



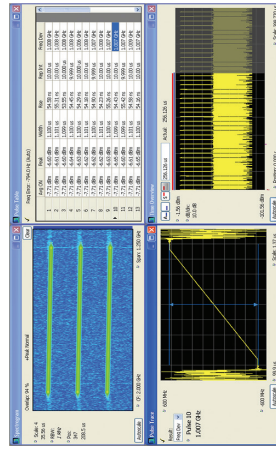
MDO4000B Series

The only oscilloscope with a built-in spectrum analyzer, the MDO4000B Series is ideal for RF signal debug and troubleshooting capabilities as well as the most affordable 802.11ac testing solution. The MDO4000B Series offers the most affordable MDO4000B Series RF measurement capability with WLAN signal analysis.



RSA5000A Series

Mid-range real-time spectrum analyzer for many applications such as WLAN testing and others. Offers the best-in-class performance up to 100 MHz resolution and 3 dB dynamic range technology.



Real-Time Oscilloscopes

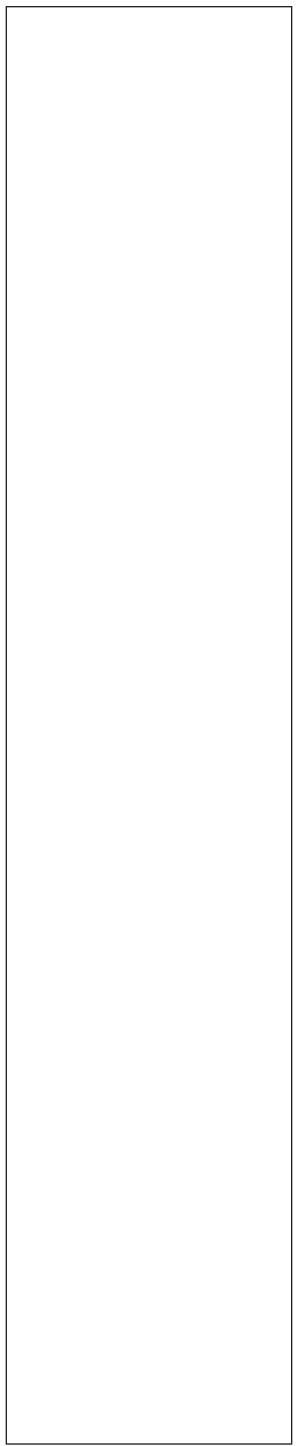
Versatile, makes it easy to solve your most difficult challenges. You can add Sigrok's Vector SVE and one of the WLAN options to analyze WLAN signals.

