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An HC11-Controlled Multiband RDS Radio

By Peter Topping
Motorola, Ltd.
East Kilbride, Scotland

This application note describes the software and hardware features of the microcontroller (MCU) of a synthesized multiband radio which includes RDS (radio data system) decoding (FM, band II). It uses an MC68HC(7)11 MCU whose program can be on-chip or contained in an external EPROM (erasable programmable read-only memory). ROM versions are available.

Both LCD (liquid crystal display) and VFD (vacuum fluorescent display) 16-character dot matrix display modules can be used to display RDS and tuning information. Traffic messages, initiated by the reception of EON (enhanced other networks) data (group 14B) or TA = TP = 1 (traffic announcement = traffic program = 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.

Introduction

Figure 1 shows a block diagram of the application. The controller hardware and software are described in detail here. The other hardware is not covered to the same depth, because that varies between different implementations, the intention being to describe a controller which could

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be added to an existing radio or to one which includes only one or two of the possible bands.

Separate FM and AM PLLs (phase-locked loop) are shown. This is not essential, but it 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.

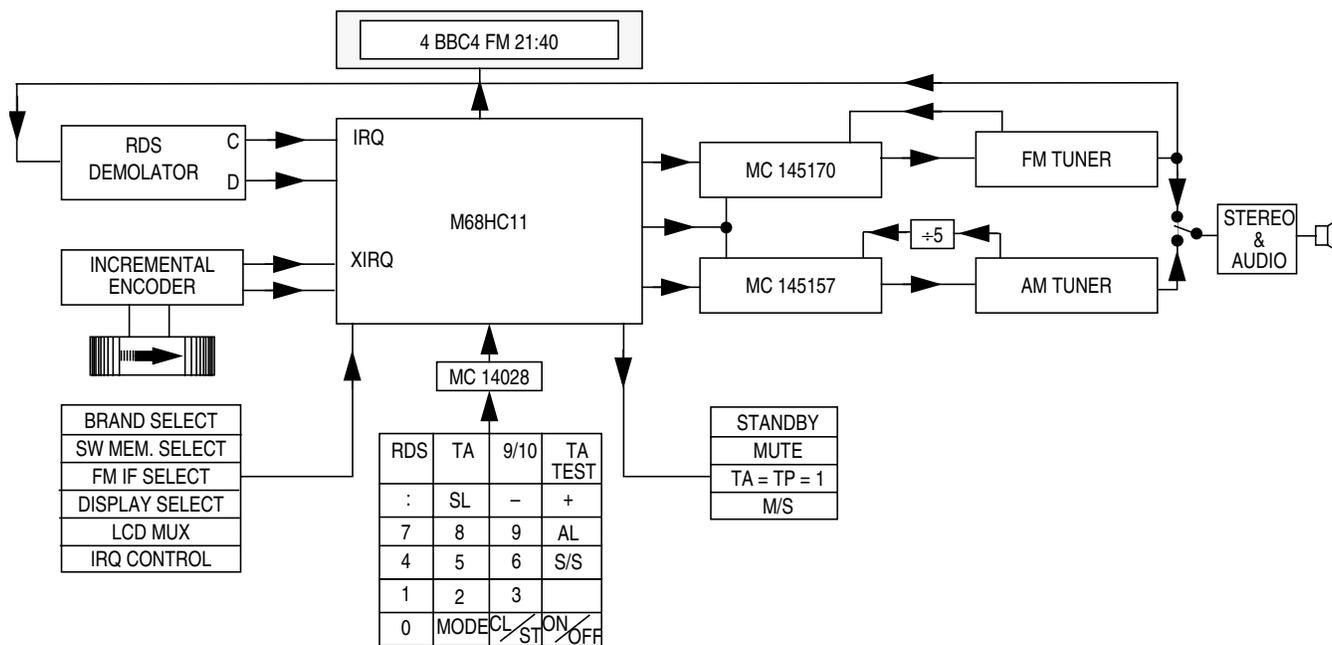


Figure 1. Main Block Diagram

The MCU used is the MC68HC(7)11. The MC68HC711K4 (K4) [and similar chips such as the MC68HC711P2 (P2) and MC68HC711PH8 (PH8)] can be used in expanded mode, but this application has been included in the ROM of an E32 and a PH8.

To use the ROMed parts in this application, the first three bytes of EEPROM (electrically erasable programmable ROM) 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 (bit users fast friendly aid to logical operation) monitor (see reference 5). The E32 version uses all the input/output (I/O) and can, therefore, be used only in single-chip mode. The circuit diagram of the HC11E controller is shown in **Figure 3** and the circuit diagram of the K4/PH8 in **Figure 4**. 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 four I/O (input/output) 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).

Forty programs (10 on FM, 10 on MW and 20 on SW) can be stored using the HC11E's on-chip EEPROM (the PH8 has 20 additional SW (shortwave) programs). Each contains frequency, an 8-character name [PS (program service) name on a station with RDS] and, on FM only, PI (program identification) code and a TA inhibit bit. For stations with no RDS (for example, 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 MCU 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 MCU is permanently powered up, as this information is also stored in non-volatile EEPROM.

The keyboard uses an MC14028 decoder to minimize 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 minimize 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 MC145157 requires an external prescaler for frequencies above 20 MHz, but the MC145170 has an on-chip 160-MHz capability.

A tuning knob can be included by using an incremental encoder. This can utilize 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 information described later) 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 +/- (plus/minus) keys, depending on the direction of rotation. This provides a 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 program 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, intermediate frequency) 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 both are intended for VHF/FM, the difference between them being in the use of the M68HC11'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 0 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 2** shows a simple circuit which can be used for this purpose.

Table 1. Available Bands

Band	PA1	PA0	IF Offset	Step	Memory	Use	Prescaler MC145157 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

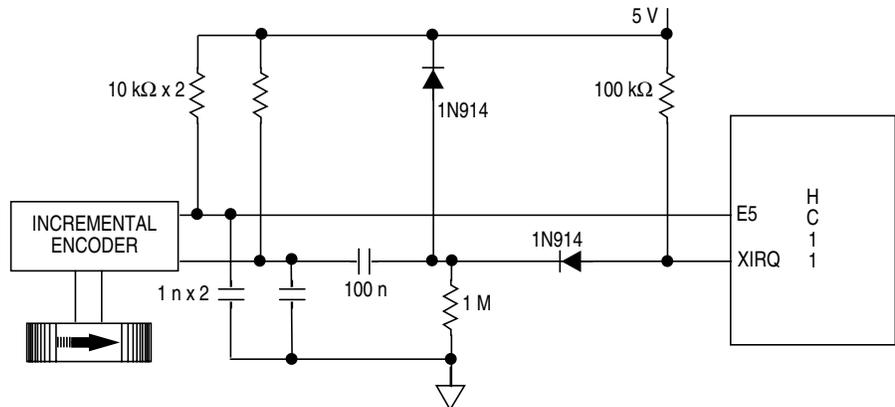


Figure 2. Incremental Encoder Interface Circuit

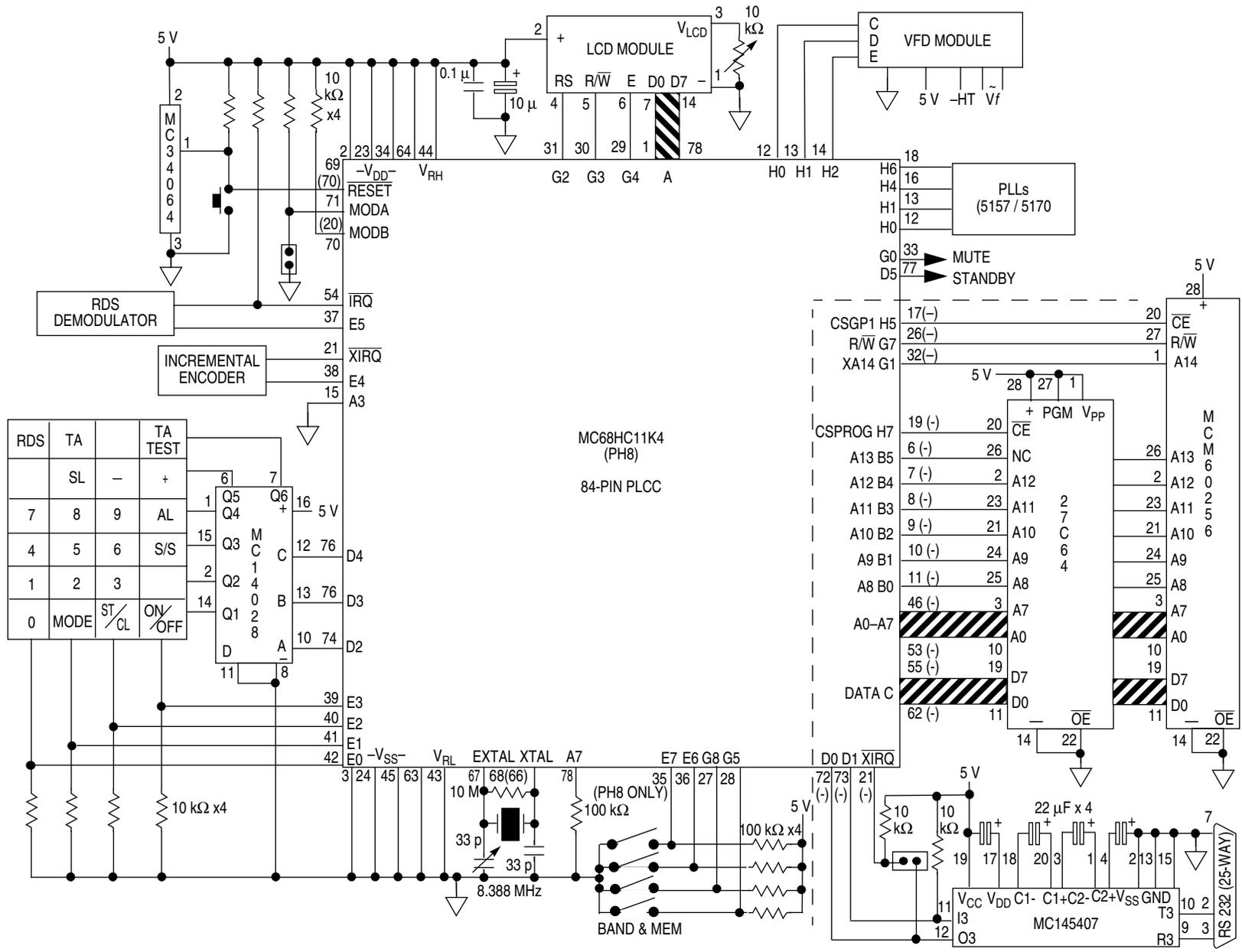


Figure 4. MC68HC11K4 and PH8 Circuit

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
- Storing of often-used frequencies.

The accuracy and stability result from the fact that the LO 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 synthesizer can be retrofitted to most radios by replacing the tuning capacitor with a varicap diode. The voltage biasing the varicap is supplied by the synthesizer and also can be used to provide RF (radio frequency) tuning. Alternatively, manual preselector or no RF tuning can be employed.

Motorola's MC145157 and MC145170 synthesizers 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 MC68HC05B4 synthesizer 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.

