

Features

- 1063Mb/s data rate
- Short wavelength (SW; distance ≤ 500m), long wavelength (LW; distance ≤ 10km), and custom versions available
- (ANSI) Fibre Channel compatible [1]
- FCSI-301-Revision 1.0 compatible (Gigabaud Link Module [2])
- 20-bit electrical interface
- Parallel electrical ↔ light conversion
- Clock and data recovery
- Serialization/deserialization
- International Class 1 laser safety certified
- UL & CSA approved
- Low bit error rate ($<10^{-12}$)
- High reliability (AFR $<0.0195\%/khr$, over 44 khours)

Applications

- Fibre Channel
- Client/Server environments
- Distributed multi-processing
- Fault tolerant applications
- Visualization, real-time video, collaboration
- Channel extenders, data storage, archiving
- Data acquisition

Overview

IBM42M10SCYAA10 and IBM42M10LCYAA20 are 1063Mb/s Gigabit Link Modules (GLMs). These highly integrated fiber optic transceivers provide high-speed serial links at a signaling rate of 1062.5Mbit/s, which equates to 100 Mbytes/s of continuous throughput simultaneously in each direction. The IBM42M10SCYAA10 conforms to the American National Standards Institute's (ANSI) Fibre Channel, FC-0 specification for short wavelength operation (100-M5-SL-I and 100-M6-SL-I) [1]. The IBM42M10LCYAA20 conforms to the ANSI FC-0 specification for longwave operation (100-SM-LL-I). These modules can also be used for other serial applications where high data rates are required. These compact, double-sided, surface mount modules are designed to easily connect to a user's system card. Data and control lines conform to industry standard TTL interface levels.

The IBM42M10SCYAA10 uses short wavelength (850nm) VCSEL lasers. This enables low cost data transmission over optical fibers at distances up to 500m. A 50/125μm multimode optical fiber, terminated with an industry standard SC connector, is the preferred media. A 62.5/125mm multimode fiber can be substituted with shorter maximum link distances.

The IBM42M10LCYAA20 uses long wavelength (1300nm) lasers. This enables data transmission over optical fibers at distances up to 10km on a single mode (9/125μm) optical fiber.

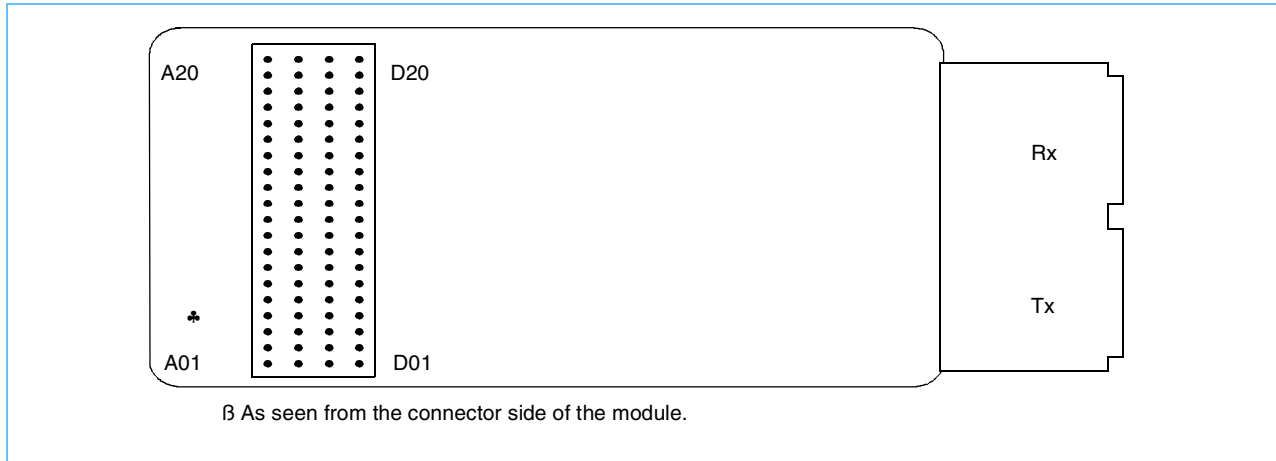
Twenty bit, encoded, transmit data is received, serialized at 1062.5 Mbaud, and modulated on the laser. The 20-bit data must be encoded using the 8B/10B encoding [3, 4] scheme specified by the Fibre Channel standard.

Incoming, modulated light is received by a photoreceiver mounted in the SC receptacle. A phase locked loop (PLL) recovers the clock and retimes the serial data which is deserialized into a 20-bit word and presented to the interface at 53.125MHz.

An Open Fibre Control (OFC) function turns off the laser if there is no modulated light received by the photoreceiver. This function guarantees that these GLMs are Class 1 laser products in the event of an open link.

As specified in the GLM document, the IBM42M10LCYAA20 uses Open Fibre Control Laser Safety protection techniques rather than the physical shutters specified by Fibre Channel. The timings are the same as those used with the GLM-266 short wavelength links.

Pin Configuration



Pin Definitions

Pin	Signal	Note	Pin	Signal	Note	Pin	Signal	Note	Pin	Signal	Note
A01	N/C	1	B01	N/C	1	C01	Ground		D01	N/C	1
A02	Ground		B02	Ground		C02	Ground		D02	N/C	1
A03	V _{CC}		B03	Tx[10]		C03	Tx [00]		D03	V _{CC}	
A04	Tx[12]		B04	Tx[11]		C04	Tx [02]		D04	Tx [01]	
A05	Tx[14]		B05	Tx[13]		C05	Tx [04]		D05	Tx [03]	
A06	Tx[16]		B06	Tx[15]		C06	Tx [06]		D06	Tx [05]	
A07	Tx[18]		B07	Tx[17]		C07	Tx [08]		D07	Tx [07]	
A08	Ground		B08	Tx[19]		C08	Tx [09]		D08	Ground	
A09	Strobed ID	2	B09	Ground		C09	Ground		D09	V _{CC}	
A10	V _{CC}		B10	Link Unusable		C10	Fault		D10	TBC	
A11	Parallel ID [1]	3	B11	Reserved	4	C11	Transmit SI (N/C)		D11	Parallel ID [0]	3
A12	RBC[0]		B12	Enable Wrap		C12	Comma Detect		D12	V _{CC}	
A13	V _{CC}		B13	Ground		C13	Reserved	5	D13	RBC [1]	
A14	Ground		B14	Rx[10]		C14	Rx [00]		D14	Ground	
A15	Rx[12]		B15	Rx[11]		C15	Rx [02]		D15	Rx [01]	
A16	Rx[14]		B16	Rx[13]		C16	Rx [04]		D16	Rx [03]	
A17	Rx[16]		B17	Rx[15]		C17	Rx [06]		D17	Rx [05]	
A18	Rx[18]		B18	Rx[17]		C18	Rx [08]		D18	Rx [07]	
A19	V _{CC}		B19	Rx[19]		C19	Rx [09]		D19	V _{CC}	
A20	Enable Comma Detect		B20	Ground		C20	Ground		D20	<u>Lock to Reference</u>	

1. The serial I/O functions of this card are not implemented. The Serial I/O lines are left open on the GLM.
2. (3)The Strobed ID function is now implemented. This function is new.
3. (4)The Parallel ID bits are tied to V_{CC} through 10k ohm resistors.
4. (2)Pin B11 is a reserved input. It is left open.
5. (1)Pin C13 is a reserved output. It is left open.



Ordering Information

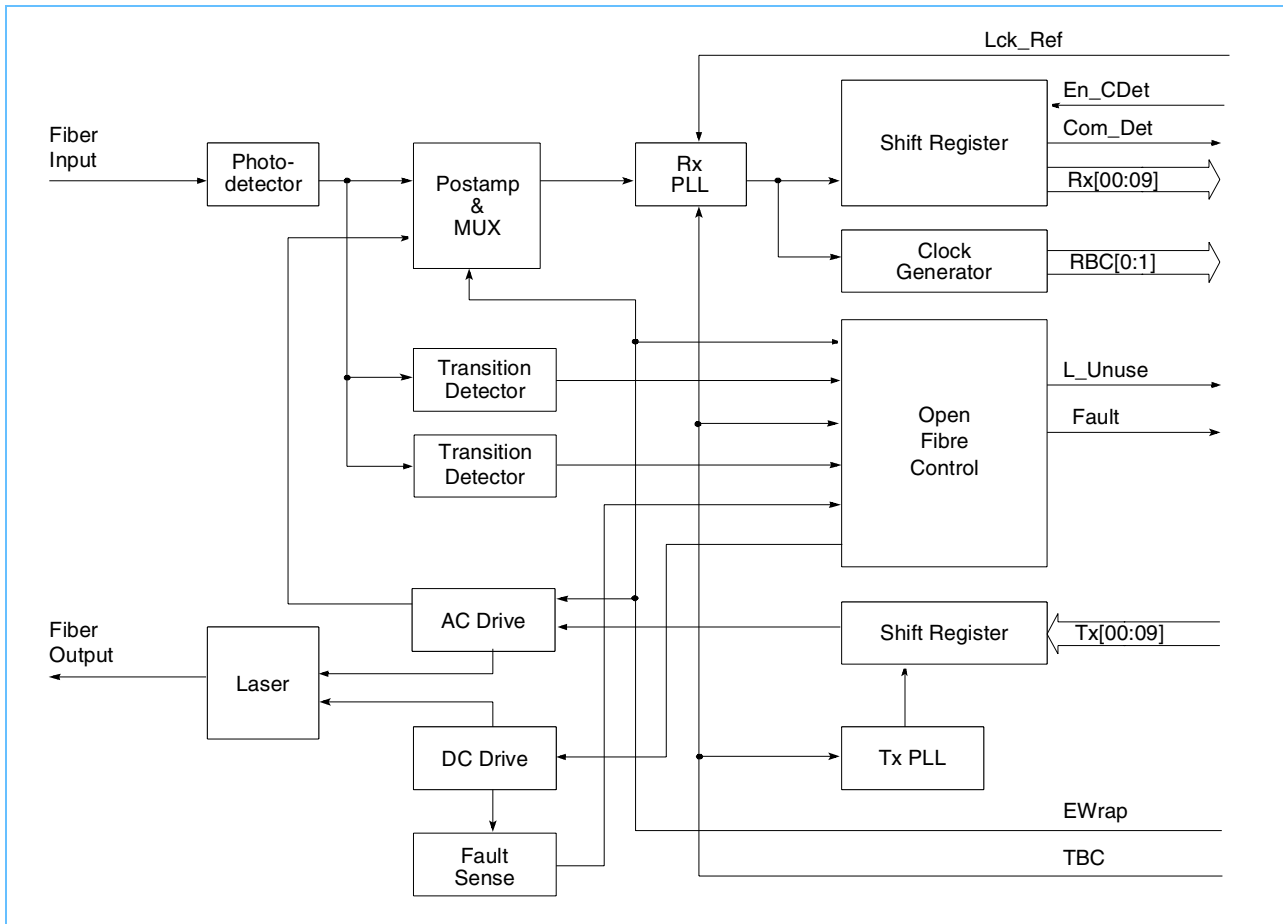
Part Number	Signalling Rate	Optical Fibre Control	Wavelength
IBM42M10SCYAA10	1063MB/s	Yes	780nm
IBM42M10LCYAA20	1063MB/s	Yes	1300nm

