLE LOOP
0134
0135 e010 3f 00                 CLR     PORTA
0136 e012 a6 ff                 LDA     #$FF           E0BUG DISPLAY/KEYBOARD I/O
0137 e014 b7 05                 STA     PORTAD         NOT USED IN RDS APPLICATION
0138 e016 3f 01                 CLR     PORTB          0, 1: SERIAL CLOCK AND DATA
0139 e018 a6 cb                 LDA     #$CB           2: RDS DATA IN, 3: VFD SELECT
0140 e01a b7 06                 STA     PORTBD         4, 5: KEYBOARD IN, 6, 7: KEYBOARD OUT
0141 e01c 3f 02                 CLR     PORTC
0142 e01e a6 ff                 LDA     #$FF           ALL OUT, LCD DATA BUS
0143 e020 b7 07                 STA     PORTCD
0144 e022 a6 3c                 LDA     #$3C           BITS 2, 3 & 4 OUT, LCD
0145 e024 3f 03                 CLR     PORTD          2: RS, 3: R/W, 4: CLOCK, 5: LED (TA=TP=1)
0146 e026 b7 08                 STA     PORTDD         0, 1, 6 & 7 USED DURING DE-BUG
0147 e028 a6 0c                 LDA     #$0C           BIT0: INPUT, ENABLE SLEEP TIMER AT ALARM TIME
0148 e02a b7 04                 STA     PORTE          BIT1: INPUT, ENABLE ALARM OUTPUT
0149                    *       LDA     #$0C           BIT2: ALARM OUTPUT (ACTIVE LOW)
0150 e02c b7 09                 STA     PORTED         BIT3: RADIO ON OUTPUT (ACTIVE HIGH)
0151
0152                    ************************************************
0153                    *                                              *
0154                    *       Initialise LCD.                        *
0155                    *                                              *
0156                    ************************************************
0157
0158 e02e a6 30                 LDA     #$30
0159 e030 cd eb 65              JSR     CLOCK          INITIALISE LCD
0160 e033 cd eb e6              JSR     CLREON         CLEAR EON DATA
0161 e036 cd eb e6              JSR     CLREON
0162 e039 cd eb e6              JSR     CLREON         4 TIMES TO PROVIDE A 5mS DELAY
0163 e03c cd eb e6              JSR     CLREON         FOR LCD MODULE INITIALISATION
0164 e03f a6 30                 LDA     #$30
0165 e041 cd eb 65              JSR     CLOCK          INITIALISE LCD
0166
0167 e044 ae 30                 LDX     #Q             INITIALISE RAM
0168 e046 7f            CLOOP   CLR     0,X
0169 e047 5c                    INCX                   PROVIDES A 1mS DELAY FOR LCD
0170 e048 a3 ed                 CPX     #STACK
0171 e04a 26 fa                 BNE     CLOOP
0172
0173 e04c a6 30                 LDA     #$30
0174 e04e cd eb 65              JSR     CLOCK          INITIALISE LCD
0175
0176 e051 cd eb 6c              JSR     WAIT
0177 e054 a6 30                 LDA     #$30           1-LINE DISPLAY
0178 e056 cd eb 65              JSR     CLOCK          LATCH IT
0179 e059 cd eb 6c              JSR     WAIT
0180 e05c a6 08                 LDA     #$08           SWITCH DISPLAY OFF
0181 e05e cd eb 65              JSR     CLOCK          LATCH IT
0182 e061 cd eb 6c              JSR     WAIT
0183 e064 a6 01                 LDA     #$01           CLEAR DISPLAY
0184 e066 cd eb 65              JSR     CLOCK          LATCH IT
0185 e069 cd eb aa              JSR     INITD
0186
0187                    ************************************************
0188                    *                                              *
0189                    *       Vectors for de-bug using E0BUG monitor.*
0190                    *                                              *
0191                    ************************************************
0192
0193                    *        LDA     #$0C           ENABLE EXTERNAL RAM WRITE
0194                    *        STA     TCR
0195
0196                    *        LDA     #$04           VECTORS FOR E0 MONITOR
0197                    *        STA     $0201
0198                    *        STA     $0204          USING JUMP TABLE AT $0400
0199                    *        STA     $0207
0200                    *        STA     $020A          (LINES 126-130)
0201                    *        LDA     #$03
0202                    *        STA     $0202          IRQ ($0403)
0203                    *        LDA     #$06
0204                    *        STA     $0205          TIMER A ($0406)
0205                    *        LDA     #$09
0206                    *        STA     $0208          TIMER B ($0409)
0207                    *        LDA     #$0C
0208                    *        STA     $020B          SERIAL ($040C)
0209
0210                    ************************************************
0211                    *                                              *
0212                    *       Enable interrupts.                     *
0213                    *                                              *
0214                    ************************************************
0215
0216 e06c a6 0b                 LDA     #$0B           EDGE SENSITIVE IRQ, TIMERS A & B ENABLED
0217 e06e b7 0c                 STA     TCR            SUB-SYS CLK = 262144 Hz  (4.194 MHz XTAL)
0218                    *                              DISSABLE EXTERNAL RAM WRITE
0219 e070 9a                    CLI
```

```
0221                        ******************************************************
0222                        *                                                    *
0223                        *       Idle loop.                                   *
0224                        *                                                    *
0225                        ******************************************************
0226
0227 e071 09 0e fd          IDLE    BRCLR   4,ICR,*         64 Hz
0228 e074 19 0e                     BCLR    4,ICR
0229
0230 e076 01 cb 07          NO2D    BRCLR   0,STAT4,NOPS    DISPLAY TRANSIENT ?
0231 e079 b6 77                     LDA     DIST
0232 e07b 26 03                     BNE     NOPS            YES, TIMED OUT ?
0233 e07d cd e8 0a                  JSR     CLTR            YES, CLEAR TRANSIENT DISPLAYS
0234
0235 e080 07 c9 05          NOPS    BRCLR   3,STAT2,SCAN    DISPLAY UPDATE REQUIRED ?
0236 e083 cd e6 b6                  JSR     MOD             YES, DO IT
0237 e086 17 c9                     BCLR    3,STAT2         AND CLEAR FLAG
0238
0239 e088 09 cb 1d          SCAN    BRCLR   4,STAT4,CHSLP   ALARM ARMED ?
0240 e08b b6 9e                     LDA     AOUR            YES, COMPARE ALARM HOURS
0241 e08d b1 9c                     CMP     OUR             WITH TIME
0242 e08f 26 17                     BNE     CHSLP           SAME ?
0243 e091 b6 9d                     LDA     AMIN            YES, COMPARE ALARM MINUTES
0244 e093 b1 9b                     CMP     MIN             WITH TIME
0245 e095 26 11                     BNE     CHSLP           SAME ?
0246 e097 b6 9a                     LDA     SEC             ONLY ALLOW WAKE-UP IN FIRST SECOND
0247 e099 26 0d                     BNE     CHSLP           TO PREVENT SWITCH-OFF LOCKOUT
0248 e09b 16 04                     BSET    3,PORTE         YES, SWITCH ON
0249
0250 e09d 02 04 02                  BRSET   1,PORTE,FULON2  ALARM ENABLED (SWITCH) ?
0251 e0a0 15 04                     BCLR    2,PORTE         YES, SOUND ALARM
0252 e0a2 00 04 03          FULON2  BRSET   0,PORTE,CHSLP   SLEEP TIMER AT ALARM TIME ?
0253 e0a5 cd e2 09                  JSR     INSLP           YES, START SLEEP TIMER
0254
0255 e0a8 03 cb 08          CHSLP   BRCLR   1,STAT4,FLN     SLEEP TIMER RUNNING ?
0256 e0ab b6 78                     LDA     SLEPT           YES
0257 e0ad 26 04                     BNE     FLN             TIME TO FINISH ?
0258 e0af 13 cb                     BCLR    1,STAT4         YES, CLEAR FLAG
0259 e0b1 17 04                     BCLR    3,PORTE         AND SWITCH OFF
0260
0261 e0b3 cd e1 11          FLN     JSR     KBD             READ KEYBOARD
0262 e0b6 cd e1 6f                  JSR     KEYP            EXECUTE KEY
0263
0264 e0b9 b6 ca                     LDA     STAT3
0265 e0bb a4 0c                     AND     #$0C
0266 e0bd a1 0c                     CMP     #$0C            TA AND TP BOTH HIGH ?
0267 e0bf 27 07                     BEQ     TATP
0268 e0c1 0a 03 09                  BRSET   5,PORTD,IOOK    NO, I/O LINE ALREADY HIGH ?
0269 e0c4 1a 03                     BSET    5,PORTD         NO, MAKE IT HIGH
0270 e0c6 20 05                     BRA     IOOK
0271 e0c8 0b 03 02          TATP    BRCLR   5,PORTD,IOOK    TA=TP=1, I/O LINE ALREADY LOW ?
0272 e0cb 1b 03                     BCLR    5,PORTD         NO, MAKE IT LOW
0273
0274 e0cd 0d ca 02          IOOK    BRCLR   6,STAT3,IDLEJ   UPDATE DATE ?
0275 e0d0 ad 02                     BSR     MJDAT           YES, CONVERT FROM MJD
0276 e0d2 20 9d             IDLEJ   BRA     IDLE
0277
0278                        ******************************************************
0279                        *                                                    *
0280                        *       Extract MJD and convert to decimal.          *
0281                        *                                                    *
0282                        ******************************************************
0283
0284 e0d4 b6 76             MJDAT   LDA     BMJD+2
0285 e0d6 b7 68                     STA     YR+2
0286 e0d8 b6 75                     LDA     BMJD+1
0287 e0da b7 67                     STA     YR+1
0288 e0dc b6 74                     LDA     BMJD
0289 e0de b7 66                     STA     YR
0290 e0e0 ae 54                     LDX     #R              CLEAR
0291 e0e2 bf ad                     STX     NUM1
0292 e0e4 cd ef 86                  JSR     CLRAS           R
0293 e0e7 3c 5c                     INC     R+ND-1          R <- 1
0294 e0e9 ae 5d                     LDX     #MJD
0295 e0eb cd ef 86                  JSR     CLRAS           CLEAR MJD
0296 e0ee a6 11                     LDA     #17             17 BITS TO CONVERT
0297 e0f0 b7 a6                     STA     W6
0298 e0f2 34 66             LOOPJ   LSR     YR              MOVE OUT
0299 e0f4 36 67                     ROR     YR+1
0300 e0f6 36 68                     ROR     YR+2            FIRST (LS) BIT
0301 e0f8 24 07                     BCC     NXTJ            ZERO ?
0302 e0fa ae 5d                     LDX     #MJD            ONE, ADD
0303 e0fc bf ae                     STX     NUM2            CURRENT VALUE
0304 e0fe cd ee 33                  JSR     ADD             OF R
0305 e101 ae 54             NXTJ    LDX     #R              ADD R
0306 e103 bf ae                     STX     NUM2            TO
0307 e105 cd ee 33                  JSR     ADD             ITSELF
0308 e108 3a a6                     DEC     W6              ALL
0309 e10a 26 e6                     BNE     LOOPJ           DONE ?
0310 e10c 1d ca                     BCLR    6,STAT3         MJD UPDATED
0311 e10e cc ef 95                  JMP     MJDC            CONVERT MJD TO DAY, DATE, MONTH & YEAR
```

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0313                        ***************************************************
0314                        *                                                 *
0315                        *       Keyboard routine.                         *
0316                        *                                                 *
0317                        ***************************************************
0318
0319 e111 a6 20             KBD     LDA     #$20
0320 e113 ae 02                     LDX     #2
0321 e115 48                KEY1    LSLA                    SELECT ROW
0322 e116 a4 c0                     AND     #$C0            BITS 6 & 7 ONLY
0323 e118 aa 08                     ORA     #$08            VFD ENABLE HIGH
0324 e11a b7 01                     STA     PORTB
0325 e11c b6 01             ROW     LDA     PORTB           READ KEYBOARD
0326 e11e a5 30                     BIT     #$30            ANY INPUT LINE HIGH ?
0327 e120 26 07                     BNE     L1
0328 e122 5a                        DECX                    NO, TRY NEXT COLUMN
0329 e123 26 f0                     BNE     KEY1            LAST COLUMN ?
0330 e125 3f a9                     CLR     KEY             YES, NO KEY PRESSED
0331 e127 20 0c                     BRA     EXIT
0332
0333 e129 b6 01             L1      LDA     PORTB           READ KEYBOARD
0334 e12b a4 f0                     AND     #$F0
0335 e12d b1 a9                     CMP     KEY             SAME AS LAST TIME ?
0336 e12f 27 04                     BEQ     EXIT
0337 e131 b7 a9                     STA     KEY             NO, SAVE THIS KEY
0338 e133 3f aa                     CLR     KOUNT
0339 e135 3c aa             EXIT    INC     KOUNT           YES, THE SAME
0340 e137 b6 aa                     LDA     KOUNT
0341 e139 09 ca 04                  BRCLR   4,STAT3,NRML    REPEATING ?
0342 e13c a1 0a                     CMP     #10             YES, REPEAT AT 6 Hz
0343 e13e 20 08                     BRA     GON2
0344 e140 a1 03             NRML    CMP     #3              NO, 3 THE SAME ?
0345 e142 25 29                     BLO     KCLC            IF NOT DO NOTHING
0346 e144 27 1b                     BEQ     GOON            IF 3 THEN PERFORM KEY FUNCTION
0347 e146 a1 30                     CMP     #48             MORE THAN 3, MORE THAN 48 (750mS) ?
0348 e148 22 06             GON2    BHI     GOON2           TIME TO DO SOMETHING ?
0349 e14a b6 a9                     LDA     KEY             NO
0350 e14c 27 19                     BEQ     RKEY            KEY PRESSED ?
0351 e14e 98                        CLC
0352 e14f 81                        RTS                     YES BUT DO NOTHING
0353
0354 e150 b6 a9             GOON2   LDA     KEY
0355 e152 a1 50                     CMP     #$50            SLEEP (DEC.)
0356 e154 27 04                     BEQ     GOON3
0357 e156 a1 90                     CMP     #$90            RDS (INC.)
0358 e158 26 0f                     BNE     DNT2            IF NOT A REPEAT KEY, DO NOTHING
0359 e15a 0b cb 0c          GOON3   BRCLR   5,STAT4,DNT2    REPEAT KEY, BUT IS MODE ALARM SET-UP ?
0360 e15d 18 ca                     BSET    4,STAT3         YES, SET REPEAT FLAG
0361 e15f 3f aa                     CLR     KOUNT
0362 e161 b6 a9             GOON    LDA     KEY
0363 e163 27 02                     BEQ     RKEY            SOMETHING TO DO ?
0364 e165 99                        SEC                     YES, SET C
0365 e166 81                        RTS
0366 e167 1b ca             RKEY    BCLR    5,STAT3         NO, CLEAR DONE FLAG
0367 e169 19 ca             DNT2    BCLR    4,STAT3         CLEAR REPEAT FLAG
0368 e16b 3f aa                     CLR     KOUNT           CLEAR COUNTER
0369 e16d 98                KCLC    CLC
0370 e16e 81                        RTS
0371
0372                        ***************************************************
0373                        *                                                 *
0374                        *       Execute key function.                     *
0375                        *                                                 *
0376                        ***************************************************
0377
0378 e16f 24 26             KEYP    BCC     DNT             ANYTHING TO DO ?
0379 e171 b6 a9             KEYP2   LDA     KEY             YES, GET KEY
0380 e173 a1 50                     CMP     #$50            SLEEP (DEC.)
0381 e175 27 07                     BEQ     RPT
0382 e177 a1 90                     CMP     #$90            RDS (INC.)
0383 e179 27 03                     BEQ     RPT
0384 e17b 0a ca 19                  BRSET   5,STAT3,DNT     NOT A REPEAT KEY, DONE FLAG SET ?
0385
0386 e17e 5f                RPT     CLRX
0387 e17f d6 e1 98          RJ      LDA     CTAB,X          FETCH KEYCODE
0388 e182 b1 a9                     CMP     KEY             THIS ONE ?
0389 e184 27 0b                     BEQ     PJ              YES
0390 e186 c1 e1 a4                  CMP     LAST            NO, LAST CHANCE ?
0391 e189 27 0c                     BEQ     DNT             YES, ABORT
0392 e18b 5c                        INCX                    NO
0393 e18c 5c                        INCX                    TRY
0394 e18d 5c                        INCX                    THE
0395 e18e 5c                        INCX                    NEXT
0396 e18f 20 ee                     BRA     RJ              KEY
0397 e191 1a ca             PJ      BSET    5,STAT3         KEY FUNCTION DONE
0398 e193 5c                        INCX
0399 e194 dd e1 98                  JSR     CTAB,X
0400 e197 81                DNT     RTS
0401
0402                        ***************************************************
0403                        *                                                 *
0404                        *       Keyboard jump table.                      *
0405                        *                                                 *
0406                        ***************************************************
0407
0408 e198 60                CTAB    FCB     $60             ALARM
0409 e199 cc e1 a8                  JMP     ALARM
0410 e19c a0                        FCB     $A0             ON/OFF
0411 e19d cc e1 c7                  JMP     ONOFF
0412 e1a0 50                        FCB     $50             SLEEP TIMER START
0413 e1a1 cc e1 fa                  JMP     SLEEP
0414 e1a4 90                LAST    FCB     $90             RDS DISPLAYS
0415 e1a5 cc e2 26                  JMP     RDS
```

