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o-mGC
FCU-050M008-012 4-Channel Media Converter
Application Note

Design Guide for 4-Channel Fiber-Optic Media Converters

Introduction

Fujitsu's 4-Channel Media Converters are parallel fiber-optic transceivers that provide an inexpensive low power-dissipation solution transporting 10 Gigabit/second data. Fujitsu's FCU-050M008-012 fiber-optic transceiver module (o-mGC) is a four channel transceiver module compatible with the popular MTP and MPO small-form-factor connectors and commonly available ribbon cables with twelve 50/125 um multimode optical fibers. Fujitsu's FCU-050M008-012 fiber-optic transceiver modules contain four independent VCSEL transmitters and four independent receivers that are capable of transferring encoded digital data at symbol rates up to 3.125 Gbps per channel. The four channel Media Converter plugs into the industry standard MDI connector as defined in SFF-8470, extending the link distance significantly beyond the 15m provided by 4x copper cable as adopted in Fiber Channel, InfiniBand and IEEE CX4 standard.

The o-mGC modules are designed to be compatible with four-channel serializer/deserializer (SERDES) or physical layer (PHY) chips that have differential serial inputs and outputs.

This publication contains helpful information on designing Fujitsu's Electrical-to-Optical Converter into your system. The objective of this application note is to maximize performance, reduce the time, and minimize the effort that system designers must expend to design low-cost low-power consumption four channel digital communication links that can carry data at a combined aggregate rate of 10 Gigabits/second.

Data Encoding Requirement

Fujitsu's optical transceiver modules contain 4 independent transmit and receive channels. The bulk of the hardware needed to provide the four high-speed serial data streams has been integrated into the quad SERDES chips and the Fujitsu four-channel optical transceiver products, so when the overall concepts and design criteria for one of

the four channels has been assimilated they can be applied to the remaining portions of the parallel communication link. The Fujitsu modules utilize optical transmitters and receivers that are compatible with the 8b10b or the scrambled modulation codes that are normally used in 10 Gigabit/second backplane and telecom systems.

Before data is transmitted through serial communication channels or optical fibers it must be either scrambled or encoded. These encoding or scrambler functions are normally embedded into the physical layer (PHY), or framer chips to ensure that that the serial data input to the fiber-optic transceiver will not remain in the logic-one or logic-zero states for random indefinite time intervals. Encoders modify the data so that a maximum time limit with no transitions, otherwise know as a run-limit, is imposed. The run-limit of the encoder ensures that the serialized data contains frequency components that will allow a phased-locked-loop to recover the clock from the data that passes through the serial communication link. Encoding enables the clock and data to be merged into a single serial steam of bits, so that an additional transmission line is not required for the clock. Encoders also balance the average duty cycle of the data at 50%, so that average of the serialized data will be equal to the mean of the logic high and logic low levels. Balancing the average value of the serial data allows the use of simple, inexpensive, receiver circuits that have a bandpass response. Receivers with bandpass responses are generally more sensitive, are less complex, and cost less than direct-coupled fiber-optic receivers that are capable of detecting dc logic levels. The Fujitsu fiber-optic receivers have a bandpass response with a maximum lower corner frequency of 140 kHz.

Getting power to the optical transceiver

The copper MDI connector does not provide power for the optical transceiver. The draft proposal of Fiber Channel standard (FC-PI-2) allows the reassignment of some ground pins as power pins, as shown in the following table. This re-assignment does not affect the function or performance of standard cable connection for InfiniBand and CX4 applications, as the power is added only when the system is sure the attached module is “active”. The re-assigned pins are all AC ground to minimize the effect on high-speed signal integrity.

Pin assignment as proposed in Fiber Channel standard.

SFF-8470 MDI connector	Fiber Channel PI-2	PI-2 ALT definition
G1	GND	GND
G2	GND	ODIS
G3	GND	GND
G4	GND	GND

G5	GND	GND
G6	GND	Fault-
G7	GND	Type_sense
G8	GND	Vcc
G9	GND	GND
S1	RX0+	RX0+
S2	RX0-	RX0-
S3	RX1+	RX1+
S4	RX1-	RX1-
S5	RX2+	RX2+
S6	RX2-	RX2-
S7	RX3+	RX3+
S8	RX3-	RX3-
S9	TX3-	TX3-
S10	TX3+	TX3+
S11	TX2-	TX2-
S12	TX2+	TX2+
S13	TX1-	TX1-
S14	TX1+	TX1+
S15	TX0-	TX0-
S16	TX0+	TX0+
Housing	Chassis ground	Chassis ground

Fujitsu recommends the following circuits on the customer's board to perform the media detect function (MDC). The circuitry uses less than ¼ square inch of board space on a single layer, and use less than 1mA of current. The recommended parts are listed in the following table.

