Product Data Sheet

3M™ Active Optical Cable (AOC) Assemblies for QSFP+ FDR Applications

REVISION HISTORY

Revision No.	Change Description	Effective Date
1.2	New Release	27/01/2014

3M Electronic Solutions Division
6801 River Place Blvd.
Austin, TX 78726-9000
http://www.3Mconnectors.com

Description

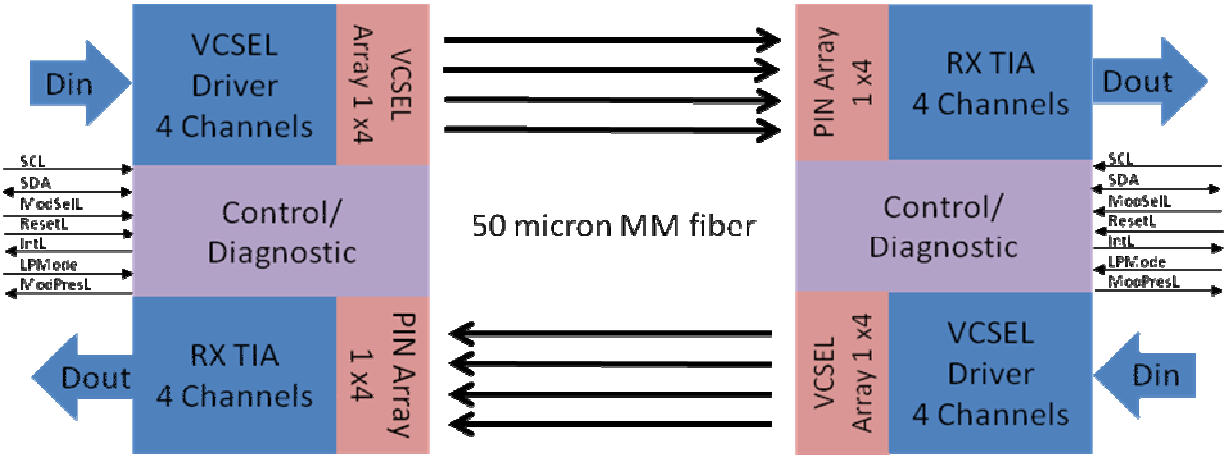
The 3M Active Optical Cable (AOC) Assembly for QSFP+ FDR (fourteen data rate) Applications extends the performance and benefits of its light engine technology to 14 Gbps per channel. This AOC provides an aggregate throughput of 56 Gbps in each direction over 100 meters of multimode fiber for applications in the new generation of 14 Gbps InfiniBand™ switches and servers. Using industry leading VCSEL technology and an advanced light-engine design, the 3M AOC assembly provides exceptional cost/performance value.

Features

- Low power
- Four channels each operating up to 14.0625 Gbps
- Fiber link up to 100m
- Reliable 850nm VCSEL technology
- 0 to +70 degree Celsius operating temperature range
- Hot pluggable
- Bend-insensitive fiber
- Includes digital diagnostic features

3M Electronic Solutions Division
Interconnect Products
6801 River Place Blvd.
Austin, TX 78726-9000
http://www.3Mconnectors.com

AOC block diagram



Absolute Maximum Rating

Parameters	Min	Typ	Max	Units
Storage temperature	-20		+70	Deg. Celsius
Relative humidity	5		85	%
Supply voltage	3.10		3.65	V
Operating case temperature	0		+70	Deg. Celsius

Note: if product is exposed to conditions beyond the levels indicated, the reliability of the product is likely to be negatively affected.

Recommended Operating Conditions

Parameter	Min	Typ	Max	Units
Supply voltage, Vcc	3.135	3.3	3.465	V
Power dissipation		600		mW
Operating case temperature	0		+70	Degree Celsius
Signal Rate per channel	2.5		14.0625	Gbps
Transmitter differential input voltage	120		1200	mVpp
Receiver differential output voltage, peak-to-peak		422		mV
Receiver differential output Impedance		100		Ohms
Signaling rate/channel, NRZ			14.0625	Gbps

Transmitter Electrical Input Characteristics

Parameters	Min	Typ	Max	Units
Single-ended output voltage	-0.3		4.0	V
Transmitter differential input voltage, peak-to-peak	120		1200	mVpp
J2 Jitter tolerance			0.19	UI
J9 Jitter tolerance			0.34	UI
Data Dependent Pulse Width Shrinkage			0.11	UI
SDD11 Differential input return loss			see note 1	dB
SCC11 Common mode input return loss			-2	dB (see note 2)
SDC11 Common mode to differential reflection			see note 3	dB

