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Digital networks – Quality and availability targets

Availability performance objectives for end-to-end international constant bit-rate digital paths at or above the primary rate

ITU-T Recommendation G.827.1

(Formerly CCITT Recommendation)

ITU-T G-SERIES RECOMMENDATIONS

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ITU-T Recommendation G.827.1

Availability performance objectives for end-to-end international constant bit-rate digital paths at or above the primary rate

Summary

This Recommendation defines network performance objectives for describing end-to-end availability performance of international constant bit-rate digital paths at or above the primary rate. The parameters to which these objectives apply are defined in ITU-T G.827.

The objectives given are independent of the physical network supporting the path. Guidance on determining expected end-to-end performance using the objectives for path elements is provided in Annex A, and depends on the actual path topology.

Source

ITU-T Recommendation G.827.1 was prepared by ITU-T Study Group 13 (2001-2004) and approved under the WTSA Resolution 1 procedure on 24 November 2000.

Keywords

Availability, Availability Objectives, Availability Performance, Availability Ratio, Mean Time Between Digital Path Outages, Outage Intensity, Path Element, Unavailability Ratio.

FOREWORD

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In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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ITU-T Recommendation G.827.1

Availability performance objectives for end-to-end international constant bit-rate digital paths at or above the primary rate

1 Introduction

1.1 Purpose

The purpose of this Recommendation is to specify the availability parameters and objectives for end-to-end international constant bit-rate digital paths operating at or above the primary rate. The Recommendation should be used:

- by transmission network planners to determine the required measures and actions within the network (e.g. system reliability, maintenance organization, network protection techniques);
- by the organization responsible for the provision of a path to determine which additional end-to-end actions (such as end-to-end protection switching) are necessary to satisfy Quality of Service objectives;
- by network operators providing path core elements which make up an international digital path to ensure that availability requirements are met;
- by purchasers of telecommunication capacity.

1.2 Scope

This Recommendation is applicable to end-to-end international constant bit-rate digital paths operating at or above the primary rate. These paths may be based on the Plesiochronous Digital Hierarchy (PDH), the Synchronous Digital Hierarchy (SDH) or some other transport technology. This Recommendation is generic in that it defines parameters and objectives independent of the physical transport network supporting the paths, e.g. optical fibre, radio relay or satellite.

The performance objectives are applicable end-to-end over a 27 500 km Hypothetical Reference Path as defined in ITU-T G.826 and G.828.

The end-to-end availability performance of an international digital path can be calculated from the arrangement of the constituent Path Elements (PEs) and their associated objectives. Annex A gives guidance on evaluating end-to-end availability objectives. The availability performance parameters and objectives for PEs are defined in ITU-T G.827.

In some countries the network may be subdivided into parts which are under the responsibility of different network operators. The partitioning of the objectives between these parts is outside the scope of this Recommendation.

1.3 Application of the Recommendation

This Recommendation is complimentary to ITU-T G.826 and G.828 that define the error performance objectives of the transport network. The performance parameters and definitions applied to paths provided using the ATM layer and the AAL for CBR services (class A, ITU-T I.362) are for further study.

Path end points may be located at user's premises.

Since the performance objectives are intended to satisfy the needs of the future digital network, it must be recognized that such objectives cannot be readily achieved by all of today's digital equipment and systems. The intent, however, is to encourage equipment design such that digital paths will satisfy the objectives in this Recommendation.

Transport network paths are used to support services such as circuit switched, packet switched and leased line services. The quality of such services, as well as the performance of the network elements belonging to the service layer, is outside of the scope of this Recommendation.

1.4 Allocation of end-to-end performance

Allocations of end-to-end performance of CBR paths are derived using the rules laid out in 5.2 which are length and complexity-based. Detailed allocations of performance to the individual components (lines, sections, multiplexers and cross-connects, etc.) are outside the scope of this Recommendation, but when such allocations are performed, the 5.2 national and international allocations should be achieved.

