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Teaching Old Tricks To New Dogs
This describes why transferring test programs and fixtures from obsolete Automatic Test Equipment (ATE) to new equipment is not as simple as it should be. No one would argue that technology has made major advances on test in the last 30 years. Today, speed, overall performance, computing power, and software tools are more sophisticated than 20 or 30 years ago, when the first ATE appeared. As these ATE now seem to be on the road to retirement and as the programs they support still have a long life to live, one would think legacy replacement with new ATE would be a simple task. Unfortunately, this is seldom the case. We realize that old ATE had a number of cards up their sleeves to deal with. For example, high voltage technology, lack of Computer Aided Engineering (CAE) data, requirements for parametric tests, extensive usage of the guided probe, and many other aspects might be not so simple to be reproduced with modern, yet powerful, ATE. The paper shall identify the specific constraints involved with old technology and give examples of success stories where new ATE has been adapted to respond to the challenge. Paraphrasing (in reverse) and old saying, it will be like "teaching old tricks to new dogs."

VXI or PXI Test System Improvement using DSP
The results of a study into the use of distributed digital signal processing (DSP) at the instrument level in a VXI and PXI based test system and the effects on test time. One of the limiting factors in testing mixed signal or analog devices using standard bus based instruments is the transfer speed from the instrument to the controlling computer of large amounts of waveform data. This is important as these types of tests use non-deterministic, quantized signals that must be mathematically processed to extract test information. This processing can either be done at the instrument or at the central controller. If the processing is done at the instrument then only the results are transferred to the controller. If the controller does the processing then the raw data must be transferred to and from the instrument. Using two instruments, one in VXI and one in PXI, this paper measures the effects of typical tests contrasting the measurements done in the central processor as opposed to a distributed DSP processor in each instrument. For each acquisition instrument, the tests were implemented by capturing the data and moving it to the controlling computer where it was processed to extract test results, or by using the instruments on-board DSP so only the final test results are sent to the controlling computer. The study results show that a significant improvement in test time can be made by selecting "smart" instruments for the test system when using PXI or VXI based instruments.

Buried Cable Sensor with Intruder Location
A buried cable sensor has been added to the Intrepid family of outdoor perimeter intrusion sensors. The sensor with the trademarked name "MICROTRACK" is similar to the "MICROPOINT" fence sensor with precise detection location, sensitivity leveling, and free format zoning. Intruder location is accomplished with low-power ultra wideband frequency stepped radar driving the sensor cables. Target range resolution also allows the use of sensitivity leveling for each individual range bin. This will compensate for differences in soil conductivity along the length of the cable and for metal objects, which may be located in the near field radiation.

Ground Penetrating Radar VIY-2
VIY-2 ground penetrating radar (GPR) with unique sounding possibilities and use simplicity is presented at this paper. VIY-2 GPR combines all units (synchronizer, transmitting and receiving modules, powering, and antenna system) into single case. The VIY-2 GPR communicates with computer via standard interface RS232 or USB1.0. Technical solutions utilized by the VIY-2 GPR reduce deployment time and simplify surveying process.

The VIY-2 GPR design features and its components interaction are considered at this paper. Some field results are also presented here. The VIY-2 GPR design concept allows reducing the data acquisition time, optimizing the time-varying gain control function, applying depth-stacking dependence, controlling the surveying window position and interference reducing by pulse repetition frequency randomizing.

Fiber Optic Gyrocompass Superluminescent Fiber Source
The objective of this work is to establish the dependence of characteristics of the fiber optics gyrocompass with respect to the parameters of the superluminescent emission source based on doped optical fiber with rare earth elements, Superluminescent Fiber Source (SFS), argument the pumping rate election of the SFS to obtain characteristics limits of the fiber optic gyroscope sensitivity.

Mm Wavelengths Complex Doppler Analysis Using Dark Field Illumination
Experimental results that indicate that at least two fundamental modes of Doppler generation are present when a rotating steel cylinder is broadband illuminated by radar. Improvised bistatic measurements at 77GHz are discussed and second order Doppler effects studied. Complex Doppler returns, consisting of two or more Doppler contributions, are decomposed and studied using empirical methods. In particular, ground illumination techniques are used to study Doppler in the shadow region of a cylinder of circumference 81 wavelengths. It is concluded that the complex Doppler response from the spinning cylinder consists of both direct (first order) and delayed (second order) Doppler components. Further measurements are proposed to study the delayed Doppler effect further.

Signature Recognition State-of-the-Art
A summation of one of the most successful behavioral biometric recognition methods: signature recognition. Probably this is one of the oldest biometric recognition methods, with high legal acceptance. Technological advances have made possible new perspectives for signature recognition, by means of capturing devices which provide more than the simple signature image: pressure, acceleration, etc., making it even more difficult to forge a signature.
Teaching Old Tricks To New Dogs

Robert Peet
SEICA, Inc.

ABSTRACT

This describes why transferring test programs and fixtures from obsolete Automatic Test Equipment (ATE) to new equipment is not as simple as it should be. No one would argue that technology has made major advances on test in the last 30 years. Today, speed, overall performance, computing power, and software tools are more sophisticated than 20 or 30 years ago, when the first ATE appeared. As these ATE now head for retirement and as the programs they support still have a long life to live, one would think legacy replacement with new ATE would be a simple task. Unfortunately, this is seldom the case. We realize that old ATE had a number of cards up their sleeves to deal with. For example, high voltage technology, lack of Computer Aided Engineering (CAE) data, requirements for parametric tests, extensive usage of the guided probe, and many other aspects might be not so simple to be reproduced with modern, yet powerful, ATE. The paper shall identify the specific constraints involved with old technology and give examples of success stories where new ATE has been adapted to respond to the challenge. Paraphrasing (in reverse) and old saying, it will be like “teaching old tricks to new dogs.”

INTRODUCTION

Both manufacturing and depot centers for military / aerospace systems have always been challenged to assure maintenance of returned Shop Replaceable Units (SRU) and Line Replaceable Units (LRU) well beyond the common commercial practices. For this purpose, a variety of ATE have been deployed together with a huge number of Test Program Sets (TPS) and fixtures for each specific weapon’s program. But as weapon systems remain in operation over multiple decades, they can easily outlive the ATE meant to support them. When the old ATE can no longer be kept in operation, migration of the entire logistic to a new ATE becomes inevitable.

OLD vs. NEW ATE

Modern commercial-off-the-shelf (COTS) ATE offered today typically has high digital performance, ability to host a variety of instrumentation, a flexible and scalable architecture, powerful software and development environments that were not available 30 years ago when the ATE industry started its life. Indeed some of us remember having worked with systems driven by a glorious PDP8, or even by custom controllers with 32K of core memory, connected to a KSR printer with punch-paper I/O for the test programs. IEC controlled instruments were a luxury and channel cards enjoyed memory behind the pin to run dynamically at a few MHz only by the late 1970s. Yet these systems were doing the work thanks to a simple, well-thought-out architecture to deal with the technology of the time.

Digital test flexibility was assured by the ability to provide drive/detect and load capability at each I/O of the SRU or LRU with enough flexibility to deal with all available technologies (TTL, ECL, and CMOS).

Parametric analog tests were assured by providing access, for each channel, to a centralized bank of DC/AC proprietary or IEC-driven instrumentation.

The guided probe assured diagnostic to the component level, with data generation either from a known good board (KGB) or from simulation. When analog parts were involved, a combination of active analog probing and passive impedance probing was often deployed.

Finally, knowing that test engineers were fundamentally electronics engineers and not software gurus, each system featured an extensive and flexible dedicated test oriented language.

Modern ATE are now based on widespread and powerful PCs, offer compact, high density channel cards capable of 25MHz or higher data rates, a wide variety of VXI instruments, plug-and-play facilities, and direct access to C++ or JAVA advanced languages. Yet, while they might be powerful to deal with complexity, they often have difficulty dealing with the simpler test requirements of old technology. Furthermore, though the trend versus standardization and widespread usage of COTS instrumentation and tools brings evident advantages,
Digital Channels

Old technology was based on TTL, ECL, and CMOS components. Often two or more technologies co-existed on the same board. Digital channels should, therefore, offer programmability of voltage levels to cover all of these families and sufficient flexibility to mix and match as required — including simultaneously. This is often a problem for new ATE, more concerned, on the contrary, with low voltage and power logic.

With old technologies, though dynamic test was possible, digital test was often performed in static mode. Static test carries advantages during debug and better control of mixed mode testing. Changing a static test to a dynamic test, if not required, might be cumbersome, and inevitably, loses some of these advantages. Many modern ATE, so worried to keep with increasing speed requirements, do not allow real static test. This might prove a major problem during TPS migration and debug.

Some of the old ATE embraced the practice used within circuit testers to multiplex the channels, or to split drivers and detectors. As SRU had internal test connectors, the number of required channels was rapidly growing. Modern ATE have abandoned this practice but one should be aware of it when dimensioning the replacement ATE. In fact, sometimes the number of effective channels required could exceed the capacity of a number of modern functional ATE.

Parametric Tests

Fear of electrostatic damages, characteristics of the technology and fault collection on digital SRU supported the practice of performing parametric DC and timing tests on most I/O pins. To do so, old ATE offered the ability to switch any channel through an internal matrix and bus to dedicated instrumentation able to perform fan-in, fan-out, and sometimes, time propagation tests. This architecture is still found, for obvious reasons, on modern in-circuit testers. It is often absent (or offered as an expensive option) on modern functional ATE. This would be another major point to verify before engaging on a migration program.

Guided Probe

When one looks at the packaging of modern boards, with high density on both sides and almost exclusively surface mounted (SMT) and ball grid arrays (BGA) components, guided probing immediately appears out of date. Most new ATE have thus abandoned or neglected its use. In few cases a digital guided probe, solely used in conjunction with data coming from simulation, is allowed. These limitations will greatly impact the effort required in migrating obsolete test programs, where guided probing was indeed a major factor. Digital probing was used on old testers for diagnostics both in combination with simulation, or directly by learning or comparing data with a KGB. When boards were complex and offered poor testability, the digital probe was also used to extend observability inside the circuit and increase fault coverage and diagnostic accuracy and speed [3]. Less common, but not so rare, was the utilization of analog probe
techniques, manual or computer driven, to identify the failing analog block and even to perform power-off impedance measurements inside the block. These techniques are now considered obsolete, but one would require them on modern ATE to re-host old test programs. See Figure 2.

Analog Tests
When migrating analog test programs three issues need to be addressed:

- 1) Original instrumentation (usually IEC driven) can either be transferred directly in the new ATE, or it should be substituted with adequate replacement, if available.

- 2) Careful attention should be made in routing the test instrumentation to the Unit Under Test (UUT). Here, the more flexible the architecture of the target ATE the easier will be the task.

- 3) The original test program should be converted, possibly preserving the same formal structure but shielding the instrument in such a way that if later changed, test programs will not be affected.

This combination of requirements may prove to be difficult, and/or costly, on modern ATE.

Fixturing
Fixtures, as well as ATE, should be refurbished when possible and convenient. Unfortunately in many cases, this may not prove to be economically viable, particularly when fixtures include active electronics (the more complex, the more difficult) or simply the cost is too high. In such cases building a fixture adapter between the new ATE receiver and the old fixtures is the preferred solution. Once again, the flexibility of the new ATE to provide adequate number of non-multiplexed independently programmable analog/digital resources on every pin would greatly simplify and reduce the cost of the fixture adapter.

Table 1 summarizes some of the key factors to consider as minimum or ideal requirements when evaluating a new ATE platform for re-hosting of old TPS and fixtures.

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Minimum</th>
<th>Best</th>
</tr>
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<tbody>
<tr>
<td><strong>Channels</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
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<td>Over 512</td>
</tr>
<tr>
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<td>NO</td>
</tr>
<tr>
<td>Speed</td>
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</tr>
<tr>
<td>Depth</td>
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<td>128K</td>
</tr>
<tr>
<td>Levels</td>
<td>-2V/+10V</td>
<td>-15V/+15V</td>
</tr>
<tr>
<td>Levels Select</td>
<td>By card</td>
<td>By Channel</td>
</tr>
<tr>
<td>Loads</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Analog Switch</td>
<td>Ch disconnect</td>
<td>8 Lines matrix</td>
</tr>
<tr>
<td>Static Test</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Dynamic Test</td>
<td>Yes</td>
<td>On-the-fly</td>
</tr>
<tr>
<td><strong>Digital Probe</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manual</td>
<td>-</td>
<td>Yes</td>
</tr>
<tr>
<td>Guided</td>
<td>Fm simulation</td>
<td>Simul./KGB</td>
</tr>
<tr>
<td>Fault Diction.</td>
<td>-</td>
<td>Fm simulation</td>
</tr>
<tr>
<td><strong>Analog Probe</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manual</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Active Guided</td>
<td>-</td>
<td>Yes</td>
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<tr>
<td>Impedance</td>
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<td><strong>Instruments</strong></td>
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<td>IEC</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>VXI</td>
<td>-</td>
<td>Yes</td>
</tr>
<tr>
<td>PXI</td>
<td>-</td>
<td>Yes</td>
</tr>
<tr>
<td>PCI</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Software</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test Language</td>
<td>Structured</td>
<td>Test Oriented</td>
</tr>
<tr>
<td>Ext DLL call</td>
<td>-</td>
<td>Yes</td>
</tr>
<tr>
<td>Flow Control</td>
<td>Structured</td>
<td>Customizable</td>
</tr>
<tr>
<td>Data Entry</td>
<td>Manual</td>
<td>Manual, CAE</td>
</tr>
<tr>
<td><strong>Fixturing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Receiver</td>
<td>Full access</td>
<td>Pin bed</td>
</tr>
<tr>
<td>Engagement</td>
<td>Mechanical</td>
<td>Mec/Pneu/Vac</td>
</tr>
<tr>
<td>Ergonomy</td>
<td>-</td>
<td>Hor/Vert</td>
</tr>
<tr>
<td>Sys Archit.</td>
<td>Scalable</td>
<td>Full Hybrid</td>
</tr>
</tbody>
</table>

CASE STUDIES
Each time SEICA has been involved with test program migration projects, the cost of the new ATE has never been identified as a major obstacle. The fat rabbit has always been TPS and fixture migration cost. Hence, SEICA has always taken a comprehensive solution approach to the problem, capable of automatic translation of the entire TPS with minimal, if any, manual intervention.

