

Embracing the Globe with Inspiration.

**Hitachi Cable**

**HITACHI**

PRODUCT DATA SHEET  
**SFP TRANSCEIVER**  
for Gigabit Ethernet/Fibre Channel

**HTR6516** Series



## Features

- Gigabit Ethernet(1.25Gbit/s,10km) and Fibre Channel(1.0625Gbit/s,10km) compliant.
- Fully comply with industry standard Small Form Factor Pluggable transceiver (Hot pluggable).
- Diagnostic monitor as enhanced functions for SFP.
- AEL class 1 laser product per FDA/CDRH and EN60825-1 laser safety regulations.
- LC duplex receptacle.
- Metal cover and inner shield for low EMI emission.
- SFP MSA compliant delatch mechanism and improved handling type (single or double bail type) delatch mechanism are available.
- +3.3V single power supply.
- Low power consumption (0.4W(typ.)).

## 1. General

This document specifies the characteristics of the Small Form Factor Pluggable optical transceiver (Type:HTR6516) with LC duplex receptacle for 1.25Gbit/s Gigabit Ethernet and 1.0625Gbit/s Fibre Channel. Maximum transmission distance is 10km at the data rate of 1.25Gbit/s and 1.0625Gbit/s. This transceiver apply single mode optical fiber - 9/125.

## 2. Function

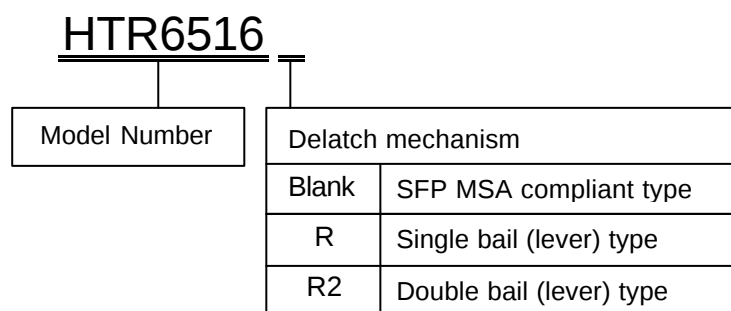
This transceiver is powered from a single +3.3V power supply and operated at a data rate of 1.25Gbit/s or 1.0625Gbit/s(NRZ). Optical output power is held constant by automatic power control over the specified operating temperature and voltage ranges.

The optical output is disabled by a TTL logic level input for that purpose. Tx Fault is provided to indicate the degradation of the laser diode. Loss Of Signal (LOS) output is provided to indicate the loss of an incoming optical signal. Tx Fault and LOS are open collector type outputs. The type of this transceiver is identified by Module Definition function using a built-in EEPROM with I<sup>2</sup>C interface.

As enhanced functions for SFP, internally measured transceiver temperature, internally measured supply voltage, laser bias current, laser optical output power and received optical power can be monitored by reading a built-in memory with I<sup>2</sup>C interface for that purpose. The interface pins for the monitor function are common with the Module Definition function.

Dimensions and pin assignment fully comply with MSA (Multi Source Agreement) for SFP (Small Form Factor Pluggable) optical transceiver.

## 3. Explanation of Part Number



#### 4. Absolute Maximum Ratings

Stresses in excess of the ratings listed in Table 1 can cause permanent damage to the device and affect device reliability. Functional operation of the device is not implied at any condition in excess of those given in the operating specification.

Table 1. Absolute Maximum Ratings

| Parameter                                    | Symbol    | Min.     | Max.         | Unit  |
|----------------------------------------------|-----------|----------|--------------|-------|
| Supply Voltage                               | $V_{CC}$  | 0        | 4.0          | V     |
| Data Input Voltage                           | $V_{IN}$  | $V_{EE}$ | $V_{CC}+0.3$ | V     |
| Receiver Optical Input Power                 | $P_{in}$  | -        | +3           | dBm   |
| Operating Ambient Temperature                | $T_A$     | -5       | 70           | deg-C |
| Storage Case Temperature                     | $T_{stg}$ | -40      | 85           | deg-C |
| Operating Relative Humidity (non-condensing) | $H_A$     | 5        | 85           | %     |

#### 5. Optical and Electrical Characteristics of Transmitter Portion

Optical and electrical characteristics of transmitter portion are shown in Table 2. Unless otherwise stated, minimum and maximum values are specified over the operating ambient temperature, and humidity ranges, DC power supply voltage range, from beginning to end of life, using 2<sup>7</sup>-1 pseudo random bit stream with a 50% duty factor.

The logic sense for the DATA input is such that a logic “1”(High) corresponds to the maximum level of an amplitude modulated light source (Light on), while a logic “0”(Low) corresponds to a minimum level of an amplitude modulated light source (Light off).

Table 2. Transmitter Optical and Electrical Characteristics

| Parameter                       | Symbol          | Min          | Typ | Max          | Unit              |
|---------------------------------|-----------------|--------------|-----|--------------|-------------------|
| Optical Output Power            | $P_o$           | -9           | -   | -3           | dBm               |
| Center Wavelength               | $\lambda$       | 1290         | -   | 1340         | nm                |
| Spectral Width(RMS)             | $\Delta\lambda$ | -            | -   | 2.8          | nm                |
| Eye Mask                        | -               | IEEE 802.3z  |     |              | -                 |
| Extinction Ratio                | -               | 9.0          | -   | -            | dB                |
| DC Power Supply Voltage         | $V_{cc}$        | 3.135        | 3.3 | 3.465        | V                 |
| DC Power Supply Current         | $I_{cc}$        | -            | -   | 100          | mA                |
| Data Input Voltage <sup>a</sup> |                 |              |     |              |                   |
| Diff'l Input Swing              | $V_{ID\ SWING}$ | 500          | -   | 2400         | mV <sub>p-p</sub> |
| Diff'l Input Impedance          | $Z_{ID}$        | 85           | 100 | 115          | $\Omega$          |
| Tx Disable Voltage              | $V_D$           | $V_{cc}-1.3$ | -   | $V_{cc}$     | V                 |
| Tx Enable Voltage               | $V_{EN}$        | $V_{EE}$     | -   | $V_{EE}+0.8$ | V                 |

a. AC coupled inside the module

## 6. Optical and Electrical Characteristics of Receiver Portion

Optical and electrical characteristics of receiver portion are shown in Table 3. Unless otherwise stated, minimum and maximum values are specified over the operating ambient temperature, and humidity ranges, DC power supply voltage range and wavelength range, from beginning to end of life, using a  $2^7-1$  pseudo random bit stream with a 50% duty factor.

