

NETminer™
Link Monitors & BER Testers
For Fibre Channel & Gigabit Ethernet™

Models # NM-30/40/50/70

User's Manual

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Revision 1.10

June 6, 2003

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1. *DESCRIPTION OF EQUIPMENT*

1.1 INTRODUCTION

There were times when we could repair almost any equipment in our house. At the beginning of the twentieth century, any blacksmith could repair the Ford model-T. Even in the Middle Ages (understand the 1940's and almost through the 1970's) we could fix our Chevy or Buick with a screwdriver and a hammer. Today's cars require specialized equipment and we must go to the dealer even though we hate the high price they charge us. The mechanics in the dealers shop then need to use specialized instruments to diagnose the problems. Then when they do the tune-up they have to read certain numbers on their testers and compare them to tables in their manuals, without understanding what and why they actually do that. Similarly, we could fix a light bulb, or even the radio or the famous RS232 interface, but now, the Fibre Channel, the GigabitEthernet (GbE) and other similar protocols require specially trained technician or an engineer with specialized and expensive equipment to do the work.

When working with communications protocols like Fibre Channel or GbEthernet, you cannot see simply "from the outside" whether the link is up, whether the traffic is running smoothly or is making errors, or if it is running at all. Before you know what is happening on the wire, you must deserialize the incoming (serial) signal, detect where the byte or word starts by detecting the "coma" characters (K28.5) in the serial bit stream. Then you must decode the incoming 10B codes by translating them to 8B and verify that only the selected legal codes are being used, you must monitor running disparity, recalculate and check the CRC (Cyclic Redundancy Check code) and check the end of every frame to verify that the frame format is correct.

The NETminerTM (or any such tool) is physically spliced (daisy-chained) in the FC link, so both signals of the full duplex link must be repeated and retransmitted. In most instruments (including the NETminerTM) the signal must be re-clocked (i.e. cleaned up before retransmission). This requires synchronization with a new crystal clock, which in turn requires using an "elasticity buffer" that allows insertion or deletion of Idle words between frames.

I hope that it is clear to you by now that there is no simple, quick, and cheap way of monitoring, diagnosing, or troubleshooting an FC or GbE link. If you want to race with the Porsches or Ferraries, you have to train more and spend more \$\$\$\$. Times of the venerable old Ford model T are history.

The NETminerTM is an instrument that can be used for monitoring traffic on Fibre Channel and/or Gigabit Ethernet links and for performing bit error rate testing (BERT) on cables and data transceiver modules (i.e. SFPs or GBICs). It supports standard Fibre Channel speeds of

either 1.062Gps or 2.125Gbps, and the Gigabit Ethernet at 1.25Gbps. It is intended for use by technicians working in the field, in the lab, or in production, as well as for use by engineers developing FC or GbE devices.

The NETminer™ has been designed for maximum flexibility, portability, and universality. It is a standalone instrument, packaged in a small, lightweight aluminum enclosure (5.5" x 7.3" x 1.1"). It uses standard GBIC and SFP transceivers. When used for link monitoring, it displays the link activity on eight LEDs (per channel), and on a 2 x 20 character LCD screen. Besides blinking LEDs showing the traffic in Real Time, it also counts frames, bytes, errors, and detects bus reset conditions and shows the total counts on the LCD. It also shows utilization of the link (in %) in a bargraph on the LCD.

Applications include FC or GbE link monitoring, performance estimation, copper/optical media conversion, or cable extension. The simple BERT tester mode allows Go/NoGo testing of cables, GBICs, or SFPs, reading SFP/GBIC module ID information, and measuring latency in the cable and cable length estimating.

The BERT function generates and transmits test pattern traffic that consists out of frames carrying strings of bytes and bits designed specifically to stress test the link for testing cables or transceivers. On the receiving side it checks for CRC errors and displays the test results together with elapsed time.

NOTE:

The NETminer™ functionality is being released in phases:

- Phase-1: FC support, GBIC and SFP, LEDs and LCD, BERT and Cable Length, USB 2.0 support (RELEASED)
- Phase-2: GbEthernet monitoring and BERT testing (RELEASED)
- Phase-3: GUI for Performance monitoring on a PC host (early 3Q03)
- Phase-4: Field Upgrades in the field via USB 2-0 port (3Q03)

Ancot expects that some customers may require specific additional functions, different packaging, private label, etc. If interested, contact the factory for a quote.

1.2 OVERVIEW

1.2.1 FEATURES

GENERAL FEATURES

- Two pairs of 1.0625/2.125/1.25 Gbps SFP or GBIC based Fibre Channel (or GbE ports)
- Dedicated Elasticity buffers and Re-timing circuitry
- Supports Fibre Channel Point to Point, Fabric and Arbitrated Loop topologies
- Supports GigabitEthernet (GbE)
- Monitors both channels simultaneously
- Dedicated LEDs for reporting status and errors on each channel
- Single LCD (2 x 20 chars) screen for displaying selected statistics and functions
- Push-button switches for selecting functions
- Low cost BERT using standard jitter test patterns for testing cables and GBIC/SFPs
- any SFP type transceivers supported
- any 5-volt or 3.3/5-volt type GBIC transceivers supported

MISCELLANEOUS FEATURES

External data port is USB 2.0 compatible. The USB port is used for transferring status information (statistics counts) about each channel to a PC host for further processing. The USB port will also be used for downloading new revisions of the FPGA code for updates in the field (Phase-4)

The Ethernet functions and the Fibre Channel functions each use its own separate configuration internal EEPROM. Selection of this EEPROM is done with a slider switch located on the left side of the case. The NETminer™ is configured for the FC or the GbE on power-up. Use the power switch located on the left side of the case.

To provide economical solutions to different customer requirements, the NETminer™ is available in four standard models: The NM-30, NM-40, NM-50, and NM-70. See the following table for a list of functions in each model and availability information:

	GbEthernet		Fibre Channel				
Model:	Link Monitor	BERT	Link Monitor	BERT	USB 2.0	Perform. Analysis	Available
NM-30		X		X	X	2Q03	Now
NM-40	X	X			X	2Q03	Now
NM-50			X	X	X	2Q03	Now
NM-70	X	X	X	X	X	2Q03	Now

NETminer™ models schedule

1.2.2 PACKAGING AND POWER

The NETminer™ is packaged in a compact, high quality aluminum enclosure.

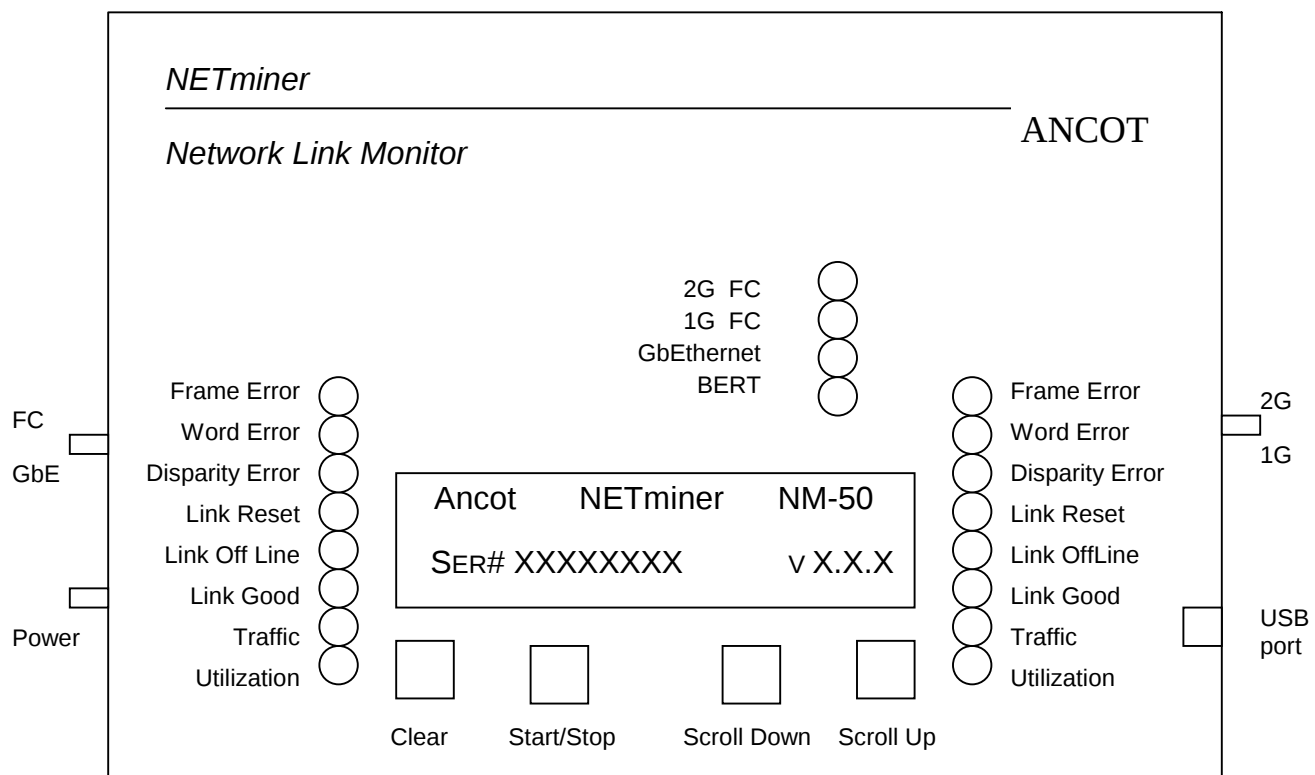
Dimensions: 5.5"x 7.3" x 1.1"

Power consumption: 1.5Amp max at 5Volt DC

Power supply: external 110/220 volt, 50-60Hz auto-ranging

1.2.3 THE CONTROL PANEL

The control panel has four push-button switches, twenty LED indicators and a two line, twenty characters per line LCD screen. Below is an illustration of the control panel layout. The circles represent the LEDs while the squares are the push-button switches.



1.2.4 LED ERROR INDICATORS

The following list details the operation of the error indicators for each channel. All error indicators are red color LEDs.

Frame Error

This LED monitors errors associated with a frame transmission.
In the FC mode this includes CRC errors and wrong EOF.
In the GbE mode this includes CRC errors and truncated frames.

Word Error

This LED monitors transmission words for illegal 10B encoding.

Link Reset

In FC mode this LED monitors the channel for the occurrence of any LR, LRR or LIP primitives.
In GbE mode This LED checks for a configuration primitive.

Link Off-line

In FC mode this LED monitors the channel for the occurrence of the NOS or OLS primitives.
In GbE mode this LED checks for a configuration primitive with the Offline bit encoding.

Disparity Error

This LED monitors the channel for the occurrence of disparity errors in the received data.

1.2.5 LED MONITOR STATUS INDICATORS

The following list details the operation of the status indicators for each channel.

Link Good (green)

This LED is driven by the Loss of Sync (LOS) state machine. This LED is off until the receiver has achieved word sync. If the actual speed of the traffic on the link does not match the speed selected (by the 1G / 2G FC switch on the right or the GbE / FC switch on the left side) this LED will be blinking.

Link Traffic (yellow)

This LED monitors the channel for any non-fill words. An FC fillword is defined as an IDLE or any ARB. A GbE fillword is defined as an IDLE or Carrier Extent. If a non-fill word or a frame is detected on the link this LED turns On for a few hundred milliseconds.

