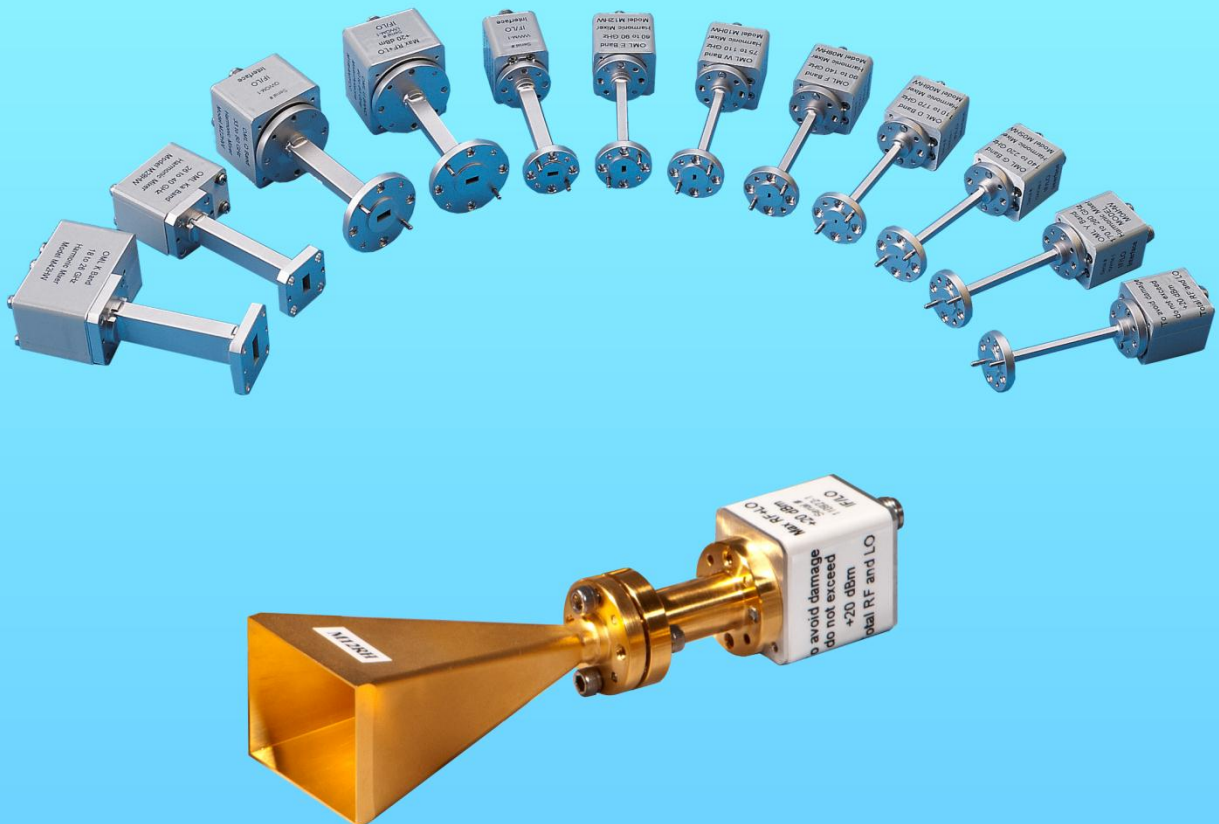




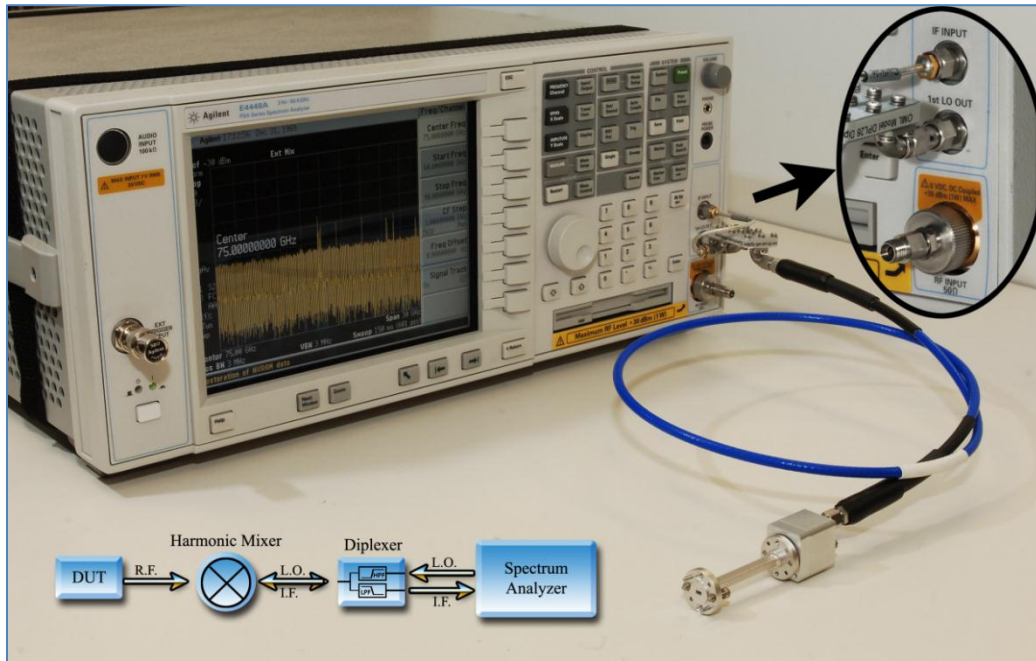
# MILLIMETER WAVE HARMONIC MIXER BROCHURE