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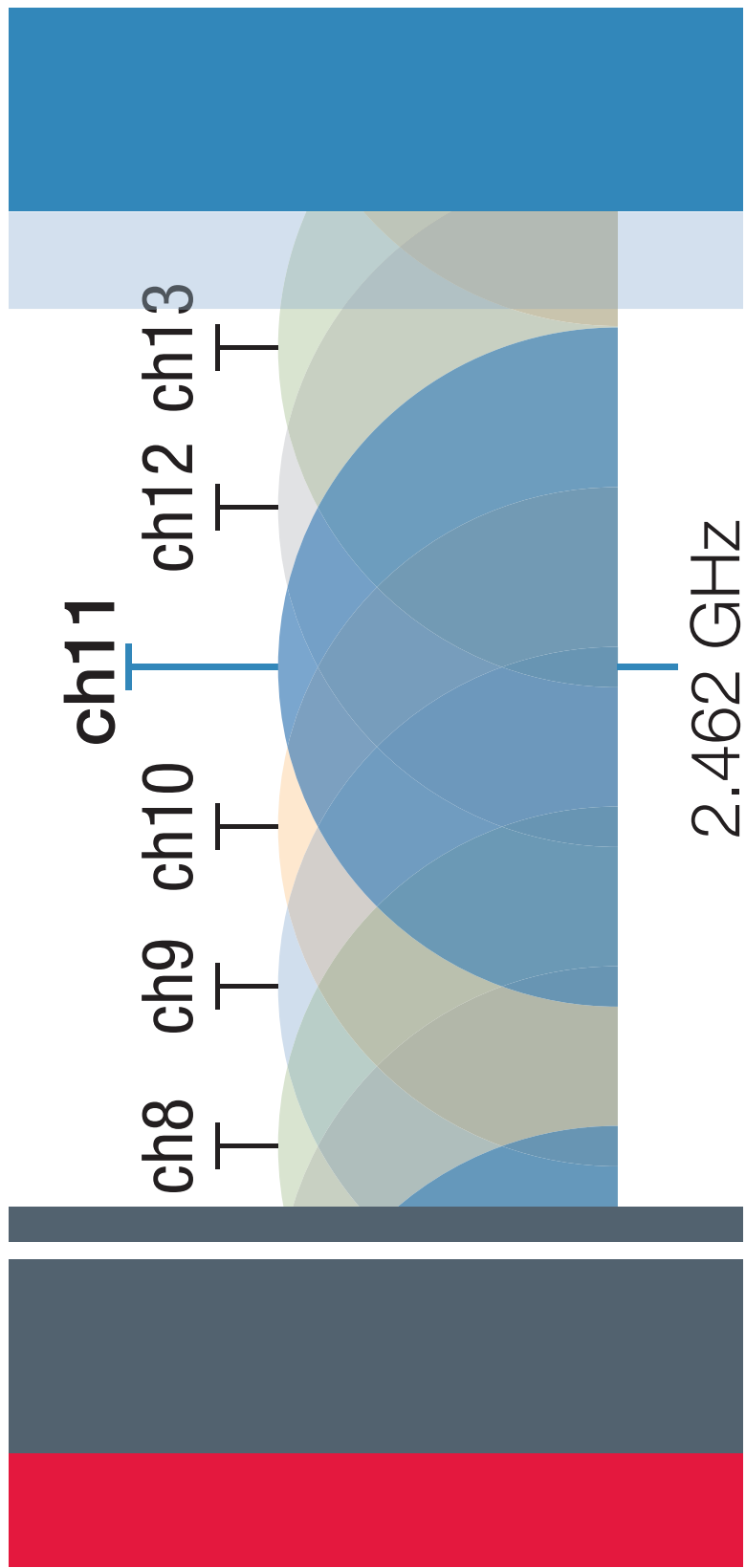
*If the European phone number above is not applicable, please call the local number. Contact List Updated June 2013
RF Software Modules: Tektronix maintains a comprehensive, constantly expanding collection of application notes, technical briefs, and other resources to help engineers working on the cutting edge of technology. Please visit www.tektronix.com

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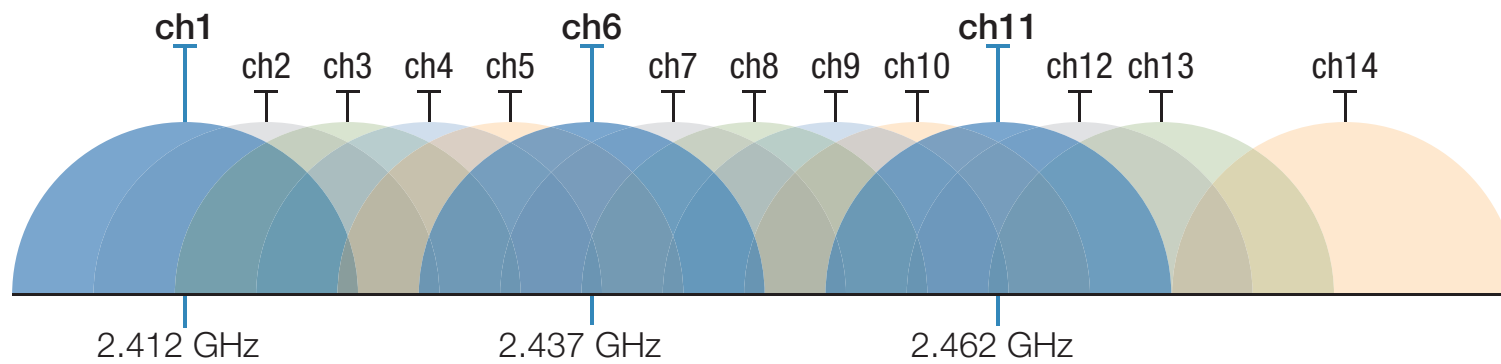


