Introduction

SDH and SONET are the technologies of choice for longhaul transmission for most of the network operators worldwide. One of the reasons are the proven self-healing mechanisms. A guaranteed uptime of 99.99% and more is the rule. But what happens when impairments do occur? Conformance with the switchover time from "working line" to "protection line" is highly critical. If the switch-over does not take place within the stipulated time, an avalanche effect may be set off. There is a deluge of alarms and either the complete ring or certain route segments may no longer be serviceable.

The measurement of the service disruption time ensures the proper implementation of APS (automatic protection switching) during verification, installation and commissioning of new transmission systems.

Test configuration

In order to check the protection switching time the ANT-20 is connected to a tributary port of a transmission system. This set-up ensures the independence from the applied protection mechanism and assures that the switching time is directly measured for the service transported by SDH or SONET networks.
Measurement principle
The prerequisite for this type of testing is an error-free transmission system. Any background error and alarm event would certainly affect the test result. The test procedure itself is based either on using a test pattern transmitted as part of a PDH/DSn or as a mapped payload within an SDH/SONET signal. This method requires a loop back of the test pattern as shown in the figure above.

The ANT-20 APS measurement can also be triggered by an AIS (alarm indication signal) event. The use of AIS as a trigger criterion allows to test the switching time without a loop back of the test channel. In order to simulate a fiber break the fiber bearing the working channel is disconnected. The ANT-20 measures how long a particular event (e.g. AIS or loss of test pattern) remains present after the APS event has been first recognized.

Some systems react with multiple, short service disruptions. However, the only significant parameter for the overall assessment of the APS performance is the TOTAL disruption time. The ANT-20 measures the total disruption time even in the advent of multiple disruptions within a time frame of up to 5000 milliseconds. This measurement principle ensures that SDH/SONET systems can be safely verified.

The following picture will illustrate the method by means of two examples:

**Example A: “Ideal” service disruption**

**Example B: Multiple service disruptions**

**Gate time t2:**
The measurement begins as soon as the sensor event first occurs. It ends after the set measurement time has elapsed. During the gate time all detected trigger events are added to the measured APS time. This ensures that multiple switching is also detected. The ANT-20 always measures the total APS time whether it is detecting an “ideal” disruption or a disruption with micro interrupts.
**Result display on ANT-20**
The measured time is compared with a previously set threshold. This provides a simple PASSED/FAILED assessment of the APS switching time.

**Service disruption measurements on DWDM systems**
The evolution of DWDM systems from pure point-to-point capacity booster towards an All Optical Network contains a growing number of SDH/SONET features. Amongst these features can be found the automatic protection switching on the optical layer. The applied protection scheme is 1+1 which means that the traffic is transported in parallel over working and protection path. In the case of DWDM systems working and protection path are two different channels transmitted in the opposite direction around the ring. The APS switchover takes place at the receiver.

The test instrument is directly connected to the lambda routing unit. The well known SDH/SONET maintenance interaction scheme is not part of DWDM systems, which means there will be no downstream AIS activated as a result of physical layer defects.
The ANT-20 supports the switch over time test for the previously described systems with a trigger criterion - "service disruption". The measurement of switch over time is based on detected bit errors. The test principle assumes the line is bit error free before the test is started, so should a single background error be present, the test result could potentially be affected. The sensitivity is necessary in order to detect even short protection switching.

The test principle works as follows:

**Case 1:** Service disruption starts/stops triggered by single bit errors.

The test is triggered by a single bit error. Any event - single bit errors, error bursts or alarms - will be considered part of the switching procedure. Hence the last detected event during the pre selected gate time will halt the measurement.

**Case 2:** An alarm such as LOS for example, occurs during the measurement.

The protection switching of DWDM systems may also lead to alarms such as LOS, LOF or LOP. The "service disruption" trigger criterion interprets these alarms as error bursts. In addition to this, LOS alarms detected will trigger the APS time measurement directly without a preceding TSE event.
Long-term multiple APS testing during verification

During the verification of new SDH/SONET systems it is of interest to determine the long term stability. Manufacturers need to check their pilot networks in regards of protection switching. The questions which need to be addressed are whether a switch over take place and if so, how long the line was out of operation. A combination of long term monitoring and APS time measurement with high resolution is required.

The ANT-20 along with the test sequencing software CATS offers the ideal solution. It combines the APS test capabilities of the ANT-20 and one of the many easy to use test cases. The test case starts the above described APS time function of the ANT-20. Once this test is started it monitors the signal for the pre selected trigger criteria. This may last over several seconds until days. The detection of an error burst or AIS triggers the APS time measurement. The time measurement is running until the total switch over time has reached max. 2000ms or the gate time of max. 5000ms is expired. In this case CATS will store the results of the first APS event together with a time stamp and restart the APS time measurement automatically (see figure below). The result presentation gives the user an insight of the network behavior. All APS events are listed in a table with time stamp and duration.

Example for a result file:

<table>
<thead>
<tr>
<th>Event</th>
<th>Start time</th>
<th>Duration</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>01:10:43</td>
<td>22 ms</td>
<td>PASS</td>
</tr>
<tr>
<td>#2</td>
<td>01:12:45</td>
<td>54 ms</td>
<td>FAILED</td>
</tr>
<tr>
<td>...</td>
<td>........</td>
<td>......</td>
<td>........</td>
</tr>
</tbody>
</table>
Conclusion
APS or service disruption time is an important parameter of SDH/SONET systems. In times where service level agreements of 99% and more are a given every network provider need to make sure that his revenue stream is protected against network failures. Manufacturer of such network elements need to verify that the implemented APS mechanisms are absolutely reliable in the short run as well as in the long run. The SDH/SONET test solution JDSU ANT-20 has offered for many years an APS test solution that does not leave this question unanswered. In the frame work of constant product improvement following emerging testing needs we have consequently added new functions. These new functions enabling the user of the ANT-20 to check systems which include DWDM systems. Additionally the ANT-20 supports now long term APS monitoring. JDSU will continue to develop test solution reflecting the latest testing needs and providing solutions which have positive impact on our customers business.