Care must be taken to select the dual comparator and the AND gate. LVCMOS type should be avoided because they could turn on before the rest of the circuits and could send power momentarily even when an active module is not present. This could cause a current surge when a copper cable is present at the connector.

Items	Reference Designator	Description	Number	Recommended Manufacturer	Recommended Part number
1	U1	Dual push pull output comparator	1	Maxim	MAX9032AKA
2	R2	5.1K 0402 resistor	1		
3	R1	10K 0402 resistor	1		
4	R3; R5	3.9K 0402 resistor	2		

5	R4	6.8K 0402 resistor	1		
6	C3, C4, C5	0.01uF ceramic 0402 Cap	3		
7	U2	Single 2-Input Positive-AND Gate	1	TI	SN74AHC1G08DCKR
8	U3	Power Distribution Switch	1	TI	TPS2031D
9	C2	0.1uF ceramic 0402	1		
10	C1	10uF Tantalum Case B cap	1		

ODIS

FAULT-

VCC

R2
5.1K

C5
0.01UF

GND

C4
0.01UF

GND

VCC

VCC

R3
3.9K

R4
6.8K

R5
3.9K

GND

DUAL_PUSH_PULL_OUTPUT_COMP
U1

GND

VCC

AND GATE
U2

GND

DUAL_PUSH_PULL_OUTPUT_COMP
U1

C3
0.01UF

GND

ODIS
FAULT-
TYPE_SENSE
VCC

MDI Connector

TXIP-0
TXIN-0
TXIP-1
TXIN-1
TXIP-2
TXIN-2
TXIP-3
TXIN-3
TXOP-3
TXON-3
TXOP-2
TXON-2
TXOP-1
TXON-1
TXOP-0
TXON-0

GND-5
GND-4
GND-3
GND-1

U4

GND

EN
IN-1
IN-2
GND
VCC
OUT-1
OUT-2
OUT-3

TPS2031_POWER_DISTRIBUTION_SWITCH
U3

VCC

GND

C2
0.1UF

C1
10UF

GND

R1
10K

GND

If system designers decide to use other media detect circuitry we recommend they accommodate hot plug capability. Specifically the power should be monotonically ramped. The microprocessor used inside the media converter cannot tolerate a voltage swing below 2.5V once it reaches that level. Some power filtering after the power switch is recommended.

The optical modules that intend to get power through the MDI connector have a 5K resistor between G7 and GND. The media detect circuit sense the voltage level at the connector G7 pin, and if the voltage level is between 0.9 and 2.4V then power is supplied to pin G8. For standard copper cables no power will be added to the system.

ODIS is used to turn on or off the optical transmitter. Customers can tie it to a control signal if they desire to control the optical transmitter. If it is tied to GND then the optical transmitter is default on when power is applied.

Fault- is a return signal from the optical module. It is default high, and will turn low when there is a TX_fault or loss of signal on any receiver lane. Shorting this pin to ground will not affect the performance of the module.

For systems that desire monitoring one can sense G7 or G8 to determine the type of module attached to the connector. ODIS can be controlled and Fault- can be monitored.

In laying out the board, care should be taken to avoid cross-talk in between high-speed channels. Follow PCB layout rules from your connector supplier. The AC coupling capacitors for G7 and G8 (and G6, G2 if they are not grounded) should be as close to the connector as possible.

Purchasing Optical Fiber Jumpers

Fujitsu's Optical Media converter is compatible with the popular MTP and MPO small-form-factor connectors and commonly available ribbon cables with twelve multimode optical fibers.

There are currently two common configurations for parallel ribbon jumpers. One is for 12 channel devices (such as Snap12 MSA devices) where channel 1 of one end goes to channel 1 on the other end (or some times called "key up to key down" or "flipped"). The other is for 4X applications where channel 1 of one end goes to channel 12 on the other end (or sometimes called "Key up to key up", or "non-flipped"), as shown in the

following table. When ordering fiber ribbon cables for this application please make sure it is the latter type.

