SCT/PIXEL off detector opto array plug-in

1. Introduction:

Both SCT and Pixel sub-detector decided to use optical fiber to take data from detector and send trigger, timing and control signal to detector. This document describe the array optical module for use in off-detector for optical to electrical conversion.

2. Engineer detail of opto array plug-in

There are two differences between SCT off-detector opto array and PIXEL off-detector opto array, the number of channels and the operation speed. SCT use array of 12 ways while PIXEL use array of 8 ways. SCT operate opto array at 40Mbps for both to and from detector direction, Pixel operate opto array with 40Mbps to detector and up to 160Mbps from detector. In making the opto array module, the number of channels of array chips are different, hence 12/8 way opto array chips were used for SCT/Pixel respectively. No arrangement were made to differentiate the performance of SCT opto array module to Pixel opto array module.

Opto array modules are designed so in a small plug-in type module provide necessary conversion between optical and electrical signal. When plug onto the BOC (back of crate) card, it interface with the BOC card as components with standard digital electrical interface.

For sending TTC (trigger, timing and control signal) signal to detector, TX opto array plug-in (TX plug-in) are used. A TX plug-in consist three main parts, a custom VCSEL array of 12/8 channels, a custom chip BPM12[(1)] and necessary circuit for setting the operation current of each VCSEL in array.

For receiving data from detector, RX opto array plug-in (RX plug-in) are used. A RX plug-in consist three main parts, a custom PIN array of 12/8 channels, a custom chip DRX12[(2)] and necessary circuit for setting the receiver sensitivity.

2.1 Optical array chip

VCSEL array chip:

VCSEL array chips used in TX plug-in are none standard parts from Truelight (www.truelight.com.tw). Non-standard coating process on top of Truelight's standard

part TSA-8B12-000 resulting mainly twice of optical power at 10mA. Other effects of this special coating process are about 1mA increase in threshold current and small switching time degradation, both side effect are un-important in the purpose of TX plug-in. See table 1 for the specification of VCSEL array.

Si-PIN array chip:

Si-PIN array chips used in RX Plug-in is custom designed by Truelight for ATLAS. The specification of Si-PIN array ship is in table 2.

Parameters	Min	Typ	Max	Unit	
Wavelength	830	850	860	Nm	
Threshold Current		2.5	3	MA	
Threshold uniformity		0.1	0.2	MA	in one array
Output power (10mA)	5	6		MW	
Slope efficiency	.25	.4		mW/mA	
Forward voltage		2	2.5	V	10mA
Breakdown voltage	10	15		V	10uA
Beam divergence (FWHM)		15	20	Degree	
Switching time			500	Ps	20%-80%

Table 1. Specification of VCSEL array chip

Parameters	Min	Typ	Max	Unit	
Sensitive Wavelength		850		Nm	
Responsivity		0.5	0.6	mA/mW	@ 850nm
Diameter of sensitivity area		100		Um	
Breakdown voltage	20			V	1uA
Switching time		1.5	2	Ns	20%-80%, 3V bias

Table 2. Specification of Si-PIN array chip

2.2 Optical array sub-assembly

Figure 1 shows the detail of opto array sub-assembly. Identical design for VCSEL and PIN array sub-assembly, except the opto array chip. The location of two precisely machined guide pins define the location of fibers in MT connector when inserted in. The array chip was placed precisely on base PCB with respect to guide pins on base PCB. The precision location between guide pins and opto array chip guarantee the alignment of opto array chip to optical fibers.

