AN494/D

An HC11-controlled Multiband RDS Radio

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This application note describes the software and hardware features of the microprocessor controller of a synthesised multiband radio which includes RDS decoding (FM, band II). It uses an MC68HC(7)11 microprocessor whose program can be on-chip or contained in an external EPROM. ROMed versions are available. Both LCD and VFD 16-character dot-matrix display modules can be used to display RDS and tuning information. Traffic messages, initiated by the reception of EON data (group 14B) or TA=TP=1 on the current frequency, are handled. The station carrying the TA is tuned for the duration of the message, followed by a return to the original frequency. A tuning knob employing an incremental encoder is supported.

1. Introduction

Figure 1 shows a block diagram of the application. The controller hardware and software will be described in detail. The other hardware is not covered to the same depth as it will vary between different implementations, the intention being to describe a controller which could be added to an existing radio or to one which includes only one or two of the possible bands. Separate FM and AM PLLs are shown. This is not essential but reduces the amount of band switching necessary and simplifies hardware fault-finding. The illustrated configuration corresponds to that used by the author for software development and debugging.

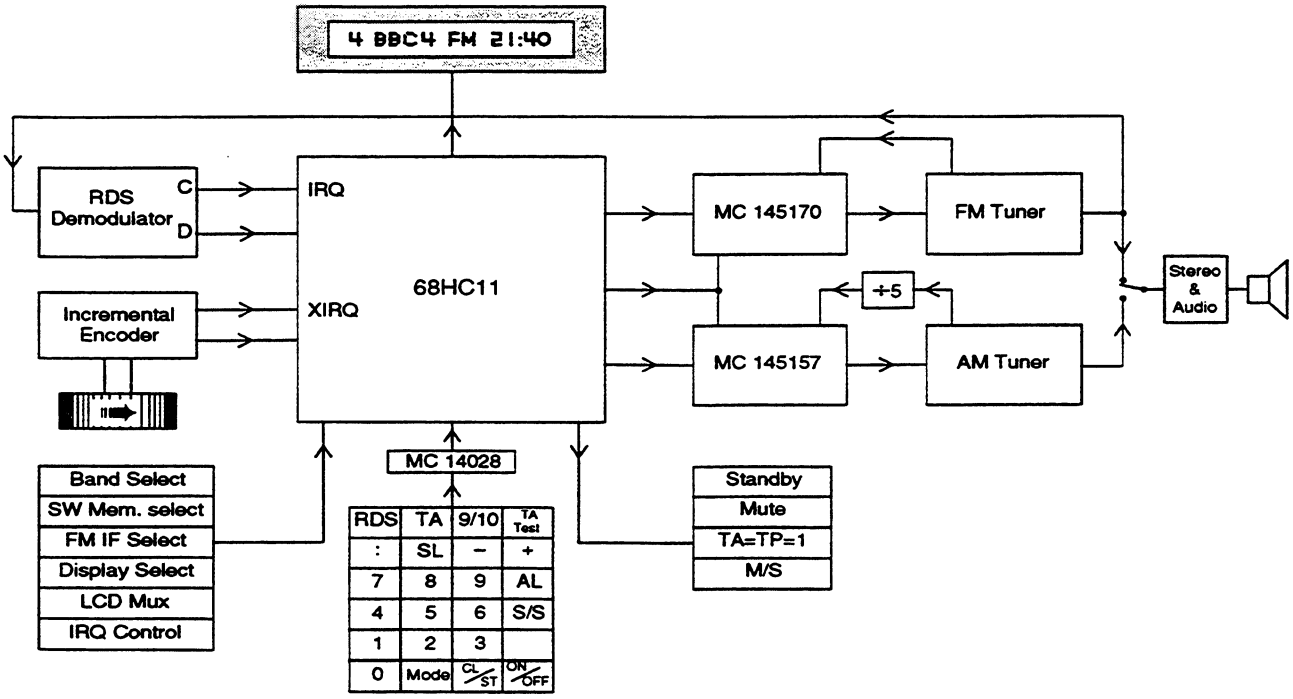

Figure 1. Main block diagram

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The microprocessor used is the MC68HC(7)11. The K4 (and similar chips such as the P2 and PH8) can be used in expanded mode but the application has been included in the ROM of an E32 and a PH8. In order to use the ROMed parts in this application, the first three bytes of EEPROM should contain an extended jump to the appropriate start address. The E32 (ZC403311) requires $7E, $90 and $00 at addresses $B600, $B601 and $B602, while the PH8 (ZC428200 or ZC428202) requires $7E, $40 and $00 at addresses $0D00, $0D01 and $0D02. This can be done using either PCbug11 or the Buffalo monotor (see reference 5). The E32 version uses all the I/O and can therefore only be used in single-chip mode. The circuit diagram of the HC11E controller is shown in figure 2 and that of the K4/PH8 in figure 3. The K4/PH8 version shows the additional hardware (within the dotted line) used to develop and debug the software on a K4 using PCbug11. This implementation uses two of the K4's chip selects to enable external memories allowing debug to be done with the code in RAM and the PCbug11 talker in an EPROM. This arrangement requires a further 4 I/O lines, leaving 30 for use in the application. The description of the application, and the listed software, corresponds to the E32 ROMed version (ZC403311). Later sections list the port allocation and functional differences which apply to the PH8 ROMed versions (ZC428200 and ZC428202).

40 programs (10 on FM and MW and 20 on SW) can be stored using the HC11E's on-chip EEPROM (the PH8 has 20 additional SW programs). Each contains frequency, an 8-character name (PS name on a station with RDS) and, on FM only, PI code and a TA inhibit bit. For stations with no RDS (e.g., all AM stations), the saved name can be manually entered. Programs saved with no name use their frequency instead. The SW banks are selected by an I/O line (two for the PH8). When the microprocessor is reset, or any of the band or memory select inputs are changed, the last used program in the selected band is tuned. This feature does not require that the microprocessor is permanently powered up, as this information is also stored in non-volatile EEPROM.

The keyboard uses an MC14028 decoder to minimise the number of I/O lines used. Either LCD or VFD 16-digit dot-matrix displays can be used. The VFD display driver supported is the MSC7128, and the LCD driver the HD44780. This driver on its own provides a 16-way multiplexed LCD. In conjunction with an HD44100 it can facilitate an 8-way multiplexed higher contrast display. The input level on a port pin selects the appropriate type of multiplexing to match the display in use. To minimise the I/O activity, only one display is driven, the choice between LCD and VFD again being determined by an I/O line.

MC145170 and MC145157 PLLs are supported, using the same data and clock lines as the VFD driver, along with dedicated chip selects. The 5157 requires an external pre-scaler for frequencies above 20 MHz, but the 5170 has an on-chip 160 MHz capability.

A tuning knob can be included by using an incremental encoder. This can utilise either IRQ or XIRQ. As IRQ is used for the RDS clock, XIRQ is most appropriate for the tuning function. The possibility of using IRQ (see below) has been included to facilitate debug with PCbug11 which can employ XIRQ for its communication with the PC. Edges detected on the encoder execute the PS edit and alarm setup functions of the +/- keys (depending on the direction of rotation). This provides a very quick and convenient method of editing the PS name and changing the alarm time. A difference in function between the encoder and the +/- keys applies in normal mode. The program number is not affected by the tuning knob. In this mode, when the +/- keys control the programme number, the tuning knob increments or decrements the frequency.

Two I/O lines are used to select the band. These lines are regularly monitored; if they change, the radio is retuned to the last used station in the selected band. Table 1 shows the bands which are available. Band 2 is intended for single-conversion (low IF) MW or SW radios. The large step size of 9 or 10 kHz is suitable for MW rather than SW, but the small step size of 1 kHz is suitable for either SW or MW. Band 3 is for dual-conversion (10.7 MHz first IF) SW designs.The FM IF offset is selected as + or - according to the level on port A, bit 2 (high: LO high; low: LO low). Bands 0 and 1 are both intended for VHF/FM, the difference between them being in the use of the HC11's IRQ pin. It is possible to use IRQ interrupts for both RDS and the tuning knob, as the two functions are not required simultaneously. To facilitate this, the band-select inputs affect the function performed when an edge is detected in the IRQ pin. When band zero is selected, an RDS bit is read, but in any other band the incremental encoder function is performed. This enables automatic selection of function if bit 0 on port A is taken high when movement is detected from the shaft encoder. This facility can be disabled (RDS function only) by holding bit 3 of port A low. This should be done if XIRQ is being used for the tuning knob. As XIRQ is level-sensitive, some additional components are required to interface it with the incremental encoder. Figure 4 shows a simple circuit which can be used for this purpose.

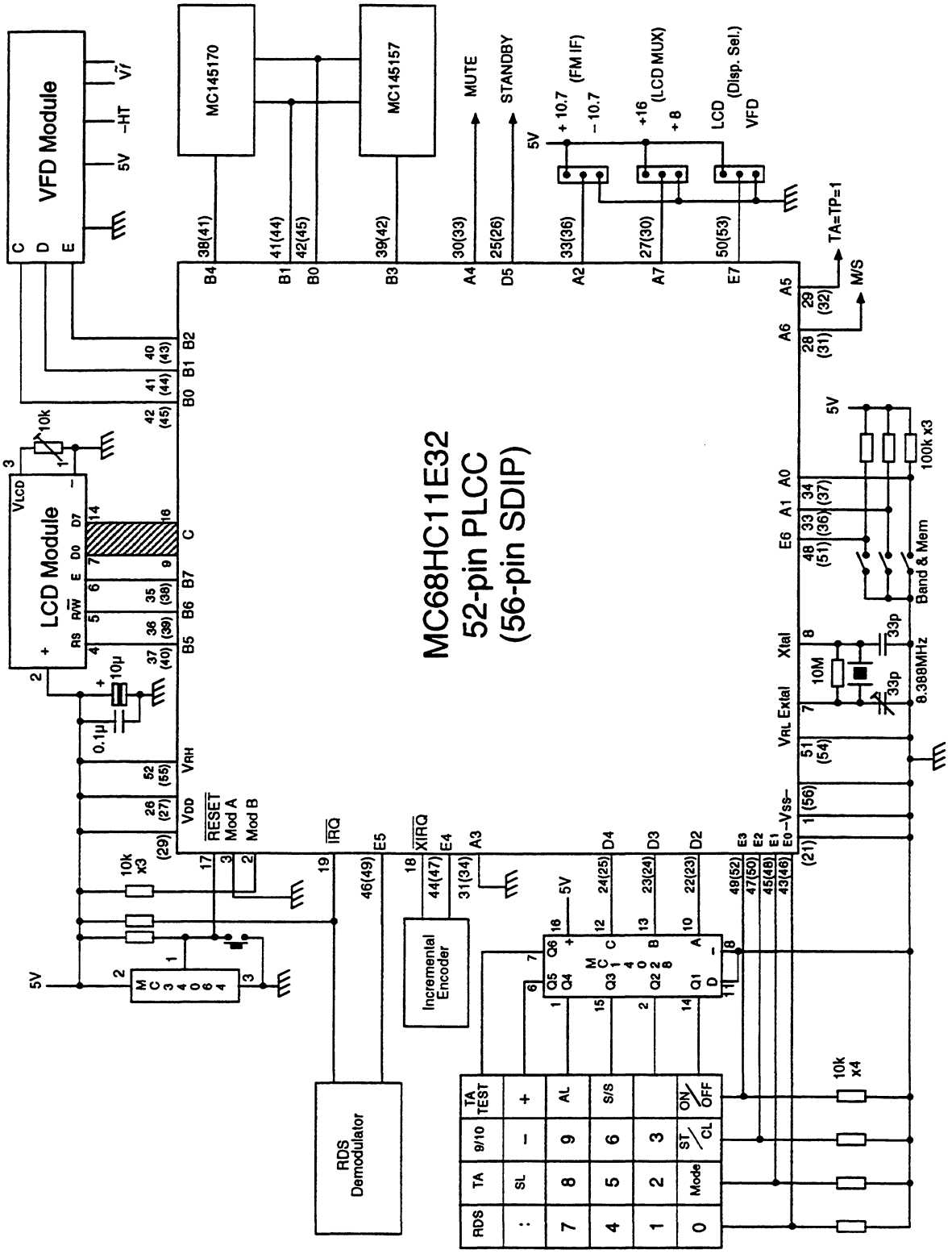

Figure 2. 68HC11E32 circuit

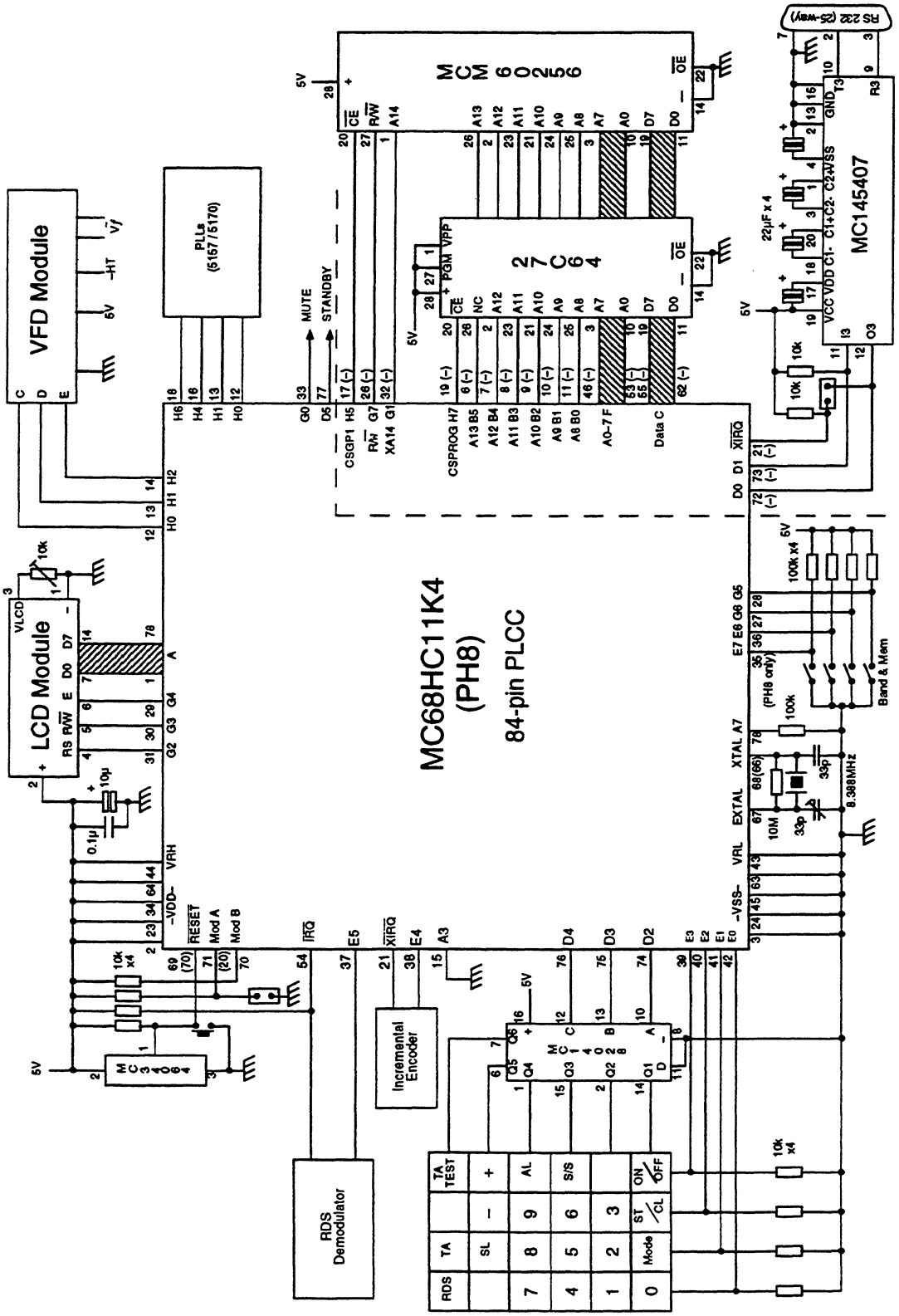

Figure 3. 68HC11K4 and PH8 circuit

Table 1. Available bands

Band	PA1	PA0	IF offset	Step	Memory	Use	Pre-scaler (5157 only)
0	0	0	+/-10,700	50, 10	10	VHF	10
1	0	1	+/-10,700	50, 10	10	VHF	10
2	1	0	455	9 (or 10), 1	10	MW/SW	-
3	1	1	10,700	5	20/40	SW	5

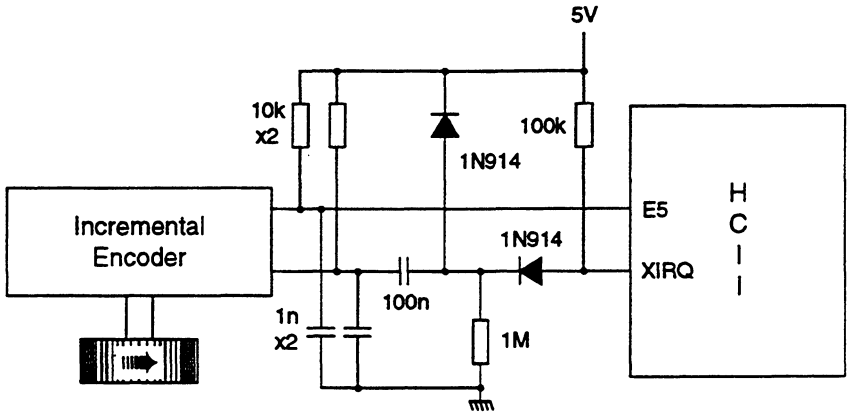

Figure 4. Incremental encoder interface crcuit

2. Frequency synthesis

Synthesis of the local oscillator (LO) in a superheterodyne radio provides many advantages over mechanical tuning. The main benefits are tuning accuracy, stability and the storing of often-used frequencies. The accuracy and stability result from the fact that the local oscillator is phase-locked to a crystal oscillator. In conjunction with RDS, frequency synthesis provides the additional facility of allowing the radio to retune itself to a traffic announcement or news bulletin. A synthesiser can be retrofitted to most radios by replacing the tuning capacitor with a varicap diode. The voltage biasing the varicap is supplied by the synthesiser and can also be used to provide RF tuning. Alternatively, manual preselector or no RF tuning can be employed.

Motorola MC145157 and MC145170 synthesisers are two of a series offering a variety of options including serial or parallel interfacing and single or dual modulus prescaling. The MC145157 requires a prescaler for frequencies above 20 MHz but the MC145170 can handle input frequencies up to 160 MHz. The MC145157 has been included to retain compatibility with hardware developed for use with the HC05B4 synthesiser described in ANE416 (reference 1).

Figure 5 shows the block diagram of the MC145170. It uses the Motorola bitgrabber system, whereby the number of bits sent determines the register which is written to. There is therefore no need for the control bit which is required by the MC145157.

