Agilent HFCT-5915E Characterization Report for MT-RJ Duplex Single Mode Transceiver

Application Note 1209

Introduction

The HFCT-5915E transceiver is a high performance, cost effective module for serial optical data communication 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 long reach applications over 0°C to +70°C temperature range. 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 5 platform. It incorporates Agilent's high performance, reliable, long wavelength optical devices and proven circuit technology to give long life and consistent service.

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

Summary

- **The characterization demonstrates that the HFCT-5915E complies with the Product Specification**
- **HFCT-5915E - SONET OC3 SDH STM-1 Compliant**

This report evaluates the HFCT-5915E transmitter performance under all conditions against target parameters in the Product Specification.

The HFCT-5915E receiver characterization has been completed by claimed similarity with the HFCT-5905E, due to common optical subassembly, electrical assembly and package style. The results of the HFCT-5905E receiver characterization are included here from Application Note 1181 for completeness.

The following transmitter parameters were characterized at 3.1 V, 3.3 V and 3.5 V at 0°C, +25°C and +70°C:

- Output Power
- Extinction Ratio
- Transmitter Supply Current
- Wavelength
- Spectral Width
- Eye Mask

SONET/SDH compliant eye diagrams are also presented.

Definition of terms

Transmitter Parameters

Output Power (dBm)

The optical output power is an averaged measurement using a 1 m MT-RJ patchcord terminated with an SC connector into a large area detector. This measurement allows for the loss of the MT-RJ Connector. The module was modulated at 155.52 Mb/s using a $2E^{23}$-1 PRBS data pattern .

Extinction Ratio (dB)

This is the ratio of optical power in a "1" or "on" logic state to the optical power in a "0" or "off" logic state. The Extinction Ratio is measured using a 1010... data pattern at 50 MHz. This gives a flat top and bottom to the output pulse in order to make accurate measurements.

Transmitter Supply Current (mA)

This is the current supplied to the transmitter at the relevant supply voltage including that drawn by the test fixture but excluding that drawn by the termination resistance network.

Wavelength (nm)
The mean wavelength is measured on an optical spectrum analyzer. The transmitter is modulated with a $2E^{23}$-1 PRBS at 155.52 Mb/s.

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.

Transmitter Power Supply Noise Rejection
Modules were measured using test fixtures fitted with the power supply filter shown in Figure 1. Wideband noise was introduced through a signal generator and the optical eye was viewed using an Agilent 83480A Digital Communications Analyzer with a SONET/SDH eye mask applied. The noise to the device is increased until the eye mask margin is reduced to 20%.

Receiver Parameters
Sensitivity (dBm)
This measures the receiver sensitivity with a $2E^{23}$-1 PRBS input signal. The sensitivity is the minimum optical input power required so that the receiver can recover a signal with an error rate better than $1e^{-10}$.

Receiver Supply Current (mA)
This is the receiver supply current at the stated supply voltage excluding that drawn by the termination resistance network of the evaluation board.

Signal Detect Levels (V)
This is the measured voltage through 50 ohms, referenced to V_{CC} -2 V at the signal detect output. Signal Detect is High during an 'ON' state and low during an 'OFF' state. Table 1 shows that Signal Detect levels are within data sheet specifications.

Signal Detect Deassert (dBm)
This is the point at which the signal detect flags low to indicate a loss of signal due to low optical power.

SD Deassert and Assert Times (µs)
The time taken for a high to low transition or a low to high transition after the optical input signal is removed or applied respectively. Measured with -7 dBm of optical power at the receiver input. Table 2 shows that Signal Detect Assert and Deassert times are within data sheet specifications.

Receiver Power Supply Noise Rejection
Modules were measured using test fixtures fitted with the power supply filter shown in Figure 1. Wideband noise was introduced through a signal generator and the receiver measured for 1 dB sensitivity degradation.

Overload (dBm)
The maximum optical signal power to the receiver such that the recovered data has an error rate of $1e^{-10}$. This parameter was checked at 155.52 Mb/s using a $2E^{23}$-1 PRBS pattern. All receivers operate with a 8 dB margin above G.957 (-8 dBm).

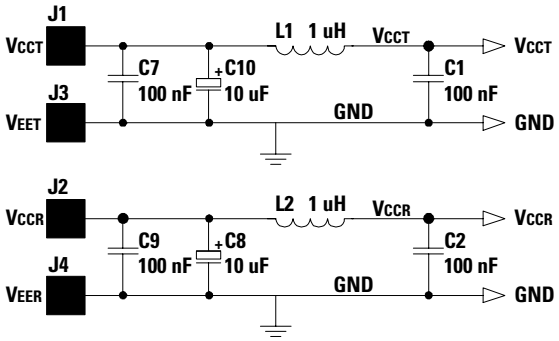


Figure 1. Multi Source Agreement Power Supply Filter

Table 1 - HFCT-5915E Signal Detect voltage levels with respect to V_{CC}.

