P25-Phase 2 Tx Test Solution

MS2830A
Signal Analyzer
P25-Phase 2
Tx Test Solution

P25 Phase 2 Technical Specifications
Physical Layer Protocol Specification
TIA-102.BBAB (Jul 2009)
Transceiver Performance Recommendations
TIA-102.CCBA (Oct 2011)
Transceiver Measurement Methods
TIA-102.CCAA-A (May 2011)

Note: For details, refer to the TIA-102 standard.

Version 2.00
August 2014
Anritsu Corporation
[Anritsu] P25-Phase 2 Tx Test Solution

**Tx Evaluation**

*Multi-functions supported with one unit!*

**Unit, Module**

*Output in Test Mode*

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**MS2830A Signal Analyzer**

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**Spectrum Analyzer**

**Frequency Counter**

**Modulation Analyzer (MX269017A)**

**FM Demodulator (MX269018A)**

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**MX269017A Vector Modulation Analysis Software**

**MX269018A Analog Modulation Analysis Software**
### TIA-102 Transmitter test items

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</tr>
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<td>H-CPM Transmitter Logical Channel</td>
<td>( \sqrt{3} )</td>
<td></td>
</tr>
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<td>Time Alignment (IB only)</td>
<td>Under investigation</td>
<td>SG for VCH &amp; CCH Signal Autocorrelation Processor</td>
</tr>
</tbody>
</table>

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1. Requires MS2830A-006 Analysis Bandwidth 10 MHz for Frequency vs. Time function
2. Requires MX269018A Analog Measurement Software with A0086A USB Audio
3. Requires MX269017A Vector Modulation Analysis Software with MS2830A-006
Transmitter Performance Measurement Methods

RF Output Power

Measures transmitter output power

Limits: (≤+20%: Specified by manufacturer)

Limits: (≤10 W for mobile or portable radios intended for public safety airborne application)

Limits: for FCC part 27.50-b (775-776/805-806 MHz) and part 90.541 (769-775/799-805 MHz)

<table>
<thead>
<tr>
<th>Station Type</th>
<th>Maximum output power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile, and Control</td>
<td>30 Watts</td>
</tr>
<tr>
<td>Portable (handheld)</td>
<td>3 Watts</td>
</tr>
</tbody>
</table>

Note: For details, refer to the TIA-102 standard.

- Measure the transmitter output power during the defined duty cycle (see CCAA 1.5.2)
- The power is measured using a gated power measurement over a 24 ms duration centered over the center of the transmit on time slot intervals.
**Transmitter Performance Measurement Methods**

**RF Output Power**

Measures transmitter output power

**Burst Average Power Function [pre-installed]**

**Power vs. Time [Opt-006]**

Burst Average Power Function

Note: For details, refer to the TIA-102 standard.
Transmitter Performance Measurement Methods

Operating Frequency Accuracy

Measures frequency of transmitter
Calculate the ppm frequency error.

Example: AFC Disable

Limits:

<table>
<thead>
<tr>
<th>Assigned Frequency [MHz]</th>
<th>Mobile and Portable</th>
<th>Base Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 100</td>
<td>5.0</td>
<td>2.5</td>
</tr>
<tr>
<td>From 138 to 174</td>
<td>2.5</td>
<td>1.5</td>
</tr>
<tr>
<td>From 406 to 512</td>
<td>2.0</td>
<td>0.5</td>
</tr>
<tr>
<td>From 769 to 806</td>
<td>0.4(^{1,3}/1.5^{2})</td>
<td>0.1</td>
</tr>
<tr>
<td>From 806 to 869</td>
<td>1.5</td>
<td>0.15</td>
</tr>
<tr>
<td>From 896 to 941</td>
<td>1.5</td>
<td>0.1</td>
</tr>
</tbody>
</table>

1. When AFC locked to base station
2. When AFC not locked to base station
3. Requires "External Reference Clock" or "High Stability Reference Oscillator (Opt.002)"

Note: For details, refer to the TIA-102 standard.
## Transmitter Performance Measurement Methods