Table 3. Receiver Optical and Electrical Characteristics

| Parameter                                  | Symbol                | Min                    | Typ  | Max                  | Unit              |
|--------------------------------------------|-----------------------|------------------------|------|----------------------|-------------------|
| Optical input Power (Average) <sup>a</sup> | P <sub>IN</sub>       | -20 <sup>b</sup>       | -    | -3 <sup>b</sup>      | dBm               |
| LOS Threshold:                             |                       |                        |      |                      |                   |
| Decreasing Light Input                     | LOST <sub>D</sub>     | -45                    | -    | -23.5                | dBm               |
| Increasing Light Input                     | LOST <sub>I</sub>     | LOST <sub>D</sub> +0.5 | -    | -23                  | dBm               |
| Hysteresis                                 | LOST <sub>H</sub>     | 0.5                    | -    | 4.0                  | dB                |
| DC Power Supply Voltage                    | V <sub>CC</sub>       | 3.135                  | -    | 3.465                | V                 |
| DC Power Supply Current                    | I <sub>CC</sub>       | -                      | -    | 100                  | mA                |
| Data Output Voltage <sup>c</sup>           |                       |                        |      |                      |                   |
| Diff'l Output Swing                        | V <sub>OD SWING</sub> | 1100                   | 1600 | 2000                 | mV <sub>p-p</sub> |
| Output Transition Time <sup>d</sup>        | t <sub>o</sub>        | -                      | -    | 0.28                 | ns                |
| LOS Output Voltage: <sup>e</sup>           |                       |                        |      |                      |                   |
| Low                                        | V <sub>OL</sub>       | -                      | -    | V <sub>ee</sub> +0.4 | V                 |
| High                                       | V <sub>OH</sub>       | V <sub>CC</sub> -0.9   | -    | -                    | V                 |
| LOS Response Time:                         |                       |                        |      |                      |                   |
| Decreasing Light Input                     | LOSRT <sub>D</sub>    | -                      | -    | 100                  | μs                |
| Increasing Light Input                     | LOSRT <sub>I</sub>    | -                      | -    | 100                  | μs                |

a. At a BER of  $1 \times 10^{-12}$  and an extinction ratio of 9.0dB.

b. At 1.25Gbit/s and 1.0625Gbit/s.

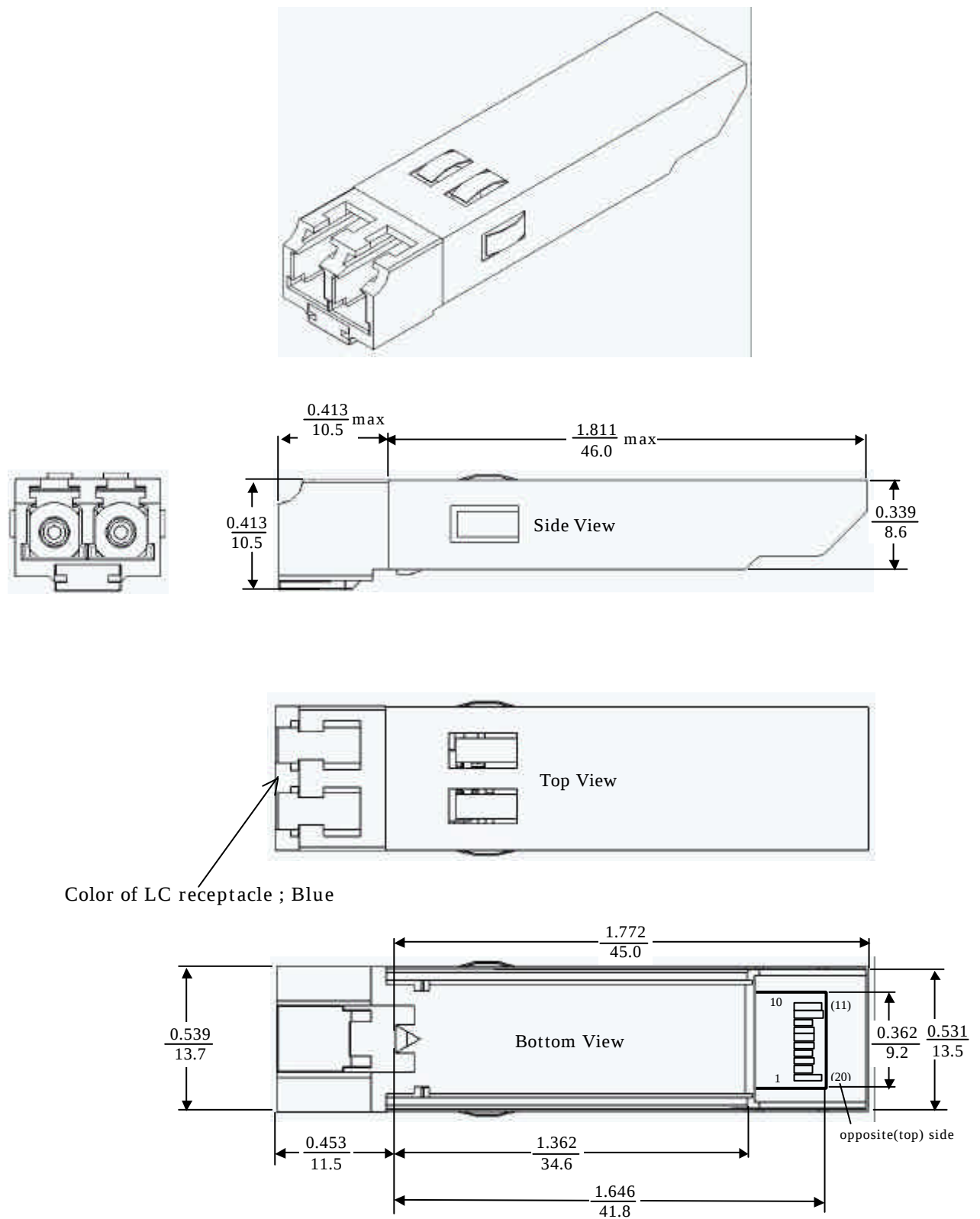
c. AC coupled inside the module.

d. Between 20% and 80% (50% duty cycle).

e. TTL compatible.

## 7. Physical Design

The package outline of SFP MSA compliant delatch mechanism is shown in Figure 1



Unless otherwise stated, typical values are shown

unit:  $\frac{\text{inch}}{\text{mm}}$

Figure 1. The package outline of SFP MSA compliant delatch mechanism

The package outline of bail (lever) delach mechanism type is shown in Figure 2.