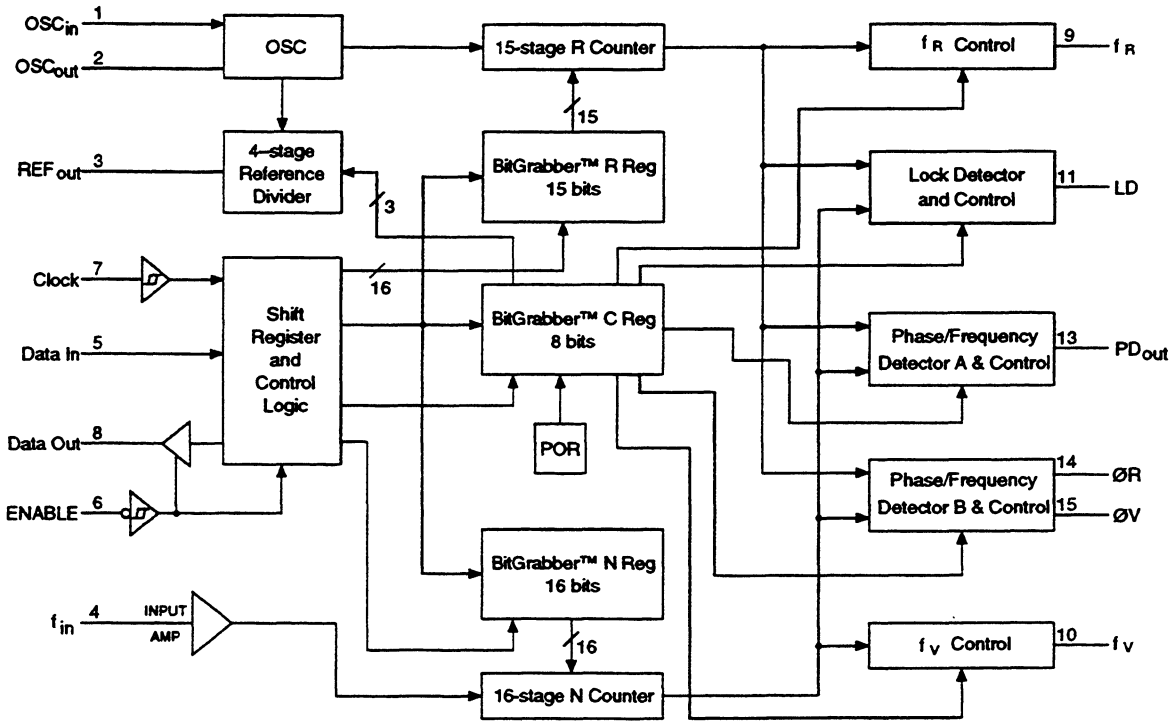

Figure 5. MC145170 block diagram

The reference counter divides the 8 MHz crystal oscillator (10 MHz for the 5157) down to the reference frequency (in this case 1 kHz for the 5157 and 10 kHz for the 5170) at which the comparison is made with the (also divided down) local oscillator. The filtered output of the phase comparator supplies the tuning voltage to the local oscillator. The numbers chosen as the divide ratios determine the frequency at which this oscillator stabilises. The equation below shows the relationship between the various frequencies where P is the LO prescaler (5157 only). The received frequency can be changed by altering the LO divide ratio. The microprocessor takes care of the decimal to binary conversion, IF offset and the other arithmetic required.

LO freq. = RF + IF = P . [(Xtal freq.) / (ref. div. ratio)] . LO div. ratio

The MC145157 is specified to operate up to 20 MHz, so pre-scaling is required on FM and SW (10.7 MHz IF). For this SW band, divide by 5 pre-scaling is used; for FM, divide by 10 is used. This increases the minimum step size to 10 kHz of FM, which is ideal for this band, and to 5 kHz on SW, which is suitable for almost all broadcast stations. The MC145170 does not require any prescaling even on the FM band and can use this to advantage by allowing the use of a higher reference frequency, making the low pass filter design less critical.

An important part of any phase-locked loop is the loop filter. The filter shown in figure 6 is an active filter using the double-ended phase detector outputs from the MC145170 feeding a CA3460 operational amplifier. This dual op-amp allows the simple double-ended low pass filter to be followed by a 2nd order Sallen and Key filter. An active filter has the added advantage of increasing the available voltage swing beyond the supply rail of the MC145170/5157.

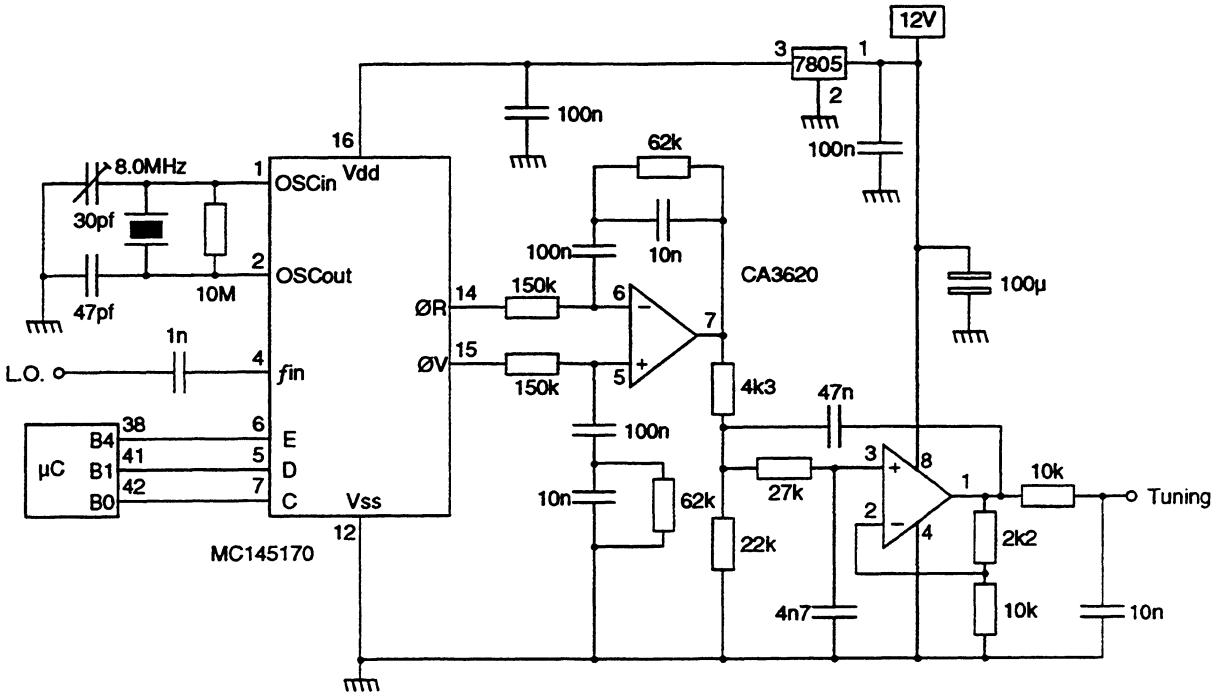

Figure 6. MC145170 circuit

The combination of active filter and double-ended phase detector outputs makes it simple to select the correct relationship between voltage and frequency. Usually, the fixed side of the varicap diode is earthed, so increased voltage increases the frequency of the oscillator; in some oscillator designs, the fixed side may be taken to the supply rail, and increasing the voltage will decrease the frequency. With the filter design shown, the choice can be made simply by swapping the phase detector outputs from the PLLs.

3. RDS

The Radio Data System (RDS) adds a digital data capability to the FM VHF transmissions on band II (87.5 to 108 MHz). The specification is defined in CENELEC EN 50067 (formerly EBU Technical Document 3244, reference 2). An MC68HC05E0 implementation of RDS was described in AN460/D (reference 3). It monitored the RDS activity on the MPX signal of a VHF radio but was not able to tune the radio and could therefore not use AF or EON data. This application can tune the radio and uses EON data to retune the radio when a traffic announcement is taking place on another frequency. An announcement is initiated by a packet 14B and the radio retunes if TAs are enabled. At the end of the TA the original station is re-tuned. TAs are not active in standby mode (standby line high).

To transmit the data, a subcarrier is added at 57 KHz. This subcarrier is amplitude-modulated with the shaped bi-phase coded data signal. The subcarrier 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 subcarrier 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 to decide which features are transmitted as long as the specified format is adhered to and PI, PTY and TP are included. Each group contains a different sub-set of the RDS features; a list of all currently defined features is shown in table 2.

The retrieval of data is carried out by demodulation hardware, which generates clock and data signals that can be used by the microprocessor. Suitable devices which can perform this function include SAA6579, SAA7579T (plus an external filter), TDA7330, LA2231 and RDS hybrids.

Table 2. 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

This application supports PI, PTY, PS, RT, CT, TP, TA, MS, DI, PIN and EON. 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 information (see table 5). EON data can be displayed and used to switch to traffic announcements, but the retuning features associated with AF are not supported, as they are only appropriate for a radio intended for use in a vehicle. In a car radio, AF data would be used to tune the radio to the strongest signal carrying the selected service. PI is a 2-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 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 3 shows the display used for each PTY code.

PS is the eight character name of the station and is permanently displayed (except in standby mode). In the absence of RDS (e.g., AM bands) the name can be manually entered. If none is entered, then the frequency is used as the station name when the program is stored in EEPROM.

Radiotext (RT) 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. The data often contains extra spaces to centre the text on a 2 x 32-character display. As these are not appropriate 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.

Table 3. 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

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. A port line (port A, bit 5) is asserted (low) when TA=TP=1. This can be used to demute or switch from another source (e.g., cassette) when a traffic announcement occurs.

M/S 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 M/S bit is displayed on request. A port line (port A, bit 6) is asserted (low) when M/S=1. This can be used to control external hardware.

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. Type 14A groups are used to send information about other networks. The PS name and principal frequency of up to 16 other networks can be displayed. Type 14B groups are used to switch to traffic announcements; they include the PI code of the station carrying the announcement. This PI code is searched for in NVM, and the required station is tuned if it is stored in NVM. This method allows the user to select which TAs are allowed (they will not occur if the station is not in NVM or if its TA inhibit bit is set) and avoids attempts to jump to an announcement which is not relevant or not receivable with sufficient signal strength to be useful.

4a. Keyboard

The keyboard has 23 keys. The illustration below shows the layout and table 4 contains a summary of key-function against mode.

	PE0	PE1	PE2	PE3
Q6	RDS	Traffic	MW step	TA test
Q5	Time colon	Sleep	-	+
Q4	7	8	9	Alarm
Q3	4	5	6	Store
Q2	1	2	3	
Q1	0	Manual	Clear/Step	On/Off

The following functions are available:

On/Off

This key is intended as an on/off control for the radio. It sets a port line low for on and high for standby and can be used to control the power supply to the radio. Its status affects the behaviour of other keys as described below.

Sleep

When pressed, the 1 hour sleep timer starts, leaving the standby line low (radio on) until the sleep time has elapsed. At this time the line is switched to the standby mode (high). In the normal display mode, the sleep timer running causes the decimal point to appear on the display modules' first character. The sleep timer can be cancelled by pressing ON/OFF. The sleep time can be reduced in increments of 5 minutes by re-pressing or holding down the SLEEP key.

Alarm

The alarm key selects the alarm display mode and toggles the alarm armed status. When the alarm is not armed, the legend "ALARM - OFF" is displayed. When it is armed, the alarm time is shown and adjustment of the alarm set-up can be done by selecting the field (5/7 day, hours or minutes) with the STORE/SET key. The selected field (hours or minutes) flashes and can be adjusted with the +/- keys or the tuning knob. The alarm set-up display returns to normal 3 seconds after the last adjustment. If the radio is in standby mode and the alarm is set, the alarm time is displayed instead of the date. The radio will come fully on (standby line low) at the alarm time. After a 500 ms delay to allow power supplies to stabilise, the programme which was tuned when the radio was last used is retuned. When set to the 5 day alarm, the alarm will not occur on Saturdays or Sundays.

\+ & -

Pressing + or - , while in normal mode, increments or decrements the program number. The program number wraps round at 0 and 9. The mute line is set high before retuning and returned low 100ms after the new frequency has been sent to the PLL. Changing the tuned program using the +/- keys (or the 0 - 9 keys) disables PS name clearing if RDS information is absent or contains multiple errors.

In PS-edit mode (see below), the + and - keys are used to change the character at the cursor position. This function is duplicated on the tuning knob incremental encoder. In the alarm set-up mode, the + and - keys are used to change the alarm time as described above. The field which is currently selected for adjustment (using the STORE key) flashes. This function is also duplicated on the tuning knob.

In manual mode, these keys increment and decrement the current frequency in steps of 10 kHz or 50 kHz (FM) as selected by the CLEAR/STEP key. The default is 10 kHz. On the SW band, 1kHz (455kHz IF only) or 5 kHz steps are available; on the MW/LW band, 1 or 9 kHz steps are available. In the USA, 10 kHz is appropriate instead of 9 kHz; this can be selected with a special key (see below). This function is duplicated on the tuning knob both in this mode and in normal mode. Use of the +/- keys (or the incremental encoder) to adjust the frequency enables PS name clearing if RDS information is absent or contains multiple errors. In normal mode, on the AM bands, use of the tuning knob displays the frequency in the PS name field, facilitating simultaneous display of frequency and time.

Store/Set

In normal modes (not manual or alarm) the store key selects the PS-edit mode in which the first character of the displayed PS-name flashes and can be changed by the + and - keys or the tuning knob. Subsequent presses of STORE move to the next character. A space is shown as a "-". This mode returns to the normal display mode 10 seconds after the last key-press. This mode can be used to give a name to a station with no RDS PS name (all AM stations or an FM station with no RDS or with RDS of unusable quality). See below for the method of saving this name in EEPROM. Entry of a PS name in this way requires that PS name clearing is disabled. This is achieved by changing the program number (by using the +/- or 0 - 9 keys). Fine tuning enables PS name clearing (see +/- key description above). Direct frequency entry does not affect the PS name clearing status.

In the alarm-setup mode, STORE selects what will be changed when the + or - keys or the tuning knob are used (5/7 day, hours or minutes). Hours or minutes flash when they are selected.

In manual mode, STORE enters a special manual store mode in which the 0-9 keys save, rather than recall, a program. After pressing STORE, the program number flashes to indicate this change of function. Alternatively, a second press of STORE saves the current tuning information into the current program number. The current frequency, PI code (FM), PS name and TA inhibit flag (FM) are saved in EEPROM. The TA inhibit status can be changed using the TRAFFIC key (see below). If the PS edit mode has been used, then manual store mode should be used to save the entered PS name.

Manual

Select manual entry of frequency; a second press returns to normal mode if the tuned frequency has not been changed. If it has been changed, the second press retunes to the new frequency and an additional press is required to return to the normal mode. In manual mode, frequency is displayed instead of the time; the + and - keys or the tuning knob enable incrementing and decrementing of the current frequency. Direct entry of frequency can be made using 0 - 9 keys. In this mode, the STORE key enters the manual store mode in which the program number flashes, allowing storing of the tuned program and PS name into the current, or a different, program number. A second press of STORE saves the current frequency, PS name, PI code and TA inhibit bit (FM) in EEPROM.

In MANUAL mode, the TRAFFIC (TA) key controls the TA inhibit bit, which can be stored with each program. If the current station has its TP flag high, the least significant digit of the frequency will alternate with a decimal point. Pressing TP toggles the NVM inhibit bit. When inhibited, the decimal point between the MHz and the kHz becomes a "-". A subsequent press of STORE saves this bit in NVM along with the frequency, PI code and PS name.

0 to 9

These keys are used both for direct frequency entry and for recalling the 40 (PH8: 60) available programs. In all modes, except standby and manual, when a 0 - 9 key is pressed the selected program is tuned. Changing the tuned program using the 0 - 9 keys (or the +/- keys) disables PS name clearing if RDS information is absent or contains multiple errors. In manual mode these keys are used for the direct entry of frequency. After entering the required frequency, pressing MANUAL retunes to the new frequency. The mute line is set high before retuning and returned low 100ms after the new frequency has been sent to the PLL. In manual store mode, the program number flashes and the 0 - 9 keys save the tuned program into the selected program number in EEPROM.

RDS

The first press displays scrolling RT data. Subsequent presses display: PTY code, PI code, TA & TP, PIN code (2 formats), MJD, MS and DI, last TA PI code, the reason for returning from last TA and EON (up to 16 networks with their principal frequency). See table 5 for the display formats. The RDS key is operational in all modes except standby.

Traffic

Enable/disable traffic switching. When disabled, this is indicated by a decimal point in the eleventh character of the dot-matrix displays. Default at power-up is enabled. The TRAFFIC key works in all modes except standby. During manual mode and manual store mode, it toggles the TA inhibit status, which can subsequently be saved in NVM.

Clear/
Step

Toggles between 10 kHz and 50 KHz steps on the FM band, or between 1 and 9 kHz (or 10 kHz) on the MW band. There is no indication on the dot matrix displays. In manual mode, the displayed frequency is cleared to facilitate the entry of a new frequency. If the clear is followed by use of the + or - keys or the tuning knob, the original frequency is retained, allowing a change of step size only. In PS edit mode, the clear key clears the current PS name.

TA test

Pressing TA test simulates the arrival of a group 14B. The PI code of the other network is embedded in the code (C5B1, Radio Clyde in the ROMed version).

Time
Colon

This key enables or disables the flashing colon in the time display. This can be used to prevent unnecessary I/O activity thus reducing RFI. Disabling the colon prevents 1 Hz updating, as the display modules are only updated if the data to be displayed has changed.

MW
Step

This optional key selects 9 or 10 kHz steps on MW. 9 kHz is appropriate in Europe and 10 kHz in the USA. The default is 9 kHz, and the key need not be implemented if 10 kHz will never be required.

Table 4. Key function by mode

	On/Off	Sleep	Alarm	+/-	Store	Manual	TP	RDS	0-9	Clear
Standby (OFF)	mode normal (ON)	mode sleep (ON)	mode alarm	–	–	–	–	–	–	–
Normal (ON)	mode standby (OFF)	"	"	+/- prog.	mode PS-edit	mode manual	toggle traffic enable flag	display RT PTY PI TA TP PIN hex PIN dec MJD M/S DI TA ret. TA PI EON (16)	tune prog.	toggle step 10/ 50kHz
PS edit	"	"	"	+/- ASCII	next char.	"	"		"	"
A off	"	"	mode alarm on	+/- prog.	–	"	"		"	"
L on A	"	"	mode alarm off	5/7 day toggle	mode set-up	"	"		"	"
R set M -up	"	"		+/- hour/min	hour/ min toggle	"	"		"	"
MANUAL store	"	"	mode alarm	+/- freq.	mode store	mode normal	toggle traffic enable NV bit		input freq.	"
	"	"	"	"	save prog.	"		"	save prog.	& clear freq.

5. Circuit

The circuit is in two distinct parts. The circuit for the MC145170 synthesiser is shown in figure 6. The synthesiser board is the only part of the synthesiser controller which need actually be in (or close to) the radio. A local oscillator signal to supply the synthesiser should be taken from a low impedance point so that the oscillator is not significantly loaded. Pulling of the oscillator frequency is not a problem as the PLL circuitry will compensate, but loading the tuned circuit itself is not recommended unless a high impedance buffer is included. This prevents affecting the tuning range or the "Q" of the oscillator. The MC145157 requires a divide-by-10 prescaler for FM and divide-by-5 for band 3. The MC145170 does not require prescaling. The standard LP1186 FM tuner does not have an LO take-off but a signal can be taken, without other modification, from the emitter of the oscillator BF195 (near the centre of the PCB). The Mullard LP1186 is unusual in having its local oscillator low. More recent tuners, e.g., the Larsholt 7254/55, almost always have their local oscillator above the tuned frequency. This selection can be made using port A, bit 2.

A 16-digit LCD (parallel) or VFD (serial) dot-matrix display module can be driven. The two display modules show the same data (within the limitations of their character ROMs). The VFD display driver supported is the MSC7128, and the LCD driver the HD44780. This driver on its own can be used to provide a 16-way multiplexed display, but an 8-way multiplexed higher contrast display is possible if the module also incorporates an HD44100. If, in an application which drives an LCD module (e.g., a ROMed PH8), a module is not connected, a 10k pulldown resistor should be added to bit 7 of port A. This prevents the software hanging up waiting for the busy line to go low.

Figures 2 and 3 show the circuit diagrams of the controllers. Figure 2 gives the pin numbers for the 52-pin PLCC HC11E with the numbers for the 56-pin SDIP (if different) in brackets. With the E32, the display in use can be selected by the level on port E, bit 7 (high for LCD and low for VFD) and the LCD multiplexing by port A, bit 7 (high for divide-by-16, low for divide-by-8). The SW bank is selected by the level on port E, bit 6.

Figure 3 shows pin number for the 84-pin PLCC K4, with the differences for the PH8 in brackets. Debug on the K4 using PCbug11 (reference 4) requires some additional hardware (within the dotted line) and Port D bits 0 and 1 (SCI), Port G bits 1 and 7 (XA14 & R/W) and Port H bits 5 and 7 (CSGP1 & CSPROG), leaving 30 I/O lines for use in the application. The display selections are not available on the PH8 ROMed versions, but there are four SW banks of 10 program memories; they are selected by Port E, bits 6 and 7.