*“Innovation in Millimeter Wave Measurements”*

## General Information

OML millimeter wave harmonic mixers connect to the test port of your existing spectrum analyzer to extend microwave measurement capabilities to millimeter and sub-millimeter wave frequencies between 50 and 325 GHz. A modern system configuration with the Agilent PSA is shown below, which consists of signal analyzer, diplexer, and OML harmonic mixer. The close-up inset shows connectivity between the spectrum analyzer L.O. & I.F. ports and the external diplexer accessory. Simply connect the output of your device to the waveguide interface of the two-port harmonic mixer to conduct mm-wave measurements using your existing microwave instrumentation.



## Direct Connect Solutions

The two-port MxxHWD series of harmonic mixers are compatible with spectrum analyzers that offer an external mixer option. These spectrum analyzer manufacturers include: Advantest, Anritsu, Agilent/HP, IFR (Marconi), Rohde & Schwarz, and Tektronix. In general, the external mixer option adds two features that enable substitution of the harmonic mixer for the existing microwave R.F. input:

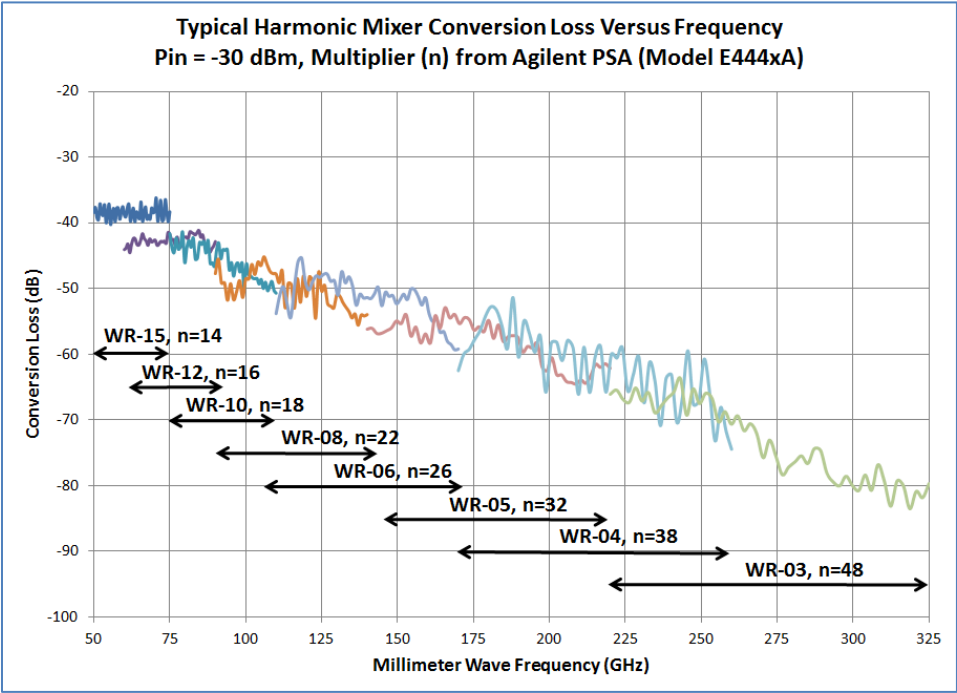
1. External hardware connections for access to the internal L.O. and I.F. signals.
2. Firmware updates to manage predefined multipliers for the available harmonic mixers.

The diplexer, which is either internal or external to the spectrum analyzer, simplifies the overall setup for bench measurements by combining L.O. & I.F. into a single connection. For the external scenario, OML offers an external diplexer accessory that adapts the separate L.O. & I.F. connections on the spectrum analyzer to the second coaxial port on the harmonic mixer.

Please indicate to your sales representative the target spectrum analyzer so OML can characterize the harmonic mixer using the corresponding predetermined L.O., I.F., and multiplier settings.

