Harnessing the power of the Web brings new possibilities to relay test equipment and data.

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Abstract – **Applied Relay Testing Ltd is a specialist Company that has created a range of advanced test products dedicated to relays and switch devices which cover the test areas of low-level parametric measurement, contact life-testing and high-voltage performance.**

This paper will review how wide-area and local-area networks can be used in conjunction with suitably designed relay test products and tools. These test resources, previously used 'stand-alone', can now be interlinked and combined into powerful, focused or distributed test solutions. With the power of TCP/IP, systems can be created that mix and match life-test system resources, high-voltage and parametric test systems and distribute relay test programs and reports.

Specific examples will be shown of a relay life-test system based on TCP/IP and of company and world-wide integration of relay test programs and reports – a solution which is already benefiting companies operating multiple, scattered global locations.

I. INTRODUCTION.

It's later than you think. This paper should have been with the conference organisers two weeks ago. Another deadline that has to be met. More pressure into an already packed, bullet-point lifestyle. Does this feeling resonate with you? To focus on the task of writing this paper I've isolated myself temporarily from the telephone and I'm here at home. Between paragraphs I can seek a writers inspiration by glancing up from my laptop to a classic English garden scene, green grass, trees beginning to come into leaf and birds singing. So what's special about this situation? How could this possibly be relevant to relay manufacture and test? Well, I'm not writing this paper on my laptop at all, in fact it is an open document on my office PC upstairs and I'm connected to that desktop PC by a radio network connection that hosts a remote desktop connection which makes the laptop look as if it is actually the keyboard and screen of the desktop PC. So, I can sit where I like and even more importantly, where I work the smartest.

To implement this connection takes several individual technologies, none of which by themselves are particularly revolutionary or exciting. What is exciting though is the 'convergence' of these technologies into opportunities for working with data both locally and remotely. In the context of this paper we will look at how this gives relay manufacturers and users tools with which time can be saved and information gained.

II. FOUNDATIONS – TCP/IP AND HTML.

On the home technology scene at the moment the big buzzword is 'convergence' – the integration of data, music, video and home control and how this is distributed around the home, often from a central PC 'server'. The drive behind this is the low-cost availability of fast PC hardware, radio networks and common standards of data interchange. Devices are beginning to talk to each other. The main reason for this is the internet, not only as a repository of information but as a mighty force that has given us HTML (the software structure of a web page) and TCP/IP (usually via an Ethernet connection and the protocol which conveys data such as HTML from point to point across the internet and within a local network). Because so many millions of users are working with these protocols the hardware and software to implement and manipulate them has become extraordinarily cheap. This capability and low cost is a powerful stimulus to an equipment manufacturer to assess the possible technology benefits and whether they are relevant to his equipment.

III. TCP/IP – THE MODERN BUS THAT CALLS EVERYWHERE.

Here at Applied Relay Testing we had identified the technological benefits of TCP/IP some time ago and had wanted to apply it to our established products [1]. Relay test equipment is often either remotely controlled via a bus (for example by a production line host controller) or is itself a distributed solution that requires its internal modules to be connected by a bus. When designing this interconnection solution the test equipment designer has a number of choices of bus systems, each with their costs and physical and electrical strengths and weaknesses. In general though, the evolution of these busses has followed the capability of low-cost technology to implement them, for example:

- 1970's – GPIB / HPIB and serial RS232
- 1980's – PC ISA bus
- 1990's – PC PCI bus
- 2000's – USB / Firewire

All of these connection systems are in use to varying degrees but with the advent of TCP/IP, we have a new, powerful option with which to interconnect equipment. Since TCP/IP defines only the software interface and is available on a range of processor hardware from small circuit card processors up to large servers, once the hardware connection is made, you have a high-speed bus that is both powerful and low-cost. In addition, comply with this standard and your equipment immediately becomes accessible to existing tools and techniques. (Incidentally, for the purposes of this paper, where you see a reference to the term 'Ethernet', we are also inferring that TCP/IP is being used. Ethernet is the most common hardware connection that carries the TCP/IP software protocol).

Let's look at the benefits of connecting equipment using TCP/IP:

- All PC's have an Ethernet network connection port (which hosts the TCP/IP protocol).
- The connection cables and hardware are very low cost (a few dollars for a cable).
- Addressing is built into the design, allowing multiple equipment nodes with ease.
- TCP/IP guarantees the delivery of a data packet to the destination.
- It is fast, at least 10 MBPS, with 100 MBPS common and faster speeds emerging.
- Nodes are electrically isolated from each other, at least by transformer coupling at the network port and with the option of fibre-optic connections if the electrical environment is particularly demanding.
- With suitable equipment node design, no software needs to be installed on a host PC, a simple web browser is sufficient to control the equipment and view data.
- TCP/IP via radio connection is now commonplace, further binding PC's (and therefore compliant test equipment) together.

