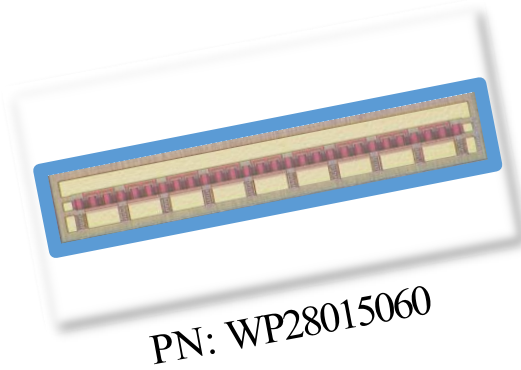




# WP28015060

## 60W, 28V GaN HEMT Die



The WP28015060 is a 60W gallium nitride (GaN) High Electron Mobility Transistor (HEMT). This GaN HEMT is a wideband transistor optimized for X-band operation in a user-friendly device for high bandwidth applications. Gallium nitride (GaN) HEMT is a device optimized for 10GHz applications. GaN HEMT resistance is only 1/10 that of silicon transistors, making it capable of switching frequencies faster for greater energy efficiency.

### Features

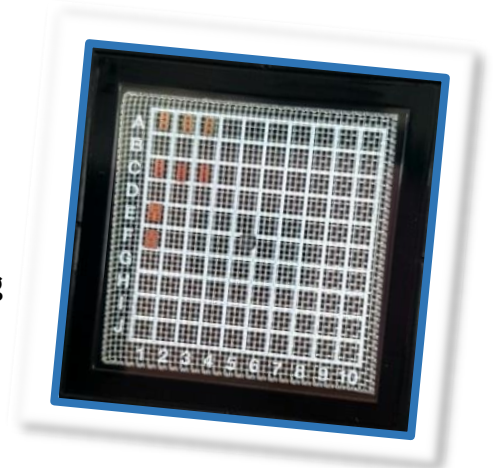
- Up to 15 GHz Operation
- 10.0 dB Typical Small Signal Gain @ 8.15 GHz
- 60 W Typical Psat @8.15GHz
- 28V Operation
- High Breakdown Voltage
- High Breakdown Voltage
- High Efficiency
- Reliability Monitoring Supporting

### Applications

- U/VHF Amplifiers
- Broadband Amplifiers
- Base Station Communications
- Drone, UAV
- WiMAX, LTE, WCDMA, GSM
- WPT, V2X
- Radar application

### Packaging Information

- Bare die are shipped in Wafer-level with Expander Ring or Gel-Pak® containers.
- Possible UV Curing for Wafer-level with dicing saw



## Absolute Maximum Ratings (not simultaneous) at 25 °C

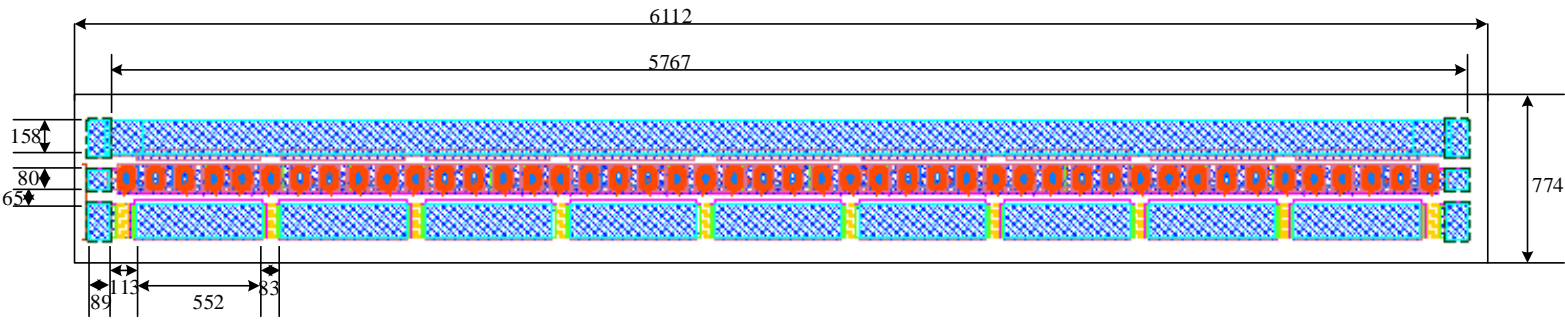
| Parameter                                       | Parameter        | Typical Value | Units | Conditions |
|---|------------------|---------------|-------|------------|
| Threshold voltage @ Id=1mA/mm, Vd=10V           | V <sub>to</sub>  | -3.2          | V     | 25°C       |
| Breakdown voltage @ Id=1mA/mm                   | V <sub>DG</sub>  | >100          | V     | 25°C       |
| Drain-source current, Id @ Vd=10V, Vg=0         | I <sub>dss</sub> | 880           | mA/mm | 25°C       |
| Operating Junction Temperature                  | T <sub>J</sub>   | 225           | °C    |            |
| Storage Temperature                             | T <sub>STG</sub> | -65, +150     | °C    |            |
| Thermal Resistance, Junction to Case (packaged) | R <sub>θJC</sub> |               | °C/W  |            |
| Thermal Resistance, Junction to Case (die only) | R <sub>θJC</sub> |               | °C/W  |            |
| Mounting Temperature (30 seconds)               | T <sub>S</sub>   | 320           | °C    | 30 seconds |