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 5 of port E.

6. Software

An assembled listing of part of the HC11E32 ROMed version (ZC403311) of the application is included. The software is in three modules and was assembled and linked using the Introl re-locatable assembler and linker. The first module is listed. It contains all the main control routines, including the main loop and keyboard scanning, and the function to be performed by each key. The second module contains the RDS and display functions, while the third module is the 4-function 9-digit integer BCD arithmetic required for the MJD date calculations. The second and third modules are described and listed in AN495/D (reference 4). EB419/D (reference 5) describes and lists additional debug code contained in the ROMed parts.

The code which is executed only on start-up (power-on or reset) begins at the label START on the third page of the first module's listing, while the main loop starts at the label IDLE on the next page. The idle loop is quite long, as many functions and checks have to be carried out. These include:

- pacing the loop using the main timer
- checking to see if the display needs updating or if a transient display has timed out
- checking if the alarm is armed and if so, comparing its time with the current time
- sleep timer operation
- traffic announcement timing and return
- keyboard scanning and selected function execution
- incremental encoder execution
- checking for changes in the band and memory selection inputs
- timing band changes
- updating TA=TP=1 and M/S outputs.

The keyboard subroutine, KBD, is executed at 64 Hz from the idle loop and checks to see if a key is pressed. If the same key is pressed on three consecutive tries, its function is performed. The remainder of the first module constitutes the subroutines performed by each key and the arithmetic and serial activity required to tune the synthesisers. The batch files used for linking the modules are shown as comments at the end of the listing, along with the pseudo-vectors required by PCbug11 during de-bug.

The displays are only updated when there is a change in the displayed data. At 8 Hz, a check is made to see if any characters have changed; if there has been a change, the display update routine is executed. This is done to minimise interference caused by communication with the displays. The colon between the hours and minutes of the time display changes at 1 Hz. This can be disabled (colon permanently displayed) by using the Time Colon key. The display routine (MOD) is executed in the idle loop if the flag bit 3 of STAT2 is set. It is set every 125 ms by timer B interrupts. If flag bit 4 of STAT2 is set, the display is initialised, indicating no valid RDS data. The dot-matrix modules are then updated, if necessary, with new data. Each time, before anything is written to the LCD module, the subroutine WAIT is used; this checks that the controller in the module is not busy. 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, loops are used to send the data to the display modules. The standby display (alarm not enabled) shows date and time. After a power-up, the display "Mon 0 inv 0:00" indicates that the date and time are invalid. The date and time will be correct once a valid RDS CT group has been received.

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 VFDL. The LCD and VFD routines are in the second software module (see reference 4).

Table 5. Display formats

Display Mode		Format
Standby (Off)	Alarm off Alarm off, no CT Alarm on	Thu 12 May 21:35 Mon 0 inv 0:00 0659 Alarm 21:35
Normal (On)	With RDS PS name Without RDS Auto. name Tuning knob (AM)	4 BBC 4 FM 21:40 5 -------- 21:40 6 - 9410 21:40 6 --- 9415 21:40
Alarm	Alarm off Alarm on/set-up	Alarm - OFF 5 day Alarm 0659
Sleep		Sleep 60 min.
RDS	RT PTY PI TA & TP PIN(hex) PIN(decoded) MJD MS & DI last TA 1. 2. EON (16)	Kaleidoscope .... Culture PI code - C204 TP - 0 TA - 1 PIN no. - 655E 12th at 21:30 MJ day - 49484 M/S M DI 01 last TA PI C514 TA rtrn: EON PI BBC 3 FM 92.10 BBC Gael 103.70 BBC Nwcl 96.00 BBC Scot 94.30 BBC Scot 92.50 BBC Scot 94.70 BBC Scot 93.50 Classic 101.70 BBC Eng 107.90 BBC 1 FM 99.50 BBC 2 FM 89.90 -------- --------
Manual		6 Classic 101.70

7. Traffic announcements

The radio can respond to EON initiated traffic announcements if they are enabled by the TRAFFIC (TA) key. This status is indicated by a decimal point at the 11th character on the dot-matrix displays. A switch to a TA on another frequency will only occur if the station has previously been stored in NVM; the EON data which can be displayed using the RDS key is not used for TA switching. The PI code of the last TA (or attempted TA) can be displayed by pressing the RDS key eight times. A further press displays one of the TA return/inhibit messages shown below. TAs which are the result of TA=TP=1 on the current frequency do not update the last TA PI or TA return/inhibit messages.

When a 14B group is received, the following occurs:

Check traffic flag, if enabled proceed, otherwise set TA rtrn/inhb message to:

TA inhb: flag - Traffic key inhibit flag (d.p. at the 11th character position).

Search for TA PI code in NVM, if found proceed, otherwise set TA rtrn/inhb message to:

TA inhb: EON PI - The PI code given in 14B is not in the NVM.

Check station TA inhibit flag in NVM, if clear proceed, otherwise set TA rtrn/inhb message to:

TA inhb: NVM - User inhibit of station using bit stored in NVM.

Retune to frequency stored in NVM against EON PI code. The PS name display changes to show the PS name of the service carrying the traffic announcement and the time display is replaced by the new frequency. If the service has its TP flag high, then the 10s of kHz digit will flash as in the manual mode display. After one second, check TP flag at the new frequency. If high then proceed, otherwise return to original frequency and set TA rtrn/inhb message to:

TA rtrn: TP low - TP station does not have TP bit high.

Check PI code at new frequency. If correct (same as 14B EON TA PI code) then proceed, otherwise retune to original frequency and set TA rtrn/inhb message to:

TA rtrn: PI code - PI code of TP station was not as expected.

After an additional 2 seconds, start to monitor the TA flag, if high, remain on current frequency, if low return to original frequency and set TA rtrn/inhb message to:

TA rtrn: TA low - TA flag of TP station low. This is the normal return method.

If, during a TA, the radio is manually retuned, the TA rtrn/inhb message is set to:

TA rtrn: manual - User initiated manual return

8. Microprocessor I/O

K4 & PH8		Function	E32	
Port A bits	0-7	LCD module data bus	Port C bits	0-7
Port B bits	0-7	High order addresses (K4)	N/A	
Port C bits	0-7	Data bus (K4)	N/A	
Port D bits	0-1	Debug (PCbug11 or Buffalo)	Port D bits	0-1
	2-4	Keyboard rows (via 14028 encoder)		2-4
	5	Standby (high: standby, low: on)		5
Port E bits	0-3	Keyboard columns	Port E bits	0-3
	4	Shaft direction (XIRQ)		4
	5	RDS data in or shaft direction (IRQ)		5
	6	Short-wave memory select 1		6
	7	Short-wave memory select 2 (PH8 only)	N/A	
Port F bits	0-7	Low order addresses	N/A	
Port G bits	0	Mute	Port A bit	4
	1	XA14 (K4 only)	N/A	
	2-4	LCD control lines (RS, R/W & Clock)	Port B bits	5-7
	5-6	Band select	Port A bits	0-1
	7	R/W (K4)	N/A	
Port H bits	0-1	Serial clock/data for VFD & PLLs	Port B bits	0-1
	2	VFD chip enable (PH8: +/- 10.7 MHz)	Port B bit	2
	3	Port E, bit 5 input control	Port A bit	3
	4	MC145170 PLL chip enable	Port B bit	4
	5	CSGP1 (K4 only)	N/A	
	6	MC145157 PLL chip enable	Port B bit	3
	7	CSPROG (K4 only)	N/A	
N/A		FM IF select (+/- 10.7 MHz)	Port A bit	2
N/A		TA=TP=1	Port A bit	5
N/A		M/S=1	Port A bit	6
N/A		LCD multiplex select (8/16)	Port A bit	7
N/A		Display module (LCD/VFD) select	Port E bit	7

9. Set-up & Testing

An effective method of faultfinding a PLL circuit is to initially do the tuning with a potentiometer, leaving the output of the filter disconnected from the VCO. As the radio is tuned through the frequency set up in the synthesiser, the filter output should switch from one extreme to the other. Until this test passes, it is not useful to close the loop, as it is very hard to distinguish the cause of a problem from its effects.

Check operation of the MC34064 LVI circuit. As the supply voltage is lowered, it should pull the reset pin low. This should occur between 4.70 and 4.50 Volts. Adjust trimmer on the EXTAL pin of the HC711 for accurate timekeeping in the absence of RDS CT information (radio should be detuned or tuned to a station known not to provide RDS). The trimmer on pin 2 of the PLL chip (MC145157 or MC145170) should be adjusted to provide an accurate reference frequency. This adjustment can be made simply by tuning to a strong broadcast of known frequency and adjusting for optimum reception or symmetric adjacent-channel response.

10. PH8 ROMed application

The ROMed PH8s (ZC428200 and ZC428202) differ from the described E32 version of this application as follows:

1. 40 short-wave programmes can be stored instead of 20. These are accessed by the use of a second memory-select line (port E, bit 7).
2. There is no display selection; both LCD and VFD signals are generated. If an LCD module is not connected, a pull-down on port A, bit 7 should be included (see figure 3).
3. LCD multiplexing is fixed at divide-by-8.
4. Traffic announcement (retune to TA frequency) is not fully implemented in the ZC428200.
5. Time colon flash defeat key is not implemented; the display modules are always updated at 8 Hz.
6. TA=TP=1 and M/S outputs are not implemented.
7. 10 kHz MW steps are not available (no 9/10 key).
8. +/- 10.7 MHz IF selection (FM) is carried out on port H, bit 2 which is read after reset but before it is set up as an output. A pull-up or pull-down resistor will determine the IF selection (pull-up for LO high and pull-down for LO low) without affecting the pin's subsequent function as an output (VFD chip enable).
9. The 500 ms delay at switch-on between the standby line moving and the PLLs being retuned is not implemented.
10. The sleep d.p. flashes during operation of the sleep timer.

11. References

1. Application note ANE416, A Radio Synthesiser using the MC68HC05B4.

2. CENELEC EN 50067, Specifications of the Radio Data System (RDS).
   (formerly EBU Technical Document 3244).

3. Application note AN460/D, An RDS Decoder using the MC68HC05E0.

4. Application note AN495/D, RDS decoding for an HC11 controlled radio.

5. EB419/D, ROMed HC11E32 and HC11PH8 including Buffalo monitor and PCbug11 talker.

Appendix

```
 2                          ************************************************
 3                          *                                              *
 4                          *        MC68HC11E32 RDS multiband radio.      *
 5                          *                                              *
 6                          *    Used with RDSE.S11, FNCE.S11 & RDRAME.S11.*
 7                          *                                              *
 8                          *       P. Topping             3rd April'94     *
 9                          *                                              *
10                          ************************************************
11
12                                  IMPORT  SDATA,TINTB,INITD,MOD,CLOCK,MJDAT,WAIT,CLREON,CBCD,PROC,TFCC
13
14                                  EXPORT  DCON2,NEW,CLTR,SHAFT
15
16                                  LIB     RDRAME.S11
16
16 00000000                 PORTA   EQU     $00             PORT A ADDRESS
16 00000004                 PORTB   EQU     $04               "  B    "
16 00000003                 PORTC   EQU     $03               "  C    "
16 00000008                 PORTD   EQU     $08               "  D    "
16 0000000a                 PORTE   EQU     $0A               "  E    "
16 00000007                 PORTCD  EQU     $07             PORT C DATA DIRECTION REG.
16 00000009                 PORTDD  EQU     $09               "  D  "       "       "
16 00000024                 TMSK2   EQU     $24
16 00000026                 PACTL   EQU     $26
16 00000039                 OPTION  EQU     $39
16 0000003d                 INIT    EQU     $3D
16
16 00001000                 RBO     EQU     $1000           REGISTER BLOCK OFFSET
16 0000003b                 PPROG   EQU     $3B             EEPROM CONTROL REGISTER
16 00000009                 ND      EQU     9               No. DIGITS
16
16                                  SECTION.S .RAM1,COMM
16
16 00000000                 BMJD    RMB     3               BINARY MJD
16 00000003                 Q       RMB     9               WORKING NUMBER 1 - RDS
16 0000000c                 TMQ     RMB     9               SCRATCH
16 00000015                 P       RMB     9               WORKING NUMBER 2 - RDS
16 0000001e                 TMP     RMB     9               MULT. OVER. OR DIV. REMAINDER
16 00000027                 R       RMB     9               WORKING NUMBER 3 - RDS
16 00000030                 MJD     RMB     9               MODIFIED JULIAN DAY NUMBER
16 00000039                 YR      RMB     9               YEAR
16 00000042                 MNTH    RMB     2               MONTH
16 00000044                 DOM     RMB     2               DATE
16 00000046                 DOW     RMB     1               DAY OF WEEK
16
16                          ****************************************
16                          *                                      *
16                          *       RAM allocation, RDS & radio.   *
16                          *                                      *
16                          ****************************************
16
16 00000047                 DIST    RMB     1               TRANSIENT DISPLAY TIMEOUT COUNTER
16 00000048                 SLEPT   RMB     1               SLEEP TIMER MINUTES COUNTER
16 00000049                 RDSTO   RMB     1               RDS TIMEOUT COUNTER
16 0000004a                 PSNP    RMB     1               PS DISPLAY POINTER
16 0000004b                 DAT     RMB     4               SERIAL DATA BUFFER
16 0000004f                 TMPGRP  RMB     8               TEMPORARY GROUP DATA
16 00000057                 GROUP   RMB     8               COMPLETE GROUP DATA
16 0000005f                 PTY     RMB     1               PROGRAM-TYPE CODE (CURRENT)
16 00000060                 PTYCMP  RMB     1               PROGRAM-TYPE CODE (PTY SCAN)
16 00000061                 PI      RMB     2               PROGRAM IDENTIFICATION CODE
16 00000063                 PION    RMB     2               PROGRAM IDENTIFICATION CODE (EON)
16 00000065                 PIN     RMB     2               PROGRAM ITEM NUMBER
16 00000067                 LEV     RMB     1               VALID BLOCK LEVEL
16 00000068                 BIT     RMB     1               BIT LEVEL
16 00000069                 ITMP1   RMB     1               TEMP BYTE FOR USE IN IRQ
16 0000006a                 SYN     RMB     2               SYNDROME
16 0000006c                 CONF    RMB     1               SYNDROME CONFIDENCE
16 0000006d                 TH32    RMB     1               TICS (SECONDS/32)
16 0000006e                 TH8     RMB     1               EIGHTHS OF SECONDS
16 0000006f                 SEC     RMB     1               SECONDS
16 00000070                 MIN     RMB     1               MINUTES
16 00000071                 OUR     RMB     1               HOURS
16 00000072                 AMIN    RMB     1               ALARM MINUTES
16 00000073                 AOUR    RMB     1               ALARM HOURS
16 00000074                 DISP1   RMB     1               RT DISPLAY POINTER #1
16 00000075                 DISP2   RMB     1               RT DISPLAY POINTER #2
16
16 00000076                 RQ      RMB     6               WORKING BCD NUMBER 1 RADIO
16 0000007c                 RP      RMB     6                  "    "    "    2   "
16 00000082                 RR      RMB     6                  "    "    "    3   "
16 00000088                 W1      RMB     2               W
16 0000008a                 W2      RMB     2               O
16 0000008c                 W3      RMB     2               R
16 0000008e                 W4      RMB     2               K
16 00000090                 W5      RMB     2               I
16 00000092                 W6      RMB     2               N
16 00000094                 W7      RMB     2               G
16 00000096                 KEY     RMB     1               CODE OF PRESSED KEY
16 00000097                 KOUNT   RMB     1               KEYBOARD COUNTER
16 00000098                 DIG2    RMB     1               2nd DIGIT TIMEOUT COUNTER
16 00000099                 CARRY   RMB     1               BCD CARRY
16 0000009a                 COUNT   RMB     1               LOOP COUNTER
16 0000009b                 NUM1    RMB     2               1ST No. POINTER (ADD & SUBTRACT)
16 0000009d                 NUM2    RMB     2               2ND No. POINTER (ADD & SUBTRACT)
16 0000009f                 LED     RMB     1               STATION NUMBER
16 000000a0                 SMEM    RMB     2               CURRENT FREQUENCY
16 000000a2                 REARET  RMB     1               LAST TA REASON FOR RETURN
16 000000a3                 RTDIS   RMB     1               RDS DISPLAY TYPE
16 000000a4                 DI      RMB     1               DECODER IDENTIFICATION
16 000000a5                 SCHAN   RMB     1               SCAN CHANNEL
```

```
16                              ******************************************
16                              *                                        *
16                              *       Flags, & pages 1-2.              *
16                              *                                        *
16                              ******************************************
16
16 000000a6                     STAT    RMB     1               0: MODE 1: STATION, 0: FREQ
16                              *                               1: STEP 1: 50KHz, 0: 10KHz
16                              *                               2: CLRQ 1: CLEAR IF NO. KEYED
16                              *                               3: TIMER MS BIT TOGGLE (64 Hz)
16                              *                               4: RDS DATA CLEARING ENABLE
16                              *                               5: KEY FUNCTION PERFORMED
16                              *                               6: KEY REPEATING
16                              *                               7: NOT JUST POWERED UP
16 000000a7                     STAT2   RMB     1               0: VALID SYNDROME
16                              *                               1: VALID GROUP
16                              *                               2: RT DISPLAY
16                              *                               3: UPDATE DISPLAY
16                              *                               4: CLEAR DISPLAY
16                              *                               5: SPACE FLAG
16                              *                               6: NOT ON PROGRAM (AM)
16                              *                               7: TA RETUNE DONE
16 000000a8                     STAT3   RMB     1               0: NOT ON PROGRAM (FM)
16                              *                               1: TEXTA/TEXTB BIT (RT)
16                              *                               2: TA FLAG
16                              *                               3: TP FLAG
16                              *                               4: SHAFT DIRECTION
16                              *                               5: SHAFT ROTATION
16                              *                               6: UPDATE DATE
16                              *                               7: SHAFT INTERRUPTS
16 000000a9                     STAT4   RMB     1               0: DISPLAY (OR TA SWITCH) TRANSIENT
16                              *                               1: SLEEP TIMER RUNNING
16                              *                               2: TRAFFIC ENABLED
16                              *                               3: ALARM DISPLAY
16                              *                               4: ALARM ARMED
16                              *                               5: ALARM SET-UP
16                              *                               6: ALARM HOURS (SET-UP)
16                              *                               7: VALID GROUP 14B RECEIVED
16 000000aa                     STAT5   RMB     1               0: BAND CHANGE TIMEOUT
16                              *                               1: RDS DISPLAYS
16                              *                               2: SLEEP DISPLAY
16                              *                               3: M/S 0: M, 1: S
16                              *                               4: RETUNE FLAG (FREQUENCY MODE)
16                              *                               5: TA INHIBIT FLAG (NVM)
16                              *                               6: STORE MODE
16                              *                               7: WEEKDAY ONLY ALARM
16
16 000000ab                     STAT6   RMB     1               BAND/BANK (,MW STEP,COLON, ,A1,A0,,E6)
16 000000ac                     BCTO    RMB     1               BAND CHANGE TIMEOUT
16 000000ad                     SCNT    RMB     1               SHAFT DETENT COUNTER
16
16                              SECTION .RAM2,COMM
16 00000000                     EON     RMB     256             EON DATA (16 NETWORKS)
16                              SECTION .RAM3,COMM
16 00000000                     DISP    RMB     16              LCD MODULE BUFFER
16 00000010                     DISPP   RMB     16              CURRENT LCD MODULE CONTENTS
16 00000020                     PSN     RMB     8
16 00000028                     RT      RMB     69              RADIOTEXT
```

```
                                        SECTION .ROM1

00000000 >7e0000                STRST   JMP     START           RESET VECTOR
00000003 >7e0000                TMRB    JMP     TINTB           RTI
00000006 >7e0000                IRQ     JMP     SDATA           IRQ

                                ************************************************
                                *                                              *
                                *       Reset routine - set-up ports etc.      *
                                *                                              *
                                ************************************************

00000009  8601                  START   LDAA    #$01
0000000b  973d                          STAA    INIT            REGISTERS AT $1000
0000000d  8610                          LDAA    #$10            ENABLE EEPROM WRITE (NOT CONFIG)
0000000f  b71035                        STAA    $1035

00000012  8630                          LDAA    #$30            IRQ EDGE SENSITIVE
00000014  b71039                        STAA    $1039
00000017  8603                          LDAA    #$03            32Hz RTI (8.388MHz XTAL)
00000019  b71026                        STAA    $1026           PORTA, BITS 3 & 7 INPUTS
0000001c  8640                          LDAA    #$40            ENABLE REAL TIME INTERRUPTS
0000001e  b71024                        STAA    $1024
00000021  8600                          LDAA    #$00            DWOM = 0, PORTD PUSH-PULL
00000023  b71028                        STAA    $1028

00000026  8e02ff                        LDS     #$02FF          INITIALISE STACK POINTER

00000029  18ce1000                      LDY     #$1000          0,1:   BAND INPUTS (FM, FM, MW, SW), 2: FM IF
0000002d  8610                          LDAA    #$10            3:     IRQ CONTROL, 4: MUTE, 5: TA=TP=1
0000002f  18a700                        STAA    PORTA,Y         6:     M/S=1, 7: 8/16 LCD MUX

00000032  8600                  H2L     LDAA    #$00            0,1:   SERIAL CLOCK/DATA, 5,6,7: LCD CONTROL
00000034  18a704                        STAA    PORTB,Y         2,3,4: LATCH SIGNALS (VFD, 5157 & 5170)

00000037  186f03                        CLR     PORTC,Y
0000003a  86ff                          LDAA    #$FF            0-7:   LCD PARALLEL BUS
0000003c  18a707                        STAA    PORTCD,Y

0000003f  186f08                        CLR     PORTD,Y         0,1:   SCI (DEBUG)
00000042  863c                          LDAA    #$3C            2-4:   KEYBOARD OUTPUTS
00000044  18a709                        STAA    PORTDD,Y        5:     STANDBY

                                *       PORTE                   0-3:   KEYBOARD INPUTS, 4: SHAFT INPUT (XIRQ)
                                *         "                     5:     RDS/SHAFT INPUT, 6: SW BANK, 7: LCD/VFD

                                ************************************************
                                *                                              *
                                *       Initialise LCD and RAM.                *
                                *                                              *
                                ************************************************

00000047 >bd0000                        JSR     DBOUNC                  WAIT 15ms
0000004a  8630                          LDAA    #$30
0000004c >bd0000                        JSR     CLOCK                   INITIALISE LCD
0000004f >bd0000                        JSR     DBOUNC                  WAIT 15ms
00000052  8630                          LDAA    #$30
00000054 >bd0000                        JSR     CLOCK                   INITIALISE LCD

00000057 >ce0000                        LDX     #BMJD                   INITIALISE PAGE 0 RAM
0000005a  6f00                  CLOOP   CLR     0,X
0000005c  08                            INX
0000005d >8c0001                        CPX     #SCNT+1                 MORE ?
00000060  26f8                          BNE     CLOOP
00000062 >140004                        BSET    STAT4,$04               ENABLE TRAFFIC SWITCHING - DEFAULT ?
00000065 >140001                        BSET    STAT,$01                STATION MODE

00000068  8630                          LDAA    #$30
0000006a >bd0000                        JSR     CLOCK                   INITIALISE LCD
0000006d >bd0000                        JSR     WAIT
00000070  8630                          LDAA    #$30                    /8  DISPLAY
00000072  181f008002                    BRCLR   PORTA,Y,$80,M8
00000077  8638                          LDAA    #$38                    /16 DISPLAY
00000079 >bd0000                M8      JSR     CLOCK                   LATCH IT
0000007c >bd0000                        JSR     WAIT
0000007f  8608                          LDAA    #$08                    SWITCH DISPLAY OFF
00000081 >bd0000                        JSR     CLOCK                   LATCH IT
00000084 >bd0000                        JSR     WAIT
00000087  8601                          LDAA    #$01                    CLEAR DISPLAY
00000089 >bd0000                        JSR     CLOCK                   LATCH IT
0000008c >bd0000                        JSR     INITD                   INITIALISE RDS DATA & DISPLAY
0000008f >bd0000                        JSR     CLREON                  AND EON DATA

                                *       Initialise interrupt JMPs

000000eb                        JRTI    EQU     $00EB                   E32 BUFFALO RAM JUMP TABLE
000000ee                        JIRQ    EQU     $00EE                    "   "   "   "   "
000000f1                        JXIRQ   EQU     $00F1                    "   "   "   "   "

00000092  867e                          LDAA    #$7E
00000094  97eb                          STAA    JRTI
00000096  97ee                          STAA    JIRQ
00000098  97f1                          STAA    JXIRQ
0000009a >cc0000                        LDD     #TINTB
0000009d  ddec                          STD     JRTI+1                  RTI
0000009f >cc0000                        LDD     #SDATA
000000a2  ddef                          STD     JIRQ+1                  IRQ
000000a4 >cc0000                        LDD     #SHAFTX
000000a7  ddf2                          STD     JXIRQ+1                 XIRQ

000000a9  8600                          LDAA    #$00                    ENABLE IRQ & XIRQ
000000ab  06                            TAP
```