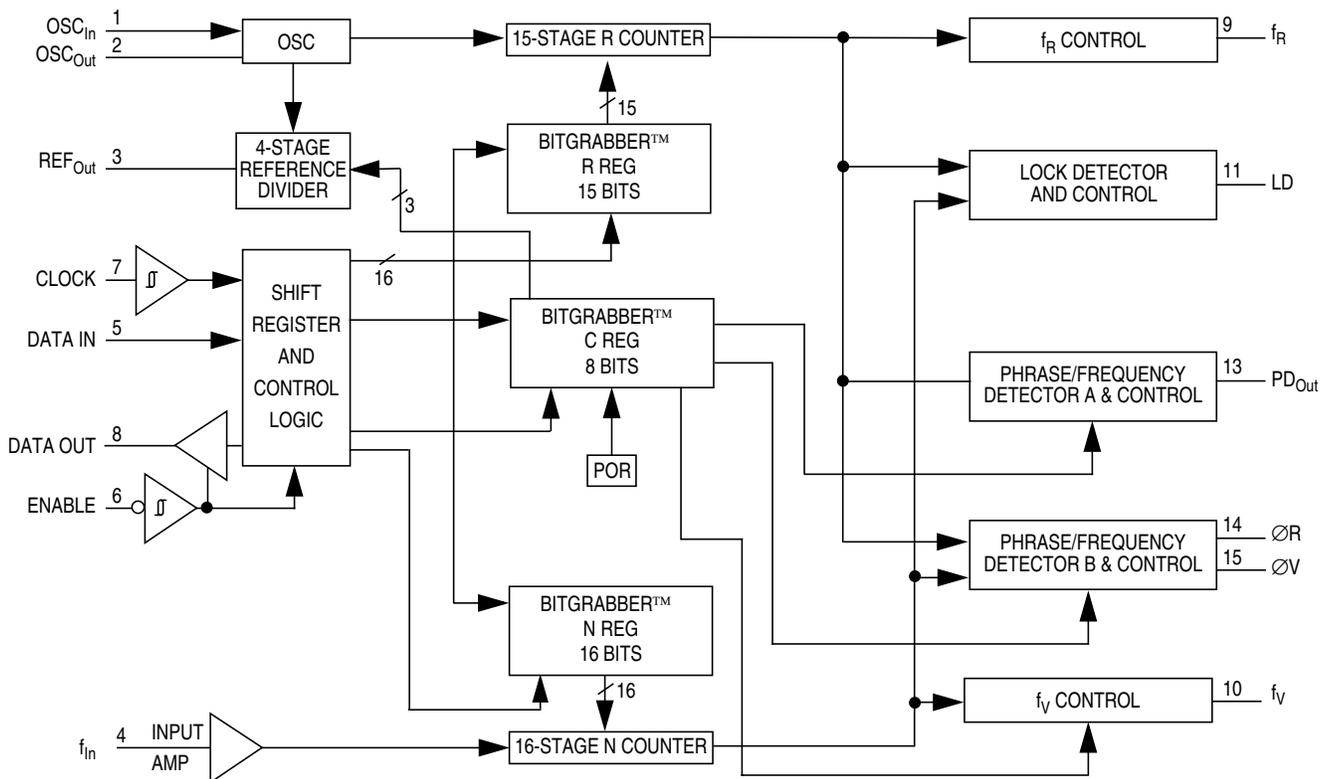


Figure 5. MC145170 Block Diagram

The reference counter divides the 8-MHz crystal oscillator (10 MHz for the MC145157) down to the reference frequency (in this case, 1 kHz for the MC145157 and 10 kHz for the MC145170) 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 stabilizes. The equation that follows shows the relationship between the various frequencies where P is the LO prescaler (MC145157 only). The received frequency can be changed by altering the LO divide ratio. The MCU takes care of the decimal-to-binary conversion, IF offset, and the other arithmetic required.

$$\text{LO frequency} = \text{RF} + \text{IF} = P \times [(\text{Xtal frequency}) / (\text{ref. divide ratio})] \times \text{LO divide ratio}$$

The MC145157 is specified to operate up to 20 MHz, so prescaling is required on FM and SW (10.7-MHz IF). For this SW band, divide-by-5

prescaling 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 PLL is the loop filter. The filter 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 second 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/MC145157.

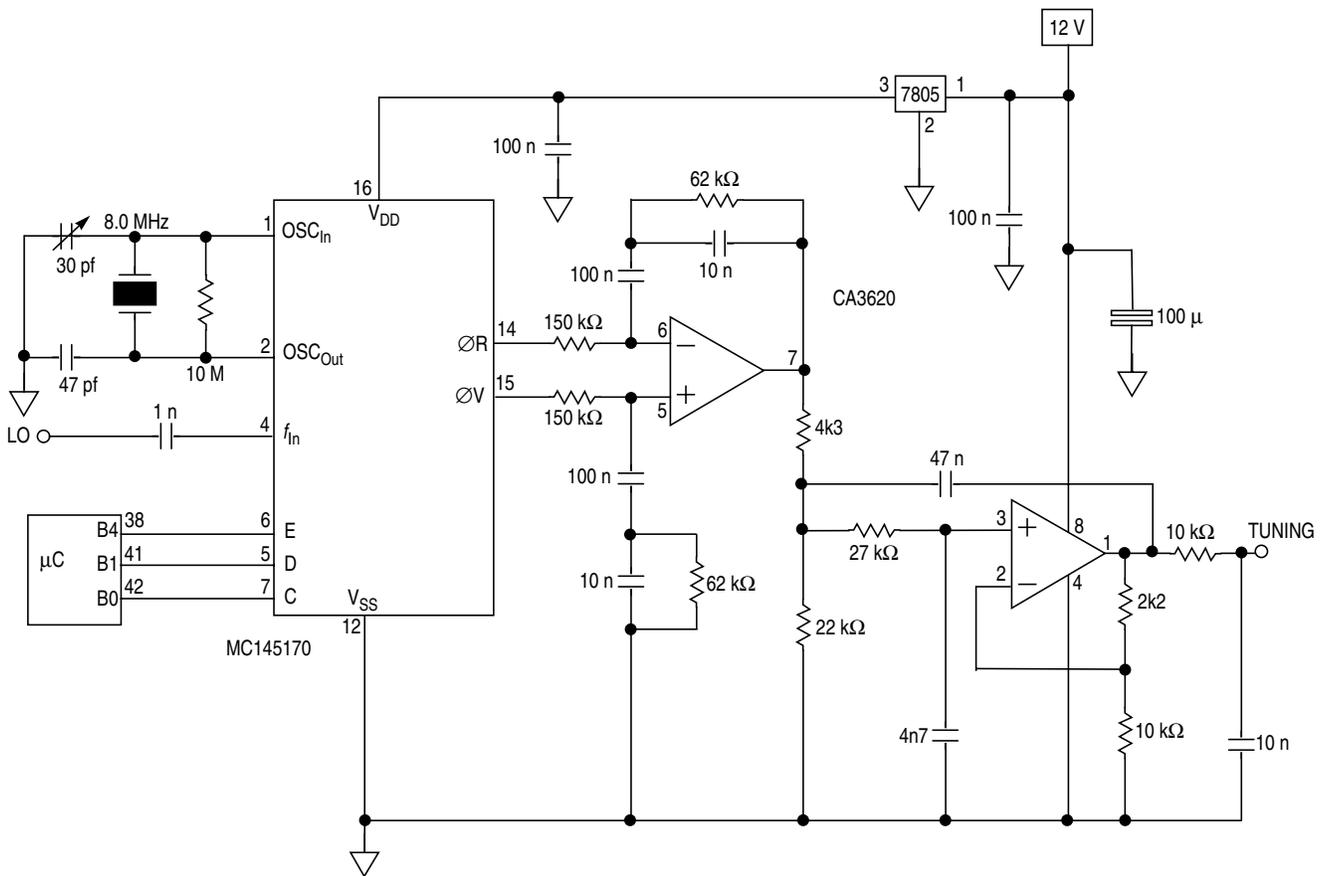


Figure 6. MC145170 Circuit

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 grounded, 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 here, the choice can be made simply by swapping the phase detector outputs from the PLLs.

Radio Data System

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, see reference 2). An MC68HC05E0 implementation of RDS is described in AN460, (reference 5). It monitors the RDS activity on the MPX signal of a VHF radio but is not able to tune the radio and, therefore, cannot, use AF (alternative frequencies) 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 subset 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 MCU. 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	Program 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 appropriate only 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 MCU but is not normally intended for display. A change in PI code causes the initialization 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 MCU. In this example, PTY can be displayed on request; **Table 3** shows the display used for each PTY code.

PS is the 8-character name of the station and is permanently displayed (except in standby mode). In the absence of RDS (for example, AM bands), the name can be entered manually. 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 program 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 center 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 (clock time and date) 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 information later), 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 MCU converts this number into day-of-week, day-of-month, month and year.

AF would be used by a car radio to retune to the strongest signal carrying the selected service. AF data, along with TDC (transparent data channel) and INH (in-house data), 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 (for instance, cassette when a TA occurs).

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

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.). Currently, it is not in use in the United Kingdom, but it can be displayed as a number between 1 and 15.

Program item number (PIN) is used to identify the program 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 program. PIN 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.

Keyboard

The keyboard has 23 keys. [Table 4](#) shows the layout and [Table 5](#) contains a summary of key functions against mode.

Table 4. Keyboard Layout

	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

Application Note

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 behavior of other keys as described later in this application note.

Sleep



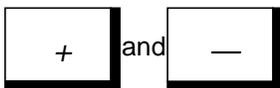
When pressed, the 1-hour sleep timer starts, leaving the standby line low (radio on) until the sleep time has elapsed. At this time, the line is switched to the standby mode (high). In the normal display mode, the sleep timer running causes the decimal point to appear on the display modules' first character. The sleep timer can be cancelled by pressing ON/OFF. The sleep time can be reduced in increments of five minutes by repressing 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 setup 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 setup display returns to normal three 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 stabilize, the program 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 and Sundays.

Plus (+) and Minus (-)



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 100 ms 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 entry that follows), 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 setup mode, the + and – keys are used to change the alarm time as described earlier. The field which is currently selected for adjustment (using the STORE key) flashes. This function is duplicated on the tuning knob also.

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, 1-kHz (455 kHz IF only) or 5-kHz steps are available; on the MW/LW band, 1- or 9-kHz steps are available. In the U.S.A., 10 kHz is appropriate instead of 9 kHz; this can be selected with a special key (see entry that follows). 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



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 hyphen (–). 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 or unusable quality). See the entry that follows 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). 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.

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In manual mode, STORE enters a special manual store mode in which the 9–0 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 entry that follows). If the PS edit mode has been used, then manual store mode should be used to save the entered PS name.

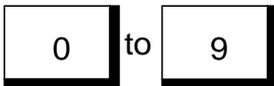
Manual



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 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 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 100 ms 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 and TP, PIN code (two 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 11th 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.

Application Note

MW Step

MW STEP

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

Table 5. 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 (ON)	“	“	+/- prog.	mode PS-edit	mode manual	toggle traffic enable flag	display RT	tune prog.	toggle step 10/50 kHz
PS edit	“	“	“	+/- ASCII	next char.	“	“	PTY PI	“	“
A off	“	“	mode alarm on	+/- prog.	—	“	“	TA TP	“	“
L on	“	“	mode alarm off	5/7 day toggle	mode setup	“	“	PIN hex PIN dec	“	“
A R	“	“		+/- hour/min	hour/min toggle	“	“	MJD	“	“
M setup	“	“	mode alarm	+/- freq.	mode store	mode normal	toggle traffic enable NV bit	TA ret. TA PI	“	“
M A N U A L store	“	“		“	“	save prog.		“	EON (16)	input freq.
									save prog.	& clear freq.

