WIDENING THE CALIBRATION BANDWIDTH

Paul Roberts
Fluke Precision Measurement Ltd
Norwich, UK.
+44 (0)1603 256781
paul.roberts@fluke.com

Abstract - Working over a wide range of frequencies up to microwave and beyond is not a new requirement for measurement and calibration. There are mature fields with established infrastructures, methodologies, and availability of instrumentation and expertise at all levels from the national metrology institutes down to equipment users. What is new are the principal drivers and applications. In the past these were primarily military and defence industry lead, but in today's world the needs of commercial industry, businesses and society are shaping this area of measurement. Rapidly emerging and developing technologies ranging from information systems to telecommunications involving faster data rates, wider bandwidth signals and higher operating frequencies are the new drivers for RF, microwave, and optical measurements, bringing in their wake corresponding requirements for calibration. Alongside the technical challenges are the business and economic challenges of lower cost, reduced downtime and improved efficiency. This paper raises the question of what do we need to do to support these measurements and provide traceability at the required uncertainty levels by exploring these new drivers and the technical, logistical, and economic issues involved.

Introduction

The world of measurement and calibration has seen dramatic change over recent years. Changes in the international political scene have rippled down through reduction in defence spending to change the shape of the electronics industry, particularly in North America and Europe, shifting the bias toward commercial and industrial applications. At almost the same time interest in quality management and improvement has raised the profile and need for good measurement science and traceable calibration. More recently, another factor is emerging as one of the dominant agents for change – the communications explosion. The demand for greater communications systems capacity is stimulating development and implementation of new and novel technologies and expansion of existing systems. Alongside and intrinsically implicit within is the demand for greater capacity, speed and bandwidth. The result is systems operating at higher frequencies extending through the radio frequencies, into the microwave frequencies and beyond to light itself with the emerging all optically switched networks.

So what's new – what could be more technologically demanding than maintaining the edge in the defence race? There are many similar technical challenges to be faced, and indeed many of the defence lead developments have become enablers for recent developments – such as the digital radio technology developed for secure military communications now appearing in applications as diverse as mobile telephones to frequency hopping wireless LANs. A significant difference is the rate of change, driven by the rapid surge in telecommunications technology. By exploring the background, trends, drivers, and a few example applications this paper raises the question of what metrology requirements will emerge as a result of new technology developments.

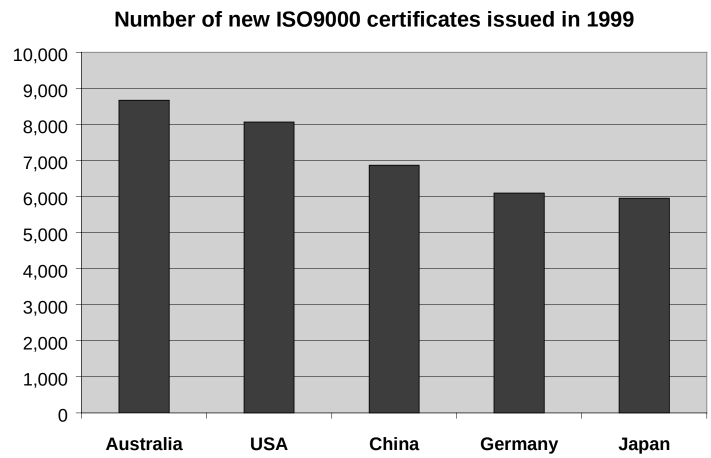
Trends and Drivers

According to published market studies, the Test & Measurement instrument market is growing at an annual compound rate of 6%. The bias has shifted away from the military lead defence market of the past toward commercial and industrial applications. In the early 1990s uptake of the ISO9000 quality management standard focussed attention on measurement and calibration in many industries that had previously ignored the need for traceable measurements and calibration. Today, ISO9000 is often thought of as 'old news', but at the end of 1999 the number of ISO9000 registration certificates issued grew by 26% over the previous year, with the USA in second place to Australia with the highest growth rate.

Figure 1:
New ISO9000 certificates issued in 1999

At the end of 1999, the number of ISO9000 certificates totalled 343,643, a gain of 26.4% over the previous year.

Australia had the highest increase, followed by the USA, China, Germany, and Japan.



The proportion (by value) of new test equipment used in communications related applications wills rise from 25% in 1992 to 33% in 2002 – almost a 50%growth in the amount of test equipment expenditure in comms. The trend is a direct reflection of the dramatic growth in communications applications and markets. On a worldwide basis, two out of every three telephones installed is wireless. Wireless data services will grow seven fold from 1999 to 2003, GSM mobile phone subscribers will increase five fold over a similar timescale, and the number of internet calls made are doubling every 100 days. Optical communications system component manufacturers see their markets doubling in value in three years.

Although ISO9000 implementation is still growing, the interest in good measurement science backed up by traceable calibration appears to be driven from a different perspective than just the need to comply with the ISO9000 standard. Discussions with people involved in development and manufacturing within these growth areas reveal a real need for confidence in measurement results. Reasons include the need to explore characteristics of new technologies having confidence in the validity of results (remember the 'cold fusion' discovery fiasco a few years ago?), and the need to guarantee reliably meeting performance specifications and achieve customer satisfaction. The route to confidence in measurement results is recognised as being through traceable calibration. However in some areas, such as optical, the required standards and metrology are not yet sufficiently mature to satisfy the demand. Even in less complex technologies such as copper cable testing, the metrology is not fully established.

A few example applications

This section describes a few of the higher visibility applications, intended to illustrate the diversity of emerging technologies, and is not to be taken as a definitive list of requirements.

