

Right on the Money!



Application Note 66

**Advanced Network
Test Solutions:**

**Test SONET/SDH/PDH
and DWDM networks
fast and efficiently
with WG CATS**

Wandel & Goltermann
Communications Test Solutions



Abbreviations:

| | |
|--------|--|
| AIS | Alarm Indication Signal |
| ANSI | American National Standards Institute |
| APS | Automatic Protection Switching |
| ATM | Asynchronous Transfer Modus |
| CATS | CVI Application Test Sequences |
| CRC | Cyclic Redundancy Check |
| DWDM | Dense Wavelength Division Multiplex |
| ES | Errored Seconds |
| GUI | Graphical User Interface |
| ITU-T | International Telecommunications Union Telecommunications |
| LOS | Loss of Signal |
| LOF | Loss of Frame |
| LW CVI | LabWindows CVI |
| NE | Network Element |
| PDH | Plesiochronous Digital Hierarchy |
| PRBS | Pseudorandom Bit Sequence |
| RX | Receiver |
| SES | Severely Errored Seconds |
| SDH | Synchronous Digital Hierarchy |
| SONET | Synchronous Optical Network |
| STM | Synchronous Transport Module |
| TX | Transmitter |
| US | Unavailable Seconds |

The ANT-20 Advanced Network Tester is a powerful test platform which provides test solutions for SDH, SONET, PDH, and ATM. The WG CATS software (CVI Application Test Sequencer) is available as an option. As described in this brochure, the software enables control of ANT-20 test functions using automated program sequences. It runs directly on the instrument's built-in PC.



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Test SONET/SDH/PDH networks fast and efficiently with WG CATS

The push for full availability makes new demands of test equipment

With today's telecommunications networks reaching for the 100% availability mark, we must offer some thanks to the test equipment used for quality assurance. However, the expense of lining up and maintaining lines is considerable, representing a major cost factor that is growing along with demand for new lines. To get a grip on these costs, network operators require economical test solutions for installing and maintaining network elements and lines. These are the major requirements:

- Higher test speed to reduce overall test time
- Greater test depth to check the (complex) interplay of all functions
- Avoidance of potential measurement errors to assure good reproducibility of results
- Easy interpretation of results with specification of limits (PASS/FAIL)
- Documentation of all results as a basis for quality and reliability analysis
- Verification of compliance with norms

In a conventional test strategy, the test specification (or line-up specification) is worked through item by item. The test equipment is operated interactively and manually. Most results have to be manually entered into the test report. This traditional technique is time-consuming and expensive, however, and faulty operation can easily lead to measurement errors. During the documentation process too, even if you are very careful an error can creep in when reading off results or entering them into the report. Such errors make it impossible to properly reproduce results later.

This Application Note considers the examples of commissioning of leased lines and measurements involving very complex signals on DWDM links, and shows that a flexible test automation system can reduce test times and prevent measurement errors.

Example: Commissioning a 2 Mbit/s leased line

Depending on whether the leased line uses an SDH path or a PDH line, various built-in mechanisms are available for quality monitoring. Common techniques include:

- Cyclic redundancy check (CRC) in 2 Mbit/s PDH lines
- Bit interleaved parity check (BIP) on SDH and SONET paths.

To assure reliable operation, careful line-up is necessary once installation is finished. All functions relating to normal operation are checked, as well as the behavior in response to abnormal operating conditions, as described in the relevant Recommendations (ITU-T, ANSI). It is particularly important to analyze system-related phenomena that occur in response to clock deviations, pointer movements, jitter and wander.

Likewise, the alarm signalling and error monitoring equipment in the network transporting the new line must also be checked for proper operation. To do this, certain error states are simulated and the network management system is checked for a proper response.

To check alarm signalling, the following measurements are typical:

- Verification of alarm-free / error-free signal during normal operation
- Verification of proper response to the following alarm states: LOS (loss of signal), LOF (loss of frame) and AIS (alarm indication signal on incoming line).

Further tests are required to verify that all of the interface parameters lie within the prescribed tolerances. The following measurements are conventional:

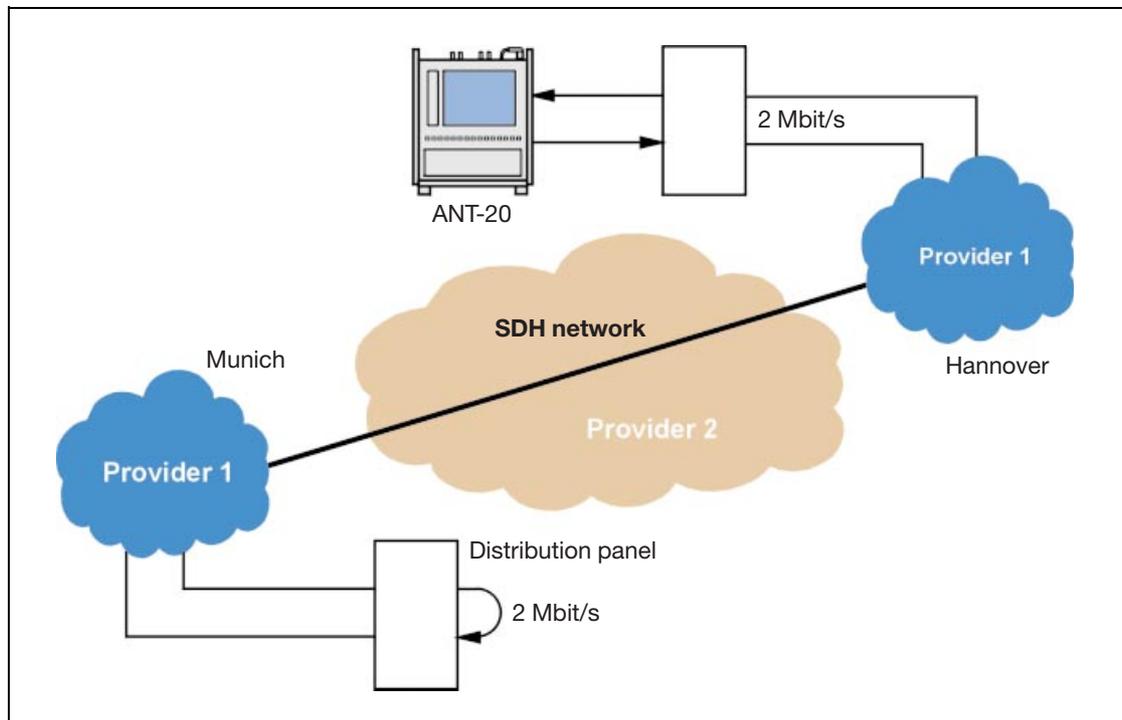
- Output jitter
- Jitter tolerance
- Pulling range (maximum clock offset)

The final step involves a long-term bit error ratio test (BERT) using a pseudorandom bit sequence (PRBS) as the test pattern.

To enable comparison with results from long-term in-service monitoring, the measurements are normally based on the quality parameters from ITU-T Recommendation G.826 (ES, SES, US). This final test should last 24 hours in order to generate results that are truly applicable to normal operation.

As you can see, the overall test procedure is complex and can require a lot of time to execute.

Fig. 1: As the demand for leased lines grows, so does the cost of verifying their quality. Complete PDH connections and SDH paths are often routed via networks from different providers. Leased lines must be carefully lined up to make sure everything runs smoothly.



Comparison between automated and manual testing

Fig. 2 shows the individual steps in the typical test procedure. In a manual measurement, the operator performs all steps by hand. In other words, each checkpoint in the test specification must be handled individually when commissioning a system or a connection. Based on real-world experience, it is clear that errors can creep in here at a number of places.

With an automated procedure, the operator does not intervene manually, thereby practically eliminating the potential for operating errors. Test speed increases too since it is no longer dependent on human operator response time. Instead, it is a function of system timing.

Test automation: The economical alternative

Due to the many benefits over manual measurements, an automated test system comes to mind when looking for more efficient test procedures for field use. System manufacturers have long deployed such automation in development, production and final acceptance for quality assurance. The test program generally runs on an external controller. Settings and test commands are transmitted to the test instrument via a remote control interface. Almost all test instruments today provide a standardized remote control interface for this purpose (e. g. IEC 625/IEEE 488 bus or RS232 interface).

To simplify generation of user interfaces for the test programs, powerful tools are now available such as LabView® or LabWindows® from National Instruments, hp-VEE and Keithley Testpoint. Some test instrument manufacturers even offer their own script languages to accelerate the process of creating test routines.

Using these tools, an automatic routine can be optimally tailored to an existing test problem. The time required depends on the complexity of the task and can range from a few days to several person-months. Creating test routines requires, besides in-depth expertise in test technology, knowledge of a common programming language such as C or Visual Basic, or a graphical programming language (GPL).

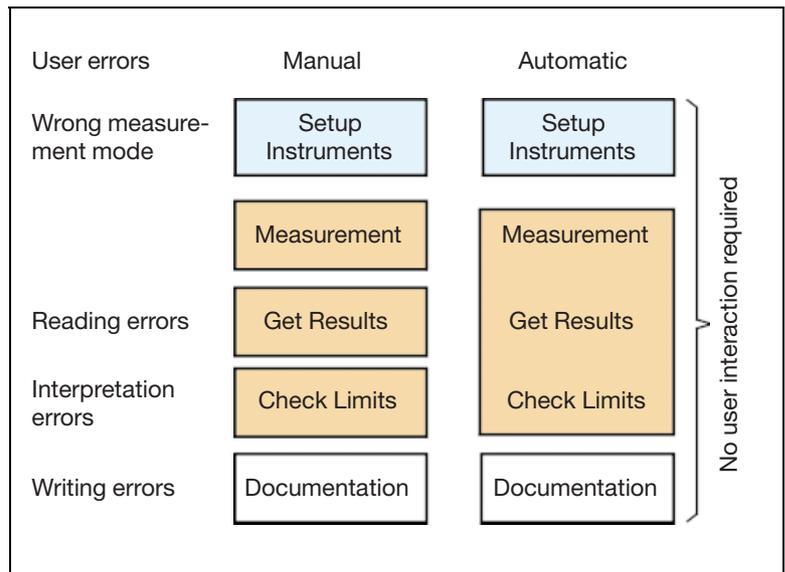


Fig. 2: Comparison between manual and automatic test

Nowadays, fluency in these tools and related technologies is commonplace in test labs, in quality assurance and in regression testing and development departments. However, this is not true among installation groups of manufacturers and among network operators. Due to the many required tests and the different interfaces to be tested, test programs tend towards great complexity. They can also be inflexible, and require significant time to be adapted to a change in the test or line-up specifications. Finally, test technicians are usually lacking in the expertise it takes to develop such test programs.