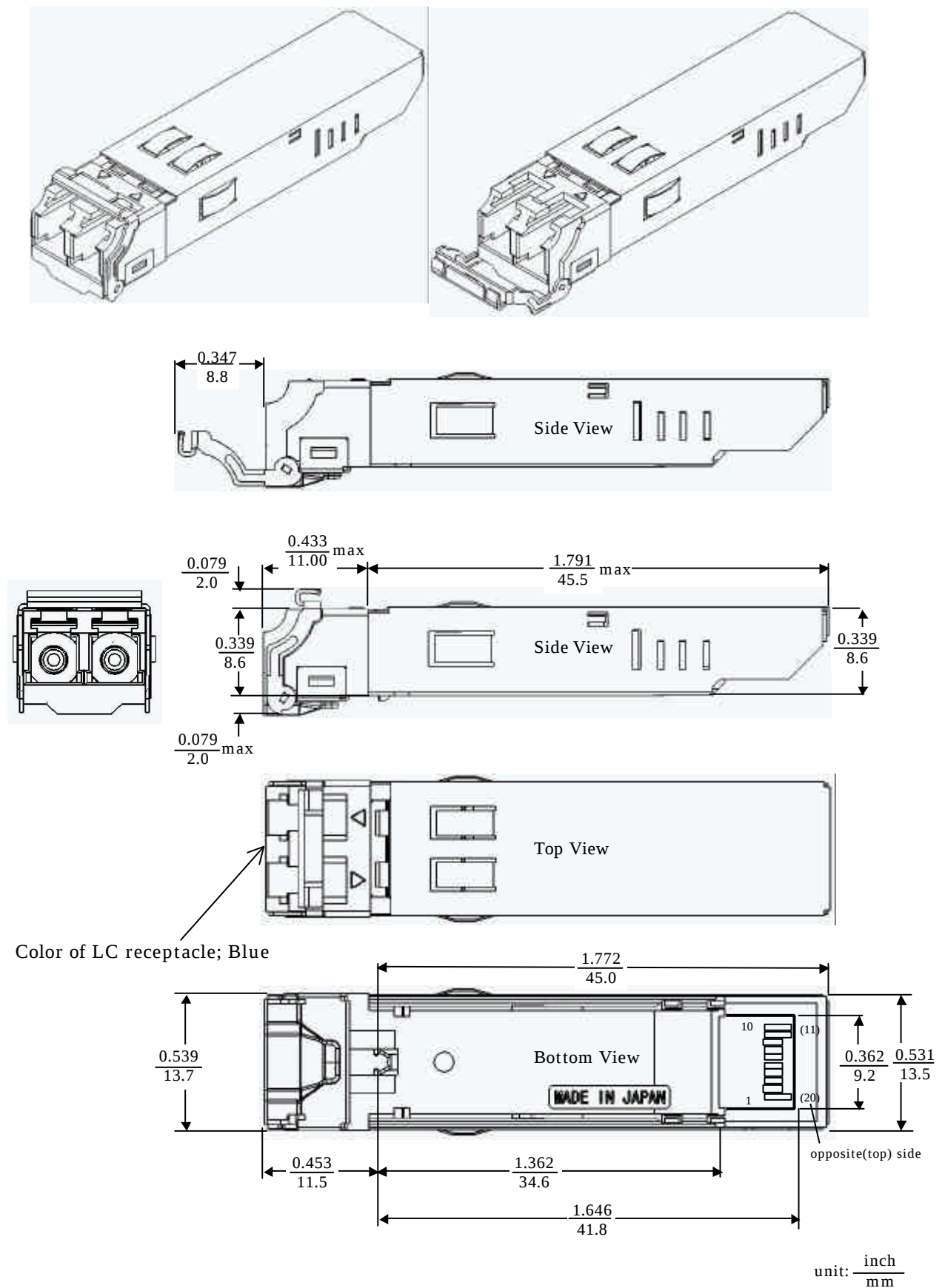


Figure 2. The package outline of Single bail (lever) delach mechanism type

The package outline of double bail delach mechanism type is shown in Figure 3.