Exceptions to GLM and Fibre Channel Specifications

The IBM42M10SCYAA10 and IBM42M10LCYAA20 comply with the Fibre Channel (100-M5-SL-I, 100-M6-SL-I 100-SM-LL-I) and GLM specifications except for the following:

- The GLM specification [1] requires that the Fault line be reset by toggling the EWRAP signal. The IBM42M10SCYAA10 and IBM42M10LCYAA20 do not operate this way. The Fault line is reset only when it has been determined that the laser is operating correctly. Per Open Fibre Control requirements, the laser will only be turned on every 10.1 seconds until the link is established.
- As specified in the GLM document, the IBM42M10LCYAA20 (long wavelength) uses Open Fibre Control Laser Safety protection techniques rather than the physical shutters specified by Fibre Channel. The timings are the same as those used with the GLM-266 short wavelength links.
- The optical receptacles on the end of the IBM42M10LCYAA20 (long wavelength) do not contain the Fibre Channel specified "single mode keying" features. Either singlemode or multimode Fibre Channel compliant SC duplex connectors can be inserted into the ports of the GLM.

Block Diagram



Transmit Section

The 20-bit transmit data enters the shift register and is clocked out at 1062.5Mbit/s to the serial output pins and the multiplexer. The AC Drive modulates the laser with the data from the Serial Input pins or the serialized version of the Transmit Data. The Transmit Phase Locked Loop (Tx PLL) generates the internal 1062.5MHz clock for the shift register from the 53.125MHz Transmit Byte Clock provided by the system. The DC Drive maintains the laser at the correct preset power level. Safety circuits in the DC Drive will shut off the laser if a fault is detected. The multiplexer is used to route the serialized data to the Receive Section while in wrap mode.

Receive Section

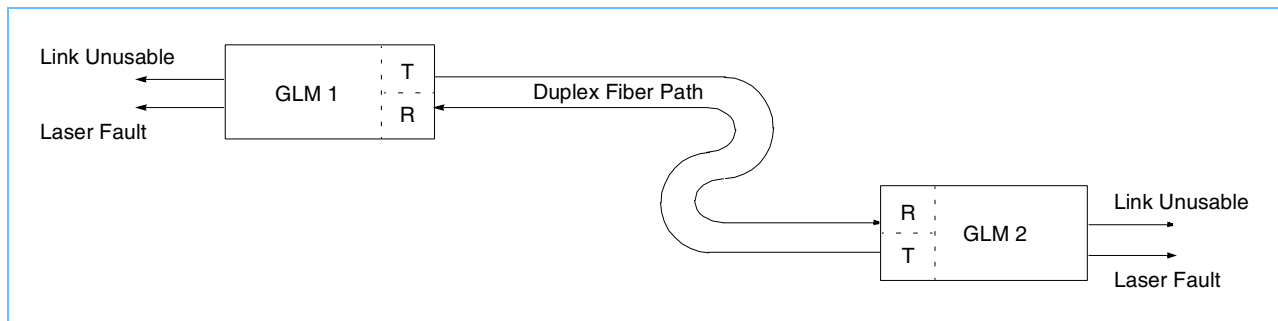
The incoming, modulated optical signal is received by the photoreceiver. The Receive PLL (Rx PLL) phase locks a 1062.5MHz clock to the data and sends the data and clock to the shift register (S/R) to be deserialized. The S/R has a byte synchronization detector that recognizes a unique comma character so that complete bytes can be unloaded from the S/R without being fragmented. The Clock Generator creates two complementary phases of a 53.125MHz clock for use by the host system to latch the Receive Data.

Open Fibre Control

A safety interlock is provided by the Open Fibre Control (OFC) module on these GLMs. Two GLMs must be connected in a point-to-point duplex configuration as shown below for proper operation. The OFC module pulses the laser at a low duty cycle while the fiber is open. This produces Class 1 optical power in the open fiber.

The two Transition Detectors shown in the Block Diagram on page 4 detect a minimum AC level of modulated light entering the photoreceiver. These redundant signals shut down the link if either fiber path is open. When the fibers are reconnected, the OFC returns the laser to continuous power. The timing for this sequence is shown on page 6.

GLM Fiber Connection



If the fiber path is opened (both fiber paths are broken), the OFC on each GLM detects the loss of signal and turns off its laser. Each GLM enters the Inactive mode where it pulses its laser at a very low duty cycle. This pulsing behavior provides a safe (laser safety Class 1) laser emission level in the fiber cable. The pulse duration of the laser is roughly equal to the Decode 1 timing modified by the transmitter turn-on/turn-off delays. If the GLM does not receive a responding optical signal during the Decode 1 time period, it continues to emit this pulse every 10.1 sec.

When the fiber path is restored as shown in OFC Timing: Reconnect on page 6, the pulse from one of the GLMs appears at the other GLM. The presence of light is detected and recognized and immediately an optical pulse is returned. (The initiating GLM is referred to as the “master” and the responding GLM is referred to as the “slave”.) This returned optical pulse (emitted by the slave) is received by the initiating (or master) GLM. If this returned optical pulse is detected and recognized by the master during the Decode 1 time interval, the master GLM proceeds to a second timing interval (or state), after the first timing interval expires. During this second timing interval the master GLM waits to see the absence of light (“the lights go off”). This second timing interval is equal to the Decode 2 timing. If the received optical signal goes off during this Decode 2 interval, the master GLM proceeds to a third timing interval after the second interval expires. At the start of this third timing interval, the master GLM energizes its laser where it expects to see the presence of light within a period of time equal to the Decode 3 interval. If the slave GLM complies and energizes its laser and it is received and recognized by the master GLM within the Decode 3 timing interval, the link becomes Active. This “on-off-on” handshake is the basic link initiation sequence.

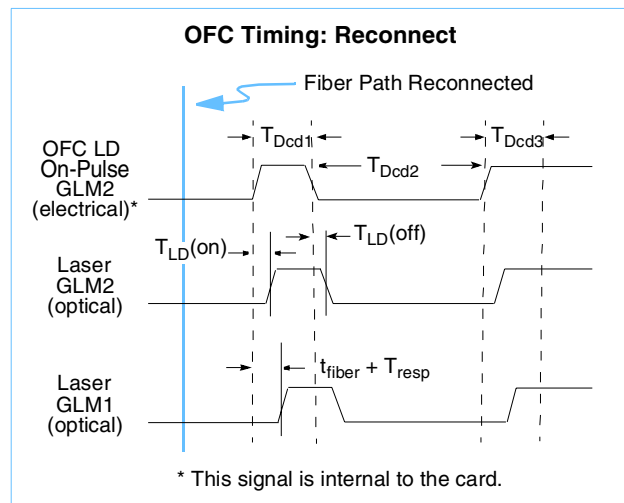
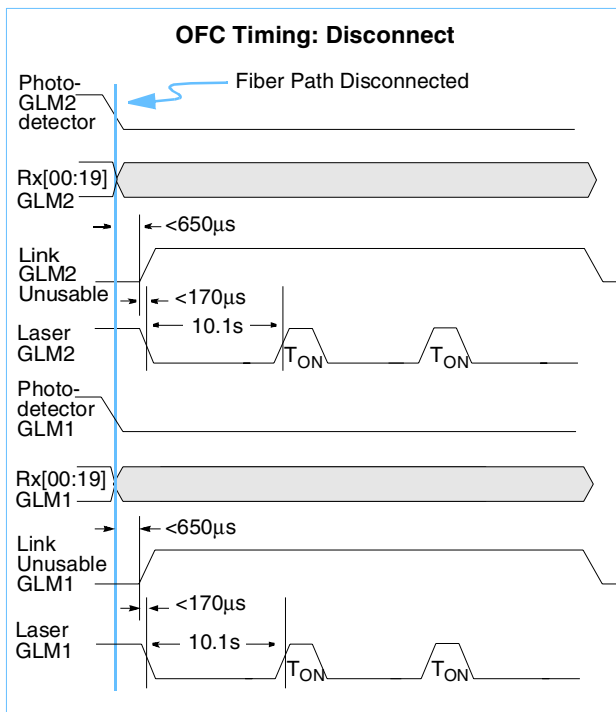
The responding and initiating (slave and master) GLM cards have nominally identical timing intervals (T_{dcd1}, T_{dcd2} and T_{dcd3}). Any GLM card in the Disconnect state functions as a master, sending out an optical pulse every 10.1 sec. The width of this pulse is nominally equal to the Decode 1 time interval. If an optical pulse is received outside this Decode 1 interval, the card immediately becomes a slave, responding with the “on-off-on” handshake sequence.

The timing intervals, Decode 1, 2, and 3, are provided by the OFC IC module (internal to the GLM card) and are extremely accurate since they are driven by a 100ppm 53MHz clock. However, analog circuits on the GLM such as the transmitter driver and receiver amplifier alter the exact timing behavior (see the Open Fibre Control Timing diagrams below). For example, the laser turn-on (T_{LD(on)}) and turn-off delay (T_{LD(off)}) change the duration of the optical pulse emitted during the first Decode 1 timing interval. In addition, during all three Decode timing intervals, the time it takes for the GLM to recognize (or detect) the presence or absence of light must be included in the timing intervals. Three factors: the laser “ON-pulse” (T_{ON}), the laser “OFF-pulse” (T_{OFF}), and the “response” time (T_{resp}), are specified to ensure interoperability with other optical link card manufacturers.