MTP Side One	Light Path	MTP Side Two
Fiber 1		Fiber 12
Fiber 2		Fiber 11
Fiber 3		Fiber 10
Fiber 4		Fiber 9
Fiber 5		Fiber 8
Fiber 6		Fiber 7
Fiber 7		Fiber 6
Fiber 8		Fiber 5
Fiber 9		Fiber 4
Fiber 10		Fiber 3
Fiber 11		Fiber 2
Fiber 12		Fiber 1

Fujitsu also offers standard ribbon fiber cable assemblies in various lengths. In addition, for specials, we can also provide maintains a list of vendors that manufacture MPO-MPO parallel fiber optical ribbon cables. Please contact Fujitsu for more information.

Link distance

The link distance of Fujitsu's o-mGC modules depends on several factors, including optical fiber type and quality, the jitter performance of the physical devices (Serdes, Switches, or Retimer chips) that interface with the optical module, whether additional optical connectors are used, and the data rate the link is running at.

There are three types of multimode fiber that can be used in this application: standard 62.5/125 fiber with bandwidth of 150Mhh.km, standard 50/125um fiber with bandwidth of 500MHz.km, and laser grade high bandwidth (2000Mhz.km) 50/125um fibers. The bandwidth of fiber affects the inter-symbol-interference of the optical signal, thus significantly impact the maximum link distance. Fujitsu recommends only the 50/125um fiber ribbon be used.

When fiber-to-fiber connectors are used there is additional optical loss at the interface, thus reduce the optical power passing through and reduce the optical link distance.

The maximum possible link distance is also determined by the quality of electrical signal coming from the physical devices driving the TX side of the optical module, as well its jitter tolerance when receiving electrical signal from the optical module. The smaller the output jitter of the physical layer device, and the more jitter tolerance of that device on the receiving side, the longer the link distance could be.

For typical physical devices, please use the following table as guideline. This is assuming there is no additional optical connector, and the physical layers meet the minimum jitter generation and jitter tolerance specs of their respective standards (XAUI and IB).

Fiber type / Data rate	62.5/125um 150Mhz.km	50/125um 500Mhz.km	50/125um 2000Mhz.km
2.5G	100m	300m	500m
3.125G	50m	100m	300m

Since the link distance is also affected by other factors, such as transmission line quality on the PCB, electrical connector quality etc, we suggest customers err on the safe side.

Power supply and supply filtering

The key concept to keep in mind is that the SERDES chips and the fiber-optic transceivers located at the physical layer (PHY layer) of the system contain a mixture of digital and analog functional blocks. Since the PHY layer contains both digital and analog functions precautions must be taken to ensure that the simultaneous switching noise and power supply noise of the host digital system will not interfere with the serialized data. This power supply noise interference usually appears as unwanted phase disturbances (AKA jitter) in the clock and data signals of the SERDES chip, however power supply noise can also degrade the performance of the fiber-optic transmitter and receiver unless precautions are taken to ensure that the host system's conducted noise is not applied to the power pins of the fiber-optic transceiver module.

Fujitsu's o-mGC optical modules internally employ a two-stage π filtering network to reduce power supply noise. Customers are encouraged to maintain a clean voltage supplier, but no special power supplier filtering is needed other than the decoupling capacitor recommended in the media detection circuit.

The laser driver inside the optical module requires a certain minimum voltage. Since inductors and power supplier switches can reduce the supply voltage slightly customers are also encouraged to maintain a good 3.3V supply. We recommend 3.3V –5% as the lowest power supply for Fujitsu's o-mGC optical module.

Interfaces to Quad SERDES Chips

Fujitsu's o-mGC optical modules can be used with SERDES chips from various manufacturers. Fujitsu's o-mGC fiber-optic transceiver's transmitter input is AC coupled, and has a maximum differential input voltage of 2.2V. We recommend customers limit their signal amplitude to less than 1.4V differential. Higher amplitude input tends to increase optical transmitter jitter. The output from Fujitsu's o-mGC optical modules is also AC coupled, and can usually be directly interfaced to the SERDES input, assuming the SERDES input can take ac coupled signal. Check with the SERDES manufacturer to determine the exact interface needed between Fujitsu's o-mGC optical module and the SERDES chip.

For SERDES chips that have adjustable pre-emphasis and equalization capabilities link performance might be improved by optimizing the settings. These settings need to be optimized according to the specific customer situations. In general only very little pre-emphasis and equalization is needed for a reasonable transmission line length between the SERDES chip and the MDI connector for Fujitsu's o-mGC optical modules.