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

000000ac  18ce1000              IDLE    LDY     #$1000
000000b0 >1200080a                      BRSET   STAT,$08,TBH
000000b4  181e0e80fb                    BRSET   $0E,Y,$80,*
000000b9 >140008                        BSET    STAT,$08
000000bc  2008                          BRA     NO2D
000000be  181f0e80fb            TBH     BRCLR   $0E,Y,$80,*
000000c3 >150008                        BCLR    STAT,$08

000000c6 >13000107              NO2D    BRCLR   STAT4,$01,NOPS          DISPLAY TRANSIENT ?
000000ca >9600                          LDAA    DIST
000000cc  2603                          BNE     NOPS                    YES, TIMED OUT ?
000000ce >bd0000                        JSR     CLTR

000000d1 >13000806              NOPS    BRCLR   STAT2,$08,NDU           DISPLAY UPDATE REQUIRED ?
000000d5 >bd0000                        JSR     MOD                     YES, DO IT
000000d8 >150008                        BCLR    STAT2,$08               AND CLEAR FLAG

000000db  181f08202f            NDU     BRCLR   PORTD,Y,$20,FULON       STANDBY ?

000000e0 >12001003              NOTSNZ  BRSET   STAT4,$10,NNT2           STANDBY, ALARM ARMED ?
000000e4 >7e0000                NT2J    JMP     NT2

000000e7 >13008006              NNT2    BRCLR   STAT5,$80,NWA           YES, WEEKDAY ALARM ONLY ?
000000eb >9600                          LDAA    DOW                     YES
000000ed  8104                          CMPA    #4                      SATURDAY OR
000000ef  22f3                          BHI     NT2J                    SUNDAY ?
000000f1 >9600                  NWA     LDAA    AOUR                    NO, COMPARE ALARM HOURS
000000f3 >9100                          CMPA    OUR                     WITH TIME
000000f5  26ed                          BNE     NT2J                    SAME ?
000000f7 >9600                          LDAA    AMIN                    YES, COMPARE ALARM MINUTES
000000f9 >9100                          CMPA    MIN                     WITH TIME
000000fb  26e7                          BNE     NT2J                    SAME ?
000000fd >9600                          LDAA    SEC                     ONLY ALLOW WAKE-UP IN FIRST SECOND
000000ff  267a                          BNE     NT2                     TO PREVENT SWITCH-OFF LOCKOUT
00000101  181d0820              ONAG    BCLR    PORTD,Y,$20             YES, SWITCH ON,
00000105 >bd0000                        JSR     DEL500                  WAIT 500ms,
00000108  181d0010                      BCLR    PORTA,Y,$10             DEMUTE
0000010c >bd0000                        JSR     P5170                   AND TUNE (5170 & 5157)

0000010f >1300020f              FULON   BRCLR   STAT4,$02,FLN           SLEEP TIMER RUNNING ?
00000113 >9600                          LDAA    SLEPT                   YES
00000115  260b                          BNE     FLN                     TIME TO FINISH ?
00000117 >150002                        BCLR    STAT4,$02               YES, CLEAR FLAG,
0000011a  181c0820                      BSET    PORTD,Y,$20             SWITCH OFF
0000011e  181c0010                      BSET    PORTA,Y,$10             AND MUTE

                                ******************************************************
                                *                                                    *
                                *       Idle loop (cont.).                           *
                                *                                                    *
                                ******************************************************

00000122 >1300803f              FLN     BRCLR   STAT4,$80,NT1           14B FLAG HIGH ?
00000126 >12008051                      BRSET   STAT2,$80,NT2           YES, BIT AGREES ?
0000012a >140080                        BSET    STAT2,$80               NO, SET BIT
0000012d >7f0000                        CLR     REARET
00000130  8619                          LDAA    #25                     LOCK OUT RETURN
00000132 >9700                          STAA    DIST                    FOR 3 SECONDS
00000134 >140001                        BSET    STAT4,$01               SET DISPLAY TRANSIENT FLAG
00000137  181c0010                      BSET    PORTA,Y,$10             MUTE
0000013b >bd0000                        JSR     DBNC                    WAIT 150 mS
0000013e >bd0000                        JSR     RETUNE2                 AND RETUNE
00000141 >1300802e                      BRCLR   STAT4,$80,NWWS          PI CODE NOT IN EON LIST ?
00000145 >bd0000                        JSR     DEL500                  WAIT 500ms
                                *       BRCLR   PORTE,Y,$10,SOK         SIGNAL OK ?
                                *       LDAA    #2
                                *       STAA    REARET
                                *       BRA     NT1
00000148 >bd0000                SOK     JSR     DEL500                  WAIT 500ms
0000014b >12000806                      BRSET   STAT3,$08,TPOK          TP OK ?
0000014f  8605                          LDAA    #5
00000151 >9700                          STAA    REARET
00000153  2010                          BRA     NT1
00000155 >9600                  TPOK    LDAA    PI                      YES, CHECK PI CODE
00000157 >9100                          CMPA    PION
00000159  2606                          BNE     PINOK1
0000015b >9601                          LDAA    PI+1
0000015d >9101                          CMPA    PION+1                  AGAINST PI (EON)
0000015f  271a                          BEQ     NT2                     IF OK STAY SWITCHED
00000161  8603                  PINOK1  LDAA    #3
00000163 >9700                          STAA    REARET

00000165 >13008012              NT1     BRCLR   STAT2,$80,NT2           14B FLAG LOW, BIT AGREES ?
00000169 >150080                        BCLR    STAT4,$80               MAKE SURE 14B CANCELLED
0000016c  181c0010                      BSET    PORTA,Y,$10             MUTE
00000170 >bd0000                        JSR     DBNC                    WAIT 150 mS
00000173 >150080                NWWS    BCLR    STAT2,$80               CLEAR FLAG
00000176 >9600                          LDAA    LED                     SELECTED PROG.
00000178 >bd0000                        JSR     RETUNE2                 AND RETURN TO ORIGINAL PROGRAM

0000017b >bd0000                NT2     JSR     KBD                     READ KEYBOARD
0000017e >bd0000                        JSR     KEYP                    EXECUTE KEY
00000181 >1300200f                      BRCLR   STAT3,$20,NSRO          SHAFT ROTATION PENDING ?
00000185 >150020                        BCLR    STAT3,$20               YES, CLEAR FLAG
00000188 >12001005                      BRSET   STAT3,$10,ANTI          DIRECTION ?
0000018c >bd0000                        JSR     PINC2                   CLOCKWISE, INCREMENT
0000018f  2003                          BRA     NSRO
00000191 >bd0000                ANTI    JSR     PDEC2                   ANTI-CLOCKWIRE, DECREMENT
00000194 >13004003              NSRO    BRCLR   STAT3,$40,NRDSP         UPDATE DATE ?
00000198 >bd0000                        JSR     MJDAT                   YES, CONVERT FROM MJD
```

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                                ******************************************************
                                *                                                    *
                                *       Idle loop (cont.).                           *
                                *       Retune if band or SW bank inputs changed.    *
                                *                                                    *
                                ******************************************************

0000019b  18ce1000              NRDSP   LDY     #$1000
0000019f >1300805e                      BRCLR   STAT,$80,BTO            JUST POWERED UP ?
000001a3  181f000110                    BRCLR   PORTA,Y,$01,L5          NO, A0 LOW ?
000001a8 >1200041c                      BRSET   STAT6,$04,CG6           NO, HIGH, BIT ARGEES ?
000001ac >140004                        BSET    STAT6,$04               NO, MAKE IT HIGH
000001af >1200084e                      BRSET   STAT6,$08,BTO           BAND ONE ?
000001b3 >140080                        BSET    STAT3,$80               YES, SHAFT INTERRUPTS
000001b6  202e                          BRA     CHE                     AND NOTHING ELSE TO DO

000001b8 >1300040c              L5      BRCLR   STAT6,$04,CG6           YES, A0 LOW, BIT ARGEES ?
000001bc >150004                        BCLR    STAT6,$04               NO, MAKE IT LOW
000001bf >1200083e                      BRSET   STAT6,$08,BTO           BAND ZERO ?
000001c3 >150080                        BCLR    STAT3,$80               YES, RDS INTERRUPTS
000001c6  201e                          BRA     CHE                     AND NOTHING ELSE TO DO

000001c8  181f000209            CG6     BRCLR   PORTA,Y,$02,L6          A1 LOW ?
000001cd >12000815                      BRSET   STAT6,$08,CHE           NO, HIGH, BIT ARGEES ?
000001d1 >140008                        BSET    STAT6,$08               NO, MAKE IT HIGH
000001d4  202b                          BRA     BTO

000001d6 >1300080c              L6      BRCLR   STAT6,$08,CHE           YES, A1 LOW, BIT ARGEES ?
000001da >150008                        BCLR    STAT6,$08               NO, MAKE IT LOW
000001dd >12000420                      BRSET   STAT6,$04,BTO           BAND ZERO ?
000001e1 >150080                        BCLR    STAT3,$80               YES, RDS INTERRUPTS
000001e4  201b                          BRA     BTO

000001e6 >12000c02              CHE     BRSET   STAT6,$0C,BD3           BAND 3 ?
000001ea  201f                          BRA     OK6
000001ec                        BD3
000001ec  181f0a4009            CE6     BRCLR   PORTE,Y,$40,E6L         NO, E6 LOW ?
000001f1 >12000116                      BRSET   STAT6,$01,OK6           NO, HIGH, BIT ARGEES ?
000001f5 >140001                        BSET    STAT6,$01               NO, MAKE IT HIGH
000001f8  2007                          BRA     BTO

000001fa >1300010d              E6L     BRCLR   STAT6,$01,OK6           YES, E6 LOW, BIT ARGEES ?
000001fe >150001                        BCLR    STAT6,$01               NO, MAKE IT LOW

00000201 >140080                BTO     BSET    STAT,$80                SET POWER-UP FLAG,
00000204  860a                          LDAA    #10
00000206 >9700                          STAA    BCTO                    INITIALISE
00000208 >140001                        BSET    STAT5,$01               AND START BAND-CHANGE TIMEOUT

                                ******************************************************
                                *                                                    *
                                *       Idle loop (cont.).                           *
                                *                                                    *
                                ******************************************************

0000020b >13000111              OK6     BRCLR   STAT5,$01,ARI           TIMEOUT RUNNING ?
0000020f >7a0000                        DEC     BCTO                    YES, DECREMENT COUNT
00000212  260c                          BNE     ARI                     FINISHED ?
00000214 >150001                        BCLR    STAT5,$01               YES, CLEAR FLAG
00000217  8d26                          BSR     RCLP                    AND RECALL LAST USED PROG. No.
00000219 >13000c03                      BRCLR   STAT6,$0C,ARI           BAND 0 ?
0000021d >140080                        BSET    STAT3,$80               NO, SHAFT INTERUPTS

00000220 >12000c06              ARI     BRSET   STAT3,$0C,TATP          TA=TP=1 ?
00000224  181c0020                      BSET    PORTA,Y,$20
00000228  2004                          BRA     IOOK
0000022a  181d0020              TATP    BCLR    PORTA,Y,$20             YES, A5 LOW

0000022e >12000806              IOOK    BRSET   STAT5,$08,MSH           M/S=1 ?
00000232  181c0040                      BSET    PORTA,Y,$40
00000236  2004                          BRA     IDLJ
00000238  181d0040              MSH     BCLR    PORTA,Y,$40             YES, A6 LOW

0000023c >7e0000                IDLJ    JMP     IDLE

0000023f  181c0010              RCLP    BSET    PORTA,Y,$10             MUTE
00000243  c678                          LDAB    #120
00000245 >bd0000                        JSR     READ1                   GET STORED PROG. No.
00000248 >9700                          STAA    LED
0000024a >7e0000                        JMP     RETUNE2                 PROGRAM 145170/57

                                ******************************************************
                                *                                                    *
                                *       Shaft rotation interrupts.                   *
                                *                                                    *
                                ******************************************************

0000024d  181e0a2005            SHAFT   BRSET   PORTE,Y,$20,SEM         IRQ, SHAFT I/O HIGH (E5) ?
00000252 >150010                        BCLR    STAT3,$10               NO, CLEAR DIRECTION BIT
00000255  2003                          BRA     TEM
00000257 >140010                SEM     BSET    STAT3,$10               YES, SET DIRECTION BIT
0000025a >140020                TEM     BSET    STAT3,$20               SET FLAG TO INDICATE ROTATION
0000025d  3b                            RTI

0000025e  181e0a1005            SHAFTX  BRSET   PORTE,Y,$10,XEM         XIRQ, SHAFT I/O HIGH (E4) ?
00000263 >150010                        BCLR    STAT3,$10               NO, CLEAR DIRECTION BIT
00000266  2003                          BRA     YEM
00000268 >140010                XEM     BSET    STAT3,$10               YES, SET DIRECTION BIT
0000026b >140020                YEM     BSET    STAT3,$20               SET FLAG TO INDICATE ROTATION
0000026e  3b                            RTI
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                                ****************************************************
                                *                                                  *
                                *       Keyboard routine.                          *
                                *                                                  *
                                ****************************************************

0000026f >7f0000        KBD     CLR     W1
00000272  18ce1000              LDY     #$1000
00000276  ce0007                LDX     #7
00000279 >d600          KEY1    LDAB    W1
0000027b  cb04                  ADDB    #$04                    SELECT COLUMN
0000027d >d700                  STAB    W1
0000027f  18e608                LDAB    PORTD,Y
00000282  c420                  ANDB    #$20                    PRESERVE OTHER PORTD DATA
00000284 >db00                  ADDB    W1
00000286  18e708                STAB    PORTD,Y
00000289  18a60a                LDAA    PORTE,Y                 READ KEYBOARD
0000028c  850f                  BITA    #$0F                    ANY INPUT LINE HIGH ?
0000028e  2608                  BNE     L1
00000290  09                    DEX                             NO, TRY NEXT COLUMN
00000291  26e6                  BNE     KEY1                    LAST COLUMN ?
00000293 >7f0000                CLR     KEY                     YES, NO KEY PRESSED
00000296  2013                  BRA     EXIT
00000298 >d600          L1      LDAB    W1
0000029a  58                    LSLB
0000029b  58                    LSLB
0000029c  18a60a                LDAA    PORTE,Y                 READ KEYBOARD
0000029f  840f                  ANDA    #$0F
000002a1  1b                    ABA
000002a2 >9100                  CMPA    KEY                     SAME AS LAST TIME ?
000002a4  2705                  BEQ     EXIT
000002a6 >9700                  STAA    KEY                     NO, SAVE THIS KEY
000002a8 >7f0000                CLR     KOUNT
000002ab >7c0000        EXIT    INC     KOUNT                   YES, THE SAME
000002ae >9600                  LDAA    KOUNT
000002b0 >1300400c              BRCLR   STAT,$40,NRML           REPEATING ?
000002b4 >d600                  LDAB    PSNP                    YES
000002b6  2704                  BEQ     NOTCH                   CHARACTER CHANGE ?
000002b8  8108                  CMPA    #8                      YES, REPEAT AT 8 Hz
000002ba  200c                  BRA     GON2
000002bc  8110          NOTCH   CMPA    #16                     NO, REPEAT AT 4 Hz
000002be  2008                  BRA     GON2
000002c0  8103          NRML    CMPA    #3                      NO, 3 THE SAME ?
000002c2  252f                  BLO     KCLC                    IF NOT DO NOTHING
000002c4  271e                  BEQ     GOON                    IF 3 THEN PERFORM KEY FUNCTION
000002c6  812f                  CMPA    #47                     MORE THAN 3, MORE THAN 47 (750mS) ?
000002c8  2206          GON2    BHI     GOON2                   TIME TO DO SOMETHING ?
000002ca >9600                  LDAA    KEY                     NO
000002cc  271c                  BEQ     RKEY                    KEY PRESSED ?
000002ce  0c                    CLC
000002cf  39                    RTS                             YES BUT DO NOTHING
000002d0 >9600          GOON2   LDAA    KEY
000002d2  8154                  CMPA    #$54                    DEC. PROG.
000002d4  2708                  BEQ     GOON3
000002d6  8158                  CMPA    #$58                    INC. PROG.
000002d8  2704                  BEQ     GOON3
000002da  8152                  CMPA    #$52                    SLEEP
000002dc  260f                  BNE     DNT2                    IF NOT A REPEAT KEY, DO NOTHING
000002de >140040        GOON3   BSET    STAT,$40                SET REPEAT FLAG
000002e1 >7f0000                CLR     KOUNT
000002e4 >9600          GOON    LDAA    KEY
000002e6  2702                  BEQ     RKEY                    SOMETHING TO DO ?
000002e8  0d                    SEC                             YES, SET C
000002e9  39                    RTS
000002ea >150020        RKEY    BCLR    STAT,$20                NO, CLEAR DONE FLAG
000002ed >150040        DNT2    BCLR    STAT,$40                CLEAR REPEAT FLAG
000002f0 >7f0000                CLR     KOUNT                   CLEAR COUNTER
000002f3  0c            KCLC    CLC
000002f4  39            DNT     RTS

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

000002f5  24fd          KEYP    BCC     DNT                     ANYTHING TO DO ?
000002f7 >9600          KEYP2   LDAA    KEY                     YES, GET KEY
000002f9  8154                  CMPA    #$54                    DEC. PROG. (M)
000002fb  270c                  BEQ     RPT
000002fd  8158                  CMPA    #$58                    INC. PROG. (S)
000002ff  2708                  BEQ     RPT
00000301  8152                  CMPA    #$52                    SLEEP
00000303  2704                  BEQ     RPT
00000305 >120020eb              BRSET   STAT,$20,DNT            NOT A REPEAT KEY, FLAG SET ?

00000309  5f            RPT     CLRB
0000030a >ce0000        RJ      LDX     #CTAB
0000030d  3a                    ABX
0000030e  a600                  LDAA    0,X                     FETCH KEYCODE
00000310 >9100                  CMPA    KEY                     THIS ONE ?
00000312  2709                  BEQ     PJ                      YES
00000314 >b10000                CMPA    LAST                    NO, LAST CHANCE ?
00000317  27db                  BEQ     DNT                     YES, ABORT
00000319  cb04                  ADDB    #4                      NO TRY THE NEXT KEY
0000031b  20ed                  BRA     RJ
0000031d >140020        PJ      BSET    STAT,$20
00000320  ad01                  JSR     1,X
00000322 >7e0000                JMP     P5170
```