Link Utilization (yellow)

This LED indicates the level of link utilization. Link utilization is defined as the ratio of non-fill words to the total bandwidth. This LED stays off if the utilization is less than 20%.. If utilization is between 20% and 50% the LED blinks slowly, if it is between 50% and 80% the LED blinks rapidly, and if it is over 80% the LED stays on.

1.2.6 OTHER LED INDICATORS**FC or GbE Protocol Indicators (yellow)**

There are three LED indicators that show whether the device is configured as a Fibre Channel 1G / 2G or GbEthernet tool.

Speed Indicators (yellow)

The two FC (Fibre Channel) indicators show what speed is currently selected when the NETminerTM is monitoring Fibre Channel traffic. The lower LED indicates the 1.0625Gbps operation and the upper LED indicates the 2.125Gbps. Moving the FC Speed Select switch (on the right side of the enclosure) toggles between the two speeds. The speed is set immediately, as soon as the switch is changed, however we recommend that you restart the unit (by switching the Power Of and On again) because some counters may have counted errors during this transition.

If the GbEthernet functionality (is included in the unit and) is enabled, the FC Speed Select switch is ignored, the two FC speed indicators stay Off and the GbEthernet indicator is On.

1.2.7 CONTROL PANEL SWITCHES

The following is a list of the control panel switches, push-buttons, with descriptions of their function.

Configuration Select

This is a slide switch that selects between Fibre Channel or GbEthernet functionality. It is located on the left side panel of the unit.

Power On

This is a toggle switch that reloads the FPGA with the appropriate code indicated by the Configuration Select switch and the Speed selection, then it restarts the tool. It is located next to the Configuration Select switch on the left side of the enclosure.

Speed Select

This slide switch, located on the right side panel of the unit, selects between 1.062 Gbps and 2.125 Gbps for the Fibre Channel mode. The appropriate speed LED turns On in response to this input. If the NETminer is connected to a live FC link and the speed switch is selected wrong, the device will not recognize the incoming signal and the Link Good LED will be blinking. Always restart NETminer (turn the power Off and On) if you change the speed selection. This speed select switch is ignored if GbEthernet mode is enabled.

Clear

This push-button switch, when pressed, clears all latched error flags, the elapsed time counter, and the maximum latch of the utilization bargraph. If pressed when a BERT is running, all error counters (and latches) and the timer will be cleared, but the BERT operation will continue without interruption.

Start / Stop

This switch is used to start or stop the BERT operation and execute various selections.

Scroll Up & Down

These switches are used to scroll through the list of functions on the LCD. Each time they are pressed the LCD displays the next or previous function in a predefined list.

Read Section 2.4 for a detailed description of operation of these four push-buttons.

1.2.8 LIQUID CRYSTAL DISPLAY (LCD)

The LCD is a small, two-line display with 20 characters per line. It is used to display various statistics about each channel. Below is a list of the functions displayed by the LCD. Each display shows the statistics for Channel A on the top and Channel B on the bottom row.

On power up (use the switch on the left side of the unit) the initial screen is displayed.

Ancot NETminer	NM-50
Ser# XXXXXXXX	v1.6.5

The "Ser# XXXX" on the left bottom is the serial number of the unit. The "v.X.X.X" on the right is the revision number of the embedded SW.

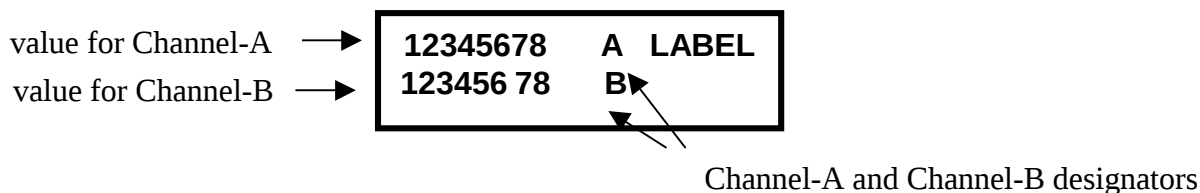
This initial screen stays for about five seconds following Power Up; after about five seconds, or when any of the push-buttons is pressed, it is replaced by the Data Link Monitor starting screen.

The initial screen is shown only briefly following the Power Up, it cannot be entered using the push-buttons.



From this point on, use the Scroll Up or Down push-buttons to go sequentially through all the other selections in a circular fashion. The initial screen is shown only once and will not be shown again unless the NETminer™ is restarted.

The generic format of the statistics counters data displays is as follows:

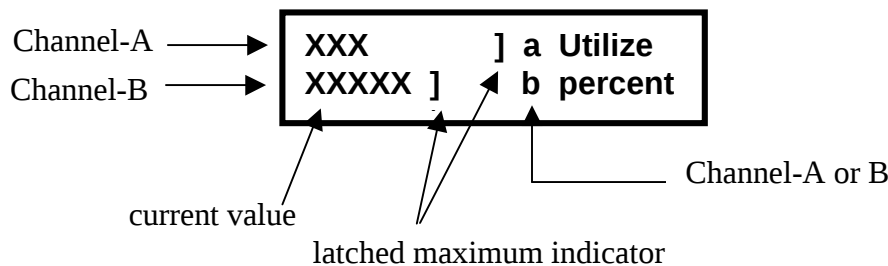


There are two numbers shown, each up to 10 digits long: the upper one is a value for Channel-A and the lower one is for Channel-B. The maximum count is 4,294,967,295. When this value is reached, the counter stops and a “overflow” message is displayed instead.

Some of the displays show “filtered” or “other” frames or data. In the FC mode the “filtered data frames” are the “solicited” kind which have a value of x01 in the R_CTL field of the frame header. In the GbE mode the “filtered data frames” are the “MAC Control” kind which have a value of 88-08 in the link type field. The term “solicited” as defined by the Fibre Channel specification is data that has been specifically solicited. It is sometimes also called “Data data” or “Data frames”. The term “unsolicited” refers to data associated with a command or status. It is sometimes called “Overhead data”. As an example, a Read command executes as a series of frames: First, a command frame with the op-code = Read and several parameters is sent to the target, then the target device responds by sending the frames requested, followed by a frame that carries the status. In this case, the command frame and the response (status) frame carry “unsolicited data” in their payload, and the data frames sent by the target carry the “solicited data”. The word “filtered” refers to an internal filter that is programmed to exclude a certain part of the traffic to be counted. In standalone applications, this fileter is set up as described above. If an external PC (laptop or other) is used to control the NETminer (via the USB 2.0 port) then a client utility can be used to change the filter setting.

Link Utilization

This function displays the current and the maximum link utilization value. Link utilization is defined as the ratio of all non-fillwords to the total available bandwidth. In FC, a fillword is defined as either an IDLE or (any of the) ARB. In GbE a fillword is an IDLE or Carrier Extent. Link utilization is displayed as a bargraph in 100 steps. The left part of the bar (shown here as “XXX”) represents the current value. The “]” to the right of the bar is the latched maximum indicator. The latched maximum indicator can be reset by the CLEAR push-button.



Data Counts

This is the total data count in bytes calculated by counting only payload bytes. There are two data count displays: one for filtered data frames only and one for all other frames.

In the FC mode the “filtered data frames” are the “solicited” kind which have a value of x01 in the R_CTL field of the frame header.

In the GbE mode the “filtered data frames” are the “MAC Control” kind which have a value of 88-08 in the link type field.

Frame Counts

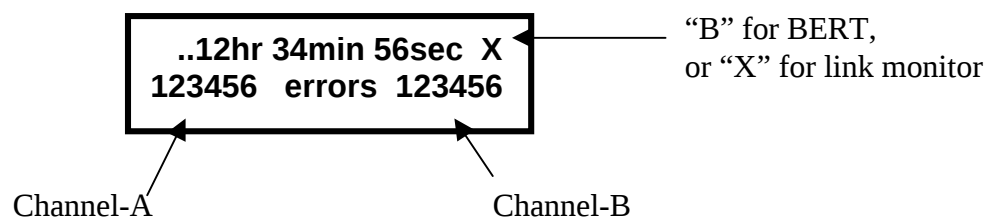
The total frame count is displayed as Frames. There are two different frame displays: one for filtered data frames only and one for all other frames.

In the FC mode the “filtered data frames” are the “solicited” kind which have a value of x01 in the R_CTL field of the frame header.

In the GbE mode the “filtered data frames” are the “MAC Control” kind which have a value of 88-08 in the link type field.

Elapsed Time and Error Count

This display shows the elapsed time and the total accumulated error count for each channel since the last time the CLEAR switch was pressed. This screen is also used during the BERT. During BERT testing, the LCD shows a “B” in the upper right corner. During link monitoring it shows an “X”.



Note that when the error counters reach their maximum displayable value of 999,999, they stop counting and a message “Overflow” is displayed on the screen. The NETminer™ stops counting at this point assuming that if the actual count is too high, it does not add to the clarity of the information. Errors should not occur at all in live systems, but if there are errors, it may be useful to know whether there was a single isolated error or a few sporadic intermittent errors. When there are very many errors, usually more than a dozen or possibly a hundred, we know that we have a serious problem which needs to be addressed, and the exact error count does not add anything to the information we already have.

If there is no signal detected in the Channel-A or Channel-B receiver the “No Sig” message is displayed for that channel.

The time counter can count up to 9,999 hours, which would be over a year before it would wrap around.

The error count and the time can be reset by pressing the CLEAR push-button.

The “X” or “B” marker in the upper right indicates the Link Monitoring or the BERT mode respectively.

1.2.9 FIBRE CHANNEL TRANSMISSION SPEED SELECTION

The Fibre Channel traffic can operate at two different speeds: the 1.062Gbps and the 2.125Gbps. The NETminer™ is a test tool that must be transparent to the FC link under test; therefore it cannot participate in the speed negotiation cycle. The speed in the NETminer™ must be selected (manually) by the user. When in the FC mode (selected by the slider switch on the left side of the case) the 1G or 2G speed can be selected by a similar slider switch located on the right side of the case. When switched, a corresponding crystal is internally enabled to drive the internal circuitry. The switching occurs instantly, however we still recommend that you restart the unit, since it could have counted errors during the transition. If the GbEthernet mode is selected the FC speed selection switch is ignored and the crystal corresponding to the GbE speed of 1.25Gbps is internally enabled.

1.2.10 PLUGGABLE TRANSCEIVERS (SFPs & GBICs)

The NETminer™ supports both types of transceivers. The newer transceivers are called SFP (Small Form Pluggable) and the older ones are called GBIC. The GBIC is the original transceiver that was initially introduced for the 1.062Gbps FC and is still used in most 1G FC systems and in most 1.25Gbps GbE systems. The SFP was introduced later when the FC speed

was increased to 2.125Gbps, and is now used in almost all (1/2G FC as well as GbE) systems shipped today. The SFP module AC characteristics are better suited for the higher speeds.

There are four receptacle sockets provided on the NETminer™, two for SFPs and two for GBICs. One SFP and one GBIC on the left side of the case are for channel-A. Similarly, one SFP and one GBIC on the right side of the case are for channel-B. Either the SFP or GBIC can be used, its presence is detected automatically when the module is inserted, cable is connected, and the signal is applied. If both transceivers (the SFP and GBIC) are activated on one side at the same time, then the NETminer™ selects the SFP and ignores the GBIC. Note that the two transmitters in the GBIC and SFP (on each channel) are driven with the same signal even though the receiver on one of them is ignored.

