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# Characterization Report on 155 Mb/s Single Mode Fiber Transceiver for ATM, SONET OC-3/SDH STM-1

## Application Note 1115

## HFCT-5202

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### Introduction

The HFCT-5202 transceiver is a high performance, cost effective module for serial optical data communications applications specified for a signal rate of 155 Mb/s. It is designed to provide an ATM/SONET/SDH compliant link for 155 Mb/s intermediate reach applications. The module is intended for single mode fiber, operates at a nominal wavelength of 1300 nm and is packaged in an industry standard 2 x 9 platform. It incorporates Hewlett-Packard's high performance, reliable, long wavelength optical devices and proven circuit technology to give long life and consistent service.

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This characterization was performed using HFCT-5202 devices and so is representative of both HFCT-5202A/C (-40°C to +85°C) and HFCT-5202B/D (0°C to +70°C) variants.

The characterization was performed in accordance with Bellcore Specification TA-NWT-000983.

### Summary

- **The characterization demonstrates that the HFCT-5202 complied with the Product Specification.**
- **Typical Receiver Sensitivity: -35 dBm**
- **HFCT-5202 - SONET/SDH Compliant**

This report details the characterization work performed on the HFCT-5202 Duplex Single Mode Transceiver. The report evaluates the HFCT-5202 performance under all conditions against target parameters in the product specification. The following parameters were evaluated over the supply voltage range at -40°C, +25°C and +85°C:

- Output Power
- Extinction Ratio
- Transmitter Supply Current
- Wavelength
- Spectral Width
- Sensitivity
- Receiver Supply Current
- Signal Detect Threshold
- Signal Detect High
- Signal Detect Low
- Signal Detect Hysteresis

Additionally, a thermal analysis, the typical values of propagation delay, signal detect de-assert/as-

sert time, spectra and SONET/SDH compliant eye diagrams are presented.

A reference standard device which was not exposed to the environmental stress was reviewed daily to confirm measurement repeatability.

### Definition of Terms

#### *Output Power (dBm)*

This measures the optical output of the laser transmitter modulated with a 155.52 Mb/s, pseudo random data pattern with worst case consecutive intersymbol duration as specified in CCITT G.958. As recommended by CCITT G.957, the output power is measured at a point after the first connector in order to account for the SC connector loss. To accomplish this, the optical output is coupled to a large area detector by a 1m patchcord.

#### *Extinction Ratio (dB)*

The extinction ratio measures the ratio of the output power of the light in a "1" or the "on" logic state to the output power of the light in a "0" or the "off" logic state.

#### *Transmitter Supply Current (mA)*

This is the current supplied to the transmitter at the stated supply

voltage excluding the ECL termination resistances.

#### *Wavelength (nm)*

The mean wavelength as measured by an HP70950A optical spectrum analyzer. The transmitter is modulated by a 155.52 Mb/s, pseudo random data pattern signal with worst case consecutive intersymbol duration.

#### *Spectral Width (nm)*

Spectral Width is defined as the RMS width containing all modes with energy greater than 20 dB down from the peak wavelength.

#### *Sensitivity (dBm)*

This measures the minimum received optical power which returns a bit error rate of  $1 \times 10^{-10}$  when operated at 155.52 Mb/s, with a pseudo random data pattern signal with worst case consecutive intersymbol duration.

#### *Receiver Supply Current (mA)*

This is the current supplied to the receiver at the stated supply voltage excluding the ECL termination resistances.

#### *Signal Detect Threshold (dBm)*

This is the optical power level that causes the device's Signal Detect circuit to switch on (logic "low") due to optical signal loss.

#### *Signal Detect Hysteresis (dB)*

This is the difference between the Signal Detect Threshold value and the value at which the signal detect voltage returns to the "high state" in response to an increased optical signal.

#### *Signal Detect High (V)*

This measures the Signal Detect output voltage for a logic "high" state. The output was not terminated on the evaluation board for this measurement. This output is

terminated in  $50 \Omega$  on the IC. The Alarm output is measured with respect to the positive supply  $V_{CC}$ .