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

00000325  11                  CTAB    FCB     $11             0
00000326 >7e0000                      JMP     DIGIT
00000329  21                          FCB     $21             1
0000032a >7e0000                      JMP     DIGIT
0000032d  22                          FCB     $22             2
0000032e >7e0000                      JMP     DIGIT
00000331  24                          FCB     $24             3
00000332 >7e0000                      JMP     DIGIT
00000335  31                          FCB     $31             4
00000336 >7e0000                      JMP     DIGIT
00000339  32                          FCB     $32             5
0000033a >7e0000                      JMP     DIGIT
0000033d  34                          FCB     $34             6
0000033e >7e0000                      JMP     DIGIT
00000341  41                          FCB     $41             7
00000342 >7e0000                      JMP     DIGIT
00000345  42                          FCB     $42             8
00000346 >7e0000                      JMP     DIGIT
00000349  44                          FCB     $44             9
0000034a >7e0000                      JMP     DIGIT
0000034d  48                          FCB     $48             ALARM
0000034e >7e0000                      JMP     ALARM
00000351  38                          FCB     $38             STORE/SET
00000352 >7e0000                      JMP     SAVE
00000355  18                          FCB     $18             ON/OFF
00000356 >7e0000                      JMP     ONOFF
00000359  14                          FCB     $14             CLEAR/STEP
0000035a >7e0000                      JMP     CLEAR
0000035d  12                          FCB     $12             MODE (PROG./FREQ.)
0000035e >7e0000                      JMP     MODE
00000361  52                          FCB     $52             SLEEP TIMER START
00000362 >7e0000                      JMP     SLEEP
00000365  54                          FCB     $54             DEC. PROG./FREQ./CHAR.
00000366 >7e0000                      JMP     PDEC
00000369  58                          FCB     $58             INC. PROG./FREQ./CHAR.
0000036a >7e0000                      JMP     PINC
0000036d  61                          FCB     $61             RDS DISPLAYS
0000036e >7e0000                      JMP     RTDSP
00000371  62                          FCB     $62             TRAFFIC ENABLE (TOGGLE)
00000372 >7e0000                      JMP     TPEN
00000375  64                          FCB     $64             MW STEP 9/10kHz (TOGGLE)
00000376 >7e0000                      JMP     T910
00000379  51                          FCB     $51             COLON CONTROL
0000037a >7e0000                      JMP     TFCC
0000037d  68                  LAST    FCB     $68             TA TEST
0000037e >7e0000                      JMP     TEST

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

00000381 >1300080e            ALARM   BRCLR   STAT4,$08,ADON          ALARM DISPLAY ON ?
00000385 >13001005                    BRCLR   STAT4,$10,ALOF          YES, ALARM ON ?
00000389 >150010                      BCLR    STAT4,$10               YES, SWITCH OFF
0000038c  200b                        BRA     UDCNT
0000038e >140010              ALOF    BSET    STAT4,$10               NO, SWITCH ON
00000391  2006                        BRA     UDCNT

00000393 >bd0000              ADON    JSR     CLTR                    NO, ENABLE ALARM DISPLAY
00000396 >140008                      BSET    STAT4,$08               ALARM DISPLAY FLAG
00000399 >150020              UDCNT   BCLR    STAT4,$20               CANCEL SET-UP
0000039c  8619                        LDAA    #25                     3 SECONDS TIMEOUT
0000039e >9700                        STAA    DIST
000003a0 >140001                      BSET    STAT4,$01               SET DISPLAY TRANSIENT FLAG
000003a3  39                  ABOA    RTS

                                ****************************************************
                                *                                                  *
                                *       On/Off key.                                *
                                *                                                  *
                                ****************************************************

000003a4 >bd0000              ONOFF   JSR     CLTR                    CLEAR DISPLAY TRANSIENTS
000003a7 >150082                      BCLR    STAT4,$82               CANCELL SLEEP TIMER & TA SWITCH FLAG
000003aa >150040                      BCLR    STAT5,$40               CANCEL STORE MODE

000003ad  181f08200c                  BRCLR   PORTD,Y,$20,ALRON       ON ?
000003b2  181d0820            SODM    BCLR    PORTD,Y,$20             NO, SWITCH ON
000003b6 >bd0000                      JSR     DEL500                  WAIT 500ms
000003b9  181d0010                    BCLR    PORTA,Y,$10             AND DEMUTE
000003bd  39                          RTS
000003be  181c0820            ALRON   BSET    PORTD,Y,$20             YES, SWITCH Off
000003c2  181c0010                    BSET    PORTA,Y,$10             AND MUTE
000003c6  39                          RTS

                                ****************************************************
                                *                                                  *
                                *       PS name clear.                             *
                                *                                                  *
                                ****************************************************

