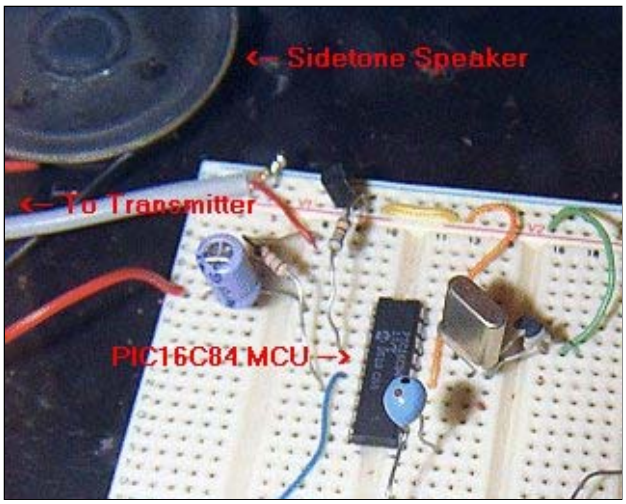
ZL1HIT Hellschreiber / PIC Beacon



This is a simple circuit that does a fair bit of work. The core of the circuit is my favourite IC - the Microchip PIC 16F84 Microcontroller / RISC Microprocessor.

This project was inspired by my new friend Murray, ZL1BPU. Murray is very interested in H.F. band "digital" modes. He and a group of others are responbile for resurrecting the 1927 Hellschreiber visually received "fuzzy" digital mode of communication. More information about Hellschreiber can be read **here**. I highly recommend you take a look. It's fascinating stuff to be sure.

This project produces base band Hellschreiber "digital" output which directly keys an HF radio transmitter. In my case I simply connect the output transistor to the CW Key input on my ICOM IC-706 Mk II transceiver. Since this rig is electronically keyed it works very well for this task.

Here is a sample of the Hellschrieber sent by this project:

Following is the PIC MPASM Source Code for Version 0.03 of the Beacon:

```
;*****************************************************************************
; Feld Hellschreiber / CW Beacon Base Band Beacon
; Author: Bryan J. Rentoul
; Date: 10-April-1999
;
; All rights reserved
;
; Description: This project was inspired, yeh "specced" even, by Murray,
; ZL1BPU. It purpose is to send a mixture of CW and Hellschreiber via
; a simple CW transmitter based around a 3.58 MHz Xtal oscillator in the
; classic style. This is an early version and lacks any "user friendly"
; interface for loading new messages etc.
;
; This version uses the 5x5 pixel all upper case font set provided
; by ZL1BPU. (Letters 'C', 'V' an 'O' slighly modified for clarity.
;
;
;*****************************************************************************
        include "p16c84.inc"
        include "bits.inc"      ; Bit processing Macros

;*** SET CONFIG FUSES ***

        __CONFIG _CP_OFF & _WDT_OFF & _HS_OSC

;For Assembler PORTAbility

W       EQU     0               ;For file,W
w       EQU     0               ;For file,W
F       EQU     1               ;For file,F
f       EQU     1               ;For file,F
```

```
;*****************************************************************
;* REGISTER DECLARATIONS
;*****************************************************************

ind     equ     0               ;0=pseudo-reg 0 for indirect (FSR)
RTCC    equ     1               ;1=Real Time Clock/Counter
TMR0    equ     1               ;1=Timer0 (same as above)
PC      equ     2               ;2=PC
STATUS  equ     3               ;3=Status Reg
INTCON  equ     0Bh
PCLATH  equ     0Ah

;* Status reg bits
        BIT     B_C,0,STATUS    ;Carry
        BIT     B_DC,1,STATUS   ;Half carry
        BIT     B_Z,2,STATUS    ;Zero
        BIT     B_PD,3,STATUS   ;Power down
        BIT     B_TO,4,STATUS   ;Timeout
        BIT     B_PA0,5,STATUS  ;Page select (56/57 only)
        BIT     B_PA1,6,STATUS  ;Page select (56/57 only)
        BIT     B_PA2,7,STATUS  ;GP flag
;----
;* OPTION reg bits
        BIT     B_RBPU,7,1
;----
;* INTCON reg bits (defined in p16c84.inc)
        BIT     I_GIE,7,INTCON
        BIT     I_EEIE,6,INTCON
        BIT     I_T0IE,5,INTCON
        BIT     I_INTE,4,INTCON
        BIT     I_RBIE,3,INTCON
        BIT     I_T0IF,2,INTCON
        BIT     I_INTF,1,INTCON
        BIT     I_RBIF,0,INTCON

;---------------------------------

FSR     equ     4               ;4=file select reg 0-4=indirect address
fsr     equ     4               ;4=file select reg 0-4=indirect address
PORTA   equ     5               ;5=port A I/O register (4 bits)