Radio frequency identification (RFID) is an interesting field combining RF and low power technology with potential applications ranging from supermarket product labelling to airline baggage handling. Miniature transponders carry encoded data which can be interrogated by non contact radio frequency links operating in the 14MHz region. The radio frequency energy is also used to power the devices, avoiding the need for batteries. Physical size is extremely small and costs can be kept low if volumes are high.

The third generation of mobile telephones, referred to as 3G, is well under development. Taking the next steps from existing digital systems, it will bring a true worldwide system capable of much higher data rates, the potential for videophones, and high speed internet access from devices that will probably look much more like today's Palmtops and PDAs (Personal Digital Assistants) than simple mobile telephone handsets.

Wireless Local Area Networks (LANs) are already well established, but recent developments bring the promise of low power short range radio links in the 2.4GHz region to applications almost too numerous to imagine – Bluetooth is the name given to one system likely to be used to link multiple devices such as peripherals to PCs, remote handsets to mobile phones, domestic appliances, and even toys. The Bluetooth market is expected to grow to 700million units/year within five years.

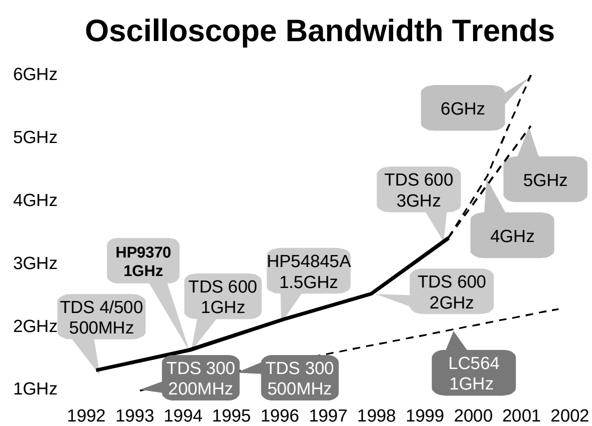
Operating at higher frequencies of many tens of GHz, collision avoidance systems are being developed for automotive applications. Initially targeting luxury cars, price/volume curves will eventually extend down to the mass market.

At even higher frequencies, in the Terahertz region, optical systems are providing the backbones for the global telecommunication systems. There is even the prospect of fibre direct to the home. In addition to characterising and testing the optical components and systems, there are requirements to measure the electrical signals which form the 'baseband' information transmitted optically. Modulating frequencies in the tens of GHz are common, being measured routinely by readily available equipment. In the past bench oscilloscope bandwidths of a few hundred MHz were common. But now for any serious work, a 1GHz scope is almost the minimum and scope with bandwidths of several GHz are commonplace on development and test engineers benches.

Figure 2:
Increase in oscilloscope bandwidths

Increases in oscilloscope bandwidths are a direct result of greater communications systems speed and capacity. Scope bandwidth increases are in turn matched by corresponding increases in oscilloscope calibrator bandwidths. This trend is expected to continue in the future.

The most recent scope introduction, not shown on this chart, is the 4GHz TDS7000.



The measurement and calibration challenge

Working over a wide range of frequencies up to microwave and beyond is not a new requirement for measurement and calibration. These are mature fields with established infrastructures, methodologies, and availability of instrumentation and expertise at all levels from the national metrology institutes down to equipment users. Many of the specific measurement issues are new, related to the new applications. For example, measurement capability and traceability for continuous wave RF power is well established, but what about peak power, in particular traceable measurement of the GSM phone system RF pulse envelope? There are analogies to other fields of measurement where traceability for steady state sinusoids is well established and there is growing interest in traceable measurement at know uncertainty of non-sinusoidal waveforms – such as power quality measurement.

The test equipment being developed is becoming more sophisticated and integrated, targeting specific applications. For example mobile phone testers are single instruments combining the functionality of a number of separate instruments, in this case typically an RF power meter, RF spectrum analyser, audio analyser, modulation meter, etc – capable of handling the various signals and systems standards associated with the many cell phone systems currently in use. So how do we calibrate these instruments, what are the traceability needs and how well can we satisfy them?

The author's personal impression is that there will be a pragmatic demand for cost effective measurement traceability arising from the need to provide confidence in measurement results. The commercial nature of the end-user market will demand reliable products and services, but at the lowest cost. Many of the applications are at the development stage where measurement is critical. Measurement to explore and confirm performance during development is supported from within the R&D investment. However, the price sensitive volume nature of eventual implementation will mean that production testing must be very cost efficient. The supporting calibration activities must also be cost effective. Volume production lines cannot tolerate downtime for calibration. Perhaps some form of process metrology will be employed to provide traceability by running known test items through the system rather than performing calibration of the test instruments within the systems. Furthermore, the highly integrated 'on-chip' system designs are likely to need the minimum setting up and testing. The challenge will be to establish and provide measurement capability, supported by traceable standards, capable of satisfying all of these technical, economic and business demands.

Conclusion

The intent of this paper is to encourage awareness of emerging technological developments, raise issues and questions, stimulating discussion, rather than present answers and conclusions. It is clear that measurement practice must keep pace with these emerging technologies, and that one of the most rapidly growing areas driving the need for calibration over a much wider frequency range is the area of communications. A simple example of this is oscilloscope calibration. Another example is in cable LAN testers, where there is a need to educate the calibration community on what the measurement problems are, and how the measurements are performed. The author expects to provide more details of these emerging requirements and their impacts at the time of the conference when this paper is presented.

References

Prime Data Inc., Test Instrument Industry Report December 1999.

Global Design News, October 2000 edition, Technical Standards Update.

Electronics Times, 26th June 2000 edition.