Bringing simplicity and clarity back into the parametric and life-testing of relay devices.

***Abstract* –This paper outlines the strides that our company has made to bring back simplicity of testing to relay devices, particularly for the less automated production test situations where only partly skilled personnel are employed. Examples will be shown of improvements to the presentation of relay data and to the ways in which actual relay test systems are constructed. The techniques outlined in this paper will be shown to take us back towards the clarity and customisation that test engineers expect from in-house built equipment and which allow Applied Relay Testing to offer commercially as a professional product at an economic cost.**

I. THE "KISS" PRINCIPLE – "KEEP IT SIMPLE, STUPID" – BUT CAN WE?

A. Introduction.

Since Applied Relay Testing Ltd produced it's first RT90 parametric relay test system some 10 years ago, the company has made great strides forward with the features and facilities to be found in both the product hardware and software [1]. At the lowest level the most undemanding features are defined by test specifications such as MIL, IEC and CECC [2], whilst more sophisticated features are often the result of customer input and those proactively inserted during development as seeming 'useful until proven otherwise'. Over time, this leads to a feature-rich product which should – in theory – be attractive to as many potential users as possible, a necessary commercial objective if our position as a leading test equipment supplier is to be preserved.

A natural consequence of a mature, stable product is to look again at how it might be made even more suitable for its intended application, and we started to do this some 2 years ago with our 'flagship' RT290 parametric test system. At time of writing the RT290 has become well established in the industry and with its fast hardware and flexible Windows software it provides many relay design and production features all wrapped up within a single product, but we had noticed this very strength sometimes conflicted with a need for simplicity. This can be seem in Fig 1 where a example of several RT290 features a visible together and are vying for the user's attention.

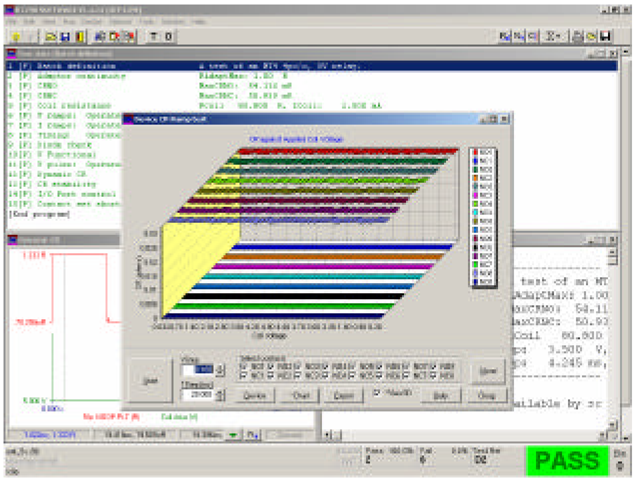

Figure 1
A feature-rich screen layout taken from the RT290 parametric test system.

B. 'Poles apart' – Laboratory and production.

It makes perfect sense to apply the same relay measuring instrument both for qualification and investigative tasks in the laboratory and for the rigors of production. There are obvious benefits such as traceability and flexibility yet the actual demands of each situation are quite far apart. The laboratory demands flexibility with high levels of equipment interaction usually by skilled personnel who are already very familiar with PC environments whilst production requirements are much more routine with an environment ranging from relatively unskilled operators simply pushing test buttons through to fully automatic high-speed production test handlers.

Relay test equipment built in-house has always naturally coped with these differing requirements since it is built to directly target its complexity and presentation to the demands of the user, but the down-side is that it offers less flexibility outside of its intended application. We felt that it was increasingly important to provide our users with sophisticated levels of data that could be exposed in controlled and simple ways.

II. SIMPLYIFYING THE SCREEN PRESENTATION OF COMPLEX DATA

A. Traditional and historical approaches.

To present screen layouts of relay data, designers of test application software have usually tried to used totally custom screen layouts since this is the easiest and most suitable method of conveying information, particularly when designing in-house equipment and where the intended end-user is well identified.

As the PC format became the platform of choice for test equipment designers, the simple MS-DOS text screen layout could be used in this way to lay out data in a simple X-Y text matrix which was quick to create and fast to draw. This very 'free-form' format spawned a generation of software applications which were excellent for production operators and for unattended 'output-only' display but were unique in their 'look and feel', an increasing nuisance to users who spent time moving between applications or exchanging data.

