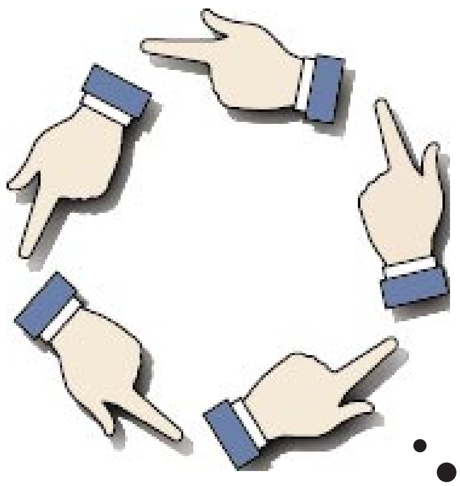
Tandem connection monitoring



Product note

For point-to-point SDH transmission, user data may be routed and carried by a number of network operators working 'in tandem' to its final destination. In such situations, the traditional SDH model of a single path between two end points is no longer appropriate.

A more relevant model would be to break the path into a series of 'tandem paths', each owned and managed by individual network operators. Errors and defects along the path could then be traced to a particular tandem path, allowing fast troubleshooting and 'finger-pointing' between the different operators. This solution is referred to as tandem connection monitoring (TCM).

This product note explains the implementation of TCM for SDH networks and the type of testing that can be applied to tandem connection paths.

Agilent Technologies
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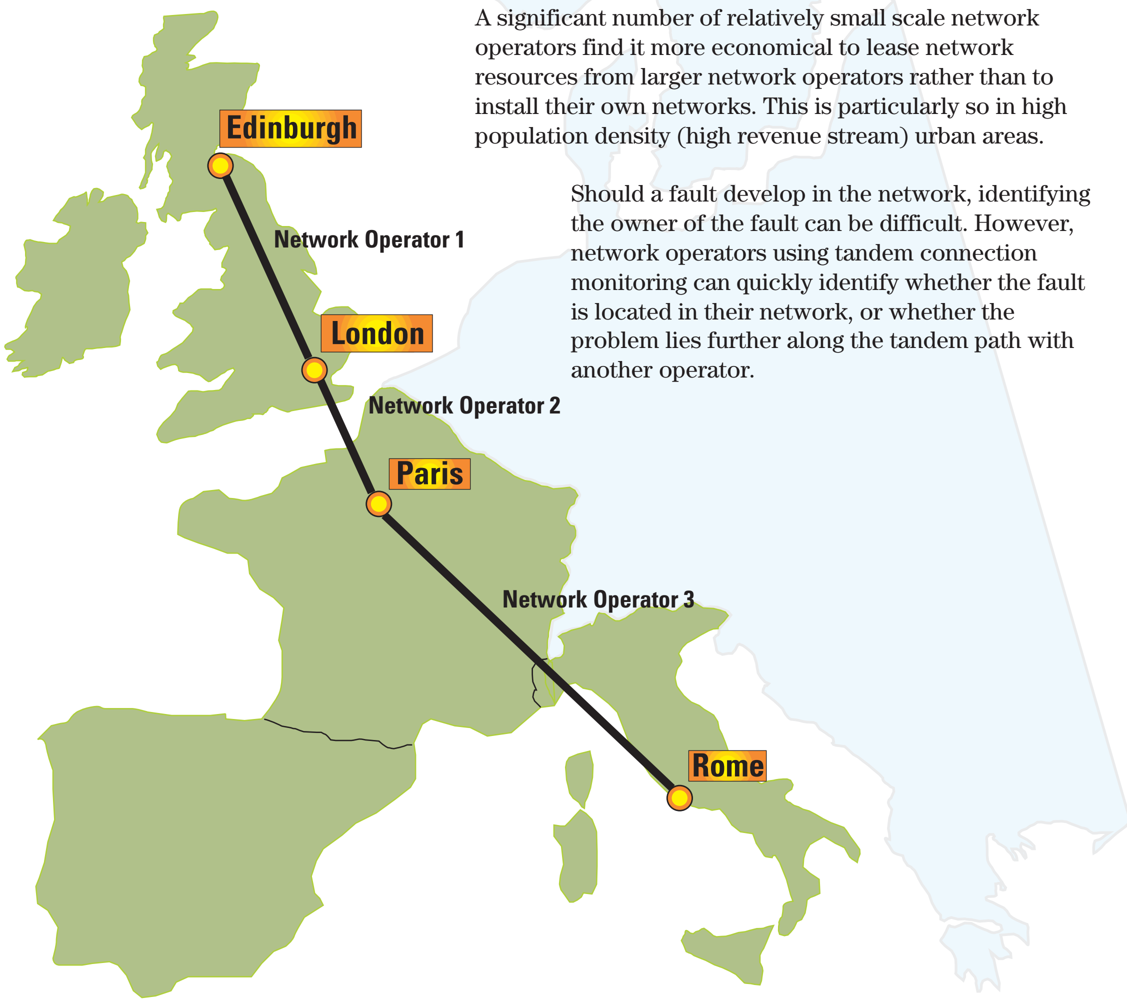
Introduction