000003c7 >ce0000              PSC     LDX     #PSN
000003ca  86ff                        LDAA    #$FF
000003cc  a700                CPSL    STAA    0,X
000003ce  08                          INX
000003cf >8c0008                      CPX     #PSN+8
000003d2  26f8                        BNE     CPSL
000003d4  39                          RTS
```

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                                ****************************************************
                                *                                                  *
                                *       TP.                                        *
                                *                                                  *
                                ****************************************************

000003d5  181e08200f  TPEN    BRSET   PORTD,Y,$20,HIGH        STANDBY ?
000003da >1200010c            BRSET   STAT,$01,NS1            NO, NORMAL MODE ?
000003de >12002004            BRSET   STAT5,$20,TAEH          NO, FREQ. MODE, NVM DISSABLE FLAG SET ?
000003e2 >140020              BSET    STAT5,$20               NO, SET IT
000003e5  39                  RTS
000003e6 >150020      TAEH    BCLR    STAT5,$20               YES, CLEAR IT
000003e9  39          HIGH    RTS

000003ea >13000404    NS1     BRCLR   STAT4,$04,TPOF          NORMAL MODE, TRAFFIC ON ?
000003ee >150004              BCLR    STAT4,$04               YES, DISSABLE
000003f1  39                  RTS
000003f2 >140004      TPOF    BSET    STAT4,$04               NO, ENABLE
000003f5  39                  RTS

                                ****************************************************
                                *                                                  *
                                *       Sleep timer.                               *
                                *                                                  *
                                ****************************************************


000003f6 >12000413    SLEEP   BRSET   STAT5,$04,DECS          ALREADY SLEEP DISPLAY ?
000003fa >12000207            BRSET   STAT4,$02,STR           NO, SLEEP TIMER ALREADY RUNNING ?
000003fe  863c        INSLP   LDAA    #60                     NO, INITIALISE SLEEP TIMER
00000400 >9700        SLEP    STAA    SLEPT
00000402 >140002              BSET    STAT4,$02               START SLEEP TIMER
00000405 >bd0000      STR     JSR     CLTR                    YES, CLEAR DISPLAY TRANSIENTS
00000408 >140004              BSET    STAT5,$04               SLEEP DISPLAY
0000040b  2008                BRA     SLPTOK                  NO DECREMENT IF FIRST TIME
0000040d >9600        DECS    LDAA    SLEPT                   DECREMENT SLEEP TIMER
0000040f  8005                SUBA    #5
00000411 >9700                STAA    SLEPT
00000413  2be9                BMI     INSLP

00000415  8619        SLPTOK  LDAA    #25
00000417 >9700                STAA    DIST
00000419 >140001              BSET    STAT4,$01               START DISPLAY TRANSIENT
0000041c  181e082091          BRSET   PORTD,Y,$20,SODM        ALREADY ON ?
00000421  181d0010            BCLR    PORTA,Y,$10             YES, JUST DEMUTE
00000425  39                  RTS

                                ****************************************************
                                *                                                  *
                                *       Number entry routine.                      *
                                *                                                  *
                                ****************************************************

00000426  181e082045  DIGIT   BRSET   PORTD,Y,$20,ABO3        STANDBY ?
0000042b >bd0000              JSR     CLTR                    NO, CLEAR DISPLAY TRANSIENTS
0000042e  54                  LSRB
0000042f  54                  LSRB
00000430 >12000128            BRSET   STAT,$01,SKP            STATION MODE ?
00000434 >12004024            BRSET   STAT5,$40,SKP           NO, STORE MODE ?
00000438 >140010              BSET    STAT5,$10               NO, SET RETUNE FLAG (FREQUENCY MODE)
0000043b >150020              BCLR    STAT5,$20               AND CLEAR TA INHIBIT BIT (NVM)
0000043e >d700                STAB    W3
00000440 >13000406            BRCLR   STAT,$04,SHIFT          CLEAR Q ?
00000444 >150004              BCLR    STAT,$04                YES, CLEAR FLAG
00000447 >bd0000              JSR     CLQ                     AND CLEAR Q
0000044a  8d1a        SHIFT   BSR     DR1                     W1: MSD, W2: LSD
0000044c >de00                LDX     W1
0000044e  a601        AGS     LDAA    1,X                     MOVE ALL DIGITS
00000450  a700                STAA    0,X                     UP ONE PLACE
00000452  08                  INX
00000453 >9c00                CPX     W2
00000455  26f7                BNE     AGS                     DONE ?
00000457 >9600                LDAA    W3                      YES, RECOVER NEW DIGIT
00000459  a700                STAA    0,X                     AND PUT IT IN LSD
0000045b  39                  RTS

0000045c  181c0010    SKP     BSET    PORTA,Y,$10             MUTE
00000460  17                  TBA
00000461 >9700                STAA    LED
00000463 >7e0000              JMP     RETUNE

                                ****************************************************
                                *                                                  *
                                *       Save pointers & 500ms delay.               *
                                *                                                  *
                                ****************************************************

00000466 >ce0000      DR1     LDX     #RQ                     STORE POINTERS
00000469 >df00                STX     W1
0000046b  c605                LDAB    #5
0000046d  3a                  ABX
0000046e >df00                STX     W2
00000470  39          ABO3    RTS

00000471  ce00ff      DEL500  LDX     #255
00000474 >bd0000              JSR     SKDB
00000477  ce00ff              LDX     #255
0000047a >7e0000              JMP     SKDB
```

```
                                ******************************************************
                                *                                                    *
                                *       Increment key (& knob).                      *
                                *                                                    *
                                ******************************************************

0000047d >12002024              PINC2   BRSET   STAT4,$20,ALSU1          ALARM SET-UP ?
00000481 >12000810                      BRSET   STAT4,$08,TOG57J         NO, ALARM DISPLAY ?
00000485  181e082048                    BRSET   PORTD,Y,$20,DMI          NO, STANDBY ?
0000048a >d600                          LDAB    PSNP
0000048c  2649                          BNE     PSN0                     NO, PS EDIT MODE ?
0000048e >7e0000                        JMP     UP                       NO, STEP UP

00000491 >12002010              PINC    BRSET   STAT4,$20,ALSU1          ALARM SET-UP ?
00000495 >1200087e              TOG57J  BRSET   STAT4,$08,TOG57          NO, ALARM DISPLAY ?
00000499  181e082034                    BRSET   PORTD,Y,$20,DMI          NO, STANDBY ?
0000049e >12000131                      BRSET   STAT,$01,NACS            NO, FREQ. MODE ?
000004a2 >7e0000                        JMP     UP                       YES, STEP UP

                                ******************************************************
                                *                                                    *
                                *       Alarm inc. (hours/minutes).                  *
                                *                                                    *
                                ******************************************************

000004a5 >12004010              ALSU1   BRSET   STAT4,$40,IHR            YES, SET-UP HOURS ?
000004a9 >9600                          LDAA    AMIN                     NO, MINUTES
000004ab  813b                          CMPA    #59
000004ad  2405                          BHS     TOOH
000004af >7c0000                        INC     AMIN
000004b2  2013                          BRA     T5S
000004b4 >7f0000                TOOH    CLR     AMIN
000004b7  200e                          BRA     T5S
000004b9 >9600                  IHR     LDAA    AOUR
000004bb  8117                          CMPA    #23
000004bd  2505                          BLO     HTOH
000004bf >7f0000                        CLR     AOUR
000004c2  2003                          BRA     T5S
000004c4 >7c0000                HTOH    INC     AOUR
000004c7  8650                  T5S     LDAA    #80                      10 SECOND TIMEOUT
000004c9 >9700                          STAA    DIST
000004cb >140001                        BSET    STAT4,$01                SET DISPLAY TRANSIENT FLAG
000004ce  181d0010                      BCLR    PORTA,Y,$10              DEMUTE
000004d2  39                    DMI     RTS

000004d3 >d600                  NACS    LDAB    PSNP
000004d5  2752                          BEQ     CONTI                    NO, PS EDIT MODE ?

                                ******************************************************
                                *                                                    *
                                *       P-S Edit inc. (ASCII) and 5/7 day toggle.    *
                                *                                                    *
                                ******************************************************

000004d7 >ceffff                PSN0    LDX     #PSN-1
000004da  3a                            ABX
000004db  a600                          LDAA    0,X                      YES
000004dd  4c                            INCA                             INCREMENT ASCII VALUE
000004de  8120                          CMPA    #$20                     SPACE
000004e0  231c                          BLS     MAK20                    LESS OR EQUAL ?
000004e2  812e                          CMPA    #$2E                     NO, .
000004e4  231c                          BLS     MAK2E                    LESS OR EQUAL ?
000004e6  8130                          CMPA    #$30                     NO, 0
000004e8  251c                          BLO     MAK30                    LESS ?
000004ea  8139                          CMPA    #$39                     NO, 9
000004ec  2322                          BLS     CNTB                     LESS OR EQUAL ?
000004ee  8141                          CMPA    #$41                     NO, A
000004f0  2518                          BLO     MAK41                    LESS ?
000004f2  815a                          CMPA    #$5A                     NO, Z
000004f4  231a                          BLS     CNTB                     LESS OR EQUAL ?
000004f6  8161                          CMPA    #$61                     NO, a
000004f8  2514                          BLO     MAK61                    LESS ?
000004fa  817a                          CMPA    #$7A                     NO, z
000004fc  2312                          BLS     CNTB                     LESS OR EQUAL ?
000004fe  8620                  MAK20   LDAA    #$20                     MAKE SPACE
00000500  200e                          BRA     CNTB
00000502  862e                  MAK2E   LDAA    #$2E                     MAKE .
00000504  200a                          BRA     CNTB
00000506  8630                  MAK30   LDAA    #$30                     MAKE 0
00000508  2006                          BRA     CNTB
0000050a  8641                  MAK41   LDAA    #$41                     MAKE A
0000050c  2002                          BRA     CNTB
0000050e  8661                  MAK61   LDAA    #$61                     MAKE a
00000510  a700                  CNTB    STAA    0,X
00000512  8650                          LDAA    #80
00000514 >7e0000                        JMP     OUTCH

00000517 >130010b7              TOG57   BRCLR   STAT4,$10,DMI           ALARM ARMED ?
0000051b >13008005                      BRCLR   STAT5,$80,A7             YES, 7-DAY ALARM ?
0000051f >150080                        BCLR    STAT5,$80                NO, MAKE IT 7 DAY
00000522  20a3                          BRA     T5S
00000524 >140080                A7      BSET    STAT5,$80                YES, MAKE IT 5 DAY
00000527  209e                          BRA     T5S

                                ******************************************************
                                *                                                    *
                                *       Program number increment.                    *
                                *                                                    *
                                ******************************************************

00000529  181c0010              CONTI   BSET    PORTA,Y,$10              MUTE
0000052d >140008                        BSET    STAT2,$08                PROG. No. INCREMENT, UPDATE DISPLAY
00000530 >9600                          LDAA    LED
00000532 >12008006                      BRSET   STAT2,$80,IOK            IF SWITCHED TO TA DON'T INCREMENT
00000536  4c                            INCA                             NEXT PROG.
00000537  8109                          CMPA    #9                       TOO HIGH ?
00000539  2301                          BLS     IOK
0000053b  4f                            CLRA                             YES, BACK TO ZERO
0000053c >9700                  IOK     STAA    LED
0000053e >7e0000                        JMP     RETUNE
```

```
                                ********************************************************
                                *                                                      *
                                *       Decrement key (& knob).                        *
                                *                                                      *
                                ********************************************************

00000541 >12002024      PDEC2   BRSET   STAT4,$20,ALSU2          ALARM SET-UP ?
00000545 >120008ce              BRSET   STAT4,$08,TOG57          NO, ALARM DISPLAY ?
00000549  181e082046            BRSET   PORTD,Y,$20,DMD          NO, STANDBY ?
0000054e >d600                  LDAB    PSNP
00000550  2647                  BNE     PSN1                    NO, PS EDIT MODE ?
00000552 >7e0000                JMP     DOWN                    NO, STEP DOWN

00000555 >12002010      PDEC    BRSET   STAT4,$20,ALSU2          ALARM SET-UP ?
00000559 >120008ba              BRSET   STAT4,$08,TOG57          NO, ALARM DISPLAY ?
0000055d  181e082032            BRSET   PORTD,Y,$20,DMD          NO, STANDBY ?
00000562 >1200012f              BRSET   STAT,$01,NACS2           NO, FREQ. MODE ?
00000566 >7e0000                JMP     DOWN                    YES, STEP DOWN

                                ********************************************************
                                *                                                      *
                                *       Alarm dec. (hours/minutes).                    *
                                *                                                      *
                                ********************************************************

00000569 >12004010      ALSU2   BRSET   STAT4,$40,IHRD          YES, SET-UP HOURS ?
0000056d >7d0000                TST     AMIN                    NO, MINUTES
00000570  2705                  BEQ     MZ
00000572 >7a0000                DEC     AMIN
00000575  2012                  BRA     T5SD
00000577  863b          MZ      LDAA    #59
00000579 >9700                  STAA    AMIN
0000057b  200c                  BRA     T5SD
0000057d >7d0000        IHRD    TST     AOUR
00000580  2604                  BNE     HZ
00000582  8618                  LDAA    #24
00000584 >9700                  STAA    AOUR
00000586 >7a0000        HZ      DEC     AOUR
00000589  8650          T5SD    LDAA    #80                     10 SECOND TIMEOUT
0000058b >9700                  STAA    DIST
0000058d >140001                BSET    STAT4,$01               SET DISPLAY TRANSIENT FLAG
00000590  181d0010              BCLR    PORTA,Y,$10             DEMUTE
00000594  39            DMD     RTS

00000595 >d600          NACS2   LDAB    PSNP
00000597  2746                  BEQ     CONTD                   PS EDIT CHARACTER CHANGE ?

                                ********************************************************
                                *                                                      *
                                *       P-S Edit dec. (ASCII).                         *
                                *                                                      *
                                ********************************************************

00000599 >ceffff        PSN1    LDX     #PSN-1
0000059c  3a                    ABX
0000059d  a600                  LDAA    0,X                     YES
0000059f  4a                    DECA                            DECRENENT ASCII VALUE
000005a0  8120                  CMPA    #$20                    SPACE
000005a2  2328                  BLS     MKE7A                   LESS OR EQUAL ?
000005a4  812e                  CMPA    #$2E                    NO, .
000005a6  2318                  BLS     MKE20                   LESS OR EQUAL ?
000005a8  8130                  CMPA    #$30                    NO, 0
000005aa  2518                  BLO     MKE2E                   LESS ?
000005ac  8139                  CMPA    #$39                    NO, 9
000005ae  2322                  BLS     CNTS                    LESS OR EQUAL ?
000005b0  8141                  CMPA    #$41                    NO, A
000005b2  251c                  BLO     MKE39                   LESS ?
000005b4  815a                  CMPA    #$5A                    NO, Z
000005b6  231a                  BLS     CNTS                    LESS OR EQUAL ?
000005b8  8161                  CMPA    #$61                    NO, a
000005ba  250c                  BLO     MKE5A                   LESS ?
000005bc  817a                  CMPA    #$7A                    NO, z
000005be  2312                  BLS     CNTS                    LESS OR EQUAL ?
000005c0  8620          MKE20   LDAA    #$20                    MAKE SPACE
000005c2  200e                  BRA     CNTS
000005c4  862e          MKE2E   LDAA    #$2E                    MAKE .
000005c6  200a                  BRA     CNTS
000005c8  865a          MKE5A   LDAA    #$5A                    MAKE Z
000005ca  2006                  BRA     CNTS
000005cc  867a          MKE7A   LDAA    #$7A                    MAKE z
000005ce  2002                  BRA     CNTS
000005d0  8639          MKE39   LDAA    #$39                    MAKE A
000005d2  a700          CNTS    STAA    0,X
000005d4  8650                  LDAA    #80

000005d6 >9700          OUTCH   STAA    DIST
000005d8 >140001                BSET    STAT4,$01               SET DISPLAY TRANSIENT FLAG
000005db >150008                BCLR    STAT4,$08               NOT ALARM DISPLAY MODE
000005de  39                    RTS
```

```
                                ******************************************************
                                *                                                    *
                                *       Program number decrement.                    *
                                *                                                    *
                                ******************************************************

000005df  181c0010              CONTD   BSET    PORTA,Y,$10             MUTE
000005e3 >9600                          LDAA    LED                     PROG. No. DECREMENT
000005e5 >12008007                      BRSET   STAT2,$80,RETUNE        IF SWITCHED TO TA DON'T DECREMENT
000005e9  4a                    PNM1    DECA                            DECREMENT PROGRAM NUMBER
000005ea  2a02                          BPL     SK2P                    TOO FAR ?
000005ec  8609                          LDAA    #9
000005ee >9700                  SK2P    STAA    LED                     SAVE NEW PROGRAM NUMBER
000005f0  36                    RETUNE  PSHA
000005f1  c678                          LDAB    #120                    CHANGE PROGRAM NUMBER IN NVM
000005f3 >bd0000                        JSR     WRITE1
000005f6  32                            PULA
000005f7 >13008008                      BRCLR   STAT4,$80,RETUNE2       TA SWITCHED ?
000005fb >150080                        BCLR    STAT4,$80               YES, MANUAL RETURN FROM TA
000005fe  8609                          LDAA    #9
00000600 >9700                          STAA    REARET
00000602  39                            RTS

00000603 >bd0000                RETUNE2 JSR     DOIT                    NEW PROGRAM
00000606 >bd0000                        JSR     P5170
00000609  ce0040                        LDX     #64                     WAIT 100ms
0000060c >bd0000                        JSR     SKDB
0000060f  181d0010                      BCLR    PORTA,Y,$10             DEMUTE
00000613 >150002                        BCLR    STAT2,$02               KILL ANY PENDING RDS GROUP
00000616 >150001                        BCLR    STAT3,$01               AND INHIBIT FM PS-NAME CLEARING
00000619 >150010                        BCLR    STAT,$10                RE-ENABLE RDS DATA CLEARING
0000061c  39                            RTS


0000061d  c60a                  FOK     LDAB    #10
0000061f  3d                            MUL
00000620  cb5c                          ADDB    #$5C
00000622 >d700                          STAB    SMEM
00000624  8926                          ADCA    #$26
00000626 >9701                          STAA    SMEM+1
00000628 >7e0000                        JMP     NEW

                                ******************************************************
                                *                                                    *
                                *       Tune to TA (using EEPROM data).              *
                                *                                                    *
                                ******************************************************

0000062b  5f                    TASW    CLRB
0000062c  cb0a                  TPIC    ADDB    #10
0000062e >bd0000                        JSR     READ1                   FIND PI
00000631  5c                            INCB
00000632 >9100                          CMPA    PION                    MSB OK ?
00000634  261f                          BNE     TNP
00000636  5a                            DECB
00000637 >bd0000                        JSR     READ1
0000063a >9101                          CMPA    PION+1                  LSB OK ?
0000063c  2617                          BNE     TNP
0000063e  c00c                          SUBB    #12                     YES, FOUND IT
00000640 >bd0000                        JSR     READ1
00000643  36                            PSHA
00000644  8480                          ANDA    #$80                    NVM INHIBIT FLAG SET ?
00000646  2704                          BEQ     TASOK
00000648  8608                          LDAA    #8                      NVM INHIBIT MESSAGE
0000064a  2010                          BRA     ABTA
0000064c  32                    TASOK   PULA
0000064d >9701                          STAA    SMEM+1
0000064f >bd0000                        JSR     NEWSUB2
00000652 >7e0000                        JMP     NEW

00000655  c1fc                  TNP     CMPB    #252                    TRY NEXT RECORD
00000657  25d3                          BLO     TPIC
00000659  36                            PSHA
0000065a  8607                          LDAA    #7
0000065c >9700                  ABTA    STAA    REARET
0000065e  32                            PULA
0000065f >150080                        BCLR    STAT4,$80               PI MATCH NOT FOUND, FORGET IT
00000662  39                            RTS

                                ******************************************************
                                *                                                    *
                                *       Program store/recall.                        *
                                *                                                    *
                                ******************************************************

00000663 >120080c4              DOIT    BRSET   STAT2,$80,TASW
00000667  c60c                          LDAB    #12
00000669  3d                            MUL
0000066a >12004003                      BRSET   STAT5,$40,STORE
0000066e >7e0000                        JMP     RECALL
```

```
                                ****************************************************
                                *                                                  *
                                *       NVM write, sub-address in X.               *
                                *                                                  *
                                ****************************************************

00000671 >150180        STORE   BCLR    SMEM+1,$80
00000674 >13002003              BRCLR   STAT5,$20,SKTA          TA NVM INHIBIT FLAG SET ?
00000678 >140180                BSET    SMEM+1,$80
0000067b >9601          SKTA    LDAA    SMEM+1                  BINARY FREQUENCY MSB
0000067d >bd0000                JSR     WRITE1
00000680 >9600                  LDAA    SMEM                    BINARY FREQUENCY LSB
00000682 >bd0000                JSR     WRITE1
00000685 >b60000                LDAA    PSN
00000688  81a0                  CMPA    #$A0                    PS NAME OK ?
0000068a  2704                  BEQ     PSNOK
0000068c  81ff                  CMPA    #$FF                    PERHAPS, TRY FF
0000068e  2637                  BNE     PSOK
00000690  86ff          PSNOK   LDAA    #$FF
00000692 >bd0000                JSR     WRITE1
00000695 >b6000a                LDAA    DISP+10
00000698 >bd0000                JSR     WRITE1
0000069b >b6000b                LDAA    DISP+11
0000069e >bd0000                JSR     WRITE1
000006a1 >b6000c                LDAA    DISP+12
000006a4 >bd0000                JSR     WRITE1
000006a7 >b6000d                LDAA    DISP+13
000006aa >bd0000                JSR     WRITE1
000006ad >b6000e                LDAA    DISP+14
000006b0 >bd0000                JSR     WRITE1
000006b3 >b6000f                LDAA    DISP+15
000006b6 >bd0000                JSR     WRITE1
000006b9  8620                  LDAA    #$20
000006bb >bd0000                JSR     WRITE1
000006be  8600                  LDAA    #$00                    DUMMY PI CODE
000006c0 >bd0000                JSR     WRITE1
000006c3  8600                  LDAA    #$00
000006c5  2034                  BRA     FINST

000006c7 >bd0000        PSOK    JSR     WRITE1
000006ca >b60001                LDAA    PSN+1
000006cd >bd0000                JSR     WRITE1
000006d0 >b60002                LDAA    PSN+2
000006d3 >bd0000                JSR     WRITE1
000006d6 >b60003                LDAA    PSN+3
000006d9 >bd0000                JSR     WRITE1
000006dc >b60004                LDAA    PSN+4
000006df >bd0000                JSR     WRITE1
000006e2 >b60005                LDAA    PSN+5
000006e5 >bd0000                JSR     WRITE1
000006e8 >b60006                LDAA    PSN+6
000006eb >bd0000                JSR     WRITE1
000006ee >b60007                LDAA    PSN+7
000006f1 >bd0000                JSR     WRITE1
000006f4 >9600                  LDAA    PI                      PI CODE
000006f6 >bd0000                JSR     WRITE1
000006f9 >9601                  LDAA    PI+1
000006fb >bd0000        FINST   JSR     WRITE1
000006fe >150040                BCLR    STAT5,$40               CLEAR STORE MODE
00000701  39                    RTS

                                ****************************************************
                                *                                                  *
                                *       NVM read, sub-address in X.                *
                                *                                                  *
                                ****************************************************

00000702  8d03          RECALL  BSR     NEWSUB
00000704 >7e0000                JMP     NEW

00000707 >bd0000        NEWSUB  JSR     READ1
0000070a >9701                  STAA    SMEM+1
0000070c >150020                BCLR    STAT5,$20
0000070f >13018003              BRCLR   SMEM+1,$80,NEWSUB2
00000713 >140020                BSET    STAT5,$20
00000716 >bd0000        NEWSUB2 JSR     READ1
00000719  81ff                  CMPA    #$FF
0000071b  2606                  BNE     NOTFF2
0000071d  8626                  LDAA    #$26                    $04
0000071f >9701                  STAA    SMEM+1
00000721  865c                  LDAA    #$5C                    $2E
00000723 >9700          NOTFF2  STAA    SMEM
00000725 >bd0000                JSR     READ1
00000728 >b70000                STAA    PSN
0000072b >bd0000                JSR     READ1
0000072e >b70001                STAA    PSN+1
00000731 >bd0000                JSR     READ1
00000734 >b70002                STAA    PSN+2
00000737 >bd0000                JSR     READ1
0000073a >b70003                STAA    PSN+3
0000073d >bd0000                JSR     READ1
00000740 >b70004                STAA    PSN+4
00000743 >bd0000                JSR     READ1
00000746 >b70005                STAA    PSN+5
00000749 >bd0000                JSR     READ1
0000074c >b70006                STAA    PSN+6
0000074f >bd0000                JSR     READ1
00000752 >b70007                STAA    PSN+7
00000755  39                    RTS
```

```
1075                                ****************************************************
1076                                *                                                  *
1077                                *       NVM read & write one byte.                 *
1078                                *                                                  *
1079                                ****************************************************
1080
1081 00000756 >bd0000               READ1   JSR     GETAD
1082 00000759  a600                         LDAA    0,X
1083 0000075b  5c                           INCB
1084 0000075c  39                           RTS
1085
1086 0000075d  18ce1000             WRITE1  LDY     #$1000
1087 00000761  181c3b16                     BSET    PPROG,Y,$16             SET EELAT, ERASE & BYTE ERASE BITS
1088 00000765  8d08                         BSR     WBYTE                   ERASE BYTE
1089 00000767 >bd0000                       JSR     DBOUNC                  WAIT 15 mS
1090 0000076a  181c3b02                     BSET    PPROG,Y,$02             SET EELAT TO WRITE BYTE
1091 0000076e  5a                           DECB
1092
1093 0000076f >bd0000               WBYTE   JSR     GETAD
1094 00000772  a700                         STAA    0,X                     LATCH DATA
1095 00000774  181c3b01                     BSET    PPROG,Y,$01             SET EEPGM BIT TO START PROGRAMMING
1096 00000778 >bd0000                       JSR     DBOUNC                  WAIT 15 mS
1097 0000077b  186f3b                       CLR     PPROG,Y                 STOP
1098 0000077e  5c                           INCB
1099 0000077f  39                           RTS
1100
1101 00000780  36                   GETAD   PSHA
1102 00000781  37                           PSHB
1103 00000782 >bd0000                       JSR     BAND                    GET BAND
1104 00000785  ceb618                       LDX     #$B618                  EEPROM START ADDRESS
1105 00000788  17                           TBA
1106 00000789  8101                         CMPA    #1                      FM ?
1107 0000078b  230e                         BLS     FMB
1108 0000078d  c67a                         LDAB    #122                    NO, AM
1109 0000078f  3a                           ABX
1110 00000790  8102                         CMPA    #2                      MW ?
1111 00000792  2707                         BEQ     FMB
1112 00000794  3a                           ABX                             NO, SW
1113 00000795  181f0a4001                   BRCLR   PORTE,Y,$40,SWB2        SECOND BANK ?
1114 0000079a  3a                           ABX                             YES
1115 0000079b                       SWB2
1116                                *       BRCLR   PORTE,Y,$80,FMB         SECOND PAIR OF BANKS ?
1117                                *       ABX                             YES
1118                                *       ABX
1119 0000079b  33                   FMB     PULB
1120 0000079c  32                           PULA
1121 0000079d  3a                           ABX
1122 0000079e  39                           RTS
1123
1124                                ****************************************************
1125                                *                                                  *
1126                                *       RDS displays.                              *
1127                                *                                                  *
1128                                ****************************************************
1129
1130 0000079f  181e08207c           RTDSP   BRSET   PORTD,Y,$20,SRT         STANDBY ?
1131 000007a4 >12000204                     BRSET   STAT5,$02,NOTRT         ALREADY RDS DISPLAY ?
1132 000007a8 >13000414                     BRCLR   STAT2,$04,NORT          ALREADY RT DISPLAY ?
1133
1134 000007ac >140002               NOTRT   BSET    STAT5,$02               SET RDS DISPLAY FLAG
1135 000007af >9600                         LDAA    RTDIS                   YES, MOVE ON
1136 000007b1  4c                           INCA
1137 000007b2  811a                         CMPA    #26
1138 000007b4  270a                         BEQ     NORT
1139 000007b6 >9700                         STAA    RTDIS
1140 000007b8  8664                         LDAA    #100
1141 000007ba >9700                         STAA    DIST
1142 000007bc >140001                       BSET    STAT4,$01               RE-START TRANSIENT TIMEOUT
1143 000007bf  39                           RTS
1144
1145 000007c0 >bd0000               NORT    JSR     CLTR
1146 000007c3 >140004                       BSET    STAT2,$04               SET RT DISPLAY FLAG
1147 000007c6  8609                         LDAA    #9
1148 000007c8 >9700                         STAA    DISP1
1149 000007ca  8601                         LDAA    #1
1150 000007cc >9700                         STAA    DISP2
1151 000007ce  39                           RTS
```

```
                                ****************************************************
                                *                                                  *
                                *       Increment and decrement routines.          *
                                *                                                  *
                                ****************************************************

000007cf  8d28          UP      BSR     LDXR
000007d1 >7c0000        IF      INC     SMEM                    NO, INCREMENT LSB
000007d4  2603                  BNE     TT1                     DID IT WRAP ROUND
000007d6 >7c0001                INC     SMEM+1                  YES, INCREMENT MSB
000007d9  5a            TT1     DECB
000007da  26f5                  BNE     IF                      ALL DONE ?
000007dc  2010                  BRA     NEWJ

000007de  8d19          DOWN    BSR     LDXR
000007e0 >7d0000        DF      TST     SMEM                    NO, IS LSB ZERO ?
000007e3  2603                  BNE     TT2                     IF NOT LEAVE MSD
000007e5 >7a0001                DEC     SMEM+1                  DECREMENT MSB
000007e8 >7a0000        TT2     DEC     SMEM                    DECREMENT LSB
000007eb  5a                    DECB
000007ec  26f2                  BNE     DF                      ALL DONE ?
000007ee >bd0000        NEWJ    JSR     NEW
000007f1 >bd0000                JSR     P5170
000007f4  181d0010              BCLR    PORTA,Y,$10             DEMUTE
000007f8  39                    RTS

000007f9 >13000805      LDXR    BRCLR   STAT6,$08,LDXR2          AM ?
000007fd >140040                BSET    STAT2,$40               YES, CLEAR PS NAME
00000800  2003                  BRA     NFMB
00000802 >140001        LDXR2   BSET    STAT3,$01               NO, FM, ENABLE PS NAME CLEARING
