## Tissue Parameters

**Recipe for liquids below 1 GHz:**
Water 35-58%
Sugar 40-60%
Salt 0-6%
Hydroxyethyl-cellulose <0.3%
Preventol-D7 0.1-0.7%

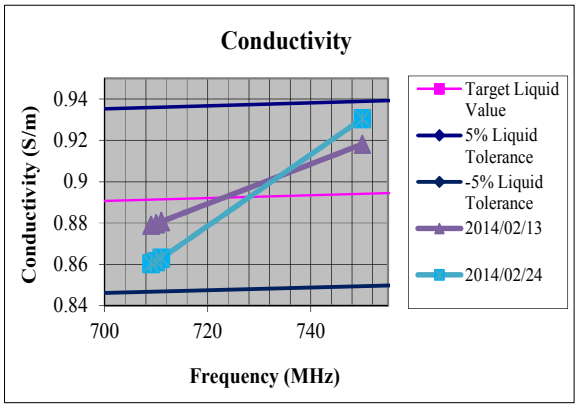
**Recipe for liquids above 1-3 GHz:**
Water 52-75%
DGBE 25-48%
Salt <1.0%

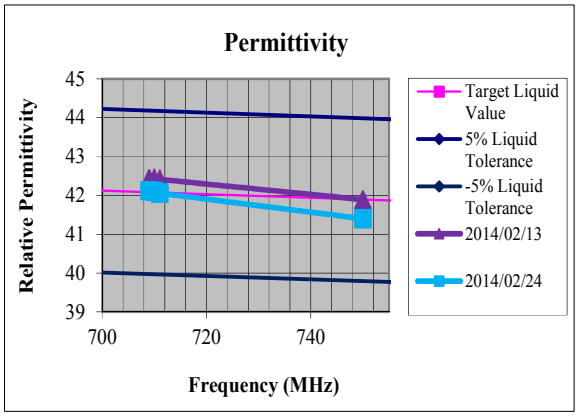
**Recipe for liquids 5-6 GHz:**
Water 60-80%
Esters, Emulsifiers, Inhibitors 20-40%
Sodium Chloride 0-1.5%

SAR measurements were made within 24 hours of the measurement of liquid parameters. Relative permittivity and conductivity are within ±5% of the target.

## 750 MHz Head Liquid

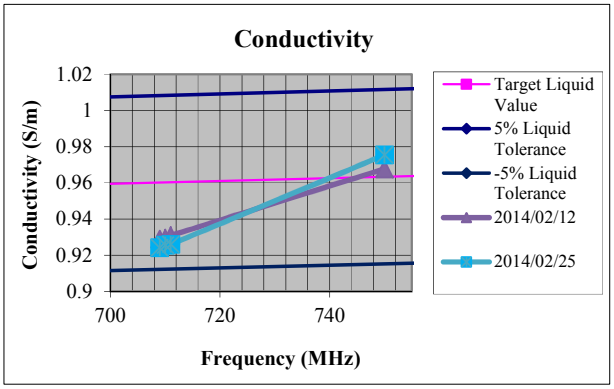
| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2014/02/13 | 21.3 | 709 | 42.4325 | 0.8789 |
| | | 710 | 42.4351 | 0.8796 |
| | | 711 | 42.4141 | 0.8807 |
| | | 750 | 41.8912 | 0.9181 |
| 2014/02/24 | 20.2 | 709 | 42.1197 | 0.8604 |
| | | 710 | 42.1015 | 0.8613 |
| | | 711 | 42.058 | 0.863 |
| | | 750 | 41.3988 | 0.9305 |

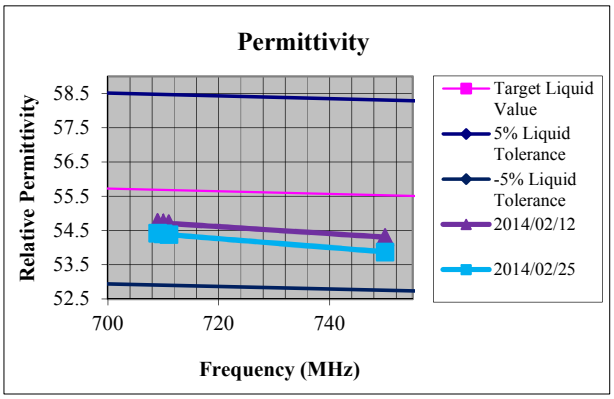


## 750 MHz Body Liquid

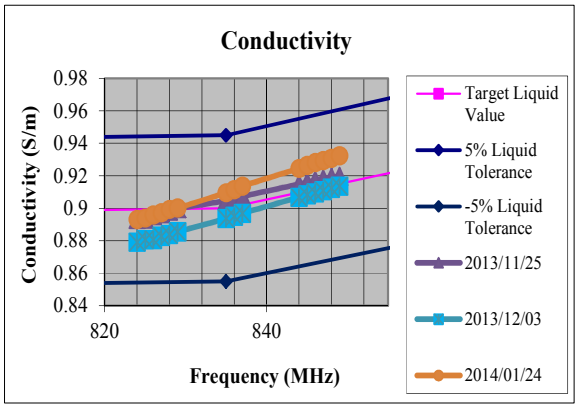
| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2014/02/12 | 22.1 | 709 | 54.741 | 0.9289 |
| | | 710 | 54.7162 | 0.9294 |
| | | 711 | 54.7063 | 0.9308 |
| | | 750 | 54.3064 | 0.9677 |
| 2014/02/25 | 20.4 | 709 | 54.4214 | 0.9241 |
| | | 710 | 54.4017 | 0.9256 |
| | | 711 | 54.3788 | 0.926 |
| | | 750 | 53.876 | 0.9754 |

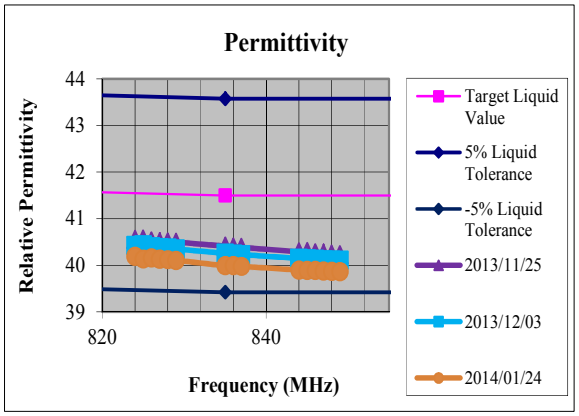


## 850 MHz Head Liquid

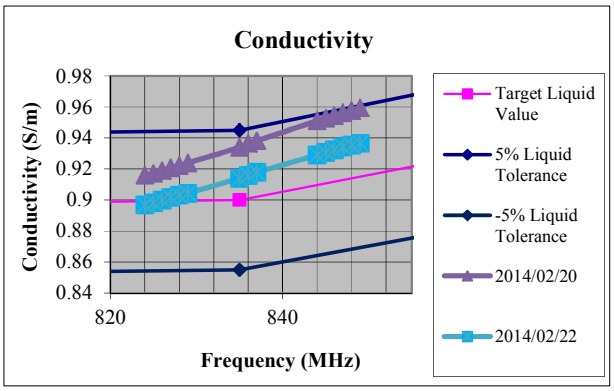
| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2013/11/25 | 21.1 | 824 | 40.5587 | 0.8932 |
| | | 825 | 40.5637 | 0.8934 |
| | | 826 | 40.5257 | 0.8955 |
| | | 827 | 40.508 | 0.8966 |
| | | 828 | 40.5023 | 0.8982 |
| | | 829 | 40.4974 | 0.8998 |
| | | 835 | 40.4136 | 0.9047 |
| | | 836 | 40.3943 | 0.906 |
| | | 837 | 40.3859 | 0.9073 |
| | | 844 | 40.2918 | 0.9149 |
| | | 845 | 40.2941 | 0.9161 |
| | | 846 | 40.2696 | 0.9172 |
| | | 847 | 40.2591 | 0.9181 |
| | | 848 | 40.2438 | 0.9192 |
| | | 849 | 40.2264 | 0.9197 |
| 2013/12/03 | 20.6 | 824 | 40.43 | 0.8791 |
| | | 825 | 40.44 | 0.8807 |
| | | 826 | 40.4 | 0.8807 |
| | | 827 | 40.38 | 0.8828 |
| | | 828 | 40.37 | 0.8839 |
| | | 829 | 40.35 | 0.8855 |
| | | 835 | 40.26 | 0.8937 |
| | | 836 | 40.24 | 0.8951 |
| | | 837 | 40.23 | 0.8969 |
| | | 844 | 40.15 | 0.9068 |
| | | 845 | 40.14 | 0.9083 |
| | | 846 | 40.13 | 0.9095 |
| | | 847 | 40.12 | 0.9108 |
| | | 848 | 40.11 | 0.9123 |
| | | 849 | 40.11 | 0.9136 |
| 2014/01/24 | 20.7 | 824 | 40.1955 | 0.8932 |
| | | 825 | 40.1374 | 0.894 |
| | | 826 | 40.1603 | 0.896 |
| | | 827 | 40.135 | 0.8973 |
| | | 828 | 40.1241 | 0.8994 |
| | | 829 | 40.1084 | 0.9002 |
| | | 835 | 39.9946 | 0.9096 |
| | | 836 | 39.9992 | 0.9116 |
| | | 837 | 39.9797 | 0.9137 |
| | | 844 | 39.8995 | 0.9246 |
| | | 845 | 39.8916 | 0.9264 |
| | | 846 | 39.8927 | 0.9282 |
| | | 847 | 39.8798 | 0.9295 |
| | | 848 | 39.8742 | 0.9309 |
| | | 849 | 39.8672 | 0.9324 |

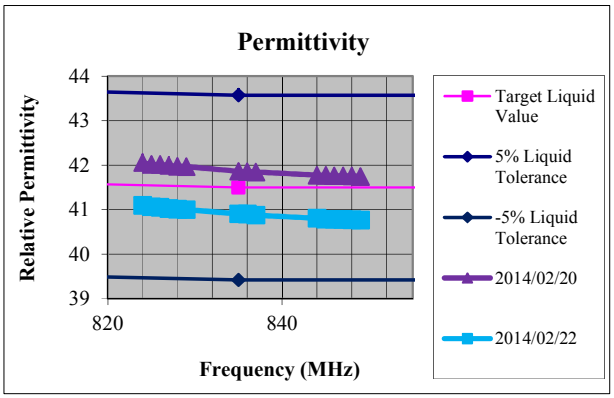


## 850 MHz Head Liquid

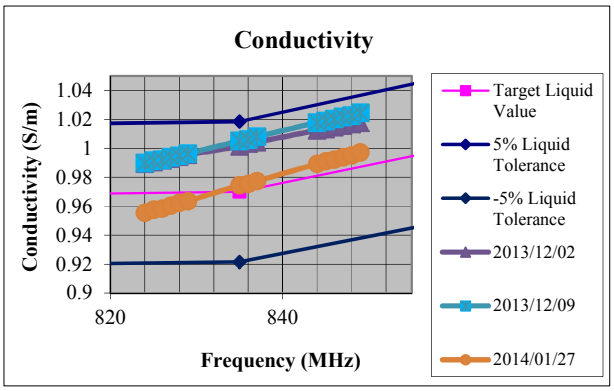
| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2014/02/20 | 21 | 824 | 42.0593 | 0.916 |
| | | 825 | 42.0173 | 0.9172 |
| | | 826 | 42.0192 | 0.919 |
| | | 827 | 41.9949 | 0.9208 |
| | | 828 | 41.975 | 0.9222 |
| | | 829 | 41.9706 | 0.9239 |
| | | 835 | 41.863 | 0.934 |
| | | 836 | 41.8559 | 0.9366 |
| | | 837 | 41.8479 | 0.9382 |
| | | 844 | 41.7784 | 0.9511 |
| | | 845 | 41.778 | 0.9528 |
| | | 846 | 41.7655 | 0.9545 |
| | | 847 | 41.7655 | 0.9562 |
| | | 848 | 41.7596 | 0.9578 |
| | | 849 | 41.7462 | 0.9595 |
| 2014/02/22 | 20.3 | 824 | 41.0974 | 0.8968 |
| | | 825 | 41.0658 | 0.8982 |
| | | 826 | 41.0544 | 0.9 |
| | | 827 | 41.0272 | 0.9017 |
| | | 828 | 41.0147 | 0.9032 |
| | | 829 | 41.0027 | 0.9044 |
| | | 835 | 40.9078 | 0.9141 |
| | | 836 | 40.9041 | 0.9159 |
| | | 837 | 40.8789 | 0.9178 |
| | | 844 | 40.8076 | 0.9291 |
| | | 845 | 40.7877 | 0.9308 |
| | | 846 | 40.7881 | 0.9324 |
| | | 847 | 40.7804 | 0.9342 |
| | | 848 | 40.7735 | 0.9355 |
| | | 849 | 40.7677 | 0.9366 |

