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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.

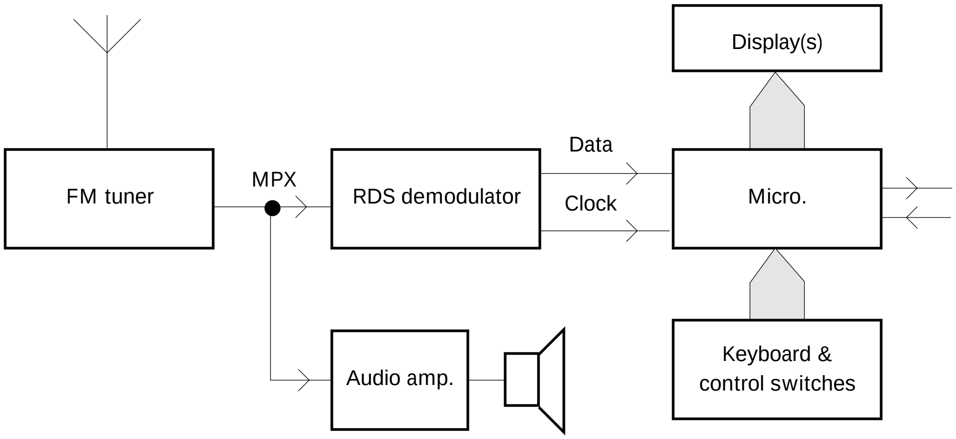

Figure 1. Typical application

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.

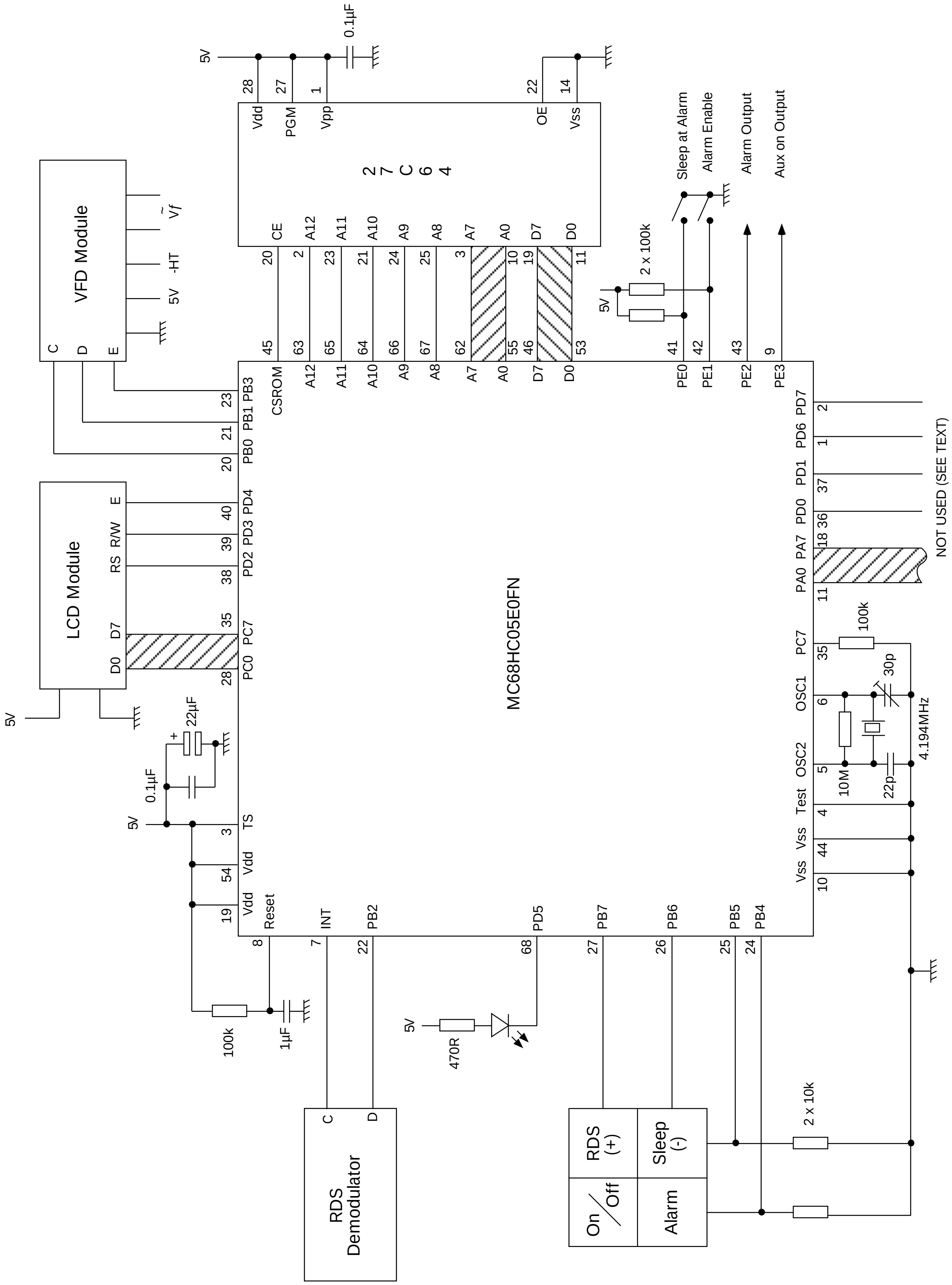

Figure 3. Circuit diagram

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

MODE	KEY			
	On/Off	**Sleep**	**Alarm**	**RDS**
Standby (Off)	mode normal (On)	mode sleep (On)	mode alarm	—
Normal (On)	mode stndby (Off)			RT PTY PI TA/TP PIN(h) PIN(d) MJD MS/DI EON 1 : : EON 11
Alarm OFF			mode alarm ON	
Alarm ON	mode alarm set-up		mode alarm OFF	
Alarm SET UP	toggle hr/min	dec. hr/min		inc. hr/min

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	Alarm off	`Thu 30 Apr 18:05`
(Off)	Alarm off, no CT	`Mon  0 inv  0:00`
	Alarm on	`0659 ALARM 18:05`
Normal	With RDS PS name	`BBC R4  18:05`
(On)	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:

```
$Y' = \mathrm{int}[(MJD-15078.2)/365.25]$
$M' = \mathrm{int}[(MJD-14956.1-\mathrm{int}\{Y'x365.25\})/30.6001]$
$Day = MJD-14956-\mathrm{int}(Y'x365.25)-\mathrm{int}(M'x30.6001)$
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

```
                        ****************************************************
                        *                                                  *
                        *                HC05E0 RDS Decoder.               *
                        *                                                  *
                        *     P. Topping            29th February '92      *
                        *                                                  *
                        ****************************************************

0000                    PORTA   EQU     $00             PORT A ADDRESS
0001                    PORTB   EQU     $01               "  B    "
0002                    PORTC   EQU     $02               "  C    "
0003                    PORTD   EQU     $03               "  D    "
0004                    PORTE   EQU     $04               "  E    "
0005                    PORTAD  EQU     $05             PORT A DATA DIRECTION REG.
0006                    PORTBD  EQU     $06               "  B  "       "      "
0007                    PORTCD  EQU     $07               "  C  "       "      "
0008                    PORTDD  EQU     $08               "  D  "       "      "
0009                    PORTED  EQU     $09               "  E  "       "      "
000a                    TAP     EQU     $0A             TIMER A PRE-SCALLER
000b                    TBS     EQU     $0B             TIMER B SCALLER
000c                    TCR     EQU     $0C             TIMER CONTROL REGISTER
000e                    ICR     EQU     $0E             INTERRUPT CONTROL REGISTER
0012                    PORTDSF EQU     $12             PORTD SPECIAL FUNCTIONS

0009                    ND      EQU     9               No. BCD DIGITS

0030                            ORG     $0030

0030                    Q       RMB     9               BCD WORKING NUMBERS
0039                    TMQ     RMB     9               SCRATCH
0042                    P       RMB     9               WORKING NUMBER 2
004b                    TMP     RMB     9               MULT. OVER. OR DIV. REMAINDER
0054                    R       RMB     9               WORKING NUMBER 3
005d                    MJD     RMB     9               MODIFIED JULIAN DAY NUMBER
0066                    YR      RMB     9               YEAR
006f                    MNTH    RMB     2               MONTH
0071                    DOM     RMB     2               DATE
0073                    DOW     RMB     1               DAY OF WEEK
0074                    BMJD    RMB     3               BINARY MJD
0077                    DIST    RMB     1               DISPLAY TRANSIENT TIMEOUT COUNTER
0078                    SLEPT   RMB     1               SLEEP TIMER MINUTES COUNTER
0079                    RDSTO   RMB     1               RDS TIMEOUT COUNTER
007a                    DAT     RMB     4               SERIAL DATA BUFFER
007e                    TMPGRP  RMB     8               TEMPORARY GROUP DATA
0086                    GROUP   RMB     8               COMPLETE GROUP DATA
008e                    PTY     RMB     1               PROGRAM-TYPE CODE (CURRENT)
008f                    PI      RMB     2               PROGRAM IDENTIFICATION CODE
0091                    PIN     RMB     2               PROGRAM ITEM NUMBER
0093                    LEV     RMB     1               VALID BLOCK LEVEL
0094                    BIT     RMB     1               BIT LEVEL
0095                    ITMP1   RMB     1               TEMP BYTE FOR USE IN IRQ
0096                    SYN     RMB     2               SYNDROME
0098                    CONF    RMB     1               SYNDROME CONFIDENCE
0099                    TH8     RMB     1               TICS (EIGHTHS OF SECONDS)
009a                    SEC     RMB     1               SECONDS
009b                    MIN     RMB     1               MINUTES
009c                    OUR     RMB     1               HOURS
009d                    AMIN    RMB     1               ALARM MINUTES
009e                    AOUR    RMB     1               ALARM HOURS
009f                    DISP1   RMB     1               RT DISPLAY POINTER #1
00a0                    DISP2   RMB     1               RT DISPLAY POINTER #2
00a1                    W1      RMB     1               W
00a2                    W2      RMB     1               O
00a3                    W3      RMB     1               R
00a4                    W4      RMB     1               K
00a5                    W5      RMB     1               I
00a6                    W6      RMB     1               N
00a7                    W7      RMB     1               G
00a8                    W8      RMB     1
00a9                    KEY     RMB     1               CODE OF PRESSED KEY
00aa                    KOUNT   RMB     1               KEYBOARD COUNTER
00ab                    CARRY   RMB     1               BCD CARRY
00ac                    COUNT   RMB     1               LOOP COUNTER
00ad                    NUM1    RMB     1               1ST No. POINTER (ADD & SUBTRACT)
00ae                    NUM2    RMB     1               2ND No. POINTER (ADD & SUBTRACT)
00af                    RTDIS   RMB     1               RDS DISPLAY TYPE
00b0                    DI      RMB     1               DECODER IDENTIFICATION
00b1                    DISP    RMB     16              LCD MODULE BUFFER
00c1                    PSN     RMB     8               PS NAME

00c9                    STAT2   RMB     1               0: VALID SYNDROME
                        *                               1: VALID GROUP
                        *                               2: RT DISPLAY
                        *                               3: UPDATE DISPLAY
                        *                               4: CLEAR DISPLAY
                        *                               5: SPACE FLAG
00ca                    STAT3   RMB     1               0: M/S, 0: M, 1: S
                        *                               1: TEXTA/TEXTB BIT (RT)
                        *                               2: TA FLAG
                        *                               3: TP FLAG
                        *                               4: KEY REPEATING
                        *                               5: KEY FUNCTION PERFORMED
                        *                               6: UPDATE DATE
00cb                    STAT4   RMB     1               0: DISPLAY TRANSIENT
                        *                               1: SLEEP TIMER RUNNING
                        *                               2: SLEEP DISPLAY
                        *                               3: ALARM DISPLAY
                        *                               4: ALARM ARMED
                        *                               5: ALARM SET-UP
                        *                               6: ALARM HOURS (SET-UP)
                        *                               7: RDS DISPLAYS

00cc                            RMB     33              not used
00ed                    STACK   RMB     18              19 BYTES USED (1 INTERRUPT
00ff                    SP      RMB     1               AND 7 NESTED SUBROUTINES)

0100                            ORG     $0100

0100                    RT      RMB     69              RADIOTEXT
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
```

```
                        *******************************************************
                        *                                                     *
                        *       Idle loop.                                    *
                        *                                                     *
                        *******************************************************

e071 09 0e fd           IDLE    BRCLR   4,ICR,*         64 Hz
e074 19 0e                      BCLR    4,ICR

e076 01 cb 07           NO2D    BRCLR   0,STAT4,NOPS    DISPLAY TRANSIENT ?
e079 b6 77                      LDA     DIST
e07b 26 03                      BNE     NOPS            YES, TIMED OUT ?
e07d cd e8 0a                   JSR     CLTR            YES, CLEAR TRANSIENT DISPLAYS

e080 07 c9 05           NOPS    BRCLR   3,STAT2,SCAN    DISPLAY UPDATE REQUIRED ?
e083 cd e6 b6                   JSR     MOD             YES, DO IT
e086 17 c9                      BCLR    3,STAT2         AND CLEAR FLAG

e088 09 cb 1d           SCAN    BRCLR   4,STAT4,CHSLP   ALARM ARMED ?
e08b b6 9e                      LDA     AOUR            YES, COMPARE ALARM HOURS
e08d b1 9c                      CMP     OUR             WITH TIME
e08f 26 17                      BNE     CHSLP           SAME ?
e091 b6 9d                      LDA     AMIN            YES, COMPARE ALARM MINUTES
e093 b1 9b                      CMP     MIN             WITH TIME
e095 26 11                      BNE     CHSLP           SAME ?
e097 b6 9a                      LDA     SEC             ONLY ALLOW WAKE-UP IN FIRST SECOND
e099 26 0d                      BNE     CHSLP           TO PREVENT SWITCH-OFF LOCKOUT
e09b 16 04                      BSET    3,PORTE         YES, SWITCH ON

e09d 02 04 02                   BRSET   1,PORTE,FULON2  ALARM ENABLED (SWITCH) ?
e0a0 15 04                      BCLR    2,PORTE         YES, SOUND ALARM
e0a2 00 04 03           FULON2  BRSET   0,PORTE,CHSLP   SLEEP TIMER AT ALARM TIME ?
e0a5 cd e2 09                   JSR     INSLP           YES, START SLEEP TIMER

e0a8 03 cb 08           CHSLP   BRCLR   1,STAT4,FLN     SLEEP TIMER RUNNING ?
e0ab b6 78                      LDA     SLEPT           YES
e0ad 26 04                      BNE     FLN             TIME TO FINISH ?
e0af 13 cb                      BCLR    1,STAT4         YES, CLEAR FLAG
e0b1 17 04                      BCLR    3,PORTE         AND SWITCH OFF

e0b3 cd e1 11           FLN     JSR     KBD             READ KEYBOARD
e0b6 cd e1 6f                   JSR     KEYP            EXECUTE KEY

e0b9 b6 ca                      LDA     STAT3
e0bb a4 0c                      AND     #$0C
e0bd a1 0c                      CMP     #$0C            TA AND TP BOTH HIGH ?
e0bf 27 07                      BEQ     TATP
e0c1 0a 03 09                   BRSET   5,PORTD,IOOK    NO, I/O LINE ALREADY HIGH ?
e0c4 1a 03                      BSET    5,PORTD         NO, MAKE IT HIGH
e0c6 20 05                      BRA     IOOK
e0c8 0b 03 02           TATP    BRCLR   5,PORTD,IOOK    TA=TP=1, I/O LINE ALREADY LOW ?
e0cb 1b 03                      BCLR    5,PORTD         NO, MAKE IT LOW

e0cd 0d ca 02           IOOK    BRCLR   6,STAT3,IDLEJ   UPDATE DATE ?
e0d0 ad 02                      BSR     MJDAT           YES, CONVERT FROM MJD
e0d2 20 9d              IDLEJ   BRA     IDLE