This proliferation of unique DOS applications was not restricted to relay test equipment and as the Microsoft Windows operating system began to gain credibility, its standardisation of a menu-based, consistent application framework helped bring familiarity to the operation of PC software. Despite this, whilst desktop applications such as word-processing gained immediate benefit from the graphical user interface (GUI) of Windows, relay test applications were much slower in adopting these benefits, mainly because DOS relay test applications were already well established and trusted on production lines and Windows had yet to 'prove itself' as a stable operating system outside of the laboratory and office.

For companies such as Applied Relay Testing, this was an important evolutionary transition between DOS and Windows and it was clear that for some time period there would be a parallel requirement for both styles of software. To cope with this transition we were pro-active in implementing a DOS menu interface that matched the look and feel of a simple Windows application whilst embarking upon the work necessary to port existing relay test capability over to the Windows platform.

As companies began to discover the benefits of working in the Windows environment we were able to extend our test capability beyond that of our DOS environment and to offer graphical display and measurement previously only achievable with significant work within the limited DOS graphics screen modes [3]. Although Windows now offers a perfect way of mixing graphics and text within one window, the choice of how best to present multiple windows remains. If a relay test application can fit its required display into one display window it can be wrapped within what Microsoft calls a Single Document Interface (SDI) framework – many simple Windows programs use this format (Fig 2).

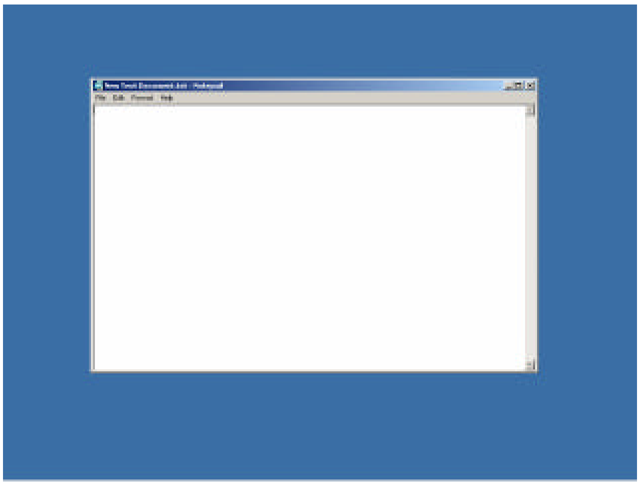

Figure 2 An example of the simple 'single document interface' (SDI).

Where more than one window of information may need to be open at the same time – such as is the case with a word-processor or when displaying graphical data and test program result data from a laboratory relay test, Microsoft created the Multiple Document Interface (MDI) framework to 'manage' the opening, closing and simple layout of the windows and to impose some consistency on this for the users who would be moving between various multiple window applications.

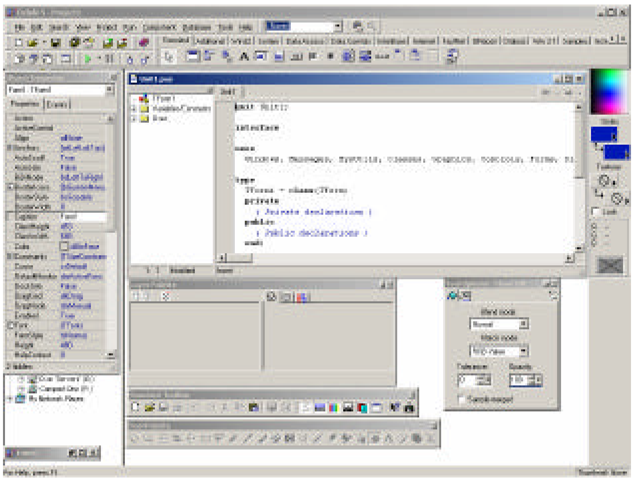

Figure 3 An example of the popular 'multiple document interface' (MDI).

Here at Applied Relay Testing we quickly adopted the MDI solution because it seemed the best way of providing a 'word-processor' for relay test data, allowing us to easily present the various RT290 window content types from the simplicity of selected test data result values to sophisticated graphical screens with cursors. (Fig 4). This solution was very effective but with customer expectation and gradual market trends the MDI solution is now being called into question as to whether it is actually the most efficient way of presenting our data.