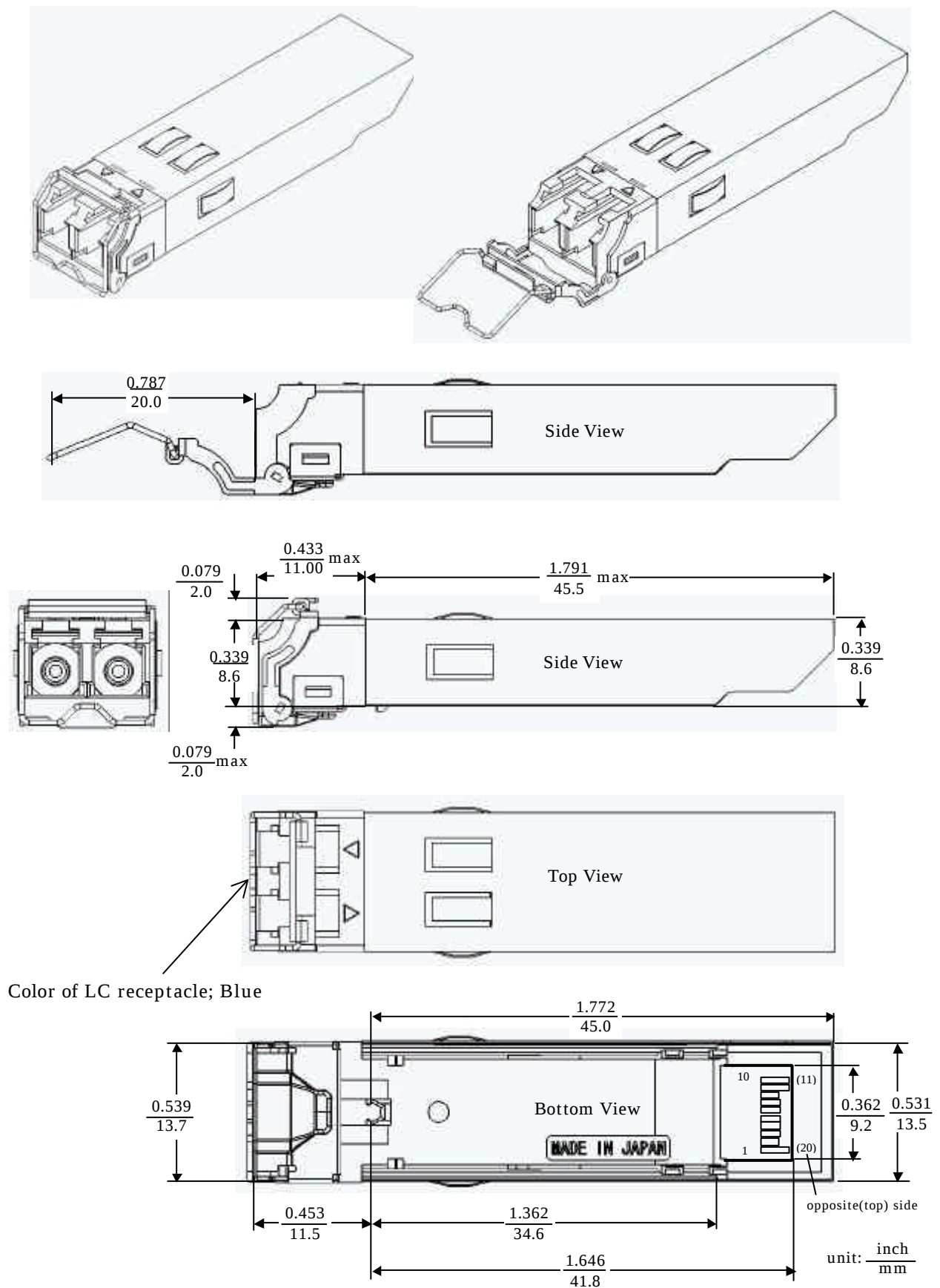


Figure 3. The package outline of double bail delach mechanism type

## 8. Label

Label that describe the following items is indicated on the top of transceiver.

Product name, Serial number, Wavelength, Manufacture name and “CLASS 1 LASER PRODUCT”.

## 9. PINOUT

Pinout is shown in Table 4.

Table 4. Pin Designations

| Name                   | Symbol | Pin |  | Pin | Symbol        | Name                         |
|------------------------|--------|-----|--|-----|---------------|------------------------------|
| Transmitter Ground     | VeeT   | 20  |  | 1   | VeeT          | Transmitter Ground           |
| Inv. Transmit Data In  | TD-    | 19  |  | 2   | Tx Fault      | Transmitter Fault Indication |
| Transmit Data In       | TD+    | 18  |  | 3   | Tx Disable    | Transmitter Disable          |
| Transmitter Ground     | VeeT   | 17  |  | 4   | MOD_DEF(2)*   | Module Definition 2          |
| Transmitter Power      | VccT   | 16  |  | 5   | MOD_DEF(1)*   | Module Definition 1          |
| Receiver Power         | VccR   | 15  |  | 6   | MOD_DEF(0)*   | Module Definition 0          |
| Receiver Ground        | VeeR   | 14  |  | 7   | (Rate Select) | Unused function              |
| Received Data Out      | RD+    | 13  |  | 8   | LOS           | Loss of Signal               |
| Inv. Received Data Out | RD-    | 12  |  | 9   | VeeR          | Receiver Ground              |
| Received Ground        | VeeR   | 11  |  | 10  | VeeR          | Receiver Ground              |

\* Mod-Def 0,1,2 are the module definition pins. They should be pulled up with a 4.7K-10K $\Omega$  resistor on the host board.

Mod-Def 0 is grounded by the module to indicate that the module is present.

Mod-Def 1 is the clock line of two wire serial interface (I<sup>2</sup>C) for serial ID.

Mod-Def 2 is the data line of two wire serial interface (I<sup>2</sup>C) for serial ID.

For use of two wire serial interface (I<sup>2</sup>C), referring to Philips PC bus specification or ATMEL AT24C01A/02/04 data sheet is recommended. Refer to URL below for more detail:

<http://www.semiconductors.philips.com/buses/i2c/facts/index.html> or,

<http://www.atmel.com/acrobat/doc0180.pdf>

## 10. Block Diagram and Recommended Circuit

Block diagram and recommended decoupling and termination for HTR6516 is illustrated in Figure 4. This recommendation will provide a good performance of the optical transceiver.

Host board layout, the design of SFP cage and SFP electrical connector should comply with the SFP MSA requirements.

