

## Task Example

### MSF-GPS Receiver for Navtech Systems



#### Task Outline

Phasor Design were commissioned by Navtech Systems Ltd. to contribute to the development of a combined 60kHz MSF receiver and GPS receiver. The primary purpose of this exercise was to produce a very reliable time signal at reasonable cost. See the following link for details of the completed product.

[http://www.navtechsystems.co.uk/products/3%20Other%20Products/8%20MSF%20Radio%20Systems/MSF\\_GPS\\_Off-Air\\_Time\\_Reference\\_19052009.htm](http://www.navtechsystems.co.uk/products/3%20Other%20Products/8%20MSF%20Radio%20Systems/MSF_GPS_Off-Air_Time_Reference_19052009.htm)

#### Background

Very reliable time signals are required in a number of applications and the 60kHz MSF time service provided by the National Physical Laboratory is the traditional way of achieving this. Unfortunately low cost receivers for this service tend to be unreliable. See the following link for details of the MSF service from NPL.

<http://www.npl.co.uk/science-technology/time-frequency/time/products-and-services/msf-radio-time-signal>

#### The Solution

This task led to the following solution, which involved:

- A higher quality MSF receiver with twin diversity channels.
- A GPS receiver as an alternative time source.
- A good quality internal 10MHz oscillator, which is permitted to run for 24 hours before off-air time is restored.

In addition the MSF time waveform is re-created so that this system becomes a direct replacement for existing low cost MSF receivers. Accuracy of a few tens of milliseconds exceeded the requirement and in addition the 10MHz oscillator was made available at an output.

#### Software Defined Radio

The dual channel 60kHz MSF receiver was implemented in a single 16-bit microcontroller as a software defined radio. The only additional filtering is a single pole filter in the active antenna. For full details see the following link to a paper presented at the ARMMS RF and Microwave conference.

[http://www.armms.org/images/conference/s\\_day\\_implementation\\_of\\_a\\_software\\_defined\\_radio\\_for\\_the\\_60khz\\_msf\\_time\\_signal.pdf](http://www.armms.org/images/conference/s_day_implementation_of_a_software_defined_radio_for_the_60khz_msf_time_signal.pdf)

The embedded software was implemented in HiTech C for the DSPIC33FJ256GP710 microcontroller.

## Compatibility of MSF and GPS time sources

It was necessary to ensure that MSF signal was re-created exactly as transmitted which implies predicting in advance events, which might alter the time signal. The following events were addressed.

- Leap years.
- British summer time.
- Calculation of the day of the week number.
- Addition of leap seconds both positive and negative

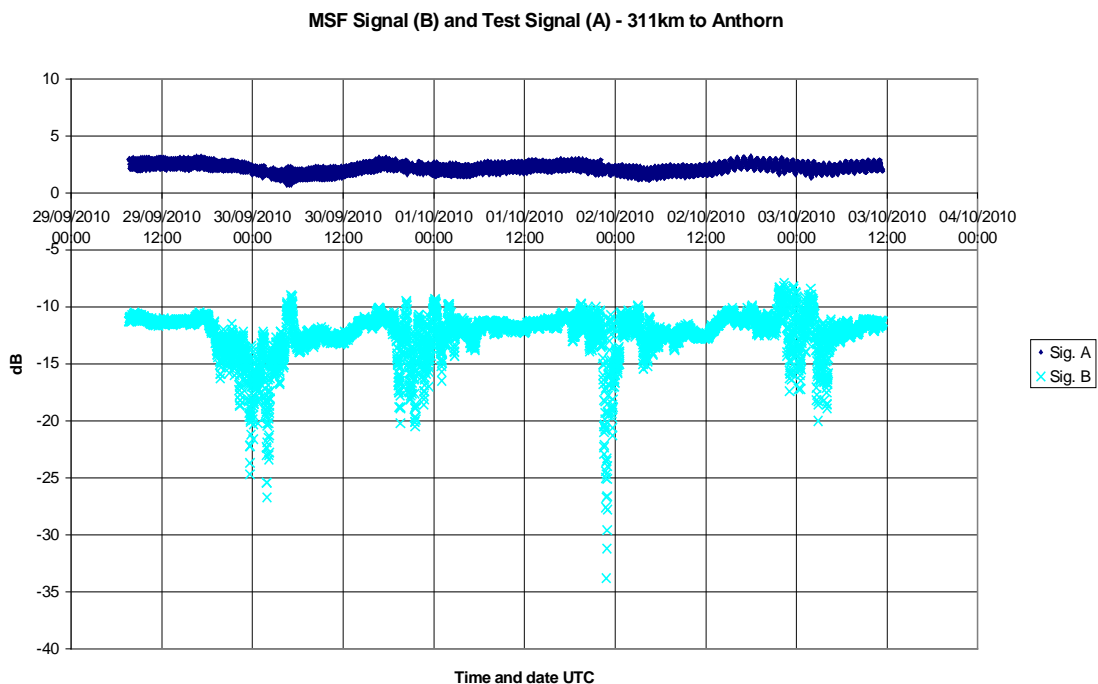
Verification that the system responded correctly to these events was not trivial. Special software was written to generate these events in simulated form and correct behaviour was observed. In addition algorithms were tested for each second over the next 50 years.

It was necessary to have external validation of the correctness of the re-created time code output and this validation was performed by NPL under contract from Navtech Systems. NPL report number I2D/TQEM/TT2009-01 is available from Navtech Systems on request.

## MSF received signal measurements

An additional benefit of the software defined radio method is the ability to bring out signal and noise level data, which can then be logged using a PC. The plot below shows the signal levels over a four-day period in September 2010. To eliminate the possibility of daily temperature variation being a cause of the signal variations a known reference is included (shown dark blue below).

Note that MSF signal variation is greatest around midnight and can be quite large exceeding 10dB. This variation is thought to be a result of destructive interference between the ground wave and sky wave. The range to the Anthorn transmitter is 311km which compares to about 450km for London. This suggests the signal level variation in London could be greater. As most MSF receivers switch their receivers on only briefly around 2am to conserve battery power, the potential for failure to synchronise is clear.



## Conclusions

The MSF / GPS Receiver NTS-MSF-G/M-01, verified and approved by the National Physical Laboratory is available from Navtech Systems Ltd. Medium volumes of these systems are now in service.

Phasor Design worked with the client's engineers to contribute to the cost-effective development of a very sophisticated product. The task included devising methods of verification, which were in turn validated by NPL.

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