## Electrical Characteristics (Frequency = 8.15 GHz unless otherwise stated; TC = 25 °C)

| Parameter   | Parameter         | Typical Value | Units  | Conditions                                   |
|---|-------------------|---------------|--------|--|
| <b>DC Characteristics</b>   |                   |               |        |  |
| Ohmic contact resistance  | RC                | 0.4           | Ohm-mm | 25°C   |
| Maximum Drain-source current, Id @ Vd=10V, Vg=1V (1X125µm device) | I <sub>dmax</sub> | 1050          | mA/mm  | 25°C   |
| Max. trans-conductance, @ Vd=10V, Vg=-4V ~ -1V (1X125µm device)   | GM_PEAK           | 340           | mS/mm  | 25°C   |
| Maximum Drain-source current, Id @ Vd=10V, Vg=1V (1X125µm device) | I <sub>dmax</sub> | 1000          | mA/mm  | 25°C   |
| <b>RF Characteristics</b>   |                   |               |        |  |
| Small Signal Gain   | G <sub>SS</sub>   | >10           | dB     | V <sub>DD</sub> =28V, I <sub>DQ</sub> =410mA |
| Saturated Power Output  | P <sub>SAT</sub>  | 60            | W      | V <sub>DD</sub> =28V, I <sub>DQ</sub> =410mA |
| Drain Efficiency  | η                 | >40           | %      | V <sub>DD</sub> =28V, I <sub>DQ</sub> =410mA |
| Intermodulation Distortion  | IM3               | <-30          | dBc    | V <sub>DD</sub> =28V, I <sub>DQ</sub> =410mA |
| Output Mismatch Stress  | VSWR              | 10:1          | ψ      |  |



**DIE Dimensions (units in microns)**



Overall die size 6112 x 774 (+0/-50) microns, die thickness 100 (+/- 10) microns.  
All Gate and Drain pads must be wire bonded for electrical connection.

**Assembly Notes:**

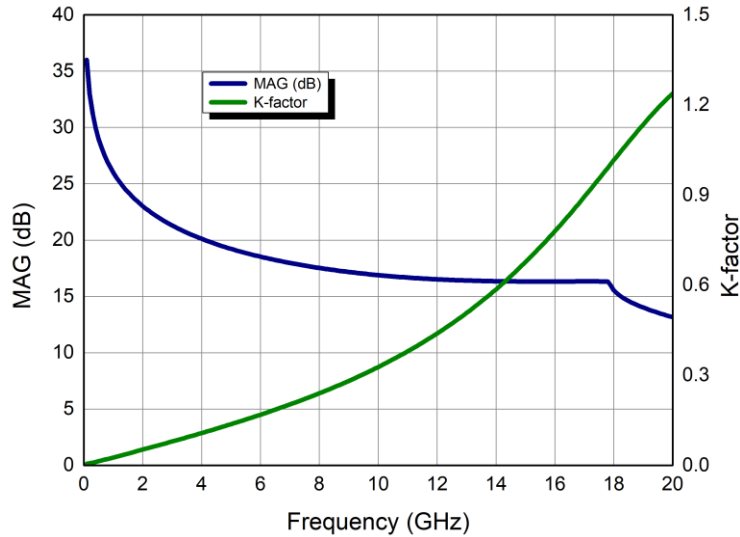
- Recommended solder is AuSn (80/20) solder. Refer to Wavepia's guide for the Eutectic Die Bond Procedure
- Vacuum collet is the preferred method of pick-up.
- The backside of the die is the Source (ground) contact.
- Die back side gold plating is 5 microns thick minimum.
- Thermosonic ball or wedge bonding are the preferred connection methods.
- Gold wire must be used for connections.