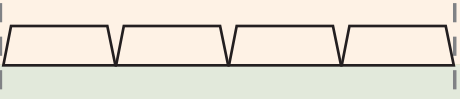

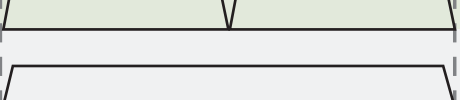
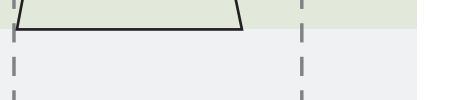

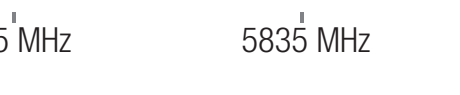


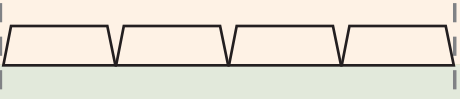

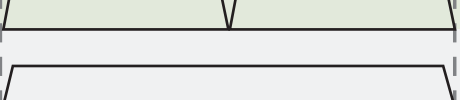
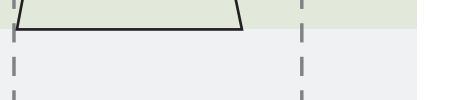

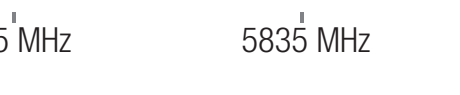


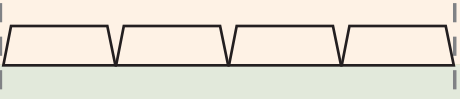

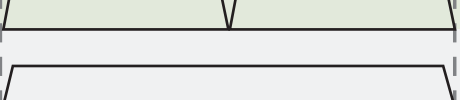
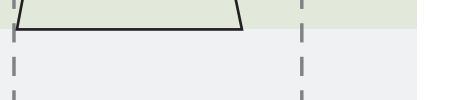

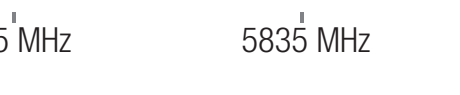
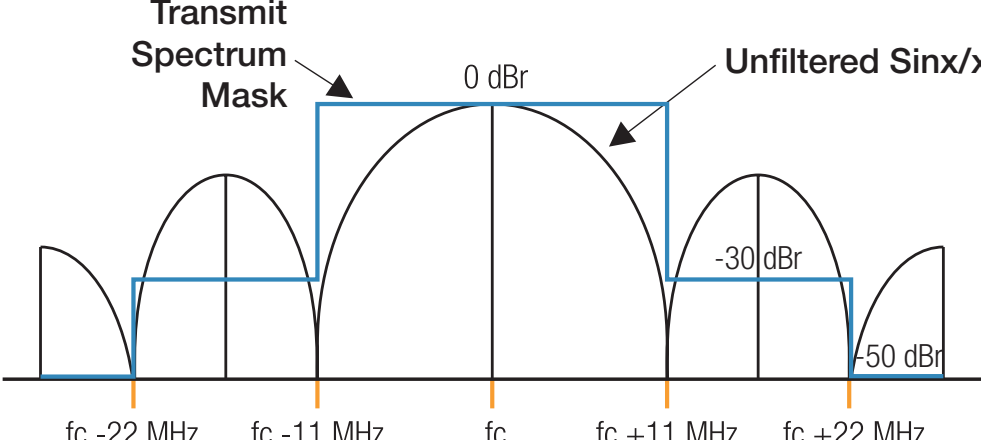
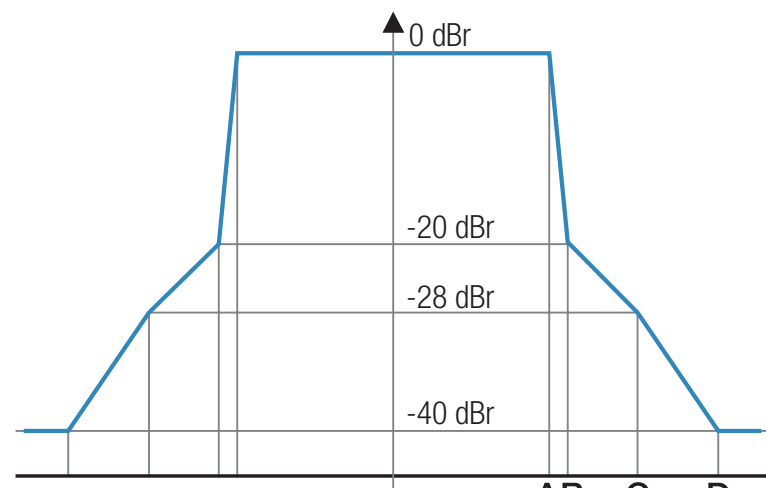
02/14 DMW 37W-20687-0



