AN689

Engineer's Assistant Using a PIC16F84A

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INTRODUCTION

This compact instrument is intended to be a digital laboratory tool for hardware and, in some cases, software debugging. It contains four instruments in one unit: logic probe, single channel logic state analyzer, frequency counter and serial code receiver.

The only chip used is a PIC16F84A running at 10 MHz. The display unit is a LCD dot matrix alphanumeric module with 2 rows of 20 characters. The LCD is used as the display device for all functions, except for the logic probe which indicates low, high and pulse logic states on individual LEDs. Mode select, parameter change, function execute and ON/OFF switching is activated by two keys.

The probe tip is the common input for all functions, and the GND cable is used for connection to Vss of the tested circuit.

Although there are a lot of functions integrated in a single chip unit, it did not increase the complexity of hardware, as all functions are implemented in software. This enables a very good price/performance ratio.

The power supply is obtained by four 1.2V/180 mAh or 250 mAh NiCd batteries of LR03 (AAA) size. The instrument also has a battery manager, which supports automatic battery discharging and charging.

The source code is written in MPASM. As it is highly optimized for code space, most of the code could not be written in a modular format. For the same reason, a lot of subroutines have more than one entry point and some of them are terminated by a GOTO instruction instead of using a RETURN instruction.

FEATURES

- Stand-alone hand-held instrument
- Single chip design
- Built-in rechargeable power supply
- Easy to assemble and ready to use, no adjustment needed
- User interface with LCD output and command input by two keys
- TTL or 5V CMOS input, or direct input from RS-232C +/-12V signals

SPECIFIC FEATURES FOR INDIVIDUAL FUNCTIONS

Logic Probe

The low and high logic levels are displayed by LEDs, which are OFF if the probe tip is floating or connected to a hi-impedance (>220k) output. A pulse transition is detected and is indicated by turning on the LED for 80 ms.

Logic State Analyzer

The analyzer fetches 300 single bit samples at a selectable rate (in 16 steps from 40 Hz to 1 MHz). It has a programmable start at High-to-Low or Low-to-High transition at input. Digital waveforms are displayed in a pseudographic mode on the LCD.

Serial Code Receiver

The Serial Code Receiver receives 42 bytes and displays them in both HEX and ASCII. The baud rate is selectable in 8 steps, from 1200 to 115200. The selectable format is 7 or 8 bits with or without a parity bit which is not displayed. Signal polarity is also selectable. Direct signal stealing from an RS-232 or an RS-232C interface is possible.

Frequency Counter

The Frequency Counter counts frequency and displays it in an 8-digit decimal format on the LCD with a refresh rate of 500 ms. There are four ranges, from 5 to 40 MHz, which affect the count resolution (from 4 to 32).

Battery Manager

The Battery Manager provides for discharging with an automatic switch that changes to charge mode at 4V battery voltage, charging with 18 mA of constant current and automatic power off after 14 hours. Any DC source between 10V and 30V, at any polarity, can be used for charging.

SYSTEM FUNCTIONS

User Interface

There are four modes of operation: Analyzer, Serial Code Receiver, Frequency Counter and Battery Manager. The logic probe function is transparent in all modes except in the Frequency Counter.

In all modes, submodes are listed in the lower row of the LCD. The submodes list can be cycled through by pressing the right key, which moves the cursor (blinking block) to the right. The left key activates the selected submode (executes a function or changes the parameter state/value).

The right-most submode (right arrow symbol) acts as a shortcut jump to the next mode. After power-on (by pressing any key), a mode is chosen by pressing the left key, then the submode by the right key, and then the eventual parameter change or command execution by the left key again. The only exception is the Logic Probe function, the only action needed is to switch the instrument on, and the logic probe is ready to use.

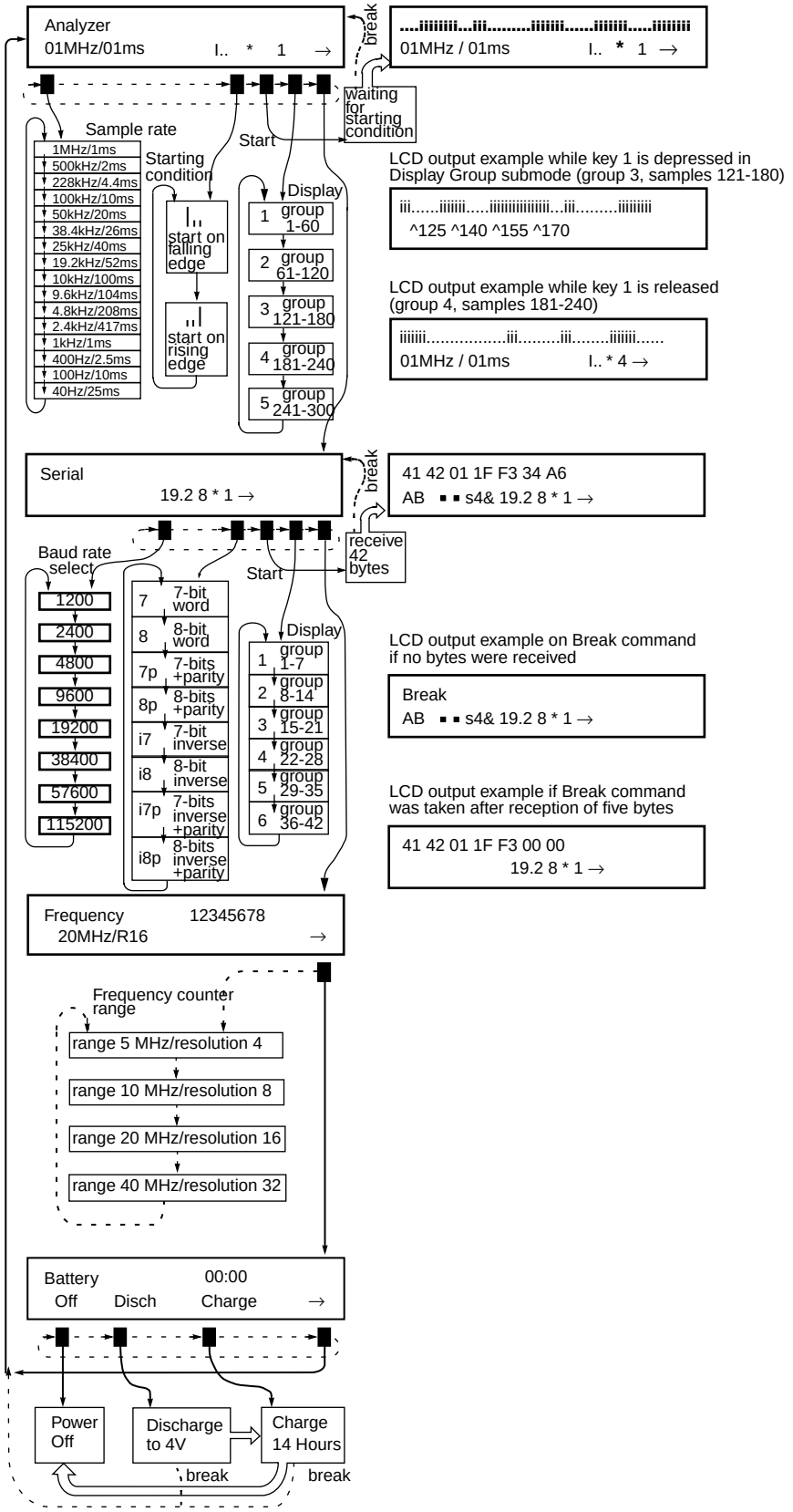
In Analyzer and Serial Code Receiver mode, the asterisk (*) is a special symbol for the "Start" command. When executed (left key pressed while the cursor is on asterisk), it causes the program to wait for a start condition or a start bit.

Although there is a manual Switch Off command (accessible in Battery mode), there is also the automatic power off after approximately 8 minutes of inactivity if no key is pressed. Note that the down counter for automatic power-off is "frozen", while the instrument is waiting for a start condition in analyzer mode and for the start bit in serial code receiver mode. Of course, the same applies to the discharging and charging processes, as another conditions are used to define the end of those processes.

Figure 1 represents the key functions diagram. The dotted line represents actions taken when the right key is pressed, and the solid line is for the left key. The cursor, which is the blinking block on the LCD, is represented as a solid block in Figure 1, but it is moved down on the drawing for clarity.

A variable (named REL) in the assembler source code, defines the position of the cursor on the LCD. If it is a '1' (default), the cursor will be placed on the first character of the command (or parameter). If it is a '0', the code will be assembled so that the cursor will be moved to the preceding location (if it exists) before the command.

FIGURE 1: HIGH LEVEL FUNCTION FLOWCHART



Logic Probe

The typical hardware solution for a logic probe is shown in Figure 2. Two inverters, for low and high indication, and two monostables, for pulse detection, are commonly used in most low-cost logic probes. This solution will display an unconnected probe tip as high logic level. There are some better versions which can detect a floating input and turn all LEDS off if it is detected. Figure 3 represents the common solution for such functions, where two analog comparators are employed to detect the low, high and floating inputs.

FIGURE 2: TYPICAL LOGIC PROBE SCHEMATIC

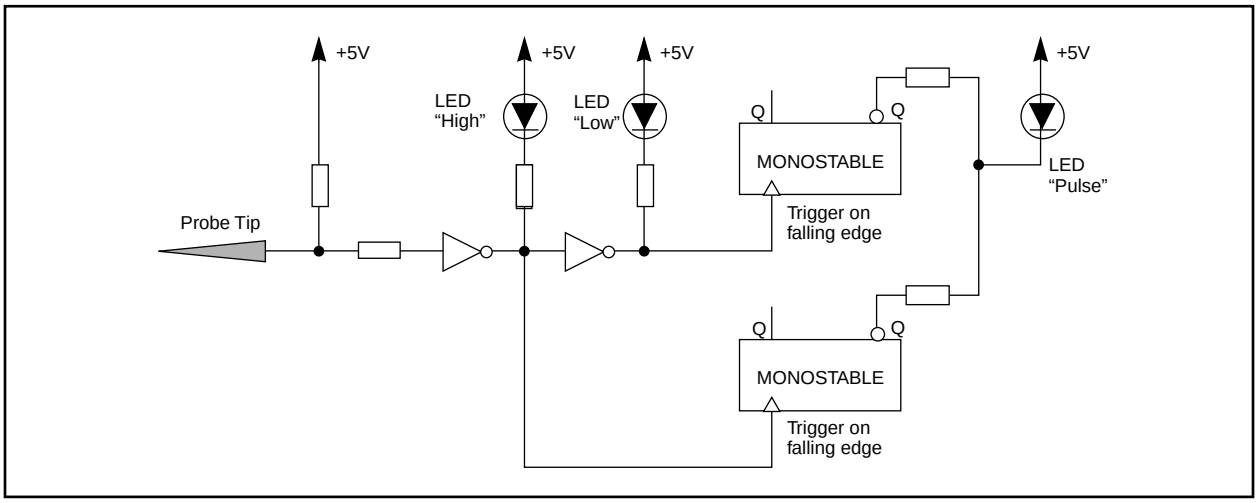
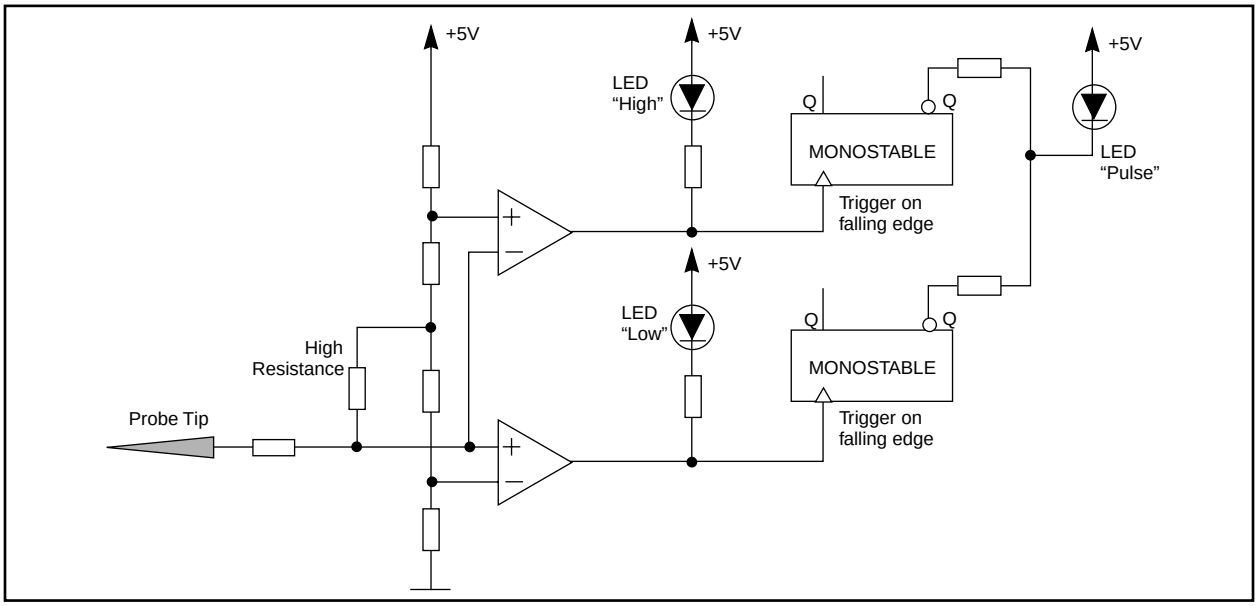


FIGURE 3: IMPROVED LOGIC PROBE SCHEMATIC



Instead of using such approaches, the logic probe function in this instrument is software aided, and the floating input is detected in a dynamic way instead of a static one. The equivalent hardware schematic diagram of this solution is shown in Figure 4 (Pulse detection circuit not shown). The hardware detail which supports the operation of the logic probe used in this unit is represented by Figure 5. The microcontroller polls the input tip and services LEDs L and H. If a transition is detected, LED P is switched ON and the down counter switches it OFF after 80 ms if no additional transition is detected.

This approach has two disadvantages. Logic state latching at a uniform rate may cause visible interference if the frequency of the monitored signal is near the latching rate. This problem is minimized by adding a self-variable extra delay in software, which makes the latching frequency unstable. This makes the range of critical frequencies much wider, but the interference appears as a very short burst of pauses in LED L or H activity, which is completely avoided by adding an extra debouncer of only 250 microseconds. Although unnoticeable, this delay helps prevent LED level instability while monitoring critical frequencies.

FIGURE 4: FUNCTIONAL SCHEMATIC OF PIC16F84A LOGIC PROBE

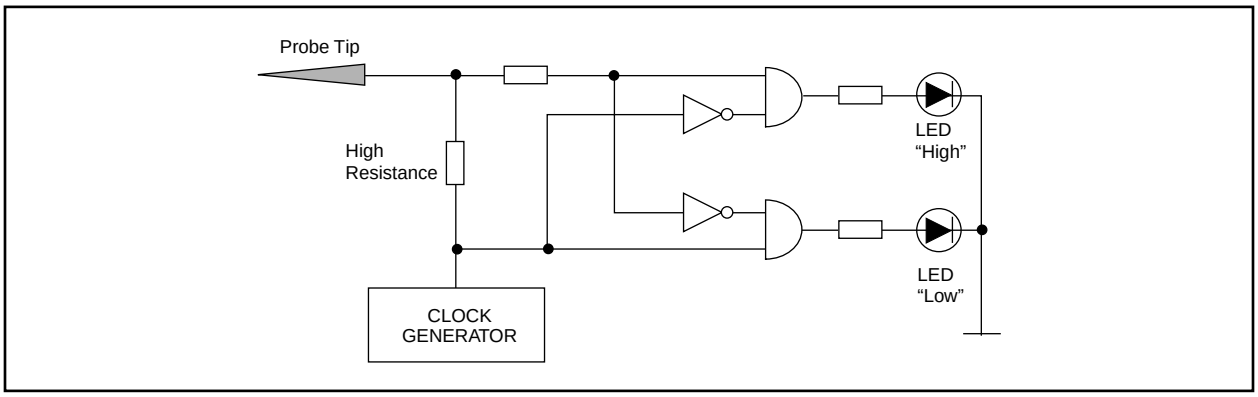
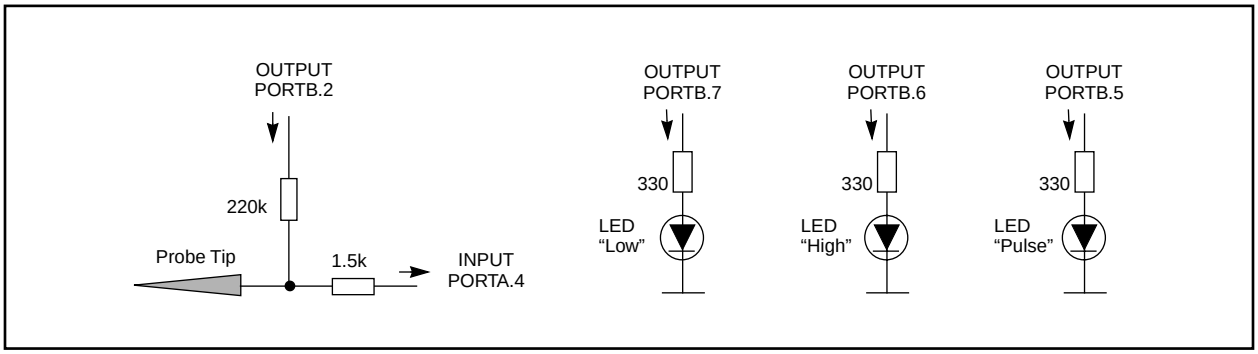


FIGURE 5: SUPPORTING PIC16F84A LOGIC PROBE CIRCUITS



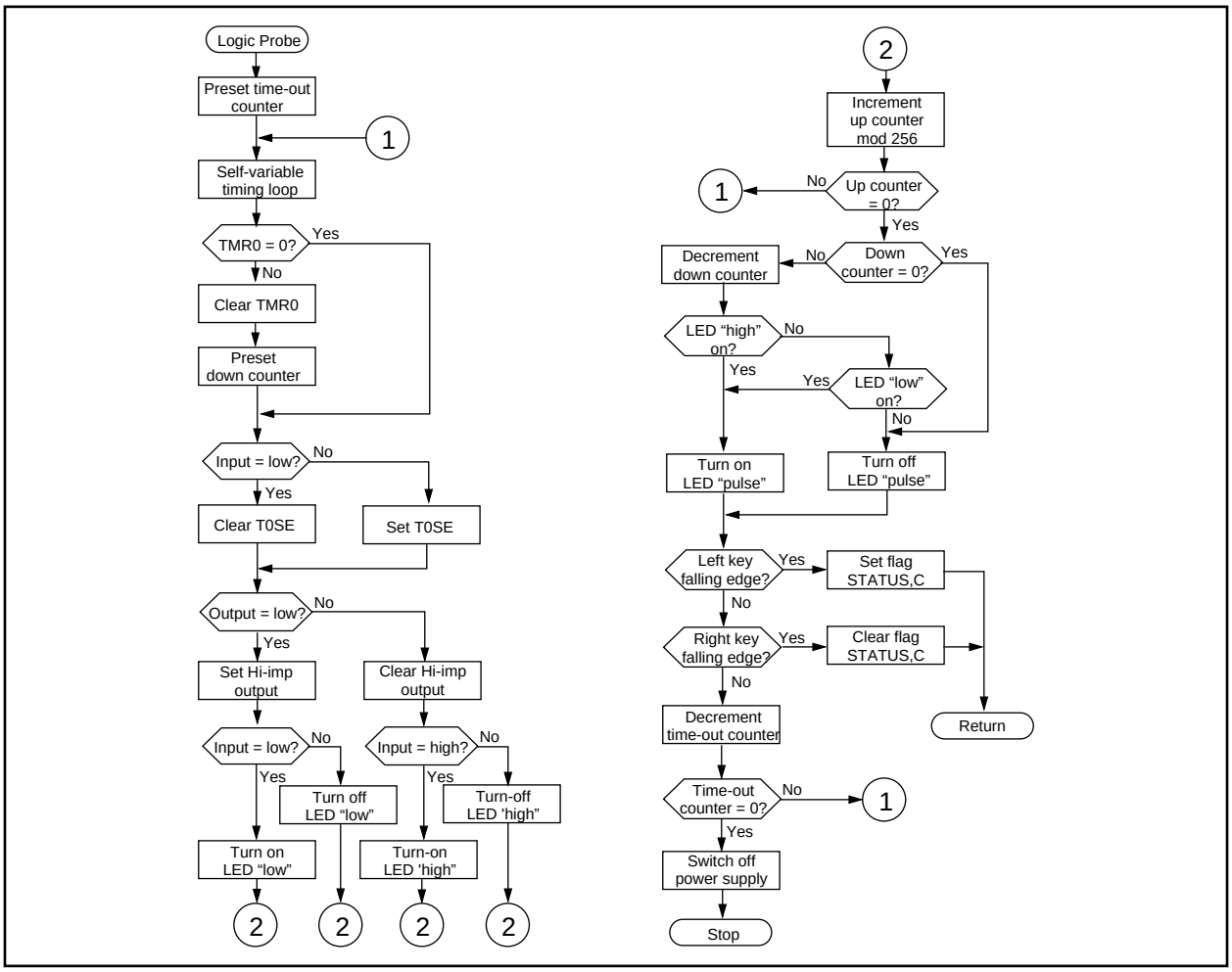
Another disadvantage is related to pulse indication on LED P. In the case of a very short pulse, it is likely that the microcontroller, which polls the input, may omit it between two input reads. Instead of simple polling, the internal counter, TMR0, is used here so that instead of testing the logic state of the input, the state of TMR0 is tested. In this way, pulses as short as 10 ns might be detected. In reality, the minimal pulse width is limited by resistor R6 and the input pin RA4 capacitance. The T0SE bit in the OPTION_REG register is properly updated at each pass, so that the first incoming transition will increment TMR0.

The logic probe software support is integrated in the keyboard routine. LEDs L, H and P are active only while the instrument is idle (doing nothing but waiting for some key to be pressed), which is all the time while the unit is ON, except in frequency counter mode, during battery discharging or charging, or if the START command is issued in analyzer or serial receiver mode and the job (300 samples fetched or all bytes received) is not yet finished.

Pin RB2 is the output which generates square-wave pulses. These pulses are fed through R5 to the probe tip. The resistance is high enough not to affect the tested circuit, except if the tested point is the floating input. However, in that case it will probably make the circuit unstable and thus help in locating the floating input. This pulse stream is also used by software to detect the floating probe tip, and in this case to switch all LEDS off. This saves energy in batteries and helps to detect if the probe tip is validly connected to the point under test.

A simplified flow chart for the logic probe is represented by Figure 6. As this subroutine is an integral part of the key scan routine, the key (debouncers are not shown in detail) and time-out testing (which employs a 16-bit counter, "Time-out Counter") are also provided. "Up Counter" is the free running counter which enables execution of the second part of the subroutine to be performed at each 256th pass. "Down Counter" is the timing base for the LED Pulse. If the state of this counter is greater than zero and the LED Low or LED High is on, the LED Pulse will be turned on. The program exits only if some key is pressed (flag bit STATUS,C denotes which) or when the time-out counter reaches zero.

FIGURE 6: LOGIC PROBE FLOWCHART



Logic State Analyzer

The commonly used hardware concept for a logic analyzer design is represented in Figure 7. All those functions are realized in software, which is much easier to implement, but results in a loss of sampling speed. The software solution is briefly represented on the flow chart in Figure 8.

In analyzer mode, a sequence of 300 one-bit fetches is performed. Samples are stored in internal RAM (actually, 304 samples are read, but the last 4 are dummy reads). The upper row of the LCD is used to display the samples. As the LCD (Hitachi's LM032L) has no graphic capabilities (it is not possible to address a single dot), this is simulated by eight special user-defined characters (which are stored in the character generator RAM), each for a group of 3-bit samples. This enables a pseudo-graphic mode which, in this case, looks as if all pixels were individually addressed.

The display shows a window of 60 samples. One of five windows is selected by placing the cursor on the group number and advancing it by pressing the left key. While the key is pressed, the lower row displays the numeric pointers, which help by counting the sample number and calculating the timings in the recorded sequence. When the key is released, the normal row 2 is restored.

A uniform clock, for sample rate, is internally generated. It is selectable to 16 steps. The frequency and period are both displayed. The following is a list of available sample rates:

1 MHz	50 kHz	10 kHz	1 kHz
500 kHz	38.4 kHz	9.6 kHz	400 Hz
228 kHz	25 kHz	4.8 kHz	100 Hz
100 kHz	19.2 kHz	2.4 kHz	40 Hz

The sampling sequence does not start immediately after the command is issued, but after the selected transition (L to H or H to L) is detected. While waiting for the transition to occur, the RB2 output is continuously held in the state which is opposite of the triggering logic level. This enables application on the wired-or logic, even if it is without pull-ups. If this condition never occurs, it is possible to escape by pressing the right key. In this case, message "Break" is displayed in the LCD upper row.

LED P has an additional function while sampling in analyzer mode. It is turned OFF when the start command is issued, then turned ON when sampling or the receiving condition was met, and then OFF again when all samples are fetched. In slower rates, it is noticeable that LED P blinks while sampling. One blinking period is equal to 32 sampling periods.