The plug-in transceivers are available for all standard speeds and media: for FC 1G, FC 2G, or dual FC speed, GbE 1.25G speed, copper, optical Multimode or SingleMode. They are available for all levels of standard output and input power.

2. FUNCTIONAL OVERVIEW

2.1 INTRODUCTION

The NETminer[™] is designed to be used in two basic applications:

1. As a passive FC or GbE Link Monitor, media converter (copper to optical, optical MM to SM, etc), cable extension, SFP to GBIC conversion.
2. As a BERT (Bit Error Rate Tester) for testing SFPs, GBICs, copper or optical cables, and for qualification of installed wiring systems

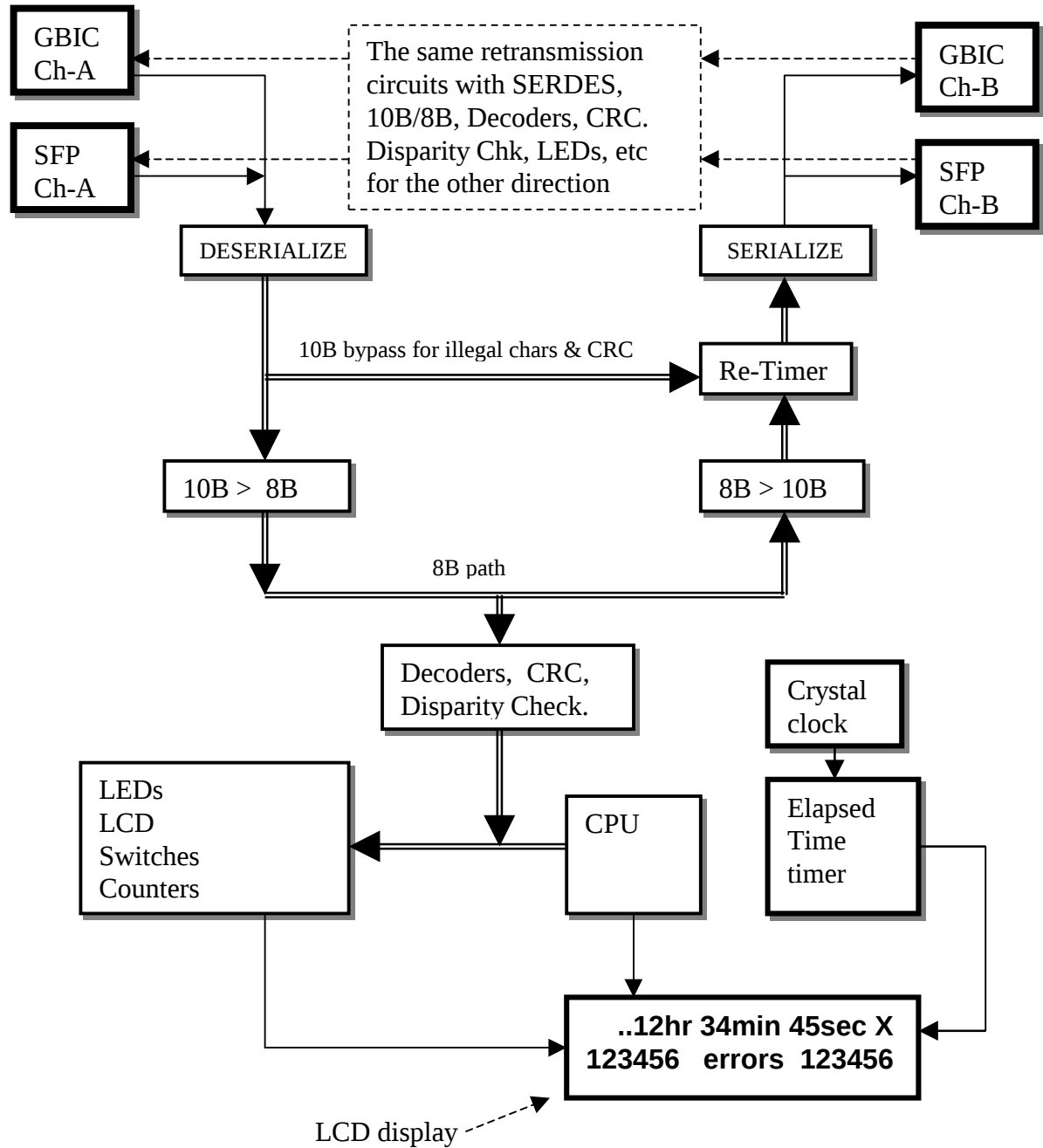
2.2 FC LINK MONITORING

The NETminer[™] is designed to passively monitor an Fibre Channel or GbEthernet link and to report various errors and statistics relevant to traffic on each channel of the full duplex FC link. Error conditions are reported via dedicated LEDs while most of the statistics are displayed on a small liquid crystal display (LCD). The front panel has several push-button switches for selecting various functions and for controlling the LCD. Red LEDs indicate errors, green LED indicates Link Up, and yellow LEDs indicate traffic activity or utilization. Each error condition causes the red LED to flash once for each occurrence of an event. Occurrence of an error event is also saved in a history latch. Once the history latch is set, the error LED stays on constantly, but the LED blinks (to the off level) at every additional occurrence of an error. Pressing the CLEAR push-button resets the history latches. The green and yellow LEDs are used as additional status indicators

The LCD is used to display various summary statistics about each channel such as data byte count, frame count, or link utilization (in real time). The UP and DOWN scroll push-button switches allow selecting one of the statistics data to show on the LCD. Each pressing of these switches scrolls the menus (on the LCD) up or down to the next page in a predefined order. If a displayed function requires the user to make a choice, then pressing the START switch initiates the selected function. As an example, the BERT is one of the functions that require the START.

2.2.1 CONNECTING THE NETminer™ TO THE LINK

When the NETminer™ is used for monitoring an FC or GbE link it is daisy-chained in the link connecting the two ports on both ends. See the block diagram below.



The incoming serial signal is deserialized, converted from 10B to 8B code, checked for errors, decoded, and statistics counters are updated. On the way out the signal is converted back to 10B, re-timed and serialized. The FC or GbE link carries a full duplex signal; there are two identical sets of circuits, one for each direction.

Note that when an illegal 10B character or a bad CRC is detected, it is passed through to the output port without change. This guarantees that the NETminerTM is transparent to the devices connected to the monitored link.

Also note that an illegal 10B character will most likely cause a disparity error at the receive end of the link.

2.3 BIT ERROR RATE TEST (BERT)

The BERT function allows the user to check the quality of the link. When the BERT is started, a stream of frames carrying a specific test pattern is transmitted while the receive side of the BER tester monitors for CRC errors. Difference of the BERT executed in FC or GbE modes is only in the frame formats used and the transmit speeds. BERT function is initiated by pressing the START and is terminated by pressing the STOP push-button switch. Actually, the Start/Stop is a single push-button switch that toggles between the two.

The BERT uses three jitter test patterns defined by the standards specifications, the CJTPAT (Compliant Jitter Tolerance Pattern), the CRPAT (Compliant Random Data Pattern), and the CSPAT (Compliant Supply Noise Test Sequence Pattern). Each of these test patterns tests a different type of jitter tolerance and the user can select which one to use.

The test patterns are formatted to look like normal FC or GbE frames respectively. The test frames use a specific start of frame (SOF) delimiter followed by the test pattern, then CRC and an end of frame (EOF) delimiter. Note that the test pattern data covers the entire frame including what would normally be the header; only the SOF, CRC, and EOF words are added. Note again that the BERT counts CRC errors and therefore it reports counts of bad frames, not counts of bad bits.

The three test patterns are defined by the ANSI, T11 Fibre Channel Jitter Working Group in their T11.2/Project 1316-DT/Rev 0.0 document, and the IEEE Draft P802.3z/D3.0 document. See Appendix-A for a brief explanation.

The BERT can be started from the following screen by pressing the START.

BER Test CJT pattern
Press START to begin

Once started, the screen changes to the 'time & error' format with the "B" in the upper right corner.

1234hr 56min 78s B
123456 errors 123456

Channel-AChannel-B

After the START is pressed, the ‘time & error’ counter screen is shown, and the time and errors start counting from zero. The time and error counters can be reset at any time by pressing the CLEAR push-button without disturbing the BERT function.

The BERT can be stopped by pressing the STOP push-button. While the BERT is running, the UP or DOWN push-buttons are ignored. You must STOP the test before using the UP or DOWN push-buttons to exit the BERT screen.

Note that the timer is always running, it counts and displays elapsed time even when not in the BERT mode. During the BERT, the LCD shows the “B” character in the upper right corner, it shows the “X” while link monitoring. The timer wraps around to zero after 9999 hours (about 416 days).

2.3.1 DURATION OF THE BERT TEST

Depending on what are you trying to accomplish with the test, you may need to run it for just a few seconds, for several minutes, or for a day or two.

a) The “a few seconds” test will tell you whether your tested cable is wired correctly (as a “null modem”) or whether the wires in the cable are basically good. If you do not get the “Link Good” light, try to swap the two signals in the connector on one side of the cable (the fibers in optical connectors can usually be easily taken apart and reassembled, wires in copper cables may need to be re-soldered). You would want to run this test when you unpack a new cable or transceiver before installing it. This test gives you confidence that the part had not been damaged in transport to your receiving site.

b) The “several minutes” test will tell you whether you have gross cable quality problems in addition to whether your cable is wired correctly. You would run this test immediately after installing individual cables in the field.

c) The “day or two” test will confirm the quality of the cable to insure that it complies with the FC or GbE specification requiring 10^{-12} maximum error rate. You would run this test when qualifying new (vendor) cables, in the lab during cable development, or after installation in the field as the final acceptance test.

It is true that it takes only about 15 minutes to transmit 10^{12} bits across a 1Gbps link, but if you do not get any errors detected during this time window, it could have been because you were just plain lucky during this time. The long duration (like a day or two) of the compliance test is needed from the practical standpoint if you want to get a better statistical reading.

These rules apply equally for testing of the copper as well optical cables or transceivers (SFPs or GBICs).

