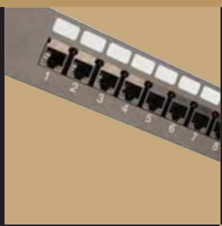
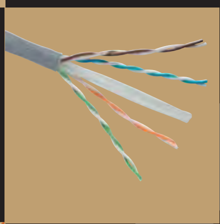
SIGNAMAX™
CONNECTIVITY SYSTEMS

Structured Cabling





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Introduction to Structured Cabling

History

Until the beginning of the 1980's, the majority of computer networks worked in the host/terminal mode. Applications as well as data were stored centrally on a host computer and user stations, so-called terminals, handled them in this centralized way. Considering the text character of this type of communication, it was not necessary to build special high capacity transmission paths in terminal networks.

The prevalence of terminal networks ended in 1981 when IBM launched their first personal computer onto the market. This new type of work station, which, contrary to terminals, was equipped with a local memory and their own outputs for connecting peripherals, meant a different—decentralized—mode of operation for users. This greater independence, however, brought two important issues,

1. Difficult administration of workstations (i.e. problem solving and software installation).
2. Mutual user cooperation.

It was therefore necessary to find a way that would enable to connect the new PC's into a network, through which it would be possible to share files, applications, and costly peripherals in the same manner as it had been previously on terminal networks.

In the beginning, several solutions arose from different producers. The differences in applied technologies and the diversity in the components of these new systems, however, led to their mutual incompatibility. The solution was to design a universal system, which would set recommended standards determining the electrical and physical characteristics of cables as well as connecting hardware. At the beginning of the 1990's, therefore, the American National Standards Institute (ANSI) asked Telecommunications Industry Association (TIA) and Electronic Industries Alliance (EIA) to propose a uniform standard for cabling systems. One of the most suitable ways for the new cabling system design was to use the already existing solution introduced by the American telecommunication company AT&T. These networks used AT&T's telephone distribution systems that were installed in most administrative buildings. They had a star topology and used a twisted pair cable as the main transmission medium. The outcome of the Standards Commission work was the first specification for structured cabling, which was published in July 1991 and was referred to as ANSI/TIA/EIA 568. Together with technical bulletins TSB-36 and TSB-40 issued a little later, the standard defined the basic transmission requirements for Category 3, 4, and 5.

In 1995, the first update of the above mentioned standard and also the first version of an international ISO/IEC 11801 standard were issued. A year later, in 1996, the organization CENELEC published the first European standard for structured cabling, with the designation EN 50173. As a result of a new high-speed protocols development (e.g. Gigabit Ethernet), these standards were updated in 2000 and 2002. The updates defined new parameters, which must be met by structured cabling components in order to comply with the new protocol requirements. The standards were supplemented with further measured or numerated parameters, such as PSNEXT, PSACR, PSELFEXT, Delay Skew, and so on. In these specification updates new Category 5 (today known as Category 5E, please see bellow for more information), and later Category 6 as well as Category 7, were introduced.

Introduction to Structured Cabling

Currently existing categories

Category 3—this is the first and thus oldest category in structured cabling. In the beginning, Category 3 components were used for both voice and data transmissions. The bandwidth was defined up to 16 MHz with data rates of 10 Mbps. Today, Category 3 is predominantly used only for telephone distribution systems (e.g. connection from ISDN patch panels to telephone PBX board, telephone equipment cords etc).

Category 5E—at present, Category 5E (or Enhanced Category 5) is still the most frequently used category in structured cabling. The first standard for Category 5E was published in 2000 and was referred to as ANSI/TIA/EIA 568B.1 (for the American standards), CENELEC EN 50173-1:2000 (for the European standards), and ISO/IEC 11801:2000 (for the international standards). In CENELEC as well as ISO/IEC specifications it is still referred to as Category 5 (i.e. not Category 5E). The “Category 5E” is officially used only in ANSI/TIA/EIA standards; it was originally introduced by the manufactures themselves in order to distinguish between the already existing Category 5 components and the “new” improved Category 5 products (i.e. today known as Category 5E). As mentioned above, Category 5E structured cabling components are suitable for the Gigabit Ethernet protocol (i.e. 1000BaseT), which should fit the requirements of most company networks with regular data traffic. However, the 1 Gbps transmission rate is the limit for all Category 5e components and no further improvement will be possible.