GR179X Test System
Migration of test programs and fixtures from GR1795, GR1796, and GR1799 to a modern ATE was one of the first operations undertaken by SEICA. Feasibility analysis showed that digital performances were quite limited, but a wide flexibility was required in terms of voltage levels (covering as a minimum ECL, TTL, and CMOS technologies). Most TPS included guided probe supported diagnostics, which had to be preserved. All test programs included parametric DC tests and a variety of timing tests across all I/Os of the boards, thus imposing a digital/analog configuration across all tester's channels. Finally, one of customer's requirements was to re-use existing IEC instrumentation. The basic architecture of the new ATE was more than adequate to the task. The final project included the design of a program converter, of a test adapter to host the original fixtures and the integration and utilization of the same IEC instruments. The program
The translator converts the .ET, .DA, .SR, and .PF files and allows the new ATE to execute the test program without the need for re-simulation but maintaining the guided probe diagnostics. Both static and dynamic modes are fully supported. The test adaptor replicates the receiver and connectivity of the GR179X systems and adapts it to the pneumatic receiver of the new ATE. All existing fixtures are preserved for direct utilization on the new ATE. Finally, in order to warrant total compatibility with the original systems, and in accordance with user's desires, the original instrumentation (HP 34401A DMM, HP 53131A T/C, and PM5138 FGEN) has been directly integrated into the new ATE, maintaining the same test instructions as on the original ATE. Over 1,000 TPS have been migrated and are currently in use at different sites. The conversion process was very fast, typically being complete in about one day.

**GR275X Test System**

A more challenging project was the migration of test programs and fixtures from the GR275X ATE. Here the major issues were on the digital performances (up to 20 MHz with timing-on-the-fly) associated with large channel capacity requirements. In fact, the original ATE was equipped with 480 channels, but taking advantage of multiplexing, over 900 I/O points were used across the SRU connectors and its test connectors. For this, the new ATE was equipped with high performance channel cards, capable of data rates up to 25 MHz, full timing-on-the-fly control, and expansion capacity up to 2,048 non-multiplexed channels. Program translation was eased by the similarities on the test languages and involved conversion of .TSR, .NDB, and .TPC files. All digital tests as well as analog tests were converted by accessing information included in “TP FIXTURE” and “TP CONTROL” files, with full replication of timing, software loops, and algorithmic tests. The availability on the new ATE of a multiple-instrument dedicated resource, capable of providing guarded DC/AC tests as well as complex active functional tests allowed the Seica converter to replicate similar tests used on the GR275X system. The results of the migration have been excellent, with almost no manual correction to the converted test program. Because the original test programs were not done through simulation and the timing parameters were very tight, some digital tests required additional debug, which resulted however in more stable test programs.

**CONCLUSIONS**

Over the last five years, SEICA’s engineers have been challenged to provide cost controlled migration solutions from other well known ATE including CA Marathon, Teradyne L300 (and LASAR simulator), Schlumberger S790 and have gained major understanding on how to design new ATE technology with an eye to old practices and requirements. The software and hardware architecture of their modern ATE system has thus been adapted to also bend new technology to old requirements. One lesson to be learned (given the unchanged needs of the military/aerospace industry to warrant a program’s life across many decades): it is imperative, when designing new ATE architectures not to forget the past experience and, whenever possible, to evolve without discontinuity.

**REFERENCES**


VXI or PXI Test System
Improvement using DSP

Joseph A. Mielke
Honeywell

ABSTRACT

The results of a study into the use of distributed digital signal processing (DSP) at the instrument level in a VXI and PXI based test system and the effects on test time. One of the limiting factors in testing mixed signal or analog devices using standard bus based instruments is the transfer speed from the instrument to the controlling computer of large amounts of waveform data. This is important as these types of tests use non-deterministic, quantized signals that must be mathematically processed to extract test information. This processing can either be done at the instrument or at the central controller. If the processing is done at the instrument then only the results are transferred to the controller. If the controller does the processing then the raw data must be transferred to and from the instrument. Using two instruments, one in VXI and one in PXI, this paper measures the effects of typical tests contrasting the measurements as done in the central processor as opposed to a distributed DSP processor in each instrument. For each acquisition instrument, tests were implemented by capturing the data and moving it to the controlling computer where it was processed to extract test results, or by using the instruments on-board DSP so only the final test results were set to the controlling computer. The study results show that a significant improvement in test time can be made by selecting “smart” instruments for the test system when using PXI or VXI based instruments.

INTRODUCTION

There is a drive in the test industry to move to a standard open automated test equipment (ATE) architecture to reduce the cost of test [1]. The consumers of these test systems are challenging the manufacturers to move to an open standard for test systems [1, 2] and using their economic strength as driving force to a common architecture [3]. Although there are currently several open architectures being proposed, the two most common currently in use today as a general purpose ATE system are based on VXI [4] or PXI test busses.

The first generation of VXI and PXI instruments kept the cost of hardware down and the instruments simple by putting a minimum amount of intelligence within the instruments. However, data throughput became an issue in these types of systems [5]. The ATE system must stimulate the device under test (DUT), capture and process the results [6]. If the instrument is not intelligent enough to process that data in place then the entire data set must be transferred to a host computer for processing.

The purpose of this paper is to present the results of instrument experiments using PXI and VXI instruments to study the limitations and solutions of using a standard test bus to implement a mixed signal test and measurement system. There are several challenges to using the standard VXI or PXI test busses. This paper explores and quantifies the use of
Table 1. VXI Test Results

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Central Measurement</th>
<th>Distributed Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30.5 ms</td>
<td>7.6 ms</td>
</tr>
<tr>
<td>2</td>
<td>2.8 ms</td>
<td>1.8 ms</td>
</tr>
<tr>
<td>3</td>
<td>2.2 ms</td>
<td>1.6 ms</td>
</tr>
<tr>
<td>4</td>
<td>1.9 ms</td>
<td>1.5 ms</td>
</tr>
<tr>
<td>5</td>
<td>119.2 ms</td>
<td>25.7 ms</td>
</tr>
<tr>
<td>6</td>
<td>1.8 ms</td>
<td>1.5 ms</td>
</tr>
</tbody>
</table>

distributed DSP to enhance test time and improve test performance by capturing a waveform and performing various measurements on these waveforms.

STANDARD TEST BUS CHALLENGES

Distributed DSP

A standard test system architecture consists of device stimulus and capture instruments and a system controller tied together with the test bus. Normally, the stimulus and capture instruments are divided into analog and digital because of the very different requirements of each. The analog instruments may further be divided to separate instruments based on speed and resolution. For this simple discussion we shall omit the power distribution. A basic block diagram of this architecture is shown in Figure 1.

One method of implementing this architecture is to use very simple instruments with a powerful system controller providing the intelligence for the system and providing tight system control. The main advantage to this type of system is that the software provides most of the instrument functionality while the local instrument hardware provides only rudimentary stimulus and capture capabilities. In effect, in this model, the system controller software is most of the instrument functionality.

In this central processing model, all of the data is transferred to or from the system controller for processing. Digital stimulus, like a memory test pattern, must be created in the system controller and downloaded to an instrument. Digital capture data must be sent to the system controller for comparison to deterministic data. Waveforms must be generated in the system controller and downloaded to the analog stimulus instrument (normally an arbitrary waveform generator). Analog captured data must be analyzed in the system controller for non-deterministic testing. With large amounts of data being transferred between the controller and instruments in this central processing model, the test time is often limited by the bus data throughput.

Another method of implementing this test system architecture, the distributed DSP model provides intelligence within the instruments. This approach puts a much lower demand on the bus speed and central system controller and only requires simple system setup to perform complex tests. In this model the instruments become similar to stand-alone, traditional instruments.

In this distributed DSP model, all of the data is processed in place and only the setup and results are transferred to or from the system controller for display and logging. Digital stimulus, like a memory test pattern, is created in the instrument with only simple setup and handshaking commands. Digital capture data is compared directly in the instrument and only a pass/fail result is transferred to the system controller. Waveforms would be generated in place in the analog stimulus instrument using on-board DSP. Analog non-deterministic captured data could be analyzed in the analog capture instrument DSP.

Fig. 2. VXI test results percentage of improvement

An Analog Capture Instrument

It was theorized that the distributed DSP method of implementing this ATE architecture would result in significantly faster test times and be much simpler to implement and use. The simplicity would result from fewer commands being needed to control the instrument and less data moving back and forth between the instrument and the controller. To test this theory, two standard test bus architectures, VXI and PXI, were chosen.

For the comparison between these two architectures a similar analog capture instrument (Digitizer) was chosen from each. For the VXI capture instrument, the ZT1428VXI was chosen to provide 8-bit analog capture resolution at 1 GS/s. For the PXI capture instrument the ZT430PXI was chosen to provide 12-bits of analog capture resolution at 200 MS/s.

The tests for each of these instruments were implemented in one of two ways:

1) The instrument was used to capture the data and move it to the controlling computer where it was processed to extract test results.
Fig. 3. PXI test results percentage of improvement

2) The instrument’s on-board DSP was used to make the measurement and only the final test results were sent to the controlling computer.

The test times for each of these methods were measured using a variety of typical tests.

Table 2. PXI Test Results

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Central Measurement</th>
<th>Distributed Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>31 ms</td>
<td>24 ms</td>
</tr>
<tr>
<td>2</td>
<td>842 ms</td>
<td>83 ms</td>
</tr>
<tr>
<td>3</td>
<td>8544 ms</td>
<td>617 ms</td>
</tr>
<tr>
<td>4</td>
<td>37 ms</td>
<td>24 ms</td>
</tr>
<tr>
<td>5</td>
<td>839 ms</td>
<td>83 ms</td>
</tr>
<tr>
<td>6</td>
<td>8556 ms</td>
<td>611 ms</td>
</tr>
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</table>

EXPERIMENTAL RESULTS

VXI Capture Instrument

The VXI test bus provides a common platform for instrumentation. Although VXI is one of the oldest of the ATE test buses, with a broad range of available high performance test instruments, it still is a bus of choice as a basis for ATE systems. A ZT1428VXI digitizing oscilloscope was chosen for the VXI capture instrument. This instrument samples at 8 bits of vertical resolution at up to 1 GS/s. For all of these experiments the maximum 1 GS/s sample rate was used. This instrument is a drop-in replacement for the popular HP1428.

The types of tests chosen for this benchmark were selected to measure the effects of bus on test times without getting into complex or proprietary test methodologies. As such the two tests chosen were a simple peak-to-peak measurement and a RMS measurement on a waveform. The number of samples for the measurement varied from 1024 to 8192. Also the tests were made by averaging the captured waveforms 1, 16, or 64 times to increase accuracy. A PC was used as the system controller and the communication link from the PC to the VXI chassis was a National Instruments (NI) MXI-2. LabVIEW was used as the controlling language.

The raw test results for the six tests are shown in Table 1. The central measurements were made by capturing the data and moving it to central system controller in a “dumb” mode and processing the waveforms using the central controller to analyze and provide the test results. The distributed measurements were made using the instruments on-board DSP processor to analyze the data in a distributed DSP or “smart” mode and only transferring the results to the system controller.

The VXI test results show that, as expected, when transferring small amounts of data there is only a small amount of difference in the test times. However, when large waveforms are transferred or, in the case of averaging, when multiple waveforms are transferred there is a much more significant difference in test time. The percent improvement for each test is shown in Figure 2.

For a VXI-based system, the test results showed at least a 20% improvement in overall test time and greater than a 75% improvement for complex test cases. The typical test result improvement among the six test cases averaged a 42% improvement in test time.

PXI Capture Instrument

The PXI test bus is one of the newer platforms for ATE test system implementation. Although PXI still does not see the breadth or performance of instruments as the VXI test bus, with new instruments being added at a rapid pace, it is fast becoming a contender as an ATE test bus. A ZT430PXE digitizing oscilloscope was chosen for the PXI capture instrument. This instrument samples at 12 bits of vertical resolution at up to a 200 MS/s acquisition rate. For all tests implemented the maximum 200MS/s sample rate was used.

The same simple peak-to-peak and RMS measurements chosen for the VXI tests were also chosen for the PXI measurements. However, because of the greater capture depth of this instrument the number of samples for the measurement varied from 1024 to 1M. Averaging was not used on these measurements. A PC was used as the system controller and the communication link from the PC to the VXI chassis was a National Instruments (NI) MXI-3. NI CVI-based “C” programming was used as the controlling language.

The raw test results for the six PXI tests are shown in Table 2. The central and distributed DSP methods were done in the same manner as the VXI test time measurements.
Like the VXI results, the PXI test results also show that when transferring small amounts of data there is a small amount of difference in the test times. And like the VXI, when large waveforms are transferred there is a much more significant difference in test time. The raw test times show that the improvements with complex test implementations is even more significant with PXI then with VXI. The percent improvement for each test is shown in Figure 3.

For a PXI-based system, the test results were surprisingly similar to the VXI test results. Like VXI, each test showed at least a 20% improvement in overall test time. In four of the six tests there was greater than 90% test time improvement. The typical test result improvement among the 6 PXI test cases averaged a 71% improvement in test time.