Increased revenue opportunities from services, driven by advances in optical networking technology and by deregulation in the industry, have led to a corresponding dramatic increase in the number of telecom network operators and service providers around the globe.

A significant number of relatively small scale network operators find it more economical to lease network resources from larger network operators rather than to install their own networks. This is particularly so in high population density (high revenue stream) urban areas.

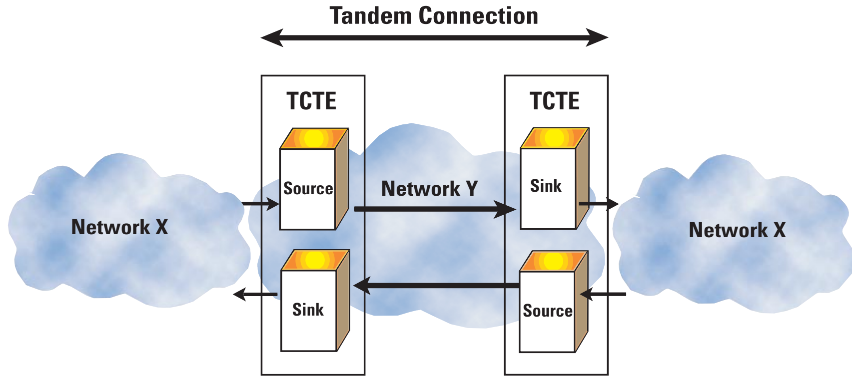
Should a fault develop in the network, identifying the owner of the fault can be difficult. However, network operators using tandem connection monitoring can quickly identify whether the fault is located in their network, or whether the problem lies further along the tandem path with another operator.



Contents

What is a tandem connection?

A tandem connection is a bi-directional connection between two tandem connection terminating elements (TCTEs) along an SDH path, which is managed as a separate entity. The tandem path is formed from an SDH virtual container (VC) with special maintenance signals carried in the path overhead (POH) bytes. These bytes enable monitoring of tandem paths, performance analysis, and fault location—the ability to 'finger-point'.



How is TCM achieved?

The tandem paths described in this product note are defined in ITU Recommendation G.707 Annex D for VC4 and VC3, and Annex E for VC2 and VC1. ITU-T Recommendation G.707 defines a tandem connection source and sink as shown above, and describes the responses of each when defect (alarm) and error conditions are detected. Tandem connection maintenance signals are carried in the N1 byte for VC4 and VC3, and in the N2 byte for VC2 and VC1. These two bytes are structured similarly, but their functions are not identical.

N1 byte structure

b1	b2	b3	b4	b5	b6	b7	b8
IEC (IAIS)				TC-REI	OEI	TC-APId, TC-DI,ODI, reserved	

N2 byte structure

b1	b2	b3	b4	b5	b6	b7	b8
TC-B1P		"1"	IAIS	TC-REI	OEI	TC-APId, TC-RDI,ODI, reserved	

IEC: Incoming Error Count. Indicates IAIS when set to '1110' (seebelow)

IAIS: Incoming AIS alarm

TC-REI: Tandem Connection Remote Error Indication

OEI: Outgoing Error Indication

TC-APId: Tandem Connection Access Point Identifier (16-byte message)