	Units	Mean	Min.	Max.	Product Specifications	
					Min.	Max.
SD Low	V	-1.80	-1.78	-1.82	-1.84	-1.62
SD High	V	-1.01	-1.00	-1.02	-0.88	-1.05

Table 2 - HFCT-5915E Mean, Minimum and Maximum Signal Detect Assert and Deassert times over temperature and voltage

Test Parameters	Units	Mean	Min.	Max.	Limits	
					Min.	Max.
SD Assert	µs	73.0	67.0	78.1	-	100
SD Deassert	µs	3.5	3.0	3.5	-	-

Results Summary
Voltage Dependence

One of the objectives for this characterization exercise was to assess the influence of voltage supply variation on transceiver performance. The summary of results shown in Tables 3a and b indicate that the HFCT-5915E has negligible dependence on supply voltage (within the limits of 3.1 V to 3.5 V) for parameters over the operating temperature range.

As such there is sufficient confidence in evaluating remaining characterization parts under nominal 3.3 V voltage supplies over its rated operating temperature range.

Table 3a - HFCT-5915E Mean, Minimum and Maximum measured parameters over operating temperature at 3.3 V

Test Parameters	Units	Measured		
		Mean	Minimum	Maximum
Transmitter				
Supply Current	mA	73	52	101
Output Power	dBm	-2.58	-4.17	-1.53
Extinction Ratio	dB	13.6	10.7	16
Receiver				
Supply Current	mA	70.1	63.1	82.1
Sensitivity	dBm	-38.9	-39.7	-37.0
SD Deassert	dBm	-42.5	-43.8	-40.0
SD Hysteresis	dB	2.2	2.0	2.4

Table 3b - HFCT-5915E Mean, Minimum and Maximum measured parameters over operating temperature and voltage (3.1 V, 3.5 V excluding 3.3 V)

Test Parameters	Units	Measured		
		Mean	Minimum	Maximum
Transmitter				
Supply Current	mA	73	51	102
Output Power	dBm	-2.57	-4.16	-1.52
Extinction Ratio	dB	13.6	10.33	16
Receiver				
Supply Current	mA	71.2	61.6	84.8
Sensitivity	dBm	-38.9	-39.8	-37.0
SD Deassert	dBm	-42.5	-43.8	-40.1
SD Hysteresis	dB	2.2	2.0	2.5

Overall Performance

Tables 4a, b and c show a summary of parametric performance at a nominal voltage supply of 3.3 V over the temperature range 0°C, +25°C and +70°C. The results show that all parameters were within data sheet limits.

Table 4a - Temperature = 0°C

Test Parameters	Units	Mean	Min	Max	Limits	
					Min	Max
Transmitter						
Supply Current	mA	63	52	73	-	140
Output Power	dBm	-2.69	-4.17	-1.82	-5.0	0
Extinction Ratio	dB	14.13	11.61	16.0	10	-
Centre Wavelength	nm	1295	1292	1299	1285	1335
Spectral Width	nm	1.35	0.89	1.65	-	4
Receiver						
Supply Current	mA	64.1	63.1	67.1	-	100
Sensitivity	dBm	-39.16	-39.7	-37.6	-	-34.0
SD Deassert	dBm	-42.7	-43.7	-40.9	-45.0	-37.0
SD Hysteresis	dB	2.2	2.1	2.3	0.5	4.0

Table 4b - Temperature = +25°C

Test Parameters	Units	Mean	Min	Max	Limits	
					Min	Max
Transmitter						
Supply Current	mA	67	55	76	-	140
Output Power	dBm	-2.50	-3.22	-1.53	-5.0	0
Extinction Ratio	dB	13.6	10.8	15.83	10	-
Centre Wavelength	nm	1305	1301	1311	1285	1335
Spectral Width	nm	1.46	1.27	1.78	-	4
Receiver						
Supply Current	mA	69.1	67.1	74.1	-	100
Sensitivity	dBm	-38.91	-39.4	-37.2	-	-34.0
SD Deassert	dBm	-42.6	-43.8	-40.7	-45.0	-37.0
SD Hysteresis	dB	2.2	2.1	2.4	0.5	4.0