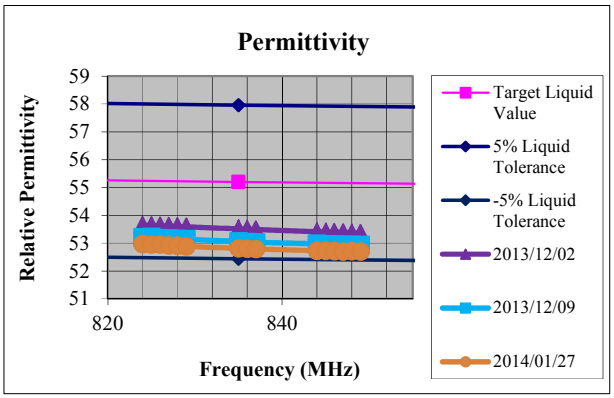


## 850 MHz Body Liquid

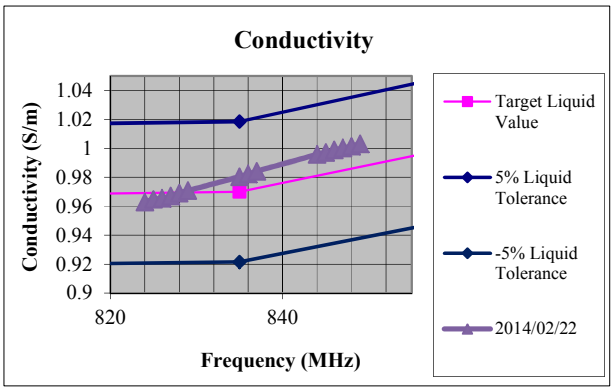
| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2013/12/02 | 20.5 | 824 | 53.6481 | 0.9894 |
| | | 825 | 53.6362 | 0.9906 |
| | | 826 | 53.6283 | 0.9918 |
| | | 827 | 53.6132 | 0.9929 |
| | | 828 | 53.5995 | 0.9943 |
| | | 829 | 53.5853 | 0.9957 |
| | | 835 | 53.5143 | 1.0013 |
| | | 836 | 53.5044 | 1.0034 |
| | | 837 | 53.4894 | 1.0043 |
| | | 844 | 53.4118 | 1.0125 |
| | | 845 | 53.401 | 1.0133 |
| | | 846 | 53.3908 | 1.0146 |
| | | 847 | 53.3876 | 1.0157 |
| | | 848 | 53.3666 | 1.0168 |
| | | 849 | 53.3599 | 1.0177 |
| 2013/12/09 | 20 | 824 | 53.2072 | 0.9898 |
| | | 825 | 53.2224 | 0.9915 |
| | | 826 | 53.1771 | 0.9921 |
| | | 827 | 53.1627 | 0.9939 |
| | | 828 | 53.1563 | 0.9949 |
| | | 829 | 53.1378 | 0.9963 |
| | | 835 | 53.0631 | 1.0051 |
| | | 836 | 53.0415 | 1.006 |
| | | 837 | 53.0301 | 1.0081 |
| | | 844 | 52.9755 | 1.0178 |
| | | 845 | 52.957 | 1.0189 |
| | | 846 | 52.9479 | 1.0203 |
| | | 847 | 52.9445 | 1.0217 |
| | | 848 | 52.9313 | 1.0227 |
| | | 849 | 52.929 | 1.0245 |
| 2014/01/27 | 20.8 | 824 | 52.9697 | 0.9556 |
| | | 825 | 52.9468 | 0.9577 |
| | | 826 | 52.9478 | 0.9584 |
| | | 827 | 52.9197 | 0.9605 |
| | | 828 | 52.9098 | 0.9624 |
| | | 829 | 52.8823 | 0.9635 |
| | | 835 | 52.8144 | 0.9746 |
| | | 836 | 52.8019 | 0.9755 |
| | | 837 | 52.7899 | 0.9774 |
| | | 844 | 52.7285 | 0.9893 |
| | | 845 | 52.7262 | 0.9911 |
| | | 846 | 52.7171 | 0.9923 |
| | | 847 | 52.7005 | 0.9939 |
| | | 848 | 52.7096 | 0.9952 |
| | | 849 | 52.7009 | 0.9972 |

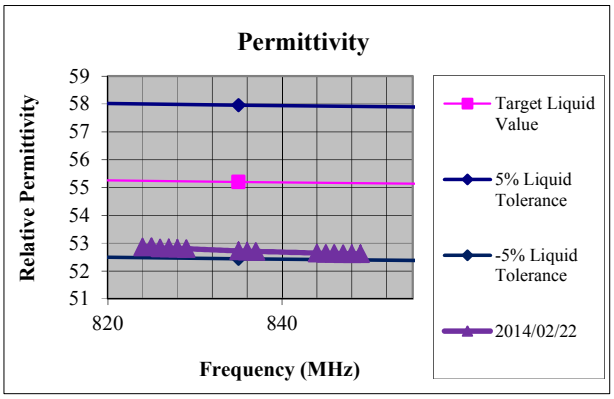


## 850 MHz Body Liquid

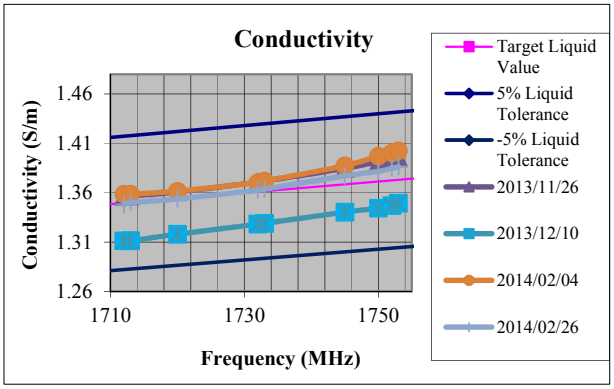
| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2014/02/22 | 20.9 | 824 | 52.8671 | 0.9628 |
| | | 825 | 52.8813 | 0.9648 |
| | | 826 | 52.8297 | 0.9655 |
| | | 827 | 52.8241 | 0.9671 |
| | | 828 | 52.8125 | 0.9692 |
| | | 829 | 52.8018 | 0.9708 |
| | | 835 | 52.7198 | 0.9804 |
| | | 836 | 52.713 | 0.9823 |
| | | 837 | 52.7046 | 0.9842 |
| | | 844 | 52.6445 | 0.9958 |
| | | 845 | 52.6355 | 0.9971 |
| | | 846 | 52.6336 | 0.9989 |
| | | 847 | 52.6264 | 1.0002 |
| | | 848 | 52.6213 | 1.0015 |
| | | 849 | 52.6175 | 1.0032 |

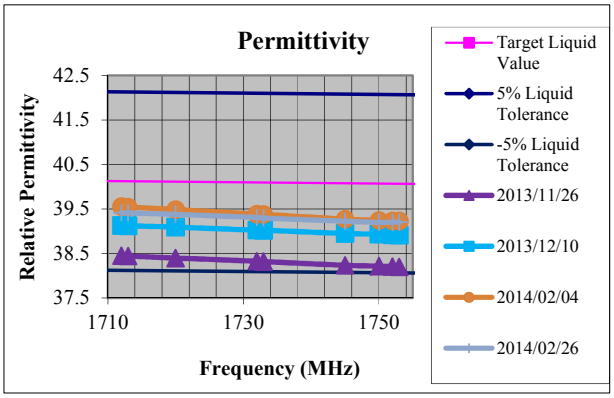


## 1750 MHz Head Liquid

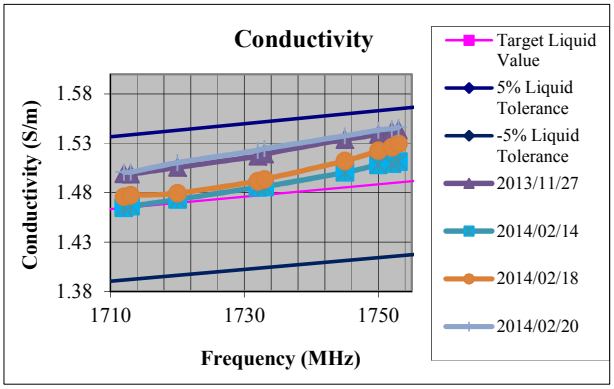
| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2013/11/26 | 20.3 | 1712 | 38.4523 | 1.3561 |
| | | 1713 | 38.444 | 1.3567 |
| | | 1720 | 38.3991 | 1.3608 |
| | | 1732 | 38.3276 | 1.3707 |
| | | 1733 | 38.3194 | 1.3718 |
| | | 1745 | 38.2362 | 1.3847 |
| | | 1750 | 38.2184 | 1.3916 |
| | | 1752 | 38.2056 | 1.3946 |
| | | 1753 | 38.2 | 1.3953 |
| 2013/12/10 | 21.8 | 1712 | 39.1285 | 1.3113 |
| | | 1713 | 39.1229 | 1.3114 |
| | | 1720 | 39.0931 | 1.3179 |
| | | 1732 | 39.0249 | 1.3282 |
| | | 1733 | 39.0241 | 1.329 |
| | | 1745 | 38.9513 | 1.3403 |
| | | 1750 | 38.9352 | 1.3443 |
| | | 1752 | 38.9218 | 1.347 |
| | | 1753 | 38.9112 | 1.3493 |
| 2014/02/04 | 20.7 | 1712 | 39.5557 | 1.3585 |
| | | 1713 | 39.5473 | 1.3586 |
| | | 1720 | 39.4885 | 1.3616 |
| | | 1732 | 39.3843 | 1.3703 |
| | | 1733 | 39.3803 | 1.3718 |
| | | 1745 | 39.2733 | 1.3874 |
| | | 1750 | 39.2451 | 1.3971 |
| | | 1752 | 39.2318 | 1.4003 |
| | | 1753 | 39.2325 | 1.4026 |
| 2014/02/26 | 20.7 | 1712 | 39.4138 | 1.3478 |
| | | 1713 | 39.4125 | 1.3499 |
| | | 1720 | 39.379 | 1.3537 |
| | | 1732 | 39.3099 | 1.3625 |
| | | 1733 | 39.2964 | 1.3636 |
| | | 1745 | 39.2262 | 1.377 |
| | | 1750 | 39.1991 | 1.3817 |
| | | 1752 | 39.2065 | 1.3847 |
| | | 1753 | 39.2042 | 1.3864 |

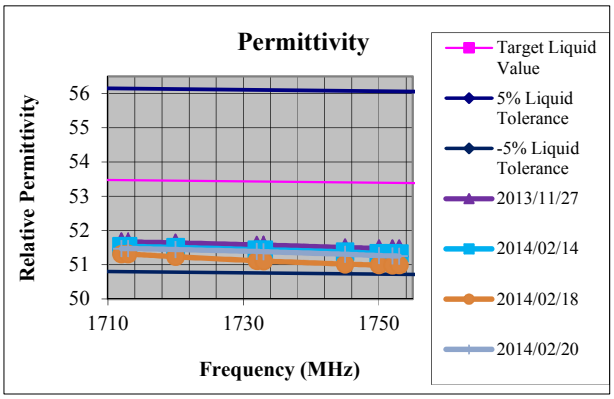


## 1750 MHz Body Liquid

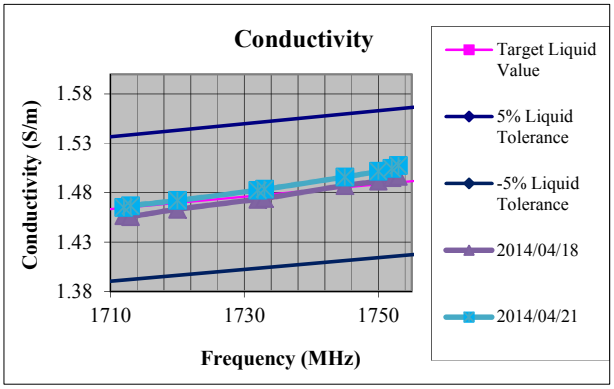
| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2013/11/27 | 20.4 | 1712 | 51.6773 | 1.4991 |
| | | 1713 | 51.6669 | 1.4989 |
| | | 1720 | 51.6402 | 1.5056 |
| | | 1732 | 51.5781 | 1.517 |
| | | 1733 | 51.5746 | 1.5192 |
| | | 1745 | 51.5046 | 1.534 |
| | | 1750 | 51.4775 | 1.5389 |
| | | 1752 | 51.4758 | 1.5423 |
| | | 1753 | 51.4764 | 1.5432 |
| 2014/02/14 | 21.2 | 1712 | 51.5431 | 1.4648 |
| | | 1713 | 51.5383 | 1.4662 |
| | | 1720 | 51.5079 | 1.4731 |
| | | 1732 | 51.4424 | 1.4854 |
| | | 1733 | 51.442 | 1.486 |
| | | 1745 | 51.3768 | 1.5006 |
| | | 1750 | 51.3307 | 1.5082 |
| | | 1752 | 51.3357 | 1.5096 |
| | | 1753 | 51.3299 | 1.5114 |
| 2014/02/18 | 20.4 | 1712 | 51.3108 | 1.476 |
| | | 1713 | 51.3167 | 1.4775 |
| | | 1720 | 51.2343 | 1.4795 |
| | | 1732 | 51.1173 | 1.4917 |
| | | 1733 | 51.1096 | 1.4936 |
| | | 1745 | 51.0202 | 1.5122 |
| | | 1750 | 50.9919 | 1.5226 |
| | | 1752 | 50.988 | 1.5261 |
| | | 1753 | 50.9943 | 1.5296 |
| 2014/02/20 | 20.9 | 1712 | 51.4696 | 1.5009 |
| | | 1713 | 51.4763 | 1.5008 |
| | | 1720 | 51.445 | 1.5104 |
| | | 1732 | 51.3905 | 1.5229 |
| | | 1733 | 51.3829 | 1.5246 |
| | | 1745 | 51.3071 | 1.5376 |
| | | 1750 | 51.2692 | 1.5434 |
| | | 1752 | 51.2605 | 1.5449 |
| | | 1753 | 51.254 | 1.5463 |

