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TIME AND FREQUENCY USER CLUB

Summer 2003 Newsletter

Galileo Update - Director Announced ESA

The appointment of Rainer Grohe as Director of the Galileo Joint Undertaking marks a further key step forward for Galileo, the first civil global satellite navigation programme.

"I am delighted at Rainer Grohe's appointment to manage the first Joint Undertaking established by the European Space Agency and the European Commission", said Antonio Rodotà, ESA's Director General. "His industrial experience will be invaluable to us in carrying out this programme, which can now get fully into its stride for the benefit of everyone in Europe." The Administrative Board of the Galileo Joint Undertaking endorsed the appointment on Monday 16 June in Brussels. This means that the JU can now proceed with the various steps towards setting up the Galileo network, which will give users in Europe - and throughout the world - a precise and secure satellite positioning and navigation system

The Joint Undertaking's main task is to prepare for the Galileo programme deployment and operational phase, which should culminate in the selection of a concession holder to take charge of running the future Galileo operating company. That private entity will take over to finish deployment of the constellation in orbit and finalise installation of the ground segment necessary to complete the system. It will then manage the operational

Joint Undertaking

phase.

In the near term, under the development and in-orbit validation phase, ESA is responsible for the launch of a first experimental satellite scheduled for September 2005. This will serve the dual purpose of securing the frequencies reserved for Galileo until June 2006 by the International Telecommunications Union and testing of the new technologies. To minimise the risks, two contracts will be awarded to industry by early July to build two separate satellites. Three or four test satellites will subsequently be launched for validation of the system around 2006/2007.

All this adds up to a magnificent challenge for ESA and the Commission together with the Galileo Joint Undertaking: achieving European independence in the strategically important area of satellite navigation, a sector having numerous economic spin-offs.

The core of the Galileo system is its constellation of 30 satellites (27 operational, 3 spare) circling in medium Earth orbit in three planes inclined at 56° to the equator at 23616 km altitude. This will provide excellent global coverage. Two centres will be set up in Europe to control satellite operations and manage the navigation system.

2001-2003 Meeting Subjects & Speakers

29/07/03

The European Time & Frequency Forum 2004, Guildford
Mike Underhill, Surrey University

Anti Jitter Circuitry for Phase Noise Reduction
Mike Underhill, Surrey University

Galileo Update
Graham Gunn, Integral Dynamics

Aquila/ Qinetiq/ Wiley - MoD's Calibration Laboratory, It's Future
John Adams, ASAP Calibration

Caesium Frequency Standards
Steve Newcombe, Sematron UK

06-02-03

The Work of The Radiocommunications Agency
Richard Drinkwater, Radiocommunications Agency

Evolution of Synchronisation Quality Metrics & Test Procedures
Charles Curry, Ian Wright, Chronos Technology

National Measurement Programme 2003-2006
John Laverty, NPL; John Lee, DTI

A New Quartz Oscillator
Paul Glover, Wavelength Electronics

25-09-02

Rubidium Lamp & Cell Research
Dr G M Saxena, NPL India

Hydrogen Masers - An introduction
Dr John Ponsonby

Digital Alias-free Spectrum Analysis of High Frequency Signals
Andrzej Tarczyński, University of Westminster

Phase Noise Test Set Capabilities
IFR, Aeroflex

28/03/02

The Work of the RGO
Matthew Read, Royal Greenwich Observatory

Frequency Calibration Practices
Alan Coster, Dowding & Mills

Galileo - A View From Astrium
Matt Peren, Astrium

Using A Digital Storage Oscilloscope to Perform Jitter and Timing Analysis
Graham Gibbons, LeCroy

Galileo (IEE Presentation)
John Owen, DSTL (Defence Science & Technology Laboratories)

20-06-01

Current GPS traceability criteria
John Davis, NPL

Where has GPS timing moved?
Jacqueline Bickerstaff, Parthus

OCXO designed for GPS disciplined frequency standards
Peter Davenport, HCD Research

Commonly encountered limitations in measuring phase noise
Kanak Tuladhar

Oscilloscope calibration and calibration software
Kevin Fielding

Where have L/F off air frequency standards moved?
Mark Rainer

Club News

Future Meetings

The Club will be hosting its last meeting under Quartzlock management on September 30th. After this date the Club will return to NPL management. Anybody who wishes to present a paper at this meeting is more than welcome - please contact John Aplin or Clive Green for more information before the end of August. The primary subject will be frequency measurement.