Table 4c - Temperature = +70°C

Test Parameters	Units	Mean	Min	Max	Limits	
					Min	Max
Transmitter						
Supply Current	mA	89.3	76	101	-	140
Output Power	dBm	-2.55	-3.03	-1.82	-5.0	0
Extinction Ratio	dB	13.03	10.68	14.9	10	-
Centre Wavelength	nm	1320	1317	1324	1285	1335
Spectral Width	nm	1.7	1.4	2.2	-	4
Receiver						
Supply Current	mA	76.1	75.1	82.1	-	100
Sensitivity	dBm	-38.52	-39.00	-37.00	-	-34.0
SD Deassert	dBm	-42.33	-43.40	-40.00	-45.0	-37.0
SD Hysteresis	dB	2.2	2.0	2.3	0.5	4.0

Receiver and Transmitter power supply noise immunity

Using the MSA power supply filter shown in Figure 1, noise of varying amplitude and frequency was injected onto the Rx V_{CC} and receiver sensitivity monitored. The worst case receiver noise immunity observed was 200 mV pk-pk for 1 dB degradation in sensitivity.

The transmitter worst case immunity occurred at 1 MHz. At this frequency a 164 mV pk-pk sinusoid signal on the V_{CC} rail reduces the data output eye mask margin to 20%.

Figure 2 shows the transmitter's noise rejection performance as a function of frequency.

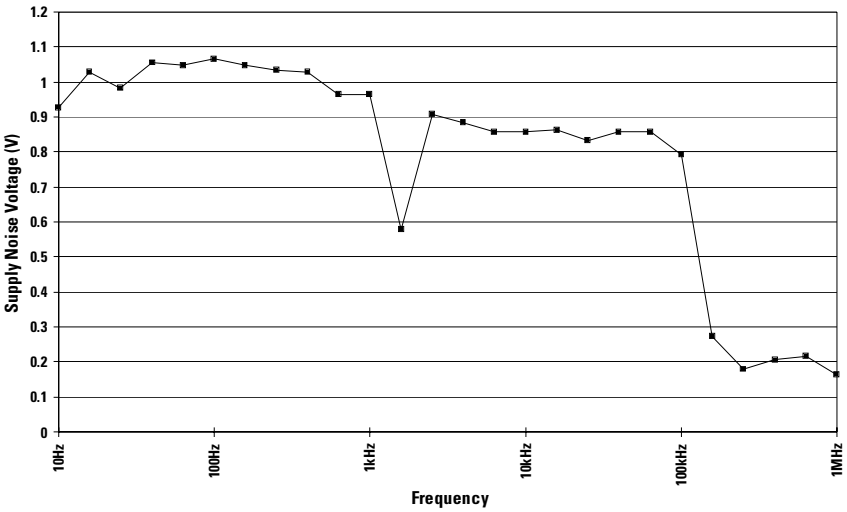
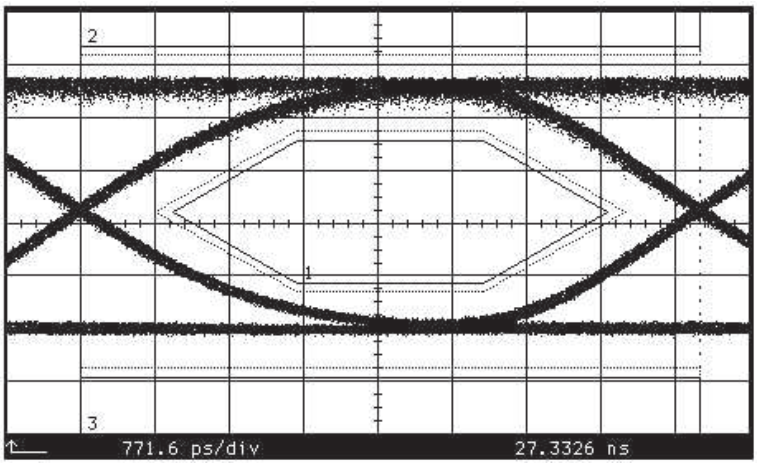


Figure 2. Tolerable Transmitter Injected Power Supply Noise versus Frequency with MSA Power Supply Filter

Eye Diagram

Typical filtered output eye diagrams for the HFCT-5915E at 0°C, +25°C and +70°C and 3.3 V are displayed in Figure 3. The eye mask was measured through a filter as defined by the SONET/SDH recommendation and is compared to the standard's output eye diagram mask. Figure 4 shows typical unfiltered eye responses and transmitter optical output spectral plots at 0°C, +25°C and +70°C for the HFCT-5915E.