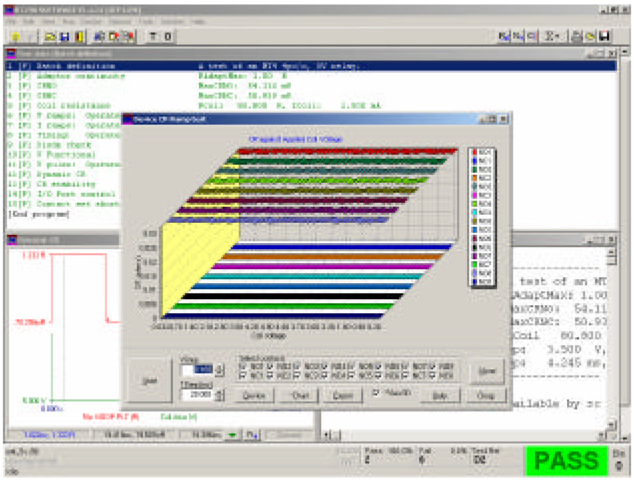

Figure 4 An example of our implementation of MDI on the RT290

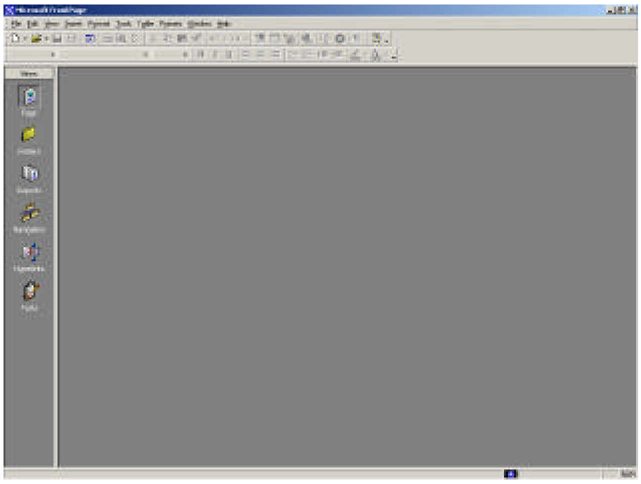

Figure 5 An example of a shortcut page interface as used in Microsoft's FrontPage

As we noted the occasional difficulties in offering a Windows MDI environment to less skilled personnel (for example in production) it was clear that these problems were not confined to relay testing alone. Microsoft themselves indicated a trend away from exclusively MDI presentation techniques as their Office application moved through its various versions until today there is a well established 'page-switched' format embodied by their applications that they see as requiring improved levels of clarity such as Outlook, FrontPage and others. Microsoft's solution for this employs a common single page display based on a shortcut bar together with an area that reveals only the data that is required at any one moment. Selection of other pages is simply achieved by invoking one of the exposed shortcuts on the shortcut bar (Fig 5). No direct provision is made for the user to 'casually' rearrange windows on the screen. For us, a solution such as this has very real benefits for the majority of relay test equipment users since the basic screen layout is simple by default and the available pages can be tailored to various levels of end-users simply by allowing an administrator to program the available shortcuts. (Since there seems to be no existing definition for this style of interface we shall refer to it from now on as a 'Shortcut Page Interface', or SPI).

B. Improving the clarity of Relay data within the Windows environment.

Achieving a simplicity of relay test data display became paramount to us as we prepared to introduce our ReFlex range of low-cost test products. This was important because these products have significant end-use within production test applications where less-skilled operators are to be found and who are still often using very basic DOS information screens. It was clear to us however that the SPI's simple single pages of information as designed by ourselves would still create some difficulties where the end-user perceived a need to 'blend' a mix of data such as on an automated high-speed production line where some textual data might need to coexist with graphical displays of on-line trends.

To solve this dilemma we decided to take this already flexible SPI interface and to blend two more customer customisable features that we felt would create an application framework that we could employ within any level of end-use and which would permit us to offer a wide range of software solutions from simple production parametric testing through to the data-intensive requirements of life-testing. We made the following additions:

1. We added the ability for the end-user 'administrator' to build each single displayed page from one or more sizeable 'frames', each of which could contain any of relay the information displays – graphical or text. After choosing and designing this frame layout, it is 'locked' into a fixed page layout preventing anyone from intentionally or inadvertently modifying the appearance of the page. This one feature alone creates the possibility of having pages that are completely suited to any application of the test system. An example of an unattended automated test display is shown in Fig 6, and an example of an unskilled operator display in Fig 7 – both of these screen layouts can be designed and modified by the end-user.