                        *******************************************************
                        *                                                     *
                        *       Extract MJD and convert to decimal.           *
                        *                                                     *
                        *******************************************************

e0d4 b6 76              MJDAT   LDA     BMJD+2
e0d6 b7 68                      STA     YR+2
e0d8 b6 75                      LDA     BMJD+1
e0da b7 67                      STA     YR+1
e0dc b6 74                      LDA     BMJD
e0de b7 66                      STA     YR
e0e0 ae 54                      LDX     #R              CLEAR
e0e2 bf ad                      STX     NUM1
e0e4 cd ef 86                   JSR     CLRAS           R
e0e7 3c 5c                      INC     R+ND-1          R <- 1
e0e9 ae 5d                      LDX     #MJD
e0eb cd ef 86                   JSR     CLRAS           CLEAR MJD
e0ee a6 11                      LDA     #17             17 BITS TO CONVERT
e0f0 b7 a6                      STA     W6
e0f2 34 66              LOOPJ   LSR     YR              MOVE OUT
e0f4 36 67                      ROR     YR+1
e0f6 36 68                      ROR     YR+2            FIRST (LS) BIT
e0f8 24 07                      BCC     NXTJ            ZERO ?
e0fa ae 5d                      LDX     #MJD            ONE, ADD
e0fc bf ae                      STX     NUM2            CURRENT VALUE
e0fe cd ee 33                   JSR     ADD             OF R
e101 ae 54              NXTJ    LDX     #R              ADD R
e103 bf ae                      STX     NUM2            TO
e105 cd ee 33                   JSR     ADD             ITSELF
e108 3a a6                      DEC     W6              ALL
e10a 26 e6                      BNE     LOOPJ           DONE ?
e10c 1d ca                      BCLR    6,STAT3         MJD UPDATED
e10e cc ef 95                   JMP     MJDC            CONVERT MJD TO DAY, DATE, MONTH & YEAR
```

```
                        *****************************************************
                        *                                                   *
                        *       Keyboard routine.                           *
                        *                                                   *
                        *****************************************************

e111 a6 20              KBD     LDA     #$20
e113 ae 02                      LDX     #2
e115 48                 KEY1    LSLA                    SELECT ROW
e116 a4 c0                      AND     #$C0            BITS 6 & 7 ONLY
e118 aa 08                      ORA     #$08            VFD ENABLE HIGH
e11a b7 01                      STA     PORTB
e11c b6 01              ROW     LDA     PORTB           READ KEYBOARD
e11e a5 30                      BIT     #$30            ANY INPUT LINE HIGH ?
e120 26 07                      BNE     L1
e122 5a                         DECX                    NO, TRY NEXT COLUMN
e123 26 f0                      BNE     KEY1            LAST COLUMN ?
e125 3f a9                      CLR     KEY             YES, NO KEY PRESSED
e127 20 0c                      BRA     EXIT

e129 b6 01              L1      LDA     PORTB           READ KEYBOARD
e12b a4 f0                      AND     #$F0
e12d b1 a9                      CMP     KEY             SAME AS LAST TIME ?
e12f 27 04                      BEQ     EXIT
e131 b7 a9                      STA     KEY             NO, SAVE THIS KEY
e133 3f aa                      CLR     KOUNT
e135 3c aa              EXIT    INC     KOUNT           YES, THE SAME
e137 b6 aa                      LDA     KOUNT
e139 09 ca 04                   BRCLR   4,STAT3,NRML    REPEATING ?
e13c a1 0a                      CMP     #10             YES, REPEAT AT 6 Hz
e13e 20 08                      BRA     GON2
e140 a1 03              NRML    CMP     #3              NO, 3 THE SAME ?
e142 25 29                      BLO     KCLC            IF NOT DO NOTHING
e144 27 1b                      BEQ     GOON            IF 3 THEN PERFORM KEY FUNCTION
e146 a1 30                      CMP     #48             MORE THAN 3, MORE THAN 48 (750mS) ?
e148 22 06              GON2    BHI     GOON2           TIME TO DO SOMETHING ?
e14a b6 a9                      LDA     KEY             NO
e14c 27 19                      BEQ     RKEY            KEY PRESSED ?
e14e 98                         CLC
e14f 81                         RTS                     YES BUT DO NOTHING

e150 b6 a9              GOON2   LDA     KEY
e152 a1 50                      CMP     #$50            SLEEP (DEC.)
e154 27 04                      BEQ     GOON3
e156 a1 90                      CMP     #$90            RDS (INC.)
e158 26 0f                      BNE     DNT2            IF NOT A REPEAT KEY, DO NOTHING
e15a 0b cb 0c           GOON3   BRCLR   5,STAT4,DNT2    REPEAT KEY, BUT IS MODE ALARM SET-UP ?
e15d 18 ca                      BSET    4,STAT3         YES, SET REPEAT FLAG
e15f 3f aa                      CLR     KOUNT
e161 b6 a9              GOON    LDA     KEY
e163 27 02                      BEQ     RKEY            SOMETHING TO DO ?
e165 99                         SEC                     YES, SET C
e166 81                         RTS
e167 1b ca              RKEY    BCLR    5,STAT3         NO, CLEAR DONE FLAG
e169 19 ca              DNT2    BCLR    4,STAT3         CLEAR REPEAT FLAG
e16b 3f aa                      CLR     KOUNT           CLEAR COUNTER
e16d 98                 KCLC    CLC
e16e 81                         RTS

                        *****************************************************
                        *                                                   *
                        *       Execute key function.                       *
                        *                                                   *
                        *****************************************************

e16f 24 26              KEYP    BCC     DNT             ANYTHING TO DO ?
e171 b6 a9              KEYP2   LDA     KEY             YES, GET KEY
e173 a1 50                      CMP     #$50            SLEEP (DEC.)
e175 27 07                      BEQ     RPT
e177 a1 90                      CMP     #$90            RDS (INC.)
e179 27 03                      BEQ     RPT
e17b 0a ca 19                   BRSET   5,STAT3,DNT     NOT A REPEAT KEY, DONE FLAG SET ?

e17e 5f                 RPT     CLRX
e17f d6 e1 98           RJ      LDA     CTAB,X          FETCH KEYCODE
e182 b1 a9                      CMP     KEY             THIS ONE ?
e184 27 0b                      BEQ     PJ              YES
e186 c1 e1 a4                   CMP     LAST            NO, LAST CHANCE ?
e189 27 0c                      BEQ     DNT             YES, ABORT
e18b 5c                         INCX                    NO
e18c 5c                         INCX                    TRY
e18d 5c                         INCX                    THE
e18e 5c                         INCX                    NEXT
e18f 20 ee                      BRA     RJ              KEY
e191 1a ca              PJ      BSET    5,STAT3         KEY FUNCTION DONE
e193 5c                         INCX
e194 dd e1 98                   JSR     CTAB,X
e197 81                 DNT     RTS

                        *****************************************************
                        *                                                   *
                        *       Keyboard jump table.                        *
                        *                                                   *
                        *****************************************************

e198 60                 CTAB    FCB     $60             ALARM
e199 cc e1 a8                   JMP     ALARM
e19c a0                         FCB     $A0             ON/OFF
e19d cc e1 c7                   JMP     ONOFF
e1a0 50                         FCB     $50             SLEEP TIMER START
e1a1 cc e1 fa                   JMP     SLEEP
e1a4 90                 LAST    FCB     $90             RDS DISPLAYS
e1a5 cc e2 26                   JMP     RDS
```

```
                        ********************************************************
                        *                                                      *
                        *       Alarm key.                                     *
                        *                                                      *
                        ********************************************************

e1a8 05 04 4c           ALARM   BRCLR   2,PORTE,ALRG    ALARM RINGING ?
e1ab 07 cb 0b                   BRCLR   3,STAT4,ADON    NO, ALARM DISPLAY ON ?
e1ae 09 cb 04                   BRCLR   4,STAT4,ALOF    YES, ALARM ON ?
e1b1 19 cb                      BCLR    4,STAT4         YES, SWITCH OFF
e1b3 20 09                      BRA     UDCNT
e1b5 18 cb              ALOF    BSET    4,STAT4         NO, SWITCH ON
e1b7 20 05                      BRA     UDCNT
e1b9 cd e8 0a           ADON    JSR     CLTR
e1bc 16 cb                      BSET    3,STAT4         ALARM DISPLAY FLAG
e1be 1b cb              UDCNT   BCLR    5,STAT4         CANCEL SET-UP
e1c0 a6 19                      LDA     #25             3 SECOND TIMEOUT
e1c2 b7 77                      STA     DIST
e1c4 10 cb                      BSET    0,STAT4         SET DISPLAY TRANSIENT FLAG
e1c6 81                 ABOA    RTS

                        ********************************************************
                        *                                                      *
                        *       On/off key (alarm set-up).                     *
                        *                                                      *
                        ********************************************************

e1c7 05 04 2d           ONOFF   BRCLR   2,PORTE,ALRG    ALARM RINGING ?
e1ca 07 cb 1c                   BRCLR   3,STAT4,NOTALR  NO, ALARM DISPLAY ?
e1cd 09 cb 19                   BRCLR   4,STAT4,NOTALR  YES, ALARM ARMED ?
e1d0 0a cb 0b                   BRSET   5,STAT4,AISM    YES, ALREADY SET-UP MODE ?
e1d3 1a cb                      BSET    5,STAT4         NO, ENTER SET-UP MODE
e1d5 1c cb                      BSET    6,STAT4         WITH HOURS
e1d7 a6 50              A5SD    LDA     #80
e1d9 b7 77                      STA     DIST
e1db 10 cb                      BSET    0,STAT4         SET DISPLAY TRANSIENT FLAG
e1dd 81                 NTB2    RTS

e1de 0c cb 04           AISM    BRSET   6,STAT4,MSM     SET-UP HOURS ?
e1e1 1b cb                      BCLR    5,STAT4         NO, CANCELL SET-UP
e1e3 20 f2                      BRA     A5SD
e1e5 1d cb              MSM     BCLR    6,STAT4         YES, MAKE IT MINUTES
e1e7 20 ee                      BRA     A5SD

                        ********************************************************
                        *                                                      *
                        *       On/off key (normal function).                  *
                        *                                                      *
                        ********************************************************

e1e9 cd e8 0a           NOTALR  JSR     CLTR            CLEAR DISPLAY TRANSIENTS
e1ec 13 cb                      BCLR    1,STAT4         CANCEL SLEEP TIMER
e1ee 06 04 03                   BRSET   3,PORTE,ALRON   ON ?
e1f1 16 04              SODM    BSET    3,PORTE         NO, SWITCH ON
e1f3 81                         RTS
e1f4 17 04              ALRON   BCLR    3,PORTE         YES, SWITCH OFF
e1f6 81                         RTS
e1f7 14 04              ALRG    BSET    2,PORTE         CANCEL ALARM
e1f9 81                         RTS

                        ********************************************************
                        *                                                      *
                        *       Sleep key.                                     *
                        *                                                      *
                        ********************************************************

e1fa 05 04 fa           SLEEP   BRCLR   2,PORTE,ALRG    ALARM RINGING ?
e1fd 0b cb 03                   BRCLR   5,STAT4,NOTAL   NO, ALARM SET-UP ?
e200 cc e2 79                   JMP     PDEC            YES
e203 04 cb 10           NOTAL   BRSET   2,STAT4,DECS    NO, ALREADY SLEEP DISPLAY ?
e206 02 cb 06                   BRSET   1,STAT4,STR2    NO, SLEEP TIMER ALREADY RUNNING ?
e209 a6 3c              INSLP   LDA     #60             NO, INITIALISE SLEEP TIMER
e20b b7 78                      STA     SLEPT
e20d 12 cb                      BSET    1,STAT4         START SLEEP TIMER
e20f cd e8 0a           STR2    JSR     CLTR            YES, CLEAR DISPLAY TRANSIENTS
e212 14 cb                      BSET    2,STAT4         SLEEP DISPLAY
e214 20 08                      BRA     SLPTOK          NO DECREMENT IF FIRST TIME
e216 b6 78              DECS    LDA     SLEPT           DECREMENT SLEEP TIMER
e218 a0 05                      SUB     #5
e21a b7 78                      STA     SLEPT
e21c 2b eb                      BMI     INSLP           IF UNDERFLOW WRAP ROUND TO 60
e21e a6 19              SLPTOK  LDA     #25
e220 b7 77                      STA     DIST
e222 10 cb                      BSET    0,STAT4         START DISPLAY TRANSIENT
e224 20 cb                      BRA     SODM

                        ********************************************************
                        *                                                      *
                        *       RDS display key.                               *
                        *                                                      *
                        ********************************************************

e226 05 04 ce           RDS     BRCLR   2,PORTE,ALRG    ALARM RINGING ?
e229 0a cb 29                   BRSET   5,STAT4,PINC    NO, ALARM SET-UP ?
e22c 07 04 17                   BRCLR   3,PORTE,SRT3    NO, STANDBY ?
e22f 0e cb 03                   BRSET   7,STAT4,NOTRT   ALREADY RDS ?
e232 05 c9 12                   BRCLR   2,STAT2,NORT    ALREADY RT DISPLAY ?
e235 1e cb              NOTRT   BSET    7,STAT4         SET RDS DISPLAY FLAG
e237 b6 af                      LDA     RTDIS           MOVE ON
e239 4c                         INCA
e23a a1 13                      CMP     #19
e23c 27 09                      BEQ     NORT
e23e b7 af                      STA     RTDIS
e240 a6 64                      LDA     #100            12 SECOND TIMEOUT
e242 b7 77                      STA     DIST
e244 10 cb                      BSET    0,STAT4         RE-START TRANSIENT TIMEOUT
e246 81                 SRT3    RTS

e247 cd e8 0a           NORT    JSR     CLTR            CLEAR DISPLAY TRANSIENTS
e24a 14 c9                      BSET    2,STAT2         SET RT DISPLAY FLAG
e24c a6 09                      LDA     #9
e24e b7 9f                      STA     DISP1
e250 a6 01                      LDA     #1
e252 b7 a0                      STA     DISP2
e254 81                         RTS
```

