This version (DD_SYNTH v2.30) for the EME85 or EME170, is designed to be used with
a 4x4 keypad and the EME159 control board.

It will also detect if a 3x4 keypad and the EME129 control board are in use.
This version will not work with the old version 1.xx button wiring. (use ver 2.10)
It is a minor modification to DD_SYNTH v2.20 to support the EME170 / EME167 boards
an extra setup screen has been added to allow for the use of a divider on the
EME167 board. (AD9851 DDS board with I/Q outputs)
The number of memories avaliable for storing frequencies has been more than doubled.
The software now remembers if memory mode was in use when the power is removed. When
powered up again memory mode will be selected, and the correct memory will be used.
Reduced the sensitivity of the rotory encoder, now works better with different low
cost mechanical encoders.
Also fixed a bug that prevented the display of RIT or RPT on the LCD in memory mode.

It now uses the internal 4MHz clock.
So the 4MHz crystal and the 2 x 22pF capacitors on the EME85 DDS board
are not required but may be left on the board as they causes no problems.

It provides the following features,

1) This version is for the PIC 16F648A, no changes to the
   circuit board are required to use these PICs.
2) The software allows 2 modes of operation,
   a) VFO (variable frequency oscillator) mode, where the encoder is used to
      adjust the frequency, is the default mode. This is the only mode
      that was available in previous versions of DD_Synth.
      While in this mode, VFO is displayed on the top line of the LCD.
   b) MEM (memory) mode, where the encoder is used to select a previously
      saved frequency.
      While in this mode, MEM is displayed on the top line of the LCD.
3) Setup screens have been added for enabling/disabling the repeater
   function, selecting the DDS ref multiplier, and selecting what is saved to
   memory by the SAVE function.
4) The DDS 10MHz cal setup screen has been simplified.
5) All settings can now be made in the setup screens, except the DDS chip type.
   There are separate hex files for use with the AD9850 and AD9851.

      ** Using the new 4x4 keypad. **

In early versions of DD_Synth (ver 1.xx), 5 press butons were used.
See the Ver_1.pdf file. (This wiring is no longer supported)

This version of software, allows 2 different keypad layouts.
A) It can be used with a 4x4 keypad and the EME159 control board.
   See the Ver_3.pdf file.
B) It can also be used with 7 press buttons and an optional 3x4 numeric keypad.
   (3x4 keypad and the EME129 control board) See the Ver_2.pdf file.

If using the EME159 control board and 4x4 keypad the A, B, C, D and * buttons
are assigned as follows.

        A = MEM.
        B = CAL.
        C = RIT.
        D = RPT.
        * = Step Size.

If using the EME129 control board and optional 3x4 keypad the buttons are
assigned as follows.

        Top left hand button   = Step Size.
        Middle left hand button = CAL.
        Bottom left hand button = MEM.
        Top right hand button   = RIT.
        Middle right hand button = RPT.
        Bottom right hand button = unused.

No setup screen is needed to select the kepad wiring, when the power is
turned on, the software determines what version of wiring is fitted.
(it looks for the diode between SWITCH A and LCD E on the EME129 control board)

The keypad can be used to quickly enter any frequency in the setup
screens, or the RX, TX or RPT frequency on the VFO display. (not RIT)
Frequencies are entered in MHz, the * is used to enter a decimal point,
the # is used to ENTER the completed frequency.
If the first digit entered is the #, the number entered will be negative.
(only allowed in some setup screens where negative frequencies are valid)

If using the 4x4 keypad, the first button press cannot be the * as this
would be interpreted as setting the STEP SIZE. You can get round this conflict
by pressing 0 then * to enter frequencies below 1MHz.

As an aid to verifying that keypad entry has been started, the MHz on the
second line of the LCD is changed to #, this is also a reminder that # must
be used to enter the number after it has been typed in.

The keypads tested have a contact resistance of 100-150 ohms, but keypad with
a contact resistance as high as 1K ohm should work ok. If your keypad has a
higher contact resistance, changing the pullup resistors on SWITCH A,
SWITCH B, ENCODER A & ENCODER B on the DDS board to 10K ohms should help.

        ** Memory function. **

A memory function is used to save and recall RX frequencies to EEPROM.
The number of frequencies that can be saved depends upon the memory mode you
elect to use. There are 7 modes to choose from, (described below)

Mode 1   "52x RX"   Allows 52 (RX FREQUENCIES) to be saved and
                        recalled. The TX OFFSET FREQUENCY, RX DDS LIMITS,
                        OFFSETS, MULTIPLIER, etc, remain unchanged.