# Typical Performance at a Glance

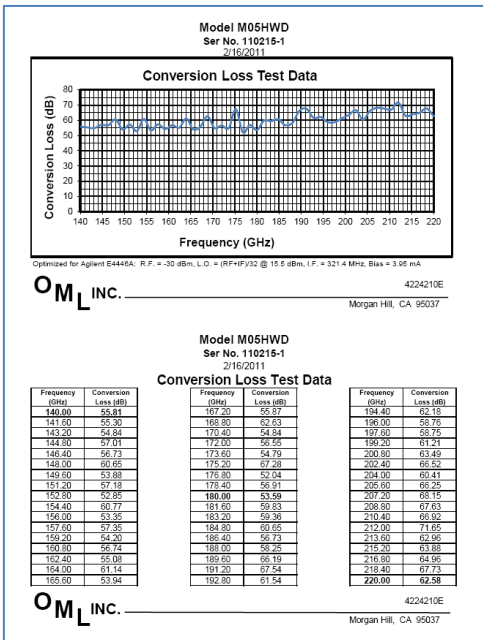
Using the Agilent PSA Signal Analyzer (model E444xA) as a target spectrum analyzer, the following chart overviews the typical conversion loss of our single diode unbalanced harmonic mixer versus the mm-wave frequency range. The waveguide designator and corresponding multiplier factor overlays help in deciphering the typical conversion loss values. These results are typical for the predefined L.O., I.F., and multiplier settings of the PSA. Results may vary when using other spectrum analyzers due to differences in their respective L.O., I.F., and multiplier settings.



## Typical Test Report On Conversion Loss

OML characterizes the MxxHWD mixer by using the predefined settings of the external mixer option in the target spectrum analyzer. These settings include L.O., I.F., and multiplier values. As shown in the sample M05HWD test report, the results contain both a graphical plot versus frequency and 51-point readout for amplitude corrections. This test report format is shipped with every mixer so you can manually correct for these conversion loss values in your spectrum analyzer readouts. Some spectrum analyzers offer automatic amplitude correction features to simplify this correction.

For a nominal charge, OML can also provide this test data in an electronic CSV format on USB flash drive. Contact OML for more details on this optional output capability.



| SPECIFICATIONS <sup>1</sup>                              | MxxHWD MODELS      |            |          |          |                    |          |
|----------------------------------------------------------|--------------------|------------|----------|----------|--------------------|----------|
|                                                          | M42HWD             | M28HWD     | M22HWD   | M19HWD   | M15HWD             | M12HWD   |
| System Operating Freq. (GHz)                             | 18 to 26.5         | 26.5 to 40 | 33 to 50 | 40 to 60 | 50 to 75           | 60 to 90 |
| System Waveguide Interface <sup>2</sup>                  | WR-42              | WR-28      | WR-22    | WR-19    | WR-15              | WR-12    |
| Conversion Loss (dB) <sup>3,4</sup><br>RF in = -30 dBm   | 25 dB              | 31 dB      | 32 dB    | 32 dB    | 39 dB              | 43 dB    |
| Sensitivity (dBm) <sup>5</sup>                           | -119 dBm           | -113 dBm   | -112 dBm | -112 dBm | -105 dBm           | -101 dBm |
| Maximum Power, RF + LO (mW, dBm)                         | 100 mW (20 dBm)    |            |          |          |                    |          |
| Typical LO Input (dBm) <sup>6</sup>                      | +12 to +17 dBm     |            |          |          |                    |          |
| Mixer Bias                                               | ±10 mA typical     |            |          |          |                    |          |
| IF Frequency Range <sup>7</sup>                          | DC to 2.4 GHz      |            |          |          |                    |          |
| Typical RF Power to Avoid Compression (dBm) <sup>8</sup> | -20 dBm (10 μW)    |            |          |          |                    |          |
| Typical RF Match <sup>8</sup>                            | 6-9 dB             |            |          |          |                    |          |
| Weight                                                   | < 8 ounces         |            |          |          | < 6 ounces         |          |
| Size (L x W x H)                                         | 3.0” x 1.6” x 0.9” |            |          |          | 2.9” x 0.9” x 0.8” |          |
| System LO/IF Interface                                   | SMA(f)             |            |          |          |                    |          |
| Operating Temperature                                    | +20 to +30°C       |            |          |          |                    |          |

<sup>1</sup> Specifications are typical and subject to change without notice

<sup>2</sup> Test Port Flange Configuration is compatible with MIL-DTL-3922/54 and MIL-DTL-3922/67D

<sup>3</sup> Typical conversion loss for Agilent E444xA; results may vary when using other spectrum analyzers

<sup>4</sup> No recognized reference standards > 110 GHz exist so conversion loss value in this scenario relies on RF power traceable to OML's calorimeter