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0417                            ******************************************************
0418                            *                                                    *
0419                            *       Alarm key.                                   *
0420                            *                                                    *
0421                            ******************************************************
0422
0423 e1a8 05 04 4c              ALARM   BRCLR   2,PORTE,ALRG    ALARM RINGING ?
0424 e1ab 07 cb 0b                      BRCLR   3,STAT4,ADON    NO, ALARM DISPLAY ON ?
0425 e1ae 09 cb 04                      BRCLR   4,STAT4,ALOF    YES, ALARM ON ?
0426 e1b1 19 cb                         BCLR    4,STAT4         YES, SWITCH OFF
0427 e1b3 20 09                         BRA     UDCNT
0428 e1b5 18 cb                 ALOF    BSET    4,STAT4         NO, SWITCH ON
0429 e1b7 20 05                         BRA     UDCNT
0430 e1b9 cd e8 0a              ADON    JSR     CLTR
0431 e1bc 16 cb                         BSET    3,STAT4         ALARM DISPLAY FLAG
0432 e1be 1b cb                 UDCNT   BCLR    5,STAT4         CANCEL SET-UP
0433 e1c0 a6 19                         LDA     #25             3 SECOND TIMEOUT
0434 e1c2 b7 77                         STA     DIST
0435 e1c4 10 cb                         BSET    0,STAT4         SET DISPLAY TRANSIENT FLAG
0436 e1c6 81                    ABOA    RTS
0437
0438                            ******************************************************
0439                            *                                                    *
0440                            *       On/off key (alarm set-up).                   *
0441                            *                                                    *
0442                            ******************************************************
0443
0444 e1c7 05 04 2d              ONOFF   BRCLR   2,PORTE,ALRG    ALARM RINGING ?
0445 e1ca 07 cb 1c                      BRCLR   3,STAT4,NOTALR  NO, ALARM DISPLAY ?
0446 e1cd 09 cb 19                      BRCLR   4,STAT4,NOTALR  YES, ALARM ARMED ?
0447 e1d0 0a cb 0b                      BRSET   5,STAT4,AISM    YES, ALREADY SET-UP MODE ?
0448 e1d3 1a cb                         BSET    5,STAT4         NO, ENTER SET-UP MODE
0449 e1d5 1c cb                         BSET    6,STAT4         WITH HOURS
0450 e1d7 a6 50                 A5SD    LDA     #80
0451 e1d9 b7 77                         STA     DIST
0452 e1db 10 cb                         BSET    0,STAT4         SET DISPLAY TRANSIENT FLAG
0453 e1dd 81                    NTB2    RTS
0454
0455 e1de 0c cb 04              AISM    BRSET   6,STAT4,MSM     SET-UP HOURS ?
0456 e1e1 1b cb                         BCLR    5,STAT4         NO, CANCELL SET-UP
0457 e1e3 20 f2                         BRA     A5SD
0458 e1e5 1d cb                 MSM     BCLR    6,STAT4         YES, MAKE IT MINUTES
0459 e1e7 20 ee                         BRA     A5SD
0460
0461                            ******************************************************
0462                            *                                                    *
0463                            *       On/off key (normal function).                *
0464                            *                                                    *
0465                            ******************************************************
0466
0467 e1e9 cd e8 0a              NOTALR  JSR     CLTR            CLEAR DISPLAY TRANSIENTS
0468 e1ec 13 cb                         BCLR    1,STAT4         CANCEL SLEEP TIMER
0469 e1ee 06 04 03                      BRSET   3,PORTE,ALRON   ON ?
0470 e1f1 16 04                 SODM    BSET    3,PORTE         NO, SWITCH ON
0471 e1f3 81                            RTS
0472 e1f4 17 04                 ALRON   BCLR    3,PORTE         YES, SWITCH OFF
0473 e1f6 81                            RTS
0474 e1f7 14 04                 ALRG    BSET    2,PORTE         CANCEL ALARM
0475 e1f9 81                            RTS
0476
0477                            ******************************************************
0478                            *                                                    *
0479                            *       Sleep key.                                   *
0480                            *                                                    *
0481                            ******************************************************
0482
0483 e1fa 05 04 fa              SLEEP   BRCLR   2,PORTE,ALRG    ALARM RINGING ?
0484 e1fd 0b cb 03                      BRCLR   5,STAT4,NOTAL   NO, ALARM SET-UP ?
0485 e200 cc e2 79                      JMP     PDEC            YES
0486 e203 04 cb 10              NOTAL   BRSET   2,STAT4,DECS    NO, ALREADY SLEEP DISPLAY ?
0487 e206 02 cb 06                      BRSET   1,STAT4,STR2    NO, SLEEP TIMER ALREADY RUNNING ?
0488 e209 a6 3c                 INSLP   LDA     #60             NO, INITIALISE SLEEP TIMER
0489 e20b b7 78                         STA     SLEPT
0490 e20d 12 cb                         BSET    1,STAT4         START SLEEP TIMER
0491 e20f cd e8 0a              STR2    JSR     CLTR            YES, CLEAR DISPLAY TRANSIENTS
0492 e212 14 cb                         BSET    2,STAT4         SLEEP DISPLAY
0493 e214 20 08                         BRA     SLPTOK          NO DECREMENT IF FIRST TIME
0494 e216 b6 78                 DECS    LDA     SLEPT           DECREMENT SLEEP TIMER
0495 e218 a0 05                         SUB     #5
0496 e21a b7 78                         STA     SLEPT
0497 e21c 2b eb                         BMI     INSLP           IF UNDERFLOW WRAP ROUND TO 60
0498 e21e a6 19                 SLPTOK  LDA     #25
0499 e220 b7 77                         STA     DIST
0500 e222 10 cb                         BSET    0,STAT4         START DISPLAY TRANSIENT
0501 e224 20 cb                         BRA     SODM
0502
0503                            ******************************************************
0504                            *                                                    *
0505                            *       RDS display key.                             *
0506                            *                                                    *
0507                            ******************************************************
0508
0509 e226 05 04 ce              RDS     BRCLR   2,PORTE,ALRG    ALARM RINGING ?
0510 e229 0a cb 29                      BRSET   5,STAT4,PINC    NO, ALARM SET-UP ?
0511 e22c 07 04 17                      BRCLR   3,PORTE,SRT3    NO, STANDBY ?
0512 e22f 0e cb 03                      BRSET   7,STAT4,NOTRT   ALREADY RDS ?
0513 e232 05 c9 12                      BRCLR   2,STAT2,NORT    ALREADY RT DISPLAY ?
0514 e235 1e cb                 NOTRT   BSET    7,STAT4         SET RDS DISPLAY FLAG
0515 e237 b6 af                         LDA     RTDIS           MOVE ON
0516 e239 4c                            INCA
0517 e23a a1 13                         CMP     #19
0518 e23c 27 09                         BEQ     NORT
0519 e23e b7 af                         STA     RTDIS
0520 e240 a6 64                         LDA     #100            12 SECOND TIMEOUT
0521 e242 b7 77                         STA     DIST
0522 e244 10 cb                         BSET    0,STAT4         RE-START TRANSIENT TIMEOUT
0523 e246 81                    SRT3    RTS
0524
0525 e247 cd e8 0a              NORT    JSR     CLTR            CLEAR DISPLAY TRANSIENTS
0526 e24a 14 c9                         BSET    2,STAT2         SET RT DISPLAY FLAG
0527 e24c a6 09                         LDA     #9
0528 e24e b7 9f                         STA     DISP1
0529 e250 a6 01                         LDA     #1
0530 e252 b7 a0                         STA     DISP2
0531 e254 81                            RTS
```

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0533                        ****************************************************
0534                        *                                                  *
0535                        *       Increment alarm time.                      *
0536                        *                                                  *
0537                        ****************************************************
0538
0539 e255 0c cb 0e          PINC    BRSET   6,STAT4,IHR     SET-UP HOURS ?
0540 e258 b6 9d                     LDA     AMIN            NO, MINUTES
0541 e25a a1 3b                     CMP     #59
0542 e25c 24 04                     BHS     TOOH
0543 e25e 3c 9d                     INC     AMIN
0544 e260 20 0c                     BRA     T5S
0545 e262 3f 9d             TOOH    CLR     AMIN
0546 e264 20 08                     BRA     T5S
0547 e266 b6 9e             IHR     LDA     AOUR
0548 e268 a1 17                     CMP     #23
0549 e26a 24 09                     BHS     HTOH
0550 e26c 3c 9e                     INC     AOUR
0551 e26e a6 50             T5S     LDA     #80             10 SECOND TIMEOUT
0552 e270 b7 77                     STA     DIST
0553 e272 10 cb                     BSET    0,STAT4         SET DISPLAY TRANSIENT FLAG
0554 e274 81                        RTS
0555 e275 3f 9e             HTOH    CLR     AOUR
0556 e277 20 f5                     BRA     T5S
0557
0558                        ****************************************************
0559                        *                                                  *
0560                        *       Decrement alarm time.                      *
0561                        *                                                  *
0562                        ****************************************************
0563
0564 e279 0c cb 0e          PDEC    BRSET   6,STAT4,IHRD    SET-UP HOURS ?
0565 e27c 3d 9d                     TST     AMIN            NO, MINUTES
0566 e27e 27 04                     BEQ     MZ
0567 e280 3a 9d                     DEC     AMIN
0568 e282 20 0c                     BRA     T5SD
0569 e284 a6 3b             MZ      LDA     #59
0570 e286 b7 9d                     STA     AMIN
0571 e288 20 06                     BRA     T5SD
0572 e28a 3d 9e             IHRD    TST     AOUR
0573 e28c 27 09                     BEQ     HZ
0574 e28e 3a 9e                     DEC     AOUR
0575 e290 a6 50             T5SD    LDA     #80             10 SECOND TIMEOUT
0576 e292 b7 77                     STA     DIST
0577 e294 10 cb                     BSET    0,STAT4         SET DISPLAY TRANSIENT FLAG
0578 e296 81                        RTS
0579 e297 a6 17             HZ      LDA     #23
0580 e299 b7 9e                     STA     AOUR
0581 e29b 20 f3                     BRA     T5SD
0582
0583                        ************************************************
0584                        *                                              *
0585                        *       Timer interrupt routine.               *
0586                        *                                              *
0587                        ************************************************
0588
0589 e29d 3c 9f             TINTB   INC     DISP1             DISP1    DISP2    DISPLAY
0590 e29f b6 9f                     LDA     DISP1            0 -   8        0   PTY
0591 e2a1 a1 08                     CMP     #8               9 -  78   1 - 70   MOVING RT
0592 e2a3 23 06                     BLS     NWR             78 -  88       70   END OF RT
0593 e2a5 a1 4e                     CMP     #78
0594 e2a7 22 02                     BHI     NWR             END OF RADIOTEXT ?
0595 e2a9 3c a0                     INC     DISP2           NO, MOVE RADIOTEXT ONE CHARACTER
0596 e2ab a1 58             NWR     CMP     #88             2 SECONDS AT END OF RADIOTEXT
0597 e2ad 25 02                     BLO     NWR2
0598 e2af 15 c9                     BCLR    2,STAT2         RETURN TO NORMAL DISPLAY
0599 e2b1 1b 0e             NWR2    BCLR    5,ICR           CLEAR TIMER B INTERRUPT FLAG
0600 e2b3 16 c9                     BSET    3,STAT2         UPDATE DISPLAY
0601 e2b5 3c 99             CLCK    INC     TH8             UPDATE EIGHTHS OF SECONDS
0602 e2b7 3a 77                     DEC     DIST            DECREMENT TRANSIENT DISPLAY TIMER
0603 e2b9 3c 79                     INC     RDSTO
0604 e2bb b6 79                     LDA     RDSTO
0605 e2bd a1 50                     CMP     #80             10S WITHOUT A GROUP 0 OR 15 ?
0606 e2bf 25 10                     BLO     RDSOK
0607 e2c1 15 ca                     BCLR    2,STAT3         YES, CLEAR TA FLAG
0608 e2c3 3f 8e             N14B    CLR     PTY             PROGRAM TYPE
0609 e2c5 3f 8f                     CLR     PI              AND
0610 e2c7 3f 90                     CLR     PI+1            PI CODE
0611 e2c9 3f 91                     CLR     PIN             AND
0612 e2cb 3f 92                     CLR     PIN+1           PIN
0613 e2cd 3f b0                     CLR     DI              AND DI
0614 e2cf 11 ca                     BCLR    0,STAT3         AND M/S
0615 e2d1 b6 99             RDSOK   LDA     TH8             EIGHTHS OF SECONDS
0616 e2d3 a1 08                     CMP     #8
0617 e2d5 26 32                     BNE     NOTC            PAST 7 ?
0618 e2d7 3f 99                     CLR     TH8             YES, CLEAR
0619 e2d9 3c 9a                     INC     SEC             UPDATE SECONDS
0620 e2db b6 9a                     LDA     SEC
0621 e2dd a1 38                     CMP     #56
0622 e2df 26 02                     BNE     NOT5
0623 e2e1 3a 78                     DEC     SLEPT           DECREMENT SLEEP TIMER MINUTES
0624 e2e3 a1 3c             NOT5    CMP     #60
0625 e2e5 26 22                     BNE     NOTC            PAST 59 ?
0626 e2e7 3f 9a                     CLR     SEC             YES, CLEAR
0627 e2e9 3c 9b                     INC     MIN             UPDATE MINUTES
0628 e2eb b6 9b                     LDA     MIN
0629 e2ed a1 3c                     CMP     #60
0630 e2ef 26 18                     BNE     NOTC            PAST 59 ?
0631 e2f1 3f 9b                     CLR     MIN             YES, CLEAR
0632 e2f3 3c 9c                     INC     OUR             UPDATE HOURS
0633 e2f5 b6 9c                     LDA     OUR
0634 e2f7 a1 18                     CMP     #24
0635 e2f9 26 0e                     BNE     NOTC            PAST 23 ?
0636 e2fb 3f 9c                     CLR     OUR             YES CLEAR
0637 e2fd 3c 76                     INC     BMJD+2          AND ADD A DAY
0638 e2ff 26 06                     BNE     NOTD
0639 e301 3c 75                     INC     BMJD+1
0640 e303 26 02                     BNE     NOTD            INC BMJD only ever executes once, at midnight
0641 e305 3c 74                     INC     BMJD            on the night of Thu/Fri 22/23 April 2038.
0642 e307 1c ca             NOTD    BSET    6,STAT3         UPDATE DATE
0643 e309 80                NOTC    RTI
```

