How Reliable is the Routing in Your SDH Network?

Application Note 64

Advanced Network Test Solutions:

Path trace analysis in complex SDH networks

Wandel & Goltermann
Communications Test Solutions

Abbreviations

AIS	Alarm Indication Signal
APS	Automatic Protection Switching
ATM	Asynchronous Transfer Mode
C-n	Container, n = 1 ... 4
CRC	Cyclic Redundancy Check
HP	Higher Order Path
J0	Regenerator Section Trace
J1	Path Trace (POH in VC-3,4)
J2	Path Trace (POH in VC-1,2)
LP	Lower Order Path
MS	Multiplex Section
MS-AIS	Multiplex AIS
MSOH	Multiplex Section Overhead
NE	Network Element
POH	Path Overhead
RDI	Remote Defect Indicator
RS	Regenerator Section
RSOH	Regenerator Section Overhead
RX	Receiver
SDH	Synchronous Digital Hierarchy
SOH	Section Overhead
STM	Synchronous Transport Module
STM-N	Synchronous Transport Module, Level N = 1; 4; 16; 64
TI	Path Trace Identifier
TIM	Trace Identifier Mismatch
TX	Transmitter
VC	Virtual Container
VC-n	Virtual Container, Level n = 1; 2; 3; 4

The ANT-20 Advanced Network Tester from Wandel & Goltermann is a very powerful test platform for SDH, SONET, PDH and ATM networks. It is a compact instrument with a large screen for easy evaluation and display of results. The graphical user interface makes the ANT-20 very simple to operate.

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Publishing details

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Published by:
Wandel & Goltermann GmbH & Co.
Elektronische Meßtechnik
Mühleweg 5
D-72800 Eningen u. A.
Germany

Subject to change without notice
Order no. E 3.99/WG1/64/3.5
Printed in Germany

The application of the Trace Identifier in complex SDH networks

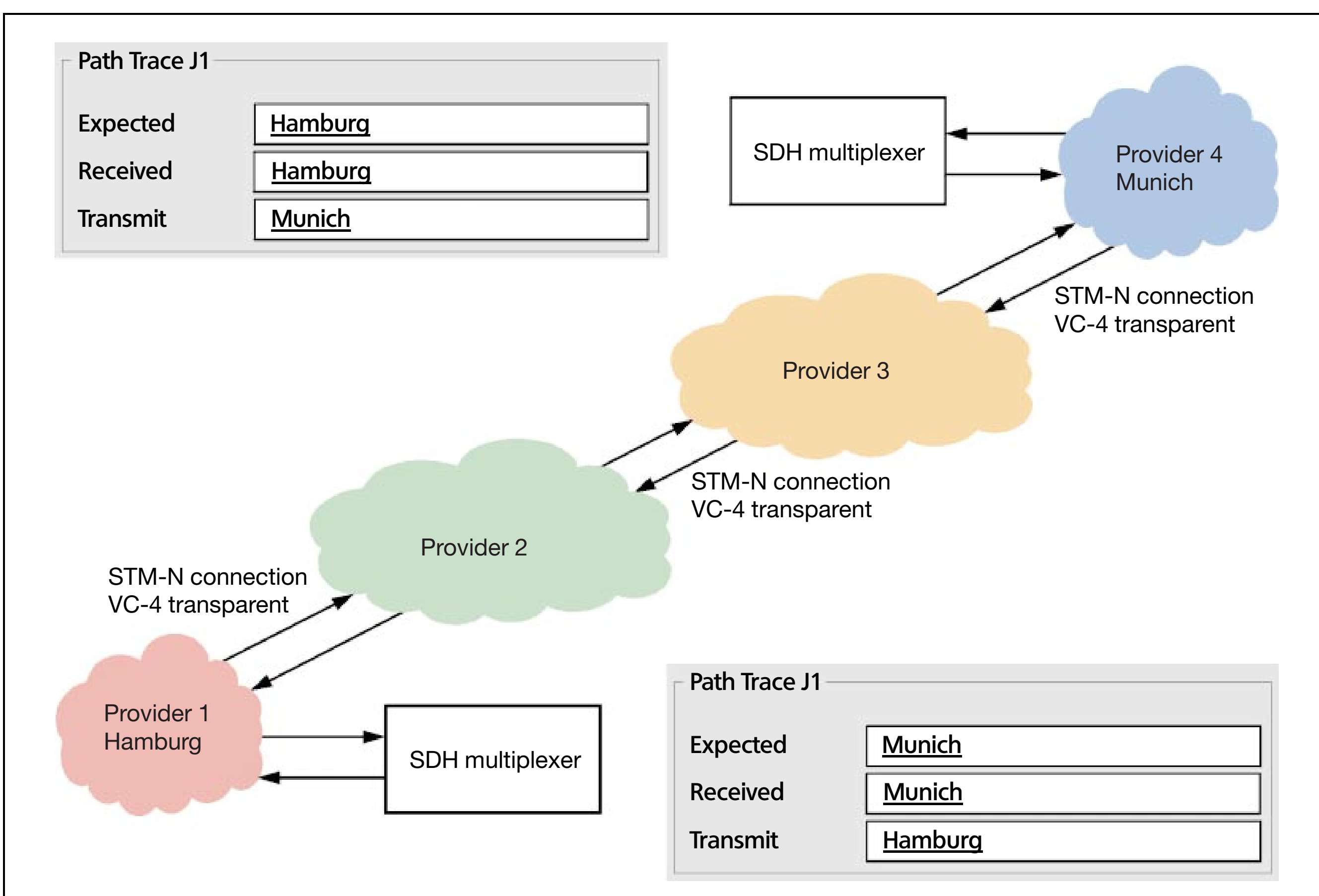
The arisal of a complex telecommunications environment

The removal of the state telecommunications monopoly in many countries has lead to a rapid increase in the number of domestic network operators and service providers.