Circuit

The circuit is in two distinct parts. The circuit for the MC145170 synthesizer is shown in **Figure 6**. The synthesizer board is the only part of the synthesizer controller which actually needs to be in (or close to) the radio. A local oscillator signal to supply the synthesizer 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 center of the PCB).

The Mullard LP1186 is unusual in having its local oscillator low. More recent tuners, for instance, 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. On its own, this driver 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. In an application which drives an LCD module (for instance, a ROMed PH8) and the module is not connected, a 10-k 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.

Figure 3 and **Figure 4** show the circuit diagrams of the controllers. **Figure 3** 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 4 shows pin numbers for the 84-pin PLCC K4, with the differences for the PH8 in brackets. Debug on the K4 using PCbug11 (reference 5) requires some additional hardware (within the dotted line) and port D bits 0 and 1 (SCI), port G bits 1 and 7 (XA14 and R/W), and port H bits 5 and 7 (CSGP1 and CSPROG), leaving 30 input/output (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.

Since 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.

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 (reference 4). EB419/D (reference 5) describes and lists additional debug code contained in the ROMed parts.

The code which is executed only on startup (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 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 synthesizers. 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 debug.

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 minimize 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 initialized, 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 initialization 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 VF DL. The LCD and VFD routines are in the second software module (see reference 4).

Table 6. Display Formats

Display Mode		Format
Standby Off	Alarm off	Thu 12 May 21:35
	Alarm off, no CT	Mon 0 inv 0:00
	Alarm on	0659 alarm 21:35
Normal On	With RDS PS name	4 BBC 4 FM 21:40
	Without RDS	5 ----- 21:40
	Auto name	6 -- 9410 21:40
	Tuning knob (AM)	6 -- 9415 21:40
Alarm	Alarm off	Alarm - OFF
	Alarm on/setup	5-day alarm 0659
Sleep		Sleep 60 minutes

Table 6. Display Formats (Continued)

Display Mode		Format
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

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 here. 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 rtn/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 rtn/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 rtn/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 rtn/inhb message to:
TA rtn: 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 rtn/inhb message to:
TA rtn: PI code — PI code of TP station was not as expected.
- After an additional two seconds, start to monitor the TA flag; if high, remain on current frequency, if low, return to original frequency and set TA rtn/inhb message to:
TA rtn: 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 rtn/inhb message is set to:
TA rtn:manual — User-initiated manual return

Table 7. MCU I/O

K4 and 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 2–4 5	Debug (PCbug11 or BUFFALO) Keyboard rows (via 14028 encoder) Standby (high:standby, low:on)	Port D bits 0–1 2–4 5
Port E bits 0–3 4 5 6 7	Keyboard columns Shaft direction (XIRQ) RDS data in or shaft direction (IRQ) Short-wave memory select 1 Short-wave memory select 2 (PH8 only)	Port E bits 0–3 4 5 6 N/A —
Port F bits 0–7	Low-order addresses	N/A —
Port G bits 0 1 2–4 5–6 7	Mute XA14 (K4 only) LCD control lines (RS, R/W, and clock) Band select R/W (K4)	Port A bit 4 N/A — Port B bits 5–7 Port A bits 0–1 N/A —
Port H bits 0–1 2 3 4 5 6 7	Serial clock/data for VFD and PLLs VFD chip enable (PH8: +/- 10.7 MHz) Port E, bit 5 input control MC145170 PLL chip enable CSGP1 (K4 only) MC145157 PLL chip enable CSPROG (K4 only)	Port B bits 0–1 Port B bit 2 Port A bit 3 Port B bit 4 N/A — Port B bit 3 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

Setup and Testing

An effective method of fault finding 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 setup in the synthesizer, 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 difficult 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 M68HC711 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 to tuning to a strong broadcast of known frequency and adjusting for optimum reception or symmetric adjacent-channel response.

PH8 ROMed Application

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

1. 40 short-wave programs 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 pulldown on port A, bit 7 should be included (see [Figure 4](#)).
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 pullup or pulldown resistor will determine the IF selection (pullup for LO high and pulldown 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.

References

1. *A Radio Synthesizer Using the MC68HC05B4*, Motorola document order number ANE416/D
2. CENELEC EN 50067, *Specifications of the Radio Data System (RDS)*, formerly EBU technical document 3244
3. *An RDS Decoder Using the MC68HC05E0*, Motorola document order number AN460/D
4. *RDS Decoding for an HC11 Controlled Radio*, Motorola document order number AN495/D
5. *ROMed HC11E32 and HC11PH8 Including BUFFALO Monitor and PCbug 11 Talker*, Motorola document order number EB419/D

Application Note

Code Listing

```
*****
*
*          MC68HC11E32 RDS multiband radio.
*
*          Used with RDSE.S11, FNCE.S11 & RDRAME.S11.
*
*          P. Topping          3rd April '94
*****

          IMPORT          SDATA,TINTB,INITD,MOD,CLOCK,MJDAT,WAIT,CLREON,CBCD, PROC, TFCC

          EXPORT          DCON2,NEW,CLTR,SHAFT

          LIB             RDRAME.S11

PORTA      EQU           $00          PORT A ADDRESS
PORTB      EQU           $04          " B "
PORTC      EQU           $03          " C "
PORTD      EQU           $08          " D "
PORTE      EQU           $0A          " E "
PORTCD     EQU           $07          PORT C DATA DIRECTION REG.
PORTDD     EQU           $09          " D " " " " "
TMSK2      EQU           $24
PACTL      EQU           $26
OPTION     EQU           $39
INIT       EQU           $3D

RBO        EQU           $1000        REGISTER BLOCK OFFSET
PPROGRAM   EQU           $3B          EEPROM CONTROL REGISTER
ND         EQU           9            No. DIGITS

          SECTION.S .RAM1,COMM

BMJD       RMB           3            BINARY MJD
Q          RMB           9            WORKING NUMBER 1 - RDS
TMQ        RMB           9            SCRATCH
R          RMB           9            WORKING NUMBER 2 - RDS
TMP        RMB           9            MULT. OVER. OR DIV. REMAINDER
R          RMB           9            WORKING NUMBER 3 - RDS
MJD        RMB           9            MODIFIED JULIAN DAY NUMBER
YR         RMB           9            YEAR
MNTH       RMB           2            MONTH
DOM        RMB           2            DATE
DOW        RMB           1            DAY OF WEEK

*****
*
*          RAM allocation, RDS & radio.
*
*****

DIST       RMB           1            TRANSIENT DISPLAY, TIMEOUT,COUNTER
SLEPT      RMB           1            SLEEP TIMER MINUTES COUNTER
RDSTO      RMB           1            RDS TIMEOUT COUNTER
PSNP       RMB           1            PS DISPLAY POINTER
DAT        RMB           4            SERIAL DATA BUFFER
TMPGRP     RMB           8            TEMPORARY GROUP DATA
GROUP      RMB           8            COMPLETE GROUP DATA
PTY        RMB           1            PROGRAM-TYPE CODE (CURRENT)
PTYCMP     RMB           1            PROGRAM TYPE CODE (PTY SCAN)
PI         RMB           2            PROGRAM IDENTIFICATION CODE
PION       RMB           2            PROGRAM IDENTIFICATION CODE (EON)
PIN        RMB           2            PROGRAM ITEM NUMBER
LEV        RMB           1            VALID BLOCK LEVEL
BIT        RMB           1            BIT LEVEL
ITMP1      RMB           1            TEMP BYTE FOR USE IN IRQ
SYN        RMB           2            SYNDROME
```

CONF	RMB	1	SYNDROME CONFIDENCE
TH32	RMB	1	TICS (SECONDS/32)
TH8	RMB	1	EIGHTHS OF SECONDS
SEC	RMB	1	SECONDS
MIN	RMB	1	MINUTES
OUR	RMB	1	HOURS
AMIN	RMB	1	ALARM MINUTES
AOUR	RMB	1	ALARM HOURS
DISP1	RMB	1	RT DISPLAY POINTER #1
DISP2	RMB	1	RT DISPLAY POINTER #2
		6	
RQ	RMB	6	WORKING BCD NUMBER 1 RADIO
RP	RMB	6	" " " 2 "
RR	RMB	2	" " " 3 "
W1	RMB	2	W
W2	RMB	2	O
W3	RMB	2	R
W4	RMB	2	K
W5	RMB	2	I
W6	RMB	2	N
W7	RMB	2	G
KEY	RMB	1	CODE OF PRESSED KEY
KOUNT	RMB	1	KEYBOARD COUNTER
DIG2	RMB	1	2nd DIGIT TIMEOUT COUNTER
CARRY	RMB	1	BCD CARRY
COUNT	RMB	1	LOOP COUNTER
NUM1	RMB	2	1ST No. POINTER (ADD & SUBTRACT)
NUM2	RMB	2	2ND No. POINTER (ADD & SUBTRACT)
LED	RMB	1	STATION NUMBER
SMEM	RMB	2	CURRENT FREQUENCY
REARET	RMB	1	LAST TA REASON FOR RETURN
RTDIS	RMB	1	RDS DISPLAY TYPE
DI	RMB	1	DECODER IDENTIFICATION
SCHAN	RMB	1	SCAN CHANNEL

*
* Flags, & pages 1-2.
*

STAT	RMB	1	0: MODE 1: STATION, 0: FREQ
*			1: STEP 1: 50KHz, 0: 10KHz
*			2: CLRQ 1: CLEAR IF NO. KEYED
*			3: TIMER MS BIT TOGGLE (64 Hz)
*			4: RDS DATA CLEARING ENABLE
*			5: KEY FUNCTION PERFORMED
*			6: KEY REPEATING
*			7: NOT JUST POWERED UP
STAT2	RMB	1	0: VALID SYNDROME
*			1: VALID GROUP
*			2: RT DISPLAY
*			3: UPDATE DISPLAY
*			4: CLEAR DISPLAY
*			5: SPACE FLAG
*			6: NOT ON PROGRAM (AM)
*			7: TA RETUNE DONE
STAT3	RMB	1	0: NOT ON PROGRAM (FM)
*			1: TEXTA/TEXTB BIT (RT)
*			2: TA FLAG
*			3: TP FLAG
*			4: SHAFT DIRECTION
*			5: SHAFT ROTATION
*			6: UPDATE DATE
*			7: SHAFT INTERRUPTS
STAT4	RMB	1	0: DISPLAY (OR TA SWITCH) TRANSIENT
*			1: SLEEP TIMER RUNNING
*			2: TRAFFIC ENABLED
*			3: ALARM DISPLAY
*			4: ALARM ARMED
*			5: ALARM SET-UP
*			6: ALARM HOURS (SET-UP)
*			7: VALID GROUP 14B RECEIVED
STAT5	RMB	1	0: BAND CHANGE TIMEOUT
*			1: RDS DISPLAYS
*			2: SLEEP DISPLAY
*			3: M/S 0: M, 1: S