TC-RDI: Tandem Connection Remote Defect Indication

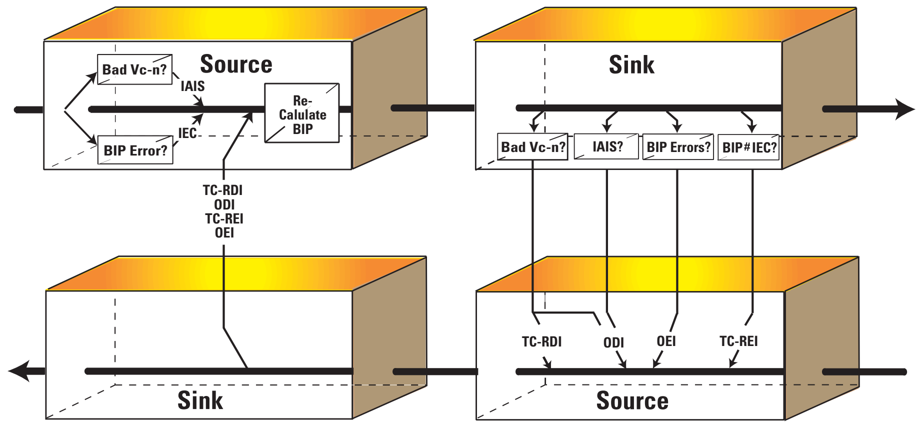
ODI: Outgoing Defect Indication

TC-BIP: 2-bit Bit Interleaved Parity for Tandem Connection

In both N1 and N2, bits 7 and 8 form a 76-frame multiframe to carry remote defect indications and the access point identifier (TC-APId) which is a repeating 16-byte message that identifies the tandem connection source.

Throughout this product note the emphasis is be on the operation of N1. The key differences between N1 and N2 are described later.

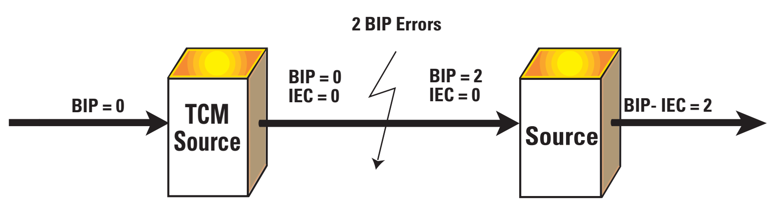
The figure below summarizes the actions of the TCM *source* and *sink* in response to *defects* and *errors*.



Error detection on a tandem connection

For VC3 and VC4 the B3 byte in the POH carries a BIP-8 checksum to allow error detection over the whole path. At the TCM source, the number of errors indicated by B3 (that is, errors that occurred before the tandem connection source) is noted and copied into the IEC field of the N1 byte. On its way to the TCM sink, the data may suffer further errors which will 'add' to B3. At the TCM sink, the B3 errors are compared to the IEC value to indicate how many errors were added over the tandem connection. This information is passed to the network management layer allowing network operators to determine if errors are occurring in their part of the network.

In the following example, B3 indicates no BIP errors prior to the sink. The sink, therefore, sets IEC to zero. Two errors are then introduced over the tandem connection so B3 indicates two errors at the tandem sink. The sink subtracts IEC from the B3 errors to deduce that two errors were added by the tandem connection.



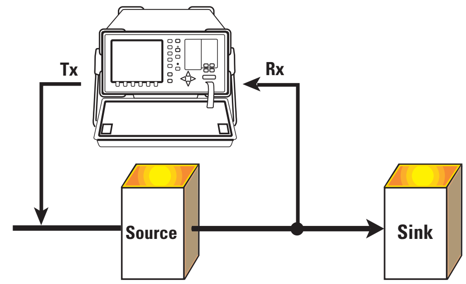
This process is not perfect. Errors on the TCM link could cancel errors indicated in B3, and it is possible for the sum B3 - IEC to go negative. For this reason only the magnitude of B3 - IEC is taken so that at low error rates, the correct result is given.

B3 compensation

Because the path overhead data (N1 or N2) is modified by the TCM source and sink, it is necessary for B3 to be compensated before being sent on. In other words, B3 must indicate the same number of errors as it did on entry to the TCM equipment.

TCTE testing

Testing the operation of a TCTE involves sending an SDH stimulus with various impairments and checking the output.



TCTE source checks

Basic checks:

1. Send a valid VC-n with no errors.
2. Check the Rx for alarms.
3. Check for correct TC-APId (access point identifier).

If there are any problems for example, TCM not enabled on the TCTE, then the TCM Loss of Multiframe alarm (TC-LOM) will be indicated by the test equipment. The absence of any alarms means that TCM is provisioned and working.

Error monitoring checks:

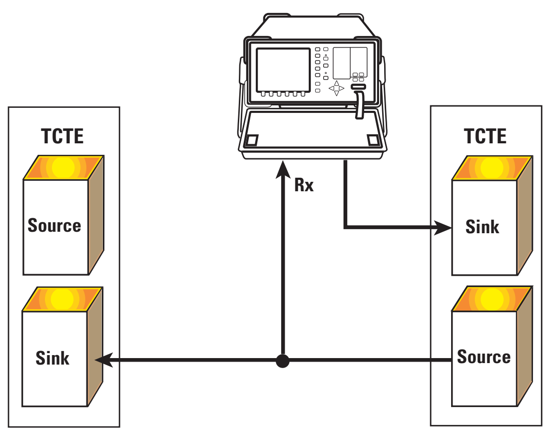
1. Inject B3 errors at a rate of 1E-5.
2. On the Rx, verify that the B3 rate is 1E-5.
3. On the Rx, verify that the IEC reading is also 1E-5.