## Typical Performance

Simulated Maximum Available Gain (MAG) and K Factor of the WP28015060

$$V_{DD} = 28 \text{ V}, I_{DQ} = 410 \text{ mA}$$



Intrinsic die parameters - reference planes at centers of gate and drain bonding pads. No wire bonds assumed.

## Typical Performance

Simulated Minimum Noise Figure of the WP28015060

$$V_{DD} = 28 \text{ V}, I_{DQ} = 410 \text{ mA}$$

**Under construction**



## Typical Die S-Parameters

(Small Signal,  $V_{DS} = 28\text{ V}$ ,  $I_{DQ} = 410\text{ mA}$ , magnitude / angle)

| Frequency | Mag S11  | Ang S11     | Mag S21  | Ang S21  | Mag S12  | Ang S12  | Mag S22  | Ang S22  |
|-----------|----------|-------------|----------|----------|----------|----------|----------|----------|
| 1000MHz   | 0.945679 | -174.734    | 4.574213 | 78.94312 | 0.011466 | -9.52983 | 0.783716 | -174.216 |
| 1100MHz   | 0.946223 | -175.093    | 4.136715 | 77.46203 | 0.011402 | -10.8551 | 0.786394 | -174.106 |
| 1200MHz   | 0.946809 | -175.385    | 3.770439 | 76.02882 | 0.011332 | -12.1326 | 0.78922  | -173.976 |
| 1300MHz   | 0.947433 | -175.626    | 3.459067 | 74.63661 | 0.011257 | -13.369  | 0.792187 | -173.836 |
| 1400MHz   | 0.948092 | -175.827    | 3.190931 | 73.28068 | 0.011177 | -14.5691 | 0.795282 | -173.691 |
| 1500MHz   | 0.948781 | -175.997    | 2.957474 | 71.95769 | 0.011093 | -15.7362 | 0.798493 | -173.546 |
| 1600MHz   | 0.949497 | -176.142    | 2.752272 | 70.66527 | 0.011005 | -16.8725 | 0.801805 | -173.402 |
| 1700MHz   | 0.950237 | -176.268    | 2.570411 | 69.40169 | 0.010913 | -17.9798 | 0.805205 | -173.263 |
| 1800MHz   | 0.950997 | -176.377    | 2.40807  | 68.16564 | 0.010818 | -19.0594 | 0.808679 | -173.13  |
| 1900MHz   | 0.951774 | -176.474    | 2.262228 | 66.95616 | 0.01072  | -20.1122 | 0.812212 | -173.004 |
| 2000MHz   | 0.952566 | -176.559    | 2.130467 | 65.77246 | 0.010619 | -21.139  | 0.815791 | -172.887 |
| 2100MHz   | 0.953368 | -176.636    | 2.01083  | 64.61394 | 0.010515 | -22.1404 | 0.819404 | -172.778 |
| 2200MHz   | 0.954179 | -176.705    | 1.901711 | 63.48008 | 0.010409 | -23.1168 | 0.823038 | -172.678 |
| 2300MHz   | 0.954995 | -176.768    | 1.801783 | 62.37042 | 0.010302 | -24.0687 | 0.826683 | -172.588 |
| 2400MHz   | 0.955815 | -176.826    | 1.70994  | 61.28458 | 0.010192 | -24.9965 | 0.830328 | -172.507 |
| 2500MHz   | 0.956636 | -176.88     | 1.625248 | 60.22218 | 0.010081 | -25.9005 | 0.833963 | -172.434 |