Application Note

```

*
*
*
*
4: RETUNE FLAG (FREQUENCY MODE)
5: TA INHIBIT FLAG (NVM)
6: STORE MODE
7: WEEKDAY ONLY ALARM

STAT6   RMB      1
BCTO    RMB      1
SCNT     RMB      1
        BAND/BANK (,MW STEP,COLON, ,A1,A0,,E6)
        BAND CHANGE TIMEOUT
        SHAFT DETENT COUNTER

EON      SECTION .RAM2,COMM
        RMB      256
        SECTION .RAM3,COMM
DISP     RMB      16
DISPP    RMB      16
PSN      RMB      8
RT       RMB      69
        EON DATA (16 NETWORKS)
        LCD MODULE BUFFER
        CURRENT LCD MODULE CONTENTS
        RADIOTEXT
        SECTION .ROM1
STRST    JMP      START
TMRB     JMP      TINTB
IRQ      JMP      SDATA
        RESET VECTOR
        RTI
        IRQ

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

START    LDAA     #$01
        STAA     INIT
        LDAA     #$10
        STAA     $1035
        REGISTERS AT $1000
        ENABLE EEPROM WRITE (NOT CONFIG)

        LDAA     #$30
        STAA     $1039
        LDAA     #$03
        STAA     $1026
        LDAA     #$40
        STAA     $1024
        LDAA     #$00
        STAA     $1028
        IRQ EDGE SENSITIVE
        32Hz RTI (8.388MHz XTAL)
        PORTA, BITS 3 & 7 INPUTS
        ENABLE REAL TIME INTERRUPTS
        DWOM = 0, PORTD PUSH-PULL

        LDS      #$02FF
        INITIALISE STACK POINTER

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

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

        CLR      PORTC,Y
        LDAA     #$FF
        STAA     PORTCD,Y
        0-7:  LCD PARALLEL BUS

        CLR      PORTD,Y
        LDAA     #$3C
        STAA     PORTDD,Y
        0,1:  SCI (DEBUG)
        2-4:  KEYBOARD OUTPUTS
        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.
*
*****

        JSR      DBOUNC
        LDAA     #$30
        JSR      CLOCK
        JSR      DBOUNC
        LDAA     #$30
        JSR      CLOCK
        WAIT 15ms
        INITIALISE LCD
        WAIT 15ms
        INITIALISE LCD

        LDX      #BMJD
        CLR      0,X
        INITIALISE PAGE 0 RAM

```

```

      INX
      CPX          #SCNT+1          MORE ?
      BNE          CLOOP
      BSET         STAT4,$04        ENABLE TRAFFIC SWITCHING - DEFAULT ?
      BSET         STAT,$01         STATION MODE

      LDAA         #$30
      JSR          CLOCK            INITIALISE LCD
      JSR          WAIT
      LDAA         #$30            /8 DISPLAY
      BRCLR       PORTA,Y,$80,M8
      LDAA         #$38            /16 DISPLAY
      JSR          CLOCK            LATCH IT
      JSR          WAIT
      LDAA         #$08            SWITCH DISPLAY OFF
      JSR          CLOCK            LATCH IT
      JSR          WAIT
      LDAA         #$01            CLEAR DISPLAY
      JSR          CLOCK            LATCH IT
      JSR          INITD           INITIALISE RDS DATA & DISPLAY
      JSR          CLREON          AND EON DATA

*      Initialise interrupt JMPs

JRT1   EQU          $00EB          E32 BUFFALO RAM JUMP TABLE
JIRQ   EQU          $00EE          " " " " "
JXIRQ  EQU          $00F1          " " " " "

      LDAA         #$7E
      STAA         JRTI
      STAA         JIRQ
      STAA         JXIRQ
      LDD          #TINTB
      STD          JRTI+1          RTI
      LDD          #SDATA
      STD          JIRQ+1          IRQ
      LDD          #SHAFTX
      STD          JXIRQ+1         XIRQ

      LDAA         #$00
      TAP          ENABLE IRQ & XIRQ

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

IDLE   LDY          #$1000
      BRSET       STAT,$08,TBH
      BRSET       $0E,Y,$80,*
      BSET        STAT,$08
      BRA         NO2D
      TBH         BRCLR       $0E,Y,$80,*
      BCLR        STAT,$80

NO2D   BRCLR       STAT4,$01,NOPS  DISPLAY TRANSIENT ?
      LDAA         DIST
      BNE         NOPS            YES, TIMED OUT ?
      JSR          CLTR

NOPS   BRCLR       STAT2,$08,NDU   DISPLAY UPDATE REQUIRED ?
      JSR          MOD            YES, DO IT
      BCLR        STAT2,$08       AND CLEAR FLAG

NDU    BRCLR       PORTD,Y,$20,FULON  STANDBY ?

NOTSNZ BRSET       STAT4,$10,NNT2   STANDBY, ALARM ARMED ?
NTJ2   JMP         NT2

NNT2   BRCLR       STAT5,$80,NWA   YES, WEEKDAY ALARM ONLY ?
      LDAA         DOW            YES
      CMPA        #4             SATURDAY OR
      BHI         NT2J           SUNDAY ?
      NWA         LDAA         AOUR  NO, COMPARE ALARM HOURS
      CMPA        OUR           WITH TIME

```

Application Note

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BNE          NT2J          SAME ?
LDAA         AMIN          YES, COMPARE ALARM MINUTES
CMPA        MIN           WITH TIME
BNE          NT2J          SAME ?
LDAA         SEC           ONLY ALLOW WAKE-UP IN FIRST SECOND
BNE          NT2          TO PREVENT SWITCH-OFF LOCKOUT
ONAG         BCLR          PORTD,Y,$20 YES, SWITCH ON,
JSR          DEL500        WAIT 500ms,
BCLR          PORTA,Y,$10  DEMUTE
JSR          P5170        AND TUNE (5170 & 5157)

FULON        BRCLR         STAT4,$02,FLN SLEEP TIMER RUNNING ?
LDAA         SLEPT        YES
BNE          FLN          TIME TO FINISH ?
BCLR         STAT4,$02    YES, CLEAR FLAG,
BSET         PORTD,Y,$20  SWITCH OFF
BSET         PORTA,Y,$10  AND MUTE

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

FLN          BRCLR         STAT4,$80,NT1 14B FLAG HIGH ?
BRSET        STAT2,$80,NT2 YES, BIT AGREES ?
BSET         STAT2,$80    NO, SET BIT
CLR          REARET
LDAA         #25         LOCK OUT RETURN
STAA         DIST        FOR 3 SECONDS
BSET         STAT4,$01   SET DISPLAY TRANSIENT FLAG
BSET         PORTA,Y,$10 MUTE
JSR          DBNC        WAIT 150 ms
JSR          RETUNE2     AND RETUNE
BRCLR        STAT4,$80,NWWS PI CODE NOT IN EON LIST ?
JSR          DEL500      WAIT 500ms
*           BRCLR         PORTE,Y,$10,SOK SIGNAL OK ?
*           LDAA         #2
*           STAA         REARET
*           BRA          NT1
SOK          JSR          DEL500        WAIT 500ms
BRSET        STAT3,S08,TPOK TP OK?
LDAA         #5
STAA         REARET
BRA          NT1
TPOK        LDAA         PI           YES, CHECK PI CODE
CMPA        PION
BNE          PINOK1
LDAA         PI+1
CMPA        PION+1       AGAINST PI (EON)
BEQ         NT2          IF OK STAY SWITCHED
PINOK1      LDAA         #3
STAA         REARET

NT1         BRCLR         STAT2,$80,NT2 14B FLAG LOW, BIT AGREES ?
BCLR         STAT4,$80   MAKE SURE 14B CANCELLED
BSET         PORTA,Y,$10 MUTE
JSR          DBNC        WAIT 150 ms
NWWS        BCLR         STAT2,$80    CLEAR FLAG
LDAA         LED         SELECTED PROG.
JSR          RETUNE2     AND RETURN TO ORIGINAL PROGRAM

NT2         JSR          KBD         READ KEYBOARD
JSR          KEYP        EXECUTE KEY
BRCLR        STAT3,$20,NSRO SHAFT ROTATION PENDING ?
BCLR         STAT3,$20   YES, CLEAR FLAG
BRSET        STAT3,$10,ANTI DIRECTION ?
JSR          PINC2      CLOCKWISE, INCREMENT
BRA          NSRO
ANTI        JSR          PDEC2      ANTI-CLOCKWIRE, DECREMENT
NSRO        BRCLR         STAT3,$40,NRDSP UPDATE DATE ?
JSR          MJDAT      YES, CONVERT FROM MJD

```

```

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

```

```

* Retune if band or SW bank inputs changed. *
*
*****
NRDSP LDY          #$1000
      BRCLR      STAT,$80,BTO      JUST POWERED UP ?
      BRCLR      PORTA,Y,$01,L5    NO, A0 LOW ?
      BRSET      STAT6,$04,CG6     NO, HIGH, BIT AGREES ?
      BSET       STAT6,$04         NO, MAKE IT HIGH
      BRSET      STAT6,$08,BTO     BAND ONE ?
      BSET       STAT3,$80         YES, SHAFT INTERRUPTS
      BRA        CHE              AND NOTHING ELSE TO DO

L5    BRCLR      STAT6,$04,CG6     YES, A0 LOW, BUT AGREES ?
      BCLR       STAT6,$04         NO, MAKE IT LOW
      BRSET      STAT6,$08,BTO     BAND ZERO ?
      BCLR       STAT3,$80         YES, RDS INTERRUPTS
      BRA        CHE              AND NOTHING ELSE TO DO

CG6   BRCLR      PORTA,Y,$02,L6    A1 LOW ?
      BRSET      STAT6,$08,CHE     NO, HIGH, BIT AGREES ?
      BSET       STAT6,$08         NO, MAKE IT HIGH
      BRA        BTO

L6    BRCLR      STAT6,$08,CHE     YES, A1 LOW, BIT AGREES ?
      BCLR       STAT6,$08         NO, MAKE IT LOW
      BRSET      STAT6,$04,BTO     BAND ZERO ?
      BCLR       STAT3,$80         YES, RDS INTERRUPTS
      BRA        BTO

CHE   BRSET      STAT6,$0C,BD3     BAND 3 ?
      BRA        OK6

BD3   BRCLR      PORTE,Y,$40,E6L   NO, E6 LOW ?
CE6   BRSET      STAT6,$01,OK6     NO, HIGH, BIT AGREES ?
      BSET       STAT6,$01         NO, MAKE IT HIGH
      BRA        BTO

E6L   BRCLR      STAT6,$01,OK6     YES, E6 LOW, BIT AGREES ?
      BCLR       STAT6,$01         NO, MAKE IT LOW

BTO   BSET       STAT,$80          SET POWER-UP FLAG,
      LDAA      #10
      STAA     BCTO              INITIALISE
      BSET      STAT5,$01         AND START BAND-CHANGE TIMEOUT

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

OK6   BRCLR      STAT5,$01,ARI     TIMEOUT RUNNING?
      DEC       BCTO             YES, DECREMENT COUNT
      BNE      ARI              FINISHED ?
      BCLR      STAT5,$01        YES, CLEAR FLAG
      BSR      RCLP             AND RECALL LAST USED PROG. No.
      BRCLR    STAT6,$0C,ARI     BAND 0 ?
      BSET     STAT3,$80        NO, SHAFT INTERRUPTS

ARI   BRSET      STAT3,$0C,TATP    TA=TP=1 ?
      BSET     PORTA,Y,$20
      BRA     IOOK

TATP  BCLR      PORTA,7,$20        YES, A5 LOW

IOOK  BRSET      STAT5,$08,MSH     M/S=1 ?
      BSET     PORTA,Y,$40
      BRA     IDLJ

MSH   BCLR      PORTA,Y,$40        YES, A6 LOW

IDLJ  JMP       IDLE

RCLP  BSET      PORTA,Y,$10        MUTE
      LDAB     #120
      JSR     READ1              GET STORED PROG. No.
      STAA    LED

```

Application Note