This verifies that the network element (NE) has correctly copied the B3 count into bits 1-4 of the N1 byte, and that B3 is correctly compensated.

Alarm checks:

1. Send an invalid VC-n to the NE.
2. Check Rx for a TC-IAIS alarm.
3. Check the signal label (in C2 or V5) is set to all-ones, which indicates a VC-AIS.

TCTE sink/source checks



Remote error/alarm checks:

Send the following in sequence to the TCM sink input:

1. No signal , loss of frame, loss of pointer – check for TC-RDI and ODI
2. TC-APId mismatch – check for TC-RDI and ODI
3. TC-IAIS – check for ODI
4. BIP errors at 1E-5 – check for OEI at 1E-5
5. BIP or IEC errors at 1E-5 – check for TC-REI at 1E-5*

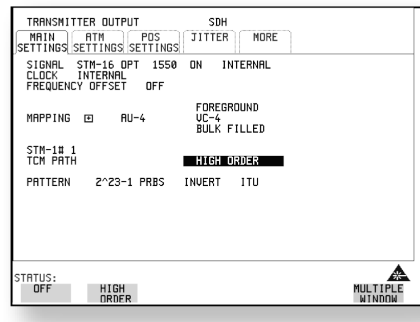
* *Sending BIP errors without IEC errors, or IEC errors without BIP errors, gives rise to a non-zero result when the TCTE calculates [B3 - IEC] . These errors are counted as TC-errors (that is, errors arising on the TCM link) which in turn are reported on TC-REI.*

N1 byte vs. N2 byte

The emphasis so far has been on the N1 byte which is used at VC3 and VC4. The N2 byte is used in a very similar way except that there is no IEC field. Instead, a completely new BIP-2 calculation is performed over the VC2 or VC1 at the TCTE source, and this value is passed down as N2. The TCTE sink simply has to check the N2 BIP-2 to calculate the errors added by the TCM link. There is no need for 'BIP minus IEC' calculations with N2.

TCM testing with the OmniBER 718

For network operators and service providers operating tandem SDH network paths, the OmniBER 718's TCM test solution can isolate errors and defects to a particular tandem path. This allows both fast trouble-shooting and finger pointing between different operators.

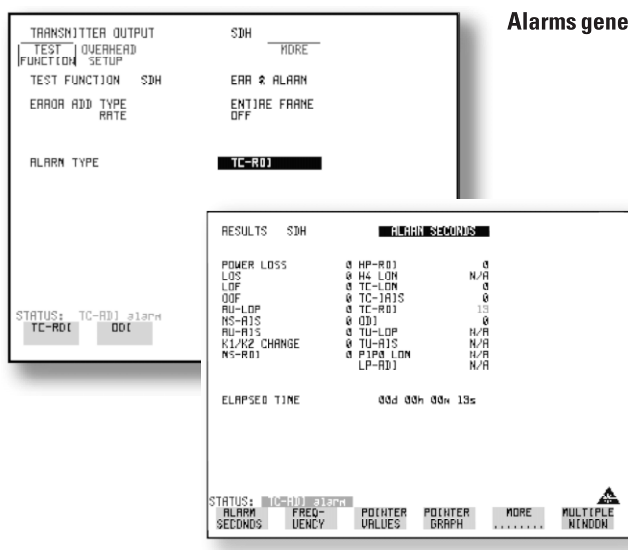


The OmniBER TCM test capability complies with ITU-T G.707 Annex D and Annex E recommendations, and includes alarm generation and detection, error generation and detection, plus access point identifier generation and decode. The test capability also covers the requirements for both high-order and low-order paths:

High Order:	VC4 → AU4, VC3 3. Uses N1 byte.
Low Order:	VC3 → TU3. Uses N1 byte.
	VC2 → TU2, VC1x → TU1x. Uses N2 byte.