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0645                        ************************************************
0646                        *                                              *
0647                        *       RDS clock interrupt (IRQ).             *
0648                        *       Get a bit and calculate syndrome.      *
0649                        *                                              *
0650                        ************************************************
0651
0652 e30a 04 01 00          SDATA   BRSET   2,PORTB,*+3
0653 e30d 39 7d                     ROL     DAT+3
0654 e30f 39 7c                     ROL     DAT+2
0655 e311 39 7b                     ROL     DAT+1
0656 e313 39 7a                     ROL     DAT
0657 e315 01 c9 0b                  BRCLR   0,STAT2,TRY2    BIT BY BIT CHECK ?
0658 e318 3a 94                     DEC     BIT             NO, WAIT FOR BIT 26
0659 e31a 27 03                     BEQ     TRY1            THIS TIME ?
0660 e31c 17 0e                     BCLR    3,ICR           CLEAR IRQ INTERRUPT FLAG
0661 e31e 80                        RTI
0662
0663 e31f a6 1a             TRY1    LDA     #26
0664 e321 b7 94                     STA     BIT
0665 e323 b6 7a             TRY2    LDA     DAT             MSB (2 BITS)
0666 e325 a4 03                     AND     #3
0667 e327 97                        TAX
0668 e328 b6 7b                     LDA     DAT+1
0669 e32a b7 97                     STA     SYN+1           LSB
0670 e32c 01 7d 0a          S03     BRCLR   0,DAT+3,S13
0671 e32f b6 97                     LDA     SYN+1
0672 e331 a8 1b                     EOR     #$1B
0673 e333 b7 97                     STA     SYN+1
0674 e335 9f                        TXA
0675 e336 a8 03                     EOR     #$03
0676 e338 97                        TAX
0677 e339 03 7d 0a          S13     BRCLR   1,DAT+3,S23
0678 e33c b6 97                     LDA     SYN+1
0679 e33e a8 8f                     EOR     #$8F
0680 e340 b7 97                     STA     SYN+1
0681 e342 9f                        TXA
0682 e343 a8 03                     EOR     #$03
0683 e345 97                        TAX
0684 e346 05 7d 0a          S23     BRCLR   2,DAT+3,S43
0685 e349 b6 97                     LDA     SYN+1
0686 e34b a8 a7                     EOR     #$A7
0687 e34d b7 97                     STA     SYN+1
0688 e34f 9f                        TXA
0689 e350 a8 02                     EOR     #$02
0690 e352 97                        TAX
0691 e353 09 7d 0a          S43     BRCLR   4,DAT+3,S53
0692 e356 b6 97                     LDA     SYN+1
0693 e358 a8 ee                     EOR     #$EE
0694 e35a b7 97                     STA     SYN+1
0695 e35c 9f                        TXA
0696 e35d a8 01                     EOR     #$01
0697 e35f 97                        TAX
0698 e360 0b 7d 0a          S53     BRCLR   5,DAT+3,S63
0699 e363 b6 97                     LDA     SYN+1
0700 e365 a8 dc                     EOR     #$DC
0701 e367 b7 97                     STA     SYN+1
0702 e369 9f                        TXA
0703 e36a a8 03                     EOR     #$03
0704 e36c 97                        TAX
0705 e36d 0d 7d 0a          S63     BRCLR   6,DAT+3,S73
0706 e370 b6 97                     LDA     SYN+1
0707 e372 a8 01                     EOR     #$01
0708 e374 b7 97                     STA     SYN+1
0709 e376 9f                        TXA
0710 e377 a8 02                     EOR     #$02
0711 e379 97                        TAX
0712 e37a 0f 7d 0a          S73     BRCLR   7,DAT+3,S02
0713 e37d b6 97                     LDA     SYN+1
0714 e37f a8 bb                     EOR     #$BB
0715 e381 b7 97                     STA     SYN+1
0716 e383 9f                        TXA
0717 e384 a8 01                     EOR     #$01
0718 e386 97                        TAX
0719 e387 01 7c 0a          S02     BRCLR   0,DAT+2,S12
0720 e38a b6 97                     LDA     SYN+1
0721 e38c a8 76                     EOR     #$76
0722 e38e b7 97                     STA     SYN+1
0723 e390 9f                        TXA
0724 e391 a8 03                     EOR     #$03
0725 e393 97                        TAX
0726 e394 03 7c 0a          S12     BRCLR   1,DAT+2,S22
0727 e397 b6 97                     LDA     SYN+1
0728 e399 a8 55                     EOR     #$55
0729 e39b b7 97                     STA     SYN+1
0730 e39d 9f                        TXA
0731 e39e a8 03                     EOR     #$03
0732 e3a0 97                        TAX
0733 e3a1 05 7c 0a          S22     BRCLR   2,DAT+2,S32
0734 e3a4 b6 97                     LDA     SYN+1
0735 e3a6 a8 13                     EOR     #$13
0736 e3a8 b7 97                     STA     SYN+1
0737 e3aa 9f                        TXA
0738 e3ab a8 03                     EOR     #$03
0739 e3ad 97                        TAX
0740 e3ae 07 7c 0a          S32     BRCLR   3,DAT+2,S42
0741 e3b1 b6 97                     LDA     SYN+1
0742 e3b3 a8 9f                     EOR     #$9F
0743 e3b5 b7 97                     STA     SYN+1
0744 e3b7 9f                        TXA
0745 e3b8 a8 03                     EOR     #$03
0746 e3ba 97                        TAX
0747 e3bb 09 7c 0a          S42     BRCLR   4,DAT+2,S62
0748 e3be b6 97                     LDA     SYN+1
0749 e3c0 a8 87                     EOR     #$87
0750 e3c2 b7 97                     STA     SYN+1
0751 e3c4 9f                        TXA
0752 e3c5 a8 02                     EOR     #$02
0753 e3c7 97                        TAX
0754 e3c8 0d 7c 0a          S62     BRCLR   6,DAT+2,S72
0755 e3cb b6 97                     LDA     SYN+1
0756 e3cd a8 6e                     EOR     #$6E
0757 e3cf b7 97                     STA     SYN+1
0758 e3d1 9f                        TXA
0759 e3d2 a8 01                     EOR     #$01
0760 e3d4 97                        TAX
0761 e3d5 0f 7c 09          S72     BRCLR   7,DAT+2,S33
0762 e3d8 b6 97                     LDA     SYN+1
0763 e3da a8 dc                     EOR     #$DC
0764 e3dc b7 97                     STA     SYN+1
0765 e3de 9f                        TXA
0766 e3df a8 02                     EOR     #$02
0767 e3e1 b7 96             S33     STA     SYN
0768 e3e3 b6 97                     LDA     SYN+1
0769 e3e5 07 7d 02                  BRCLR   3,DAT+3,S52
0770 e3e8 a8 f7                     EOR     #$F7
0771 e3ea 0b 7c 02          S52     BRCLR   5,DAT+2,FIN
0772 e3ed a8 b7                     EOR     #$B7
0773 e3ef b7 97             FIN     STA     SYN+1
```

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0775                        ************************************************
0776                        *                                              *
0777                        *       Check for syndromes A, B, C & C'.      *
0778                        *                                              *
0779                        ************************************************
0780
0781 e3f1 17 0e                    BCLR    3,ICR           CLEAR IRQ INTERRUPT FLAG
0782
0783 e3f3 b6 93                    LDA     LEV
0784 e3f5 a1 03                    CMP     #3
0785 e3f7 27 5d                    BEQ     TRYD
0786 e3f9 a1 02                    CMP     #2
0787 e3fb 27 22                    BEQ     TRYC
0788 e3fd a1 01                    CMP     #1
0789 e3ff 27 10                    BEQ     TRYB
0790 e401 3f 93                    CLR     LEV
0791
0792 e403 b6 97             TRYA   LDA     SYN+1           BLOCK 1
0793 e405 a1 d8                    CMP     #$D8
0794 e407 26 31                    BNE     NOTV
0795 e409 b6 96                    LDA     SYN
0796 e40b a1 03                    CMP     #$03
0797 e40d 26 2b                    BNE     NOTV
0798 e40f 20 53                    BRA     VALID
0799
0800 e411 b6 97             TRYB   LDA     SYN+1           BLOCK 2
0801 e413 a1 d4                    CMP     #$D4
0802 e415 26 23                    BNE     NOTV
0803 e417 b6 96                    LDA     SYN
0804 e419 a1 03                    CMP     #$03
0805 e41b 26 1d                    BNE     NOTV
0806 e41d 20 45                    BRA     VALID
0807
0808 e41f 06 80 0c          TRYC   BRSET   3,TMPGRP+2,TRYCD    BLOCK 3 TYPE A
0809 e422 b6 97                    LDA     SYN+1
0810 e424 a1 5c                    CMP     #$5C
0811 e426 26 12                    BNE     NOTV
0812 e428 b6 96                    LDA     SYN
0813 e42a a1 02                    CMP     #$02
0814 e42c 20 0a                    BRA     VC
0815
0816 e42e b6 97             TRYCD  LDA     SYN+1               BLOCK 3 TYPE B
0817 e430 a1 cc                    CMP     #$CC
0818 e432 26 06                    BNE     NOTV
0819 e434 b6 96                    LDA     SYN
0820 e436 a1 03                    CMP     #$03
0821 e438 27 2a             VC     BEQ     VALID
0822
0823                        ************************************************
0824                        *                                              *
0825                        *       Invalid syndrome handling, check for   *
0826                        *       block 4 and save group data if valid.  *
0827                        *                                              *
0828                        ************************************************
0829
0830 e43a 3f 93             NOTV   CLR     LEV             RESTART AT BLOCK 1
0831 e43c b6 98                    LDA     CONF
0832 e43e a1 29                    CMP     #41             CONFIDENCE 41 OR GREATER ?
0833 e440 24 0e                    BHS     DECC
0834 e442 11 c9                    BCLR    0,STAT2         BIT BY BIT SYNDROME CHECK
0835 e444 a1 0a                    CMP     #10
0836 e446 23 0b                    BLS     SKPDC           CONFIDENCE 10 OR LESS ?
0837 e448 3a 94                    DEC     BIT
0838 e44a 26 06                    BNE     NNOW            USE BIT COUNTER TO SLOW CONFIDENCE
0839 e44c a6 1a                    LDA     #26             DROP DURING BIT BY BIT ATTEMPT TO
0840 e44e b7 94                    STA     BIT             RE-SYNCRONISE
0841 e450 3a 98             DECC   DEC     CONF
0842 e452 80                NNOW   RTI
0843 e453 18 c9             SKPDC  BSET    4,STAT2         10 OR LESS, INITIALISE DISPLAY
0844 e455 80                NOT4   RTI
0845
0846 e456 b6 97             TRYD   LDA     SYN+1
0847 e458 a1 58                    CMP     #$58
0848 e45a 26 de                    BNE     NOTV
0849 e45c b6 96                    LDA     SYN
0850 e45e a1 02                    CMP     #$02
0851 e460 26 d8                    BNE     NOTV
0852 e462 12 c9                    BSET    1,STAT2         GROUP COMPLETE
0853
0854 e464 00 c9 06          VALID  BRSET   0,STAT2,VLD     VALID SYNDROME FLAG ALREADY SET ?
0855 e467 a6 26                    LDA     #38             NO,
0856 e469 b7 98                    STA     CONF            INITIALISE CONFIDENCE (38+4=42)
0857 e46b 10 c9                    BSET    0,STAT2         AND SET FLAG
0858 e46d b6 98             VLD    LDA     CONF
0859 e46f a1 38                    CMP     #56
0860 e471 22 04                    BHI     NMR
0861 e473 ab 04                    ADD     #4
0862 e475 b7 98                    STA     CONF
0863 e477 be 93             NMR    LDX     LEV
0864 e479 59                       ROLX
0865 e47a 3c 93                    INC     LEV
0866 e47c a6 1a                    LDA     #26
0867 e47e b7 94                    STA     BIT
0868 e480 36 7a                    ROR     DAT
0869 e482 36 7b                    ROR     DAT+1
0870 e484 36 7c                    ROR     DAT+2
0871 e486 36 7a                    ROR     DAT
0872 e488 36 7b                    ROR     DAT+1
0873 e48a 36 7c                    ROR     DAT+2
0874 e48c b6 7c                    LDA     DAT+2
0875 e48e e7 7f                    STA     TMPGRP+1,X
0876 e490 b6 7b                    LDA     DAT+1
0877 e492 e7 7e                    STA     TMPGRP,X
0878 e494 03 c9 be                 BRCLR   1,STAT2,NOT4    GROUP COMPLETE ?
0879 e497 ae 08             XFER   LDX     #8
0880 e499 e6 7d             TXLP   LDA     TMPGRP-1,X
0881 e49b e7 85                    STA     GROUP-1,X
0882 e49d 5a                       DECX
0883 e49e 26 f9                    BNE     TXLP
```

```
0885                        ************************************************
0886                        *                                              *
0887                        *       Update PI code, initialise if changed. *
0888                        *       All block 1s used, block 3s not used.  *
0889                        *                                              *
0890                        ************************************************
0891
0892 e4a0 b6 86              PROC    LDA     GROUP           COMPARE PI WITH PREVIOUS
0893 e4a2 b1 8f                      CMP     PI
0894 e4a4 26 06                      BNE     DNDX
0895 e4a6 b6 87                      LDA     GROUP+1
0896 e4a8 b1 90                      CMP     PI+1
0897 e4aa 27 10                      BEQ     PTYL
0898 e4ac b6 86              DNDX    LDA     GROUP           DIFFERENT, SAVE NEW PI
0899 e4ae b7 8f                      STA     PI
0900 e4b0 b6 87                      LDA     GROUP+1
0901 e4b2 b7 90                      STA     PI+1
0902 e4b4 cd eb e6                   JSR     CLREON          CLEAR EON,
0903 e4b7 cd e8 0a                   JSR     CLTR            TRANSIENTS
0904 e4ba 18 c9                      BSET    4,STAT2         AND INITIALISE DISPLAY DATA
0905
0906                        ************************************************
0907                        *                                              *
0908                        *       Update PTY and TP.                     *
0909                        *       All block 2s used, not block 4 (grp 15B).  *
0910                        *                                              *
0911                        ************************************************
0912
0913 e4bc b6 88              PTYL    LDA     GROUP+2
0914 e4be b7 95                      STA     ITMP1
0915 e4c0 05 95 04                   BRCLR   2,ITMP1,TPL1    TP HIGH ?
0916 e4c3 16 ca                      BSET    3,STAT3         YES, FLAG HIGH
0917 e4c5 20 02                      BRA     TPL
0918 e4c7 17 ca              TPL1    BCLR    3,STAT3         NO, FLAG LOW
0919 e4c9 b6 89              TPL     LDA     GROUP+3
0920 e4cb 36 95                      ROR     ITMP1
0921 e4cd 46                         RORA
0922 e4ce 44                         LSRA
0923 e4cf 44                         LSRA
0924 e4d0 44                         LSRA
0925 e4d1 44                         LSRA
0926 e4d2 b7 8e                      STA     PTY
0927
0928                        ************************************************
0929                        *                                              *
0930                        *       Groups handled.                        *
0931                        *                                              *
0932                        *       All         PI, PTY & TP               *
0933                        *       0 A & B     TA, PS, DI & M/S           *
0934                        *       1 A & B     PIN                        *
0935                        *       2 A         RT                         *
0936                        *       4 A         CT                         *
0937                        *      14 A         EON                        *
0938                        *      15 B         TA, DI & M/S               *
0939                        *                                              *
0940                        ************************************************
0941
0942                        ************************************************
0943                        *                                              *
0944                        *       Process groups 0 & 15B (PS & TA).      *
0945                        *                                              *
0946                        ************************************************
0947
0948 e4d4 b6 88                      LDA     GROUP+2
0949 e4d6 a4 f8                      AND     #$F8
0950 e4d8 27 0a                      BEQ     GRP0            GROUP 0A
0951 e4da a1 08                      CMP     #$08            GROUP 0B
0952 e4dc 27 06                      BEQ     GRP0
0953
0954 e4de a1 f8              TGRP15  CMP     #$F8            GROUP 15B
0955 e4e0 27 10                      BEQ     TACK
0956 e4e2 20 57                      BRA     PROC1
0957
0958 e4e4 b6 89              GRP0    LDA     GROUP+3         GROUP 0  -  PS & TA
0959 e4e6 a4 03                      AND     #$03
0960 e4e8 48                         LSLA
0961 e4e9 97                         TAX
0962 e4ea b6 8c                      LDA     GROUP+6
0963 e4ec e7 c1                      STA     PSN,X
0964 e4ee b6 8d                      LDA     GROUP+7
0965 e4f0 e7 c2                      STA     PSN+1,X
0966
0967 e4f2 3f 79              TACK    CLR     RDSTO           RDS OK, RESET TIME-OUT
0968 e4f4 08 89 04                   BRSET   4,GROUP+3,TAH   TA HIGH ?
0969 e4f7 15 ca                      BCLR    2,STAT3         NO, TA FLAG LOW
0970 e4f9 20 02                      BRA     NTD
0971 e4fb 14 ca              TAH     BSET    2,STAT3         YES, TA FLAG HIGH
```

```
0973                        ************************************************
0974                        *                                              *
0975                        *       Process group 0 & 15B (DI & M/S).      *
0976                        *                                              *
0977                        ************************************************
0978
0979 e4fd b6 89             NTD     LDA     GROUP+3         DI
0980 e4ff a4 03                     AND     #3
0981 e501 97                        TAX
0982 e502 b6 89                     LDA     GROUP+3
0983 e504 a4 40                     AND     #$40
0984 e506 5d                        TSTX
0985 e507 26 07                     BNE     NOT0
0986 e509 11 b0                     BCLR    0,DI
0987 e50b 4d                        TSTA
0988 e50c 27 02                     BEQ     NOT0
0989 e50e 10 b0                     BSET    0,DI
0990 e510 a3 01             NOT0    CPX     #1
0991 e512 26 07                     BNE     NOT1
0992 e514 13 b0                     BCLR    1,DI
0993 e516 4d                        TSTA
0994 e517 27 02                     BEQ     NOT1
0995 e519 12 b0                     BSET    1,DI
0996 e51b a3 02             NOT1    CPX     #2
0997 e51d 26 07                     BNE     NOT2
0998 e51f 15 b0                     BCLR    2,DI
0999 e521 4d                        TSTA
1000 e522 27 02                     BEQ     NOT2
1001 e524 14 b0                     BSET    2,DI
1002 e526 a3 03             NOT2    CPX     #3
1003 e528 26 07                     BNE     NOT3
1004 e52a 17 b0                     BCLR    3,DI
1005 e52c 4d                        TSTA
1006 e52d 27 02                     BEQ     NOT3
1007 e52f 16 b0                     BSET    3,DI
1008
1009 e531 11 ca             NOT3    BCLR    0,STAT3         M/S
1010 e533 07 89 02                  BRCLR   3,GROUP+3,MSZ
1011 e536 10 ca                     BSET    0,STAT3
1012 e538 cc e6 18          MSZ     JMP     OUT1
1013
1014                        ************************************************
1015                        *                                              *
1016                        *       Process group 1 (PIN).                 *
1017                        *                                              *
1018                        ************************************************
1019
1020 e53b a1 10             PROC1   CMP     #$10            GROUP 1A
1021 e53d 27 04                     BEQ     GRP1
1022 e53f a1 18                     CMP     #$18            GROUP 1B
1023 e541 26 0b                     BNE     PROC2
1024
1025 e543 b6 8c             GRP1    LDA     GROUP+6
1026 e545 b7 91                     STA     PIN
1027 e547 b6 8d                     LDA     GROUP+7
1028 e549 b7 92                     STA     PIN+1
1029
1030 e54b cc e6 18                  JMP     OUT1
1031
1032                        ************************************************
1033                        *                                              *
1034                        *       Process group 2A (RT).                 *
1035                        *       Group 2B not handled.                  *
1036                        *                                              *
1037                        ************************************************
1038
1039 e54e a1 20             PROC2   CMP     #$20            GROUP 2A
1040 e550 26 30                     BNE     PROC4
1041
1042 e552 08 89 07          GRP2    BRSET   4,GROUP+3,TEXTB
1043 e555 02 ca 0c          TEXTA   BRSET   1,STAT3,NCH
1044 e558 12 ca                     BSET    1,STAT3
1045 e55a 20 05                     BRA     LCDINI
1046 e55c 03 ca 05          TEXTB   BRCLR   1,STAT3,NCH
1047 e55f 13 ca                     BCLR    1,STAT3
1048 e561 cd eb aa          LCDINI  JSR     INITD
1049
1050 e564 b6 89             NCH     LDA     GROUP+3         GROUP 2A  -  RT
1051 e566 a4 0f                     AND     #$0F
1052 e568 48                        LSLA
1053 e569 48                        LSLA
1054 e56a 97                        TAX
1055 e56b b6 8a                     LDA     GROUP+4
1056 e56d d7 01 05                  STA     RT+5,X
1057 e570 b6 8b                     LDA     GROUP+5
1058 e572 d7 01 06                  STA     RT+6,X
1059 e575 b6 8c                     LDA     GROUP+6
1060 e577 d7 01 07                  STA     RT+7,X
1061 e57a b6 8d                     LDA     GROUP+7
1062 e57c d7 01 08                  STA     RT+8,X
1063 e57f cc e6 18                  JMP     OUT1
```

```
1065                            ************************************************
1066                            *                                              *
1067                            *       Process group 4A (CT).                 *
1068                            *                                              *
1069                            ************************************************
1070
1071 e582 a1 40                 PROC4   CMP     #$40            GROUP 4A  -  CT
1072 e584 27 03                         BEQ     GRP4
1073 e586 cc e6 1b                      JMP     PROC14
1074
1075 e589 b6 89                 GRP4    LDA     GROUP+3
1076 e58b 46                            RORA
1077 e58c a4 01                         AND     #$01
1078 e58e b7 74                         STA     BMJD            MJD MS BIT
1079 e590 b6 8a                         LDA     GROUP+4
1080 e592 46                            RORA
1081 e593 b7 75                         STA     BMJD+1          MJD MSD
1082
1083 e595 b6 8c                         LDA     GROUP+6         GROUP 4
1084 e597 36 8b                         ROR     GROUP+5         3210xxxx 4
1085 e599 46                            RORA                    43210xxx x
1086 e59a 44                            LSRA                    -43210xx x
1087 e59b 44                            LSRA                    --43210x x
1088 e59c 44                            LSRA                    ---43210 x
1089 e59d b7 9c                         STA     OUR
1090
1091 e59f b6 8b                         LDA     GROUP+5
1092 e5a1 b7 76                         STA     BMJD+2          MJD LSD
1093
1094 e5a3 b6 8c                         LDA     GROUP+6         xxxx5432 x
1095 e5a5 38 8d                         LSL     GROUP+7         xxxx5432 1
1096 e5a7 49                            ROLA                    xxx54321 x
1097 e5a8 38 8d                         LSL     GROUP+7         xxx54321 0
1098 e5aa 49                            ROLA                    xx543210 x
1099 e5ab a4 3f                         AND     #$3F            --543210 x
1100 e5ad b7 9b                         STA     MIN
1101 e5af 3f 9a                         CLR     SEC
1102 e5b1 3f 99                         CLR     TH8
1103 e5b3 1c ca                         BSET    6,STAT3         UPDATE MJD
1104
1105                            ************************************************
1106                            *                                              *
1107                            *       Local time difference adjustment.      *
1108                            *                                              *
1109                            ************************************************
1110
1111 e5b5 b6 8d                 LOCAL   LDA     GROUP+7
1112 e5b7 48                            LSLA
1113 e5b8 27 5e                         BEQ     OUT1            ADJUSTMENT ?
1114 e5ba 24 32                         BCC     POS             YES, POSITIVE ?
1115
1116 e5bc 44                    NEG     LSRA                    NO, NEGATIVE
1117 e5bd 44                            LSRA
1118 e5be 44                            LSRA
1119 e5bf 44                            LSRA
1120 e5c0 97                            TAX                     HOURS IN X
1121 e5c1 24 0c                         BCC     NOTHN           1/2 HOUR ?
1122 e5c3 b6 9b                         LDA     MIN             YES
1123 e5c5 a0 1e                         SUB     #30             SUBTRACT 30 MINUTES
1124 e5c7 2a 04                         BPL     LT60            UNDERFLOW ?
1125 e5c9 ab 3c                         ADD     #60             YES, ADD 60 MINUTES
1126 e5cb 3a 9c                         DEC     OUR             AND SUBTRACT 1 HOUR
1127 e5cd b7 9b                 LT60    STA     MIN
1128
1129 e5cf 9f                    NOTHN   TXA                     NEGATIVE HOUR OFFSET
1130 e5d0 b0 9c                         SUB     OUR             MINUS UTC HOURS
1131 e5d2 43                            COMA                    WRONG WAY ROUND SO COMPLEMENT
1132 e5d3 4c                            INCA                    AND INCREMENT
1133 e5d4 2a 14                         BPL     ZOM             UNDERFLOW ?
1134 e5d6 ab 18                         ADD     #24             YES, ADD 24 HOURS
1135 e5d8 b7 9c                         STA     OUR
1136
1137 e5da 3d 76                         TST     BMJD+2          AND SUBTRACT A DAY
1138 e5dc 26 08                         BNE     TT2             LSB WILL UNDERFLOW ?
1139 e5de 3d 75                         TST     BMJD+1          YES
1140 e5e0 26 02                         BNE     TT1             MSB WILL UNDERFLOW ?
1141 e5e2 3a 74                         DEC     BMJD            YES DECREMENT MS BIT
1142 e5e4 3a 75                 TT1     DEC     BMJD+1          DECREMENT MSB
1143 e5e6 3a 76                 TT2     DEC     BMJD+2          DECREMENT LSB
1144 e5e8 20 2e                         BRA     OUT1
1145
1146 e5ea b7 9c                 ZOM     STA     OUR
1147 e5ec 20 2a                         BRA     OUT1
1148
1149 e5ee 44                    POS     LSRA                    POSITIVE ADJUSTMENT
1150 e5ef 44                            LSRA
1151 e5f0 44                            LSRA
1152 e5f1 44                            LSRA
1153 e5f2 97                            TAX                     HOURS IN X
1154 e5f3 24 0e                         BCC     NOTHP           HALF HOUR ?
1155 e5f5 a6 1e                         LDA     #30             YES, ADD 30 MINUTES
1156 e5f7 bb 9b                         ADD     MIN
1157 e5f9 a1 3b                         CMP     #59
1158 e5fb 23 04                         BLS     HDON            OVERFLOW ?
1159 e5fd a0 3c                         SUB     #60             YES, SUBTRACT 60 MINUTES
1160 e5ff 3c 9c                         INC     OUR             AND ADD AN HOUR
1161 e601 b7 9b                 HDON    STA     MIN
1162
1163 e603 9f                    NOTHP   TXA                     HOUR OFFSET
1164 e604 bb 9c                         ADD     OUR             ADD UTC HOURS
1165 e606 a1 17                         CMP     #23
1166 e608 23 0c                         BLS     ADDON           OVERFLOW ?
1167 e60a a0 18                         SUB     #24             YES, SUBTRACT 24 HOURS
1168 e60c 3c 76                         INC     BMJD+2          AND ADD A DAY
1169 e60e 26 06                         BNE     ADDON
1170 e610 3c 75                         INC     BMJD+1
1171 e612 26 02                         BNE     ADDON
1172 e614 3c 74                         INC     BMJD
1173 e616 b7 9c                 ADDON   STA     OUR
1174 e618 13 c9                 OUT1    BCLR    1,STAT2         GROUP HANDLED, CLEAR FLAG
1175 e61a 80                            RTI
```