| 2600MHz   | 0.957456 | -176.93     | 1.546917 | 59.18285 | 0.009969 | -26.781  | 0.83758  | -172.371 |
| 2700MHz   | 0.958273 | -176.977    | 1.474272 | 58.16626 | 0.009857 | -27.6384 | 0.841171 | -172.317 |
| 2800MHz   | 0.959086 | -177.021    | 1.406732 | 57.17206 | 0.009743 | -28.4731 | 0.844729 | -172.27  |
| 2900MHz   | 0.959892 | -177.063    | 1.343794 | 56.19988 | 0.009629 | -29.2853 | 0.848247 | -172.232 |
| 3000MHz   | 0.960691 | -177.104    | 1.285023 | 55.24938 | 0.009514 | -30.0755 | 0.85172  | -172.201 |
| 3100MHz   | 0.961481 | -177.143    | 1.230035 | 54.32019 | 0.009399 | -30.8438 | 0.855142 | -172.178 |
| 3200MHz   | 0.962261 | -177.18     | 1.178495 | 53.41194 | 0.009284 | -31.5908 | 0.858511 | -172.161 |
| 3300MHz   | 0.96303  | -177.217    | 1.130107 | 52.52425 | 0.00917  | -32.3167 | 0.861822 | -172.151 |
| 3400MHz   | 0.963787 | -177.252    | 1.084607 | 51.65673 | 0.009055 | -33.0219 | 0.865071 | -172.147 |
| 3500MHz   | 0.964532 | -177.287    | 1.041762 | 50.809   | 0.008941 | -33.7068 | 0.868258 | -172.149 |
| 3600MHz   | 0.965264 | -177.321    | 1.001361 | 49.98066 | 0.008828 | -34.3718 | 0.871379 | -172.156 |
| 3700MHz   | 0.965982 | -177.354163 | 0.963218 | 49.1713  | 0.008715 | -35.0173 | 0.874434 | -172.167 |
| 3800MHz   | 0.966686 | -177.387    | 0.927163 | 48.38053 | 0.008603 | -35.6436 | 0.87742  | -172.184 |
| 3900MHz   | 0.967375 | -177.41915  | 0.893044 | 47.60794 | 0.008491 | -36.2511 | 0.880338 | -172.204 |
| 4000MHz   | 0.96805  | -177.450943 | 0.860723 | 46.85312 | 0.008381 | -36.8402 | 0.883186 | -172.229 |
| 4100MHz   | 0.968711 | -177.482    | 0.830074 | 46.11566 | 0.008271 | -37.4114 | 0.885965 | -172.257 |
| 4200MHz   | 0.969356 | -177.513339 | 0.800983 | 45.39517 | 0.008163 | -37.9649 | 0.888675 | -172.288 |
| 4300MHz   | 0.969987 | -177.544001 | 0.773346 | 44.69122 | 0.008055 | -38.5012 | 0.891316 | -172.323 |
| 4400MHz   | 0.970602 | -177.574337 | 0.747068 | 44.00344 | 0.007949 | -39.0206 | 0.893889 | -172.36  |
| 4500MHz   | 0.971203 | -177.604365 | 0.722061 | 43.33141 | 0.007843 | -39.5235 | 0.896393 | -172.399 |
| 4600MHz   | 0.971789 | -177.634097 | 0.698245 | 42.67475 | 0.007739 | -40.0104 | 0.898831 | -172.441 |
| 4700MHz   | 0.972361 | -177.663544 | 0.675546 | 42.03307 | 0.007636 | -40.4815 | 0.901203 | -172.485 |
| 4800MHz   | 0.972918 | -177.692715 | 0.653896 | 41.40599 | 0.007535 | -40.9373 | 0.903511 | -172.53  |