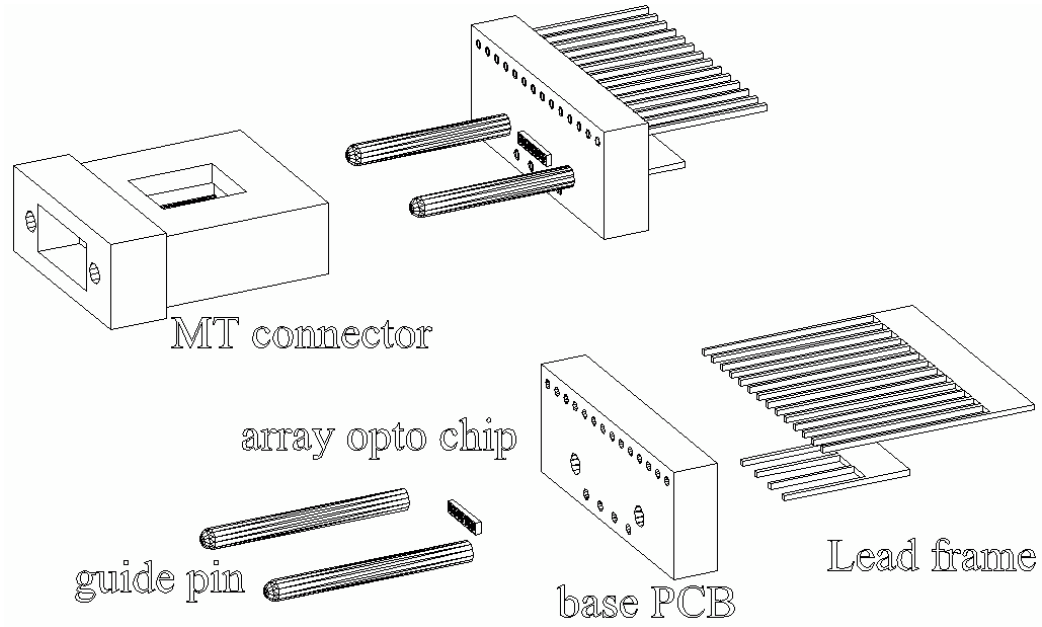


Figure 1. The construction of opto array sub-assembly

2.3 Plug-in circuit

BPM12 chip used on TX plug-in is an ASIC designed specifically for use in TX plug-in, see Ref. 1 for details of BPM12. DRX12 chip used in RX plug-in is another ASIC design specifically for use in RX plug-in, see Ref. 2 for details of DRX12.

The function of TX plug-in is to take input data of 12 bit wide, encode input data to BPM (bi phase mark) format, then send the encoded data in optical form to optical fibers. See figure 2 for the circuit of TX plug-in. BPM12 chip take input data from 12 Data pins, encode data and drive VCSEL accordingly. The driving current to VCSEL is controlled by dc input voltage present on BIAS_n pins. Two serial interfaced multi-channel DAC LTC1665 were used to set the voltage at BIAS_n pins. There are many other control signals (DB_n and AB_n) to BPM12 chip to set internal register for the adjustment of delay and duty cycle of the output waveform. These register read/write signals are not used on TX plug-in and were routed to the interface connector to interface with BOCcard.

The function of RX plug-in is to convert the input digital optical signal back to digital electrical signal. See figure 3 for the circuit of RX plug-in. PIN array send photo current pulse to DRX12 chip input. Discriminator in DRX12 set output digital “1” or “0” according to the pre-set dc voltage at Thr_n pins. Two serial interfaced multi-channel DAC LTC1665 were used to set the sensitivity to each channel of DRX12.