Notes:

1. SDD11 differential input return loss is defined at TP5a as: $\leq$
   { -12+1.71 SQRT(f), $0.05 \leq f < 5.6$;
   -6.7+13log(f/7), $5.6 \leq f < 14.1$ }, freq in GHz
2. SCC11 is measured at TP5a from 200MHz to 14.1 GHz
3. SDC11 is defined as $<$ { -16+(2/3)f, measured at TP5a from 50MHz to 14.1 GHz}
   (TP5a is defined in the Infiniband Architecture specification)

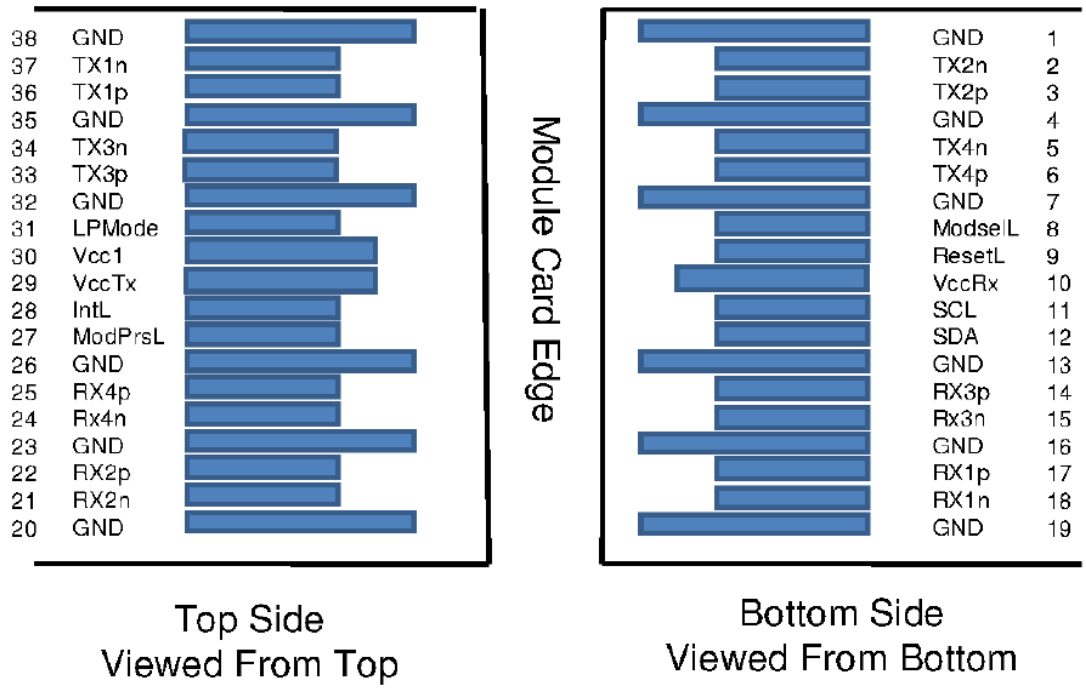
Receiver Electrical Output Characteristics

Parameters	Min	Typ	Max	Units
Single-ended output voltage	-0.3		4.0	V
Receiver differential output impedance		100		Ohms
J2 Jitter [5]			0.44	UI
J9 Jitter [5]			0.69	UI
Output transition time (20% to 80%)	17			ps
SDD22 Differential output return loss			see note 1	
SCC22 Common mode output return loss			-2	dB (see note 2.
SDC22 Common mode to differential reflection			see note 3	dB
Link bit error rate (BER)	<10E-12			Bit
Eye mask parameter, time X	0.30			UI
Differential output Voltage, Y1, Y2	100, 350 (default setting = IBTA range 1)			mV (see note 4)

Notes:

1. SDD22 differential output return loss is defined at TP7a as: ≤
   { -12+1.71 SQRT(f), 0.05 < f < 5.6;
   -6.7+13log(f/7), 5.6 < f < 14.1}, freq in GHz
2. SCC22 measured at TP7a from 200MHz to 14.1 GHz
3. SDC22 is defined as: ≤ { -16+(2/3)f, measured at TP7a from 50MHz to 14.1 GHz}
4. Eye mask Y1,Y2 = 50, 225 (IBTA range 0 is supported)
5. J2 and J9 Jitter are tested under condition with maximum 2 nearest aggressors.