### Modulation Emission Spectrum

Measures *spectrum of emitted modulation signal*

Limits: FCC standard mandatory and NTIA standard recommended

#### FCC Standard (47 CFR 90.210-d)

<table>
<thead>
<tr>
<th>Displacement Frequency ((f_d))</th>
<th>Attenuation ([\text{dB}])</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 kHz to 5.625 kHz</td>
<td>0.0</td>
</tr>
<tr>
<td>5.625 kHz &lt; (f_d) ≤ 12.5 kHz</td>
<td>7.27 ((f_d - 2.88 \text{ kHz}))</td>
</tr>
<tr>
<td>12.5 kHz &lt; (f_d)</td>
<td>50 + 10\log_{10}(\text{RFOP}), or 70 whichever smaller</td>
</tr>
</tbody>
</table>

**RFOP:** RF Output Power in Watts

#### NTIA Standard (NTIA manual part 5.3.5.2)

<table>
<thead>
<tr>
<th>Displacement Frequency ((f_d))</th>
<th>Attenuation ([\text{dB}])</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 kHz to 2.5 kHz</td>
<td>0.0</td>
</tr>
<tr>
<td>2.5 kHz &lt; (f_d) ≤ 12.5 kHz</td>
<td>7 ((f_d - 2.5 \text{ kHz}))</td>
</tr>
<tr>
<td>12.5 kHz &lt; (f_d)</td>
<td>50 + 10\log_{10}(\text{RFOP}), or 70 whichever smaller</td>
</tr>
</tbody>
</table>

**RFOP:** RF Output Power in Watts

*Note: For details, refer to the TIA-102 standard.*
Transmitter Performance Measurement Methods

Modulation Emission Spectrum

Inbound Symmetrical Time Slot Standard Transmitter Test Pattern
Outbound Standard Transmitter Test Pattern

RF Signal

Spectrum Emission Mask Function [pre-installed]

Example: FCC 12.5 kHz
Transmitter Performance Measurement Methods

Unwanted Emission: Radiated Spurious

Measures **power of spurious signals**

- **Limits:** Non-radiating load (47 CFR 2.1053 and 47 CFR 90.210-d)
  Shall be attenuated by at least $50 + 10\log(P)$ dB, or 70 dB, whichever is smaller

- **Limits:** 700 MHz Band (47 CFR 27.53-e-8 and 47 CFR 90.543-c)
  Shall be attenuated by at least $43 + 10\log(P)$ dB below average carrier power

- **Limits:** EIRP Emission in GNSS Band (47 CFR 27.53-f and 47 CFR 90.543-f)
  Shall be limited to $–70$ dBW/MHz equivalent isotropically radiated power (EIPR) for wideband signals, and $–80$ dBW EIRP for discrete emissions of less than 700 Hz bandwidth

- **Limits:** Calculated EIRP Emission in GNSS Band (47 CFR 27.53-f and 47 CFR 90.543-f)
  (Same as above)
Transmitter Performance Measurement Methods

Unwanted Emission: Conducted Spurious

Measures power of spurious signals

Limits: Applicable to all frequency bands below 1 GHz, excluding frequencies in 700 MHz band as specified in 47 CFR 27.53-e-8 and 47 CFR 90.543-e

Shall be attenuated by at least $50 + 10\log(P)$ dB, or 70 dB, whichever is lesser attenuation below the reference. $P$ is the average carrier power in watts.

Limits: 700 MHz Band (47 CFR 27.53-e-8 and 47 CFR 90.543-c)

Shall be attenuated by at least $43 + 10\log(P)$ dB below the reference. $P$ is the average carrier power in watts.

Check the application note (MS2830A_EF6100.pdf)
Transmitter Performance Measurement Methods

Unwanted Emissions: Non-Spurious Adjacent Channel Power Ratio

Measures ratio of total power of transmitter in standard transmitter test pattern to leakage power falling within bandwidth of adjacent channels.

Limits: Applicable to all frequency bands below 1 GHz excluding frequencies in 700 MHz band as specified in 47 CFR 27.53-e-6 and 47 CFR 90.543-a

Shall meet or exceed the applicable limit in following table when measured using a measurement (integration) bandwidth of 6kHz.