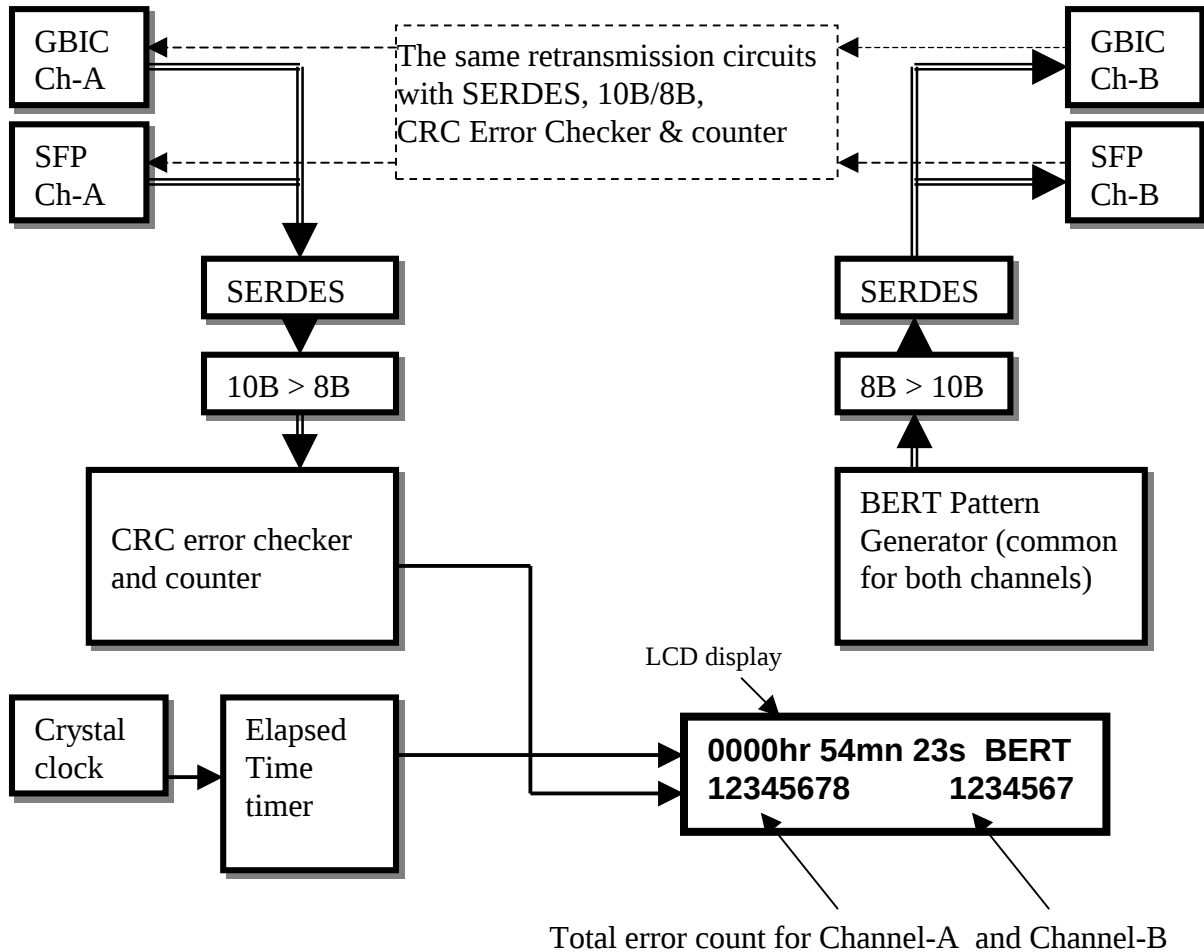
2.3.2 SELECTING THE TRANSFER RATE (“speed” of the link)

It is important to test the cables, the SFPs, or the GBICs at the speed they are rated for. Copper cables rated for 2Gbps usually will pass the test at 1Gbps, however cables rated for 1Gbps may not pass at 2Gbps. Optical cables should work the same at both speeds.

The transceivers are rated for a specific speed and/or a specific protocol like FC or GbE. Some transceivers are rated for a range of speeds. It is not unusual to have a 1.25G rated GbE transceiver that would not run without errors at 1.062G FC speed, or a 2.125G FC transceiver that would not run without errors at 1.25G GbE or 1.062G FC speeds. It is recommended that you test transceivers at each speed that you intent to use them, regardless for which speed they were rated.

2.3.3 BERT IMPLEMENTATION

The NETminer™, in addition to standard receiver and transmitter circuitry, uses a BERT pattern generator to drive the transmitters, and CRC checkers to detect potential CRC errors on the receiver sides. The pattern is transmitted through transceivers on both channels simultaneously.



The receivers synchronize on the incoming test frames and check for bit errors by monitoring the CRC. Note that the NETminer™ checks for CRC errors, therefore it counts and reports bad frames rather than the number of bad bits.

It is possible to check the received signal on either channel of the NETminer™ (examples “Case #1 and #2 on pages 30-31). It is also possible to do the BERT checking on very long cables using another NETminer™ located at the other end of the tested cable (case #3 on pages 31-32).

2.4 NAVIGATING THE MENU TREE

The following charts show structure of the menu system.

On power up (the power switch is on the left side of the case), the initial screen is displayed. After about 5 seconds it is replaced by the first screen of the Main Menu loop, which is the Data Link Monitor selection.

2.4.1 MAIN MENU LOOP & THE LINK MONITOR

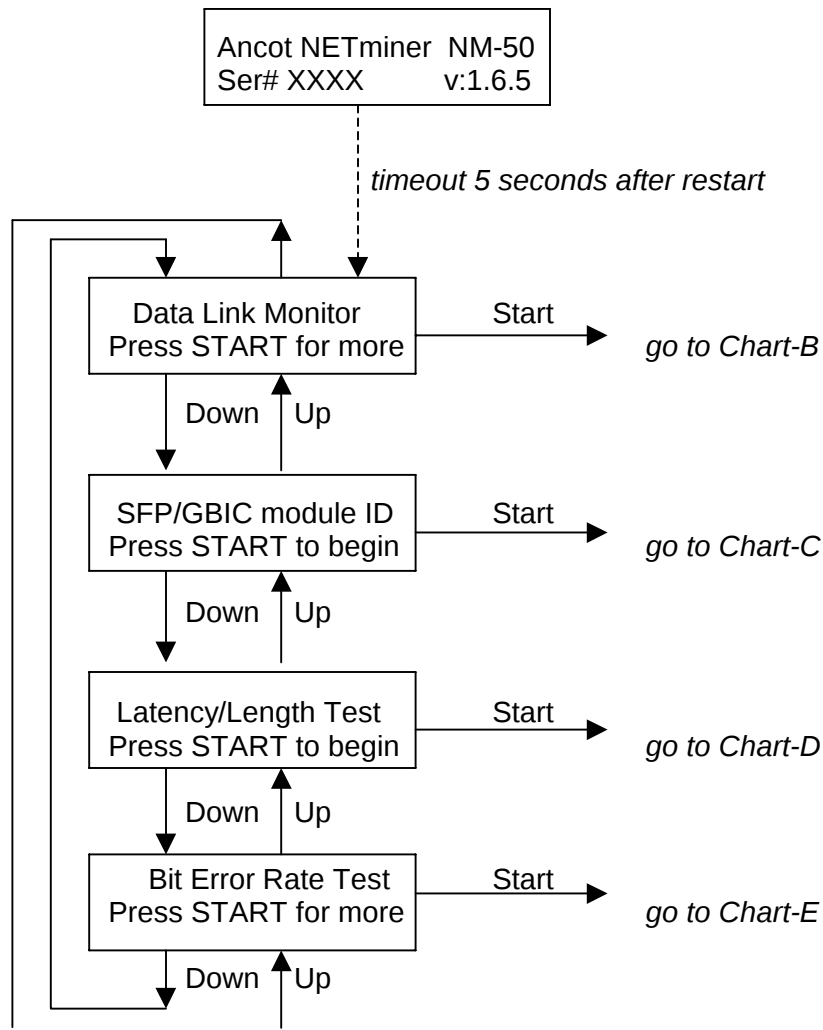


Chart-A - the Main Menu loop

The Main Menu loop shown above on Chart-A leads you through the four main functions selection. Use the Scroll DOWN and UP buttons to move around in this loop. Choose one of the four functions and press the START button to enter its menu selection sub-loop. Use the STOP button to return to the Main Menu loop.

Note that the START and STOP functions are the same physical push-button switch.

Use the Scroll DOWN and UP buttons to move through selections in the sub-menus.

*From / To the
Link Monitor*

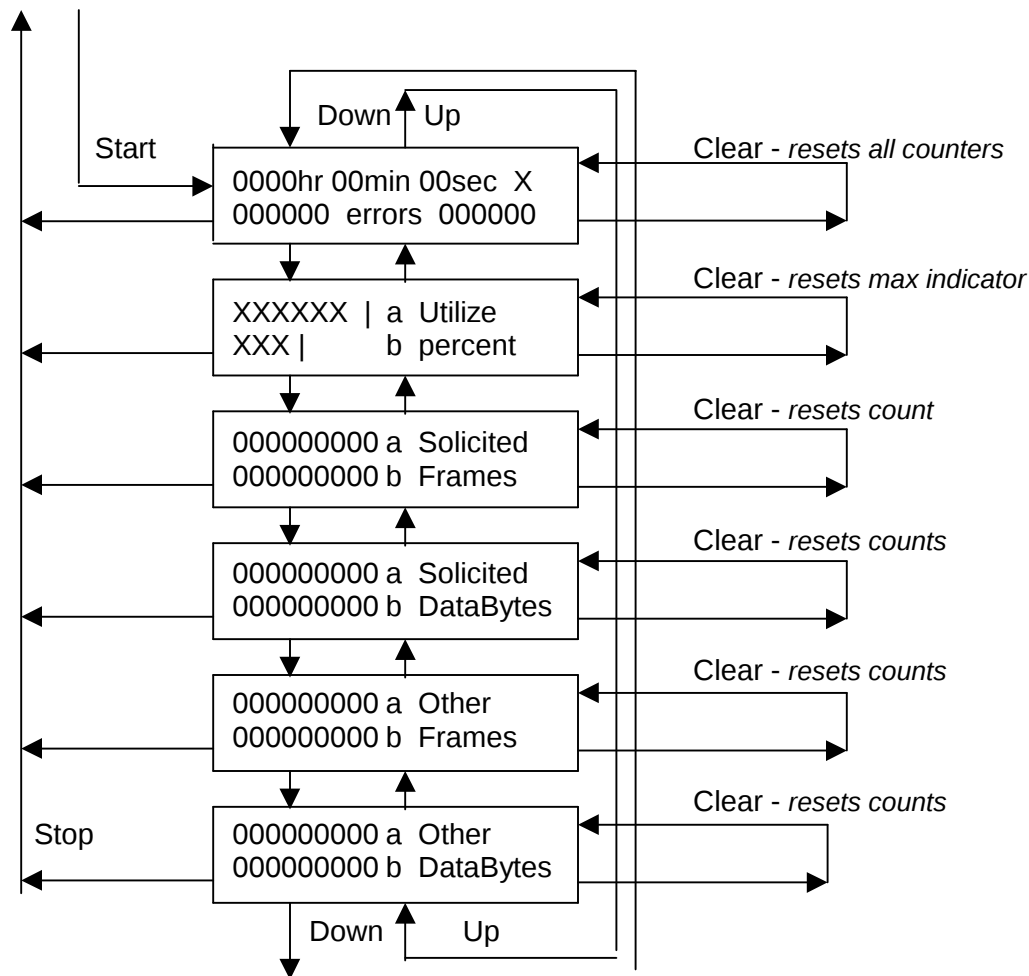


Chart-B - the Link Monitor sub-menu

The Data Link Monitor sub-loop:

Use the START button to enter this loop from the "Data Link Monitor" screen.

The Data Link Monitor runs all the time measuring elapsed time and counting errors, frames and bytes. The base screen (shown as the top screen on Chart-B) counts elapsed time in the upper row. In the lower row, it shows two error counters. The one on the left counts errors detected in Channel-A and the one on the right counts errors detected in Channel-B. The upper row in all other screens holds statistics counter for channel-A (marked “a”) and the lower row for channel-B (marked “b”).

The CLEAR button resets all counters, it can be used at any time.

Use the Scroll DOWN and UP buttons to view different counters during link monitoring.

The “Utilize” screen (the second one on Chart-B) monitors utilization (in percent) of the link bandwidth for both channels, in real time. The resolution is in 100 steps, 1% per step. The maximum marker on the right of each horizontal bar shows the maximum utilization value detected during the session. This value is latched and can be reset by the CLEAR button (together with the other counters). The bargraph in the upper row is for channel-A and the one in the lower row is for channel-B

The statistics counters screens (the third to seventh ones on Chart-B) show the total counts of frames or data bytes. In the FC mode the term “solicited”, sometimes also called “data- data”, is used by the FC users to designate data or frames that were solicited by the read/write commands. In the GbE mode the “MAC Control” frames or data bytes are counted.