February 2003 Meeting - RCA Whyteleafe

The February meeting at the Radiocommunications Agency's Whyteleafe Facility was again an excellent day of knowledge exchange for all attendees. The Club would like to thank Richard Drinkwater and his colleagues at RCA Whyteleafe for hosting the day.

July 2003 Meeting - Rutherford Appleton Laboratory

Another excellent meeting at the Club's 'base', the Rutherford Appleton Laboratory in Oxford. A Galileo update, an EFTF 2004 update, anti jitter circuitry and caesium frequency standards presentations and a debate on lab practises made for an exciting day.

Autumn 2003 Newsletter

Short technical articles are invited for the autumn issue of the Club newsletter. Please e-mail to quartzlock@quartzlock.com before the end of August

Important Notice

Members were sent a link to the proposed National Measurement Programme 2003-2006 with reference to Time and Frequency Metrology. It's our NPL and this is an opportunity to consider how the £3M budget can be used to make the UK work more competitive and NPL's position more significant as an NMI to enable us to compete for international project support (i.e. Galileo) and EU funded research.

Please consider this document and issues such as the future of Rugby GBR 60kHz transmission and the 'leap second'.

The Droitwich Transmission, 198kHz

Andy Savage, Crown Castle

Currently there are 3 UK transmitters carrying BBC Radio 4 Longwave on 198kHz. These are Droitwich serving England and Wales, Westerglen in Scotland, serving the Edinburgh and Glasgow area, and Burghead, also in Scotland, serving the Inverness and Northern Scotland areas. Each of these sites use rubidium frequency standards but only the one at Droitwich is traceable to the NPL standard via the monthly bulletin. The two sites in Scotland are compared locally with, and adjusted against, a received 60kHz MSF signal but are not independently checked by NPL.

In between two adjacent transmitters there are areas where the received signals from the two sites concerned are of similar strength, and cancellation can occur, giving a poor or non-existent reception. These areas are known as "mush areas", and they can move north or south slightly if one of the two transmitters concerned goes to reduced power. One of the "mush" areas lies across the area of Carlisle to Newcastle. North of this area you would be receiving Westerglen, south of this area it would be Droitwich, and inside the area you would be receiving both.

At Droitwich there are 2 Hewlett Packard 5065A Vapour Frequency Standards arranged in a main/standby configuration with an automatic changeover from the main to the standby if there is a failure. The main Frequency Standard is adjusted against data from NPL and the standby Frequency Standard is compared to, and adjusted against, the main Standard. The two Frequency Standards are run off battery supplies to isolate them from mains fluctuations.

The resulting 5MHz frequency signal from the "In Service" Frequency Standard is fed to two 198kHz synthesisers also arranged in a main/standby configuration with automatic changeover. After that the 198kHz signal is phase modulated between plus and minus 22.5 degrees at a data rate of 25 bits per second. Amongst other things the modulated data carries information for the electricity supply industry and flood warnings for the Lincolnshire to Suffolk areas. Again there are 2 phase modulators arranged in a

main/standby configuration.

After Phase Modulation the 198kHz signal is passed to the two transmitters. The transmitters are Marconi B6042's, and can each deliver 250kW of carrier power with audio level amplitude modulation; in this case the programme is the BBC Radio 4 Longwave service. The transmitters are run as a parallel pair so the carrier power to the antenna is 500kW. In order to reduce running costs the transmitters are run in Amplitude Modulation Companding mode, or AMC for short. AMC takes advantage of the fact that high audio levels mask background noise so that at 100% amplitude modulation the total carrier output power is reduced (in this case) to half what it is at zero % modulation. In a receiver any background noise would rise as the carrier falls in level, but the high audio level at 100% modulation would mask this rise in noise. So at zero % modulation the total carrier output is 500kW and at 100% modulation the total carrier output is 250kW. The AMC controller maintains the correct modulation ratio so that the carrier is never under or over modulated. The AGC in a receiver will remove the effect of AMC so that the demodulator is presented with a normal amplitude modulated signal.