```
                        ********************************************************
                        *                                                      *
                        *       Increment alarm time.                          *
                        *                                                      *
                        ********************************************************

e255 0c cb 0e           PINC    BRSET   6,STAT4,IHR     SET-UP HOURS ?
e258 b6 9d                      LDA     AMIN            NO, MINUTES
e25a a1 3b                      CMP     #59
e25c 24 04                      BHS     TOOH
e25e 3c 9d                      INC     AMIN
e260 20 0c                      BRA     T5S
e262 3f 9d              TOOH    CLR     AMIN
e264 20 08                      BRA     T5S
e266 b6 9e              IHR     LDA     AOUR
e268 a1 17                      CMP     #23
e26a 24 09                      BHS     HTOH
e26c 3c 9e                      INC     AOUR
e26e a6 50              T5S     LDA     #80             10 SECOND TIMEOUT
e270 b7 77                      STA     DIST
e272 10 cb                      BSET    0,STAT4         SET DISPLAY TRANSIENT FLAG
e274 81                         RTS
e275 3f 9e              HTOH    CLR     AOUR
e277 20 f5                      BRA     T5S

                        ********************************************************
                        *                                                      *
                        *       Decrement alarm time.                          *
                        *                                                      *
                        ********************************************************

e279 0c cb 0e           PDEC    BRSET   6,STAT4,IHRD    SET-UP HOURS ?
e27c 3d 9d                      TST     AMIN            NO, MINUTES
e27e 27 04                      BEQ     MZ
e280 3a 9d                      DEC     AMIN
e282 20 0c                      BRA     T5SD
e284 a6 3b              MZ      LDA     #59
e286 b7 9d                      STA     AMIN
e288 20 06                      BRA     T5SD
e28a 3d 9e              IHRD    TST     AOUR
e28c 27 09                      BEQ     HZ
e28e 3a 9e                      DEC     AOUR
e290 a6 50              T5SD    LDA     #80             10 SECOND TIMEOUT
e292 b7 77                      STA     DIST
e294 10 cb                      BSET    0,STAT4         SET DISPLAY TRANSIENT FLAG
e296 81                         RTS
e297 a6 17              HZ      LDA     #23
e299 b7 9e                      STA     AOUR
e29b 20 f3                      BRA     T5SD

                        *****************************************************
                        *                                                   *
                        *       Timer interrupt routine.                    *
                        *                                                   *
                        *****************************************************

e29d 3c 9f              TINTB   INC     DISP1             DISP1    DISP2    DISPLAY
e29f b6 9f                      LDA     DISP1            0 -   8        0   PTY
e2a1 a1 08                      CMP     #8                9 - 78   1 - 70   MOVING RT
e2a3 23 06                      BLS     NWR             78 -  88       70   END OF RT
e2a5 a1 4e                      CMP     #78
e2a7 22 02                      BHI     NWR             END OF RADIOTEXT ?
e2a9 3c a0                      INC     DISP2           NO, MOVE RADIOTEXT ONE CHARACTER
e2ab a1 58              NWR     CMP     #88             2 SECONDS AT END OF RADIOTEXT
e2ad 25 02                      BLO     NWR2
e2af 15 c9                      BCLR    2,STAT2         RETURN TO NORMAL DISPLAY
e2b1 1b 0e              NWR2    BCLR    5,ICR           CLEAR TIMER B INTERRUPT FLAG
e2b3 16 c9                      BSET    3,STAT2         UPDATE DISPLAY
e2b5 3c 99              CLCK    INC     TH8             UPDATE EIGHTHS OF SECONDS
e2b7 3a 77                      DEC     DIST            DECREMENT TRANSIENT DISPLAY TIMER
e2b9 3c 79                      INC     RDSTO
e2bb b6 79                      LDA     RDSTO
e2bd a1 50                      CMP     #80             10S WITHOUT A GROUP 0 OR 15 ?
e2bf 25 10                      BLO     RDSOK
e2c1 15 ca                      BCLR    2,STAT3         YES, CLEAR TA FLAG
e2c3 3f 8e              N14B    CLR     PTY             PROGRAM TYPE
e2c5 3f 8f                      CLR     PI              AND
e2c7 3f 90                      CLR     PI+1            PI CODE
e2c9 3f 91                      CLR     PIN             AND
e2cb 3f 92                      CLR     PIN+1           PIN
e2cd 3f b0                      CLR     DI              AND DI
e2cf 11 ca                      BCLR    0,STAT3         AND M/S
e2d1 b6 99              RDSOK   LDA     TH8             EIGHTHS OF SECONDS
e2d3 a1 08                      CMP     #8
e2d5 26 32                      BNE     NOTC            PAST 7 ?
e2d7 3f 99                      CLR     TH8             YES, CLEAR
e2d9 3c 9a                      INC     SEC             UPDATE SECONDS
e2db b6 9a                      LDA     SEC
e2dd a1 38                      CMP     #56
e2df 26 02                      BNE     NOT5
e2e1 3a 78                      DEC     SLEPT           DECREMENT SLEEP TIMER MINUTES
e2e3 a1 3c              NOT5    CMP     #60
e2e5 26 22                      BNE     NOTC            PAST 59 ?
e2e7 3f 9a                      CLR     SEC             YES, CLEAR
e2e9 3c 9b                      INC     MIN             UPDATE MINUTES
e2eb b6 9b                      LDA     MIN
e2ed a1 3c                      CMP     #60
e2ef 26 18                      BNE     NOTC            PAST 59 ?
e2f1 3f 9b                      CLR     MIN             YES, CLEAR
e2f3 3c 9c                      INC     OUR             UPDATE HOURS
e2f5 b6 9c                      LDA     OUR
e2f7 a1 18                      CMP     #24
e2f9 26 0e                      BNE     NOTC            PAST 23 ?
e2fb 3f 9c                      CLR     OUR             YES CLEAR
e2fd 3c 76                      INC     BMJD+2          AND ADD A DAY
e2ff 26 06                      BNE     NOTD
e301 3c 75                      INC     BMJD+1
e303 26 02                      BNE     NOTD            INC BMJD only ever executes once, at midnight
e305 3c 74                      INC     BMJD            on the night of Thu/Fri 22/23 April 2038.
e307 1c ca              NOTD    BSET    6,STAT3         UPDATE DATE
e309 80                 NOTC    RTI
```

```
                   ****************************************************
                   *                                                  *
                   *       RDS clock interrupt (IRQ).                 *
                   *       Get a bit and calculate syndrome.          *
                   *                                                  *
                   ****************************************************

e30a 04 01 00      SDATA   BRSET   2,PORTB,*+3
e30d 39 7d                 ROL     DAT+3
e30f 39 7c                 ROL     DAT+2
e311 39 7b                 ROL     DAT+1
e313 39 7a                 ROL     DAT
e315 01 c9 0b              BRCLR   0,STAT2,TRY2    BIT BY BIT CHECK ?
e318 3a 94                 DEC     BIT             NO, WAIT FOR BIT 26
e31a 27 03                 BEQ     TRY1            THIS TIME ?
e31c 17 0e                 BCLR    3,ICR           CLEAR IRQ INTERRUPT FLAG
e31e 80                    RTI

e31f a6 1a         TRY1    LDA     #26
e321 b7 94                 STA     BIT
e323 b6 7a         TRY2    LDA     DAT             MSB (2 BITS)
e325 a4 03                 AND     #3
e327 97                    TAX
e328 b6 7b                 LDA     DAT+1
e32a b7 97                 STA     SYN+1           LSB
e32c 01 7d 0a      S03     BRCLR   0,DAT+3,S13
e32f b6 97                 LDA     SYN+1
e331 a8 1b                 EOR     #$1B
e333 b7 97                 STA     SYN+1
e335 9f                    TXA
e336 a8 03                 EOR     #$03
e338 97                    TAX
e339 03 7d 0a      S13     BRCLR   1,DAT+3,S23
e33c b6 97                 LDA     SYN+1
e33e a8 8f                 EOR     #$8F
e340 b7 97                 STA     SYN+1
e342 9f                    TXA
e343 a8 03                 EOR     #$03
e345 97                    TAX
e346 05 7d 0a      S23     BRCLR   2,DAT+3,S43
e349 b6 97                 LDA     SYN+1
e34b a8 a7                 EOR     #$A7
e34d b7 97                 STA     SYN+1
e34f 9f                    TXA
e350 a8 02                 EOR     #$02
e352 97                    TAX
e353 09 7d 0a      S43     BRCLR   4,DAT+3,S53
e356 b6 97                 LDA     SYN+1
e358 a8 ee                 EOR     #$EE
e35a b7 97                 STA     SYN+1
e35c 9f                    TXA
e35d a8 01                 EOR     #$01
e35f 97                    TAX
e360 0b 7d 0a      S53     BRCLR   5,DAT+3,S63
e363 b6 97                 LDA     SYN+1
e365 a8 dc                 EOR     #$DC
e367 b7 97                 STA     SYN+1
e369 9f                    TXA
e36a a8 03                 EOR     #$03
e36c 97                    TAX
e36d 0d 7d 0a      S63     BRCLR   6,DAT+3,S73
e370 b6 97                 LDA     SYN+1
e372 a8 01                 EOR     #$01
e374 b7 97                 STA     SYN+1
e376 9f                    TXA
e377 a8 02                 EOR     #$02
e379 97                    TAX
e37a 0f 7d 0a      S73     BRCLR   7,DAT+3,S02
e37d b6 97                 LDA     SYN+1
e37f a8 bb                 EOR     #$BB
e381 b7 97                 STA     SYN+1
e383 9f                    TXA
e384 a8 01                 EOR     #$01
e386 97                    TAX
e387 01 7c 0a      S02     BRCLR   0,DAT+2,S12
e38a b6 97                 LDA     SYN+1
e38c a8 76                 EOR     #$76
e38e b7 97                 STA     SYN+1
e390 9f                    TXA
e391 a8 03                 EOR     #$03
e393 97                    TAX
e394 03 7c 0a      S12     BRCLR   1,DAT+2,S22
e397 b6 97                 LDA     SYN+1
e399 a8 55                 EOR     #$55
e39b b7 97                 STA     SYN+1
e39d 9f                    TXA
e39e a8 03                 EOR     #$03
e3a0 97                    TAX
e3a1 05 7c 0a      S22     BRCLR   2,DAT+2,S32
e3a4 b6 97                 LDA     SYN+1
e3a6 a8 13                 EOR     #$13
e3a8 b7 97                 STA     SYN+1
e3aa 9f                    TXA
e3ab a8 03                 EOR     #$03
e3ad 97                    TAX
e3ae 07 7c 0a      S32     BRCLR   3,DAT+2,S42
e3b1 b6 97                 LDA     SYN+1
e3b3 a8 9f                 EOR     #$9F
e3b5 b7 97                 STA     SYN+1
e3b7 9f                    TXA
e3b8 a8 03                 EOR     #$03
e3ba 97                    TAX
e3bb 09 7c 0a      S42     BRCLR   4,DAT+2,S62
e3be b6 97                 LDA     SYN+1
e3c0 a8 87                 EOR     #$87
e3c2 b7 97                 STA     SYN+1
e3c4 9f                    TXA
e3c5 a8 02                 EOR     #$02
e3c7 97                    TAX
e3c8 0d 7c 0a      S62     BRCLR   6,DAT+2,S72
e3cb b6 97                 LDA     SYN+1
e3cd a8 6e                 EOR     #$6E
e3cf b7 97                 STA     SYN+1
e3d1 9f                    TXA
e3d2 a8 01                 EOR     #$01
e3d4 97                    TAX
e3d5 0f 7c 09      S72     BRCLR   7,DAT+2,S33
e3d8 b6 97                 LDA     SYN+1
e3da a8 dc                 EOR     #$DC
e3dc b7 97                 STA     SYN+1
e3de 9f                    TXA
e3df a8 02                 EOR     #$02
e3e1 b7 96         S33     STA     SYN
e3e3 b6 97                 LDA     SYN+1
e3e5 07 7d 02              BRCLR   3,DAT+3,S52
e3e8 a8 f7                 EOR     #$F7
e3ea 0b 7c 02      S52     BRCLR   5,DAT+2,FIN
e3ed a8 b7                 EOR     #$B7
e3ef b7 97         FIN     STA     SYN+1
```

```
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
```

```
                        ****************************************************
                        *                                                  *
                        *       Update PI code, initialise if changed.     *
                        *       All block 1s used, block 3s not used.      *
                        *                                                  *
                        ****************************************************

e4a0 b6 86              PROC    LDA     GROUP           COMPARE PI WITH PREVIOUS
e4a2 b1 8f                      CMP     PI
e4a4 26 06                      BNE     DNDX
e4a6 b6 87                      LDA     GROUP+1
e4a8 b1 90                      CMP     PI+1
e4aa 27 10                      BEQ     PTYL
e4ac b6 86              DNDX    LDA     GROUP           DIFFERENT, SAVE NEW PI
e4ae b7 8f                      STA     PI
e4b0 b6 87                      LDA     GROUP+1
e4b2 b7 90                      STA     PI+1
e4b4 cd eb e6                   JSR     CLREON          CLEAR EON,
e4b7 cd e8 0a                   JSR     CLTR            TRANSIENTS
e4ba 18 c9                      BSET    4,STAT2         AND INITIALISE DISPLAY DATA

                        ****************************************************
                        *                                                  *
                        *       Update PTY and TP.                         *
                        *       All block 2s used, not block 4 (grp 15B).  *
                        *                                                  *
                        ****************************************************

e4bc b6 88              PTYL    LDA     GROUP+2
e4be b7 95                      STA     ITMP1
e4c0 05 95 04                   BRCLR   2,ITMP1,TPL1    TP HIGH ?
e4c3 16 ca                      BSET    3,STAT3         YES, FLAG HIGH
e4c5 20 02                      BRA     TPL
e4c7 17 ca              TPL1    BCLR    3,STAT3         NO, FLAG LOW
e4c9 b6 89              TPL     LDA     GROUP+3
e4cb 36 95                      ROR     ITMP1
e4cd 46                         RORA
e4ce 44                         LSRA
e4cf 44                         LSRA
e4d0 44                         LSRA
e4d1 44                         LSRA
e4d2 b7 8e                      STA     PTY

                        ****************************************************
                        *                                                  *
                        *       Groups handled.                            *
                        *                                                  *
                        *       All         PI, PTY & TP                   *
                        *       0 A & B     TA, PS, DI & M/S               *
                        *       1 A & B     PIN                            *
                        *       2 A         RT                             *
                        *       4 A         CT                             *
                        *      14 A         EON                            *
                        *      15 B         TA, DI & M/S                   *
                        *                                                  *
                        ****************************************************

                        ****************************************************
                        *                                                  *
                        *       Process groups 0 & 15B (PS & TA).          *
                        *                                                  *
                        ****************************************************

e4d4 b6 88                      LDA     GROUP+2
e4d6 a4 f8                      AND     #$F8
e4d8 27 0a                      BEQ     GRP0            GROUP 0A
e4da a1 08                      CMP     #$08            GROUP 0B
e4dc 27 06                      BEQ     GRP0

e4de a1 f8              TGRP15  CMP     #$F8            GROUP 15B
e4e0 27 10                      BEQ     TACK
e4e2 20 57                      BRA     PROC1

e4e4 b6 89              GRP0    LDA     GROUP+3         GROUP 0  -  PS & TA
e4e6 a4 03                      AND     #$03
e4e8 48                         LSLA
e4e9 97                         TAX
e4ea b6 8c                      LDA     GROUP+6
e4ec e7 c1                      STA     PSN,X
e4ee b6 8d                      LDA     GROUP+7
e4f0 e7 c2                      STA     PSN+1,X

e4f2 3f 79              TACK    CLR     RDSTO           RDS OK, RESET TIME-OUT
e4f4 08 89 04                   BRSET   4,GROUP+3,TAH   TA HIGH ?
e4f7 15 ca                      BCLR    2,STAT3         NO, TA FLAG LOW
e4f9 20 02                      BRA     NTD
e4fb 14 ca              TAH     BSET    2,STAT3         YES, TA FLAG HIGH
```