Not all of these competing network providers can achieve complete coverage with their own back-bone networks. Particularly for long-distance traffic, they tend to lease transport capacity from competitors. This applies especially to the many mobile radio network operators, who depend on the 2 Mbit/s transport channels from a full-coverage backbone network. Added on top of this are the many new Internet providers, PBX inter-connections, router links between local area net-works (LANs) and, due to the construction of new ATM networks, providers of broadband multimedia services, all of whom need a share of the transport capacity of WANs. In the end run, all of these factors are creating more and more complex network environments with many network inter-connections.

Special network equipment is needed in order to provide reliable routing through these complex SDH networks and to provide long-term monitoring. This is the only way to ensure that a through path reaches the correct destination and remains switched through to that point. Within the various SDH hierarchies, so-called Path Trace Identifiers (or Trace Identifiers, TI for short) are used to accomplish this **(Fig. 1)**.

Fig. 1: Path Trace Identifiers ensure that a connection through the complex SDH network environment reaches the correct destination.



Trace Identifiers in the various SDH levels

There is a corresponding Trace Identifier for each hierarchy level in the ITU-T hierarchy model. Each Trace Identifier is used to monitor a certain portion of the path **(Fig. 2).** One overhead byte in each overhead section is used for this:

J0: for the regenerator sections (RSOH)
J1: for the VC-4 higher-order path (HP) and for the VC-3 lower-order path (LP), channels 1 - 3, PDH bit rate 34 (45) Mbit/s
J2: for the VC-12 lower-order path (LP), channels 1 - 63, PDH bit rate 2 Mbit/s

The Trace Identifier operates in the same way in every hierarchy level: A Trace Identifier is set on the transmit side (TX) which assigns a name for the path. This is then compared on the receive side (TR) with an Expected Trace Identifier.
If the two are identical, the path is correctly routed and no alarm will be triggered on the receive side. If the incoming Trace Identifier differs from the Expected Trace Identifier, this triggers an alarm on the receive side, called a defect in the latest ITU-T standard. This defect is known as a Trace Identifier Mismatch (TIM). If a defect occurs, the so-called Remote Defect Indicator (RDI) alarm is set for the backward path. It is then no longer possible to transmit the payload in the corresponding hierarchy level and the levels below it (Regenerator Section Overhead, Higher Order Path or Lower Order Path) **(see Fig. 2).**
In practice, monitoring the routing at the regenerator section level (J0 byte) has little meaning, since the possibilities for incorrect switching are much less here than, say, at the much more complicated 2 Mbit/s level.
The J2 byte is therefore used for overall monitoring from the time that the 2 Mbit/s is mapped into the SDH network through to its final demapping. This setup allows reliable end-to-end routing control in the SDH network. However, this presupposes that, for example, the 2 Mbit/s signal is only used at the SDH level and that no other network gateways are included for which mapping and demapping takes place. This should be taken into account when planning and during route selection **(Fig. 3).**

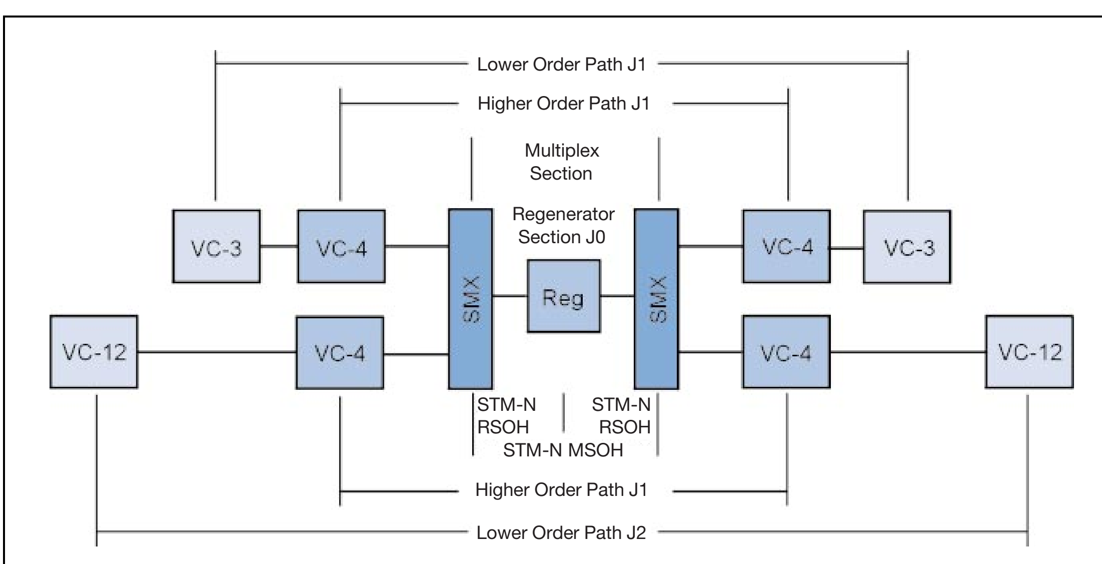
The J0 byte in the RSOH

The Trace Identifier in byte J0 in the RSOH level comprises a 2-byte word or a 16-byte frame containing 15 ASCII characters and a check sum. A total of 16 consecutive STM-1 frames, each 125 µs long are thus required to transmit the complete Trace Identifier.