An automated test system running under an external controller is generally immobile and thus ill-suited to field use. This is the case even with notebook-based solutions.

These problems have made it – hitherto – very difficult to find more economical test solutions for field use.

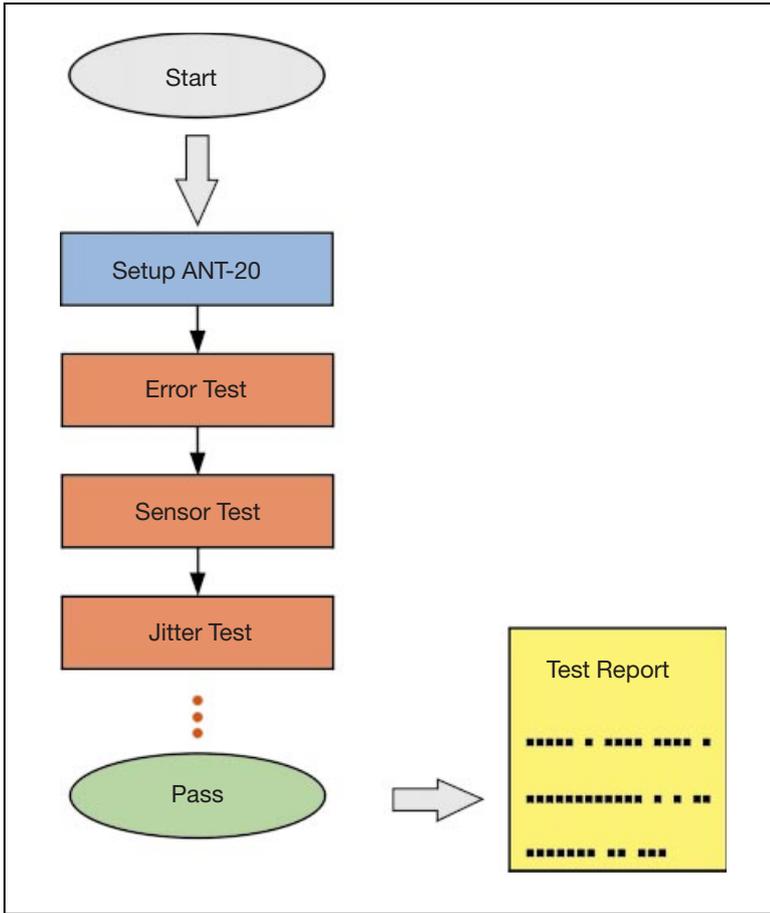


Fig. 3: Predefined test cases make it possible to generate an automated test sequence quickly and without any programming experience

WG CATS: The network operator's optimum solution

The WG CATS (CVI Application Test Sequencer) software enables fast and easy entry into the world of test automation even for complex measurements. WG CATS was created with NI LW CVI and basically comprises a collection of standard test cases that users can assemble in any sequence with no programming experience. Once created, just click on the sequence to execute it. Features of the software tool include:

- Fully automated test execution without user intervention
- Clear assessment of results for each test step, e.g. PASS/FAIL decision based on a specified tolerance or threshold
- Simple user interaction in configuring the system
- Complete recording of all measurement data in a (printable) file
- Uniform, easy to interpret test reports
- Flexible adaptation to different test interfaces and parameters

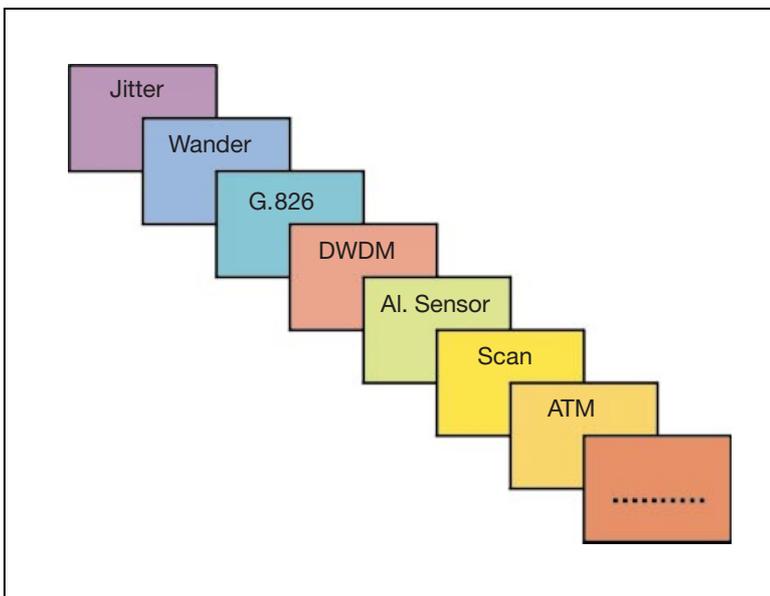


Fig. 4: As the basis for building fast, automated test solutions, Wandel & Goltermann offers a comprehensive library of predefined test cases covering all measurements needed for SONET/SDH/PDH and DWDM links.