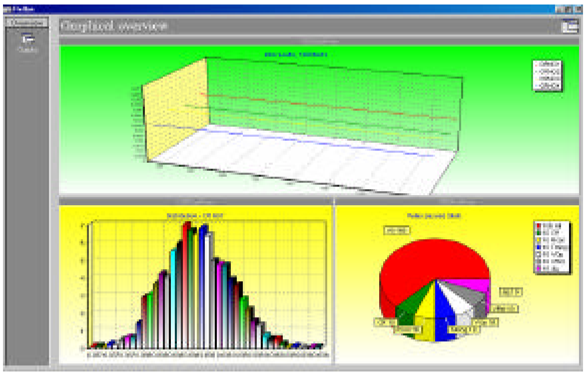

Figure 6 An example of an unattended automated test display.

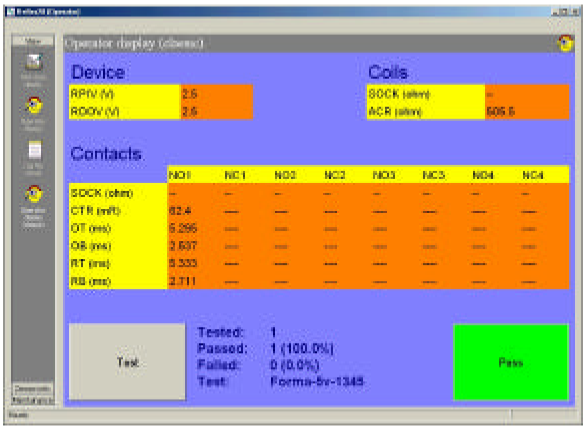

Figure 7 An example of an unskilled operator display

2. We presented as much frame information as possible in HTML format to allow seamless interchange with the rapidly emerging world of web content. The result is a relay test display content that can be designed and managed using the plethora of web content tools and which allows extremely 'free-form' layout of displays. As a simple example Fig 8 shows how easy it is to add company-specific pictures or a logo to the relay data.

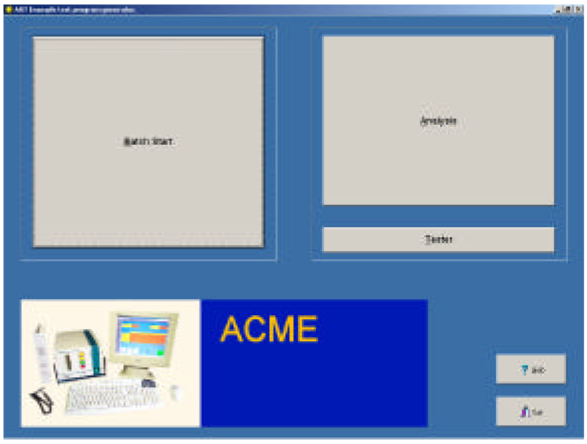

Figure 8 An example of adding customer-specific HTML content to a display.

To summarise the features of the final relay test application framework we have:

1. A simple single layout page only ever visible to the user.
2. There can be as many pages as are required. Some default pages are designed by ourselves at shipment but others can be added by a customer as required.
3. Each page is accessed by a named shortcut. Shortcut visibility is controlled by user level with an Operator-supervisor-administrator hierarchy and restricted by passwords. For further clarity, shortcuts can be organised into customer defined 'folders' on the shortcut bar such as 'Operator', 'Maintenance', 'Detailed device info' etc.
4. Pages contain one or more hidden but sizeable frames, each frame contains any of the display information available on the test system. Customers design or modify their own page appearance by manipulating these frames and then locking the design into what appears to be a fixed single page layout.
5. The most flexible display data is actually a 'web page' – HTML content that offers excellent display formatting and interchange with web tools.
6. The 'floating' windows of the MDI solution are still possible (i.e. windows that are not locked into a page layout) for example when a temporary graphics display of contact timing is required.

III. DISTILLING HARDWARE COMPONENTS TO CREATE RELAY TEST SYSTEM SIMPLICITY

A. How separate should parametric testing and life-testing be?.

In the quest to simplify and unify our relay test hardware and software we asked ourselves whether it might be possible to simplify relay testing by somehow crossing the gap that exists between the requirement of parametric testing and life-testing.

From the point of view of the end-user, a parametric test system and a life test system are quite different machines. They implement different test methods and examine different parameters but more fundamentally a parametric test system (usually) works with only a single relay device whilst a life-test system may be simultaneously testing many tens of devices.