#### *Signal Detect Low (V)*

This measures the Signal Detect output voltage for a logic "low" state. The output was not terminated on the evaluation board for this measurement. This output is terminated in  $50 \Omega$  on the IC. The Alarm output is measured with respect to the positive supply  $V_{CC}$ .

#### *Jitter Tolerance ( $UI_{p-p}$ )*

Jitter amplitude required to increase by 1 dB, the input signal level at which the HFCT-5202 will operate with a BER of  $1 \times 10^{-10}$ .

#### *Temperature ( $^{\circ}C$ )*

The Tests were conducted in a controlled environment with an approximate airflow of 2 m/s, to ensure that the devices under test had settled to the required temperature  $\pm 1^{\circ}C$ .

## Characterization

### General

Figure 1 depicts the Typical Test Configuration used to collect data presented in the report.

Characterization of the HFCT-5202 was performed on 10 devices. The devices were characterized over the operating temperature range ( $-40^{\circ}C$ ,  $+25^{\circ}C$  and  $+85^{\circ}C$ ) at 4.75 V, 5.0 V, and 5.25 V supply voltage to confirm compliance with the product specification.

The following parameters were recorded for each device:

- Output Power
- Extinction Ratio
- Transmitter Supply Current
- Wavelength

- Spectral Width
- Sensitivity
- Receiver Supply Current
- Signal Detect Threshold
- Signal Detect High
- Signal Detect Low
- Signal Detect Hysteresis

Only summaries of the results are shown in this report. All results are available for inspection at Hewlett-Packard.

## Results

### Initial Characterization of the 10 HFCT-5202 devices at 4.75 and 5.25 V and $-40^{\circ}C$ , $+25^{\circ}C$ and $+85^{\circ}C$ .

Table 1 reports results from the extreme single point and mean measurements against the Product Specification over the supply range voltages (4.75 and 5.25 V) and the operating temperature range ( $-40^{\circ}C$ ,  $+25^{\circ}C$  and  $+85^{\circ}C$ ).

These results demonstrate that the HFCT-5202 remains within the product specification at the extreme supply voltages over the operating temperature range. Appendix A contains a more complete set of data featuring results taken for each parameter at all the possible combinations of voltage and temperature.



**Table 1. HFCT-5202 Maximum, minimum and mean measured parameters at  $V_{CC} = 4.75\text{ V}$  and  $5.25\text{ V}$  over the operating temperature range compared to product specification limits.**

Parameter	Unit	Measured (10 Devices)			Product Specification	
		Min.	Mean	Max.	Min.	Max.
Output Power	dBm	-11.55	-10.53	-8.42	-15	-8
Extinction Ratio		12.89	21.50	31.79	8.2	-
Tx Supply Current	mA	27.00	56.54	105.00	-	140
Wavelength	nm	1287.04	1313.29	1339.20	1261	1360
Spectral Width	nm	0.67	1.04	1.65	-	7.7
Sensitivity	dBm	-36.80	-35.22	-33.80	-	-28
Rx Supply Current	mA	200.00	236.43	272.00	-	290
Signal Detect Threshold	dBm	-40.70	-39.68	-38.40	-42	-31
Signal Detect High	V	-0.96	-0.88	-0.79	-1.05	-0.74
Signal Detect Low	V	-1.92	-1.86	-1.78	-1.95	-1.62
Signal Detect Hysteresis	dB	1.40	2.25	3.10	0.5	4.0

**Table 2. HFCT-5202 Maximum, minimum and mean measured parameters at  $V_{CC} = 5.0\text{ V}$  over the operating temperature range compared to product specification limits.**