Fig. 3: Section Overhead format

A1	A1	A1	A2	A2	A2	J0		
B1			E1			F1		
D1			D2			D3		
Pointer								
B2	B2	B2	K1			K2		
D4			D5			D6		
D7			D8			D9		
D10			D11			D12		
S1	Z1	Z1	Z2	Z2	M1	E2		

Fig. 2: Each path section is monitored by its own Path Trace Identifier in the overhead.



The J1 byte in the VC-4 HP or as VC-3 LP

The Trace Identifiers for the HP level in VC-4 or for the LP level in VC-3 (34 Mbit/s or 45 Mbit/s payload) are identical. They comprise 16 J1 bytes that are combined into a frame of 15 ASCII characters and a check sum as per ITU-T G.707. In this method, the Trace Identifier is only evaluated on the receive side if the incoming CRC check sum and the check sum calculated by the receiver are in agreement. Again, 16 consecutive STM-1 frames are needed to transmit this Trace Identifier. For easy detection of the CRC check sum, the first bit of the first byte is set to “1” while the first bit in the remaining 15 bytes is set to “0” **(Fig. 4 and 5).**

In practice, it may be that a bit error occurs in an ASCII character of the Trace Identifier during transmission. The incorrect Trace Identifier results in the triggering of a Trace Identifier Mismatch Alarm on the receive side, even though the routing was correct. Since the CRC check sum of the incoming signal and the check sum calculated for the receiver do not agree, the Trace Identifier will be rejected and not evaluated.

A further method of transmitting the Trace Identifier uses a 64 byte frame. The frame end is indicated by the ASCII value 00D ($^{C}{}_{R}$) for ASCII character 64 or 00A ($^{L}{}_{F}$) for ASCII character 63. 64 consecutive STM-1 frames are needed to transmit this Trace Identifier. In practice, however, a 16-byte Trace Identifier is used.

If a STM-1 signal consists of a VC-4 with 3 × 34 Mbit/s substructure, then in addition to the VC-4 level Trace Identifier (Higher Order Path Trace Identifier) separate Trace Identifiers also exist for each of the 34 Mbit/s channels (Lower Order Path Trace Identifiers) on the VC-3 level.

J1	Trace Identifier
B3	Quality Monitoring
C2	Container Contents
G1	Error Reporting
F2	Maintenance
H4	Multiframe Indicator
F3	Maintenance
K3	Automatic Protection Switching
N1	Tandem Connection Monitoring

Fig. 4: The Trace Identifier is transmitted in the J1 byte of the overhead.

Format according to ITU-T G.707

1	C	C	C	C	C	C	C	Start of the 16-byte frame
0	X	X	X	X	X	X	X	15-byte ASCII character
0	X	X	X	X	X	X	X	
•								
•								
•								
0	X	X	X	X	X	X	X	
0	X	X	X	X	X	X	X	
0	X	X	X	X	X	X	X	
0	X	X	X	X	X	X	X	

Fig. 5: The Trace Identifier consists of 16 J1 bytes (15 ASCII characters and check sum) combined into a frame (format as per ITU-T G.707).

The J2 byte in the VC-12 LP

On the LP level in the VC-12 (2 Mbit/s), the Trace Identifier is formed from the J2 byte **(Fig. 6).** Basically the same method is used as for the J1 byte in the VC-4/VC-3. Since the VC-12 only has one overhead byte, the four bytes shown in Fig. 6 must be transmitted periodically one after the other. The H4 byte in the VC-4 overhead is used to indicate which byte is being transmitted at the moment **(Fig. 4);** this counts up from 0 to 3 continually, thus serving as a pointer for the VC-12 overhead byte. 4 byte sequences and hence 64 STM-1 frames are required to transmit a complete 16 byte Trace Identifier, so a 64 byte Trace Identifier would require 4 × 64 = 256 STM-1 frames.

For a STM-1 frame structure with VC-4 loaded with 63 2 Mbit/s channels there is a total of further 63 Trace Identifiers on the VC-12 level in addition to the Trace Identifier on the VC-4 level.

V5	Path Overhead VC-12
J2	Trace Identifier
N2	Tandem Connection Monitoring
K4	Automatic Protection Switching

Fig. 6: The J2 byte forms the Trace Identifier on the VC-12 LP level.

Special meaning of the 2 Mbit/s Trace Identifier

The 2 Mbit/s Trace Identifier has a special meaning in the SDH network environment. The reason for this is the large number of existing connections and their complex interconnection. A link from A to B can be via the networks of different providers.
Fig. 1 shows a connection from Hamburg to Munich via four different network providers, of whom two are city network providers and two are multi-regional providers. The last mile of the connection is provided by the city networks. Each of these network providers has their own network management system which is limited to their own property area. Trace Identifiers ensure that incorrect routing is detected immediately, despite the distributed management, and that appropriate remedial action can be taken straight away. If there were no Trace Identifiers, only the end user would notice that the connection was no longer functioning if incorrect switching in one of the network sections caused a 2 Mbit/s connection to be routed to another location with the same signal structure.
For the application of the Trace Identifier to be useful, a system of assigning identifications that specify the source of the signal as exactly as possible needs to be set up first.

Differences between SDH systems from different manufacturers

There are differences in the way that the Trace Identifier function is implemented by different system manufacturers. While some systems manufacturers have yet to integrate this function into their latest systems, others have incorporated the function but not on every hierarchy level. Still other manufacturers have realized the function on all levels completely, but it cannot be disabled. A full solution would mean that Trace Identifiers should be implemented on every SDH hierarchy level in such a way as they can be disabled if required.