Wandel & Goltermann offers this software tool for the ANT-20 Advanced Network Tester and other test instruments. Use it to create test sequences that execute right on the ANT-20's internal PC. They can include:

- Bit error ratio tests (BERTs)
- Alarm sensor tests
- Tests of performance monitoring sensors
- Tests of error and alarm signalling
- Measurement of APS time
- Jitter and wander tests
- Jitter tolerance and jitter transfer
- G.826 long-term test
- Trouble scan for all hierarchy levels of an SDH/SONET signal

Creating automatically executable test sequences using “generic” test cases

As an example, we will now consider the test sequence shown here. It was created with the ANT-20 Advanced Network Tester and automatically executes all measurements required to commission 2 Mbit/s leased lines.

WG CATS uses “generic” test cases, which are automatic test algorithms written in a generalized way. By adding user-specific data, they can be adapted to a particular situation. For example, the test case “G.826 Analysis” is just as useful for a 2 Mbit/s signal with a 64 kbit/s PRBS payload as an STM-1 or OC-3 signal with a 150 Mbit/s PRBS bulk payload. Test parameters such as the bit rate, signal structure, test pattern and electrical or optical interface are set in the preceding test cases. In the sequence here, for example, the signal structure is defined right at the start of the test sequence (Fig. 8). The overall test sequence can thus be adapted very quickly to other bit rates by simply choosing different signal structure parameters; everything else stays the same. Besides test cases that perform measurements, there are many others to provide specific instructions to the user (e.g. make a connection), start timers, insert delays, display graphics, transmit control commands to other devices or output an audible signal in response to certain events.

| | Test sequence | Operation |
|-----------------|---|---|
| Basic settings | <ul style="list-style-type: none"> ● TX 2 Mbit/s CRC ● RX 2 Mbit/s CRC | <ul style="list-style-type: none"> ● Set TX signal structure ● Set RX signal structure |
| Test parameters | <ul style="list-style-type: none"> ● View Alarm ● Continuity Check ● Pulling Range ● Check LOS ● Jitter Measurement ● Jitter Tolerance ● Delay Measurement ● G.826 Analysis | <ul style="list-style-type: none"> ● Check for lack of alarms ● Measure bit errors in channel ● Check offset ● Set LOS, wait for AIS ● Measure intrinsic jitter ● Measure jitter tolerance ● Measure dela ● G.826 analysis (24 h) |
| Test end | <ul style="list-style-type: none"> ● Thank You! | Test end |

So easy: Load a test sequence and start measuring!

Fig. 5 shows the *Test Sequencer* with the test sequence from the above table. To start the test sequence, just click on “Run Sequence”. The entire test sequence then executes automatically. On the other hand, “Run Test” just starts a single test case. This is useful during troubleshooting, for instance.

Table:
Test sequence for commissioning 2 Mbit/s lines, including jitter measurements