Parameter	Unit	Measured (10 Devices)			Product Specification	
		Min.	Mean	Max.	Min.	Max.
Output Power	dBm	-11.52	-8.42	-10.51	-15	-8
Extinction Ratio		13.87	28.39	21.39	8.2	-
Tx Supply Current	mA	30.00	103.00	56.90	-	140
Wavelength	nm	1287.20	1339.00	1313.26	1261	1360
Spectral Width	nm	0.72	1.65	1.05	-	7.7
Sensitivity	dBm	-36.80	-33.80	-35.15	-	-28
Rx Supply Current	mA	206.00	265.00	236.87	-	290
Signal Detect Threshold	dBm	-40.70	-38.40	-39.67	-42	-31
Signal Detect High	V	-0.96	-0.79	-0.88	-1.05	-0.74
Signal Detect Low	V	-1.91	-1.78	-1.86	-1.95	-1.62
Signal Detect Hysteresis	dB	1.50	3.10	2.26	0.5	4.0

of -28 dBm and -7 dBm. The measured de-assert times were 22.4  $\mu\text{s}$  and 14.4  $\mu\text{s}$  respectively. These values are compared to 600  $\mu\text{s}$ , as defined by the product specification.

Additionally, the Signal Detect De-assert Time, which is the time required for the signal detect to swing from the high to the low logic state in response to the loss of the input optical signal, was measured for both input power levels. The measured response was 300  $\mu\text{s}$  and 1.2 ms for -28 dBm and -7 dBm, respectively. The differences in response time are attributed to the dynamics of the Automatic Gain Control circuit in the receiver section. The results are summarized in Table 4.

### Recovered Clock and Data Alignment

Clock and Data alignment is measured as the time difference between the 50% amplitude levels on the falling edges of the clock and data output waveforms. This measurement was performed on two HFCT-5202 modules. Results of 8 ps and 10 ps recorded for these two modules compare favorably with a specified maximum of  $\pm 125$  ps.

**Table 3. Measurements taken in Still and Moving Air**

With an air flow of 2 m/s (approx.)	Ambient Temperature ( $^{\circ}\text{C}$ )	
	+25	+85
Temperature [1]	+41.4	+104.0
Temperature [2]	+51.8	+114.1
<b>With no air flow</b>		
Temperature [1]	+46.8	+112.4
Temperature [2]	+57.1	+123.0

Notes: (1) Top of shield above receiver IC.  
(2) Underside of PCB directly below receiver IC.

**Table 4. Alarm Switching Time in response to “no light” and “light” conditions**

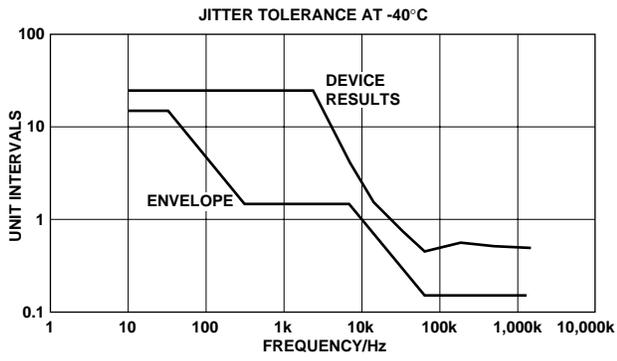
Input Optical Power	Signal Detect De-Assert Time	Signal Detect Assert Time
-7 dBm	1.2 ms	14.4 $\mu\text{s}$
-28 dBm	300 $\mu\text{s}$	22.4 $\mu\text{s}$

### Jitter Tolerance

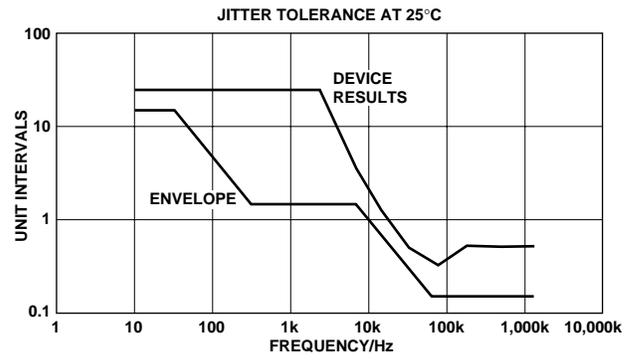
A typical jitter tolerance plot for the HFCT-5202 at  $-40^{\circ}\text{C}$ ,  $+25^{\circ}\text{C}$  and  $+85^{\circ}\text{C}$  is shown in Figure 2. The tolerance was measured with a module power supply of 5 V and is the jitter amplitude required to increase by 1 dB the input signal level at which the module will operate with a BER of  $1 \times 10^{-10}$ .