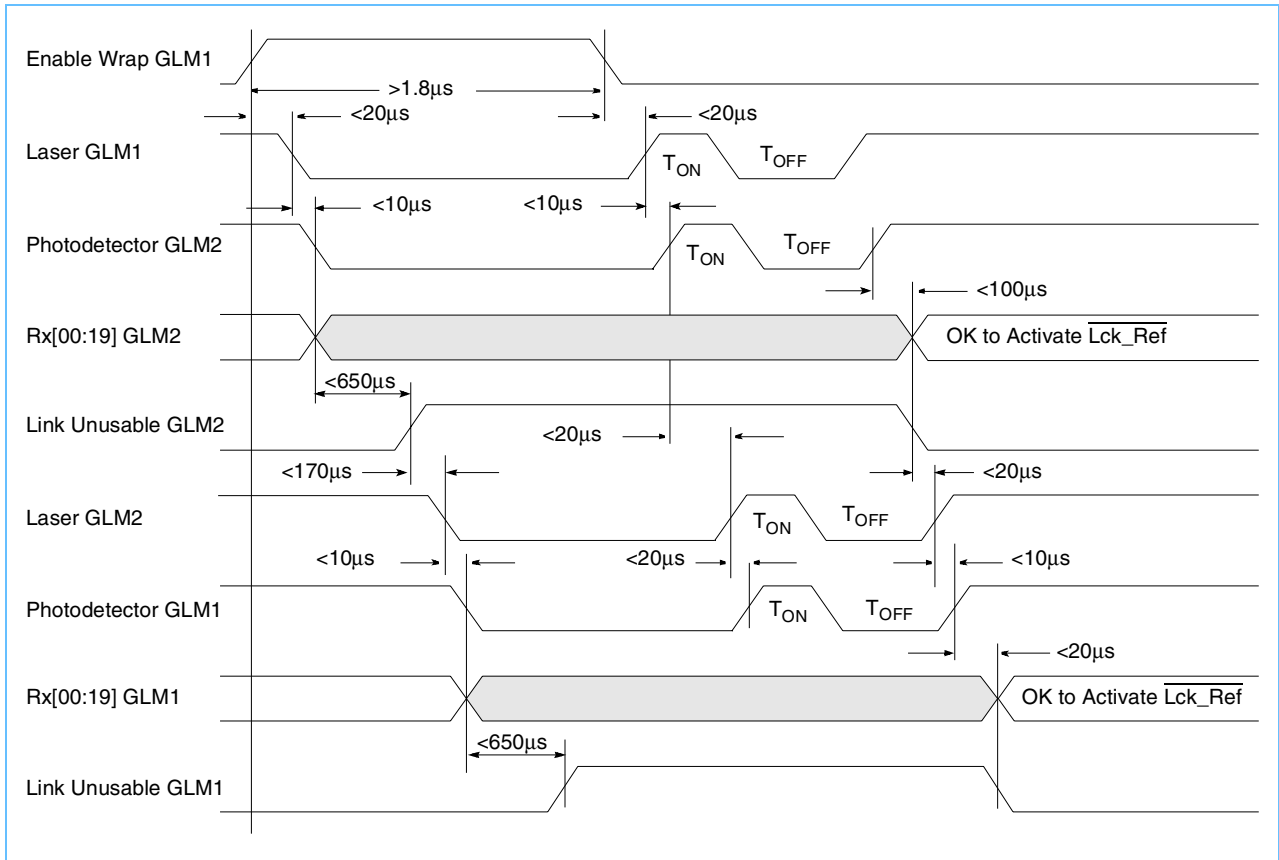
The Open Fibre Control Sequence During Enable Wrap timing diagram on page 7 shows the OFC sequence during an Enable Wrap sequence. As mentioned earlier, if the link is active prior to turning on the Enable Wrap signal, the OFC will respond to the Enable Wrap signal being brought low later by immediately initiating the “on-off-on” handshake.

The Fault Sequence timing diagram on page 8 shows the timing for the Fault and Link Unusable signals with Open Fibre Control.

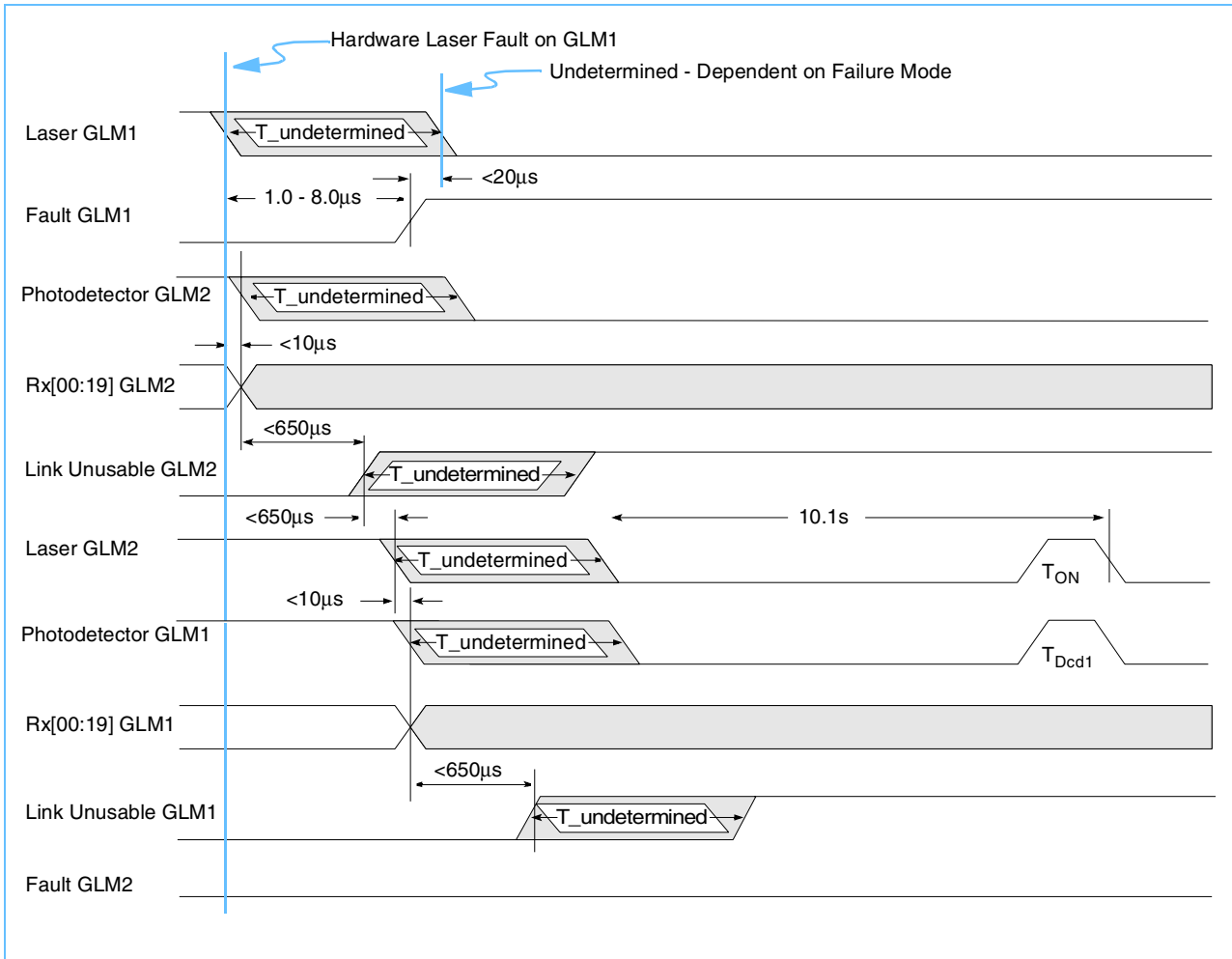
Open Fibre Control Timing



Open Fibre Control Sequence During Enable Wrap



Fault Sequence



Output Signal Definitions

Levels for the signals described in this section are listed in Digital Outputs on page 18.

Receive Byte Clocks (RBC[0:1])

The Clock Generator generates two clock signals, 180 degrees out of phase, for use in clocking the parallel data (Rx[00:19]). Each of the Receive Byte Clocks has a nominal 53.125MHz frequency. The timing of these clocks is shown in the Receive Timings diagram below. If the Enable Comma Detect Signal is active, these clocks will be reset any time that a Comma Character is received (see Comma Detect (Com_Det) on page 10 and Transmit and Lock to Reference Timings on page 13).

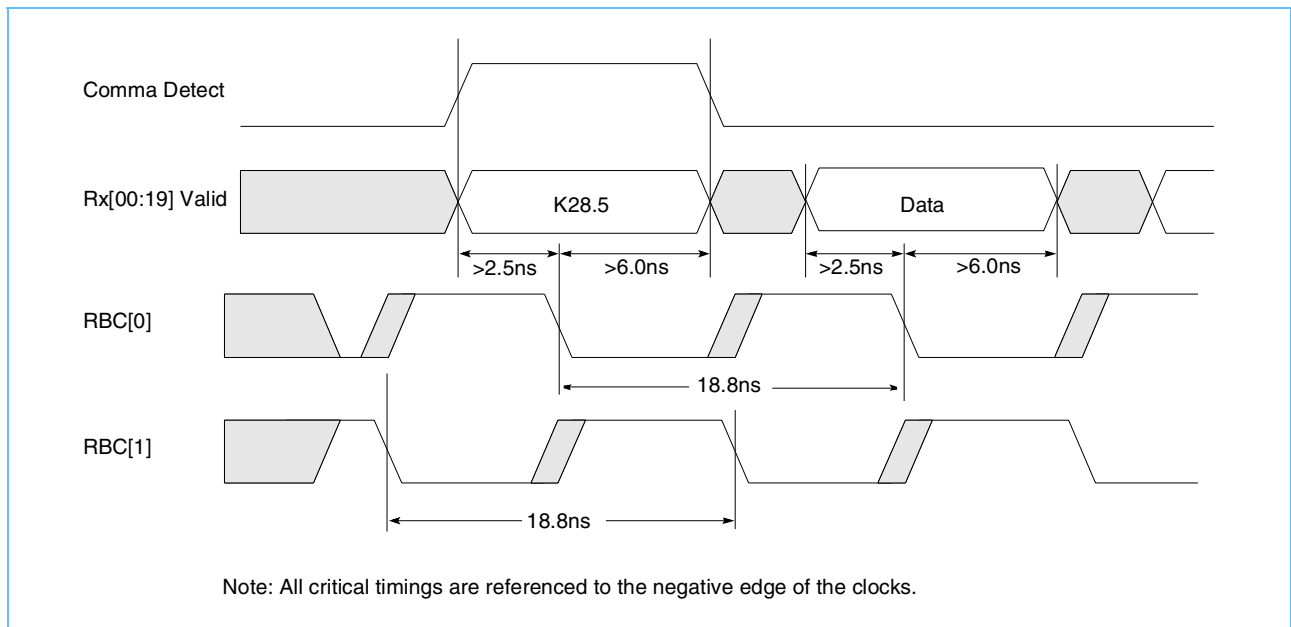
If a stream of comma characters (transmitted on both Tx[00:09] and Tx[10:19]) is received, RBC[0:1] will not operate properly. Having adjacent comma characters violates 8B/10B coding.