A further problem is given by the fact that different manufacturer's systems use different methods for automatically filling the Trace Identifier to 15 ASCII characters when less than 15 characters are entered due to an incomplete identifier assignment. For example, some manufacturers' systems fill the blanks with spaces (ASCII value 200) as shown in **Fig. 7.** The other possibility is to use the ASCII zero character (ASCII value 000) as shown in **Fig. 8.**

Since the ASCII values from Fig. 7 and Fig. 8 are not the same, a Trace Identifier Mismatch (TIM) alarm will result if the wrong setting is made on the receive side, even though both the Trace Identifiers are set to identical values. This problem often leads to difficulties in coupling SDH networks together when they are made up from system components from different manufacturers. The same can also occur within a SDH network if network elements from various sources are combined together.

It is therefore important to have a SDH analyzer available when coupling networks. This should be capable of displaying the individual characters in ASCII format so that the differences in the Trace Identifier fillers can be seen. This is important, too, because the network management system can not usually indicate any difference between spaces and ASCII zeros.

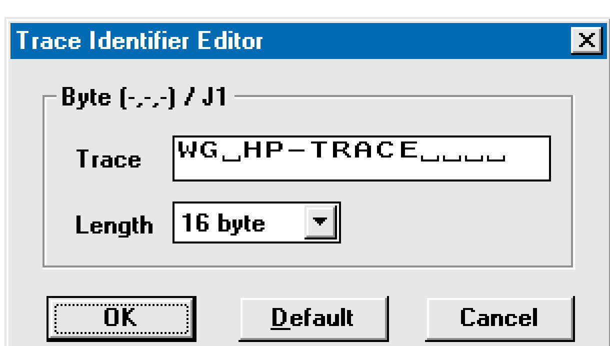


Fig. 7: Depending on the manufacturer, missing characters in identifier assignments are replaced with spaces …

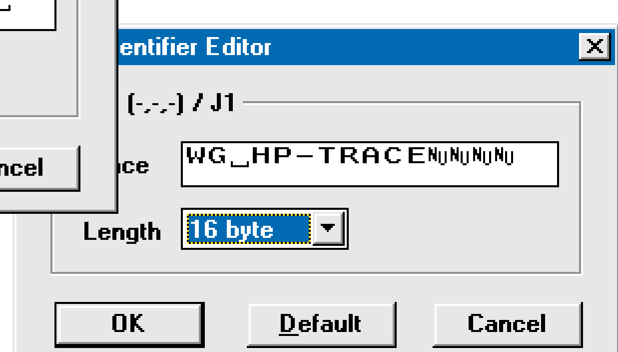


Fig. 8: … or with ASCII zero characters.

Use of the Trace Identifier in the ANT-20

Selecting the channel for a given Trace Identifier

Selection of the channel in which measurements are to be made or in which the Trace Identifier is to be analyzed is made using the "Signal Structure Editor" of the ANT-20. The same procedure is also used for the Trace Identifier itself.

In the following example, the 2 Mbit/s channel with the number 1 is selected in the ANT-20 signal structure editor **(Fig. 9).**

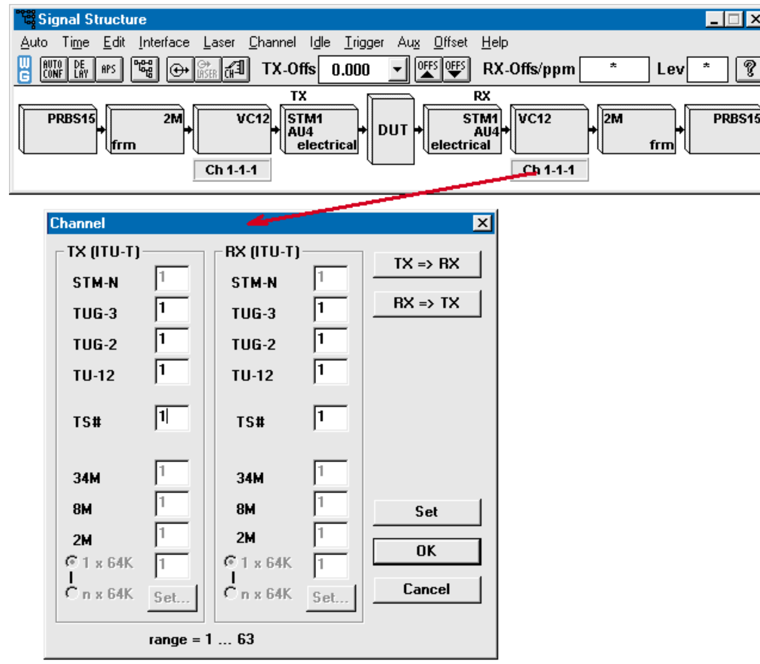


Fig. 9: ANT-20 signal structure editor

Activation / deactivation of Trace Identifier monitoring

A check (✓) in the settings of the "Overhead Analyzer" activates the Trace Identifier in the corresponding hierarchy level **(Fig. 10).** If the Trace Identifier on the receive side is activated, the incoming Trace Identifier can be displayed. Otherwise, viewing the incoming Trace Identifier is not possible. The default settings are restored by pressing the *"Default"* button.