802.11 Wi-Fi Physical Layer and Transmitter Measurements Poster



802.11 Wi-Fi Physical Layer and Transmitter Measurements

		802.11b (HR/DSSS)	802.11a and 802.11g (ERP)	802.11n (HT)	802.11ac (VHT)	Channel # / Center Frequency																																																																																																																																																																																																																																																																						
Channel Allocation	2.4 GHz				<table><tr><th colspan="10">2.4 GHz</th></tr><tr><td>Primary Channel</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr><tr><td>2nd Channel</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td></tr><tr><td>Center Channel</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td></tr><tr><td>Center Frequency</td><td>2422</td><td>2427</td><td>2432</td><td>2437</td><td>2442</td><td>2442</td><td>2452</td><td>2457</td><td>2462</td></tr></table>		2.4 GHz										Primary Channel	1	2	3	4	5	6	7	8	9	2nd Channel	5	6	7	8	9	10	11	12	13	Center Channel	3	4	5	6	7	8	9	10	11	Center Frequency	2422	2427	2432	2437	2442	2442	2452	2457	2462																																																																																																																																																																																																																				
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Packet Information	<div>Bits:</div> <div><div>Preamble 144 or 72 bits</div><div>Header 48 bits</div><div>Payload Data N bits</div></div> <div>IQ:</div> <div><div>DBPSK 1584 or 792 chips</div><div>DBPSK or DQPSK 528 or 264 chips</div><div>DBPSK or DQPSK or CCK5.5M or CCK11M N*K chips</div></div> <div>192 usec (Long) or 96 usec (Short)</div> <div>(N*K) / 11 * 10e-6 usec</div> <div>* (N*M) = (Nbits/Mchips), K= M / N</div>	<div>Preamble</div> <div>STF 2 symbols 8 usec (160 chips)</div> <div>LTF 2 symbols 8 usec (160 chips)</div> <div>SIGNAL 1 symbol 4 usec (80 chips)</div> <div>Data N symbols N * 4 usec (N*80 chips)</div>	<div>Preamble</div> <div>Legacy (a/g)</div> <div>HT</div> <div>Subcarriers (20-40 MHz)</div> <div>L-STF 2 symbols 20 usec (5 symbols)</div> <div>L-LTF 2 symbols</div> <div>L-SIG 1 symbol</div> <div>HT-SIG 2 symbols</div> <div>HT-STF 1 symbol ≥16 usec (≥4 symbols)</div> <div>HT-LTF ≥1 symbol</div> <div>Data N symbols</div>	<div>Preamble</div> <div>Legacy (a/g)</div> <div>VHT</div> <div>Subcarriers (20/40/80/160 MHz)</div> <div>L-STF 2 symbols 20 usec (5 symbols)</div> <div>L-LTF 2 symbols</div> <div>L-SIG 1 symbol</div> <div>VHT-SIG 2 symbols</div> <div>VHT-STF 1 symbol ≥20 usec (≥5 symbols)</div> <div>VHT-LTF ≥1 symbol</div> <div>VHT-SIGB 1 symbol</div> <div>Data N symbols</div>																																																																																																																																																																																																																																																																								
Data Rates and Modulation Types	<table><tr><th colspan="4">802.11b</th></tr><tr><th>Signal Field HEX</th><th>Data Rate</th><th>Spreading/Coding Scheme</th><th>Modulation</th></tr><tr><td>0A</td><td>1 Mbps</td><td>11 chip barker code</td><td>DBPSK</td></tr><tr><td>14</td><td>2 Mbps</td><td>11 chip barker code</td><td>DQPSK</td></tr><tr><td>37</td><td>5.5 Mbps</td><td>CCK</td><td>DQPSK</td></tr><tr><td>6E</td><td>11 Mbps</td><td>CCK</td><td>DQPSK</td></tr></table>	802.11b				Signal Field HEX	Data Rate	Spreading/Coding Scheme	Modulation	0A	1 Mbps	11 chip barker code	DBPSK	14	2 Mbps	11 chip barker code	DQPSK	37	5.5 Mbps	CCK	DQPSK	6E	11 Mbps	CCK	DQPSK	<table><tr><th colspan="4">802.11a/g (20 MHz