## Typical Die S-Parameters

(Small Signal,  $V_{DS} = 28\text{ V}$ ,  $I_{DQ} = 300\text{ mA}$ , magnitude / angle)

| Frequency | Mag S11  | Ang S11     | Mag S21  | Ang S21  | Mag S12  | Ang S12  | Mag S22  | Ang S22  |
|-----------|----------|-------------|----------|----------|----------|----------|----------|----------|
| 4900MHz   | 0.97346  | -177.721616 | 0.633233 | 40.79312 | 0.007434 | -41.378  | 0.905754 | -172.577 |
| 5000MHz   | 0.973989 | -177.750252 | 0.613497 | 40.19411 | 0.007335 | -41.804  | 0.907935 | -172.626 |
| 5100MHz   | 0.974504 | -177.778626 | 0.594636 | 39.60859 | 0.007237 | -42.2157 | 0.910056 | -172.676 |
| 5200MHz   | 0.975005 | -177.80674  | 0.576599 | 39.0362  | 0.007141 | -42.6134 | 0.912116 | -172.727 |
| 5300MHz   | 0.975492 | -177.834596 | 0.55934  | 38.47661 | 0.007045 | -42.9974 | 0.914118 | -172.779 |
| 5400MHz   | 0.975967 | -177.862195 | 0.542815 | 37.92945 | 0.006951 | -43.3681 | 0.916063 | -172.832 |
| 5500MHz   | 0.976429 | -177.89     | 0.526985 | 37.39441 | 0.006859 | -43.7257 | 0.917953 | -172.885 |
| 5600MHz   | 0.976878 | -177.916626 | 0.511812 | 36.87116 | 0.006767 | -44.0705 | 0.919788 | -172.939 |
| 5700MHz   | 0.977316 | -177.943458 | 0.49726  | 36.35939 | 0.006677 | -44.4029 | 0.921571 | -172.994 |
| 5800MHz   | 0.977741 | -177.970034 | 0.483298 | 35.85877 | 0.006588 | -44.7231 | 0.923303 | -173.049 |
| 5900MHz   | 0.978154 | -177.996355 | 0.469895 | 35.36902 | 0.006501 | -45.0314 | 0.924985 | -173.105 |
| 6000MHz   | 0.978557 | -178.022421 | 0.457021 | 34.88983 | 0.006414 | -45.328  | 0.926619 | -173.16  |
| 6100MHz   | 0.978948 | -178.048231 | 0.44465  | 34.42093 | 0.006329 | -45.6133 | 0.928205 | -173.216 |
| 6200MHz   | 0.979329 | -178.073786 | 0.432757 | 33.96204 | 0.006245 | -45.8875 | 0.929747 | -173.272 |
| 6300MHz   | 0.979699 | -178.099087 | 0.421318 | 33.51288 | 0.006163 | -46.1507 | 0.931244 | -173.328 |
| 6400MHz   | 0.980059 | -178.124133 | 0.410312 | 33.0732  | 0.006081 | -46.4033 | 0.932698 | -173.384 |
| 6500MHz   | 0.980409 | -178.148926 | 0.399716 | 32.64273 | 0.006001 | -46.6455 | 0.93411  | -173.44  |
| 6600MHz   | 0.980749 | -178.173467 | 0.389512 | 32.22123 | 0.005922 | -46.8775 | 0.935482 | -173.495 |
| 6700MHz   | 0.98108  | -178.197755 | 0.379681 | 31.80847 | 0.005844 | -47.0995 | 0.936816 | -173.551 |
| 6800MHz   | 0.981402 | -178.221793 | 0.370205 | 31.4042  | 0.005768 | -47.3117 | 0.938111 | -173.606 |
| 6900MHz   | 0.981716 | -178.246    | 0.361068 | 31.0082  | 0.005692 | -47.5143 | 0.93937  | -173.661 |
| 7000MHz   | 0.98202  | -178.269121 | 0.352254 | 30.62026 | 0.005618 | -47.7074 | 0.940593 | -173.716 |
| 7100MHz   | 0.982317 | -178.292414 | 0.343749 | 30.24015 | 0.005544 | -47.8914 | 0.941782 | -173.771 |
| 7200MHz   | 0.982605 | -178.315463 | 0.33554  | 29.86767 | 0.005472 | -48.0663 | 0.942937 | -173.825 |
| 7300MHz   | 0.982886 | -178.338268 | 0.327612 | 29.50262 | 0.005401 | -48.2323 | 0.94406  | -173.879 |
| 7400MHz   | 0.983159 | -178.360832 | 0.319953 | 29.14481 | 0.005331 | -48.3895 | 0.945153 | -173.932 |
| 7500MHz   | 0.983425 | -178.383157 | 0.312552 | 28.79404 | 0.005262 | -48.5382 | 0.946214 | -173.985 |
| 7600MHz   | 0.983683 | -178.405245 | 0.305397 | 28.45014 | 0.005193 | -48.6785 | 0.947247 | -174.038 |
| 7700MHz   | 0.983935 | -178.427098 | 0.298479 | 28.11293 | 0.005126 | -48.8104 | 0.948251 | -174.09  |
| 7800MHz   | 0.98418  | -178.448719 | 0.291786 | 27.78224 | 0.00506  | -48.9342 | 0.949228 | -174.142 |
| 7900MHz   | 0.984419 | -178.47011  | 0.28531  | 27.45789 | 0.004995 | -49.05   | 0.950179 | -174.193 |
| 8000MHz   | 0.984651 | -178.491273 | 0.279042 | 27.13973 | 0.004931 | -49.1579 | 0.951103 | -174.244 |
| 8100MHz   | 0.984878 | -178.512211 | 0.272972 | 26.82761 | 0.004868 | -49.258  | 0.952003 | -174.294 |
| 8200MHz   | 0.985098 | -178.532927 | 0.267094 | 26.52136 | 0.004805 | -49.3504 | 0.952879 | -174.344 |
| 8300MHz   | 0.985313 | -178.553422 | 0.261398 | 26.22085 | 0.004744 | -49.4352 | 0.953731 | -174.394 |
| 8400MHz   | 0.985522 | -178.573701 | 0.255879 | 25.92593 | 0.004683 | -49.5125 | 0.954561 | -174.443 |
| 8500MHz   | 0.985726 | -178.593766 | 0.250528 | 25.63647 | 0.004623 | -49.5825 | 0.955369 | -174.491 |
| 8600MHz   | 0.985924 | -178.613619 | 0.245339 | 25.35232 | 0.004565 | -49.6452 | 0.956155 | -174.539 |
| 8700MHz   | 0.986118 | -178.633263 | 0.240306 | 25.07337 | 0.004507 | -49.7006 | 0.956922 | -174.587 |