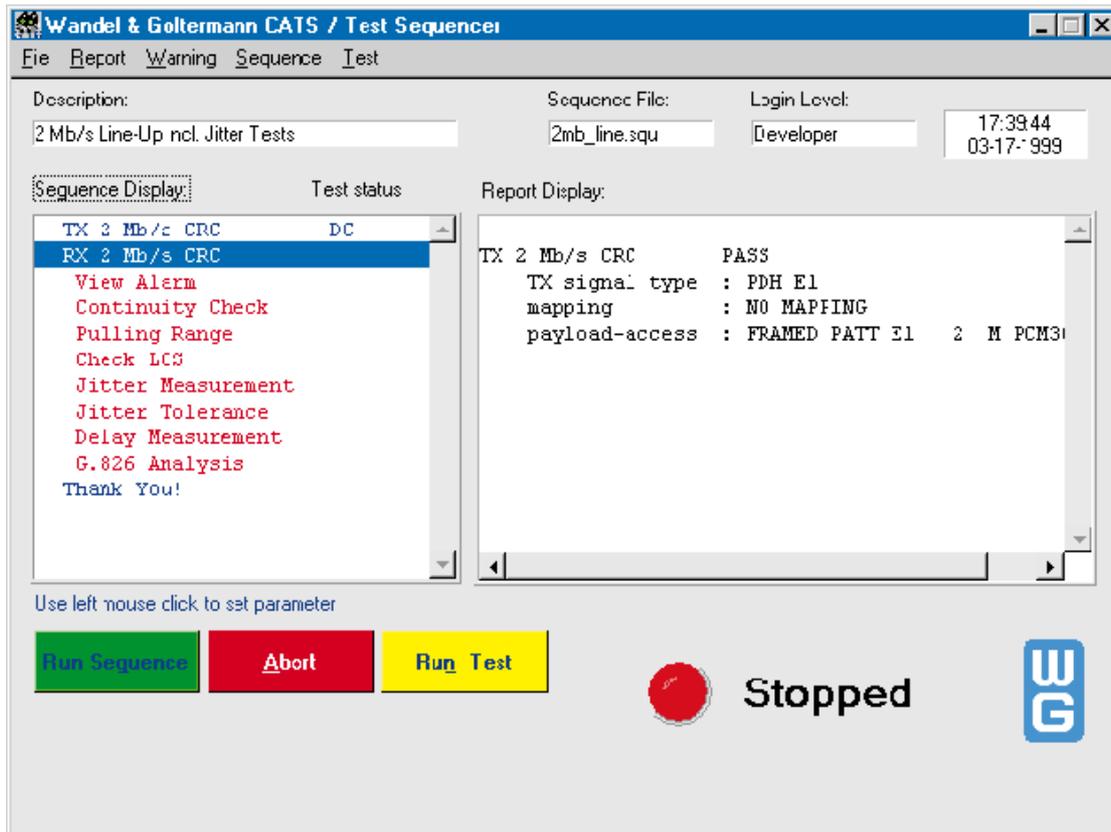
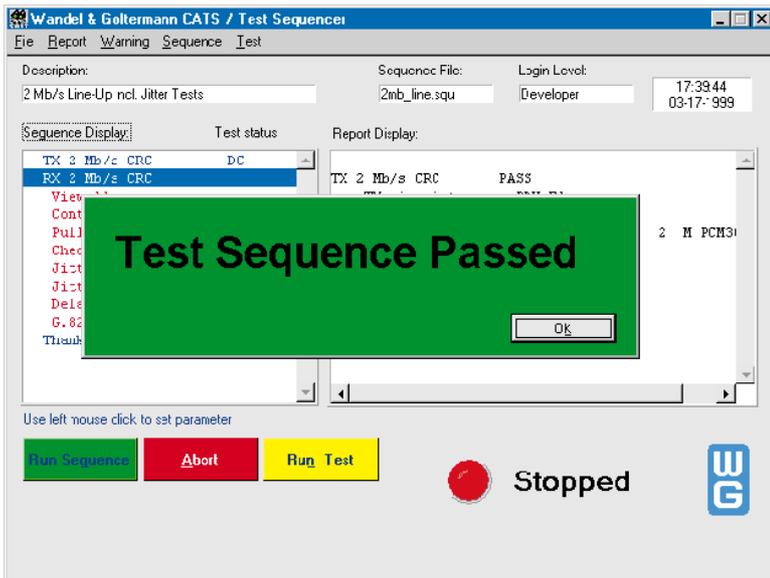


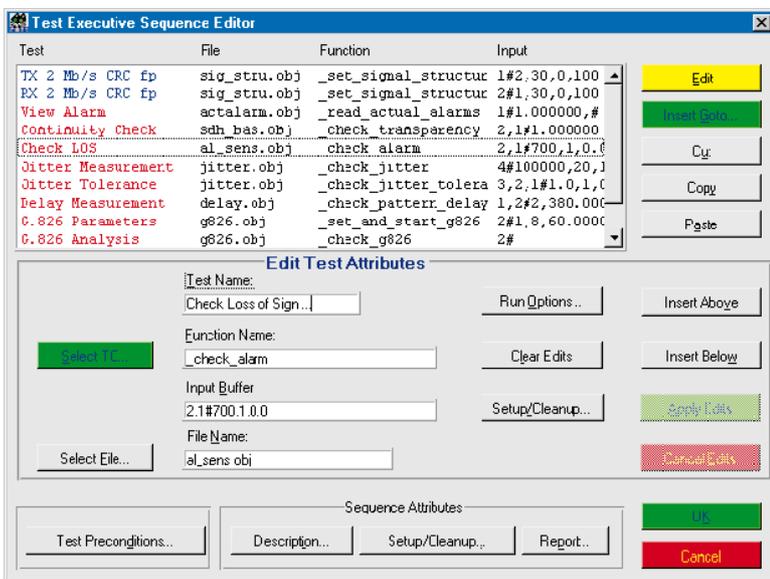
Fig. 5: To execute an automatic test, just load and start the test sequence. The entire test then runs without any further user intervention.



When a test sequence executes automatically, no user intervention is generally required. The current test status is indicated by highlighted the active test case.

Based on its current results, each test case provides a clear PASS/FAIL decision. The PASS/FAIL status for previous tests is also shown. Measurement can be interrupted at any time if necessary, e. g. to correct an error. A test sequence gets a PASS if none of the specified limits are violated in any of the tests. The end of the test is indicated by displaying a PASS or FAIL banner (Fig. 6). An audible signal can also be output.

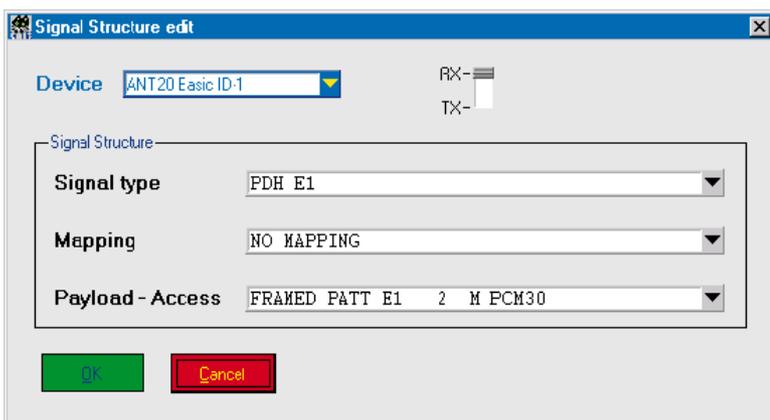
Fig. 6: The PASSED banner appears when a test terminates satisfactorily.