```
                        *****************************************************
                        *                                                   *
                        *       Process group 0 & 15B (DI & M/S).          *
                        *                                                   *
                        *****************************************************

e4fd b6 89              NTD     LDA     GROUP+3         DI
e4ff a4 03                      AND     #3
e501 97                         TAX
e502 b6 89                      LDA     GROUP+3
e504 a4 40                      AND     #$40
e506 5d                         TSTX
e507 26 07                      BNE     NOT0
e509 11 b0                      BCLR    0,DI
e50b 4d                         TSTA
e50c 27 02                      BEQ     NOT0
e50e 10 b0                      BSET    0,DI
e510 a3 01              NOT0    CPX     #1
e512 26 07                      BNE     NOT1
e514 13 b0                      BCLR    1,DI
e516 4d                         TSTA
e517 27 02                      BEQ     NOT1
e519 12 b0                      BSET    1,DI
e51b a3 02              NOT1    CPX     #2
e51d 26 07                      BNE     NOT2
e51f 15 b0                      BCLR    2,DI
e521 4d                         TSTA
e522 27 02                      BEQ     NOT2
e524 14 b0                      BSET    2,DI
e526 a3 03              NOT2    CPX     #3
e528 26 07                      BNE     NOT3
e52a 17 b0                      BCLR    3,DI
e52c 4d                         TSTA
e52d 27 02                      BEQ     NOT3
e52f 16 b0                      BSET    3,DI

e531 11 ca              NOT3    BCLR    0,STAT3         M/S
e533 07 89 02                   BRCLR   3,GROUP+3,MSZ
e536 10 ca                      BSET    0,STAT3
e538 cc e6 18           MSZ     JMP     OUT1

                        *****************************************************
                        *                                                   *
                        *       Process group 1 (PIN).                      *
                        *                                                   *
                        *****************************************************

e53b a1 10              PROC1   CMP     #$10            GROUP 1A
e53d 27 04                      BEQ     GRP1
e53f a1 18                      CMP     #$18            GROUP 1B
e541 26 0b                      BNE     PROC2

e543 b6 8c              GRP1    LDA     GROUP+6
e545 b7 91                      STA     PIN
e547 b6 8d                      LDA     GROUP+7
e549 b7 92                      STA     PIN+1

e54b cc e6 18                   JMP     OUT1

                        *****************************************************
                        *                                                   *
                        *       Process group 2A (RT).                      *
                        *       Group 2B not handled.                       *
                        *                                                   *
                        *****************************************************

e54e a1 20              PROC2   CMP     #$20            GROUP 2A
e550 26 30                      BNE     PROC4

e552 08 89 07           GRP2    BRSET   4,GROUP+3,TEXTB
e555 02 ca 0c           TEXTA   BRSET   1,STAT3,NCH
e558 12 ca                      BSET    1,STAT3
e55a 20 05                      BRA     LCDINI
e55c 03 ca 05           TEXTB   BRCLR   1,STAT3,NCH
e55f 13 ca                      BCLR    1,STAT3
e561 cd eb aa           LCDINI  JSR     INITD

e564 b6 89              NCH     LDA     GROUP+3         GROUP 2A  -  RT
e566 a4 0f                      AND     #$0F
e568 48                         LSLA
e569 48                         LSLA
e56a 97                         TAX
e56b b6 8a                      LDA     GROUP+4
e56d d7 01 05                   STA     RT+5,X
e570 b6 8b                      LDA     GROUP+5
e572 d7 01 06                   STA     RT+6,X
e575 b6 8c                      LDA     GROUP+6
e577 d7 01 07                   STA     RT+7,X
e57a b6 8d                      LDA     GROUP+7
e57c d7 01 08                   STA     RT+8,X
e57f cc e6 18                   JMP     OUT1
```

```
                        ****************************************************
                        *                                                  *
                        *       Process group 4A (CT).                     *
                        *                                                  *
                        ****************************************************

e582 a1 40              PROC4   CMP     #$40            GROUP 4A  -  CT
e584 27 03                      BEQ     GRP4
e586 cc e6 1b                   JMP     PROC14

e589 b6 89              GRP4    LDA     GROUP+3
e58b 46                         RORA
e58c a4 01                      AND     #$01
e58e b7 74                      STA     BMJD            MJD MS BIT
e590 b6 8a                      LDA     GROUP+4
e592 46                         RORA
e593 b7 75                      STA     BMJD+1          MJD MSD

e595 b6 8c                      LDA     GROUP+6         GROUP 4
e597 36 8b                      ROR     GROUP+5         3210xxxx 4
e599 46                         RORA                    43210xxx x
e59a 44                         LSRA                    -43210xx x
e59b 44                         LSRA                    --43210x x
e59c 44                         LSRA                    ---43210 x
e59d b7 9c                      STA     OUR

e59f b6 8b                      LDA     GROUP+5
e5a1 b7 76                      STA     BMJD+2          MJD LSD

e5a3 b6 8c                      LDA     GROUP+6         xxxx5432 x
e5a5 38 8d                      LSL     GROUP+7         xxxx5432 1
e5a7 49                         ROLA                    xxx54321 x
e5a8 38 8d                      LSL     GROUP+7         xxx54321 0
e5aa 49                         ROLA                    xx543210 x
e5ab a4 3f                      AND     #$3F            --543210 x
e5ad b7 9b                      STA     MIN
e5af 3f 9a                      CLR     SEC
e5b1 3f 99                      CLR     TH8
e5b3 1c ca                      BSET    6,STAT3         UPDATE MJD

                        ****************************************************
                        *                                                  *
                        *       Local time difference adjustment.          *
                        *                                                  *
                        ****************************************************

e5b5 b6 8d              LOCAL   LDA     GROUP+7
e5b7 48                         LSLA
e5b8 27 5e                      BEQ     OUT1            ADJUSTMENT ?
e5ba 24 32                      BCC     POS             YES, POSITIVE ?

e5bc 44                 NEG     LSRA                    NO, NEGATIVE
e5bd 44                         LSRA
e5be 44                         LSRA
e5bf 44                         LSRA
e5c0 97                         TAX                     HOURS IN X
e5c1 24 0c                      BCC     NOTHN           1/2 HOUR ?
e5c3 b6 9b                      LDA     MIN             YES
e5c5 a0 1e                      SUB     #30             SUBTRACT 30 MINUTES
e5c7 2a 04                      BPL     LT60            UNDERFLOW ?
e5c9 ab 3c                      ADD     #60             YES, ADD 60 MINUTES
e5cb 3a 9c                      DEC     OUR             AND SUBTRACT 1 HOUR
e5cd b7 9b              LT60    STA     MIN

e5cf 9f                 NOTHN   TXA                     NEGATIVE HOUR OFFSET
e5d0 b0 9c                      SUB     OUR             MINUS UTC HOURS
e5d2 43                         COMA                    WRONG WAY ROUND SO COMPLEMENT
e5d3 4c                         INCA                    AND INCREMENT
e5d4 2a 14                      BPL     ZOM             UNDERFLOW ?
e5d6 ab 18                      ADD     #24             YES, ADD 24 HOURS
e5d8 b7 9c                      STA     OUR

e5da 3d 76                      TST     BMJD+2          AND SUBTRACT A DAY
e5dc 26 08                      BNE     TT2             LSB WILL UNDERFLOW ?
e5de 3d 75                      TST     BMJD+1          YES
e5e0 26 02                      BNE     TT1             MSB WILL UNDERFLOW ?
e5e2 3a 74                      DEC     BMJD            YES DECREMENT MS BIT
e5e4 3a 75              TT1     DEC     BMJD+1          DECREMENT MSB
e5e6 3a 76              TT2     DEC     BMJD+2          DECREMENT LSB
e5e8 20 2e                      BRA     OUT1

e5ea b7 9c              ZOM     STA     OUR
e5ec 20 2a                      BRA     OUT1

e5ee 44                 POS     LSRA                    POSITIVE ADJUSTMENT
e5ef 44                         LSRA
e5f0 44                         LSRA
e5f1 44                         LSRA
e5f2 97                         TAX                     HOURS IN X
e5f3 24 0e                      BCC     NOTHP           HALF HOUR ?
e5f5 a6 1e                      LDA     #30             YES, ADD 30 MINUTES
e5f7 bb 9b                      ADD     MIN
e5f9 a1 3b                      CMP     #59
e5fb 23 04                      BLS     HDON            OVERFLOW ?
e5fd a0 3c                      SUB     #60             YES, SUBTRACT 60 MINUTES
e5ff 3c 9c                      INC     OUR             AND ADD AN HOUR
e601 b7 9b              HDON    STA     MIN

e603 9f                 NOTHP   TXA                     HOUR OFFSET
e604 bb 9c                      ADD     OUR             ADD UTC HOURS
e606 a1 17                      CMP     #23
e608 23 0c                      BLS     ADDON           OVERFLOW ?
e60a a0 18                      SUB     #24             YES, SUBTRACT 24 HOURS
e60c 3c 76                      INC     BMJD+2          AND ADD A DAY
e60e 26 06                      BNE     ADDON
e610 3c 75                      INC     BMJD+1
e612 26 02                      BNE     ADDON
e614 3c 74                      INC     BMJD
e616 b7 9c              ADDON   STA     OUR
e618 13 c9              OUT1    BCLR    1,STAT2         GROUP HANDLED, CLEAR FLAG
e61a 80                         RTI
```

```
                        ****************************************************
                        *                                                  *
                        *       Process group 14 (EON).                    *
                        *                                                  *
                        ****************************************************

e61b a1 e0              PROC14  CMP     #$E0
e61d 27 03                      BEQ     GRP14A
e61f cc e6 b3                   JMP     OUT2

e622 3f 95              GRP14A  CLR     ITMP1           LOOK FOR PI CODE IN TABLE
e624 be 95              LPIL    LDX     ITMP1
e626 d6 01 45                   LDA     EON,X
e629 b1 8c                      CMP     GROUP+6
e62b 26 69                      BNE     NOTH
e62d d6 01 46                   LDA     EON+1,X
e630 b1 8d                      CMP     GROUP+7
e632 26 62                      BNE     NOTH

                        *       LDA     GROUP+3         TP (ON), NOT USED
                        *       AND     #$10
                        *       LDX     ITMP1
                        *       STA     EON+11,X

e634 b6 89                      LDA     GROUP+3         PI CODE FOUND
e636 a4 0f                      AND     #$0F
e638 a1 04                      CMP     #4              PS ?
e63a 24 10                      BHS     NPS
e63c 48                         LSLA                    YES
e63d bb 95                      ADD     ITMP1
e63f 97                         TAX
e640 b6 8a                      LDA     GROUP+4
e642 d7 01 47                   STA     EON+2,X         SAVE 2 PS-NAME CHARACTERS
e645 b6 8b                      LDA     GROUP+5
e647 d7 01 48                   STA     EON+3,X
e64a 20 cc                      BRA     OUT1

e64c a1 04              NPS     CMP     #4              AF ?
e64e 26 34                      BNE     TRYPIN

e650 b6 8a                      LDA     GROUP+4         YES, METHOD A

e652 a1 fa                      CMP     #250
e654 26 1a                      BNE     NMLW            MEDIUM OR LONG WAVE ?
e656 d6 01 51                   LDA     EON+12,X        YES
e659 a1 ff                      CMP     #$FF            FIRST 2 BYTES ALREADY IN ?
e65b 27 56                      BEQ     OUT2            IF NOT, DO NOTHING
e65d d6 01 53                   LDA     EON+14,X        YES
e660 a1 ff                      CMP     #$FF            M/L FREQUENCY ALREADY IN ?
e662 26 4f                      BNE     OUT2            IF SO, DO NOTHING
e664 a6 fa                      LDA     #250            NO, STORE FIRST FREQUENCY AFTER
e666 d7 01 53                   STA     EON+14,X        ARRIVAL OF INITIAL BYTES
e669 b6 8b                      LDA     GROUP+5
e66b d7 01 54                   STA     EON+15,X
e66e 20 43                      BRA     OUT2

e670 a1 e0              NMLW    CMP     #224            FM
e672 25 0e                      BLO     TOOLS           LEGAL ? (No. OF FREQUENCIES)
e674 a1 f9                      CMP     #249
e676 22 0a                      BHI     TOOLS
e678 be 95                      LDX     ITMP1
e67a d7 01 51                   STA     EON+12,X        YES, SAVE No. OF FREQUENCIES
e67d b6 8b                      LDA     GROUP+5
e67f d7 01 52                   STA     EON+13,X        AND FIRST FREQUENCY
e682 20 2f              TOOLS   BRA     OUT2