For the relay test equipment designer, TCP/IP actually has two main attractions:

- To connect electrical modules within an item of equipment.
- To connect the item of equipment to the 'outside world' (i.e. a host or server).

We will look at each of these in detail.

IV. BUILDING RELAY TEST EQUIPMENT USING TCP/IP.

The use of TCP/IP to connect relay test equipment modules internally is a technique that is hidden from the end user but is actually a key benefit in offering equipment which is fast, reliable and low-cost. A typical application is shown in Figures 1 and 2. Our RT901 high-voltage test system measures relay insulation resistance to over 10^{14} ohms and breakdown voltages to 5kV. The design of the test system is based on modular DC and AC generators, a wide-range current detector and relay pin switching modules, the final interface to the outside world being high-voltage shielded connectors as shown in Figure 1. Internally the modules are linked by a high-speed serial bus, effectively a derivation of an RS232 connection. This is fast enough to allow the main controller (a PC in fact) to control and monitor each module yet it cuts the number of wires between each module down to two. A traditional multi-wire bus such as GP-IB would provide a faster throughput but would be dangerously prone to corruption or damage from the high-voltage transients that exist within such a system.

Figure 1. Our RT901 high-voltage test system which requires a simple, noise-immune internal communications bus.

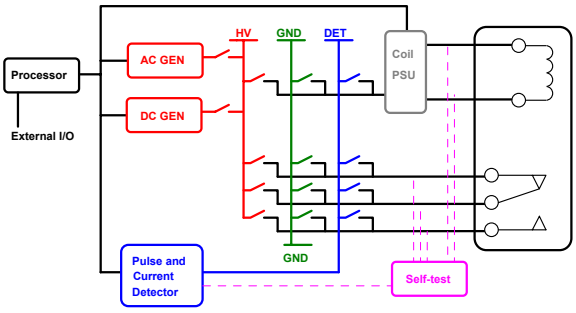

Figure 2. The internal architecture of the RT901 communication bus.

This architecture and the modular concept – first designed in 1990 - have stood the test of time testing relays 24 hours per day, 7 days per week at up to 1 device per second on fully automated production lines. Recent developments around this identical architecture however have allowed us to replace the internal serial bus with a TCP/IP connection. The result has been an increase in test speed and the ability to physically increase the equipment

size to cope with an enhanced test voltage of up to 10kV, all without changing the fundamental architecture.

Another example of the suitability of TCP/IP connection as an internal equipment 'bus' is within our Reflex 50 life-test system shown in Figure 3 below. The core of the test system are our 'contact measurement' modules (circled in Figure 3) which 'watch' the contact open and close under the load conditions, recording the contact voltage drop into their internal RAM memory. This provides high-speed local processing behind each relay contact that does not become 'diluted' when more contacts are added, all whilst offering relay switching speeds in excess of 100 Hz [5].

Figure 3. A TCP/IP connected solution - the Reflex50 life-test system.

During the design of this system a flexible means of connecting these contact modules to an overall controller was required. In a typical customer installation there will be a variable number of such contact modules and the means of connecting them must be physically robust, electrically noise immune and easy to implement. To meet this requirement we chose a standard Ethernet TCP/IP link, which meets all of these needs. Figure 4 shows the rear view of the system and the ease with which the contact monitoring chassis are interconnected.

Figure 4 – Ethernet connections carry TCP/IP at the rear of the Reflex 50 life-test system.

Although these modules are interconnected with TCP/IP within an equipment rack, the solution lends itself ideally to large life-test systems where the device contacts are physically remote from the main controller and where multiple life-test systems are required to be connected together. It is in these situations that the electrical isolation of Ethernet is excellent, since the small contact voltages that are being monitored do not become influenced by the potentially large group loop voltages induced by high-power load distribution cables extending over large life-test areas.

V. EQUIPMENT WITH EXTERNAL TCP/IP CONNECTIVITY.

The external connection of relay test equipment by TCP/IP falls into three main categories:

- Access to data files on the equipment via the network.
- Remotely controlling the equipment test application.
- The equipment application presenting itself as a network or web server

We will look at these categories now in more detail.