Category 6—the final specification of Category 6 was published in 2002. The document update is known as ANSI/TIA/EIA 568B.2-1 (for the American standards), EN 50173-1:2002 (for the European standards), and ISO/IEC 11801:2002 (for the international standards). Category 6 is specified up to 200 MHz (standard bandwidth) and 250 MHz (testing bandwidth). The double available bandwidth in comparison with Category 5E requires higher component quality. On the other hand, if these quality requirements are met, Category 6 components offer improved performance and transmission reliability.

Category 6A—a new category that is currently being defined by the organizations that set the standard recommendations for structured cabling. The “new” Category 6 will be referred to as “Augmented Category 6” or “Category 6A”. It is developed specifically for the new 10GBaseT Ethernet protocol in mind. Category 6A will offer 500 MHz bandwidth and thus will be suitable for the most data-intensive applications used on metallic computer networks. You can learn more about the 10GBaseT protocol as well as Category 6A further on in this catalogue (please see the “10GBaseT and Structured Cabling” section).

Category 7—this category was first mentioned in 1997, however, its specification was not finished before 2002. Now Category 7 is specified in CENELEC EN 50173-1:2002 and ISO/IEC 11801:2002 standards; in the TIA/EIA standards Category 7 is not mentioned. The bandwidth that is defined for the current Category 7 is 600 MHz (standard bandwidth) and 750 MHz (testing bandwidth). With reference to the Category 6a and its 500 MHz frequency, it will be necessary to re-define the current Category 7. It is estimated that a “new” Category 7 will be introduced and it will be referred to as “Augmented Category 7” or “Category 7A” with the bandwidth of up to 1,000 MHz.

The table bellow shows supported protocols, bandwidth, maximum transmission rates, and recommended use for all categories.

	Cat 3	Cat 4	Cat 5	Cat 5E	Cat 6	Cat 6A	Cat 7	Cat 7A
Supported Protocols	Analog. Voice, ISDN, 10BaseT	IBM Token Ring	100BaseT and lower	1000BaseT and lower	1000BaseTX and lower	10GBaseT and lower	10GBaseT and lower	10GBaseT and lower
Bandwidth	16 MHz	20 MHz	100 MHz	100 MHz	200 MHz/ 250 MHz	500 MHz	600 MHz/ 750 MHz	1,000 MHz
Maximum Transmission Rate	10 Mbps	16 Mbps	100 Mbps (Fast Ethernet)	1,000 Mbps (Gigabit Ethernet)	1,000 Mbps (Gigabit Ethernet)	10 Gbps	10 Gbps	10 Gbps
Usability	Predominantly telephone distribution systems	No longer installed	No longer installed	Regular data and voice traffic	Higher data traffic (multimedia, streaming)	High data traffic, backbone distribution systems, SAN	High data traffic, backbone distribution systems, SAN	High data traffic, backbone distribution systems, SAN

Introduction to Structured Cabling

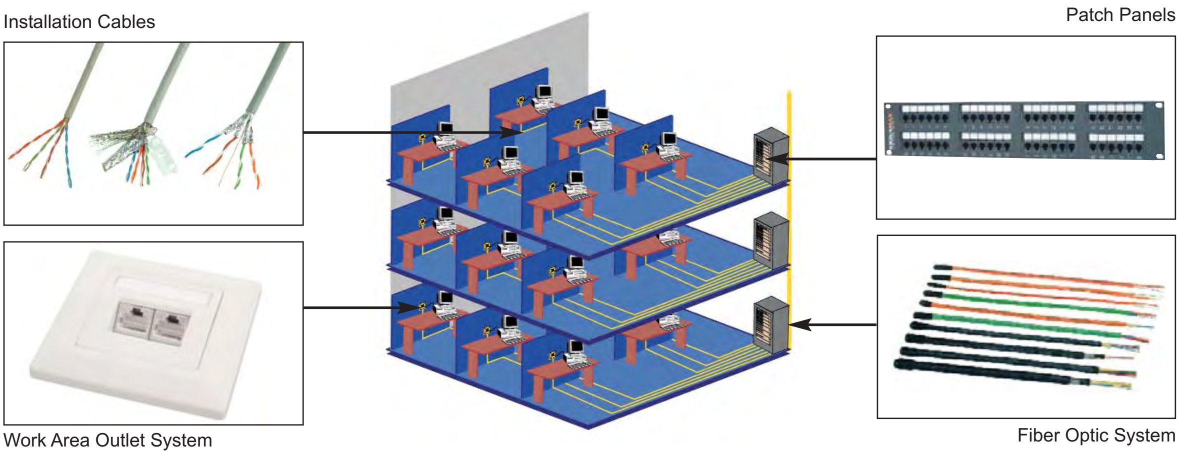
In the ISO/IEC 11801 generic cabling standard document, further copper cabling distinctions referred to as “Classes” were introduced. Classes are used for classifying the permanent link or channel performance rather than for rating the individual structured cabling components. The brief description of all classes as specified in the ISO/IEC standard is the following:

Class A – analogue voice telephony with the bandwidth of up to 10 KHz.
Class B – frequencies up to 1 MHz for voice and slow data links (i.e. IBM 3270 terminals etc.)
Class C – this class corresponds to a permanent link or channel performance using Category 3 components. Similarly to Category 3, it covers the bandwidth of up to 16 MHz. Its primary application today is to classify telephone distribution systems.
Class D – ratified in 1995 but updated in 2000 and 2002. Today Class D covers the bandwidth of up to 100 MHz.
Class E – this class was finished in 2002. Class E corresponds to the permanent link or channel performance using Category 6 components with the bandwidth of up to 200 MHz as standard and 250 MHz as the bandwidth to which Class E/Category 6 is actually tested.
Class E_A – a new class that is currently being defined. Class E_A will be specified up to 500 MHz and corresponds to permanent link or channel performance of Category 6A cabling. In particular, Class E_A is aimed to be used with 10GBaseT protocol.
Class F – this class covers the standard bandwidth of up to 600 MHz and the testing bandwidth of up to 750 MHz. Class F corresponds to the permanent link or channel performance of Category 7 components.

What is Structured Cabling?

Structured cabling is a universal system

- **that supports digital as well as analog signal transmissions,**
- **in which the telecommunication outlets are installed even in locations where they are not needed at the moment of installation,**
- **that use data cables with four twisted pairs and fiber cables,**
- **in which long technical and also moral service life is expected,**
- **whose correct functionality is as important for a company as the functioning of the electrical distribution system or any other system in company’s infrastructure.**



Structured Cabling Testing

Testing has a major significance for the correct functionality of structured cabling. Testing devices are able to measure installed components and determine whether all requirements defined in the international standards necessary for reliable operation have been met. For Category 5e and Category 6 the following main parameters are measured:

Wire Map

This parameter checks the correct termination of cable wires in telecommunication outlets and patch panels, including the shielding in STP cabling. At the same time, it checks the signal throughput on the whole cable length—i.e. it is able to show any open-circuit or short circuit faults. The Wire Map parameter is very important but in itself it cannot ensure the correct functionality of an installed computer network.

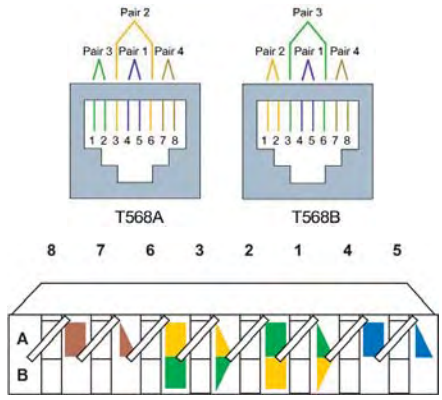
What to do if the Wire Map parameter fails?

First, it is necessary to check whether the individual wires have been installed correctly in the termination block. If so (i.e. the wire map corresponds to the standardized T568A or T568B schemes) and the Wire Map parameter still fails, there could be several causes for this: an incorrectly terminated wire in the termination block, a wire interruption inside the cable, or a short-circuit. Advanced testing devices are able to determine the location of the fault with a relatively high accuracy and by doing so make fixing the problem easier.

T568A and T568B wire map schemes:

T568A
1. white-green
2. green
3. white-orange
4. blue
5. white-blue
6. orange
7. white-brown
8. brown

T568B
1. white-orange
2. orange
3. white-green
4. blue
5. white-blue
6. green
7. white-brown
8. brown



NEXT (Near End Cross Talk)

NEXT is the value that expresses how much signal can get from one pair to another pair within one cable. The measurement of cross-talk at the near end takes place at the same end of the cable as the location of the signal source. For this parameter, all combinations of pairs are measured within one cable—i.e. 12-36, 12-45, 12-78, 36-45, 36-78, 45-78. This measuring is done for both ends.