                        *TRYPTY CMP     #$0D
                        *       BNE     TRYPIN
                        *       LDA     GROUP+4         PTY (EON), NOT USED
                        *       LSRA
                        *       LSRA
                        *       LSRA
                        *       LDX     ITMP1
                        *       STA     EON+10,X
                        *       BRA     OUT2

e684 a1 0e              TRYPIN  CMP     #$0E
e686 26 2b                      BNE     OUT2
e688 be 95                      LDX     ITMP1           PIN
e68a b6 8a                      LDA     GROUP+4
e68c d7 01 4f                   STA     EON+10,X
e68f b6 8b                      LDA     GROUP+5
e691 d7 01 50                   STA     EON+11,X
e694 20 1d                      BRA     OUT2

e696 a1 ff              NOTH    CMP     #$FF            END OF PI LIST ?
e698 26 0c                      BNE     NOTH1
e69a b6 8c                      LDA     GROUP+6         YES, ADD THIS PI CODE
e69c d7 01 45                   STA     EON,X
e69f b6 8d                      LDA     GROUP+7         TO EON TABLE
e6a1 d7 01 46                   STA     EON+1,X
e6a4 20 0d                      BRA     OUT2

e6a6 b6 95              NOTH1   LDA     ITMP1           NOT END, TRY NEXT ENTRY
e6a8 ab 10                      ADD     #16
e6aa b7 95                      STA     ITMP1
e6ac a1 b0                      CMP     #$B0            END OF TABLE (11 ENTRIES) ?
e6ae 27 03                      BEQ     OUT2
e6b0 cc e6 24                   JMP     LPIL

e6b3 13 c9              OUT2    BCLR    1,STAT2         GROUP HANDLED, CLEAR FLAG
e6b5 80                         RTI
```

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                        ****************************************************
                        *                                                  *
                        *       Display type selection.                    *
                        *                                                  *
                        ****************************************************

e6b6 09 c9 05           MOD     BRCLR   4,STAT2,NOCL    SHOULD DISPALY BE INITIALISED ?
e6b9 cd eb aa                   JSR     INITD           YES, DO IT
e6bc 19 c9                      BCLR    4,STAT2         AND CLEAR FLAG
e6be cd eb 6c           NOCL    JSR     WAIT
e6c1 a6 0c                      LDA     #$0C            SWITCH DISPLAY ON
e6c3 cd eb 65                   JSR     CLOCK           LATCH IT
e6c6 cd eb 6c                   JSR     WAIT
                        *       LDA     #$38            /16 DISPLAY
e6c9 a6 30                      LDA     #$30            /8  DISPLAY
e6cb cd eb 65                   JSR     CLOCK           LATCH IT
e6ce cd eb 6c                   JSR     WAIT
e6d1 a6 80                      LDA     #$80            ADDRESS DISPLAY RAM
e6d3 cd eb 65                   JSR     CLOCK           LATCH IT

e6d6 06 04 0b                   BRSET   3,PORTE,TRYRT   STANDBY ?
e6d9 04 cb 59                   BRSET   2,STAT4,SLPD    YES, SLEEP DISPLAY ?
e6dc 06 cb 66                   BRSET   3,STAT4,ALRMJ   NO, ALARM DISPLAY ?
e6df cd e8 69                   JSR     STBYD           NO, NORMAL STANDBY DISPLAY
e6e2 20 64                      BRA     ROW1

e6e4 0f cb 46           TRYRT   BRCLR   7,STAT4,RTITS   RDS DISPLAYS ?
e6e7 b6 af                      LDA     RTDIS
e6e9 a1 01                      CMP     #1
e6eb 26 05                      BNE     NPTY
e6ed cd e8 19                   JSR     PTYD            PTY
e6f0 20 56                      BRA     ROW1

e6f2 a1 02              NPTY    CMP     #2
e6f4 26 05                      BNE     NPI
e6f6 cd e8 fa                   JSR     DIPI            PI
e6f9 20 4d                      BRA     ROW1

e6fb a1 03              NPI     CMP     #3
e6fd 26 05                      BNE     NTAP
e6ff cd e9 5a                   JSR     DITAP           TA & TP
e702 20 44                      BRA     ROW1

e704 a1 04              NTAP    CMP     #4
e706 26 05                      BNE     NPIN1
e708 cd e9 72                   JSR     DPIN1           PIN - HEX
e70b 20 3b                      BRA     ROW1

e70d a1 05              NPIN1   CMP     #5
e70f 26 05                      BNE     NPIN2
e711 cd e9 92                   JSR     DPIN2           PIN - DAY AND TIME
e714 20 32                      BRA     ROW1

e716 a1 06              NPIN2   CMP     #6
e718 26 05                      BNE     NMJD
e71a cd e9 f6                   JSR     DMJD            MJD
e71d 20 29                      BRA     ROW1

e71f a1 07              NMJD    CMP     #7
e721 26 05                      BNE     NMSD
e723 cd eb 03                   JSR     DMSD            M/S & DI
e726 20 20                      BRA     ROW1

e728 cd ea 25           NMSD    JSR     DEON
e72b 20 1b                      BRA     ROW1

e72d 05 c9 05           RTITS   BRCLR   2,STAT2,SLPD    RT DISPLAY ?
e730 cd e8 4a                   JSR     RTDS
e733 20 13                      BRA     ROW1

e735 05 cb 05           SLPD    BRCLR   2,STAT4,NRMD    SLEEP TIMER DISPLAY ?
e738 cd ea ee                   JSR     SLEEPD
e73b 20 0b                      BRA     ROW1

e73d 06 cb 05           NRMD    BRSET   3,STAT4,ALRMJ   ALARM DISPLAY ?
e740 cd e7 cc                   JSR     NORMD
e743 20 03                      BRA     ROW1

e745 cd e9 1a           ALRMJ   JSR     ALRMD

e748 5f                 ROW1    CLRX
e749 cd eb 6c           LCD     JSR     WAIT
e74c 14 03                      BSET    2,PORTD         WRITE DATA
e74e e6 b1                      LDA     DISP,X          GET A BYTE
e750 a1 ff                      CMP     #$FF
e752 26 02                      BNE     COK
e754 a6 2d                      LDA     #$2D
e756 cd eb 65           COK     JSR     CLOCK           SEND IT TO MODULE
e759 5c                         INCX
e75a a3 10                      CPX     #16             DONE ?
e75c 26 eb                      BNE     LCD
e75e 20 1e                      BRA     VFD             REMOVE FOR /16 LCDs

                        ****************************************************
                        *                                                  *
                        *       Additional bits for /16 LCD modules.       *
                        *                                                  *
                        ****************************************************

e760 cd eb 6c           LCD401  JSR     WAIT
e763 a6 a8                      LDA     #$A8            TO 40
e765 cd eb 65                   JSR     CLOCK           SEND IT TO MODULE
e768 5f                         CLRX
e769 cd eb 6c           LCD41   JSR     WAIT
e76c 14 03                      BSET    2,PORTD         WRITE DATA
e76e e6 b9                      LDA     DISP+8,X        GET A BYTE
e770 a1 ff                      CMP     #$FF
e772 26 02                      BNE     COK2
e774 a6 2d                      LDA     #$2D
e776 cd eb 65           COK2    JSR     CLOCK           SEND IT TO MODULE
e779 5c                         INCX
e77a a3 08                      CPX     #8              DONE ?
e77c 26 eb                      BNE     LCD41
```

```
                        *****************************************************
                        *                                                   *
                        *       VFD.                                        *
                        *                                                   *
                        *****************************************************

e77e 13 01              VFD     BCLR    1,PORTB         DATA LOW ?
e780 10 01                      BSET    0,PORTB         CLOCK HIGH ?
e782 17 01                      BCLR    3,PORTB         ENABLE LOW

e784 5f                         CLRX                    SEND VFD SET-UP BYTES
e785 d6 e7 c5           DIS5    LDA     INITF,X
e788 bf a7                      STX     W7              SAVE INDEX
e78a ad 20                      BSR     VFDL
e78c a3 07                      CPX     #7
e78e 26 f5                      BNE     DIS5            LAST BYTE ?

e790 5f                         CLRX                    SEND 16 CHARACTER BYTES
e791 bf a7              VFD3    STX     W7              SAVE INDEX
e793 e6 b1                      LDA     DISP,X          ASCII
e795 a1 ff                      CMP     #$FF
e797 26 02                      BNE     NOTFF
e799 a6 2d                      LDA     #$2D            REPLACE $FF WITH "-"
e79b a4 7f              NOTFF   AND     #$7F            IGNORE BIT 7
e79d 97                         TAX
e79e d6 ed ae                   LDA     VTAB,X          CONVERT TO VFD CHARACTER SET
e7a1 ad 09                      BSR     VFDL
e7a3 a3 10                      CPX     #16
e7a5 26 ea                      BNE     VFD3            LAST BYTE ?

e7a7 16 01                      BSET    3,PORTB         ENABLE HIGH
e7a9 11 01                      BCLR    0,PORTB         CLOCK LOW ?
e7ab 81                         RTS

e7ac ae 08              VFDL    LDX     #8
e7ae 44                 DIS3    LSRA                    GET A BIT
e7af 24 02                      BCC     DIS4
e7b1 12 01                      BSET    1,PORTB         DATA HIGH
e7b3 11 01              DIS4    BCLR    0,PORTB         CLOCK
e7b5 10 01                      BSET    0,PORTB         IT
e7b7 13 01                      BCLR    1,PORTB         CLEAR DATA
e7b9 5a                         DECX                    COMPLETE ?
e7ba 26 f2                      BNE     DIS3            NO
e7bc ae 40                      LDX     #64
e7be 5a                 DEL     DECX                    WAIT 200uS
e7bf 26 fd                      BNE     DEL
e7c1 be a7                      LDX     W7              RESTORE INDEX
e7c3 5c                         INCX
e7c4 81                         RTS

e7c5 a0 0f b0 00 80 00  INITF   FCB     $A0,$0F,$B0,$00,$80,$00,$90
90

                        *****************************************************
                        *                                                   *
                        *       Normal display (PS and time).               *
                        *                                                   *
                        *****************************************************

e7cc a6 20              NORMD   LDA     #$20
e7ce b7 b1                      STA     DISP
e7d0 b7 ba                      STA     DISP+9
e7d2 b7 c0                      STA     DISP+15
e7d4 a6 2e                      LDA     #$2E            .
e7d6 03 cb 05                   BRCLR   1,STAT4,TYP1    DP TO INDICATE SLEEP TIMER RUNNING
e7d9 05 99 02                   BRCLR   2,TH8,TYP1      FLASH IT
e7dc b7 c0                      STA     DISP+15

e7de 5f                 TYP1    CLRX
e7df e6 c1              MPS     LDA     PSN,X           GET PS NAME
e7e1 e7 b2                      STA     DISP+1,X
e7e3 5c                 SCNG    INCX
e7e4 a3 07                      CPX     #7
e7e6 23 f7                      BLS     MPS

e7e8 b6 9c              CJ      LDA     OUR             GET TIME
e7ea cd eb 84                   JSR     CBCD
e7ed a3 30                      CPX     #$30            LEADING ZERO ?
e7ef 26 02                      BNE     TNZ
e7f1 ae 20                      LDX     #$20            YES, MAKE IT A SPACE
e7f3 bf bb              TNZ     STX     DISP+10
e7f5 b7 bc                      STA     DISP+11
e7f7 b6 9b              CMIN    LDA     MIN
e7f9 cd eb 84                   JSR     CBCD
e7fc bf be                      STX     DISP+13
e7fe b7 bf                      STA     DISP+14
e800 a6 20              CSEC    LDA     #$20
e802 05 99 02                   BRCLR   2,TH8,DDC
e805 a6 3a                      LDA     #$3A            0.5 Hz FLASHING COLON
e807 b7 bd              DDC     STA     DISP+12
e809 81                         RTS

                        *****************************************************
                        *                                                   *
                        *       Clear display transient flags.              *
                        *                                                   *
                        *****************************************************

e80a 11 cb              CLTR    BCLR    0,STAT4         CLEAR DISPLAY TRANSIENT FLAG
e80c 15 c9                      BCLR    2,STAT2         NOT RT DISPLAY
e80e 3f af                      CLR     RTDIS           CLEAR RDS DISPLAY INDEX
e810 17 cb                      BCLR    3,STAT4         NOT ALARM DISPLAY
e812 1b cb                      BCLR    5,STAT4         NOT ALARM SET-UP
e814 1f cb                      BCLR    7,STAT4         NOT RDS DISPLAYS
e816 15 cb                      BCLR    2,STAT4         NOT SLEEP TIMER DISPLAY
e818 81                         RTS
```

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                        *****************************************************
                        *                                                   *
                        *       PTY display.                                *
                        *                                                   *
                        *****************************************************

e819 be 8e              PTYD    LDX     PTY             PTY
e81b a3 10                      CPX     #16
e81d 25 01                      BLO     XOK2
e81f 5f                         CLRX
e820 a6 10              XOK2    LDA     #16
e822 42                         MUL
e823 b7 a8                      STA     W8
e825 3f a7                      CLR     W7
e827 be a8              LCD3    LDX     W8
e829 d6 ec ae                   LDA     PTYT,X
e82c be a7                      LDX     W7
e82e e7 b1                      STA     DISP,X          WAS MOD2
e830 3c a8                      INC     W8
e832 3c a7                      INC     W7
e834 b6 a7                      LDA     W7
e836 a1 10                      CMP     #16
e838 25 ed                      BLO     LCD3
e83a 81                         RTS

                        *****************************************************
                        *                                                   *
                        *       RDS display.                                *
                        *                                                   *
                        *****************************************************

e83b be a0              NXTC    LDX     DISP2
e83d e6 ff                      LDA     RT-1,X          RT
e83f a1 20                      CMP     #$20
e841 26 13                      BNE     NOTSP           SPACE ?
e843 0b c9 0c                   BRCLR   5,STAT2,FSP     YES, FIRST ONE ?
e846 3c 9f                      INC     DISP1           NO, SKIP THIS ONE
e848 3c a0                      INC     DISP2
e84a b6 a0              RTDS    LDA     DISP2
e84c a1 45              SKP1    CMP     #69
e84e 22 18                      BHI     LCD4            END OF RT BUFFER
e850 20 e9                      BRA     NXTC            NO, GET NEXT CHARACTER

e852 1a c9              FSP     BSET    5,STAT2         FIRST SPACE, SET FLAG
e854 20 02                      BRA     CONT
e856 1b c9              NOTSP   BCLR    5,STAT2         NOT A SPACE, CLEAR FLAG
e858 b7 a8              CONT    STA     W8              SAVE NEW CHARACTER
e85a 5f                         CLRX
e85b e6 b2              ILP1    LDA     DISP+1,X        MOVE
e85d e7 b1                      STA     DISP,X          REST
e85f 5c                         INCX                    LEFT
e860 a3 0f                      CPX     #15             ONE
e862 26 f7                      BNE     ILP1            PLACE
e864 b6 a8                      LDA     W8
e866 b7 c0                      STA     DISP+15         ADD NEW CHAR. (WAS MOD2)
e868 81                 LCD4    RTS