```

JMP          RETUNE2          PROGRAM 145170/57

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

SHAFT        BRSET           PORTE,Y,$20,SEM      IRQ,SHAFT I/O HIGH (E5) ?
             BCLR           STAT3,$10           NO, CLEAR DIRECTION BIT
             BRA            TEM
SEM          BSET           STAT3,$10           YES, SET DIRECTION BIT
TEM         BSET           STAT3,$20           SET FLAG TO INDICATE ROTATION
             RTI

SHAFTX       BRSET           PORTE,Y,$10,XEM     XIRQ, SHAFT I/O HIGH (E4) ?
             BCLR           STAT3,$10           NO, CLEAR DIRECTION BIT
             BRA            YEM
XEM         BSET           STAT3,$10           YES, SET DIRECTION BIT
YEM        BSET           STAT3,$20           SET FLAG TO INDICATE ROTATION
             RTI

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

KBD         CLR            W1
             LDY           #$1000
             LDX           #7
KEY1        LDAB           W1
             ADDB          #$04                SELECT COLUMN
             STAB          W1
             LDAB          PORTD,Y
             ANDB          #$20                PRESERVE OTHER PORTD DATA
             ADDB          W1
             STAB          PORTD,Y
             LDAA          PORTE,Y
             BITA          #$0F                READ KEYBOARD
             BNE          L1                    ANY INPUT LINE HIGH ?
             DEX
             BNE          KEY1                 NO, TRY NEXT COLUMN
             CLR          KEY                  LAST COLUMN ?
             BRA          EXIT                 YES, NO KEY PRESSED
L1          LDAB          W1
             LSLB
             LSLB
             LDAA          PORTE,Y           READ KEYBOARD
             ANDA          #$0F
             ABA
             CMPA          KEY                SAME AS LAST TIME ?
             BEQ          EXIT
             STAA          KEY                NO, SAVE THIS KEY
             CLR          KOUNT
EXIT        INC          KOUNT                YES, THE SAME
             LDAA          KOUNT
             BRCLR        STAT,$40,NRML      REPEATING ?
             LDAB          PSNP              YES
             BEQ          NOTCH              CHARACTER CHANGE ?
             CMPA          #8                YES, REPEAT AT 8 Hz
             BRA          GON2
NOTCH       CMPA          #16                NO, REPEAT AT 4 Hz
             BRA          GON2
NRML        CMPA          #3                NO, 3 THE SAME ?
             BLO          KCLC              IF NOT DO NOTHING
             BEQ          GOON              IF 3 THEN PERFORM KEY FUNCTION
             CMPA          #47              MORE THAN 3, MORE THAN 47 (750mS) ?
GON2        BHI          GOON2              TIME TO DO SOMETHING ?
             LDAA          KEY              NO
             BEQ          RKEY              KEY PRESSED ?
             CLC
             RTS
GOON2       LDAA          KEY                YES BUT DO NOTHING
             CMPA          #$54
             BEQ          GOON3              DEC. PROG.

```

```

        CMPA      #$58          INC.PROG.
        BEQ      GOON3
        CMPA      #$52          SLEEP
        BNE      DNT2          IF NOT A REPEAT KEY, DO NOTHING
GOON3   BSET      STAT,$40      SET REPEAT FLAG
        CLR      KOUNT
GOON    LDAA      KEY
        BEQ      RKEY          SOMETHING TO DO ?
        SEC
        RTS
RKEY    BCLR      STAT,$20     NO, CLEAR DONE FLAG
DNT2    BCLR      STAT,$40     CLEAR REPEAT FLAG
        CLR      KOUNT        CLEAR COUNTER
KCLC    CLC
DNT     RTS

```

```

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

```

```

KEYP    BCC      DNT          ANYTHING TO DO ?
KEYP2   LDAA      KEY        YES, GET KEY
        CMPA      #$54          DEC. PROG. (M)
        BEQ      RPT
        CMPA      #$58          INC. PROG. (S)
        BEQ      RPT
        CMPA      #$52          SLEEP
        BEQ      RPT
BRSET   STAT,$20,DNT        NOT A REPEAT KEY, FLAG SET ?

```

```

RPT     CLRB
RJ      LDX      #CTAB
        ABX
        LDAA      0,X         FETCH KEYCODE
        CMPA      KEY        THIS ONE ?
        BEQ      PJ          YES
        CMPA      LAST       NO, LAST CHANCE ?
        BEQ      DNT         YES, ABORT
        ADDB      #4         NO TRY THE NEXT KEY
PJ      BRA      RJ
        BSET      STAT,$20
        JSR      1,X
        JMP      P5170

```

```

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

```

```

CTAB    FCB      $11          0
        JMP      DIGIT
        FCB      $21          1
        JMP      DIGIT
        FCB      $22          2
        JMP      DIGIT
        FCB      $24          3
        JMP      DIGIT
        FCB      $31          4
        JMP      DIGIT
        FCB      $32          5
        JMP      DIGIT
        FCB      $34          6
        JMP      DIGIT
        FCB      $41          7
        JMP      DIGIT
        FCB      $42          8
        JMP      DIGIT
        FCB      $44          9
        JMP      DIGIT
        FCB      $48          ALARM
        JMP      ALARM
        FCB      $38          STORE/SET
        JMP      SAVE

```

Application Note

	FCB	\$18	ON/OFF
	JMP	ONOFF	
	FCB	\$14	CLEAR/STEP
	JMP	CLEAR	
	FCB	\$12	MODE (PROG./FREQ.)
	JMP	MODE	
	FCB	\$52	SLEEP TIMER START
	JMP	SLEEP	
	FCB	\$54	DEC. PROG./FREQ./CHAR.
	JMP	PDEC	
	FCB	\$58	INC. PROG./FREQ./CHAR.
	JMP	PINC	
	FCB	\$61	RDS DISPLAYS
	JMP	RTDSP	
	FCB	\$62	TRAFFIC ENABLE (TOGGLE)
	JMP	TPEN	
	FCB	\$64	MW STEP 9/10kHz (TOGGLE)
	JMP	T910	
	FCB	\$51	COLON CONTROL
	JMP	TFCC	
LAST	FCB	\$68	TA TEST
	JMP	TEST	

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

ALARM	BRCLR	STAT4,\$08,ADON	ALARM DISPLAY ON ?
	BRCLR	STAT4,\$10,ALOF	YES, ALARM ON ?
	BCLR	STAT4,\$10	YES, SWITCH OFF
	BRA	UDCNT	
ALOF	BSET	STAT4,\$10	NO, SWITCH ON
	BRA	UDCNT	
ADON	JSR	CLTR	NO, ENABLE ALARM DISPLAY
	BSET	STAT4,\$08	ALARM DISPLAY FLAG
UDCNT	BCLR	STAT4,\$20	CANCEL SET-UP
	LDAA	#25	3 SECONDS TIMEOUT
	STAA	DIST	
	BSET	STAT4,\$01	SET DISPLAY TRANSIENT FLAG
ABOA	RTS		

```
*****
*                                     *
*           On/off key.                 *
*                                     *
*****
```

ONOFF	JSR	CLTR	CLEAR DISPLAY TRANSIENTS
	BCLR	STAT4,\$82	CANCEL SLEEP TIMER & TA SWITCH FLAG
	BCLR	STAT5,\$40	CANCEL STORE MODE
SODM	BRCLR	PORTD,Y,\$20,ALRON	ON ?
	BCLR	PORTD,Y,\$20	NO, SWITCH ON
	JSR	DEL500	WAIT 500ms
	BCLR	PORTA,Y,\$10	AND DEMUTE
	RTS		
ALRON	BSET	PORTD,Y,\$20	YES, SWITCH OFF
	BSET	PORTA,Y,\$10	AND MUTE
	RTS		

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

PSC	LDX	#PSN	
	LDAA	#\$FF	
CPSL	STAA	0,X	
	INX		
	CPX	#PSN+8	
	BNE	CPSL	
	RTS		

```

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

TPEN      BRSET      PORTD,Y,$20,HIGH      STANDBY ?
          BRSET      STAT,$01,NS1        NO, NORMAL MODE ?
          BRSET      STAT5,$20,TAEH      NO, FREQ. MODE, NVM DISABLE FLAG SET ?
          BSET       STAT5,$20          NO, SET IT
          RTS
TAEH      BCLR       STAT5,$20          YES, CLEAR IT
HIGH      RTS

NS1       BRCLR     STAT4,$04,TPOF      NORMAL MODE, TRAFFIC ON ?
          BCLR     STAT4,$04          YES, DISABLE
          RTS
TPOF      BSET      STAT4,$04          NO, ENABLE
          RTS

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

SLEEP     BRSET     STAT5,$04,DECS      ALREADY SLEEP DISPLAY ?
          BRSET     STAT4,$02,STR      NO, SLEEP TIMER ALREADY RUNNING ?
INSLP     LDAA     #60                  NO, INITIALISE SLEEP TIMER
SLEP      STAA     SLEPT
          BSET     STAT4,$02          START SLEEP TIMER
STR       JSR     CLTR                  YES, CLEAR DISPLAY TRANSIENTS
          BSET     STAT5,$04          SLEEP DISPLAY
          BRA     SLPTOK              NO DECREMENT IF FIRST TIME
DECS     LDAA     SLEPT                DECREMENT SLEEP TIMER
          SUBA     #5
          STAA     SLEPT
          BMI     INSLP

SLPTOK    LDAA     #25
          STAA     DIST
          BSET     STAT4,$01          START DISPLAY TRANSIENT
          BRSET     PORTD,Y,$20,SODM  ALREADY ON ?
          BCLR     PORTA,Y,$10       YES, JUST DEMUTE
          RTS

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

DIGIT     BRSET     PORTD,Y,$20,AB03    STANDBY ?
          JSR     CLTR                NO, CLEAR DISPLAY TRANSIENTS
          LSRB
          LSRB
          BRSET     STAT,$01,SKP      STATION MODE ?
          BRSET     STAT5,$40,SKP     NO, STORE MODE ?
          BSET     STAT5,$10          NO, SET RETUNE FLAG (FREQUENCY MODE)
          BLCR     STAT5,$20          AND CLEAR TA INHIBIT BIT (NVM)
          STAB     W3
          BRCLR    STAT,$04,SHIFT     CLEAR Q ?
          BCLR     STAT,$04          YES, CLEAR FLAG
          JSR     CLQ                 AND CLEAR Q
SHIFT     BSR     DR1                 W1: MSD, W2: LSD
          LDX     W1
AGS       LDAA     1,X                MOVE ALL DIGITS
          STAA     1,X                UP ONE PLACE
          INX
          CPX     W2
          BNE     AGS                DONE ?
          LDAA     W3                 YES, RECOVER NEW DIGIT
          STAA     0,X                AND PUT IT IN LSD
          RTS

```

Application Note

```

SKP      BSET      PORTA,Y,$10      MUTE
        TBA
        STAA
        JMP      RETUNE

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

DR1      LDX      #RQ      STORE POINTERS
        STX      W1
        LDAB     #5
        ABX
        STX      W2
ABO3     RTS

DEL500   LDX      #255
        JSR      SKDB
        LDX      #255
        JMP      SKDB

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

PINC2    BRSET    STAT4,$20,ALSU1    ALARM SET-UP ?
        BRSET    STAT4,$08,TOG57    NO, ALARM DISPLAY ?
        BRSET    PORTD,Y,$20,DMI    NO,STANDBY ?
        LDAB     PSNP
        BNE      PSN0              NO,PS EDIT MODE ?
        JMP      UP                NO, STEP UP

PINC     BRSET    STAT4,$20,ALSU1    ALARM SET-UP ?
TOG57J   BRSET    STAT4,#08,TOG57    NO, ALARM DISPLAY ?