SUMMARY

In a PXI or VXI-based test system a typical 2X improvement can be achieved if the system is implemented using instrumentation capable of distributed signal processing. Depending on the tests executed, up to a 10X improvement can be realized. Even for small amounts of data, there was at least a 20% improvement in test times. Over the 12 tests using the two tests buses, an average improvement of better than 56% in test time was achieved.

With the competition for a standard ATE test bus showing no clear winners at this time, it is important that these results are consistent over the two forerunning test buses.

ACKNOWLEDGEMENT

The author thanks ZTEC Instruments for providing the instruments and technical support in the development of this paper.

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Buried Cable Sensor with Intruder Location

James Cheal, Steven O'Brien & Mike Tutor
Southwest Microwave, Inc.

ABSTRACT

A buried cable sensor has been added to the Intrepid family of outdoor perimeter intrusion sensors. The sensor with the trademarked name “MICROTRACK” is similar to the “MICROPOINT” fence sensor with precise detection location, sensitivity leveling, and free format zoning. Intruder location is accomplished with low-power ultra wideband frequency stepped radar driving the sensor cables. Target range resolution also allows the use of sensitivity leveling for each individual range bin. This will compensate for differences in soil conductivity along the length of the cable and for metal objects, which may be located in the near field radiation.

The design of the MICROTRACK sensor was presented at the 2002 Carnahan Conference in Atlantic City. It has been described as FM-CW radar, however it differs from the generic form in that the frequency is stepped rather than continuously swept and phase code modulation is added to discriminate against interference. The wide bandwidth of the MICROTRACK sensor fills in the nulls typical of a single frequency radar and provides a more uniform field profile along the entire length of the sensor cables.

This describes the testing that has been performed to characterize the system for different environmental conditions. Southwest Microwave, Inc. has procured an open field site of 31 acres of flat desert land for testing the buried cable. Another site in Canada is used for testing with an additional set of weather and soil conditions. Detection patterns, proximity to stationary objects, and various environmental factors will be discussed. Extensive measurements of both electric and magnetic fields along the length and perpendicular to the sensor cables show a detailed map of the multiple frequency surface wave. When the cables are buried, the uniformity of the field is degraded slightly but no deep nulls are observed. Site testing has confirmed major benefits of the MICROTRACK sensor:

- Uniform Detection Zone
- Elimination of Deep Nulls
- Precise Target Location
- Sensitivity Leveling.

INTRODUCTION

The conceptual design of the MICROTRACK buried cable sensor was first presented at the 2002 Carnahan Conference by Dr. Keith Harman. The MICROTRACK sensor can be described as an Ultrawideband (UWB) stepped frequency radar with phase code modulation. It is designed to detect and locate intruders crossing the reactive near field of a buried leaky cable. The system has been designed for low power and makes use of surface wave transmission lines. Two pairs of 200 meters each of leaky cable extend out from the MICROTRACK PROCESSOR to form a perimeter length of 400 meters.

One cable from each pair is used for transmission and the other for reception. These are positioned parallel and closely spaced to one another to provide a reactive electromagnetic field confined to the near vicinity of the transmit cable. The electromagnetic field remains closely associated with the cable and is significantly less than 30 μV/m as required by FCC 15.209.

The transmitted frequencies are generated by a Direct Digital Synthesizer (DDS). These also serve as the LO signal which is mixed with the received signal to create IF frequencies proportional to the location of an intruder crossing the cable and perturbing the electromagnetic field. A Fast Fourier Transform (FFT) is used to translate IF frequencies to
Fig. 1. Measured field strength parallel to buried and unburied leaky cable

range bins corresponding to distance along the cable. The salient features of the MICROTRACK system—target location, free format zoning, and individual sub-cell thresholds—are described in the earlier paper. This paper covers the extensive field tests required for a buried cable sensor. Data from these tests will be used to establish performance criteria for installation and operation for various climatic and soil conditions anticipated throughout the world.

SURFACE WAVE TRANSMISSION

Surface waves are generally defined as non-radiating transmission from an open guide. Leaky coaxial cable fits this definition, although power is continuously fed along the entire length of the cable rather than just at one end. The external electromagnetic field supported by the cable decreases exponentially with distance perpendicular to the cable. Open field measurements of the MICROTRACK system confirm the existence of the surface wave confined to the near vicinity of the cable. The field has been mapped extensively, both parallel and perpendicular to the longitudinal axis of the cable. Field strength contours parallel to the cable are relatively uniform, less than ±3 dB variation. However, when buried, the local variation increases to approximately ±7 dB as seen in Figure 1.

The fluctuation when buried is consistent with recent literature on the analysis of buried leaky cables [2]. When the external field is lightly coupled to the internal field within the cable, the phase velocity will be the same as the internal mode. When buried, the external mode is slowed by the relatively high dielectric constant of soil. It now goes in and out of phase creating a standing wave along the cable, but then decays due to the conductivity of the soil. At the end of the cable, the pattern becomes more complicated with an additional standing wave caused by the imperfect termination.

This underscores the need for the sensitivity leveling feature of the MICROTRACK signal processing to provide a predictable detection zone.

Fig. 2. Field strength perpendicular to the cable

CLIMATE AND ENVIRONMENTAL EFFECTS

For buried cable systems, one of the major issues is the climate and soil conditions at the location where it is installed. Electromagnetic properties of the soil are strong functions of moisture and texture. The electromagnetic characteristic of interest is the complex dielectric constant which defines the attenuation and phase velocity of wave propagation through the soil. The complex dielectric constant of the soil is composed of both real and imaginary components. The real
Table 1. Electrical Characteristics of Soil and Water [5]

<table>
<thead>
<tr>
<th>Media</th>
<th>Conductivity (σ)</th>
<th>Dielectric Constant (εr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land &amp; Water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sea Water</td>
<td>5 S/m</td>
<td>70</td>
</tr>
<tr>
<td>Fresh Water</td>
<td>3 mS/m</td>
<td>80</td>
</tr>
<tr>
<td>Soil (saturated)</td>
<td>30 mS/m</td>
<td>40</td>
</tr>
<tr>
<td>Soil (wet)</td>
<td>10 mS/m</td>
<td>30</td>
</tr>
<tr>
<td>Soil</td>
<td>3 mS/m</td>
<td>22</td>
</tr>
<tr>
<td>Soil (medium dry)</td>
<td>1 mS/m</td>
<td>15</td>
</tr>
<tr>
<td>Soil (dry)</td>
<td>.3 mS/m</td>
<td>7</td>
</tr>
<tr>
<td>Soil (very dry)</td>
<td>.1 mS/m</td>
<td>3</td>
</tr>
<tr>
<td>Fresh Water Ice –1°C</td>
<td>.030 mS/m</td>
<td>3</td>
</tr>
<tr>
<td>Fresh Water Ice –10°C</td>
<td>.010 mS/m</td>
<td>3</td>
</tr>
</tbody>
</table>

The differences between [3] and the Southwest Microwave, Inc. data can be explained because the cable design and frequency were not the same although the attenuation due to soil conductivity was similar.

**DETECTION AND CALIBRATION**

Given the variations in the electrical characteristics of the burial medium and the change in field patterns, how does this affect the detection performance of the sensor? Detection and calibration tests were recorded at the Southwest Microwave, Inc. test site in Ontario, Canada with saturated wet soil, frozen soil, and thawing conditions. Figure 5 is a plot of receiver sensitivity for a target moving parallel to the cable from the lead-in input to the terminated end 200 meters away. This is an engineering screen without final digital processing which will adjust individual sub-cells thresholds. Each of the curves represent a different climate condition, from frozen (−18°F) with conductivity as low as 10 mS/m to saturated soil (muddy) with a conductivity of 20 to 30 mS/m. AGC over an extended dynamic range maintains the sensitivity due to weather conditions to a 3 db window. This will translate to less than 1 foot variation in the width of the detection zone with hot to cold and wet to dry soil conditions. Figure 6 shows an intruder crossing the buried cable and the vertical line in Figure 7 is the detected signal that locates the intruder 24 meters from the start of the cable radiation.

**CONCLUSION**

Field tests on the MICROTRACK buried leaky cable sensor have been conducted for various climatic and soil conditions. Extensive mapping of the surface wave fields indicate minor
Fig. 3. Attenuation due to conductivity of soil

level shifts with changing soil conditions but the pattern shape shows little change. Long term signal level changes are compensated for by the receiver's AGC and system calibration will hold over severe weather conditions.

Cyclical level perturbations of the surface wave as a function of distance along the cable is shown to be caused by the propagation constant of the soil which changes the velocity of the external mode as compared with the internal mode within the cable.

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Fig. 5. Calibration for various climate conditions

Fig. 6. Crossing the buried cable

Fig. 7. Target detection
Ground Penetrating Radar VIY-2

V.P. Prokhorenko, V.E. Ivashchuk & S.V. Korsun
VIY, Transient Technologies

ABSTRACT

VIY-2 ground penetrating radar (GPR) with unique sounding possibilities and use simplicity is presented at this paper. VIY-2 GPR combines all units (synchronizer, transmitting and receiving modules, powering, and antenna system) into single case. The VIY-2 GPR communicates with computer via standard interface RS232 or USB1.0. Technical solutions utilized by the VIY-2 GPR reduce deployment time and simplify surveying process.

The VIY-2 GPR design features and its components interaction are considered at this paper. Some field results are also presented here. The VIY-2 GPR design concept allows reducing the data acquisition time, optimizing the time-varying gain control function, applying depth-stacking dependence, controlling the surveying window position and interference reducing by pulse repetition frequency randomizing.

INTRODUCTION

Ground penetrating radar (also known as earth sounding radar, ground probing radar, subsurface radar, or georadar) (GPR) uses radar principles to image, locate, and quantitatively identify changes in electromagnetic properties under the ground. Information that can be obtained from ground penetrating radar includes the depth, orientation, size, and shape of buried objects, and the density and water content of soils. It can be utilized for utilities detection, civil engineering, archeology, hydrology, geological applications, sedimentology, concrete/pavement evaluation, unexploded ordnance (UXO) and mine detection, soil characterization, ice, and permafrost.

There are known various GPR systems including pulsed, continuous wave (CW), frequency-modulated continuous wave (FMCW), stepped-frequency continuous wave (SF CW), chirp, noise, and so on [1, 2]. The main idea is getting of subsurface pulse responses in separate point of surveying surface and producing of media slice (B-scan). The pulse response can be acquired either frequency or time domains.

The pulsed GPR systems acquire pulse response in time domain directly. It is the simplest and understandable method, that allows getting unique operation flexibility. It requires the following conditions fulfillment: presence of powerful stable nanosecond pulse generation, low-noise ultrawideband (UWB) receiving with overloaded preserving, short pulse response antenna system, and timing stability.

The main goal of the VIY-2 GPR development was easy in operation GPR with improved energy and operation parameters.

In order to realize the GPR synchronizing algorithm, GPR-PC transfer protocol, high efficient UWB transmitter module, low noise UWB sampling receiver module were developed. Appropriate software was developed also and field test was fulfilled.

This paper describes pulsed GPR system that satisfies all requirements mentioned above, and has unique possibilities that differ it from other pulsed GPR systems.

THE VIY-2 GPR OPERATION PRINCIPLES

The VIY-2 GPR operation is based on a principle of sampling with arbitrary time sweeping. Applied algorithm assumes trace samples acquisition with arbitrary sequence and variable sounding impulse repetition frequency. The proposed attempt allows wide range varying such the VIY-2 GPR parameters as surveying window, sample numbers per trace, stacking number, time dependence of gain control, etc.

The VIY-2 GPR Hardware

The VIY-2 GPR is assembled in single box (Figure 1). There are interface and power connectors, power switch, and three LED indicators. Such technical solution reduces deployment time and simplifies surveying process. The GPR hardware includes transmitting and receiver modules, synchronizer, and power supply.

Transmitting Module

The VIY-2 GPR utilizes active transmitting module based on novel concept of kinetic energy accumulated antenna and drift step-recovery technology [3]. Antenna system is exponential TEM horn adopted for operation in antenna.
current interruption mode. We developed a balanced current driver that provides specific conditions for drift step-recovery diode (DSRD) operation. Owing to used proposed concept the transmitting module combines powerful electromagnetic impulse radiation, high efficiency, and low jitter. The transmitting module generates 8 ns monocycle pulses with up to 1600-Watt peak power on the antenna terminal at 20 kHz pulse repetition frequency (PRF).

Receiving Module

The VIY-2 GPR utilizes active receiving module consisted of differential variable gain sampler-and-hold amplifier with analog-to-digital conversion. The receiver is directly connected to the antenna terminal to provide required bandwidth and high sensitivity. Dynamic range of the receiver exceeds 110 dB with input noise factor less than 1 dB in frequency range from 10 MHz to 1 GHz. The receiving module is characterized by high sensitivity, wide dynamic range, and bandwidth.

Synchronizer

Synchronizer is a key hardware element that determines operation features of the GPR. It controls transmitting and receiving module, makes signals preprocessing, and data interchange with computer. We developed synchronizer that provides arbitrary sampling algorithm. It means that any point of signal waveform is acquired and digitized independently from another. Every sample gain and stacking number is set independently and order of samples sequence can be arbitrary. Owing to realized principle number of samples can be arbitrary set from 2 to 1023 with arbitrary beginning and end in the window. Number of stacking can reach 78 for 128-point waveform. Variable gain control is arbitrary too and varies from 0 dB to 48 dB.