FIGURE 7: LOGIC ANALYZER SCHEMATIC

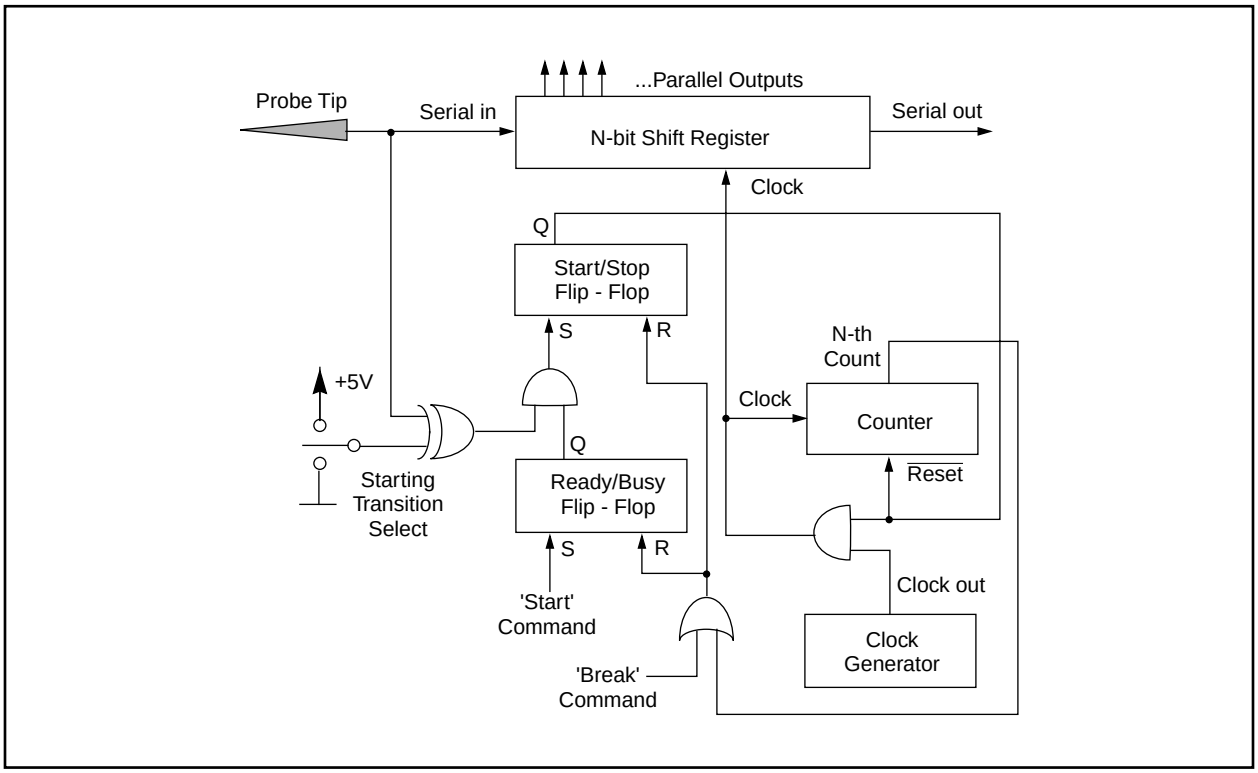
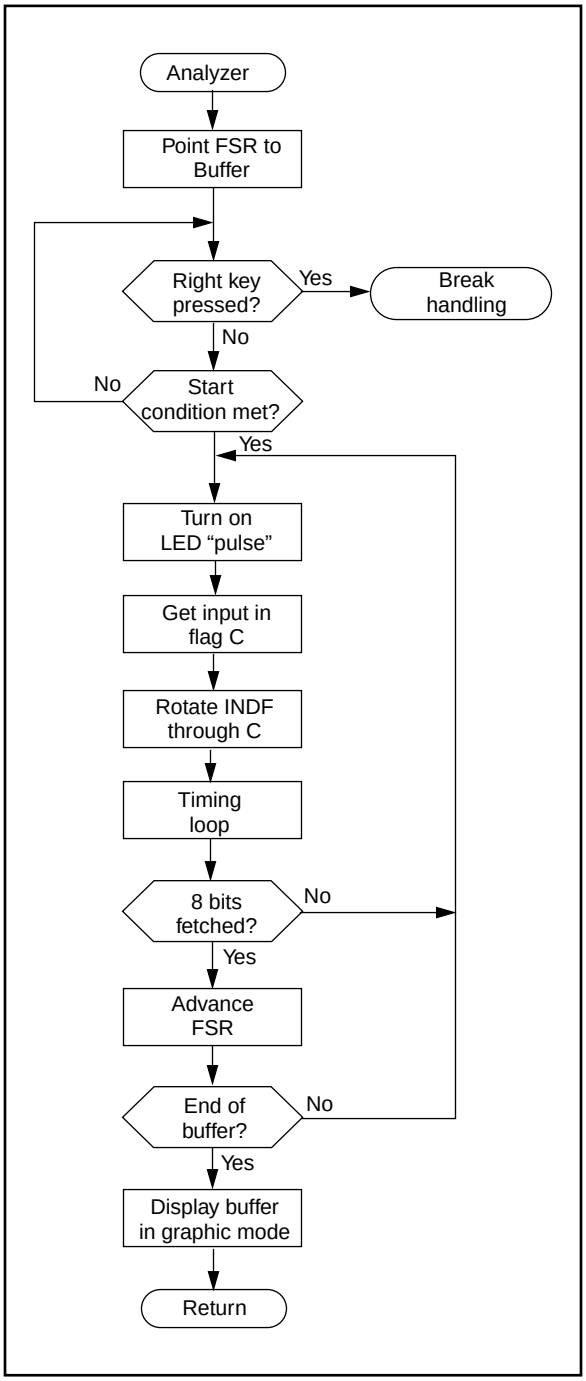


FIGURE 8: LOGIC ANALYZER FLOWCHART



All sample rates are generated by software, and the three highest ones use individual subroutines. The sample rate for 1 MHz, which is at the very beginning of the program, has to fetch and memorize a single bit sample by rotating it into the buffer, change the destination address after every 8 samples and exit the loop after 304 samples. All this while keeping uniform timing of 2 and 3 (alternated, which gives an average of 2.5) instruction cycles for one fetch. That could not be realized in a conventional manner, so it has a location-sensitive structure. Upon exit, it jumps to address 4Dh (which is far from the subroutine itself). If you modify anything in this program, take care not to affect this location.

The analyzer may have some unpredictable delays between an external starting event (rising or falling edge) and the first sample. In all cases, this delay may vary from 0 to 4 microseconds, so it may have some significance only in highest sample rates. One of the reasons for this delay is the time which the microcontroller requires for a key test, which enables the manual break if this event never comes. Also, there is some minor jitter at the 1 MHz analyzer sample rate. In the worst case, it might be 300 ns.

Serial Code Receiver

In this mode, a total of 42 bytes is received and displayed in both HEX and ASCII. The acceptable format is:

> 1 Start Bit / 7 or 8 Data Bits / 0 or 1 Parity Bit / 1 or more Stop Bits.

It is possible to connect the probe tip directly to the RS-232 or RS-232C +/- 12V voltage levels, to RS-422 or RS-485, or to +5V logic.

The available baud rates are:

1200	(1.2)
2400	(2.4)
4800	(4.8)
9600	(9.6)
19200	(19.2)
38400	(38.4)
57600	(57.6)
115200	(115)

7 or 8 data bits may be selected to adjust for the desired data format.

Parity or no parity bit (suffix "p"). This affects only the proper timing for this bit during reception. It is neither tested for validity nor displayed.

Standard RS232C or inverse polarity. If prefix "i" is displayed, then inverse polarity is active (low start bit, inverted data and optional parity bits and high stop bit). This is useful if the serial message must be fetched before the RS-232C TX drivers and after the RX buffers (which are both inverters).

Received bytes are displayed both in HEX and ASCII in 6 groups of 7 bytes each. ASCII representation is with bit 7 cleared, and the non-printable characters (00h-1Fh) are represented as dots. All other codes are standard ASCII.

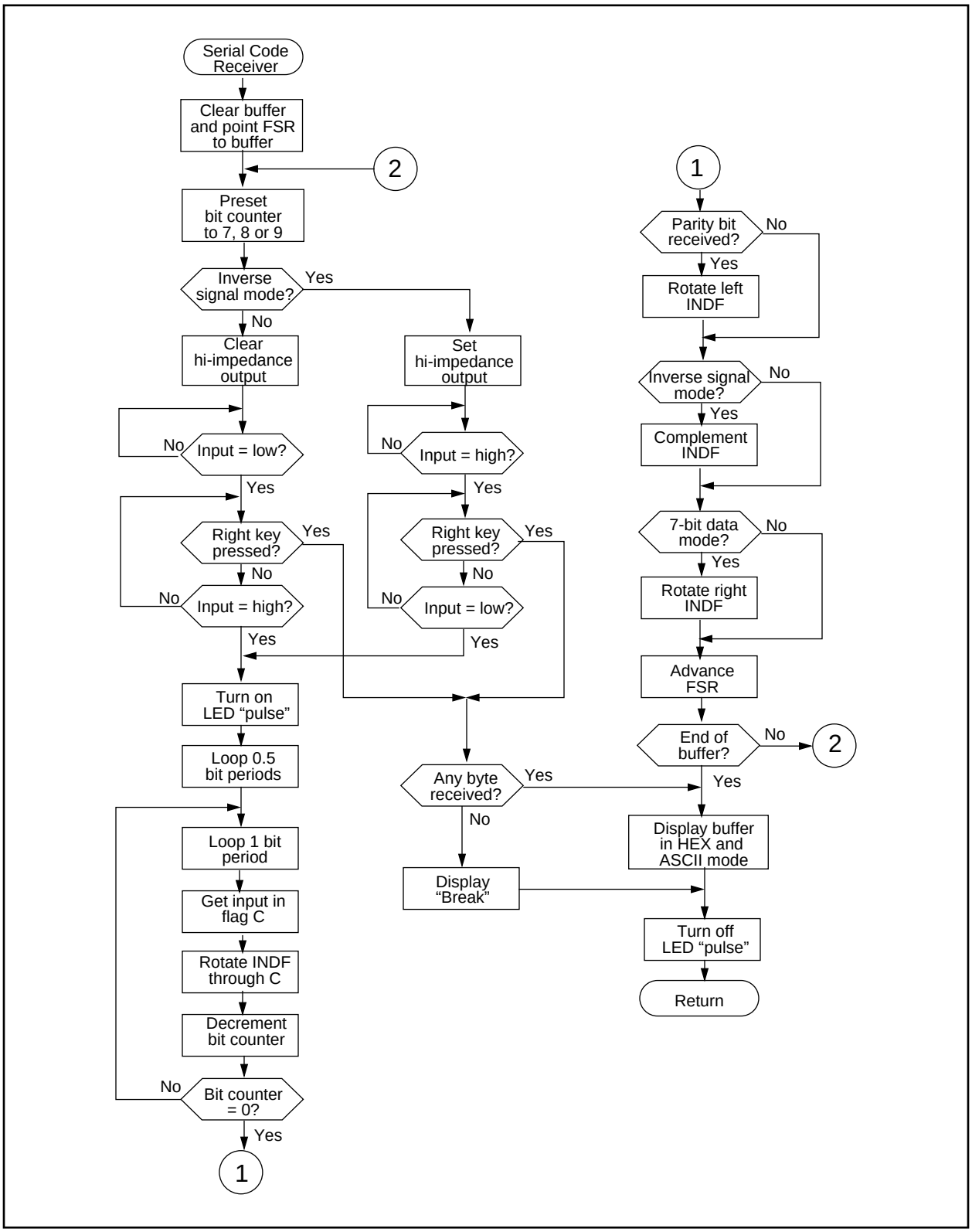
The string of received serial codes is 42 bytes long. If the string is shorter, the instrument will wait for next start bit, so it may look like it is stuck without any message. In that case, reception may be stopped by pressing the right key. If no bytes were received, the message "Break" will be displayed, but if at least one byte was received, the received sequence will be displayed with all unreceived bytes represented as zeros.

Similar to the analyzer mode, LED P will be turned ON when the first start bit is detected. This helps to detect sequences of less than 42 bytes in length.

No error test is performed during reception.

Figure 9 represents the flowchart for the serial code receiver.

FIGURE 9: SERIAL CODE RECEIVER FLOWCHART



Frequency Counter

Figure 10 shows the standard structure of the hardware solution for a frequency counter. All this is substituted by software in the PICmicro® microcontroller (MCU) aided by the existing TMR0. All counters are binary, and the counter state is displayed after a 4-byte binary to 8-digit decimal conversion. The display refresh rate is 2 Hz.

The flow chart for the frequency counter is represented in Figure 11. As this is the real-time function, the existing keyboard subroutine might not be used, but separate key and time-out tests are written. The logic probe function is disabled in this mode.

There is no "Start" command here, as this function is active all the time while the instrument is in Frequency Counter mode. There is only one submode, range select, so pressing the right button is not used for stepping through submodes, but it changes the range immediately.

Internal counter TMR0 is used, and the program expands the width of the counter for an additional two bytes. The fourth byte is added after 500 ms of counting and multiplying the 24-bit counter state by a constant, which depends on which prescaler factor was used.

The prescaler also affects the counter resolution. Here are the counter ranges and corresponding resolutions:

Range 5 MHz / Resolution 4
Range 10 MHz / Resolution 8
Range 20 MHz / Resolution 16
Range 40 MHz / Resolution 32

The resolution surely affects the reading error of the frequency counter, but this error is still less than the error which is caused by the initial non-accuracy of industrial class quartz crystals.

FIGURE 10: FREQUENCY COUNTER SCHEMATIC

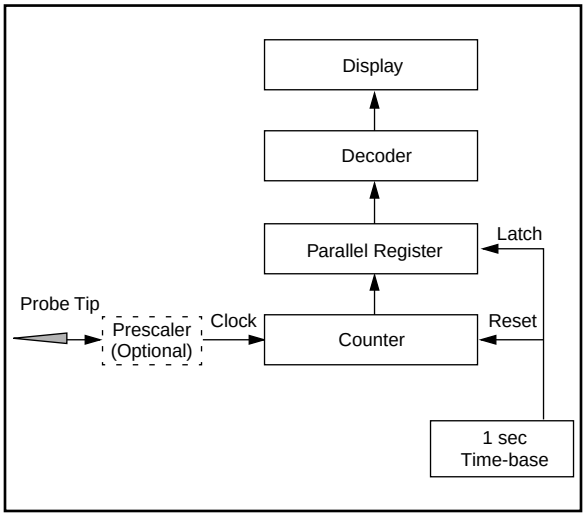
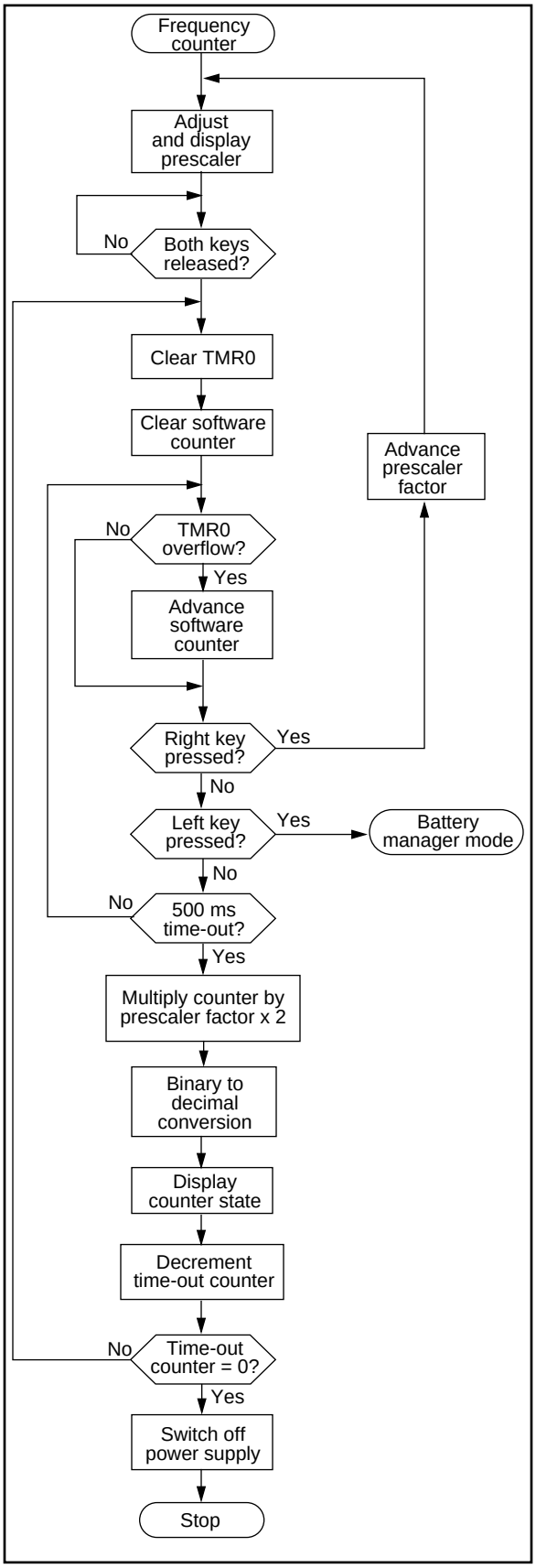


FIGURE 11: FREQUENCY COUNTER FLOWCHART



Battery Manager

The battery manager has three submodes. The first one is **manual power-off**, although there is also the automatic power off after approximately 8 minutes of inactivity (no key pressed).

The second submode is **discharging**. It is performed with 100 mA current through the resistors. The voltage monitor informs the PICmicro MCU if battery voltage is lower than 4V. If it is, the mode is automatically switched to charging. It is recommended that an external DC power supply be connected before the discharging command is issued. This will decrease the resulting discharging current to about 80 mA when the instrument is ON, and the DC supply is connected as the charging current flows independently of the mode selected.

Charge submode, when started, displays the time in HH:MM format, starting from 00:00, and switches off the instrument (and charging current also) at 14:00.

It is also possible to charge the NiCd battery even if it is not discharged, but this is not recommended, as unintentional overcharging may affect its capacity and life.

The unit is ready to charge the battery all the time if it is switched ON, even if the command charge is not active. It is enough to connect the external DC supply and to turn the instrument ON.

If the LCD were not counted, more than half of the hardware is used for discharging and charging. Figure 12 explains the structure of the battery manager hardware in a simplified form, where transistors T1, T4 and T5 are replaced by switches, for clarity. The flow chart for the battery discharger and charger is shown in Figure 13.

FIGURE 12: BATTERY MANAGEMENT SCHEMATIC

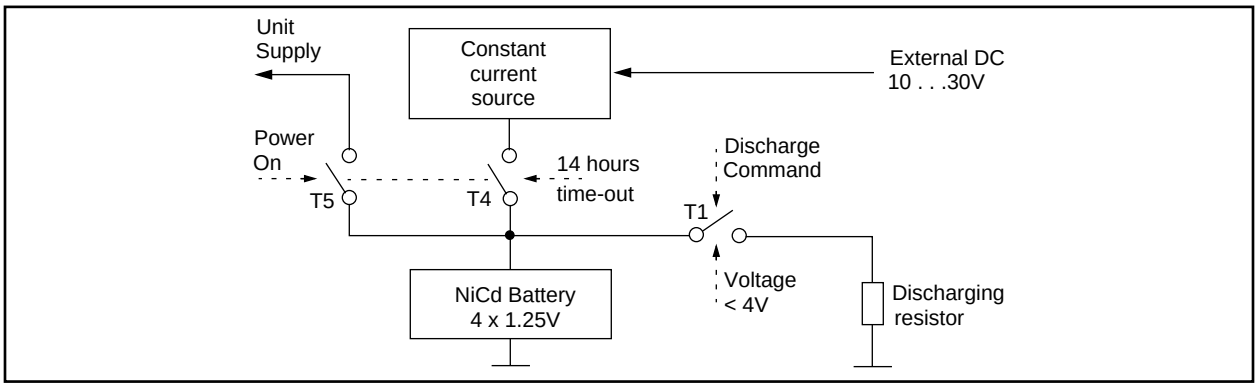
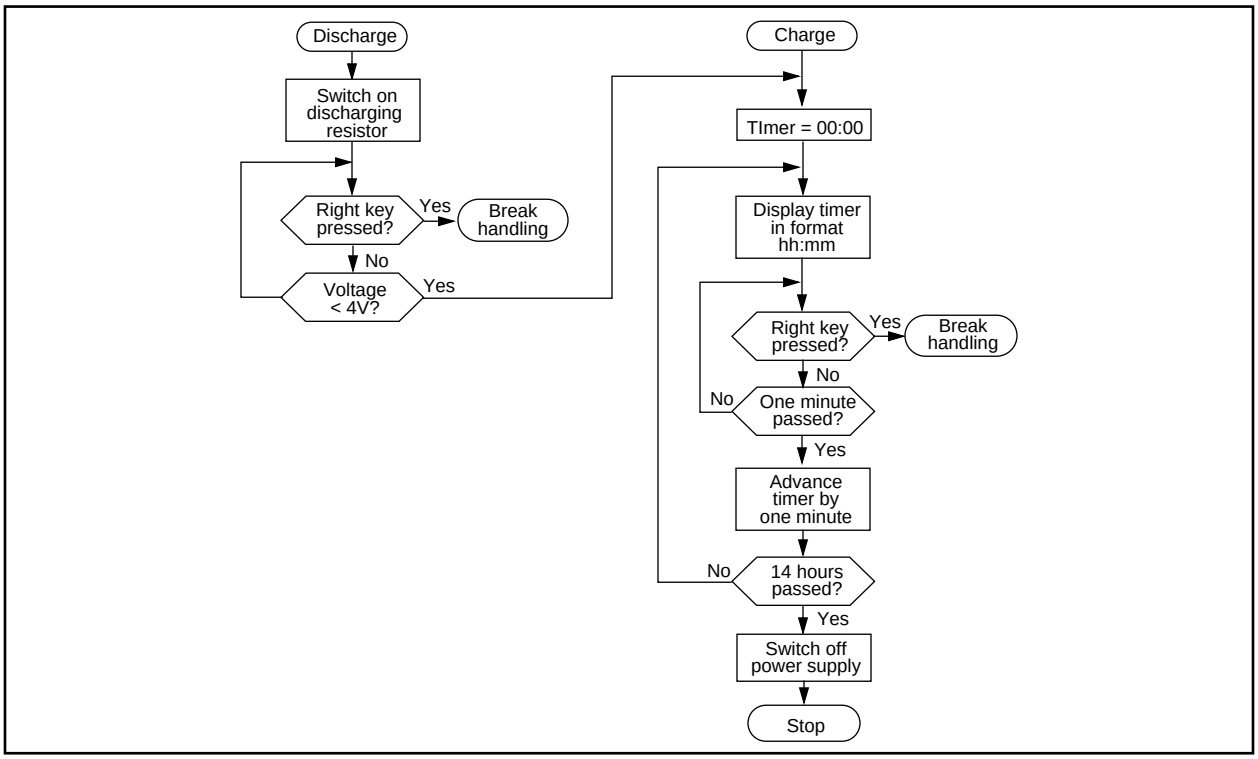


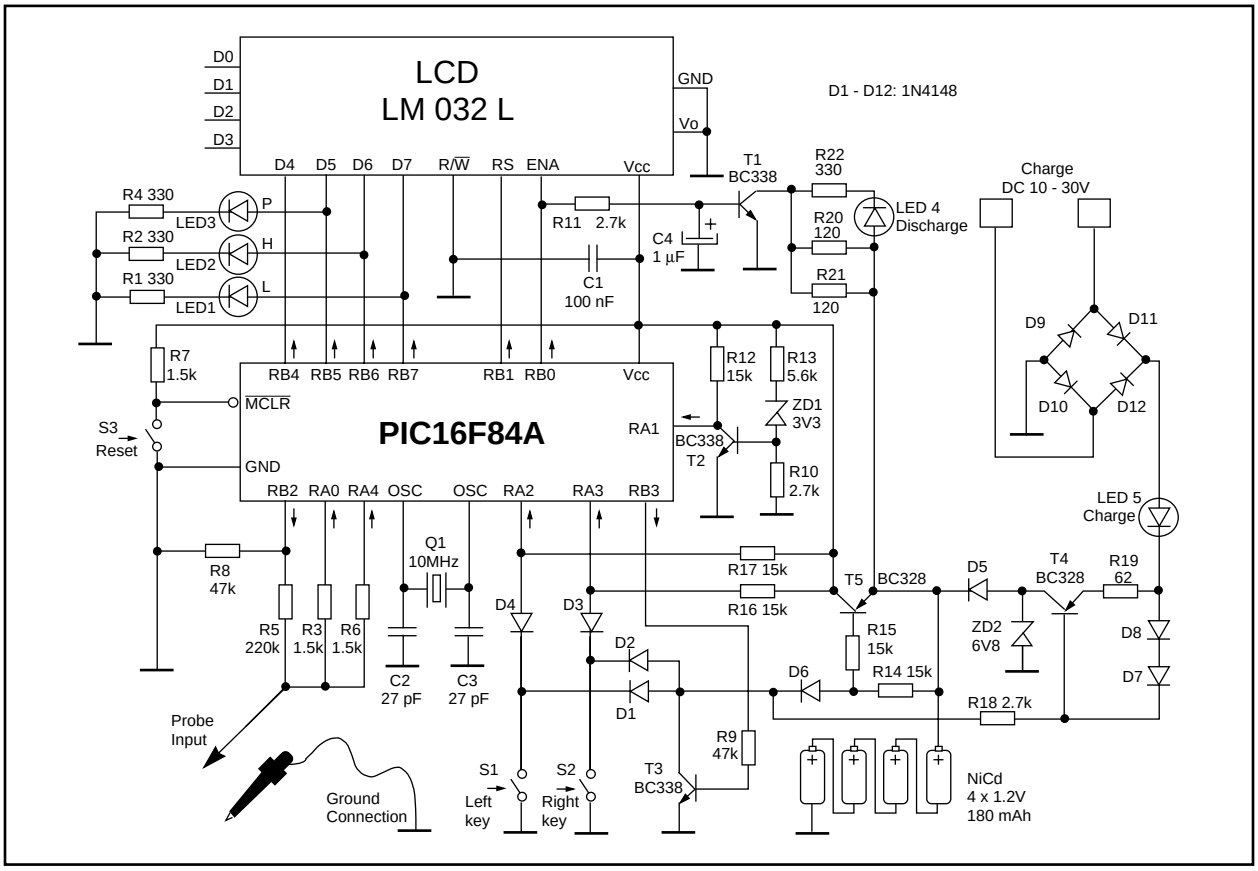
FIGURE 13: BATTERY MANAGER FLOWCHART



HARDWARE OVERVIEW

The complete schematic diagram is shown in Figure 14. The only IC used is the PIC16F84A-10/P, running at 10 MHz. It controls the intelligent LCD module via pins RB4-RB7, using two additional ports (RB0 and RB1) for the Enable signal and Register Select (Control/Data).

FIGURE 14: PIC16F84A PROBE SCHEMATIC



LCD module LM032L may be controlled in 4-bit parallel mode, which is used in this project. That is why pins 7-10 of the LCD are not used.