If the NETminer is under external control (via the USB 2.0 port), then rather than “solicited” or “MAC Control” we also call these frames/bytes “filtered”. This is because the user can choose different filtering criteria, other than the solicited/MAC Control types.

The term “other” is used for all other frames or data.

Exit the Link Monitoring mode by pressing the STOP button.

Note that the START and STOP are the same physical push-button switch.

2.4.2 SFP and GBIC MODULE Serial ID INFORMATION

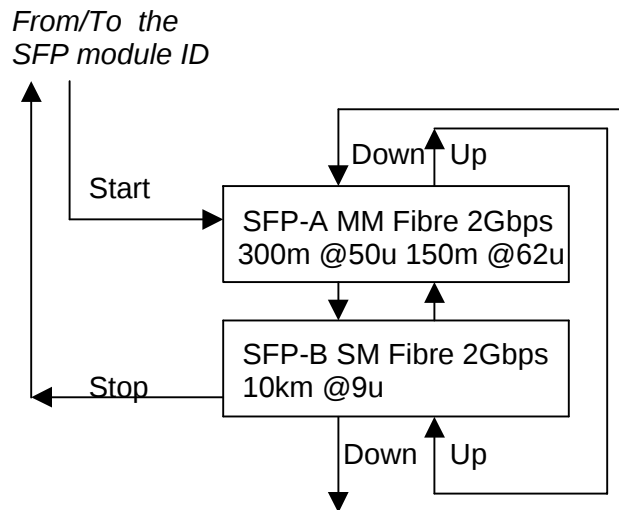


Chart-C: the SFP/GBIC module ID sub-menu

This function reads the Serial ID from the module and displays a part of the information on the LCD screen.

The SFP/GBIC module ID:

Use the START button to enter this loop from the “SFP/GBIC module ID” screen.

Use Scroll DOWN and UP buttons to move sequentially between modules.

Use the STOP (= Start) buttons to return back to the “SFP/GBIC module ID” screen.

The CLEAR button is ignored in this menu loop.

Note that the START and STOP are the same physical push-button switch.

2.4.3 LATENCY & CABLE LENGTH MEASUREMENT

*From/To the
Latency/Length Test*

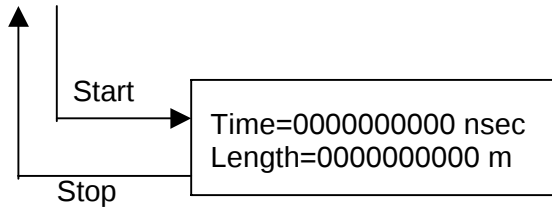


Chart – D: the Latency and Cable Length Test sub-menu

This function sends out a certain transmission word through the cable and measures the time elapsed until it is received back. The cable length is calculated under the assumption that propagation speed of the signal in copper or optical media is 4.895 nsec/meter (approximately 200,000 km/sec).

The Latency/Length Test:

Use the START button to enter this function from the Main Menu loop.

Use the START button again to start the test.

Press STOP and START button to execute another test.

While in the stopped state, use the DOWN or UP buttons to exit this function and return to the Main Menu loop..

The CLEAR button is ignored in this mode.

The Scroll DOWN or UP buttons are ignored unless in the stopped state.

Note that the START and STOP are the same physical push-button switch.

2.4.4 BIT ERROR RATE TEST MEASUREMENT

From / To the
"Bit Error Rate Test" screen

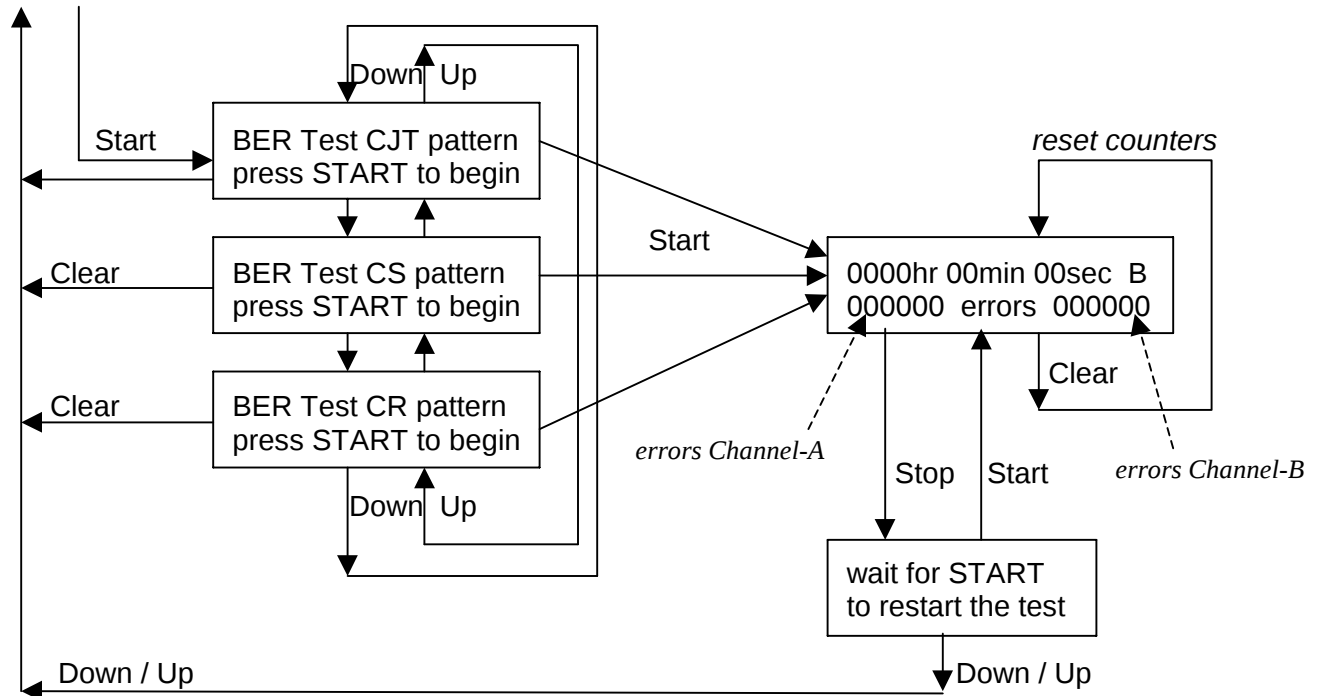


Chart-E – the Bit Error Rate Test sub-menu

Use the **START** button to enter the BERT selections from the "Bit Error Test" main screen.

Use Scroll **DOWN** and **UP** buttons to move between selections of the test patterns.

Use the **START** button again to start the test.

Use the **CLEAR** button anytime during the test to reset the time and error counters. Note that the **CLEAR** button merely resets the counters however it does not stop the test.

Use the **STOP** (=Start) button to freeze the test so that you can read the counters, then use the **START** button to restart the test again. While in the stopped mode, you can press the Scroll **DOWN** or **UP** buttons and return to the test pattern selection screen that you entered this test from. Use the **DOWN** or **UP** buttons again to move around to select another test pattern, and press **START** to start a new test. While the test is running, the **DOWN** and **UP** buttons are inactive.

To stop and terminate the BER Test, stop the current test by pressing the **STOP** then use the **DOWN / UP** buttons to return to the main menu loop.

Note that the **START** and **STOP** are the same physical push-button switch.

It is recommended running the Latency/Length Test to verify that the cable is connected correctly before starting the cable BERT test or when you cannot see loopback on the other end of the cable.

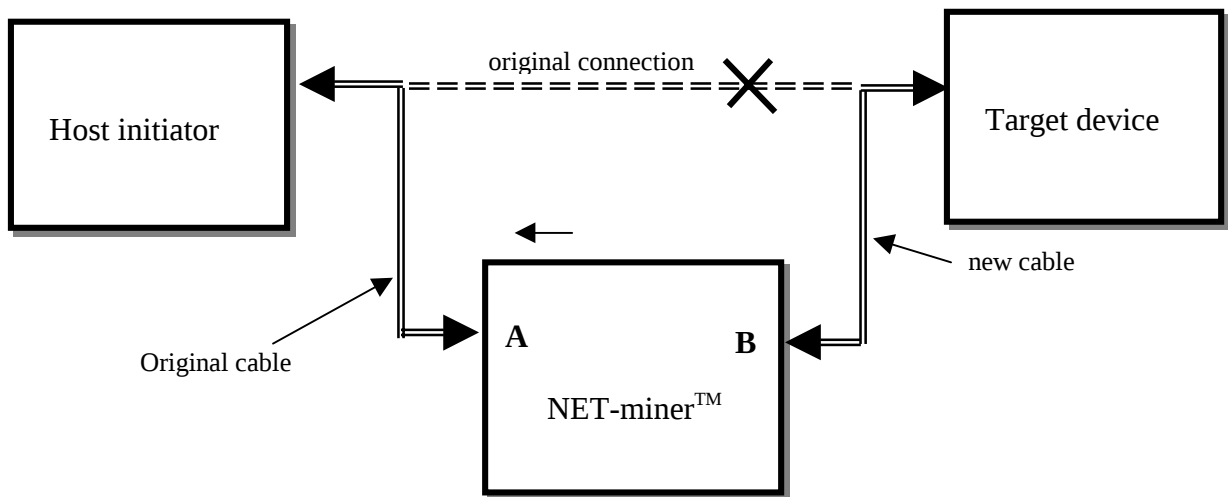
The only difference between the BERT run for the FC or the GbE is in the format of the encapsulating frame, but the test patterns themselves are the same. Select the FC or GbE mode using the sliding switch on the left side of the case and restart the unit by turning the power switch off and On.

3. APPLICATIONS

3.1 SIMPLE LINK MONITORING

Basic function of the NETminerTM is monitoring an FC or GbE link. The NETminerTM, daisy-chained in the FC or GbE full duplex link, repeats without modification all incoming traffic and passes it over to the output ports in both directions. At the same time it detects, counts and displays the characteristics of the traffic, including errors. The block diagram in Section 2.2.1 shows the path of the signal and the monitoring circuits in the NETminerTM.