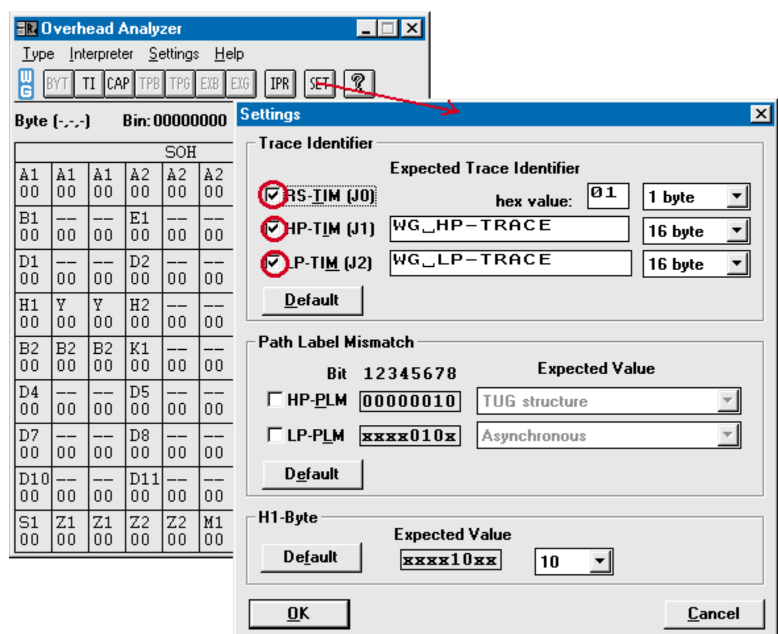
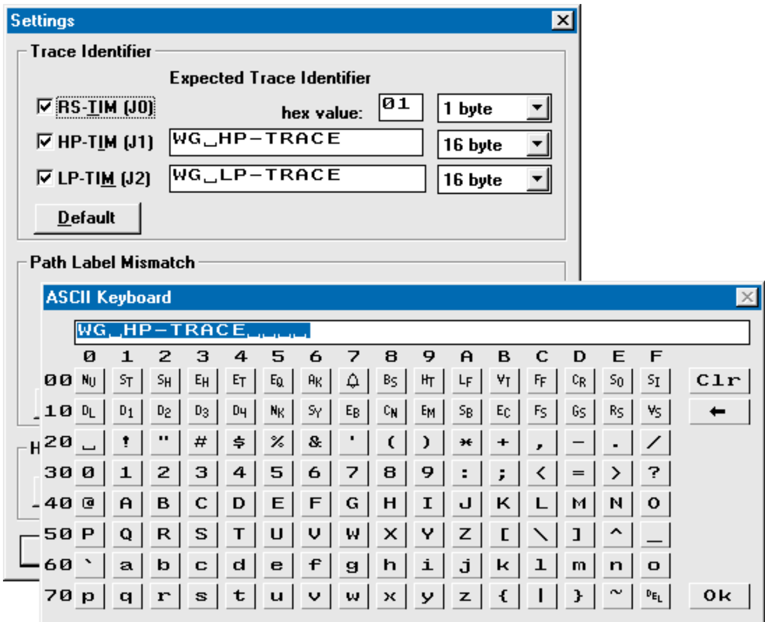


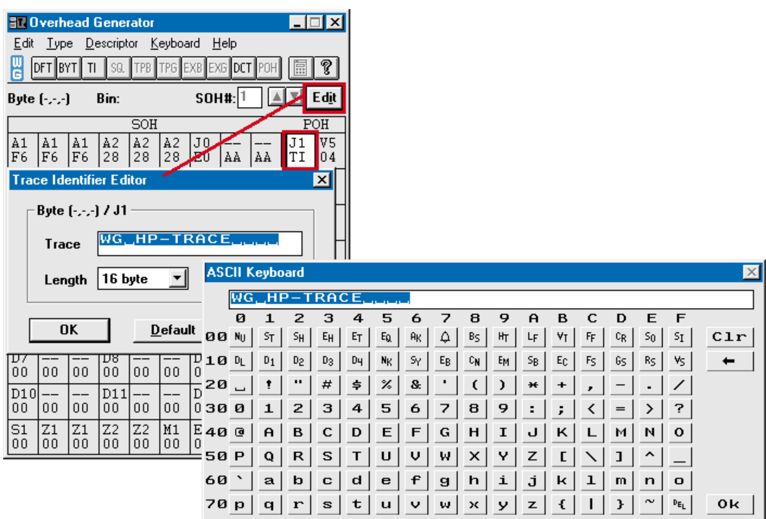
Fig. 10: The setting menus for the ANT-20 "Overhead Analyzer"



Setting the Expected Trace Identifier value

On the receive side, the value of the Expected Trace Identifier to be received must be entered in the “Overhead Analyzer” after it has been activated **(Fig. 11).** The incoming Trace Identifier is compared with this expected value.

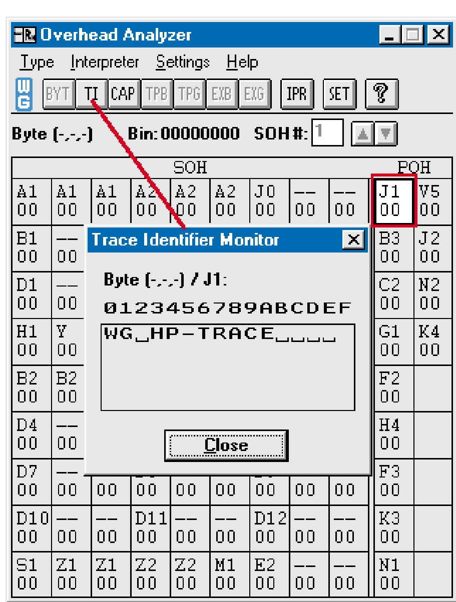
Fig. 11: Entering the expected value of the Trace Identifier with the ANT-20



Setting the Trace Identifier on the transmit side

On the transmit side, the Trace Identifier to be transmitted is entered in the “Overhead Generator”. To do this, the appropriate byte is selected in the Overhead Generator, after which the *“Trace Identifier Editor”* can be opened by clicking the “Edit” button or the “TI” button.
The ANT-20 automatically fills the Trace Identifier up to 15 ASCII characters with spaces **(Fig. 12).**
Note: The “TI” button is not activated until a J byte has been selected.