PORTB   equ     6               ;6=port B I/O register
porta   equ     5               ;5=port A I/O register (4 bits)
portb   equ     6               ;6=port B I/O register

;--------
        BIT     RA0,0,PORTA
        BIT     RA1,1,PORTA
        BIT     RA2,2,PORTA
        BIT     RA3,3,PORTA
        BIT     RA4,4,PORTA

        BIT     RB0,0,PORTB
        BIT     RB1,1,PORTB
        BIT     RB2,2,PORTB
        BIT     RB3,3,PORTB
        BIT     RB4,4,PORTB
        BIT     RB5,5,PORTB
        BIT     RB6,6,PORTB
        BIT     RB7,7,PORTB

        BIT     PTT,0,PORTA     ; PTT Output
        BIT     SPAREA1,1,PORTA
        BIT     SIDETONE,2,PORTA
        BIT     TIMECAP,3,PORTA ; Timer capacitor output
        BIT     TIMEIN,4,PORTA  ; Timer cap. input
```

```
        BIT     TXOUT,0,PORTB
        BIT     FSK0,1,PORTB
        BIT     FSK1,2,PORTB
        BIT     FSK2,3,PORTB
        BIT     DXMODE,4,PORTB  ; DX Mode input. Jumper to GND for DX mode enable

;--------
SAVEW   equ     0Ch     ; Used in INT routine to save W and STATUS register
SAVES   equ     0Dh
FLAGS   equ     0Eh     ; Inputs status register
DL1     equ     0Fh     ; Delay routine counters
DL2     equ     10h     ;    "     "       "
DL3     equ     11h     ;    "     "       "
INTCNT  equ     12h     ; Interrupt call counter to count 64 calls then reset
TONECNT equ     13h     ; Tone counter using to toggle output every 8 int calls
COLCNT  equ     14h     ; Column counter
ROWCNT  equ     15h     ; Row counter
CURCOL  equ     16h     ; Current column data for rotating each bit into carry flag
CHAR    equ     17h     ; Character code to send (ASCII values from 32 to 95 OK)
TEMP    equ     18h
TEMP1   equ     19h
TIMER   equ     20h     ; We use this as a free running timer incremented
                        ; by the Int routine. It is for CW dot / dash timing etc
SAVE1   equ     21h     ; Just another TEMP variable
SAVE2   equ     22h     ;
OUTBUF  equ     23h     ; CW Output buffer

; 24h to 2B  free

        ; Define some status bits (flags)
        BIT     BUSY,0,FLAGS            ; 0 = Buffer awaits new character to send (1 = busy)
        BIT     F_SIDETONE,1,FLAGS
        BIT     F_TABLE,2,FLAGS         ; 0 = Font Table 1, 1 = Font Table 2
        BIT     F_CW,3,FLAGS            ; In CW mode (1) the Int does not toggle TXOUT

;*** Reset Vector *********************************************************

        ORG     0000
reset
        GOTO    INIT

; =========================
; == INTERRUPT PROCEDURE ==
; =========================
        ORG     0004
TIMERINT   ; Interrupt routine called (17.5 * 5 * 60) times per second providing
           ; pixel timing (5 pixels/rows  per column)

        ; Save W and Status
        CLB     I_T0IE          ; Disable this interrupt
        CLB     I_T0IF          ; clear the interrupt
        movwf   SAVEW           ; save w reg in Buffer
        swapf   SAVEW, f        ; swap it
        swapf   STATUS,w        ; get status (swapped)
        movwf   SAVES           ; and save it

        movlw   18              ; Reset Counter to 18 (instead of around zero or so)
        movwf   TMR0            ;   /

        ; Interrupt procedure propper starts here

        decfsz  TONECNT, f      ; Time for side tone click?
        goto    INEXT1

        movlw   4               ; Toggle the Sidetone output every 6 calls
        movwf   TONECNT         ;   /
        SKBC    F_SIDETONE      ; ...but only if the F_SIDETONE flag is set
```

```
        TBIT    SIDETONE        ;

INEXT1
        decfsz  INTCNT, f       ; Time to send a dot pixel?
        goto    IEND            ; Nope...