2 References

The following Recommendations and other references, contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

[1] ITU-T G.827 (2000), *Availability parameters and objectives for path elements of international constant bit-rate digital paths at or above the primary rate.*

[2] ITU-T G.826 (1999), *Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate.*

[3] ITU-T M.20 (1992), *Maintenance philosophy for telecommunication networks.*

[4] ITU-T M.1010 (1988), *Constitution and nomenclature of international leased circuits.*

[5] ITU-T G.828 (2000), *Error performance parameters and objectives for international constant bit-rate synchronous digital paths.*

[6] ITU-T E.800 (1994), *Terms and definitions related to quality of service and network performance including dependability.*

[7] ITU-T E.801 (1996), *Framework for Service Quality Agreement.*

3 Abbreviations

This Recommendation uses the following abbreviations:

AR Availability Ratio

FS Frontier Station

HRP Hypothetical reference path

IB International Border

ICPCE Inter-Country Path Core Element

IG International Gateway

IPCE International Path Core Element

ISC	International Switching Centre
Mo	Mean Time Between Digital Path Outages
NPCE	National Path Core Element
NPE	National Path Element
OI	Outage Intensity
PAE	Path Access Element
PDH	Plesiochronous Digital Hierarchy
PE	Path Element
PEP	Path End Point
PSE	Path Switching Element
SDH	Synchronous Digital Hierarchy
SES	Severely Errored Second
SIE	Short Interruption Event
SLA	Service Level Agreement
SQA	Service Quality Agreement
UR	Unavailability Ratio

4 Definitions

This Recommendation defines the following terms:

4.1 path: A path is a transport entity responsible for the integrity of client network information transfer. Paths are terminated at each end by a Path End Point (PEP) (see ITU-T G.827).

4.2 path element: A PE is a portion of a path resulting from partitioning for the purpose of availability management (see ITU-T G.827).

The physical realization and topology of the PEs are under the responsibility of each network operator.

ITU-T G.827 defines the following PEs:

– National Path Element (NPE);
– International Path Core Element (IPCE);
– Inter-Country Path Core Element (ICPCE).

4.3 path categories: Paths are categorized on the basis of the level of availability performance.

Three different path categories are distinguished:

- High priority – which will usually consist of high grade equipment and/or some degree of redundancy protection.
- Standard priority – which may or may not have some degree of redundancy protection.
- Pre-emptible priority – which may form part of the protection of another path and from which traffic can be dropped if the capacity is required for a high or standard path that has experienced a loss of transmission in one or more of its path elements.

NOTE – Customers of network operators may negotiate a defined level of availability for any particular Path by employing the "Framework for Service Quality Agreement" as defined in ITU-T E.801.

4.4 availability ratio: The Availability Ratio AR, is the proportion of time that an end-to-end Path is in the available state during an observation period. AR is calculated by dividing the total available time during the observation period by the duration of the observation period. The converse of AR, the unavailable ratio, UR, is the proportion of time that an end-to-end Path is in the unavailable state during an observation period. UR is calculated by dividing the total unavailable time during the observation period by the duration of the observation period.

4.5 mean time between end-to-end Path outages: The mean time between end-to-end Path outages, Mo, is the average duration of any continuous interval during which the end-to-end Path is available. Consecutive intervals of planned available time are concatenated.

The reciprocal of Mo is defined as the Outage Intensity OI.

5 Availability performance objectives

5.1 End-to-end objectives

Table 1 specifies the end-to-end objectives for a 27 500 km HRP in terms of the parameters defined in 5.2 and 5.3. An international digital path at or above the primary rate shall meet its allocated objectives for all parameters concurrently. The path fails to meet the availability performance requirement if any of these objectives is not met.

The objectives apply to observation periods of one year (365 consecutive days), using a sliding window with 24-hour granularity.

Table 1/G.827.1 – End-to-end availability performance objectives for a 27 500 km international digital HRP at or above the primary rate