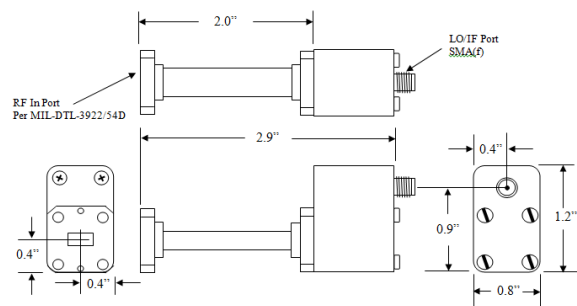
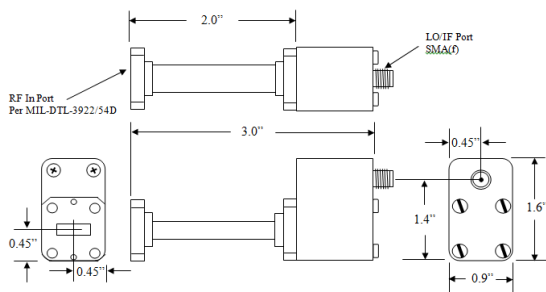
<sup>5</sup> Calculate Sensitivity (RBW of 1 kHz) = -144 dBm + conversion loss; represents theoretical minimum discernable signal

<sup>6</sup> Predetermined by spectrum analyzer manufacturer

<sup>7</sup> Limited by diplexer's IF characteristics

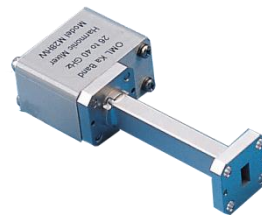
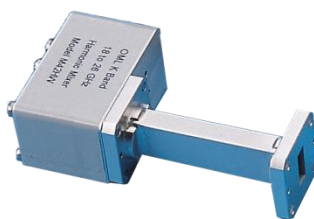
<sup>8</sup> Not tested

## MxxHWD's Mechanical Dimensions:



| Model  | W/G Flange          | UG-xxx/U Equivalent |
|--------|---------------------|---------------------|
| M42HWD | MIL-DTL-3922/54-001 | UG-595U             |

| Model  | W/G Flange          | UG-xxx/U Equivalent |
|--------|---------------------|---------------------|
| M28HWD | MIL-DTL-3922/54-003 | UG-599U             |



| SPECIFICATIONS <sup>1</sup>                              | MxxHWD MODELS      |           |            |            |            |            |
|----------------------------------------------------------|--------------------|-----------|------------|------------|------------|------------|
|                                                          | M10HWD             | M08HWD    | M06HWD     | M05HWD     | M04HWD     | M03HWD     |
| System Operating Freq. (GHz)                             | 75 to 110          | 90 to 140 | 110 to 170 | 140 to 220 | 170 to 260 | 220 to 325 |
| System Waveguide Interface <sup>2</sup>                  | WR-10              | WR-08     | WR-06      | WR-05      | WR-04      | WR-03      |
| Conversion Loss (dB) <sup>3,4</sup><br>RF in = -30 dBm   | 46 dB              | 47 dB     | 52 dB      | 59 dB      | 63 dB      | 74 dB      |
| Sensitivity (dBm) <sup>5</sup>                           | -98 dBm            | -97 dBm   | -92 dBm    | -85 dBm    | -81 dBm    | -70 dBm    |
| Maximum Power, RF + LO (mW, dBm)                         | 100 mW (20 dBm)    |           |            |            |            |            |
| Typical LO Input (dBm) <sup>6</sup>                      | +12 to +17 dBm     |           |            |            |            |            |
| Mixer Bias                                               | ±10 mA typical     |           |            |            |            |            |
| IF Frequency Range <sup>7</sup>                          | DC to 2.4 GHz      |           |            |            |            |            |
| Typical RF Power to Avoid Compression (dBm) <sup>8</sup> | -20 dBm (10 µW)    |           |            |            |            |            |
| Typical RF Match <sup>8</sup>                            | 6-9 dB             |           |            |            |            |            |
| Weight                                                   | < 6 ounces         |           |            |            |            |            |
| Size (L x W x H)                                         | 2.9" x 0.9" x 0.8" |           |            |            |            |            |
| System LO/IF Interface                                   | SMA(f)             |           |            |            |            |            |
| Operating Temperature                                    | +20 to +30°C       |           |            |            |            |            |

<sup>1</sup> Specifications are typical and subject to change without notice

<sup>2</sup> Test Port Flange Configuration is compatible with MIL-DTL-3922/54 and MIL-DTL-3922/67D

<sup>3</sup> Typical conversion loss for Agilent E444xA; results may vary when using other spectrum analyzers

<sup>4</sup> No recognized reference standards > 110 GHz exist so conversion loss value in this scenario relies on RF power traceable to OML's calorimeter