Contact WAVEPIA to receive this s-parameter file in “.s2p” format at [platune@wavepia.com](mailto:platune@wavepia.com)



## Typical Die S-Parameters

(Small Signal,  $V_{DS} = 28\text{ V}$ ,  $I_{DQ} = 400\text{ mA}$ , magnitude / angle)

| Frequency | Mag S11  | Ang S11     | Mag S21  | Ang S21  | Mag S12  | Ang S12  | Mag S22  | Ang S22  |
|-----------|----------|-------------|----------|----------|----------|----------|----------|----------|
| 8800MHz   | 0.986306 | -178.652701 | 0.235423 | 24.79948 | 0.004449 | -49.7489 | 0.957668 | -174.634 |
| 8900MHz   | 0.98649  | -178.671936 | 0.230684 | 24.53053 | 0.004393 | -49.7902 | 0.958395 | -174.68  |
| 9000MHz   | 0.986669 | -178.69097  | 0.226084 | 24.26641 | 0.004337 | -49.8245 | 0.959104 | -174.726 |
| 9100MHz   | 0.986844 | -178.709807 | 0.221617 | 24.007   | 0.004282 | -49.8519 | 0.959794 | -174.772 |
| 9200MHz   | 0.987014 | -178.72845  | 0.217278 | 23.75219 | 0.004228 | -49.8724 | 0.960467 | -174.817 |
| 9300MHz   | 0.98718  | -178.7469   | 0.213063 | 23.50188 | 0.004175 | -49.8861 | 0.961123 | -174.861 |
| 9400MHz   | 0.987343 | -178.765162 | 0.208967 | 23.25595 | 0.004122 | -49.893  | 0.961763 | -174.905 |
| 9500MHz   | 0.987501 | -178.783237 | 0.204986 | 23.01431 | 0.00407  | -49.8932 | 0.962386 | -174.949 |
| 9600MHz   | 0.987655 | -178.801129 | 0.201115 | 22.77686 | 0.004019 | -49.8868 | 0.962994 | -174.992 |
| 9700MHz   | 0.987806 | -178.81884  | 0.197351 | 22.5435  | 0.003969 | -49.8737 | 0.963588 | -175.035 |
| 9800MHz   | 0.987952 | -178.836374 | 0.19369  | 22.31414 | 0.003919 | -49.854  | 0.964166 | -175.077 |
| 9900MHz   | 0.988096 | -178.853732 | 0.190128 | 22.0887  | 0.00387  | -49.8278 | 0.964731 | -175.118 |
| 10000MHz  | 0.988236 | -178.870918 | 0.186662 | 21.86708 | 0.003821 | -49.795  | 0.965282 | -175.16  |
| 11000MHz  | 0.988373 | -178.887934 | 0.183288 | 21.64921 | 0.003773 | -49.7557 | 0.96582  | -175.2   |
| 11100MHz  | 0.988506 | -178.904783 | 0.180003 | 21.43499 | 0.003726 | -49.7099 | 0.966344 | -175.24  |
| 11200MHz  | 0.988637 | -178.921    | 0.176804 | 21.22436 | 0.003679 | -49.6576 | 0.966857 | -175.28  |
| 11300MHz  | 0.988764 | -178.93799  | 0.173689 | 21.01723 | 0.003633 | -49.5988 | 0.967357 | -175.32  |
