Testing PTC-ACSES (TD220MAX) Radios Using Astronics Communications System Analyzers

NOTE: This document is a high-level overview of the PTC-ACSES test capabilities of Astronics Communications System Analyzers. For a much more in-depth Application Note, visit www.freedomcte.com/PTC and submit the form to request more information.

PTC Background

Two major technical architectures have emerged in the USA for PTC (Positive Train Control) operation:

- ITCR – Interoperable Electronic Train Management System (I-ETMS)
- ACSES – Advanced Civil Speed Enforcement System

Although both systems are used as PTC (Positive Train Control), the two systems are very different and not interoperable. Operational PTC Systems are designed to prevent the following events:

1. Train-to-train collisions.
2. Over-speed derailments.
3. Injuries to workers as the result of unauthorized incursions by train into a work zone.
4. Movement of a train through an improperly aligned switch

To achieve the desired goals, all parts of the PTC system must be operating at optimal performance. In the event of component failure, it is critical that faults be located and corrected as quickly as possible. The GE MDS TD220MAX radio is utilized in the ACSES system for over-the-air communications between on-board (rolling stock) and wayside (interlocking and right of way infrastructure).

To this end, the R8000 family of Communications System Analyzers supports the test and troubleshooting of TD220MAX radios. This document is an overview of Astronics PTC-ACSES radio test using Astronics analyzers.

PTC-ACSES Overview

RF Physical layer description:

- Frequency Band: 217.0 – 221.9875 Mhz
- Channel Bandwidth: 12.5 kHz
- Data Rate: 9.6 kbps raw OTA
- Modulation: GMSK BT 0.2, 1.5 kHz and 3kHz deviation

RF Over the Air description:

A time division channel access method is used by the TD220MAX for wireless communication. Each second is divided into eight (8) 125 ms time slots. The radio further defines a multi-second epoch to allow the effective number of time slots to be scaled according to system design. All radios in a system must be configured with the same epoch size.

Precise synchronization of timing amongst radios is necessary for operation. Each radio can be configured to use one of three timing sources: GPS, Precision Time Protocol IEEE 1588(PTP), and over-the-air ("OTA"). While system design can be flexible, a base radio installation typically uses either GPS or PTP timing and a mobile radio typically uses OTA to synchronize to the wireless transmissions of a base radio.

Operation in ACSES utilizes GPS/PTP on base and OTA at locomotive.

Test Modes of Operation

The PTC-ACSES test mode on the R8100 is designed to support two modes of operation.

Test Mode 1: Single UUT configuration

The Single unit under test (UUT) configuration is the primary test and verification mode. This is one R8100 unit and one TD220MAX connected together for testing. A breakout box designed and manufactured by Astronics is utilized to allow both ethernet communications and serial communications to the TD220MAX radio. Then a RF coax cable is used to connect direct from the Antenna port on the radio to the RF In/Out port on the R8100.

Test Mode 2: Dual UUT configuration

To test two TD220MAX radios, one at a wayside and one on a moving train, will require two R8100s. The R8000/R8100s will be directly connected to the baseband side of each radio with RF connection between the radios.

For the wayside baseband side, the Astronics breakout box will be utilized to allow R8100 access to the Ethernet and serial ports of the DB-25 connector on the TD220MAX. On the rolling side, the same breakout box can be utilized even though mobile radio will receive its timing from wayside radio.

When testing involves two PTC-ACSES radios and two R8100s, the R8100 is configured for Monitor operation only and the RF interface is not in use.

The approach is both sides are operating in the same way. R8100 on way side will transmit test pattern and packet identification data, while receiving test pattern and packet identification data from R8100 in moving system. The R8100 on the moving system will do the same.

Five test configurations are available to perform specific tests of the two test modes. For the first test mode – one R8100 and one TD220 radio there are four operational configurations, listed as configuration 1-4.

For the second test mode – two R8100s and two TD220MAX radios - there are two operational configurations, listed as configuration 5a and 5b in Table 1 below.