Fig. 12: Entering the Trace Identifier to be transmitted in the “Overhead Generator” on the transmit side



Trace Identifier analysis

If the Trace Identifier on the receive side is activated in the “Overhead Analyzer”, the “Trace Identifier Monitor” can be used to analyze and display the received Trace Identifier. To do this, the corresponding Trace Identifier byte and then the “TI” button must be activated **(Fig. 13).**

Fig. 13: The “Trace Identifier Monitor” of the ANT-20

Alarm detection and processing

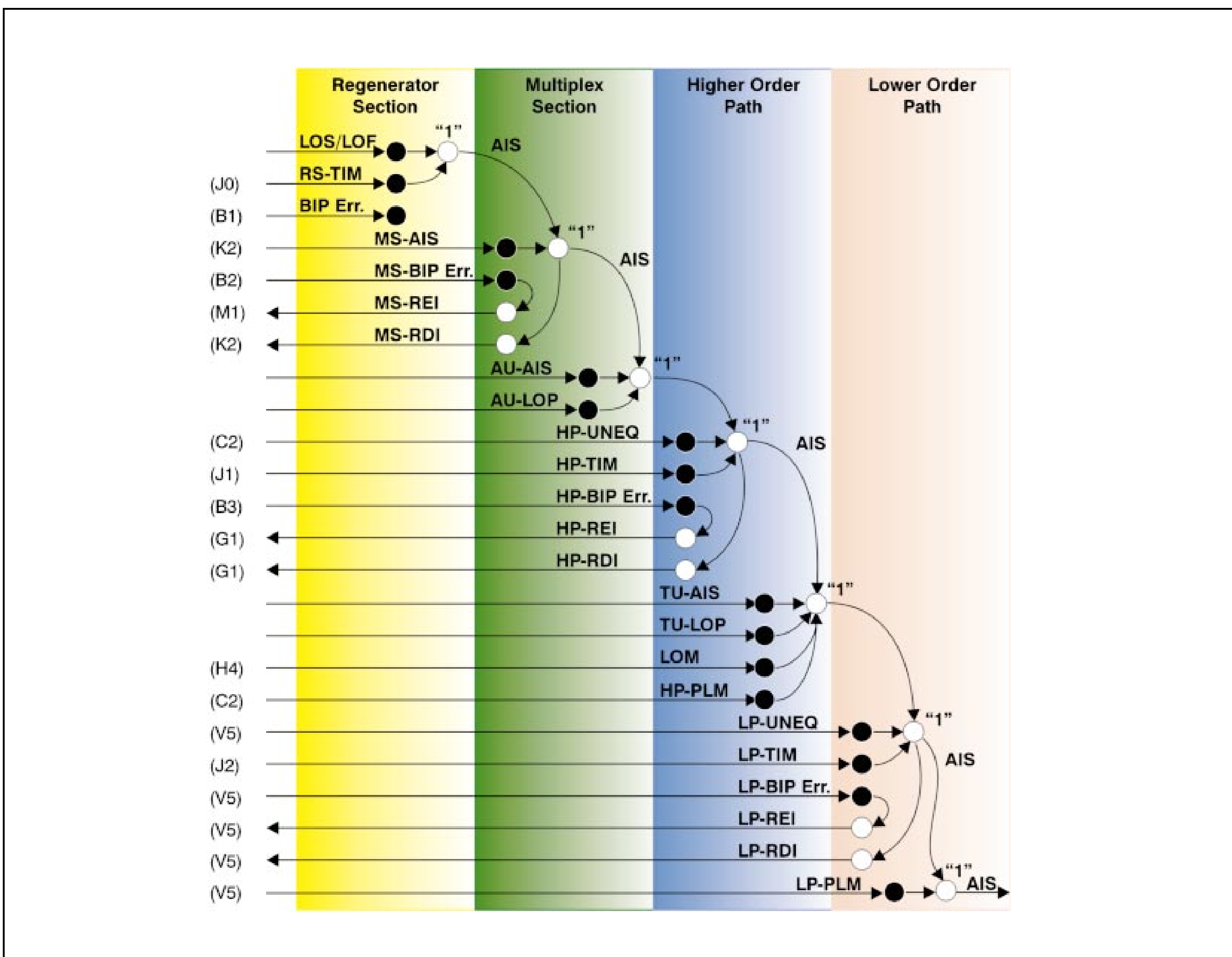
The way that the payload signal is affected varies depending on the SDH hierarchy level in which a Trace Identifier is evaluated. This can range from a blockade of a single 2 Mbit/s payload signal in the LP level up to a blockade of the entire payload signal in the regenerator section. The next part of this Application Note describes the effects on the individual levels **(Fig. 14).**

If the J0 byte in the regenerator section signals a Trace Identifier Mismatch Alarm (RS-TIM), this results in the Alarm Indication Signal (AIS) being set to "all ones" and transmitted to the multiplex section. At this point, the Multiplex Section Remote Defect Indicator (MS-RDI) is activated for the return path. The AIS has an effect right down to the payload channel level via the higher-order path and the lower-order path. Transmission of payload signals is therefore no longer possible. Since this also applies to STM-4 or STM-16 signals, the result may finally be that the entire payload cannot be transmitted.

If the J1 byte in the higher-order path level signals a TIM alarm (HP-TIM), the Alarm Indication Signal (AIS) is set to "all ones" and passed on to the lower-order path level. Here, the higher-order path Remote Defect Indicator (HP-RDI) is activated for the return path. The AIS has an effect right down to the payload channels via the lower-order path. Transmission of payload signals then becomes impossible in all payload channels of the affected VC-4.