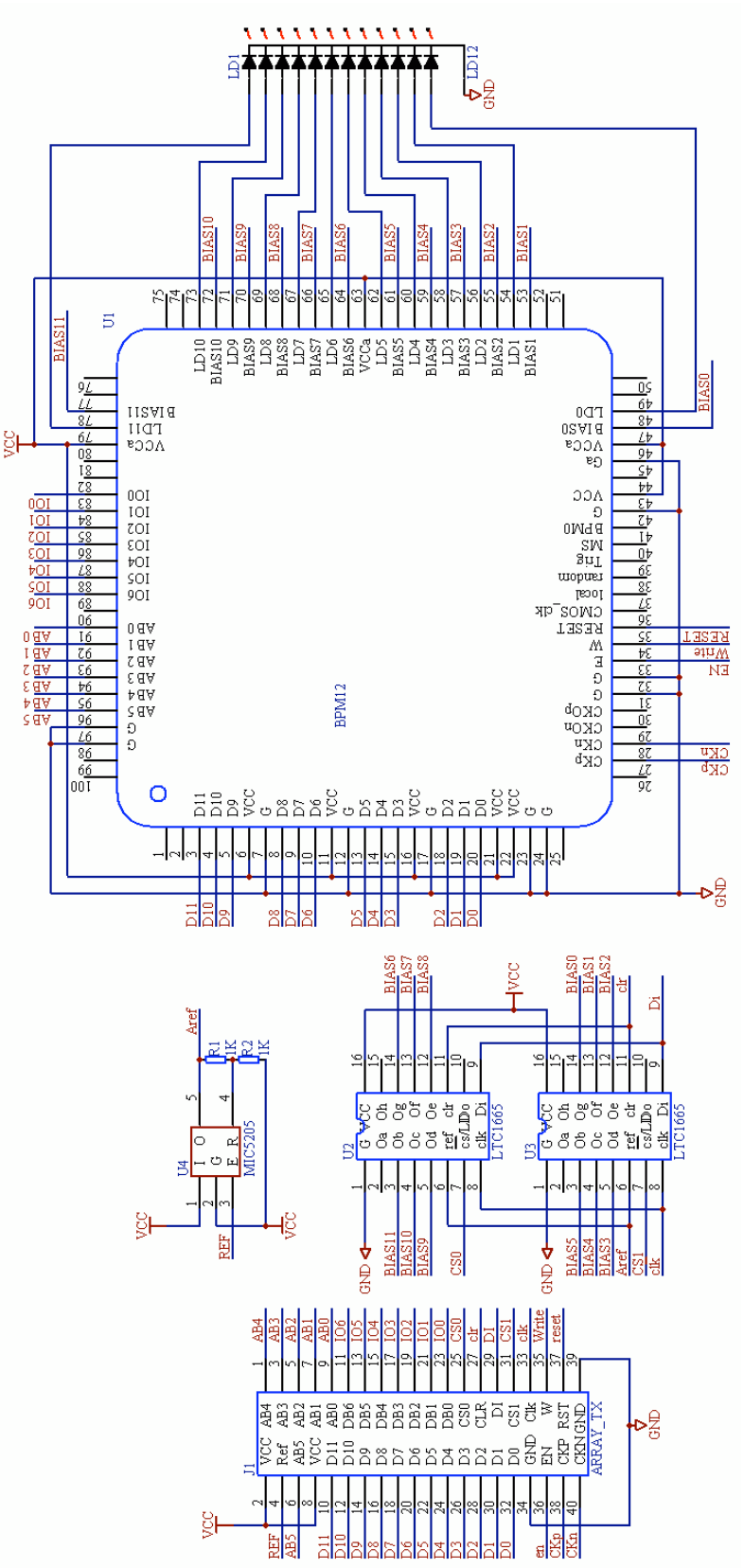
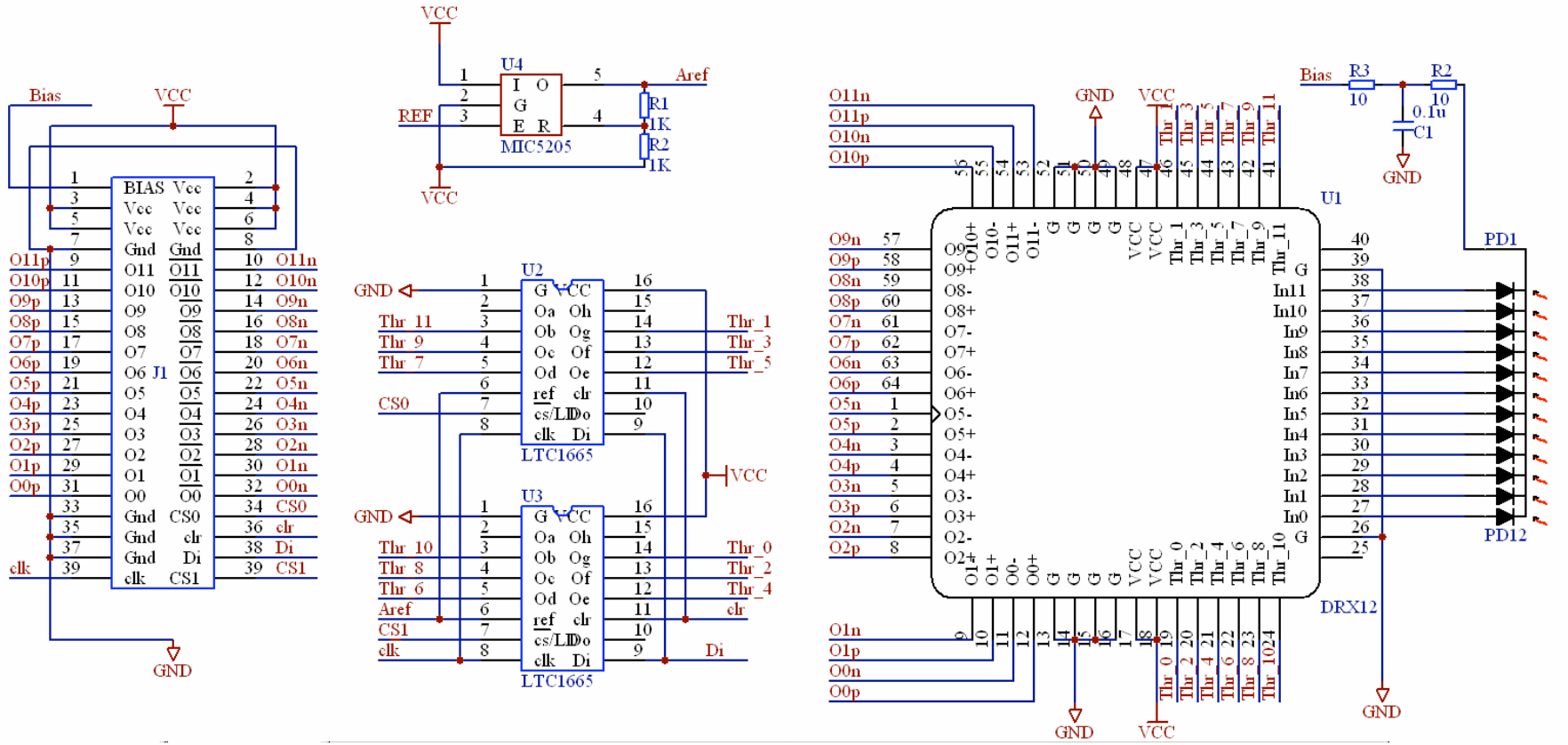