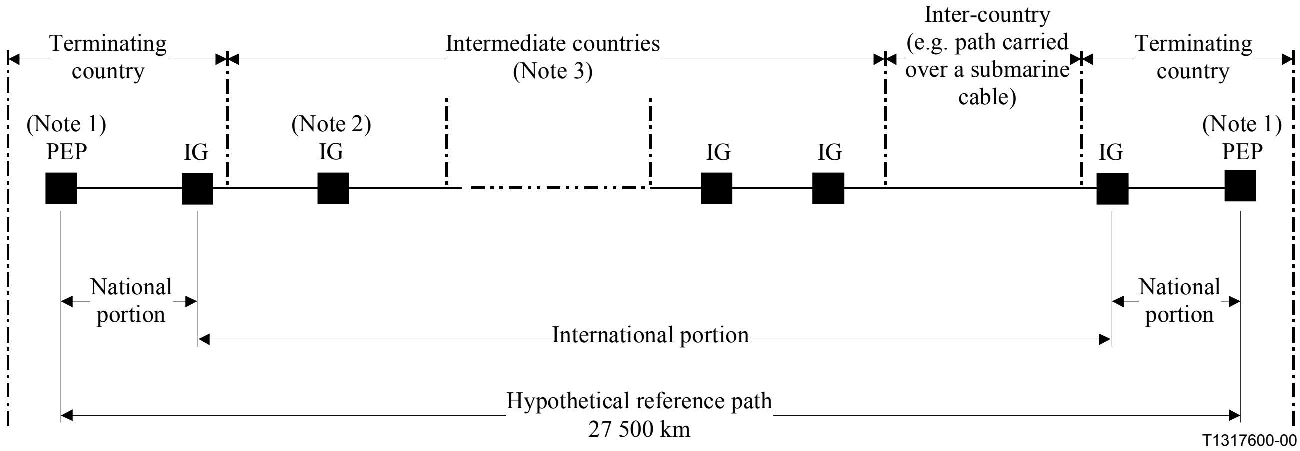
Rate Mbit/s	1.5 to 5		> 5 to 15		> 15 to 55		> 55 to 160		> 160 to 3 500	
	AR	Mo	AR	Mo	AR	Mo	AR	Mo	AR	Mo
High priority	F.F.S.	F.F.S.	F.F.S.	F.F.S.	F.F.S.	F.F.S.	F.F.S.	F.F.S.	F.F.S.	F.F.S.
Standard priority	F.F.S.	F.F.S.	F.F.S.	F.F.S.	F.F.S.	F.F.S.	F.F.S.	F.F.S.	F.F.S.	F.F.S.
Pre-emptible priority	F.F.S.	F.F.S.	F.F.S.	F.F.S.	F.F.S.	F.F.S.	F.F.S.	F.F.S.	F.F.S.	F.F.S.

Digital paths operating at bit-rates covered by this Recommendation are carried by transmission systems (digital sections) operating at equal or higher bit-rates. Such systems must meet their allocations of the end-to-end objectives for the highest bit-rate paths which are foreseen to be carried. Meeting the allocated objectives for this highest bit-rate path should be sufficient to ensure that all paths through the system are achieving their objective. For example, in SDH, an STM-1 section may carry a VC-4 path and therefore the STM-1 section should be designed such that it will ensure that the objectives as specified in this Recommendation for the bit-rate corresponding to a VC-4 path are met.

NOTE – Objectives are allocated in this Recommendation to the national and international portions of a path. In the above example, if the STM-1 section does not form a complete national or international portion, the corresponding national/international allocation must be subdivided to determine the appropriate allocation for the digital section. This is outside the scope of this Recommendation.

5.2 Apportionment of end-to-end objectives

The following apportionment methodology specifies the levels of performance expected from the national and international portions of an HRP. Further subdivision of these objectives is beyond the scope of this Recommendation. [See Figure 1 (Figure 3/G.826)].



NOTE 1 – If a path is considered to terminate at the IG, only the international portion allocation applies.
NOTE 2 – One or two International Gateways (entry or exit) may be defined per intermediate country.
NOTE 3 – Four intermediate countries are assumed.

Figure 1/G.827.1 – Hypothetical reference path

For the purposes of this Recommendation the boundary between the national and international portions is defined to be at an International Gateway which usually corresponds to a cross-connect, a higher-order multiplexer or a switch (N-ISDN or B-ISDN). IGs are always terrestrially based equipment physically resident in the terminating (or intermediate) country. Higher-order paths (relative to the HRP under consideration) may be used between IGs. Such paths receive only the allocation corresponding to the international portion between the IGs. In intermediate countries, the IGs are only located in order to calculate the overall length of the international portion of the path in order to deduce the overall allocation.

The following allocation methodology applies to each parameter defined in G.827.1 and takes into account both the length and complexity of the international path. All paths should be engineered to meet their allocated objectives as described in 5.2.1 and 5.2.2. If the overall allocation exceeds 100%, then the performance of the path may not fulfil the objectives of Table 1. Network Operators should note that if performance could be improved in practical implementations to be superior to allocated objectives, the occurrence of paths exceeding the objectives of Table 1 can be minimized.