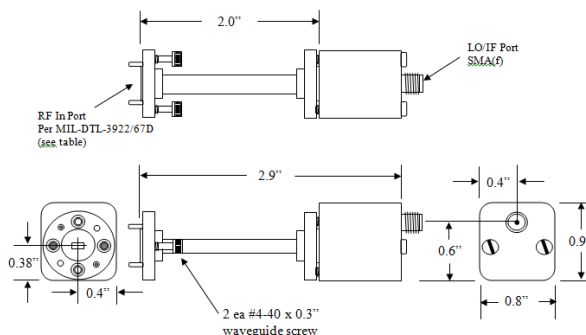
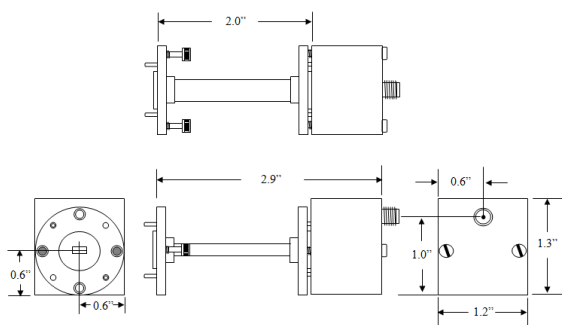
<sup>5</sup> Calculate Sensitivity (RBW of 10 Hz) = -144 dBm + conversion loss; represents theoretical minimum discernable signal

<sup>6</sup> Predetermined by spectrum analyzer manufacturer

<sup>7</sup> Limited by diplexer's IF characteristics

<sup>8</sup> Not tested

## MxxHWD's Mechanical Dimensions:



| Model  | W/G Flange           | UG-xxx/U Equivalent |
|--------|----------------------|---------------------|
| M22HWD | MIL-DTL-3922/67D-006 | UG-383U             |
| M19HWD | MIL-DTL-3922/67D-007 | UG-383U-M           |



| Model  | W/G Flange            | UG-xxx/U Equivalent |
|--------|-----------------------|---------------------|
| M15HWD | MIL-DTL-3922/67D-008  | UG-385/U            |
| M12HWD | MIL-DTL-3922/67D -009 | UG-387/U            |
| M10HWD | MIL-DTL-3922/67D -010 | UG-387/U-M          |
| M08HWD | MIL-DTL-3922/67D -M08 | UG-387/U-M          |
| M06HWD | MIL-DTL-3922/67D -M06 | UG-387/U-M          |
| M05HWD | MIL-DTL-3922/67D -M05 | UG-387/U-M          |
| M04HWD | MIL-DTL-3922/67D -M04 | UG-387/U-M          |
| M03HWD | MIL-DTL-3922/67D -M03 | UG-387/U-M          |



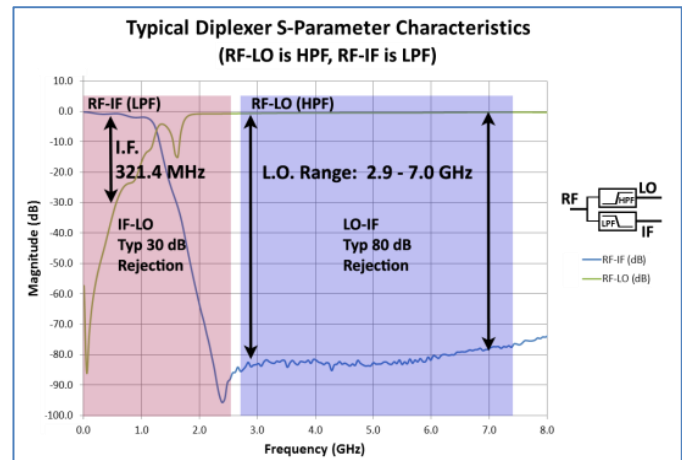
## Compatible Spectrum Analyzers

OML characterizes conversion loss of the MxxHWD harmonic mixer using the available settings from manufacturers for their external mixer options. The following table overviews the compatible spectrum analyzers we currently emulate when characterizing conversion loss of our harmonic mixer.

| Manufacturer | Compatible Spectrum Analyzer Models                      | Internal Diplexer                                 |
|--------------|----------------------------------------------------------|---------------------------------------------------|
| Advantest    | R327x, R3172, R3182                                      | Yes                                               |
| Anritsu      | MS2830A, 710C/D, 2702/ 2802, 2667C, 2668C, 2687B         | Yes                                               |
| Agilent (HP) | PXA (N9030A), PSA (E444xA), 71209A, 8566B, 856x, E4407B, | No, external diplexer necessary<br>Except for PXA |
| IFR          | 930/ 940, 1800, 239xA, 684x                              | No, external diplexer necessary                   |
| Marconi      | 2393                                                     | No, external diplexer necessary                   |
| R & S        | FSV, FSEK/M, FSIQ, ESMI, ESIB, FSQ, FSU, FSP-40          | Yes, external diplexer possible in newer models   |
| Tektronix    | 49x/ 27xx<br>2782/84                                     | Yes<br>No, must use Tek 015-0385-00               |

## Diplexer Function

Although it is more convenient when the diplexer is integrated into the spectrum analyzer, this is not always the case. For example, the Agilent PSA (model E488xA) requires an external diplexer as part of their external mixer setup. As shown in the typical DPL26 S-parameter measurements, the diplexer design enables signal flow with adequate signal separation to optimize performance for mm-wave spectrum analysis.