QSFP+ Pad layout



Mechanical Characteristics

Parameters	Min	Typ	Max	Units
Cable Installation Tension			90	N
Cable Operating Tension			31	N
Operating Cable Bend Radius	3			cm
Installation Cable Bend Radius	6			cm
Cable Outer Diameter	2.85	3.0	3.15	mm

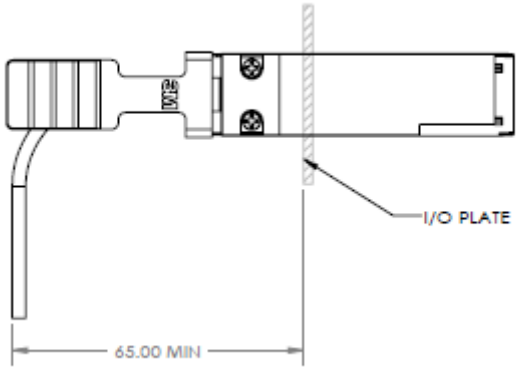
Link Performance

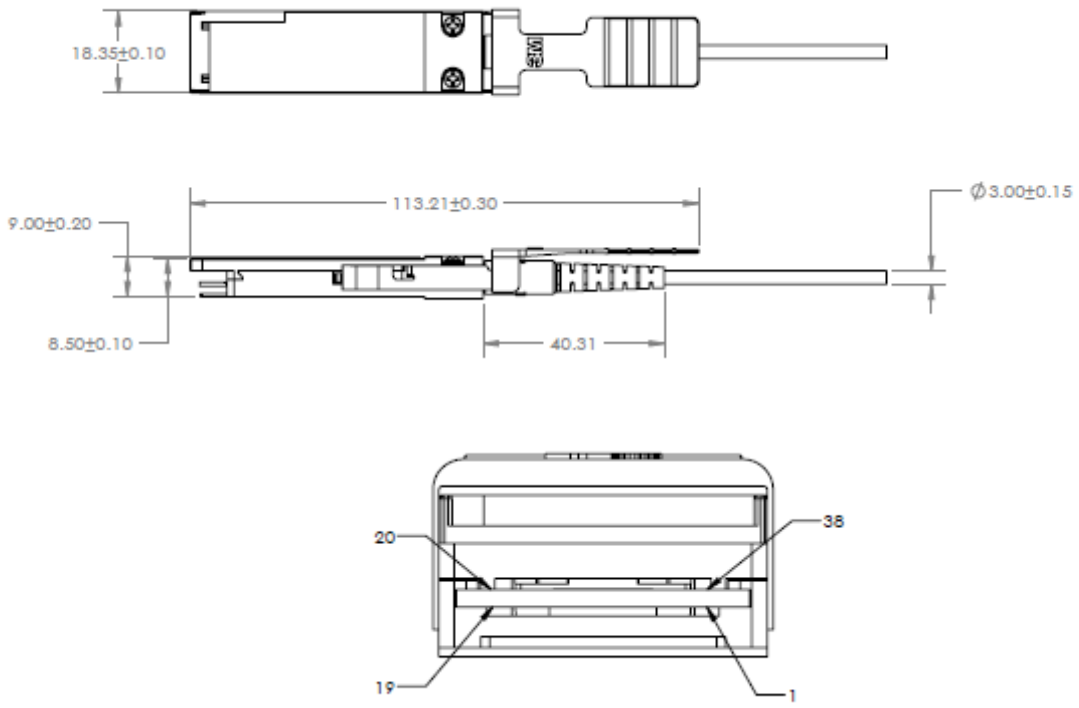
The 3M Active Optical Cable (AOC) Assembly for QSFP+ FDR Applications uses advance OM2+ multimode fiber with overfilled modal bandwidth of >700MHz.Km and effective modal bandwidth of >950MHz.km at wavelength of 850nm. This allows excellent link performance up to 100 meter for InfiniBand™ FDR applications.