A. Access to data files on the equipment via the network.

All of us should be familiar with network file access by now, since this ability to share files and printers across a company network underpins most internal company procedures today. In general though, this means that all PC controlled relay test equipment shares by default the capability to be networked, even if the relay test software application does not directly interact with that network. This permits such file-based activities as sharing test programs from a common repository (e.g. the company main network server) and / or producing reports that pass electronically to a central location. Many of our customers already use such a central facility for obtaining run-time test programs.

More recently, and with increasing network hardware and software robustness, some companies have been moving to adopt a 'thin-client' solution, a term used to designate a network structure where connected PC's do not contain their own MS Windows operating system but obtain it – and any required software applications such as a MS Word or relay test software – from a central server at boot time. This further reduces the maintenance burden on a remote PC.

B. Remotely controlling the equipment test application.

Traditional remote control of relay test equipment is often by means of a custom 'handler interface' port on the equipment or by a character-based RS232 or RS432 serial port connection. More recently, TCP/IP connectivity has been used to implement a host connection to our relay test equipment that eliminates the need for other forms of interface. An extremely interesting application supported by a TCP/IP connection between two PC's is to host a 'remote desktop' connection – this is the feature that I'm using as I type here and now on my laptop – and although I'm using Microsoft Word for my writing, I might just as easily be viewing or configuring a relay test application in another country on one of our connected relay test systems. This remote desktop connection can only be initiated from certain Microsoft Windows versions, but with the appropriate software installed, any Windows client can be remotely controlled [3].

A useful feature of establishing this type of external access to an item of equipment is that of remote maintenance and / or fault diagnosis. There are a number of solutions for the hardware remote control of a PC and where it has been requested by a customer, Applied Relay Testing already installed both PCI card and external remote control solutions using tools from Peppercon AG, of Munich Germany such as their 'ERIC' card. [2]. This card is installed within the remote PC and is able to remotely shut-down and attempt the restart of a faulty PC motherboard, making complete remote hardware and software diagnosis feasible. If complete boot failure is ignored though, there are software-only solutions which permit 'taking-over' control of a remote PC. [3]

C. The equipment application presenting itself as a network or web server.

With a little more intelligence within the relay test application itself, it is possible for the test equipment designer to provide end users with even more monitoring and control capability via a network. For some years, all of Applied Relay Testing's equipment software has included full logging of major software events such as operator logon, batch start / stop etc. More recently, this has been extended with a configurable in-built email server so that log files or specific events can be auto-mailed within the company to designated destination or group recipients. Examples of this are to send regular emails to the maintenance department informing them that routine system maintenance is required or to email equipment usage data to production supervision.

The most recent developments in web integration of test equipment centre around exposing the test equipment as an actual web server. For example, many network devices such as hubs, switches and routers are now themselves becoming configurable by typing a specific HTTP address into any web browser on the network, revealing one or more pages of device-specific data and controls. Here at Applied Relay Testing we have utilised this to create a new generation of thin-client high-power life-test components which can not only be widely spread in their location within a building, but can be viewed, configured and managed from anywhere.

VI. REPORTING – LOCAL AND GLOBAL

Applied Relay Testing Ltd made a decision several years ago to move to Microsoft Word as a reporting tool for all of our relay test equipment software and reporting tools. To this end we developed our own software interface with MSWord that 'pushes' our report data into an MSWord document using what is termed 'COM automation' – a feature well standardised within Windows for many years now. This means that to the end user, there is no perceived separation between the test system software and a report document, the only restriction being that MSWord must be installed on the system. Since most engineering personnel are quite intimately familiar with MSWord this is an ideal

vehicle for transporting reports out of a test system and onward to management or engineering staff. MSWord's support of printer issues is also very valuable since this allows us to concentrate on the tasks of developing test equipment and not solving issues arising from various combinations of printers and PC's.

A couple of examples of an MSWord report from a life-test system are shown in Figures 5 and 6 below.