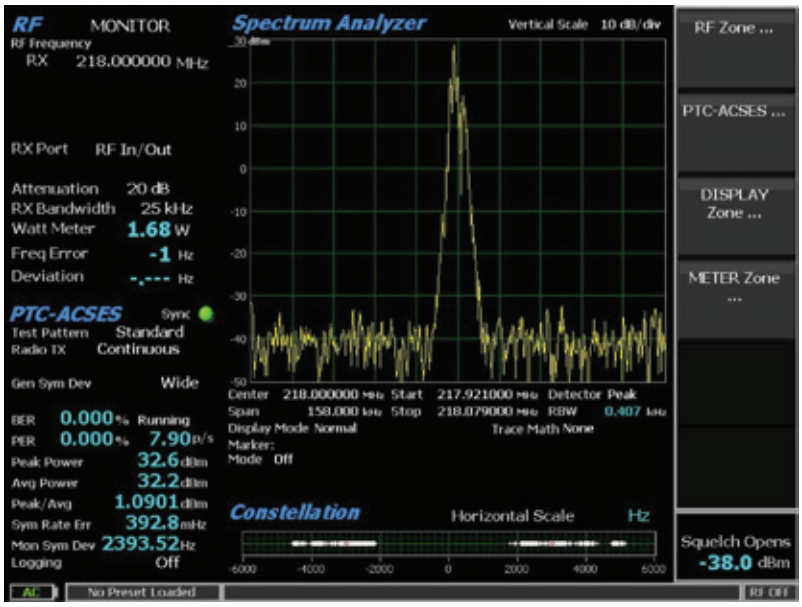
Table 1: PTC-ACSES Test Modes

Modes	TD220 Timing	TD220 Test
Config 1	GPS/PTP	Transmit
Config 2	GPS/PTP	Receiver
Config 3	OTA	Transmit
Config 4	OTA	Receiver
Config 5a	GPS/PTP Unit A	Duplex
Config 5b	OTA Unit B	Duplex

NOTE: R8100 RF configuration and Ethernet packet details are available in the full Application Note available by request at www.freedomcte.com/PTC