<table>
<thead>
<tr>
<th>Modulation</th>
<th>Mobile</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-CPM</td>
<td>65 dB</td>
</tr>
<tr>
<td>H-DQPSK</td>
<td>67 dB</td>
</tr>
</tbody>
</table>

Note: For details, refer to the TIA-102 standard.
Transmitter Performance Measurement Methods

Unwanted Emissions: Non-Spurious Adjacent Channel Power Ratio

Limits: 700 MHz Band (47 CFR 27.53-e-6 and 47 CFR 90.543-a)

<table>
<thead>
<tr>
<th>Offset from Center Frequency [kHz]</th>
<th>Measurement Bandwidth [kHz]</th>
<th>ACPR [dB]</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.375</td>
<td>6.25</td>
<td>40</td>
</tr>
<tr>
<td>15.625</td>
<td>6.25</td>
<td>60</td>
</tr>
<tr>
<td>21.875</td>
<td>6.25</td>
<td>60</td>
</tr>
<tr>
<td>37.5</td>
<td>25</td>
<td>60</td>
</tr>
<tr>
<td>62.5</td>
<td>25</td>
<td>65</td>
</tr>
<tr>
<td>87.5</td>
<td>25</td>
<td>65</td>
</tr>
<tr>
<td>150</td>
<td>100</td>
<td>65</td>
</tr>
<tr>
<td>250</td>
<td>100</td>
<td>65</td>
</tr>
<tr>
<td>350</td>
<td>100</td>
<td>65</td>
</tr>
<tr>
<td>&gt;400 kHz to 12 MHz</td>
<td>30 (s)¹</td>
<td>75²/80³</td>
</tr>
<tr>
<td>12 MHz to Paired Receiver Band</td>
<td>30 (s)¹</td>
<td>75²/80³</td>
</tr>
<tr>
<td>In Paired Rx Band</td>
<td>30 (s)¹</td>
<td>100⁴</td>
</tr>
</tbody>
</table>

1) (s) indicates that a swept measurement may be used. RBW <2% x Measurement Bandwidth
2) 12.5 kHz Mobile and Portable transmitter ACPR limits
3) 12.5 kHz Base transmitter ACPR limits
4) Requires “Band pass filter for Rx-band”
Transmitter Performance Measurement Methods

Unwanted Emissions: Non-Spurious Adjacent Channel Power Ratio

Inbound Symmetrical Time Slot Standard Transmitter Test Pattern

Outbound Standard Transmitter Test Pattern

RF Signal

Adjacent Channel Power Function [pre-installed]

ACP Analyzer

MS2830A

Ex: Applicable to all frequency bands below 1 GHz

Span: 100 kHz
Measurement BW: 6 kHz
Detection: Sample or RMS
RBW: 100 Hz
VBW: RBW x10

Example: Except 700 MHz band

Burst signal (IB) is measured by a gate sweep function. However, it will take 30 seconds per once.
Unwanted Emissions: Non-Spurious Adjacent Channel Power Ratio

Note: For details, refer to the TIA-102 standard.

ACP function [Opt-006]

With the signal analyzer mode (Opt-006), FFT processing is supported. Therefore one measurement will be completed in 150ms.
Transmitter Performance Measurement Methods

Intermodulation Attenuation

Measures ability of transmitter to withstand generation of intermodulation components caused by carrier signal and interference signal input to transmitter antenna.

Limits: Shall meet or exceed 40 dB (Base Station only)

Note: For details, refer to the TIA-102 standard.
**Transmitter Performance Measurement Methods**

**Frequency Deviation for H-CPM (IB)**

Measures frequency deviation when modulating with High and Low deviation symbols.

Set the audio bandwidth of the FM demodulator so that the high-pass corner frequency is ≤15 Hz and the low-pass corner frequency is ≥3 kHz. Turn the De-emphasis function off.

**Limits:**
- High deviation = 2995 Hz to 3310 Hz
- Low deviation = 998 Hz to 1104 Hz

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Note: For details, refer to the TIA-102 standard.