| 11400MHz  | 0.988888 | -178.954354 | 0.170654 | 20.81352 | 0.003588 | -49.5335 | 0.967846 | -175.359 |
| 11500MHz  | 0.98901  | -178.971    | 0.167697 | 20.61318 | 0.003543 | -49.4618 | 0.968323 | -175.397 |
| 11600MHz  | 0.989129 | -178.986614 | 0.164815 | 20.41612 | 0.003499 | -49.3836 | 0.968789 | -175.435 |
| 11700MHz  | 0.989245 | -179.002515 | 0.162005 | 20.22228 | 0.003455 | -49.2989 | 0.969244 | -175.473 |
| 11800MHz  | 0.989358 | -179.018267 | 0.159266 | 20.03159 | 0.003412 | -49.2077 | 0.969689 | -175.51  |
| 11900MHz  | 0.989469 | -179.033872 | 0.156595 | 19.84398 | 0.00337  | -49.11   | 0.970124 | -175.547 |
| 12000MHz  | 0.989578 | -179.049333 | 0.15399  | 19.6594  | 0.003327 | -49.0058 | 0.970549 | -175.583 |
| 12100MHz  | 0.989684 | -179.064653 | 0.151448 | 19.47779 | 0.003286 | -48.895  | 0.970964 | -175.619 |
| 12200MHz  | 0.989787 | -179.079832 | 0.148968 | 19.29908 | 0.003245 | -48.7777 | 0.97137  | -175.654 |
| 12300MHz  | 0.989889 | -179.094874 | 0.146548 | 19.12322 | 0.003205 | -48.6538 | 0.971767 | -175.69  |
| 12400MHz  | 0.989988 | -179.109781 | 0.144186 | 18.95014 | 0.003165 | -48.5233 | 0.972155 | -175.724 |
| 12500MHz  | 0.990085 | -179.124554 | 0.141879 | 18.77981 | 0.003125 | -48.3861 | 0.972535 | -175.759 |
| 12600MHz  | 0.99018  | -179.139198 | 0.139627 | 18.61216 | 0.003086 | -48.2422 | 0.972907 | -175.793 |
| 12700MHz  | 0.990273 | -179.153712 | 0.137428 | 18.44714 | 0.003048 | -48.0916 | 0.97327  | -175.826 |
| 12800MHz  | 0.990364 | -179.1681   | 0.13528  | 18.28471 | 0.00301  | -47.9342 | 0.973625 | -175.859 |
| 12900MHz  | 0.990453 | -179.182364 | 0.133181 | 18.12481 | 0.002972 | -47.77   | 0.973973 | -175.892 |
| 13000MHz  | 0.99054  | -179.196505 | 0.131131 | 17.9674  | 0.002935 | -47.5989 | 0.974314 | -175.925 |
| 13100MHz  | 0.990625 | -179.210526 | 0.129127 | 17.81243 | 0.002899 | -47.4208 | 0.974647 | -175.957 |
| 13200MHz  | 0.990709 | -179.224429 | 0.127168 | 17.65986 | 0.002863 | -47.2358 | 0.974973 | -175.989 |
| 13300MHz  | 0.990791 | -179.238215 | 0.125253 | 17.50965 | 0.002827 | -47.0436 | 0.975293 | -176.02  |
| 13400MHz  | 0.990871 | -179.251886 | 0.123381 | 17.36175 | 0.002792 | -46.8444 | 0.975605 | -176.051 |
| 13500MHz  | 0.990949 | -179.265445 | 0.12155  | 17.21612 | 0.002757 | -46.6379 | 0.975911 | -176.082 |