The following diagram shows how the NETminerTM is cabled (daisy-chained) in the FC link:

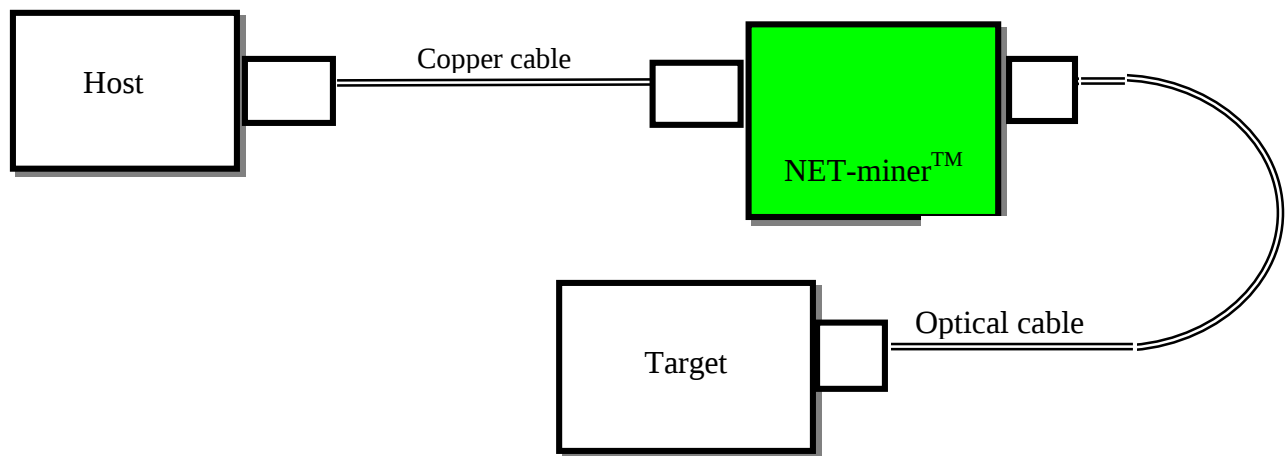


Originally, the Host is connected to the Target by a straight cable from the host to the target. When inserting the NETminerTM in the link, disconnect the original cable from the Target and connect it to port A in the NETminerTM. Then take a new cable, and connect port B on the other side of the NETminerTM to the Target. The link should come up automatically if the Host and Target are started, and you should see the “Link Good” LED on the NETminerTM to turn green.

3.2 MEDIA CONVERSION

The NETminerTM uses removable (pluggable) transceiver modules to connect the cables of the FC or GbE link. These modules are available for all standard media types; for copper as well as optical, Multimode and SingleMode. Both SFPs and GBICs are commercially available from multiple vendors. If interested, contact Ancot for more information.

Both sides of the NETminerTM are independent and can use different type modules. For example, you can use copper SFP (or GBIC) on one side and optical (MM or SM) SFP (or GBIC) on the other side.

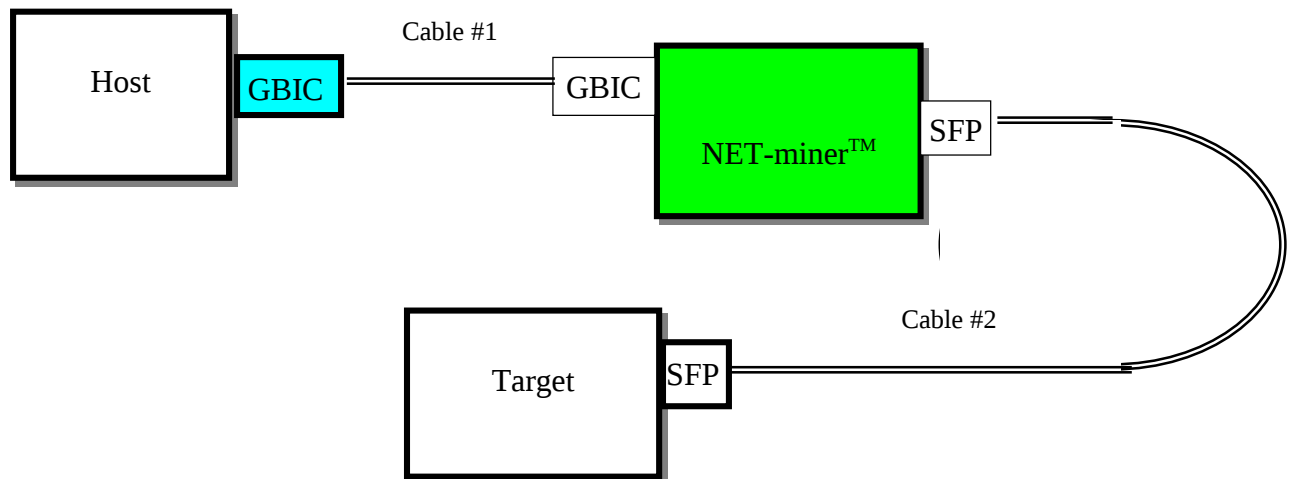


In this example, the first link uses copper cable and copper GBICs, the second link uses optical cable and optical SFPs.

3.3 GBIC/SFP CONVERSION

The NETminer™ uses removable (pluggable) transceiver modules to connect to the cables of the FC or GbE link. Both channels have two sockets each, one for the GBIC and the other for the SFP plug-in module. Any of the two (GBIC or SFP) can be used independently on both channels, the internal circuitry on each channel automatically detects which one of the two has a signal, and enables the corresponding internal path. For example, if you have the SFP and the GBIC in the same channel (on the same side of the NETminer™) plugged in, but only the GBIC has the cable connected to an active device on the other end, the NETminer™ enables the GBIC connection and ignores the SFP. If both the SFP and the GBIC, on the same side are receiving signal at the same time (have the module plugged in and cables connected to an active device), then the SFP connection is selected and enabled, and the GBIC is ignored.

Both sides of the NETminer™ are independent and can use different type modules, for example for SFP to GBIC conversion, Channel-A can use SFP and Channel-B the GBIC, or vice versa.



In this example the Host uses GBIC and the Target uses the SFP transceiver. Using cables with the same connectors on both ends, the NETminer™ acts as a GBIC to SFP translator. The only requirement is that both GBICs on cable #1 use copper, or both use optical. The same rules apply to cable #2.

Note that if the Host and the Target use the same type of media (both use copper or both use optical) then the same connection could be accomplished using a single cable with different connectors on each end, one for the SFP and the other for the GBIC. You would use this cable if you do not need to monitor this link.

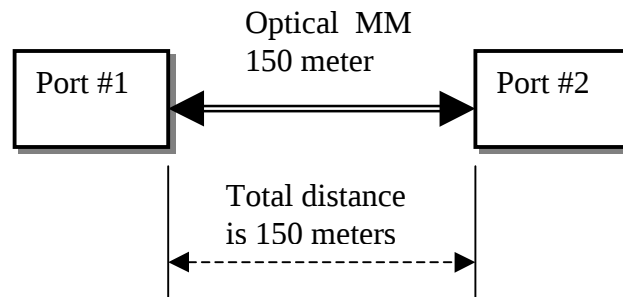
3.4 CABLE EXTENSION

Propagation of optical signal over fiber is not unlimited. Over distance, there is accumulation of power loss, and degradation of the quality of the signal by dispersion. For this reason, the FC protocol specification defines maximum distances for different types of media. For example, a Multimode optical over 50u fiber is specified for use up to a 500meter distance with 1Gbps signal, or 300 meters with 2Gbps signal. For more on this see Appendix-B.

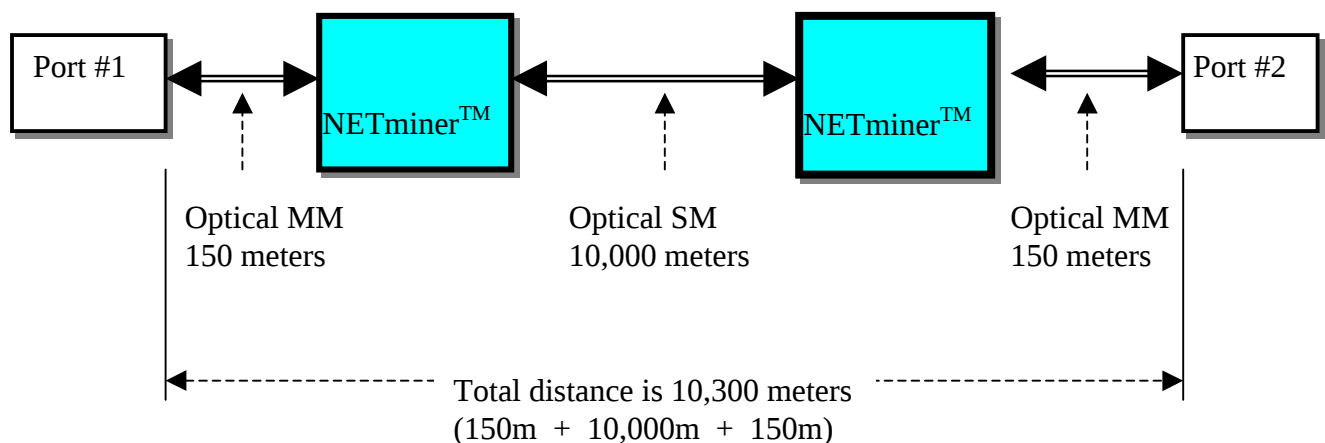
The NETminerTM receives a signal, re-times it and retransmits it. Transceivers (copper or optical) on each side generate a new, fresh signal, therefore the maximum allowed cable length applies to each cable segment. By inserting the NETminerTM in the link, the maximum distance between end ports can be significantly extended.

See the following examples:

Original 2Gbps FC link can reach up to 150 meters:



2Gbps FC link extended to 10,300 meters:



3.5 TESTING CABLES & TRANSCEIVERS

3.5.1 USING BERT FOR TESTING CABLES

There are many things that can cause transmission errors in cables. The optical fiber itself can be damaged, connectors can be bad or sloppily installed, or the mating surfaces in the connectors can be poorly polished or just dirty. The copper cables can be faulty as well. Usually, the copper wire itself would be good, but connections in the connectors can be bad, or the contacts can be dirty.

Why do we need to test cables ?

Connectors - The NETminer™ can test both kinds of cables, the optical as well as the copper type with all standard connectors. Using matching transceivers (SFP / GBIC), the following connectors can be used: copper: HSSDC and HSSDC2, optical: LC/LC, SC/SC, and LC/SC. Ancot offers plug-in transceiver modules for testing copper cables as well as optical Multimode and SingleMode.

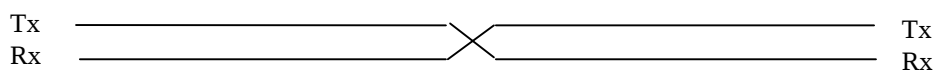
Output power - In addition to matching the physical connectors, you also need to provide adequate output power when testing cables. When testing copper cables, you can choose active or passive transceivers depending on the output power required. When testing optical cables, you need to supply enough output power (in the transceiver) to overcome the power loss in the cable.

Transfer rates - Cables rated for a particular speed should be tested at that speed; the 1G probably would not pass a test at 2G. Cables rated for 2G would pass the 1G test but they should be tested at 2G also. Make sure that for tests at 2G you use transceivers also rated for 2G. Select the BERT transfer rate by the GbE / FC and the 1G / 2G FC slider switches and restart the unit (push-button on the left side). When you switch to 1G or 2G or GbE, a corresponding LED on the control panel will light up.

When testing cables, use only known GOOD transceivers so that the only unknown part is the cable to be tested. All standard transceiver modules are available from Ancot.

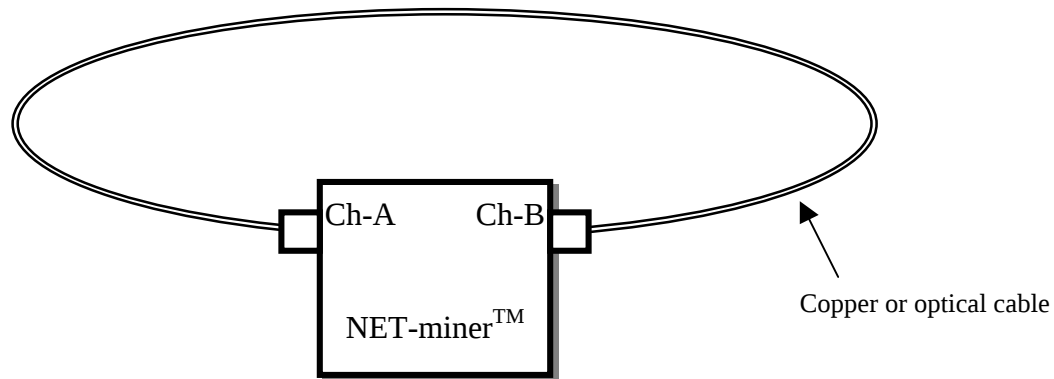
Duration of the test – varies, it depends on what are you trying to accomplish by the test. The BER test can take a few seconds, several minutes, or a day or two. See Section 2.3.1 for more information on this issue.