(a)



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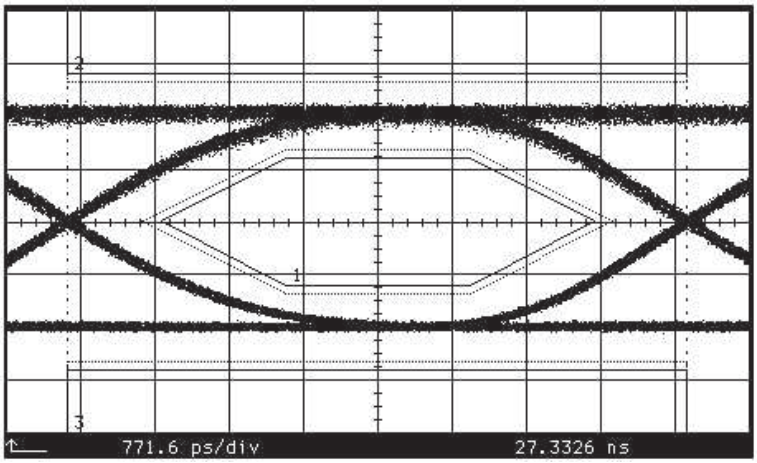


(c)

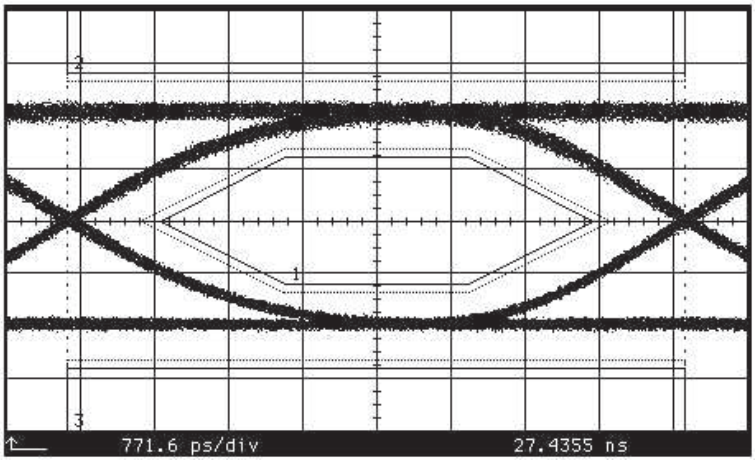
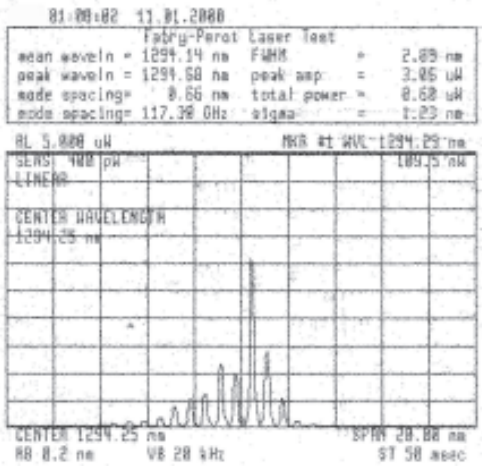
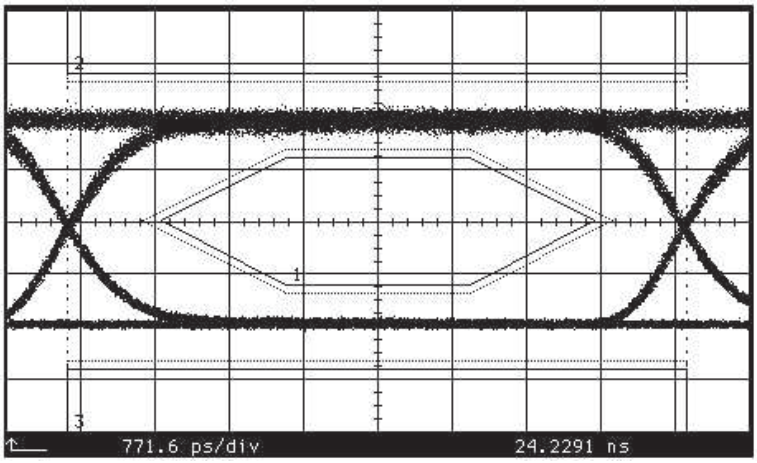


Figure 3. HFCT-5915E Filtered Output Eye Diagram at (a) 0°C, (b) +25°C (c) +70°C and 3.3 V.