A changeover of either the Frequency Standards or the phase modulators will result in a step change in phase of the 198kHz signal and this will be reflected in the output of Off-air Frequency Standards.

Similarly Off-air Frequency Standards can produce an arbitrary jump in output phase when we have a 3 second break to remove a transmitter for maintenance, or a fault. With 500kW of RF power it's very difficult to arrange a no break system that doesn't involve balancing loads capable of a continuous dissipation of 125kW.

AMC has been known to cause phase modulation of some Of-air Frequency Standard outputs. In this case the incoming signal level, which is varying at an audio rate, pulls the phase of the receivers reference oscillator, fortunately this is easy to identify.

DIARY DATES

DATE	EVENT	LOCATION	WEBSITE
17th - 21st August 2003	NCSL	Florida, USA	www.ncslinternational.org
9th-12th September 2003	ION GPS/GNSS	Oregon, USA	www.ion.org
30th September 2003	T&F Club Meet	TBA	www.quartzlock.com
21st-22nd October 2003	GPS Traceability	London, UK	www.npl.co.uk
18th-20th November 2003	BEMC	Cardiff, UK	www.npl.co.uk
2nd-4th December 2003	PTTI	San Diego, USA	www.usno.navy.mil
28th June - 2nd July 2004	CPEM	London, UK	www.npl.co.uk
5th-7th April 2004	EFTF	Surrey, UK	www.surrey.ac.uk
23rd-27th August 2004	FCS	Montreal, Canada	www.ptti.org

The noise and suppression transfer functions of the Anti-Jitter Circuit (Abstract)

Professor Michael J. Underhill.

School of Electronics and Physical Sciences, University of Surrey, Guildford, Surrey, GU2 5XH, UK. and Toric Limited, of London NW1 6AD UK. Email: m.underhill@surrey.ac.uk

The AJC suppresses phase noise and time jitter on any input signal by a feed-forward cancellation process. The process is self-adjusting so that as the frequency is changed the degree of cancellation and noise suppression is maintained. However it always has a lower frequency limit for noise and jitter

suppression. This limit and the associated settling time after a frequency or phase step, is determined by the integrator time constant and the feedback gain and time constants. Feedback has to be applied to maintain correct AJC operation as the input frequency is changed; often over a 10:1 frequency range. A circuit designer must make a selection from a range of possibilities for the loop transfer function, and so a method is needed to find the best choice.

(Please contact Professor Underhill for a full copy of the paper)

New/ Potential Members Information

Joining

We invite prospective members of the Time and Frequency User Club to join. The club's aim is to provide a forum for exchange of ideas and information on time and frequency standards, enabling solutions to be found for existing measurement problems and identification of future requirements for time and frequency measurement standards. Membership of the club is free of charge.

Existing and new Club members include industrial users, SME's, defence organisations, universities, utilities, security, energy and telecoms. The club holds two meetings per year with presentations from guest speakers on relevant subjects.

Newsletters are published with meeting notes, articles on focus subjects and general information on developments in the time and frequency field.

Club objectives

- to provide a forum for members to discuss time and frequency technology issues and exchange information.
- to seek common initiatives to problems and opportunities, and underpinning measurement standards.
- to disseminate information on national and international activities.
- to identify future requirements for time and frequency technologies and underpinning standards.
- to coordinate inputs to standardisation bodies and other organisations.

Benefits of Joining

- Participation in a coordinated group with a common interest in time and frequency technologies, their application, and underpinning standards.
 - Rapid access to news of developments in time and frequency technologies in the UK and around the world.
 - Opportunities to disseminate latest results and exchange ideas and information.
 - Report on national and international activities.
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