Modifying test cases

The *Sequence Editor* is used to create new test sequences or modify existing ones. A set of standard test cases is used, which are imported from the *Test Case List* (Fig. 10). Using simple operations (Copy, Paste), they can be assembled to form sequences of any desired complexity. Or you can take an existing sequence and modify it by changing parameters and adding or deleting test cases to suit the new requirements.

Fig. 7: In the *Sequence Editor*, you can use the *Cut* and *Paste* functions to modify a sequence to fit your requirements.

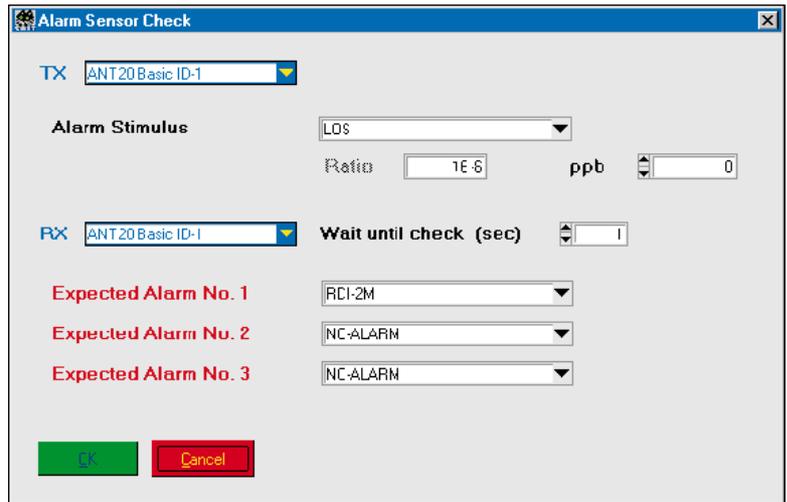


Graphical user interface (GUI)

The measurement parameters required in a particular application (e. g. signal structure, bit rate, mapping, tolerance limits, gating time) are edited using a graphical user interface (GUI). The GUI lets you easily modify parameters to meet current requirements (Figs. 8 and 9).

Fig. 8: Sample test case with graphical user interface: With *Signal Structure edit*, you can define the signal structure for the entire test sequence.

Fig. 9: Using the *Alarm Sensor Check* test case, different error states can be simulated to test error signalling and check the response of the device under test.



The popularity is growing!

Programmable test sequences relieve the user of dumb, repetitive tasks and free up his or her time for more interesting and challenging activities. WG CATS brings you a little closer to this objective. Because WG CATS makes it possible to create test sequences by linking predefined tests (without significant programming background), users are embracing the software more and more.

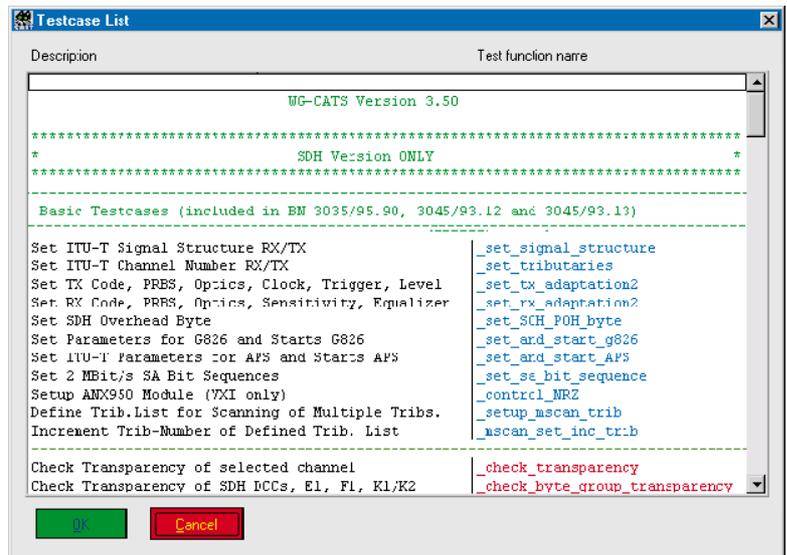


Fig. 10: *The Test Case List* shows what test cases are available in the software. A selected test case can be renamed in the *Sequence Editor* before inserting it into a test sequence.

Available test cases

Within the WG CATS family, there are many different test case packages available. Over the following pages, you will see how to control single instruments such as the ANT-20 and also complete test systems, encompassing optical test instruments, test point scanners and other devices. Here, one device is the controller, and it runs the others via an RS232 or IEC 625/IEEE 488 interface. If necessary, the test setup can be remotely controlled via modem or LAN.