If there is no modulated light into the receiver or the PLL is out of lock for some other reason, the Receive Byte Clocks will be operating at an unknown frequency. This frequency will be between 27 and 106MHz.

Receive Data (Rx[00:19])

These 20 lines are used to output the deserialized data to the system logic in parallel. Rx00 is received at the photoreceiver first. Rx19 is received last. The relationship between the Receive Byte Clocks and Receive Data is shown in the Receive Timings diagram below. The alignment of the comma character will always be on Rx[00:09].

Receive Timings



If there is no modulated light into the receiver or the Receive PLL is out of lock for some other reason, the Receive Data lines change randomly.



In most applications, it is assumed that the byte sync character will be transmitted on Tx[00:09]. In the event that the byte sync is transmitted on Tx[10:19], it will still be received on Rx[00:09]. It is essential that the comma character always be sent on the even boundary. (Fibre Channel requires word boundaries.)

Comma Detect (Com_Det)

This signal is driven high for one cycle whenever a Comma Character is detected by the deserializer; the Receive Byte Clocks are also reset. The Comma Character (K28.5) is defined in [3].

This function is referred in the Fibre Channel standard [1] as *byte alignment*. The K28.5 Comma Character is defined with two polarities. The GLM only detects the polarity shown in the Comma Character Description table below.

When the Enable Comma Detect line is high, the Receive Byte Clocks and the byte boundary are aligned upon receiving a Comma Character. In some applications, including Fibre Channel, this Comma Detect character is sent out frequently. Many of these applications wish to (re)align the byte boundary relative to the Receive Byte Clocks whenever a Comma Character is received (Enable Comma Detect line is kept high). One of the disadvantages of this approach is that in the event of a bit error there is a possibility that a Comma Character will be created and the GLM will change its byte boundary and thereby cause all subsequent data to be erroneous until the next Comma Character is received. The decision to keep the Enable Comma Detect line high should be based on the user's application.

One oddity with the current Comma Detect function is that a low Enable Comma Detect only quits detecting a comma character after one has been received.

If there is no modulated light into the receiver or the PLL is out of lock for some other reason, the Comma Detect line will pulse randomly.

The Comma Detect function can be disabled with the Enable Comma Detect input signal. This is described in Enable Comma Detect (En_CDet) on page 14.

The Comma Detect function will not operate properly if a stream of comma characters is transmitted.

Comma Character Description

	Data Bits									
	Rx00	Rx01	Rx02	Rx03	Rx04	Rx05	Rx06	Rx07	Rx08	Rx09
8B/10B Designation ¹	a	b	c	d	e	i	f	g	h	j
Logic Level	0	0	1	1	1	1	1	X	X	X

1. The alphabetical notation (a, b, c, d, e, i, f, g, h, j) conforms to the 8B/10B code description in [3], but is not used in this document because of the confusion frequently caused by these alpha characters being out of alphabetical order.

Link Unusable (L_Unuse)

This signal is driven by the OFC module. When this line is high it indicates that the fiber path is open and the OFC module is pulsing the laser at a low duty cycle. The Link Unusable line goes high within 650µs of the disruption of the incoming received signal.

Link Acquisition Sequence: The following 6-step sequence should be followed to get the GLM in full synchronization with a companion card undergoing a similar sequence. This sequence will also work with a single card when using an optical wrap connector.

1. Power up the GLM. The Transmit Byte Clock should be running as defined in Transmit Byte Clock (TBC) on page 13.
2. The OFC will drive the Link Unusable line to a high state indicating that its receiver is not detecting any signal from the link. Having the Link Unusable line in the high state does not assure that the OFC is operational. This is a necessary but not a sufficient condition.
3. Drive the Transmit Data lines to a 010101010101010101. (This speeds up the synchronization process and assures that the Comma Detect line will not pulse randomly on the companion card during the remainder of this sequence.)
4. Drive the input control lines as follows:
 1. Enable Wrap: low (will not be changed)
 2. Enable Comma Detect: high (will not be changed)
 3. Lock to Reference: high

If a link is properly connected and the companion card is in an equivalent state of readiness, the laser will turn on in 10.1 seconds as indicated by the Link Unusable line going low. This transition indicates that the OFC is indeed operational and in control.

4. After the laser has come on, bring Lock to Reference low for at least 500µs. See Lock to Reference (Lck_Ref) on page 13.
5. Bring the Lock to Reference high.

After 2500 bit times (2.4µs), the GLM should be in bit synchronization (the internal clocks are aligned to the incoming bit stream), but not yet byte synchronization (the byte is aligned along the same boundary it had when sent from the companion system to the companion GLM prior to serialization). The Receive Byte Clock frequency should now be running at 53.125MHz (the frequency of the companion Transmit Byte Clock) and the Comma Detect line is ready to indicate reception of the Comma Character.

6. Drive the Transmit Data lines with a K28.5 (Byte Sync) character.

As soon as the GLM receives the K28.5 character from the other side of the link, the clocks will align to the byte boundary and all the Receive Data lines will have valid data. This will be indicated by the activation of the Comma Detect line (see Receive Section on page 4).

Fault (Fault)

Upon sensing an improper power level in the laser driver, the GLM sets this signal high and turns off the laser within 20µs.

The GLM specification [2] requires that the Fault line be reset by toggling the EWRAP signal. The GLM, however, resets the Fault line only after it has determined that the laser is operating correctly. Per Open Fibre Control requirements, the laser will only be turned on every 10.1 seconds until the link is established.



Strobed ID (Strob_ID)

This output is for use in accessing the serial Strobed ID configuration information. It is retrieved by the method specified in the GLM specification.

Strobed ID Data for IBM42M10SCYAA10

D0	D1	D2	D3	D4	D5	D6	D7
1	0	1	1	1	1	1	1

Strobed ID Data for IBM42M10LCYAA20

D0	D1	D2	D3	D4	D5	D6	D7
0	1	1	1	1	1	0	1

Parallel ID (Par_ID[0:1])

These two pins tell the system logic what speed GLM is installed.

Parallel ID Definition

Par_ID[1]	Par_ID[0]	GLM Type
0	0	132Mb/s
0	1	266Mb/s
1	0	531Mb/s
1	1	1063Mb/s

Input Signal Definitions

Levels for the signals described in this section are listed in Digital Inputs on page 19.

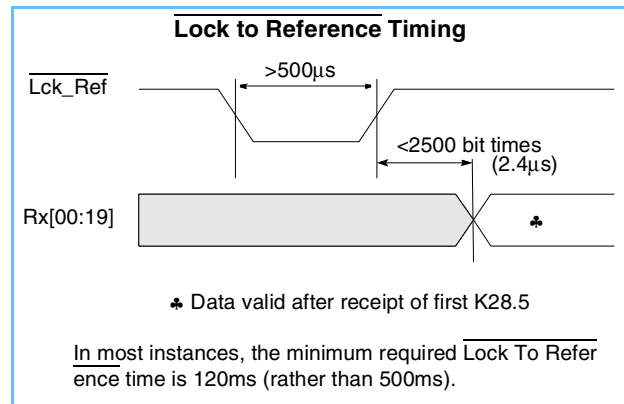
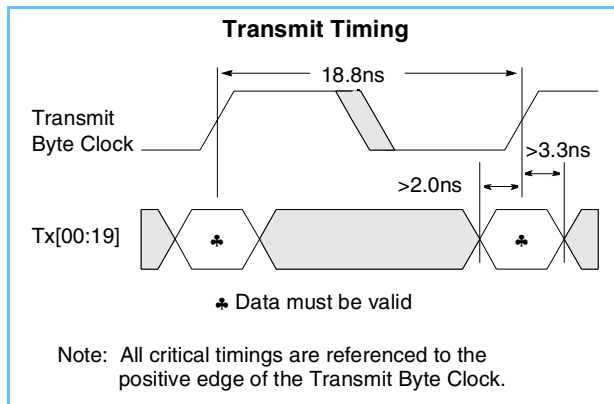
Transmit Byte Clock (TBC)

The system logic provides a single-phase Transmit Byte Clock for transmission operations. The relationship between the Transmit Data and the Transmit Byte Clock is shown in the Transmit Timing diagram below.

Transmit Data (Tx[00:19])

Two 10-bit pre-encoded data bytes from the system logic are presented to the GLM for serialization. Byte 0, comprised of bits Tx00 through Tx09, is launched first. Byte 1, comprised of Tx10 through Tx19, is launched last. The Transmit Timing diagram below shows the Setup and Hold Times for the Transmit Data.

Transmit and Lock to Reference Timings



Lock to Reference (Lck_Ref)

This active low signal causes the deserializer PLL to acquire frequency lock on the Transmit Byte Clock (TBC). The Lock to Reference Timing diagram shows the required Lock to Reference time and the wait time for valid data.