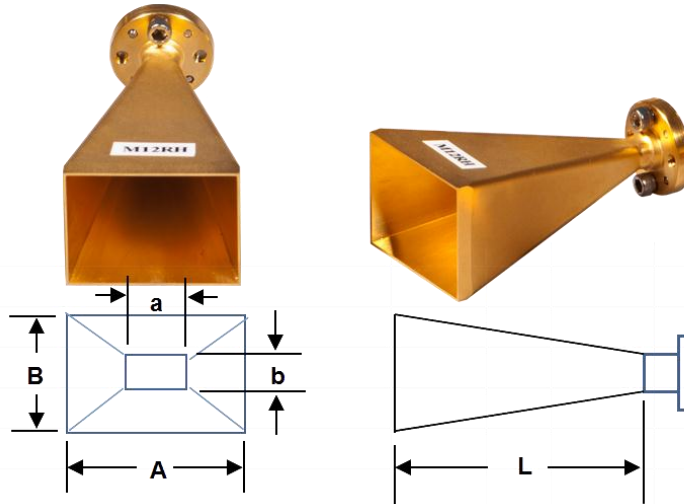
## Standard Gain Horn Antennas

OML offers harmonic mixers and standard gain horn antennas for testing compliance according to FCC Part 15 regulations on transmitters operating in the 10 GHz to 100 GHz spectrum. Per FCC 15.33, four waveguide bands (WR-19, WR-12, WR-08 and WR-05) enable measurements of the highest fundamental up to the fifth harmonic (or to 200 GHz). Standard gain horn antennas (+24 dBi) also satisfy ANSI C63.4, C63.5 and C63.10. This solution is compatible with most high performance spectrum analyzers offering optional external mixer capabilities (e.g., Agilent PXA).



The following table overviews the available standard gain horn antennas from OML.

| WG Band | OML Horn P/N | Wg Width "a" (in) | Wg Height "b" (in) | Aperture Width "A" (in) | Aperture Height "B" (in) | Horn Length "L" (in) | Gain (dBi) @ Fc | 3 dB Beamwidth Elevation | 3 dB Beamwidth Azimuth | Antenna Factor (dB/m) |
|---------|--------------|-------------------|--------------------|-------------------------|--------------------------|----------------------|-----------------|--------------------------|------------------------|-----------------------|
| WR-28   | M28RH        | 0.280             | 0.140              | 2.712                   | 2.069                    | 5.000                | 23.8            | 8.7                      | 9.2                    | 36.9                  |
| WR-22   | M22RH        | 0.224             | 0.112              | 2.170                   | 1.656                    | 4.070                | 23.9            | 8.8                      | 9.2                    | 38.7                  |
| WR-19   | M19RH        | 0.188             | 0.094              | 1.821                   | 1.390                    | 3.480                | 24.0            | 8.7                      | 9.1                    | 40.2                  |
| WR-15   | M15RH        | 0.148             | 0.074              | 1.434                   | 1.094                    | 2.780                | 24.0            | 8.8                      | 9.2                    | 42.1                  |
| WR-12   | M12RH        | 0.122             | 0.061              | 1.182                   | 0.902                    | 2.350                | 24.1            | 8.9                      | 9.3                    | 43.6                  |
| WR-10   | M10RH        | 0.100             | 0.050              | 0.969                   | 0.740                    | 1.940                | 24.2            | 8.8                      | 9.2                    | 45.4                  |
| WR-08   | M08RH        | 0.080             | 0.040              | 0.775                   | 0.591                    | 1.560                | 24.2            | 8.9                      | 9.3                    | 47.3                  |
| WR-06   | M06RH        | 0.065             | 0.033              | 0.630                   | 0.481                    | 1.260                | 24.1            | 8.9                      | 9.4                    | 49.1                  |
| WR-05   | M05RH        | 0.051             | 0.026              | 0.494                   | 0.377                    | 1.040                | 24.3            | 8.9                      | 9.3                    | 51.0                  |
| WR-04   | M04RH        | 0.043             | 0.022              | 0.417                   | 0.318                    | 0.860                | 24.3            | 8.8                      | 9.2                    | 52.6                  |
| WR-03   | M03RH        | 0.034             | 0.017              | 0.329                   | 0.251                    | 0.710                | 24.5            | 8.8                      | 9.2                    | 54.5                  |