Standards and Regulatory Compliance

- Designed to meet SFF-8436 specification, Rev 4.2, March 21, 2012
- Supports Infiniband Architecture Specification Volume 2, Release 1.3 (November 6, 2012)
- Restriction on Hazardous Substances (RoHS) per EU requirements (ROHS directive)*
- Class 1M Eye safe per IEC 60825-1/CDRH
- UL 94 –V0 rating
- FCC Class B and CE Emissions and Immunity requirements
- EN61000-4-2 (15KV air discharge during operation, and 8KV direct contact discharges to the case), Human Body Model per JEDEC JESD22-A114-B

Mechanical dimensions





Laser safety warning

INVISIBLE LASER RADIATION
CLASS 1M LASER PRODUCT.

DO NOT VIEW THE END OF OPTICAL FIBER WITH OPTICAL INSTRUMENTS AS THIS MAY RESULT IN HAZARDOUS RADIATION EXPOSURE (i.e. FIBER OPTIC VIEWERS, HAND-HELD MAGNIFIERS OR BINOCULARS OR OTHER DIRECT IMAGING DEVICES).

QSFP + Memory Map

QSFP+ Register	Access	Purpose	Implemented	Default Value
0	RO	Device type identifier	Yes	Hex 0d ("QSFP+")
1	RO	Revision compliance	Yes	Hex 02 ("Infiniband spec")
2	RO	Status	Yes Bit 1 copies INTL line state Bit 0 is zero when module is ready	0 (bit 2 zero =paged memory is implemented)
3	RO	Loss of signal	Bit 7-4 (transmit LOS) not supported Bits 3-0 (receive LOS) are implemented, bit is set when receive is squelched INTL output will be asserted (low) if any of these bits are set and not masked. The bits are cleared on read.	n/a
4	RO	TX fault	Yes (bits 3-0), bit will be set for any fault indicated by the VCSEL driver INTL output will be asserted (low) if any of these bits are set and not masked These bits are cleared on read.	n/a
6	RO	Temperature alarms	Yes. Bits 7 to 4 are set as appropriate when measured temperature goes above or below the thresholds listed at the start of register page 3. INTL output will be asserted (low) if any of these bits are set and not masked. These bits are cleared on read.	0

QSFP+ Register	Access	Purpose	Implemented	Default Value
7	RO	Voltage alarms	Yes. Bits 7 to 4 are set as appropriate when measured supply voltage goes above or below the thresholds listed at the start of register page 3. INTL output will be asserted (low) if any of these bits are set and not masked. These bits are cleared on read.	0
9, 10	RO	RSSI alarms	Not supported	n/a
11, 12	RO	TX bias alarms	Not supported	n/a
22, 23	RO	Measured temperature	Yes. 22 is MSB, 23 is LSB. Measurement in 1/256th degree C	n/a
26, 27	RO	Measured supply voltage	Yes. 26 is MSB, 27 is LSB. Measurement in 100uV	Expected to read appropriately (129, 00), i.e. 3.3 volts
34-41	RO	Measured RSSI	Not supported	n/a
42-49	RO	Measured TX bias	Not supported	n/a
86	RW	TX channel disable	Yes. Setting bits 3-0 will disable the corresponding TX channel. Note that if a TX fault (e.g. laser shorted or open) is detected by the VCSEL driver, the channel will be disabled and the corresponding bit in this register will be set. The host must clear the bit to re-enable transmission if the fault is cleared. QSFP+ spec does not state whether this behavior is OK.	0 (all TX channels enabled)
87, 88	RW	Software rate select	No (AOC functions from 2.5 Gbps to 14 Gbps)	n/a
89-92	RW	Software application	No. Application select is not currently supported (and QSFP+	n/a

QSFP+ Register	Access	Purpose	Implemented	Default Value
		select	page 1 is correspondingly not supported)	
93	RW	LP mode override	Partial. Low power mode is not needed for this module because power consumption should always be below the LP mode threshold. Values written in register 93 are stored for later read back but will not cause any action to be taken.	0 (low power mode off, LPMODE hardware signal not overridden)
94-99	RW	Software application select	No. Application select is not currently supported (and QSFP+ page 1 is correspondingly not supported)	n/a
100	RW	LOS INTL mask	Bits 7-4 are not implemented (LOS detection not supported) Bits 3-0 are implemented – setting one of these bits will prevent the corresponding receive LOS event from asserting the INTL hardware output. The LOS event will still be signaled in QSFP+ register 3.	0 (no alarms masked)
101	RW	TX fault INTL mask	Yes. Setting bit 3-0 will prevent the corresponding TX fault event from asserting the INTL hardware output. The TX fault event will still be signaled in QSFP+ register 4.	0 (no alarms masked)
103	RW	Temperature INTL mask	Yes. Setting bit 7-4 will prevent the corresponding temperature out of range alarms from asserting the INTL output. The temperature alarm will still be signaled in QSFP+ register 6.	0 (no alarms masked)
104	RW	Voltage INTL mask	Yes. Setting bits 7-4 will prevent the corresponding supply voltage out of range alarm from asserting the INTL output. The voltage alarm will still be	0 (no alarms masked)