Bandwidth)</th></tr><tr><th>Rate</th><th>Modulation</th><th>FEC Rate</th><th>Data Rate</th></tr><tr><td>1101 (13)</td><td>BPSK</td><td>1/2</td><td>6 Mbps</td></tr><tr><td>1111 (15)</td><td>BPSK</td><td>3/4</td><td>9 Mbps</td></tr><tr><td>0101 (5)</td><td>QPSK</td><td>1/2</td><td>12 Mbps</td></tr><tr><td>0111 (7)</td><td>QPSK</td><td>3/4</td><td>18 Mbps</td></tr><tr><td>1001 (9)</td><td>16QAM</td><td>1/2</td><td>24 Mbps</td></tr><tr><td>1011 (11)</td><td>16QAM</td><td>3/4</td><td>36 Mbps</td></tr><tr><td>0001 (1)</td><td>64QAM</td><td>2/3</td><td>48 Mbps</td></tr><tr><td>0011 (3)</td><td>64QAM</td><td>3/4</td><td>54 Mbps</td></tr></table>	802.11a/g (20 MHz Bandwidth)				Rate	Modulation	FEC Rate	Data Rate	1101 (13)	BPSK	1/2	6 Mbps	1111 (15)	BPSK	3/4	9 Mbps	0101 (5)	QPSK	1/2	12 Mbps	0111 (7)	QPSK	3/4	18 Mbps	1001 (9)	16QAM	1/2	24 Mbps	1011 (11)	16QAM	3/4	36 Mbps	0001 (1)	64QAM	2/3	48 Mbps	0011 (3)	64QAM	3/4	54 Mbps	<table><tr><th colspan="4">802.11n</th><th colspan="4">802.11ac</th></tr><tr><th>MCS</th><th>Modulation</th><th>FEC Rate</th><th colspan="4">Data Rate (SISO: 1 Stream, Short Guard Interval)</th></tr><tr><th></th><th></th><th></th><th>20 MHz</th><th>40 MHz</th><th>20 MHz</th><th>40 MHz</th><th>80 MHz</th><th>160 MHz</th></tr><tr><td>0</td><td>BPSK</td><td>3/4</td><td>7.2 Mbps</td><td>15.0 Mbps</td><td>7.2 Mbps</td><td>15.0 Mbps</td><td>32.5 Mbps</td><td>65 Mbps</td></tr><tr><td>1</td><td>QPSK</td><td>1/2</td><td>14.4 Mbps</td><td>30.0 Mbps</td><td>14.4 Mbps</td><td>30.0 Mbps</td><td>65 Mbps</td><td>130 Mbps</td></tr><tr><td>2</td><td>QPSK</td><td>3/4</td><td>21.7 Mbps</td><td>45.0 Mbps</td><td>21.7 Mbps</td><td>45.0 Mbps</td><td>97.5 Mbps</td><td>195 Mbps</td></tr><tr><td>3</td><td>16QAM</td><td>1/2</td><td>28.9 Mbps</td><td>60.0 Mbps</td><td>28.9 Mbps</td><td>60.0 Mbps</td><td>130 Mbps</td><td>250 Mbps</td></tr><tr><td>4</td><td>16QAM</td><td>3/4</td><td>43.3 Mbps</td><td>90.0 Mbps</td><td>43.3 Mbps</td><td>90.0 Mbps</td><td>195 Mbps</td><td>390 Mbps</td></tr><tr><td>5</td><td>64QAM</td><td>2/3</td><td>57.8 Mbps</td><td>120.0 Mbps</td><td>57.8 Mbps</td><td>120.0 Mbps</td><td>260 Mbps</td><td>525 Mbps</td></tr><tr><td>6</td><td>64QAM</td><td>3/4</td><td>65.0 Mbps</td><td>135.0 Mbps</td><td>65.0 Mbps</td><td>135.0 Mbps</td><td>292.5 Mbps</td><td>585 Mbps</td></tr><tr><td>7</td><td>64QAM</td><td>5/6</td><td>72.2 Mbps</td><td>150.0 Mbps</td><td>72.2 Mbps</td><td>150.0 Mbps</td><td>325 Mbps</td><td>650 Mbps</td></tr><tr><td>8</td><td>256QAM</td><td>3/4</td><td></td><td></td><td>86.7 Mbps</td><td>180.0 Mbps</td><td>390 Mbps</td><td>780 Mbps</td></tr><tr><td>9</td><td>256QAM</td><td>5/6</td><td></td><td></td><td>200.0 Mbps</td><td>433.3 Mbps</td><td>866.7 Mbps</td><td></td></tr></table>	802.11n				802.11ac				MCS	Modulation	FEC Rate	Data Rate (SISO: 1 Stream, Short Guard Interval)							20 MHz	40 MHz	20 MHz	40 MHz	80 MHz	160 MHz	0	BPSK	3/4	7.2 Mbps	15.0 Mbps	7.2 Mbps	15.0 Mbps	32.5 Mbps	65 Mbps	1	QPSK	1/2	14.4 Mbps	30.0 Mbps	14.4 Mbps	30.0 Mbps	65 Mbps	130 Mbps	2	QPSK	3/4	21.7 Mbps	45.0 Mbps	21.7 Mbps	45.0 Mbps	97.5 Mbps	195 Mbps	3	16QAM	1/2	28.9 Mbps	60.0 Mbps	28.9 Mbps	60.0 Mbps	130 Mbps	250 Mbps	4	16QAM	3/4	43.3 Mbps	90.0 Mbps	43.3 Mbps	90.0 Mbps	195 Mbps	390 Mbps	5	64QAM	2/3	57.8 Mbps	120.0 Mbps	57.8 Mbps	120.0 Mbps	260 Mbps	525 Mbps	6	64QAM	3/4	65.0 Mbps	135.0 Mbps	65.0 Mbps	135.0 Mbps	292.5 Mbps	585 Mbps	7	64QAM	5/6	72.2 Mbps	150.0 Mbps	72.2 Mbps	150.0 Mbps	325 Mbps	650 Mbps	8	256QAM	3/4			86.7 Mbps	180.0 Mbps	390 Mbps	780 Mbps	9	256QAM	5/6			200.0 Mbps	433.3 Mbps	866.7 Mbps																																																																																								