From our point of view as the manufacturer of relay test equipment though, the varied end-user requirements for various parametric and life-test systems have a parallel to the requests for various screen display types in that they range from simple to complex and with an attendant range of costs to achieve the desired result. It would seem that there is no way of imposing fixed life-test hardware capability on an end-user without serious impact on cost and acceptability and therefore the best situation for ourselves as suppliers of test equipment is to be able to offer quickly customisable complexities of equipment that while implementing the fundamentally required specification test methods, best fits with the end-users expectation of capability. This situation is most pronounced with relay life-test systems where cost escalates rapidly as number of devices and contacts increase and where there are vastly different expectations in terms of batch size and electrical requirements.

After having created the RT290 fast parametric test system and the very different RT96 real-world load life-test system we began to see how it might be possible to bring together the hardware parallelism of the RT290 and the RT96 into a general architecture that would not change the end-user test capability but would permit us to create test systems that were at once ‘standard’ yet apparently tailored to customer requirements to a degree previously only achievable by in-house equipment.

The result was our new ReFlex range of hardware modular components which employed a novel architecture described in a previous paper [1]. These hardware components match with the coils and contacts of the device or devices under test and can be built quickly and flexibly into various test system configurations. One of the several cards within a ReFlex test system is shown in Fig 9 and is built around a field programmable gate array combined with relay-specific analogue circuitry. This ‘card-per-device’ architecture contains circuitry which permits a range of software-controlled operating modes such as:

1. Contact monitoring for timing, stick/miss, voltage drop and contact resistance in both single measurement and waveform capture modes.
2. Coil driving of latching, non-latching, DC and AC coils in both programmable V/I levels and waveform-synthesised modes.
3. The ability to cascade cards into multiple cards per chassis and to cascade multiple chassis into racks of equipment.

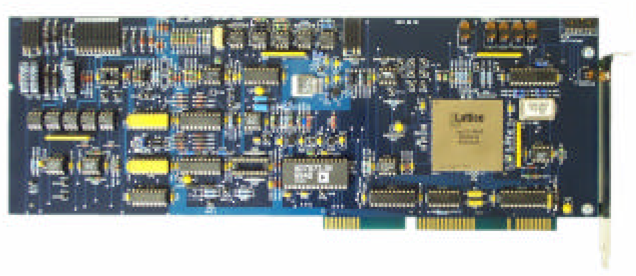

Figure 9 An example of relay specific analogue circuitry built around a FPGA.

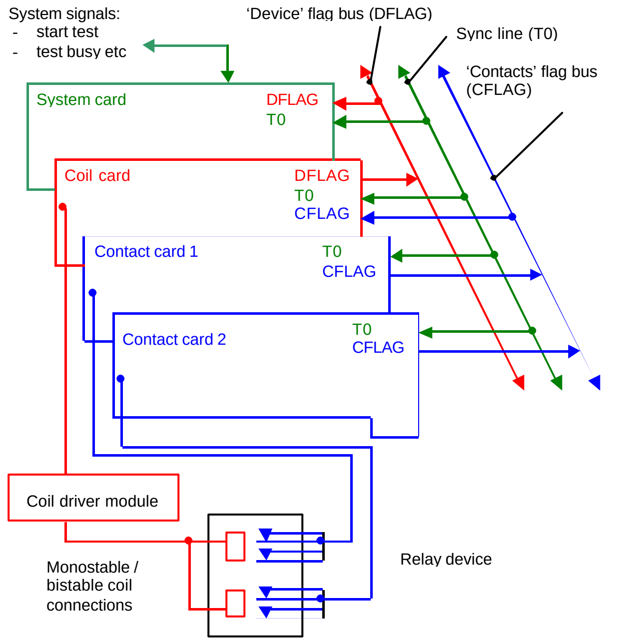

Figure 10 The parallel testing solution employed by the ReFlex architecture.

This replicated and generic card solution (Fig 10) permits parallel testing and inherently provides no degradation of test capability as numbers of channels (i.e. coils and contacts) are added to the test system. In contrast, a more traditional multiplexed solution that utilises central resources shows a performance that slows as the number of channels increases.

Upon examination, it turns out that this parallel ReFlex architecture therefore ‘crosses’ the gap between parametric testing and life-testing, since test hardware is dedicated to every device coil and contact in exactly the way that is needed for the test bandwidth demands of a life-test system. This allows us to configure a test system simply by taking the customer requirements for parametric testing or life-testing and presenting the system capability within the appropriate housings. Figs 10 to 12 inc. show how broad this configuration can be – the same hardware exists in the low-cost Reflex 20 parametric test system (Fig 11), a single chassis version of the flexible ReFlex 50 life-test system (Fig 12) and the multiple chassis version of the Reflex 50 (Fig 13). These systems are actually the same internal hardware simply replicated and configured slightly differently and with different relay test methods exposed at the software level.