The Lock to Reference line is used in the operation of the receiver PLL. When the incoming data stream is absent (e.g. when the companion GLM is in wrap mode), the receiver PLL will drift to a minimum or maximum frequency (27 to 106MHz) far from the nominal operating point. If the incoming data is turned back on, the PLL will attempt to readjust and may lock onto either the incoming data rate **or to one of its harmonics**.

To guarantee that the PLL locks on to the fundamental frequency of the incoming data, the Lock to Reference line is driven low, forcing the PLL to lock onto the Transmit Byte Clock supplied by the system (which is extremely close to the frequency of the incoming data). It takes a maximum of 500 µs for the PLL to lock onto to the Transmit Byte Clock reference. Thereafter, the Lock to Reference line is driven high by the system and the incoming data stream is directed into the receiver PLL. The receiver PLL will achieve phase and frequency lock of the incoming data within 2500 bit times (2.4µs).

The designer needs to be careful in choosing when the logic exercises the Lock to Reference signal. Since the receiving system is not generally in control of the incoming signal, it must make some savvy decisions about when PLL synchronization is lost.

Lock to Reference Timings:

The GLM specification for the minimum required lock-to-reference time is 500 μ s. Under certain conditions this minimum required time can be reduced to 120 μ s. The following paragraph describes under what conditions this reduced lock time is met.

The frequency of the receiver PLL needs to be in close proximity to the frequency of the incoming data in order to attain phase lock on the data. To do this, the Transmit Byte Clock is applied to receiver IC module through a separate pin. The Lock-to-Reference pin toggles whether the receiver PLL phase locks to the incoming data stream or the Transmit Byte Clock. This process shortens the overall data locking acquisition time. Whenever the Link Unusable line goes high and the Enable E-wrap line is low, the receiver PLL will switch to frequency lock on to the Transmit Byte Clock. If, however, the Enable E-wrap line is high, the receiver PLL will stay locked to the incoming data stream even when the Link Unusable line goes high. By taking advantage of this feature, it is possible to achieve lock-to-reference times as short as 120 μ s.

Enable Comma Detect (En_CDet)

This signal activates the Comma Detect function described in Comma Detect (Com_Det) on page 10. When this line is high, the Comma Detect line will strobe and the Receive Byte Clocks will be reset when a K28.5 character is received.

Enable Wrap (EWrap)

This signal causes the serializer to wrap the Transmit Data to the deserializer and turn off the laser within 20 μ s (which results in the link going down and the Link Unusable line subsequently being driven high). If the link is active (Link Unusable line low) prior to turning on the Enable Wrap signal, the OFC responds to the Enable Wrap signal being brought low later by immediately initiating the “on-off-on” handshake as described in Open Fibre Control on page 5 and shown in Fault Sequence on page 8.

This handshake causes the PLL to lose bit synchronization, making it necessary to cycle the Lock to Reference line after the Link Unusable line again indicates the link is active (see the Transmit and Lock to Reference Timings diagram on page 13).

If for any reason the companion card does not respond as shown in Fault Sequence on page 8 (e.g. the link becomes defective), the OFC sequence will not complete on this cycle. The OFC will try again in 10.1 seconds. For example:

Assume that GLM-1 is put into wrap mode. GLM-2 detects a loss of light and activates the Link_Unusable line. System-2 sees this as a link failure and decides to start diagnostics and similarly goes into wrap mode. GLM-1 comes out of wrap mode and initiates the ‘on-off-on’ handshake. GLM-2 does not respond. System-2 completes diagnostics and comes out of wrap mode. Since the link was not active when GLM-2 went into wrap mode, GLM-2 will not initiate the ‘on-off-on’ sequence for 10.1 seconds. GLM-1 is similarly waiting 10.1 seconds from when it last initiated the ‘on-off-on’ handshake.

The wrap function on the GLM can be used to improve fault isolation. When the Enable Wrap line is driven high, the data that would normally have been transmitted on the fiber is routed to the receiver. The same Lock to Reference sequence used for optical data must still be used to lock to the wrapped data. When the Lock to Reference sequence is completed, the data written to the transmit data lines can be read from the receive data lines.

The Enable Wrap function is useful in determining whether the GLM is correctly seated in the electrical connector. If the GLM functions correctly in wrap mode, any fault is likely to be in the optical path.

Operation

Powering On: Initial Card Outputs

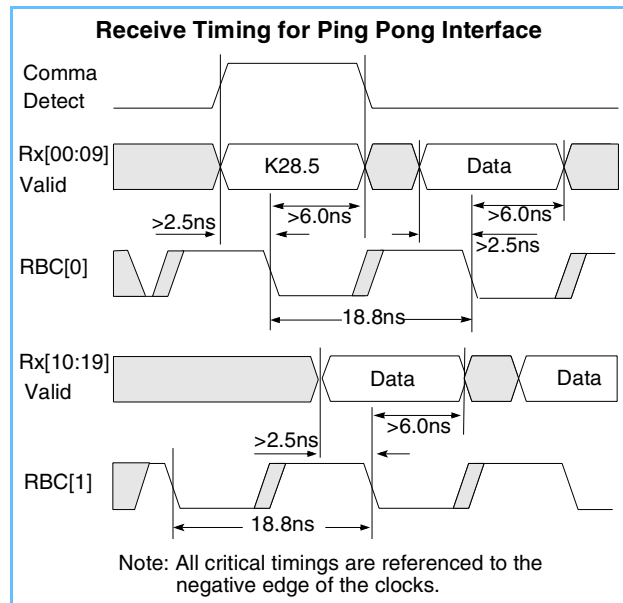
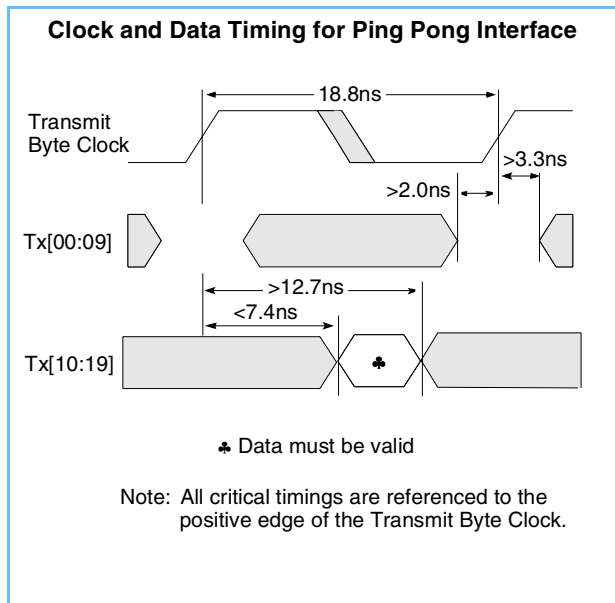
- Receive Data outputs are random.
- Comma Detect will be random.
- Receive Byte Clocks will run between 27 and 106MHz.
- Fault is low.
- Link Unusable is high.

Ping Pong Interface Available

A shortwave 1063Mb/s GLM that utilizes a 20 bit, ping ponged interface is available as a distinct IBM product. This interface is designed to reduce simultaneous switching noise. The ping-ponged interface is designed into the module and is not user selectable (determined only by part number).

Tx[00:09] is timed off the rising edge of the Transmit Byte Clock as shown below. Tx[10:19] is timed off the rising edge of TBC plus one half of the TBC period using identical timing specifications as in "Transmit Data (Tx[00:19])" on page 13.

Ping Pong Interface Timings



Rx[00:09] is timed off of RBC[0] as shown in the IBM42M10LCYAA20 portion of the OFC Timings on page 23. Rx[10:19] is timed off RBC[1] using identical timing specifications as in Receive Data (Rx[00:19]) on page 9. The skew between RBC[0] and RBC[1] shall not exceed $\pm 1.5ns$.

Isolating Hardware Faults

The following sequence can be helpful in isolating most hardware faults:

1. Check the Link Unusable line. If it is low, then the link is active and this process won't help.
2. Check the Fault line. If it is high, then the laser or the laser control circuitry is faulty: replace the GLM.
Note: See Fault (Fault) on page 11 concerning when the GLM resets the Fault line.
Note: The Fault line is known to come on due to probing.
3. Run a set of patterns through the card while in wrap mode (see Enable Wrap (EWrap) on page 14). If these fail, run through the checks in "Troubleshooting: What If ..." below.
4. Disconnect the cable and insert an optical wrap plug, or a simplex 50-micron optical cable, that works properly. Rerun the same tests you did in line 3 (not in wrap mode). If these fail, the optics are defective: replace the GLM.
5. Rerun steps 1 to 4 on the companion GLM. If all tests pass, replace the cable.
Note: If the tests in line 3 pass, this also verifies that the system and all connections to the GLM are operating correctly.
Note: This sequence assumes the use of the Link Acquisition sequence listed on page 11.

Troubleshooting: What If ...

The laser never comes on (the Link Unusable line remains high):

- Verify 5 volts on the GLM.
- Verify Enable Wrap is low (should not be in electrical wrap mode).
- With a scope, verify the Transmit Byte Clock line to ensure that the card is receiving a clean square wave at 53.125MHz.

The module does not achieve bit synchronization:

- Verify that the transmit and receive frequencies are within 0.01% of each other.
- Verify that valid 8B/10B data is being sent on the transmit side. If the transmit side transmits a 01010101010101010101 pattern, the GLM will synchronize the clock to the data stream in the least time.

The module never gets into byte synchronization:

- Verify that the Enable Comma Detect line is high so that a Comma Character will reset the shift register.
- Verify that the transmitting GLM is getting a correct Comma Character on its Tx[00:09] or Tx[10:19] lines, but not both.
Note: A common mistake is switching the order of the lines.

The Fault line comes on:

The laser or its control circuitry is broken. Repeat the power-on sequence to verify the problem.

Note: The Fault line is known to come on due to probing.



Absolute Maximum Ratings

Parameter	Symbol	Min.	Typical	Max.	Units	Notes
Storage Temperature	T_S	-40		75	°C	1
Relative Humidity–Storage	RH_S	0		95	%	1, 2
Ambient Operating Temperature	T_{OP}	0		70	°C	1
Relative Humidity Operating	RH_{OP}	8		80	%	1
Supply Voltage	V_{CC}	-0.5		6.0	V	1
TTL DC Input Voltage	V_I	0		$V_{CC} + 0.7$	V	1

1. Stresses listed may be applied one at a time without causing permanent damage. Functionality at or above the values listed is not implied. Exposure to these values for extended periods may affect reliability.
2. Excludes condensing environment.