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0111 (7)	QPSK	3/4	18 Mbps																																																																																																																																																																																																																																																																									
1001 (9)	16QAM	1/2	24 Mbps																																																																																																																																																																																																																																																																									
1011 (11)	16QAM	3/4	36 Mbps																																																																																																																																																																																																																																																																									
0001 (1)	64QAM	2/3	48 Mbps																																																																																																																																																																																																																																																																									
0011 (3)	64QAM	3/4	54 Mbps																																																																																																																																																																																																																																																																									
802.11n				802.11ac																																																																																																																																																																																																																																																																								
MCS	Modulation	FEC Rate	Data Rate (SISO: 1 Stream, Short Guard Interval)																																																																																																																																																																																																																																																																									
			20 MHz	40 MHz	20 MHz	40 MHz	80 MHz	160 MHz																																																																																																																																																																																																																																																																				
0	BPSK	3/4	7.2 Mbps	15.0 Mbps	7.2 Mbps	15.0 Mbps	32.5 Mbps	65 Mbps																																																																																																																																																																																																																																																																				
1	QPSK	1/2	14.4 Mbps	30.0 Mbps	14.4 Mbps	30.0 Mbps	65 Mbps	130 Mbps																																																																																																																																																																																																																																																																				
2	QPSK	3/4	21.7 Mbps	45.0 Mbps	21.7 Mbps	45.0 Mbps	97.5 Mbps	195 Mbps																																																																																																																																																																																																																																																																				
3	16QAM	1/2	28.9 Mbps	60.0 Mbps	28.9 Mbps	60.0 Mbps	130 Mbps	250 Mbps																																																																																																																																																																																																																																																																				