Mode 2   "26x RX,TX"   Allows 26 pairs of (RX/TX OFFSET) to be
                        saved and recalled. (other settings unchanged)

Mode 3   "17x RX,TX,RPT"   Allows 17 sets of (RX/TX/RPT OFFSETS) to be
                        saved and recalled. (other settings unchanged)

Mode 4   "17x RX,LIM"   Allows 17 sets of (RX/RX DDS LIMITS) to be
                        saved and recalled. (other settings unchanged)

Mode 5   "13x RX,TX,LIM"   Allows 13 sets of (RX/TX/RX DDS LIMITS) to be
                        saved and recalled. (other settings unchanged)

Mode 6   "9x RX,TX,RPT,LIM" Allows 9 sets of (RX/TX/RPT/RX DDS LIMITS) to be
                        saved and recalled. (other settings unchanged)

Mode 7   "7x ALL SETTINGS"   Allows 7 sets of (RX & all setup freq's, limits,
                        offsets, multiplier etc) to be saved and recalled.
                        (not the first 4 setup screens, ENABLE RPT,
                        DDS CHIP TYPE, DDS SYSTEM CLK or DDS MAX FREQ)

Modes 1 to 3 are probably the most useful, the others have been included
for people who use the same DDS board in different setups.
Mode 1 is the default, but it can be changed in the memory mode setup screen.

To enter the memory setup screen, make sure you are in VFO mode before turning
off the power, then press the MEM button, while turning on the power.
After the version number display, the current memory mode will be displayed.
Use the rotary encoder to make a selection, then briefly press the MEM button.
If you have selected a different memory mode, You will be prompted to confirm
your selection. **Warning** All frequencies currently saved in the memories
will be destroyed. If you are sure you want to change modes, use the rotary
encoder to select YES, then press the MEM button briefly. (all memories will
be filled with the same default info from the setup screens)

It is advisable to make sure that all the setting screens have been set
correctly before selecting or changing the memory mode. This will prevent
invalid info being placed into the memories.

** Saving to the memories **

To SAVE the current VFO RX frequency, (and other settings if using modes 2-7)
hold down the MEM button for 1 second, use the rotary encoder to select the
memory number you want to save to.
As an aid to selecting a memory location that is no longer wanted, the
bottom line of the LCD displays the RX frequency of the selected memory.
Then press the MEM button again for 1 second to complete the SAVE.
A message, "SAVING" will be displayed briefly, before returning you to the VFO
display.
If you decide that you want to return to the VFO display without proceeding
with the SAVE, briefly press the MEM button, or wait for the 10 second timeout.

It is advisable to make sure that all the setting screens have been set
correctly before using the SAVE function. This will prevent invalid info being
placed into the memories.

** Using the saved memories **

To switch from the default VFO (variable frequency oscillator) mode,
(where the encoder is used to adjust the frequency) to the MEM mode,
where the encoder is used to select a previously saved RX frequency,
(and other settings if using modes 2-7) briefly press the MEM button.
"MEM 1" will be displayed on the top line of the LCD, you can use the rotary
encoder to select the memory number you want to use. While in the MEM mode
the TX and RPT buttons function normally, but you can't use the encoder to
adjust the frequency, the RIT function operates normally. (the encoder can be
used to adjust the RIT frequency)
While in the MEM mode, you cannot use the setup screens or the memory
save function.
The program uses the info in the setup screens to check that the memory is
valid. If it finds that the memory contains invalid info, the "MEM" display
is change to "---", this is caused when you change something in one of the
setup screens, then try to use a memory that was saved before the change.
(for example, assume 30 MHz RX freq is saved in MEM 1, if you then lower the
MAX RX DDS FREQ in the setup screen, to 29 MHz. When you try to use MEM 1,
the checks made with the setup screens will find that the 30 MHz RX freq is
invalid because it is to high) So it is advisable to make sure that all the
setting screens have been set correctly before using the SAVE function.
There are two ways to exit the MEM mode, and go back to the VFO mode,
1) Briefly pressing the MEM button, ignores the memory you were using and
   returns the frequency you were using prior to entering the MEM mode.
2) Pressing the MEM button for 1 second, copies the memory you were using into
   the setup screens, so it is available in the VFO mode.