Interface

To provide the VIY-2 GPR compatibility with commercially available computers (notebooks) control signals and acquired data are transferred via serial interface RS232 (or USB 1.0). To improve the GPR working efficiency special data transfer protocol was developed. Its utilizing allows to acquire ten 512-point waveforms per second (without stacking) with 16-bit resolution.

The VIY-2 GPR Software

The VIY-2 GPR base software package is compatible with any computers with Win9X and higher operating system. It allows making the GPR adjustment, fulfilling the field surveying, and executing the acquired data processing.

During the surveying the acquired data are displayed on the computer screen as B-scan in online regime. After acquisition the data can be processed by appropriate tools (normalizing, low and high pass filtering, median filtering, correlation, color coding, averaging, rectifying, and so on.)

The B-scan processing tools are reflected by tree view. This solution allows reducing the processing time. The tools can be added, deleted, adjusted, and rearranged with reflection of applied tools on the B-scan in online.

EXPERIMENTAL RESULTS

The VIY-2 GPR was tested for looking for utility lines in Dneprskiy region, Kiev. One of the concrete tubes was founded in sandy soil on depth about 4 meters (approximate electromagnetic wave velocity in the soil is 15 cm/ns) (see Figure 4).
CONCLUSIONS

The VIY-2 ground penetrating radar (GPR) with unique sounding possibilities and use simplicity is presented at this paper. The VIY-2 GPR combines all units (synchronizer, transmitting and receiving modules, powering, and antenna system) into single case. The VIY-2 GPR communicates with computer via standard interface RS232 or USB1.0. Technical solutions utilized by the VIY-2 GPR reduce deployment time and simplify surveying process.

The VIY-2 GPR design features and its components interaction are considered at this paper. Some field results are also presented here. The VIY-2 GPR design concept allows reducing the data acquisition time, optimizing the time-varying gain control function, applying depth-stacking dependence, controlling the surveying window position, and interference reducing by impulse repetition frequency randomizing.

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Fiber Optic Gyrocompass Superluminescent Fiber Source

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ABSTRACT

The objective of this work is to establish the dependence of characteristics of the fiber optics gyrocompass with respect to the parameters of the superluminescent emission source based on doped optical fiber with rare earth elements, Superluminescent Fiber Source (SFS), argument the pumping rate election of the SFS to obtain characteristics limits of the fiber optic gyroscope sensibility.

INTRODUCTION

Using a superluminescent emission source in a fiber optic gyroscope, we incorporate a sensitive element in the gyrocompass arrangement. Fiber optic gyroscopes (FOGs) based on the Sagnac effect are optical rotation sensors. These sensors are resistant to vibration, start quickly, and require little power. These advantages over conventional gyroscopes arise from the use of optical interferometry as their operational principle [1, 2].

Measurement of rotational movement is one element in the control of robotic devices. Fiber optic gyroscopes are beginning to replace conventional momentum-based techniques. Important attributes of this new technology are no moving parts, high reliability, stable performance, and low cost. Many of its components are derived from the fiber optic telecommunications industry. Angular rotation is one of the parameters that need to be accurately measured in order to describe the position and orientation of an object moving in space. This is particularly true with robotic applications that depend on dead reckoning navigation or precise angular position [3].

A fiber optic gyroscope is under intensive investigation aiming to practical applications such as inertial navigators for space rockets or automobiles [4, 5]. Another interesting application is for geodesic surveying, e.g., for a transit instrument [6].

Gyrocompass, by definition, is a gyroscope-based system for the measurement of true heading, that is to say, angular measurement of a position in relation to geographical North, whatever the movements made by the object on which the gyrocompass is placed. This means, for example, that the gyrocompass must remain relatively insensitive to pitch and roll movements, which may be at high levels on certain ships [7]. Gyrocompass is one of the oldest gyroscope-based systems in existence: a rapidly spinning top can align its angular moment with the angular moment of the turning Earth just as a compass will align its magnetic moment with the terrestrial magnetic field, thus defining an orientation (heading) in relation to geographical North [8].

The rotation rate sensor and gyrocompass, has been utilized as a high performance fiber optic gyroscope, with high sensitivity, in particular, they increase the sensitivity of this type of device, thanks to minimization of noise levels caused by the presence of bulk electro-optical elements. In gyroscope interferometers, the noise level is minimized when the number of bulk electro-optical elements and the coherence length of the source are reduced [1].

Fig. 1. Superluminescent Fiber Source, SFS:
1 - polarizator, 2 - beam splitter,
3 - FOG, 4 - modulator, 5 - photodetector

In fibers optic sources, it is simple to achieve a coherence length larger than the difference in passing in opposite directions in the interferometer, caused by rotation and reciprocal effects. Generally, the superluminescent signal from a doped fiber has a bandwidth greater than 15 nm and peak
output powers of approximately 50 mW. Furthermore, they can be easily coupled to fiber-based ring interferometers [9].

We present a theoretical study of an erbium-doped optical fiber operating in the superluminescent regime. Experimental results for different pump power levels and fiber length show that the theoretical model could render useful information for predicting parameters such as total output power, spectral bandwidth, and optimum fiber length to achieve the superluminescent regime. These types of sources could have direct application in wavelength multiplexed arrangements of fiber sensor, fiber gyroscopes, or in general, in any sensors in which a broad wavelength and stable light source is required.

We proposed a method that allows the calculation of two of the principal parameters in a broadband fiber source. These fiber sources are capable of producing the needed power signals, around 1.53 gm, with a large bandwidth when operating in a superluminescent regime. For fiber optic gyroscope applications, the fiber source parameters can be selected to produce a highly stable device, as shown in Figure 1. These exceptional properties make superluminescent fiber sources the light source of choice for the fiber-optic gyroscope.

To record such a rotational velocity, the fiber optic gyroscope must possess high sensitivity, low intrinsic noise level, and low drift of the output signal. In using a FOG, two methods of using the gyrocompass can be distinguished: static and dynamic. In the first method, the sensitive element (FOG) remains fixed at the instant of measuring its signal, and, in the second method, forced rotation of the sensitive element is carried out. We consider the case on the dynamic method.

In implementing this method, the FOG is rotated with a constant angular velocity around an axis perpendicular to a horizontal plane, so that its sensitivity vector remains in a horizontal plane, Figure 2. The output signal of the FOG is thereby modulated at the rotational frequency. In this case, information on the desired azimuth is contained in the phase of the FOG signal, and its determination reduces to phase detection of the FOG signal. Such method makes it possible to use a FOG with less rigorous requirements on its signal drift. The disadvantages of this system are an increase in the mechanical vibrations during the measurements recorded by the FOG and rigorous requirements on the deviation of the rotational velocity of the FOG [10].

The FOG signal caused by the Earth’s rotation is distorted by systematic and random errors that are inherent to that FOG itself and that arise during the measurement. These errors, in turn, result in errors of the gyrocompass. This work study theoretically and experimentally process in the FOG and we reduce these errors with the use of the superluminescent fiber source.

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Mm Wavelengths Complex Doppler Analysis Using Dark Field Illumination

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&

M.J. Underhill

University of Surrey

ABSTRACT

Experimental results that indicate that at least two fundamental modes of Doppler generation are present when a rotating steel cylinder is broadside illuminated by radar. Improvised bistatic measurements at 77GHz are discussed and second order Doppler effects studied. Complex Doppler returns, consisting of two or more Doppler contributions, are decomposed and studied using empirical methods. In particular, ground illumination techniques are used to study Doppler in the shadow region of a cylinder of circumference 8l wavelengths. It is concluded that the complex Doppler response from the spinning cylinder consists of both direct (first order) and delayed (second order) Doppler components. Further measurements are proposed to study the delayed Doppler effect further.

INTRODUCTION

It has been found that the radar backscatter response from a broadside illuminated nominally axisymmetric electrically large spinning steel cylinder will exhibit strong “Doppler shifted” harmonics at the rotation frequency [1]. This paper builds on that work and presents additional measurement results that provide insights into the complex Doppler effects observed in the earlier paper. Direct and delayed Doppler mechanisms are hypothesised and measurement results will be presented to support the proposition. To understand the complex Doppler spectra an empirical approach is adopted to isolate the lower magnitude second order Doppler returns. In particular dark ground illumination techniques are reviewed and applied in a new context. It will be shown that by creative measurement design the primary and secondary Doppler generation mechanisms can be decomposed and hence the complex Doppler understood. Further avenues of investigation and additional novel measurement techniques are also proposed.

The philosophy of static and dynamic RCS measurements and the lack of “dynamic realism” associated with many static experimental results is a topic on contemporary interest for fixed wing aircraft targets [2]. Similarly the identification of rotary wing vehicles based on characteristic modulations imposed on radar returns is an in vogue topic for ground based radar applications [3]. However, the emphasis has been directed toward the radar (inverse synthetic aperture radar) measurement of large complex targets. There remains a gap in the current literature addressing the radar measurement of simple canonical targets under dynamic conditions. It will be shown that significant phenomenological information can be derived about a simple target through correct and thoughtful measurement design. The empirical approach adopted herein uses a coherent phase coded pulse Doppler (PCPD) polarimetric radar to provide target illumination at millimetre wavelengths. For simple targets, dynamic measurements are more insightful (and appropriate) than using a mixture of static measurements and statistical techniques to estimate a target’s dynamic radar cross section. Typically statistical approaches have been used to classify clutter at millimetre wave wavelengths; notable texts include [4, 5]. The results presented are thus a useful addition to augment existing literature.

Of special interest in this paper is the Doppler contribution due to diffraction and surface waves propagating around curved surface of a cylinder and re-radiating creating delayed Doppler components. The topic has only received cursory consideration in open literature. However, previous work performed at the Naval Air Warfare Centre [6] indicated the presence of strong surface wave coupling and scattering in the shadow region of a drone air vehicle. To study the phenomena further a novel radar technique, based on the principal of dark

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delayed (second order) Doppler components. The Doppler mechanisms are illustrated in Figure 1 for the direct Doppler and Figure 2 for the delayed Doppler.

The go and return Doppler responses are suggested to be the dominating Doppler effects.

The delayed Doppler returns are suggested to be of lesser magnitude and thus a second order effect. In Figure 2 the surface waves will be launched in both a clockwise and counter-clockwise direction.

**EXPERIMENTAL DESIGN**

Measurements using a polarimetric and coherent PCPD radar were performed under two configurations:

- improvised bistatic (transmit coupled)
- improvised bistatic (receive coupled).

The PCPD radar bit rate frequency was 6.25MHz corresponding to a 31 bit code repetition interval of 210.6 kHZ. The polarisation switch frequency is 6.3 kHZ.

The basic test layout shown in Figure 3 was used to obtain bistatic measurements of the spinning cylinder. The specific aim was to study diffraction and creeping wave induced Doppler mechanisms. The approach fundamentally differs from the more common multi-site bistatic configuration; typically used to detect stealthy far field objects using the Babinet principle [8]. In that regime beam-fill conditions are not observed and the target will be small in comparison with ground illumination [7], will be used to investigate a 100mm diameter steel cylinder illuminated at 77GHz.

**DOPPLER HYPOTHESIS**

It is proposed that the complex Doppler response from the spinning cylinder comprises both direct (first order) and the radar footprint. In the improvised bistatic scenario beam-fill conditions are always observed allowing detailed interrogation of the target surface untainted by localised clutter. The transmit antenna coupled test configuration is shown Figure 3.

The coupling aperture area at the radar head was 1,452mm² and the coupling aperture area at the cylinder target was
Fig. 4. Time domain VV&HV polarisation (receive coupled): 60rpm clockwise

Fig. 5. Time domain VV&HV polarisation (transmit coupled): 60rpm clockwise

Fig. 6. Frequency domain VV (solid) and HV (dots) polarisation (receive coupled): 60rpm clockwise

Fig. 7. Frequency domain VV (solid) and HV (dots) polarisation (receive coupled): 60rpm anti-clockwise

784mm². To perform receive coupled tests the radar head was rotated through 180 degrees. The received coupled configuration was inspired by the optical theory of dark field (ground) illumination [7]. Whilst such approaches are common for applications such as interference microscopy the use of the technique at millimetre wavelengths for the study of diffraction and creeping wave effects is somewhat unique.

In dark ground illumination the direct light is obstructed by the target allowing only the phase contributions of diffracted light, to sum constructively and destructively behind the target, to form an image in the shadow region.

The experiment design shown in Figure 3 when reconfigured to provide receive coupled operation also allows reciprocity effects (for diffraction and creeping wave re-radiation) to be studied, by comparing the results with the transmit coupled results.

TIME DOMAIN RESULTS

The results shown in this section show the root sum of squares (RSS) of the in-phase (I) and quadrature (Q) radar data. The cylinder spin rate is nominally 60 revolutions per minute (rpm). At spin rates between 50rpm to 120rpm the precision with which the rotation apparatus can be set is typically ±10rpm. However, once set the rotation accuracy will be better than ±1rpm.

Figure 4 shows a typical polarimetric radar response over a period of two seconds. A 20 second data set is also available for further analysis. Only vertical receive results are given for brevity.

The results for the bistatic receive coupled configuration indicate that a dark field (ground) illumination effect is present. A periodic modulation effect at 1 Hz is seen for both vertical and horizontal polarisations.

Figure 5 shows results for the transmit coupled configuration. The responses are more defined than for the receive coupled scenario. However, in absolute terms the magnitude of the respective receive coupled and transmit
The results for the bistatic transmit coupled configuration indicate that a diffraction/creeping wave re-radiation effect is present. A periodic modulation effect at 1 Hz is seen for both vertical and horizontal polarisations. The VV results show deep and distinctive nulls suggesting the presence of Doppler frequency components beating together. The effect is more prominent than for the receive coupled results. It is speculated that the effect is a function of the free space distance of the receive antenna aperture from the cylinder. At 77GHz 1005nm equates to 258 wavelengths of travel, and 90mm equates to 23 wavelengths of travel. Hence, it is debatable whether the two sets of results in their current form can be used to prove or disprove the system reciprocity. It is therefore proposed that further experiments be performed to investigate spatial effects due to target position with respect to the transmit and receive antennas.