        ;-------
        decf    TIMER, f        ; decrement out free runing timer used in DELAY function
        ;-------

        movlw   60              ; Yes...
        movwf   INTCNT          ; Reset INTCNT to 60

        ; Check the BUSY FLAG. If zero do nothing
        BBC     BUSY, IEND

        movfw   ROWCNT
        BBS     B_Z, IENDCOL    ; If ROWCNT is zero then we are done

        ; Other wise send next bit

        movfw   CURCOL
        rrf     CURCOL, f       ; Rotate bit into carry flag for testing
        BBS     B_C, ITONEON

        BBS     F_CW, INEXT2    ; Dont touch TXOUT or F_SIDETONE if in CW mode
        CLB     TXOUT           ; Turn TX carrier OFF
        CLB     F_SIDETONE      ; flag side tone to OFF
        goto    INEXT2

ITONEON
        BBS     F_CW, INEXT2    ; Dont touch TXOUT or F_SIDETONE if in CW mode
        SEB     TXOUT           ; Turn TX carrier ON
        SEB     F_SIDETONE      ; flag side tone to ON

INEXT2
        decf    ROWCNT, f       ; Decrement row counter
        goto    IEND            ; Exit the int routine

IENDCOL
        CLB     BUSY            ; Clear the BUSY flag to indicate column sent

IEND
        swapf   SAVES,w         ; get status (swapped back)
        movwf   STATUS          ; and restore it
        swapf   SAVEW,w         ; restore W reg (swapped back to restore Z,C,DC flags)
        SEB     I_T0IE          ; Re-enable the interrupt
        retfie

;---- END OF INTERRUPT ROUTINE ------
;-----------------------------------

;*************************************************************************
;** INIT
;** Hardware reset entry point
;**
;*************************************************************************

INIT    ;Power-on entry

;*************************************************************************
;** RESET
;** software reset entry point
;**
;*************************************************************************
RESET   ;Soft reset
```

```
        ;Init ports
        movlw   10h     ; All Port A bits to outputs except RA4 (Timer Cap input)
        tris    PORTA

        movlw   0F0h    ; Initialize Port B I/O pins
        movwf   PORTB
        movlw   0F0h    ; Port B<0-3> Output, Port B<4-7> Input
        tris    PORTB

        movlw   b'00011001' ; 0 Turn ON Port B pullups
                            ; 0 External Int triggers on falling edge
                            ; 0 TOCS low (timer run from internal clock)
                            ; 1 TOSE - Counter timer/counter triggers on rising edge
                            ; 1 Prescaler switched OUT (to WDT) ...
                            ; 110  ...with div. 64 (WDT) or 128 (TMR0)

        option  ; Store W in the Option register.


        CLB     BUSY            ; Clear busy flag
        CLB     F_SIDETONE
        CLB     F_CW            ; Start in Hell' mode

        clrf    COLCNT
        clrf    ROWCNT

        ; Set up the timer interrupt to give us the required 122.5 dots per second
        ; (17.5 columns per second with 7 pixel rows)
        ; We reset the counter to 18 each time to yield 240 counts per
        ; interrupt = (7.3728 / 4 / 240) = 7680 ints. per second.
        ; 7680 / (17.5 x 7 row pixels) = 62.69. So every 63rd call to the int. should
        ; send one pixel.
        ;
        ; NOTE: In practice it was found tat every 60th call produced the right timing!

        movlw   6
        movwf   TONECNT ; Init tone counter reg. Toggle TXOUT every 6 calls to int.
        movlw   60
        movwf   INTCNT  ; Initialize the INTCNT counter reg.
        SEB     I_T0IE  ; enable timer overflow interrupt
        SEB     I_GIE   ; global interrupt enable
                        ; The TIMERINT interrupt routine is now running

        goto    MAIN_LOOP

;====================

DELAY   ; Arbitary delay routine for CW dash/dot timing or whatever

        ; Make a delay send one blank column
        clrf    CURCOL
        call    TXCOL
        return
;----------------------------------

;================================================
; Subroutines for various things shall go here..