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1177                        ************************************************
1178                        *                                              *
1179                        *       Process group 14 (EON).                *
1180                        *                                              *
1181                        ************************************************
1182
1183 e61b a1 e0            PROC14  CMP     #$E0
1184 e61d 27 03                    BEQ     GRP14A
1185 e61f cc e6 b3                JMP     OUT2
1186
1187 e622 3f 95            GRP14A  CLR     ITMP1           LOOK FOR PI CODE IN TABLE
1188 e624 be 95            LPIL    LDX     ITMP1
1189 e626 d6 01 45                LDA     EON,X
1190 e629 b1 8c                   CMP     GROUP+6
1191 e62b 26 69                   BNE     NOTH
1192 e62d d6 01 46                LDA     EON+1,X
1193 e630 b1 8d                   CMP     GROUP+7
1194 e632 26 62                   BNE     NOTH
1195
1196                        *       LDA     GROUP+3         TP (ON), NOT USED
1197                        *       AND     #$10
1198                        *       LDX     ITMP1
1199                        *       STA     EON+11,X
1200
1201 e634 b6 89                   LDA     GROUP+3         PI CODE FOUND
1202 e636 a4 0f                   AND     #$0F
1203 e638 a1 04                   CMP     #4              PS ?
1204 e63a 24 10                   BHS     NPS
1205 e63c 48                      LSLA                    YES
1206 e63d bb 95                   ADD     ITMP1
1207 e63f 97                      TAX
1208 e640 b6 8a                   LDA     GROUP+4
1209 e642 d7 01 47                STA     EON+2,X         SAVE 2 PS-NAME CHARACTERS
1210 e645 b6 8b                   LDA     GROUP+5
1211 e647 d7 01 48                STA     EON+3,X
1212 e64a 20 cc                   BRA     OUT1
1213
1214 e64c a1 04            NPS     CMP     #4              AF ?
1215 e64e 26 34                   BNE     TRYPIN
1216
1217 e650 b6 8a                   LDA     GROUP+4         YES, METHOD A
1218
1219 e652 a1 fa                   CMP     #250
1220 e654 26 1a                   BNE     NMLW            MEDIUM OR LONG WAVE ?
1221 e656 d6 01 51                LDA     EON+12,X        YES
1222 e659 a1 ff                   CMP     #$FF            FIRST 2 BYTES ALREADY IN ?
1223 e65b 27 56                   BEQ     OUT2            IF NOT, DO NOTHING
1224 e65d d6 01 53                LDA     EON+14,X        YES
1225 e660 a1 ff                   CMP     #$FF            M/L FREQUENCY ALREADY IN ?
1226 e662 26 4f                   BNE     OUT2            IF SO, DO NOTHING
1227 e664 a6 fa                   LDA     #250            NO, STORE FIRST FREQUENCY AFTER
1228 e666 d7 01 53                STA     EON+14,X        ARRIVAL OF INITIAL BYTES
1229 e669 b6 8b                   LDA     GROUP+5
1230 e66b d7 01 54                STA     EON+15,X
1231 e66e 20 43                   BRA     OUT2
1232
1233 e670 a1 e0            NMLW    CMP     #224            FM
1234 e672 25 0e                   BLO     TOOLS           LEGAL ? (No. OF FREQUENCIES)
1235 e674 a1 f9                   CMP     #249
1236 e676 22 0a                   BHI     TOOLS
1237 e678 be 95                   LDX     ITMP1
1238 e67a d7 01 51                STA     EON+12,X        YES, SAVE No. OF FREQUENCIES
1239 e67d b6 8b                   LDA     GROUP+5
1240 e67f d7 01 52                STA     EON+13,X        AND FIRST FREQUENCY
1241 e682 20 2f            TOOLS   BRA     OUT2
1242
1243                        *TRYPTY CMP     #$0D
1244                        *       BNE     TRYPIN
1245                        *       LDA     GROUP+4         PTY (EON), NOT USED
1246                        *       LSRA
1247                        *       LSRA
1248                        *       LSRA
1249                        *       LDX     ITMP1
1250                        *       STA     EON+10,X
1251                        *       BRA     OUT2
1252
1253 e684 a1 0e            TRYPIN  CMP     #$0E
1254 e686 26 2b                   BNE     OUT2
1255 e688 be 95                   LDX     ITMP1           PIN
1256 e68a b6 8a                   LDA     GROUP+4
1257 e68c d7 01 4f                STA     EON+10,X
1258 e68f b6 8b                   LDA     GROUP+5
1259 e691 d7 01 50                STA     EON+11,X
1260 e694 20 1d                   BRA     OUT2
1261
1262 e696 a1 ff            NOTH    CMP     #$FF            END OF PI LIST ?
1263 e698 26 0c                   BNE     NOTH1
1264 e69a b6 8c                   LDA     GROUP+6         YES, ADD THIS PI CODE
1265 e69c d7 01 45                STA     EON,X
1266 e69f b6 8d                   LDA     GROUP+7         TO EON TABLE
1267 e6a1 d7 01 46                STA     EON+1,X
1268 e6a4 20 0d                   BRA     OUT2
1269
1270 e6a6 b6 95            NOTH1   LDA     ITMP1           NOT END, TRY NEXT ENTRY
1271 e6a8 ab 10                   ADD     #16
1272 e6aa b7 95                   STA     ITMP1
1273 e6ac a1 b0                   CMP     #$B0            END OF TABLE (11 ENTRIES) ?
1274 e6ae 27 03                   BEQ     OUT2
1275 e6b0 cc e6 24                JMP     LPIL
1276
1277 e6b3 13 c9            OUT2    BCLR    1,STAT2         GROUP HANDLED, CLEAR FLAG
1278 e6b5 80                      RTI
```

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1280                        ************************************************
1281                        *                                              *
1282                        *       Display type selection.                *
1283                        *                                              *
1284                        ************************************************
1285
1286 e6b6 09 c9 05          MOD     BRCLR   4,STAT2,NOCL    SHOULD DISPALY BE INITIALISED ?
1287 e6b9 cd eb aa                  JSR     INITD           YES, DO IT
1288 e6bc 19 c9                     BCLR    4,STAT2         AND CLEAR FLAG
1289 e6be cd eb 6c          NOCL    JSR     WAIT
1290 e6c1 a6 0c                     LDA     #$0C            SWITCH DISPLAY ON
1291 e6c3 cd eb 65                  JSR     CLOCK           LATCH IT
1292 e6c6 cd eb 6c                  JSR     WAIT
1293                        *       LDA     #$38            /16 DISPLAY
1294 e6c9 a6 30                     LDA     #$30            /8  DISPLAY
1295 e6cb cd eb 65                  JSR     CLOCK           LATCH IT
1296 e6ce cd eb 6c                  JSR     WAIT
1297 e6d1 a6 80                     LDA     #$80            ADDRESS DISPLAY RAM
1298 e6d3 cd eb 65                  JSR     CLOCK           LATCH IT
1299
1300 e6d6 06 04 0b                  BRSET   3,PORTE,TRYRT   STANDBY ?
1301 e6d9 04 cb 59                  BRSET   2,STAT4,SLPD    YES, SLEEP DISPLAY ?
1302 e6dc 06 cb 66                  BRSET   3,STAT4,ALRMJ   NO, ALARM DISPLAY ?
1303 e6df cd e8 69                  JSR     STBYD           NO, NORMAL STANDBY DISPLAY
1304 e6e2 20 64                     BRA     ROW1
1305
1306 e6e4 0f cb 46          TRYRT   BRCLR   7,STAT4,RTITS   RDS DISPLAYS ?
1307 e6e7 b6 af                     LDA     RTDIS
1308 e6e9 a1 01                     CMP     #1
1309 e6eb 26 05                     BNE     NPTY
1310 e6ed cd e8 19                  JSR     PTYD            PTY
1311 e6f0 20 56                     BRA     ROW1
1312
1313 e6f2 a1 02             NPTY    CMP     #2
1314 e6f4 26 05                     BNE     NPI
1315 e6f6 cd e8 fa                  JSR     DIPI            PI
1316 e6f9 20 4d                     BRA     ROW1
1317
1318 e6fb a1 03             NPI     CMP     #3
1319 e6fd 26 05                     BNE     NTAP
1320 e6ff cd e9 5a                  JSR     DITAP           TA & TP
1321 e702 20 44                     BRA     ROW1
1322
1323 e704 a1 04             NTAP    CMP     #4
1324 e706 26 05                     BNE     NPIN1
1325 e708 cd e9 72                  JSR     DPIN1           PIN - HEX
1326 e70b 20 3b                     BRA     ROW1
1327
1328 e70d a1 05             NPIN1   CMP     #5
1329 e70f 26 05                     BNE     NPIN2
1330 e711 cd e9 92                  JSR     DPIN2           PIN - DAY AND TIME
1331 e714 20 32                     BRA     ROW1
1332
1333 e716 a1 06             NPIN2   CMP     #6
1334 e718 26 05                     BNE     NMJD
1335 e71a cd e9 f6                  JSR     DMJD            MJD
1336 e71d 20 29                     BRA     ROW1
1337
1338 e71f a1 07             NMJD    CMP     #7
1339 e721 26 05                     BNE     NMSD
1340 e723 cd eb 03                  JSR     DMSD            M/S & DI
1341 e726 20 20                     BRA     ROW1
1342
1343 e728 cd ea 25          NMSD    JSR     DEON
1344 e72b 20 1b                     BRA     ROW1
1345
1346 e72d 05 c9 05          RTITS   BRCLR   2,STAT2,SLPD    RT DISPLAY ?
1347 e730 cd e8 4a                  JSR     RTDS
1348 e733 20 13                     BRA     ROW1
1349
1350 e735 05 cb 05          SLPD    BRCLR   2,STAT4,NRMD    SLEEP TIMER DISPLAY ?
1351 e738 cd ea ee                  JSR     SLEEPD
1352 e73b 20 0b                     BRA     ROW1
1353
1354 e73d 06 cb 05          NRMD    BRSET   3,STAT4,ALRMJ   ALARM DISPLAY ?
1355 e740 cd e7 cc                  JSR     NORMD
1356 e743 20 03                     BRA     ROW1
1357
1358 e745 cd e9 1a          ALRMJ   JSR     ALRMD
1359
1360 e748 5f                ROW1    CLRX
1361 e749 cd eb 6c          LCD     JSR     WAIT
1362 e74c 14 03                     BSET    2,PORTD         WRITE DATA
1363 e74e e6 b1                     LDA     DISP,X          GET A BYTE
1364 e750 a1 ff                     CMP     #$FF
1365 e752 26 02                     BNE     COK
1366 e754 a6 2d                     LDA     #$2D
1367 e756 cd eb 65          COK     JSR     CLOCK           SEND IT TO MODULE
1368 e759 5c                        INCX
1369 e75a a3 10                     CPX     #16             DONE ?
1370 e75c 26 eb                     BNE     LCD
1371 e75e 20 1e                     BRA     VFD             REMOVE FOR /16 LCDs
1372
1373                        ************************************************
1374                        *                                              *
1375                        *       Additional bits for /16 LCD modules.   *
1376                        *                                              *
1377                        ************************************************
1378
1379 e760 cd eb 6c          LCD401  JSR     WAIT
1380 e763 a6 a8                     LDA     #$A8            TO 40
1381 e765 cd eb 65                  JSR     CLOCK           SEND IT TO MODULE
1382 e768 5f                        CLRX
1383 e769 cd eb 6c          LCD41   JSR     WAIT
1384 e76c 14 03                     BSET    2,PORTD         WRITE DATA
1385 e76e e6 b9                     LDA     DISP+8,X        GET A BYTE
1386 e770 a1 ff                     CMP     #$FF
1387 e772 26 02                     BNE     COK2
1388 e774 a6 2d                     LDA     #$2D
1389 e776 cd eb 65          COK2    JSR     CLOCK           SEND IT TO MODULE
1390 e779 5c                        INCX
1391 e77a a3 08                     CPX     #8              DONE ?
1392 e77c 26 eb                     BNE     LCD41
```