Recommended DC Operating Conditions

Parameter	Symbol	Min.	Typical	Max.	Units
Ambient Operating Temperature	T_{OP}	10		50	°C
Supply Voltage	V_{CC}	4.5	5.0	5.5	V
Relative Humidity Operating	RH_{OP}	8		80	%
Transmit Byte Clock	f_{TBC}	53.1197	53.1250	53.1303	MHz



Electrical Characteristics

Power Supply

Parameter	Symbol	Min.	Typical	Max.	Units
Current (@ 5.0 V)			520		mA
Current (@ 5.5 V)			530		mA
Ripple & Noise				100	mV(pk-pk)

Digital Outputs

Parameter	Symbol	Min.	Typical	Max.	Unit	Notes
Receive Byte Clock, Receive Data, Comma Detect Drive Levels						
Data Output, Voltage - High (Source 0.5mA)	V_{OH}	2.4		V_{CC}	V	
Data Output, Voltage - Low (Sink 0.5mA)	V_{OL}	0		0.6	V	
Receive Byte Clock, Receive Data, Comma Detect Timing						
Receive Byte Clock Duty Cycle		40		60	%	
Rise Time	t_r	0.7	2	3.0	ns	1
Fall Time	t_f	0.7	2	2.4	ns	1
Receive Data Setup Time		2.5			ns	
Receive Data Hold Time		6.0			ns	
Setup Time for Data Rx[10:19] in Ping-Pong Mode		2.5			ns	2
Hold Time for Data Rx[10:19] in Ping-Pong Mode		6.0			ns	2
Unlocked Frequency		27		106	MHz	
Link Unusable and Fault Driver Levels						
Data Output, Voltage - High (Source 4.0mA)	V_{OH}	2.4		V_{CC}	V	
Data Output, Voltage - Low (Sink 4.0mA)	V_{OL}	0.0		0.4	V	
Parallel ID Bits						
Output Voltage	V_{OH}		V_{CC}		V	2
<ol style="list-style-type: none"> 1. Rise and fall times are measured from 0.8 to 2.0 volts with the outputs driving a 10pF lumped capacitive load. 2. See "Ping Pong Interface Available" on page 15 for a description of this timing interface. 3. The Parallel ID bits are tied to V_{CC} through 10k ohm resistors. 						



Digital Inputs

Parameter	Symbol	Min.	Typical	Max.	Units	Notes
Enable Wrap Level						
Data Input, Voltage - High (Sink 10 μ A)	V_{IH}	2.0		V_{CC}	V	1
Data Input, Voltage - Low (Source 2mA)	V_{IL}	0.0		0.8	V	1
Transmit Data, Transmit Byte Clock, Enable Comma Detect, Lock to Reference, and Transmit SI Levels						
Data Input, Voltage - High (Sink 10 μ A)	V_{IH}	2.0		V_{CC}	V	1
Data Input, Voltage - Low (Source 1mA)	V_{IL}	0.0		0.8	V	1
Transmit Byte Clock, Transmit Data Timing						
Rise Time	t_r			3.2	ns	2
Fall Time	t_f			3.2	ns	2
Duty Cycle		32		68	%	
Positive Edge Jitter				0.5	ns	
Frequency	f_{TBC}	53.1197	53.1250	53.1303	MHz	
Transmit Data Setup Time	2.0				ns	
Transmit Data Hold Time	3.3				ns	
<p>1. The overshoot and undershoot limits for the logic inputs are 0.7 V above V_{CC} and ground, respectively. 2. Rise and fall times are measured from 0.8 to 2.0 volts with the outputs driving a 10pF lumped capacitive load.</p>						



Optical Characteristics

Short Wavelength

Parameter	Symbol	Min.	Typical	Max.	Units	Notes
Optical Power Budget	OPB	6			dB	
Receiver Specifications						
Return Loss of Receiver	RL	12			dB	
Received Power		-13.0		1.3	dBm (avg)	1
Operating Wavelength	λ	770		860	nm	
Transmitter Specifications						
Spectral Center Wavelength	λ_C	770		860	nm	
Spectral Width	$\Delta\lambda$			4	nm (rms)	
Launched Optical Power	PT	-7.0		-1.0	dBm (avg)	2
Optical Extinction Ratio		6			dB	3
Relative Intensity Noise	RIN ₁₂			-116	dB/Hz	4
Eye Opening		57			% (pk-pk)	5
Deterministic Jitter	DJ			20	% (pk-pk)	6

1. The minimum and maximum values of the average received power in dBm give the input power range to maintain a BER < 10⁻¹². These values take into account power penalties caused by the use of a transmitter with a worst-case combination of transmitter spectral width, extinction ratio, and pulse shape characteristics.
2. Launched optical power is measured at the end of a 2 meter section of a 50/125 μ m fiber (N.A.=0.20) for the IBM42M10SCYAA10 (short wavelength GLM) and a 9/125 μ m fiber for the IBM42M10LCYAA20 (long wavelength GLM). The maximum and minimum of the allowed range of average transmitter power coupled into the fiber are worst case values to account for manufacturing variances, drift due to temperature variations, and aging effects.
3. Extinction Ratio is the ratio of the average optical power (in dB) in a logic level one to the average optical power in a logic level zero measured under fully modulated conditions in the presence of worst case reflections.
4. RIN₁₂ is the laser noise, integrated over a specified bandwidth, measured relative to average optical power with 12dB return loss. See ANSI Fibre Channel Specification Annex A.5 [1].
5. Eye opening is the portion of the bit time which is error free for a given bit error rate (BER). The Fibre Channel standard for BER is < 10⁻¹². The general laser transmitter pulse shape characteristics are specified in the form of a mask of the transmitter eye diagram. These characteristics include rise time, fall time, pulse overshoot, pulse undershoot, and ringing, all of which should be controlled to prevent excessive degradation of the receiver sensitivity. When assessing the transmit signal, it is important to consider not only the eye opening, but also the overshoot and undershoot limitations.
6. Deterministic Jitter is measured as the peak-to-peak timing variation of the 50% optical signal crossings when transmitting repetitive K28.5 characters. It is defined in FC-PH, version 4.1, clause 3.1.84 as:

Timing distortions caused by normal circuit effects in the transmission system. Deterministic jitter is often subdivided into duty cycle distortion (DCD) caused by propagation differences between the two transitions of a signal and data dependent jitter (DDJ) caused by the interaction of the limited bandwidth of the transmission system components and the symbol sequence.

Long Wavelength

Parameter	Symbol	Min.	Typical	Max.	Units	Notes
Optical Power Budget	OPB	9			dB	7
Receiver Specifications						
Return Loss of Receiver	RL	12			dB	
Received Power		-20.0		-3.0	dBm(avg)	1
Operating Wavelength	λ	1270		1355	nm	
Transmitter Specifications						
Spectral Center Wavelength	λ_C	1270		1355	nm	
Spectral Width	$\Delta\lambda$			6	nm (RMS)	
Launched Optical Power	PT	-9.0		-3.0	dBm(avg)	2
Optical Extinction Ratio		9			dB	3
Relative Intensity Noise	RIN_{12}			-116	dB/Hz	4
Eye Opening		57			% (pk-pk)	5
Deterministic Jitter	DJ			20	% (pk-pk)	6

- The minimum and maximum values of the average received power in dBm give the input power range to maintain a BER 10^{-12}. These values take into account power penalties caused by the use of a transmitter with a worst-case combination of transmitter spectral, extinction ratio, and pulse shape characteristics.
- Launched optical power is measured at the end of a 2 meter section of a 50/125 μ m fiber (N.A.=0.20) for the IBM42M10SCYAA10 (short wavelength GLM) and a 9/125 μ m fiber for the IBM42M10LCYAA20 (long wavelength GLM). The maximum and minimum of the allowed range of average transmitter power coupled into the fiber are worst case values to account for manufacturing variances, drift due to temperature variations, and aging effects.
- Extinction Ratio is the value of the ratio of the average optical power (in dB) in a logic level one to the average optical power in a logic level zero measured under fully modulated conditions in the presence of worst case reflections.
- RIN_{12} is the laser noise, integrated over a specified bandwidth, measured relative to average optical power with 12dB return loss. See ANSI Fibre Channel Specification Annex A.5 [1].
- Eye opening is the portion of the bit time which is error free for a given bit error rate (BER). The Fibre Channel standard for BER is 10^{-12}. The general laser transmitter pulse shape characteristics are specified in the form of a mask of the transmitter eye diagram. These characteristics include rise time, fall time, pulse overshoot, pulse undershoot, and ringing, all of which should be controlled to prevent excessive degradation of the receiver sensitivity. For the purpose of an assessment of the transmit signal, it is important to consider not only the eye opening, but also the overshoot and undershoot limitations.
- Deterministic Jitter is measured as the peak-to-peak timing variation of the 50% optical signal crossings when transmitting repetitive K28.5 characters. It is defined in FC-PH, version 4.1, clause 3.1.84 as:
Timing distortions caused by normal circuit effects in the transmission system. Deterministic jitter is often subdivided into duty cycle distortion (DCD) caused by propagation differences between the two transitions of a signal and data dependent jitter (DDJ) caused by the interaction of the limited bandwidth of the transmission system components and the symbol sequence.
- This 9dB optical power budget is a result of the difference between the worst case transmitted launch power, the receiver sensitivity and a 2dB optical path power penalty (as specified in the ANSI Fibre Channel specification):