QSFP+ Register	Access	Purpose	Implemented	Default Value
			signaled in QSFP+ register 7.	
119-126	RW	EEPROM area password	No. EEPROM (QSFP+ page 2) is not implemented in this release.	n/a
127	RW	QSFP+ register page select	Yes. Implements page 0 and 3	0
128	RO	Device type identifier	Yes. Implemented pages 0 and 3	Hex 0d ("QSFP+")
129	RO	Extended identifier	Yes	0 ("Power class 1 module", "No CLEI code", "No CDR in TX')
130	RO	Connector type	Yes	Hex 23 ("no separable connector")
131	RO	Ethernet compliance	Yes	Hex 04 ("40GBASE-SR")
132-138	RO	Specification compliance	Yes	("OC 48 short reach", "1000Base-SX", "Short distance", "Multi-mode 50um", "1200 Mbytes/sec")
139	RO	Encoding	Yes	Hex 05 ("64B66B")
140	RO	Nominal bit rate	Yes	141 dec (Hex 8d) (14100 Mbps)
141	RO	Extended rate select compliance	Yes	0 ("extended rate select not supported")
142-145	RO	Link length	Yes	0 ("active optical cable")
146	RO	AOC length	Yes	Example 2 dec (2 meters) Exact length of cable set in the factory
147	RO	Device	Yes	0

QSFP+ Register	Access	Purpose	Implemented	Default Value
		technology		(“no laser tuning”, “no cooling”, “PIN detector”, “850nm VCSEL transmitter”)
148-163	RO	Vendor name	Yes	“3M Company”
164	RO	Infiniband compliance code	Yes	Hex 0f (“FDR, QDR, DDR and SDR”)
165-167	RO	Vendor OUI	Yes	Hex 08, hex 00, hex 21 (“08-00-21” -3M OUI)
168-183	RO	Vendor part number	Yes	“6A22D0421XXX.0-0” ASCII
184-185	RO	Vendor revision code	Yes	“03” ASCII
186-187	RO	Operating wavelength	Yes	Hex 42, hex 68 (850nm)
188-189	RO	Wavelength tolerance	Yes	Hex 07, hex d0 (+/- 10nm)
190	RO	Max case temp	Yes	0 (“QSFP+ standard temperature of 70 degrees”
191	RO	Page 0 checksum #1	Yes	n/a
193	RO	Options	Yes	1 (“RX output amplitude can be programmed”)
194	RO	Options	Yes	4 (“No RX squelch disable”, “No TX squelch”, “RX output disable is possible”)
195	RO	Options	Yes	Hex 1a (“No memory pages 1 and 2”, “Rate select not implemented”, “TX disable and TX fault implemented”, “No TX squelch or TX

QSFP+ Register	Access	Purpose	Implemented	Default Value
				LOS detection").
196-211	RO	Vendor serial number	Yes	"0000000000000" ASCII Note: unique SN numbers will be implemented
212-219	RO	Date code	Yes	"YYMMDDXX" ASCII XX=lot code
220	RO	Monitoring type	Yes	0 ("No RSSI or BER monitoring"
221	RO	Enhanced options	Yes	0 ("No rate select or application select implemented")
223	RO	Page 0 checksum #2	Yes	
224-255	RO	Vendor specific information	Yes	

QSFP+ Page 1
This optional page (application select) is not supported.

QSFP+ Page 2
This optional page (EEPROM) is not supported.

QSFP+ Page 3
Page 3 has registers 128 to 255 only. These are accessible when the page select register (number 127 in page 0) is set to 3.