5.2.1 Allocation to the national portion of the end-to-end path

Each national portion is allocated a fixed block allowance of 17.5% of the end-to-end objective. Furthermore, a distance-based allocation is added to the block allowance. The actual route length between the PEP and IG should first be calculated if known. The air-route distance between the PEP and IG should also be determined and multiplied by an appropriate routing factor. This routing factor is specified as follows:

- if the air route distance is < 1 000 km, the routing factor is 1.5;
- if the air route distance is ≥ 1 000 km and < 1 200 km, the calculated route length is taken to be 1 500 km;
- if the air route distance is ≥ 1 200 km, the routing factor is 1.25.

When both the actual and calculated route lengths are known, the smaller value is retained. This distance should be rounded up to the nearest 100 km. An allocation of 0.25 per 100 km is then applied to the resulting distance. The two national portions are allocated a minimum of 500 km (i.e. 1%) each.

When a national portion includes a satellite hop, a total allowance of 42% of the end-to-end objectives in Table 1 is allocated to this national portion. The 42% allowance completely replaces both the distance-based allowance and the 17.5% block allowance otherwise given to national portions.

5.2.2 Allocation to the international portion of the end-to-end path

The international portion is allocated a block allowance of 2% per intermediate country plus 1% for each terminating country. Furthermore, a distance-based allocation is added to the block allowance. As the international path may pass through intermediate countries, the actual route length between consecutive IGs (one or two for each intermediate country) should be added to calculate the overall length of the international portion. The air-route distance between consecutive IGs should also be determined and multiplied by an appropriate routing factor. This routing factor is specified as follows for each element between IGs:

- if the air route distance between two IGs is < 1 000 km, the routing factor is 1.5;
- if the air route distance is ≥ 1 000 km and < 1 200 km, the calculated route length is taken to be 1 500 km;
- if the air route distance between two IGs is ≥ 1 200 km, the routing factor is 1.25.

When both actual and calculated route lengths are known, the smaller value is retained for each element between IGs for the calculation of the overall length of the international portion. This overall distance should be rounded up to the nearest 100 km but shall not exceed 26 500 km. An allocation of 0.2% per 100 km is then applied to the resulting distance.

In the case where the allocation to the international portion is less than 6%, then 6% shall be used as the allocation.

Independent of the distance spanned, any satellite hop in the international portion receives a 35% allocation of the objectives in Table 1. The 35% allowance completely replaces all distance-based and block allowances otherwise given to parts of the international portion spanned by the satellite hop.

ANNEX A

Examples of path topologies and end-to-end availability performance derivations

A.1 Purpose

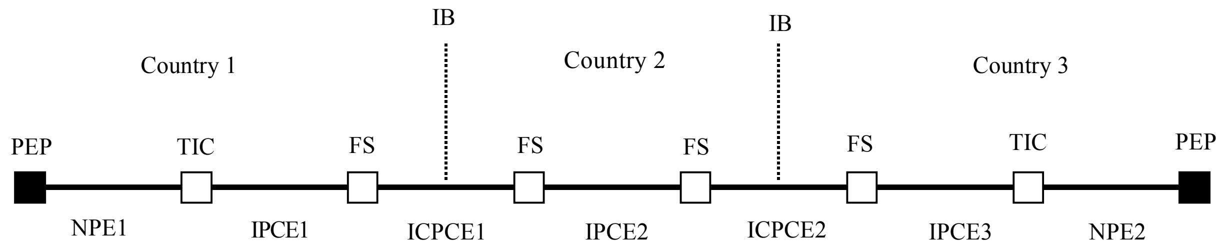
The purpose of this annex is to provide guidance for the calculation of the end-to-end performance of a path from the performances of path elements (PEs), using examples of basic topologies (linear and redundant).

In some cases, more complex topologies will result from negotiations between operators, but the principles of calculation given here will still apply.

Currently, there are no objectives specified for end-to-end performance. This is under study and will be included in a later revision. Only worst-case objectives will be specified for end-to-end availability, the formulae for mean values in this Annex are given for further information.