**FREQUENCY DOMAIN RESULTS**

The results shown Figures 6 to 9 were generated using a standard complex fast Fourier transform. The approach was adopted to opportunistically exploit the availability of coherent I-Q radar data and hence to enable asymmetries within the Doppler spectra to be studied. To further investigate issues associated with spectral imbalances and the reciprocity of the target signature a complementary set of clockwise and anti-clockwise data are presented for both the dark field illumination and transmit coupled scenarios.

Figure 6 show results for receive coupled clockwise target rotations. The results shown in Figure 7 were measured under identical conditions but with anti-clockwise target rotation. No significant components were observed beyond ±15Hz and hence are not presented.

In Figure 6 Doppler shifted harmonics of the rotation frequency are present and the spectra are asymmetric. Figure 7 shows the corresponding anti-clockwise results.

In Figure 7 Doppler shifted harmonics of the rotation frequency are present and the spectra are asymmetric.

The comparison of Figure 6 to Figure 7 suggests that reciprocity is generally observed, i.e., the negative frequency
components close to the carrier for the clockwise rotations appear to be a mirror image of the positive frequency components close to the carrier for the anti-clockwise rotations, etc. The correlation was greatest for HH polarisation.

Figure 8 shows transmit coupled results for clockwise target rotations. The results shown in Figure 9 were measured under identical conditions but with anti-clockwise target rotation. No significant components were observed beyond ± 15Hz and hence are not presented.

In Figure 8 the transmit coupled mode the frequency spectra are more asymmetric than for the receive coupled scenario. More Doppler shifted harmonics are present and especially so for VV polarisation. Figure 9 shows the corresponding anti-clockwise results.

The anti-clockwise results of Figure 9 show that Doppler shifted harmonics of the rotation frequency are present, and that the spectra are asymmetric.

Comparison of Figure 8 to Figure 9 suggests that there is less correlation, in terms of reciprocity between the positive and negative spectra for the respective clockwise and anti-clockwise cases, than seen in the receive coupled results. The results for VV polarisation were also significantly more asymmetric than those for HH polarisation. It is speculated that the asymmetric effects observed for the receive coupled results are accentuated in the transmit coupled mode due to the position of the transmit antenna in the shadow region. The antenna will act as a splash feed in the near field and will have rapidly fluctuating phase components that will propagate around the cylinder before being radiated away. In the receive coupled mode the received field would be more uniform on arrival, i.e., the cylinder would be excited by a plane wave with a constant phase front.

**SUMMARY AND ANALYSIS OF RESULTS**

A key feature of the results is that subtle effects may be observed using bistatic measurements that would otherwise be obscured when adopting a quasi-monostatic approach. For example, the deep nulls seen in the transmit coupled VV polarisation results of Figure 5 would normally be overwhelmed by the corresponding "go and return" component present in a quasi-monostatic measurement.

Whilst the bistatic results presented in this paper are insightful and help to more fully explain the more complicated quasi-static results there are shortcomings in the approach. The results do not take into account the effect of target rotation on the diffraction and creeping wave components. Further measurements are recommended using the test configuration shown in Figure 10. The configuration allows measurements to be taken for anti-clockwise rotations where the diffraction and creeping wave energy flows with the angular direction of travel; and for clockwise rotations where the diffraction and creeping wave energy flows against the angular direction of travel. Of course in a true quasi-monostatic situation both effects would occur simultaneously and a standing wave type effect would likely occur.

To study the delayed Doppler further it would be necessary to attempt to isolate the diffraction components from creeping wave re-radiation components. RAM could be used in contact with the cylinder to prevent diffraction around the curved surface as shown in Figure 11.

The study is also deficient in measurement results of pure "go and return Doppler." It is suggested that the test set shown in Figure 12 could be used to minimise diffraction and creeping wave re-radiation contributions. However, RAM is
not easy to employ at millimetre wavelengths and further work is required to prove / disprove the viability of the approach.

Further trials are recommended using the apparatus of Figure 12 to isolate backscatter from the left and right hand edges to gain further insights into the cylinder target phenomenology.

DISCUSSION

The results support the hypothesis that the complex Doppler consists of direct and delayed Doppler mechanisms. Hence:

Point 1: The modus operandi for the generation of the Doppler components consists of instantaneous backscattered returns (go and return same edge) and delayed backscattered returns due to diffraction and creeping wave re-radiation.

The study of the results also generated a number of propositions (in some cases supported by theory, and in others, yet to be substantiated) to help explain the underlying Doppler mechanisms. Hence, Points 1 to 10:

Point 1: Both diffraction and creeping wave re-radiation effects will contribute to the bistatic backscattered response.

Point 2: The re-radiation of creeping waves will occur uniformly but will decay with an exponential type response with respect to path length from "launch to lift."

Point 3: The decay time of the surface creeping wave will intuitively be invariant for a single excitation (assuming homogeneous surface characteristics). However, the cylinder is continuously stimulated by a 31 bit bi-phase modulated pulse train with a code bit rate of 160 ns, code repetition interval of 4.96 µs, and with polarisation switching every 158.72 µs. Hence forced resonant effects may be induced depending upon the natural eigenoscillations of the system.

Point 4: The creeping wave returns will introduce asymmetries due to the sense of rotation of the cylinder, i.e., the path length of the surface wave travelling with the rotation will be shorter than the path length of the surface wave travelling counter to the rotation.

Point 5: Creeping waves propagating around the surface of a steel cylinder will travel slower than a free space / diffraction wave; and hence different Doppler delays will be present.

Point 6: At faster rotation rates the creeping wave induced asymmetries will be greater.

Point 7: If the cylinder is not perfectly conducting the asymmetries will be greater, i.e., asymmetries are dependent upon the conductivity of the cylinder.
Point 8: If the cylinder surface is rough less creeping wave effects will be induced, i.e., the “go and return on the same edge” returns will be stronger.

Point 9: Superposition of opposite sense creeping waves will give rise to peaks and nulls that are related to the rotation frequency.

Point 10: If the steel cylinder is not perfectly conducting the re-radiation of the creeping waves, it may exhibit polarisation tilt in the direction of travel.

CONCLUSIONS AND RECOMMENDATIONS

Novel experimental results were presented that indicate that at least two fundamental modes of Doppler generation are present when a rotating steel cylinder is broadside illuminated by radar. The results confirmed the hypothesis that the resultant complex Doppler response from the spinning cylinder consists of both direct (first order) and delayed (second order) Doppler components.

Improvised bistatic measurements were performed allowing an initial insight into the specular and non-specular (diffraction and creeping wave re-radiation) Doppler generation mechanisms. However, the tests did not allow the pure specular Doppler to be measured in isolation or the diffraction generated Doppler to be separated from the surface wave re-radiated Doppler. Additional tests were therefore proposed for follow-on studies.

Dark field illumination and the transmit coupled techniques are highly appropriate for the study of spinning electrically large metallic cylinders by radar. The application of these bistatic techniques at millimetre wavelengths is novel; having previously been used exclusively in the optics domain. Further work in this area is recommended.

ACKNOWLEDGEMENTS

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Signature Recognition State-of-the-Art

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ABSTRACT

A summarization of one of the most successful behavioral biometric recognition methods: signature recognition. Probably this is one of the oldest biometric recognition methods, with high legal acceptance. Technological advances have made possible new perspectives for signature recognition, by means of capturing devices which provide more than the simple signature image: pressure, acceleration, etc., making it even more difficult to forge a signature.

INTRODUCTION

People recognition by means of biometrics [1-3] can be split into two main categories:

**Physiological Biometrics:** based on direct measurements of a part of the human body. Fingerprint, face, iris, and hand-scan recognition belong to this group.

**Behavioral Biometrics:** based on measurements and data derived from an action performed by the user, and thus indirectly measure some characteristics of the human body. However, this classification is quite artificial. For instance, the speech signal depends on behavioral traits such as semantics, dictation, pronunciation, idiosyncrasy, etc. (related to socio-economic status, education, place of birth, etc.) [4]. However, it also depends on the speaker’s physiology, such as the shape of the vocal tract. On the other hand, physiological traits are also influenced by user behavior, such as the manner in which a user presents a finger, looks at a camera, etc.

Signature recognition belongs to this last category, and according to market share reports [5] it is the second most important within this group, just behind speech recognition, and over keystroke, gait, and gesture.

SIGNATURE RECOGNITION

Signature recognition can be split into two categories:

**Static:** In this mode, users write their signature on paper, digitize it through an optical scanner or a camera, and the biometric system recognizes the signature analyzing its shape. This group is also known as “off-line.”

**Dynamic:** In this mode, users write their signature in a digitizing tablet such as the device [6] shown in Figure 1, which acquires the signature in real-time. Another possibility is the acquisition by means of stylus-operated PDAs. Dynamic recognition is also known as “on-line.” For instance, the WACOM pen tablet, model INTUOS A6 USB [7] captures the following information:

- Position in x-axis.
- Position in y-axis.
- Pressure applied by the pen.
- Azimuth angle of the pen with respect to the tablet (see Figure 2).
- Altitude angle of the pen with respect to the tablet (see Figure 2).

Using this set of dynamic data, further information can be inferred, such as acceleration, velocity, instantaneous trajectory angle, instantaneous displacement, tangential acceleration, curvature radius, and centripetal acceleration.
etc. [8]. Figure 3 shows a signature and its corresponding dynamic information, acquired at 100 points per second.

People recognition by means of their signature presents an interesting set of advantages:

1. It is resistant to impostor attempts. Although, theoretically, a person could learn to sign in exactly the same manner as another person, in practice, it is very difficult to replicate the dynamic information (pressure, azimuth, altitude, etc.) for each digitized signature point (pixel), which cannot be ascertained from examining a written signature or by observing a person signing.

2. It is accepted in many government, legal, and commercial transactions as a method of personal authentication. Signatures have traditionally played the role of documents authentication. Thus, it is perceived as a non-invasive and non-threatening process, and can overcome some of the privacy problems [9-10].

3. The user can change his/her signature. Biometrics presents a serious drawback when compared with classical methods passwords and tokens (while it is possible to obtain a new card number, it is not possible to replace any biometric data, which should last forever) [11]. However, signature is an exception, because users can change their signature.

However, they also have some drawbacks:

1. Some people exhibit a lot of variability between different realizations of their signature, mainly due to lack of habit. This limitation for this population subset can be overcome with a multimodal system [12], or with the acquisition of a series of signatures for enrollment, rather than relying on a single realization. Also the test must be done in similar conditions to enrollment.
Fig. 4. General scheme of a biometric recognition system

(seated or standing position, same area for
resting the upper arm during signing, etc.)

2. They evolve with time and are influenced by
physical and emotional conditions of the
signatories.

3. Professional forgers can reproduce signatures in
order to fool a biometric system. This is
especially important for static signature
recognition.

Biometric recognition tasks can be split into two groups:
identification (Who is the owner of this signature?) and
verification (Am I the person I claimed to be?). However, most
of the practical applications are related to verification rather
than identification.

For a signature verification system, depending on testing
condition and environment, three types of forgeries can be
established [13]:

1. "Simple" forgery: where the forger makes no
attempt to simulate or trace a genuine signature.

2. "Substitution" or "Random" forgery: where
the forger uses his/her own signature as
a forgery.

3. "Freehand" or "Skilled" forgery: where the
forger practices imitating as closely as possible
the static and dynamic information of the
signature to be forged.

Obviously, the most damaging one, from the point of view
of security, is the last one. For this reason, there exist some
databases suitable for system development, which include
some trained forgeries [14].

**DYNAMIC SIGNATURE VERIFICATION**

Taking into account the highest security levels which can be
achieved by dynamic systems, most of the efforts of the
international scientific community are addressed toward this
group. Static systems are restricted to be used as an aid to
identify criminals in the legal cases [3]. The remaining section
of this paper will be devoted to dynamic signature verification,
also known as authentication.

Figure 4 shows the general scheme of a biometric system.
The description is the following:

1. **Sensor**: Online signatures are scanned with a
   graphic tablet such as the one shown in Figure 1.
   It provides, for a given signature, the
   information shown in Figure 3.

2. **Feature Extraction**: Some features will exhibit
   more discriminatory capability than others.
   Thus, once extracted, some feature selection
   should be done. Two classes of features can be
   extracted in dynamic systems:

   a. **Static Features**: These features are extracted
      from the whole process of signing, such as
      maximum, minimum, and average of writing
      speed, curvature measurements, ratio of long
to short stroke, segments length, etc. The
      concatenation of all these measurements
      constitutes an N-dimensional feature vector,
      being N the number of measurements. These
      features are also known as parameters.

   b. **Dynamic Features**: These features are the
      evolution of a given parameter as function of
time f(t), such as the ones plotted in Figure
      3. Examples are position x(t), y(t), velocity
      v(t), acceleration a(t), pressure p(t),
tangential acceleration ta(t), curvature radius
      cr(t), normal acceleration na(t), etc. These
      features are also named functions.