QSFP+ Register	Access	Purpose	Implemented	Default Value
128, 129	RO	High temperature Alarm threshold	Yes	70, 0 ("70 degree C")
130, 131	RO	Low temperature alarm threshold	Yes	Hex fd, hex 00 ("-3 degree C")
132, 133	RO	High temperature warning threshold	Yes	70, 0 ("70 degree C")
134, 135	RO	Low temperature	Yes	Hex fd, hex0,0

QSFP+ Register	Access	Purpose	Implemented	Default Value
		warning threshold		("-3 degree C")
144, 145	RO	High supply voltage alarm threshold	Yes	Hex 8e, hex 94 ("3.65 volts")
146, 147	RO	Low supply voltage alarm threshold	Yes	Hex 7a, hex 44 ("3.13 volts)
148, 149	RO	High voltage warning threshold	Yes	Hex 8e, hex 94 (3.65 volts)
150, 151	RO	Low voltage warning threshold	Yes	Hex 7a, hex 44 ("3.13 volts")
176-183	RO	RSSI alarm thresholds	No	n/a
184-191	RO	TX bias alarm thresholds	No	n/a
237	RW	Vendor specific: RX output pre-emphasis	Yes – This field allows the host to control the RX output voltage pre-emphasis for each channel. Channel 4: bits 7-6 Channel 3: bits 5-4 Channel 2: bits 3-2 Channel 1: bits 1-0 (per channel settings are: 00=0mV, 01=125mV, 10=175mV, 11=325mV)	Hex 00 (0mV on all channels)
238, 239	RW	RX output amplitude levels	Yes See table below.	Hex 11, Hex 11 (default value set to range 1)
240	RW	Squelch disable	No – squelch disable is not possible	0
241	RW	RX output disable	Yes – setting bit 7-4 will disable the	0 (all outputs enabled)

QSFP+ Register	Access	Purpose	Implemented	Default Value
			corresponding receiver channel output	
242, 243	RW	RSSI alarm INTL mask	No – RX power measurement is not possible	0
244, 245	RW	TX bias alarm INTL mask	No	0

Note 1: The mapping of QSFP+ output amplitude codes to actual output voltages are given in table below.

QSFP+ Value	QSFP+ Voltage levels	Actual output voltage from the AOC
0000	range 0	317mV
0001	range 1	422mV
0010	range 2	739mV
All others	″reserved″	422mV

UNLESS OTHERWISE NOTED, REFERENCES TO INDUSTRY SPECIFICATIONS ARE INTENDED TO INDICATE SUBSTANTIAL COMPLIANCE TO THE MATERIAL ELEMENTS OF THE SPECIFICATION. SUCH REFERENCES SHOULD NOT BE CONSTRUED AS A GUARANTEE OF COMPLIANCE TO ALL REQUIREMENTS IN A GIVEN SPECIFICATION.

"RoHS 2011/65/EU" means that the product or part does not contain any of the substances in excess of the maximum concentration values ("MCVs") in EU RoHS Directive 2011/65/EU. The MCVs are by weight in homogeneous materials. This information represents 3M's knowledge and belief, which may be based in whole or in part on information provided by third party suppliers to 3M.

In the event any product is proven not to conform with 3M's Regulatory Information Appendix, then 3M's entire liability and Buyer's exclusive remedy will be in accordance with the Warranty stated below.

3M is a trademark of 3M Company.

Important Notice

All statements, technical information, and recommendations related to 3M's products are based on information believed to be reliable, but the accuracy or completeness is not guaranteed. Before using this product, you must evaluate it and determine if it is suitable for your intended application. You assume all risks and liability associated with such use. Any statements related to the product which are not contained in 3M's current publications, or any contrary statements contained on your purchase order shall have no force or effect unless expressly agreed upon, in writing by an authorized officer of 3M.

Warranty; Limited Remedy; Limited Liability

This product will be free from defects in material and manufacture for a period of two (2) years from the time of purchase. **3M MAKES NO OTHER WARRANTIES INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OR MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.** If this product is defective within the warranty period stated above, your exclusive remedy shall be, at 3M's option, to replace or repair the 3M product or refund the purchase price of the 3M product. **Except where prohibited by law, 3M will not be liable for any indirect, special, incidental or consequential loss or damage arising from this 3M product, regardless of this legal theory asserted.**

3M Electronic Solutions Division
Interconnect Products
6801 River Place Blvd.
Austin, TX 78726-9000
http://www.3Mconnectors.com