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1394                            ************************************************
1395                            *                                              *
1396                            *       VFD.                                   *
1397                            *                                              *
1398                            ************************************************
1399
1400 e77e 13 01                VFD     BCLR    1,PORTB         DATA LOW ?
1401 e780 10 01                        BSET    0,PORTB         CLOCK HIGH ?
1402 e782 17 01                        BCLR    3,PORTB         ENABLE LOW
1403
1404 e784 5f                            CLRX                    SEND VFD SET-UP BYTES
1405 e785 d6 e7 c5             DIS5    LDA     INITF,X
1406 e788 bf a7                        STX     W7              SAVE INDEX
1407 e78a ad 20                        BSR     VFDL
1408 e78c a3 07                        CPX     #7
1409 e78e 26 f5                        BNE     DIS5            LAST BYTE ?
1410
1411 e790 5f                            CLRX                    SEND 16 CHARACTER BYTES
1412 e791 bf a7                VFD3    STX     W7              SAVE INDEX
1413 e793 e6 b1                        LDA     DISP,X          ASCII
1414 e795 a1 ff                        CMP     #$FF
1415 e797 26 02                        BNE     NOTFF
1416 e799 a6 2d                        LDA     #$2D            REPLACE $FF WITH "-"
1417 e79b a4 7f                NOTFF   AND     #$7F            IGNORE BIT 7
1418 e79d 97                            TAX
1419 e79e d6 ed ae                      LDA     VTAB,X          CONVERT TO VFD CHARACTER SET
1420 e7a1 ad 09                        BSR     VFDL
1421 e7a3 a3 10                        CPX     #16
1422 e7a5 26 ea                        BNE     VFD3            LAST BYTE ?
1423
1424 e7a7 16 01                        BSET    3,PORTB         ENABLE HIGH
1425 e7a9 11 01                        BCLR    0,PORTB         CLOCK LOW ?
1426 e7ab 81                            RTS
1427
1428 e7ac ae 08                VFDL    LDX     #8
1429 e7ae 44                   DIS3    LSRA                    GET A BIT
1430 e7af 24 02                        BCC     DIS4
1431 e7b1 12 01                        BSET    1,PORTB         DATA HIGH
1432 e7b3 11 01                DIS4    BCLR    0,PORTB         CLOCK
1433 e7b5 10 01                        BSET    0,PORTB         IT
1434 e7b7 13 01                        BCLR    1,PORTB         CLEAR DATA
1435 e7b9 5a                            DECX                    COMPLETE ?
1436 e7ba 26 f2                        BNE     DIS3            NO
1437 e7bc ae 40                        LDX     #64
1438 e7be 5a                   DEL     DECX                    WAIT 200uS
1439 e7bf 26 fd                        BNE     DEL
1440 e7c1 be a7                        LDX     W7              RESTORE INDEX
1441 e7c3 5c                            INCX
1442 e7c4 81                            RTS
1443
1444 e7c5 a0 0f b0 00 80 00    INITF   FCB     $A0,$0F,$B0,$00,$80,$00,$90
     90
1445
1446                            ************************************************
1447                            *                                              *
1448                            *       Normal display (PS and time).          *
1449                            *                                              *
1450                            ************************************************
1451
1452 e7cc a6 20                NORMD   LDA     #$20
1453 e7ce b7 b1                        STA     DISP
1454 e7d0 b7 ba                        STA     DISP+9
1455 e7d2 b7 c0                        STA     DISP+15
1456 e7d4 a6 2e                        LDA     #$2E            .
1457 e7d6 03 cb 05                     BRCLR   1,STAT4,TYP1    DP TO INDICATE SLEEP TIMER RUNNING
1458 e7d9 05 99 02                     BRCLR   2,TH8,TYP1      FLASH IT
1459 e7dc b7 c0                        STA     DISP+15
1460
1461 e7de 5f                   TYP1    CLRX
1462 e7df e6 c1                MPS     LDA     PSN,X           GET PS NAME
1463 e7e1 e7 b2                        STA     DISP+1,X
1464 e7e3 5c                   SCNG    INCX
1465 e7e4 a3 07                        CPX     #7
1466 e7e6 23 f7                        BLS     MPS
1467
1468 e7e8 b6 9c                CJ      LDA     OUR             GET TIME
1469 e7ea cd eb 84                     JSR     CBCD
1470 e7ed a3 30                        CPX     #$30            LEADING ZERO ?
1471 e7ef 26 02                        BNE     TNZ
1472 e7f1 ae 20                        LDX     #$20            YES, MAKE IT A SPACE
1473 e7f3 bf bb                TNZ     STX     DISP+10
1474 e7f5 b7 bc                        STA     DISP+11
1475 e7f7 b6 9b                CMIN    LDA     MIN
1476 e7f9 cd eb 84                     JSR     CBCD
1477 e7fc bf be                        STX     DISP+13
1478 e7fe b7 bf                        STA     DISP+14
1479 e800 a6 20                CSEC    LDA     #$20
1480 e802 05 99 02                     BRCLR   2,TH8,DDC
1481 e805 a6 3a                        LDA     #$3A            0.5 Hz FLASHING COLON
1482 e807 b7 bd                DDC     STA     DISP+12
1483 e809 81                            RTS
1484
1485                            ************************************************
1486                            *                                              *
1487                            *       Clear display transient flags.         *
1488                            *                                              *
1489                            ************************************************
1490
1491 e80a 11 cb                CLTR    BCLR    0,STAT4         CLEAR DISPLAY TRANSIENT FLAG
1492 e80c 15 c9                        BCLR    2,STAT2         NOT RT DISPLAY
1493 e80e 3f af                        CLR     RTDIS           CLEAR RDS DISPLAY INDEX
1494 e810 17 cb                        BCLR    3,STAT4         NOT ALARM DISPLAY
1495 e812 1b cb                        BCLR    5,STAT4         NOT ALARM SET-UP
1496 e814 1f cb                        BCLR    7,STAT4         NOT RDS DISPLAYS
1497 e816 15 cb                        BCLR    2,STAT4         NOT SLEEP TIMER DISPLAY
1498 e818 81                            RTS
```

```
1500                        ************************************************
1501                        *                                              *
1502                        *       PTY display.                           *
1503                        *                                              *
1504                        ************************************************
1505
1506 e819 be 8e            PTYD    LDX     PTY             PTY
1507 e81b a3 10                    CPX     #16
1508 e81d 25 01                    BLO     XOK2
1509 e81f 5f                       CLRX
1510 e820 a6 10            XOK2    LDA     #16
1511 e822 42                       MUL
1512 e823 b7 a8                    STA     W8
1513 e825 3f a7                    CLR     W7
1514 e827 be a8            LCD3    LDX     W8
1515 e829 d6 ec ae                 LDA     PTYT,X
1516 e82c be a7                    LDX     W7
1517 e82e e7 b1                    STA     DISP,X          WAS MOD2
1518 e830 3c a8                    INC     W8
1519 e832 3c a7                    INC     W7
1520 e834 b6 a7                    LDA     W7
1521 e836 a1 10                    CMP     #16
1522 e838 25 ed                    BLO     LCD3
1523 e83a 81                       RTS
1524
1525                        ************************************************
1526                        *                                              *
1527                        *       RDS display.                           *
1528                        *                                              *
1529                        ************************************************
1530
1531 e83b be a0            NXTC    LDX     DISP2
1532 e83d e6 ff                    LDA     RT-1,X          RT
1533 e83f a1 20                    CMP     #$20
1534 e841 26 13                    BNE     NOTSP           SPACE ?
1535 e843 0b c9 0c                 BRCLR   5,STAT2,FSP     YES, FIRST ONE ?
1536 e846 3c 9f                    INC     DISP1           NO, SKIP THIS ONE
1537 e848 3c a0                    INC     DISP2
1538 e84a b6 a0            RTDS    LDA     DISP2
1539 e84c a1 45            SKP1    CMP     #69
1540 e84e 22 18                    BHI     LCD4            END OF RT BUFFER
1541 e850 20 e9                    BRA     NXTC            NO, GET NEXT CHARACTER
1542
1543 e852 1a c9            FSP     BSET    5,STAT2         FIRST SPACE, SET FLAG
1544 e854 20 02                    BRA     CONT
1545 e856 1b c9            NOTSP   BCLR    5,STAT2         NOT A SPACE, CLEAR FLAG
1546 e858 b7 a8            CONT    STA     W8              SAVE NEW CHARACTER
1547 e85a 5f                       CLRX
1548 e85b e6 b2            ILP1    LDA     DISP+1,X        MOVE
1549 e85d e7 b1                    STA     DISP,X          REST
1550 e85f 5c                       INCX                    LEFT
1551 e860 a3 0f                    CPX     #15             ONE
1552 e862 26 f7                    BNE     ILP1            PLACE
1553 e864 b6 a8                    LDA     W8
1554 e866 b7 c0                    STA     DISP+15         ADD NEW CHAR. (WAS MOD2)
1555 e868 81               LCD4    RTS
1556
1557
1558                        ************************************************
1559                        *                                              *
1560                        *       Standby display.                       *
1561                        *                                              *
1562                        ************************************************
1563
1564 e869 08 cb 4f          STBYD   BRSET   4,STAT4,ALRMA   ALARM ARMED ?
1565 e86c b6 73                    LDA     DOW             NO, GET DAY OF WEEK
1566 e86e 48                       LSLA
1567 e86f bb 73                    ADD     DOW
1568 e871 97                       TAX
1569 e872 d6 ec 72                 LDA     DNAME,X
1570 e875 b7 b1                    STA     DISP
1571 e877 d6 ec 73                 LDA     DNAME+1,X
1572 e87a b7 b2                    STA     DISP+1
1573 e87c d6 ec 74                 LDA     DNAME+2,X
1574 e87f b7 b3                    STA     DISP+2
1575 e881 a6 20                    LDA     #$20
1576 e883 b7 b4                    STA     DISP+3
1577 e885 b7 b7                    STA     DISP+6
1578 e887 b7 bb                    STA     DISP+10
1579 e889 b6 72                    LDA     DOM+1           DATE
1580 e88b ab 30                    ADD     #$30
1581 e88d b7 b6                    STA     DISP+5
1582 e88f b6 71                    LDA     DOM
1583 e891 27 02                    BEQ     ADD20           IF ZERO USE A SPACE
1584 e893 ab 10                    ADD     #$10            IF NOT MAKE ASCII
1585 e895 ab 20            ADD20   ADD     #$20
1586 e897 b7 b5                    STA     DISP+4
1587 e899 be 70                    LDX     MNTH+1          MONTH, LSD
1588 e89b b6 6f                    LDA     MNTH            MONTH, MSD
1589 e89d 27 04                    BEQ     MTHZ
1590 e89f 9f                       TXA
1591 e8a0 ab 0a                    ADD     #10
1592 e8a2 97                       TAX
1593 e8a3 bf a8            MTHZ    STX     W8
1594 e8a5 9f                       TXA
1595 e8a6 48                       LSLA
1596 e8a7 bb a8                    ADD     W8
1597 e8a9 97                       TAX
1598 e8aa d6 ec 87                 LDA     MNAME-3,X
1599 e8ad b7 b8                    STA     DISP+7
1600 e8af d6 ec 88                 LDA     MNAME-2,X
1601 e8b2 b7 b9                    STA     DISP+8
1602 e8b4 d6 ec 89                 LDA     MNAME-1,X
1603 e8b7 b7 ba                    STA     DISP+9
1604 e8b9 20 1d                    BRA     STIME
```

```
1606                        ************************************************
1607                        *                                              *
1608                        *       Standby (alarm armed) display.         *
1609                        *                                              *
1610                        ************************************************
1611
1612 e8bb b6 9e            ALRMA   LDA     AOUR            GET ALARM HOURS
1613 e8bd cd eb 84                 JSR     CBCD
1614 e8c0 bf b1                    STX     DISP
1615 e8c2 b7 b2                    STA     DISP+1
1616 e8c4 b6 9d                    LDA     AMIN
1617 e8c6 cd eb 84                 JSR     CBCD
1618 e8c9 bf b3                    STX     DISP+2
1619 e8cb b7 b4                    STA     DISP+3
1620 e8cd 5f                       CLRX
1621 e8ce d6 eb f3          ALOP2   LDA     ALARMS+1,X
1622 e8d1 e7 b5                    STA     DISP+4,X
1623 e8d3 5c                       INCX
1624 e8d4 a3 06                    CPX     #6
1625 e8d6 23 f6                    BLS     ALOP2
1626 e8d8 b6 9c            STIME   LDA     OUR             GET TIME
1627 e8da cd eb 84                 JSR     CBCD
1628 e8dd a3 30                    CPX     #$30            LEADING ZERO ?
1629 e8df 26 02                    BNE     TMZ
1630 e8e1 ae 20                    LDX     #$20            YES, MAKE IT A SPACE
1631 e8e3 bf bc            TMZ     STX     DISP+11
1632 e8e5 b7 bd                    STA     DISP+12
1633 e8e7 b6 9b                    LDA     MIN
1634 e8e9 cd eb 84                 JSR     CBCD
1635 e8ec bf bf                    STX     DISP+14
1636 e8ee b7 c0                    STA     DISP+15
1637 e8f0 a6 20                    LDA     #$20
1638 e8f2 05 99 02                 BRCLR   2,TH8,DTF       FLASH ?
1639 e8f5 a6 3a                    LDA     #$3A            0.5 Hz FLASHING COLON
1640 e8f7 b7 be            DTF     STA     DISP+13
1641 e8f9 81                       RTS
1642
1643                        ************************************************
1644                        *                                              *
1645                        *       PI display.                            *
1646                        *                                              *
1647                        ************************************************
1648
1649 e8fa 5f                DIPI    CLRX
1650 e8fb d6 ec 02          DLOP    LDA     PIST,X
1651 e8fe e7 b1                    STA     DISP,X
1652 e900 5c                       INCX
1653 e901 a3 0f                    CPX     #15
1654 e903 23 f6                    BLS     DLOP
1655 e905 b6 8f                    LDA     PI
1656 e907 27 10                    BEQ     PINV
1657 e909 cd eb 48                 JSR     SPLIT
1658 e90c bf bc                    STX     DISP+11
1659 e90e b7 bd                    STA     DISP+12
1660 e910 b6 90                    LDA     PI+1
1661 e912 cd eb 48                 JSR     SPLIT
1662 e915 bf be                    STX     DISP+13
1663 e917 b7 bf                    STA     DISP+14
1664 e919 81                PINV    RTS
1665
1666                        ************************************************
1667                        *                                              *
1668                        *       Alarm display.                         *
1669                        *                                              *
1670                        ************************************************
1671
1672 e91a 5f                ALRMD   CLRX                    YES
1673 e91b d6 eb f2          ALOP    LDA     ALARMS,X
1674 e91e e7 b1                    STA     DISP,X
1675 e920 5c                       INCX
1676 e921 a3 0f                    CPX     #15
1677 e923 23 f6                    BLS     ALOP
1678 e925 09 cb 31                 BRCLR   4,STAT4,ALOF2   ALARM ARMED ?
1679 e928 a6 3a                    LDA     #$3A            YES
1680 e92a b7 bd                    STA     DISP+12
1681 e92c b6 9e                    LDA     AOUR            GET ALARM HOURS
1682 e92e cd eb 84                 JSR     CBCD
1683 e931 a3 30                    CPX     #$30            LEADING ZERO ?
1684 e933 26 02                    BNE     TN3
1685 e935 ae 20                    LDX     #$20            YES, MAKE IT A SPACE
1686 e937 bf bb            TN3     STX     DISP+10
1687 e939 b7 bc                    STA     DISP+11
1688 e93b b6 9d                    LDA     AMIN
1689 e93d cd eb 84                 JSR     CBCD
1690 e940 bf be                    STX     DISP+13
1691 e942 b7 bf                    STA     DISP+14
1692 e944 0b cb 12                 BRCLR   5,STAT4,ALOF2   SET-UP ?
1693 e947 05 99 0f                 BRCLR   2,TH8,ALOF2
1694 e94a a6 20                    LDA     #$20
1695 e94c 0c cb 06                 BRSET   6,STAT4,FH      HOURS ?
1696 e94f b7 be                    STA     DISP+13         NO, FLASH MINUTES
1697 e951 b7 bf                    STA     DISP+14
1698 e953 20 04                    BRA     ALOF2
1699 e955 b7 bb            FH      STA     DISP+10         YES, FLASH HOURS
1700 e957 b7 bc                    STA     DISP+11
1701 e959 81                ALOF2   RTS
1702
1703                        ************************************************
1704                        *                                              *
1705                        *       TA & TP flags display.                 *
1706                        *                                              *
1707                        ************************************************
1708
1709 e95a 5f                DITAP   CLRX
1710 e95b d6 ec 12          BLOP    LDA     TAPST,X
1711 e95e e7 b1                    STA     DISP,X
1712 e960 5c                       INCX
1713 e961 a3 0f                    CPX     #15
1714 e963 23 f6                    BLS     BLOP
1715 e965 a6 31                    LDA     #$31
1716 e967 07 ca 02                 BRCLR   3,STAT3,TPLOW   TP FLAG HIGH ?
1717 e96a b7 b7                    STA     DISP+6          YES, DISPLAY A 1
1718 e96c 05 ca 02          TPLOW   BRCLR   2,STAT3,TALOW   TA FLAG HIGH ?
1719 e96f b7 bf                    STA     DISP+14         YES, DISPLAY A 1
1720 e971 81                TALOW   RTS
```