(a)





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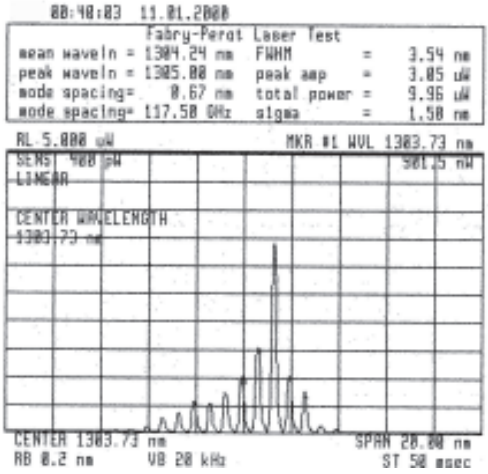
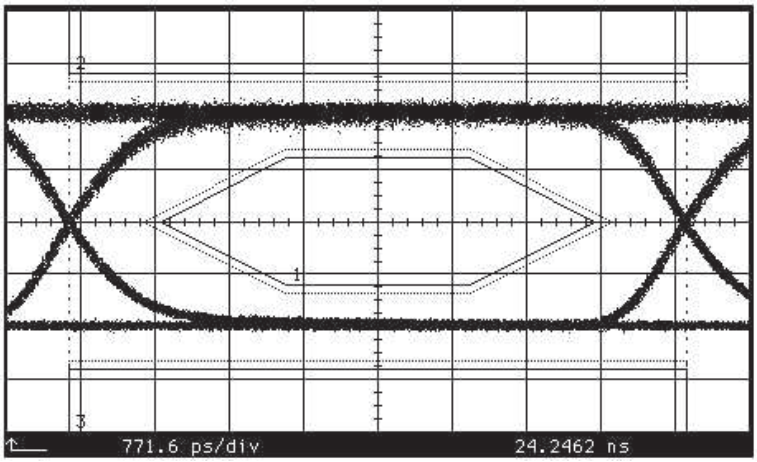
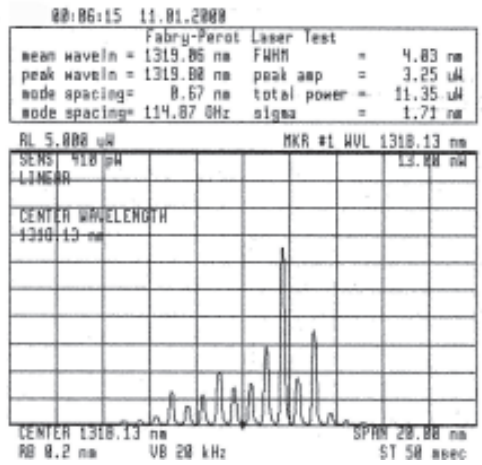




(c)



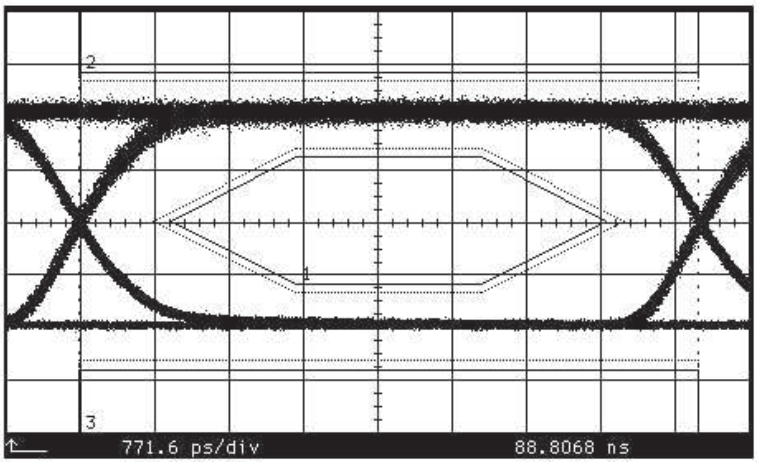


Figure 4. HFCT-5915E Unfiltered Output Eye Diagram and Spectra at (a) 0°C, (b) +25°C (c) +70°C at nominal supply voltage 3.3 V.

Transmitter Jitter Generation
2 HFCT-5915E modules were tested over temperature and voltage using a $2E^{23}$-1 PRBS pattern and measuring jitter on an Agilent 83480A Digital Communications Analyzer. Table 5 shows that HFCT-5915E meets and exceeds the SONET/SDH specification.

Conclusions
The results of this characterization exercise show that the HFCT-5915E meets all performance requirements.

Table 5 - HFCT-5915E Mean, Minimum and Maximum measured Transmitter Jitter over temperature and voltage

Test Parameters	Units	Mean	Min.	Max.	Limits	
					Min.	Max.
Jitter (pk - pk)	mUI	34.96	27.68	49	-	100
Jitter (rms)	mUI	5.83	4.52	7.7	-	10

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