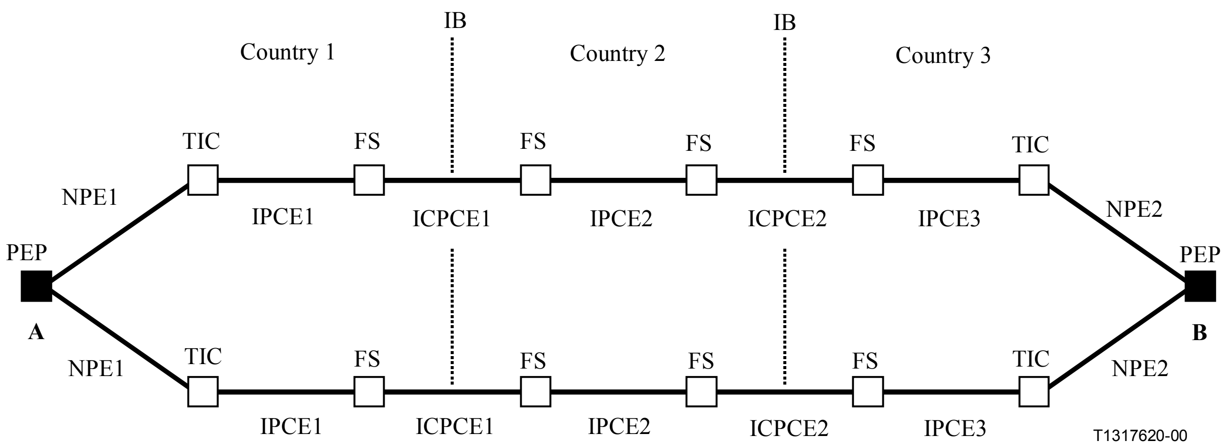
A.2 Path topologies

Figures A.1 and A.2 give the basic path topologies that can be built using the PEs defined in ITU-T G.827. The real configurations illustrated in the following examples are based upon ITU-T M-series Recommendations.



FS	Frontier Station	NPE	National Path Element
IB	International Border	PEP	Path End Point
ICPCE	Inter-Country Path Core Element	TIC	Terminal International Centre
IPCE	International Path Core Element		

Figure A.1/G.827.1 – Example of a path with linear topology



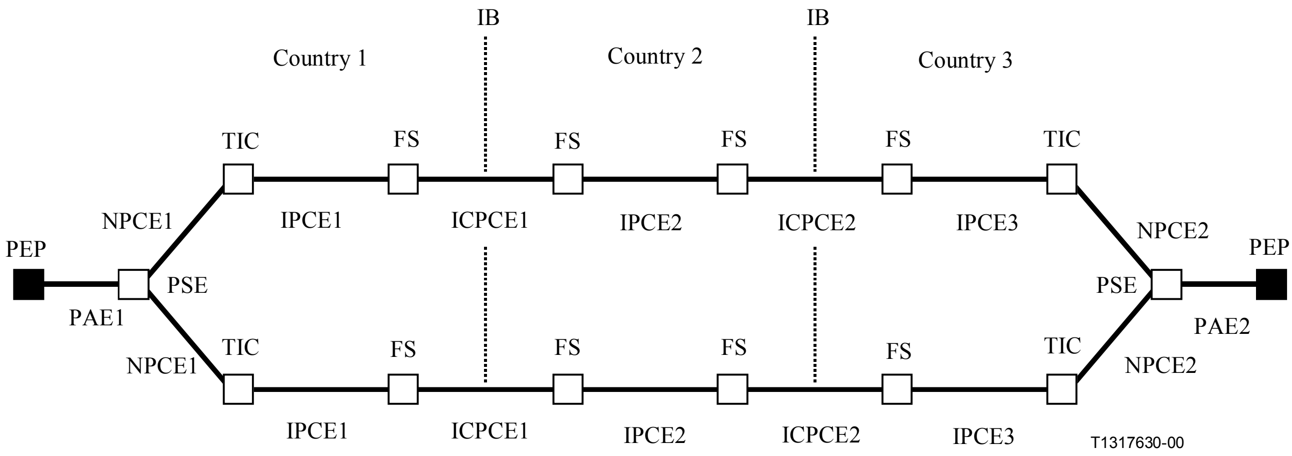
FS	Frontier Station	NPE	National Path Element
IB	International Border	PEP	Path End Point
ICPCE	Inter-Country Path Core Element	TIC	Terminal International Centre
IPCE	International Path Core Element		

Figure A.2/G.827.1 – Example of a path with redundant topology

A path may be built using a linear topology as seen from the outside of each transit and terminating country. This is shown in Figure A.1. Figure A.2 shows the situation in which two independent links are used end-to-end through all transit countries and terminating countries.