LEDs L, H and P share the same outputs with the LCD data bus. The only consequence is that some very minor and short LED flashing is visible while the PICmicro MCU is accessing the LCD (mostly when some key is pressed). **RB0** also has two functions. It controls the Enable signal for the LCD module and the transistor T1, which is used for the discharging function. To eliminate current spikes through T1 while accessing the LCD, capacitor C4 is added, which disables activating T1 by short Enable pulses. The main discharging resistors (R20 and R21) are intentionally located at two distant places on the PCB to minimize heat dissipation in a small area.

Inputs RA0 and RA4 are used to read the same signal, which was necessary because RA4 is the only port which may be directed to the TMR0 counter, and RA0 had to be the "edge bit" in the port. The analyzer fetch routine in the highest rate must rotate PORTA bits in a single instruction and perform bit transfers from the input pin to the STATUS, C flag.

Resistors R3 and R6 are used for signal voltage limitation, with internal reverse diodes in the PIC16F84A. This enables connecting the probe tip directly to the RS-232C connector, which has +/- 12V voltage range. Resistor R8 disables input floating while the unit is OFF.

The voltage monitor (transistor T2 with ZD1) acts as a comparator which holds input port RA1 low if the battery voltage is higher than 4V. This is used to automatically detect the end of the discharging process. The value of resistor R13 can be modified to fine trim this cut-off voltage to 4V.

Transistor T5 is the main ON-OFF switch. **RB3** controls this transistor through T3. It is also activated by pressing the left or right key. Diodes D3 and D4 disable false activation of T5 through internal diodes in the PICmicro MCU when it is powered OFF.

Transistor T4 is the constant current regulator, which enables the use of any DC supply between 10V and 30V for battery charging. **Diodes D9-D12** allow application of any voltage polarity. **Zener diode ZD2** is not the voltage stabilizer, but it protects the hardware from overvoltage if the battery contacts are not properly tied while charging.

S3 is the RESET key, which is mounted on the solder side of the PCB, and is accessible from the lower side of the instrument through the small hole at the bottom plane of the package. It is used if the MCU drops into a deadlock state for some reason or when the unit is switched ON for the first time after assembly.

Pin 3 (Vo) on the LCD connector is for LCD driving voltage. The manufacturer recommends the use of a potentiometer (10-20k) for voltage adjustment on this input and to fine trim the LCD contrast, but in all cases the contrast was optimal when the potentiometer was in its lower-most position (Vo shortened to GND). So it was rejected and pin 3 was connected to GND in the final version of this instrument.

Charging current will flow all the time while DC supply is connected and the unit is ON, even if the unit is not in Charge mode. When the unit is OFF (e.g. when the charging 14-hour process is finished), the charging current is stopped.

Both charging and discharging are indicated on individual LEDs.

Note: The LCD module used is Hitachi's LM032L. Type LM032LT may also be used, but it is not recommended, as it is a transflective type and contains the integrated illumination (which may not be used in this case, as it requires high voltage). Do not use modules LM032H or LM032HT as they require a dual voltage supply (+5/-5V).

FIRST SWITCHING ON AFTER ASSEMBLING

The batteries should be connected last, as there is no easy way to disconnect them once they are soldered, also it is not recommended to assemble the hardware while the voltage is present. The best way is to test the instrument with some external 5V power supply, and when it is completely debugged and tested, the batteries may be soldered. Do not connect the external DC supply for charging batteries if the batteries are not safely in their places! Zener diode ZD2 will reduce the voltage to 6.8V, but avoid testing the efficiency of this protection if at all avoidable.

If the NiCd batteries are discharged to the point the PICmicro cannot operate, it will be necessary to keep the left or right key pressed for some time (while the DC supply is connected for charging), as the pressing of any key makes hardware bypass for charging current. After about one minute of such charging, the battery voltage will be sufficient and then the unit will probably need to be reset by pressing S3. The normal charging process should then be used by executing the Charge command in Battery mode.

The contrast on the LCD is voltage-dependent, and as there is no voltage stabilizer, it appears to be a little darker immediately after a full charge. The battery voltage will be slightly over 5V. This will not affect readability. After a few minutes of operation, the battery voltage stabilizes and the LCD appears as normal.

Note: Data EEPROM is used for some lookup tables. This is read-only data and the Data EEPROM must be programmed before the unit is ready to use. The MCU will not affect data EEPROM contents. If your programmer does not support automatic loading of Data EEPROM contents from the HEX file, it must be loaded manually (a total of 61 bytes are used, and the last three bytes are don't care). The following will help in that case (all values are hexadecimal):

```
addr 00-07h:   88 01 01 98 F4 02 8C E4
addr 08-0Fh:   2C 88 64 0A 88 32 14 D8
addr 10-17h:   80 1A 88 19 28 C8 C0 34
addr 18-1Fh:   88 0A 64 C8 60 68 C8 30
addr 20-27h:   D0 C9 18 A1 80 01 01 14
addr 28-2Fh:   90 19 00 64 0A 00 28 19
addr 30-37h:   01 06 09 10 16 2E 30 64
addr 38-3Ch:   CC 05 0E 3B 95
```

MECHANICAL CONSTRUCTION

The components layout is shown in Figure 16. All components are placed on the component side of the PCB, except key S3 (reset), which is on the solder side. So are the NiCd batteries, which are placed in the specially shaped PCB edges and soldered directly to the PCB.

The LCD module is placed on M3 spacers, 7 mm long, which are tightened to 5 mm long spacers at the bottom side of the PCB. This leaves enough room for batteries which are 10 mm in diameter. Key 3 should not be higher than 5 mm, and the recommended height for keys 1 and 2 is about 16 mm. As the keys listed in the parts list are 14.5 mm high, they should be mounted on an extra spacer about 1.5 mm thick, non-conductive material.

The probe tip is fixed using three wire loops soldered to the PCB and to the tip. If it is not possible to get a connector for the DC supply which fits to the PCB pads, it is also possible to cut the PCB (across the dotted line on the components layout) to make enough space for some other type of connector, which may be tightened to the package. Pads for wires, needed in this case, are provided on the PCB. The polarity is not significant.

It is possible to build the package of the same material which is used for printed circuit boards, as it can easily be cut and joints soldered. Figure 15 shows the package detail.

FIGURE 15: CASE/PCB CONSTRUCTION

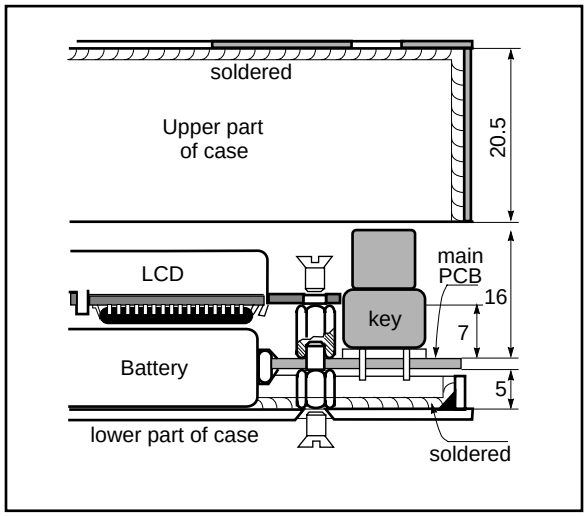
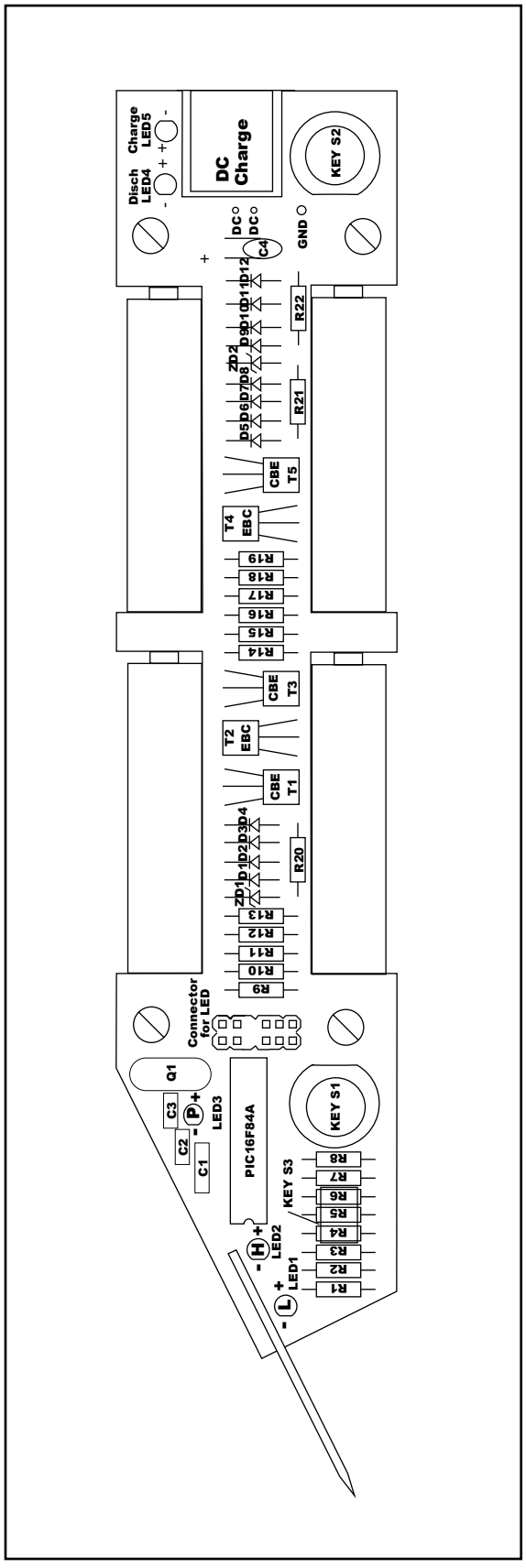


FIGURE 16: PCB PARTS LAYOUT



PARTS LIST

1. LCD module type LM032L (Hitachi) 1
2. PCB 1
3. Microcontroller PIC16F84A-10/P (Microchip) 1
4. Transistors:

   BC338 (or any small signal silicon NPN in SOT-54, pinning CBE)3

   BC328 (or any small signal silicon PNP in SOT-54, pinning CBE)2
5. Diodes:

   1N4148 (or any small signal silicon diode)12

   ZPD 6V8 (or any low power 6.8V zener diode)1

   ZPD 3V3 (or any low power 3.3V zener diode)1
6. Resistors:

   62R 1/4W axial1

   120R 1/4W axial 2

   330R 1/4W axial 4

   1K5 1/4W axial3

   2K7 1/4W axial3

   5K6 1/4W axial1

   15K 1/4W axial5

   47K 1/4W axial2

   220K 1/4W axial1
7. Capacitors:

   27 pF ceramic2

   100 nF ceramic1

   1 uF tantal1
8. Quartz:

   10 MHz 1
9. LEDs:

   red, 3 mm diameter 2

   green, 3 mm diameter2

   yellow, 3 mm diameter1
10. I.C. socket:

    18-pin 1
11. Keys:

    typ ITT D 6 (raster 5*5 mm, 14.5 mm high) 2

    typ SEL ET 5 (raster 5.5*3) or SEL ET 11 (raster 7.5*5)1
12. Connectors:

    2*7 pins male connector for PCB, raster 2.54 mm (100 mils)1

    2*7 pins female connector for PCB, raster 2.54 mm (100 mils)1

    cable-end crocodil-grip for GND connection1

    coaxial 3.5 mm female connector typ PG2031
13. Mechanical parts:

    spacer M3, 7 mm high 4

    spacer M3, 5 mm high 4

MPASM 02.15 Released PROBE.ASM 8-5-1998 13:51:00 PAGE 1

```
LOC  OBJECT CODE     LINE SOURCE TEXT
  VALUE

                     00001 ;***********************************************************************
                     00002 ;* Filename: PROBE.ASM
                     00003 ;***********************************************************************
                     00004 ;* Author:   Voja Antonic
                     00005 ;* Company:  PC Press
                     00006 ;* Revision: RevA1
                     00007 ;* Date:     07-09-98
                     00008 ;* Assembled using MPASM rev 01.50
                     00009 ;***********************************************************************
                     00010 ;* Include files:
                     00011 ;*      p16f84.inc
                     00012 ;***********************************************************************
                     00013 ;* This is the program for multi-purpose laboratory instrument which
                     00014 ;*  consists of logic probe, single-channel logic state analyzer,
                     00015 ;*  serial code receiver and frequency counter. As this is single-chip
                     00016 ;*  instrument, all functions are supported by software.
                     00017 ;* LCD module used is Hitachi's LM032L with 2 lines of 20 columns.
                     00018 ;*
                     00019 ;* Note: The code is optimized for code space, and for that reason the
                     00020 ;*  most of code could not be written in modular format. For the same
                     00021 ;*  reason a lot of subroutines have more than one entry point and some
                     00022 ;*  of them are terminated by GOTO instead of RETURN.
                     00023 ;*
                     00024 ;* I/O port usage (all PORTA bits are inputs, all PORTB bits outputs)
                     00025 ;*  (note: bits 0, 5, 6 and 7 in port B have two functions each):
                     00026 ;*  PORTA,0 (input)   probe input
                     00027 ;*  PORTA,1 (input)   voltage monitor (high if battery voltage < 4 V)
                     00028 ;*  PORTA,2 (input)   left key (key 1) (low = key pressed)
                     00029 ;*  PORTA,3 (input)   right key (key 2) (low = key pressed)
                     00030 ;*  PORTA,4 (input)   probe input
                     00031 ;*  PORTB,0 (output)  enable LCD (high=select LCD),discharge (high=on)
                     00032 ;*  PORTB,1 (output)  register select LCD (low=instruction,high=data)
                     00033 ;*  PORTB,2 (output)  hi-imp output for probe pin
                     00034 ;*  PORTB,3 (output)  current hold for MCU supply (low = off)
                     00035 ;*  PORTB,4 (output)  LCD module D4
                     00036 ;*  PORTB,5 (output)  LCD module D5, LED P (high = on)
                     00037 ;*  PORTB,6 (output)  LCD module D6, LED H (high = on)
                     00038 ;*  PORTB,7 (output)  LCD module D7, LED L (high = on)
                     00039 ;*
                     00040 ;* External Clock Frequency: 10 MHz
                     00041 ;* Config Bit Settings: CP=OFF, PWRTE=ON, WDT=OFF, OSC=HS
                     00042 ;* Program Memory Usage: 1023 words
                     00043 ;* Data RAM Usage: 68 bytes
                     00044 ;* Data EEPROM Usage: 61 bytes
                     00045 ;*  Note: This is read-only data, so the Data EEPROM must be programmed
                     00046 ;*  before the unit is used. MCU will not affect data EEPROM contents.
                     00047 ;***********************************************************************
                     00048         list p=16f84, f=inhx8m, n=0
                     00049         include "p16f84.inc"
                     00001         LIST
                     00002 ; P16F84.INC Standard Header File, V 2.00 Microchip Technology, Inc.
                     00136         LIST
                     00050
  0000000C           00051 FLAG    equ     0ch     ; 1 by  flag register
  0000000D           00052 RXBITS  equ     0dh     ; 1 by  bit0=parity,bit1=7/8 bits,bit 2=inverse
  0000000E           00053 DJNZ    equ     0eh     ; 1 by  general purpose, e.g. loop counter
  0000000F           00054 SCRATCH equ     0fh     ; 1 by  general purpose scratchpad
  00000010           00055 PCOUNT  equ     10h     ; 1 by  timing count for led P (monostable sim)
  00000011           00056 SUBMODE equ     11h     ; 1 by  submode (cursor horizontal position)
  00000012           00057 DEBO1   equ     12h     ; 1 by  rotor for key 1 debouncing
```

```
  00000013      00058 DEBO2   equ     13h     ; 1 by  rotor for key 2 debouncing
  00000014      00059 COUNT   equ     14h     ; 1 by  general purpose counter
  00000015      00060 RATE    equ     15h     ; 1 by  analyzer sample rate, 0...15
  00000016      00061 CHARCOU equ     16h     ; 1 by  char counter for fixed format display
  00000017      00062 SHOWCOU equ     17h     ; 1 by  1-4, which group of 60 samples is shown
  00000018      00063 DELAYL  equ     18h     ; 1 by  delay for led P on when led L is on
  00000019      00064 DELAYH  equ     19h     ; 1 by  delay for led P on when led H is on
  0000001A      00065 PRESC   equ     1ah     ; 1 by  prescaler rate for frequency counter
  0000001B      00066 TIMOUTL equ     1bh     ; 1 by  timeout counter lo, for auto power off
  0000001C      00067 TIMOUTH equ     1ch     ; 1 by  timeout counter hi, for auto power off
  0000001D      00068 RXRATE  equ     1dh     ; 1 by  rx baud rate, 0...7
  0000001E      00069 BIN4    equ     1eh     ; 4 by  arith buf bin value, lo byte first
  00000022      00070 CMP4    equ     22h     ; 4 by  arith buf for comparing, lo byte first
  00000026      00071 BUFFER  equ     26h     ;42 by  42 by receive buf for analyzer and RX
  00000001      00072 REL     equ     1       ;=1 to put cursor on 1st char of command
                00073                         ;=0 to put cursor before the command
                00074
                00075 ; Bits definitions for FLAG register (bit 0 not used):
  00000001      00076 DP      equ     1       ; decimal point in 3-digit bin2dec conv
  00000002      00077 PTIP    equ     2       ; prev.state of probe input (for edge detect)
  00000003      00078 RIPPLE  equ     3       ; zero blanking bit
  00000004      00079 XTOX    equ     4       ; analyzer start at: 1=rising, 0=falling edge
  00000005      00080 LEDP    equ     5       ; led Pulse, 1=on
  00000006      00081 LEDH    equ     6       ; led High, 1=on
  00000007      00082 LEDL    equ     7       ; led Low, 1=on
                00083
                00084 ;*****************************************************************
                00085 ;* Reset vector
                00086 ;*****************************************************************
0000 28A8       00087         goto    Start
                00088
                00089 ;*****************************************************************
                00090 ;* Get1MHz
                00091 ;* This subroutine fetches 307 samples (last 7 will be ignored) from
                00092 ;*  PORTA.0 rotating through CARRY at 1 MHz rate - 2.5 instr. cycles
                00093 ;*  for each sample, realized mostly as 2 and 3 cycles alternatively,
                00094 ;*  at the following order:
                00095
                00096 ;*  4t-2t-2t (not in main loop, executed only once), and then
                00097 ;*  2t-2t-3t-2t-3t-2t-3t-2t-3t-2t-3t-2t-3t-2t-2t-4t  (repeat 19 times)
                00098 ;*
                00099 ;* Call Common inits loop counter (COUNT) to make 19 cycles before
                00100 ;*  exiting (16 samples are fetched at each pass), and FSR to point to
                00101 ;*  BUFF. It also presets T0SE bit depending on XTOX bit (in FLAG reg)
                00102 ;*  to enable proper edge detect, as it will affect TMR0 state.
                00103 ;*  State of key 2 (Break) is tested while waiting for start condition.
                00104 ;* Write ptr FSR is incremented after every 8 samples. COUNT initial
                00105 ;*  value is 01101101, after ANDing 0c0h and subtracting 33h from it,
                00106 ;*  makes 0dh, even if COUNT is incremented 18 times. After 19 passes,
                00107 ;*  COUNT is incremented to b'10000000', which after AND 0c0h and
                00108 ;*  SUB 33h makes 4dh. Those jumps are location sensitive, and it makes
                00109 ;*  the whole subroutine unrelocateable.
                00110 ;* Between this subroutine and the instruction goto Finished (below),
                00111 ;*  which must be at loc. 4dh, there are 25 free locations. They are
                00112 ;*  used for tables DecTab and CurTab, which causes that those tables
                00113 ;*  must have the fixed length. If anything relocates here, take care
                00114 ;*  not to affect location of instruction goto Finished.
                00115 ;* Input/Output variables: None
                00116 ;*****************************************************************
0001            00117         org     1               ; this subroutine must start at addr 1
                00118
0001            00119 Get1MHz                         ; 2.5 t read cycle
0001 306D       00120         movlw   80h-.19         ; loop end in 19 cyc(38 by=304 smpls)
0002 226F       00121         call    Common          ; initialize COUNT, FSR, hi-imp out...
                00122                                 ; ...bit XTOX and T0SE bit
0003            00123 GetEdge
```

```
0003 1D85      00124         btfss   PORTA,3         ; test status of key 2 and...
0004 28CC      00125         goto    Break           ; ...jump to Break routine if pressed
               00126
0005 0801      00127         movf    TMR0,W          ; TMR0 = logic level edge detector
0006 0C85      00128         rrf     PORTA,F  ; <--- ; the first sample is a little earlier
               00129                                 ; ... to compensate starting delay
0007 1903      00130         btfsc   STATUS,Z        ; test if there was egde...
0008 2803      00131         goto    GetEdge         ; ...and loop if not
               00132
0009 0C80      00133         rrf     INDF,F          ; rotate bit into destination byte
000A 0C85      00134         rrf     PORTA,F  ; <---   get bit from input to C
000B 0C80      00135         rrf     INDF,F          ; rotate bit into destination byte
000C 0C85      00136         rrf     PORTA,F  ; <---   get bit from input to C
               00137                                 ; movwf PCL will jump here at 18 passes
               00138                                 ; ...@addr 0100 0000 (40h) - 33h = 0dh
000D 0C80      00139         rrf     INDF,F          ; rotate bit into destination byte
000E 0C85      00140         rrf     PORTA,F  ; <---   get bit from input to C
000F 0C80      00141         rrf     INDF,F          ; rotate bit into destination byte
0010 0C85      00142         rrf     PORTA,F  ; <---   get bit from input to C
0011 0C80      00143         rrf     INDF,F          ; rotate bit into destination byte
0012 0C85      00144         rrf     PORTA,F  ; <---   get bit from input to C
0013 0C80      00145         rrf     INDF,F          ; rotate bit into destination byte
               00146
0014 0A94      00147         incf    COUNT,F         ; COUNT = loop counter
               00148
0015 0C85      00149         rrf     PORTA,F  ; <---   get bit from input to C
0016 0C80      00150         rrf     INDF,F          ; rotate bit into destination byte
0017 0C85      00151         rrf     PORTA,F  ; <---   get bit from input to C
0018 0C80      00152         rrf     INDF,F          ; rotate bit into destination byte
               00153
0019 0A84      00154         incf    FSR,F           ; must be exactly 8 read cycles apart
               00155                                 ; ... between FSR incrementing
001A 0C85      00156         rrf     PORTA,F  ; <---   get bit from input to C
001B 0C80      00157         rrf     INDF,F          ; rotate bit into destination byte
001C 0C85      00158         rrf     PORTA,F  ; <---   get bit from input to C
001D 0C80      00159         rrf     INDF,F          ; rotate bit into destination byte
               00160
001E 0814      00161         movf    COUNT,W         ; COUNT = loop counter
               00162
001F 0C85      00163         rrf     PORTA,F  ; <---   get bit from input to C
0020 0C80      00164         rrf     INDF,F          ; rotate bit into destination byte
0021 0C85      00165         rrf     PORTA,F  ; <---   get bit from input to C
0022 0C80      00166         rrf     INDF,F          ; rotate bit into destination byte
               00167
0023 39C0      00168         andlw   0c0h            ; this will make first 18 jumps to 0dh,
               00169                                 ; ...and the 19th one to 4dh
0024 0C85      00170         rrf     PORTA,F  ; <---   get bit from input to C
0025 0C80      00171         rrf     INDF,F          ; rotate bit into destination byte
0026 0C85      00172         rrf     PORTA,F  ; <---   get bit from input to C
0027 0C80      00173         rrf     INDF,F          ; rotate bit into destination byte
               00174
0028 3ECD      00175         addlw   -33h            ; this will make first 18 jumps to 0dh,
               00176                                 ; ...and the 19th one to 4dh
0029 0C85      00177         rrf     PORTA,F  ; <---   get bit from input to C
002A 0C80      00178         rrf     INDF,F          ; rotate bit into destination byte
002B 0C85      00179         rrf     PORTA,F  ; <---   get bit from input to C
002C 0C80      00180         rrf     INDF,F          ; rotate bit into destination byte
               00181
002D 0A84      00182         incf    FSR,F           ; must be exactly 8 read cycles apart
               00183                                 ; ... between FSR incrementing
002E 0C85      00184         rrf     PORTA,F  ; <---   get bit from input to C
002F 0C80      00185         rrf     INDF,F          ; rotate bit into destination byte
0030 0C85      00186         rrf     PORTA,F  ; <---   get bit from input to C
0031 0C80      00187         rrf     INDF,F          ; rotate bit into destination byte
0032 0C85      00188         rrf     PORTA,F  ; <---   get bit from input to C
               00189
```

```
0033  0082            00190         movwf   PCL         ; jumps to 0dh in first 18 passes
                      00191                             ; jumps to 4dh at 19th pass
                      00192
                      00193
;*****************************************************************
                      00194 ;* This table is used for bin2ascii (4-byte to 8-digit) conversion
                      00195
;*****************************************************************
0034                  00196 DecTab
0034  3498            3496                  3480        00197         dt      098h,096h,080h  ;
decimal 10 000 000
0037  340F 3442 3440  00198         dt      00fh,042h,040h  ; decimal 1 000 000
003A  3401 3486 34A0  00199         dt      001h,086h,0a0h  ; decimal 100 000
003D  3400 3427 3410  00200         dt      000h,027h,010h  ; decimal 10 000
0040  3400 3403 34E8  00201         dt      000h,003h,0e8h  ; decimal 1 000
0043  3400 3400 3464  00202         dt      000h,000h,064h  ; decimal 100
0046  3400 3400 340A  00203         dt      000h,000h,00ah  ; decimal 10
                      00204
                      00205 ;*****************************************************************
                      00206 ;* Cursor position table for all SUBMODEs in mode 4 (battery manager)
                      00207 ;*****************************************************************
0049                  00208 CurTab4
0049  34D3 34C0 34C4  00209         dt      0d2h+REL,0c0h,0c3h+REL,0cah+REL
      34CB
                      00210
                      00211 ;*****************************************************************
                      00212 ;* This is exit point for subroutine Get1MHz. Do not move this
                      00213 ;*  instruction, it must be at address 4dh!
                      00214 ;*****************************************************************
004D                  00215         org     80h-33h         ; addr 1000 0000 (80h) - 33h = 4dh
                      00216                                 ; Get1MHz jumps here
004D  2A6A            00217         goto    Finished
                      00218
                      00219 ;*****************************************************************
                      00220 ;* Table for LCD module character generator redefinition, to enable
                      00221 ;*  pseudographic representation of bit samples in analyzer mode. It
                      00222 ;*  defines first 8 characters, which are stored in LCD module's RAM.
                      00223 ;*****************************************************************
004E                  00224 Graphs
                      00225         ;       ...  ..*  .*.  .**  *..  *.*  **.  ***
004E  3400 3401 3404  00226         dt      00h, 01h, 04h, 05h, 10h, 11h, 14h, 15h
      3405 3410 3411
      3414 3415
                      00227
                      00228 ;*****************************************************************
                      00229 ;* Cursor position table for all SUBMODEs in mode 1 (Analyzer)
                      00230 ;*****************************************************************
0056                  00231 CurTab1
0056  34D3 34C0 34CD0 0232        dt      0d2h+REL,0c0h,0cch+REL,0ceh+REL,0d0h+REL
      34CF 34D1
                      00233
                      00234 ;*****************************************************************
                      00235 ;* Cursor position table for all SUBMODEs in mode 2 (Serial rcvr)
                      00236 ;*****************************************************************
005B                  00237 CurTab2
005B  34D3 34C8 34CD  00238         dt      0d2h+REL,0c7h+REL,0cch+REL,0ceh+REL,0d0h+REL
      34CF 34D1
                      00239
                      00240 ;*****************************************************************
                      00241 ;* Prescaler table for resolution display in mode 3 (freq counter)
                      00242 ;*****************************************************************
0060                  00243 PrescTab
0060  3404 3408 3410  00244         dt      .4, .8, .16, .32
      3420
                      00245
                      00246 ;*****************************************************************
```

```
                     00247 ;* Range table for max. frequency display in mode 3 (freq counter)
                     00248 ;*****************************************************************
0064                 00249 RangeTab
0064  3405 340A 3414 00250         dt      .5, .10, .20, .40
      3428
                     00251 ;*****************************************************************
                     00252 ;* Timing constants for serial code receiver
                     00253 ;*****************************************************************
0068                 00254 BaudRate
0068  34BC 345E 342E 00255         dt      .188, .94, .46, .23, .11, .5, .3, .1
      3417 340B 3405
      3403 3401
                     00256
                     00257 ;*****************************************************************
                     00258 ;* Text strings (terminator = last character with bit 7 set)
                     00259 ;*****************************************************************
0070                 00260 TxtHz
0070  344D 3448 347A 00261         dt      "MHz",'/'+80h
      34AF
0074                 00262 DisTxt
0074  344F 3466 3466 00263         dt      "Off Disch. Charg",'e'+80h
      3420 3444 3469
      3473 3463 3468
      342E 3420 3443
      3468 3461 3472
      3467 34E5
0085                 00264 Head1
0085  3441 346E 3461 00265         dt      "Analyze",'r'+80h
      346C 3479 347A
      3465 34F2
008D                 00266 Head2
008D  3453 3465 3472 00267         dt      "Seria",'l'+80h
      3469 3461 34EC
0093                 00268 Head3
0093  3446 3472 3465 00269         dt      "Frequenc",'y'+80h
      3471 3475 3465
      346E 3463 34F9
009C                 00270 Head4
009C  3442 3461 3474 00271         dt      "Batter",'y'+80h
      3474 3465 3472
      34F9
00A3                 00272 BrkMes
00A3  3442 3472 3465 00273         dt      "Brea",'k'+80h
      3461 34EB
                     00274
                     00275 ;******* START
                     00276 ;*****************************************************************
                     00277 ;* Power Up sequence:I/O port B defined as all outputs,PORTB,3 set to
                     00278 ;*  switch power supply on and the internal Data Ram is cleared
                     00279 ;*****************************************************************
00A8                 00280 Start
00A8  1683           00281      bsf     STATUS,RP0
00A9  0186           00282      clrf    TRISB           ; portb: all bits outputs,port a:inputs
00AA  1283           00283      bcf     STATUS,RP0
00AB  300C           00284      movlw   0ch             ; start of RAM clr, & PORTB output byte
00AC  0086           00285      movwf   PORTB           ; switch power supply ON (set PORTB,3)
00AD  23B8           00286      call    ClrRam          ; clear internal RAM and wait 33.8 ms
                     00287
                     00288 ;*****************************************************************
                     00289 ;* LCD module initialization. 4-bit mode selected, display data RAM
                     00290 ;* cleared cursor set to blink mode, and the pseudographics character
                     00291 ;*  for character set 00h-07h preset from table Graphs.
                     00292 ;*****************************************************************
00AE  1086           00293         bcf     PORTB,1         ; rs lo (instruction)
00AF  3002           00294         movlw   2               ; 4-bit mode
00B0  23E9           00295         call    Nibble          ; write 4-bit mode command
```

```
00B1  3028            00296         movlw  28h          ; func set: 4 bit mode,2 lines,5*7 dots
00B2  23CF            00297         call   WrComL       ; write command and wait 130 us
00B3  3006            00298         movlw  06h          ; modeset: cursor moves right, no shift
00B4  23CF            00299         call   WrComL       ; write command and wait 130 us
00B5  300D            00300         movlw  0dh          ; disp on, no cursor,blink cursor pos
00B6  23CF            00301         call   WrComL       ; write command and wait 130 us
                      00302
00B7  3040            00303         movlw  40h          ; cg ram addr 0
00B8  23CF            00304         call   WrComL       ; write address and wait 130 us
00B9  304E            00305         movlw  Graphs       ; start addr of graph set for lcd disp
00BA  008F            00306         movwf  SCRATCH      ; move start address to pointer
00BB  3020            00307         movlw  .8*.4        ; 8 special characters to define
                      00308                             ; CHARCOU decremented in Char routine,
                      00309                             ; ...that is why here is 8*4
00BC  0096            00310         movwf  CHARCOU      ; loop counter for 8 special characters
00BD                  00311         GoGraph
00BD  3005            00312         movlw  .5           ; five rows are equal
00BE  0094            00313         movwf  COUNT        ; counter for 5 rows
00BF                  00314         FiveRows            ; inner loop: 5 rows are equal
00BF  23B5            00315         call   PclSub1      ; move SCRATCH to PCL
00C0  23D9            00316         call   CharNCC      ; rows 1-5 from the table
00C1  0B94            00317         decfsz COUNT,F      ; five passes over?
00C2  28BF            00318         goto   FiveRows     ; no, loop
                      00319
00C3  3015            00320         movlw  15h          ; 15h=b'10101'=dot-space-dot-space-dot
00C4  23D6            00321         call   CharBl       ; row 6:all dots set,row 7:all dots clr
00C5  23D7            00322         call   Blank        ; row 8: all dots cleared
00C6  0A8F            00323         incf   SCRATCH,F    ; inc ptr
00C7  0B96            00324         decfsz CHARCOU,F    ; 8 characters defined?
00C8  28BD            00325         goto   GoGraph      ; no, loop 8 x
                      00326
                      00327 ;*******  USER INTERFACE
                      00328 ;*****************************************************************
                      00329 ;* This is home point for mode 1(Analyzer): prints text"Analyzer" and
                      00330 ;* command line in line 2, w/cursor location set on variable SUBMODE.
                      00331 ;* Then the keyboard routine is called, where it waits for key to be
                      00332 ;* pressed.
                      00333 ;* Break entry point prints message Break in line 1 and redraws line 2
                      00334 ;*****************************************************************
00C9                  00335 Mode1                       ; Mode 1: Analyzer
00C9  3084            00336         movlw  Head1-1      ; start address of string -1
00CA  235F            00337         call   Headline     ; print "Analyzer"
00CB  28CD            00338         goto   Farm1        ; avoid "Break" message
00CC                  00339 Break                       ; Break entry pt (if Break in Mode 1)
00CC  23DB            00340         call   PrintBrk     ; print "Break"
00CD                  00341 Farm1
00CD  227D            00342         call   PrintM1      ; print string in line 2
00CE                  00343 Farm1B
00CE  3056            00344         movlw  CurTab1      ; get cursor table addr in analyze mode
00CF  2170            00345         call   CurPosKb     ; place cursor on proper position
                      00346                             ; test keys / probe input,service leds
                      00347                             ; return if key press (C:key1,NC:key2)
                      00348
                      00349 ;*****************************************************************
                      00350 ;* If key 1 pressed (C),SUBMODE is advanced (range 0...4,then wrapto 0
                      00351 ;* If key 2 pressed (NC), program vectors to corresponding routine
                      00352 ;*(except if SUBMODE=1,then the sample rate is advanced and displayed)
                      00353 ;*****************************************************************
00D0  1803            00354         btfsc  STATUS,C     ; test which key was pressed
00D1  28D4            00355         goto   Key1A        ; jump if key 1
                      00356                             ; continue if key 2 pressed
00D2  212A            00357         call   Range5       ; advance var SUBMODE in range 0...4
00D3  28CE            00358         goto   Farm1B       ; go wait next key
00D4                  00359 Key1A                       ; key 1 pressed
00D4  0B11            00360         decfsz SUBMODE,W    ; test SUBMODE (set Z if SUBMODE=1)
00D5  28DF            00361         goto   NoRate       ; jump if SUBMODE <>1
```

```
                    00362                           ; continue if SUBMODE=1
00D6  0A95          00363         incf    RATE,F    ; advance sample rate
00D7  1215          00364         bcf     RATE,4    ; RATE range 0...15
                    00365
00D8  22B7          00366         call    ClrRow1   ; prepare line 1 to print sample rate #
00D9  0A15          00367         incf    RATE,W    ; readjust RATE from 0...15 to 1...16
00DA  2370          00368         call    Print255  ; print serial # of sample rate 1...16
00DB  28CD          00369         goto    Farm1     ; go redraw row 2, wait next command
                    00370
00DC                00371 EdgeSet                   ; Change start cond(L-2-H or H-2-L)
00DC  3010          00372         movlw   10h       ; bit 4 is flag XTOX
00DD  068C          00373         xorwf   FLAG,F    ; change flag
00DE  28CD          00374         goto    Farm1     ; go redraw row 2, wait next command
00DF                00375 NoRate
00DF  1811          00376         btfsc   SUBMODE,0 ; bit 0 will be set only if SUBMODE=3
00E0  2A0E          00377         goto    Mode1Go   ; if SUBMODE=3
00E1  1891          00378         btfsc   SUBMODE,1 ; bit 1 will be set only if SUBMODE=2
00E2  28DC          00379         goto    EdgeSet   ; if SUBMODE=2
00E3  1911          00380         btfsc   SUBMODE,2 ; bit 2 will be set only if SUBMODE=4
00E4  29D4          00381         goto    Mode1Show ; if SUBMODE=4
                    00382                           ; if SUBMODE=0, program drops to Mode2.
                    00383
                    00384 ;*****************************************************************
                    00385 ;* This is home for mode 2 (RS232 receiver): prints text "Serial" and
                    00386 ;* command line in line 2,cursor placed depended on variable SUBMODE.
                    00387 ;* BrkRS entry point prints message Break in line 1 and redraws line 2
                    00388 ;* if 0 bytes are received, display first 7 bytes if any byte received
                    00389 ;*****************************************************************
00E5                00390 Mode2                     ; mode 2: Serial receiver
00E5  308C          00391         movlw   Head2-1   ; start address of string -1
00E6  235F          00392         call    Headline  ; print "Serial"
00E7  28ED          00393         goto    Farm2     ; avoid "Break" message
00E8                00394 BrkRS                     ; Break entry pt (if Break in mode 2)
00E8  0804          00395         movf    FSR,W     ; FSR points to write next rcvd byte
00E9  3A26          00396         xorlw   BUFFER    ; if FSR=literal BUFF the 0 bytes rcvd
00EA  1D03          00397         btfss   STATUS,Z  ; test if FSR = literal BUFFER
00EB  2AC6          00398         goto    Show2     ; no -some bytes received,show them
00EC  23DB          00399         call    PrintBrk  ; yes -no bytes received, print "Break"
                    00400
                    00401 ;*****************************************************************
                    00402 ;* Prints baud rate in KBaud on LCD
                    00403 ;*
                    00404 ;* Input variables: RXRATE in range 0...7
                    00405 ;* Output variables: CHARCOU decremented by num of characters printed
                    00406 ;*****************************************************************
00ED                00407 Farm2
00ED  30C8          00408         movlw   0c8h      ; baud rate position on LCD
00EE  23CF          00409         call    WrComL    ; move cursor command
                    00410
00EF  108C          00411         bcf     FLAG,DP   ; no decimal point printing if RATE=0
00F0  019F          00412         clrf    BIN4+1    ; BIN4+1 is high byte for baudrate disp
                    00413
00F1  0A1D          00414         incf    RXRATE,W  ; move RXRATE from range 0...7 to 1...8
00F2  008E          00415         movwf   DJNZ      ; DJNZ = RXRATE+1
                    00416
00F3  3073          00417         movlw   .115      ; case RXRATE=7:then Baudrate=115 Kbaud
00F4  198E          00418         btfsc   DJNZ,3    ; test if DJNZ=8 (same as RXRATE=7)
00F5  2905          00419         goto    Lth256    ; yes, go case 115.2 (RXRATE=7)
                    00420
00F6  148C          00421         bsf     FLAG,DP   ; for rete 0...6 there is decimal point
00F7  149F          00422         bsf     BIN4+1,1  ; case RXRATE=6:is hi byte for 57.6
00F8  3040          00423         movlw   .576-.512 ; case RXRATE=6:is lo byte for 57.6
00F9  0A8E          00424         incf    DJNZ,F    ; DJNZ=RXRATE+2
00FA  198E          00425         btfsc   DJNZ,3    ; test if DJNZ=8 (same as RXRATE=6)
00FB  2905          00426         goto    Lth256    ; yes, go case 57.6 (RXRATE=6)
                    00427
```

```
00FC  019F            00428         clrf    BIN4+1      ; for rates 0...5 hi byte is zero
00FD  3003            00429         movlw   .3          ; constant for rates 0...5
00FE  009E            00430         movwf   BIN4        ; BIN4 will be rotated (mult by 2)
                      00431                             ; RXRATE+2 times to get 1.2 - 2.4 - 4.8
                      00432                             ; - 9.6 - 19.2 - 38.4
00FF                  00433 X2Loop
00FF  1003            00434         bcf     STATUS,C    ; clear bit C to get multiplying by 2
0100  0D9E            00435         rlf     BIN4,F      ; multiply low byte
0101  0D9F            00436         rlf     BIN4+1,F    ; multiply hibyte,that is 16-bit rotate
0102  0B8E            00437         decfsz  DJNZ,F      ; test if RXRATE+2 times multiplied
0103  28FF            00438         goto    X2Loop      ; no, loop
0104  081E            00439         movf    BIN4,W      ; yes, get result to print it
0105                  00440 Lth256
0105  2372            00441         call    PrintBR     ; print baud rate,incl. decimal point
0106  23D7            00442         call    Blank       ; to delete last # from previous rate
                      00443
                      00444 ;*********************************************************************
                      00445 ;* Prints num bits to be received (7 or 8), with suffix "p" if parity
                      00446 ;* bit will be received (not written to RAM!), and with prefix "i" if
                      00447 ;* inverse input polarity is expected. Input variable RXBITS, bit0 set
                      00448 ;* if parity bit expected, bit 1 set if 8-bit word and bit 2 set if
                      00449 ;* inverse polarity (lo start bit,inverse data bits and high stop bit)
                      00450 ;*********************************************************************
0107  30CC            00451         movlw   0cch        ; bit# pos (7/8/7p/8p/i7/i8/i7p/i8p) -1
0108  23CF            00452         call    WrComL      ; write command
                      00453
0109  3020            00454         movlw   ' '         ; space: true polarity
010A  190D            00455         btfsc   RXBITS,2    ; let it be space if RXBITS,2 cleared
010B  3069            00456         movlw   'i'         ; "i": inverse polarity
010C  23D8            00457         call    Char        ; print blank or "i"
                      00458
010D  3037            00459         movlw   '7'         ; "7": 7 bits
010E  1C8D            00460         btfss   RXBITS,1    ; let it be 7 if RXBITS,1 set
010F  3038            00461         movlw   '8'         ; "8": 8 bits
0110  23D8            00462         call    Char        ; print "7" or "8" (bits)
                      00463
0111  3020            00464         movlw   ' '         ; space: no parity
0112  180D            00465         btfsc   RXBITS,0    ; let it be space if RXBITS,0 cleared
0113  3070            00466         movlw   'p'         ; "p": parity bit exists
0114  23D8            00467         call    Char        ; print "p" (parity bit) or blank
                      00468
                      00469 ;*********************************************************************
                      00470 ;* This call prints number of group displayed and "*" (execution) symb
                      00471 ;*********************************************************************
0115  22A5            00472         call    KaoAna      ; print rest of line - is the same as
                      00473                             ; on mode 1 (analyzer)
                      00474
                      00475 ;*********************************************************************
                      00476 ;* Places cursor on proper position (input variable SUBMODE) and calls
                      00477 ;* keyboard subroutine, where it will wait for key to be pressed
                      00478 ;*********************************************************************
0116  305B            00479         movlw   CurTab2     ; table with cursor positions
0117  2170            00480         call    CurPosKb    ; place cursor on proper pos
                      00481                             ; test keys / probe input,service leds
                      00482                             ; return if key press (C:key1,NC:key2)
                      00483
                      00484 ;*********************************************************************
                      00485 ;* If key1 pressed (C), SUBMODE is advanced (range 0..4, then wrap to 0
                      00486 ;* If key 2 pressed (NC), program vectors to corresponding routine
                      00487 ;*  (except if SUBMODE=1, then the Baud rate is advanced and displayed)
                      00488 ;*********************************************************************
0118  1803            00489         btfsc   STATUS,C    ; test which key was pressed
0119  291C            00490         goto    Key1B       ; jump if C set, means key 1 pressed
                      00491                             ; key 2 pressed
011A  212A            00492         call    Range5      ; increment SUBMODE in range 0...4
011B  28ED            00493         goto    Farm2       ; go redraw row2, wait for next command
```

```
011C                 00494         Key1B             ; key 1 pressed
011C  1911           00495         btfsc  SUBMODE,2  ; bit 2 is set only if SUBMODE = 4
011D  2AC1           00496         goto   Mode2Show  ; jump if SUBMODE = 4
                     00497
011E  1C91           00498         btfss  SUBMODE,1  ; bit1 cleared only if SUBMODE = 0 or 1
011F  2925           00499         goto   Sub01      ; jump if SUBMODE = 0 or SUBMODE = 1
                     00500
0120  1811           00501         btfsc  SUBMODE,0  ; bit 0 is set here only if SUBMODE = 3
0121  2AEA           00502         goto   Mode2Go    ; jump if SUBMODE = 3
                     00503                           ; drops here if SUBMODE = 2
0122  0A8D           00504         incf   RXBITS,F   ; advance RXBITS (command)
0123  118D           00505         bcf    RXBITS,3   ; RXBITS cycle in range = 0...7
0124  28ED           00506         goto   Farm2      ; go redraw row2, wait for next command
0125                 00507 Sub01
0125  1C11           00508         btfss  SUBMODE,0  ; bit 0 is set here only if SUBMODE = 0
0126  2B28           00509         goto   FreqEp     ; if SUBMODE =0,goto frequency entry pt
                     00510
0127  0A9D           00511         incf   RXRATE,F   ; if SUBMODE = 1 then advance RXRATE
0128  119D           00512         bcf    RXRATE,3   ; RXRATE cycle in range 0...7
0129  28ED           00513         goto   Farm2      ; go redraw row2, wait for next command
                     00514
                     00515 ;*****************************************************************
                     00516 ;* This subroutine increments variable SUBMODE,and if the result is >4
                     00517 ;* it wraps to 0
                     00518 ;*****************************************************************
012A                 00519 Range5                    ; increment SUBMODE in range 0...4
012A  0A91           00520         incf   SUBMODE,F  ; advance SUBMODE
012B  1911           00521         btfsc  SUBMODE,2  ; if SUBMODE,2 cleared then no overflow
012C  1C11           00522         btfss  SUBMODE,0  ; if SUBMODE,0 cleared then no overflow
012D  0008           00523         return            ; no overflow: return
012E  0191           00524         clrf   SUBMODE    ; SUBMODE cycle in range 0...4
012F  0008           00525         return            ; SUBMODE wrapped to 0, return
                     00526
                     00527 ;*****************************************************************
                     00528 ;* Mode4 is home point for mode 4 (off/discharge/charge): prints text
                     00529 ;* "Battery" and command line in line2, with cursor placed depended on
                     00530 ;* variable SUBMODE. Then keyboard routine is called, where it will
                     00531 ;* wait for key to be pressed
                     00532 ;* Break4 entry point prints message Break in line1 and readraws line2
                     00533 ;* ExitDis is the entry point if key 2 is pressed during discharging
                     00534 ;*****************************************************************
0130                 00535 ExitDis                   ; exit disch entry point,if disch Break
0130  23BD           00536         call   DisEna30   ; turn off PORTB,0 discharge transistor
0131                 00537 Break4                    ; exit Chg entry point, if Charge Break
0131  23DB           00538         call   PrintBrk   ; print "Break"
0132  2934           00539         goto   Contm4     ; avoid headline printing
0133                 00540 Mode4                     ; mode 4: discharge/charge
0133  2360           00541         call   Headline2  ; print "Battery"
0134                 00542 Contm4
0134  23CE           00543         call   Row2       ; move cursor to line 2
0135  3073           00544         movlw  DisTxt-1   ; point to message -1
0136  23DD           00545         call   Write      ; print Off Disch Charge
0137                 00546 Farm4
0137  3049           00547         movlw  CurTab4    ; point to cursor table for mode 4
0138  2170           00548         call   CurPosKb   ; place cursor @ Off/Disch/Charge/-->
                     00549                           ; test keys / probe input,service leds
                     00550                           ; return if key press (C:key1,NC:key2)
                     00551
                     00552 ;*****************************************************************
                     00553 ;* If key1 pressed (C), SUBMODE is advanced (range 0..3,then wrap to 0
                     00554 ;* If key 2 pressed (NC), program jumps to corresponding routine
                     00555 ;*****************************************************************
0139  1803           00556         btfsc  STATUS,C   ; test which key was pressed
013A  293E           00557         goto   Key1D      ; C set: key 1 pressed
                     00558                           ; key 2 pressed
013B  0A91           00559         incf   SUBMODE,F  ; advance SUBMODE
```

```
013C  1111            00560         bcf    SUBMODE,2   ; SUBMODE cycle in range 0...3
013D  2937            00561         goto   Farm4       ; go redraw row2, wait for next command
013E                  00562 Key1D                      ; key 1 pressed
013E  1891            00563         btfsc  SUBMODE,1   ; bit 1 set only if Chg/Disch. submode
013F  2943            00564         goto   ChargDis    ; goto Charge or Discharge process
                      00565                            ; depended on bit 0 in variable SUBMODE
0140  1C11            00566         btfss  SUBMODE,0   ; SUBMODE,0 cleared here if SUBMODE=0
0141  28C9            00567         goto   Mode1       ; shortcut to mode 1 (Analyzer)
                      00568
0142  29BC            00569         goto   Suicide     ; manual power off
                      00570
                      00571 ;*******  CHARGE/DISCHARGE
                      00572 ;*****************************************************************
                      00573 ;* Charge/Disch entry point. If bit SUBMODE,0 set, then go to Charge
                      00574 ;*  SUBMODE,1 is set in this point. (SUBMODE=2 or 3)
                      00575 ;*****************************************************************
0143                  00576 ChargDis
0143  22B7            00577         call   ClrRow1     ; in both cases row 1 must be cleared
0144  1811            00578         btfsc  SUBMODE,0   ; test if SUBMODE,0 set, if so...
0145  2952            00579         goto   Charge      ; ...jump to Charge (SUBMODE=3)
                      00580                            ; ...else continue to disch (SUBMODE=2)
                      00581
                      00582 ;*****************************************************************
                      00583 ;* Discharge starts here (SUBMODE=2)
                      00584 ;* Cursor moved to line 1 under text "Disch."
                      00585 ;* Then command 02h (Home Cursor) issued to LCD controller, but this
                      00586 ;* is dummy command - sense is to freeze it after first nibble, and
                      00587 ;* thus to leave PORTB,0 (ENA) in high state as long as discharging
                      00588 ;* lasts. After the discharging termination (if volt monitor detects
                      00589 ;* <4V or key 2 pressed), the command for LCD controller will be
                      00590 ;* completed, switching discharging transistor off.
                      00591 ;* If discharging is broken by key, program returns to user interface
                      00592 ;* for mode 4, if terminated by voltage monitor, charging takes place
                      00593 ;*****************************************************************
0146  1086            00594         bcf    PORTB,1     ; pull LCD Reg Select low (=instr)
0147  0103            00595         clrw               ; high nibble of instruction 02h = 0h
0148  23F1            00596         call   Hinib_B     ; output W,4-7 to 4-bit LCD data bus
0149  23ED            00597         call   EnaLCD      ; generate En signal (1200us) for LCD
014A  3020            00598         movlw  20h         ; command 02h=home cursor(swap nibbles)
                      00599
014B  23F1            00600         call   Hinib_B     ; output W,4-7 to 4-bit LCD data bus
014C  1406            00601         bsf    PORTB,0     ; ENA activated (the command won't be
                      00602                            ; finished until Break or voltage < 4V)
014D                  00603 DisLoop
014D  1D85            00604         btfss  PORTA,3     ; test key 2 status...
014E  2930            00605         goto   ExitDis     ; if low,disching manually broke by key
                      00606
014F  1C85            00607         btfss  PORTA,1     ; test voltage monitor...
0150  294D            00608         goto   DisLoop     ; if still >=4V, loop
                      00609                            ; dischging terminated (voltage < 4V)
                      00610
0151  23BD            00611         call   DisEna30    ; switch off discahge transistor
                      00612
                      00613 ;*****************************************************************
                      00614 ;* Charging starts here (by command or after successful discharging)
                      00615 ;* Minute and hour counters are init'd and counting process starts.
                      00616 ;* Clock(in format HH:MM) is displayed in line 1 under text "Charge".
                      00617 ;* If charging broken by key, program returns to user interface for
                      00618 ;*  mode 4, if terminated by timeout (14 hours), the unit jumps to
                      00619 ;*  SUICIDE (switches off the unit forcing the output PORTB,3 low).
                      00620 ;*****************************************************************
0152                  00621 Charge                     ; Charge entry point
                      00622
0152  019B            00623         clrf   TIMOUTL     ; initialize minute counter 0...59
0153  019C            00624         clrf   TIMOUTH     ; initialize hour counter 0...13
0154                  00625 ChLoop
```

```
0154  308B           00626         movlw  8bh         ; position of digital clock on LCD
0155  23CF           00627         call   WrComL      ; cursor to digital clock pos
0156  081C           00628         movf   TIMOUTH,W   ; TIMOUTH=hours in binary format
0157  2370           00629         call   Print255    ; print hour in format HH
0158  303A           00630         movlw  ':'         ; ":" = separator
0159  21D1           00631         call   PrintTL     ; print ":" and minute in format MM
                     00632
015A  30E4           00633         movlw  .228        ; 228 x 263270.4 us = 60 sec
015B  008F           00634         movwf  SCRATCH     ; high byte loop counter for 1 min loop
015C                 00635 Min1
015C  23D2           00636         call   GoLoop      ; 1283t (513.2us) inclusive     ; 1283t
015D  23D2           00637         call   GoLoop      ; total 1026.4us                ; 1283t
                     00638
015E  1D85           00639         btfss  PORTA,3     ; 2t  test status of key 2...
015F  2931           00640         goto   Break4      ; -   ...if low,chg manually terminated
                     00641
0160  0B94           00642         decfsz COUNT,F     ; 1t  low byte loop counter
0161  295C           00643         goto   Min1        ; 2t  inner pass 1028.4 us
                     00644
0162  0B8F           00645         decfsz SCRATCH,F   ; high byte loop counter for 1 minute
0163  295C           00646         goto   Min1        ; one pass 263270.4 us
                     00647
0164  0A9B           00648         incf   TIMOUTL,F   ; advance minute counter
0165  081B           00649         movf   TIMOUTL,W   ; TIMOUTL = minute up counter
0166  3EC4           00650         addlw  -.60        ; test if 60 minutes of charging done..
0167  1C03           00651         btfss  STATUS,C    ; if 60 minutes passed, C should be set
0168  296B           00652         goto   NotHour     ; not yet hour advance
0169  019B           00653         clrf   TIMOUTL     ; if 60 minutes done, clr minute cntr
016A  0A9C           00654         incf   TIMOUTH,F   ; ..and advance TIMOUTH=hour up counter
016B                 00655 NotHour
016B  081C           00656         movf   TIMOUTH,W   ; TIMOUTH = hour up counter
016C  3EF2           00657         addlw  -.14        ; test if 14 hours of charging
016D  1C03           00658         btfss  STATUS,C    ; if 14 hours passed, C should be set
016E  2954           00659         goto   ChLoop      ; ...if not yet 14 hours, loop
016F  29BC           00660         goto   Suicide     ; charging terminated after 14 h
                     00661
                     00662 ;*******  KEYBOARD AND PROBE
                     00663 ;*****************************************************************
                     00664 ;* CurPosKb
                     00665 ;* This subroutine places cursor in line 2 at position taken from the
                     00666 ;* lookup table: table offset is addressed by W at input, and table
                     00667 ;* read location by variable SUBMODE.
                     00668 ;* High timeout counter (TIMOUTH) is initialized. This sets automatic
                     00669 ;* Power Off timing to about 8 minutes. TIMOUTL is of minor importance
                     00670 ;* here (it affects less than 2 secs of timing), so it was not worth
                     00671 ;* waisting one instruction word.
                     00672 ;* Bit DEBO,0 set to disable false recognizing of PORTA,3 low level as
                     00673 ;* falling edge (as if key 2 was just pressed). This could happen if
                     00674 ;* some function was broken by pressing key2, as those are simple port
                     00675 ;* tests without affecting debouncer.
                     00676 ;* This subroutine continues to keyboard scan subroutine.
                     00677 ;*
                     00678 ;* Input variables: SUBMODE, affects cursor position
                     00679 ;* Output variables: TIMOUTH=0, high timeout counter
                     00680 ;*****************************************************************
0170                 00681 CurPosKb
0170  0711           00682         addwf  SUBMODE,W   ; add SUBMODE to lookup table offset
0171  23B6           00683         call   PclSub      ; get cursor position from table
0172  23CF           00684         call   WrComL      ; write new cursor position to LCD
0173  019C           00685         clrf   TIMOUTH
                     00686
0174  1412           00687         bsf    DEBO1,0     ; set any bit in both debouncers...