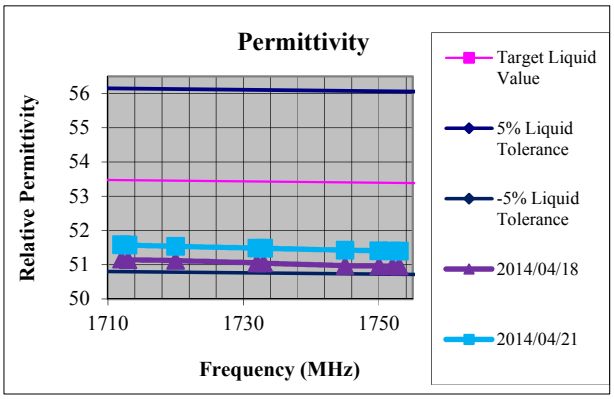


## 1750 MHz Body Liquid

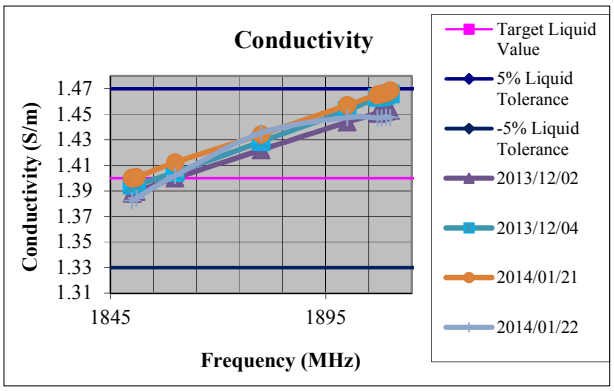
| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2014/04/18 | 21.9 | 1712 | 51.1627 | 1.4567 |
| | | 1713 | 51.1458 | 1.4558 |
| | | 1720 | 51.1217 | 1.4632 |
| | | 1732 | 51.0563 | 1.4733 |
| | | 1733 | 51.046 | 1.4741 |
| | | 1745 | 50.9759 | 1.4873 |
| | | 1750 | 50.9665 | 1.4916 |
| | | 1752 | 50.9651 | 1.4954 |
| | | 1753 | 50.9609 | 1.4964 |
| 2014/04/21 | 22.3 | 1712 | 51.5809 | 1.465 |
| | | 1713 | 51.5759 | 1.4668 |
| | | 1720 | 51.5384 | 1.4721 |
| | | 1732 | 51.4867 | 1.4825 |
| | | 1733 | 51.4809 | 1.4834 |
| | | 1745 | 51.4276 | 1.4959 |
| | | 1750 | 51.4092 | 1.5017 |
| | | 1752 | 51.405 | 1.5047 |
| | | 1753 | 51.4003 | 1.5076 |

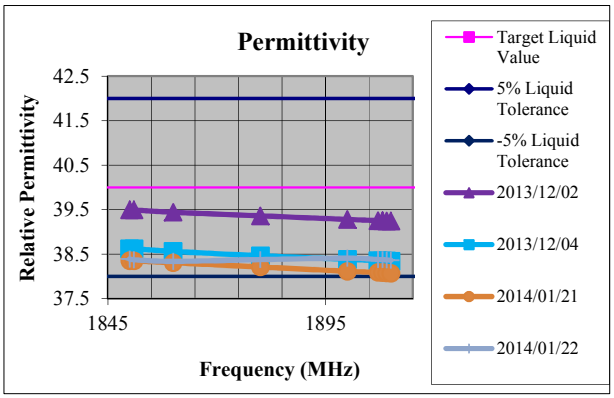


## 1900 MHz Head Liquid

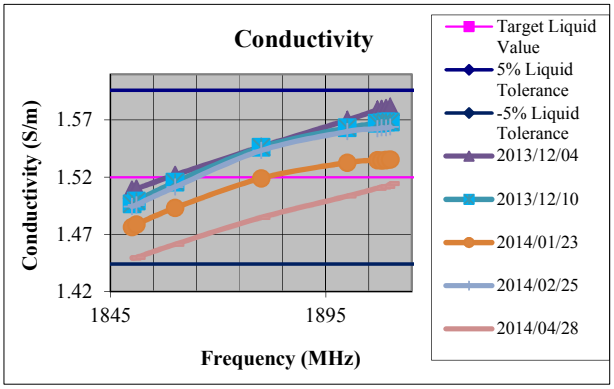
| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2013/12/02 | 22 | 1850 | 39.4947 | 1.3879 |
| | | 1851 | 39.4948 | 1.3895 |
| | | 1860 | 39.443 | 1.4 |
| | | 1880 | 39.3635 | 1.4221 |
| | | 1900 | 39.282 | 1.4439 |
| | | 1907 | 39.2552 | 1.4507 |
| | | 1908 | 39.2521 | 1.4516 |
| | | 1909 | 39.2495 | 1.4524 |
| | | 1910 | 39.246 | 1.4532 |
| 2013/12/04 | 20.6 | 1850 | 38.6219 | 1.3947 |
| | | 1851 | 38.6215 | 1.395 |
| | | 1860 | 38.5644 | 1.4043 |
| | | 1880 | 38.4668 | 1.4286 |
| | | 1900 | 38.3863 | 1.4531 |
| | | 1907 | 38.356 | 1.4632 |
| | | 1908 | 38.3515 | 1.4638 |
| | | 1909 | 38.3479 | 1.4649 |
| | | 1910 | 38.3417 | 1.466 |
| 2014/01/21 | 20.9 | 1850 | 38.357 | 1.4002 |
| | | 1851 | 38.3504 | 1.4006 |
| | | 1860 | 38.3093 | 1.4123 |
| | | 1880 | 38.2147 | 1.4343 |
| | | 1900 | 38.1175 | 1.4572 |
| | | 1907 | 38.0951 | 1.4653 |
| | | 1908 | 38.09 | 1.466 |
| | | 1909 | 38.0791 | 1.467 |
| | | 1910 | 38.0719 | 1.4687 |
| 2014/01/22 | 22 | 1850 | 38.3917 | 1.3824 |
| | | 1851 | 38.3758 | 1.3844 |
| | | 1860 | 38.3405 | 1.402 |
| | | 1880 | 38.3805 | 1.4354 |
| | | 1900 | 38.4137 | 1.4474 |
| | | 1907 | 38.3821 | 1.4472 |
| | | 1908 | 38.3811 | 1.4473 |
| | | 1909 | 38.3738 | 1.448 |
| | | 1910 | 38.3666 | 1.4474 |

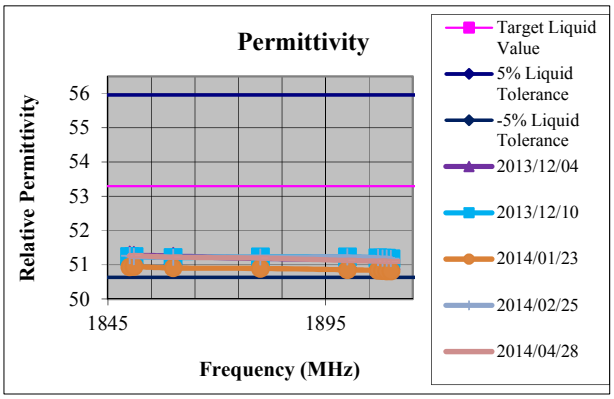


## 1900 MHz Body Liquid

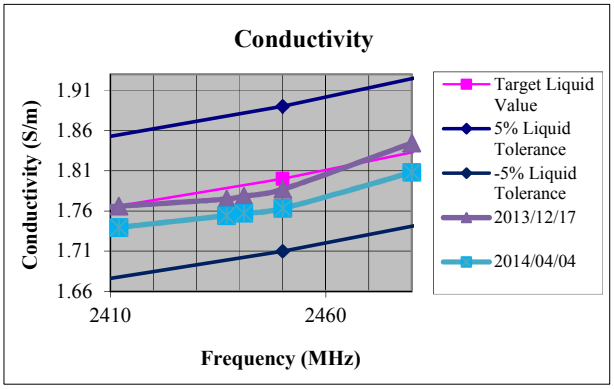
| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2013/12/04 | 20 | 1850 | 51.289 | 1.509 |
| | | 1851 | 51.2831 | 1.5098 |
| | | 1860 | 51.2551 | 1.5219 |
| | | 1880 | 51.1898 | 1.5466 |
| | | 1900 | 51.1566 | 1.5699 |
| | | 1907 | 51.1295 | 1.5789 |
| | | 1908 | 51.1293 | 1.5794 |
| | | 1909 | 51.1257 | 1.5804 |
| | | 1910 | 51.1226 | 1.5814 |
| 2013/12/10 | 21.6 | 1850 | 51.2412 | 1.4967 |
| | | 1851 | 51.2464 | 1.4991 |
| | | 1860 | 51.2148 | 1.5156 |
| | | 1880 | 51.2326 | 1.5462 |
| | | 1900 | 51.2301 | 1.5632 |
| | | 1907 | 51.2029 | 1.5671 |
| | | 1908 | 51.1932 | 1.5676 |
| | | 1909 | 51.193 | 1.5683 |
| | | 1910 | 51.1834 | 1.5682 |
| 2014/01/23 | 21.9 | 1850 | 50.941 | 1.4763 |
| | | 1851 | 50.9542 | 1.4786 |
| | | 1860 | 50.9085 | 1.4931 |
| | | 1880 | 50.8957 | 1.519 |
| | | 1900 | 50.8568 | 1.5327 |
| | | 1907 | 50.8372 | 1.5349 |
| | | 1908 | 50.8263 | 1.5347 |
| | | 1909 | 50.8172 | 1.535 |
| | | 1910 | 50.8162 | 1.5356 |
| 2014/02/25 | 22 | 1850 | 51.2714 | 1.4943 |
| | | 1851 | 51.2451 | 1.4957 |
| | | 1860 | 51.2211 | 1.5114 |
| | | 1880 | 51.2267 | 1.5433 |
| | | 1900 | 51.2318 | 1.5599 |
| | | 1907 | 51.2099 | 1.5624 |
| | | 1908 | 51.1966 | 1.5632 |
| | | 1909 | 51.1981 | 1.5631 |
| | | 1910 | 51.1849 | 1.564 |
| 2014/04/28 | 21.6 | 1850 | 51.2617 | 1.4493 |
| | | 1851 | 51.2734 | 1.4497 |
| | | 1860 | 51.2255 | 1.4612 |
| | | 1880 | 51.1964 | 1.4847 |
| | | 1900 | 51.1287 | 1.5034 |
| | | 1907 | 51.1086 | 1.5103 |
| | | 1908 | 51.108 | 1.5114 |
| | | 1909 | 51.0975 | 1.5118 |
| | | 1910 | 51.093 | 1.5142 |