$$(-9dBm) - (-20dBm + 2dB) = 9dB$$



Optical Cable/Connector Requirements

Parameter	Symbol	Min.	Typical	Max.	Units	Notes
9/125µm Cable and Connector Specifications (Single Mode)						
Length	L	2		10000	m	
Attenuation @ 1300nm	μ_c			0.5	dB/km	
SC Optical Connector (Single Mode)						
Nominal Attenuation	μ_{con}		0.75			1
Attenuation Standard Deviation	σ_{con}		0.2			1
Connects/Disconnects				250	cycles	1
50/125µm Cable and Connector Specifications (Multimode)						
Length	L	2		550	m	2
Bandwidth @ 850nm	BW	500			MHz-km	2
Attenuation @ 850nm	μ_c			3.0	dB/km	2
Numerical Aperture	N.A.		0.20			2
62.5/125µm Cable Specifications (Multimode)						
Length		2		300	m	3
Bandwidth @ 850nm	BW	160			MHz-km	3
Attenuation @ 850nm				3.0	dB/km	3
Numerical Aperture	N.A.		0.275			3
SC Optical Connector (Multimode)						
Nominal Attenuation	μ_{con}		0.3	0.5	dB	1
Attenuation Standard Deviation	σ_{con}		0.2		dB	1
Connects/Disconnects				250	cycles	1
<ol style="list-style-type: none"> 1. The optical interface connector dimensionally conforms to the industry standard SC type connector documented in JIS-5973. A dual keyed SC receptacle serves to align the optical transmission fiber mechanically to the GLM. See "Duplex SC Receptacle" on page 27 for a drawing of the duplex SC receptacle that is part of the GLM. 2. The recommended optical fiber has a core diameter of 50µm, cladding diameter of 125µm, and a nominal Numerical Aperture of 0.20. The minimum modal bandwidth (-3dB optical) should be 500MHz•km at a wavelength of 850nm. This ensures a modal bandwidth of 400MHz•km at a wavelength of 780nm, capable of supporting the specified distance. Fiber attenuation should be 3.0dB/km maximum at $\lambda=850\text{nm}$. This ensures a fiber attenuation of 4.0dB/km maximum at $\lambda=780\text{nm}$. 3. Optical fiber with a core diameter of 62.5µm, cladding diameter of 125µm, and a nominal Numerical Aperture of 0.275 can also be used with the IBM42M10SCYAA10. The minimum modal bandwidth (-3dB optical) should be 160MHz•km at a wavelength of 850nm which will support the specified distance at 780nm. 						



OFC Timings

Parameter	Symbol	Min.	Typical	Max.	Units	Notes
for IBM42M10SCYAA10 (short wavelength)						
Decode 1 Time	T_{Dcd1}		154		μs	1
Decode 2 Time	T_{Dcd2}		617		μs	1
Decode 3 Time	T_{Dcd3}		154		μs	1
Laser ON-pulse	T_{ON}	80		220	μs	1
Laser OFF-pulse	T_{OFF}	300			μs	1
Laser-ON + Laser-OFF				805	μs	1
Response Time	T_{resp}			55	μs	1
for IBM42M10LCYAA20 (long wavelength)						
Decode 1 Time	T_{Dcd1}		617		μs	1
Decode 2 Time	T_{Dcd2}		1234		μs	1
Decode 3 Time	T_{Dcd3}		617		μs	1
Laser ON-pulse	T_{ON}	400		800	μs	1
Laser OFF-pulse	T_{OFF}	1000			μs	1
Laser-ON + Laser-OFF				1950	μs	1
Response Time	T_{resp}			150	μs	1
1. The Decode_1 (T_{Dcd1}) and Decode_2 (T_{Dcd2}) timings are defined in FC-PH, version 4.2, clause 6.2.3.3. The nominal tolerances are the same as the Transmit Byte Clock: 100ppm. These times are constrained by the laser turn-on delay, laser turn-off delay, detection delay, laser power and relevant laser safety standards. T_{ON} , T_{OFF} and T_{resp} are specified to guarantee interoperability.						



Thermal Characteristics

Air Speed (lfpm)	External Thermal Resistance (R_{ext}) (°C/W)	Notes
Ser/Des IC Module		
161	18.0	1
268	20.9	1
375	25.9	1
Laser Driver/Post Amp IC Module		
161	38.7	1
268	43.2	1
375	51.2	1

1. The case temperature can be calculated using the following equation:

$$CASE = T_{ambient} + R_{ext} \times ACF \times Power$$

where ACF = Altitude Correction Factor (1 for Sea Level & 1.12 for 4200 ft.) and $Power$ = power dissipated in the serializer or deserializer IC module (calculated from table below).

$V_{CC} = 4.5V$ to $5.5V$

IC Module	Typical	Max
Serializer/Des.	0.92W	1.32W
Laser Driver/Post Amp	0.65W	0.84W

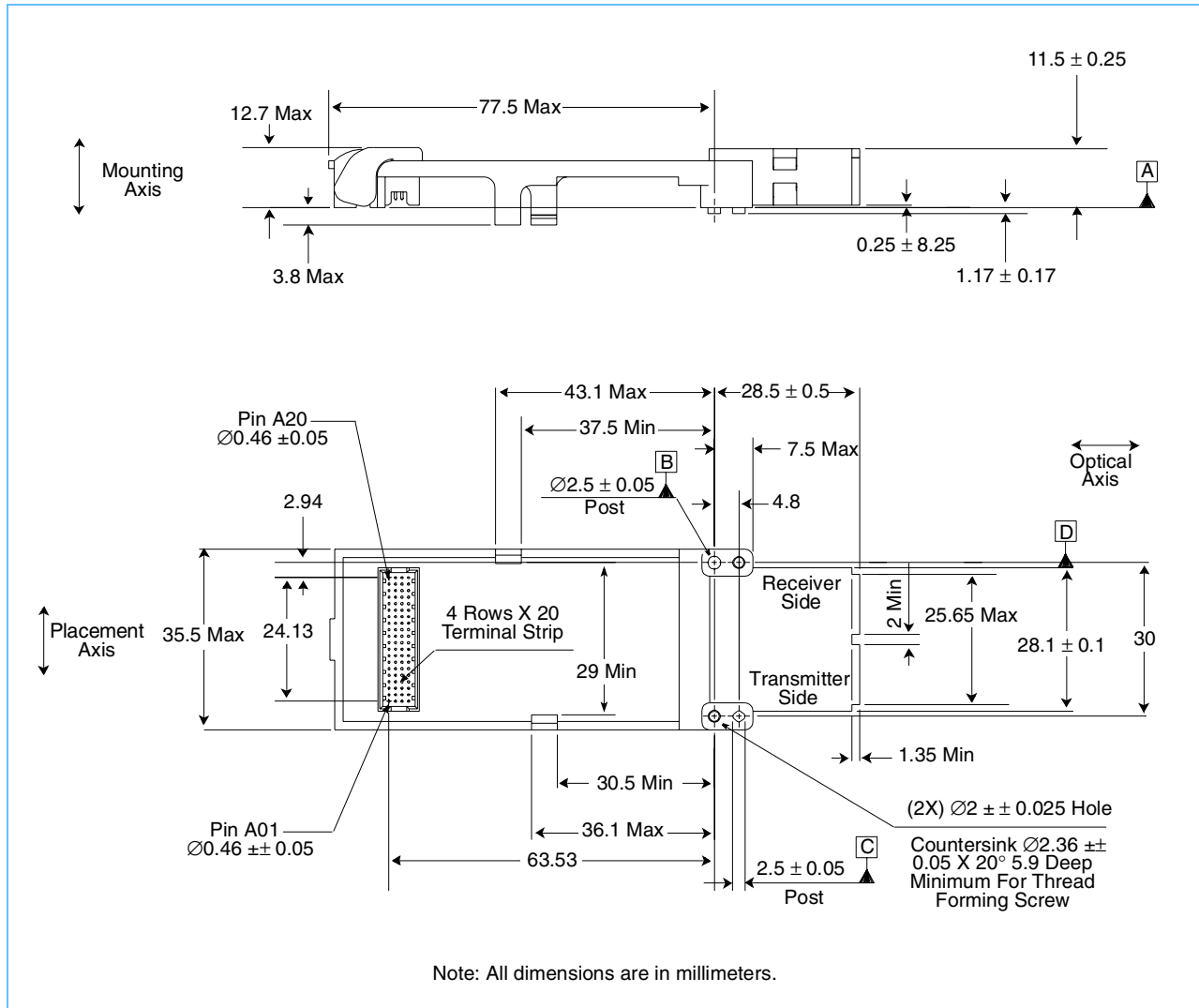
Reliability Projections

Parameter	Symbol	Min	Typical	Max.	Units	Notes
Average Failure Rate	AFR			0.0195	%/khr	1

1. AFR specified over 44 khours. To meet the specified AFR, the case temperatures of the serializer and deserializer IC modules should not exceed 85°C. In addition, the case temperature of the laser should not exceed 50°C.