Figure 2: TX plug-in circuit


Bias
VCC
J1
BIAS Vee
Vee Vee
Vee Vee
Gnd Gnd
O11 O11
O10 O10
O9 O9
O8 O8
O7 O7
O6 O6
O5 O5
O4 O4
O3 O3
O2 O2
O1 O1
O0 O0
Gnd CS0
Gnd clr
Gnd Di
clk CS1
O11p
O10p
O9p
O8p
O7p
O6p
O5p
O4p
O3p
O2p
O1p
O0p
O11n
O10n
O9n
O8n
O7n
O6n
O5n
O4n
O3n
O2n
O1n
O0n
CS0
clr
Di
CS1
clk
GND
U4
MIC5205
REF
Aref
R1
1K
R2
1K
U2
U3
LTC1665
Thr_11
Thr_9
Thr_7
Thr_10
Thr_8
Thr_6
Aref
CS1
Thr_1
Thr_3
Thr_5
Thr_0
Thr_2
Thr_4
clr
Di
U1
DRX12
Bias
R3
R2
10
10
0.1u
C1
PD1
PD12

2.4 Mechanical

Insert Maurice's mechanical specification draft here

2.5 Electrical Interface

Electrical interface of opto plug-in is a 40 pins connector QTE-40 from Samtec.

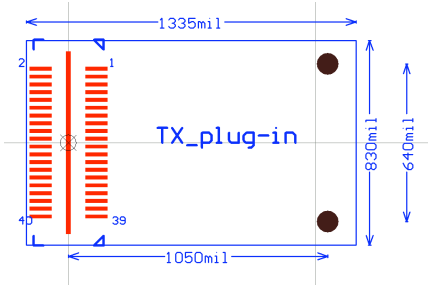


Figure X.a QSE-40 socket on BOC for RX plug-in

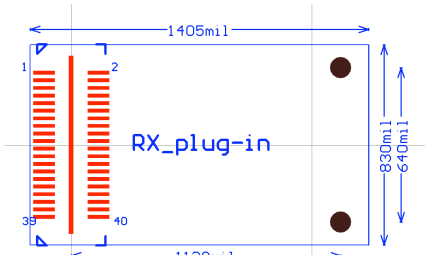


Figure X.b QSE-40 socket on BOC for RX plug-in

The mating connector is QSE-40. See figure X and table Y for the pin name on the QSE-40 connector on BOC card.