4	16QAM	3/4	43.3 Mbps	90.0 Mbps	43.3 Mbps	90.0 Mbps	195 Mbps	390 Mbps																																																																																																																																																																																																																																																																				
5	64QAM	2/3	57.8 Mbps	120.0 Mbps	57.8 Mbps	120.0 Mbps	260 Mbps	525 Mbps																																																																																																																																																																																																																																																																				
6	64QAM	3/4	65.0 Mbps	135.0 Mbps	65.0 Mbps	135.0 Mbps	292.5 Mbps	585 Mbps																																																																																																																																																																																																																																																																				
7	64QAM	5/6	72.2 Mbps	150.0 Mbps	72.2 Mbps	150.0 Mbps	325 Mbps	650 Mbps																																																																																																																																																																																																																																																																				
8	256QAM	3/4			86.7 Mbps	180.0 Mbps	390 Mbps	780 Mbps																																																																																																																																																																																																																																																																				
9	256QAM	5/6			200.0 Mbps	433.3 Mbps	866.7 Mbps																																																																																																																																																																																																																																																																					
Transmitter Measurements	<table><tr><th>Type of Measurement</th><th>Measurement</th><th colspan="6">802.11</th><th>IEEE Standard Limit</th></tr><tr><th></th><th></th><th>DSSS</th><th>b</th><th>a</th><th>g</th><th>n</th><th>ac</th><th></th></tr><tr><td rowspan="2">Transmit Power</td><td>Transmit Power</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td><td></td><td>Country Dependent</td></tr><tr><td>Transmit Power On/Off Ramp</td><td>Yes</td><td>Yes</td><td></td><td></td><td></td><td></td><td>(10% - 90%) 2 us</td></tr><tr><td rowspan="5">Transmit Spectral</td><td>Transmit Spectrum Mask</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Standard Mask</td></tr><tr><td>RF Carrier Suppression</td><td>Yes</td><td>Yes</td><td></td><td></td><td></td><td></td><td>-15 dB</td></tr><tr><td>Center Frequency Leakage</td><td></td><td></td><td>Yes</td><td></td><td>20 MHz</td><td></td><td>-15 dBc or +2 dB w.r.t. averages subcarrier power</td></tr><tr><td></td><td></td><td></td><td></td><td></td><td>40 MHz</td><td></td><td>-20 dBc or +0 dB w.r.t. averages subcarrier power</td></tr><tr><td>Transmit Spectral Flatness</td><td></td><td></td><td>Yes</td><td></td><td></td><td>Yes</td><td>± 4 dBc, + 4/-6 dB (various BWs, 20 - 160 MHz)</td></tr><tr><td rowspan="5">Transmit Frequency</td><td>Transmission Spurious</td><td></td><td></td><td>Yes</td><td></td><td></td><td></td><td>Country Dependent</td></tr><tr><td>Out-of-band Spurious Emission</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td><td></td><td></td><td>Country Dependent</td></tr><tr><td>Transmit Center Frequency Tolerance</td><td>Yes</td><td>Yes</td><td></td><td>Yes</td><td></td><td></td><td>± 25 ppm (DSSS, b, g)</td></tr><tr><td></td><td></td><td></td><td>Yes</td><td></td><td></td><td></td><td>± 20 ppm (20 MHz and 10 MHz), ± 10 