If the J2 byte in the lower-order path level signals a TIM alarm (RS-TIM), the Alarm Indication Signal (AIS) is set to "all ones" and passed on to the affected payload (VC-12). There, the lower-order path Remote Defect Indicator (LP-RDI) is activated for the return path. This means that transmission of payload signals is impossible in this channel.

Fig. 14:
SDH maintenance interactions



In-service monitoring of the Path Trace Identifier at a protected monitor point (PMP)

The SDH analyzer is connected to a protected monitor point; these are usually only available on the transmit side **(Fig. 15).** In the case described, the PMP is a STM-1 electrical monitor point with CMI line code. The transmit signal is attenuated by 20 dB and is boosted by the input amplifier of the SDH analyzer.
The expected Trace Identifier at network element A (NE A) does not match the Trace Identifier transmitted from network element B (NE B). This leads to a higher-order path Trace Identifier Mismatch Alarm (HP-TIM) at network element A. A higher-order path Remote Defect Indicator (HP-RDI) is activated for the return path; this is detected by the SDH analyzer. The cause must therefore lie in the link from B to A. The Trace Identifier in the direction from A to B can be monitored with the Overhead Analyzer as shown in Fig. 13.

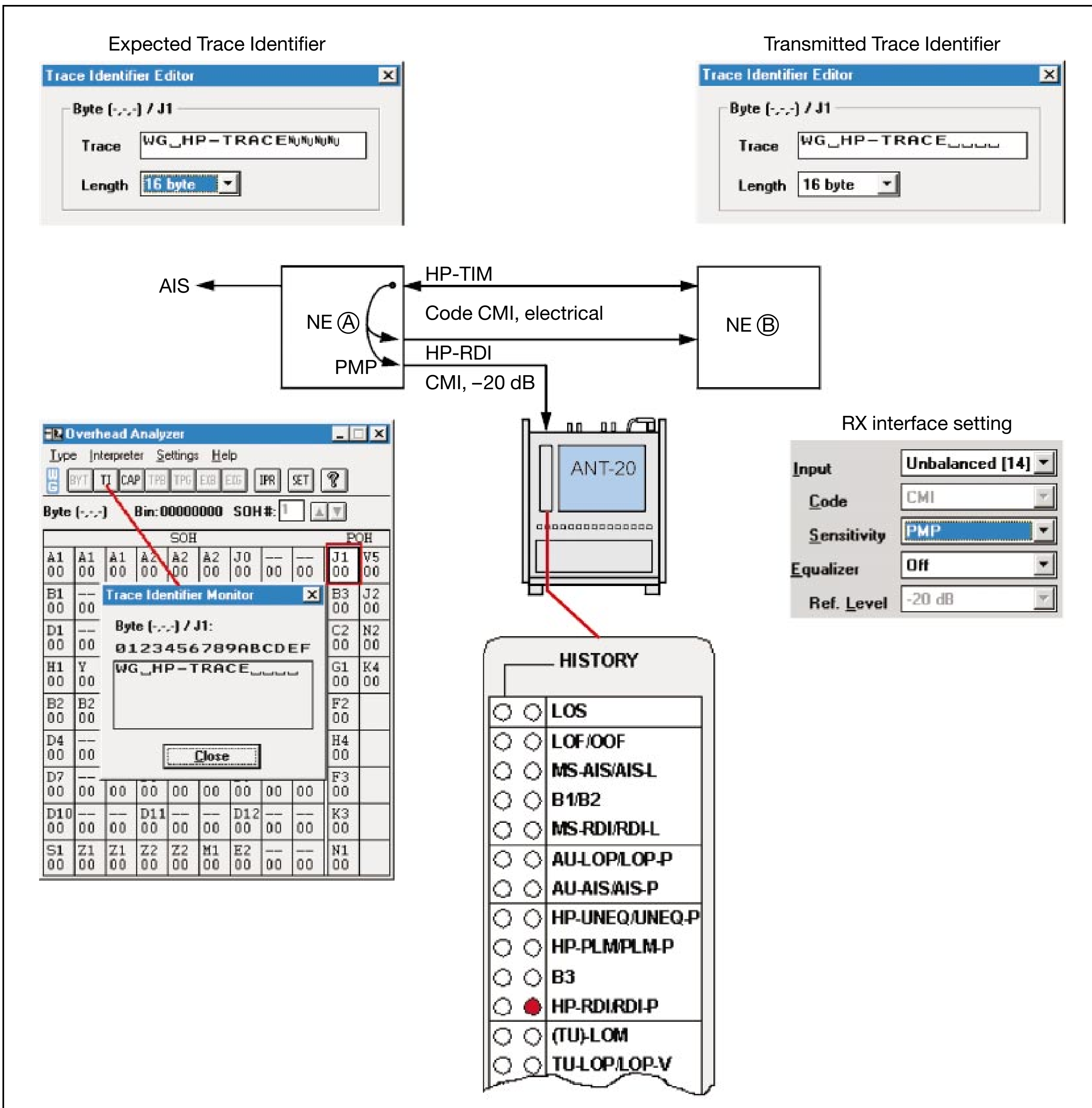


Fig. 15: In-service analysis with the ANT-20 at a protected monitor point

The Path Trace Identifier in a STM-1 VC-4 transparent leased line

STM-1 VC-4 transparent leased lines (as per ETSI EN 301 164, chapter 5) are mainly used by network providers that do not have their own optical fiber paths, forming their entire SDH network from these leased lines. Cross connects are installed at the crossing points of the STM-1 paths. These allow flexible switching of the payload (VC-4 containers). This type of circuit is also used by network providers in regions where they do not maintain their own infrastructure.