0175  1413           00688         bsf    DEBO2,0     ; ...to disable false recognizing of...
                     00689                            ; ...low level as falling edge
                     00690
```

```
                     00691 ;***********************************************************************
                     00692 ;* GoKbd
                     00693 ;* Is main keyboard subroutine, in which program loops all the time
                     00694 ;* except in freq counter mode, or while wait for start condition or
                     00695 ;* executing some command. Program exits subrout only if some key is
                     00696 ;* just pressed (not if continuosly pressed), or when timeout counter
                     00697 ;* (TIMOUTH, TIMOUTL) after 8 min reaches zero. If key 1 was pressed,
                     00698 ;* flag STATUS,C will be reset at exit, if key 2 was pressed, flag
                     00699 ;* STATUS,C will be set. If timeout detected, the routine SUICIDE is
                     00700 ;* executed (the unit is switched off forcing the output PORTB,3 low).
                     00701 ;* During keyboard scan, LEDs L, H and P are serviced. Logic state at
                     00702 ;* PORTA,4 affects LEDs L and H directly, and LED P is under control
                     00703 ;* of down counter PCOUNT. This counter is initialized at every logic
                     00704 ;* level transition at PORTA,4, and while counting down, if PCOUNT>0,
                     00705 ;* LED P is switched on.
                     00706 ;* Loop labeled "Unstable" adds the extra delay which timing is not
                     00707 ;* constant, but changes from 3 to 49t. This mins the interference
                     00708 ;* between the input scan and tested signal frequency.
                     00709 ;* Counter TMR0 is used for detecting of short pulses. At each
                     00710 ;* transition detected, TMR0 is cleared, then periodicaly tested if
                     00711 ;* counter state was incremented. If so, PCOUNT is initialized and LED
                     00712 ;* P turned on.
                     00713 ;* Register DJNZ is used as a freerunning counter, which divides loop
                     00714 ;* count by 256 and slows down PCOUNT countdown / keys scanning. Keys
                     00715 ;* are debounced and falling edge (pressing moment) detected by
                     00716 ;* rotating registers DEBO1 and DEBO2, and testing them if the key was
                     00717 ;* unpressed at least at 7 passes and then pressed at 1 pass.
                     00718 ;*
                     00719 ;* Input variables: none
                     00720 ;* Output variables: Bit STATUS,C reset if key 1 pressed, set if key 2
                     00721 ;***********************************************************************
0176                 00722 GoKbd
0176  080E           00723         movf   DJNZ,W      ; 1t to avoid intrference,total avg 29t
0177  38F0           00724         iorlw  0f0h        ; 1t extra time range from -.16 and -1
0178  008F           00725         movwf  SCRATCH     ; 1t here SCRATCH varies 0f0h to 0ffh
0179                 00726 UnStable
0179  0F8F           00727         incfsz SCRATCH,F   ; 1-17t (avg .9) adv extra timing count
017A  2979           00728         goto   UnStable    ; 2-32t (avg .17) loop loses extra time
                     00729
017B  0801           00730         movf   TMR0,W      ; TMR0 = hardware transition detector
017C  1903           00731         btfsc  STATUS,Z    ; test if transition at PORTA,4...
017D  2980           00732         goto   NoIniP      ; ...if not, do not affect LED P status
017E  1590           00733         bsf    PCOUNT,3    ; initialize PCOUNT for LED P timing
017F  0181           00734         clrf   TMR0        ; re-init hardware transition detector
0180                 00735 NoIniP
0180  3028           00736         movlw  28h         ; bit 4 (TOSE) RESET: L-to-H transition
0181  1A05           00737         btfsc  PORTA,4     ; if probe tip low,leave TOSE reset...
0182  3038           00738         movlw  38h         ; if high, set TOSE: H-to-L transition
                     00739
0183  1683           00740         bsf    STATUS,RP0  ; select bank 1 of registers
0184  0081           00741         movwf  OPTION_REG  ; set/reset TOSE
0185  1283           00742         bcf    STATUS,RP0  ; reselect bank 0
                     00743
0186  1019           00744         bcf    DELAYH,0    ; init input bit in delay HI rotor
0187  1018           00745         bcf    DELAYL,0    ; init input bit in delay LOW rotor
0188  3004           00746         movlw  4           ; value 4 = bit 2 set
0189  0686           00747         xorwf  PORTB,F     ; change state of PORTB.2 (square wave.
                     00748                            ; generation probe tip hi-imp output
018A  1A05           00749         btfsc  PORTA,4     ; test probe input logic level...
018B  2990           00750         goto   InputHi     ; ...and jump if case 2: input high
                     00751                            ; ...or continue if case 1: input low
018C  1D06           00752         btfss  PORTB,2     ; test hi-impedance output state and...
018D  1418           00753         bsf    DELAYL,0    ; ...turn on led L, hi-ipm out was lo
018E  110C           00754         bcf    FLAG,PTIP   ; reset flag to notify that previous...
                     00755                            ; ...state of probe tip was low
018F  2993           00756         goto   ContInpX    ; jump to skip case 2
```

```
0190                 00757 InputHi                     ; entry point for case 2: input high
0190  1906           00758         btfsc   PORTB,2     ; test hi-impedance output state and...
0191  1419           00759         bsf     DELAYH,0    ; ...turn on led L, PORTB,2 was high
0192  150C           00760         bsf     FLAG,PTIP   ; set flag to notify that previoust...
                     00761                             ; ...state of probe tip was high
0193                 00762 ContInpX                    ; moves LHP leds from FLAG to PORTB
0193  138C           00763         bcf     FLAG,LEDL   ; init input bit for led L delay rotor
0194  0898           00764         movf    DELAYL,F    ; test DEALYL status...
0195  1D03           00765         btfss   STATUS,Z    ; ...and skip if DELAYL=0
0196  178C           00766         bsf     FLAG,LEDL   ; turn on led L if DELAYL rotor > 0
0197  0D98           00767         rlf     DELAYL,F    ; propagate bit thru DELAYL rotor
                     00768
0198  130C           00769         bcf     FLAG,LEDH   ; init input bit for led H delay rotor
0199  0899           00770         movf    DELAYH,F    ; test DEALYH status...
019A  1D03           00771         btfss   STATUS,Z    ; ...and skip if DELAYH=0
019B  170C           00772         bsf     FLAG,LEDH   ; turn on led H if DELAYH rotor > 0
019C  0D99           00773         rlf     DELAYH,F    ; propagate bit thru DELAYH rotor
                     00774
019D  23F0           00775         call    MoveLESd    ; send leds status flag bits to PORTB
                     00776
019E  0F8E           00777         incfsz  DJNZ,F      ; test if this is 256th pass...
019F  2976           00778         goto    GoKbd       ; ...if not, loop
                     00779
                     00780 ;------------------------ passes here each 256 pass (about 8.9ms)
                     00781
01A0  128C           00782         bcf     FLAG,LEDP   ; reset led P flag (set if PCOUNT>0)
01A1  0890           00783         movf    PCOUNT,F    ; test PCOUNT status...
01A2  1903           00784         btfsc   STATUS,Z    ; ...and skip jump if PCOUNT>0
01A3  29A9           00785         goto    PCount0     ; ...else jump if PCOUNT = 0
                     00786
01A4  0390           00787         decf    PCOUNT,F    ; if PCOUNT>0, then decrement it
01A5  0818           00788         movf    DELAYL,W    ; W>0 if led L is on
01A6  0419           00789         iorwf   DELAYH,W    ; W>0 if led L or led H is on
01A7  1D03           00790         btfss   STATUS,Z    ; ...skip if both L and H leds are off
01A8  168C           00791         bsf     FLAG,LEDP   ; if PCOUNT>0, dec PCOUNT, & set led P
01A9                 00792 PCount0
                     00793                             ; ----------- key 2 test (right key)
01A9  0E05           00794         swapf   PORTA,W     ; let key 1&2 status move to bits 6&7
01AA  008F           00795         movwf   SCRATCH     ; SCRATCH,7=key2, SCARTCH,6=key1
01AB  098F           00796         comf    SCRATCH,F   ; complement to set bit if key pressed
                     00797
01AC  0D8F           00798         rlf     SCRATCH,F   ; set C if key 2 pressed
                     00799
01AD  0D93           00800         rlf     DEBO2,F     ; propagate key 2 bit thru rotor
01AE  1003           00801         bcf     STATUS,C    ; reset C,notify at exit key 2 pressed
01AF  0313           00802         decf    DEBO2,W     ; DEBO2 = b'00000001' if just pressed
01B0  1903           00803         btfsc   STATUS,Z    ; skip return if key 2 not just pressed
01B1  0008           00804         return              ; *** exit 1: key 2 just pressed (NC)
                     00805
                     00806                             ; ----------- key 1 test (left key)
                     00807
01B2  0D8F           00808         rlf     SCRATCH,F   ; set C if key 1 pressed
                     00809
01B3  0D92           00810         rlf     DEBO1,F     ; propagate key 1 bit thru rotor
01B4  1403           00811         bsf     STATUS,C    ; set C, notify at exit key 1 pressed
01B5  0312           00812         decf    DEBO1,W     ; DEBO1 = b'00000001' if just pressed
01B6  1903           00813         btfsc   STATUS,Z    ; skip return if key 1 not just pressed
01B7  0008           00814         return              ; *** exit 2: key 1 just pressed (C)
                     00815
01B8  0B9B           00816         decfsz  TIMOUTL,F   ; timeout lo counter...
01B9  2976           00817         goto    GoKbd       ; ... not yet zero: loop
                     00818
01BA  0B9C           00819         decfsz  TIMOUTH,F   ; timeout hi counter...
01BB  2976           00820         goto    GoKbd       ; ... not yet zero: loop
                     00821                             ; *** exit 3:cont with timeout process
                     00822
```

```
                    00823 ;*****************************************************************
                    00824 ;* Power Off entry point
                    00825 ;* Wait until both keys off for 34 ms, and then switch power off.
                    00826 ;* PORTB,3, when low, switches the unit off.
                    00827 ;*****************************************************************
01BC                00828 Suicide
01BC  21BF          00829         call    KeysOff     ; test keys off to avoud re-trigering
01BD  0186          00830         clrf    PORTB       ; pull PORTB,3 low to switch power off
01BE  29BE          00831         goto    $           ; loop until power off
                    00832
                    00833 ;*****************************************************************
                    00834 ;* KeysOff
                    00835 ;* Loop until both keys off for 34 ms, then exit
                    00836 ;*
                    00837 ;* Input variables: none
                    00838 ;* Output variables: TIMOUTH is cleared to 0
                    00839 ;*****************************************************************
01BF                00840 KeysOff
01BF  019C          00841         clrf    TIMOUTH     ; initialize pointer
01C0                00842 BothOff
01C0  1905          00843         btfsc   PORTA,2     ; skip if key 1 on
01C1  1D85          00844         btfss   PORTA,3     ; do not skip if key 2 on
01C2  29BF          00845         goto    KeysOff     ; reinitialize ptr if any key on
01C3  23D0          00846         call    loop130     ; loop 130us
01C4  0B9C          00847         decfsz  TIMOUTH,F   ; test pointer
01C5  29C0          00848         goto    BothOff     ; loop 256xs to verify both keys off
01C6  0008          00849         return              ; both keys are off for at least 34 ms
                    00850
                    00851 ;*******  ANALYZER
                    00852 ;*****************************************************************
                    00853 ;* Pointer2
                    00854 ;* Writes 2 measuring points for analyzer reference. 1st=TIMOUTL*10+5,
                    00855 ;* then TIMOUTL is incremented by 2 and the second one is TIMOUTL*10+0
                    00856 ;*
                    00857 ;* Input variables: TIMOUTL will first be printed as TIMOUTL*10+5
                    00858 ;* Output variables: TIMOUTL incremented by 3 (pointer advanced by 30)
                    00859 ;*****************************************************************
01C7                00860 Pointer2
01C7  21CF          00861         call    Pointer1    ; first two digits
01C8  3035          00862         movlw   '5'         ; third digit is 5 for odd pointer
01C9  0A9B          00863         incf    TIMOUTL,F   ; each incr advances pointer by 10
01CA  21CD          00864         call    AdvToCh     ; advance ptr and print "5"
01CB  21CF          00865         call    Pointer1    ; first two digits
01CC  304F          00866         movlw   'O'         ; third digit is 0 for even pointer
01CD                00867 AdvToCh
01CD  0A9B          00868         incf    TIMOUTL,F   ; each incr advances pointer by 10
01CE  2BD8          00869         goto    Char        ; print 0 or 5
                    00870
                    00871 ;*****************************************************************
                    00872 ;* Pointer1
                    00873 ;* Writes blank, then symbol "^" and then converts TIMOUTL and prints
                    00874 ;* as 2 digits.
                    00875 ;*
                    00876 ;* Input variables: TIMOUTL, bin value which prints as 2-digits
                    00877 ;* Output variables: none
                    00878 ;*****************************************************************
01CF                00879 Pointer1
01CF  23D7          00880         call    Blank       ; skip first 3 samples (one character)
01D0  305E          00881         movlw   '^'         ; "^" (pointing tool)
01D1                00882 PrintTL
01D1  23D8          00883         call    Char        ; print "^"
01D2  081B          00884         movf    TIMOUTL,W   ; TIMOUTL is the main pointer for...
01D3  2B70          00885         goto    Print255    ; ...first two digits
                    00886
                    00887 ;*****************************************************************
                    00888 ;* Mode1Show
```

```
                    00889 ;* Write measuring points at row 2, and wait until keys are released.
                    00890 ;* Then incr. SHOWCOU in range 0...4 and continue to Draw subroutine
                    00891 ;* This command,which executes when key 2 is pressed in analyzer mode,
                    00892 ;* while the cursor is on the number of 60-sample group, advances the
                    00893 ;* pointer.
                    00894 ;* It continues to Draw routine.
                    00895 ;*****************************************************************
01D4                00896 Mode1Show
01D4  23CE          00897         call    Row2        ; pointers are in row 2
01D5  1003          00898         bcf     STATUS,C    ; prepare for multiplying by 2
01D6  0D17          00899         rlf     SHOWCOU,W   ; W=SHOWCOU*2
01D7  009B          00900         movwf   TIMOUTL     ; TIMOUTL=SHOWCOU*2
01D8  0D9B          00901         rlf     TIMOUTL,F   ; TIMOUTL-SHOWCOU*4
01D9  079B          00902         addwf   TIMOUTL,F   ; TIMOUTL-SHOWCOU*6
                    00903
01DA  21C7          00904         call    Pointer2    ; print 1st and 2nd pointer
01DB  21C7          00905         call    Pointer2    ; print 3rd and 4th pointer
                    00906
01DC  21BF          00907         call    KeysOff     ; wait until key off
01DD  227D          00908         call    PrintM1     ; restore normal row 2
                    00909
01DE  0A97          00910         incf    SHOWCOU,F   ; advance number of groups displayed
01DF  1917          00911         btfsc   SHOWCOU,2   ; test if SHOWCOU=5: first test bit2...
01E0  1C17          00912         btfss   SHOWCOU,0   ; test if SHOWCOU=5: ...then test bit 0
01E1  29E3          00913         goto    Draw        ; skip wrapping if SHOWCOU<5
01E2  0197          00914         clrf    SHOWCOU     ; SHOWCOU cycle in range 0...4
                    00915
                    00916 ;*****************************************************************
                    00917 ;* Draw
                    00918 ;* This subroutine writes 20 pseudographic chars in line 1 in analyzer
                    00919 ;* mode. First, whole buffer is rotated 0/60/120/180/240 bit places to
                    00920 ;* the right (if SHOWCOU=0/1/2/3/4,respectively) to adj. the sequence
                    00921 ;* to be displayed to the start of the buffer. Then the string of 20
                    00922 ;* 3-bit groups is rotated right, and displayed as 20 special chars
                    00923 ;* (codes 0-7), defined at program setup (at loop labeled GoGraph).
                    00924 ;* Then the buffer is rotated again, to the total of 304 bit places,
                    00925 ;* so the buffer contents is unmodified on exit.
                    00926 ;*
                    00927 ;* Input variables:
                    00928 ;* SHOWCOU, denotes which group of 60 samples will be displayed
                    00929 ;* Output variables: none
                    00930 ;*****************************************************************
01E3                00931 Draw
01E3  0817          00932         movf    SHOWCOU,W   ; prep to rotate buf SHOWCOU*60 times
01E4  1D03          00933         btfss   STATUS,Z    ; avoid rotating if SHOWCOU=0
01E5  21F9          00934         call    Carusel     ; rotate buffer SHOWCOU*60 times
                    00935
01E6  22BF          00936         call    Row1        ; samples must be written in row 1
01E7  3014          00937         movlw   .20         ; .20 characters to write
01E8  0096          00938         movwf   CHARCOU     ; CHARCOU is the main character counter
01E9                00939 Go20Chars
01E9  018F          00940         clrf    SCRATCH     ; register for 3-bit code gen (0...7)
01EA  2202          00941         call    RRBuf       ; bit from buffer in C...
01EB  0D8F          00942         rlf     SCRATCH,F   ; ...bit from C in code register
01EC  2202          00943         call    RRBuf       ; bit from buffer in C...
01ED  0D8F          00944         rlf     SCRATCH,F   ; ...bit from C in code register
01EE  2202          00945         call    RRBuf       ; bit from buffer in C...
01EF  0D0F          00946         rlf     SCRATCH,W   ; ...bit from C in code reg and in W
01F0  23D9          00947         call    CharNCC     ; draw one char = 3 samples
01F1  0B96          00948         decfsz  CHARCOU,F   ; 20 characters written?
01F2  29E9          00949         goto    Go20Chars   ; no, loop
                    00950
01F3  0817          00951         movf    SHOWCOU,W   ; prep to rotate to total of 304 bits
01F4  3C04          00952         sublw   .4          ; W=4-SHOWCOU
01F5  1D03          00953         btfss   STATUS,Z    ; avoid rotating if SHOWCOU=0
01F6  21F9          00954         call    Carusel     ; rotate buffer again to restore it
```

```
01F7  2200            00955         call   RRBuf4      ; four more times to get 304 times
01F8  28CD            00956         goto   Farm1       ; done, go back to user interface
                      00957
                      00958 ;*****************************************************************
                      00959 ;* Carusel
                      00960 ;* This subroutine rotates BUFFER right W*60 times
                      00961 ;* Note: if W=0, rotating will be performed 1024 times
                      00962 ;*
                      00963 ;* Input variables: W,how many (*60) x the buf is rotated right (W>0)
                      00964 ;* Output variables: none
                      00965 ;*****************************************************************
01F9                  00966 Carusel
01F9  008F            00967         movwf  SCRATCH     ; SCRATCH=W
01FA  0E8F            00968         swapf  SCRATCH,F   ; SCRATCH=W*16
01FB  028F            00969         subwf  SCRATCH,F   ; SCRATCH=W*15
01FC                  00970 RRLoop
01FC  2200            00971         call   RRBuf4      ; 4 rotates in every pass
01FD  0B8F            00972         decfsz SCRATCH,F   ; done W*15*4 times?
01FE  29FC            00973         goto   RRLoop      ; no, continue rotating BUFFER
01FF  0008            00974         return             ; done
                      00975
                      00976 ;*****************************************************************
                      00977 ;* RRBuf4 executes RRBuf 4 times
                      00978 ;* RRBuf rotates buffer(38 bytes=304 bits) right for one bit position.
                      00979 ;* Bit STATUS,C is first loaded from the first bit in buffer, so
                      00980 ;* will rotating be completely performed at 304 bits, not through C.
                      00981 ;*
                      00982 ;* Input/Output variables: none
                      00983 ;*****************************************************************
0200                  00984 RRBuf4                     ; 4 times rotates right 38 bytes
0200  2201            00985         call   RRBuf2      ; rotate BUFFER 2* and then again 2*
0201                  00986 RRBuf2
0201  2202            00987         call   RRBuf       ; rotate BUFF once and then again once
0202                  00988 RRBuf                      ; rotates rt 38 bytes,bit in C at exit
0202  304B            00989         movlw  BUFFER+.37  ; start with last byte to be rotated
0203  0084            00990         movwf  FSR         ; FSR = pointing register for rotating
0204  3026            00991         movlw  .38         ; 38 bytes total buffer
0205  0094            00992         movwf  COUNT       ; byte counter
                      00993
0206  1003            00994         bcf    STATUS,C    ; C rotated into BUFFER+.37,so it...
0207  1826            00995         btfsc  BUFFER,0    ; ...must be equal to bit BUFFER+0,0...
0208  1403            00996         bsf    STATUS,C    ; ...to perform non-destruct rotating
0209                  00997 ByteLoop
0209  0C80            00998         rrf    INDF,F      ; byte rotated here
020A  0384            00999         decf   FSR,F       ; let FSR point to next byte
020B  0B94            01000         decfsz COUNT,F     ; COUNT is byte counter, done?
020C  2A09            01001         goto   ByteLoop    ; no, loop
020D  0008            01002         return             ; here the output bit is in STATUS,C
                      01003
                      01004 ;*****************************************************************
                      01005 ;* Mode1Go
                      01006 ;* This is entry point for analyzer start command (symbol * ). After
                      01007 ;* clearing line1 of LCD, the program vectors to routines which handle
                      01008 ;* different sampling rates. Three highest rates (1 MHz, 500 KHz and
                      01009 ;* 228 KHz are sampled at individual routines (Get1MHz, Get500KHz and
                      01010 ;* Get228KHz), andthe remining rates at routine GetSlowClk. All those
                      01011 ;* routines (except Get1MHz, which is location-sensitive (so it is at
                      01012 ;* the very beginning of the program), are listed here.
                      01013 ;*
                      01014 ;* Input/Output variables: none
                      01015 ;*****************************************************************
020E                  01016 Mode1Go                    ; *** ept: analyzer start
                      01017
020E  22B7            01018         call   ClrRow1     ; clear LCD line 1 and turn LEDs off
                      01019
020F  0815            01020         movf   RATE,W      ; RATE = sample rate in range 0...15
```

```
0210  1903           01021         btfsc  STATUS,Z    ; skip if sample rate>0
0211  2801           01022         goto   Get1MHz     ; jump to individual routine if RATE=0
                     01023
                     01024                            ; --- try 500 KHz rate
0212  008F           01025         movwf  SCRATCH     ; SCRATCH = RATE
0213  0B8F           01026         decfsz SCRATCH,F   ; test if RATE=1
0214  2A2B           01027         goto   Try228KHz   ; if not RATE=1, then try if RATE=2
                     01028                            ; if RATE=1, then drop to Get500KHz
                     01029
                     01030 ;*****************************************************************
                     01031 ;* Get500KHz
                     01032 ;* This subroutine fetches 304 samples at 2us rate (5 instr cycles
                     01033 ;* timing).
                     01034 ;* Call Common initializes loop counter (COUNT) to 38*8=304 samples
                     01035 ;* and FSR to point to BUFFER. It also presets T0SE bit depended on
                     01036 ;* XTOX bit (in FLAG register)to enable proper edge detecting, as it
                     01037 ;* will affect TMR0 state.
                     01038 ;* State of key 2(Break) tested while waiting for starting condition.
                     01039 ;*
                     01040 ;* Input/Output variables: none
                     01041 ;*****************************************************************
0215                 01042 Get500KHz                  ; 5 t read cycle
0215  3026           01043         movlw  .38         ; 38 bytes * 8 bits = 304 samples
0216  226F           01044         call   Common      ; initialize COUNT, FSR, hi-imp out...
                     01045                            ; ...bit XTOX and T0SE bit
0217                 01046 Edge500
0217  1D85           01047         btfss  PORTA,3     ; test status of key 2 and...
0218  28CC           01048         goto   Break       ; ...jump to Break routine if pressed
                     01049
0219  0801           01050         movf   TMR0,W      ; TMR0 = logic level edge detector
021A  1903           01051         btfsc  STATUS,Z    ; test if there was egde...
021B  2A17           01052         goto   Edge500     ; ...and loop if not
021C  0384           01053         decf   FSR,F       ; adj pointer as it will be advanced...
                     01054                            ; ... before data write
021D                 01055 Get500Loop
021D  0C85           01056         rrf    PORTA,F     ; <-- move input status to C
021E  0A84           01057         incf   FSR,F       ; advance write pointer
021F  0C80           01058         rrf    INDF,F      ; write bit C in destination rotor
0220  3006           01059         movlw  .6          ; initialize count for 6 bits
0221  008E           01060         movwf  DJNZ        ; DJNZ = bit counter
0222                 01061 Go6Bits
0222  0C85           01062         rrf    PORTA,F     ; <-- 6*  move input status to C
0223  0C80           01063         rrf    INDF,F      ; write bit C in destination rotor
0224  0B8E           01064         decfsz DJNZ,F      ; DJNZ = bit counter
0225  2A22           01065         goto   Go6Bits     ; loop if not yet 6 bits fetched
                     01066
0226  0C85           01067         rrf    PORTA,F     ; <--     move input status to C
0227  0C80           01068         rrf    INDF,F      ; write bit C in destination rotor
0228  0B94           01069         decfsz COUNT,F     ; COUNT = byte counter
0229  2A1D           01070         goto   Get500Loop  ; loop if not yet 38 bytes fetched
022A  2A6A           01071         goto   Finished    ; all bits fetched; go display them
                     01072
                     01073 ;*****************************************************************
                     01074 ;* Test if register SCRATCH reaches 0 after decrementing(this happens
                     01075 ;* if RATE = 2), if so drop to Get228KHz else go to GetSlowClk
                     01076 ;*****************************************************************
022B                 01077 Try228KHz
022B  0B8F           01078         decfsz SCRATCH,F   ; test RATE status (SCRATCH=RATE-1)
022C  2A3F           01079         goto   GetSlowClk  ; jump if not RATE=2
                     01080
                     01081 ;*****************************************************************
                     01083 ;* This subroutine fetches 304 samples at 4.4us rate (11 instruction
                     01084 ;* cycles timing).
                     01085 ;* Call Common304 initializes loop counter (COUNT) to 304 samples
                     01086 ;* and FSR to point to BUFFER. It also presets T0SE bit depended on
                     01087 ;* XTOX bit (in FLAG register)to enable proper edge detecting, as it
```

```
                  01088 ;* will affect TMR0 state.
                  01089 ;* State of key 2(Break) tested while waiting for starting condition.
                  01090 ;*
                  01091 ;* Input/Ouput variables: none
                  01092 ;*****************************************************************
022D              01093 Get228KHz                 ; 11 t read cycle
022D  226C        01094         call    Common304  ; init COUNT(lo), TIMOUTH(hi byte)...
                  01095                            ; ...FSR, hi-imp outbit XTOX & T0SE bit
022E              01096 Edge228
022E  1D85        01097         btfss   PORTA,3    ; test status of key 2 and...
022F  28CC        01098         goto    Break      ; ...jump to Break routine if pressed
                  01099
0230  0801        01100         movf    TMR0,W     ; TMR0 = logic level edge detector
0231  1903        01101         btfsc   STATUS,Z   ; test if there was egde...
0232  2A2E        01102         goto    Edge228    ; ...and loop if not
0233              01103 Go228
0233  2A34        01104         goto    $+1        ; 2     two extra cycles to make 11t
0234              01105 Go228B
0234  0C85        01106         rrf     PORTA,F ; <---  ; 1     move input bit to C
0235  0C80        01107         rrf     INDF,F     ; 1     write bitC in destination rotor
                  01108
0236  0314        01109         decf    COUNT,W    ; 1     COUNT = bit counter
0237  3907        01110         andlw   7          ; 1     test if 8th pass...
0238  1903        01111         btfsc   STATUS,Z   ; 1 (2) ...and skip if not
0239  0A84        01112         incf    FSR,F      ; 1 (0) ...else advance pointer
                  01113
023A  0B94        01114         decfsz  COUNT,F    ; 1     COUNT = (lo byte) bit counter
023B  2A33        01115         goto    Go228      ; 2     loop if not yet = 0
                  01116
023C 0B9C         01117         decfsz  TIMOUTH,F      ; TIMOUTH = (hi byte) bit counter
023D 2A34         01118         goto    Go228B         ; this does not add extra cycles, as it
                  01119                                ; ...jumps after goto $+1
023E 2A6A         01120         goto    Finished       ; all bits fetched; go display them
                  01121
                  01122 ;*****************************************************************
                  01123 ;* GetSlowClk
                  01124 ;* This subroutine fetches 304 samples at variable rate, depended on
                  01125 ;*  RATE (SCRATCH=RATE-3). Timing constant is loaded from lookup table
                  01126 ;*  located at DATA EEPROM (locations 30h-3ch).
                  01127 ;*
                  01128 ;* Call Common304 initializes 16-bit loop counter to 304 samples
                  01129 ;*  (lo byte: COUNT=.304-.256, hi byte: TIMOUTH=.1)
                  01130 ;*  and FSR to point to BUFFER. It also presets T0SE bit depended on
                  01131 ;*  XTOX bit (in FLAG register)to enable proper edge detecting, as it
                  01132 ;*  will affect TMR0 state.
                  01133 ;*
                  01134 ;* Rates 3-11 (100KHz-2.4KHz) have loop period of factor from EEPROM
                  01135 ;*  table multiplied by 5 instruction cycles and adding 20 instruction
                  01136 ;*  cycles (Factor*5T+20T), and rates 12-15 (1.2KHz-40Hz) multilied the
                  01137 ;*  factor by 417 instruction cycles and adding 415 instruction cycle
                  01138 ;*  (Factor*417T+415T)
                  01139 ;*
                  01140 ;*  RATE =  3, factor:   1, T/cycle:    25, Freq:  100   KHz
                  01141 ;*  RATE =  4, factor:   6, T/cycle:    50, Freq:   50   KHz
                  01142 ;*  RATE =  5, factor:   9, T/cycle:    65, Freq:   38.4 KHz
                  01143 ;*  RATE =  6, factor:  16, T/cycle:   100, Freq:   25   KHz
                  01144 ;*  RATE =  7, factor:  22, T/cycle:   130, Freq:   19.2 KHz
                  01145 ;*  RATE =  8, factor:  46, T/cycle:   250, Freq:   10   KHz
                  01146 ;*  RATE =  9, factor:  48, T/cycle:   260, Freq:    9.6 KHz
                  01147 ;*  RATE = 10, factor: 100, T/cycle:   520, Freq:    4.8 KHz
                  01148 ;*  RATE = 11, factor: 204, T/cycle:  1040, Freq:    2.4 KHz
                  01149 ;*  RATE = 12, factor:   5, T/cycle:  2500, Freq:    1   KHz
                  01150 ;*  RATE = 13, factor:  14, T/cycle:  6253, Freq:  400    Hz
                  01151 ;*  RATE = 14, factor:  59, T/cycle: 25018, Freq:  100    Hz
                  01152 ;*  RATE = 15, factor: 149, T/cycle: 62548, Freq:   40    Hz
                  01153 ;*
```

```
                 01154 ;* State of key 2 (Break) is tested while waiting for start condition.
                 01155 ;* LED P is turned on while sampling, indicate sample period at slower
                 01156 ;*  rates, in which it appears to be visible.
                 01157 ;*
                 01158 ;* Input variables: RATE, affects timing factor
                 01159 ;* Output variables: none
                 01160 ;*****************************************************************
023F             01161 GetSlowClk
023F 030F        01162         decf    SCRATCH,W       ; W = RATE-3
0240 3E30        01163         addlw   .48             ; rate table in data eeprom @ addr .48
                 01164
0241 22AC        01165         call    AGet_EE         ; get time const. from dataeeprom table
0242 008F        01166         movwf   SCRATCH         ; time const for rates 3-15 -> SCRATCH
                 01167
0243 226C        01168         call    Common304       ; init COUNT(lo), TIMOUTH(hi byte)...
                 01169                                 ; ...FSR, hi-imp outbit XTOX & T0SE bit
0244             01170 EdgeSlow
0244 1D85        01171         btfss   PORTA,3         ; test status of key 2 and...
0245 28CC        01172         goto    Break           ; ...jump to Break routine if pressed
                 01173
0246 0801        01174         movf    TMR0,W          ; TMR0 = logic level edge detector
0247 1903        01175         btfsc   STATUS,Z        ; test if there was egde...
0248 2A44        01176         goto    EdgeSlow        ; ...and loop if not
                 01177
0249 1686        01178         bsf     PORTB,5         ; turn led P on, notify sampling on
                 01179
024A             01180 GoSlow
024A 0C85        01181         rrf     PORTA,F ; <---  ; 1     move input bit to C
024B 0C80        01182         rrf     INDF,F          ; 1     write bitC in destination rotor
                 01183
024C 0314        01184         decf    COUNT,W         ; 1     COUNT = bit counter
024D 3907        01185         andlw   7               ; 1     test if 8th pass...
024E 1903        01186         btfsc   STATUS,Z        ; 1 (2) ...and skip if not
024F 0A84        01187         incf    FSR,F           ; 1 (0) ...else advance pointer
                 01188
0250 1995        01189         btfsc   RATE,3          ; 1 1   if bits2 and 3 cleared, that...
0251 1D15        01190         btfss   RATE,2          ; 2 1   ...means that rate<12...
0252 2A62        01191         goto    Not417          ; - 2   ...if so, jump to short timing
                 01192                                 ; --------417 (RATE 12-15,bits 2,3 set)
0253 080F        01193         movf    SCRATCH,W       ; 1       SCRATCH = timing constant
0254 0096        01194         movwf   CHARCOU         ; 1       CHARCOU = loop counter
0255             01195 Loop417                         ;   \
0255 3052        01196         movlw   .82             ; 1  \
0256 008E        01197         movwf   DJNZ            ; 1   \
0257 23D3        01198         call    Loop7           ; 411  > total cyc here 417*SCRATCH-1
0258 0000        01199         nop                     ; 1   /
0259 0B96        01200         decfsz  CHARCOU,F       ; 1  / 2t at exit only
025A 2A55        01201         goto    Loop417         ; 2 /  0t at exit only
                 01202
025B 0806        01203         movf    PORTB,W         ; 1
025C 39DF        01204         andlw   0dfh            ; 1     reset bit 5 (LED P)
025D 1E14        01205         btfss   COUNT,4         ; 1 2
025E 3820        01206         iorlw   20h             ; 1 0  set bit 5 (LED P) if COUNT,4 = 0
025F 0086        01207         movwf   PORTB           ; 1    blink LED P while sampling each
                 01208                                 ;       16th pass
0260 304E        01209         movlw   .78             ; 1    constant for long timing
0261 2A64        01210         goto    SameAs5         ; 2    skip short timing
0262             01211 Not417                          ; ---------- 5 (RATE 3-11)
0262 2A63        01212         goto    $+1             ; 2    waist 2 cycles
0263 080F        01213         movf    SCRATCH,W       ; 1    SCRATCH = timing constant
0264             01214 SameAs5                         ; ---------- 417 and 5 (RATE 3-15)
0264 008E        01215         movwf   DJNZ            ; 1    DJNZ = loop counter
0265 23D2        01216         call    GoLoop          ; short time: 3T+5T*SCRATCH, long:393T
                 01217
0266 0B94        01218         decfsz  COUNT,F         ; 1    COUNT = (lo byte) bit counter
0267 2A4A        01219         goto    GoSlow          ; 2    loop if not yet = 0
```

```
                  01220
0268 0B9C         01221         decfsz  TIMOUTH,F       ; TIMOUTH = (hi byte) bit counter
0269 2A4A         01222         goto    GoSlow          ; adds 2T extra 1time, after 48th pass
026A              01223 Finished
026A 0197         01224         clrf    SHOWCOU         ; reset pointer to 1st group of 60 samp
026B 29E3         01225         goto    Draw            ; all bits fetched; display them
                  01226
                  01227 ;*****************************************************************
                  01228 ;* Common304
                  01229 ;* This subroutine initializes low byte loop counter (COUNT) to 304
                  01230 ;*  samples (lo byte: COUNT=.304-.256, hi byte: TIMOUTH=.1+1)
                  01231 ;*  and FSR to point to BUFFER. It also presets T0SE bit depended on
                  01232 ;*  XTOX bit (in FLAG register)to enable proper edge detecting, as it
                  01233 ;*  will affect TMR0 state.
                  01234 ;* Entry point Common allows subroutines Get1MHz and GetSlowClk to
                  01235 ;*  preset COUNT to another values.
                  01236 ;*
                  01237 ;* Input variables:
                  01238 ;*    For entry point COMMON, register W is placed in COUNT
                  01239 ;* Output variables:
                  01240 ;*    COUNT is initialized to # of loop passes (W or low byte of 304)
                  01241 ;*    TMR0 is cleared
                  01242 ;*    T0SE and PORTB,2 are copied from FLAG,XTOX
                  01243 ;*****************************************************************
026C              01244 Common304
026C 3002         01245         movlw   .2              ; hi byte=2 for reg lo byte value...
                  01246                                 ; ...plus extra 256 passes
026D 009C         01247         movwf   TIMOUTH         ; hi byte loop counter for 304 passes
026E 3030         01248         movlw   .304-.256       ; lo byte value for 304 passes
026F              01249 Common
026F 0094         01250         movwf   COUNT           ; COUNT = loop counter
0270 3026         01251         movlw   BUFFER          ; first byte of destination
0271 0084         01252         movwf   FSR             ; FSR = destination pointer
                  01253
0272 3028         01254         movlw   28h             ; initialize T0SE fot L-to-H transition
0273 1106         01255         bcf     PORTB,2         ; clr hi-imp out if expecting rise edge
                  01256
0274 1A0C         01257         btfsc   FLAG,XTOX       ; test slctd edge for start condition
0275 2A78         01258         goto    ToOption        ; and skip falling edge if rise slctd
                  01259
0276 3038         01260         movlw   38h             ; initialize T0SE fot H-to-L transition
0277 1506         01261         bsf     PORTB,2         ; set hi-imp out if expecting fall edge
0278              01262 ToOption
0278 1683         01263         bsf     STATUS,RP0      ; select bank 1 of registers
0279 0081         01264         movwf   OPTION_REG      ; set/reset TOSE
027A 1283         01265         bcf     STATUS,RP0      ; reselect bank 0
027B 0181         01266         clrf    TMR0            ; initialize TMR0 as edge detector
027C 0008         01267         return                  ; finished
                  01268
                  01269 ;*****************************************************************
                  01270 ;* PrintM1
                  01271 ;* Print string at line 2 in analyzer mode.
                  01272 ;* At pos 0, rate in format XX[[.]X][M|K]Hz/XX[[.]X][u|m]s is printed.
                  01273 ;*  Those values picked from table located in Data EEPROM, locations
                  01274 ;*  0-2Fh. Register CHARCOU is used to fill blanks up to pos 13 in line
                  01275 ;*  2, to disable phantom characters appearance when changing rate from
                  01276 ;*  some long-string to short-string value.
                  01277 ;* Symbol for starting or rising edge for starting event is written at
                  01278 ;*  pos 13, symbol "*" for start command at pos 15 and the number of
                  01279 ;*  group displayed at pos. 17.
                  01280 ;*
                  01281 ;* Input variables:
                  01282 ;*    RATE will be printed in pos 0, row2
                  01283 ;*    bit FLAG,XTOX affects the printed symbol of rising/falling edge
                  01284 ;*    SHOWCOU (number of group displayed) is printed as numeric (+1)
                  01285 ;* Output variables: none
```

```
                    01286 ;*****************************************************************
027D                01287 PrintM1
027D 23CE           01288         call    Row2            ; move cursor to row 2
                    01289
027E 300D           01290         movlw   .13             ; init counter for 13 char fix format
027F 0096           01291         movwf   CHARCOU         ; CHARCOU = character counter
                    01292
0280 0815           01293         movf    RATE,W          ; W = RATE
0281 0715           01294         addwf   RATE,W          ; W = 2 * RATE
0282 0715           01295         addwf   RATE,W          ; W = 3 * RATE (ea rate has 3 bytes
                    01296                                 ;                  in table)
0283 22AC           01297         call    AGet_EE         ; get 1st byte via table in data eeprom
0284 009B           01298         movwf   TIMOUTL         ; TIMOUTL = 1st byte from table
0285 0E1B           01299         swapf   TIMOUTL,W       ; move to bits 0-3, bits 4-7 are freq
                    01300
0286 22AD           01301         call    Get_EE          ; get 2nd byte via table in data eeprom
                    01302
0287 1B1B           01303         btfsc   TIMOUTL,6       ; bit 6 = decimal point for frequency
0288 148C           01304         bsf     FLAG,DP         ; set decimal point bit if bit 6 set
                    01305
0289 2373           01306         call    Print3          ; display sampling frequency
                    01307
028A 304D           01308         movlw   'M'             ; for "MHz" display
028B 0895           01309         movf    RATE,F          ; if RATE=0...
028C 1D03           01310         btfss   STATUS,Z        ; ...then let it be MHz
028D 304B           01311         movlw   'K'             ; for "KHz" display
028E 1B9B           01312         btfsc   TIMOUTL,7       ; bit 7=KHz or MHz,skip 1st char if clr
028F 23D8           01313         call    Char            ; print "M" or "K" if bit 7 set
0290 3070           01314         movlw   TxtHz-1+1       ; for "Hz" display
0291 23DD           01315         call    Write           ; print "Hz"
                    01316
0292 081B           01317         movf    TIMOUTL,W       ; TIMOUTL = 1st byte from table
                    01318
0293 22AD           01319         call    Get_EE          ; get 2nd byte via table in data eeprom
                    01320
0294 191B           01321         btfsc   TIMOUTL,2       ; bit 2 = decimal point for period
0295 148C           01322         bsf     FLAG,DP         ; set decimal point bit if bit 2 set
                    01323
0296 2373           01324         call    Print3          ; display digits for period
                    01325
0297 30E4           01326         movlw   0e4h            ; Greek "micro"
0298 1D9B           01327         btfss   TIMOUTL,3       ; if bit 3 set, let it be "micro"
0299 306D           01328         movlw   'm'             ; ...if not, convert to "milli" (m)
029A 23D8           01329         call    Char            ; print "micro" or "m"
029B 3073           01330         movlw   's'             ; s stands for seconds
029C 23D8           01331         call    Char            ; print "s"
029D                01332 XtraChar                        ; adds extra (CHARCOU) blanks
029D 3020           01333         movlw   ' '             ; print blank to overprint prev string
029E 23D9           01334         call    CharNCC         ; print blank without affecting CHARCOU
029F 0B96           01335         decfsz  CHARCOU,F       ; CHARCOU=character counter
02A0 2A9D           01336         goto    XtraChar        ; loop if not yet pos 13
                    01337
                    01338                                 ; ----- here is start condition symbol
02A1 3001           01339         movlw   1               ; symbol of rising edge
02A2 1E0C           01340         btfss   FLAG,XTOX       ; let it be rising if XTOX set
02A3 3004           01341         movlw   4               ; symbol of falling edge
02A4 23D6           01342         call    CharBl          ; print symbol and blank
02A5                01343 KaoAna                          ; ----- here is "start" ("*") symbol
02A5 302A           01344         movlw   '*'             ; "start" symbol
02A6 23D6           01345         call    CharBl          ; print "start" symbol and blank
                    01346                                 ; --- here follows # of 60 smples group
02A7 0A17           01347         incf    SHOWCOU,W       ; SHOWCOU =  number of 60 samples group
02A8 23C9           01348         call    Num             ; print it (incremented by 1)
02A9 23D7           01349         call    Blank           ; print blank
02AA                01350 Arrow
02AA 307E           01351         movlw   7eh             ; 7Eh=right arrow in LM032L char set
```

```
02AB 2BD8          01352         goto    Char            ; print arrow in rightmost pos
                   01353
                   01354 ;*****************************************************************
                   01355 ;* AGet_EE
                   01356 ;* Get_EE
                   01357 ;*  This is routine for reading from Data EEPROM. Writing to BIN4+0 and
                   01358 ;*  BIN4+1 is also integrated here, as those variables are used for bin
                   01359 ;*  to decimal conversion.
                   01360 ;*
                   01361 ;* Input variables: W, data address at AGet_EE
                   01362 ;* Output variables: BIN4, binary data of rate display from DATA EEPROM
                   01363 ;*****************************************************************
02AC               01364 AGet_EE
02AC 0089          01365         movwf   EEADR           ; initialize eeprom address pointer
02AD               01366 Get_EE
02AD 3903          01367         andlw   3               ; hi byte BIN4 for freq display
02AE 009F          01368         movwf   BIN4+1          ; BIN4+1 = hi byte for range 0...999
                   01369
02AF 1683          01370         bsf     STATUS,RP0      ; select bank 1 of registers
02B0 1408          01371         bsf     EECON1,RD       ; set handshaking bit for data ee read
02B1 1283          01372         bcf     STATUS,RP0      ; reselect bank 0
02B2 0808          01373         movf    EEDATA,W        ; reading from data eeprom
02B3 0A89          01374         incf    EEADR,F         ; adv address pointer for future read
02B4 009E          01375         movwf   BIN4            ; lo byte BIN4 for freq display
02B5 108C          01376         bcf     FLAG,DP         ; clear decimal point flag
02B6 0008          01377         return                  ; finished
                   01378
                   01379 ;*****************************************************************
                   01380 ;* ClrRow1
                   01381 ;* SameAs20
                   01382 ;* This subroutine clears line 1 of LCD and switches off LEDs. Entry
                   01383 ;*  point SameAs20 allows clearing some other number of character
                   01384 ;*  positions starting from line 1 of LCD. Alll LEDs are turned off,
                   01385 ;*  flags for LEDs also Cursor pointer of LCD is restored to first pos
                   01386 ;*  of line 1 at exit of subroutine.
                   01387 ;*
                   01388 ;* Input variables:
                   01389 ;*          entry point ClrRow1:  none
                   01390 ;*          entry point SameAs20: W=number of characters to be cleared
                   01391 ;* Output variables:
                   01392 ;*          CHARCOU is decremented by the number of cleared characters
                   01393 ;*          SHOWCOU is cleared to 0
                   01394 ;*****************************************************************
                   01395 ;* Row1
                   01396 ;*  This subroutine moves cursor to pos 0 of row 1 on LCD.
                   01397 ;*
                   01398 ;*  Input variables: none
                   01399 ;*  Output variables: none
                   01400 ;*****************************************************************
02B7               01401 ClrRow1
02B7 3014          01402         movlw   .20             ; 20 spaces (one row) to write
02B8               01403 SameAs20
02B8 0097          01404         movwf   SHOWCOU         ; SHOWCOU = space counter
02B9 22BF          01405         call    Row1            ; move cursor to row 1
02BA               01406 LoopClD
02BA 23D7          01407         call    Blank           ; print one space
02BB 0B97          01408         decfsz  SHOWCOU,F       ; SHOWCOU = space counter
02BC 2ABA          01409         goto    LoopClD         ; loop if not yet 20 spaces
                   01410
02BD 301F          01411         movlw   1fh             ; bits 7,6,5 (LED flags) reset
02BE 058C          01412         andwf   FLAG,F          ; turn LED flags off
02BF               01413 Row1
02BF 3080          01414         movlw   080h            ; command for line 1
02C0 2BCF          01415         goto    WrComL          ; go write command
                   01416
                   01417 ;*******  SERIAL CODE RECEIVER
```