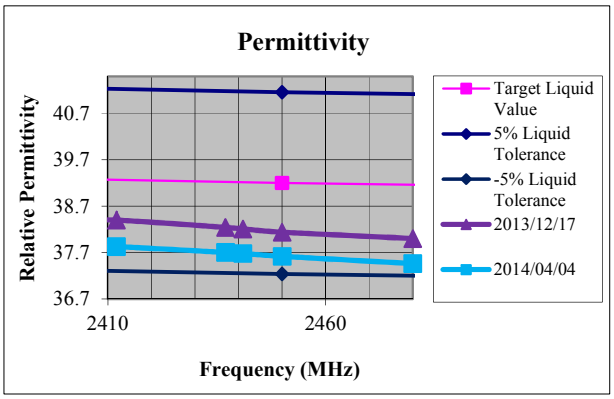


## 2450 MHz Head Liquid

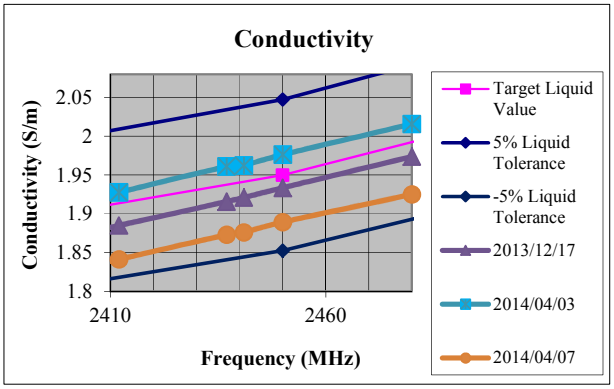
| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2013/12/17 | 24.65 | 2402 | 38.3892 | 1.7621 |
| | | 2412 | 38.4008 | 1.7659 |
| | | 2437 | 38.2444 | 1.7748 |
| | | 2441 | 38.2128 | 1.7785 |
| | | 2450 | 38.1404 | 1.7869 |
| | | 2480 | 38.0053 | 1.8444 |
| 2014/04/04 | 24.71 | 2402 | 37.8358 | 1.7309 |
| | | 2412 | 37.829 | 1.7394 |
| | | 2437 | 37.7043 | 1.7542 |
| | | 2441 | 37.6816 | 1.757 |
| | | 2450 | 37.6202 | 1.7631 |
| | | 2480 | 37.4655 | 1.808 |

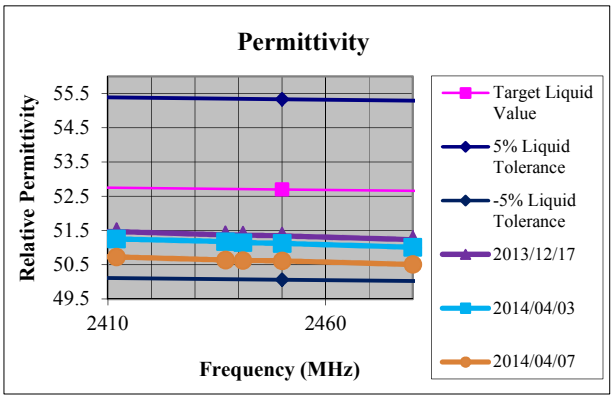


## 2450 MHz Body Liquid

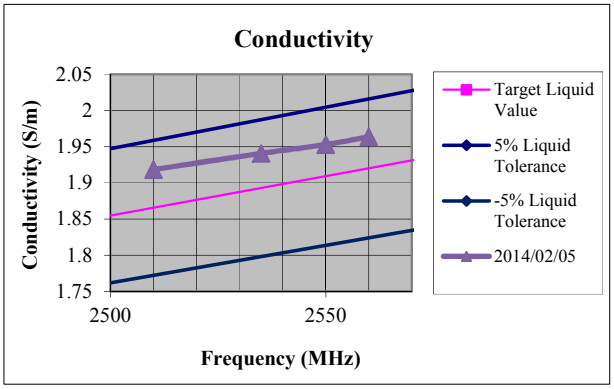
| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2013/12/17 | 23.6 | 2402 | 51.4892 | 1.8728 |
| | | 2412 | 51.4681 | 1.885 |
| | | 2437 | 51.3739 | 1.9158 |
| | | 2441 | 51.3663 | 1.921 |
| | | 2450 | 51.3432 | 1.9336 |
| | | 2480 | 51.2328 | 1.9738 |
| 2014/04/03 | 23.17 | 2402 | 51.2816 | 1.9148 |
| | | 2412 | 51.2538 | 1.9278 |
| | | 2437 | 51.1763 | 1.961 |
| | | 2441 | 51.1471 | 1.9626 |
| | | 2450 | 51.1234 | 1.9763 |
| | | 2480 | 51.0128 | 2.0159 |
| 2014/04/07 | 24.5 | 2402 | 50.7533 | 1.8284 |
| | | 2412 | 50.7289 | 1.8413 |
| | | 2437 | 50.6387 | 1.873 |
| | | 2441 | 50.6251 | 1.8762 |
| | | 2450 | 50.6127 | 1.8893 |
| | | 2480 | 50.5083 | 1.9251 |

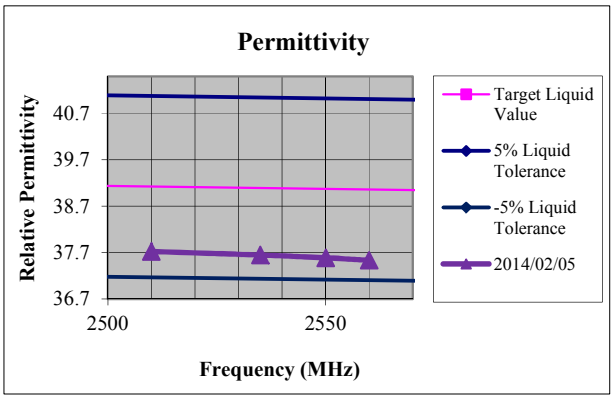


## 2550 MHz Head Liquid

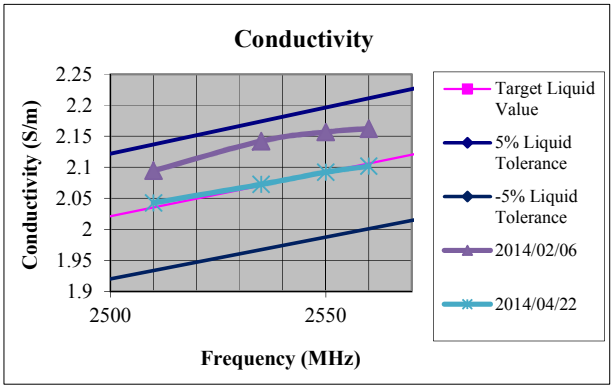
| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2014/02/05 | 22.6 | 2510 | 37.725 | 1.9184 |
| | | 2535 | 37.649 | 1.9406 |
| | | 2550 | 37.588 | 1.9529 |
| | | 2560 | 37.5356 | 1.9637 |

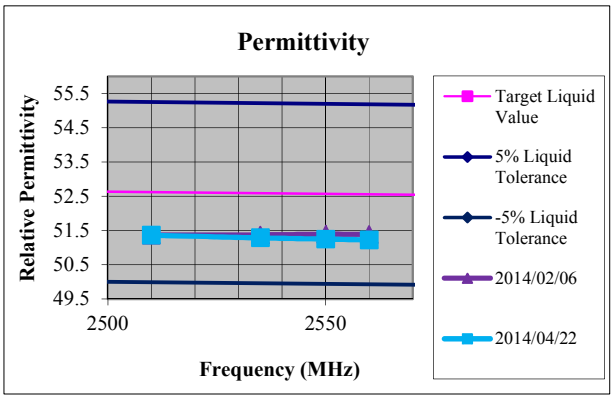


## 2550 MHz Body Liquid

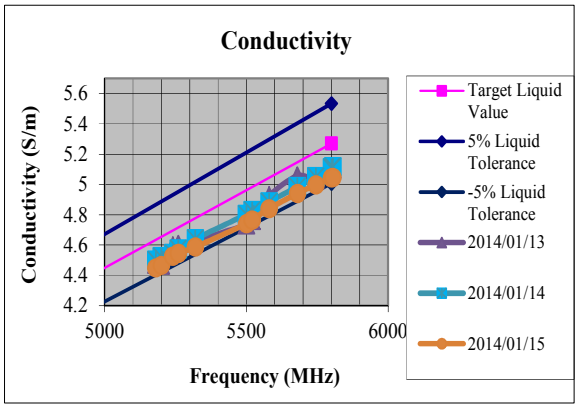
| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2014/02/06 | 21.5 | 2510 | 51.3662 | 2.0946 |
| | | 2535 | 51.3732 | 2.1423 |
| | | 2550 | 51.3923 | 2.1569 |
| | | 2560 | 51.3863 | 2.1625 |
| 2014/04/22 | 23.2 | 2510 | 51.3635 | 2.0428 |
| | | 2535 | 51.2861 | 2.0726 |
| | | 2550 | 51.2502 | 2.0921 |
| | | 2560 | 51.2245 | 2.1019 |

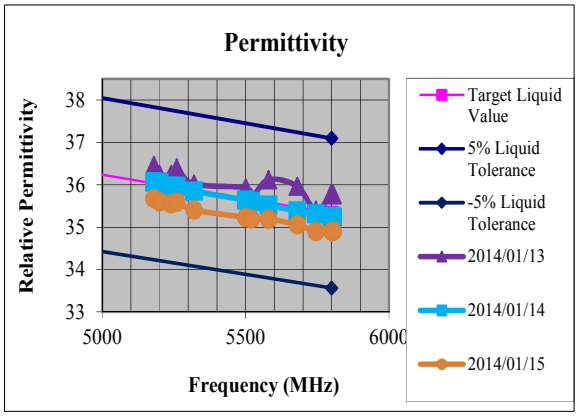


## 5000 MHz Head Liquid

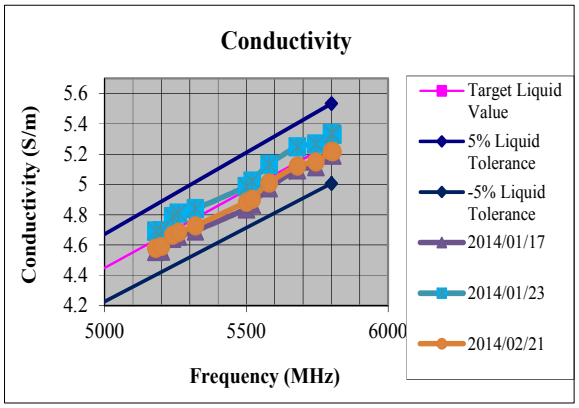
| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2014/01/13 | 22.7 | 5180 | 36.4574 | 4.473 |
| | | 5200 | 36.2374 | 4.4675 |
| | | 5240 | 36.2472 | 4.5934 |
| | | 5260 | 36.3933 | 4.6048 |
| | | 5320 | 36.0192 | 4.6293 |
| | | 5500 | 35.9288 | 4.7343 |
| | | 5520 | 35.6995 | 4.763 |
| | | 5580 | 36.1225 | 4.9244 |
| | | 5680 | 35.9684 | 5.0571 |
| | | 5745 | 35.3953 | 5.0313 |
| | | 5800 | 35.8111 | 5.1156 |
| | | 5805 | 35.768 | 5.102 |
| 2014/01/14 | 22.14 | 5180 | 36.0703 | 4.5013 |
| | | 5200 | 36.049 | 4.5238 |
| | | 5240 | 35.9679 | 4.5444 |
| | | 5260 | 35.9702 | 4.575 |
| | | 5320 | 35.8539 | 4.641 |
| | | 5500 | 35.6403 | 4.803 |
| | | 5520 | 35.6104 | 4.8271 |
| | | 5580 | 35.5251 | 4.8852 |
| | | 5680 | 35.3857 | 4.9855 |
| | | 5745 | 35.3161 | 5.0505 |
| | | 5800 | 35.2549 | 5.1099 |
| | | 5805 | 35.2359 | 5.117 |
| 2014/01/15 | 21.8 | 5180 | 35.6718 | 4.4497 |
| | | 5200 | 35.6025 | 4.4669 |
| | | 5240 | 35.5529 | 4.5272 |
| | | 5260 | 35.5929 | 4.5464 |
| | | 5320 | 35.4069 | 4.5878 |
| | | 5500 | 35.2321 | 4.7416 |
| | | 5520 | 35.1982 | 4.7662 |
| | | 5580 | 35.1913 | 4.8407 |
| | | 5680 | 35.0591 | 4.941 |
| | | 5745 | 34.8965 | 4.9983 |
| | | 5800 | 34.9023 | 5.0444 |
| | | 5805 | 34.9007 | 5.0466 |