Note that the cables (copper as well as optical) used in FC and GbE networks are wired in a “null modem” fashion (rather than simple “extenders”). The cable should connect the transmitter on one end to the receiver on the other end and vice versa.



The cables can be tested using the following three methods:

Case #1. If the cable starts and ends in the same physical location, both of its connectors can be connected to the transceivers of the same NETminerTM; one to the transceiver of channel-A and the other to the transceiver of channel-B. See the following illustration:



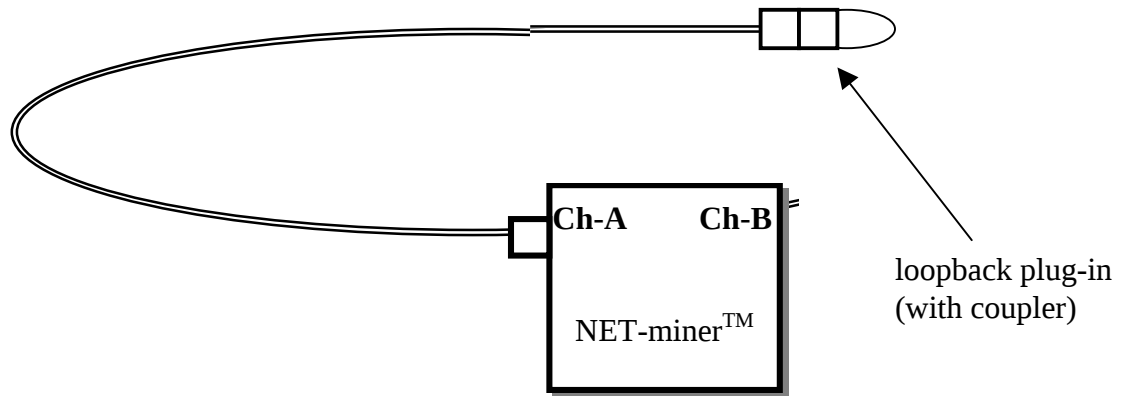
In this configuration, the transceivers on both sides are transmitting test patterns at the same time while the receivers on both sides are checking for errors, thus performing concurrent tests on both wires of the full duplex cable. The LED indicators and error counters (shown on the LCD screen) of both channels monitor the signal for errors in each of the two pairs of wires (of the full duplex cable) separately.

Using this method, you also verify that the cable ends are routed correctly (in “null modem” fashion). If the ends of the cable are swapped, then the transmitter on one end is connected to the transmitter on the other end, and the receiver on one end is connected to the receiver on the other end. In such a case, the receivers on both sides will be detecting the “Loss of Signal” state and all LEDs will be blank. When you initially plug in both ends of the cable and before you start the first test, there is no traffic on the cable. When you start the BERT test for the first time, the link-up is established and the BERT test pattern traffic starts. Whenever you pause the BERT test the Idle transmission words will be circulating, maintaining the link (in both directions). At this point, and if the cable is wired correctly, you should see the “Link Good” LED on.

After this you can start the BERT test (or restart it by pressing the START) and the test pattern traffic starts in both directions. During the test, you should see only the “Link Good”, “Traffic” and “Utilization” LEDs On and the “BERT” LED flashing. You should not see any red LEDs indicating errors if the cable is good.

Duration of the test can vary widely depending on what you are trying to accomplish. Quick test verifying routing of wires in the cable may take a second, and a full-blown BERT test may take a day or two. See Section 2.3.1 “Duration of Test”.

Case #2. If the cable is laid such that the other end is far away and cannot be brought back and to plugged into the other port of the NETminer™ easily, then plug the connector of the local end to the NETminer™ (on either channel) and plug the loopback connector in the connector of the far end of the cable as illustrated in the following figure.

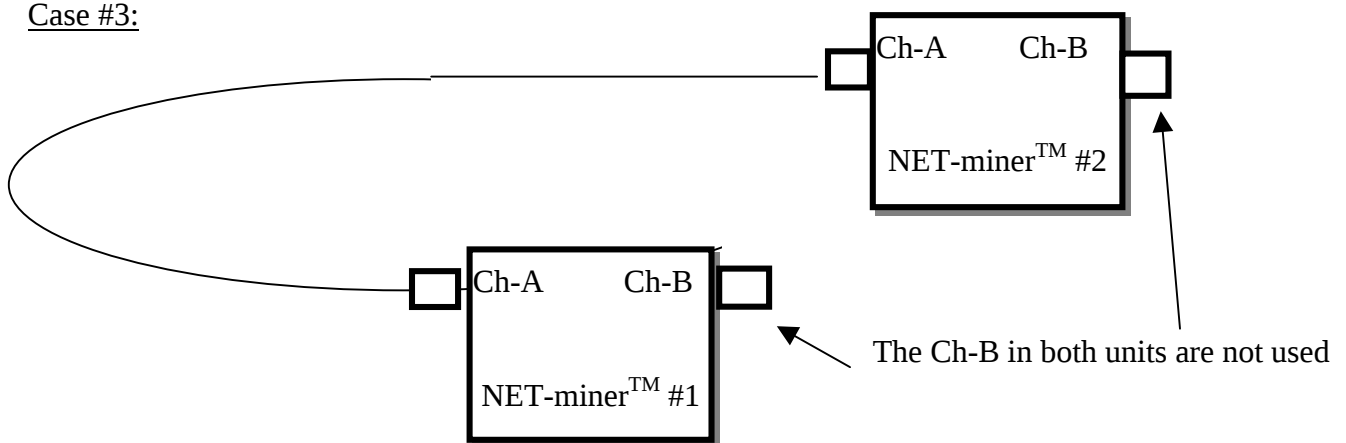


In this setup, LED indicators of Ch-A monitor the signal going through both wires of the cable and LED indicators of Ch-B are all Off indicating no signal.

Remember that when using the loopback method the signal has to travel the full length of the cable out and the same distance back. This makes the length of the cable appear twice as long to the transceiver. Therefore, if you are using the maximum allowed cable length, you may exceed the available power budget. In such a case you must use method described in case #3 below instead.

When using the optical loopback, you need to use a special vinyl cable coupler (supplied with the optical loopback if purchased from Ancot) in order to mate the male connector of the cable and male connector (marked "Loopback") of the loopback. When testing copper cables, use the copper loopback. The copper loopback, supplied with the copper cable kit (by Ancot), has two circuits, one loopback with HSSDC and another one with HSSDC2 connector.

Case #3:



This setup with two independent NETminer™s can be used because the BERT test patterns are formatted as standard FC or GbE frames, and the receivers on both ends only need to recognize the FC or GbE frame and check for CRC errors. Actually, the test is a little more strenuous if you use different NETminer™s on each end. This is because all transmitters and receivers in the same unit are synchronized to the same (internal) clock, but using the transmitter in one unit and the receiver in another unit, each running from a different clock, a little more jitter is added in the receivers and the cable must be a little better quality to pass the test.

Using this test setup, the LED indicators in Ch-A of the NETminer™ #1 monitor one signal (of the full duplex cable) and LED indicators in Ch-A of the NETminer™ #2 monitor the other signal of the cable. You will see the LEDs “Link Good”, “Traffic” and “Utilization” all On. The LED indicators in channel-B of both NETminer™s should be off.

Are the mating surfaces of optical cables good?

Terminating the optical cables is not an easy task. Mating ferrules must be precisely centered and well polished to guarantee minimum light power loss in transition. Good precise contact of the two fibers is important for the MM 62.5u fiber, even more so for the MM 50u fiber, and it is extremely critical for the SM 9u fibers. One way to test whether the ends are well polished is by gently wiggling the cable as it is plugged in the SFP/GBIC; you should not be getting any errors unless you move the cable too much.

Crosstalk in Copper cables

Copper cables have wires for one signal direction running parallel with wires for the other signal direction. Even though the FC or GbE uses differential signals and twisted pairs to minimize the crosstalk, there is always some residual coupling that results in interference between the two signals (of the FDX link). We recommend using test method described as Case #3 for testing for presence of the crosstalk coupling. This test method which uses two separate NETminer™ units controlled by independent and therefore asynchronous clocks better approximates the actual situations in the field.

3.5.2 MEASURING CABLE LENGTH & LATENCY

Length of cables is measured indirectly by measuring the propagation delay of a signal sent through the cable. The tolerance is one transmission word (37.77nsec at 1Gbps, 18.8nsec at 2Gbps, and 16nsec at 1.25G GbE) that translates to less than 5 meters in cable length at 2Gbps.

To perform the measurement, connect the ends of the cable as shown in illustration Case#1 (in the previous section). You will have one end of the cable plugged in SFP/GBIC of one channel and the other end in SFP/GBIC of the other channel. You can also connect one end of the cable into the SFP/GBICs for Channel-A (!) and plug the loopback in one end of the cable as shown for Case#2. Note that you should use only the Channel-A SFP/GBIC, Channel-B cannot be used

for this type of measurement. Data is transmitted from both the A and B channels but only the Channel-A receiver checks for reception errors.

To execute the measurement select “Latency/Length Test” screen on the LCD and press START and the screen will show the measured latency and length. To repeat the test simply press the START button and the test is repeated. Only remember that if you use the second method with the loopback (Case#2) the actual latency/length is one half of the value displayed for Case#2; this is because the signal has to travel through the cable twice the distance – once out to the loopback and then back.

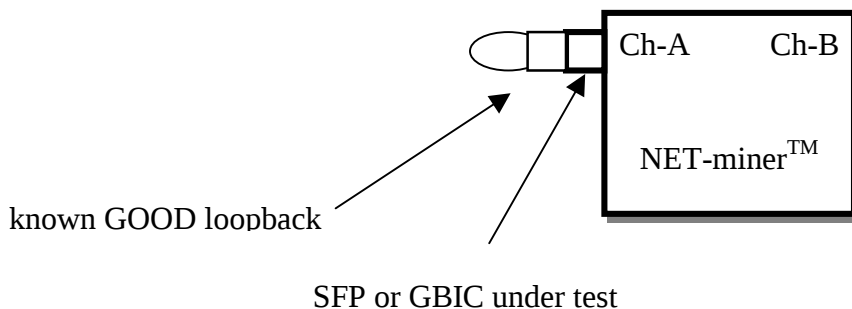
3.5.3 USING BERT FOR TESTING TRANSCEIVERS (SFPs & GBICs)

Testing transceivers is very similar to testing cables. The BERT transmitter sends out test patterns and the receiver checks for CRC errors. The rules for choosing the duration of the test are the same as for testing cables. See Section 2.3 for more information.

Test setup shown for cables as Case #1 or Case #2 can be used. If you use the Case #1, make sure that you use a known GOOD cable and known GOOD transceiver on the other end, so that only the transceiver under test is unknown.