What to do if the NEXT parameter fails?

First, it is essential to find out at which end of the cable NEXT is showing the error (this function is supported by all advanced testing devices). Then it is necessary to check the maximum permitted unlaid of wires in one pair on the termination block—that should not be more than 13 mm. Typically for category 6, the 13 mm does not necessarily ensure that the NEXT parameter will pass so it is essential to keep the pair unlaid as short as possible. It is also important that the original twisting of each pair is preserved during installation and that there is no air core between the twisted wires in a pair. A frequent source of cross-talk problems can also be the use of cable couplings. Hence if a cable is not long enough, it is better to replace it with a cable of a corresponding length rather than use couplings.

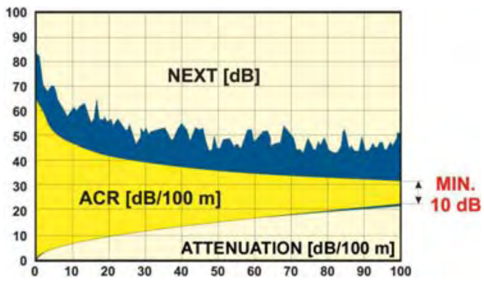
Attenuation

Attenuation shows the difference between the strength of the initial signal and the strength of the signal after it gets to the other end of the wire. It is caused mainly by the wire resistance and is usually larger for higher frequencies. Attenuation also increases as the diameter of the cable decreases—this means that a cable with a size of AWG 24 has a slightly higher attenuation than an AWG 23 cable.

What to do if the attenuation parameter fails?

The length of the horizontal cable must be checked—i.e. whether the electrical length of the link (the actual length of the twisted pairs inside the cable) corresponds to the maximum permitted permanent link of 90 m. A frequent cause of higher attenuation is also an incorrectly terminated wire in patch panels, outlets, or keystones.

Structured Cabling Testing



ACR (Attenuation to Crosstalk Ratio)
ACR is a theoretical parameter (i.e. it is not measured but is deduced from two previously measured values) which shows the margin between the NEXT and attenuation values: ACR [dB] = NEXT [dB] - A [dB]. If the level of attenuation meets or approaches the level of near end cross-talk, the transmitted signal will be lost. The interval between NEXT and attenuation must be at least 10 dB.

What to do if the ACR parameter fails?
As the ACR parameter is dependent on the NEXT as well as attenuation values, an improvement of these two parameters will influence the resulting ACR values.

FEXT (Far End Cross Talk)
FEXT expresses the cross-talk of the signal from one pair to another pair within one cable measured at the far end. This is the same parameter as NEXT, only with FEXT, the measurement is done at a different cable end. Again, all combinations of pairs are measured within one cable—i.e. 12-36, 12-45, 12-78, 36-45, 36-78, and 45-78. FEXT servers an important basis for the following ELFEXT parameter.

ELFEXT (Equal Level Far End Cross Talk)
ELFEXT corresponds much better to the actual situation during data transfer than FEXT. It is because the cross-talk inside the cable decreases as the attenuation increases. Just as with ACR, ELFEXT is a theoretical parameter (i.e. it is not measured but is calculated from other previously measured values): ELFEXT [dB] = FEXT [dB] - A [dB]. Thus ELFEXT is the cross-talk at the far end decreased by the attenuation.

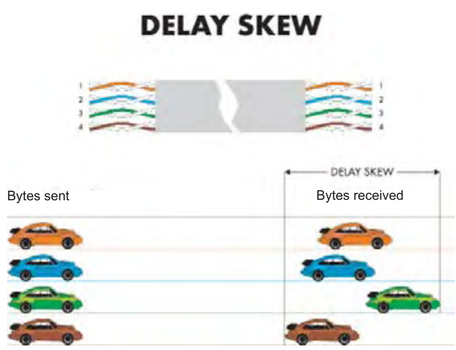
PSNEXT (Power Sum NEXT)
PSNEXT is a theoretical value calculated from the previously measured NEXT. The PSNEXT parameter is primarily important for protocols that use all four pairs for signal transfer (e.g. Gigabit Ethernet). The output sum of cross-talk at the near end shows how much signal gets from three pairs to the remaining fourth pair. The source of the signal and measurement of cross-talk takes place at the same end of the cable.