Figure 11 The Reflex 20 parametric relay test system.

Figure 12 The Reflex 50 life test system

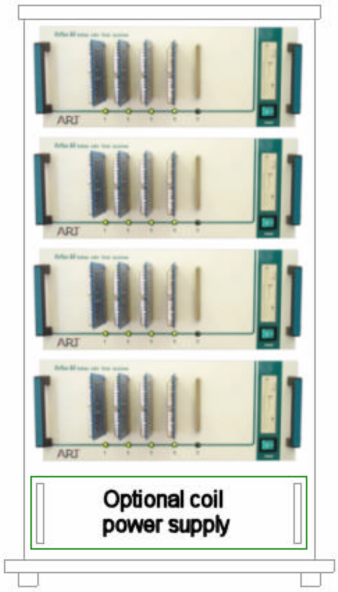

Figure 13 An illustration of a multiple chassis version of the Reflex 50 life-test system.

B. 'Dotting the I's and crossing the T's'.

Since we need to be able to manufacture relay test systems quickly and efficiently, we needed to address the ways in which we could quickly ensure correct hardware operation. For example checks on the hardware that could only be run when the complete system was finally assembled would not be performed early enough in the commissioning process to be of best use. This is huge disadvantage of a central-resource based multiplexed approach which only permits realistic system self-test when all system hardware coexists.

With a parallel solution such as ReFlex however, it was possible for us to embed hardware tests of all digital and analogue circuitry on each card and to invoke these tests on a card-by-card basis, allowing any card to be tested separately at any time, both before and after system integration. The benefits are major:

1. The system self-test points totally to one card, allowing system self-test failures to refer exactly to the faulty card without ambiguity.
2. Systems are expandable almost without limit, since the self-test automatically expands with the system.

The re-design of our existing hardware architecture also allowed us to include more recent hardware support features, for example it is now cost-effective to employ on-card monitoring of in-box temperature (Fig 15). This allows us to investigate our thermal management not only during the physical configuration of a wide range of systems but to ensure that field operation conforms to the limits that we have allowed. This may have no direct effect on the testing of relay devices but the cost is trivial and the indirect benefits of system reliability and up-time are vital in today's competitive marketplace.

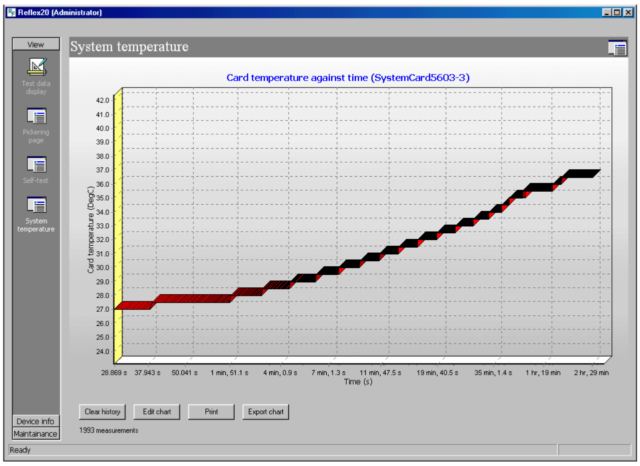

Figure 14 Graph depicting card temperature against time as used for thermal management.

CONCLUSION

Applied Relay Testing Ltd has evolved a unique software solution to convey relay test data in a simple yet flexible form and for the first time it is possible to apply a sophisticated test system to simple operator-based production and for the end-user to choose exactly the level and content of the information exposed. Combined with the new modular ReFlex hardware which allows systems to be quickly configured both for parametric testing and for life-testing, truly cost-effective solutions now exist for relay testing.

ACKNOWLEDGEMENT.

This paper and its contents have been influenced by valuable comments and discussions with various companies whom Applied Relay Testing Ltd would like to thank, including: Axicom AG (Switzerland), Teledyne Relays (CA, USA), CII Technologies Inc (NC, USA) Pickering Electronics (UK).

REFERENCES.

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

[2] Specifications CECC 16000 Section 5, MIL-R-39016E section 4.8 etc.

[3] B.J.Frost "Real-time analysis of the Contact Electrical Environment During Switching" *Proc. of the 47th relay conference, NARM, April 1999*

[4] B.J.Frost "A new relay test architecture brings low-cost parametric testing and life-testing together" *Proc. of the 48th relay conference, NARM, April 2000*