## Ordering Information

Please indicate to your sales representative the target spectrum analyzer for the harmonic mixer. As a prerequisite, the harmonic mixer setup relies on the optional external mixer in the spectrum analyzer. Without access to the internal L.O. & I.F. signals, the harmonic mixer setup will not work.

| Harmonic Mixer | Standard Gain Horn | Waveguide Interface | Frequency GHz |
|----------------|--------------------|---------------------|---------------|
| <b>M42HWD</b>  | N/A                | WR-42               | 18-26.5       |
| <b>M28HWD</b>  | <b>M28RH</b>       | WR-28               | 26.5-40       |
| <b>M22HWD</b>  | <b>M22RH</b>       | WR-22               | 33-50         |
| <b>M19HWD</b>  | <b>M19RH</b>       | WR-19               | 40-60         |
| <b>M15HWD</b>  | <b>M15RH</b>       | WR-15               | 50-75         |
| <b>M12HWD</b>  | <b>M12RH</b>       | WR-12               | 60-90         |
| <b>M10HWD</b>  | <b>M10RH</b>       | WR-10               | 75-110        |
| <b>M08HWD</b>  | <b>M08RH</b>       | WR-08               | 90-140        |
| <b>M06HWD</b>  | <b>M06RH</b>       | WR-06               | 110-170       |
| <b>M05HWD</b>  | <b>M05RH</b>       | WR-05               | 140-220       |
| <b>M04HWD</b>  | <b>M04RH</b>       | WR-04               | 170-260       |
| <b>M03HWD</b>  | <b>M03RH</b>       | WR-03               | 220-325       |

|                       |                                       |
|-----------------------|---------------------------------------|
| <b>2378H231</b>       | <b>FCC Part 15 Bundle, 40-220 GHz</b> |
| <b>M19HWD + M19RH</b> | WR-19, 40-60 GHz, mixer + horn        |
| <b>M12HWD + M12RH</b> | WR-12, 60-90 GHz, mixer + horn        |
| <b>M08HWD + M08RH</b> | WR-08, 90-140 GHz, mixer + horn       |
| <b>M05HWD + M05RH</b> | WR-05, 140-220 GHz, mixer + horn      |

For the external diplexer scenario, OML offers the following diplexer accessories to adapt the separate L.O. & I.F. connection on the spectrum analyzer to the single coaxial SMA(f) port of the harmonic mixer. As a practical tip, only a single diplexer is usually necessary per spectrum analyzer. In this way, one diplexer adapts the spectrum analyzer to the various harmonic mixers.

| <b>Diplexers</b>                                                                  |                                                                         |
|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| <b>DPL26</b>                                                                      | Diplexer, L.O. 2-7.5 GHz, I.F. < 1 GHz for Agilent/HP                   |
| <b>DPL313</b>                                                                     | Diplexer, L.O. 3-13 GHz, I.F. < 1 GHz                                   |
| <b>DPL518</b>                                                                     | Diplexer, L.O. 5-18 GHz, I.F. < 2 GHz                                   |
| <b>Diplexer Standard Accessories (Each diplexer includes the following items)</b> |                                                                         |
| <b>V00LOIF</b>                                                                    | Test Port Ext. Cable, DC to 18 GHz, 3 ft, SMA(m) - SMA(m), 50 Ohm       |
| <b>M00IF</b>                                                                      | IF Test Port Ext. Cable, DC to 1 GHz, 5 inches, SMA(m) - SMA(m), 50 Ohm |
| <b>M00DLP</b>                                                                     | Adapter, DC to 18 GHz, SMA(m)-SMA(m), 50 Ohm                            |



## Contact Information

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### MILLIMETER WAVE RECTANGULAR TE<sub>10</sub> WAVEGUIDE INFORMATION