3. **Matching**: Consists of measuring the similarity
   between the claimed identity model and the
   input features. When using dynamic features,
some kind of length normalization must be
done, because different repetitions of a
signature from a given person will last
differently. The matching techniques can be
split into three categories: template matching
methods, stochastic methods, and neural
networks:
Fig. 5 An example of signature DTW alignment. The matrix is filled with cross-distances between all the vectors. There is a dark path which indicates minimum distance between test and reference signals. It is interesting to observe that the test signal is a little bit longer than the reference signal. If both signals were identical, the path would be a straight line on the diagonal. Each number \( n \) on each axis represents one feature vector at instant \( t = nT \):

\[
\text{\( \mathbf{v}[n] = [x(nT), y(nT), p(nT), az(nT), ln(nT)] \)}
\]

a. **Template Matching Methods:** The input and model signatures are expressed as feature vectors and compared using a distance measure between them. The most successful method belonging to this category is Dynamic Time Warping (DTW). In DTW the input and model signatures are compared by using a dynamic programming strategy that can manage the variability on the signature’s length. Figure 5 shows an example of alignment between a genuine signature (on the left) and a forgery (on the right) with the model signature.

b. **Stochastic Models:** The features extracted from the training signatures are used to work out a statistical model. During testing, the similarity of input and reference is established. The most popular method belonging to this category are Hidden Markov Models (HMM). An HMM is a finite state machine, where a probability density function is associated with each state. The states are connected by transition probability. The probability that a sequence of feature vectors was generated by this model can be found by Baum-Welch decoding. HMMs have become very successful in speech recognition. It can manage signals of different time duration (utterances, signatures, etc.). For this reason it is popular for speech and signature recognition applications. Usually a left-to-right model is used (see Figure 6).

c. **Neural Networks:** For instance, a Multi-Layer Perceptron can perform as a classifier. In order to adapt to the dynamic characteristics, recurrent neural networks, time-delay neural networks, and hybrid networks can be used. Although neural networks have shown capabilities in generalization, they require large amounts of genuine and forgery signatures, which are not always available.

**4. Decision:** Once a similarity (probability) measure, also known as opinion and score, is obtained, the decision implies the computation of a decision threshold. If the similarity is greater than a threshold, the decision is ACCEPT; otherwise it is REJECT. Contrarily, if the matching block produces a distance (dissimilarity) measure, the person is accepted if the score is smaller than the threshold, and otherwise it is rejected.

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Strapdown Inertial Navigation Technology – 2nd Edition

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Anyone exercising outdoor activities as scouting, hunting, or wildlife photographing—not to mention walking in the city—plus those of us engaged with defense activities can state it is more convenient to get lost if one knows where this happens. Perhaps this is one of the key reasons why methods and technologies for navigation have been an area of continuing efforts and interest. After the introduction of fast moving vehicles, and later when defensive or hostile weapons came into use, it was not sufficient to know where the platform was located but it was really vital to be aware of its momentary alignment, of course, in a three dimensional space. New challenges were put to the shoulders of the navigator. When time, equipment, and location allow, navigation relying on external references such as radio beacons on ground or up in the space orbits are often preferred. However, such cooperative systems may not be available, or their performance is inadequate for the short time constants of platform motion. We are thus forced to use autonomous navigation modes. It is here that inertial navigation systems exist, for long, been the way to go. First, we had simple gimbals, the mechanical spinning gyroscopes and later came fiber optic laser devices. “Strapdown Inertial Navigation Technology” by Prof. David Titterton and Dr. John Weston is a new entry to this complicated field, surely of interest to many Systems readers.

A brief quantitative study of this book indicates 558 relatively dense-packed pages containing 15 chapters, four appendices, an alphabetical Index of some 1000 words and a List of Symbols. The size of individual chapters varies from less than about ten pages to over 60. Line drawings (both graphic presentations of functions and pictures of equipment constructions) and photographs are extensively used so that their total number is roughly 250. Unavoidably a book about navigation gets mathematical in nature and here the amount of equations is close to 390. Matrices, vectors, and integrals are needed constantly. The authors have not followed a strict logic in the internal arrangement. This can be seen in the treatment of tables. The first half of “Strapdown Inertial Navigation Technology” has many tables without any numbering, just data and headings placed in small rectangular boxes. However, later the authors have selected conventional numbering and have discarded frames. Due to this, we are unable to give any value for the amount of tabulated information. Most publishers seem to prefer references placed after each chapter. Therefore, even considerable overlapping may occur. Anyhow, the total of references is about 210.

After a very short introduction in Chapter 1, Chapter 2 gives a historical perspective to inertial navigation and briefly defines some of the fundamental concepts. First, “strapdown” is the alternative for “stable.” Systems in this book allow full rotational motion of the sensor at hand, not just linear movements. A more thorough treatment follows in Chapter 3, where we read about rotating and reference frames, inertial mechanizations, attitude representations, and navigation equations. Then, in Chapter 4 we have a description of various mechanical gyroscopes including rate sensors, vibrating gyroscopes, fluid sensors, and fluxgates. Optical sensors are discussed in Chapter 5 where the fiber optic and ring laser devices get a lot of attention. Chapter 6 is about accelerometer and multi-sensor technologies such as solid state accelerometers and inclinometers. Micro Electro Mechanical Sensors, MEMS in brief, are covered in Chapter 7. Various forms of MEMS devices, (pendulous mass, resonant and tunneling) are illustrated. Entire integrated MEMS inertial units are included. Chapter 8 defines means, methods, and practices for testing, calibration, and compensation. Separate sections are devoted to gyroscopes and accelerometers. Then, in Chapter 9 we learn about the main point, strapdown system technology. Interesting elements such as skewed sensor configurations are highlighted. Chapter 10 tells the reader how to align the inertial system, either on the ground, at sea, or in the air. Computation requirements and algorithmic solutions for strapdown inertial systems are outlined in Chapter 11, separately for attitude computation and for acceleration vector transformation. A generalized system performance analysis is in Chapter 12, with a comprehensive discussion of errors, error budgets, and error accumulation. Navigation systems having other sources of location information to supplement inertia are discussed in Chapter 13. Here, a look at Kalman filtering in aided inertial navigation is given as well. A realistic design example, although a rather compact one, is given in Chapter 14. The platform is a surface-launched tactical missile. Finally, Chapter 15 illustrates the growing set of less well-known applications of inertial navigation sensors such as ground vehicle stabilization, artillery pointing, agricultural survey, and geodetic devices. The first Appendix is a dense view of Kalman filtering. Appendix B defines some statistical error budget fundamentals in the form of distributions, Appendix C shows the two fundamental inertial system configurations (stable platform and strapdown) and the last has two tables of comparison for GPS and GLONASS satellite systems. There is also a Glossary of Principal Terms.
It is sad indeed that our sister organization in the UK, The Institution of Electrical Engineers, seldom publishes full biographies of their new authors. Or maybe the British authors prefer a “low profile?” As other reliable sources were not available for this review, we are forced to repeat only the very condensed data given by the book’s sales promotion material. Professor Titterton works in the British DSTL, a set of UK government laboratories for military scientific research. He holds the DSTL College of Fellows position, based on his merits as a distinguished scientist and is currently a team leader in the field of laser systems. Parallel to this, he is a Professor at the University of Cranfield. Dr Weston is a Principal Scientist at Sperry-Sun in Halliburton. His main research topics at the moment are focused at inertial and gyroscopic systems needed for the surveying of underground pipelines and well bores. He has also worked in the field of missile guidance and control, originally with British Aerospace.

The general appearance of “Strapdown Inertial Navigation Technology” is professional. This review revealed no major technical errors. The authors have been able to simultaneously write in an easily understandable way and yet maintain an adequate accuracy of expression. Also a non-native user of the English language – such as this reviewer – should have no major problems in following the text. Playing with vectors in space and multiple differential equations plus coordinate transformations cannot be just elementary school algebra. The reader must concentrate on those parts to get a true understanding. It certainly would have added to the value of this book if selected sections had some worked numerical examples. Now most of the equations remain “dead” as the reader cannot readily get a touch to the respective real world and relevant parameter values. Descriptions of system components and existing hardware are clear and useful, because the authors have been able to find pretty up-to-date designs and products. For this European reviewer, device examples coming not only from the North American continent are a reason for special delight. It cannot be just by accident that the authors have taken in their selected references the original papers of Sagnac from 1913 and Michelson from 1925. This shows a very solid sense of background. Of course, much of the remaining references are more up-to-date. Items after 2000 appear as well.

It looks as if the IEE has a high standard for print quality. Illustrations are not scanned photocopies but I think all of the drawings have been prepared for this book only. Details are meaningful and captions or text inserted into the drawings give valuable information, especially pictures showing the internal – though schematic – arrangements of inertial sensors and systems are of very high quality and help in understanding the topic. Photographs are also used to some extent and many are interesting despite at times the increase in information is not immense. Apparently many graphs containing measured sensor performance characteristics, such as those in Chapter 8, have no scaling due to their classified content. However, it might have been nice to have at least one example with realistic numerical values as well.

Much of the text in the first half of this book deals with general inertial principles and sensor technology fundamentals. It is clear the author’s target is true strapdown systems, but possibly the title of the book could have been less restrictive. Maybe “Fundamentals of Inertial Navigation Technology” would have been fine. Now there is the risk that potential readers might overlook this book because of the too-narrow title. Otherwise the logic inside the covers looks precise and carefully thought-out. Of course, some of us might consider Appendix C less necessary. Perhaps the authors could have placed this basic discussion in the introduction. The treatment of Kalman things is of adequate depth but one realistic example containing numeric input would have been a fantastic add-on. Speaking about examples, the case in Chapter 14 is very attractive and the authors carefully define the desired target values and discuss various alternative approaches. Unfortunately, the example itself is not really worked through but results seem to pop up from Alice’s Wonderland. The step-by-step method would have been here a more appropriate way to go. A slight flavor of a too hasty proofreading remains. As mentioned above, tables generally have no numbering. Well, equations occasionally appear without numbers as well, for example in Chapter 7 on page 204. And a couple of photographs, e.g., Fig. 5.12 and Fig. 15.35 suffer from excessive zooming and the original raster comes up.

“Strapdown Inertial Navigation Technology” has many strong sections and details worth studying. The entire Chapter on sensor testing is practical and the authors included lots of useful tips for a first-time gyroscope experimenter. Comparisons between sensor technologies on types in Chapters 4 and 5 look valuable indeed. MEMS pieces are well explained and illustrated – as has been done in other recent books. Those of us currently involved in entire systems, e.g., for the defense sector, may find the generalized analysis tools useful. Also exotic sensor principles and applications, such as the use of cold atoms are discussed. Many drawings of the category “how this works,” such as the different variations of fiber optic sensors, are very informative and well documented. A small illustration, showing the scale of factors due to our planet Earth perturbing ring laser gyro measurements, is in its simplicity a very fine example of thorough thinking and a nice educational touch. Circuit diagrams do not exist, design outlines for such are not given and most of the numerical data reflecting device performance is order-of-magnitude only, unsuitable as a dimensioning base. Equipment principles come up in block diagrams. This is a system designer world; others must consider the electronics needed.

Titterton and Weston have done a fine job in the 2nd edition of “Strapdown Inertial Navigation Technology.” Modern navigation books are not common and technologies mandatory for inertial sensors are generally quite diverse. This book is worth considering, if looking for a comprehensive course text for fourth year university courses (perhaps better for post graduate lectures). A system designer needing inertial sensors but not having own solid experience certainly finds use for this volume.

— Reviewed by Pekka Eskelinen
The Cambridge Aerospace Dictionary

Bill Gunston
Cambridge University Press, Cambridge, UK
2004, 741 pages, Hard cover

My first dictionary was small, worn-out, and had red covers and a slight smell of coffee. It was given to me by my mother when she wanted to encourage me to study English. It was her first dictionary as well, from 1939 or so. And, believe it or not, I used it up to the point that it was merely a collection of separate sheets of paper when I graduated from secondary high school. A decade later, as a young electronic engineer, I joined our national aviation authority for some flight inspection work and was instantly irritated and shocked by the overwhelming usage of cryptic acronyms, abbreviations and artificial-looking phrases that I could not understand at all. My older co-workers told me that this is how it has been as long as they can recall. Possibly it all started during the Second World War, or perhaps it has been here forever. I went to the small office library to get some help, but ordinary dictionaries could not relieve my pain. Almost word-by-word I had to go through long manuals and ICAO documentation to figure out what and how we should do. Obviously, the efficient way of writing had caused a loss of vital information. Only months later I came to realize that the aviation way of using English is completely different to that taught at colleges and in university courses. It is, in fact, a language of its own.

Task-specific dictionaries for the major field of sciences have been available from distinguished publishers since the 1950s but engineering-breed versions have not always found their way to the actual users. This must be at least partly due to our educational heritage. Medical doctors and lawyers are expected to apply knowledge from their professional dictionaries and cookbooks already when they are still under supervision of older colleagues; but we engineers seem to be more "on our own." We prefer to sketch, design, simulate, build, measure, test, and re-build. Our culture is not that much used to having a book of terminology at hand and some individuals could even consider such as a symptom of severe incompetence or as a lack of creativity. However, a proper source of definitions could save a lot of useless searching and prevent unnecessary misconceptions.

This time our review target is Bill Gunston's, The Cambridge Aerospace Dictionary, published by Cambridge University Press in Cambridge, UK. The story started already in 1980 in the form of Aerospace Dictionary, at that time from Jane's, with some updates in 1986 and 1988. Covered topics and fields included aviation, space, aircraft engineering, jet engines, electronics for aerospace applications, radars, geography and surveying, administration, organizations and management. The layout is precisely that of a dictionary — thin high-quality paper, a bit too small font to be readable at my home office with my driving glasses on my nose and words running in strict alphabetical order from column to column. The author of this new book, Bill Gunston, seems to be one of the most well-known aerospace journalists of our time. He has served the RAF as pilot and then became the Technical Editor of Flight International. He also joined Science Journal as a Technology Editor. Mr. Gunston is currently a member in the Jane's Information Group staff and has authored and contributed to more than 300 books. His long professional career, now exceeding fifty years, has earned him the appointment of an Officer of the Order of the British Empire. Mr. Gunston is also a Fellow of the Royal Aeronautical Society in the United Kingdom.