;================================================

TXCOL   ; Sets the Int routine up to send a column - 5 rows
        ; (bits stretched over usual 14 rows)
        ; The CURCOL variable hold the column dat to send

        movfw   CURCOL          ; Save column data (the Int routine destroys it)
        movwf   SAVE1

        movlw   6
```

```
        movwf   ROWCNT          ; ROWCNT will process 5 rows (0 not processed)
        SEB     BUSY            ; Setting this bit signals Int routine to send a column
        LOOPBS  BUSY            ; sit in loop waiting for BUSY to clear

        movfw   SAVE1           ; Restore column data (in case we want to send it again)
        movwf   CURCOL

        return
;----------------------

TXCHAR  ; Send character in "W" using Hellscheiber
        movwf   TEMP
        movlw   32              ; make the char code zero based
        subwf   TEMP,f          ; and store in TEMP

        ; The FONT table is split into two parts. Characters 0 to 31 are in part 1
        ; The rest are in part 2 (FONTTAB2)

        movlw   32              ; Is the character to send less than 32?
        subwf   TEMP, w         ; Subtract W (32) from TEMP
        BBS     B_C, USETABLE2  ; Carry Flag is SET for a positive result (TEMP > 32)
USETABLE1
        movlw   HIGH FONTTAB1   ; Get the jump page right and stick
        movwf   PCLATH          ; it in PCLATH as per the book :)
        CLB     F_TABLE         ; Clear the F_TABLE flag to indicate FONTTAB1 below
        goto    SENDCHAR        ; --> go lookup and send this character

USETABLE2
        movlw   32              ; Subtract addition 32 to correct char offset for table 2
        subwf   TEMP, f         ;   /
        movlw   HIGH  FONTTAB2  ; Load PCLATH to correct memory page is used
        movwf   PCLATH          ;   /
        SEB     F_TABLE         ; Set the F_TABLE flag to indicate FONTTAB2 below

SENDCHAR
        movfw   TEMP            ; Retrive char offset
        addwf   TEMP, f         ; multiply by 5 to get to start of
        addwf   TEMP, f         ; char in font table
        addwf   TEMP, f         ;   /
        addwf   TEMP, f         ;   /

        clrf    COLCNT          ; Reset COLCNT (column counter)
TAB1LOOP
        movfw   TEMP            ; Retrieve char font table offset
        addwf   COLCNT, w       ; Add the column number
        CBC     F_TABLE, FONTTAB1       ; Call the right table based on F_TABLE flag ...
        CBS     F_TABLE, FONTTAB2       ; ...set above to get the column data
        movwf   CURCOL

        call    TXCOL           ; Flag the Interrupt routine to send this column
        SKBS    DXMODE          ; If no jumper on for DX mode then exit
        call    TXCOL           ; otherwise send the column a 2nd time

        incf    COLCNT, f       ; Increment COLCNT
        movfw   COLCNT          ; Last column (5) ?
        sublw   5
        BBC     B_Z, TAB1LOOP   ; If not then send next column

        clrf    CURCOL          ; Send one blank column
        call    TXCOL           ;    /

        return

;--------------------------------
;--- CW ROUTINES START HERE -----
;--------------------------------
SENDDASH
```

```
        SEB     F_SIDETONE
        SEB     TXOUT           ; PTT on
        call    DELAY           ; Dash delay
        call    DELAY
        call    DELAY
        call    DELAY
        call    DELAY
        CLB     TXOUT           ; PTT off
        CLB     F_SIDETONE
        call    DELAY
        return
;-----------------------------------
SENDDOT
        SEB     F_SIDETONE
        SEB     TXOUT           ; PTT on
        call    DELAY           ; Dot delay
        call    DELAY
        CLB     TXOUT           ; PTT off
        CLB     F_SIDETONE
        call    DELAY           ; "space between" delay
        return
;-----------------------------------

SENDCW  ; Sends CW character held in W. RRF's each bit out until W = 1
        ; 00h in W means send space between words

        SEB     F_CW            ; Tell the Int routine we are in CW mode

        movwf   OUTBUF
        xorlw   0               ; Trigger Z flag (maybe)
        BBS     B_Z, SSPACE     ; Its zero so just send a space