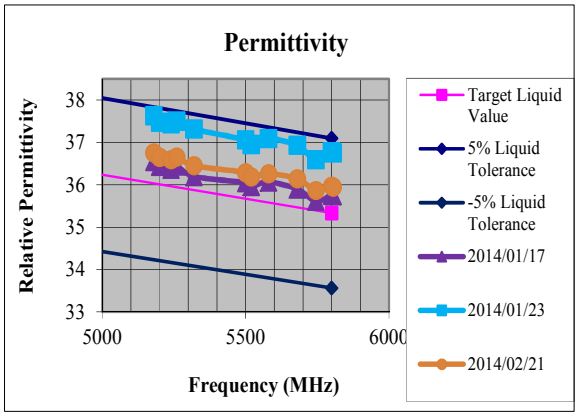


## 5000 MHz Head Liquid

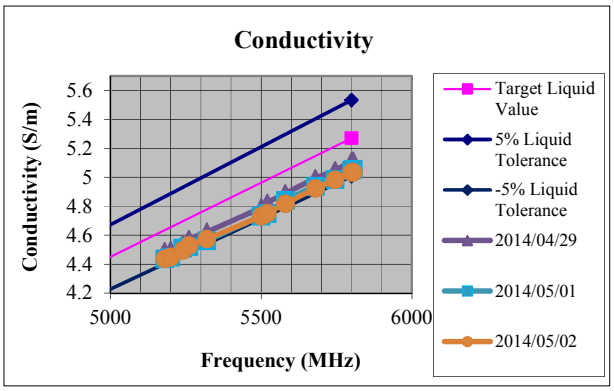
| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2014/01/17 | 21.5 | 5180 | 36.5531 | 4.5587 |
| | | 5200 | 36.436 | 4.5589 |
| | | 5240 | 36.3677 | 4.6446 |
| | | 5260 | 36.4427 | 4.6596 |
| | | 5320 | 36.1964 | 4.694 |
| | | 5500 | 36.0529 | 4.8395 |
| | | 5520 | 35.9606 | 4.8712 |
| | | 5580 | 36.0677 | 4.9787 |
| | | 5680 | 35.8992 | 5.0971 |
| | | 5745 | 35.6138 | 5.1179 |
| | | 5800 | 35.7671 | 5.1996 |
| | | 5805 | 35.7398 | 5.1941 |
| 2014/01/23 | 21.9 | 5180 | 37.6337 | 4.6917 |
| | | 5200 | 37.4754 | 4.6944 |
| | | 5240 | 37.4412 | 4.7891 |
| | | 5260 | 37.5053 | 4.8118 |
| | | 5320 | 37.3168 | 4.8399 |
| | | 5500 | 37.0615 | 4.987 |
| | | 5520 | 36.9514 | 5.0226 |
| | | 5580 | 37.0952 | 5.1325 |
| | | 5680 | 36.9309 | 5.2484 |
| | | 5745 | 36.5942 | 5.2675 |
| | | 5800 | 36.7796 | 5.3362 |
| | | 5805 | 36.7562 | 5.3308 |
| 2014/02/21 | 20.55 | 5180 | 36.754 | 4.5803 |
| | | 5200 | 36.6483 | 4.5911 |
| | | 5240 | 36.5968 | 4.6658 |
| | | 5260 | 36.6564 | 4.6851 |
| | | 5320 | 36.4549 | 4.7274 |
| | | 5500 | 36.2893 | 4.884 |
| | | 5520 | 36.1861 | 4.903 |
| | | 5580 | 36.2639 | 5.0108 |
| | | 5680 | 36.1446 | 5.1219 |
| | | 5745 | 35.8681 | 5.1502 |
| | | 5800 | 35.9737 | 5.2194 |
| | | 5805 | 35.9469 | 5.2173 |

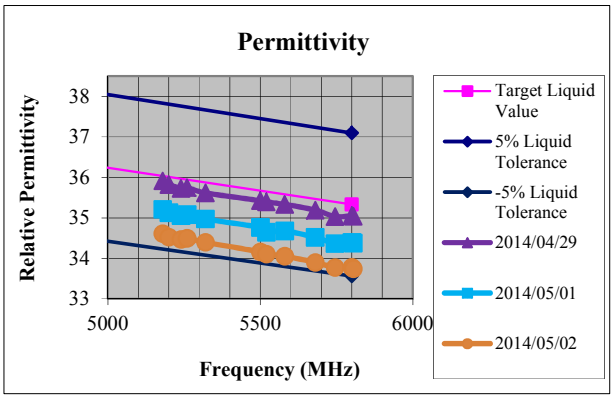


## 5000 MHz Head Liquid

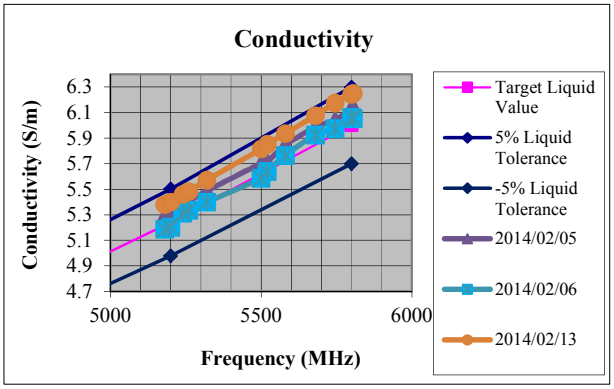
| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2014/04/29 | 20.8 | 5180 | 35.9122 | 4.4892 |
| | | 5200 | 35.8227 | 4.4972 |
| | | 5240 | 35.7308 | 4.538 |
| | | 5260 | 35.7478 | 4.573 |
| | | 5320 | 35.6162 | 4.623 |
| | | 5500 | 35.4243 | 4.7904 |
| | | 5520 | 35.3919 | 4.8236 |
| | | 5580 | 35.3335 | 4.8896 |
| | | 5680 | 35.1922 | 4.9921 |
| | | 5745 | 35.0323 | 5.0485 |
| | | 5800 | 35.0537 | 5.1116 |
| | | 5805 | 35.0405 | 5.1154 |
| 2014/05/01 | 21.3 | 5180 | 35.2101 | 4.437 |
| | | 5200 | 35.123 | 4.4474 |
| | | 5240 | 35.0547 | 4.5097 |
| | | 5260 | 35.0822 | 4.5206 |
| | | 5320 | 34.971 | 4.5628 |
| | | 5500 | 34.763 | 4.7326 |
| | | 5520 | 34.6429 | 4.749 |
| | | 5580 | 34.6737 | 4.8405 |
| | | 5680 | 34.5204 | 4.9374 |
| | | 5745 | 34.3635 | 4.9846 |
| | | 5800 | 34.3975 | 5.0513 |
| | | 5805 | 34.377 | 5.056 |
| 2014/05/02 | 21.8 | 5180 | 34.6119 | 4.4369 |
| | | 5200 | 34.5244 | 4.4492 |
| | | 5240 | 34.4654 | 4.4945 |
| | | 5260 | 34.4957 | 4.5285 |
| | | 5320 | 34.3962 | 4.574 |
| | | 5500 | 34.1594 | 4.7319 |
| | | 5520 | 34.1042 | 4.7525 |
| | | 5580 | 34.0539 | 4.8176 |
| | | 5680 | 33.8974 | 4.9231 |
| | | 5745 | 33.7718 | 4.9827 |
| | | 5800 | 33.7761 | 5.0342 |
| | | 5805 | 33.7409 | 5.0351 |

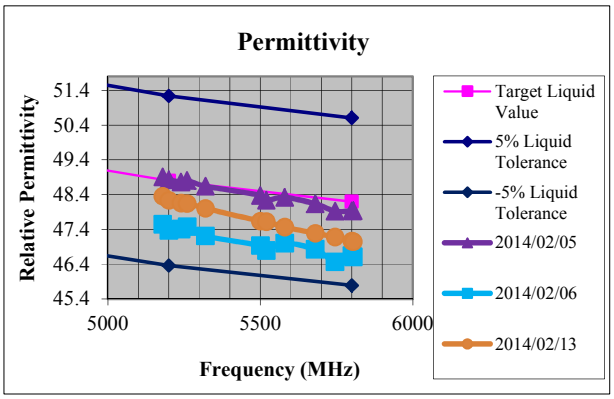


## 5000 MHz Body Liquid

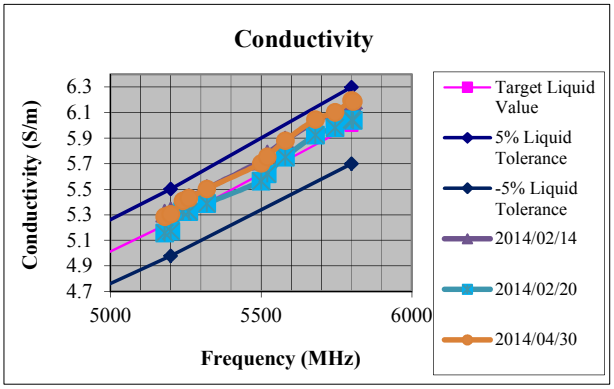
| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2014/02/05 | 20.43 | 5180 | 48.9146 | 5.2888 |
| | | 5200 | 48.8277 | 5.3054 |
| | | 5240 | 48.7671 | 5.3746 |
| | | 5260 | 48.8095 | 5.4038 |
| | | 5320 | 48.6453 | 5.4865 |
| | | 5500 | 48.3799 | 5.7023 |
| | | 5520 | 48.2387 | 5.714 |
| | | 5580 | 48.3227 | 5.845 |
| | | 5680 | 48.1401 | 5.987 |
| | | 5745 | 47.9282 | 6.0406 |
| | | 5800 | 47.9377 | 6.1358 |
| | | 5805 | 47.9359 | 6.1475 |
| 2014/02/06 | 20.81 | 5180 | 47.5485 | 5.1856 |
| | | 5200 | 47.3708 | 5.2012 |
| | | 5240 | 47.4125 | 5.3109 |
| | | 5260 | 47.4805 | 5.3352 |
| | | 5320 | 47.2131 | 5.3991 |
| | | 5500 | 46.9365 | 5.5853 |
| | | 5520 | 46.7971 | 5.6374 |
| | | 5580 | 47.004 | 5.7645 |
| | | 5680 | 46.8292 | 5.9248 |
| | | 5745 | 46.4689 | 5.9743 |
| | | 5800 | 46.6498 | 6.0608 |
| | | 5805 | 46.6109 | 6.0508 |
| 2014/02/13 | 20.6 | 5180 | 48.3569 | 5.3793 |
| | | 5200 | 48.2397 | 5.4001 |
| | | 5240 | 48.159 | 5.4593 |
| | | 5260 | 48.1482 | 5.4823 |
| | | 5320 | 48.0082 | 5.5716 |
| | | 5500 | 47.6395 | 5.8156 |
| | | 5520 | 47.6237 | 5.852 |
| | | 5580 | 47.4679 | 5.9356 |
| | | 5680 | 47.2931 | 6.0768 |
| | | 5745 | 47.1842 | 6.1754 |
| | | 5800 | 47.0665 | 6.2424 |
| | | 5805 | 47.0481 | 6.2503 |

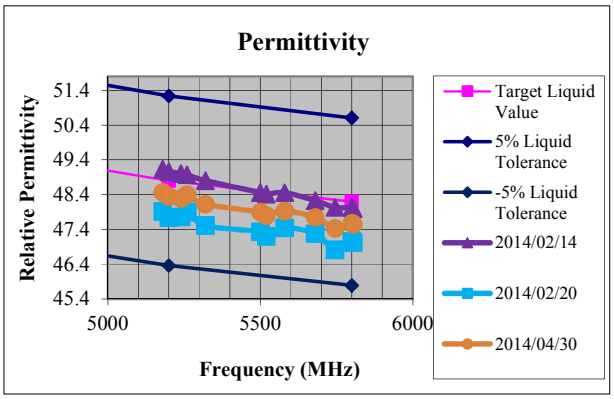


## 5000 MHz Body Liquid

| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2014/02/14 | 21.2 | 5180 | 49.1326 | 5.3124 |
| | | 5200 | 49.0629 | 5.3316 |
| | | 5240 | 49.0098 | 5.4136 |
| | | 5260 | 48.9704 | 5.4371 |
| | | 5320 | 48.8038 | 5.5057 |
| | | 5500 | 48.4627 | 5.7218 |
| | | 5520 | 48.4155 | 5.7773 |
| | | 5580 | 48.4566 | 5.8831 |
| | | 5680 | 48.2328 | 6.0301 |
| | | 5745 | 48.0326 | 6.1013 |
| | | 5800 | 48.0338 | 6.184 |
| | | 5805 | 48.0012 | 6.199 |
| 2014/02/20 | 21.05 | 5180 | 47.9191 | 5.1571 |
| | | 5200 | 47.7435 | 5.1707 |
| | | 5240 | 47.7575 | 5.3243 |
| | | 5260 | 47.8968 | 5.3231 |
| | | 5320 | 47.5108 | 5.3891 |
| | | 5500 | 47.3326 | 5.5618 |
| | | 5520 | 47.1999 | 5.6205 |
| | | 5580 | 47.4452 | 5.7522 |
| | | 5680 | 47.2803 | 5.9232 |
| | | 5745 | 46.8132 | 5.9814 |
| | | 5800 | 47.0517 | 6.0437 |
| | | 5805 | 47.0208 | 6.0398 |
| 2014/04/30 | 22 | 5180 | 48.4682 | 5.2852 |
| | | 5200 | 48.3479 | 5.304 |
| | | 5240 | 48.2936 | 5.4088 |
| | | 5260 | 48.4021 | 5.4314 |
| | | 5320 | 48.1255 | 5.503 |
| | | 5500 | 47.8984 | 5.7023 |
| | | 5520 | 47.8036 | 5.7537 |
| | | 5580 | 47.9278 | 5.8809 |
| | | 5680 | 47.7492 | 6.0467 |
| | | 5745 | 47.432 | 6.102 |
| | | 5800 | 47.583 | 6.1971 |
| | | 5805 | 47.5496 | 6.187 |