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Example: High Deviation

<table>
<thead>
<tr>
<th>Deviation</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak+</td>
<td>3.199 11 kHz</td>
</tr>
<tr>
<td>Peak-</td>
<td>-3.198 70 kHz</td>
</tr>
<tr>
<td>(Pk-Pk)/2</td>
<td>3.198 91 kHz</td>
</tr>
<tr>
<td>RMS</td>
<td>2.266 03 kHz</td>
</tr>
</tbody>
</table>

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Analog Modulation Analysis Software

MX269018A
Transmitter Performance Measurement Methods

Modulation Fidelity: H-CPM, H-DQPSK

Measures modulation fidelity rms.

Limits: Modulation Fidelity limits

<table>
<thead>
<tr>
<th>Radio Application</th>
<th>Mobile</th>
<th>Portable</th>
<th>Base Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class A</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>Class B</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
</tr>
</tbody>
</table>

Inbound Symmetrical Time Slot Standard Transmitter Test Pattern

Outbound Standard Transmitter Test Pattern

RF Signal

Modulation Fidelity

MX269017A
Vector Modulation Analysis Software

Example: Frequency Error = 1 kHz

Note: For details, refer to the TIA-102 standard.

Note: This feature is under development.
Transmitter Performance Measurement Methods

Modulation Fidelity: 
H-CPM, H-DQPSK

Trace: Custom Numeric

Any of seven types of numeric measurement result or two types of graphical result can be selected for display at the Custom Numeric screen. (Note: The Custom Numeric screen does not support Zoom.)

[Trace] > (page 2) [F2: Custom Numeric Setting]

Numeric and graphical results can be checked simultaneously on four sub-screens by displaying any item from the many numeric results on the Numeric screen. Moreover, difficult-to-evaluate numeric values can be evaluated intuitively from bar graphs.

Note: For details, refer to the TIA-102 standard.

Note: This feature is under development.
Transmitter Performance Measurement Methods

Symbol Rate Accuracy

Measures **accuracy of modulation speed** of transmitter

Limits: **Shall not exceed 10 ppm**

![Diagram showing the flow of measurement](image)

**AF Measure**
- **Frequency**: 1 500.00 Hz
- **Level**: 2.266 kHz rms

\[
\text{ppm error} = \frac{\text{Frequency}_{Hz}}{1500} - 1 \times 10^6
\]

*Note: For details, refer to the TIA-102 standard.*

For 1500 Hz x 10 ppm = 0.015 Hz

*Resolution performance is insufficient*

=> Under development: The number of digits will be increased.
Transmitter Performance Measurement Methods

H-CPM Transmitter Logical Channel
Peak Adjacent Channel Power Ratio (IB only)

Note: For details, refer to the TIA-102 standard.

Limits: $P_{TX} - P_{HI}$ : 35 dB or greater
$P_{TX} - P_{LOW}$ : 35 dB or greater

Spectrum analyzer setting
- Center Frequency: DUT ± 12.5 kHz
- Span: Zero Hz
- RBW: 5 kHz (± 5%)
- Filter Type: Gaussian
- Detection: Peak
- Sweep Time: 360 ms
- Trigger: Internal Magnitude
- $P_{HI}$, $P_{LOW}$: Maximum power level

Transmitter under Test

Inbound Symmetrical Time Slot Standard
Transmitter Test Pattern

RF Signal

Spectrum Analyzer
MS2830A

Inbound Symmetrical Time Slot Standard
Powers

Transmitter Frequency
$P_{TX}$
($P_{TX}$ = RF Output Power)

$P_{LOW}$

$P_{HI}$

12.5 kHz

Zero Span
RBW: 5 kHz

Span: 0
RBW: 5 kHz
Transmitter Performance Measurement Methods

H-CPM Transmitter Logical Channel
Peak Adjacent Channel Power Ratio (IB only)

Note: For details, refer to the TIA-102 standard.