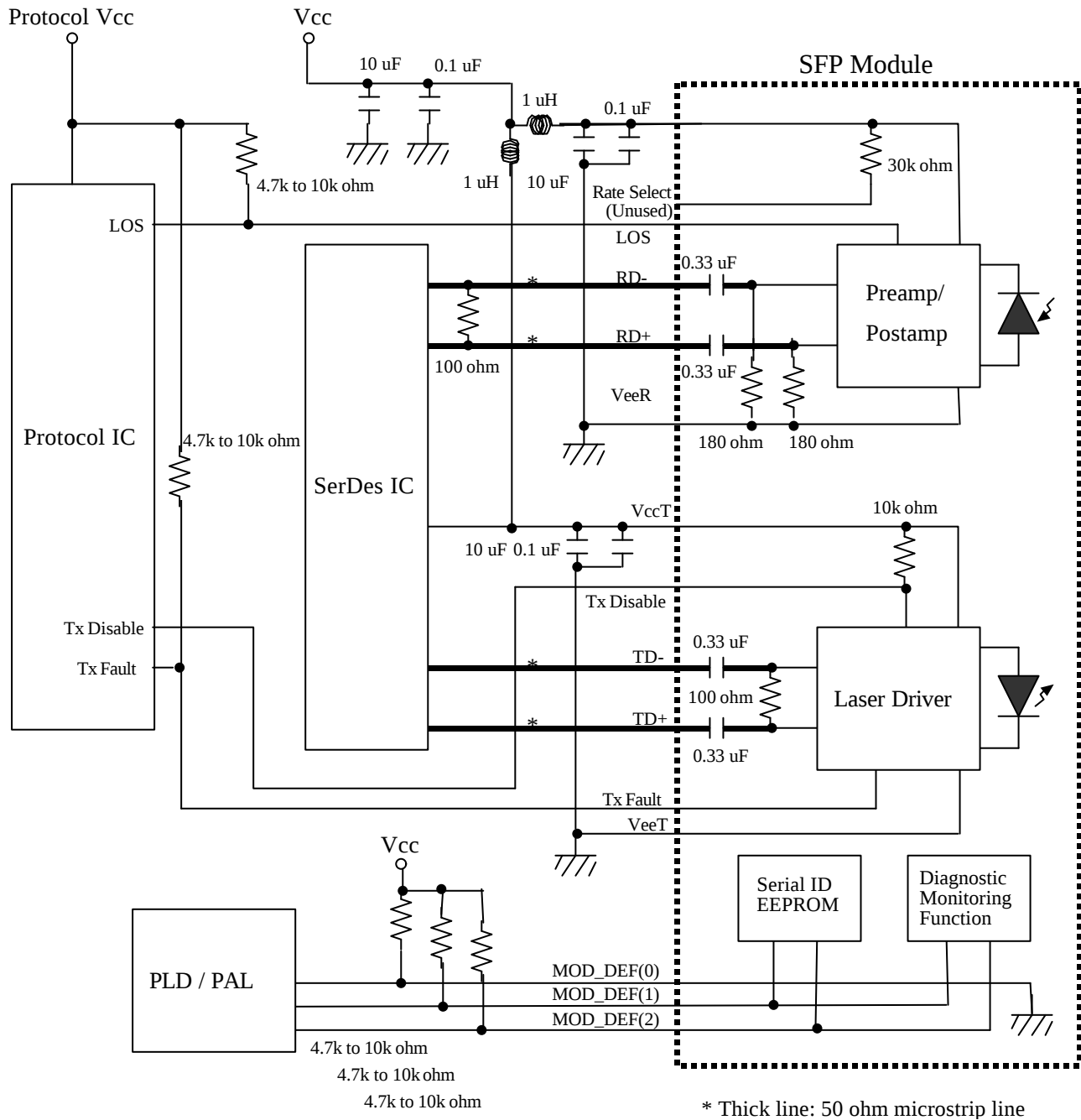


Figure 4. Block Diagram and Recommended Circuit

## 11. Serial identification

This transceiver features an EEPROM for Serial ID. Contents of the Serial ID are shown in Table 5.

Table 5. EEPROM Serial ID Memory Contents

| Data Address              | Field Size (Bytes) | Name of Field              | Value(Hex)                                              | Remark                                                                                                                               |
|---------------------------|--------------------|----------------------------|---------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| BASE ID FIELDS            |                    |                            |                                                         |                                                                                                                                      |
| 0                         | 1                  | Identifier                 | 03                                                      | SFP                                                                                                                                  |
| 1                         | 1                  | Ext.Identifier             | 04                                                      |                                                                                                                                      |
| 2                         | 1                  | Connector                  | 07                                                      | LC connector                                                                                                                         |
| 3-10                      | 8                  | Transceiver                | 00 00 00 02 12 00 01 01                                 | Transceiver codes                                                                                                                    |
| 11                        | 1                  | Encoding                   | 03                                                      | NRZ                                                                                                                                  |
| 12                        | 1                  | BR, Nominal                | 00                                                      | Bit rate is not specified                                                                                                            |
| 13                        | 1                  | Reserved                   | 00                                                      |                                                                                                                                      |
| 14                        | 1                  | Length(9u)-km              | 0A                                                      | 10km(units of km)                                                                                                                    |
| 15                        | 1                  | Length(9u)                 | 64                                                      | 10000m(units of 100m)                                                                                                                |
| 16                        | 1                  | Length(50u)                | 00                                                      | Not supported                                                                                                                        |
| 17                        | 1                  | Length(62.5u)              | 00                                                      | Not supported                                                                                                                        |
| 18                        | 1                  | Length(Copper)             | 00                                                      | Not supported                                                                                                                        |
| 19                        | 1                  | Reserved                   | 00                                                      | Not supported                                                                                                                        |
| 20-35                     | 16                 | Vendor name                | 48 69 74 61 63 68 69 20<br>43 61 62 6C 65 20 20 20      | "Hitachi Cable"(ASCII)                                                                                                               |
| 36                        | 1                  | Reserved                   | 00                                                      |                                                                                                                                      |
| 37-39                     | 3                  | Vendor OUI                 | 00 40 66                                                |                                                                                                                                      |
| 40-55                     | 16                 | Vendor PN                  | 48 54 52 36 35 31 36 20<br>20 20 20 20 20 20 20 20      | "HTR6516"(ASCII)<br>PN of SFP MSA compliant delatch type                                                                             |
|                           |                    |                            | 48 54 52 36 35 31 36 52<br>20 20 20 20 20 20 20 20      | "HTR6516R"(ASCII)<br>PN of single bail delatch type                                                                                  |
|                           |                    |                            | 48 54 52 36 35 31 36 52<br>32 20 20 20 20 20 20 20      | "HTR6516R2"(ASCII)<br>PN of double bail delatch type                                                                                 |
|                           |                    |                            |                                                         |                                                                                                                                      |
| 56-59                     | 4                  | Vendor rev                 | 20 20 20 20                                             | (ASCII)                                                                                                                              |
| 60-61                     | 2                  | Wavelength                 | 05 1E                                                   | 1310nm(16-bit unsigned integer)                                                                                                      |
| 62                        | 1                  | Reserved                   | 00                                                      |                                                                                                                                      |
| 63                        | 1                  | CC_BASE                    | Check sum(Variable)                                     | Check code for Base ID Fields                                                                                                        |
| EXTENDED ID FIELDS        |                    |                            |                                                         |                                                                                                                                      |
| 64-65                     | 2                  | Options                    | 00 1A                                                   | Loss of Signal, TX_FAULT, TX_DISABLE implemented                                                                                     |
| 66                        | 1                  | BR, max                    | 05                                                      | 5%(units of %)                                                                                                                       |
| 67                        | 1                  | BR, min                    | 05                                                      | 5%(units of %)                                                                                                                       |
| 68-83                     | 16                 | Vendor SN                  | 30 30 30 31 32 33 20 20<br>20 20 20 20 20 20 20 20 (*1) | Serial number of transceiver(ASCII)<br>(*1 Sample of number is "000123")                                                             |
| 84-91                     | 8                  | Date code                  | 30 32 31 31 31 38 30 30 (*2)                            | Manufacturing date code(ASCII)<br>(*2 Sample of date is "02111800")                                                                  |
| 92                        | 1                  | Diagnostic Monitoring Type | 58 (01011000 in binary)                                 | Digital Diagnostic monitoring implemented. Calibration type is "External Calibration". Rx power measurement type is "Average Power". |
| 93                        | 1                  | Enhanced optins            | 80 (10000000 in binary)                                 | Alarm/Warning flags implemented for all monitored quantities.                                                                        |
| 94                        | 1                  | SFF-8472 Compliance        | 01                                                      | Includes functionality described in Rev.9.0 SFF-8472.                                                                                |
| 95                        | 1                  | CC_EXT                     | Check sum(Variable)                                     | Check code for Extended ID Fields                                                                                                    |
| VENDOR SPECIFIC ID FIELDS |                    |                            |                                                         |                                                                                                                                      |
| 96-127                    | 32                 | Read-only                  | Unused                                                  | Filled by zero                                                                                                                       |
| 128-511                   | 384                | Reserved                   | Unused                                                  | Filled by zero                                                                                                                       |
| 511-n                     | -                  |                            | Unused                                                  | Filled by zero                                                                                                                       |

## 12.Enhanced Functions

Enhanced functions interface uses the 2 wire address 1010001X (0xA2). Memory contents of enhanced functions are shown in Table 6.1.