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                 01418 ;*******************************************************************
                 01419 ;* Mode2Show
                 01420 ;* This subroutine advances SHOWCOU in range 0...5, and then continues
                 01421 ;*  to subroutine Show2
                 01422 ;*******************************************************************
02C1             01423 Mode2Show
02C1 0A97        01424         incf    SHOWCOU,F       ; advance SHOWCOU
02C2 1917        01425         btfsc   SHOWCOU,2       ; bits 1 & 2 will be set if SHOWCOU...
02C3 1C97        01426         btfss   SHOWCOU,1       ; ...is equal to 5...
02C4 2AC6        01427         goto    Show2           ; ...if not, skip clearing
02C5 0197        01428         clrf    SHOWCOU         ; cycle show counter in range 0...5
                 01429
                 01430 ;*******************************************************************
                 01431 ;* Show2
                 01432 ;* This subroutine prints the 7 bytes of Buffer (+0,+7,+14,+21,+28 or
                 01433 ;*  +35) in hex mode at line 1, and the same bytes in ASCII at line 2.
                 01434 ;*  ASCII representation is with bit 7 reset, and non-printables (<20h)
                 01435 ;*  are printed as dots
                 01436 ;*
                 01437 ;* Input variables:
                 01438 ;*     SHOWCOU, denotes which group of 7 bytes will be displayed
                 01439 ;* Output variables:
                 01440 ;*     CHARCOU is decremented by the number of characters printed
                 01441 ;*******************************************************************
02C6             01442 Show2
02C6 3025        01443         movlw   BUFFER-1        ; source pointer for reading -1
02C7 1917        01444         btfsc   SHOWCOU,2       ; if bit 2 of SHOWCOU set...
02C8 3E1C        01445         addlw   .28             ; ...then add 28 (4 groups) to pointer
02C9 1897        01446         btfsc   SHOWCOU,1       ; if bit 1 of SHOWCOU set...
02CA 3E0E        01447         addlw   .14             ; ...then add 14 (2 groups) to pointer
02CB 1817        01448         btfsc   SHOWCOU,0       ; if bit 0 of SHOWCOU set...
02CC 3E07        01449         addlw   .7              ; ...then add 7 to pointer
02CD 0084        01450         movwf   FSR             ; FSR on (1st byte pos)-1 to display
                 01451
02CE 22BF        01452         call    Row1            ; move cursor to row 1
02CF 3007        01453         movlw   .7              ; bytes to display
02D0 008F        01454         movwf   SCRATCH         ; SCRATCH = byte display counter
02D1             01455 Hex7
02D1 0A84        01456         incf    FSR,F           ; adv pointer (it was x-1 at beginning)
02D2 0E00        01457         swapf   INDF,W          ; move hi nibble to display1. hex digit
02D3 23F8        01458         call    HexDigit        ; display 1st digit in hex mode
02D4 0800        01459         movf    INDF,W          ; move lo nibble to disp 2nd hex digit
02D5 23F8        01460         call    HexDigit        ; display 2nd digit in hex mode
02D6 23D7        01461         call    Blank           ; blank after hex number
                 01462
02D7 0B8F        01463         decfsz  SCRATCH,F       ; SCRATCH = byte counter
02D8 2AD1        01464         goto    Hex7            ; loop if not yet 7 bytes
                 01465
02D9 0804        01466         movf    FSR,W           ; FSR = read pointer
02DA 3EF9        01467         addlw   -.7             ; restore it for ASCII mode printing
02DB 0084        01468         movwf   FSR             ; FSR on (1st byte pos)-1 to display
                 01469
02DC 23CE        01470         call    Row2            ; move cursor to row 2
02DD 3007        01471         movlw   .7              ; bytes to display
02DE 008F        01472         movwf   SCRATCH         ; SCRATCH = byte display counter
02DF             01473 Ascii7
02DF 0A84        01474         incf    FSR,F           ; adv pointer (it was x-1 at beginning)
02E0 0800        01475         movf    INDF,W          ; read byte
02E1 397F        01476         andlw   7fh             ; reduce ascii representation to 7 bits
                 01477
02E2 3EE0        01478         addlw   -20h            ; test if byte < 20h
02E3 3E20        01479         addlw   20h             ; restore previous value
02E4 1803        01480         btfsc   STATUS,C        ; C is set if byte < 20h
02E5 30A5        01481         movlw   0a5h            ; represent non-printables as dots
                 01482                                 ; (0a5h = dot)
02E6 23D8        01483         call    Char            ; display ascii char
```