Power vs. Time [Opt-006]

P_{HI} and P_{LOW} are the maximum power level.
Transmitter Performance Measurement Methods

H-CPM Transmitter Logical Channel
Off Slot Power  (IB only)

Inbound Symmetrical Time Slot Standard Transmitter Test Pattern

RF Signal, $P_{TX}$

Spectrum Analyzer

$P_{TX} - (P_{ON-REL} - P_{OFF-REL})$: Shall not exceed – 57 dBm

Limits:

Spectrum analyzer setting

- Span: Zero Hz
- RBW: 100 kHz
- VBW: 100 kHz
- Sweep Speed(Time): 60 ms
- Trigger: Video, Rising Edge
- Detector: Average (sample)
- Average: Power, 10 sweeps

$P_{TX} = RF$ Output Power, ex: 30Wmax for Mobile)
Transmitter Performance Measurement Methods

H-CPM Transmitter Logical Channel
Off Slot Power (IB only)

**P\text{ON-REL}**

\[
\text{MKR 1} \quad 28.669 \, \text{ms} \quad -0.17 \, \text{dBm}
\]

**P\text{OFF-REL}**

\[
\text{MKR 1} \quad 53.927 \, \text{ms} \quad -78.32 \, \text{dBm}
\]

\(P\text{ON-REL}\) is the maximum level observed during the interval from 1 ms to 29 ms.

\(P\text{OFF-REL}\) is the maximum level observed during the interval from 30.2 ms to 59.8 ms.

\[
(P\text{ON-REL} - P\text{OFF-REL}) = -0.17 - (-78.32) = 78.15 \, \text{dB}
\]

Note: For details, refer to the TIA-102 standard.
## Transmitter Performance Measurement Methods

### H-CPM Transmitter Logical Channel Power Envelope (IB only)

**Transmitter under Test**

Inbound Symmetrical Time Slot Standard Transmitter Test Pattern

**RF Signal, P_{TX}**

#### Spectrum Analyzer

**MS2830A**

---

**Limits:**

<table>
<thead>
<tr>
<th>Limit</th>
<th>Time1 [ms]</th>
<th>Power [dBc]</th>
</tr>
</thead>
<tbody>
<tr>
<td>P max-on</td>
<td>- 0.2 to 1.0</td>
<td>4</td>
</tr>
<tr>
<td>P max-ss</td>
<td>1.0 to 29.0</td>
<td>1</td>
</tr>
<tr>
<td>P min-ss</td>
<td>1.0 to 29.0</td>
<td>-3</td>
</tr>
<tr>
<td>P max-off</td>
<td>29.0 to 30.2</td>
<td>4</td>
</tr>
</tbody>
</table>

---

**Spectrum analyzer setting**

- **Span**: Zero Hz
- **RBW**: 100 kHz
- **VBW**: 100 kHz
- **Sweep Speed(Time)**: 60 ms
- **Trigger**: Video, Rising Edge
- **Detector**: Peak

**Spectrum Analyzer Setting**

- **P_{max-on} = P_{REF} - P_{max(t1)}**
  
  \[ P_{max(t1)} - P_{REF} \]

- **P_{max-ss} = P_{REF} - P_{max(t2)}**
  
  \[ P_{max(t2)} - P_{REF} \]

- **P_{min-ss} = P_{REF} - P_{min(t2)}**
  
  \[ P_{min(t2)} - P_{REF} \]

- **P_{max-off} = P_{REF} - P_{max(t3)}**
  
  \[ P_{max(t3)} - P_{REF} \]
Transmitter Performance Measurement Methods

H-CPM Transmitter Logical Channel Power Envelope (IB only)