## Test Equipment

### SAR1 Lab

| Instrument description | Supplier / Manufacturer | Model | Serial No. | Calibration (date) | Calibration Due (date) |
|---|---|---|---|---|---|
| Robot | Staubli | TX90 | F10/5D3NA 1/A/01 | N/A | N/A |
| SAM Twin Phantom | SPEAG | SM 000 T01 DA | 1592 | N/A | N/A |
| Elliptical Phantom | SPEAG | QD OVA 001 BB | 1092 | N/A | N/A |
| Software | SPEAG | Dasy52.6.2.482 | N/A | N/A | N/A |
| Device Holder | SPEAG | SD 000H01 | N/A | N/A | N/A |

### SAR 3 Lab

| Instrument description | Supplier / Manufacturer | Model | Serial No. | Calibration (date) | Calibration Due (date) |
|---|---|---|---|---|---|
| Robot | Staubli | TX90 | F11/5G2MA 1/C/01 | N/A | N/A |
| SAM Twin Phantom | SPEAG | SM 000 T01 DA | 1637 | N/A | N/A |
| SAM Twin Phantom | SPEAG | SM 000 T01 DA | 1638 | N/A | N/A |
| Elliptical Phantom | SPEAG | QD OVA 001 BB | 1124 | N/A | N/A |
| Software | SPEAG | Dasy52.6.2.482 | N/A | N/A | N/A |
| Device Holder | SPEAG | SD 000H01 | N/A | N/A | N/A |

### SAR 4 Lab

| Instrument description | Supplier / Manufacturer | Model | Serial No. | Calibration (date) | Calibration Due (date) |
|---|---|---|---|---|---|
| Robot | Staubli | TX90 | F11/5GW9A 1/A/01 | N/A | N/A |
| SAM Twin Phantom | SPEAG | SM 000 T01 DA | 1639 | N/A | N/A |
| SAM Twin Phantom | SPEAG | SM 000 T01 DA | 1640 | N/A | N/A |
| Elliptical Phantom | SPEAG | QD OVA 001 BB | 1125 | N/A | N/A |
| Software | SPEAG | Dasy52.6.2.482 | N/A | N/A | N/A |
| Device Holder | SPEAG | SD 000H01 | N/A | N/A | N/A |

## Shared Equipment

| Instrument description | Supplier / Manufacturer | Model | Serial No. | Calibration (date) | Calibration Due (date) |
|---|---|---|---|---|---|
| 750 MHz Head Tissue Simulant | SPEAG | HSL 750 | 110524-3 | 2014/02/13 – 2014/02/24 | N/A |
| 750 MHz Body Tissue Simulant | SPEAG | MSL 750 | 110526-1 | 2014/02/12 – 2014/02/25 | N/A |
| 900 MHz Head Tissue Simulant | SPEAG | HSL 900 | 100922-1 | 2013/11/25 – 2014/02/22 | N/A |
| 900 MHz Body Tissue Simulant | SPEAG | MSL 900 | 110614-1 | 2013/12/02 – 2013/12/09 | N/A |
| 900 MHz Body Tissue Simulant | SPEAG | MSL 900 | 110518-7 | 2014/01/27 – 2014/02/22 | N/A |
| 1750 MHz Head Tissue Simulant | SPEAG | HSL 1750 | 100907-4 | 2013/11/26 – 2014/02/26 | N/A |
| 1750 MHz Body Tissue Simulant | SPEAG | MSL 1750 | 100824-2 | 2013/11/27 – 2014/04/21 | N/A |
| 1900 MHz Head Tissue Simulant | SPEAG | HSL 1900 | 110530-2 | 2013/12/02 – 2013/12/04 | N/A |
| 1900 MHz Head Tissue Simulant | SPEAG | HSL 1900 | 100907-3 | 1/21/2014 – 2014/01/22 | N/A |
| 1900 MHz Body Tissue Simulant | SPEAG | MSL 1900 | 110615-4 | 2013/12/04 – 2013/12/10 | N/A |
| 1900 MHz Body Tissue Simulant | SPEAG | MSL 1900 | 110530-3 | 2014/01/23 – 2014/02/25 | N/A |
| 1900 MHz Body Tissue Simulant | SPEAG | MSL 1900 | 100824-3 | 2014/04/28 | N/A |
| 2450 MHz Head Tissue Simulant | SPEAG | HSL 2450 | 110531-2 | 2013/12/17 – 2014/04/04 | N/A |
| 2450 MHz Body Tissue Simulant | SPEAG | MSL 2450 | 110530-1 | 2013/12/17 - | N/A |
| 2450 MHz Body Tissue Simulant | SPEAG | MSL 2450 | 100824-5 | 2014/04/03 – 2014/04/07 | N/A |
| 2550 MHz Head Tissue Simulant | SPEAG | HBBL 1900-3800 | 130605-2 | 2014/02/05 | N/A |
| 2550 MHz Body Tissue Simulant | SPEAG | MBBL 1900-3800 | 130604-1 | 2014/02/06 – 2014/04/22 | N/A |
| 5000 MHz Head Tissue Simulant | SPEAG | HSL 501 | 100901-1 | 2014/01/13 – 2014/05/02 | N/A |
| 5000 MHz Body Tissue Simulant | SPEAG | MSL 501 | 100823-1 | 2014/02/05 – 2014/05/01 | N/A |
| 750 MHz Dipole | SPEAG | D750V3 | 1090 | 2013/06/06 | 2014/06/06 |
| 835 MHz Dipole | SPEAG | D835V2 | 4d113 | 2012/11/05 | 2013/11/05 |
| 835 MHz Dipole | SPEAG | D835V2 | 4d155 | 2013/06/06 | 2014/06/06 |
| 1750 MHz Dipole | SPEAG | D1750V2 | 1045 | 2012/11/08 | 2013/11/08 |
| 1750 MHz Dipole | SPEAG | D1750V2 | 1094 | 2013/06/06 | 2014/06/06 |
| 1900 MHz Dipole | SPEAG | D1900V2 | 5d135 | 2012/11/06 | 2013/11/06 |
| 1900 MHz Dipole | SPEAG | D1900V2 | 5d172 | 2013/06/10 | 2014/06/10 |
| 2450 MHz Dipole | SPEAG | D2450V2 | 911 | 2013/06/07 | 2014/06/07 |
| 2550 MHz Dipole | SPEAG | D2550V2 | 1009 | 2013/06/07 | 2014/06/07 |
| 5000 MHz Dipole | SPEAG | D5GHzV2 | 1096 | 2012/11/13 | 2013/11/13 |
| 5000 MHz Dipole | SPEAG | D5GHzV2 | 1096 | 2014/04/15 | 2015/04/15 |
| 5000 MHz Dipole | SPEAG | D5GHzV2 | 1154 | 2013/06/04 | 2014/06/04 |

| Instrument description | Supplier / Manufacturer | Model | Serial No. | Calibration (date) | Calibration Due (date) |
|---|---|---|---|---|---|
| Data Acquisition Electronics | SPEAG | DAE4 | 1233 | 2012/11/06 | 2014/03/16 |
| Data Acquisition Electronics | SPEAG | DAE4 | 1233 | 2014/03/17 | 2015/03/17 |
| Data Acquisition Electronics | SPEAG | DAE4 | 1265 | 2013/06/11 | 2014/01/28 |
| Data Acquisition Electronics | SPEAG | DAE4 | 1265 | 2014/01/29 | 2015/01/29 |
| Data Acquisition Electronics | SPEAG | DAE4 | 1266 | 2013/08/15 | 2014/08/15 |
| Data Acquisition Electronics | SPEAG | DAE4 | 1375 | 2013/06/10 | 2014/06/10 |
| SAR Probe | SPEAG | ES3DV3 | 3260 | 2013/06/19 | 2014/03/18 |
| SAR Probe | SPEAG | ES3DV3 | 3260 | 2014/03/19 | 2015/03/19 |
| SAR Probe | SPEAG | ES3DV3 | 3323 | 2013/06/12 | 2014/06/12 |
| SAR Probe | SPEAG | EX3DV4 | 3739 | 2014/03/18 | 2015/03/18 |
| SAR Probe | SPEAG | EX3DV4 | 3771 | 2013/06/14 | 2014/03/17 |
| SAR Probe | SPEAG | EX3DV4 | 3771 | 2014/03/18 | 2015/03/18 |
| Network Analyzer | Agilent | FieldFox N9923A | MY51491621 | 2013/06/21 | 2014/06/21 |
| Directional coupler | Werlatone | C6529 | 11249 | N/A | N/A |
| RF Amplifier | Vectawave | VTL5400 | N/A | N/A | N/A |
| Dielectric Measurement Kit | SPEAG | DAK-3.5 | 1023 | 2013/08/13 | 2014/08/13 |
| Synthesized CW Generator | Agilent | 8371213 | US37101255 | N/A | N/A |
| Power Meter | Agilent | E4419B | MY45101996 | 2013/06/03 | 2015/06/03 |
| Power Sensor | Agilent | E9300A | MY41498484 | 2013/06/04 | 2015/06/04 |
| Power Sensor | Agilent | E9300A | MY41498492 | 2013/06/04 | 2015/06/04 |
| Radio Communications Tester | Rohde & Schwarz | CMU 200 | 101821 | 2013/06 | 2015/06 |
| Radio Communications Tester | Rohde & Schwarz | CMU 200 | 109879 | 2013/06 | 2015/06 |
| Radio Communications Tester | Rohde & Schwarz | CMU 200 | 110759 | 2013/06 | 2015/06 |
| Radio Communications Tester | Rohde & Schwarz | CMW500 | 109825 | 2013/06 | 2015/06 |

NOTES:

1. Calibrations with calibration due dates before May 2, 2014 are not used after the calibration due date.

# Equipment Calibration/Performance Documents:

*Attached:*
*SAR Probe ES3DV3 Calibration Report*
*SAR Probe EX3DV4 Calibration Report*

**Calibration Laboratory of**
Schmid & Partner
Engineering AG
**Zeughausstrasse 43, 8004 Zurich, Switzerland**

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
S Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
**The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates**

Accreditation No.: **SCS 108**

Client **Cetecom USA** Certificate No: **ES3-3260_Jun13**

# CALIBRATION CERTIFICATE

Object ES3DV3 - SN:3260

Calibration procedure(s) QA CAL-01.v8, QA CAL-14.v3, QA CAL-23.v4, QA CAL-25.v4
Calibration procedure for dosimetric E-field probes

Calibration date: June 19, 2013

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter E4419B | GB41293874 | 04-Apr-13 (No. 217-01733) | Apr-14 |
| Power sensor E4412A | MY41498087 | 04-Apr-13 (No. 217-01733) | Apr-14 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 04-Apr-13 (No. 217-01737) | Apr-14 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 04-Apr-13 (No. 217-01735) | Apr-14 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 04-Apr-13 (No. 217-01736) | Apr-14 |
| Reference Probe ES3DV2 | SN: 3013 | 28-Dec-12 (No. ES3-3013_Dec12) | Dec-13 |
| DAE4 | SN: 660 | 31-Jan-13 (No. DAE4-660_Jan13) | Jan-14 |
| | | | |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| RF generator HP 8648C | US3642U01700 | 4-Aug-99 (in house check Apr-13) | in house check: Apr-15 |
| Network Analyzer HP 8753E | US37390585 | 18-Oct-01 (in house check Oct-12) | in house check: Oct-13 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Israe El-Naouq | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: June 19, 2013

**Calibration Laboratory of**
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
S Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

## Glossary:

| | |
|---|---|
| TSL | tissue simulating liquid |
| NORMx,y,z | sensitivity in free space |
| ConvF | sensitivity in TSL / NORMx,y,z |
| DCP | diode compression point |
| CF | crest factor (1/duty_cycle) of the RF signal |
| A, B, C, D | modulation dependent linearization parameters |
| Polarization φ | φ rotation around probe axis |
| Polarization ϑ | ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis |

## Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005

## Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the $E^2$-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConvF*.
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- *PAR:* PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z:* A, B, C, D are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- *ConvF and Boundary Effect Parameters:* Assessed in flat phantom using E-field (or Temperature Transfer Standard for f ≤ 800 MHz) and inside waveguide using analytical field distributions based on power measurements for f > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to *NORMx,y,z * ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- *Spherical isotropy (3D deviation from isotropy):* in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *Sensor Offset:* The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.

# Probe ES3DV3

## SN:3260

Manufactured: January 25, 2010
Calibrated: June 19, 2013

Calibrated for DASY/EASY Systems
(Note: non-compatible with DASY2 system!)