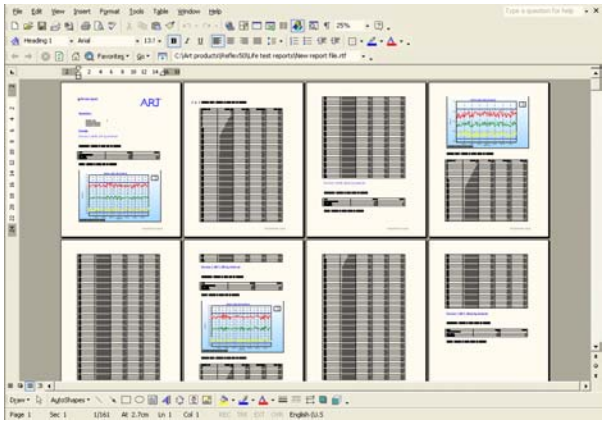

Figure 5 Applied Relay Testing's MS Word-based reporting - 1

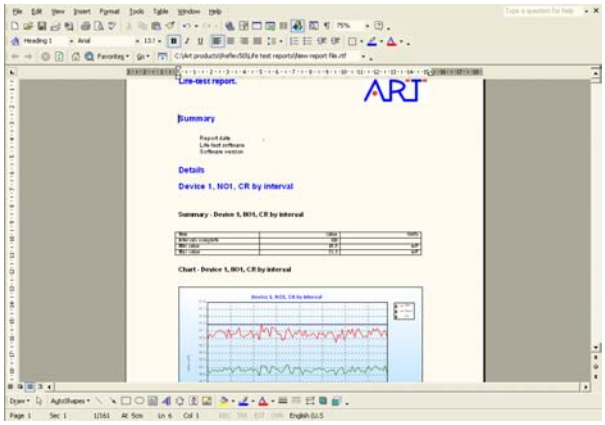

Figure 6 Applied Relay Testing's MS Word-based reporting - 2

As can be seen, logos, text and graphics are easily included within a report. Our implementation of MSWord reporting uses a document template that can be customised by the end user. This template takes care of the standard formatting aspects of the document such as page size and layout, fonts and pre-defined items such as logos and contains special ART-specific codes that 'pull' in the relevant report data into those code locations. The result is a flexible report content which whilst it may lack the rigid formatting of some report solutions, it achieves a professional looking document quickly and easily.

A. Producing reports from web server devices.

IBM recently ran a T.V advert in the UK showing a hypothetical IT consultant presenting the company board a 'business adaptor' – apparently a round thing with lots of spikes sticking out on all sides - which 'connected everything to everything else'. Since such a device does not exist of course, the point was that IBM software solutions were the 'next best thing'. Of course this interconnectivity of data is a 'hot' topic right now, keeping managers on the road with their PDA's, mobile phones and laptops updated with company data. Marrying relay reports and data from scattered relay test equipment is a challenge that would be eased by such a device, but until and if someone actually invents one, we have several technologies which are moving in this direction.

Applied Relay Testing is developing XML-based report aggregation software which takes a step away from the actual test equipment that is supplying the data and is able to manage and report on multiple test systems – even if they are located in differing locations. The benefit of this is that such an application can be used locally across a limited number of (say) life-test system nodes or more globally to monitor and report on tests running in different countries. In this scenario, our use of Microsoft Word as a reporting medium is even more relevant regarding its support for XML.

VII. A PRACTICAL DEMONSTRATION OF REMOTE OPERATION AND MONITORING OF A LIFE-TEST SYSTEM ACROSS THE INTERNET.

To put these points into perspective, Applied Relay Testing Ltd is able to demonstrate a practical application of a life-test system running remotely whilst remaining accessible anywhere in the world. [4] To set up for this demonstration, point your browser at www.appliedrelaytesting.co.uk/remote

VIII. CONCLUSION

This paper has shown how wide-area and local-area networks can be used in conjunction with suitably designed relay test products and tools. These test resources, previously used 'stand-alone', can now be interlinked and combined into powerful, focused or distributed test solutions. With the power of TCP/IP, systems can be created which mix and match life-test system resources, high-voltage and parametric test systems and distribute relay test programs and reports. Examples have been shown of a relay life-test system based on TCP/IP and how relay test reporting and control can be achieved using network connections.

IX. ACKNOWLEDGEMENT.

Applied Relay Testing Ltd wishes to thank its customers and its engineering staff for helpful advice and assistance in the preparation of this paper, particularly David Palmer, Stuart Hobday, Simon Farrant and Ian Flemming.

X. REFERENCES.

[1] B.J.Frost "A new generation of test equipment" *Proc. of the 45th relay conference, NARM, April 1997*

[2] Remote diagnostic tools from Peppercon AG, Munich Germany, www.peppercon.com.

[3] Microsoft remote desktop tools and techniques, www.microsoft.com/windowsxp/remotedesktop/

[4] Remote control of Applied Relay Testing's tools and equipment. Details are available at www.appliedrelaytesting.co.uk/remote

[5] S.J.Hobday "Bringing insight into the analysis of relay life-test failures" *Proc. of the 51st relay conference, NARM, April 2003*