Table 6.1 Memory Contents / 2 wire address 1010001X (0xA2)

| Data Address           | Field Size (Bytes) | Name                                       | Remark                                                                                                                  |
|------------------------|--------------------|--------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|
| CONSTANTS FIELDS       |                    |                                            |                                                                                                                         |
| 00-01                  | 2                  | Temperature High Alarm                     | Set to 85 deg-C                                                                                                         |
| 02-03                  | 2                  | Temperature Low Alarm                      | Set to -15 deg-C                                                                                                        |
| 04-05                  | 2                  | Temperature High Warning                   | Set to 80 deg-C                                                                                                         |
| 06-07                  | 2                  | Temperature Low Warning                    | Set to -5 deg-C                                                                                                         |
| 08-09                  | 2                  | Vcc High Alarm                             | Set to 3.6 V                                                                                                            |
| 10-11                  | 2                  | Vcc Low Alarm                              | Set to 3.0 V                                                                                                            |
| 12-13                  | 2                  | Vcc High Warning                           | Set to 3.5 V                                                                                                            |
| 14-15                  | 2                  | Vcc Low Warning                            | Set to 3.1 V                                                                                                            |
| 16-17                  | 2                  | Laser Bias High Alarm                      | Various at each device                                                                                                  |
| 18-19                  | 2                  | Laser Bias Low Alarm                       | Various at each device                                                                                                  |
| 20-21                  | 2                  | Laser Bias High Warning                    | Various at each device                                                                                                  |
| 22-23                  | 2                  | Laser Bias Low Warning                     | Various at each device                                                                                                  |
| 24-25                  | 2                  | Tx Power High Alarm                        | Manufacture measurement plus 3 dB                                                                                       |
| 26-27                  | 2                  | Tx Power Low Alarm                         | Manufacture measurement minus 3dB                                                                                       |
| 28-29                  | 2                  | Tx Power High Warning                      | Manufacture measurement plus 2 dB                                                                                       |
| 30-31                  | 2                  | Tx Power Low Warning                       | Manufacture measurement minus 2dB                                                                                       |
| 32-33                  | 2                  | Rx Power High Alarm                        | Maximum input power plus 1 dB                                                                                           |
| 34-35                  | 2                  | Rx Power Low Alarm                         | Minimum input power minus 2 dB                                                                                          |
| 36-37                  | 2                  | Rx Power High Warning                      | Maximum input power plus 0.5 dB                                                                                         |
| 38-39                  | 2                  | Rx Power Low Warning                       | Minimum input power minus 1 dB                                                                                          |
| 40-55                  | 16                 | Reserved                                   | All bytes set to 0x00                                                                                                   |
| 56-59                  | 4                  | Rx Power Calibration Data R <sub>4</sub>   | Single precision floating-point numbers (various values at each device for incompatibility with “internal calibration”) |
| 60-63                  | 4                  | Rx Power Calibration Data R <sub>3</sub>   |                                                                                                                         |
| 64-67                  | 4                  | Rx Power Calibration Data R <sub>2</sub>   |                                                                                                                         |
| 68-71                  | 4                  | Rx Power Calibration Data R <sub>1</sub>   |                                                                                                                         |
| 72-75                  | 4                  | Rx Power Calibration Data R <sub>0</sub>   |                                                                                                                         |
| 76-77                  | 2                  | Laser Bias Calibration Data B <sub>1</sub> | Unsigned fixed-point number (set to 1) *                                                                                |
| 78-79                  | 2                  | Laser Bias Calibration Data B <sub>0</sub> | 16-bit signed 2's complement number (set to 0) *                                                                        |
| 80-81                  | 2                  | Tx Power Calibration Data P <sub>1</sub>   | Unsigned fixed-point number (set to 1) *                                                                                |
| 82-83                  | 2                  | Tx Power Calibration Data P <sub>0</sub>   | 16-bit signed 2's complement number (set to 0) *                                                                        |
| 84-85                  | 2                  | Temp. Calibration Data T <sub>1</sub>      | Unsigned fixed-point number (set to 1) *                                                                                |
| 86-87                  | 2                  | Temp. Calibration Data T <sub>0</sub>      | 16-bit signed 2's complement number (set to 0) *                                                                        |
| 88-89                  | 2                  | Vcc Calibration Data V <sub>1</sub>        | Unsigned fixed-point number (set to 1) *                                                                                |
| 90-91                  | 2                  | Vcc Calibration Data V <sub>0</sub>        | 16-bit signed 2's complement number (set to 0) *                                                                        |
| 92-94                  | 3                  | Reserved                                   | All bytes set to 0x00                                                                                                   |
| 95                     | 1                  | Checksum                                   | Low order 8 bits of the sum of byte 0-94.                                                                               |
| VARIABLES FIELDS       |                    |                                            |                                                                                                                         |
| 96-97                  | 2                  | Measured Temperature                       | Raw 16-bit A/D value (see Table 6.2)                                                                                    |
| 98-99                  | 2                  | Measured Vcc                               | Raw 16-bit A/D value (see Table 6.2)                                                                                    |
| 100-101                | 2                  | Measured Laser Bias                        | Raw 16-bit A/D value (see Table 6.2)                                                                                    |
| 102-103                | 2                  | Measured Tx Power                          | Raw 16-bit A/D value (see Table 6.2)                                                                                    |
| 104-105                | 2                  | Measured Rx Power                          | Raw 16-bit A/D value (see Table 6.2)                                                                                    |
| 106-109                | 4                  | Reserved                                   | All bytes set to 0x00                                                                                                   |
| 110                    | 1                  | Logic States                               | See Table 6.4                                                                                                           |
| 111                    | 1                  | AD Updated                                 | See Table 6.4                                                                                                           |
| 112-119                | 8                  | Alarm and Warning Flags                    | See Table 6.5                                                                                                           |
| VENDOR SPECIFIC FIELDS |                    |                                            |                                                                                                                         |
| 120-127                | 4                  | Vendor Specific                            | Do not access in order to operate normally                                                                              |
| 128-255                | 136                |                                            | No physical memory                                                                                                      |

\* Slopes B<sub>1</sub>=P<sub>1</sub>=T<sub>1</sub>=V<sub>1</sub>=1, intercepts B<sub>0</sub>=P<sub>0</sub>=T<sub>0</sub>=V<sub>0</sub>=0, for compatibility with “internal calibration”.

The measured values located at bytes 96-105 (in the 2 wire address 0xA2) are raw A/D values (16-bit integers) of transceiver temperature, supply voltage, laser bias current, laser optical output power and received power. All the measured values are "externally calibrated" over specified temperature and supply voltage, and then it is necessary to convert raw A/D values to real world units using the external calibration constants located at bytes 56-91 (0xA2) by the manner as shown in Table 6.2.