00000805 >bd0000        NFMB    JSR     BAND                    GET BAND
00000808  17                    TBA
00000809  c601                  LDAB    #1                      SINGLE STEP (1,5,10 kHz FOR MW,SW,FM)
0000080b >13000211              BRCLR   STAT,$02,SRT            LARGE STEPS SELECTED ?
0000080f  8103                  CMPA    #3                      YES, BAND 3 (SW) ?
00000811  270d                  BEQ     SRT
00000813  c605                  LDAB    #5                      NO, x5 STEP (50 kHz FOR FM)
00000815  8102                  CMPA    #2                      MW ?
00000817  2607                  BNE     SRT
00000819  c609                  LDAB    #9                      YES, 9kHz
0000081b >13004001              BRCLR   STAT6,$40,SRT           OR SHOULD IT BE 10kHz
0000081f  5c                    INCB                            YES
00000820  39            SRT     RTS

                                ****************************************************
                                *                                                  *
                                *       TA test.                                   *
                                *                                                  *
                                ****************************************************

00000821  181e08200d    TEST    BRSET   PORTD,Y,$20,AOB         STANDBY ?
00000826  ccc5b1                LDD     #$C5B1                  CLYDE 1
00000829 >dd00                  STD     PION
0000082b >12000405              BRSET   STAT4,$04,NABT          TA SWITCHING ENABLED ?
0000082f  8601                  LDAA    #1                      NO, SET RETURN REASON
00000831 >9700                  STAA    REARET
00000833  39            AOB     RTS
00000834 >140080        NABT    BSET    STAT4,$80               YES, DO IT
00000837  39                    RTS

                                ****************************************************
                                *                                                  *
                                *       Store key.                                 *
                                *                                                  *
                                ****************************************************

00000838 >1300081d      SAVE    BRCLR   STAT4,$08,NAME          ALARM DISPLAY ?
0000083c >13001049              BRCLR   STAT4,$10,NTB2          YES, ALARM ARMED ?
00000840 >12002007              BRSET   STAT4,$20,AISM          YES, ALREADY SET-UP MODE ?
00000844 >140060                BSET    STAT4,$60               NO, ENTER SET-UP MODE, HOURS
00000847  8650          A5SD    LDAA    #80
00000849  2039                  BRA     SDT
0000084b >12004005      AISM    BRSET   STAT4,$40,MSM           YES, SET-UP HOURS ?
0000084f >150020                BCLR    STAT4,$20               NO, CANCELL SET-UP
00000852  20f3                  BRA     A5SD
00000854 >150040        MSM     BCLR    STAT4,$40               YES, MAKE IT MINUTES
00000857  20ee                  BRA     A5SD

00000859  181e08202b    NAME    BRSET   PORTD,Y,$20,NTB2         STANDBY ?
0000085e >1200010d              BRSET   STAT,$01,NFM            NO, FREQUENCY MODE ?
00000862 >12004004              BRSET   STAT5,$40,ASM            YES, STORE MODE ?
00000866 >140040                BSET    STAT5,$40               NO, ENTER STORE MODE
00000869  39                    RTS

0000086a >9600          ASM     LDAA    LED
0000086c >7e0000                JMP     DOIT                    SAVE

0000086f >9600          NFM     LDAA    PSNP                    NOT FREQUENCY MODE
00000871  2603                  BNE     SKPCLR                  SET
00000873 >bd0000                JSR     CLTR                    UP
00000876 >7c0000        SKPCLR  INC     PSNP                    PS-NAME CHANGE MODE
00000879 >9600                  LDAA    PSNP
0000087b  8108                  CMPA    #8
0000087d  2303                  BLS     NTB3
0000087f >7f0000                CLR     PSNP
00000882  8650          NTB3    LDAA    #80
00000884 >9700          SDT     STAA    DIST
00000886 >140001                BSET    STAT4,$01               SET DISPLAY TRANSIENT FLAG
00000889  39            NTB2    RTS
```

```
1253                                ****************************************************
1254                                *                                                  *
1255                                *       PROG,  the displayed number is added to    *
1256                                *       the IF offset,  converted to binary and    *
1257                                *       stored in SMEM & SMEM+1.                   *
1258                                *                                                  *
1259                                *       NEW takes the binary  working frequency    *
1260                                *       in SMEM & SMEM+1 converts it to BCD and    *
1261                                *       subtracts the IF offset.                   *
1262                                *                                                  *
1263                                ****************************************************
1264
1265 0000088a >1200011b            PROG    BRSET   STAT,$01,NEW            STATION MODE ?
1266 0000088e >bd0000                  JSR     IFO                     P < IF OFFSET
1267 00000891 >bd0000                  JSR     ADD                     Q < FREQ + IF
1268
1269 00000894 >bd0000                  JSR     BAND
1270 00000897  260d                    BNE     ONE                     BAND 3 (SW) ?
1271 00000899 >bd0000                  JSR     ADD                     YES, DIVIDE BY 5, Q < 2 X (FREQ + IF)
1272 0000089c  ce0005                  LDX     #5
1273 0000089f >a6ff            LPP     LDAA    RQ-1,X                  MOVE ALL DIGITS
1274 000008a1 >a700                    STAA    RQ,X                    IN Q DOWN ONE
1275 000008a3  09                      DEX                             PLACE TO DEVIDE
1276 000008a4  26f9                    BNE     LPP                     BY 10 (Q < Q/5)
1277
1278 000008a6 >bd0000          ONE     JSR     BCON                    CONVERT Q TO BINARY
1279
1280 000008a9 >bd0000          NEW     JSR     DCON                    CONVERT TO BCD IN Q
1281
1282 000008ac >bd0000                  JSR     BAND
1283 000008af  2619                    BNE     STIF                    BAND 3 (SW) ?
1284 000008b1 >df00                    STX     NUM1                    YES
1285 000008b3 >ce0000                  LDX     #RP
1286 000008b6 >bd0000                  JSR     ADD                     P < 2Q
1287 000008b9 >ce0000                  LDX     #RP
1288 000008bc >df00                    STX     NUM1
1289 000008be >ce0000                  LDX     #RQ
1290 000008c1 >bd0000                  JSR     ADD                     Q < 3Q
1291 000008c4 >ce0000                  LDX     #RQ
1292 000008c7 >bd0000                  JSR     ADD                     Q < 5Q
1293
1294 000008ca >bd0000          STIF    JSR     IFO                     P < IF OFFSET
1295 000008cd >140004                  BSET    STAT,$04
1296 000008d0 >7e0000                  JMP     SUB                     Q < (RATIO X STEP) -IF
1297
1298                                ****************************************************
1299                                *                                                  *
1300                                *      The IF offset is selected according to      *
1301                                *      the required band and placed in "RP".       *
1302                                *                                                  *
1303                                ****************************************************
1304
1305 000008d3  8d51              IFO     BSR     BAND                    FIND BAND
1306 000008d5  181e000406              BRSET   PORTA,Y,$04,NOTN        NEGATIVE FM IF ?
1307 000008da  c101                    CMPB    #1                      YES
1308 000008dc  2202                    BHI     NOTN                    BUT IS IT FM ?
1309 000008de  c604                    LDAB    #4                      YES, FIFTH IF FROM TABLE
1310 000008e0  8606            NOTN    LDAA    #6
1311 000008e2  3d                      MUL                             TIMES 6
1312 000008e3 >ce0000                  LDX     #IFS
1313 000008e6  3a                      ABX
1314 000008e7 >18ce0000                LDY     #RP
1315 000008eb  a600            LP6     LDAA    0,X                     TRANSFER
1316 000008ed  18a700                  STAA    0,Y                     INTO RP
1317 000008f0  08                      INX
1318 000008f1  1808                    INY
1319 000008f3 >188c0006                CPY     #RP+6
1320 000008f7  25f2                    BLO     LP6                     DONE ?
1321 000008f9  18ce1000                LDY     #$1000                  RE-INITIALISE Y
1322 000008fd >ce0000                  LDX     #RP                     SET-UP POINTERS
1323 00000900 >df00                    STX     NUM2
1324 00000902 >ce0000                  LDX     #RQ
1325 00000905 >df00                    STX     NUM1
1326 00000907  39                      RTS
1327
1328 00000908  000001000700    IFS     FCB     0,0,1,0,7,0              10.70 MHz FM OSC HIGH
1329 0000090e  000001000700            FCB     0,0,1,0,7,0              10.70 MHz FM OSC HIGH
1330 00000914  000000040505            FCB     0,0,0,4,5,5                455 kHz SW/MW
1331 0000091a  000100070000            FCB     0,1,0,7,0,0              10.70 MHz SW (EXT/5 FOR 5157)
1332 00000920  090908090300            FCB     9,9,8,9,3,0             -10.70 MHz FM OSC LOW
1333
1334 00000926  18e600          BAND    LDAB    PORTA,Y                 GET BAND
1335 00000929  c403                    ANDB    #$03
1336 0000092b >ce0000                  LDX     #RQ
1337 0000092e >df00                    STX     NUM2
1338 00000930  c103                    CMPB    #3                      BAND 3 (SW, /5) ?
1339 00000932  39                      RTS
```

```
1341                                ****************************************************
1342                                *                                                  *
1343                                *       Mode change & clear routines.              *
1344                                *                                                  *
1345                                ****************************************************
1346
1347 00000933  181e08205a     MODE    BRSET   PORTD,Y,$20,CLP         STANDBY ?
1348 00000938 >bd0000                 JSR     CLTR
1349 0000093b >bd0000                 JSR     PROG                    SEND DISPLAYED FREQUENCY
1350 0000093e >13000104       SKIP    BRCLR   STAT,$01,SK             FREQUENCY MODE ?
1351 00000942 >150001                 BCLR    STAT,$01                NO, SET TO FREQUENCY MODE
1352 00000945  39                     RTS
1353
1354 00000946 >150040         SK      BCLR    STAT5,$40               FREQ. MODE, CLEAR STORE MODE
1355 00000949 >1300101b               BRCLR   STAT5,$10,NNTR          NEW FREQUENCY ENTERED ?
1356 0000094d  181c0010               BSET    PORTA,Y,$10             YES, MUTE
1357 00000951 >bd0000                 JSR     DBNC                    WAIT 15ms
1358 00000954 >bd0000                 JSR     P5170
1359 00000957  ce0040                 LDX     #64
1360 0000095a >bd0000                 JSR     SKDB                    WAIT 100mS
1361 0000095d  181d0010               BCLR    PORTA,Y,$10             DE-MUTE
1362 00000961 >150002                 BCLR    STAT2,$02               AND KILL ANY PENDING RDS GROUP
1363 00000964 >150010         SKSM    BCLR    STAT5,$10               CLEAR RETUNE FLAG
1364 00000967  39                     RTS
1365 00000968 >140001         NNTR    BSET    STAT,$01                NO, RETURN TO STATION MODE
1366 0000096b >150040                 BCLR    STAT5,$40               CANCEL STORE MODE
1367 0000096e  39                     RTS
1368
1369 0000096f  181e08201e     CLEAR   BRSET   PORTD,Y,$20,CLP         STANDBY ?
1370 00000974 >12000105               BRSET   STAT,$01,SM             NO, STATION MODE ?
1371 00000978 >140010                 BSET    STAT5,$10               FREQUENCY CHANGED
1372 0000097b  8d16           CLAL    BSR     CLQ                     NO, CLEAR Q
1373 0000097d >9600           SM      LDAA    PSNP
1374 0000097f  2703                   BEQ     SPCC
1375 00000981 >bd0000                 JSR     PSC
1376 00000984 >bd0000         SPCC    JSR     CLTR                    CLEAR DISPLAY TRANSIENTS
1377 00000987 >12000204               BRSET   STAT,$02,KHZ
1378 0000098b >140002                 BSET    STAT,$02                9 (MW), 50 (FM) kHz STEPS
1379 0000098e  39                     RTS
1380 0000098f >150002         KHZ     BCLR    STAT,$02                1 (MW), 10 (FM) kHz STEPS
1381 00000992  39             CLP     RTS
1382
1383 00000993 >ce0000         CLQ     LDX     #RQ                     CLEAR RQ
1384 00000996  8606           CLRAS   LDAA    #06                     CLEAR 6 BYTES
1385 00000998 >9700                   STAA    COUNT                   STARTING AT X
1386 0000099a  6f00           CR      CLR     0,X
1387 0000099c  08                     INX
1388 0000099d >7a0000                 DEC     COUNT
1389 000009a0  26f8                   BNE     CR                      DONE ?
1390 000009a2  39                     RTS
1391
1392 000009a3 >150001         CLTR    BCLR    STAT4,$01               CLEAR DISPLAY TRANSIENT FLAG
1393 000009a6 >150004         CLTR2   BCLR    STAT2,$04               CANCEL RT DISPLAY
1394 000009a9 >7f0000                 CLR     RTDIS
1395 000009ac >150028                 BCLR    STAT4,$28               NOT ALARM (DISPLAY OR SET-UP)
1396 000009af >150006                 BCLR    STAT5,$06               NOT RT OR SLEEP DISPLAY
1397 000009b2 >7f0000                 CLR     PSNP                    NOT PS-EDIT
1398 000009b5  39                     RTS
1399
1400                                ****************************************************
1401                                *                                                  *
1402                                *       BCD to binary conversion. No. in "RQ" is   *
1403                                *       converted to binary in SMEM & SMEM+1.      *
1404                                *                                                  *
1405                                ****************************************************
1406
1407 000009b6 >7f0000         BCON    CLR     SMEM                    CLEAR WORKING
1408 000009b9 >7f0001                 CLR     SMEM+1                  FREQUENCY LOCATIONS
1409 000009bc  ce0000                 LDX     #0
1410 000009bf >9600           L2      LDAA    SMEM                    LS BYTE
1411 000009c1  48                     LSLA                            2xLSB
1412 000009c2 >9700                   STAA    W1                      SAVE 2xLSB
1413 000009c4 >790001                 ROL     SMEM+1                  2xMS BYTE
1414 000009c7 >9601                   LDAA    SMEM+1
1415 000009c9 >9700                   STAA    W2                      SAVE 2xMSB
1416 000009cb >9600                   LDAA    W1                      2xLSB
1417 000009cd  48                     LSLA                            4xLSB
1418 000009ce >790001                 ROL     SMEM+1                  4xMSB
1419 000009d1  48                     LSLA                            8xLSB
1420 000009d2 >790001                 ROL     SMEM+1                  8xMSB
1421 000009d5 >9b00                   ADDA    W1                      10xLSB
1422 000009d7 >9700                   STAA    SMEM
1423 000009d9 >9601                   LDAA    SMEM+1
1424 000009db >9900                   ADCA    W2                      10xMSB
1425 000009dd >9701                   STAA    SMEM+1
1426 000009df  08                     INX                             FETCH
1427 000009e0 >a600                   LDAA    RQ,X                    NEXT
1428 000009e2 >9b00                   ADDA    SMEM                    DIGIT
1429 000009e4 >9700                   STAA    SMEM                    AND
1430 000009e6  8600                   LDAA    #0                      (CLRA CLEARS THE C BIT)
1431 000009e8 >9901                   ADCA    SMEM+1                  ADD IT TO WORKING
1432 000009ea >9701                   STAA    SMEM+1                  FREQUENCY
1433 000009ec  8c0005                 CPX     #5                      DONE ?
1434 000009ef  26ce                   BNE     L2
1435 000009f1  39                     RTS
1436
1437                                ****************************************************
1438                                *                                                  *
1439                                *       Clear NVM - not used.                      *
1440                                *                                                  *
1441                                ****************************************************
1442
1443 000009f2 >7f0000         CLRNVM  CLR     COUNT
1444 000009f5  86ff           CLOP    LDAA    #$FF
1445 000009f7 >d600                   LDAB    COUNT
1446 000009f9 >bd0000                 JSR     WRITE1
1447 000009fc >7c0000                 INC     COUNT
1448 000009ff  26f4                   BNE     CLOP
1449 00000a01  4f                     CLRA
1450 00000a02  c678                   LDAB    #120                    CLEAR MAX. PROG. No.
1451 00000a04 >7e0000                 JMP     WRITE1
```

```
                                ********************************************************
                                *                                                      *
                                *       Addition and subtraction of BCD numbers.       *
                                *                                                      *
                                ********************************************************

00000a07 >df00          SUB     STX     W5                      ANSWER POINTER
00000a09 >de00          COM2    LDX     NUM2                    9s COMPLIMENT
00000a0b  c606          COMP    LDAB    #$06                    SECOND NUMBER
00000a0d  8609          LOOP3   LDAA    #$09
00000a0f  a005                  SUBA    5,X                     SUBTRACT FROM 9
00000a11  a705                  STAA    5,X                     AND PUT IT BACK
00000a13  09                    DEX
00000a14  5a                    DECB
00000a15  26f6                  BNE     LOOP3
00000a17 >7f0000                CLR     CARRY                   SET CARRY TO ONE
00000a1a >7c0000                INC     CARRY                   BEFORE ADDING
00000a1d  2005                  BRA     AD                      ADD FIRST NUMBER

00000a1f >7f0000        ADD     CLR     CARRY
00000a22 >df00                  STX     W5                      ANSWER POINTER
00000a24  c606          AD      LDAB    #$06
00000a26 >de00                  LDX     NUM1                    1st No. POINTER
00000a28 >df00                  STX     W3
00000a2a >de00                  LDX     NUM2                    2nd No. POINTER
00000a2c >df00                  STX     W4
00000a2e >de00          LOOP    LDX     W3
00000a30  a605                  LDAA    5,X
00000a32  09                    DEX
00000a33 >df00                  STX     W3
00000a35 >de00                  LDX     W4
00000a37  ab05                  ADDA    5,X                     ADD
00000a39  09                    DEX
00000a3a >df00                  STX     W4
00000a3c >9b00                  ADDA    CARRY                   SET ON ADDITION OVERFLOW
00000a3e >7f0000                CLR     CARRY                   OR POS. RESULT SUBTRACTION
00000a41  8d10                  BSR     ADJ                     DECIMAL ADJUST
00000a43 >de00                  LDX     W5
00000a45  a705                  STAA    5,X                     SAVE ANSWER
00000a47  09                    DEX
00000a48 >df00                  STX     W5
00000a4a  5a                    DECB
00000a4b  26e1                  BNE     LOOP                    DONE ?
00000a4d  39                    RTS

00000a4e  800a          AJ      SUBA    #10                     YES, SUTRACT 10
00000a50 >7c0000                INC     CARRY                   AND RECORD CARRY
00000a53  810a          ADJ     CMPA    #10
00000a55  24f7                  BHS     AJ                      10 OR MORE ?
00000a57  39                    RTS                             NO

                                ********************************************************
                                *                                                      *
                                *       Current  binary divide ratio in  SMEM &        *
                                *       SMEM+1 is converted to decimal in RQ.          *
                                *                                                      *
                                ********************************************************

00000a58 >9601          DCON    LDAA    SMEM+1                  TRANSFER CURRENT
00000a5a >9700                  STAA    W2                      FREQUENCY DIVIDE
00000a5c >9600                  LDAA    SMEM                    RATIO INTO
00000a5e >9700                  STAA    W1                      WORKING AREA
00000a60 >ce0000        DCON2   LDX     #RR                     CLEAR
00000a63 >df00                  STX     NUM1
00000a65 >bd0000                JSR     CLRAS                   RR
00000a68 >7c0005                INC     RR+5                    RR <- 1
00000a6b >bd0000                JSR     CLQ                     CLEAR RQ
00000a6e  860e                  LDAA    #14                     14 BITS TO CONVERT
00000a70 >9700                  STAA    W6
00000a72 >740000        LOOP2   LSR     W2                      MOVE OUT
00000a75 >760000                ROR     W1                      FIRST (LS) BIT
00000a78  2407                  BCC     NXT                     ZERO
00000a7a >ce0000                LDX     #RQ                     ONE, ADD
00000a7d >df00                  STX     NUM2                    CURRENT VALUE
00000a7f  8d9e                  BSR     ADD                     OF RR
00000a81 >ce0000        NXT     LDX     #RR                     ADD RR
00000a84 >df00                  STX     NUM2                    TO
00000a86  8d97                  BSR     ADD                     ITSELF
00000a88 >7a0000                DEC     W6                      ALL
00000a8b  26e5                  BNE     LOOP2                   DONE ?
00000a8d  39                    RTS

                                ********************************************************
                                *                                                      *
                                *       Delay (X x 1.5mS).                             *
                                *                                                      *
                                ********************************************************

00000a8e  ce0064        DBNC    LDX     #100                    150mS
00000a91  2003                  BRA     SKDB
00000a93  ce000a        DBOUNC  LDX     #10                     APPROX 15mS WITH A 8.388 MHz XTAL
00000a96 >df00          SKDB    STX     W6                      X x 1.5mS
00000a98  ce00ff        DLP     LDX     #$FF                    PAUSE
00000a9b  21fe          DLOOP   BRN     *                       256X12
00000a9d  21fe                  BRN     *                       CYCLES
00000a9f  09                    DEX
00000aa0  26f9                  BNE     DLOOP
00000aa2 >7a0001                DEC     W6+1
00000aa5  26f1                  BNE     DLP
00000aa7  39            ABO     RTS
```

```
1554                                    ****************************************************
1555                                    *                                                  *
1556                                    *       Serial output routine to MC145170.         *
1557                                    *                                                  *
1558                                    ****************************************************
1559
1560 00000aa8  181d0401          P5170  BCLR   PORTB,Y,$01          CLOCK LOW
1561 00000aac  181d0410                 BCLR   PORTB,Y,$10          LE LOW
1562 00000ab0  8600                     LDAA   #0                   CLEAR
1563 00000ab2  8d4d                     BSR    SQU8I                CONTROL REGISTER
1564 00000ab4  181c0410                 BSET   PORTB,Y,$10          LATCH IT
1565
1566 00000ab8  181d0410                 BCLR   PORTB,Y,$10          LE LOW
1567 00000abc >9601                     LDAA   SMEM+1
1568 00000abe  847f                     ANDA   #$7F
1569 00000ac0  8d3f                     BSR    SQU8I                SEND MSBYTE
1570 00000ac2 >9600                     LDAA   SMEM                 AND LSBYTE OF
1571 00000ac4  8d3b                     BSR    SQU8I                NEW FREQUENCY
1572 00000ac6  181c0410                 BSET   PORTB,Y,$10          LATCH IT
1573
1574 00000aca  181d0410                 BCLR   PORTB,Y,$10          LE LOW
1575 00000ace  8603                     LDAA   #$03                 SEND
1576 00000ad0  8d33                     BSR    SQU7I                REFERENCE
1577 00000ad2  8620                     LDAA   #$20                 DIVIDE RATIO
1578 00000ad4  8d2b                     BSR    SQU8I                800 = 8MHz/10kHz
1579 00000ad6  181c0410                 BSET   PORTB,Y,$10          LATCH IT
1580
1581                                    ****************************************************
1582                                    *                                                  *
1583                                    *       Serial output routine to the MC145157.     *
1584                                    *                                                  *
1585                                    ****************************************************
1586
1587 00000ada >9600              P5157  LDAA   SMEM                 TRANSFER SMEM AND
1588 00000adc  48                       LSLA                        SMEM+1 TO TEMPORARY
1589 00000add >9700                     STAA   W4                   LOCATIONS AND MOVE
1590 00000adf >9601                     LDAA   SMEM+1               UP ONE BIT TO INCLUDE
1591 00000ae1  49                       ROLA                        THE 5157 CONTROL BIT.
1592 00000ae2  8d3f                     BSR    SQU7                 SEND MSBYTE (7 BITS)
1593 00000ae4 >9600                     LDAA   W4                   AND LSBYTE OF
1594 00000ae6  8d37                     BSR    SQU8                 NEW FREQUENCY
1595 00000ae8  181c0408                 BSET   PORTB,Y,$08          LATCH
1596 00000aec  181d0408                 BCLR   PORTB,Y,$08          IT
1597 00000af0  864e                     LDAA   #$4E                 SEND 15 BIT (14+1)
1598 00000af2  8d2f                     BSR    SQU7                 REFERENCE
1599 00000af4  8621                     LDAA   #$21                 DIVIDE RATIO
1600 00000af6  8d27                     BSR    SQU8
1601 00000af8  181c0408                 BSET   PORTB,Y,$08          LATCH IT
1602 00000afc  181d040b                 BCLR   PORTB,Y,$0B          ALL LOW (5157/70 SWITCHED OFF)
1603 00000b00  39                       RTS
1604
1605                                    ****************************************************
1606                                    *                                                  *
1607                                    *       Subroutines for the MC145157/170.          *
1608                                    *                                                  *
1609                                    ****************************************************
1610
1611 00000b01  c608              SQU8I  LDAB   #8                   SEND 8 BITS
1612 00000b03  2003                     BRA    S1I
1613 00000b05  48                SQU7I  LSLA                        MOVE OUT MS BIT
1614 00000b06  c607                     LDAB   #7                   AND SEND OTHER 7
1615 00000b08  48                S1I    LSLA                        MOVE 1 BIT INTO "C"
1616 00000b09  2404                     BCC    S2I                  ZERO ?
1617 00000b0b  181c0402                 BSET   PORTB,Y,$02          NO
1618 00000b0f  181c0401          S2I    BSET   PORTB,Y,$01          CLOCK
1619 00000b13  181d0401                 BCLR   PORTB,Y,$01          IT
1620 00000b17  181d0402                 BCLR   PORTB,Y,$02
1621 00000b1b  5a                       DECB
1622 00000b1c  26ea                     BNE    S1I                  ANY MORE ?
1623 00000b1e  39                       RTS
1624
1625 00000b1f  c608              SQU8   LDAB   #8                   SEND 8 BITS
1626 00000b21  2003                     BRA    S1
1627 00000b23  48                SQU7   LSLA                        MOVE OUT MS BIT
1628 00000b24  c607                     LDAB   #7                   AND SEND OTHER 7
1629 00000b26  48                S1     LSLA                        MOVE 1 BIT INTO "C"
1630 00000b27  2404                     BCC    S2                   ZERO ?
1631 00000b29  181c0402                 BSET   PORTB,Y,$02          NO
1632 00000b2d  181d0401          S2     BCLR   PORTB,Y,$01          CLOCK
1633 00000b31  181c0401                 BSET   PORTB,Y,$01          IT
1634 00000b35  181d0402                 BCLR   PORTB,Y,$02
1635 00000b39  5a                       DECB
1636 00000b3a  26ea                     BNE    S1                   ANY MORE ?
1637 00000b3c  39                       RTS
1638
1639                                    ****************************************************
1640                                    *                                                  *
1641                                    *       Toggle 9/10 kHz step (MW).                 *
1642                                    *                                                  *
1643                                    ****************************************************
1644
1645 00000b3d >12004004          T910   BRSET  STAT6,$40,CBH
1646 00000b41 >140040                   BSET   STAT6,$40
1647 00000b44  39                       RTS
1648 00000b45 >150040            CBH    BCLR   STAT6,$40
1649 00000b48  39                       RTS
```

```
1651                                ********************************************************************************
1652                                *                                                                              *
1653                                *       LINK batch files (RLE.BAT & RDE.LD) and PCBUG11 Vectors.               *
1654                                *                                                                              *
1655                                *       ILD11 RADE.O FNCE.O RDSE.O -MKUF E32.MAP -G RDE -O RDE.OUT             *
1656                                *       IHEX RDE.OUT -O RDE.0                                                  *
1657                                *       TYPE E32.MAP                                                           *
1658                                *                                                                              *
1659                                *       section .RAM1 BSS origin 0x0000                                        *
1660                                *       section .RAM2 BSS origin 0x0100                                        *
1661                                *       section .RAM3 BSS origin 0x0200     E32                                *
1662                                *       section .ROM1 origin 0xD000        $9000                               *
1663                                *       section .ROM2 origin 0xE000        $9C00                               *
1664                                *       section .ROM3 origin 0xF000        $A000                               *
1665                                *       section .VECT origin 0xBFC1          -                                 *
1666                                *       section .VECT2 origin 0xFFD6      ($FFD6)                              *
1667                                *                                                                              *
1668                                ********************************************************************************
1669
1670                                *        SECTION .VECT
1671
1672                                *        JMP     START           SCI
1673                                *        JMP     START           SPI
1674                                *        JMP     START           PULSE ACCUMULATOR EDGE
1675                                *        JMP     START             "       "       OVER
1676                                *        JMP     START           TIMER OVER
1677                                *        JMP     START             "   IC4/OC5
1678                                *        JMP     START             "   OC4
1679                                *        JMP     START             "   OC3
1680                                *        JMP     START             "   OC2
1681                                *        JMP     START             "   OC1
1682                                *        JMP     START             "   IC3
1683                                *        JMP     START             "   IC2
1684                                *        JMP     START             "   IC1
1685                                *        JMP     TINTB           RTI
1686                                *        JMP     SDATA           IRQ
1687                                *        JMP     SHAFTX          NOT USED, XIRQ USED BY PCbug11
1688                                *        JMP     START           SWI
1689                                *        JMP     START           ILLEGAL OP CODE
1690                                *        JMP     START           COP
1691                                *        JMP     START           CLOCK MONITOR
1692                                *        JMP     START           RESET
1693
1694                                ********************************************************************************
1695                                *                                                                              *
1696                                *       MC68HC11E32 Vectors.                                                   *
1697                                *                                                                              *
1698                                ********************************************************************************
1699
1700                                        SECTION .VECT2
1701                                *       ORG     $FFD6
1702
1703 00000000 >0000                        FDB     START           SCI
1704 00000002 >0000                        FDB     START           SPI
1705 00000004 >0000                        FDB     START           PULSE ACCUMULATOR EDGE
1706 00000006 >0000                        FDB     START             "       "       OVER
1707 00000008 >0000                        FDB     START           TIMER OVER
1708 0000000a >0000                        FDB     START             "   IC4/OC5
1709 0000000c >0000                        FDB     START             "   OC4
1710 0000000e >0000                        FDB     START             "   OC3
1711 00000010 >0000                        FDB     START             "   OC2
1712 00000012 >0000                        FDB     START             "   OC1
1713 00000014 >0000                        FDB     START             "   IC3
1714 00000016 >0000                        FDB     START             "   IC2
1715 00000018 >0000                        FDB     START             "   IC1
1716 0000001a >0000                        FDB     TINTB           RTI
1717 0000001c >0000                        FDB     SDATA           IRQ
1718 0000001e >0000                        FDB     SHAFTX          XIRQ
1719 00000020 >0000                        FDB     START           SWI
1720 00000022 >0000                        FDB     START           ILLEGAL OP CODE
1721 00000024 >0000                        FDB     START           COP
1722 00000026 >0000                        FDB     START           CLOCK MONITOR
1723 00000028 >0000                        FDB     START           RESET
1724
1725                                        END
```