WG CATS simplifies measurements on DWDM systems

Unlike conventional fiber optical systems which transport a single SDH or SONET signal per fiber, DWDM (dense wavelength division multiplex) uses parallel transmission channels at different wavelengths (“colors”). To measure the SDH or SONET parameters in such a system, a classic test set with a broadband optical input is no use since it is unable to filter the wavelength of interest out of the composite signal. An adjustable filter is required prior to the input of the SDH or SONET tester. This function is provided by the same optical spectrum analyzer used to measure the DWDM-specific parameters. Fig. 11 shows a test solution with the ANT-20 Advanced Network Tester and an OSA-155 Optical Spectrum Analyzer connected to its input. The selected channel is connected through to the monitor output of the OSA-155 for analysis by the ANT-20. This test setup enables a complete functional test, with the OSA-155 measuring the optical power level, signal-to-noise ratio and the wavelength deviation at each wavelength. The ANT-20 analyzes the typical SDH and SONET parameters (alarms, error rates, jitter, etc.) at each wavelength.

into a single test sequence. One possible example is as follows:

| Level | Test sequence |
|------------------|---|
| DWDM signal | <ul style="list-style-type: none"> • Measure optical power level for each “color” • Measure optical signal-to-noise ratio for each “color” • Measure wavelength deviation for each “color” |
| | <ul style="list-style-type: none"> • Set filter to “Color 1” |
| Select “Color 1” | <ul style="list-style-type: none"> • Measure SONET/SDH parameter |
| | <ul style="list-style-type: none"> • Set filter to “Color 2” |
| Select “Color 2” | <ul style="list-style-type: none"> • Measure SONET/SDH parameter |
| | <ul style="list-style-type: none"> • ... • ... |

Clearly, a typical DWDM test procedure encompasses many individual tests.

WG CATS lets you automate the entire DWDM procedure to save time and prevent errors. You can incorporate the measurements on the DWDM signal and the typical SONET/SDH tests

The WG CATS DWDM software runs on the ANT-20’s built-in PC, which also handles control of the OSA-155 via the RS232 or GPIB interface. Fig. 12 shows the graphical user interface employed to configure the entire test setup. For measuring SONET/SDH parameters, the same test cases are used as with other interfaces. Fig. 13 shows the test case for measuring the DWDM-specific signal parameters.

Fig.11: The CATS DWDM test automation software is installed in the ANT-20, which controls the OSA-155 DWDM system analyzer

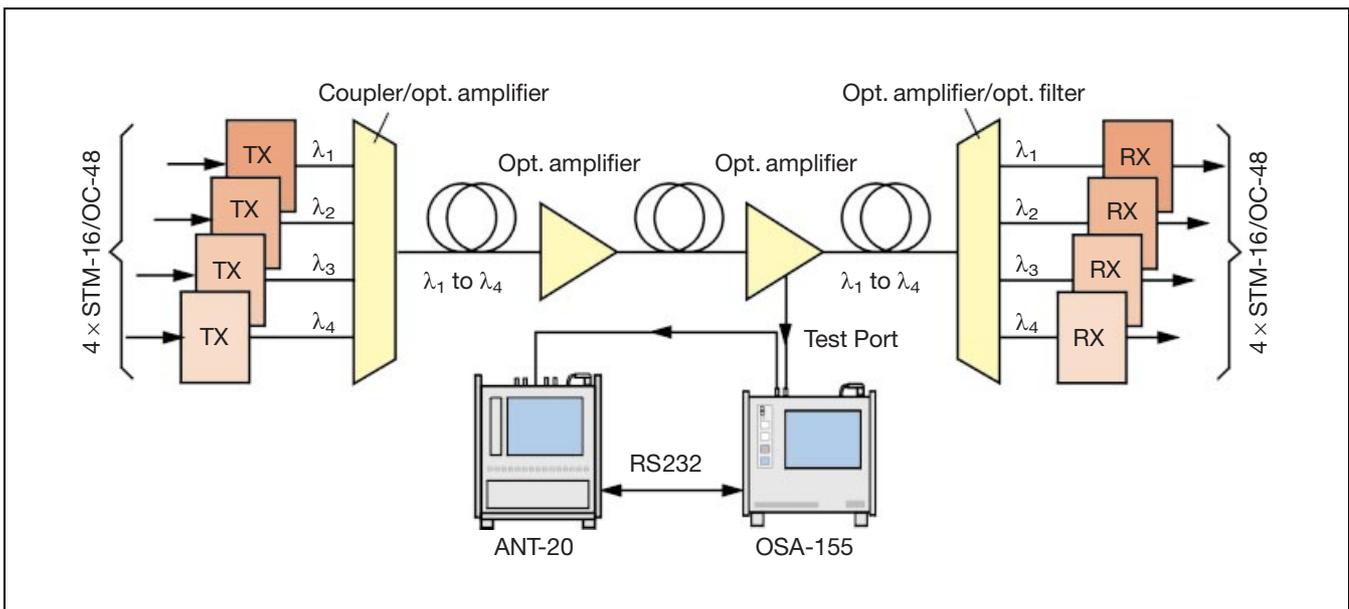


Fig. 12: The *Device Configuration* window is used to configure the entire test setup. It is automatically displayed when loading a new sequence. All settings can be made quickly in the selection fields.