## Typical Die S-Parameters

(Small Signal,  $V_{DS} = 28\text{ V}$ ,  $I_{DQ} = 400\text{ mA}$ , magnitude / angle)

| Frequency | Mag S11  | Ang S11     | Mag S21  | Ang S21  | Mag S12  | Ang S12  | Mag S22  | Ang S22  |
|-----------|----------|-------------|----------|----------|----------|----------|----------|----------|
| 13600MHz  | 0.974996 | -177.047    | 0.402075 | 24.27448 | 0.007443 | -45.4096 | 0.93402  | -169.818 |
| 13700MHz  | 0.975184 | -177.071    | 0.396785 | 24.10007 | 0.007383 | -45.3912 | 0.934747 | -169.878 |
| 13800MHz  | 0.975368 | -177.094851 | 0.391597 | 23.92772 | 0.007324 | -45.3695 | 0.935461 | -169.938 |
| 13900MHz  | 0.97555  | -177.118699 | 0.386508 | 23.7574  | 0.007265 | -45.3447 | 0.936162 | -169.997 |
| 14000MHz  | 0.975728 | -177.142339 | 0.381516 | 23.58909 | 0.007207 | -45.3168 | 0.936852 | -170.056 |
| 14100MHz  | 0.975904 | -177.165774 | 0.376618 | 23.42274 | 0.007149 | -45.2857 | 0.93753  | -170.114 |
| 14200MHz  | 0.976076 | -177.189007 | 0.371813 | 23.25833 | 0.007092 | -45.2514 | 0.938196 | -170.172 |
| 14300MHz  | 0.976246 | -177.212041 | 0.367097 | 23.09584 | 0.007036 | -45.2141 | 0.938851 | -170.229 |
| 14400MHz  | 0.976413 | -177.234877 | 0.362468 | 22.93522 | 0.00698  | -45.1737 | 0.939495 | -170.285 |
| 14500MHz  | 0.976577 | -177.25752  | 0.357925 | 22.77645 | 0.006924 | -45.1302 | 0.940128 | -170.341 |
| 14600MHz  | 0.976739 | -177.27997  | 0.353466 | 22.61951 | 0.00687  | -45.0836 | 0.94075  | -170.397 |
| 14700MHz  | 0.976898 | -177.302232 | 0.349088 | 22.46436 | 0.006815 | -45.0339 | 0.941362 | -170.452 |
| 14800MHz  | 0.977054 | -177.324308 | 0.34479  | 22.31097 | 0.006762 | -44.9813 | 0.941964 | -170.507 |
| 14900MHz  | 0.977208 | -177.346199 | 0.340569 | 22.15933 | 0.006708 | -44.9255 | 0.942556 | -170.561 |
| 15000MHz  | 0.97736  | -177.367909 | 0.336424 | 22.0094  | 0.006655 | -44.8668 | 0.943139 | -170.614 |
| 15100MHz  | 0.977509 | -177.38944  | 0.332354 | 21.86116 | 0.006603 | -44.805  | 0.943711 | -170.667 |
| 15200MHz  | 0.977655 | -177.410795 | 0.328355 | 21.71458 | 0.006551 | -44.7403 | 0.944275 | -170.72  |
| 15300MHz  | 0.9778   | -177.431975 | 0.324428 | 21.56964 | 0.0065   | -44.6725 | 0.944829 | -170.772 |
| 15400MHz  | 0.977942 | -177.452983 | 0.320569 | 21.42632 | 0.006449 | -44.6017 | 0.945374 | -170.824 |
| 15500MHz  | 0.978082 | -177.473821 | 0.316778 | 21.28459 | 0.006399 | -44.528  | 0.945911 | -170.875 |
| 15600MHz  | 0.978219 | -177.494492 | 0.313053 | 21.14443 | 0.006349 | -44.4512 | 0.946439 | -170.926 |
| 15700MHz  | 0.978355 | -177.514998 | 0.309392 | 21.00581 | 0.0063   | -44.3715 | 0.946958 | -170.976 |
| 15800MHz  | 0.978488 | -177.53534  | 0.305794 | 20.86872 | 0.006251 | -44.2888 | 0.947469 | -171.026 |
| 15900MHz  | 0.97862  | -177.555522 | 0.302258 | 20.73313 | 0.006202 | -44.2032 | 0.947972 | -171.075 |
| 16000MHz  | 0.978749 | -177.575545 | 0.298782 | 20.59901 | 0.006154 | -44.1146 | 0.948467 | -171.124 |
| 16100MHz  | 0.978876 | -177.595    | 0.295365 | 20.46636 | 0.006107 | -44.023  | 0.948955 | -171.172 |
| 16200MHz  | 0.979002 | -177.615122 | 0.292006 | 20.33515 | 0.006059 | -43.9284 | 0.949434 | -171.221 |
| 16300MHz  | 0.979125 | -177.634681 | 0.288703 | 20.20535 | 0.006013 | -43.8309 | 0.949907 | -171.268 |
| 16400MHz  | 0.979247 | -177.654    | 0.285455 | 20.07696 | 0.005966 | -43.7304 | 0.950372 | -171.315 |
| 16500MHz  | 0.979367 | -177.673348 | 0.282261 | 19.94994 | 0.00592  | -43.627  | 0.950829 | -171.362 |
| 16600MHz  | 0.979485 | -177.69246  | 0.27912  | 19.82429 | 0.005875 | -43.5206 | 0.95128  | -171.409 |
| 16700MHz  | 0.979601 | -177.711    | 0.27603  | 19.69998 | 0.00583  | -43.4113 | 0.951724 | -171.455 |
| 16800MHz  | 0.979715 | -177.730253 | 0.272991 | 19.57699 | 0.005785 | -43.299  | 0.952161 | -171.5   |
| 16900MHz  | 0.979828 | -177.748936 | 0.270001 | 19.45531 | 0.005741 | -43.1837 | 0.952591 | -171.545 |
| 17000MHz  | 0.979939 | -177.76748  | 0.26706  | 19.33491 | 0.005697 | -43.0655 | 0.953015 | -171.59  |
| 17100MHz  | 0.980049 | -177.785886 | 0.264166 | 19.21579 | 0.005654 | -42.9443 | 0.953433 | -171.635 |
| 17200MHz  | 0.980157 | -177.804156 | 0.261318 | 19.09792 | 0.005611 | -42.8201 | 0.953844 | -171.679 |
| 17300MHz  | 0.980263 | -177.822293 | 0.258516 | 18.98129 | 0.005568 | -42.6929 | 0.954249 | -171.722 |
| 17400MHz  | 0.980368 | -177.840297 | 0.255758 | 18.86588 | 0.005526 | -42.5628 | 0.954648 | -171.766 |

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