** Changes to the 10 MHz CAL screen. **

The DDS calibration screen has been simplified, it is still set to produce
a 10MHz output. But it now displays the DDS SYSTEM CLK frequency, not
the more complicated, calibration constant which was = 2^56/DDS SYSTEM CLK.
The DDS SYSTEM CLK should be set to the DDS crystal frequency for the
AD9850 and AD9851 (using the x1 REFCLK option), and to 6 times the DDS
crystal frequency for the AD9851 (using the x6 REFCLK option).

** Changes to when the setup screen saves to EEPROM. **

The checks made in the setup screens have been improved, and if you do make
any changes, they will only be saved to EEPROM after stepping out of the
MULTIPLIER setup screen. A message, "SAVING" will be displayed before
returning to the VFO display screen.
(the RIT function will be cancelled, if any changes were made)
On all setup screens, (except DDS REF FREQ screen) if the buttons, keypad
and rotary encoder are left idle for 10 seconds, any changes made in any of
the screens will be ignored and you will be returned to the VFO display.

** Program version display. **

The meaning of the last digit of the version number, displayed at power up
has been changed.
If you are using the 4x4 keypad and EME159 control board, the last digit
has the following meaning.

 ver x.xO for AD9850. (DDS SYSTEM CLK = DDS crystal freq)
 ver x.x1 for AD9851, 1x REFCLK. (DDS SYSTEM CLK = DDS crystal freq)
 ver x.x2 for AD9851, 6x REFCLK. (DDS SYSTEM CLK = 6 x DDS crystal freq)

If you are using the 3x4 keypad and EME129 control board, the last digit is
increased by 3.
This allows you to verify that the software has correctly identified
the button wiring.

 ver x.x3 for AD9850. (DDS SYSTEM CLK = DDS crystal freq)
 ver x.x4 for AD9851, 1x REFCLK. (DDS SYSTEM CLK = DDS crystal freq)
 ver x.x5 for AD9851, 6x REFCLK. (DDS SYSTEM CLK = 6 x DDS crystal freq)

      ** General info **

When first turned on, the software name and version number is displayed.

After 1 second the VFO screen is displayed.
The frequency displayed is the same as the frequency displayed on the VFO
screen before the power was turned off.
This version remembes if memory mode was in use before power was removed
and will restart in memory mode using the correct memory.
If the TX button is pressed "TX" is displayed, and the DDS is set to
produce the TX frequency, (RX frequency + TX offset)
Otherwise RX is displayed, and the DDS is set to produce the RX frequency.
Any changes to the frequency are saved to EEPROM 2 seconds after the rotary
encoder stops moving.

If the RIT (receive incremental tuning) button is pressed briefly, RIT is
displayed on the LCD. The TX frequency cannot be changed. But the RIT
frequency can be changed as long as it does not go to far away from the RX
frequency. (the range is RX freq +/-MAX_RIT_OFFSET)
Pressing the RIT button again, removes the RIT display and the RX frequency
reverts to its pre RIT value.

If the RPT (REPEATER TX offset for use with FM) function is enabled in the
first setup screen. Briefly pressing the RPT button will display -RPT on the
the LCD and an extra offset (RPT OFFSET) is subtracted from the TX frequency.
Briefly pressing RPT again will remove the offset.
Pressing RPT for 1 sec will display +RPT and the RPT offset will be added to
the TX frequency. Briefly pressing RPT again will remove the offset.
The default REPEATER TX OFFSET is 0 KHz, but it can be changed in the
RPT OFFSET setup screen. Range = 0 to 10 MHz.
(also limited, so that the DDS remains within 0 to MAX DDS FREQ)
If the RPT function is disabled, the RPT setup screen will not be available,
and the RPT offset will be set to 0 Hz.

      ** Calibration setup screens **

To enter the setup screens, make sure you are in VFO mode before turning
off the power, then press the CAL button while turning on the power.
After the version number is displayed the first calibration setup
screen, for enabling the RPT function, will be displayed.
Use the rotary encoder to make the selection, then briefly press the CAL
button to step to the next screen.

The second screen is used to allow for the use of a post DDS divider as used on
the EME167 AD9851 DDS board with I/Q outputs. This setting multiplies the
DDS output frequency by 2 to compensate for the divider on the output of the DDS.
Use the rotary encoder to make the selection, then briefly press the CAL
button to step to the next screen.