SILOOP
        movfw   OUTBUF
        sublw   1
        BBS     B_Z, SIEND      ; If just one then we are done

        CLB     B_C
        rrf     OUTBUF, f       ; Get next bit to send

        BBC     B_C, SDOT       ; Branch to DOT if Carry clear. Otherwise its a DASH
        call    SENDDASH
        goto    SILOOP          ; loop back
SDOT
        call    SENDDOT
        goto    SILOOP          ; loop back

SSPACE
        call    DELAY   ; Send word space (just wait)
        call    DELAY
        call    DELAY
SIEND
        call    DELAY   ; Inter char delay
        call    DELAY
        call    DELAY

        CLB     F_CW            ; Tat's enough CW for now thanks :)
        return
;-----------------------------------

;*********************************
;****** M A I N   L O O P  ******
;*********************************

MAIN_LOOP

        ; Send the beacon string from the "T_BEACON" table
        clrf    TEMP1
```

```
BEACONL1
        movlw   HIGH  T_BEACON  ; Stick the MSByte of T_BEACON in PCLATH
        movwf   PCLATH
        movfw   TEMP1           ; Retrieve the beacon character offset
        call    T_BEACON        ; Go get the character
        xorlw   0               ; To update the Z flag
        BBS     B_Z, MLEND1     ; Zero? If so we are done so jump out to MLEND1
        call    TXCHAR          ; Otherwise send this character
        incf    TEMP1, f        ; Increment to next character
        goto    BEACONL1        ; Loopy de loop

MLEND1
        call    DELAY
        call    DELAY

;-----

        ; Same again but this time CW
        clrf    TEMP1
BEACONL2
        movlw   HIGH  T_CALLSIGN        ; Stick the MSByte of T_BEACON in PCLATH
        movwf   PCLATH
        movfw   TEMP1           ; Retrieve the beacon character offset
        call    T_CALLSIGN      ; Go get the character
        xorlw   0               ; To update the Z flag
        BBS     B_Z, MLEND2     ; Zero? If so we are done so jump out to MLEND1
        movwf   TEMP            ; Save W
        movlw   HIGH CWT        ; Get the dot and dashes from the CWT
        movwf   PCLATH          ; /
        movfw   TEMP            ; Restore W
        call    CWT             ; /
        call    SENDCW          ; Send this character
        incf    TEMP1, f        ; Increment to next character
        goto    BEACONL2        ; Loopy de loop

MLEND2
        call    DELAY
        call    DELAY

        goto    MAIN_LOOP       ; Luckily PIC MCU's do not get bored!
;-----------------------------------

        ORG     0200h

FONTTAB1
        addwf   PC, f

        retlw    0      ;  32 -
        retlw    0
        retlw    0
        retlw    0
        retlw    0

        retlw    0      ;  33 - !
        retlw    0
        retlw    29
        retlw    0
        retlw    0

        retlw    0      ;  34 - "
        retlw    24
        retlw    0
        retlw    24
        retlw    0

        retlw    10     ;  35 - #
        retlw    31
```

```
        retlw   10
        retlw   31
        retlw   10

        retlw   8       ;  36 - $
        retlw   21
        retlw   31
        retlw   21
        retlw   2

        retlw   25      ;  37 - %
        retlw   26
        retlw   4
        retlw   11
        retlw   19

        retlw   10      ;  38 - &
        retlw   21
        retlw   13
        retlw   2
        retlw   5

        retlw   0       ;  39 - '
        retlw   16
        retlw   24
        retlw   0
        retlw   0

        retlw   0       ;  40 - (
        retlw   14
        retlw   17
        retlw   0
        retlw   0

        retlw   0       ;  41 - )
        retlw   0
        retlw   17
        retlw   14
        retlw   0

        retlw   21      ;  42 - *
        retlw   14
        retlw   31
        retlw   14
        retlw   21

        retlw   4       ;  43 - +
        retlw   4
        retlw   31
        retlw   4
        retlw   4

        retlw   0       ;  44 - ,
        retlw   1
        retlw   6
        retlw   0
        retlw   0

        retlw   4       ;  45 - -
        retlw   4
        retlw   4
        retlw   4
        retlw   4

        retlw   0       ;  46 - .