What to do if the PSNEXT parameter fails?
Just as with other parameters, PSNEXT is also influenced by the measured values of NEXT. Thus, an improvement in the near end cross-talk value will affect the resulting value of PSNEXT.

PSELFEXT (Power Sum ELFEXT)
PSELFEXT is calculated from the ELFEXT value. Just like PSNEXT, this parameter is important for protocols that use all four pairs for signal transfer. PSELFEXT expresses how much signal in the same cable gets from three pairs to the remaining fourth pair. The source of the signal and measurement of cross-talk takes place at opposite ends of the cable.

Propagation Delay
This value expresses a delay of the signal travelling from one end of the cable to the other. The typical delay of the signal in a category 5e cable is around 5 ns per 1 m; the permitted limit is 5.7 ns per 1 m, which is 570 ns per 100 m. Propagation Delay also serves as a basis for testing the Delay Skew value.

Delay Skew
Delay Skew shows the difference in signal delay between the fastest and the slowest pair. The Delay Skew parameter is affected by (1.) different length of the pairs; (2.) difference in material (resistance, impedance etc.); (3.) the effect of surrounding interference. If the difference is too great, there can be an incorrect interpretation of data by the active device (usually a switch, network card, etc.). Just as for PSNEXT and PSELFEXT, the Delay Skew parameter is critical for protocols that use all four pairs, such as Gigabit Ethernet.

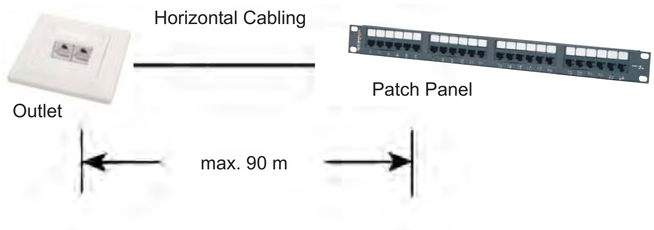


Structured Cabling Testing

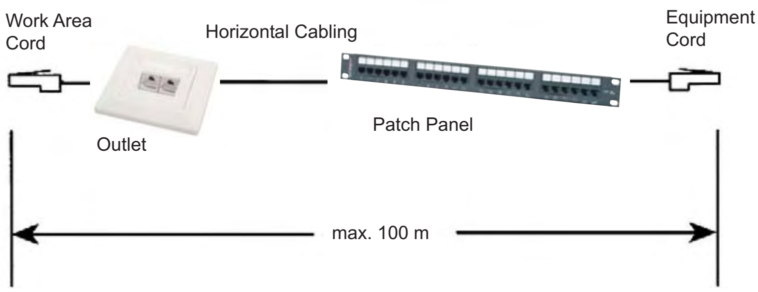
Length
There is a direct proportionality between the length and attenuation (i.e. the longer the length of cable, the higher the attenuation). Testing devices use so-called TDR (Time Domain Reflectometery) for measuring lengths. This means that a pulse is sent down the cable, then it is reflected back onto the remote unit, and subsequently the time during which the pulse travels the whole track is recorded. Based on the NVP (i.e. Nominal Velocity of Propagation, which expresses the signal speed in the cable as compared to the speed of light in a vacuum), the length of the measured segment is calculated. This concerns the length of the twisted pairs inside the cable (so-called electrical length), not “untangled” cable (so-called physical length). At 85 m, the variation between electrical and physical length can be up to 5 m depending on the twisting of each pair.

Return Loss
Return Loss shows the reflection of the signal because of varying impedance at different cable parts. Due to these impedance imbalances, part of the energy can return to the transmitter, which can cause the signal interference.

When testing structured cabling, two basic topologies are used:
Permanent link—the connection from the patch panel to the work area telecommunication outlet (i.e. horizontal cabling); this is the most permanent fixture on the structured caballing and cannot easily be taken apart. The maximum permitted length is 90 m.



Channel—the connection from the active device (e.g. switch) in the data rack to the network card in the computer, patch cords included. The recommended maximum length of an equipment cord in the data rack is 5 m; the maximum recommended length for work area cord is 20 m. The length of the channel (i.e. the horizontal caballing plus equipment cord as well as work area cord) should not exceed 100 m.



10GBaseT and Structured Cabling

Gigabit Ethernet was, until recently, considered to be the limit that would be very difficult to overcome on metallic structured cabling. Now it is obvious that 1 Gbps will not be the maximum transmission rate that can be achieved on copper twisted pair cables. The new 10GBaseT Ethernet standard that was published in June 2006 by the IEEE 802.3an group proves this. In the first stage, this new protocol with transmission speeds of up to 10 Gbps will be primarily employed in backbone distribution systems, SAN's (Storage Area Networks), and data centers.