Testing the PTC-ACSES radio

Spectrum Analyzer displaying OTA signals

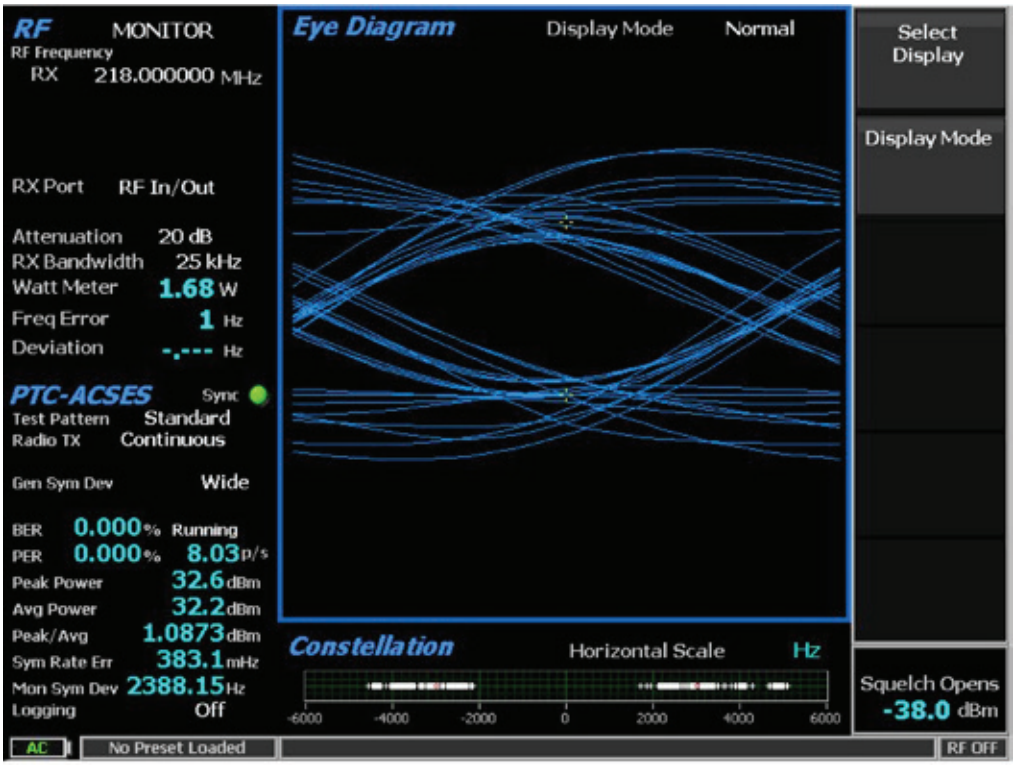


Selecting "Constellation" from the Meter Zone allows observation of the base spread of symbols.

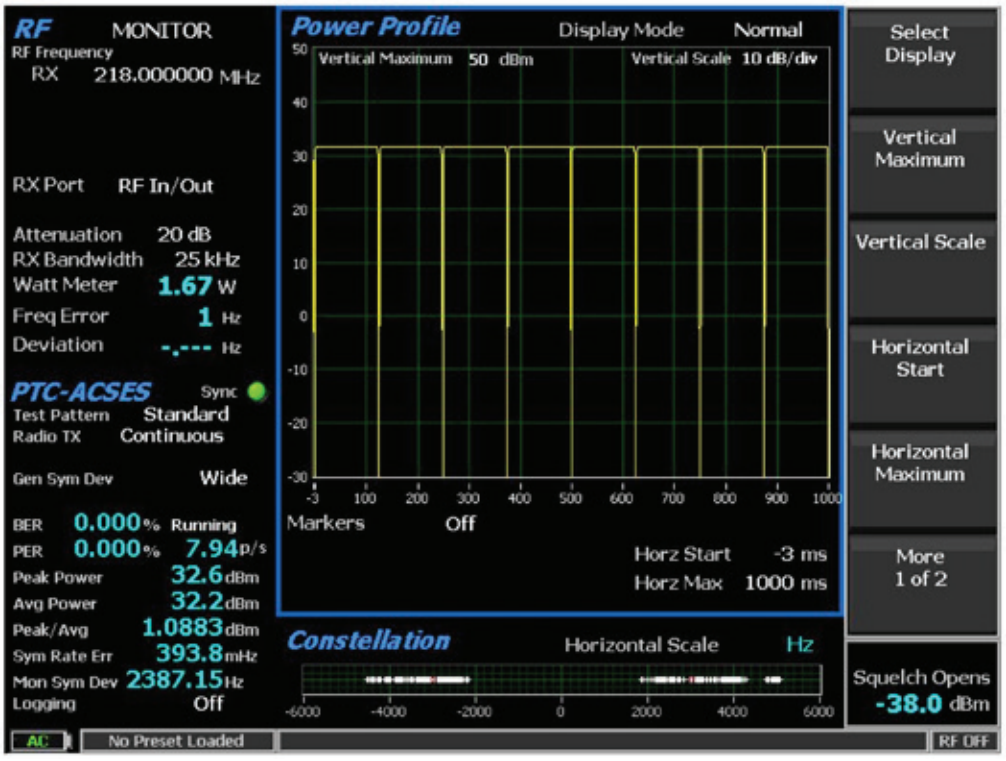
The PTC-ACSES zone and RF zone provide the following measurements of the Transmit from the radio: TD220MAX RF TX 1 signal (TD220MAX transmit to R8100).