        retlw   3
        retlw   3
```

```
retlw    0
retlw    0

retlw    1      ;  47 - /
retlw    2
retlw    4
retlw    8
retlw    16

retlw    14     ;  48 - 0
retlw    19
retlw    21
retlw    25
retlw    14

retlw    0      ;  49 - 1
retlw    16
retlw    31
retlw    0
retlw    0

retlw    3      ;  50 - 2
retlw    21
retlw    21
retlw    21
retlw    9

retlw    0      ;  51 - 3
retlw    21
retlw    21
retlw    21
retlw    10

retlw    0      ;  52 - 4
retlw    30
retlw    2
retlw    7
retlw    2

retlw    28     ;  53 - 5
retlw    21
retlw    21
retlw    21
retlw    2

retlw    14     ;  54 - 6
retlw    21
retlw    21
retlw    21
retlw    2

retlw    16     ;  55 - 7
retlw    16
retlw    23
retlw    24
retlw    0

retlw    10     ;  56 - 8
retlw    21
retlw    21
retlw    21
retlw    10

retlw    8      ;  57 - 9
retlw    21
retlw    21
retlw    21
```

```
        retlw   14

        retlw   0       ;  58 - :
        retlw   5
        retlw   5
        retlw   0
        retlw   0

        retlw   0       ;  59 - ;
        retlw   10
        retlw   11
        retlw   0
        retlw   0

        retlw   4       ;  60 - <
        retlw   10
        retlw   17
        retlw   0
        retlw   0

        retlw   0       ;  61 - =
        retlw   10
        retlw   10
        retlw   10
        retlw   0

        retlw   0       ;  62 - >
        retlw   0
        retlw   17
        retlw   10
        retlw   4

        retlw   8       ;  63 - ?
        retlw   16
        retlw   21
        retlw   20
        retlw   8
;---------------------------------------

CWT     ; CW Table      Call with W=ASC of char to send (EG. 'A' (65) for "di'dah" )
        addlw   0
        SKBC    B_Z     ; Return a zero if zero received
        retlw   0

        movwf   SAVE1           ; Calculate offset in table from ASCI char given
        movlw   48              ; [ ASCII code for "0" ]
        subwf   SAVE1, w
        addwf   PC, f

        retlw   b'00111111' ; 0
        retlw   b'00111110' ; 1
        retlw   b'00111100' ; 2
        retlw   b'00111000' ; 3
        retlw   b'00110000' ; 4
        retlw   b'00100000' ; 5
        retlw   b'00100001' ; 6
        retlw   b'00100011' ; 7
        retlw   b'00100111' ; 8
        retlw   b'00101111' ; 9
        retlw   b'00000000' ; :
        retlw   b'00000000' ; ;
        retlw   b'00000000' ; <
        retlw   b'00000000' ; =
        retlw   b'00000000' ; >
        retlw   b'00000000' ; ?
        retlw   b'00000000' ; @
        retlw   b'00000110' ; A
```

```
        retlw   b'00010001' ; B
        retlw   b'00010101' ; C
        retlw   b'00001001' ; D
        retlw   b'00000010' ; E
        retlw   b'00010100' ; F
        retlw   b'00001011' ; G
        retlw   b'00010000' ; H
        retlw   b'00000100' ; I
        retlw   b'00011110' ; J
        retlw   b'00001101' ; K
        retlw   b'00010010' ; L
        retlw   b'00000111' ; M
        retlw   b'00000101' ; N
        retlw   b'00001111' ; O
        retlw   b'00010110' ; P
        retlw   b'00011011' ; Q
        retlw   b'00001010' ; R
        retlw   b'00001000' ; S
        retlw   b'00000011' ; T
        retlw   b'00001100' ; U
        retlw   b'00011000' ; V
        retlw   b'00001110' ; W
        retlw   b'00011001' ; X
        retlw   b'00011101' ; Y
        retlw   b'00010011' ; Z

;=========================

        ; FONT TABLE 2 (second half)

        ORG     0300h   ; start table at even multiple of 256 address

FONTTAB2
        addwf   PC, f

        retlw    14     ;  64 - @
        retlw    17
        retlw    21
        retlw    21
        retlw    8

        retlw    15     ;  65 - A
        retlw    20
        retlw    20
        retlw    20
        retlw    15

        retlw    31     ;  66 - B
        retlw    21
        retlw    21
        retlw    21
        retlw    10

        retlw    14     ;  67 - C
        retlw    17
        retlw    17
        retlw    17
        retlw    0      ;was 10

        retlw    31     ;  68 - D
        retlw    17
        retlw    17
        retlw    17
        retlw    14

        retlw    31     ;  69 - E
        retlw    21
```

```
        retlw   21
        retlw   21
        retlw   17

        retlw   31      ;  70 - F
        retlw   20
        retlw   20
        retlw   20
        retlw   16