### Conclusions

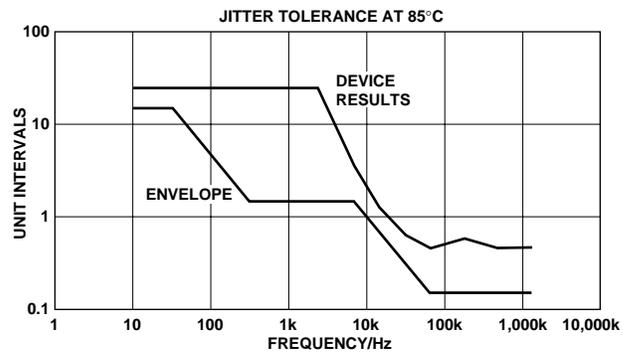
The HFCT-5202 characterization was completed and showed that all the critical parameters met the Product Specification.



(a)



(b)



(c)

Figure 2. Jitter Tolerance for a typical device at (a) -40°C, (b) +25°C, and (c) +85°C at a supply voltage of 5 V

## Appendix A. HFCT-5202 measured at +25°C, -40°C and +85°C at 4.75 V.

### Characterization Results at +25°C, 4.75 V

Parameter	Units	Mean	Mean -3 $\sigma$	Mean +3 $\sigma$	Minimum	Maximum
Output Power	dBm	-10.42	-9.50	-11.59	-11.08	-9.96
Extinction Ratio		21.68	28.17	15.19	17.90	24.00
Transmitter Supply Current	mA	41.50	47.68	35.32	40.00	47.00
Wavelength	nm	1314.28	1320.96	1307.59	1310.78	1317.90
Spectral Width	nm	0.97	1.43	0.51	0.78	1.36
Sensitivity	dBm	-35.14	-33.24	-38.61	-36.10	-34.00
Receiver Supply Current	mA	232.80	255.52	210.08	221.00	244.00
Signal Detect Threshold	dBm	-39.57	-38.52	-40.95	-40.40	-39.10
Signal Detect High	V	-0.88	-0.87	-0.89	-0.88	-0.87
Signal Detect Low	V	-1.86	-1.82	-1.90	-1.88	-1.83
Signal Detect Hysteresis	dB	2.40	3.19	1.61	2.00	2.90

### Characterization Results at -40°C, 4.75 V

Parameter	Units	Mean	Mean -3 $\sigma$	Mean +3 $\sigma$	Minimum	Maximum
Output Power	dBm	-11.14	-10.33	-12.15	-11.55	-10.75
Extinction Ratio		21.06	32.52	9.60	13.75	28.19
Transmitter Supply Current	mA	29.50	35.83	23.17	27.00	35.00
Wavelength	nm	1289.93	1295.75	1284.12	1287.04	1292.98
Spectral Width	nm	0.86	1.34	0.38	0.67	1.16
Sensitivity	dBm	-35.85	-33.89	-39.49	-36.80	-34.50
Receiver Supply Current	mA	211.20	233.56	188.84	200.00	224.00
Signal Detect Threshold	dBm	-39.81	-38.94	-40.90	-40.50	-39.40
Signal Detect High	V	-0.96	-0.95	-0.97	-0.96	-0.95
Signal Detect Low	V	-1.88	-1.84	-1.93	-1.90	-1.86
Signal Detect Hysteresis	dB	2.41	3.00	1.82	2.10	2.70