Alarms generation and detection

Alarms generation

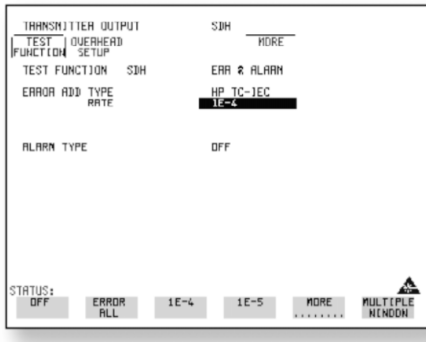


Alarms detection

Four alarms can be generated and detected using the OmniBER 718:

TC-LOM:	Tandem Connection Loss of Multi-frame in bits 7 and 8 of N1/N2
TC-RDI:	Tandem Connection Remote Defect Indication
TC-IAIS:	Incoming AIS
ODI:	Outgoing Defect Indication

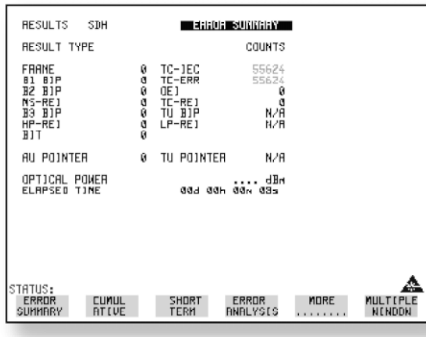
Error generation and detection



Error generation

The following errors can be generated:

TC–IEC: Incoming Error Count (N1only)
TC-REI: Remote Error Indication
OEI: Outgoing Error Indication
TC-BIP: TC BIP Error (N2 only)



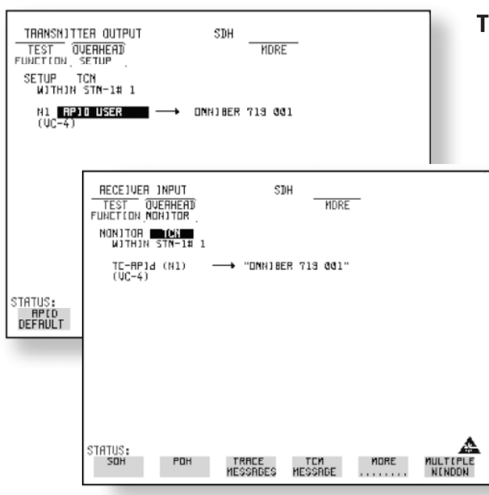
Error detection

The following can be detected and counted:

TC–IEC: Incoming Error Count (N1 only)
TC-REI: Remote Error Indication
OEI: Outgoing Error Indication
TC-ERRORS: Result of |B3-IEC| for N1, or TC BIP Error for N2

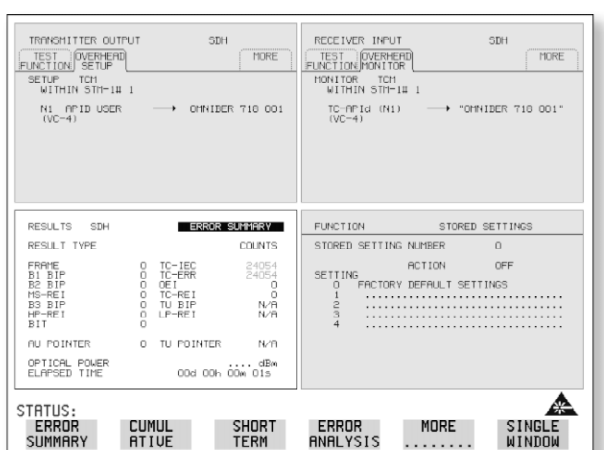
Access point identifier

The OmniBER 718 provides the facility to enter a 16-byte TC-APId message for transmission in N1 or N2. Additionally, a received TC-APId message can be decoded and displayed.



Transmitter setup

Receiver setup



Results

OmniBER 718 communications performance analyzer

The Agilent Technologies OmniBER 718 communications performance analyzer is a rugged, portable one-box solution ideally suited to installation and maintenance of SDH/SONET networks and network elements.

It provides full PDH/T-carrier and SDH/SONET capability at all rates up to 2.5 Gb/s, including STM-16c/OC-48c payloads, ATM, jitter, packet over SDH/SONET (POS), service distruption measurement, and channelized payload test.

For network operators and service providers operating tandem SDH network paths, the OmniBER 718's TCM test solution can isolate errors and defects to a particular tandem path.

Product literature

You'll find further details of the OmniBER 718 analyzer's test capability in the product brochure (publication number 5968-8740E), product specifications (publication number 5968-8335E) and configuration guide (publication number 5968-8012E).

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