<table>
<thead>
<tr>
<th>Slot</th>
<th>State</th>
<th>Avg [dBm]</th>
<th>Judge</th>
<th>Slot</th>
<th>State</th>
<th>Avg [dBm]</th>
<th>Judge</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Off</td>
<td>-85.39</td>
<td>****</td>
<td>7</td>
<td>On</td>
<td>-0.33</td>
<td>Pass</td>
</tr>
<tr>
<td>1</td>
<td>On</td>
<td>-0.33</td>
<td>Pass</td>
<td>8</td>
<td>Off</td>
<td>-85.37</td>
<td>****</td>
</tr>
<tr>
<td>2</td>
<td>Off</td>
<td>-85.49</td>
<td>****</td>
<td>9</td>
<td>On</td>
<td>-0.33</td>
<td>Pass</td>
</tr>
<tr>
<td>3</td>
<td>On</td>
<td>-0.33</td>
<td>Pass</td>
<td>10</td>
<td>Off</td>
<td>-85.37</td>
<td>****</td>
</tr>
<tr>
<td>4</td>
<td>Off</td>
<td>-85.38</td>
<td>****</td>
<td>11</td>
<td>On</td>
<td>-0.33</td>
<td>Pass</td>
</tr>
<tr>
<td>5</td>
<td>On</td>
<td>-0.33</td>
<td>Pass</td>
<td>12</td>
<td>****</td>
<td>** **</td>
<td>****</td>
</tr>
<tr>
<td>6</td>
<td>Off</td>
<td>-85.34</td>
<td>****</td>
<td>13</td>
<td>****</td>
<td>** **</td>
<td>****</td>
</tr>
</tbody>
</table>

Note: For details, refer to the TIA-102 standard.
Two-Slot TDMA Modulation

- Uplink Modulation: H-CPM (Harmonized Continuous Phase Modulation)
- Downlink Modulation: Pi/4-DQPSK
- Data Rate: 12 kbps
- Symbol Rate: 6000 sps

Note: For details, refer to the TIA-102 standard.
Two-Slot TDMA Transmission Format

Outbound (DL) H-DQPSK
- ISCH
- Information
- Pilot 8 bits
- Ramp 12 bits

Inbound (UL) H-CPM
- ISCH
- Information
- Pilot 8 bits
- Ramp 12 bits
- 20 bits (10 symbols)
- 320 bits (160 symbols)
- 20 bits (10 symbols)
- 30 ms

Outbound
1 2 1 2 1

Inbound 1

Inbound 2

Note: For details, refer to the TIA-102 standard.
## Recommended Configuration

<table>
<thead>
<tr>
<th>Model</th>
<th>Product Name</th>
<th>Recommended Set</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS2830A</td>
<td>Signal Analyzer</td>
<td>✓</td>
</tr>
<tr>
<td>MS2830A-040</td>
<td>3.6 GHz Signal Analyzer</td>
<td>✓</td>
</tr>
<tr>
<td>MS2830A-002</td>
<td>High Stability Reference Oscillator</td>
<td>✓</td>
</tr>
<tr>
<td>MS2830A-006</td>
<td>Analysis Bandwidth 10 MHz</td>
<td>✓</td>
</tr>
<tr>
<td>MS2830A-066</td>
<td>Low Phase Noise Performance</td>
<td>✓</td>
</tr>
<tr>
<td>MX269017A</td>
<td>Vector Modulation Analysis Software</td>
<td></td>
</tr>
<tr>
<td>MX269018A</td>
<td>Analog Measurement Software</td>
<td></td>
</tr>
<tr>
<td>A0086A</td>
<td>USB Audio</td>
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</tr>
</tbody>
</table>

### Ordering Information

<table>
<thead>
<tr>
<th>Receiver test items</th>
<th>MS2830A</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Basic</td>
</tr>
<tr>
<td>Operating Frequency Accuracy</td>
<td>N/A</td>
</tr>
<tr>
<td>Modulation Emission Spectrum</td>
<td>✓</td>
</tr>
<tr>
<td>Unwanted Emission: Conducted Spurious</td>
<td></td>
</tr>
<tr>
<td>Unwanted Emission: Adjacent Channel Power Ratio</td>
<td>✓</td>
</tr>
<tr>
<td>Intermodulation Attenuation</td>
<td>✓</td>
</tr>
<tr>
<td>Frequency Deviation for C4FM</td>
<td>N/A</td>
</tr>
<tr>
<td>Modulation Fidelity (C4FM, CQPSK, linear simulcast modulation)</td>
<td></td>
</tr>
<tr>
<td>Modulation Fidelity (C4FM only)</td>
<td></td>
</tr>
<tr>
<td>Symbol Rate Accuracy</td>
<td>N/A</td>
</tr>
</tbody>
</table>

1. Requires MS2830A-006 Analysis Bandwidth 10 MHz for Frequency vs. Time function
2. Requires MX269018A Analog Measurement Software