### Characterization Results at +85°C, 4.75 V

Parameter	Units	Mean	Mean -3 $\sigma$	Mean +3 $\sigma$	Minimum	Maximum
Output Power	dBm	-10.02	-8.35	-12.76	-10.88	-8.57
Extinction Ratio		20.53	28.57	12.50	15.17	25.83
Transmitter Supply Current	mA	87.70	118.32	57.08	62.00	99.00
Wavelength	nm	1335.46	1342.61	1328.30	1330.87	1339.20
Spectral Width	nm	1.34	1.78	0.89	1.20	1.63
Sensitivity	dBm	-34.65	-33.17	-36.92	-35.50	-33.80
Receiver Supply Current	mA	245.30	267.55	223.05	235.00	257.00
Signal Detect Threshold	dBm	-39.41	-38.11	-41.28	-40.40	-38.40
Signal Detect High	V	-0.80	-0.78	-0.82	-0.81	-0.79
Signal Detect Low	V	-1.81	-1.76	-1.85	-1.83	-1.78
Signal Detect Hysteresis	dB	1.97	2.56	1.38	1.50	2.20

**HFCT-5202 measured at +25°C, -40°C and +85°C at 5.25 V****Characterization Results at +25°C, 5.25 V**

Parameter	Units	Mean	Mean -3 $\sigma$	Mean +3 $\sigma$	Minimum	Maximum
Output Power	dBm	-10.39	-9.49	-11.53	-11.03	-9.90
Extinction Ratio		22.54	26.19	18.89	20.16	24.16
Transmitter Supply Current	mA	47.30	53.60	41.00	46.00	53.00
Wavelength	nm	1314.25	1320.82	1307.68	1310.81	1318.00
Spectral Width	nm	0.94	1.43	0.45	0.72	1.35
Sensitivity	dBm	-35.14	-33.25	-38.57	-36.00	-34.00
Receiver Supply Current	mA	245.50	269.32	221.68	232.00	256.00
Signal Detect Threshold	dBm	-39.70	-38.65	-41.08	-40.60	-39.30
Signal Detect High	V	-0.88	-0.87	-0.89	-0.88	-0.88
Signal Detect Low	V	-1.87	-1.82	-1.91	-1.89	-1.84
Signal Detect Hysteresis	dB	2.40	3.35	1.45	1.90	3.00

**Characterization Results at -40°C, 5.25 V**

Parameter	Units	Mean	Mean -3 $\sigma$	Mean +3 $\sigma$	Minimum	Maximum
Output Power	dBm	-11.13	-10.32	-12.12	-11.53	-10.98
Extinction Ratio		24.11	38.82	9.39	15.71	31.79
Transmitter Supply Current	mA	35.30	41.88	28.72	33.00	41.00
Wavelength	nm	1290.03	1295.64	1284.41	1287.08	1293.02
Spectral Width	nm	0.87	1.34	0.39	0.68	1.14
Sensitivity	dBm	-35.76	-33.97	-38.86	-36.70	-34.50
Receiver Supply Current	mA	223.60	247.94	199.26	211.00	236.00
Signal Detect Threshold	dBm	-39.99	-39.07	-41.15	-40.70	-39.40
Signal Detect High	V	-0.96	-0.95	-0.96	-0.96	-0.96
Signal Detect Low	V	-1.90	-1.85	-1.94	-1.92	-1.87
Signal Detect Hysteresis	dB	2.41	3.13	1.69	1.90	2.60

**Characterization Results at +85°C, 5.25 V**

Parameter	Units	Mean	Mean -3 $\sigma$	Mean +3 $\sigma$	Minimum	Maximum
Output Power	dBm	-9.93	-8.22	-12.82	-10.77	-8.45
Extinction Ratio		19.43	27.59	11.27	12.89	22.49
Transmitter Supply Current	mA	96.90	112.80	81.00	90.00	105.00
Wavelength	nm	1335.91	1342.47	1329.34	1331.75	1339.20
Spectral Width	nm	1.29	1.81	0.78	1.10	1.65
Sensitivity	dBm	-34.49	-33.19	-36.35	-35.20	-33.90
Receiver Supply Current	mA	258.90	283.14	234.66	247.00	272.00
Signal Detect Threshold	dBm	-39.45	-38.15	-41.32	-40.50	-38.50
Signal Detect High	V	-0.80	-0.78	-0.81	-0.81	-0.79
Signal Detect Low	V	-1.81	-1.77	-1.86	-1.84	-1.79
Signal Detect Hysteresis	dB	1.90	2.72	1.08	1.40	2.40