My normal statistical evaluation of books under review gives in this case quite useless figures. There are no illustrations, no references, and no indexing — but you certainly don’t expect to find such in a condensed-form dictionary. A very accurate and careful reader can, in fact, find equations because they are occasionally used in clarifying some theoretical issues. Of course no real mathematics is needed, just some small differentials, a square root for the definition of the perigee velocity, and so on. The number of individual items in this dictionary is roughly 80,000 and the author tells that about 15,000 are new since the previous edition. After the normal dictionary we find eleven Appendices that contain Greek symbols, frequency band designations, US military aircraft, engine and electronic designations, and NATO code names for former Soviet Union aircraft.

The very high number of terms forced me to make just a random and primitive check of consistency and correctness. It seems that Mr. Gunston is really a professional of airframes, aircraft maneuvering, and engine technology. However, he has not forgotten us and many things of electrical origin have found a place in the huge list of words. Somehow, I found it very sympathetic. Occasionally the definitions he used for
electronic and radio topics are not that common. Let us consider the phrase “Frequency response.” The book suggests as the first meaning “Portion of EM spectrum sensed within specified limits of error.” Sounds a bit strange to me - I would have taken “Response as a function of excitation frequency” as number one explanation. Then “Frequency hopping” is told to be “unpredictable continual and rapid changes of frequency of radar or other military electronics to defeat hostile ECM.” My own understanding of the topic is not that narrow. Basically, many systems use frequency hopping that is not unpredictable, and hostile ECM is only one - but of course important - motivation to use hopping. In caseore “Noise” it is obvious that an aerospace engineer first considers that audible chaos created by his dear engines and thus this dictionary has one of its longest definitions (about one full column) explaining acoustic noise and only a couple of lines telling about electric noise possibilities. Many phrases starting with the word “dummy” have been included, but unfortunately we have to test our radar and radio gear without a dummy load. We are not even given a termination. But, to be fair, many explanations are better and more complete than one might get from a present-day fourth-year student of electrical engineering. For example, “Volt-ampere” is very exactly defined, including the necessary equation.

For an electronic system engineer this book might offer some interesting details for further study. For example, the term “Rectifying antenna” is explained as “Receives radar wave and separates its two components, the electric field and magnetic field, the former being conducted into the hot jet(s) from the engine(s), which become(s) ionized and cooled, and the magnetic component being dissipated in the engine and degassed.” If you have never seen such a device, why not sit down and think for a while - or maybe all night long! Items having no direct connection to technology have been included, too. One is sure to fall into depression when reaching the “point of no return” which is explained as “geographical position on track or time at which fuel remaining becomes insufficient for aircraft to return to starting point.” So it is luckily only a matter of getting some more JET A-1 (given in this book as “Turbo kerosene, freezes below −50°C, flash above 37.8°C, standard commercial fuel”) or perhaps some “JP-7,” “special fuel for Mach 3 extreme altitude aircraft,” suggested being SR-71. Going to Appendix 5 we find out that “SR” means “Strategic reconnaissance.” So simple!

More than half of the items in this dictionary are abbreviations and acronyms. The author has been working hard with them and the results look attractive - well, if one can think of an attractive abbreviation. Such monsters as “FFMRRR” for “Folded fiberglass-mat rapid runway repair system” and “PMRAFNS” which means “Princess Mary’s Royal Air Force Nursing Service” (an important aerospace thing indeed) are well documented. Others like “LPD” are first given an explanation as “Labeled plan display” although we might in our typical contexts expect “Low probability of detection” that is suggested only as the last alternative in Gunston’s book. A veteran radar designer might be slightly upset, because “STALO” is there but “COHO” is not. An incomplete design indeed! Many abbreviations have a huge bundle of possible origins indeed, but I did not imagine that such simple things as “SA” or “K” really have two dozen choices. A set of abbreviations has been included from other western languages as well; for example, German and French air force terminology and even from Russian. Such cross-referencing seems to be a clear advantage in the European Union and WEAG frameworks. By the way, did you know that “TLC” stands for “Trans-lunar coast,” “Takeoff and landing chart program” and “Tender loving care” (in this aerospace environment connected to the handling of a specific - obviously a bit furious - US-made jet engine)?

At many places, Mr. Gunston goes far beyond the limits of a typical dictionary by giving in-depth explanations of physical processes (such as Bernoulli’s theorem), devices and their operating principles (propeller pitch) or even of concepts related to management and business (request for proposals). This increases the book’s value and applications, particularly if used in academic and educational institutions. The Cambridge Aerospace Dictionary is clearly written and well-edited. It gives a professional impression throughout if one accepts some minor deviations in selected words coming from our own expertise area. The given definitions have been kept short enough for easy reading yet comprehensive enough to allow understanding without further tedious research. Mr. Gunston’s long professional and practical aerospace experience has enabled him to cleverly adjust the depth of treatment according to the anticipated difficulties in understanding. I was really satisfied. This dictionary looks very suitable for engineering offices, project teams, and also for advanced classrooms, perhaps from the fourth university year upward. If your personal or corporate budgets allow, you could well consider purchasing your own copy tomorrow.

— Reviewed by Pekka Eskelinen
FROM THE EDITOR-IN-CHIEF

Publication Delivery & Conference Policies

New Procedures for IEEE Publication Delivery Complaints – A new procedure has been developed to track and respond to issues members encounter with delivery of IEEE publications or other IEEE mailings. Members who experience delivery problems should visit the new website: <http://www.ieee.org/pubdeliveryR9>. The site provides useful information to assist the member in identifying the cause of the problem. If these steps do not resolve the problem, the member can complete an online form to provide IEEE with the specific details of their situations, e.g., which publication(s) is involved, which issue(s) is missing, etc. The data from the web form will be received by IEEE Member Services, who will be responsible for researching the member’s complaint (with support from the IEEE Publications Department staff) and for responding to the member.

Changes to IEEE Conference Policies – Chapters and conference organizers should note the recent changes to IEEE policies relating to the use of IEEE Operations Audit department staff to perform the required conference audit, need for a Memorandum of Understanding (MOU), requirements for IEEE technical sponsorship and cooperation of conferences, and the inclusion of technically co-sponsored conference proceedings into the IEEE Conference Publication Program (CPP). These changes and other IEEE conference related policies and requirements are included in IEEE Policies, Section 10, MEETINGS, CONFERENCES, SYMPOSIA and EXPOSITIONS, and the IEEE Meetings Organization Manual: <http://www.ieee.org/conferences/conforward.xml>. For additional information on any conference-related issues, contact Mary Ann DeWald, IEEE Conference Services; telephone (732) 562-3873; <MailTo:m.dewald@ieee.org>.

– Evelyn Hirt

PLANS 2006 JOINS AESS WITH THE INSTITUTE OF NAVIGATION (ION)

PLANS – the Position, Location and Navigation Symposium – for 2006 will be co-sponsored by IEEE-AESS and ION, April 24-27 in Coronado, California, with Tutorials on April 24.

In March 2005, the IEEE and ION entered into an agreement whereby both organizations would equally sponsor and support the technical program and conference management of PLANS 2006. As part of the agreement, PLANS 2006 will replace the ION’s annual summer meeting. The ION’s annual awards and Fellow awards, typically awarded during ION’s summer meeting, will be awarded during the course of PLANS 2006. All are invited to participate in this joint IEEE/ION meeting with exciting new opportunities for technical exchange and networking.

Chuck Bye, Honeywell, is the General Chair; Wayne Soehren, Honeywell, is the Technical Program Chair; Frank van Graas, Ohio University, is the Technical Program Co-Chair.

For information contact: L. Beatty, (703) 383-9688 V; (703) 383-9689 F, lbeatty@ion.org; e-mail: http://www.plans2006.org/.

NOMINATIONS FOR THE 2002 M. BARRY CARLTON AWARD

The 2002 M. Barry Carlton Award to Karl Gerlach was announced on page 43 of the June issue of this title, accompanied by a sampling of the nominating letters. The announcement of the award may be found in IEEE Transactions on Aerospace and Electronic Systems, 41, 2, 768.

The nominations for the 2002 award were: Tracking multiple objects with particle filtering by Carine Hue, Jean-Pierre LeCadre & Patrick Perez [38, 3, 791-812], and Outlier resistant adaptive matched filtering by Karl Gerlach [38, 3, 885-901].
International Radar Symposium 2005
IRS 2005

6-8 September 2005  •  Berlin, Germany
Organised by German Institute of Navigation –
Deutsche Gesellschaft für Ortung und Navigation e.V. - (DGON)


We received in total 160 papers from 30 countries. The following program contains 130 contributions in oral presentations and interactive sessions. High level presentations will allow each participant to get an in-depth view on the status of radar systems and components in all fields and aspects of current applications, as well as on present and future research and developments programmes.

SECTIONS:

Tuesday, 6 September 2005
Opening Ceremony
- SAR Systems
- Automotive Radar I
- SAR/MTI
- mm-Wave Radar
- Parameter Estimation
- Bistatic SAR
- CFAR
- Maritime Radar

Wednesday, 7 September 2005
- Digital Beamforming
- Advanced Subsystems
- Signal Processing
- Air Traffic Control
- Target Classification
- Meteorological Radar
- Waveform Design
- Ground Penetration Radar/UWB

Thursday, 8 September 2005
- STAP
- Automotive Radar II
- SAR Applications
- Tracking & ECM
- Inverse SAR
- Simulation & RCS

Venue:
MARITIM proArte Hotel Berlin,
Friedrichstrasse 151
10117 Berlin, Germany
Phone:  +49 (0) 30-2033.5
Fax:  +49 (0) 30-2033.4209
E-mail:  info.bpa@maritim.com

Registration:
Via Internet <http://www.dgon.de/irs2005.htm>
The final programme will be published in early June 2005.

Please feel free to forward any questions to:
German Institute of Navigation
Deutsche Gesellschaft für Ortung
und Navigation e.V. (DGON)
Koeinstr. 70, 53111 Bonn, Germany
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or:

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21073 Hamburg, Germany
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AESS Developing New Standard for UWBR . . .


The meeting was to further the development of the product for P1672. Presentations were made by: Stephen Johnston, Chair; Joe Bruder, Vice-Chair; Arnold Greenspan, Secretary; James Taylor, Lexicographer; and Malek Hussain, Member.

Good progress was made in further defining the contents of the proposed Standard.

Members Represent Eight Countries

Those listed below are the members of the Working Group represented eight countries:


Background

The publication of the “classic” PIERS paper in 2000 by Terrence Barrett, a UWBR pioneer, initiated interest in, and subsequent collection of citations to UWB literature. During this time, James D. Taylor published two books concerning UWBR. A literature search in 2004 yielded about 600 UWB citations; the search was narrowed to UWBR terms by Steve Johnston, Jim Taylor, Hong Bo Sun, and Malek Hussain compiled lists of possible UWBR terms, which were published in the July and August 2004 issues of Systems.

There now exists an IEEE Standard for UWB Communications; one was essential for UWB Radar. A Project Approval Request (PAR) for the formation of a Working Group for the development of an IEEE Standard was submitted to the IEEE Standards Association through the Chairman of the AESS Standards Committee, Arnold Greenspan. It was approved; the designation P1672 was assigned, designating Stephen Johnston as Chair, Joseph Bruder as Vice-Chair, and Arnold Greenspan as Secretary. The Working Group rapidly grew to its present membership [listed above, as of mid-May 2005].

It is intended that an unofficial ballot on the draft standard that has been developed as a result of the May meeting will be held soon. If a great majority are in favor of the draft, a formal ballot will follow, which then will be followed by the forwarding of the product of the group to the IEEE Standards Association for formalization.

The first meeting of the Working Group was held in conjunction with IEEE Radar 2005 in Arlington, Virginia, USA; the next physical meeting will take place this fall in Atlanta, Georgia, USA.
Call for Papers

The electromagnetic spectrum has become increasingly crowded in recent years as a result of the demand for higher bandwidths. Efficient use of bandwidth is essential to meet the needs of a wide variety of technological disciplines. It has long been recognized that judicious use of properly designed waveforms, coupled with advanced receiver strategies, is fundamental to fully utilizing the capacity of the EM spectrum. However, it is only relatively recent advances in hardware technology that are enabling a much wider range of design freedoms to be explored. As a result, there are emerging and compelling changes in system requirements such as more efficient spectrum usage, higher sensitivities, greater information content, improved robustness to errors, reduced interference emissions, etc. The combination of these is fuelling a worldwide interest in the subject of waveform design and the use of waveform diversity techniques. The purpose of this conference is to bring together leading experts in waveform diversity and design representing both the communications and sensing communities, thereby facilitating the exchange and cross-fertilization of ideas and research.

The WDD organizing committee invites original contributions to Waveform Diversity and Design in the general areas of Communications, Radar, Sonar, etc. Specifically, topics to be included are:

- Radar Systems
- Sonar Systems
- 3G/4G Communication Systems
- Laser Systems
- Interference Suppression
- Band Sharing
- STAP
- Channel Estimation/equalization
- Multiuser Detection
- Passive Sensing Operation
- Target-adaptive Matched Filtering
- Multi-function Operation
- Impulsive Systems
- Tomography
- Ultra-wideband Operation
- Target Detection
- Tracking
- Interferometry
- SAR
- MIMO
- Security
- Error Correction Coding
- Modulation Schemes
- Multiple-access Schemes
- Software Radio/radar
- Bandwidth-on-Demand
- Synchronization
- Evolutionary Computing
- Hardware Efficiency
- Bi-static/Multi-static Operation
- Beam Steering
- Polarimetry
- EM Phenomenology

Abstracts of 1,000-1,500 words are solicited which should include examples of data and illustrations. The cover page should include title, name(s) of author(s) with contact person identified, address, telephone and fax number, e-mail address, and organization affiliation. Send abstracts to the Conference organizer at WaveformDiversity@rl.af.mil in Word 97 or later, or (preferably) PDF format before 15 July 2005. Receipt of abstracts will be acknowledged by e-mail. Conference organizer contact: Patricia Woodard, (315) 330-2215. Additional information is available at http://www.waveformdiversity.org.