```
                        ************************************************
                        *                                              *
                        *       PIN displays.                          *
                        *                                              *
                        ************************************************

e972 5f                 DPIN1   CLRX
e973 d6 ec 22           PLOP    LDA     PINST1,X
e976 e7 b1                      STA     DISP,X
e978 5c                         INCX
e979 a3 0f                      CPX     #15
e97b 23 f6                      BLS     PLOP
e97d b6 91                      LDA     PIN
e97f 27 10                      BEQ     PINNV
e981 cd eb 48                   JSR     SPLIT
e984 bf bc                      STX     DISP+11
e986 b7 bd                      STA     DISP+12
e988 b6 92                      LDA     PIN+1
e98a cd eb 48                   JSR     SPLIT
e98d bf be                      STX     DISP+13
e98f b7 bf                      STA     DISP+14
e991 81                 PINNV   RTS

e992 5f                 DPIN2   CLRX
e993 d6 ec 32           PLOP2   LDA     PINST2,X
e996 e7 b1                      STA     DISP,X
e998 5c                         INCX
e999 a3 0f                      CPX     #15
e99b 23 f6                      BLS     PLOP2
e99d b6 91                      LDA     PIN             DATE
e99f 27 f0                      BEQ     PINNV
e9a1 44                         LSRA
e9a2 44                         LSRA
e9a3 44                         LSRA
e9a4 cd eb 84                   JSR     CBCD
e9a7 a3 30                      CPX     #$30
e9a9 26 02                      BNE     DTN0
e9ab ae 20                      LDX     #$20
e9ad bf b3              DTN0    STX     DISP+2
e9af b7 b4                      STA     DISP+3
e9b1 a3 31                      CPX     #$31
e9b3 27 24                      BEQ     NOTRD
e9b5 a1 31                      CMP     #$31
e9b7 26 08                      BNE     NOTST
e9b9 a6 73                      LDA     #'s'
e9bb b7 b5                      STA     DISP+4
e9bd a6 74                      LDA     #'t'
e9bf b7 b6                      STA     DISP+5
e9c1 a1 32              NOTST   CMP     #$32
e9c3 26 08                      BNE     NOTND
e9c5 a6 6e                      LDA     #'n'
e9c7 b7 b5                      STA     DISP+4
e9c9 a6 64                      LDA     #'d'
e9cb b7 b6                      STA     DISP+5
e9cd a1 33              NOTND   CMP     #$33
e9cf 26 08                      BNE     NOTRD
e9d1 a6 72                      LDA     #'r'
e9d3 b7 b5                      STA     DISP+4
e9d5 a6 64                      LDA     #'d'
e9d7 b7 b6                      STA     DISP+5
e9d9 b6 91              NOTRD   LDA     PIN             HOURS
e9db a4 07                      AND     #7
e9dd be 92                      LDX     PIN+1
e9df 58                         ASLX
e9e0 49                         ROLA
e9e1 58                         ASLX
e9e2 49                         ROLA
e9e3 cd eb 84                   JSR     CBCD
e9e6 bf bb                      STX     DISP+10
e9e8 b7 bc                      STA     DISP+11
e9ea b6 92                      LDA     PIN+1           MINUTES
e9ec a4 3f                      AND     #$3F
e9ee cd eb 84                   JSR     CBCD
e9f1 bf be                      STX     DISP+13
e9f3 b7 bf                      STA     DISP+14
e9f5 81                         RTS

                        ************************************************
                        *                                              *
                        *       MJD display.                           *
                        *                                              *
                        ************************************************

e9f6 ad 21              DMJD    BSR     SMJD
e9f8 b6 5d                      LDA     MJD
e9fa 27 1c                      BEQ     MJDNV
e9fc ab 30                      ADD     #$30
e9fe b7 bb                      STA     DISP+10
ea00 b6 5e                      LDA     MJD+1
ea02 ab 30                      ADD     #$30
ea04 b7 bc                      STA     DISP+11
ea06 b6 5f                      LDA     MJD+2
ea08 ab 30                      ADD     #$30
ea0a b7 bd                      STA     DISP+12
ea0c b6 60                      LDA     MJD+3
ea0e ab 30                      ADD     #$30
ea10 b7 be                      STA     DISP+13
ea12 b6 61                      LDA     MJD+4
ea14 ab 30                      ADD     #$30
ea16 b7 bf                      STA     DISP+14
ea18 81                 MJDNV   RTS

ea19 5f                 SMJD    CLRX
ea1a d6 ec 42           MLOP    LDA     MJDST,X
ea1d e7 b1                      STA     DISP,X
ea1f 5c                         INCX
ea20 a3 0f                      CPX     #15
ea22 23 f6                      BLS     MLOP
ea24 81                         RTS
```

```
1832                            ************************************************
1833                            *                                              *
1834                            *       EON display.                           *
1835                            *                                              *
1836                            ************************************************
1837
1838 ea25 cd ea 19           DEON    JSR     SMJD            CLEAR FREQUENCY CHARACTERS
1839 ea28 b6 af                     LDA     RTDIS
1840 ea2a a0 08                     SUB     #8
1841 ea2c ae 10                     LDX     #16
1842 ea2e 42                        MUL
1843 ea2f 97                        TAX
1844 ea30 a6 20                     LDA     #$20
1845 ea32 b7 b9                     STA     DISP+8
1846 ea34 b7 ba                     STA     DISP+9
1847 ea36 d6 01 47                  LDA     EON+2,X         DISPLAY PS (EON)
1848 ea39 b7 b1                     STA     DISP
1849 ea3b d6 01 48                  LDA     EON+3,X
1850 ea3e b7 b2                     STA     DISP+1
1851 ea40 d6 01 49                  LDA     EON+4,X
1852 ea43 b7 b3                     STA     DISP+2
1853 ea45 d6 01 4a                  LDA     EON+5,X
1854 ea48 b7 b4                     STA     DISP+3
1855 ea4a d6 01 4b                  LDA     EON+6,X
1856 ea4d b7 b5                     STA     DISP+4
1857 ea4f d6 01 4c                  LDA     EON+7,X
1858 ea52 b7 b6                     STA     DISP+5
1859 ea54 d6 01 4d                  LDA     EON+8,X
1860 ea57 b7 b7                     STA     DISP+6
1861 ea59 d6 01 4e                  LDA     EON+9,X
1862 ea5c b7 b8                     STA     DISP+7
1863
1864 ea5e d6 01 52                  LDA     EON+13,X
1865 ea61 a1 cd                     CMP     #205            FILLER ?
1866 ea63 26 04                     BNE     NFIL
1867 ea65 5c                        INCX
1868 ea66 d6 01 52                  LDA     EON+13,X        YES, TRY AGAIN
1869 ea69 a1 fa              NFIL   CMP     #250            MEDIUM/LONG ?
1870 ea6b 27 43                     BEQ     MLWF
1871 ea6d a1 cc                     CMP     #204            NO, FREQUENCY OK ?
1872 ea6f 22 3e                     BHI     FNOK2
1873 ea71 ae 0a              FOK2   LDX     #10             VHF
1874 ea73 42                        MUL
1875 ea74 ab 2e                     ADD     #$2E            CALCULATE FREQUENCY (BINARY)
1876 ea76 b7 a1                     STA     W1
1877 ea78 9f                        TXA
1878 ea79 a9 22                     ADC     #$22
1879 ea7b b7 a2                     STA     W2
1880 ea7d cd eb 1f                  JSR     DCON2           CONVERT TO DECIMAL
1881
1882 ea80 b6 34              TYPE3  LDA     Q+4             DISPLAY VHF EON FREQUENCY
1883 ea82 26 02                     BNE     NZ1
1884 ea84 a6 f0                     LDA     #$F0
1885 ea86 ab 30              NZ1    ADD     #$30
1886 ea88 b7 bb                     STA     DISP+10
1887 ea8a 97                        TAX
1888 ea8b b6 35                     LDA     Q+5
1889 ea8d 26 06                     BNE     NZ2
1890 ea8f a3 20                     CPX     #$20
1891 ea91 26 02                     BNE     NZ2
1892 ea93 a6 f0                     LDA     #$F0
1893 ea95 ab 30              NZ2    ADD     #$30
1894 ea97 b7 bc                     STA     DISP+11
1895 ea99 b6 36                     LDA     Q+6
1896 ea9b ab 30                     ADD     #$30
1897 ea9d b7 bd                     STA     DISP+12
1898 ea9f a6 2e                     LDA     #$2E
1899 eaa1 b7 be                     STA     DISP+13
1900 eaa3 b6 37                     LDA     Q+7
1901 eaa5 ab 30                     ADD     #$30
1902 eaa7 b7 bf                     STA     DISP+14
1903 eaa9 b6 38                     LDA     Q+8
1904 eaab ab 30                     ADD     #$30
1905 eaad b7 c0                     STA     DISP+15
1906 eaaf 81                 FNOK2  RTS
1907
1908 eab0 5c                 MLWF   INCX                    DISPLAY M/L EON FREQUENCY
1909 eab1 d6 01 52                  LDA     EON+13,X
1910 eab4 a1 0f                     CMP     #15
1911 eab6 23 02                     BLS     LONG
1912 eab8 ab 1b                     ADD     #27             MW OFFSET
1913 eaba ab 10              LONG   ADD     #16             M/L OFFSET
1914 eabc ae 09                     LDX     #9
1915 eabe 42                        MUL
1916 eabf bf a2                     STX     W2
1917 eac1 b7 a1                     STA     W1
1918 eac3 ad 5a                     BSR     DCON2           CONVERT TO BCD IN Q
1919 eac5 b6 35                     LDA     Q+5
1920 eac7 26 02                     BNE     NZ3             IF THOUSANDS OF kHz A ZERO
1921 eac9 a6 f0                     LDA     #$F0            DISPLAY AS A SPACE
1922 eacb ab 30              NZ3    ADD     #$30
1923 eacd b7 ba                     STA     DISP+9
1924 eacf b6 36                     LDA     Q+6
1925 ead1 ab 30                     ADD     #$30
1926 ead3 b7 bb                     STA     DISP+10
1927 ead5 b6 37                     LDA     Q+7
1928 ead7 ab 30                     ADD     #$30
1929 ead9 b7 bc                     STA     DISP+11
1930 eadb b6 38                     LDA     Q+8
1931 eadd ab 30                     ADD     #$30
1932 eadf b7 bd                     STA     DISP+12
1933 eae1 a6 6b                     LDA     #'k'
1934 eae3 b7 be                     STA     DISP+13
1935 eae5 a6 48                     LDA     #'H'
1936 eae7 b7 bf                     STA     DISP+14
1937 eae9 a6 7a                     LDA     #'z'
1938 eaeb b7 c0                     STA     DISP+15
1939 eaed 81                        RTS
```

```
1941                            ***************************************************
1942                            *                                                 *
1943                            *       Sleep display.                            *
1944                            *                                                 *
1945                            ***************************************************
1946
1947 eaee 5f                   SLEEPD  CLRX
1948 eaef d6 ec 52              SLOP    LDA     SLPST,X
1949 eaf2 e7 b1                        STA     DISP,X
1950 eaf4 5c                           INCX
1951 eaf5 a3 0f                        CPX     #15
1952 eaf7 23 f6                        BLS     SLOP
1953 eaf9 b6 78                        LDA     SLEPT
1954 eafb cd eb 84                     JSR     CBCD
1955 eafe bf b9                        STX     DISP+8
1956 eb00 b7 ba                        STA     DISP+9
1957 eb02 81                           RTS
1958
1959                            ***************************************************
1960                            *                                                 *
1961                            *       M/S & DI display.                         *
1962                            *                                                 *
1963                            ***************************************************
1964
1965 eb03 5f                   DMSD    CLRX
1966 eb04 d6 ec 62              ILOP    LDA     MSDST,X
1967 eb07 e7 b1                        STA     DISP,X
1968 eb09 5c                           INCX
1969 eb0a a3 0f                        CPX     #15
1970 eb0c 23 f6                        BLS     ILOP
1971 eb0e 01 ca 04                     BRCLR   0,STAT3,MSM2    M/S FLAG SET
1972 eb11 a6 4d                        LDA     #'M'            YES, MUSIC
1973 eb13 b7 b7                        STA     DISP+6
1974 eb15 b6 b0                 MSM2    LDA     DI
1975 eb17 cd eb 84                     JSR     CBCD
1976 eb1a bf be                        STX     DISP+13
1977 eb1c b7 bf                        STA     DISP+14
1978 eb1e 81                           RTS
1979
1980                            *******************************************************
1981                            *                                                     *
1982                            *       Convert binary to unpacked BCD in Q.          *
1983                            *                                                     *
1984                            *******************************************************
1985
1986 eb1f ae 54                 DCON2   LDX     #R              CLEAR
1987 eb21 bf ad                        STX     NUM1
1988 eb23 cd ef 86                     JSR     CLRAS           RR
1989 eb26 3c 5c                        INC     R+8             R <- 1
1990 eb28 cd ef 84                     JSR     CLQ             CLEAR RQ
1991 eb2b a6 0e                        LDA     #14             14 BITS TO CONVERT
1992 eb2d b7 a6                        STA     W6
1993 eb2f 34 a2                 LOOP2   LSR     W2              MOVE OUT
1994 eb31 36 a1                        ROR     W1              FIRST (LS) BIT
1995 eb33 24 07                        BCC     NXT             ZERO
1996 eb35 ae 30                        LDX     #Q              ONE, ADD
1997 eb37 bf ae                        STX     NUM2            CURRENT VALUE
1998 eb39 cd ee 33                     JSR     ADD             OF R
1999 eb3c ae 54                 NXT     LDX     #R              ADD R
2000 eb3e bf ae                        STX     NUM2            TO
2001 eb40 cd ee 33                     JSR     ADD             ITSELF
2002 eb43 3a a6                        DEC     W6              ALL
2003 eb45 26 e8                        BNE     LOOP2           DONE ?
2004 eb47 81                           RTS
2005
2006                            ***************************************************
2007                            *                                                 *
2008                            *       Split A nibbles into A (LS) and X (MS)    *
2009                            *       and convert to ASCII.                     *
2010                            *                                                 *
2011                            ***************************************************
2012
2013 eb48 97                   SPLIT   TAX                     MSD INTO X, LSD INTO A
2014 eb49 99                           SEC
2015 eb4a 56                           RORX
2016 eb4b 99                           SEC
2017 eb4c 56                           RORX
2018 eb4d 54                           LSRX
2019 eb4e 54                           LSRX
2020 eb4f a3 39                        CPX     #$39            $30-$39 <- 0-9
2021 eb51 23 07                        BLS     XOK
2022 eb53 5c                           INCX
2023 eb54 5c                           INCX
2024 eb55 5c                           INCX
2025 eb56 5c                           INCX
2026 eb57 5c                           INCX
2027 eb58 5c                           INCX
2028 eb59 5c                           INCX
2029 eb5a a4 0f                 XOK     AND     #$0F            $41-$46 <- A-F
2030 eb5c ab 30                        ADD     #$30
2031 eb5e a1 39                        CMP     #$39
2032 eb60 23 02                        BLS     AOK
2033 eb62 ab 07                        ADD     #7
2034 eb64 81                    AOK     RTS
```

```
                        ***************************************************
                        *                                                 *
                        *       Send and clock data to LCD module.        *
                        *                                                 *
                        *       Check to see if LCD module is busy.       *
                        *                                                 *
                        ***************************************************

eb65 b7 02              CLOCK   STA     PORTC
eb67 18 03                      BSET    4,PORTD
eb69 19 03                      BCLR    4,PORTD         CLOCK IT
eb6b 81                         RTS

eb6c 15 03              WAIT    BCLR    2,PORTD
eb6e 16 03                      BSET    3,PORTD         READ LCD MODULE BUSY FLAG
eb70 19 03                      BCLR    4,PORTD
eb72 3f 07                      CLR     PORTCD          INPUT ON PORTC
eb74 18 03              WLOOP   BSET    4,PORTD         CLOCK HIGH
eb76 b6 02                      LDA     PORTC           READ MODULE
eb78 19 03                      BCLR    4,PORTD         CLOCK LOW
eb7a b7 a7                      STA     W7
eb7c 0e a7 f5                   BRSET   7,W7,WLOOP      BUSY ?
eb7f 33 07                      COM     PORTCD          OUTPUT ON PORTC
eb81 17 03                      BCLR    3,PORTD
eb83 81                         RTS

                        *****************************************************
                        *                                                   *
                        *       Hex->BCD conversion (& decimal adjust).     *
                        *                                                   *
                        *****************************************************

eb84 ad 1c              CBCD    BSR     UPX
eb86 ad 13                      BSR     ADJI            DECIMAL ADJUST
eb88 b7 a7              BCD     STA     W7              SAVE
eb8a ab 16                      ADD     #$16            ADD $16 (BCD 10)
eb8c ad 08                      BSR     ADJU            ADJUST
eb8e 5a                         DECX
eb8f 2a f7                      BPL     BCD             TOO FAR ?
eb91 b6 a7                      LDA     W7              YES, RESTORE A
eb93 cc eb 48                   JMP     SPLIT

eb96 28 03              ADJU    BHCC    ADJI            OVERFLOW ?
eb98 ab 06                      ADD     #6              YES
eb9a 81                         RTS

eb9b ab 06              ADJI    ADD     #6              NO, BUT IS LS DIGIT
eb9d 29 02                      BHCS    ARTS            BIGGER THAN 9 ?
eb9f a0 06                      SUB     #6              NO, RESTORE
eba1 81                 ARTS    RTS

eba2 97                 UPX     TAX
eba3 54                         LSRX
eba4 54                         LSRX
eba5 54                         LSRX
eba6 54                         LSRX                    MSB IN X
eba7 a4 0f                      AND     #$0F            LSB IN A
eba9 81                         RTS

                        ***************************************************
                        *                                                 *
                        *       LCD initialisation.                       *
                        *                                                 *
                        ***************************************************

ebaa a6 a0              INITD   LDA     #$A0
ebac c7 01 00                   STA     RT              SPACES BETWEEN PTY & RT
ebaf c7 01 01                   STA     RT+1
ebb2 c7 01 03                   STA     RT+3
ebb5 c7 01 04                   STA     RT+4
ebb8 a6 2d                      LDA     #$2D
ebba c7 01 02                   STA     RT+2            DASH BETWEEN EXISTING DISPLAY & RT
ebbd a6 20                      LDA     #$20            INITIALISE RADIOTEXT TO SPACES
ebbf ae 05                      LDX     #5              AFTER CONF LOSS OR TEXT A/B CHANGE
ebc1 d7 01 00           CLOP    STA     RT,X
ebc4 5c                         INCX
ebc5 a3 45                      CPX     #69
ebc7 26 f8                      BNE     CLOP
ebc9 3f 9f                      CLR     DISP1           INITIALISE SCROLLING POINTERS
ebcb 3f a0                      CLR     DISP2
ebcd 3f 8e                      CLR     PTY             CLEAR PTY
ebcf 3f 91                      CLR     PIN             AND
ebd1 3f 92                      CLR     PIN+1           PIN
ebd3 3f b0                      CLR     DI              AND DI
ebd5 11 ca                      BCLR    0,STAT3         AND M/S
ebd7 17 ca                      BCLR    3,STAT3         CLEAR TP FLAG
ebd9 15 c9                      BCLR    2,STAT2         CANCEL RT DISPLAY

ebdb 5f                         CLRX
ebdc a6 2d                      LDA     #$2D
ebde e7 c1              PLOP3   STA     PSN,X           CLEAR PS NAME
ebe0 5c                         INCX
ebe1 a3 08                      CPX     #8
ebe3 26 f9                      BNE     PLOP3
ebe5 81                         RTS

ebe6 5f                 CLREON  CLRX
ebe7 a6 ff                      LDA     #$FF
ebe9 d7 01 45           ELOP    STA     EON,X           EON RAM CLEAR
ebec 5c                         INCX
ebed a3 b0                      CPX     #176
ebef 26 f8                      BNE     ELOP
ebf1 81                         RTS
```