**Appendix B. HFCT-5202 measured at +25°C, -40°C and +85°C at 5 V.****Characterization Results at +25°C, 5 V**

Parameter	Units	Mean	Mean -3 $\sigma$	Mean +3 $\sigma$	Minimum	Maximum
Output Power	dBm	- 10.43	- 9.48	- 11.65	- 11.11	- 9.93
Extinction Ratio		22.10	27.93	16.28	17.40	24.16
Transmitter Supply Current	mA	44.20	50.88	37.52	42.00	50.00
Wavelength	nm	1314.02	1319.64	1308.40	1310.80	1317.20
Spectral Width	nm	0.95	1.44	0.46	0.73	1.37
Sensitivity	dBm	- 35.15	- 33.25	- 38.61	- 36.00	- 34.00
Receiver Supply Current	mA	239.50	264.14	214.86	226.00	251.00
Signal Detect Threshold	dBm	- 39.67	- 38.48	- 41.29	- 40.70	- 39.10
Signal Detect High	V	- 0.88	- 0.87	- 0.88	- 0.88	- 0.87
Signal Detect Low	V	- 1.86	- 1.82	- 1.91	- 1.88	- 1.84
Signal Detect Hysteresis	dB	2.39	3.48	1.30	1.90	3.10

**Characterization Results at -40°C, 5 V**

Parameter	Units	Mean	Mean -3 $\sigma$	Mean +3 $\sigma$	Minimum	Maximum
Output Power	dBm	- 11.15	- 10.38	- 12.08	- 11.52	- 10.74
Extinction Ratio		22.31	34.37	10.25	13.87	28.39
Transmitter Supply Current	mA	32.40	38.86	25.94	30.00	38.00
Wavelength	nm	1289.93	1295.51	1284.35	1287.20	1292.80
Spectral Width	nm	0.87	1.33	0.41	0.72	1.17
Sensitivity	dBm	- 35.79	- 33.91	- 39.19	- 36.80	- 34.50
Receiver Supply Current	mA	218.10	242.08	194.12	206.00	230.00
Signal Detect Threshold	dBm	- 39.92	- 38.96	- 41.13	- 40.70	- 39.50
Signal Detect High	V	- 0.96	- 0.95	- 0.96	- 0.96	- 0.96
Signal Detect Low	V	- 1.89	- 1.84	- 1.94	- 1.91	- 1.86
Signal Detect Hysteresis	dB	2.45	3.21	1.69	2.10	2.80

**Characterization Results at +85°C, 5 V**

Parameter	Units	Mean	Mean -3 $\sigma$	Mean +3 $\sigma$	Minimum	Maximum
Output Power	dBm	-9.96	-8.21	- 12.96	-10.80	- 8.42
Extinction Ratio		19.76	26.68	12.84	14.38	22.30
Transmitter Supply Current	mA	94.10	111.15	77.05	87.00	103.00
Wavelength	nm	1335.82	1342.15	1329.48	1331.94	1339.00
Spectral Width	nm	1.31	1.81	0.82	1.15	1.65
Sensitivity	dBm	- 34.51	- 33.12	-36.55	- 35.50	- 33.80
Receiver Supply Current	mA	253.00	275.25	230.75	241.00	265.00
Signal Detect Threshold	dBm	- 39.42	- 38.06	- 41.41	- 40.50	- 38.40
Signal Detect High	V	- 0.80	- 0.78	- 0.81	- 0.80	- 0.79
Signal Detect Low	V	- 1.81	- 1.76	- 1.86	- 1.83	- 1.78
Signal Detect Hysteresis	dB	1.93	2.55	1.31	1.50	2.30



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