```
                 01484
02E7 0B8F        01485         decfsz  SCRATCH,F       ; SCRATCH = byte counter
02E8 2ADF        01486         goto    Ascii7          ; loop if not yet 7 bytes
                 01487
02E9 28ED        01488         goto    Farm2           ; go back to user interface
                 01489
                 01490 ;*****************************************************************
                 01491 ;* Mode2Go
                 01492 ;* This is entry point for Start command in mode 2 (serial code rcver)
                 01493 ;*  Line 1 and first 7 positions (ASCII chars) of line 2 on LCD is clr.
                 01494 ;*  Here, buffer is cleared and a sequence of 42 bytes are received and
                 01495 ;*  written to buffer. Manual break (key 2) jumps to Break handling.
                 01496 ;* This protocol is used: High start bit, 7 or 8 data (true) bits, 0 or
                 01497 ;*  1 parity bit (not written to memory) and 1 low stop bit (not tested
                 01498 ;*  for validity). If RXBITS,2 is set then the input is inverted.
                 01499 ;* Baud rates 1200-115200 are supported.
                 01500 ;* Note: no receive errors are detected nor indicated.
                 01501 ;*
                 01502 ;* Input variables:
                 01503 ;*  RXRATE (range 0...7),which affects timing loaded via table BaudRate
                 01504 ;*  RXBITS, bits 0-2 significant:bit0=parity,bit1=7/8 bits,bit2=inverse
                 01505 ;*
                 01506 ;*  Output variables:
                 01507 ;*  Buffer (42 bytes) loaded with bytes received, all unreceived bytes
                 01508 ;*  represented as 00s.
                 01509 ;*****************************************************************
02EA             01510 Mode2Go
02EA 1106        01511         bcf     PORTB,2         ; clear hi-imp probe output...
02EB 190D        01512         btfsc   RXBITS,2        ; ...let it be low if polarity bit clr
02EC 1506        01513         bsf     PORTB,2         ; set hi-imp output if polarity bit set
02ED 23B7        01514         call    ClrBuf          ; clear wholw buffer
02EE 302F        01515         movlw   .47             ; .47 blanks to clear displayed values
02EF 22B8        01516         call    SameAs20        ; clear displayed HEX and ASCII values
                 01517
02F0 3026        01518         movlw   BUFFER          ; start of buffer...
02F1 0084        01519         movwf   FSR             ; ...assigned to destination pointer
                 01520
02F2 081D        01521         movf    RXRATE,W        ; RXRATE = selected rate in range 0...7
02F3 3E68        01522         addlw   BaudRate        ; add to timing constant table offset
02F4 23B6        01523         call    PclSub          ; get rate to W
02F5             01524 RX42Bytes
02F5 008E        01525         movwf   DJNZ            ; baudrate timing factor to time cnter
                 01526
02F6 0194        01527         clrf    COUNT           ; this is to preset bit counter to 8...
02F7 1594        01528         bsf     COUNT,3         ; ...and not to disturb W
                 01529
02F8 1C0D        01530         btfss   RXBITS,0        ; RXBITS,0 is set if 7 bits selected
02F9 1C8D        01531         btfss   RXBITS,1        ; RXBITS,1 is set if parity bit select
02FA 0A94        01532         incf    COUNT,F         ; if not(RXBITS and 3 = 2) then COUNT=9
                 01533
02FB 180D        01534         btfsc   RXBITS,0        ; RXBITS,0 is set if 7 bits selected
02FC 188D        01535         btfsc   RXBITS,1        ; RXBITS,1 is set if parity bit select
02FD 0394        01536         decf    COUNT,F         ; ifnot(RXBITS and 3=1)reduce to 8 or 7
                 01537
02FE 1D0D        01538         btfss   RXBITS,2        ; RXBITS,2 set if inverse polar slctd
02FF 2B07        01539         goto    GetSp2          ; jump to true polarity if RXBITS,2 clr
                 01540
0300             01541 GetSp1                          ; ----- inverse rx
0300 1E05        01542         btfss   PORTA,4         ; test input status...
0301 2B00        01543         goto    GetSp1          ; ...and loop if still low
0302             01544 GetStart1
0302 1D85        01545         btfss   PORTA,3         ; test status of key 2...
0303 28E8        01546         goto    BrkRS           ; ...and jump to Break if presseed
0304 1A05        01547         btfsc   PORTA,4         ; test input status...
0305 2B02        01548         goto    GetStart1       ; ...and loop if still high
0306 2B0D        01549         goto    StartFound      ; falling edge detected: start recept
```

```
                 01550
0307             01551 GetSp2                          ; ----- true rx
0307 1A05        01552         btfsc   PORTA,4         ; test input status...
0308 2B07        01553         goto    GetSp2          ; ...and loop if still high
0309             01554 GetStart2
0309 1D85        01555         btfss   PORTA,3         ; test status of key 2...
030A 28E8        01556         goto    BrkRS           ; ...and jump to Break if presseed
030B 1E05        01557         btfss   PORTA,4         ; test input status...
030C 2B09        01558         goto    GetStart2       ; ...and loop if still low
                 01559                                 ; rising edge detected: start reception
030D             01560 StartFound
                 01561                                 ; 2-9 t from starting edge
030D             01562 HalfBit
030D 1686        01563         bsf     PORTB,5         ; 1*W led P on
030E 0000        01564         nop                     ; 1*W waist one cycle
030F 0B8E        01565         decfsz  DJNZ,F          ; 1*W DJNZ = timing constant counter
0310 2B0D        01566         goto    HalfBit         ; 2*W loop if not half bit timing passd
                 01567
0311             01568 RX8Bits
0311 008E        01569         movwf   DJNZ            ;  1     move timing constant to cnter
0312             01570 OneBit
0312 23A0        01571         call    Waist8T         ; 8 8 * W  waist 8 t
0313 0B8E        01572         decfsz  DJNZ,F          ; 1 2 * W  DJNZ=timing constant counter
0314 2B12        01573         goto    OneBit          ; 2 - * W  loop if not 1 bit time passd
                 01574
0315 23A2        01575         call    Waist6T         ;  6        waist 6 t
                 01576
0316 0C85        01577         rrf     PORTA,F         ;  1   <--- move input status to C
0317 0C80        01578         rrf     INDF,F          ;  1        place C in input rotor
                 01579
0318 0B94        01580         decfsz  COUNT,F         ;  1        COUNT = bit counter
0319 2B11        01581         goto    RX8Bits         ;  2 total 22t + (w-1) * 11
                 01582                                 ;------------------received byte @ INDF
031A 180D        01583         btfsc   RXBITS,0        ; test if parity bit selected...
031B 0D80        01584         rlf     INDF,F          ; ...and discard parity bit if received
                 01585
031C 1D0D        01586         btfss   RXBITS,2        ; test if inverse polarity selected...
031D 0980        01587         comf    INDF,F          ; ...and complement if true parity
                 01588
031E 1003        01589         bcf     STATUS,C        ; clear 8th bit for 7-bit mode
031F 188D        01590         btfsc   RXBITS,1        ; test if 7-bit mode selected and...
0320 0C80        01591         rrf     INDF,F          ; ..rotate 8th(zero) bit if 7bits slctd
                 01592
0321 0A84        01593         incf    FSR,F           ; advance destination pointer
0322 1B04        01594         btfsc   FSR,6           ; bits 4 and 6 will both be set if...
0323 1E04        01595         btfss   FSR,4           ; ... end of buffer+1 reached
0324 2AF5        01596         goto    RX42Bytes       ; loop if not yet FSR=50h
0325 2AC6        01597         goto    Show2           ; over: go show received bytes
                 01598
                 01599 ;*******  FREQUENCY COUNTER
                 01600 ;*****************************************************************
                 01601 ;* GoPresc
                 01602 ;* Prescaler factor (variable PRESC, in range 0...3) is advanced
                 01603 ;*  (executes when key 2 is pressed in frequency counter mode)
                 01604 ;*****************************************************************
0326             01605 GoPresc
0326 0A9A        01606         incf    PRESC,F         ; advance prescaler
0327 111A        01607         bcf     PRESC,2         ; and cycle prescaler in range 0...3
                 01608
                 01609 ;*****************************************************************
                 01610 ;* FreqEp
                 01611 ;* Frequency counter entry point.
                 01612 ;* Subroutine WrParam does this: Displays message "Frequency" in row 1,
                 01613 ;*  counter range (taken from table RangeTab) & resolution (taken from
                 01614 ;*  table PrescTab) in row2.
                 01615 ;* LEDs are turned OFF, and the main counter (BIN4, 4 bytes) cleared.
```

```
                    01616 ;*  The following is used to count pulses:
                    01617 ;* State of TMR0 is written to BIN4+0 and sequencialy tested, and when
                    01618 ;*  bit7 of current value detected as 0 and the previous one was 1, the
                    01619 ;*  overflow is considered. In that case, state of BIN4+1 is advanced,
                    01620 ;*  extended to BIN4+2. After 500ms,the 32-bit value of BIN4 is shifted
                    01621 ;*  left in a total of PRESC+2 times, to get multiply by 4,8,16 or
                    01622 ;*  32. Then BIN+4 (4 bytes) is converted to ASCII and printed on LCD.
                    01623 ;* This routine does not call keyboard routine, as accurate timing of
                    01624 ;*  500 ms must be generated for counting (high count register is
                    01625 ;*  CHARCOU lo count SHOWCOU). Instead of this, there is the individual
                    01626 ;*  routine for key 1 and key 2 test, and also the countdown timer for
                    01627 ;*  automatic power-off (registers TIMOUTL, TIMOUTH).
                    01628 ;* If key 1 is  pressed, mode 1 (analyzer) is entered. If key 2 is
                    01629 ;*  pressed, prescaler value is advanced.
                    01630 ;*
                    01631 ;* Note: code from label "Loop500A" to comment "; 500 ms timeout" is
                    01632 ;*  real time code. If the # of cycles is changed, then the literals
                    01633 ;*  0f4h+1 and 24h+1 written to CHARCOU and SHOWCOU must be readjusted.
                    01634 ;*
                    01635 ;* Input variables: PRESC (affects prescaler factor)
                    01636 ;* Output variables: none
                    01637 ;***********************************************************************
0328                01638 FreqEp                          ; mode 3: frequency counter
0328 2364           01639         call    WrParam         ; print "Frequency" and "xxMHz/Rxx"
0329 21BF           01640         call    KeysOff         ; test both keys off for 34 ms and
                    01641                                 ; initialize 8 min auto off sequence
032A                01642 Count500
032A 30D3           01643         movlw   0d2h+REL        ; right arrow position
032B 23CF           01644         call    WrComL          ; move cursor on right arrow
                    01645
032C 019F           01646         clrf    BIN4+1          ; clear next counter byte
032D 01A0           01647         clrf    BIN4+2          ; clear next counter byte
032E 01A1           01648         clrf    BIN4+3          ; clear next counter byte
032F 018F           01649         clrf    SCRATCH         ; initialize TMR0 overflow detector
                    01650
0330 30F5           01651         movlw   0f4h+1          ; high loop counter for 500 ms
0331 0096           01652         movwf   CHARCOU         ; CHARCOU = hi byte counter
0332 3025           01653         movlw   24h+1           ; 0f424h=.62500 cycles=1250000,T=500 ms
0333 0097           01654         movwf   SHOWCOU         ; SHOWCOU = lo byte counter
                    01655
0334 081A           01656         movf    PRESC,W         ; PRESC = prescaler factor selected
0335 3E20           01657         addlw   20h             ; for PRESC 0,1,2,3  w=20h,21h,22h,23h
0336 2278           01658         call    ToOption        ; here is clrf TMR0 also
0337                01659 Loop500A
0337 1D85           01660         btfss   PORTA,3         ; 2   test key 2 status and
0338 2B26           01661         goto    GoPresc         ; -   jump to "prescaler change" if hit
0339                01662 Loop500
0339 0801           01663         movf    TMR0,W          ; 1 1 1   only place where TMR0 is read
033A 009E           01664         movwf   BIN4            ; 1 1 1   rtcc ---> freq0
                    01665
033B 0D1E           01666         rlf     BIN4,W          ; 1 1 1   carry <--- TMR0.7
033C 0D8F           01667         rlf     SCRATCH,F       ; 1 1 1   rotor <--- carry
                    01668
033D 080F           01669         movf    SCRATCH,W       ; 1 1 1   SCRATCH=TMR0 overflow detect
033E 3903           01670         andlw   3               ; 1 1 1   mask 2 LSbs for edge detect
033F 3A02           01671         xorlw   2               ; 1 1 1   00000000 if 1 <--- 0
                    01672
0340 1D03           01673         btfss   STATUS,Z        ; 1 2 2 |   skip if TMR0 overflow
0341 2B43           01674         goto    NotOvf1         ; 2 - - |   if nz
                    01675                                 ;       | 5T any case
0342 0A9F           01676         incf    BIN4+1,F        ; - 1 1 |   nsb
0343 1903           01677 NotOvf1 btfsc   STATUS,Z        ; 2 2 1 |   skip MSB adv ifnot overflow
0344 0AA0           01678         incf    BIN4+2,F        ; - - 1 |   msb
                    01679
0345 309B           01680         movlw   Head4-1         ; 1   initialize "Battery" message
0346 1D05           01681         btfss   PORTA,2         ; 2   test key 1 status and...
```

```
0347 2933          01682         goto    Mode4           ; -   got shortcut to mode 4 if pressed
                   01683
0348 0B97          01684         decfsz  SHOWCOU,F       ; 1 (2)   lo loop counter
0349 2B37          01685         goto    Loop500A        ; 2 (-)   20T total
                   01686
034A 0B96          01687         decfsz  CHARCOU,F       ;   (1)   hi loop counter
034B 2B39          01688         goto    Loop500         ;   (2)   20T total
                   01689
                   01690                                 ; --- 500 ms timeout here
034C 0A1A          01691         incf    PRESC,W         ; prepare for x2 multiply: PRESC incr
034D 0096          01692         movwf   CHARCOU         ; CHARCOU = multiply factor counter
034E 0A96          01693         incf    CHARCOU,F       ; and prescaler constant incr again
034F               01694 ShLoop                          ; BIN4 = BIN4 * 2 total (PRESC+2) times
034F 1003          01695         bcf     STATUS,C        ; clear C to allow clean x2 multiply
0350 0D9E          01696         rlf     BIN4, F         ; low byte x2 multiply
0351 0D9F          01697         rlf     BIN4+1,F        ; next byte x2 multiply
0352 0DA0          01698         rlf     BIN4+2,F        ; next byte x2 multiply
0353 0DA1          01699         rlf     BIN4+3,F        ; highest byte x2 multiply
                   01700
0354 0B96          01701         decfsz  CHARCOU,F       ; CHARCOU = multiply factor counter
0355 2B4F          01702         goto    ShLoop          ; loop if not PRESC*2 times multiplied
                   01703
0356 308A          01704         movlw   8ah             ; frequency display position
0357 23CF          01705         call    WrComL          ; cursor to freq display position
0358 238C          01706         call    Print8          ; print the frequency in 8-digit ASCII
                   01707
0359 0B9B          01708         decfsz  TIMOUTL,F       ; TIMOUTL=lo byte auto power off cnter
035A 2B2A          01709         goto    Count500        ; inner loop
035B 151B          01710         bsf     TIMOUTL,2       ; TIMOUTL is init to 4 passes instead
                   01711                                 ; of 256, 4*256*500ms=512s=8.5min appr
                   01712
035C 0B9C          01713         decfsz  TIMOUTH,F       ; TIMOUTH=hi byte auto power off cnter
035D 2B2A          01714         goto    Count500        ; loop if not yet 8.5 min
                   01715
035E 29BC          01716         goto    Suicide         ; 8.5 min timeout - go switch power off
                   01717
                   01718 ;*******  BINARY TO ASCII CONVERSION
                   01719 ;*****************************************************************
                   01720 ;* Headline
                   01721 ;* Clears SHOWCOU (Headline2 skips this), Clears LCD, prints right
                   01722 ;*  arrow @ last pos of row2, prints message addresed by W+1 at page 0.
                   01723 ;* Terminator is last character with bit 7 set.
                   01724 ;*
                   01725 ;* Input variables: W+1 addresses string (on page 0) to be printed
                   01726 ;* Output variables:
                   01727 ;*    CHARCOU is decremented by the number of characters printed
                   01728 ;*****************************************************************
035F               01729 Headline
035F 0197          01730         clrf    SHOWCOU         ; initialize show group counter
0360               01731 Headline2
0360 008F          01732         movwf   SCRATCH         ; move input parameter to SCARTCH
0361 303B          01733         movlw   .59             ; .59 characters to clear
0362 22B8          01734         call    SameAs20        ; clear all but right arrow
0363 2BDE          01735         goto    GoWrite         ; print headline message on LCD
                   01736
                   01737 ;*****************************************************************
                   01738 ;* WrParam
                   01739 ;* Prints message "Frequency" in line 1 and parameters for frequency
                   01740 ;*  counter in line 2.
                   01741 ;* Text XXMHz/RYY is printed, where XX is taken from RangeTab, and YY
                   01742 ;*  from PrescTab.
                   01743 ;*
                   01744 ;* Input variables:
                   01745 ;*    PRESC, affects displayed frequency range and resolution
                   01746 ;* Output variables:
                   01747 ;*    CHARCOU is decremented by the number of characters printed
```

```
                    01748 ;***********************************************************************
                    01749 ;* Print255
                    01750 ;* Entry point Print255 converts 8-bit binary value (<100) in BIN4 to
                    01751 ;*  2-digit ASCII and prints it on LCD, without decimal point. Leading
                    01752 ;* zeros are printed.
                    01753 ;*
                    01754 ;* Input variables: W, binary number (0-99) to be converted and printed
                    01755 ;* Output variables:
                    01756 ;*    CHARCOU is decremented by the number of characters printed
                    01757 ;***********************************************************************
                    01758 ;* Print3
                    01759 ;* Entrypoint Print3 converts 16-bit binary value (<1000) in BIN4 to 2-
                    01760 ;*  or 3-digit ASCII and prints it on LCD. Leading zero is skipped only
                    01761 ;*  if value is <100. Decimal point is printed between tens and ones if
                    01762 ;*  FLAG,DP is set, otherwise decimal point is omited.
                    01763 ;*
                    01764 ;* Input variables: BIN4 (2 bytes, LSB first, in range 0-999) binary
                    01765 ;*                       number to be converted and printed
                    01766 ;* Output variables:
                    01767 ;*    CHARCOU is decremented by the number of characters printed
                    01768 ;***********************************************************************
                    01769 ;* PrintBR
                    01770 ;* Entry point PrintBR does the same as PRINT3, but the low byte value
                    01771 ;*  is in W instead in BIN4+0. This is used for baud rate display.
                    01772 ;*
                    01773 ;* Input variables: W, BIN+1 (2 bytes, LSB in W, MSB in BIN+1, in range
                    01774 ;*  0-999) binary number to be converted and printed
                    01775 ;* Output variables:
                    01776 ;*    CHARCOU is decremented by the number of characters printed
                    01777 ;***********************************************************************
0364                01778 WrParam                         ; print xxMHz/Rxx
0364 3092           01779         movlw   Head3-1         ; address of message "Frequency"
0365 2360           01780         call    Headline2       ; print message
0366 23CE           01781         call    Row2            ; move cursor to row 2
                    01782
0367 3064           01783         movlw   RangeTab        ; offset of max frequency range table
0368 236E           01784         call    Presc255        ; print max frequency range
                    01785
0369 306F           01786         movlw   TxtHz-1         ; address of message "MHz/"
036A 23DD           01787         call    Write           ; print message
036B 3052           01788         movlw   'R'             ; "R" stands for "Resolution"
036C 23D8           01789         call    Char            ; print "R"
                    01790
036D 3060           01791         movlw   PrescTab        ; offset of resolution table
036E                01792 Presc255
036E 071A           01793         addwf   PRESC,W         ; add PRESC to offset
036F 23B6           01794         call    PclSub          ; read value from table
0370                01795 Print255
0370 108C           01796         bcf     FLAG,DP         ; clear decimal point enable flag
0371 019F           01797         clrf    BIN4+1          ; clear hi byte (allow range 00-99)
0372                01798 PrintBR
0372 009E           01799         movwf   BIN4            ; allow W as input parameter
0373                01800 Print3                          ; convert BIN4(16),print 3 decimal dgts
0373 01A1           01801         clrf    BIN4+3          ; clear hi byte
0374 01A0           01802         clrf    BIN4+2          ; clear next byte
0375 01A5           01803         clrf    CMP4+3          ; clear hi byte of temporary register
0376 01A4           01804         clrf    CMP4+2          ; clear next byte of temporary register
0377 01A3           01805         clrf    CMP4+1          ; clear next byte of temporary register
                    01806
0378 3064           01807         movlw   .100            ; first digit constant
0379 2383           01808         call    Times           ; # of times goes in BIN4+1 and BIN4?
037A 1D03           01809         btfss   STATUS,Z        ; skip printing if it goes zero times
037B 23C9           01810         call    Num             ; print digit (hundreds) if W>0
                    01811
037C 300A           01812         movlw   .10             ; second digit constant
037D 2383           01813         call    Times           ; how many times it goes in BIN4?
```