The simplest method is testing one transceiver with a loopback plugged in it

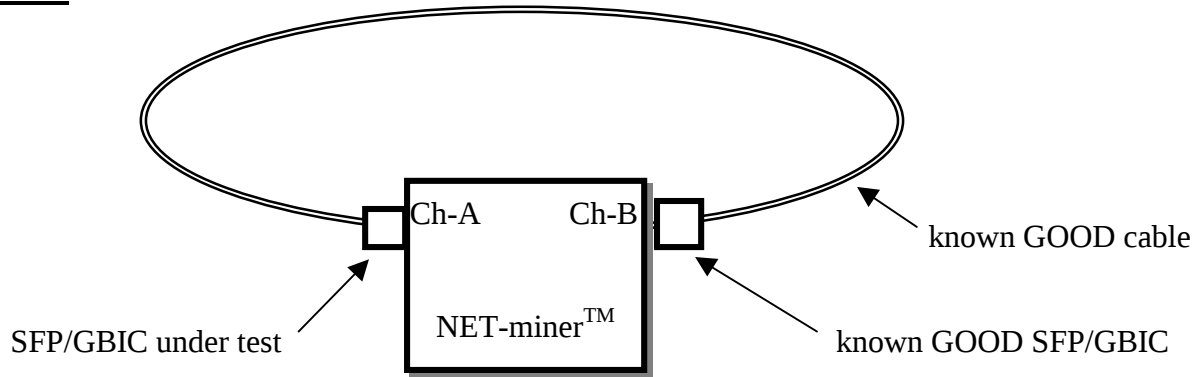
Case #1:



In this setup, LED indicators of Channel-A monitor the receiver of the same transceiver (SFP or GBIC). The LEDs for Channel-B are Off indicating no signal in Channel-B. Using this method, you cannot tell if the transmitter or the receiver of your transceiver module is bad if you detect errors. However, in practice, if a part of the transceiver is bad then it does not matter which one it was, because the entire transceiver has to be replaced.

Using this method, two transceivers can be tested independently at the same time, one on each side of the NETminer™.

Case #2:

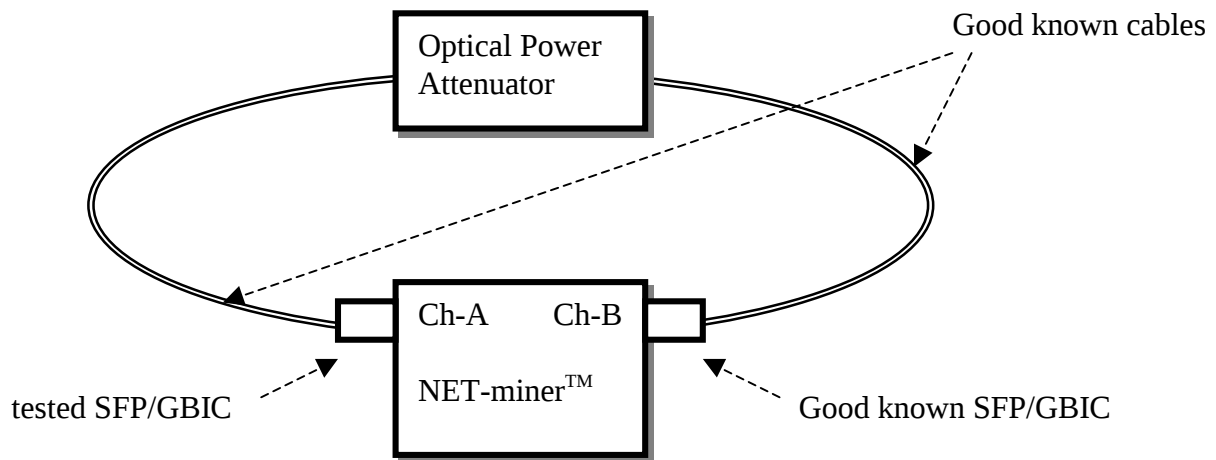


In this setup, LED indicators of Channel-A monitor the receiver of the tested SFP/GBIC, and LEDs of Channel-B monitor the transmitter operation. As you can see, you get separate readings for the receiver and for the transmitter.

Remember that you are testing the transceiver and therefore all other components of the circuit must use known GOOD parts. If you use the method shown as a case #1 above, the loopback must be guaranteed good. If you use the method shown as case #2, the cable and the second transceiver must be guaranteed good.

3.5.4 TESTING OUTPUT POWER OF A TRANSCEIVER IN THE SFP/GBIC

The transceiver (laser or LED) in the SFP or GBIC may degrade and lose power over time. The NETminer™, together with an (external) attenuator, can be used to verify the output power of an optical transceiver. The test setup is shown below:



Make sure that you use GOOD known transceiver on the receiving side and GOOD known cables. Test by gradually increasing attenuation until you start receiving errors in the receiver.

3.5.5 IDENTIFY SFP TRANSCEIVER MODULES

There are situations when you need to know the type of a transceiver but the only information you have is vendor name and a part number printed on the module. To identify your module, you may need to find the spec for that particular module and read it carefully.

It is much easier using NETminer™ and read identification information stored in an internal (read only) memory in the module (Serial ID). Simply insert the module in one of the SFP/GBIC sockets, select “SFP module ID” function on the LCD screen and press the START button. Then use the Scroll DOWN / Up buttons to cycle through the SFP and GBIC sockets; the NETminer™ reads the IDs from each module and tells you on the LCD whether it is a copper active/passive or optical MultiMode/SingleMode type, whether its speed is 1G, 1.25G or 2 Gbps, and max length information.

To exit the test press the (START/) STOP button and the NETminer™ returns to the Main Menu loop.

4. *INSTALLATION*

4.1 HARDWARE

The NETminer™ is a standalone instrument with an external power supply. It requires 5Volt DC, at a maximum 1.5Amp current.

4.2 UNPACKING

Inspect the shipping carton for signs of damage before opening. If there is any evidence of damage, notify the carrier and ANCOT immediately.

Remove the NETminer™ and all accessories from the shipping carton, and compare the contents with the parts list accompanying the package, or listed on the packing slip. If any equipment is missing, contact the ANCOT local representative or ANCOT directly, as soon as possible.

Connect the external power supply and plug the AC cord in the wall outlet

4.3 CONNECTING the FC LINK CABLES

If the NETminer™ is used for monitoring an existing FC link connecting two ports, disconnect the cable from one of the devices and connect it to one side (use either one of the two – the SFP or the GBIC) of the NETminer™. Then use another cable and connect the other side of the NETminer™ to the disconnected device. If the traffic between the two ports is active, you should see the “Link Good” LEDs for both Channels to be On, and possibly also some other LEDs may be lit depending on the characteristics of the traffic.

APPENDIX – A

BERT – THEORY OF OPERATION

The Fibre Channel links or the GbEthernet links may fail for many reasons. It could be for any part of the FC port on either end, but in most cases it is the cable, its connectors, or one of the transceivers (in the plug-in modules). Some sources indicate that in 80 % cases it is the cables, connectors, or the transceivers that fail. For this reason, it is important to insure that these components are good before using them and also verifying that they did not get damaged during installation. The method of Bit Error Rate Testing (BERT) is one way how to perform the test.

Test the 1G (FC) cables at 1Gbps speed, the 1.25G (GbE) cables at 1.25Gbps speed, and the 2G (FC) cables at 2Gbps speed. The 2Gbps test frequency is more strenuous, and there is a good chance that most of the 1G rated cables will pass test at 2G, although it is not guaranteed. The transceivers (SFPs and GBICs) have to be tested at a speed that they are certified for. Transceivers certified for dual or tripple speed should be tested at all those speeds.

The standards committees that defined the Fibre Channel and GbEthernet specifications recommend running specified test patterns through the link. The three test patterns are:

1. CRPAT - Compliant Random Data Pattern
2. CJTPAT - Compliant Jitter Tolerance Pattern
3. CSPAT - Power Supply Noise Test Sequence

The test patterns are embedded into the standard FC or GbE frame construct in order to allow them to be also carried on active FC or GbE links. Each frame is followed by six Idle primitives. The FC frames start with SOFn3 and end with CRC and EOFn with negative or positive disparity. The GbE frames start with preamble, SFD and end with CRC and EOP. By embedding enough repeating (modified) base patterns in a frame, the spectral contribution of the frame delimiters, CRC and Idle primitives is minimized.

1. The CRPAT provides a data pattern with broad spectral content and minimal peaking. A flat spectral content pattern is used to insure that any peaking seen during TX jitter testing can be attributed to the component and not the spectral content of the data. The CRPAT pattern has a broad spectrum, which produces a worst-case scenario with regard to deterministic jitter generation.

The pattern itself consist of:

- D30.5, D23.6, D03.1, D07.2
- D11.3, D15.4, D19.5, D20.0
- D30.2, D27.7, D21.1, D25.2 these three tr. words are repeated 16 times

In the FC frames this pattern is encapsulated in SOFn3 at the beginning of the frame and the CRC and EOFn at the end. In the GbE frames this pattern is encapsulated in preamble and SFD at the beginning of the frame and the CRC and EOP at the end.

The CRPAT can also be used for EMI testing.

2. The CJTPAT overall pattern alternates repeating low transition density patterns with repeating high transition patterns. The repeating 10B character durations are longer than the time constants in the receiver clock recovery circuit. This assures that the clock phase has followed the systematic pattern jitter and the data sampling circuitry is exposed to large systematic phase jumps. The CJTPAT has been designed mainly for receive jitter tolerance testing.

The pattern itself consists of:

- D30.3, D30.3, D30.3, D30.3 (low density transition pattern repeated 41 times)
- D30.3, D30.3 D30.3, D20.3
- D30.3, D11.5, D21.5, D21.5 (low to high transition densities)
- D21.5, D21.5, D21.5, D21.5 - repeated 12 times (high density transition pattern)
- D21.5, D30.2, D10.2, D30.3
- D30.3, D30.3, D30.3, D30.7 (high to low transition densities)

In the FC frames this pattern is encapsulated in SOFn3 at the beginning of the frame and the CRC and EOFn at the end. In the GbE frames this pattern is encapsulated in preamble and SFD at the beginning of the frame and the CRC and EOP at the end.

3. The CSPAT is a test pattern that simulates the worst-case power supply noise introduced by the transceiver.

The pattern itself consists of 512 times repeated transmission word: D31.3, D31.3, D31.3, D31.3
In the FC frames this pattern is encapsulated in SOFn3 at the beginning of the frame and the CRC and EOFn at the end. In the GbE frames this pattern is encapsulated in preamble and SFD at the beginning of the frame and the CRC and EOP at the end.

For more information on this topic we recommend reading the ANSI document T11.2/Project 1316-DT/Rev x.x –Working Draft titled: “Fibre Channel – Methodologies for Jitter Specification-2. Latest version is dated December 8, 2002 (as of January 2003) and the IEEE Draft P802.3z/D3.0 document dated June 20, 1997.

APPENDIX – B

CABLE LENGTHS

The ANSI FC specification defines maximum lengths for the copper and optical cables:

Transfer rates	Copper	Optical MM 50u	Optical SM 62.5	Optical SM 9u
1 Gbps	N/A	500m	300m	10,000m
2 Gbps	N/A	300m	150m	10,000m

Note that the lengths for copper cables are not specified in meters. The only requirement is that the signal on the other end of the cable be of sufficient power for the receiver. It is the responsibility of the designer to do the design and the measurements.

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