| WG Band | Waveguide Frequency Range (GHz) | Wavelength Range $\lambda_0$ (mil) | Wavelength Range $\lambda_0$ (mm) | Guide Wavelength Range $\lambda_g/\lambda_0$ | Waveguide Impedance Range ( $\Omega$ ) | TE <sub>10</sub> Cutoff Freq ( $\lambda_c$ (GHz) | TE <sub>10</sub> Cutoff $\lambda_c$ (mil) | TE <sub>10</sub> Cutoff $\lambda_c$ (mm) | Internal Dimensions (mils) | Internal Dimensions (mm) |
|---------|---------------------------------|------------------------------------|-----------------------------------|----------------------------------------------|----------------------------------------|--------------------------------------------------|-------------------------------------------|------------------------------------------|----------------------------|--------------------------|
| WR-28   | 26.5 - 40.0                     | 445.4 - 295.1                      | 11.313 - 7.495                    | 1.650 - 1.177                                | 621.9 - 443.6                          | 21.1                                             | 560.0                                     | 14.22                                    | 280.0 x 140.0              | 7.112 x 3.556            |
| WR-22   | 33.0 - 50.0                     | 357.7 - 236.1                      | 9.085 - 5.996                     | 1.661 - 1.177                                | 626.0 - 443.6                          | 26.3                                             | 448.0                                     | 11.38                                    | 224.0 x 112.0              | 5.690 x 2.845            |
| WR-19   | 40.0 - 60.0                     | 295.1 - 196.7                      | 7.495 - 4.997                     | 1.613 - 1.173                                | 608.3 - 442.4                          | 31.4                                             | 376.0                                     | 9.55                                     | 188.0 x 94.0               | 4.775 x 2.388            |
| WR-15   | 50.0 - 75.0                     | 236.1 - 157.4                      | 5.996 - 3.997                     | 1.657 - 1.181                                | 624.8 - 445.1                          | 39.9                                             | 296.0                                     | 7.52                                     | 148.0 x 74.0               | 3.759 x 1.880            |
| WR-12   | 60.0 - 90.0                     | 196.7 - 131.1                      | 4.997 - 3.331                     | 1.690 - 1.186                                | 637.2 - 447.1                          | 48.4                                             | 244.0                                     | 6.20                                     | 122.0 x 61.0               | 3.099 x 1.549            |
| WR-10   | 75.0 - 110.0                    | 157.4 - 107.3                      | 3.997 - 2.725                     | 1.620 - 1.185                                | 610.9 - 446.7                          | 59.0                                             | 200.0                                     | 5.08                                     | 100.0 x 50.0               | 2.50 x 1.270             |
| WR-08   | 90.0 - 140.0                    | 131.1 - 84.3                       | 3.331 - 2.141                     | 1.746 - 1.177                                | 658.1 - 443.6                          | 73.8                                             | 160.0                                     | 4.06                                     | 80.0 x 40.0                | 2.032 x 1.016            |
| WR-06   | 110.0 - 170.0                   | 107.3 - 69.4                       | 2.725 - 1.763                     | 1.771 - 1.183                                | 667.7 - 445.9                          | 90.8                                             | 130.0                                     | 3.30                                     | 65.0 x 32.5                | 1.651 x 0.826            |
| WR-05   | 140.0 - 220.0                   | 84.3 - 53.6                        | 2.141 - 1.363                     | 1.777 - 1.176                                | 669.7 - 443.3                          | 115.7                                            | 102.0                                     | 2.59                                     | 51.0 x 25.5                | 1.295 x 0.648            |
| WR-04   | 170.0 - 260.0                   | 69.4 - 45.4                        | 1.763 - 1.153                     | 1.695 - 1.177                                | 638.8 - 443.9                          | 137.2                                            | 86.0                                      | 2.18                                     | 43.0 x 21.5                | 1.092 x 0.546            |
| WR-03   | 220.0 - 325.0                   | 53.6 - 36.3                        | 1.363 - 0.922                     | 1.627 - 1.183                                | 613.5 - 445.9                          | 173.6                                            | 68.0                                      | 1.73                                     | 34.0 x 17.0                | 0.864 x 0.432            |
| WR-02.8 | 260.0 - 400.0                   | 45.4 - 29.5                        | 1.153 - 0.749                     | 1.708 - 1.177                                | 643.8 - 443.6                          | 210.8                                            | 56.0                                      | 1.42                                     | 28.0 x 14.0                | 0.711 x 0.356            |
| WR-02.2 | 325.0 - 500.0                   | 36.3 - 23.6                        | 0.922 - 0.600                     | 1.771 - 1.185                                | 667.7 - 446.7                          | 268.2                                            | 44.0                                      | 1.12                                     | 22.0 x 11.0                | 0.559 x 0.279            |
| WR-01.9 | 400.0 - 600.0                   | 29.5 - 19.7                        | 0.749 - 0.500                     | 1.587 - 1.169                                | 598.3 - 440.6                          | 310.6                                            | 38.0                                      | 0.97                                     | 19.0 x 9.5                 | 0.483 x 0.241            |
| WR-01.5 | 500.0 - 750.0                   | 23.6 - 15.7                        | 0.600 - 0.400                     | 1.620 - 1.175                                | 610.9 - 442.8                          | 393.4                                            | 30.0                                      | 0.76                                     | 15.0 x 7.5                 | 0.381 x 0.191            |
| WR-01.2 | 600.0 - 900.0                   | 19.7 - 13.1                        | 0.500 - 0.333                     | 1.746 - 1.194                                | 658.1 - 450.1                          | 491.8                                            | 24.0                                      | 0.61                                     | 12.0 x 6.0                 | 0.305 x 0.152            |
| WR-01.0 | 750.0 - 1100.0                  | 15.7 - 10.7                        | 0.400 - 0.273                     | 1.620 - 1.185                                | 610.9 - 446.7                          | 590.1                                            | 20.0                                      | 0.51                                     | 10.0 x 5.0                 | 0.254 x 0.127            |

Harmonic Mixer Brochure: Rev. C  
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