                        *****************************************************
                        *                                                   *
                        *       Standby display.                            *
                        *                                                   *
                        *****************************************************

e869 08 cb 4f           STBYD   BRSET   4,STAT4,ALRMA   ALARM ARMED ?
e86c b6 73                      LDA     DOW             NO, GET DAY OF WEEK
e86e 48                         LSLA
e86f bb 73                      ADD     DOW
e871 97                         TAX
e872 d6 ec 72                   LDA     DNAME,X
e875 b7 b1                      STA     DISP
e877 d6 ec 73                   LDA     DNAME+1,X
e87a b7 b2                      STA     DISP+1
e87c d6 ec 74                   LDA     DNAME+2,X
e87f b7 b3                      STA     DISP+2
e881 a6 20                      LDA     #$20
e883 b7 b4                      STA     DISP+3
e885 b7 b7                      STA     DISP+6
e887 b7 bb                      STA     DISP+10
e889 b6 72                      LDA     DOM+1           DATE
e88b ab 30                      ADD     #$30
e88d b7 b6                      STA     DISP+5
e88f b6 71                      LDA     DOM
e891 27 02                      BEQ     ADD20           IF ZERO USE A SPACE
e893 ab 10                      ADD     #$10            IF NOT MAKE ASCII
e895 ab 20              ADD20   ADD     #$20
e897 b7 b5                      STA     DISP+4
e899 be 70                      LDX     MNTH+1          MONTH, LSD
e89b b6 6f                      LDA     MNTH            MONTH, MSD
e89d 27 04                      BEQ     MTHZ
e89f 9f                         TXA
e8a0 ab 0a                      ADD     #10
e8a2 97                         TAX
e8a3 bf a8              MTHZ    STX     W8
e8a5 9f                         TXA
e8a6 48                         LSLA
e8a7 bb a8                      ADD     W8
e8a9 97                         TAX
e8aa d6 ec 87                   LDA     MNAME-3,X
e8ad b7 b8                      STA     DISP+7
e8af d6 ec 88                   LDA     MNAME-2,X
e8b2 b7 b9                      STA     DISP+8
e8b4 d6 ec 89                   LDA     MNAME-1,X
e8b7 b7 ba                      STA     DISP+9
e8b9 20 1d                      BRA     STIME
```

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                        *****************************************************
                        *                                                   *
                        *       Standby (alarm armed) display.              *
                        *                                                   *
                        *****************************************************

e8bb b6 9e              ALRMA   LDA     AOUR            GET ALARM HOURS
e8bd cd eb 84                   JSR     CBCD
e8c0 bf b1                      STX     DISP
e8c2 b7 b2                      STA     DISP+1
e8c4 b6 9d                      LDA     AMIN
e8c6 cd eb 84                   JSR     CBCD
e8c9 bf b3                      STX     DISP+2
e8cb b7 b4                      STA     DISP+3
e8cd 5f                         CLRX
e8ce d6 eb f3           ALOP2   LDA     ALARMS+1,X
e8d1 e7 b5                      STA     DISP+4,X
e8d3 5c                         INCX
e8d4 a3 06                      CPX     #6
e8d6 23 f6                      BLS     ALOP2
e8d8 b6 9c              STIME   LDA     OUR             GET TIME
e8da cd eb 84                   JSR     CBCD
e8dd a3 30                      CPX     #$30            LEADING ZERO ?
e8df 26 02                      BNE     TMZ
e8e1 ae 20                      LDX     #$20            YES, MAKE IT A SPACE
e8e3 bf bc              TMZ     STX     DISP+11
e8e5 b7 bd                      STA     DISP+12
e8e7 b6 9b                      LDA     MIN
e8e9 cd eb 84                   JSR     CBCD
e8ec bf bf                      STX     DISP+14
e8ee b7 c0                      STA     DISP+15
e8f0 a6 20                      LDA     #$20
e8f2 05 99 02                   BRCLR   2,TH8,DTF       FLASH ?
e8f5 a6 3a                      LDA     #$3A            0.5 Hz FLASHING COLON
e8f7 b7 be              DTF     STA     DISP+13
e8f9 81                         RTS

                        *****************************************************
                        *                                                   *
                        *       PI display.                                 *
                        *                                                   *
                        *****************************************************

e8fa 5f                 DIPI    CLRX
e8fb d6 ec 02           DLOP    LDA     PIST,X
e8fe e7 b1                      STA     DISP,X
e900 5c                         INCX
e901 a3 0f                      CPX     #15
e903 23 f6                      BLS     DLOP
e905 b6 8f                      LDA     PI
e907 27 10                      BEQ     PINV
e909 cd eb 48                   JSR     SPLIT
e90c bf bc                      STX     DISP+11
e90e b7 bd                      STA     DISP+12
e910 b6 90                      LDA     PI+1
e912 cd eb 48                   JSR     SPLIT
e915 bf be                      STX     DISP+13
e917 b7 bf                      STA     DISP+14
e919 81                 PINV    RTS

                        *****************************************************
                        *                                                   *
                        *       Alarm display.                              *
                        *                                                   *
                        *****************************************************

e91a 5f                 ALRMD   CLRX                    YES
e91b d6 eb f2           ALOP    LDA     ALARMS,X
e91e e7 b1                      STA     DISP,X
e920 5c                         INCX
e921 a3 0f                      CPX     #15
e923 23 f6                      BLS     ALOP
e925 09 cb 31                   BRCLR   4,STAT4,ALOF2   ALARM ARMED ?
e928 a6 3a                      LDA     #$3A            YES
e92a b7 bd                      STA     DISP+12
e92c b6 9e                      LDA     AOUR            GET ALARM HOURS
e92e cd eb 84                   JSR     CBCD
e931 a3 30                      CPX     #$30            LEADING ZERO ?
e933 26 02                      BNE     TN3
e935 ae 20                      LDX     #$20            YES, MAKE IT A SPACE
e937 bf bb              TN3     STX     DISP+10
e939 b7 bc                      STA     DISP+11
e93b b6 9d                      LDA     AMIN
e93d cd eb 84                   JSR     CBCD
e940 bf be                      STX     DISP+13
e942 b7 bf                      STA     DISP+14
e944 0b cb 12                   BRCLR   5,STAT4,ALOF2   SET-UP ?
e947 05 99 0f                   BRCLR   2,TH8,ALOF2
e94a a6 20                      LDA     #$20
e94c 0c cb 06                   BRSET   6,STAT4,FH      HOURS ?
e94f b7 be                      STA     DISP+13         NO, FLASH MINUTES
e951 b7 bf                      STA     DISP+14
e953 20 04                      BRA     ALOF2
e955 b7 bb              FH      STA     DISP+10         YES, FLASH HOURS
e957 b7 bc                      STA     DISP+11
e959 81                 ALOF2   RTS

                        *****************************************************
                        *                                                   *
                        *       TA & TP flags display.                      *
                        *                                                   *
                        *****************************************************

e95a 5f                 DITAP   CLRX
e95b d6 ec 12           BLOP    LDA     TAPST,X
e95e e7 b1                      STA     DISP,X
e960 5c                         INCX
e961 a3 0f                      CPX     #15
e963 23 f6                      BLS     BLOP
e965 a6 31                      LDA     #$31
e967 07 ca 02                   BRCLR   3,STAT3,TPLOW   TP FLAG HIGH ?
e96a b7 b7                      STA     DISP+6          YES, DISPLAY A 1
e96c 05 ca 02           TPLOW   BRCLR   2,STAT3,TALOW   TA FLAG HIGH ?
e96f b7 bf                      STA     DISP+14         YES, DISPLAY A 1
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
```

```
                        ****************************************************
                        *                                                  *
                        *       EON display.                               *
                        *                                                  *
                        ****************************************************

ea25 cd ea 19           DEON    JSR     SMJD            CLEAR FREQUENCY CHARACTERS
ea28 b6 af                      LDA     RTDIS
ea2a a0 08                      SUB     #8
ea2c ae 10                      LDX     #16
ea2e 42                         MUL
ea2f 97                         TAX
ea30 a6 20                      LDA     #$20
ea32 b7 b9                      STA     DISP+8
ea34 b7 ba                      STA     DISP+9
ea36 d6 01 47                   LDA     EON+2,X         DISPLAY PS (EON)
ea39 b7 b1                      STA     DISP
ea3b d6 01 48                   LDA     EON+3,X
ea3e b7 b2                      STA     DISP+1
ea40 d6 01 49                   LDA     EON+4,X
ea43 b7 b3                      STA     DISP+2
ea45 d6 01 4a                   LDA     EON+5,X
ea48 b7 b4                      STA     DISP+3
ea4a d6 01 4b                   LDA     EON+6,X
ea4d b7 b5                      STA     DISP+4
ea4f d6 01 4c                   LDA     EON+7,X
ea52 b7 b6                      STA     DISP+5
ea54 d6 01 4d                   LDA     EON+8,X
ea57 b7 b7                      STA     DISP+6
ea59 d6 01 4e                   LDA     EON+9,X
ea5c b7 b8                      STA     DISP+7

ea5e d6 01 52                   LDA     EON+13,X
ea61 a1 cd                      CMP     #205            FILLER ?
ea63 26 04                      BNE     NFIL
ea65 5c                         INCX
ea66 d6 01 52                   LDA     EON+13,X        YES, TRY AGAIN
ea69 a1 fa              NFIL    CMP     #250            MEDIUM/LONG ?
ea6b 27 43                      BEQ     MLWF
ea6d a1 cc                      CMP     #204            NO, FREQUENCY OK ?
ea6f 22 3e                      BHI     FNOK2
ea71 ae 0a              FOK2    LDX     #10             VHF
ea73 42                         MUL
ea74 ab 2e                      ADD     #$2E            CALCULATE FREQUENCY (BINARY)
ea76 b7 a1                      STA     W1
ea78 9f                         TXA
ea79 a9 22                      ADC     #$22
ea7b b7 a2                      STA     W2
ea7d cd eb 1f                   JSR     DCON2           CONVERT TO DECIMAL

ea80 b6 34              TYPE3   LDA     Q+4             DISPLAY VHF EON FREQUENCY
ea82 26 02                      BNE     NZ1
ea84 a6 f0                      LDA     #$F0
ea86 ab 30              NZ1     ADD     #$30
ea88 b7 bb                      STA     DISP+10
ea8a 97                         TAX
ea8b b6 35                      LDA     Q+5
ea8d 26 06                      BNE     NZ2
ea8f a3 20                      CPX     #$20
ea91 26 02                      BNE     NZ2
ea93 a6 f0                      LDA     #$F0
ea95 ab 30              NZ2     ADD     #$30
ea97 b7 bc                      STA     DISP+11
ea99 b6 36                      LDA     Q+6
ea9b ab 30                      ADD     #$30
ea9d b7 bd                      STA     DISP+12
ea9f a6 2e                      LDA     #$2E
eaa1 b7 be                      STA     DISP+13
eaa3 b6 37                      LDA     Q+7
eaa5 ab 30                      ADD     #$30
eaa7 b7 bf                      STA     DISP+14
eaa9 b6 38                      LDA     Q+8
eaab ab 30                      ADD     #$30
eaad b7 c0                      STA     DISP+15
eaaf 81                 FNOK2   RTS

eab0 5c                 MLWF    INCX                    DISPLAY M/L EON FREQUENCY
eab1 d6 01 52                   LDA     EON+13,X
eab4 a1 0f                      CMP     #15
eab6 23 02                      BLS     LONG
eab8 ab 1b                      ADD     #27             MW OFFSET
eaba ab 10              LONG    ADD     #16             M/L OFFSET
eabc ae 09                      LDX     #9
eabe 42                         MUL
eabf bf a2                      STX     W2
eac1 b7 a1                      STA     W1
eac3 ad 5a                      BSR     DCON2           CONVERT TO BCD IN Q
eac5 b6 35                      LDA     Q+5
eac7 26 02                      BNE     NZ3             IF THOUSANDS OF kHz A ZERO
eac9 a6 f0                      LDA     #$F0            DISPLAY AS A SPACE
eacb ab 30              NZ3     ADD     #$30
eacd b7 ba                      STA     DISP+9
eacf b6 36                      LDA     Q+6
ead1 ab 30                      ADD     #$30
ead3 b7 bb                      STA     DISP+10
ead5 b6 37                      LDA     Q+7
ead7 ab 30                      ADD     #$30
ead9 b7 bc                      STA     DISP+11
eadb b6 38                      LDA     Q+8
eadd ab 30                      ADD     #$30
eadf b7 bd                      STA     DISP+12
eae1 a6 6b                      LDA     #'k'
eae3 b7 be                      STA     DISP+13
eae5 a6 48                      LDA     #'H'
eae7 b7 bf                      STA     DISP+14
eae9 a6 7a                      LDA     #'z'
eaeb b7 c0                      STA     DISP+15
eaed 81                         RTS
```

```
                        *****************************************************
                        *                                                   *
                        *       Sleep display.                              *
                        *                                                   *
                        *****************************************************

eaee 5f                 SLEEPD  CLRX
eaef d6 ec 52           SLOP    LDA     SLPST,X
eaf2 e7 b1                      STA     DISP,X
eaf4 5c                         INCX
eaf5 a3 0f                      CPX     #15
eaf7 23 f6                      BLS     SLOP
eaf9 b6 78                      LDA     SLEPT
eafb cd eb 84                   JSR     CBCD
eafe bf b9                      STX     DISP+8
eb00 b7 ba                      STA     DISP+9
eb02 81                         RTS

                        *****************************************************
                        *                                                   *
                        *       M/S & DI display.                           *
                        *                                                   *
                        *****************************************************

eb03 5f                 DMSD    CLRX
eb04 d6 ec 62           ILOP    LDA     MSDST,X
eb07 e7 b1                      STA     DISP,X
eb09 5c                         INCX
eb0a a3 0f                      CPX     #15
eb0c 23 f6                      BLS     ILOP
eb0e 01 ca 04                   BRCLR   0,STAT3,MSM2    M/S FLAG SET
eb11 a6 4d                      LDA     #'M'            YES, MUSIC
eb13 b7 b7                      STA     DISP+6
eb15 b6 b0              MSM2    LDA     DI
eb17 cd eb 84                   JSR     CBCD
eb1a bf be                      STX     DISP+13
eb1c b7 bf                      STA     DISP+14
eb1e 81                         RTS

                        ********************************************************
                        *                                                      *
                        *       Convert binary to unpacked BCD in Q.           *
                        *                                                      *
                        ********************************************************

eb1f ae 54              DCON2   LDX     #R              CLEAR
eb21 bf ad                      STX     NUM1
eb23 cd ef 86                   JSR     CLRAS           RR
eb26 3c 5c                      INC     R+8             R <- 1
eb28 cd ef 84                   JSR     CLQ             CLEAR RQ
eb2b a6 0e                      LDA     #14             14 BITS TO CONVERT
eb2d b7 a6                      STA     W6
eb2f 34 a2              LOOP2   LSR     W2              MOVE OUT
eb31 36 a1                      ROR     W1              FIRST (LS) BIT
eb33 24 07                      BCC     NXT             ZERO
eb35 ae 30                      LDX     #Q              ONE, ADD
eb37 bf ae                      STX     NUM2            CURRENT VALUE
eb39 cd ee 33                   JSR     ADD             OF R
eb3c ae 54              NXT     LDX     #R              ADD R
eb3e bf ae                      STX     NUM2            TO
eb40 cd ee 33                   JSR     ADD             ITSELF
eb43 3a a6                      DEC     W6              ALL
eb45 26 e8                      BNE     LOOP2           DONE ?
eb47 81                         RTS

                        *****************************************************
                        *                                                   *
                        *       Split A nibbles into A (LS) and X (MS)      *