ES3DV3– SN:3260 June 19, 2013

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3260

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm ($\mu V/(V/m)^2$)[A] | 1.28 | 1.36 | 1.17 | ± 10.1 % |
| DCP (mV)[B] | 102.5 | 102.9 | 101.5 | |

## Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB√μV | C | D dB | VR mV | Unc[E] (k=2) |
|---|---|---|---|---|---|---|---|---|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 160.4 | ±3.5 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 167.4 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 159.1 | |
| 10011-CAA | UMTS-FDD (WCDMA) | X | 3.32 | 66.9 | 18.5 | 2.91 | 129.2 | ±0.9 % |
| | | Y | 3.48 | 68.0 | 19.1 | | 133.6 | |
| | | Z | 3.37 | 67.2 | 18.7 | | 127.3 | |
| 10012-CAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps) | X | 3.63 | 71.8 | 20.2 | 1.87 | 132.6 | ±0.7 % |
| | | Y | 3.41 | 71.0 | 19.8 | | 135.8 | |
| | | Z | 3.56 | 71.5 | 20.1 | | 131.1 | |
| 10021-DAA | GSM-FDD (TDMA, GMSK) | X | 27.70 | 99.4 | 29.0 | 9.39 | 128.0 | ±1.4 % |
| | | Y | 24.74 | 98.2 | 28.1 | | 115.2 | |
| | | Z | 26.19 | 99.6 | 29.1 | | 114.0 | |
| 10024-DAA | GPRS-FDD (TDMA, GMSK, TN 0-1) | X | 39.94 | 99.6 | 26.2 | 6.56 | 147.9 | ±1.7 % |
| | | Y | 39.52 | 99.6 | 25.7 | | 143.3 | |
| | | Z | 38.75 | 99.9 | 26.2 | | 132.6 | |
| 10027-DAA | GPRS-FDD (TDMA, GMSK, TN 0-1-2) | X | 53.95 | 99.9 | 24.4 | 4.80 | 104.7 | ±1.9 % |
| | | Y | 54.17 | 100.0 | 24.1 | | 106.3 | |
| | | Z | 48.18 | 100.0 | 24.7 | | 144.1 | |
| 10028-DAA | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3) | X | 48.51 | 99.8 | 23.9 | 3.55 | 108.4 | ±1.9 % |
| | | Y | 65.79 | 99.8 | 22.7 | | 109.9 | |
| | | Z | 46.79 | 99.8 | 23.9 | | 102.2 | |
| 10080-CAB | CDMA2000 (1xEV-DO, 153.6 kbps) | X | 4.45 | 66.6 | 18.9 | 4.22 | 129.6 | ±0.7 % |
| | | Y | 4.52 | 67.0 | 19.0 | | 138.0 | |
| | | Z | 4.42 | 66.4 | 18.8 | | 124.4 | |
| 10081-CAA | CDMA2000 (1xRTT, RC3) | X | 3.99 | 66.1 | 18.6 | 3.97 | 126.6 | ±0.7 % |
| | | Y | 4.11 | 66.6 | 18.9 | | 134.9 | |
| | | Z | 4.04 | 66.3 | 18.7 | | 121.7 | |
| 10100-CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 6.78 | 68.7 | 20.5 | 5.67 | 145.1 | ±1.2 % |
| | | Y | 6.13 | 66.3 | 19.1 | | 108.4 | |
| | | Z | 6.70 | 68.4 | 20.3 | | 139.2 | |
| 10106-CAB | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 6.66 | 68.3 | 20.4 | 5.80 | 142.9 | ±1.2 % |
| | | Y | 6.06 | 66.0 | 19.0 | | 107.8 | |
| | | Z | 6.57 | 67.9 | 20.2 | | 136.7 | |

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| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10154-CAB | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 6.31 | 67.6 | 20.1 | 5.75 | 139.4 | ±1.2 % |
| | | Y | 5.80 | 65.6 | 18.9 | | 106.0 | |
| | | Z | 6.24 | 67.2 | 19.9 | | 133.9 | |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 5.16 | 66.9 | 19.8 | 5.73 | 123.1 | ±0.9 % |
| | | Y | 5.16 | 67.0 | 19.8 | | 130.4 | |
| | | Z | 5.12 | 66.7 | 19.8 | | 118.2 | |
| 10175-CAB | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 5.17 | 66.9 | 19.9 | 5.72 | 122.8 | ±0.9 % |
| | | Y | 5.13 | 66.9 | 19.8 | | 130.1 | |
| | | Z | 5.18 | 67.0 | 19.9 | | 118.9 | |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 6.68 | 68.3 | 20.4 | 5.81 | 142.7 | ±1.2 % |
| | | Y | 6.11 | 66.1 | 19.1 | | 107.3 | |
| | | Z | 6.60 | 67.9 | 20.2 | | 143.5 | |

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

[A] The uncertainties of NormX,Y,Z do not affect the $E^2$-field uncertainty inside TSL (see Pages 6 and 7).
[B] Numerical linearization parameter: uncertainty not required.
[C] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

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# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3260

## Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha | Depth (mm) | Unct. (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 41.9 | 0.89 | 6.59 | 6.59 | 6.59 | 0.48 | 1.48 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 6.33 | 6.33 | 6.33 | 0.73 | 1.15 | ± 12.0 % |
| 900 | 41.5 | 0.97 | 6.29 | 6.29 | 6.29 | 0.50 | 1.36 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 5.47 | 5.47 | 5.47 | 0.60 | 1.29 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 5.32 | 5.32 | 5.32 | 0.65 | 1.28 | ± 12.0 % |
| 1950 | 40.0 | 1.40 | 5.16 | 5.16 | 5.16 | 0.80 | 1.17 | ± 12.0 % |
| 2300 | 39.5 | 1.67 | 4.82 | 4.82 | 4.82 | 0.73 | 1.22 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 4.50 | 4.50 | 4.50 | 0.76 | 1.28 | ± 12.0 % |
| 2550 | 39.1 | 1.91 | 4.36 | 4.36 | 4.36 | 0.80 | 1.24 | ± 12.0 % |

[C] Frequency validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

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# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3260

## Calibration Parameter Determined in Body Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha | Depth (mm) | Unct. (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 55.5 | 0.96 | 6.41 | 6.41 | 6.41 | 0.80 | 1.17 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 6.29 | 6.29 | 6.29 | 0.45 | 1.56 | ± 12.0 % |
| 900 | 55.0 | 1.05 | 6.20 | 6.20 | 6.20 | 0.34 | 1.90 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 5.10 | 5.10 | 5.10 | 0.47 | 1.66 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 4.85 | 4.85 | 4.85 | 0.45 | 1.67 | ± 12.0 % |
| 1950 | 53.3 | 1.52 | 4.99 | 4.99 | 4.99 | 0.58 | 1.43 | ± 12.0 % |
| 2300 | 52.9 | 1.81 | 4.54 | 4.54 | 4.54 | 0.67 | 1.35 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 4.34 | 4.34 | 4.34 | 0.68 | 1.14 | ± 12.0 % |
| 2550 | 52.6 | 2.09 | 4.28 | 4.28 | 4.28 | 0.66 | 1.16 | ± 12.0 % |

[C] Frequency validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

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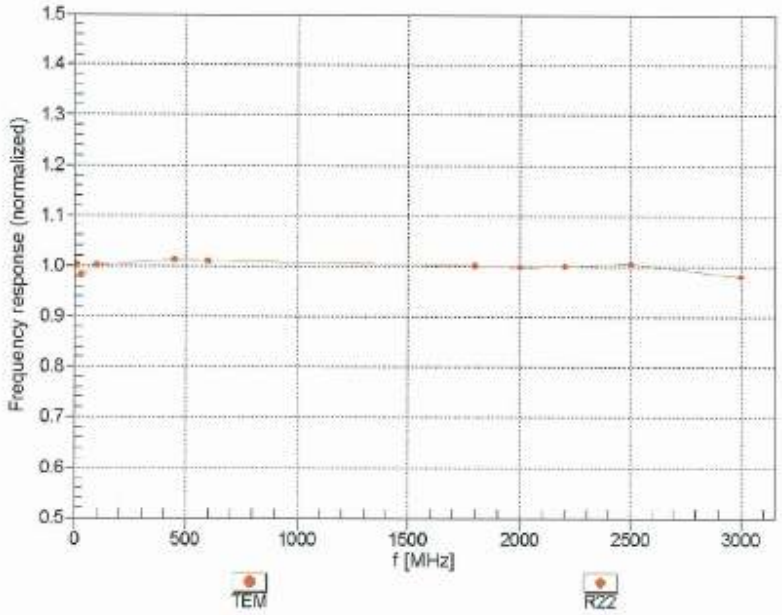
## Frequency Response of E-Field
(TEM-Cell:ifi110 EXX, Waveguide: R22)




Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)

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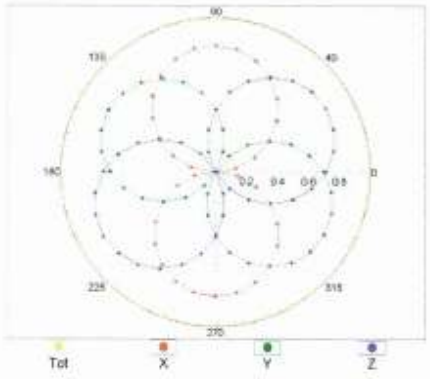
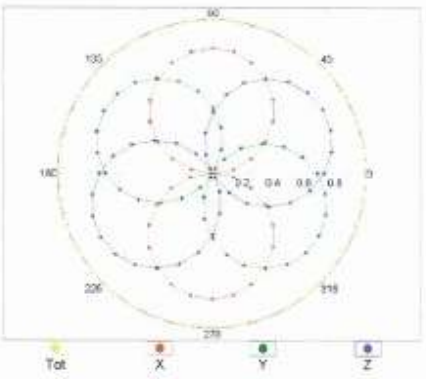
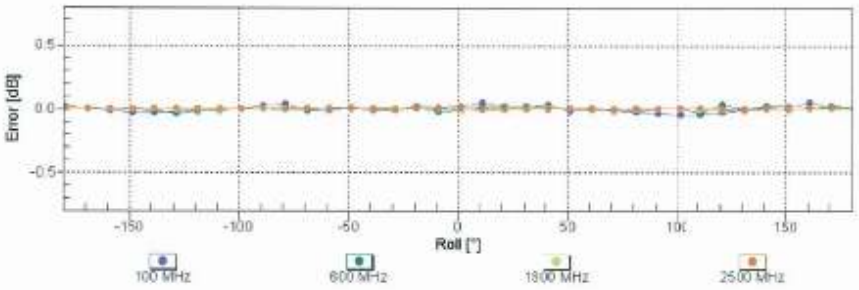
## Receiving Pattern (ϕ), ϑ = 0°

f=600 MHz,TEM




f=1800 MHz,R22

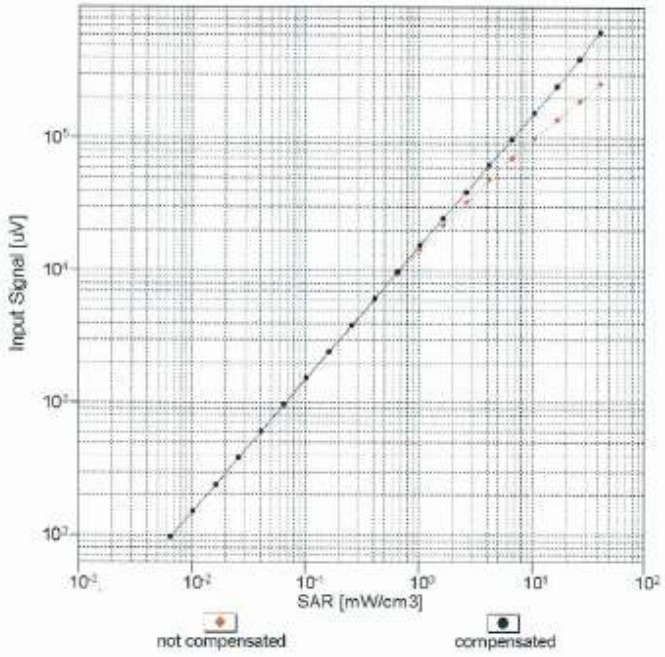


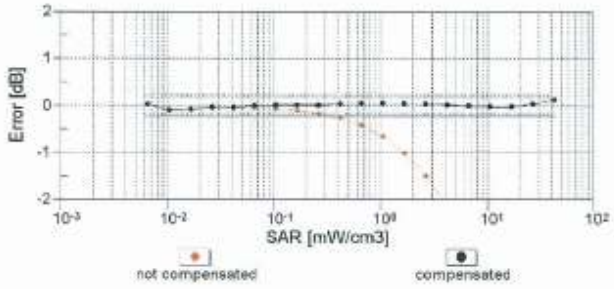




**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

ES3DV3– SN:3260 June 19, 2013

## Dynamic Range f($SAR_{head}$)
(TEM cell , f = 900 MHz)



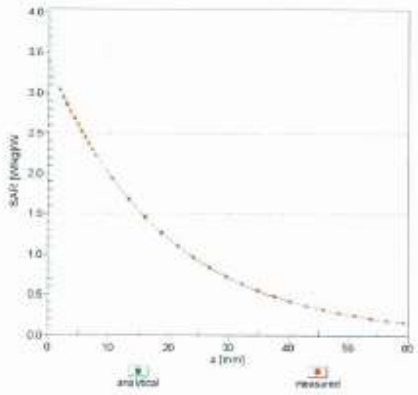




**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**

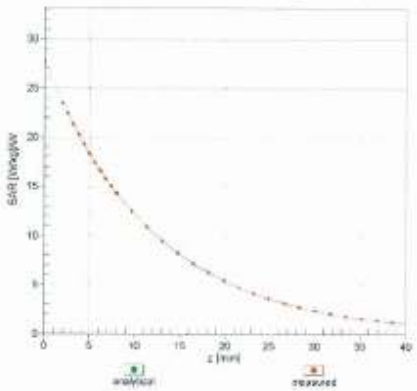
ES3DV3– SN:3260 June 19, 2013

## Conversion Factor Assessment

f = 835 MHz,WGLS R9 (H_convF)