The protection is assumed to be on a 1-to-1 basis with one switching device at the receiver side.

More complex configurations will result from a combination of the basic ones. An example is given in Figure A.3.



FS	Frontier Station	PAE	Path Access Element
IB	International Border	PEP	Path End Point
ICPCE	Inter-Country Path Core Element	PSE	Path Switching Element
IPCE	International Path Core Element	TIC	Terminal International Centre
NPCE	National Path Core Element		

Figure A.3/G.827.1 – Example of a path with both linear and redundant topologies

A.3 End-to-end Unavailability

For the purposes of end-to-end calculations, it is more convenient to use the unavailability ratio.

The following notations are used in this paragraph:

ur_{im} mean unavailability ratio of a PE;

ur_{iw} worst-case unavailability ratio of a PE;

UR_M mean unavailability of a path;

UR_W worst-case unavailability of a path.

A.3.1 Linear topology

If a path is made of N path elements used in series, as indicated in Figure A.1, then the following approximations can be used for small values of unavailability ratios:

$$UR_M = \sum_i (ur_{im}) \quad \text{(A-1)}$$

$$UR_W = UR_M + \left\{\sum_i (ur_{iw} - ur_{im})^2\right\}^{1/2} \quad \text{(A-2)}$$

Formula (A-2) assumes that the unavailability ratios of the different PEs follow normal distributions.

A.3.2 Redundant topology

In a redundant configuration using two parallel paths and a protection switch at one end (for each direction of transmission), the availability of the protected path between points A and B in Figure A.2 is:

$$UR_{AB} \approx UR_1 \times UR_2 + UR_S \quad \text{(A-3)}$$

where UR_1, UR_2 are the unavailability ratios of the parallel paths and UR_S is the unavailability of the protection switch (for one direction).

A.3.2.1 Mean values

Replacing UR_1 and UR_2 in Formula (A-3) by their mean values, calculated according to Formula (A-1), leads to the mean value of UR_{AB} as follows:

$$UR_{M(AB)} = UR_{1M} \times UR_{2M} + UR_S \tag{A-4}$$

A.3.2.2 Worst-case values

Replacing UR_1 and UR_2 in Formula (A-3) by their worst-case values, calculated according to Formula (A-2), leads to an upper bound of the worst-case value of UR_{AB} as follows:

$$UR_{W(AB)} \leq UR_{1W} \times UR_{2W} + UR_S \tag{A-5}$$

A.4 End-to-end Outage Intensity

For the purposes of end-to-end calculations, it is more convenient to use the outage intensity parameter.

The following notations are used in this paragraph for outage intensity:

i_{jm} mean outage intensity of a PE;

i_{jw} worst-case outage intensity of a PE;

I_M mean outage intensity of a path;

I_W worst-case outage intensity of a path.

A.4.1 Linear topology

If a path is made of N PEs used in series, as indicated in Figure A.1, then the following formulae can be used to derive the mean and worst-case outage intensities of the end-to-end path:

$$I_M = \sum_j \left(i_{jm}\right) \tag{A-6}$$

$$I_W = I_M + \left\{\sum_j \left(i_{jw} - i_{jm}\right)^2\right\}^{1/2} \tag{A-7}$$

Formula (A-7) assumes that the outage intensities of the various PEs involved follow normal distributions.

A.4.2 Redundant topology

In a redundant configuration using two parallel paths and a protection switch at one end (for each direction of transmission), the outage intensity of the protected path between points A and B in Figure A.2 is:

$$I_{AB} \approx I_i \times UR_2 + I_2 \times UR_1 + I_S \tag{A-8}$$

where I_1 and I_2 are the outage intensities of the parallel paths and I_S is the outage intensity of the switch.

If the mean value for I_{AB} is to be derived, then I_1 and I_2 should be calculated as mean values according to Formula (A-6).

If the worst-case value for I_{AB} is to be derived, then I_1 and I_2 should be calculated as worst-case values according to Formula (A-7). Replacing I_1 and I_2 in Formula (A-8) will lead to an upper bound of the worst-case value of I_{AB}.

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