Authors of accepted papers will be notified by 9 September 2005 and will receive instructions for publication at that time. Complete papers of a maximum of five pages (including text and illustrations) will be required by 11 November 2005.

Dates to Remember:

- Abstracts Due: 15 July 2005
- Notification of Acceptance of Papers: 09 Sept 2005
- Final Papers Due: 11 Nov 2005
# Distinguished Lecturers Program

James R. Huddle, Chairman

All AESS Chapters and IEEE Sections are encouraged to take advantage of the AESS Distinguished Lecturers Program for their regular or special meetings. We have selected an outstanding list of speakers who are experts in their fields. The AES Society will cover up to $500 of the speaker’s expenses for travel in North America, with any remaining amount normally covered by the AES Chapter or Section or by the speaker’s organization. For travel outside North America, the AES Society will cover half of the speaker’s expenses per trip, up to a maximum of $1500. The procedure for obtaining a speaker is as follows: If a Chapter or Section has an interest in inviting one of the speakers, it should first contact the speaker directly in order to obtain his agreement to give the lecture on a particular date. After this is accomplished, and if the Chapter or Section wishes to request financial support from the AESS, it should contact James R. Huddle on (818) 715-3264, F (818) 715-3976, j.huddle@ieee.org at least 30 days before the planned meeting, in order to obtain approval for the financial support. The list of distinguished speakers who have expressed their willingness to speak to Chapters or Sections, along with their organization, topics, and telephone numbers, is given below.

<table>
<thead>
<tr>
<th>Title</th>
<th>Name</th>
<th>Contact Number</th>
</tr>
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<tbody>
<tr>
<td>Active Control Technology Applied to Aircraft &amp; Automobiles</td>
<td>Dr. Kimio Kanai, National Defense Academy of Japan</td>
<td>81-45-812-1244 (V&amp;F) <a href="mailto:k-kimio@mch.biglobe.ne.jp">k-kimio@mch.biglobe.ne.jp</a></td>
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<td>Avionics for Manned Spacecraft</td>
<td>Dr. Myron Kayton, Kayton Engineering Co</td>
<td>(310) 393-1819</td>
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<td>Evolution of Aircraft Avionics</td>
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<td>(310) 393-1261 P</td>
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<td>Navigation: Land, Sea, Air and Space</td>
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<td><a href="mailto:m.kayton@ieee.org">m.kayton@ieee.org</a></td>
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<td>One Hundred Years of Inertial Navigation</td>
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<td>Practitioner’s View of System Engineering</td>
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<td>Bisistatic &amp; Multistatic Radar</td>
<td>Dr. Hugh D. Griffiths, University College, London</td>
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<td>Synthetic Aperture Radar</td>
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<td>Current Advances in Radar Technology</td>
<td>Robert T. Hill, Consulans &amp; Lecturer</td>
<td>(301) 262-8792 (V&amp;F)</td>
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<td>Evolution of Inertial Navigation</td>
<td>Dr. Itzhack Bar-Itzhack</td>
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<td><a href="mailto:lbaritz@technion.ac.il">lbaritz@technion.ac.il</a></td>
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<td>Formal Methods in System Design</td>
<td>Dr. James F. Peters, III, Univ. of Manitoba</td>
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<td>Future of Electronic Warfare and Modern Radar Signals</td>
<td>Dr. Richard G. Wiley, Research Associates of Syracuse</td>
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<td>Dick <a href="mailto:Wiley@aol.com">Wiley@aol.com</a></td>
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<td>Multisensor Data Fusion</td>
<td>Dr. Pramod Varshney, Syracuse University</td>
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<td>(315) 443-2583 F</td>
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<td><a href="mailto:varshney@syr.edu">varshney@syr.edu</a></td>
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<tr>
<td>National Missile Defense and Early Warning Radars</td>
<td>Larry Chasteen, University of Texas at Dallas</td>
<td>(972) 234-3170;</td>
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<td>Novel Orbits &amp; Satellite Constellations</td>
<td>Dr. Daniele Mortari, Texas A&amp;M University</td>
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<td>Planetary Exploration with Spacecraft — to Jupiter, Saturn, Uranus, Neptune and Beyond</td>
<td>Dr. William W. Ward, Consulans &amp; Lecturer</td>
<td>(617) 527-5331 (V&amp;F) <a href="mailto:w.ward@ieee.org">w.ward@ieee.org</a></td>
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<td>Radar — Past, Present and Future</td>
<td>Dr. Eli Brookner, Raytheon</td>
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<td>(978) 440-4040 F</td>
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<td><a href="mailto:Eli_Brookner@res.taytheon.com">Eli_Brookner@res.taytheon.com</a></td>
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<tr>
<td>Satellite Communication Systems</td>
<td>Dr. S.H. Durrani, Consulting Engineer</td>
<td>(301) 774-4607 (V&amp;F) <a href="mailto:s.durrani@ieee.org">s.durrani@ieee.org</a></td>
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<tr>
<td>System Engineering for International Development</td>
<td>Paul Gartz, Boeing Co.</td>
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<td><a href="mailto:p.gartz@ieee.org">p.gartz@ieee.org</a></td>
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<td>Target Tracking and Data Fusion: How to Get the Most Out of Your Sensors</td>
<td>Dr. Yaakov Bar-Shalom, Univ. of Connecticut</td>
<td>(860) 486-4823</td>
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<td><a href="mailto:ybs@engr.uconn.edu">ybs@engr.uconn.edu</a></td>
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All data on this page is under the purview of Walter D. Downing, VP-Member Affairs. Please send all corrections and omissions to him at the address on the inside back cover.
CALL FOR PAPERS

The conference theme Radar . . . Our sight into a Spectrum of Information emphasizes the increasingly wider spectrum of target and environmental information that is emerging from innovative radar research, systems technology, and component development for civilian, defense, and space applications. This innovation is evident today in the development of foliage penetration radars to provide MTI and SAR capabilities against targets obscured by vegetation or camouflage, in development of advanced airborne surveillance systems and space-based radars, and in ongoing research into many areas, including automatic target recognition, radar data exploitation and fusion, sensor management, knowledge-aided sensor signal processing and expert reasoning architectures, multi-static radars and radar networks, advanced component development, and much more.


PAPER SUMMARY

Authors are required to submit a 1000-1500 word paper summary with figures following the text. Electronic submission is required in either Adobe PDF or Microsoft Word (version 97 or later) format.

Refer to the 2006 IEEE Radar Conference website: www.radar06.org for additional paper format and submissions requirements.

Authors should indicate a preference for poster or oral presentation. Student papers are strongly encouraged.

PAPER SUBMISSION

Send summary papers electronically to the Technical Program Chairs at: technicalchair@radar06.org. The deadline for submission is September 30, 2005.

PAPER ACCEPTANCE

Authors will be notified of acceptance by December 1, 2005.

FINAL PAPER

Instructions and format for the final paper will be provided on the conference website www.radar06.org. Completed electronic papers will be required by February 3, 2006. Papers are limited to 8 pages, including tables and figures.

ADDITIONAL INFORMATION

Where applicable, government approval for publication as an unclassified, public release paper will be required with the final paper submission. International authors should allow extra time for visit VISA requests and should initiate the VISA process immediately after notification of paper acceptance. The conference will issue letters of invite for foreign authors to facilitate VISA applications.

CONFERENCE CHAIRS

Mark Davis, mdavis@radar06.org
James Day, jday@radar06.org

TECHNICAL PROGRAM CHAIRS

Jeff Carlo, technicalchair@radar06.org
Dennis Stadelman, technicalchair@radar06.org
IEEE AEROSPACE & ELECTRONIC SYSTEMS SOCIETY ORGANIZATION

OFFICERS

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IEEE A\E\S SYSTEMS MAGAZINE, JULY 2005
Microwave & Radar Week in Kraków, Poland

May 22-26, 2006

Microwave & Radar Week 2006 will be organized at the Symposium Hotel in Kraków, the previous capital of Poland, an internationally recognized place of history and culture, the real historic center of Poland.

Organized by: Telecommunications Research Institute – Warsaw University of Technology
Chairman: Józef Modelski; Vice-Chair, Roman Defrène

International Radar Symposium 2006 — IRS 2006

Organized by: Telecommunications Research Institute in cooperation with German Institute of Navigation, the Technical University of Hamburg-Harburg and the Warsaw University of Technology
Chairmen: Hermann Rohling & Krzysztof Kulpa

With the International Symposium 2006 (IRS-2006) the Telecommunications Research Institute together with the German Institute of Navigation continues the series of very successful radar symposia in Munich (IRS 98), Berlin (GRS 2000), Bonn (GRS 2002), Dresden (IRS 2003), Warsaw (IRS 2004), and Berlin (IRS 2005).

In 2004, for the first time, IRS took place in Poland. In 2006, IRS will be organized again in Poland. This time the conference will be hosted by Kraków, the previous capital of Poland, a historical and cultural place of world renown. The International Radar Symposium IRS 2006 together with XVI International Conference on Microwaves, Radar and Wireless Communication, MIKON 2006 will form the Microwave and Radar Week in Poland – the meeting place for microwave and radar engineers and scientists.

Due to the rapid development of technologies, radar technique is still expanding technical and economical segment with practical applications in the civil, as well as the military area. The worldwide family of radar researchers and experts is quite small and it is always a pleasure to meet scientists, engineers, and international experts to discuss new ideas, latest research results, and future developments. High-level presentations will allow each participant to get an in-depth view on the status of radar systems and components in all fields and aspects of current applications, as well as on future research programs and developments.

Secretariat: Telecommunications Research Institute, 04-051 Warszawa, 30 Poligonowa St., Poland;
Phone/Fax: (48 22) 813 37 85, E-mail: irs@pit.edu.pl; www.IRS.2006.pl

Contributions
Authors are invited to submit papers on any of the topics listed in the next section for consideration by the Program Committee. An abstract of about 500 words should be submitted as electronic data file to the conference Secretariat E-mail address; ATTN: Symposium Coordinator IRS-2006, by January 15, 2006. The cover page of submitted abstracts must include:
Title of paper with the suggestion of a relevant topic
Name(s) of author(s)
Organisation/company (if applicable)
Mailing Address
Phone and Fax Numbers
E-mail address
Name of presenting Author

Main Topics

Important Dates:
Submission of Abstracts: January 15, 2006
Notification of Authors: March 1, 2006
Provision of the full paper for the Proceedings as electronic data file: April 3, 2006
IEEE AEROSPACE AND ELECTRONIC SYSTEMS SOCIETY CHAPTERS

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2006 CIE International Conference on Radar

October 16-19, 2006 • Shanghai, China • www.cie-china.org/radar2006

CIE Radar 2006 will be held October 16-19, 2006 in Shanghai. This is the 5th International Conference on Radar held in China as one in the series of international radar conferences. CIE Radar 2006 is directed toward research and development aspects of radar technology and will establish a forum for the exchange of ideas and dissemination of information on existing and future radar technology.

The conference language is English.

Authors are required to submit a full paper in two column format for IEEE publications with a cover page. Each paper is limited to 5 pages, including text, figures, and tables.

The cover page should include the paper title, names of authors, with corresponding author identified, mailing address, telephone and fax numbers, and e-mail address.

Both oral and poster presentations will be equally accepted. The authors can indicate their preferences on oral or poster presentations on the cover page when submitting the paper.

Please send papers electronically (in Microsoft Word file format) to the Technical Program Chair at:

<http://radar2006.xidian.edu.cn>

or e-mail:

<radar2006@xidian.edu.cn>

IMPORTANT DATES:

Paper Submission: 15 April 2006
Notification of Acceptance: 15 May 2006
Revised Version of Paper Submission: 30 July 2006

TOPICS

Radar Systems
Subsystem Technology
Signal & Data Processing
Emerging Technologies
Phenomenology & Simulation

Tutorials will be held October 19, 2006. Speakers are invited to submit proposals in the topics above to the Technical Program Chair.

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Announcement

Radar Conference 2007
17–20 April 2007
Boston, Massachusetts

- "The place where it all began"

Revolutionary Time
April is the ideal time to be in Boston. The conference follows the world's oldest annual marathon, the Boston Marathon and the locally famous Patriots' Day holiday. Join the locals in a reenactment of Paul Revere's ride and the Revolutionary War battles at Lexington and Concord.

Field Trips
From "where it all began" to where "the future is being created" take a half-day guided tour inside MIT Lincoln Laboratory's 100-GHz upgrade to the Haystack radar, or go behind the scenes at Raytheon's MMIC R&D Center in Andover.

International Coordination
Technical survey talks will be encouraged highlighting recent radar developments in these and other countries:

- Canada
- Sweden
- Italy
- Britain
- Australia
- Israel
- France
- Japan
- China
- Germany
- Russia
- India

Poster Sessions
Discuss details and meet with the authors...

Tutorials
Let the experts update you on the latest topics.

Exhibits
Contact exhibits@radar2007.org

For more information visit the symposium web site:
www.radar2007.org or email: info@radar2007.org

Sponsor: IEEE, IEEE Aerospace & Electronic Systems Society Boston Section
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