If using the AD9851 DDS chip there is an extra screen for selecting the
AD9851 REF CLOCK multiplier. (x1 REFCLK. or x6 REFCLK)

Use the rotary encoder to make the selection, then briefly press the CAL
button to step to the next screen.

This screen is for calibrating the DDS reference frequency.
It sets the DDS to produce 10MHz, and displays the DDS SYSTEM CLOCK frequency.
This should be set to the DDS crystal freq for the AD9850 and AD9851 x1 REFCLK,
and to 6 times the DDS crystal frequency for the AD9851 x6 REFCLK.
This can be modified to set the boards O/P frequency to exactly 10 MHz.
(using a frequency counter)

This screen will continue to be displayed until the CAL button is pressed
briefly.
Again, pressing the CAL button will display the next setup screen. etc.
On all setup screens except the DDS SYSTEM CLK screen, if the buttons and
rotary encoder are left idle for 10 seconds, any changes made in any of the
screens will be ignored and you will be returned to the VFO display screen.
The changes made in the screens will be saved after stepping out of the
MULTIPLIER screen, back to the VFO display screen.

Once in the VFO screen, pressing the CAL button for 1 sec will take you to
the MIN RX DDS FREQ setup screen. (the first few screens rarely need changing)

All setup screens limit the range of the changes, to make sure they are valid.
eg. The TX offset cannot be set to a value that when added to the RX frequency,
    results in a frequency outside the range of the DDS.

If the adjust step size button is pressed, a cursor is displayed under one
digit of the frequency display. This can be changed using the rotary encoder.
If for example it is under the 1 KHz digit, when the (adjust step size button)
is released, rotating the encoder will change the frequency in 1 KHz steps.
There is also a small amount of variable rate tuning. (the faster the encoder
is rotated, the greater the step size) Due to 4mS software debouncing, if the
encoder is rotated to fast, no change in frequency will occur.
Any changes to the step size, while in the VFO screen, are saved to EEPROM.
(changes to the step size, while in the setup screens or RIT are not saved)

The frequency displayed on the LCD, is calculated as shown below.
RX = MULTIPLIER x (RX_DDS_FREQ + OFFSET_FREQ)
TX = MULTIPLIER x (RX_DDS_FREQ + OFFSET_FREQ + TX_OFFSET_FREQ)

The frequency programmed into the DDS, is calculated as shown below.
RX = ABS(RX_DDS_FREQ)
TX = ABS(RX_DDS_FREQ + TX_OFFSET_FREQ)

RX_DDS_FREQ, MIN_RX_DDS_FREQ, MAX_RX_DDS_FREQ, TX_OFFSET_FREQ & OFFSET_FREQ
may be positive or negative values. (as long as the resulting display
frequency is positive, and the DDS remains within limits)

Below are examples of using offsets to produce different display frequencies.
In each example the DDS output frequency range is 30 MHz to 40 MHz.

MIN_RX_DDS_FREQ	MAX_RX_DDS_FREQ	OFFSET_FREQ	RX Frequency display range.
30 MHZ	40 MHz	100 MHz	= 130 MHz to 140 MHz. \ Note 1
30 MHZ	40 MHz	-10 MHz	= 20 MHz to 30 MHz. /
-40 MHZ	-30 MHz	170 MHz	= 140 MHz to 130 MHz. \ Note 2
-40 MHZ	-30 MHz	60 MHz	= 30 MHz to 20 MHz. /

Note 1. CW rotation of the rotary encoder increase both the DDS O/P
         frequency and display frequency.
Note 2. CW rotation of the rotary encoder decrease the DDS O/P frequency
         but increases the display frequency.

The software is designed to use a 16x2 LCD with or without R/W pin.
(it uses delays rather than busy checks)
If the LCD has a R/W pin it can be tied GND pin.

      ** Setting the TX OFFSET, RIT OFFSET or RPT OFFSET **

If you are having trouble setting the TX OFFSET, RIT OFFSET or RPT OFFSET to
the value you require, it is probably because you have set MIN RX DDS FREQ to low,

or MAX RX DDS FREQ to high.

For example, to set a TX OFFSET of 1 MHz, there has to be at least 1MHz between
MAX DDS FREQ and MAX DDS RX FREQ. Because MAX RX DDS FREQ + TX OFFSET must be less
than MAX DDS FREQ.
If you wanted a TX OFFSET of -1 MHz, MIN DDS RX FREQ has to be greater than 1 MHz.
Because MIN RX DDS FREQ + TX OFFSET must be greater than 0 Hz.