ppm (5 MHz)</td></tr><tr><td>Symbol Clock Frequency Tolerance</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td><td>± 20 ppm (5 GHz band), ± 25 ppm (2.4 GHz band)</td></tr><tr><td colspan="9">same specifications as above</td></tr></table>	Type of Measurement	Measurement	802.11						IEEE Standard Limit			DSSS	b	a	g	n	ac		Transmit Power	Transmit Power	Yes	Yes	Yes	Yes	Yes		Country Dependent	Transmit Power On/Off Ramp	Yes	Yes					(10% - 90%) 2 us	Transmit Spectral	Transmit Spectrum Mask	Yes	Yes	Yes	Yes	Yes	Yes	Standard Mask	RF Carrier Suppression	Yes	Yes					-15 dB	Center Frequency Leakage			Yes		20 MHz		-15 dBc or +2 dB w.r.t. averages subcarrier power						40 MHz		-20 dBc or +0 dB w.r.t. averages subcarrier power	Transmit Spectral Flatness			Yes			Yes	± 4 dBc, + 4/-6 dB (various BWs, 20 - 160 MHz)	Transmit Frequency	Transmission Spurious			Yes				Country Dependent	Out-of-band Spurious Emission	Yes	Yes	Yes	Yes			Country Dependent	Transmit Center Frequency Tolerance	Yes	Yes		Yes			± 25 ppm (DSSS, b, g)				Yes				± 20 ppm (20 MHz and 10 MHz), ± 10 ppm (5 MHz)	Symbol Clock Frequency Tolerance	Yes	Yes	Yes	Yes	Yes	Yes	± 20 ppm (5 GHz band), ± 25 ppm (2.4 GHz band)	same specifications as above									<table><tr><th>Type of Measurement</th><th>Measurement</th><th colspan="6">802.11</th><th>IEEE Standard Limit</th></tr><tr><th></th><th></th><th>DSSS</th><th>b</th><th>a</th><th>g</th><th>n</th><th>ac</th><th></th></tr><tr><td rowspan="10">Transmit Modulation</td><td>Transmit Modulation Accuracy</td><td>Yes</td><td></td><td></td><td></td><td></td><td></td><td>Peak EVM<0.35%</td></tr><tr><td></td><td></td><td>Yes</td><td></td><td></td><td></td><td></td><td>Peak EVM<0.36%</td></tr><tr><td>Transmitter Constellation Error</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>Modulation Type</td><td></td><td></td><td></td><td></td><td></td><td></td><td>Limits in dB</td></tr><tr><td>BPSK</td><td></td><td></td><td>1/2</td><td></td><td>-5</td><td></td><td>-5</td></tr><tr><td>BPSK</td><td></td><td></td><td>3/4</td><td></td><td>-8</td><td></td><td></td></tr><tr><td>QPSK</td><td></td><td></td><td>1/2</td><td></td><td>-10</td><td></td><td>-10</td></tr><tr><td>QPSK</td><td></td><td></td><td>3/4</td><td></td><td>-13</td><td></td><td>-13</td></tr><tr><td>16-QAM</td><td></td><td></td><td>1/2</td><td></td><td>-16</td><td></td><td>-16</td></tr><tr><td>16-QAM</td><td></td><td></td><td>3/4</td><td></td><td>-19</td><td></td><td>-19</td></tr><tr><td rowspan="5"></td><td>64-QAM</td><td></td><td></td><td>2/3</td><td></td><td>-22</td><td></td><td>-22</td></tr><tr><td>64-QAM</td><td></td><td></td><td>3/4</td><td></td><td>-25</td><td></td><td>-25</td></tr><tr><td>64-QAM</td><td></td><td></td><td>5/6</td><td></td><td></td><td>-27</td><td>-27</td></tr><tr><td>256-QAM</td><td></td><td></td><td>3/4</td><td></td><td></td><td></td><td>-30</td></tr><tr><td>256-QAM</td><td></td><td></td><td>5/6</td><td></td><td></td><td></td><td>-32</td></tr></table>	Type of Measurement	Measurement	802.11						IEEE Standard Limit			DSSS	b	a	g	n	ac		Transmit Modulation	Transmit Modulation Accuracy	Yes						Peak EVM<0.35%			Yes					Peak EVM<0.36%	Transmitter Constellation Error								Modulation Type							Limits in dB	BPSK			1/2		-5		-5	BPSK			3/4		-8			QPSK			1/2		-10		-10	QPSK			3/4		-13		-13	16-QAM			1/2		-16		-16	16-QAM			3/4		-19		-19		64-QAM			2/3		-22		-22	64-QAM			3/4		-25		-25	64-QAM			5/6			-27	-27	256-QAM			3/4				-30	256-QAM			5/6				-32
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Based on IEEE802.11-2012 standard.

<http://cn.tek.com/spectrum-analyzer/rsa5000>

<http://cn.tek.com/oscilloscope/mdo4000-mixed-domain-oscilloscope>

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