Table 6.2 Measured Values / 2 wire address 1010001X (0xA2)

| Byte | Name           | Description                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|------|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 96   | Temp MSB       | Internally measured transceiver temperature, $T_{AD}$ (16-bit signed 2's complement integer). Actual temperature, $T$ , is given by, $T=T_1*T_{AD}+T_0$ , where $T_1$ and $T_0$ are calibration data at bytes 84-87. The result is 16-bit signed 2's complement value with LSB equal to 1/256 deg-C (see Table 6.3a), yielding a total range of -128 to +128 deg-C. Accuracy of result is better than +/-3 deg-C.                                     |
| 97   | Temp LSB       |                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 98   | Vcc MSB        | Internally measured supply voltage, $V_{AD}$ (16-bit unsigned integer). Actual voltage, $V$ , is given by, $V=V_1*V_{AD}+V_0$ , where $V_1$ and $V_0$ are calibration data at bytes 88-91. The result is 16-bit unsigned value with LSB equal to 100 $\mu$ V (see Table 6.3b), yielding a total range of 0 to 6.55 V. Accuracy of result is better than +/-50 mV. Note that transmitter supply voltage measured since VccT and VccR are isolated.     |
| 99   | Vcc LSB        |                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 100  | Laser Bias MSB | Measured Laser bias current, $B_{AD}$ (16-bit unsigned integer). Actual current, $B$ , is given by, $B=B_1*B_{AD}+B_0$ , where $B_1$ and $B_0$ are calibration data at bytes 76-79. The result is 16-bit unsigned value with LSB equal to 2 $\mu$ A (see Table 6.3b), yielding a total range of 0 to 131 mA. Accuracy of result is better than +/-8 mA.                                                                                               |
| 101  | Laser Bias LSB |                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 102  | Tx Power MSB   | Measured Tx power, $P_{AD}$ (16-bit unsigned integer). Actual power, $P$ , is given by, $P=P_1*P_{AD}+P_0$ , where $P_1$ and $P_0$ are calibration data at bytes 82-85. The result is 16-bit unsigned value with LSB equal to 0.1 $\mu$ W (see Table 6.3b), yielding a total range of 0 to 6.55 mW. Accuracy is better than +/-3dBm.                                                                                                                  |
| 103  | Tx Power LSB   |                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 104  | Rx Power MSB   | Measured Rx power, $R_{AD}$ (16-bit unsigned integer). Actual power, $R$ , is given by<br>$R = R_4*R_{AD}^4 + R_3*R_{AD}^3 + R_2*R_{AD}^2 + R_1*R_{AD} + R_0,$ where $R_4$ , $R_3$ , $R_2$ , $R_1$ and $R_0$ are calibration data at bytes 56-75. The result is 16-bit unsigned value with LSB equal to 0.1 $\mu$ W (see Table 6.3b), yielding a total range of 0 to 6.55 mW. Accuracy is better than +/-3dBm over the specified optical input power. |
| 105  | Rx Power LSB   |                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

The formats of values shown in Table 6.2 are interpreted below. The result of temperature,  $T$ , and the calibration intercepts,  $T_0$ ,  $V_0$ ,  $B_0$ , and  $P_0$ , are 16-bit signed 2's complement numbers with corresponding LSB (e.g. laser bias,  $B_0$ , has 2  $\mu$ A LSB) as shown in Table 6.3a. The result of Vcc,  $V$ , laser bias,  $B$ , Tx power,  $P$ , and Rx power,  $R$  are 16-bit unsigned numbers with corresponding LSB (e.g. laser bias,  $B$ , has 2  $\mu$ A LSB) as shown in Table 6.3b. The calibration slopes,  $T_1$ ,  $V_1$ ,  $B_1$ , and  $P_1$ , are unsigned fixed-point numbers as shown in Table 6.3c. The calibration coefficients,  $R_4$ ,  $R_3$ ,  $R_2$ ,  $R_1$ , and  $R_0$ , are IEEE-754 single precision floating-point numbers as shown in Table 6.3d.

Table 6.3a 16-Bit Signed 2's Complement Number (MSB at low address)

|     | Bit 7 | Bit 6    | Bit 5    | Bit 4    | Bit 3    | Bit 2    | Bit 1 | Bit 0 |
|-----|-------|----------|----------|----------|----------|----------|-------|-------|
| MSB | SIGN  | $2^{14}$ | $2^{13}$ | $2^{12}$ | $2^{11}$ | $2^{10}$ | $2^9$ | $2^8$ |
| LSB | $2^7$ | $2^6$    | $2^5$    | $2^4$    | $2^3$    | $2^2$    | $2^1$ | $2^0$ |

Table 6.3b 16-bit Unsigned Number (MSB at low address)

|     | Bit 7    | Bit 6    | Bit 5    | Bit 4    | Bit 3    | Bit 2    | Bit 1 | Bit 0 |
|-----|----------|----------|----------|----------|----------|----------|-------|-------|
| MSB | $2^{15}$ | $2^{14}$ | $2^{13}$ | $2^{12}$ | $2^{11}$ | $2^{10}$ | $2^9$ | $2^8$ |
| LSB | $2^7$    | $2^6$    | $2^5$    | $2^4$    | $2^3$    | $2^2$    | $2^1$ | $2^0$ |

Table 6.3c Unsigned Fixed-Point Number (MSB at low address)

|     | Bit 7    | Bit 6    | Bit 5    | Bit 4    | Bit 3    | Bit 2    | Bit 1    | Bit 0    |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|
| MSB | $2^7$    | $2^6$    | $2^5$    | $2^4$    | $2^3$    | $2^2$    | $2^1$    | $2^0$    |
| LSB | $2^{-1}$ | $2^{-2}$ | $2^{-3}$ | $2^{-4}$ | $2^{-5}$ | $2^{-6}$ | $2^{-7}$ | $2^{-8}$ |

Table 6.3d IEEE-754 Single Precision Floating-Point Number (MSB at low address)

|     | Bit 7    | Bit 6    | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-----|----------|----------|-------|-------|-------|-------|-------|-------|
| MSB | SIGN     | EXPONENT |       |       |       |       |       |       |
|     | EXPONENT | MANTISSA |       |       |       |       |       |       |
| LSB | MANTISSA |          |       |       |       |       |       |       |
|     | MANTISSA |          |       |       |       |       |       |       |

This transceiver is implemented two optional status bits, "Logic States" at byte 110 (0xA2) and "A/D Updated" at byte 111 (0xA2) as shown in Table 6.4. "A/D updated" status bits allows the user to verify if an update from the analog-digital conversion has occurred to the measured values, temperature, Vcc, laser bias, Tx power and Rx power. The user writes the byte to 0x00. Once a conversion is complete for a given value, its bit will change to '1'.