        retlw   14      ;  71 - G
        retlw   17
        retlw   17
        retlw   19
        retlw   10

        retlw   31      ;  72 - H
        retlw   4
        retlw   4
        retlw   4
        retlw   31

        retlw   0       ;  73 - I
        retlw   17
        retlw   31
        retlw   17
        retlw   0

        retlw   2       ;  74 - J
        retlw   17
        retlw   31
        retlw   16
        retlw   0

        retlw   31      ;  75 - K
        retlw   4
        retlw   10
        retlw   17
        retlw   0

        retlw   31      ;  76 - L
        retlw   1
        retlw   1
        retlw   1
        retlw   0

        retlw   31      ;  77 - M
        retlw   8
        retlw   4
        retlw   8
        retlw   31

        retlw   31      ;  78 - N
        retlw   8
        retlw   4
        retlw   2
        retlw   31

;       retlw   31      ;  79 - O
;       retlw   17
;       retlw   17
;       retlw   17
;       retlw   31

        retlw   14      ;  79 - O
        retlw   17
        retlw   17
```

```
        retlw   17
        retlw   14

        retlw   31      ;  80 - P
        retlw   20
        retlw   20
        retlw   20
        retlw   8

        retlw   31      ;  81 - Q
        retlw   17
        retlw   21
        retlw   19
        retlw   15

        retlw   31      ;  82 - R
        retlw   20
        retlw   22
        retlw   21
        retlw   9

        retlw   8       ;  83 - S
        retlw   21
        retlw   21
        retlw   21
        retlw   2

        retlw   16      ;  84 - T
        retlw   16
        retlw   31
        retlw   16
        retlw   16

        retlw   31      ;  85 - U
        retlw   1
        retlw   1
        retlw   1
        retlw   31

;       retlw   16      ;  86 - V
;       retlw   8
;       retlw   4
;       retlw   2
;       retlw   31

        retlw   24      ;  86 - V
        retlw   6
        retlw   1
        retlw   6
        retlw   24

        retlw   30      ;  87 - W
        retlw   1
        retlw   6
        retlw   1
        retlw   30

        retlw   17      ;  88 - X
        retlw   10
        retlw   4
        retlw   10
        retlw   17

        retlw   16      ;  89 - Y
        retlw   8
        retlw   7
        retlw   8
```

```
        retlw   16

        retlw   17      ;  90 - Z
        retlw   19
        retlw   21
        retlw   25
        retlw   17

        retlw   31      ;  91 - [
        retlw   17
        retlw   17
        retlw   0
        retlw   0

        retlw   16      ;  92 - \
        retlw   8
        retlw   4
        retlw   2
        retlw   1

        retlw   17      ;  93 - ]
        retlw   17
        retlw   31
        retlw   0
        retlw   0

        retlw   0       ;  94 - ^
        retlw   8
        retlw   16
        retlw   8
        retlw   0

        retlw   31      ;  95 - _
        retlw   31
        retlw   31
        retlw   31
        retlw   31

T_BEACON
        addwf   PC, f
        retlw   ' '
        retlw   '>'
        retlw   '>'
        retlw   ' '
        retlw   'H'
        retlw   'E'
        retlw   'L'
        retlw   'L'
        retlw   'S'
        retlw   'C'
        retlw   'H'
        retlw   'R'
        retlw   'E'
        retlw   'I'
        retlw   'B'
        retlw   'E'
        retlw   'R'
        retlw   ' '
        retlw   'B'
        retlw   'E'
        retlw   'A'
        retlw   'C'
        retlw   'O'
        retlw   'N'
        retlw   ' '
        retlw   'V'
        retlw   'I'
```

```
        retlw   'A'
        retlw   ' '
        retlw   'P'
        retlw   'I'
        retlw   'C'
        retlw   '1'
        retlw   '6'
        retlw   'C'
        retlw   '8'
        retlw   '4'
        retlw   ' '
        retlw   'M'
        retlw   'C'
        retlw   'U'
        retlw   ' '
        retlw   'D'
        retlw   'E'
        retlw   ' '
        retlw   'Z'
        retlw   'L'
        retlw   '1'
        retlw   'H'
        retlw   'I'
        retlw   'T'
        retlw   ' '
        retlw   '<'
        retlw   '<'
        retlw   ' '
        retlw   ' '
        retlw   0

T_CALLSIGN
        addwf   PC, f
        retlw   'Z'
        retlw   'L'
        retlw   '1'
        retlw   'H'
        retlw   'I'
        retlw   'T'
        retlw   0

        END
```