        BRSET    PORTD,Y,$20,DMI    NO, STANDBY ?
        BRSET    STAT,$01,NACS      NO, FREQ. MODE ?
        JMP      UP                YES, STEP UP

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

ALSU1    BRSET    STAT4,$40,IHR      YES, SET-UP HOURS ?
        LDAA     AMIN              NO, MINUTES
        CMPA     #59
        BHS     TOO
        INC      AMIN
        BRA     T5S
TOOH     CLR      AMIN
        BRA     T5S
IHR      LDAA     AO
        CMPA     #23
        BLO     HTO
        CLR      AO
        BRA     T5S
HTOH     INC      AO
T5S      LDAA     #80              10 SECOND TIMEOUT
        STAA     DIST
        BSET    STAT4,$01          SET DISPLAY TRANSIENT FLAG
        BCLR    PORTA,Y,$10       DEMUTE
DMI      RTS

NACS     LDAB     PSNP
        BEQ     CONTI             NO, PS EDIT MODE ?

```

```

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

PSN0      LDX          #PSN-1
          ABX
          LDAA        0,X          YES
          INCA        INCREMENT ASCII VALUE
          CMPA        #$20        SPACE
          BLS         MAK20       LESS OR EQUAL ?
          CMPA        #$2E        NO, .
          BLS         MAK2E       LESS OR EQUAL ?
          CMPA        #$30        NO, 0
          BLO         MAK30       LESS ?
          CMPA        #$39        NO, 9
          BLS         CNTB        LESS OR EQUAL ?
          CMPA        #$41        NO, A
          BLO         MAK41       LESS ?
          CMPA        #$5A        NO, Z
          BLS         CNTB        LESS OR EQUAL ?
          CMPA        #$61        NO, a
          BLO         MAK61       LESS ?
          CMPA        #$7A        NO, z
          BLS         CNTB        LESS OR EQUAL ?
MAK20     LDAA        #$20        MAKE SPACE
          BRA         CNTB
MAK2E     LDAA        #$2E        MAKE .
          BRA         CNTB
MAK30     LDAA        #$30        MAKE 0
          BRA         CNTB
MAK41     LDAA        #$41        MAKE A
          BRA         CNTB
MAK61     LDAA        #$61        MAKE a
CNTB      STAA        0,X
          LDAA        #80
          JMP         OUTCH

TOG57     BRCLR      STAT4,$10,DMI  ALARM ARMED ?
          BRCLR      STAT5,$80,A7  YES, 7-DAY ALARM ?
          BCLR       STAT5,$80     NO, MAKE IT 7 DAY
          BRA         T5S
A7        BSET       STAT5,$80     YES, MAKE IT 5 DAY
          BRA         T5S

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

CONTI     BSET       PORTA,Y,$10    MUTE
          BSET       STAT2,$08     PROG. No. INCREMENT, UPDATE DISPLAY
          LDAA        LED
          BRSET      STAT2,$80,IOK  IF SWITCHED TO TA DON'T INCREMENT
          INCA        NEXT PROG.
          CMPA        #9           TOO HIGH ?
          BLS         IOK
          CLRA
          STAA        LED
IOK       JMP         RETUNE
          JMP         RETUNE

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

PDEC2     BRSET      STAT4,$20,ALSU2  ALARM SET-UP ?
          BRSET      STAT4,$08,TOG57  NO, ALARM DISPLAY ?
          BRSET      PORTD,Y,$20,DMD  NO, STANDBY ?
          LDAB        PSNP
          BNE        PSN1          NO, PS EDIT MODE ?
          JMP         DOWN         NO, STEP DOWN

```

Application Note

```

PDEC      BRSET      STAT4,$20,ALSU2      ALARM SET-UP ?
          BRSET      STAT4,$08,TOG57      NO, ALARM DISPLAY ?
          BRSET      PORTD,Y,$20,DMD      NO, STANDBY ?
          BRSET      STAT,$01,NACS2       NO, FREQ. MODE ?
          JMP         DOWN                 YES, STEP DOWN

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

ALSU2     BRSET      STAT4,$40,IHRD       YES, SET-UP HOURS ?
          TST        AMIN                  NO, MINUTES
          BEQ        MZ
          DEC        AMIN
          BRA        T5SD

MZ        LDAA       #59
          STAA       AMIN
          BRA        T5SD

IHRD     TST        AOUR
          BNE        HZ
          LDAA       #24
          STAA       AOUR

HZ        DEC        AOUR

T5SD     LDAA       #80                    10 SECOND TIMEOUT
          STAA       DIST
          BSET      STAT4,$01             SET DISPLAY TRANSIENT FLAG
          BCLR     PORTA,Y,$10           DEMUTE

DMD      RTS

NACS2    LDAB       PSNP
          BEQ        CONTD               PS EDIT CHARACTER CHANGE ?

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

PSN1     LDX        #PSN-1
          ABX
          LDAA       0,X                 YES
          DECA      DECREMENT ASCII VALUE
          CMPA      #$20                 SPACE
          BLS      MKE7A                 LESS OR EQUAL ?
          CMPA      #$2E                 NO, .
          BLS      MKE20                 LESS OR EQUAL ?
          CMPA      #$30                 NO, 0
          BLO      MKE2E                 LESS ?
          CMPA      #$39                 NO, 9
          BLS      CNTS                 LESS OR EQUAL ?
          CMPA      #$41                 NO, A
          BLO      MKE39                 LESS ?
          CMPA      #$5A                 NO, Z
          BLS      CNTS                 LESS OR EQUAL ?
          CMPA      #$61                 NO, a
          BLO      MKE5A                 LESS ?
          CMPA      #$7A                 NO, z
          BLS      CNTS                 LESS OR EQUAL ?
          MKE20    LDAA       #$20         MAKE SPACE
          BRA        CNTS

MKE2E    LDAA       #$2E                 MAKE .
          BRA        CNTS

MKE5A    LDAA       #$5A                 MAKE Z
          BRA        CNTS

MKE7A    LDAA       #$7A                 MAKE z
          BRA        CNTS

MKE39    LDAA       #$39                 MAKE A
          CNTS      0,X
          LDAA       #80

OUTCH    STAA       DIST
          BSET      STAT4,$01             SET DISPLAY TRANSIENT FLAG
          BCLR     STAT4,$08           NOT ALARM DISPLAY MODE
          RTS

```

```

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

CONTD   BSET      PORTA,Y,$10      MUTE
        LDAA     LED              PROG. No. DECREMENT
        BRSET   STAT2,$80,RETUNE  IF SWITCHED TO TA DON'T DECREMENT
PNM1    DECA
        BPL     SK2P              DECREMENT PROGRAM NUMBER
        LDAA     #9               TOO FAR ?
SK2P    STAA     LED              SAVE NEW PROGRAM NUMBER
RETUNE  LDAB     #120             CHANGE PROGRAM NUMBER IN NVM
        JSR     WRITE1
        PULA
        BRCLR  STAT4,$80,RETUNE2  TA SWITCHED ?
        BCLR   STAT4,$80         YES, MANUAL RETURN FROM TA
        LDAA     #9
        STAA   REARET
RETUNE2 JSR      DOIT              NEW PROGRAM
        JSR     P5170
        LDX     #64              WAIT 100ms
        JSR     SKDB
        BCLR   PORTA,Y,$10      DEMUTE
        BCLR   STAT2,$02        KILL ANY PENDING RDS GROUP
        BCLR   STAT3,$01        AND INHIBIT FM PS-NAME CLEARING
        BCLR   STAT,$10         RE-ENABLE RDS DATA CLEARING
        RTS
FOK     LDAB     #10
        MUL
        ADDB   #$5C
        STAB   SMEM
        ADCA   #$26
        STAA   SMEM+1
        JMP    NEW

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

TASW    CLRB
TPIC    ADDB     #10
        JSR     READ1           FIND PI
        INCB
        CMPA   PION            MSB OK ?
        BNE   TNP
        DECB
        JSR     READ1
        CMPA   PION+1          LSB OK ?
        BNE   TNP
        SUBB   #12             YES, FOUND IT
        JSR     READ1
        PSHA
        ANDA   #$80            NVM INHIBIT FLAG SET ?
        BEQ   TASOK
        LDAA   #8              NVM INHIBIT MESSAGE
        BRA   ABTA
TASOK   PULA
        STAA   SMEM+1
        JSR   NEWSUB2
        JMP   NEW
TNP     CMPB    #252           TRY NEXT RECORD
        BLO   TPIC
        PSHA
        LDAA   #7
ABTA    STAA   REARET
        PULA

```

Application Note

```

BCLR          STAT4,$80          PI MATCH NOT FOUND, FORGET IT
RTS

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

DOIT          BRSET          STAT2,$80,TASW
              LDAB          #12
              MUL
              BRSET          STAT5,$40,STORE
              JMP           RECALL

*****
*
* NVW write, sub-address in X.
*
*****

STORE         BCLR          SMEM+1,$80
              BRCLR        STAT5,$20,SKTA          TA NVM INHIBIT FLAG SET ?
              BSET          SMEM+1,$80
SKTA          LDAA          SMEM+1                BINARY FREQUENCY MSB
              JSR           WRITE1
              LDAA          SMEM                BINARY FREQUENCY LSB
              JSR           WRITE1
              LDAA          PSN
              CMPA          #$A0                PS NAME OK ?
              BEQ           PSNOK
              CMPA          #$FF
              BNE          PSOK                PERHAPS, TRY FF
PSOK          LDAA          PSOK
              JSR           WRITE1
              LDAA          DISP+10
              JSR           WRITE1
              LDAA          DISP+11
              JSR           WRITE1
              LDAA          DISP+12
              JSR           WRITE1
              LDAA          DISP+13
              JSR           WRITE1
              LDAA          DISP+14
              JSR           WRITE1
              LDAA          DISP+15
              JSR           WRITE1
              LDAA          #$20
              JSR           WRITE1
              LDAA          #$00                DUMMY PI CODE
              JSR           WRITE1
              LDAA          #$00
              BRA          FINST

PSOK          JRS           WRITE1
              LDAA          PSN+1
              JSR           WRITE1
              LDAA          PSN+2
              JSR           WRITE1
              LDAA          PSN+3
              JSR           WRITE1
              LDAA          PSN+4
              JSR           WRITE1
              LDAA          PSN+5
              JSR           WRITE1
              LDAA          PSN+6
              JSR           WRITE1
              LDAA          PSN+7
              JSR           WRITE1
              LDAA          PI                PI CODE
              JSR           WRITE1
              LDAA          PI+1
FINST        JSR           WRITE1
              BCLR          STAT5,$40          CLEAR STORE MODE
              RTS

```

```

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

RECALL   BSR      NEWSUB
         JMP      NEW

NEWSUB   JSR      READ1
         STAA    SMEM+1
         BCLR   STAT5,$20
         BRCLR  SMEM+1,$80,NEWSUB2
         BSET   STAT5,$20

NEWSUB2  JSR      READ1
         CMPA   #$FF
         BNE   NOTFF2
         LDAA  #$26           $04
         STAA  SMEM+1
         LDAA  #$5C           $2E