TX Plug-in					RX plug-in			
1	AB4	2	VCC		1	BIAS	2	VCC
3	AB3	4	REF_en		3	VCC	4	VCC
5	AB2	6	AB5		5	VCC	6	VCC
7	AB1	8	VCC		7	GND	8	GND
9	AB0	10	D11		9	D11p	10	D11n
11	IO6	12	D10		11	D10p	12	D10n
13	IO5	14	D9		13	D9p	14	D9n
15	IO4	16	D8		15	D8p	16	D8n
17	IO3	18	D7		17	D7p	18	D7n
19	IO2	20	D6		19	D6p	20	D6n
21	IO1	22	D5		21	D5p	22	D5n
23	IO0	24	D4		23	D4p	24	D4n
25	CS0	26	D3		25	D3p	26	D3n
27	Clr	28	D2		27	D2p	28	D2n
29	DI	30	D1		29	D1p	30	D1n
31	CS1	32	D0		31	D0p	32	D0n
33	Clk	34	GND		33	GND	34	CS0
35	Write	36	En		35	GND	36	Clr
37	Reset	38	CKp		37	GND	38	DI
39	GND	40	CKn		39	clk	40	CS1

Table Y Pin name for electrical interface to opto plug-in

In TX Plug-in:

AB0 to AB5: The address bus to access to BPM12 register.

IO0 to IO6: data bus for read/write BPM12 register.
Write, RESET, En: control signal to BPM12
D0 to D11: TTL BPM data input
CKp,CKn: 40MHz diff. PECL clock input
VCC: 5V supply
GND: ground
CS0, CS1, clr, clk, DI: interface signal to multi channel DAC.
REF_en: Turn on/off reference chip to turn on/off VCSEL current, for laser interlock.

IN RX plug-in

D0p to D11p, D0n to D11n: LVDS data output of DRX12
BIAS: Bias voltage input for Si-PIN.
CS0, CS1, clr, clk, DI: interface signal to multi channel DAC.
VCC: 3.3V supply
GND: ground

3. Production and testing of opto array plug-in

Opto array plug-in are prepared in two main process, SMT PCB assembly of chip and SMD devices on main PCB and custom developed array alignment process for opto array sub-assembly. As illustrated in figure (Maurice's figure) a sub-module of opto array be prepared and then soldered onto main plug-in PCB.

Opto plug-in was designed to have all necessary circuit to perform conversion between electrical and optical signal on plug-in. The testing process was hence designed to test plug-in when the production was completed, to take the advantage of the connector used.

TX plug-in function test:

The testing of TX plug-in should include the measurement of VCSEL characteristic and the circuit function of electronic parts. The experience in VCSEL characteristic testing showed that the characteristic spread in wide range. A channel-to-channel characterization is essential. BPM12 chips were fully tested before sending out from Oxford, so only limited test set were needed (TBD) to ensure the proper handling of BPM12.

A homemade TX plug-in test board (figure x+1) was made to test TX-plug-in. TX plug-in test board provides follow function:

a. Connector connected to pins for Read/Write of BPM12 registers

b. Connector connected to multi-channel DAC to set VCSEL operation current.
c. 40MHz Clocked PRBS pattern to each data input to BPM12

By using this TX plug-in test board with optical probe and scope, the optical performance of VCSEL can be measured. The parameter such as switching time, optical power can be obtained in real ac operation mode. The verification of read/write function to BPM12 registers can also bb performed by checking optical waveform after setting registers.

By using the TX plug-in test board with a custom BER tester (partially developed), one can verify the proper encoding of BPM12.

RX plug-in function test

The testing of RX plug-in should include the measurement of PIN characteristic and the circuit function of electronic parts. The testing experience in PIN showed that the characteristic is very uniform and the parameters of PIN are much better than needed. Analog characterization for every parameter of Si-PIN is not needed and not practical. A compromised testing procedure will be used. The RX plug-in test will test only responsibility of PIN to ensure the coupling quality. A digital function test and BER test will be performed to check the proper production processing of the plug-in. The testing of RX plug-in will be on a BER tester (partially developed). The sensitivity threshold scan will be used to determine the Si-PIN array sub-assembly is prepared with proper alignment. A longer period BER test will be used to check RX plug-in is properly produced.

Reliability screening

The opto array plug-in will be placed and operated in normal environment with accessibility for maintenance. So normal procedure for reliability screen should be enough to keep SCT/Pixel operation smooth. The reliability screening procedure will be a burn-in in slightly elevated temperature (50C, TBD) for three days, followed by optical performance test to detect the product with enfant mortality failure.

Reference:

1. BPM12 document.
2. DRX12 document.