This type of STM-1 leased line allows the payload to be filled with any payload (VC-4 transparent). As **Fig. 16** shows, the entire higher order path overhead is contained in the payload. The J1 byte, which is responsible for the higher-order path Trace Identifier is included in this. This Trace Identifier is thus transmitted over a STM-1 VC-4 transparent leased line from one end to the other end without any changes; this can be verified using a SDH analyzer (see **Fig. 17** for test setup).

Fig. 16: The entire higher-order path overhead with the J1 byte is within the payload.

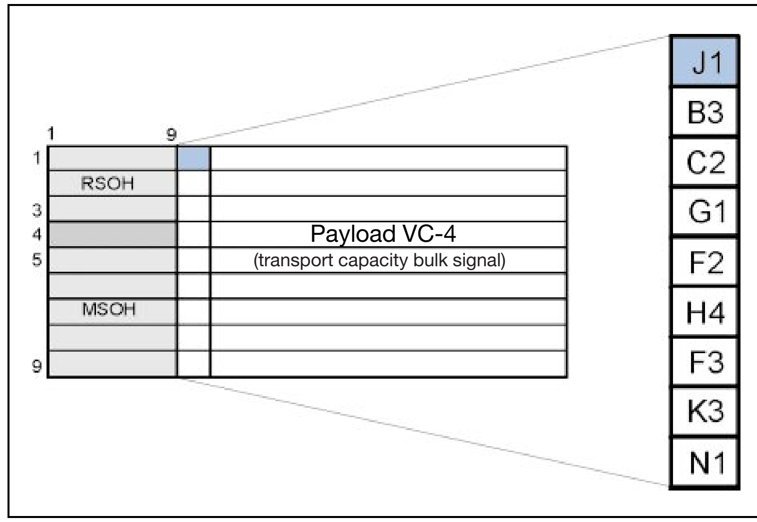
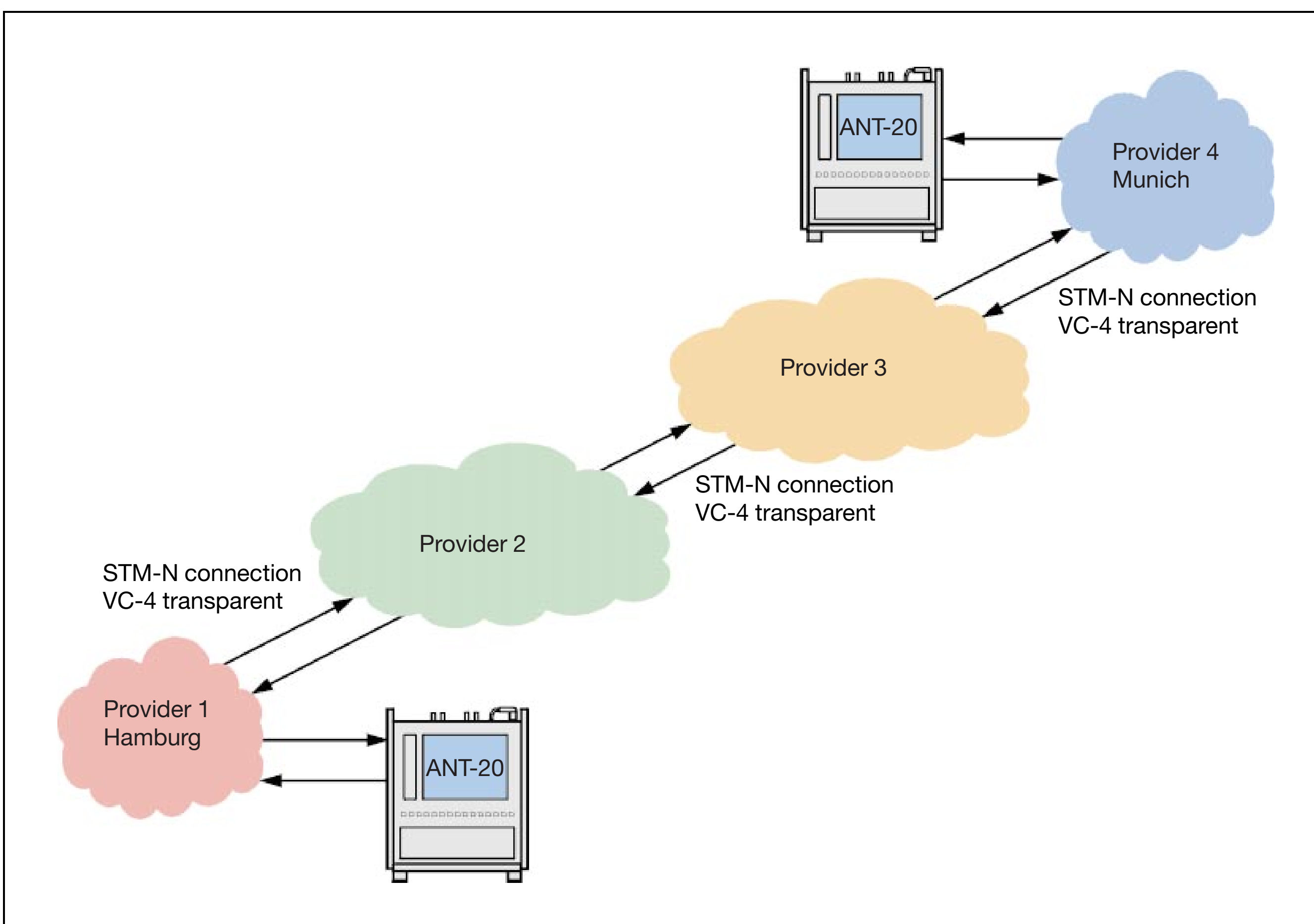


Fig. 17: Test setup with ANT-20 for end-to-end measurement on a transparent leased line



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Printed in Germany