1. Power (dBm)
   a) Peak Envelope Power (PEP)
   b) Root Mean Squared (RMS) (avg power)
   c) Peak/Avg ratio
2. Frequency Error (Hz) (RF zone)
3. Bit Error Rate (BER) %
   a. Calculated off incoming RF O.153 patterns
4. Packet Error Rate (PER)
5. Symbol Deviation (Hz)
6. Symbol Rate Error (mHz)

Eye Diagram



Power Profile displaying OTA signals

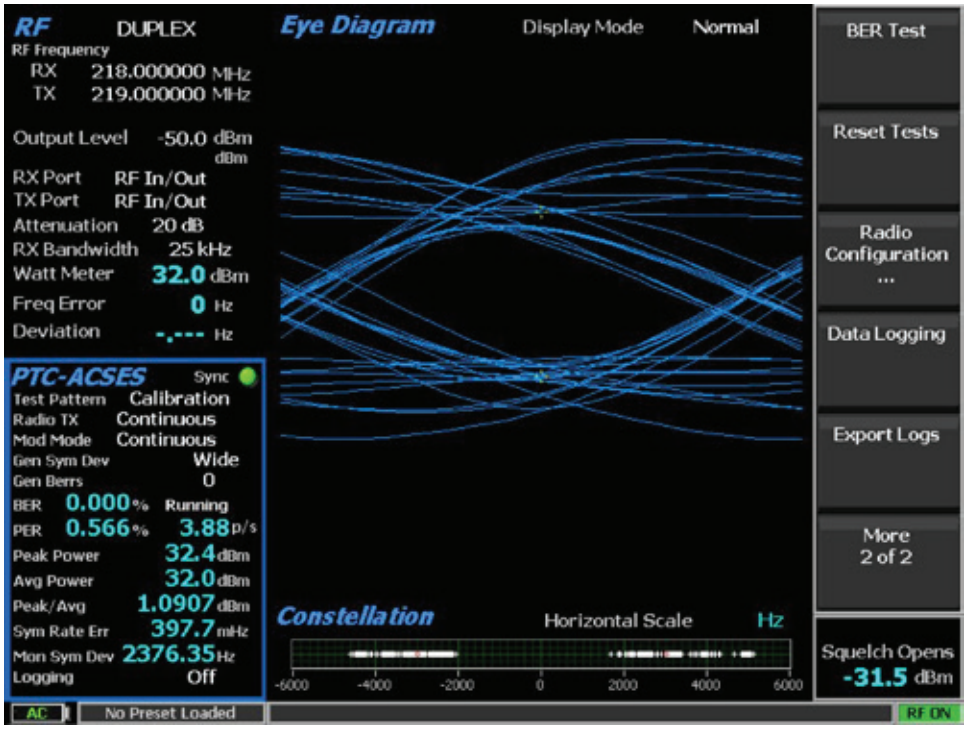


The power profile can be configured to view from 1 to 48 slots and can be adjusted to zoom in on ramp up or ramp down of any slot.

Data Logging

The R8100 has data logging support on both the RF receive and Ethernet Receive. The access to the data logging is in the softkey menu of the PTC-ACSES zone. (see screenshot below)

Data Logging and Export Log softkeys



NOTE: Type Codes and full descriptions can be found in the full Application Note available by request at www.freedomcte.com/PTC

Selecting "Export Logs" will send a snapshot of the current logs to the thumb drive.

Example of Ethernet log:

Date Time	dTime	Lost	H-Slot	P-Slot	P-Type	SEQ#	BER%	CRC?	ERR	RSSI
12/3/2018 8:56	0	0	10	10	2	5	0	1	x0	-60
12/3/2018 8:56	253	0	12	12	2	6	0	1	x0	-60
12/3/2018 8:56	248	0	14	14	2	7	0	1	x0	-60
12/3/2018 8:56	251	0	16	16	2	8	0	1	x0	-60
12/3/2018 8:56	249	0	18	18	2	9	0	1	x0	-60
12/3/2018 8:56	249	0	20	20	2	10	0	1	x0	-60

Slot Map error status by slot

Information available on the slot map:

Per slot

- Gray – no data received for that slot
- Green – Good data received in that slot, no errors
- Red – at least 1 error received in that slot since the last reset Conclusion

NOTE: Detailed Slot Map information is available in the full Application Note available by request at www.freedomcte.com/PTC

This document is intended ONLY to provide an overview of some of the capabilities of the R8100 PTC radio test capabilities. A much more detailed application note is available for those working with the unit. The user should consult this document, referenced frequently in this overview, when conducting actual tests on PTC radios.

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