Section synopsis

```
1 000000ae (        174) .RAM1
2 00000100 (        256) .RAM2
3 0000006d (        109) .RAM3
4 00000b49 (       2889) .ROM1
5 0000002a (         42) .VECT2
```

Symbol table

```
.RAM1        1 00000000 | CONTD        4 000005df | INSLP        4 000003fe | NNTR         4 00000968 | RECALL       4 00000702
.RAM2        2 00000000 | CONTI        4 00000529 | IOK          4 0000053c | NO2D         4 000000c6 | RETUNE       4 000005f0
.RAM3        3 00000000 | COUNT        1 0000009a | IOOK         4 0000022e | NOPS         4 000000d1 | RETUNE2      4 00000603
.ROM1        4 00000000 | CPSL         4 000003cc | IRQ          4 00000006 | NORT         4 000007c0 | RJ           4 0000030a
.VECT2       5 00000000 | CR           4 0000099a | ITMP1        1 00000069 | NOTCH        4 000002bc | RKEY         4 000002ea
A5SD         4 00000847 | CTAB         4 00000325 | KBD          4 0000026f | NOTFF2       4 00000723 | RP           1 0000007c
A7           4 00000524 | DAT          1 0000004b | KCLC         4 000002f3 | NOTN         4 000008e0 | RPT          4 00000309
ABO          4 00000aa7 | DBNC         4 00000a8e | KEY          1 00000096 | NOTRT        4 000007ac | RQ           1 00000076
ABO3         4 00000470 | DBOUNC       4 00000a93 | KEY1         4 00000279 | NOTSNZ       4 000000e0 | RR           1 00000082
ABOA         4 000003a3 | DCON         4 00000a58 | KEYP         4 000002f5 | NRDSP        4 0000019b | RT           3 00000028
ABTA         4 0000065c | DCON2    E   4 00000a60 | KEYP2        4 000002f7 | NRML         4 000002c0 | RTDIS        1 000000a3
AD           4 00000a24 | DECS         4 0000040d | KHZ          4 0000098f | NS1          4 000003ea | RTDSP        4 0000079f
ADD          4 00000a1f | DEL500       4 00000471 | KOUNT        1 00000097 | NSRO         4 00000194 | S1           4 00000b26
ADJ          4 00000a53 | DF           4 000007e0 | L1           4 00000298 | NT1          4 00000165 | S1I          4 00000b08
ADON         4 00000393 | DI           1 000000a4 | L2           4 000009bf | NT2          4 0000017b | S2           4 00000b2d
AGS          4 0000044e | DIG2         1 00000098 | L5           4 000001b8 | NT2J         4 000000e4 | S2I          4 00000b0f
AISM         4 0000084b | DIGIT        4 00000426 | L6           4 000001d6 | NTB2         4 00000889 | SAVE         4 00000838
AJ           4 00000a4e | DISP         3 00000000 | LAST         4 0000037d | NTB3         4 00000882 | SCHAN        1 000000a5
ALARM        4 00000381 | DISP1        1 00000074 | LDXR         4 000007f9 | NUM1         1 0000009b | SCNT         1 000000ad
ALOF         4 0000038e | DISP2        1 00000075 | LDXR2        4 00000802 | NUM2         1 0000009d | SDATA    I   0 00000000
ALRON        4 000003be | DISPP        3 00000010 | LED          1 0000009f | NWA          4 000000f1 | SDT          4 00000884
ALSU1        4 000004a5 | DIST         1 00000047 | LEV          1 00000067 | NWWS         4 00000173 | SEC          1 0000006f
ALSU2        4 00000569 | DLOOP        4 00000a9b | LOOP         4 00000a2e | NXT          4 00000a81 | SEM          4 00000257
AMIN         1 00000072 | DLP          4 00000a98 | LOOP2        4 00000a72 | OK6          4 0000020b | SHAFT    E   4 0000024d
ANTI         4 00000191 | DMD          4 00000594 | LOOP3        4 00000a0d | ONAG         4 00000101 | SHAFTX       4 0000025e
AOB          4 00000833 | DMI          4 000004d2 | LP6          4 000008eb | ONE          4 000008a6 | SHIFT        4 0000044a
AOUR         1 00000073 | DNT          4 000002f4 | LPP          4 0000089f | ONOFF        4 000003a4 | SK           4 00000946
ARI          4 00000220 | DNT2         4 000002ed | M8           4 00000079 | OUR          1 00000071 | SK2P         4 000005ee
ASM          4 0000086a | DOIT         4 00000663 | MAK20        4 000004fe | OUTCH        4 000005d6 | SKDB         4 00000a96
BAND         4 00000926 | DOM          1 00000044 | MAK2E        4 00000502 | P            1 00000015 | SKIP         4 0000093e
BCON         4 000009b6 | DOW          1 00000046 | MAK30        4 00000506 | P5157        4 00000ada | SKP          4 0000045c
BCTO         1 000000ac | DOWN         4 000007de | MAK41        4 0000050a | P5170        4 00000aa8 | SKPCLR       4 00000876
BD3          4 000001ec | DR1          4 00000466 | MAK61        4 0000050e | PDEC         4 00000555 | SKSM         4 00000964
BIT          1 00000068 | E6L          4 000001fa | MIN          1 00000070 | PDEC2        4 00000541 | SKTA         4 0000067b
BMJD         1 00000000 | EON          2 00000000 | MJD          1 00000030 | PI           1 00000061 | SLEEP        4 000003f6
BTO          4 00000201 | EXIT         4 000002ab | MJDAT    I   0 00000000 | PIN          1 00000065 | SLEP         4 00000400
CARRY        1 00000099 | FINST        4 000006fb | MKE20        4 000005c0 | PINC         4 00000491 | SLEPT        1 00000048
CBCD     I   0 00000000 | FLN          4 00000122 | MKE2E        4 000005c4 | PINC2        4 0000047d | SLPTOK       4 00000415
CBH          4 00000b45 | FMB          4 0000079b | MKE39        4 000005d0 | PINOK1       4 00000161 | SM           4 0000097d
CE6          4 000001ec | FOK          4 0000061d | MKE5A        4 000005c8 | PION         1 00000063 | SMEM         1 000000a0
CG6          4 000001c8 | FULON        4 0000010f | MKE7A        4 000005cc | PJ           4 0000031d | SODM         4 000003b2
CHE          4 000001e6 | GETAD        4 00000780 | MNTH         1 00000042 | PNM1         4 000005e9 | SOK          4 00000148
CLAL         4 0000097b | GON2         4 000002c8 | MOD      I   0 00000000 | PROC     I   0 00000000 | SPCC         4 00000984
CLEAR        4 0000096f | GOON         4 000002e4 | MODE         4 00000933 | PROG         4 0000088a | SQU7         4 00000b23
CLOCK    I   0 00000000 | GOON2        4 000002d0 | MSH          4 00000238 | PSC          4 000003c7 | SQU7I        4 00000b05
CLOOP        4 0000005a | GOON3        4 000002de | MSM          4 00000854 | PSN          3 00000020 | SQU8         4 00000b1f
CLOP         4 000009f5 | GROUP        1 00000057 | MZ           4 00000577 | PSN0         4 000004d7 | SQU8I        4 00000b01
CLP          4 00000992 | H2L          4 00000032 | NABT         4 00000834 | PSN1         4 00000599 | SRT          4 00000820
CLQ          4 00000993 | HIGH         4 000003e9 | NACS         4 000004d3 | PSNOK        4 00000690 | START        4 00000009
CLRAS        4 00000996 | HTOH         4 000004c4 | NACS2        4 00000595 | PSNP         1 0000004a | STAT         1 000000a6
CLREON   I   0 00000000 | HZ           4 00000586 | NAME         4 00000859 | PSOK         4 000006c7 | STAT2        1 000000a7
CLRNVM       4 000009f2 | IDLE         4 000000ac | NDU          4 000000db | PTY          1 0000005f | STAT3        1 000000a8
CLTR     E   4 000009a3 | IDLJ         4 0000023c | NEW      E   4 000008a9 | PTYCMP       1 00000060 | STAT4        1 000000a9
CLTR2        4 000009a6 | IF           4 000007d1 | NEWJ         4 000007ee | Q            1 00000003 | STAT5        1 000000aa
CNTB         4 00000510 | IFO          4 000008d3 | NEWSUB       4 00000707 | R            1 00000027 | STAT6        1 000000ab
CNTS         4 000005d2 | IFS          4 00000908 | NEWSUB2      4 00000716 | RCLP         4 0000023f | STIF         4 000008ca
COM2         4 00000a09 | IHR          4 000004b9 | NFM          4 0000086f | RDSTO        1 00000049 | STORE        4 00000671
COMP         4 00000a0b | IHRD         4 0000057d | NFMB         4 00000805 | READ1        4 00000756 | STR          4 00000405
CONF         1 0000006c | INITD    I   0 00000000 | NNT2         4 000000e7 | REARET       1 000000a2 | STRST        4 00000000

SUB          4 00000a07 | TATP         4 0000022a | TMPGRP       1 0000004f | TPOF         4 000003f2 | W4           1 0000008e
SWB2         4 0000079b | TBH          4 000000be | TMQ          1 0000000c | TPOK         4 00000155 | W5           1 00000090
SYN          1 0000006a | TEM          4 0000025a | TMRB         4 00000003 | TT1          4 000007d9 | W6           1 00000092
T5S          4 000004c7 | TEST         4 00000821 | TNP          4 00000655 | TT2          4 000007e8 | W7           1 00000094
T5SD         4 00000589 | TFCC     I   0 00000000 | TOG57        4 00000517 | UDCNT        4 00000399 | WAIT     I   0 00000000
T910         4 00000b3d | TH32         1 0000006d | TOG57J       4 00000495 | UP           4 000007cf | WBYTE        4 0000076f
TAEH         4 000003e6 | TH8          1 0000006e | TOOH         4 000004b4 | W1           1 00000088 | WRITE1       4 0000075d
TASOK        4 0000064c | TINTB    I   0 00000000 | TPEN         4 000003d5 | W2           1 0000008a | XEM          4 00000268
TASW         4 0000062b | TMP          1 0000001e | TPIC         4 0000062c | W3           1 0000008c | YEM          4 0000026b
TATP         4 0000022a
```

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