```
2140                        ************************************************
2141                        *                                              *
2142                        *       Display strings.                       *
2143                        *                                              *
2144                        ************************************************
2145
2146 ebf2 20 20 41 6c 61 72  ALARMS  FCC     '  Alarm -  OFF  '
     6d 20 2d 20 20 4f
     46 46 20 20
2147 ec02 20 50 49 20 63 6f  PIST    FCC     ' PI code -      '
     64 65 20 2d 20 20
     20 20 20 20
2148 ec12 20 54 50 20 2d 20  TAPST   FCC     ' TP - 0  TA - 0 '
     30 20 20 54 41 20
     2d 20 30 20
2149 ec22 20 50 49 4e 20 6e  PINST1  FCC     ' PIN no. -      '
     6f 2e 20 2d 20 20
     20 20 20 20
2150 ec32 20 20 20 20 74 68  PINST2  FCC     '    th at --.-- '
     20 61 74 20 2d 2d
     2e 2d 2d 20
2151 ec42 20 4d 4a 20 64 61  MJDST   FCC     ' MJ day -       '
     79 20 2d 20 20 20
     20 20 20 20
2152 ec52 20 53 6c 65 65 70  SLPST   FCC     ' Sleep   0 min. '
     20 20 20 30 20 6d
     69 6e 2e 20
2153 ec62 20 4d 2f 53 20 20  MSDST   FCC     ' M/S  S   DI  0 '
     53 20 20 20 44 49
     20 20 30 20
2154
2155                        ************************************************
2156                        *                                              *
2157                        *       MJD day and month strings.             *
2158                        *                                              *
2159                        ************************************************
2160
2161 ec72 4d 6f 6e 54 75 65  DNAME   FCC     'MonTueWedThuFriSatSun'
     57 65 64 54 68 75
     46 72 69 53 61 74
     53 75 6e
2162
2163 ec87 69 6e 76                  FCC     'inv'
2164
2165 ec8a 4a 61 6e 46 65 62  MNAME   FCC     'JanFebMarAprMayJunJulAugSepOctNovDec'
     4d 61 72 41 70 72
     4d 61 79 4a 75 6e
     4a 75 6c 41 75 67
     53 65 70 4f 63 74
     4e 6f 76 44 65 63
2166
2167
2168                        ************************************************
2169                        *                                              *
2170                        *       Programme Type (PTY) Codes.            *
2171                        *                                              *
2172                        ************************************************
2173
2174 ecae 6e 6f 20 70 72 6f  PTYT    FCC     'no program type '  0
     67 72 61 6d 20 74
     79 70 65 20
2175 ecbe 20 20 20 20 20 20          FCC     '      News      '  1
     4e 65 77 73 20 20
     20 20 20 20
2176 ecce 43 75 72 72 65 6e          FCC     'Current affairs '  2
     74 20 61 66 66 61
     69 72 73 20
2177 ecde 20 20 49 6e 66 6f          FCC     '  Information   '  3
     72 6d 61 74 69 6f
     6e 20 20 20
2178 ecee 20 20 20 20 20 53          FCC     '     Sport      '  4
     70 6f 72 74 20 20
     20 20 20 20
2179 ecfe 20 20 20 45 64 75          FCC     '   Education    '  5
     63 61 74 69 6f 6e
     20 20 20 20
2180 ed0e 20 20 20 20 20 44          FCC     '     Drama      '  6
     72 61 6d 61 20 20
     20 20 20 20
2181 ed1e 20 20 20 20 43 75          FCC     '    Culture     '  7
     6c 74 75 72 65 20
     20 20 20 20
2182 ed2e 20 20 20 20 53 63          FCC     '    Science     '  8
     69 65 6e 63 65 20
     20 20 20 20
2183 ed3e 20 20 20 20 20 56          FCC     '     Varied     '  9
     61 72 69 65 64 20
     20 20 20 20
2184 ed4e 20 20 20 50 6f 70          FCC     '   Pop music    ' 10
     20 6d 75 73 69 63
     20 20 20 20
2185 ed5e 20 20 20 52 6f 63          FCC     '   Rock music   ' 11
     6b 20 6d 75 73 69
     63 20 20 20
2186 ed6e 20 45 61 73 79 20          FCC     ' Easy listening ' 12
     6c 69 73 74 65 6e
     69 6e 67 20
2187 ed7e 20 4c 69 67 68 74          FCC     ' Light classics ' 13
     20 63 6c 61 73 73
     69 63 73 20
2188 ed8e 53 65 72 69 6f 75          FCC     'Serious classics' 14
     73 20 63 6c 61 73
     73 69 63 73
2189 ed9e 20 20 4f 74 68 65          FCC     '  Other music   ' 15
     72 20 6d 75 73 69
     63 20 20 20
```

```
2191                        ************************************************
2192                        *                                              *
2193                        *                VFD character set.            *
2194                        *                                              *
2195                        *       Position in table is ASCII value.      *
2196                        *       Entry is the VFD character used.       *
2197                        *       Last column shows characters replaced  *
2198                        *       by spaces. $00 to $1F are ASCII control*
2199                        *       characters and shouldn't occur.        *
2200                        *       : has been entered as -                *
2201                        *       / has been entered as -                *
2202                        *       " has been entered as '                *
2203                        *                                              *
2204                        ************************************************
2205
2206 edae 7e 7e 7e 7e      VTAB    FCB     $7E,$7E,$7E,$7E                all
2207 edb2 7e 7e 7e 7e              FCB     $7E,$7E,$7E,$7E                all
2208 edb6 7e 7e 7e 7e              FCB     $7E,$7E,$7E,$7E                all
2209 edba 7e 7e 7e 7e              FCB     $7E,$7E,$7E,$7E                all
2210
2211 edbe 7e 7e 7e 7e              FCB     $7E,$7E,$7E,$7E                all
2212 edc2 7e 7e 7e 7e              FCB     $7E,$7E,$7E,$7E                all
2213 edc6 7e 7e 7e 7e              FCB     $7E,$7E,$7E,$7E                all
2214 edca 7e 7e 7e 7e              FCB     $7E,$7E,$7E,$7E                all
2215
2216 edce 7e 7b 7a 7e              FCB     $7E,$7B,$7A,$7E       !  "  #    #
2217 edd2 7e 7e 7e 7a              FCB     $7E,$7E,$7E,$7A    $  %  &  '    $%&
2218 edd6 7e 7e 7e 7e              FCB     $7E,$7E,$7E,$7E    (  )  *  +    all
2219 edda 3f 7d 3e 7d              FCB     $3F,$7D,$3E,$7D    ,  -  .  /
2220
2221 edde 00 01 02 03              FCB     $00,$01,$02,$03    0  1  2  3
2222 ede2 04 05 06 07              FCB     $04,$05,$06,$07    4  5  6  7
2223 ede6 08 09 7d 7e              FCB     $08,$09,$7D,$7E    8  9  :  ;    ;
2224 edea 7e 7e 7e 7c              FCB     $7E,$7E,$7E,$7C    <  =  >  ?    <=>
2225
2226 edee 7e 0a 0b 0c              FCB     $7E,$0A,$0B,$0C    @  A  B  C    @
2227 edf2 0d 0e 0f 10              FCB     $0D,$0E,$0F,$10    D  E  F  G
2228 edf6 11 12 13 14              FCB     $11,$12,$13,$14    H  I  J  K
2229 edfa 15 16 17 18              FCB     $15,$16,$17,$18    L  M  N  O
2230
2231 edfe 19 1a 1b 1c              FCB     $19,$1A,$1B,$1C    P  Q  R  S
2232 ee02 1d 1e 1f 20              FCB     $1D,$1E,$1F,$20    T  U  V  W
2233 ee06 21 22 23 7e              FCB     $21,$22,$23,$7E    X  Y  Z  [    [
2234 ee0a 7e 7e 7e 7d              FCB     $7E,$7E,$7E,$7D    \  ]  ^  -    \]^
2235
2236 ee0e 7a 24 25 26              FCB     $7A,$24,$25,$26    '  a  b  c
2237 ee12 27 28 29 2a              FCB     $27,$28,$29,$2A    d  e  f  g
2238 ee16 2b 2c 2d 2e              FCB     $2B,$2C,$2D,$2E    h  i  j  k
2239 ee1a 2f 30 31 32              FCB     $2F,$30,$31,$32    l  m  n  o
2240
2241 ee1e 33 34 35 36              FCB     $33,$34,$35,$36    p  q  r  s
2242 ee22 37 38 39 3a              FCB     $37,$38,$39,$3A    t  u  v  w
2243 ee26 3b 3c 3d 7e              FCB     $3B,$3C,$3D,$7E    x  y  z  {    {
2244 ee2a 7e 7e 7e 7e              FCB     $7E,$7E,$7E,$7E    |  }  ~       all
2245
2246
2247                        ************************************************
2248                        *                                              *
2249                        *              MC68HC05E0 functions.           *
2250                        *                                              *
2251                        *       Add, Subtract, Multiply, Divide,       *
2252                        *       MJD -> day, date, month and year       *
2253                        *                                              *
2254                        *       P. Topping          5th December '91   *
2255                        *                                              *
2256                        *       Transfer of BCD numbers.               *
2257                        *       (X) <- (NUM1), X preserved             *
2258                        *                                              *
2259                        ************************************************
2260
2261 ee2e bf ae              TRA     STX     NUM2            CLEAR DESTINATION
2262 ee30 cd ef 86                   JSR     CLRAS           AND ADD IT TO No. AT NUM1
2263
2264                        ************************************************
2265                        *                                              *
2266                        *       Addition of BCD numbers.               *
2267                        *                                              *
2268                        *       (X) <- (NUM1) + (NUM2), X preserved    *
2269                        *                                              *
2270                        ************************************************
2271
2272 ee33 3f ab              ADD     CLR     CARRY
2273 ee35 bf a7                      STX     W7
2274 ee37 bf a5              AD      STX     W5              ANSWER POINTER
2275 ee39 a6 09                      LDA     #ND
2276 ee3b b7 ac                      STA     COUNT
2277 ee3d be ad                      LDX     NUM1            1st No. POINTER
2278 ee3f bf a3                      STX     W3
2279 ee41 be ae                      LDX     NUM2            2nd No. POINTER
2280 ee43 bf a4                      STX     W4
2281 ee45 be a3              LOOP    LDX     W3
2282 ee47 e6 08                      LDA     ND-1,X
2283 ee49 3a a3                      DEC     W3
2284 ee4b be a4                      LDX     W4
2285 ee4d eb 08                      ADD     ND-1,X          ADD
2286 ee4f 3a a4                      DEC     W4
2287 ee51 bb ab                      ADD     CARRY           SET ON ADDITION OVERFLOW
2288 ee53 3f ab                      CLR     CARRY           OR POS. RESULT SUBTRACTION
2289 ee55 ad 11                      BSR     ADJ             DECIMAL ADJUST
2290 ee57 be a5                      LDX     W5
2291 ee59 e7 08                      STA     ND-1,X          SAVE ANSWER
2292 ee5b 3a a5                      DEC     W5
2293 ee5d 3a ac                      DEC     COUNT
2294 ee5f 26 e4                      BNE     LOOP            DONE ?
2295 ee61 be a7                      LDX     W7
2296 ee63 81                         RTS
2297
2298 ee64 a0 0a              AJ      SUB     #10             YES, SUTRACT 10
2299 ee66 3c ab                      INC     CARRY           AND RECORD CARRY
2300 ee68 a1 0a              ADJ     CMP     #10
2301 ee6a 24 f8                      BHS     AJ              10 OR MORE ?
2302 ee6c 81                         RTS                     NO
```

```
2304                            ************************************************
2305                            *                                              *
2306                            *       Subtraction, complementing and incre-  *
2307                            *       menting (X=REG-ND) of BCD numbers.     *
2308                            *                                              *
2309                            *       (X) <- (NUM1) - (NUM2), X preserved.   *
2310                            *       (X and NUM2 should not be equal)       *
2311                            *                                              *
2312                            ************************************************
2313
2314 ee6d bf a6                 SUB     STX     W6              ANSWER POINTER
2315 ee6f ad 06                         BSR     COM2            9S COMP. SECOND NUMBER
2316 ee71 3f ab                         CLR     CARRY           SET CARRY TO ONE
2317 ee73 3c ab                         INC     CARRY           BEFORE ADDING
2318 ee75 ad c0                         BSR     AD              ADD FIRST NUMBER
2319
2320 ee77 be ae                 COM2    LDX     NUM2            9S COMPLIMENT
2321 ee79 ad 03                         BSR     COMP            SECOND NUMBER
2322 ee7b be a6                         LDX     W6              RESTORE ANSWER POINTER
2323 ee7d 81                            RTS
2324
2325 ee7e a6 09                 COMP    LDA     #ND             9S COMPLIMENT
2326 ee80 b7 ac                         STA     COUNT
2327 ee82 a6 09                 LOOP3   LDA     #$09
2328 ee84 e0 08                         SUB     ND-1,X
2329 ee86 e7 08                         STA     ND-1,X
2330 ee88 5a                            DECX
2331 ee89 3a ac                         DEC     COUNT
2332 ee8b 26 f5                         BNE     LOOP3
2333 ee8d 81                            RTS
2334
2335 ee8e ad ee                 COM10   BSR     COMP            NINES COMPLIMENT THEN
2336 ee90 a6 09                 ADD1    LDA     #ND             ADD 1 FOR TENS COMPLIMENT
2337 ee92 b7 ac                         STA     COUNT           ENTER WITH X = REG-ND
2338 ee94 6c 11                 ADD2    INC     2*ND-1,X
2339 ee96 e6 11                         LDA     2*ND-1,X
2340 ee98 a1 0a                         CMP     #$0A
2341 ee9a 25 09                         BLO     RETURN
2342 ee9c a0 0a                         SUB     #10
2343 ee9e e7 11                         STA     2*ND-1,X
2344 eea0 5a                            DECX
2345 eea1 3a ac                         DEC     COUNT
2346 eea3 26 ef                         BNE     ADD2
2347 eea5 81                    RETURN  RTS
2348
2349                            ************************************************
2350                            *                                              *
2351                            *       Mult., R <- P x Q, over. in TMP, X = #R.*
2352                            *                                              *
2353                            ************************************************
2354
2355 eea6 ae 54                 MULT    LDX     #R
2356 eea8 cd ef 86                         JSR     CLRAS
2357 eeab ae 4b                         LDX     #TMP
2358 eead cd ef 86                         JSR     CLRAS           CLEAR RESULT
2359 eeb0 ae 12                         LDX     #2*ND
2360 eeb2 bf a6                         STX     W6              INIT. R POINTER
2361 eeb4 ae 09                         LDX     #ND
2362 eeb6 e6 41                 STR     LDA     P-1,X
2363 eeb8 bf a1                         STX     W1              SAVE P POINTER
2364 eeba b7 ab                         STA     CARRY           SAVE P
2365 eebc ae 09                         LDX     #ND             INIT. Q POINTER
2366 eebe e6 2f                 XTT     LDA     Q-1,X
2367 eec0 b7 a4                         STA     W4              SAVE Q
2368 eec2 27 30                         BEQ     TZ0             IF ZERO GOTO NEXT Q
2369 eec4 b6 ab                         LDA     CARRY           RECALL P
2370 eec6 b7 a3                         STA     W3              SAVE P
2371 eec8 4f                            CLRA
2372 eec9 34 ab                 PLY     LSR     CARRY           RIGHT SHIFT INTO C
2373 eecb 24 02                         BCC     SHF             C = ZERO ?
2374 eecd bb a4                         ADD     W4              NO, A=A+Q
2375 eecf 3d ab                 SHF     TST     CARRY           ZERO ?
2376 eed1 27 04                         BEQ     C4              YES, FINISHED WITH THIS Q
2377 eed3 38 a4                         ASL     W4              NO, LEFT SHIFT Q
2378 eed5 20 f2                         BRA     PLY
2379 eed7 5a                    C4      DECX                    Q = Q + 1
2380 eed8 bf a2                         STX     W2              SAVE Q POINTER
2381 eeda be a6                         LDX     W6              R POINTER
2382 eedc eb 4a                         ADD     R-ND-1,X        ADD R TO A
2383 eede cd ee 68                      JSR     ADJ             ADJUST
2384 eee1 e7 4a                 C2      STA     R-ND-1,X        R = R + A
2385 eee3 b6 ab                         LDA     CARRY
2386 eee5 eb 49                         ADD     R-ND-2,X        ADD R-(ND+2) TO CARRY
2387 eee7 e7 49                         STA     R-ND-2,X        R-(ND+2) = R-(ND+2) + CARRY
2388 eee9 b6 a3                         LDA     W3              RECALL P
2389 eeeb b7 ab                         STA     CARRY           SAVE IN CARRY
2390 eeed 5a                            DECX
2391 eeee bf a6                         STX     W6              SAVE R POINTER
2392 eef0 be a2                         LDX     W2              Q POINTER
2393 eef2 20 03                         BRA     C3
2394 eef4 3a a6                 TZ0     DEC     W6              DEC. R POINTER
2395 eef6 5a                            DECX                    DEC. Q POINTER
2396 eef7 26 c5                 C3      BNE     XTT
2397 eef9 b6 a6                         LDA     W6              R POINTER
2398 eefb ab 08                         ADD     #ND-1
2399 eefd b7 a6                         STA     W6              R = R + ND-1
2400 eeff be a1                         LDX     W1
2401 ef01 5a                            DECX                    P = P + 1
2402 ef02 26 b2                         BNE     STR             IF NOT ZERO GOTO NEXT P
2403 ef04 ae 54                         LDX     #R
2404 ef06 81                            RTS
```