```
037E 23C9          01814         call    Num             ; print digit (tens)
                   01815
037F 302E          01816         movlw   '.'             ; decimal point
0380 188C          01817         btfsc   FLAG,DP         ; test decimal pnt flag, skip if reset
0381 23D8          01818         call    Char            ; print decimal point if DP set
0382 2B9B          01819         goto    NumBin4         ; print last digit (ones)
                   01820
                   01821 ;*****************************************************************
                   01822 ;* Times
                   01823 ;* Counts # of times CMP4 (32-bit value) "goes" in BIN4 (32-bit value).
                   01824 ;* BIN4 is sequentialy subtracted by CMP4 and counter COUNT advanced.
                   01825 ;*  When borrow is detected, BIN4 is restored to the last positiv value
                   01826 ;*  (by ADDing CMP4 again), COUNTer decremented and written to W.
                   01827 ;*
                   01828 ;* Input variables: CMP4 (32-bit value), BIN4 (32-bit value)
                   01829 ;* Output variables:
                   01830 ;*    BIN4 (32-bit value) modified to mod(CMP4)
                   01831 ;*    W (in range 0...9) = BIN4 (32-bit value) / CMP4 (32-bit value)
                   01832 ;*****************************************************************
0383               01833 Times
0383 00A2          01834         movwf   CMP4            ; place input param in CMP4 to compare
0384 0194          01835         clrf    COUNT           ; clear result counter
0385               01836 GoTD
0385 0A94          01837         incf    COUNT,F         ; advance result counter
0386 239D          01838         call    Sub4            ; BIN4=BIN4-CMP4  nc if result <0
0387 1803          01839         btfsc   STATUS,C        ; test did it "go"?
0388 2B85          01840         goto    GoTD            ; loop if so
0389 23A5          01841         call    Add4            ; BIN4=BIN4+CMP4  c set if ovf
038A 0314          01842         decf    COUNT,W         ; W=# of times CMP4 goes in BIN4(32bit)
038B 0008          01843         return                  ; result in W
                   01844
                   01845 ;*****************************************************************
                   01846 ;* Print8
                   01847 ;* This subroutine converts 32-bit value in BIN4 (low byte first), to
                   01848 ;*  8-dig ASCII and prints to LCD. Leading zeros are printed as blanks.
                   01849 ;* Table DecTab (21 words, must be at page 0 if PCLATH=0) used in conv.
                   01850 ;*
                   01851 ;* Input variables: BIN4 (32-bit value, <.100,000,000)
                   01852 ;* Output variables:
                   01853 ;*    CHARCOU is decremented by the number of characters printed
                   01854 ;*****************************************************************
038C               01855 Print8                          ; bin2dec conv BIN4(32), print 8 digits
038C 3033          01856         movlw   DecTab-1        ; inici tab ptr
038D 008F          01857         movwf   SCRATCH         ; SCRATCH = tab ptr
038E 118C          01858         bcf     FLAG,RIPPLE     ; zeros initialy print as blanks,until
                   01859                                 ; ...first non-zero appears
038F               01860 Cif7
038F 01A5          01861         clrf    CMP4+3          ; clear CMP4+3, it is =0 in all cases
0390 23B4          01862         call    PclSub2         ; get constant from table
0391 00A4          01863         movwf   CMP4+2          ; load dec. const from table in CMP4+2
0392 23B4          01864         call    PclSub2         ; get constant from table
0393 00A3          01865         movwf   CMP4+1          ; load dec. const from table in CMP4+1
0394 23B4          01866         call    PclSub2         ; get constant from table
0395 2383          01867         call    Times           ; how many times CMP4 goes in BIN4?
0396 23C3          01868         call    NZNum           ; print if w>0 or RIPPLE=1, else blank
                   01869
0397 080F          01870         movf    SCRATCH,W       ; SCRATCH = table pointer
0398 3EB9          01871         addlw   .237-DecTab     ; test if end of table
0399 1C03          01872         btfss   STATUS,C        ; C set if end of table
039A 2B8F          01873         goto    Cif7            ; if not end of table loop (will be 7x)
039B               01874 NumBin4
039B 081E          01875         movf    BIN4,W          ; last digit is in BIN4
039C 2BC9          01876         goto    Num             ; last digit must be printed always
                   01877
                   01878 ;*****************************************************************
                   01879 ;* Sub4
```

```
                    ;* Subtract CMP4 (32-byte value) from 32-bit value in BIN4, lo byte 1st
                    ;* This is performed as adding of negative value of CMP4. Negating is
                    ;*  performed as comlementing and incrementing by 1.
                    ;* Note: Incrementing by 1 is performed on least significant byte only,
                    ;*  without 32-bit extension,for code space saving. This will not cause
                    ;*  error in this case, as the number of all possible values for CMP4+0
                    ;*  is limited and none of them is equal to 0FFh before incrementing
                    ;*  (all possible values are taken from table DecTab, & are: 0ah, 64h,
                    ;*  0e8h, 10h, 0a0h, 40h and 80h, and their negative values).
                    ;*  However, this is valid if this subroutine is used for decimal
                    ;*  conversion only, and if it is used for some other application,
                    ;*  extension to 32-bit should be added after incrementing.
                    ;*
                    ;* Input variables: BIN4 (32-bit value), CMP4 (32-bit value)
                    ;* Output variables:
                    ;*    BIN4 (32-bit value)
                    ;*    STATUS,C denotes the sign of result: if cleared, output value
                    ;*              is negative (there is borrow)
                    ;*
                    ;*  Note: Entry points Waist8T and Waist6T are used only by some
                    ;*  real-time routines, in that case the instructions are dummy
                    ;*********************************************************************
039D                Sub4                            ; 32-bit sub: BIN4 = BIN4 - CMP4
                                                    ; NC if result<0
039D 239F                   call    NegCmp          ; negate CMP (32 bits) first
039E 23A5                   call    Add4            ; add as negative value
039F                NegCmp
039F 09A2                   comf    CMP4+0,F        ; complement low byte
03A0                Waist8T
03A0 09A3                   comf    CMP4+1,F        ; complement next byte
03A1 09A4                   comf    CMP4+2,F        ; complement next byte
03A2                Waist6T
03A2 09A5                   comf    CMP4+3,F        ; complement high byte
03A3 0AA2                   incf    CMP4+0,F        ; neg = complement + 1
                                                    ; (no need test overflow here,it will
                                                    ; ...never reach 0 after incrementing)
03A4 0008                   return                  ; finished
                    ;*********************************************************************
                    ;* Add4
                    ;* Add CMP4 (32-byte value) to BIN4 (32-byte value). 4-instr. groups
                    ;* (movf-btfsc-incfsz-addwf) used instead of non-existing ADD W/ CARRY.
                    ;* Input variables: BIN4 (32-bit value), CMP4 (32-bit value)
                    ;* Output variables: BIN4 (32-bit value), 33th bit in STATUS,C
                    ;*********************************************************************
03A5                Add4                            ; 32-bit add: BIN4 = BIN4 + CMP4
03A5 0822                   movf    CMP4,W          ; low byte
03A6 079E                   addwf   BIN4,F          ; low byte add
                    
03A7 0823                   movf    CMP4+1,W        ; next byte
03A8 1803                   btfsc   STATUS,C        ; skip to simple add if C was reset
03A9 0F23                   incfsz  CMP4+1,W        ; add C if it was set
03AA 079F                   addwf   BIN4+1,F        ; next byte add if NZ
                    
03AB 0824                   movf    CMP4+2,W        ; next byte
03AC 1803                   btfsc   STATUS,C        ; skip to simple add if C was reset
03AD 0F24                   incfsz  CMP4+2,W        ; add C if it was set
03AE 07A0                   addwf   BIN4+2,F        ; next byte add if NZ
                    
03AF 0825                   movf    CMP4+3,W        ; high byte
03B0 1803                   btfsc   STATUS,C        ; skip to simple add if C was reset
03B1 0F25                   incfsz  CMP4+3,W        ; add C if it was set
03B2 07A1                   addwf   BIN4+3,F        ; high byte add if NZ
                    
03B3 0008                   return                  ; finished
                    
```

```
                  01946 ;***********************************************************************
                  01947 ;* PclSub is used for indirect addressing
                  01948 ;* PclSub1 uses SCRATCH instead of W as input parameter
                  01949 ;* PclSub2 advances pointer SCRATCH before executong
                  01950 ;*
                  01951 ;* Note: PCLATH=0 in all cases. So all tables pointed by this routine
                  01952 ;*  are on page 0
                  01953 ;***********************************************************************
03B4              01954 PclSub2
03B4 0A8F         01955         incf    SCRATCH,F       ; advance table pointer
03B5              01956 PclSub1
03B5 080F         01957         movf    SCRATCH,W       ; move table pointer to W
03B6              01958 PclSub
03B6 0082         01959         movwf   PCL             ; jump to address pointed by PCLATH,W
                  01960
                  01961 ;***********************************************************************
                  01962 ;* ClrBuf
                  01963 ;* ClrRam
                  01964 ;* Subroutine ClrBuf clears BUFFER (42 bytes)
                  01965 ;* Entry point ClrRam allows some other start point for claring. It
                  01966 ;*  clears internal RAM from address in W to the location 7Fh.
                  01967 ;*  (locations 50h-7Fh, which do not exist in 16F84, are dummy).
                  01968 ;*
                  01969 ;* Both entry points continue to disabling Enable signal for LCD and
                  01970 ;*  33.8 ms timing loop
                  01971 ;*
                  01972 ;* Input variables:
                  01973 ;*  W is the start addr if area to be cleared (ClrRam entry point only)
                  01974 ;* Output variables: none
                  01975 ;***********************************************************************
03B7              01976 ClrBuf
03B7 3026         01977         movlw   BUFFER          ; get start address of buffer
03B8              01978 ClrRam
03B8 0084         01979         movwf   FSR             ; FSR = dest pointer for clearing
03B9              01980 Zeros
03B9 0180         01981         clrf    INDF            ; clear one byte
03BA 0A84         01982         incf    FSR,F           ; advance dest pointer
03BB 1F84         01983         btfss   FSR,7           ; test if end of RAM...
03BC 2BB9         01984         goto    Zeros           ; ...if not, loop - else move LEDs
                  01985
                  01986 ;***********************************************************************
                  01987 ;*  Entry point DisEna30: Remove enable and discharge signal, and
                  01988 ;*                          refresh LEDs. Then loop 33.8 ms
                  01989 ;*  Entry point Wait30: Loop 33.8 ms
                  01990 ;*  Input variables: none
                  01991 ;*  Output variables: none
                  01992 ;***********************************************************************
03BD              01993 DisEna30
03BD 23EF         01994         call    DisEna          ; disable discharging output signal
03BE              01995 Wait30
03BE 0194         01996         clrf    COUNT           ; COUNT=time loop cnter,to wait 33.8ms
03BF              01997 GoWait30
03BF 23D0         01998         call    loop130         ; waist 130 us
03C0 0B94         01999         decfsz  COUNT,F         ; COUNT = time loop counter
03C1 2BBF         02000         goto    GoWait30        ; loop if not yet 256 passes
03C2 0008         02001         return                  ; timing over
                  02002
                  02003 ;***********************************************************************
                  02004 ;* NZNum
                  02005 ;* Num
                  02006 ;* Print numeric value in W (in range 0...9) on LCD. If FLAG,RIPPLE is
                  02007 ;*  cleared, 0 is printed as blank. If non-zero numeric is printed, it
                  02008 ;*  automatically sets FLAG,RIPPLE.
                  02009 ;* 0 (30h) prints as capital O (4Fh), for improved readibility, as 0
                  02010 ;*  may easily be substituted by 8 on LCD. This changing 0 to O is not
                  02011 ;*  performed only in ASCII representation of recorded bytes in serial
```

```
                    ;*  code receiver.
                    ;* Entry point NUM prints numeric unconditionally, undependently of bit
                    ;*  FLAG,RIPPLE.
                    ;*
                    ;* Input variables:
                    ;*    W (0...9), number to be printed at current cursor position of LCD
                    ;* Output variables:
                    ;*    CHARCOU is decremented by the number of characters printed
                    ;************************************************************************
03C3                NZNum                           ; same aso Num, only blank instead of 0
03C3 198C           btfsc   FLAG,RIPPLE     ; test if RIPPLE bit set...
03C4 2BC9           goto    Num             ; ...if RIPPLE set, no more blanks
03C5 3E00           addlw   0               ; set Z flag if W=0
03C6 1903           btfsc   STATUS,Z        ; is it = 0 ?
03C7 2BD7           goto    Blank           ; if so, jump to space routine
03C8 158C           bsf     FLAG,RIPPLE     ; if>0,clr RIPPLE bit, no more blanks
03C9                Num
03C9 390F           andlw   0fh             ; isolate low nibble
03CA 1903           btfsc   STATUS,Z        ; is it = 0 ?
03CB 301F           movlw   'O'-30h         ; if so, initialize capital O
03CC 3E30           addlw   30h             ; adjust ASCII for numeric
03CD 2BD8           goto    Char            ; print digit
                    ;*******  LCD ROUTINES
                    ;************************************************************************
                    ;*  All these entry ponts of this subroutine are used in program:
                    ;*
                    ;*  Row2:    Issues command to move cursor to row2 of LCD,and loops 130
                    ;*             us,to allow time for LCD controller to execute command
                    ;*  WrComl:  Issues command in W to the LCD, and loops 130 us, to allow
                    ;*             time to LCD controller to execute the command
                    ;*  loop130: Loops 130 us including call and return
                    ;*  GoLoop:  Loops W*2 us
                    ;*  Loop7:   Same as GoLoop, only 2t shorter (for smpl rate routine)
                    ;************************************************************************
03CE                Row2
03CE 30C0           movlw   0c0h            ; command for line 2
                    ;
03CF                WrComL                          ; issues command in W
03CF 23E5           call    WrCom           ; write command in LCD
03D0                loop130                         ; * waist 130 us
03D0 018E           clrf    DJNZ            ; this is to init DJNZ to 40h and...
03D1 170E           bsf     DJNZ,6          ; not to disturb W
03D2                GoLoop
03D2 2BD3           goto    $+1             ; 2    waist 2 t
03D3                Loop7
03D3 0B8E           decfsz  DJNZ,F          ; 1    DJNZ = timing loop counter
03D4 2BD2           goto    GoLoop          ; 2    64x5=320t (128 us)
03D5 0008           return                  ; 2    finished
                    ;
                    ;************************************************************************
                    ;*  All these entry ponts of this subroutine are used in program:
                    ;*
                    ;*  CharBl:  print character in W, blank on LCD and decrement CHARCOU
                    ;*  Blank:   print blank (32h) on LCD and decrement CHARCOU
                    ;*  Char:    print character in W on LCD and decrement CHARCOU
                    ;*  CharNCC: print character in W on LCD without affecting CHARCOU
                    ;*
                    ;*  Note: CHARCOU is used to print fixed format message on LCD, as the
                    ;*  calling routine will add N-CHARCOU blanks to fill area N chars long
                    ;*
                    ;*  Input variables:
                    ;*         all entry points except Blank: W = character to be printed
                    ;*  Output variables:
                    ;*         all entry points except CharNCC: CHARCOU is decremented by 1
                    ;************************************************************************
```

```
03D6                02078 CharBl                          ; print char, then blank
03D6 23D8           02079         call    Char            ; print char first
03D7                02080 Blank                           ; print blank
03D7 3020           02081         movlw   ' '             ; print blank
03D8                02082 Char                            ; print W
03D8 0396           02083         decf    CHARCOU,F       ; decrement character counter
03D9                02084 CharNCC                         ; print W without affecting CHARCOU
03D9 1486           02085         bsf     PORTB,1         ; pull RS hi (data register select)
03DA 2BE6           02086         goto    Skr1            ; continue 4-bit mode writing to LCD
                    02087
                    02088 ;*****************************************************************
                    02089 ;* PrintBrk
                    02090 ;*  Print message "Break" in row 1, pos 0
                    02091 ;*
                    02092 ;* Input variables: none
                    02093 ;* Output variables:
                    02094 ;*    CHARCOU is decremented by the number of characters printed
                    02095 ;*****************************************************************
                    02096 ;* Write
                    02097 ;* Print message addressed by W+1 in line 1
                    02098 ;* Note: Terminator is last character in string with bit 7 set
                    02099 ;*
                    02100 ;* Input variables: W points to string (RETLWs) decremented by 1
                    02101 ;* Output variables:
                    02102 ;*     CHARCOU is decremented by the number of characters printed
                    02103 ;*****************************************************************
03DB                02104 PrintBrk
03DB 22BF           02105         call    Row1            ; move cursor to row 1
03DC 30A2           02106         movlw   BrkMes-1        ; message "Break" address-1
                    02107
03DD                02108 Write                           ; write string addressed by W, end w/ 0
03DD 008F           02109         movwf   SCRATCH         ; SCRATCH = source pointer
03DE                02110 GoWrite                         ; write string at (SCRATCH+1), wnd w/ 0
03DE 23B4           02111         call    PclSub2         ; advance pointer and read pointed byte
03DF 3E80           02112         addlw   80h             ; this is to test if bit 7 was set...
03E0 1803           02113         btfsc   STATUS,C        ; ...if so, C will be set
03E1 2BD8           02114         goto    Char            ; last character was with bit 7 set
03E2 397F           02115         andlw   7fh             ; restore initial character value
03E3 23D8           02116         call    Char            ; print one character
03E4 2BDE           02117         goto    GoWrite         ; loop
                    02118
                    02119 ;*****************************************************************
                    02120 ;* Wrcom
                    02121 ;*  Write command in W to LCD, then loop 130 us
                    02122 ;* Skr1
                    02123 ;*  Allows data write to LCD, if PORTB,1 is set previously
                    02124 ;* Nibble
                    02125 ;*  Write one nibble (W,0-3) to LCD data bus
                    02126 ;*
                    02127 ;* Note: all entry ponits are terminated by 130us timing loop, to allow
                    02128 ;*  LCD controller to execute accepted command/data.
                    02129 ;*
                    02130 ;* Input variables: command in W
                    02131 ;* Output variables: none
                    02132 ;*****************************************************************
03E5                02133 WrCom
03E5 1086           02134         bcf     PORTB,1         ; rs lo (command)
03E6                02135 Skr1
03E6 008E           02136         movwf   DJNZ            ; save W in DJNZ for lo nibble writing
03E7 23F1           02137         call    Hinib_B         ; outputs w,4-7 to PORTB,4-7
03E8 23ED           02138         call    EnaLCD          ; generate enable signal for hi nibble
03E9                02139 Nibble
03E9 0E0E           02140         swapf   DJNZ,W          ; restore init value of W and swap it
03EA 23F1           02141         call    Hinib_B         ; outputs w,0-3 to PORTB,4-7
03EB 23ED           02142         call    EnaLCD          ; generate enable signal for low nibble
03EC 2BD0           02143         goto    loop130         ; wait 130 for LCD to crunch command
```

```
                    02144
                    02145 ;***********************************************************************
                    02146 ;* Generate Enable signal (1200us) for LCD controller,and refresh LEDs.
                    02147 ;* Entry point DisEna: Remove enable & dischg signal,and refresh LEDs.
                    02148 ;***********************************************************************
03ED                02149 EnaLCD
03ED 1406           02150         bsf     PORTB,0         ; enable LCD controller
03EE 2BEF           02151         goto    $+1             ; wait 2 cycles,make signal 1.2us long
03EF                02152 DisEna
03EF 1006           02153         bcf     PORTB,0         ; terminate enable signal LCD control
                    02154
                    02155 ;***********************************************************************
                    02156 ;* MoveLEDs
                    02157 ;*  Entry point MoveLEDs: transfer FLAG,LEDP FLAG,LEDH and FLAG,LEDL to
                    02158 ;*                        PORTB,5 PORTB,6 and PORTB,7 to service LEDs.
                    02159 ;*
                    02160 ;* Input variables:
                    02161 ;*    FLAG, bits LEDP, LEDH, LEDH will affect LED1, LED2, LED3
                    02162 ;* Output variables: none
                    02163 ;***********************************************************************
                    02164 ;* Hinib_B
                    02165 ;*  Entry point Hinib_B:  output W,4-7 to 4-bit LCD data bus
                    02166 ;*
                    02167 ;* Input variables:
                    02168 ;*    hi nibble of W is copied to LCD data bus
                    02169 ;* Output variables: none
                    02170 ;***********************************************************************
03F0                02171 MoveLESd                        ; writes states LEDs L,H,P to PORTB,5-7
03F0 080C           02172         movf    FLAG,W          ; FLAG bits 5,6,7 are LED bits
03F1                02173 Hinib_B                         ; outputs w,4-7 to PORTB,4-7
03F1 1206           02174         bcf     PORTB,4         ; clear high nibble of PORTB
03F2 1286           02175         bcf     PORTB,5         ; clear high nibble of PORTB
03F3 1306           02176         bcf     PORTB,6         ; clear high nibble of PORTB
03F4 1386           02177         bcf     PORTB,7         ; clear high nibble of PORTB
03F5 39F0           02178         andlw   0f0h            ; mask for hi nibble of W
03F6 0486           02179         iorwf   PORTB,F         ; write H nibble W to H nibble PORTB
03F7 0008           02180         return                  ; finished
                    02181
                    02182 ;***********************************************************************
                    02183 ;* HexDigit
                    02184 ;* This subroutine prints low nibble of W on LCD as hexadecimal digit.
                    02185 ;*  Zero (30h) is printed as capital O (7Fh)
                    02186 ;*
                    02187 ;* Input variables: W in range 0...0fh, hex number to be printed
                    02188 ;* Output variables: CHARCOU is decremented by two
                    02189 ;***********************************************************************
03F8                02190 HexDigit                        ; hex W (lo nibble) to LCD, change 0...
                    02191                                 ; ...to capital O
03F8 390F           02192         andlw   0fh             ; isolate low nibble of W...
03F9 009E           02193         movwf   BIN4            ; ...and put it in BIN4
03FA 3EF6           02194         addlw   -0ah            ; test if input number > 9
03FB 1C03           02195         btfss   STATUS,C        ; Is it > 9 ?
03FC 2B9B           02196         goto    NumBin4         ; ...if not, just print it as-is
03FD 3E41           02197         addlw   .7+3ah          ; 3ah...3fh to 'A'...'F' correction
03FE 2BD8           02198         goto    Char            ; print ASCII adjusted hex value a...f
                    02199
                    02200 ;*******  DATA EEPROM
                    02201 ;***********************************************************************
                    02202 ;*  This table is located in data eeprom
                    02203 ;*  It contains numerical data for 16 sample frequencies period display
                    02204 ;*  for analyzer. Last 13 bytes are timing constants used by subroutine
                    02205 ;*  GetSlowClk to generate internal timing (three fastest rates need no
                    02206 ;*  constants from the table, as they are treated as special cases)
                    02207 ;***********************************************************************
                    02208 ;*  ----- TABLE 1 (00h-2Fh): Rate display table for analyzer
                    02209 ;*
```

```
                    02210 ;*  ****First byte: Flags. Bits in this byte have the following functs:
                    02211 ;*  bit 7 = 0: Frequency in Hz
                    02212 ;*         = 1: Frequency in Mhz or Khz
                    02213 ;*  bit 6 = 0: Frequency does not contain decimal point
                    02214 ;*         = 1: Frequency contains decimal point before last digit
                    02215 ;*  bits  5,4: Bits 9 and 8 for frequency display, respectively
                    02216 ;*  bit 3 = 0: Period in us (microseconds)
                    02217 ;*         = 1: Period in ms (miliseconds)
                    02218 ;*  bit 2 = 0: Period does not contain decimal point
                    02219 ;*         = 1: Period contains decimal point before last digit
                    02220 ;*  bits  1,0: Bits 9 and 8 for period display, respectively
                    02221 ;*  **** Second byte: low significant byte for frequency
                    02222 ;*  **** Third byte: low significant byte for period
                    02223 ;*********************************************************************
                    02224 ;*  ----- TABLE 2 (30h-3Ch): Timing constant table for analyzer
                    02225 ;*
                    02226 ;*  Timing constant factors to all sample rates generated by subroutine
                    02227 ;*  GetSlowClk (all except 1MHz, 500KHz and 228KHz)
                    02228 ;*********************************************************************
                    02229 ;*  Note: This is read-only data, so the Data EEPROM must be programmed
                    02230 ;*  before the unit is ready to use. MCU will not affect data EEPROM
                    02231 ;*  contents. If your programmer does not support automatic loading of
                    02232 ;*  Data EEPROM contents from the HEX file, it must be loaded manualy.
                    02233 ;*  This will help in that case (all values are hexadecimal):
                    02234 ;*
                    02235 ;*  addr 00-07:  88 01 01 98 F4 02 8C E4
                    02236 ;*  addr 08-0f:  2C 88 64 0A 88 32 14 D8
                    02237 ;*  addr 10-17:  80 1A 88 19 28 C8 C0 34
                    02238 ;*  addr 18-1f:  88 0A 64 C8 60 68 C8 30
                    02239 ;*  addr 20-27:  D0 C9 18 A1 80 01 01 14
                    02240 ;*  addr 28-2f:  90 19 00 64 0A 00 28 19
                    02241 ;*  addr 30-37:  01 06 09 10 16 2E 30 64
                    02242 ;*  addr 38-3c:  CC 05 0E 3B 95
                    02243 ;*
                    02244 ;*  Total bytes used in Data EEPROM: 61 (the last 3 bytes don't care)
                    02245 ;*********************************************************************
2100                02246         org     2100h
                    02247 ;                                       constant T/sample Hz    s    RATE
                    02248
2100 0088 0001 0001 02249         de      b'10001000', .1,   .1   ; -     2.5      1M    1u    0
2103 0098 00F4 0002 02250         de      b'10011000', .244, .2   ; -     5        500K  2u    1
2106 008C 00E4 002C 02251         de      b'10001100', .228, .44  ; -     11       228K  4.4u  2
2109 0088 0064 000A 02252         de      b'10001000', .100, .10  ; 1     25       100K  10u   3
210C 0088 0032 0014 02253         de      b'10001000', .50,  .20  ; 6     50       50K   20u   4
210F 00D8 0080 001A 02254         de      b'11011000', .128, .26  ; 9     65       38.4K 26u   5
2112 0088 0019 0028 02255         de      b'10001000', .25,  .40  ; 16    100      25K   40u   6
2115 00C8 00C0 0034 02256         de      b'11001000', .192, .52  ; 22    130      19.2K 52u   7
2118 0088 000A 0064 02257         de      b'10001000', .10,  .100 ; 46    250      10K   100u  8
211B 00C8 0060 0068 02258         de      b'11001000', .96,  .104 ; 48    260      9.6K  104u  9
211E 00C8 0030 00D0 02259         de      b'11001000', .48,  .208 ; 100   520      4.8K  208u  10
2121 00C9 0018 00A1 02260         de      b'11001001', .24,  .161 ; 204   1040     2.4K  417u  11
2124 0080 0001 0001 02261         de      b'10000000', .1,   .1   ; 5     2500     1K    1m    12
2127 0014 0090 0019 02262         de      b'00010100', .144, .25  ; 14    6253     400   2.5m  13
212A 0000 0064 000A 02263         de      b'00000000', .100, .10  ; 59    25018    100   10m   14
212D 0000 0028 0019 02264         de      b'00000000', .40,  .25  ; 149   62548    40    25m   15
                    02265
                    02266 ;       timing constants table
2130 0001 0006 0009 02267         de      .001, .006, .009, .016, .022, .046, .048
     0010 0016 002E
     0030
2137 0064 00CC 0005 02268         de      .100, .204, .005, .014, .059, .149
     000E 003B 0095
                    02269
                    02270         end
```

All other memory blocks unused.

```
Program Memory Words Used:  1023
Program Memory Words Free:     1


Errors   :     0
Warnings :     0 reported,     0 suppressed
Messages :     4 reported,     0 suppressed
```

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