NOTFF2   STAA  SMEM
         JSR   READ1
         STAA PSN
         JSR   READ1
         STAA PSN+1
         JSR   READ1
         STAA PSN+2
         JSR   READ1
         STAA PSN+3
         JSR   READ1
         STAA PSN+4
         JSR   READ1
         STAA PSN+5
         JSR   READ1
         STAA PSN+6
         JSR   READ1
         STAA PSN+7
         RTS

*****
*
*   NVW read & write one byte.
*
*****

READ1    JSR      GETAD
         LDAA    0,X
         INCB
         RTS

WRITE1   LDY      #$1000
         BSET   PPROG,Y,$16      SET EELAT, ERASE & BYTE ERASE BITS
         BSR    WBYTE            ERASE BYTE
         JSR    DBOUNC           WAIT 15 ms
         BSET   PPROG,Y,$02      SET EELAT TO WRITE BYTE
         DECB

WBYTE    JSR      GETAD
         STAA    0,X             LATCH DATA
         BSET   PPROG,Y,$01      SET EEPGM BIT TO START PROGRAMMING
         JSR    DBOUNC           WAIT 15 ms
         CLR    PPROG,Y         STOP
         INCB
         RTS

GETAD    PSHA
         PSHB
         JSR    BAND             GET BAND
         LDX    #$B618           EEPROM START ADDRESS
         TBA
         CMPA   #1              FM ?
         BLS   FMB
         LDAB  #122             NO, AM
         ABX
         CMPA   #2              MW ?
         BEQ   FMB

```

Application Note

```

ABX          NO, SW
BRCLR        PORTE,Y,$40,SWB2    SECOND BANK ?
ABX          YES
SWB2
*           BRCLR        PORTE,Y,$80,FMB    SECOND PAIR OF BANKS ?
*           ABX          YES
*           ABX
FMB         PULB
           PULA
           ABX
           RTS

*****
*           *
*           RDS displays.           *
*           *
*****

RTDSP       BRSET        PORTD,Y,$20,SRT    STANDBY ?
           BRSET        STAT5,$02,NOTRT    ALREADY RDS DISPLAY ?
           BRCLR        STAT2,$04,NORT    ALREADY RT DISPLAY ?

NOTRT       BSET         STAT5,$02          SET RDS DISPLAY FLAG
           LDAA          RTDIS             YES, MOVE ON
           INCA
           CMPA          #26
           BEQ           NORT
           STAA          RTDIS
           LDAA          #100
           STAA          DIST
           BSET         STAT4,$01          RE-START TRANSIENT TIMEOUT
           RTS

NORT        JSR          CLTR
           BSET         STAT2,$04          SET RT DISPLAY FLAG
           LDAA          #9
           STAA          DISP1
           LDAA          #1
           STAA          DISP2
           RTS

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

UP          BSR          LDXR
IF          INC          SMEM              NO, INCREMENT LSB
           BNE          TT1              DID IT WRAP ROUND
           INC          SMEM+1            YES, INCREMENT MSB

TT1         DECB
           BNE          IF               ALL DONE ?
           BRA          NEWJ

DOWN       BSR          LDXR
DF         TST          SMEM              NO, IS LSB ZERO ?
           BNE          TT2              IF NOT LEAVE MSD
           DEC          SMEM+1            DECREMENT MSB
           DECB          SMEM            DECREMENT LSB

TT2        DECB
           BNE          DF               ALL DONE ?

NEWJ       JSR          NEW
           JSR          P5170
           BCLR        PORTA,Y,$10       DEMUTE
           RTS

LDXR       BRCLR        STAT6,$08,LDXR2    AM ?
           BSET        STAT2,$40         YES, CLEAR PS NAME
           BRA          NFMB

LDXR2      BSET        STAT3,$01         NO, FM, ENABLE PS NAME CLEARING
NFMB       JSR          BAND             GET BAND
           TBA
           LDAB         #1               SINGLE STEP (1,5,10 kHz FOR MW,SW,FM)
           BRCLR       STAT,$02,SRT     LARGE STEPS SELECTED ?
           CMPA        #3               YES, BAND 3 (SW) ?

```

```

BEQ          SRT
LDAB         #5          NO, x5 STEP (50 kHz FOR FM)
CMPA        #2          MW ?
BNE         SRT
LDAB         #9          YES, 9kHz
BRCLR       STAT6,$40,SRT OR SHOULD IT BE 10kHz
INCB
SRT          RTS
RTS

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

TEST        BRSET       PORTD,Y,$20,AOB   STANDBY ?
           LDD         #C5B1           CLYDE 1
           STD         PION
           BRSET       STAT4,$04,NABT    TA SWITCHING ENABLED ?
           LDAA        #1              NO, SET RETURN REASON
           STAA        REARET

AOB
NABT        BSET       STAT4,$80        YES, DO IT
           RTS

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

SAVE        BRCLR       STAT4,$08,NAME   ALARM DISPAY ?
           BRCLR       STAT4,$10,NTB2    YES, ALARM ARMED ?
           BRSET       STAT4,$20,AISM    YES, ALREADY SET-UP MODE ?
           BSET        STAT4,$60        NO, ENTER SET-UP MODE, HOURS

A5SD        LDAA        #80
           BRA         SDT

AISM        BRSET       STAT4,$40,MSM    YES, SET-UP HOURS ?
           BCLR        STAT4,$20        NO, CANCEL SET-UP
           BRA         A5SD

MSM         BCLR        STAT4,$40        YES, MAKE IT MINUTES
           BRA         A5SD

NAME        BRSET       PORTD,Y,$20,NTB2 STANDBY ?
           BRSET       STAT,$01,NFM     NO, FREQUENCY MODE ?
           BRSET       STAT5,$40,ASM    YES, STORE MODE ?
           BSET        STAT5,$40        NO, ENTER STORE MODE
           RTS

ASM         LDAA        LED
           JMP         DOIT             SAVE

NFM         LDAA        PSNP            NOT FREQUENCY MODE
           BNE         SKPCLR          SET
           JSR         CLTR            UP
SKPCLR      INC         PSNP            PS-NAME CHANGE MODE
           LDAA        PSNP
           CMPA        #8
           BLS         NTB3
           CLR         PSNP

NTB3        LDAA        #80
           SDT        DIST
           BSET       STAT4,$01        SET DISPLAY TRANSIENT FLAG
NTB2        RTS

*****
*
*   PROG, the displayed number is added to
*   the IF offset, converted to binary and
*   stored in SMEM & SMEM+1.
*
*   NEW takes binary working frequency
*   in SMEM & SMEM+1 converts it to BCD and
*   subtracts the IF offset.
*
*****

```

Application Note

```

PROG      BRSET      STAT,$01,NEW      STATION MODE ?
          JSR        IFO                P < IF OFFSET
          JSR        ADB                Q < FREQ + IF

          JSR        BAND
          BNE        ONE                BAND 3 (SW) ?
          JSR        ADD                YES, DIVIDE BY 5, Q < 2 X (FREQ + IF)
          LDX        #5
LPP      LDAA        RQ-1,X            MOVE ALL DIGITS
          STAA       RQ,X              IN Q DOWN ONE
          DEX
          BNE        LPP                PLACE TO DEVIDE
                                          BY 10 (Q < Q/5)

ONE      JSR        BCON                CONVERT Q TO BINARY

NEW     JSR        DCON                CONVERT TO BCD IN Q

          JSR        BAND
          BNE        STIF               BAND 3 (SW) ?
          STX        NUM1              YES
          LDX        #RP
          JSR        ADD                P < 2Q
          LDX        #RP
          STX        NUM1
          LDX        #RQ
          JSR        ADD                Q < 3Q
          LDX        #RQ
          JSR        ADD                Q < 5Q

STIF    JSR        IFO                P < IF OFFSET
          BSET       STAT,$04
          JMP        SUB                Q < (RATIO X STEP) -IF

*****
*
* The IF offset is selected according to *
* the required band and placed in "RP." *
*
*****

IPO     BSR        BAND                FIND BAND
          BRSET     PORTA,Y,$04,NOTN   NEGATIVE FM IF ?
          CMPB      #1                 YES
          BHI       NOTN               BUT IS IT FM ?
          LDAB      #4                 YES, FIFTH IS FROM TABLE

NOTN    LDAA        #6
          MUL
          LDX        #1FS              TIMES 6

LP6     LDY        #RP
          LDAA      0,X                TRANSFER
          STAA      0,Y                INTO RP
          INX
          INY
          CPY       #RP+6
          BLO      LP6                 DONE ?
          LDY       #$1000             RE-INITIALISE Y
          LDX       #RP                SET-UP POINTERS
          STX       NUM2
          LDX       #RQ
          STX       NUM1

IFS     FCB        0,0,1,0,7,0        10.70 MHz FM OSC HIGH
          FCB        0,0,1,0,7,0        10.70 MHz FM OSC HIGH
          FCB        0,0,0,4,5,5        455 kHz SW/MW
          FCB        0,1,0,7,0,0        10.70 MHz SW (EXT/5 FOR 5157)
          FCB        9,9,8,9,3,0        -10.70 MHz FM OSC LOW

BAND    LDAB        PORTA,Y            GET BAND
          ANDB      #$03
          LDX       #RQ
          STX       NUM2
          CMPB      #3                 BAND 3 (SW, /5) ?
          RTS

```

```

*****
*
*   Mode change & clear routines.*
*
*****

MODE      BRSET      PORTD,Y,$20,CLP      STANDBY ?
          JSR        CLTR
          JSR        PROG
SKIP      BRCLR     STAT,$01,SK      SEND DISPLAYED FREQUENCY
          BCLR     STAT,$01          FREQUENCY MODE ?
          RTS        NO, SET TO FREQUENCY MODE

SK        BCLR     STAT5,$40          FREQ. MODE, CLEAR STORE MODE
          BRCLR    STAT5,$10,NNTR    NEW FREQUENCY ENTERED ?
          BSET     PORTA,Y,$10      YES, MUTE
          JSR     DBNC                WAIT 15ms
          JSR     P5170
          LDX     #64
          JSR     SKDB                WAIT 100ms
          BCLR    PORTA,Y,$10        DE-MUTE
          BCLR    STAT2,$02          AND KILL ANY PENDING RDS GROUP
SKSM      BCLR     STAT5,$10          CLEAR RETUNE FLAG
          RTS

NNTR      BSET     STAT,$01          NO, RETURN TO STATION MODE
          BCLR     STAT5,$40        CANCEL STORE MODE
          RTS

CLEAR     BRSET     PORTD,Y,$20,CLP  STANDBY ?
          BRSET     STAT,$01,SM      NO, STATION MODE ?
          BSET     STAT5,$10        FREQUENCY CHANGED
CLAL      BSR       CLQ              NO, CLEAR Q
SM        LDAA     PSNP
          BEQ      SPCC
          JSR     PSC
SPCC      JSR     CLTR                CLEAR DISPLAY TRANSIENTS
          BRSET    STAT,$02,KHZ      9 (MW), 50 (FM) kHz STEPS
          BSET     STAT,$02
          RTS
KHZ      BCLR     STAT,$02           1 (MW), 10 (FM) kHz STEPS
CLP      RTS

CLQ      LDX     #RQ                CLEAR RQ
CLRAS    LDAA     #06                CLEAR 6 BYTES
          STAA    COUNT              STARTING AT X
CR        CLR     0,X
          INX
          DEC     COUNT
          BNE     CR                DONE ?
          RTS

CLTR     BCLR     STAT4,$01          CLEAR DISPLAY TRANSIENT FLAG
CLTR2    BCLR     STAT2,$04          CANCEL RT DISPLAY
          CLR     RTDIS
          BCLR     STAT4,$28          NOT ALARM (DISPLAY OR SET-UP)
          BCLR     STAT5,$06          NOT RT OR SLEEP DISPLAY
          CLR     PSNP                NOT PS-EDIT
          RTS