```
2406                        ************************************************
2407                        *                                              *
2408                        *       Division of BCD numbers.               *
2409                        *                                              *
2410                        *       R <- P / Q, remainder in TMP.          *
2411                        *       on exit X = #R, TMQ used.              *
2412                        *                                              *
2413                        ************************************************
2414
2415 ef07 ae 54             DIV     LDX     #R              CLEAR
2416 ef09 cd ef 86                  JSR     CLRAS           RESULT
2417 ef0c ae 42                    LDX     #P              TRANSFER
2418 ef0e bf ad                    STX     NUM1            P TO
2419 ef10 ae 4b                    LDX     #TMP            WORKING
2420 ef12 cd ee 2e                 JSR     TRA             P (TMP)
2421 ef15 ae 30                    LDX     #Q              TRANSFER
2422 ef17 bf ad                    STX     NUM1            Q TO
2423 ef19 ae 39                    LDX     #TMQ            WORKING
2424 ef1b cd ee 2e                 JSR     TRA             Q (TMQ)
2425
2426 ef1e a6 09             POSS    LDA     #ND             NUMBER
2427 ef20 b7 ac                    STA     COUNT           DIGITS
2428 ef22 ae 39             LOOP6   LDX     #TMQ            FIND LEAST SIGNIFICANT
2429 ef24 f6                       LDA     0,X             NON-ZERO DIGIT
2430 ef25 26 07                    BNE     NOSH            ZERO ?
2431 ef27 cd ef 64                 JSR     SHIFT           YES, SHIFT Q
2432 ef2a 26 f6                    BNE     LOOP6           UP ONE PLACE
2433 ef2c 20 33             ZQ      BRA     RTRN            Q WAS ZERO
2434 ef2e b6 ac             NOSH    LDA     COUNT           SAVE
2435 ef30 b7 a1                    STA     W1              No. DIDITS - No. SHIFTS
2436
2437 ef32 ae 4b             SUBB    LDX     #TMP            SUBTRACT Q
2438 ef34 bf ad                    STX     NUM1            FROM
2439 ef36 cd ee 6d                 JSR     SUB             P
2440 ef39 b6 ab                    LDA     CARRY           TOO FAR ?
2441 ef3b 27 06                    BEQ     NEXTD           IF YES, GO TO NEXT DIGIT
2442 ef3d be a1                    LDX     W1              INCREMENT RELEVANT
2443 ef3f 6c 53                    INC     R-1,X           DIGIT IN RESULT
2444 ef41 20 ef                    BRA     SUBB            ONCE AGAIN
2445 ef43 ae 4b             NEXTD   LDX     #TMP            TOO FAR, ADD
2446 ef45 cd ee 33                 JSR     ADD             Q BACK ON
2447 ef48 ae 39             ROR     LDX     #TMQ            SET UP TO
2448 ef4a a6 08                    LDA     #ND-1           SHIFT BACK
2449 ef4c b7 ac                    STA     COUNT           WORKING Q
2450 ef4e e6 07             RRR     LDA     ND-2,X          MOVE ALL
2451 ef50 e7 08                    STA     ND-1,X          DIGITS
2452 ef52 5a                       DECX                    DOWN
2453 ef53 3a ac                    DEC     COUNT           ONE PLACE
2454 ef55 26 f7                    BNE     RRR             DONE ?
2455 ef57 6f 08                    CLR     ND-1,X          CLEAR MS DIGIT
2456 ef59 3c a1                    INC     W1              INCREMENT POINTER
2457 ef5b b6 a1                    LDA     W1
2458 ef5d a1 0a                    CMP     #ND+1           FINISHED ?
2459 ef5f 26 d1                    BNE     SUBB            NO, NEXT DIGIT
2460 ef61 ae 54             RTRN    LDX     #R
2461 ef63 81                       RTS
2462
2463                        ****************************************************************
2464                        *                                                              *
2465                        *       Shift.                                                 *
2466                        *                                                              *
2467                        ****************************************************************
2468
2469 ef64 b7 a3             SHIFT   STA     W3
2470 ef66 cd ef 79                 JSR     DR1             W1: MSD, W2: LSD
2471 ef69 be a1                    LDX     W1
2472 ef6b e6 01             AGS     LDA     1,X             MOVE ALL DIGITS
2473 ef6d f7                       STA     0,X             UP ONE PLACE
2474 ef6e 5c                       INCX
2475 ef6f b3 a2                    CPX     W2
2476 ef71 26 f8                    BNE     AGS             DONE ?
2477 ef73 b6 a3                    LDA     W3              YES, RECOVER NEW DIGIT
2478 ef75 f7                       STA     0,X             AND PUT IT IN LSD
2479 ef76 3a ac                    DEC     COUNT
2480 ef78 81                       RTS
2481
2482 ef79 bf a1             DR1     STX     W1              STORE POINTERS
2483 ef7b a6 08                    LDA     #ND-1           (USED IN DIGIT AND DQ)
2484 ef7d 5c                AXL     INCX
2485 ef7e 4a                       DECA
2486 ef7f 26 fc                    BNE     AXL
2487 ef81 bf a2                    STX     W2
2488 ef83 81                       RTS
2489
2490                        ************************************************
2491                        *                                              *
2492                        *       Clear.                                 *
2493                        *                                              *
2494                        ************************************************
2495
2496 ef84 ae 30             CLQ     LDX     #Q              CLEAR Q
2497 ef86 bf a5             CLRAS   STX     W5
2498 ef88 a6 09                    LDA     #ND             CLEAR No. DIGITS
2499 ef8a b7 ac                    STA     COUNT           STARTING AT X
2500 ef8c 7f                CR      CLR     0,X
2501 ef8d 5c                       INCX
2502 ef8e 3a ac                    DEC     COUNT
2503 ef90 26 fa                    BNE     CR              DONE ?
2504 ef92 be a5                    LDX     W5
2505 ef94 81                       RTS
```

```
2507                        ****************************************************************
2508                        *                                                              *
2509                        *       MJD - day of week and year.                            *
2510                        *                                                              *
2511                        *       DOW = (MJD+2)MOD7 (= WD-1)                    (DOW)    *
2512                        *       Y'  = INT((MJD-15078.2)/3652500)               (YR)    *
2513                        *                                                              *
2514                        ****************************************************************
2515
2516 ef95 ae 5d            MJDC    LDX     #MJD
2517 ef97 bf ad                    STX     NUM1
2518 ef99 ae 42                    LDX     #P
2519 ef9b cd ee 2e                JSR     TRA             P <- MTD
2520 ef9e ae 5d                    LDX     #MJD
2521 efa0 cd f0 83                JSR     T10K            MJD <- MJD TIMES 10,000
2522
2523 efa3 ae 39            DOFFW   LDX     #P-ND
2524 efa5 cd ee 90                JSR     ADD1            P <- MJD + 1
2525 efa8 ae 39                    LDX     #P-ND
2526 efaa cd ee 90                JSR     ADD1            P <- MJD + 2
2527 efad ae 30                    LDX     #Q
2528 efaf cd ef 86                JSR     CLRAS
2529 efb2 a6 07                    LDA     #7
2530 efb4 b7 38                    STA     Q+ND-1          Q <- 7
2531 efb6 cd ef 07                JSR     DIV             R <- (MJD+2)/7
2532 efb9 b6 53                    LDA     TMP+ND-1        REMAINDER (WD-1) IN TMP
2533 efbb b7 73                    STA     DOW
2534
2535 efbd ae 5d            YEAR    LDX     #MJD
2536 efbf bf ad                    STX     NUM1
2537 efc1 ae 30                    LDX     #Q
2538 efc3 bf ae                    STX     NUM2
2539 efc5 cd f0 98                JSR     TRCY            Q <- CY (150782000)
2540 efc8 ae 42                    LDX     #P
2541 efca cd ee 6d                JSR     SUB             P <- 10K(MJD-15078.2)
2542 efcd cd f0 a3                JSR     TRDY            Q <- 3652500
2543 efd0 cd ef 07                JSR     DIV             R <- Y' ((MJD-15078.2)/365.25)
2544 efd3 bf ad                    STX     NUM1
2545 efd5 ae 66                    LDX     #YR
2546 efd7 cd ee 2e                JSR     TRA             YR <- Y'
2547
2548                        ****************************************************************
2549                        *                                                              *
2550                        *       MJD - month and day.                                   *
2551                        *                                                              *
2552                        *       M'= INT((MJD-14956.1-INT(Y'*365.25))/306001)       (P)  *
2553                        *       D = MJD-14956-INT(Y'*365.25)-INT(M'*30.6001) (Q(x10K))  *
2554                        *                                                              *
2555                        ****************************************************************
2556
2557 efda cd f0 6b            MONTH   JSR     INT             R <- 10K(INT(Y'*365.25))
2558 efdd ae 5d                    LDX     #MJD
2559 efdf bf ad                    STX     NUM1
2560 efe1 ae 42                    LDX     #P
2561 efe3 bf ae                    STX     NUM2
2562 efe5 cd f0 b9                JSR     TRDO1           P <- 149561000
2563 efe8 ae 30                    LDX     #Q
2564 efea cd ee 6d                JSR     SUB             Q <- 10K(MJD-14956.1)
2565 efed bf ad                    STX     NUM1
2566 efef ae 54                    LDX     #R
2567 eff1 bf ae                    STX     NUM2
2568 eff3 ae 42                    LDX     #P
2569 eff5 cd ee 6d                JSR     SUB             P <- 10K(MJD-14956.1-INT(Y'*365.25))
2570 eff8 cd f0 ae                JSR     TRDM            Q <- 306001
2571 effb cd ef 07                JSR     DIV             R <- M'      (  MJD-14956.1-INT(Y'*365.25)  )
2572 effe bf ad                    STX     NUM1                  INT (  -------------------------  )
2573 f000 ae 42                    LDX     #P                    (            306001            )
2574 f002 cd ee 2e                JSR     TRA             P <- M'
2575 f005 b6 49                    LDA     P+ND-2          SAVE M'
2576 f007 b7 6f                    STA     MNTH
2577 f009 b6 4a                    LDA     P+ND-1
2578 f00b b7 70                    STA     MNTH+1
2579
2580 f00d cd f0 ae            DAY     JSR     TRDM            Q <- 306001
2581 f010 cd f0 77                JSR     MULTI           R <- 10K(INT(M'*30.6001))
2582 f013 bf ad                    STX     NUM1
2583 f015 ae 39                    LDX     #TMQ
2584 f017 cd ee 2e                JSR     TRA             TMQ <- 10K(INT(M'*30.6001))
2585 f01a cd f0 6b                JSR     INT             R <- 10K(INT(Y'*365.25))
2586 f01d bf ae                    STX     NUM2
2587 f01f ae 39                    LDX     #TMQ
2588 f021 bf ad                    STX     NUM1
2589 f023 cd ee 33                JSR     ADD             TMQ <- 10K(INT(Y'*365.25)+INT(M'*30.6001))
2590 f026 bf ad                    STX     NUM1
2591 f028 ae 42                    LDX     #P
2592 f02a bf ae                    STX     NUM2
2593 f02c cd f0 b9                JSR     TRDO1           P <- 149561000
2594 f02f 3f 47                    CLR     P+ND-4          P <- 149560000
2595 f031 ae 54                    LDX     #R
2596 f033 cd ee 33                JSR     ADD             R <- 10K(14956+INT(Y'*365.25)+INT(M'*30.6001))
2597 f036 bf ae                    STX     NUM2
2598 f038 ae 5d                    LDX     #MJD
2599 f03a bf ad                    STX     NUM1
2600 f03c ae 30                    LDX     #Q
2601 f03e cd ee 6d                JSR     SUB             Q <- MJD-R (10K*DOM)
2602 f041 e6 04                    LDA     ND-5,X
2603 f043 b7 72                    STA     DOM+1           MJD-14956-INT(Y'*365.25)-INT(M'*30.6001)
2604 f045 e6 03                    LDA     ND-6,X
2605 f047 b7 71                    STA     DOM
```

```
2607                            ************************************************************
2608                            *                                                          *
2609                            *       MJD - final correction of year & month and subs.   *
2610                            *                                                          *
2611                            *       If M' = 14 or 15, then K = 1, else K = 0           *
2612                            *       Y = Y' + K                                         *
2613                            *       M = M' - 1 - K*12                                  *
2614                            *                                                          *
2615                            ************************************************************
2616
2617 f049 b6 6f                ADJU2   LDA     MNTH            MONTH, MSD
2618 f04b 27 1b                        BEQ     KE02            0 ?
2619 f04d b6 70                        LDA     MNTH+1          NO, M'= 10 THRU 15
2620 f04f 27 11                        BEQ     KE01            0 ?
2621 f051 a1 04                        CMP     #4              NO, M'= 11 THRU 15
2622 f053 25 13                        BLO     KE02            LESS THAN 14
2623 f055 ae 5d                KE1     LDX     #YR-ND          NO, M'= 14 OR 15, K=1
2624 f057 cd ee 90                     JSR     ADD1            Y <- Y'+1
2625 f05a 3f 6f                        CLR     MNTH            MONTH, MSD (-10)
2626 f05c 3a 70                        DEC     MNTH+1          DEC. MONTH
2627 f05e 3a 70                        DEC     MNTH+1          AND AGAIN (-2)
2628 f060 20 06                        BRA     KE02            -12
2629 f062 a6 0a                KE01    LDA     #10             M'= 10
2630 f064 b7 70                        STA     MNTH+1          PUT 10 IN LSD
2631 f066 3f 6f                        CLR     MNTH            CLEAR MSD
2632 f068 3a 70                KE02    DEC     MNTH+1          9<-10, 1,2<-14,15, 3-8<-4-9, 10-12<-11-13
2633 f06a 81                           RTS
2634
2635 f06b ae 66                INT     LDX     #YR
2636 f06d bf ad                        STX     NUM1
2637 f06f ae 42                        LDX     #P
2638 f071 cd ee 2e                     JSR     TRA             P <- Y'
2639 f074 cd f0 a3                     JSR     TRDY            Q <- 10K*365.25
2640 f077 cd ee a6             MULTI   JSR     MULT            R <- 10K*Y'*365.25
2641 f07a 3f 59                        CLR     R+ND-4
2642 f07c 3f 5a                        CLR     R+ND-3
2643 f07e 3f 5b                        CLR     R+ND-2
2644 f080 3f 5c                        CLR     R+ND-1          R <- 10K(INT(Y'*365.25))
2645 f082 81                           RTS
2646
2647 f083 9f                   T10K    TXA                     TIMES 10,000
2648 f084 ab 05                        ADD     #ND-4
2649 f086 b7 a1                        STA     W1
2650 f088 e6 04                SLP     LDA     4,X
2651 f08a f7                           STA     0,X
2652 f08b 5c                           INCX
2653 f08c b3 a1                        CPX     W1
2654 f08e 26 f8                        BNE     SLP
2655 f090 7f                           CLR     0,X
2656 f091 6f 01                        CLR     1,X
2657 f093 6f 02                        CLR     2,X
2658 f095 6f 03                        CLR     3,X
2659 f097 81                           RTS
2660
2661                            ************************************************
2662                            *                                              *
2663                            *       MJD constants.                         *
2664                            *                                              *
2665                            ************************************************
2666
2667 f098 ae 09                TRCY    LDX     #ND
2668 f09a d6 f0 c3             CYL     LDA     CY-1,X
2669 f09d e7 2f                        STA     Q-1,X
2670 f09f 5a                           DECX
2671 f0a0 26 f8                        BNE     CYL
2672 f0a2 81                           RTS
2673
2674 f0a3 ae 09                TRDY    LDX     #ND
2675 f0a5 d6 f0 cc             DYL     LDA     DY-1,X
2676 f0a8 e7 2f                        STA     Q-1,X
2677 f0aa 5a                           DECX
2678 f0ab 26 f8                        BNE     DYL
2679 f0ad 81                           RTS
2680
2681 f0ae ae 09                TRDM    LDX     #ND
2682 f0b0 d6 f0 de             DML     LDA     DM-1,X
2683 f0b3 e7 2f                        STA     Q-1,X
2684 f0b5 5a                           DECX
2685 f0b6 26 f8                        BNE     DML
2686 f0b8 81                           RTS
2687
2688 f0b9 ae 09                TRDO1   LDX     #ND
2689 f0bb d6 f0 d5             DO1L    LDA     DO1-1,X
2690 f0be e7 41                        STA     P-1,X
2691 f0c0 5a                           DECX
2692 f0c1 26 f8                        BNE     DO1L
2693 f0c3 81                           RTS
2694
2695 f0c4 01 05 00 07 08 02    CY      FCB     1,5,0,7,8,2,0,0,0
     00 00 00
2696 f0cd 00 00 03 06 05 02    DY      FCB     0,0,3,6,5,2,5,0,0
     05 00 00
2697 f0d6 01 04 09 05 06 01    DO1     FCB     1,4,9,5,6,1,0,0,0
     00 00 00
2698 f0df 00 00 00 03 00 06    DM      FCB     0,0,0,3,0,6,0,0,1
     00 00 01
2699
2700                            ************************************************
2701                            *                                              *
2702                            *       Vectors.                               *
2703                            *                                              *
2704                            ************************************************
2705
2706 fff4                           ORG     $FFF4
2707
2708 fff4 e0 00                     FDB     START           SERIAL
2709 fff6 e2 9d                     FDB     TINTB           TIMER B
2710 fff8 e0 00                     FDB     START           TIMER A
2711 fffa e3 0a                     FDB     SDATA           EXTERNAL INTERRUPT & RTI
2712 fffc e0 00                     FDB     START           SWI
2713 fffe e0 00                     FDB     START           RESET
2714
2715                                END
```

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