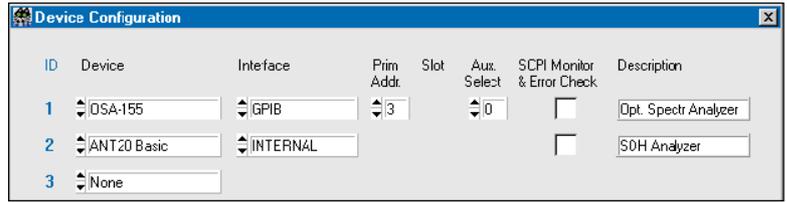
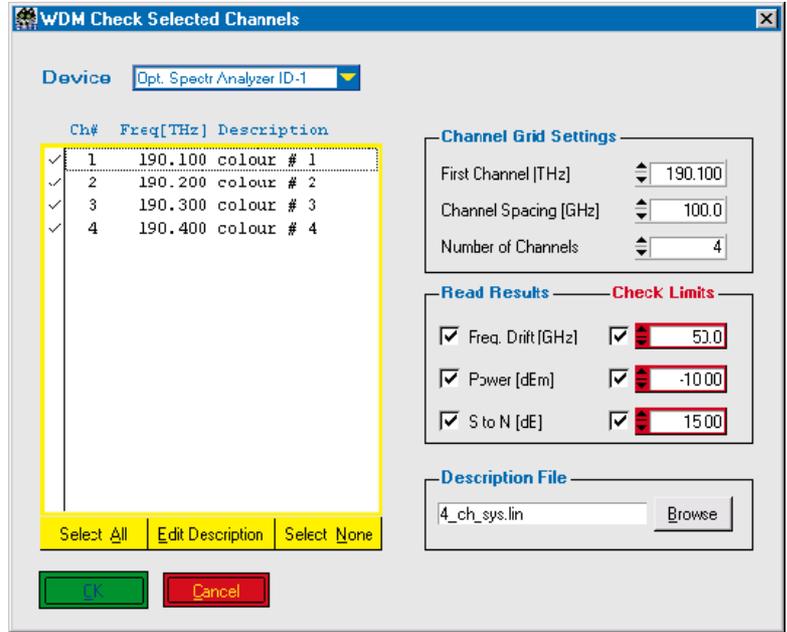


Fig. 13: Special test functions of the OSA-155 can be incorporated into the test sequence. Using the *WDM Check Selected Channels* test case, you can measure, say, the frequency, power level and S/N ratio at each wavelength. To enable fast PASS/FAIL evaluation of the measurement results, limits can be input.



A clear test report makes it all reproducible

At the start of the test, you can enter important comments such as the name of the line and the technician handling the measurement. The system automatically appends the date and time for each measurement.

All of the data are automatically stored along with the comments in a text file (ASCII format) and can be printed if required. The clear test report comes in very handy if any problems occur (Fig. 14).

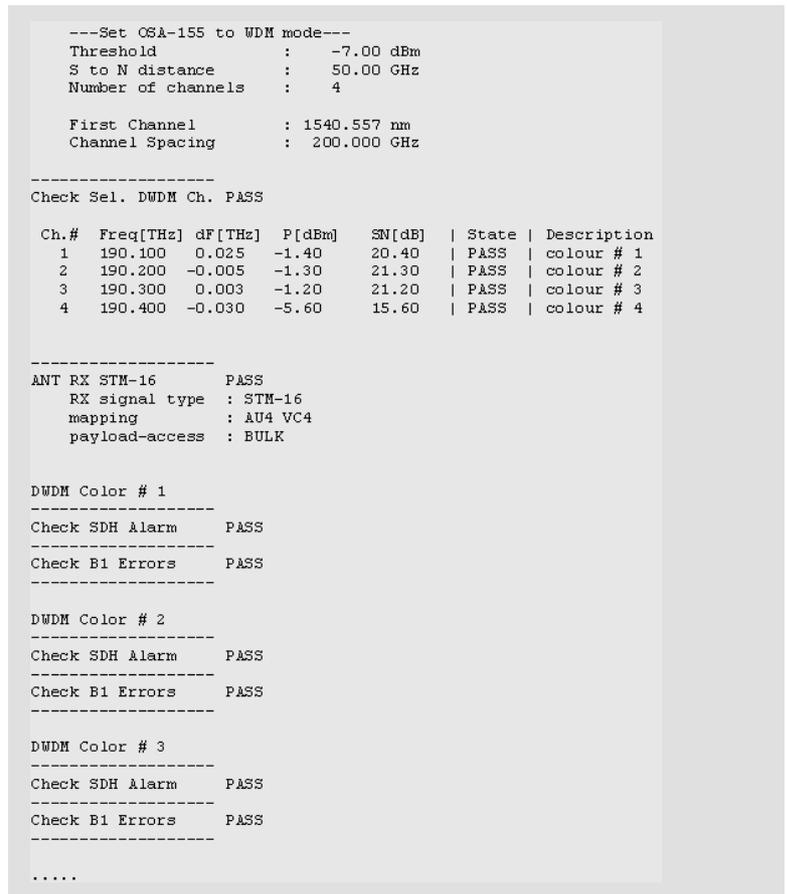


Fig. 14: The clear test report contains all important data and measurement results. This lets you repeat a measurement at any time (reproducible measurements!).

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