                        *       and convert to ASCII.                       *
                        *                                                   *
                        *****************************************************

eb48 97                 SPLIT   TAX                     MSD INTO X, LSD INTO A
eb49 99                         SEC
eb4a 56                         RORX
eb4b 99                         SEC
eb4c 56                         RORX
eb4d 54                         LSRX
eb4e 54                         LSRX
eb4f a3 39                      CPX     #$39            $30-$39 <- 0-9
eb51 23 07                      BLS     XOK
eb53 5c                         INCX
eb54 5c                         INCX
eb55 5c                         INCX
eb56 5c                         INCX
eb57 5c                         INCX
eb58 5c                         INCX
eb59 5c                         INCX
eb5a a4 0f              XOK     AND     #$0F            $41-$46 <- A-F
eb5c ab 30                      ADD     #$30
eb5e a1 39                      CMP     #$39
eb60 23 02                      BLS     AOK
eb62 ab 07                      ADD     #7
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
```

```
                        ****************************************************
                        *                                                  *
                        *       Display strings.                           *
                        *                                                  *
                        ****************************************************

ebf2 20 20 41 6c 61 72  ALARMS  FCC     '  Alarm -  OFF  '
6d 20 2d 20 20 4f
46 46 20 20
ec02 20 50 49 20 63 6f  PIST    FCC     ' PI code -      '
64 65 20 2d 20 20
20 20 20 20
ec12 20 54 50 20 2d 20  TAPST   FCC     ' TP - 0  TA - 0 '
30 20 20 54 41 20
2d 20 30 20
ec22 20 50 49 4e 20 6e  PINST1  FCC     ' PIN no. -      '
6f 2e 20 2d 20 20
20 20 20 20
ec32 20 20 20 20 74 68  PINST2  FCC     '    th at --.-- '
20 61 74 20 2d 2d
2e 2d 2d 20
ec42 20 4d 4a 20 64 61  MJDST   FCC     ' MJ day -       '
79 20 2d 20 20 20
20 20 20 20
ec52 20 53 6c 65 65 70  SLPST   FCC     ' Sleep   0 min. '
20 20 20 30 20 6d
69 6e 2e 20
ec62 20 4d 2f 53 20 20  MSDST   FCC     ' M/S  S   DI  0 '
53 20 20 20 44 49
20 20 30 20

                        ****************************************************
                        *                                                  *
                        *       MJD day and month strings.                 *
                        *                                                  *
                        ****************************************************

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

ec87 69 6e 76                   FCC     'inv'

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


                        ****************************************************
                        *                                                  *
                        *       Programme Type (PTY) Codes.                *
                        *                                                  *
                        ****************************************************

ecae 6e 6f 20 70 72 6f  PTYT    FCC     'no program type '  0
67 72 61 6d 20 74
79 70 65 20
ecbe 20 20 20 20 20 20          FCC     '      News      '  1
4e 65 77 73 20 20
20 20 20 20
ecce 43 75 72 72 65 6e          FCC     'Current affairs '  2
74 20 61 66 66 61
69 72 73 20
ecde 20 20 49 6e 66 6f          FCC     '  Information   '  3
72 6d 61 74 69 6f
6e 20 20 20
ecee 20 20 20 20 20 53          FCC     '     Sport      '  4
70 6f 72 74 20 20
20 20 20 20
ecfe 20 20 20 45 64 75          FCC     '   Education    '  5
63 61 74 69 6f 6e
20 20 20 20
ed0e 20 20 20 20 20 44          FCC     '     Drama      '  6
72 61 6d 61 20 20
20 20 20 20
ed1e 20 20 20 20 43 75          FCC     '    Culture     '  7
6c 74 75 72 65 20
20 20 20 20
ed2e 20 20 20 20 53 63          FCC     '    Science     '  8
69 65 6e 63 65 20
20 20 20 20
ed3e 20 20 20 20 20 56          FCC     '     Varied     '  9
61 72 69 65 64 20
20 20 20 20
ed4e 20 20 20 50 6f 70          FCC     '   Pop music    ' 10
20 6d 75 73 69 63
20 20 20 20
ed5e 20 20 20 52 6f 63          FCC     '   Rock music   ' 11
6b 20 6d 75 73 69
63 20 20 20
ed6e 20 45 61 73 79 20          FCC     ' Easy listening ' 12
6c 69 73 74 65 6e
69 6e 67 20
ed7e 20 4c 69 67 68 74          FCC     ' Light classics ' 13
20 63 6c 61 73 73
69 63 73 20
ed8e 53 65 72 69 6f 75          FCC     'Serious classics' 14
73 20 63 6c 61 73
73 69 63 73
ed9e 20 20 4f 74 68 65          FCC     '  Other music   ' 15
72 20 6d 75 73 69
63 20 20 20
```

```
                        ****************************************************
                        *                                                  *
                        *               VFD character set.                 *
                        *                                                  *
                        *       Position in table is ASCII value.          *
                        *       Entry is the VFD character used.           *
                        *       Last column shows characters replaced      *
                        *       by spaces. $00 to $1F are ASCII control    *
                        *       characters and shouldn't occur.            *
                        *       : has been entered as -                    *
                        *       / has been entered as -                    *
                        *       " has been entered as '                    *
                        *                                                  *
                        ****************************************************

edae 7e 7e 7e 7e        VTAB    FCB     $7E,$7E,$7E,$7E                  all
edb2 7e 7e 7e 7e                FCB     $7E,$7E,$7E,$7E                  all
edb6 7e 7e 7e 7e                FCB     $7E,$7E,$7E,$7E                  all
edba 7e 7e 7e 7e                FCB     $7E,$7E,$7E,$7E                  all

edbe 7e 7e 7e 7e                FCB     $7E,$7E,$7E,$7E                  all
edc2 7e 7e 7e 7e                FCB     $7E,$7E,$7E,$7E                  all
edc6 7e 7e 7e 7e                FCB     $7E,$7E,$7E,$7E                  all
edca 7e 7e 7e 7e                FCB     $7E,$7E,$7E,$7E                  all

edce 7e 7b 7a 7e                FCB     $7E,$7B,$7A,$7E       !  "  #    #
edd2 7e 7e 7e 7a                FCB     $7E,$7E,$7E,$7A    $  %  &  '    $%&
edd6 7e 7e 7e 7e                FCB     $7E,$7E,$7E,$7E    (  )  *  +    all
edda 3f 7d 3e 7d                FCB     $3F,$7D,$3E,$7D    ,  -  .  /

edde 00 01 02 03                FCB     $00,$01,$02,$03    0  1  2  3
ede2 04 05 06 07                FCB     $04,$05,$06,$07    4  5  6  7
ede6 08 09 7d 7e                FCB     $08,$09,$7D,$7E    8  9  :  ;    ;
edea 7e 7e 7e 7c                FCB     $7E,$7E,$7E,$7C    <  =  >  ?    <=>

edee 7e 0a 0b 0c                FCB     $7E,$0A,$0B,$0C    @  A  B  C    @
edf2 0d 0e 0f 10                FCB     $0D,$0E,$0F,$10    D  E  F  G
edf6 11 12 13 14                FCB     $11,$12,$13,$14    H  I  J  K
edfa 15 16 17 18                FCB     $15,$16,$17,$18    L  M  N  O

edfe 19 1a 1b 1c                FCB     $19,$1A,$1B,$1C    P  Q  R  S
ee02 1d 1e 1f 20                FCB     $1D,$1E,$1F,$20    T  U  V  W
ee06 21 22 23 7e                FCB     $21,$22,$23,$7E    X  Y  Z  [    [
ee0a 7e 7e 7e 7d                FCB     $7E,$7E,$7E,$7D    \  ]  ^  -    \]^

ee0e 7a 24 25 26                FCB     $7A,$24,$25,$26    '  a  b  c
ee12 27 28 29 2a                FCB     $27,$28,$29,$2A    d  e  f  g
ee16 2b 2c 2d 2e                FCB     $2B,$2C,$2D,$2E    h  i  j  k
ee1a 2f 30 31 32                FCB     $2F,$30,$31,$32    l  m  n  o

ee1e 33 34 35 36                FCB     $33,$34,$35,$36    p  q  r  s
ee22 37 38 39 3a                FCB     $37,$38,$39,$3A    t  u  v  w
ee26 3b 3c 3d 7e                FCB     $3B,$3C,$3D,$7E    x  y  z  {    {
ee2a 7e 7e 7e 7e                FCB     $7E,$7E,$7E,$7E    |  }  ~       all


                        ****************************************************
                        *                                                  *
                        *              MC68HC05E0 functions.               *
                        *                                                  *
                        *       Add, Subtract, Multiply, Divide,           *
                        *       MJD -> day, date, month and year           *
                        *                                                  *
                        *       P. Topping           5th December '91      *
                        *                                                  *
                        *       Transfer of BCD numbers.                   *
                        *       (X) <- (NUM1), X preserved                 *
                        *                                                  *
                        ****************************************************

ee2e bf ae              TRA     STX     NUM2            CLEAR DESTINATION
ee30 cd ef 86                   JSR     CLRAS           AND ADD IT TO No. AT NUM1

                        ****************************************************
                        *                                                  *
                        *       Addition of BCD numbers.                   *
                        *                                                  *
                        *       (X) <- (NUM1) + (NUM2), X preserved        *
                        *                                                  *
                        ****************************************************

ee33 3f ab              ADD     CLR     CARRY
ee35 bf a7                      STX     W7
ee37 bf a5              AD      STX     W5              ANSWER POINTER
ee39 a6 09                      LDA     #ND
ee3b b7 ac                      STA     COUNT
ee3d be ad                      LDX     NUM1            1st No. POINTER
ee3f bf a3                      STX     W3
ee41 be ae                      LDX     NUM2            2nd No. POINTER
ee43 bf a4                      STX     W4
ee45 be a3              LOOP    LDX     W3
ee47 e6 08                      LDA     ND-1,X
ee49 3a a3                      DEC     W3
ee4b be a4                      LDX     W4
ee4d eb 08                      ADD     ND-1,X          ADD
ee4f 3a a4                      DEC     W4
ee51 bb ab                      ADD     CARRY           SET ON ADDITION OVERFLOW
ee53 3f ab                      CLR     CARRY           OR POS. RESULT SUBTRACTION
ee55 ad 11                      BSR     ADJ             DECIMAL ADJUST
ee57 be a5                      LDX     W5
ee59 e7 08                      STA     ND-1,X          SAVE ANSWER
ee5b 3a a5                      DEC     W5
ee5d 3a ac                      DEC     COUNT
ee5f 26 e4                      BNE     LOOP            DONE ?
ee61 be a7                      LDX     W7
ee63 81                         RTS

ee64 a0 0a              AJ      SUB     #10             YES, SUTRACT 10
ee66 3c ab                      INC     CARRY           AND RECORD CARRY
ee68 a1 0a              ADJ     CMP     #10
ee6a 24 f8                      BHS     AJ              10 OR MORE ?
ee6c 81                         RTS                     NO
```

```
                        ****************************************************
                        *                                                  *
                        *       Subtraction, complementing and incre-      *
                        *       menting (X=REG-ND) of BCD numbers.         *
                        *                                                  *
                        *       (X) <- (NUM1) - (NUM2), X preserved.       *
                        *       (X and NUM2 should not be equal)           *
                        *                                                  *
                        ****************************************************

ee6d bf a6              SUB     STX     W6              ANSWER POINTER
ee6f ad 06                      BSR     COM2            9S COMP. SECOND NUMBER
ee71 3f ab                      CLR     CARRY           SET CARRY TO ONE
ee73 3c ab                      INC     CARRY           BEFORE ADDING
ee75 ad c0                      BSR     AD              ADD FIRST NUMBER

ee77 be ae              COM2    LDX     NUM2            9S COMPLIMENT
ee79 ad 03                      BSR     COMP            SECOND NUMBER
ee7b be a6                      LDX     W6              RESTORE ANSWER POINTER
ee7d 81                         RTS

ee7e a6 09              COMP    LDA     #ND             9S COMPLIMENT
ee80 b7 ac                      STA     COUNT
ee82 a6 09              LOOP3   LDA     #$09
ee84 e0 08                      SUB     ND-1,X
ee86 e7 08                      STA     ND-1,X
ee88 5a                         DECX
ee89 3a ac                      DEC     COUNT
ee8b 26 f5                      BNE     LOOP3
ee8d 81                         RTS

ee8e ad ee              COM10   BSR     COMP            NINES COMPLIMENT THEN
ee90 a6 09              ADD1    LDA     #ND             ADD 1 FOR TENS COMPLIMENT
ee92 b7 ac                      STA     COUNT           ENTER WITH X = REG-ND
ee94 6c 11              ADD2    INC     2*ND-1,X
ee96 e6 11                      LDA     2*ND-1,X
ee98 a1 0a                      CMP     #$0A
ee9a 25 09                      BLO     RETURN
ee9c a0 0a                      SUB     #10
ee9e e7 11                      STA     2*ND-1,X
eea0 5a                         DECX
eea1 3a ac                      DEC     COUNT
eea3 26 ef                      BNE     ADD2
eea5 81                 RETURN  RTS

                        ****************************************************
                        *                                                  *
                        *       Mult., R <- P x Q, over. in TMP, X = #R.   *
                        *                                                  *
                        ****************************************************

eea6 ae 54              MULT    LDX     #R
eea8 cd ef 86                   JSR     CLRAS
eeab ae 4b                      LDX     #TMP
eead cd ef 86                   JSR     CLRAS           CLEAR RESULT
eeb0 ae 12                      LDX     #2*ND
eeb2 bf a6                      STX     W6              INIT. R POINTER
eeb4 ae 09                      LDX     #ND
eeb6 e6 41              STR     LDA     P-1,X
eeb8 bf a1                      STX     W1              SAVE P POINTER
eeba b7 ab                      STA     CARRY           SAVE P
eebc ae 09                      LDX     #ND             INIT. Q POINTER
eebe e6 2f              XTT     LDA     Q-1,X
eec0 b7 a4                      STA     W4              SAVE Q
eec2 27 30                      BEQ     TZ0             IF ZERO GOTO NEXT Q
eec4 b6 ab                      LDA     CARRY           RECALL P
eec6 b7 a3                      STA     W3              SAVE P
eec8 4f                         CLRA
eec9 34 ab              PLY     LSR     CARRY           RIGHT SHIFT INTO C
eecb 24 02                      BCC     SHF             C = ZERO ?
eecd bb a4                      ADD     W4              NO, A=A+Q
eecf 3d ab              SHF     TST     CARRY           ZERO ?
eed1 27 04                      BEQ     C4              YES, FINISHED WITH THIS Q
eed3 38 a4                      ASL     W4              NO, LEFT SHIFT Q
eed5 20 f2                      BRA     PLY
eed7 5a                 C4      DECX                    Q = Q + 1
eed8 bf a2                      STX     W2              SAVE Q POINTER
eeda be a6                      LDX     W6              R POINTER
eedc eb 4a                      ADD     R-ND-1,X        ADD R TO A
eede cd ee 68                   JSR     ADJ             ADJUST
eee1 e7 4a              C2      STA     R-ND-1,X        R = R + A
eee3 b6 ab                      LDA     CARRY
eee5 eb 49                      ADD     R-ND-2,X        ADD R-(ND+2) TO CARRY
eee7 e7 49                      STA     R-ND-2,X        R-(ND+2) = R-(ND+2) + CARRY
eee9 b6 a3                      LDA     W3              RECALL P
eeeb b7 ab                      STA     CARRY           SAVE IN CARRY
eeed 5a                         DECX
eeee bf a6                      STX     W6              SAVE R POINTER
eef0 be a2                      LDX     W2              Q POINTER
eef2 20 03                      BRA     C3
eef4 3a a6              TZ0     DEC     W6              DEC. R POINTER
eef6 5a                         DECX                    DEC. Q POINTER
eef7 26 c5              C3      BNE     XTT
eef9 b6 a6                      LDA     W6              R POINTER
eefb ab 08                      ADD     #ND-1
eefd b7 a6                      STA     W6              R = R + ND-1
eeff be a1                      LDX     W1
ef01 5a                         DECX                    P = P + 1
ef02 26 b2                      BNE     STR             IF NOT ZERO GOTO NEXT P
ef04 ae 54                      LDX     #R
ef06 81                         RTS
```

```
                        ****************************************************
                        *                                                  *