Mechanical Description

Card Layout

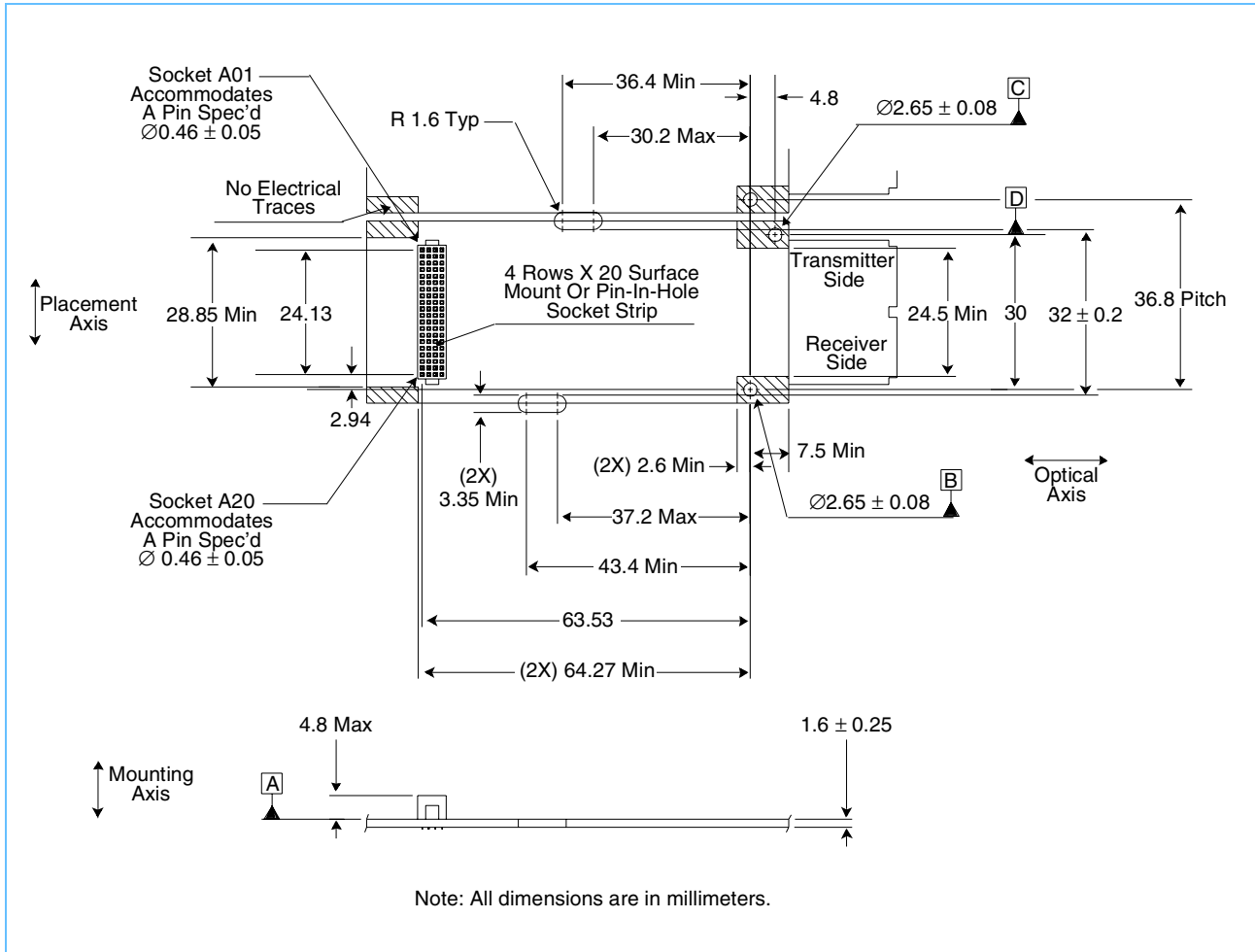


The transmit and receive circuits are electrically isolated on opposite sides of a double sided surface mount card. Two optical receptacles are at the end of the card. They are spaced 12.7mm apart to accept a standard duplex SC connector such as the one shown on page 27.

The optical receptacles on the end of the IBM42M10LCYAA20 (long wavelength GLM) do not contain the Fibre Channel specified "single mode keying" features. Both singlemode and multimode SC duplex connectors can be inserted.

The Host Card Footprint with essential keepout areas is shown on page 26.

Host Card Footprint

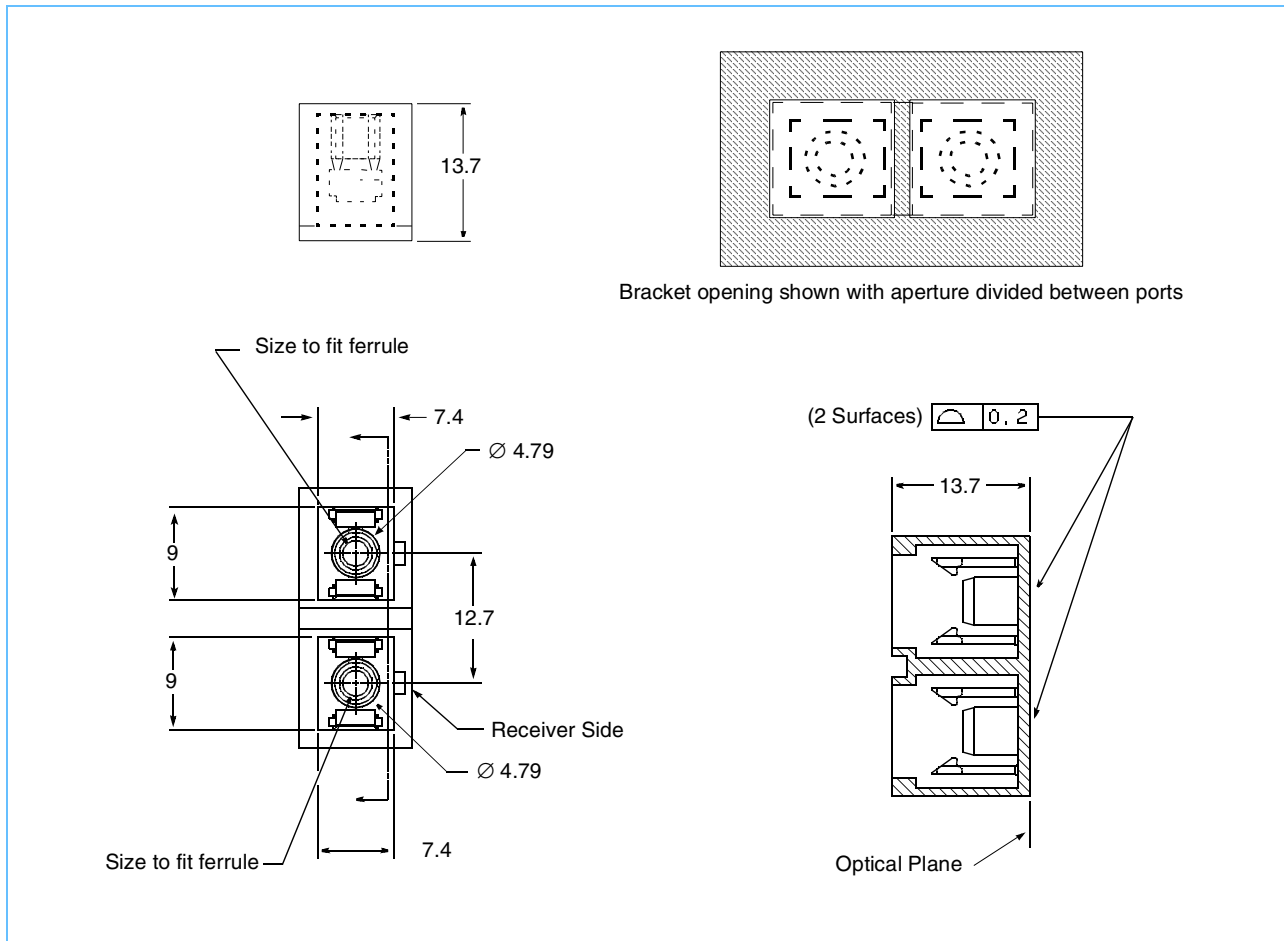


System Board Thickness

These GLMs are optimized for use with a board that is between 0.053 inches (1.35mm) and 0.073 inches (1.85mm) thick. Thicker boards can be used by:

- Routing out the area where the L-Clip latches into the board so that it does not exceed a thickness of 0.073 inches.
- Routing out a larger area than required by the L-Clips and using some other retention mechanism (e.g. the screw holes on the optical end of the card).

Duplex SC Receptacle



System Board Configurations

These GLMs are designed to be used in multiple configurations:

- **Back-to-back:** All necessary card features are offset to allow ease of installation on opposite sides of a host card. This requires the use of female surface mount connectors on the system card.
- **Close pitch side-to-side:** Cards can be placed on a 36.8mm pitch by sharing common holes for L-Clip retention.
- **Both:** Back-to-back and close pitch side-to-side are completely compatible.

Mechanical Features

Positive Retention: The integrated L-Clips provide sufficient retention for most environments. Screw holes are integrated into the retainer on the optical end of the product for use in environments with high vibration content or where tail stock or other additional mounting hardware is not used to secure the SC connectors.

Integrated Extraction Tool: This tool provides a simple method to remove the GLM from the host card without requiring access to the sides or back of the card. It also minimizes stress to both the GLM and the system card during removal of the GLM.

Alignment Pins: These pins are integrated into the product. The center of the round pin is the GDT (Geometrical Dimension and Tolerance, an industry standard mechanical drawing methodology) registration point. These pins also provide stress relief for the 80-pin connector. This is especially important when the system card uses a surface mount connector.

EMI Slot: There is a small (2mm) vertical slot in the SC connector. This allows the system to cut the aperture of SC connector in half. This is extremely important in applications where the SC connector extends outside the system box. We strongly encourage designing the tail stock with a hole for each of the SC connectors (i.e., have a small metal strip between the connectors).

Connector Availability

One source for the mating connectors is:

Samtec
810 Progress Blvd., PO Box 1147
New Albany, IN 47151-1147
(812) 944-6733

Samtec Part Numbers:
Pin-in-hole: FOLC-120-01-P-Q-LC
Surface-mount with Standard Clipping:
FOLC-120-02-P-Q-LC
Surface-mount with Reverse Clipping:
FOLC-120-02-P-Q-LCR

References

1. American National Standards Institute Inc. (ANSI), X3T11, Fibre Channel-Physical and Signaling Interface (FC-PH). Copies of this document may be purchased from:

Global Engineering
15 Inverness Way East
Englewood, CO 80112-5704
Phone: (800) 854-7179 or (303) 792-2181
Fax: (303) 792-2192.
2. Fibre Channel Systems Initiative. (FCSI), Gigabaud Link Module Family FCSI-301-Revision1.0, Feb, 16, 1994. This document may be downloaded under anonymous ftp from: playground.sun.com. It is in the file pub/incoming/fcsi-301-rev1.ps
3. A.X. Widmer and P.A. Franaszek, "A DC-Balanced, Partitioned-Block, 8B/10B Transmission Code," *IBM Journal of Research and Development*, vol. 27, no. 5, pp. 440-451, September 1983. This paper fully defines the 8B/10B code. It is primarily a theoretical work pinned in coding theory.
4. A.X. Widmer, The ANSI Fibre Channel Transmission Code, *IBM Research Report, RC 18855 (82405)*, April, 23 1993. Copies may be requested from:

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Revision Log

Rev. Date	Contents of Modification
Nov. 1998	Initial release (00).
Mar. 1999	First revision (01). Corrected part numbers. Corrected maximum wavelength to 10km.
Feb. 15, 2000	Second revision (02). Corrected part number IBM42M10LCNAA20 to IBM42M10LCYAA20. Changed Strobed_ID data for IBM42M10SCNAA10 and added it for IBM42M10LCNAA20. Refined appearance of some headings to show hierarchy of content.



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