1. Running 10GBaseT on currently existing cabling
The document ANSI/TIA/EIA TSB 155 deals with operating 10GBaseT over currently existing Category 5E and 6 cablings. The test results performed in connection with this bulletin showed that it will not be possible to run 10 Gbps data transfers on Category 5E networks and that on current unshielded Category 6 cabling the 10GBaseT protocol will be able to operate for a distance of up to 55 m. This length limitation should be improved on shielded Category 6 systems but it is highly recommended to use Category 6A components for all new 10G installations as the this new category was primarily designed to provide full compatibility with no length or other limitations for the 10GBaseT. The factor that plays an important role in the above mentioned length restriction is the so-called Alien Crosstalk. It is influenced by the amount of crosstalk signal from external sources, such as other cables in a cable bundle, electronic devices operated nearby, telephones, etc.

2. New requirements for future cabling systems for 10GBaseT
As it was already mentioned, a new category with bandwidth of up to 500 MHz (i.e. double of what is available for the current Category 6) was defined to ensure full compatibility of cabling systems with the 10GBaseT protocol, both including the Permanent Link and Channel topologies as well as unscreened and screened cablings. This new category is referred to as “Augmented Category 6” or “Category 6A” and will be published in the upcoming structured cabling specification updates (e.g. ANSI/TIA/EIA 568B.2-10). These updates are currently available in drafts and will be published for the wide public very soon.

Similarly to Category 6A, a “new” Category 7 will be defined. It will be referred to as “Augmented Category 7” or “Category 7A” with bandwidth of up to 1,000 MHz (as compared to 600 MHz of the current Category 7).

Signamax Category 7 shielded cable parameters (at temperature of 20°C).
The cable supports 10GBaseT. See page K1 for more.

f (MHz)	Attenuation (dB/100 m)	NEXT (dB)	PS-NEXT (dB)	ACR (dB/100 m)	PS-ACR (dB/100 m)	ELFEXT (dB/100 m)	PS-ELFEXT (dB/100 m)	Return loss (dB)
1	1.8	100	97	98	95	105	105	–
4	3.4	100	97	97	94	105	102	27
10	5.4	100	97	95	92	97	94	30
16	6.8	100	97	93	90	93	90	30
20	7.7	100	97	92	89	91	88	30
31.2	9.6	100	97	90	87	87	84	30
62.5	13.7	100	97	86	83	81	78	30
100	17.4	100	97	83	80	77	74	30
125	19.5	95	92	75	72	75	72	26
155.5	21.9	94	91	72	69	73	70	26
175	23.3	93	90	70	67	72	69	25
200	25.0	92	89	67	64	71	68	25
250	28.1	90	87	62	59	69	66	24
300	30.9	89	86	58	55	67	64	24
450	38.3	87	84	48	45	64	61	23
600	44.8	85	82	40	37	61	58	22
750	52.0	83	80	31	28	59	56	21
900	59.4	82	79	23	20	58	55	20

Signamax Category 6A shielded cable parameters (at temperature of 20°C).
The cable supports 10GBaseT.

f (MHz)	Attenuation (dB/100 m)	NEXT (dB)	PS-NEXT (dB)	ACR (dB/100 m)	PS-ACR (dB/100 m)	ELFEXT (dB/100 m)	PS-ELFEXT (dB/100 m)	Return loss (dB)
1	1.8	100	97	98	95	105	105	–
4	3.4	100	97	97	94	105	102	27
10	5.4	100	97	95	92	97	94	30
16	6.8	100	97	93	90	93	90	30
20	7.7	100	97	92	89	91	88	30
31.2	9.6	100	97	90	87	87	84	30
62.5	13.7	100	97	86	83	81	78	30
100	17.4	100	97	83	80	77	74	30
125	19.5	95	92	75	72	75	72	26
155.5	21.9	94	91	72	69	73	70	26
175	23.3	93	90	70	67	72	69	25
200	25.0	92	89	67	64	71	68	25
250	28.1	90	87	62	59	69	66	24
300	30.9	89	86	58	55	67	64	24
400	38.3	87	84	48	45	64	61	23
500	44.8	85	82	40	37	61	58	22