This homebrewed 10MHz frequency reference is locked by the GPS satellite system and achieves an estimated accuracy of 10,000,000.000 +/- 0.002Hz in normal operation. It includes integral power supply and is intended to be permanently switched on in the shack, and to provide an accurate frequency reference which will be piped into other homebrew equipment such as the timebase of frequency counters etc. In the description that follows, click any photo to see a larger view.

GPS Aerial

Where better to start, than where the GPS signals first arrive: the aerial. I built this design from an article "An Inexpensive External GPS Antenna" I replicated his design as exactly
{gallery}g

GPS Receiver module

Building your own GPS receiver module is surely not easy to be undertaken lightly. The module {gallery} Click for the datasheet from eBay very cheaply {gallery} ... {gallery}

10MHz OCXO

I was fortunate enough to {gallery}gps/jl/ocx{/gallery} find in the junk box this 10MHz Oven Controlled Crystal Oscillator (OCX

Circuit diagram

The circuit diagram is shown to the right. An 8-bit AVR microcontroller was used for this project, ... discrete component logic page). The output of this divider ... click here to see the remote GPS receiver module circuit diagram

Software

Click here to read the assembly language listing

The software was written entirely in assembly using the free development environment AVR Studio from Atmel. My AVR programmer connects to my PC's USB port and is the USB-AVR4U Plus model from www.micro4you.com . The software is VERY MESSY. I found the LCD controller routines, and binary-to-packed-BCD routines from internet searches and adapted them to my own purposes. The rest of the software is original! The strategy is to measure the

system clock frequency using the 8-bit timer on the ATtiny2313. At a count of exactly 10MHz this counter should theoretically contain a count of 128. A snapshot of the 8-bit timer register is taken on receipt of the 1pps pulse from the GPS receiver module which generates an interrupt. If this count is too high (128 or over) then action is taken to reduce the OCXO frequency. If it is too low, action is taken to increase the OCXO frequency.

Control over the OCXO frequency is effected by use of the 16-bit Timer in PWM mode. The PWM output signal is integrated simply by a resistor-capacitor on the PWM output pin (see circuit diagram). The PWM register is adjusted up or down once every second on receipt of the 1pps interrupt arriving from the GPS receiver module. Three separate phases are applied. Phase 1 uses step values of 128 in the PWM register, which are enough to move the OCXO frequency by about 0.5Hz. This rough-tuning phase lasts 255 seconds and approximately coincides with the amount of time taken for the OCXO to heat up. Phase two reduces the tuning step value to 16 which allows the loop to adjust the frequency with more precision and less frequency deviations occurring once every second. During these first two phases the actual measured frequency is displayed on the LCD for informational purposes. Phase 2 lasts a further 255 seconds, by which time the system has really settled down well. Phase 3 is then entered in which the PWM step is reduced to 1. The LCD display is also set to display 10,000,000 exactly rather than the actual count which would 50% of the time show 9,999,999 which is very annoying. A steady display is much nicer to look at. However a dot a few characters to the right of the frequency display is switched on and off depending on whether the frequency adjustment is up or down. Seeing it alternate at 1 second intervals as the frequency is locked very closely on 10MHz is an encouraging indication of continued correct operation of the system.

The final task of the software is to decode the incoming NMEA serial data stream which arrives at a rate of 9600 baud (the default configuration of the GPS receiver module). Each incoming ASCII character received by the ATtiny2313 microcontroller's internal USART generates an interrupt call which processes the character. The software looks for the $GPRMC sentence which contains time and position information. This sentence is parsed and formatted then displayed on the LCD screen.

Construction

A box was constructed for the frequency reference project, from a single sheet of double sided PC

NOTE: At time of writing, it was TOO tight a squeeze and the unit drastically overheats when operating f {gallery}gps/gps{/gallery}

Photographs

These photos show the low current AVR voltage supply regulator board, a close-up of the board, and the rear view. Note the copper is cut away around the red photo connector, because the shield is at +5V potential. **CLICK THE PHOTOS** for larger images.

{gallery}gpsref/photos1{/gallery}

These photographs of the completed project were taken during a recent demonstration to HM Queen Elizabeth II. Naturally she was highly impressed.

{gallery}gpsref/photos2{/gallery}

Finally some photographs showing the installation of the frequency reference in the G0UPL station, and some views of the remote unit (GPS receiver module and aerial). Note raindrops on the plastic cover.

{gallery}gpsref/photos3{/gallery}