Table 6.4 Optional Status Bits / 2 wire address 1010001X (0xA2)

| Byte | Bit | Name                     | Description                                         |
|------|-----|--------------------------|-----------------------------------------------------|
| 110  | 7   | Tx Disable State         | Optional digital state of the Tx Disable input pin. |
| 110  | 6   | Soft Tx Disable Control  | Not supported (set to 0).                           |
| 110  | 5   | Reserved                 | Set to 0.                                           |
| 110  | 4   | Rx Rate Select State     | Not supported (set to 1).                           |
| 110  | 3   | Soft Rate Select Control | Not supported (set to 0).                           |
| 110  | 2   | Tx Fault                 | Optional digital state of the Tx Fault output pin.  |
| 110  | 1   | LOS                      | Optional digital state of the LOS output pin.       |
| 110  | 0   | Power on Logic           | Bit will be 0 when the analog monitoring is active. |
| 111  | 7   | Temp A/D Valid           | Indicates A/D value in Bytes 96/97 is valid.        |
| 111  | 6   | Vcc A/D Valid            | Indicates A/D value in Bytes 98/99 is valid.        |
| 111  | 5   | Laser Bias A/D Valid     | Indicates A/D value in Bytes 100/101 is valid.      |
| 111  | 4   | Tx Power A/D Valid       | Indicates A/D value in Bytes 102/103 is valid.      |
| 111  | 3   | Rx Power A/D Valid       | Indicates A/D value in Bytes 104/105 is valid.      |
| 111  | 2   | Reserved                 | Set to 0.                                           |
| 111  | 1   | Reserved                 | Set to 0.                                           |
| 111  | 0   | Reserved                 | Set to 0.                                           |

Each of the measured values has a corresponding high alarm, low alarm, high warning and low warning threshold level at location 00-39 (0xA2) written as the data format of a corresponding value shown in Table 6.2. Alarm and warning flags at bytes 112-119 (0xA2) are defined as follows,

- (1) Alarm flags indicate conditions likely to result (or have resulted) in link failure and cause for immediate action,
- (2) Warning flags indicate conditions outside the guaranteed operating specification of transceiver but not necessarily causes of immediate link failures.

Table 6.5 Alarm and Warning Flags / 2 wire address 1010001X (0xA2)

| Byte | Bit(s) | Name                    | Description                                                   |
|------|--------|-------------------------|---------------------------------------------------------------|
| 112  | 7      | Temp. High Alarm        | Set when temp. monitor value exceeds high alarm level.        |
| 112  | 6      | Temp. Low Alarm         | Set when temp. monitor value is below low alarm level.        |
| 112  | 5      | Vcc High Alarm          | Set when Vcc monitor value exceeds high alarm level.          |
| 112  | 4      | Vcc Low Alarm           | Set when Vcc monitor value is below low alarm level.          |
| 112  | 3      | Laser Bias High Alarm   | Set when laser bias monitor value exceeds high alarm level.   |
| 112  | 2      | Laser Bias Low Alarm    | Set when laser bias monitor value is below low alarm level.   |
| 112  | 1      | Tx Power High Alarm     | Set when Tx power monitor value exceeds high alarm level.     |
| 112  | 0      | Tx Power Low Alarm      | Set when Tx power monitor value is below low alarm level.     |
| 113  | 7      | Rx Power High Alarm     | Set when Rx power monitor value exceeds high alarm level.     |
| 113  | 6      | Rx Power Low Alarm      | Set when Rx power monitor value is below low alarm level.     |
| 113  | 5-0    | Reserved                | All bits set to 0.                                            |
| 114  | 7-0    | Reserved                | All bits set to 0.                                            |
| 115  | 7-0    | Reserved                | All bits set to 0.                                            |
| 116  | 7      | Temp. High Warning      | Set when temp. monitor value exceeds high warning level.      |
| 116  | 6      | Temp. Low Warning       | Set when temp. monitor value is below low warning level.      |
| 116  | 5      | Vcc High Warning        | Set when Vcc monitor value exceeds high warning level.        |
| 116  | 4      | Vcc Low Warning         | Set when Vcc monitor value is below low warning level.        |
| 116  | 3      | Laser Bias High Warning | Set when laser bias monitor value exceeds high warning level. |
| 116  | 2      | Laser Bias Low Warning  | Set when laser bias monitor value is below low warning level. |
| 116  | 1      | Tx Power High Warning   | Set when Tx power monitor value exceeds high warning level.   |
| 116  | 0      | Tx Power Low Warning    | Set when Tx power monitor value is below low warning level.   |
| 117  | 7      | Rx Power High Warning   | Set when Rx power monitor value exceeds high warning level.   |
| 117  | 6      | Rx Power Low Warning    | Set when Rx power monitor value is below low warning level.   |
| 117  | 5-0    | Reserved                | All bits set to 0.                                            |
| 117  | 7-0    | Reserved                | All bits set to 0.                                            |
| 117  | 7-0    | Reserved                | All bits set to 0.                                            |

### 13. Inspection

Inspection items are as follows:

- (1) Appearance
- (2) Dimensions
- (3) Optical output power
- (4) Optical waveform
- (5) Optical input power
  - a) Average sensitivity
  - b) Loss of Signal / Decreasing light input
  - c) Loss of Signal / Increasing light input
- (6) Power supply current

### 14. Packing

The optical transceiver shall be packed in sturdy carton box(es) when shipping.

### 15. Caution

- (1) Do not stare into optical output port although this product is designed to meet the class 1 laser regulation.
- (2) The housing of the transceiver is possible to crack or dissolve against the particular chemicals. Although we recommend to use the aqueous fluid in the cleaning, the below chemicals are checked not to affect to the housing. Pay attention in the solder flux and cleaning process. We recommend checking the appropriateness of the cleaning fluid in advance.

/ methyl alcohol, ethyl alcohol, butyl alcohol, isopropyl alcohol, hexane, cyclohexane, naphtha, tetrachloroethylene, propylene glycol

< Do not use : Chemicals which are checked to crack or dissolve >

/ trichloroethylene, trichloroethane, benzen, methyl ethyl ketone, chloroform, toluene, acetone, phenol, ethyl acetate, methylene di chloride

- (3) Optical connectors should be cleaned completely by proper cleaning process before insertion to optical receptacles of the transceiver to avoid contamination inside the optical receptacle. The contamination may cause serious degradation of transmission performance. Using forced nitrogen and some kind of cleaning stick ("CLETOP, stick type" for LC/MU connector supplied by NTT international is recommended) should be used if the receptacle get contaminated by miss-treating optical connectors.

= MEMO =

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