                        *       Division of BCD numbers.                   *
                        *                                                  *
                        *       R <- P / Q, remainder in TMP.              *
                        *       on exit X = #R, TMQ used.                  *
                        *                                                  *
                        ****************************************************

ef07 ae 54              DIV     LDX     #R              CLEAR
ef09 cd ef 86                   JSR     CLRAS           RESULT
ef0c ae 42                      LDX     #P              TRANSFER
ef0e bf ad                      STX     NUM1            P TO
ef10 ae 4b                      LDX     #TMP            WORKING
ef12 cd ee 2e                   JSR     TRA             P (TMP)
ef15 ae 30                      LDX     #Q              TRANSFER
ef17 bf ad                      STX     NUM1            Q TO
ef19 ae 39                      LDX     #TMQ            WORKING
ef1b cd ee 2e                   JSR     TRA             Q (TMQ)

ef1e a6 09              POSS    LDA     #ND             NUMBER
ef20 b7 ac                      STA     COUNT           DIGITS
ef22 ae 39              LOOP6   LDX     #TMQ            FIND LEAST SIGNIFICANT
ef24 f6                         LDA     0,X             NON-ZERO DIGIT
ef25 26 07                      BNE     NOSH            ZERO ?
ef27 cd ef 64                   JSR     SHIFT           YES, SHIFT Q
ef2a 26 f6                      BNE     LOOP6           UP ONE PLACE
ef2c 20 33              ZQ      BRA     RTRN            Q WAS ZERO
ef2e b6 ac              NOSH    LDA     COUNT           SAVE
ef30 b7 a1                      STA     W1              No. DIDITS - No. SHIFTS

ef32 ae 4b              SUBB    LDX     #TMP            SUBTRACT Q
ef34 bf ad                      STX     NUM1            FROM
ef36 cd ee 6d                   JSR     SUB             P
ef39 b6 ab                      LDA     CARRY           TOO FAR ?
ef3b 27 06                      BEQ     NEXTD           IF YES, GO TO NEXT DIGIT
ef3d be a1                      LDX     W1              INCREMENT RELEVANT
ef3f 6c 53                      INC     R-1,X           DIGIT IN RESULT
ef41 20 ef                      BRA     SUBB            ONCE AGAIN
ef43 ae 4b              NEXTD   LDX     #TMP            TOO FAR, ADD
ef45 cd ee 33                   JSR     ADD             Q BACK ON
ef48 ae 39              ROR     LDX     #TMQ            SET UP TO
ef4a a6 08                      LDA     #ND-1           SHIFT BACK
ef4c b7 ac                      STA     COUNT           WORKING Q
ef4e e6 07              RRR     LDA     ND-2,X          MOVE ALL
ef50 e7 08                      STA     ND-1,X          DIGITS
ef52 5a                         DECX                    DOWN
ef53 3a ac                      DEC     COUNT           ONE PLACE
ef55 26 f7                      BNE     RRR             DONE ?
ef57 6f 08                      CLR     ND-1,X          CLEAR MS DIGIT
ef59 3c a1                      INC     W1              INCREMENT POINTER
ef5b b6 a1                      LDA     W1
ef5d a1 0a                      CMP     #ND+1           FINISHED ?
ef5f 26 d1                      BNE     SUBB            NO, NEXT DIGIT
ef61 ae 54              RTRN    LDX     #R
ef63 81                         RTS

                        *****************************************************************
                        *                                                               *
                        *       Shift.                                                  *
                        *                                                               *
                        *****************************************************************

ef64 b7 a3              SHIFT   STA     W3
ef66 cd ef 79                   JSR     DR1             W1: MSD, W2: LSD
ef69 be a1                      LDX     W1
ef6b e6 01              AGS     LDA     1,X             MOVE ALL DIGITS
ef6d f7                         STA     0,X             UP ONE PLACE
ef6e 5c                         INCX
ef6f b3 a2                      CPX     W2
ef71 26 f8                      BNE     AGS             DONE ?
ef73 b6 a3                      LDA     W3              YES, RECOVER NEW DIGIT
ef75 f7                         STA     0,X             AND PUT IT IN LSD
ef76 3a ac                      DEC     COUNT
ef78 81                         RTS

ef79 bf a1              DR1     STX     W1              STORE POINTERS
ef7b a6 08                      LDA     #ND-1           (USED IN DIGIT AND DQ)
ef7d 5c                 AXL     INCX
ef7e 4a                         DECA
ef7f 26 fc                      BNE     AXL
ef81 bf a2                      STX     W2
ef83 81                         RTS

                        ****************************************************
                        *                                                  *
                        *       Clear.                                     *
                        *                                                  *
                        ****************************************************

ef84 ae 30              CLQ     LDX     #Q              CLEAR Q
ef86 bf a5              CLRAS   STX     W5
ef88 a6 09                      LDA     #ND             CLEAR No. DIGITS
ef8a b7 ac                      STA     COUNT           STARTING AT X
ef8c 7f                 CR      CLR     0,X
ef8d 5c                         INCX
ef8e 3a ac                      DEC     COUNT
ef90 26 fa                      BNE     CR              DONE ?
ef92 be a5                      LDX     W5
ef94 81                         RTS
```

```
                        *****************************************************************
                        *                                                               *
                        *       MJD - day of week and year.                             *
                        *                                                               *
                        *       DOW = (MJD+2)MOD7 (= WD-1)                    (DOW)    *
                        *       Y'  = INT((MJD-15078.2)/3652500)               (YR)    *
                        *                                                               *
                        *****************************************************************

ef95 ae 5d              MJDC    LDX     #MJD
ef97 bf ad                      STX     NUM1
ef99 ae 42                      LDX     #P
ef9b cd ee 2e                   JSR     TRA             P <- MTD
ef9e ae 5d                      LDX     #MJD
efa0 cd f0 83                   JSR     T10K            MJD <- MJD TIMES 10,000

efa3 ae 39              DOFFW   LDX     #P-ND
efa5 cd ee 90                   JSR     ADD1            P <- MJD + 1
efa8 ae 39                      LDX     #P-ND
efaa cd ee 90                   JSR     ADD1            P <- MJD + 2
efad ae 30                      LDX     #Q
efaf cd ef 86                   JSR     CLRAS
efb2 a6 07                      LDA     #7
efb4 b7 38                      STA     Q+ND-1          Q <- 7
efb6 cd ef 07                   JSR     DIV             R <- (MJD+2)/7
efb9 b6 53                      LDA     TMP+ND-1        REMAINDER (WD-1) IN TMP
efbb b7 73                      STA     DOW

efbd ae 5d              YEAR    LDX     #MJD
efbf bf ad                      STX     NUM1
efc1 ae 30                      LDX     #Q
efc3 bf ae                      STX     NUM2
efc5 cd f0 98                   JSR     TRCY            Q <- CY (150782000)
efc8 ae 42                      LDX     #P
efca cd ee 6d                   JSR     SUB             P <- 10K(MJD-15078.2)
efcd cd f0 a3                   JSR     TRDY            Q <- 3652500
efd0 cd ef 07                   JSR     DIV             R <- Y' ((MJD-15078.2)/365.25)
efd3 bf ad                      STX     NUM1
efd5 ae 66                      LDX     #YR
efd7 cd ee 2e                   JSR     TRA             YR <- Y'

                        *****************************************************************
                        *                                                               *
                        *       MJD - month and day.                                    *
                        *                                                               *
                        *       M'= INT((MJD-14956.1-INT(Y'*365.25))/306001)      (P)  *
                        *       D = MJD-14956-INT(Y'*365.25)-INT(M'*30.6001) (Q(x10K))  *
                        *                                                               *
                        *****************************************************************

efda cd f0 6b           MONTH   JSR     INT             R <- 10K(INT(Y'*365.25))
efdd ae 5d                      LDX     #MJD
efdf bf ad                      STX     NUM1
efe1 ae 42                      LDX     #P
efe3 bf ae                      STX     NUM2
efe5 cd f0 b9                   JSR     TRDO1           P <- 149561000
efe8 ae 30                      LDX     #Q
efea cd ee 6d                   JSR     SUB             Q <- 10K(MJD-14956.1)
efed bf ad                      STX     NUM1
efef ae 54                      LDX     #R
eff1 bf ae                      STX     NUM2
eff3 ae 42                      LDX     #P
eff5 cd ee 6d                   JSR     SUB             P <- 10K(MJD-14956.1-INT(Y'*365.25))
eff8 cd f0 ae                   JSR     TRDM            Q <- 306001
effb cd ef 07                   JSR     DIV             R <- M'      (  MJD-14956.1-INT(Y'*365.25)  )
effe bf ad                      STX     NUM1                     INT (  --------------------------  )
f000 ae 42                      LDX     #P                           (            306001            )
f002 cd ee 2e                   JSR     TRA             P <- M'
f005 b6 49                      LDA     P+ND-2          SAVE M'
f007 b7 6f                      STA     MNTH
f009 b6 4a                      LDA     P+ND-1
f00b b7 70                      STA     MNTH+1

f00d cd f0 ae           DAY     JSR     TRDM            Q <- 306001
f010 cd f0 77                   JSR     MULTI           R <- 10K(INT(M'*30.6001))
f013 bf ad                      STX     NUM1
f015 ae 39                      LDX     #TMQ
f017 cd ee 2e                   JSR     TRA             TMQ <- 10K(INT(M'*30.6001))
f01a cd f0 6b                   JSR     INT             R <- 10K(INT(Y'*365.25))
f01d bf ae                      STX     NUM2
f01f ae 39                      LDX     #TMQ
f021 bf ad                      STX     NUM1
f023 cd ee 33                   JSR     ADD             TMQ <- 10K(INT(Y'*365.25)+INT(M'*30.6001))
f026 bf ad                      STX     NUM1
f028 ae 42                      LDX     #P
f02a bf ae                      STX     NUM2
f02c cd f0 b9                   JSR     TRDO1           P <- 149561000
f02f 3f 47                      CLR     P+ND-4          P <- 149560000
f031 ae 54                      LDX     #R
f033 cd ee 33                   JSR     ADD             R <- 10K(14956+INT(Y'*365.25)+INT(M'*30.6001))
f036 bf ae                      STX     NUM2
f038 ae 5d                      LDX     #MJD
f03a bf ad                      STX     NUM1
f03c ae 30                      LDX     #Q
f03e cd ee 6d                   JSR     SUB             Q <- MJD-R (10K*DOM)
f041 e6 04                      LDA     ND-5,X
f043 b7 72                      STA     DOM+1           MJD-14956-INT(Y'*365.25)-INT(M'*30.6001)
f045 e6 03                      LDA     ND-6,X
f047 b7 71                      STA     DOM
```

```
                        *****************************************************************
                        *                                                               *
                        *       MJD - final correction of year & month and subs.        *
                        *                                                               *
                        *       If M' = 14 or 15, then K = 1, else K = 0                *
                        *       Y = Y' + K                                              *
                        *       M = M' - 1 - K*12                                       *
                        *                                                               *
                        *****************************************************************

f049 b6 6f              ADJU2   LDA     MNTH            MONTH, MSD
f04b 27 1b                      BEQ     KE02            0 ?
f04d b6 70                      LDA     MNTH+1          NO, M'= 10 THRU 15
f04f 27 11                      BEQ     KE01            0 ?
f051 a1 04                      CMP     #4              NO, M'= 11 THRU 15
f053 25 13                      BLO     KE02            LESS THAN 14
f055 ae 5d              KE1     LDX     #YR-ND          NO, M'= 14 OR 15, K=1
f057 cd ee 90                   JSR     ADD1            Y <- Y'+1
f05a 3f 6f                      CLR     MNTH            MONTH, MSD (-10)
f05c 3a 70                      DEC     MNTH+1          DEC. MONTH
f05e 3a 70                      DEC     MNTH+1          AND AGAIN (-2)
f060 20 06                      BRA     KE02            -12
f062 a6 0a              KE01    LDA     #10             M'= 10
f064 b7 70                      STA     MNTH+1          PUT 10 IN LSD
f066 3f 6f                      CLR     MNTH            CLEAR MSD
f068 3a 70              KE02    DEC     MNTH+1          9<-10, 1,2<-14,15, 3-8<-4-9, 10-12<-11-13
f06a 81                         RTS

f06b ae 66              INT     LDX     #YR
f06d bf ad                      STX     NUM1
f06f ae 42                      LDX     #P
f071 cd ee 2e                   JSR     TRA             P <- Y'
f074 cd f0 a3                   JSR     TRDY            Q <- 10K*365.25
f077 cd ee a6           MULTI   JSR     MULT            R <- 10K*Y'*365.25
f07a 3f 59                      CLR     R+ND-4
f07c 3f 5a                      CLR     R+ND-3
f07e 3f 5b                      CLR     R+ND-2
f080 3f 5c                      CLR     R+ND-1          R <- 10K(INT(Y'*365.25))
f082 81                         RTS

f083 9f                 T10K    TXA                     TIMES 10,000
f084 ab 05                      ADD     #ND-4
f086 b7 a1                      STA     W1
f088 e6 04              SLP     LDA     4,X
f08a f7                         STA     0,X
f08b 5c                         INCX
f08c b3 a1                      CPX     W1
f08e 26 f8                      BNE     SLP
f090 7f                         CLR     0,X
f091 6f 01                      CLR     1,X
f093 6f 02                      CLR     2,X
f095 6f 03                      CLR     3,X
f097 81                         RTS

                        ****************************************************
                        *                                                  *
                        *       MJD constants.                             *
                        *                                                  *
                        ****************************************************

f098 ae 09              TRCY    LDX     #ND
f09a d6 f0 c3           CYL     LDA     CY-1,X
f09d e7 2f                      STA     Q-1,X
f09f 5a                         DECX
f0a0 26 f8                      BNE     CYL
f0a2 81                         RTS

f0a3 ae 09              TRDY    LDX     #ND
f0a5 d6 f0 cc           DYL     LDA     DY-1,X
f0a8 e7 2f                      STA     Q-1,X
f0aa 5a                         DECX
f0ab 26 f8                      BNE     DYL
f0ad 81                         RTS

f0ae ae 09              TRDM    LDX     #ND
f0b0 d6 f0 de           DML     LDA     DM-1,X
f0b3 e7 2f                      STA     Q-1,X
f0b5 5a                         DECX
f0b6 26 f8                      BNE     DML
f0b8 81                         RTS

f0b9 ae 09              TRDO1   LDX     #ND
f0bb d6 f0 d5           DO1L    LDA     DO1-1,X
f0be e7 41                      STA     P-1,X
f0c0 5a                         DECX
f0c1 26 f8                      BNE     DO1L
f0c3 81                         RTS

f0c4 01 05 00 07 08 02  CY      FCB     1,5,0,7,8,2,0,0,0
00 00 00
f0cd 00 00 03 06 05 02  DY      FCB     0,0,3,6,5,2,5,0,0
05 00 00
f0d6 01 04 09 05 06 01  DO1     FCB     1,4,9,5,6,1,0,0,0
00 00 00
f0df 00 00 00 03 00 06  DM      FCB     0,0,0,3,0,6,0,0,1
00 00 01

                        ****************************************************
                        *                                                  *
                        *       Vectors.                                   *
                        *                                                  *
                        ****************************************************

fff4                            ORG     $FFF4

fff4 e0 00                      FDB     START           SERIAL
fff6 e2 9d                      FDB     TINTB           TIMER B
fff8 e0 00                      FDB     START           TIMER A
fffa e3 0a                      FDB     SDATA           EXTERNAL INTERRUPT & RTI
fffc e0 00                      FDB     START           SWI
fffe e0 00                      FDB     START           RESET

                                END
```

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