*****
*
*   BCD to binary conversion. No, in "RQ" is *
*   converted to binary in SMEM & SMEM+1.   *
*
*****

BCON     CLR     SMEM                CLEAR WORKING
          CLR     SMEM+1              FREQUENCY LOCATIONS
          LDX     #0
L2       LDAA     SMEM                LS BYTE
          LSLA    2xLSB
          STAA    W1                  SAVE 2xLSB
          ROL     SMEM+1              2xMS BYTE
          LDAA     SMEM+1
          STAA    W2                  SAVE 2xMSB

```

Application Note

```

LDAA      W1          2xLSB
LSLA      4xLSB
ROL       SMEM+1     4xMSB
LSLA      8xLSB
ROL       SMEM+1     8xMSB
ADDA      W1          10xLSB
STAA      SMEM
LDAA      SMEM+1
ADCA      W2
STAA      SMEM+1
ADCA      W2          10xMSB
STAA      SMEM+1
INX
LDAA      RQ,X       FETCH
ADDA      SMEM       NEXT
STAA      SMEM       DIGIT
LDAA      #0         AND
ADCA      SMEM+1     (CLRA CLEARS THE C BIT)
STAA      SMEM+1     ADD IT TO WORKING
CPX       #5         FREQUENCY
BNE       L2         DONE ?
RTS

```

```

*****
*
*      Clear NVM - not used.
*
*****

```

```

CLRNVW    CLR        COUNT
CLOP      LDAA       #$FF
          LDAB       COUNT
          JSR        WRITE1
          INC        COUNT
          BNE       CLOP
          CLRA
          LDAB       #120          CLEAR MAX. PROG. No.
          JMP       WRITE1

```

```

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

```

```

SUB        STX        W5          ANSWER POINTER
COM2       LDX        NUM2        9S COMPLIMENT
COMP      LDAB       #$06        SECOND NUMBER
LOOP3     LDAA       #$09
          SUBA       5,X         SUBTRACT FROM 9
          STAA      5,X         AND PUT IT BACK
          DEX
          DECB
          BNE       LOOP3
          CLR       CARRY        SET CARRY TO ONE
          INC      CARRY        BEFORE ADDING
          BRA      AD           ADD FIRST NUMBER

ADD        CLR       CARRY
AD         STX       W5          ANSWER POINTER
          LDAB      #$06
          LDX       NUM1        1st No. POINTER
          STX       W3
          LDX       NUM2        2nd No. POINTER
          STX       W4
          LDX       W3
          LDAA      5,X
          DEX
          STX       W3
          LDX       W4
          ADDA      5,X         ADD
          DEX
          STX       W4
          ADDA      CARRY       SET ON ADDITION OVERFLOW
          CLR      CARRY       OR POS. RESULT SUBTRACTION
          BSR      ADJ        DECIMAL ADJUST

```

```

LDX      W5
STAA     5,X          SAVE ANSWER
DEX
STX      W5
DECB
BNE      LOOP        DONE ?
RTS

AJ       SUBA      #10      YES, SUBTRACT 10
          INC       CARRY   AND RECORD CARRY
ADJ      CMPA     #10
          BHS      AJ       10 OR MORE ?
          RTS      NO

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

DCON     LDAA     SMEM+1    TRANSFER CURRENT
          STAA     W2       FREQUENCY DIVIDE
          LDAA     SMEM     RATIO INTO
          STAA     W1       WORKING AREA
DCON2    LDX      #RR      CLEAR
          STX      NUM1
          JSR      CLRAS    RR
          INC      RR+5     RR <- 1
          JSR      CLQ      CLEAR RQ
          LDAA     #14      14 BITS TO CONVERT
          STAA     W6
LOOP2    LSR      W2       MOVE OUT
          ROR      W1       FIRST (LS) BIT
          BCC     NXT      ZERO
          LDX      #RQ      ONE, ADD
          STX      NUM2    CURRENT VALUE
          BSR      ADD     OF RR
NXT      LDX      #RR      ADD RR
          STX      NUM2    TO
          BSR      ADD     ITSELF
          DEC      W6      ALL
          BNE     LOOP2    DONE ?
          RTS

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

DBNC     LDX      #100     150mS
          BRA     SKDB
DBOUNC   LDX      #10     APPROX 15mS WITH A 8.388 MHz XTAL
          STX     W6      X x 1.5mS
DLP      LDX      #$FF    PAUSE
DLOOP    BRN      "       256X12
          BRN      "       CYCLES
          DEX
          BNE     DLOOP
          DEC     W6+1
          BNE     DLP
ABO      RTS

*****
*
*   Serial output routine to the MC145170.
*
*****

P5170    BCLR     PORTB,Y,$01  CLOCK LOW
          BCLR     PORTB,Y,$10  LE LOW
          LDAA     #0          CLEAR
          BSR     SQU8I        CONTROL REGISTER
          BSET     PORTB,Y,$10  LATCH IT

```

Application Note

```

BCLR      PORTB,Y,$10      LE LOW
LDAA      SMEM+1
ANDA     #$7F
BSR       SQU8I           SEND MSBYTE
LDAA      SMEM             AND LSBYTE OF
BSR       SQU8I           NEW FREQUENCY
BSET      PORTB,Y,$10     LATCH IT

BCLR      PORTB,Y,$10     LE LOW
LDAA      #$03
BSR       SQU7I           REFERENCE
LDAA      #$20
BSR       SQU8I           DIVIDE RATIO
BSET      PORTB,Y,$10     800 = 8MHz/10kHz
                                LATCH IT

```

```

*****
*
*   Serial output routine to the MC145157. *
*
*****

```

P5157

```

LDAA      SMEM             TRANSFER SMEM AND
LSLA      MEM+1           MEM+1 TO TEMPORARY
STAA      W4              LOCATIONS AND MOVE
LDAA      SMEM+1         UP ONE BIT TO INCLUDE
ROLA      THE 5157 CONTROL BIT.
BSR       SQU7           SEND MSBYTE (7 BITS)
LDAA      W4             AND LSBYTE OF
BSR       SQU8           NEW FREQUENCY
BSET      PORTB,Y,$08    LATCH
BCLR      PORTB,Y,$08    IT
LDAA      #$4E           SEND 15 BIT (14+1)
BSR       SQU7           REFERENCE
LDAA      #$21           DIVIDE RATIO
BSR       SQU8
BSET      PORTB,Y,$08    LATCH IT
BCLR      PORTB,Y,$08    ALL LOW (5157/70 SWITCHED OFF)
RTS

```

```

*****
*
*   Subroutines for the MC145157/170. *
*
*****

```

```

SQU8I     LDAB      #8           SEND 8 BITS
          BRA       S1I
SQU7I     LSLA      #7           MOVE OUT MS BIT
          LDAB      #7           AND SEND OTHER 7
S1I       LSLA      #7           MOVE I BIT INTO "C"
          BCC      S2I           ZERO ?
          BSET     PORTB,Y,$02    NO
S21       BSET     PORTB,Y,$01    CLOCK
          BCLR    PORTB,Y,$01    IT
          BCLR    PORTB,Y,$02
          DECB
          BNE     S1I           ANY MORE ?
          RTS

SQU8      LDAB      #8           SEND 8 BITS
          BRA       S1
SQU7      LSLA      #7           MOVE OUT MS BIT
          LDAB      #7           AND SEND OTHER 7
S1        LSLA      #7           MOVE 1 BIT INTO "C"
          BCC      S2           ZERO ?
          BSET     PORTB,Y,$02    NO
S2        BCLR    PORTB,Y,$01    CLOCK
          BSET     PORTB,Y,$01    IT
          BCLR    PORTB,Y,$02
          DECB
          BNE     S1           ANY MORE ?
          RTS

```

```

*****
*
*   Toggle 9/10 kHz step (MW).
*
*****

T910   BRSET      STAT6,$40,CBH
       BSET      STAT6,$40
       RTS
CBH    BCLR      STAT6,$40
       RTS

*****
*
*   LINK batch files (RLE.BAT & RDE.LD) and PCBUG11 Vectors.
*
*   ILD11 RADE.O FNCE.O RDSE.O -MKUF E32.MAP -G RDE -O RDE.OUT
*   IHEX RDE.OUT -O RDE.0
*   TYPE E32.MAP
*
*   section .RAM1 BSS origin 0x0000
*   section .RAM2 BSS origin 0x0100
*   section .RAM3 BSS origin 0x0200           E32
*   section .ROM1 origin 0xD000             $9000
*   section .ROM2 origin 0xE000             $9c00
*   section .ROM3 origin 0xF000             $A000
*   section .VECT origin 0xBFC1             -
*   section .VECT2 origin 0xFFD6            ($FFD6)
*
*****

*
SECTION      .VECT
*
*   JMP      START      SCI
*   JMP      START      SPI
*   JMP      START      PULSE ACCUMULATOR EDGE
*   JMP      START      " " OVER
*   JMP      START      TIMER OVER
*   JMP      START      " IC4/OC5
*   JMP      START      " OC4
*   JMP      START      " OC3
*   JMP      START      " OC2
*   JMP      START      " OC1
*   JMP      START      " IC3
*   JMP      START      " IC2
*   JMP      START      " IC1
*   JMP      TINTB      RTI
*   JMP      SDATA      IRQ
*   JMP      SHAF7X     NOT USED, XIRQ USED BY PCbug11
*   JMP      START      SWI
*   JMP      START      ILLEGAL OP CODE
*   JMP      START      COP
*   JMP      START      CLOCK MONITOR
*   JMP      START      RESET

*****
*
*   MC68HC11E32 Vectors.
*
*****

*
SECTION      .VECT2
ORG          $FFD6

*
FDB      START      SCI
FDB      START      SPI
FDB      START      PULSE ACCUMULATOR EDGE
FDB      START      " " OVER
FDB      START      TIMER OVER
FDB      START      " IC4/OC5
FDB      START      " OC4
FDB      START      " OC3
FDB      START      " OC2
FDB      START      " OC1
FDB      START      " IC3
FDB      START      " IC2

```

Application Note

```

FDB      START      "      ICL
FDB      TINTB      RTI
FDB      SDATA      IRQ
FDB      SHAF TX    XIRQ
FDB      START      SWI
FDB      START      ILLEGAL OP CODE
FDB      START      COP
FDB      START      CLOCK MONITOR
FDB      START      RESET

```

END

Section synopsis

```

174)      .RAM1
256)      .RAM2
109)      .RAM3
2889)     .ROM1
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	E	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	LDRX	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	SHAF TX	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	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	

Application Note
Code Listing

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														

Application Note

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How to reach us:

USA/EUROPE/Locations Not Listed: Motorola Literature Distribution; P.O. Box 5405, Denver, Colorado 80217. 1-303-675-2140 or 1-800-441-2447

JAPAN: Motorola Japan Ltd.; SPS, Technical Information Center, 3-20-1, Minami-Azabu, Minato-ku, Tokyo 106-8573 Japan. 81-3-3440-3569

ASIA/PACIFIC: Motorola Semiconductors H.K. Ltd.; Silicon Harbour Centre, 2 Dai King Street, Tai Po Industrial Estate, Tai Po, N.T., Hong Kong.
852-26668334

Technical Information Center: 1-800-521-6274

HOME PAGE: <http://www.motorola.com/semiconductors/>



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