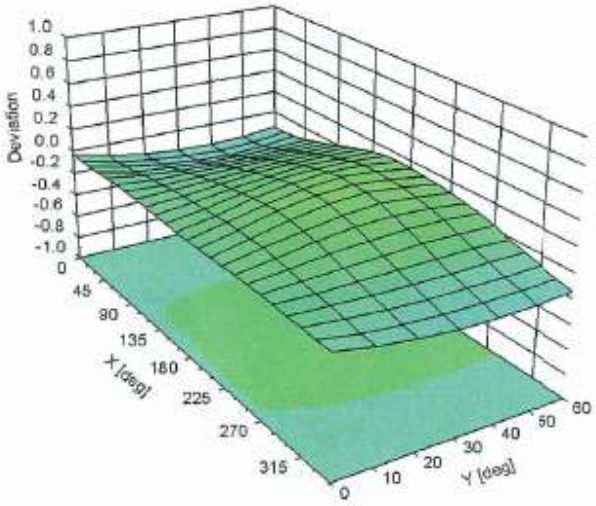



f = 1900 MHz,WGLS R22 (H_convF)




## Deviation from Isotropy in Liquid

Error (ϕ, ϑ), f = 900 MHz





Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3260

## Other Probe Parameters

| | |
|---|---|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | -68.8 |
| Mechanical Surface Detection Mode | enabled |
| Optical Surface Detection Mode | disabled |
| Probe Overall Length | 337 mm |
| Probe Body Diameter | 10 mm |
| Tip Length | 10 mm |
| Tip Diameter | 4 mm |
| Probe Tip to Sensor X Calibration Point | 2 mm |
| Probe Tip to Sensor Y Calibration Point | 2 mm |
| Probe Tip to Sensor Z Calibration Point | 2 mm |
| Recommended Measurement Distance from Surface | 3 mm |

**Calibration Laboratory of**
Schmid & Partner
Engineering AG
**Zeughausstrasse 43, 8004 Zurich, Switzerland**

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Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
**The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates**

Accreditation No.: **SCS 108**

Client **Cetecom USA** Certificate No: **ES3-3260_Mar14**

# CALIBRATION CERTIFICATE

Object ES3DV3 - SN:3260

Calibration procedure(s) QA CAL-01.v9, QA CAL-23.v5, QA CAL-25.v6
Calibration procedure for dosimetric E-field probes

Calibration date: March 19, 2014

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter E4419B | GB41293874 | 04-Apr-13 (No. 217-01733) | Apr-14 |
| Power sensor E4412A | MY41498087 | 04-Apr-13 (No. 217-01733) | Apr-14 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 04-Apr-13 (No. 217-01737) | Apr-14 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 04-Apr-13 (No. 217-01735) | Apr-14 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 04-Apr-13 (No. 217-01738) | Apr-14 |
| Reference Probe ES3DV2 | SN: 3013 | 30-Dec-13 (No. ES3-3013_Dec13) | Dec-14 |
| DAE4 | SN: 660 | 13-Dec-13 (No. DAE4-660_Dec13) | Dec-14 |
| | | | |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| RF generator HP 8648C | US3642U01700 | 4-Aug-99 (in house check Apr-13) | In house check: Apr-16 |
| Network Analyzer HP 8753E | US37390585 | 18-Oct-01 (in house check Oct-13) | In house check: Oct-14 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Claudio Leubler | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: March 20, 2014

**Calibration Laboratory of**
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
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The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 108

## Glossary:

| | |
|---|---|
| TSL | tissue simulating liquid |
| NORMx,y,z | sensitivity in free space |
| ConvF | sensitivity in TSL / NORMx,y,z |
| DCP | diode compression point |
| CF | crest factor (1/duty_cycle) of the RF signal |
| A, B, C, D | modulation dependent linearization parameters |
| Polarization φ | φ rotation around probe axis |
| Polarization ϑ | ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis |
| Connector Angle | information used in DASY system to align probe sensor X to the robot coordinate system |

## Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005

## Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the $E^2$-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConvF*.
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- *PAR:* PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z: A, B, C, D* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- *ConvF and Boundary Effect Parameters:* Assessed in flat phantom using E-field (or Temperature Transfer Standard for f ≤ 800 MHz) and inside waveguide using analytical field distributions based on power measurements for f > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to *NORMx,y,z * ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- *Spherical isotropy (3D deviation from isotropy):* in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *Sensor Offset:* The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- *Connector Angle:* The angle is assessed using the information gained by determining the *NORMx* (no uncertainty required).

# Probe ES3DV3

## SN:3260

Manufactured: January 25, 2010
Calibrated: March 19, 2014

Calibrated for DASY/EASY Systems
(Note: non-compatible with DASY2 system!)

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3260

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm ($\mu V/(V/m)^2$)[A] | 1.30 | 1.37 | 1.18 | ± 10.1 % |
| DCP (mV)[B] | 104.8 | 102.1 | 104.2 | |

## Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB√μV | C | D dB | VR mV | Unc[E] (k=2) |
|---|---|---|---|---|---|---|---|---|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 211.8 | ±3.3 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 195.7 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 208.8 | |
| 10011-CAB | UMTS-FDD (WCDMA) | X | 3.31 | 67.4 | 18.8 | 2.91 | 127.8 | ±0.7 % |
| | | Y | 3.40 | 67.4 | 18.7 | | 134.6 | |
| | | Z | 3.34 | 67.6 | 18.8 | | 145.4 | |
| 10021-DAB | GSM-FDD (TDMA, GMSK) | X | 30.39 | 99.4 | 28.9 | 9.39 | 135.6 | ±1.9 % |
| | | Y | 28.56 | 99.7 | 28.9 | | 131.2 | |
| | | Z | 29.91 | 99.6 | 28.7 | | 119.9 | |
| 10024-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1) | X | 44.86 | 99.9 | 26.3 | 6.56 | 123.6 | ±1.4 % |
| | | Y | 44.01 | 99.9 | 25.9 | | 126.4 | |
| | | Z | 42.79 | 99.7 | 26.1 | | 147.0 | |
| 10027-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2) | X | 53.01 | 99.7 | 24.7 | 4.80 | 130.0 | ±1.7 % |
| | | Y | 50.58 | 99.6 | 24.5 | | 137.2 | |
| | | Z | 52.82 | 99.6 | 24.4 | | 123.5 | |
| 10028-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3) | X | 59.40 | 99.6 | 23.5 | 3.55 | 137.7 | ±1.7 % |
| | | Y | 59.13 | 99.9 | 23.3 | | 140.0 | |
| | | Z | 56.71 | 99.7 | 23.4 | | 126.5 | |
| 10081-CAB | CDMA2000 (1xRTT, RC3) | X | 4.12 | 67.1 | 19.1 | 3.97 | 149.5 | ±0.7 % |
| | | Y | 4.00 | 66.0 | 18.4 | | 131.8 | |
| | | Z | 4.09 | 67.0 | 19.1 | | 146.9 | |
| 10100-CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 6.60 | 68.2 | 20.1 | 5.67 | 144.1 | ±1.2 % |
| | | Y | 6.35 | 67.0 | 19.4 | | 125.9 | |
| | | Z | 6.59 | 68.2 | 20.1 | | 141.7 | |
| 10103-CAB | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 12.38 | 77.7 | 26.5 | 9.29 | 127.9 | ±3.0 % |
| | | Y | 12.64 | 78.8 | 27.1 | | 136.2 | |
| | | Z | 12.27 | 78.1 | 26.9 | | 122.6 | |
| 10108-CAB | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 6.50 | 67.8 | 20.0 | 5.80 | 142.8 | ±1.2 % |
| | | Y | 6.34 | 66.9 | 19.5 | | 126.4 | |
| | | Z | 6.47 | 67.7 | 20.0 | | 140.9 | |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 11.69 | 76.9 | 26.3 | 9.28 | 122.6 | ±3.3 % |
| | | Y | 11.83 | 77.7 | 26.7 | | 130.6 | |
| | | Z | 13.11 | 80.6 | 28.1 | | 149.4 | |
| 10154-CAB | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 6.18 | 67.2 | 19.7 | 5.75 | 139.6 | ±1.4 % |
| | | Y | 6.25 | 67.2 | 19.7 | | 146.4 | |
| | | Z | 6.11 | 67.0 | 19.6 | | 138.3 | |

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| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 5.19 | 67.1 | 19.8 | 5.73 | 143.7 | ±1.2 % |
| | | Y | 5.26 | 67.3 | 19.9 | | 149.8 | |
| | | Z | 5.20 | 67.2 | 19.9 | | 143.3 | |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 13.41 | 86.4 | 30.9 | 9.21 | 138.5 | ±3.3 % |
| | | Y | 10.53 | 80.4 | 28.2 | | 121.8 | |
| | | Z | 12.56 | 85.1 | 30.3 | | 139.6 | |
| 10175-CAB | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 5.20 | 67.1 | 19.9 | 5.72 | 139.5 | ±1.2 % |
| | | Y | 5.10 | 66.5 | 19.5 | | 130.7 | |
| | | Z | 5.14 | 66.9 | 19.8 | | 139.8 | |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 6.44 | 67.5 | 19.9 | 5.8[F] | 136.9 | ±1.2 % |
| | | Y | 6.34 | 66.9 | 19.5 | | 127.4 | |
| | | Z | 6.44 | 67.6 | 19.9 | | 140.9 | |
| 10403-AAB | CDMA2000 (1xEV-DO, Rev. 0) | X | 4.64 | 66.9 | 18.3 | 3.76 | 131.9 | ±0.7 % |
| | | Y | 4.81 | 67.4 | 18.5 | | 143.6 | |
| | | Z | 4.68 | 67.1 | 18.4 | | 135.2 | |

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

[A] The uncertainties of NormX,Y,Z do not affect the $E^2$-field uncertainty inside TSL (see Pages 6 and 7).
[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3260

## Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unct. (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 41.9 | 0.89 | 6.47 | 6.47 | 6.47 | 0.80 | 1.12 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 6.25 | 6.25 | 6.25 | 0.31 | 1.77 | ± 12.0 % |
| 900 | 41.5 | 0.97 | 6.19 | 6.19 | 6.19 | 0.57 | 1.31 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 5.49 | 5.49 | 5.49 | 0.41 | 1.64 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 5.47 | 5.47 | 5.47 | 0.80 | 1.16 | ± 12.0 % |
| 1950 | 40.0 | 1.40 | 5.28 | 5.28 | 5.28 | 0.65 | 1.32 | ± 12.0 % |
| 2300 | 39.5 | 1.67 | 4.88 | 4.88 | 4.88 | 0.80 | 1.30 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 4.56 | 4.56 | 4.56 | 0.80 | 1.24 | ± 12.0 % |
| 2550 | 39.1 | 1.91 | 4.41 | 4.41 | 4.41 | 0.71 | 1.36 | ± 12.0 % |

[C] Frequency validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

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# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3260

## Calibration Parameter Determined in Body Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unct. (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 55.5 | 0.96 | 6.22 | 6.22 | 6.22 | 0.34 | 1.88 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 6.14 | 6.14 | 6.14 | 0.37 | 1.79 | ± 12.0 % |
| 900 | 55.0 | 1.05 | 6.02 | 6.02 | 6.02 | 0.56 | 1.38 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 4.90 | 4.90 | 4.90 | 0.56 | 1.48 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 4.69 | 4.69 | 4.69 | 0.60 | 1.45 | ± 12.0 % |
| 1950 | 53.3 | 1.52 | 4.81 | 4.81 | 4.81 | 0.54 | 1.58 | ± 12.0 % |
| 2300 | 52.9 | 1.81 | 4.42 | 4.42 | 4.42 | 0.80 | 1.22 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 4.26 | 4.26 | 4.26 | 0.68 | 1.12 | ± 12.0 % |
| 2550 | 52.6 | 2.09 | 4.15 | 4.15 | 4.15 | 0.80 | 1.01 | ± 12.0 % |

[C] Frequency validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

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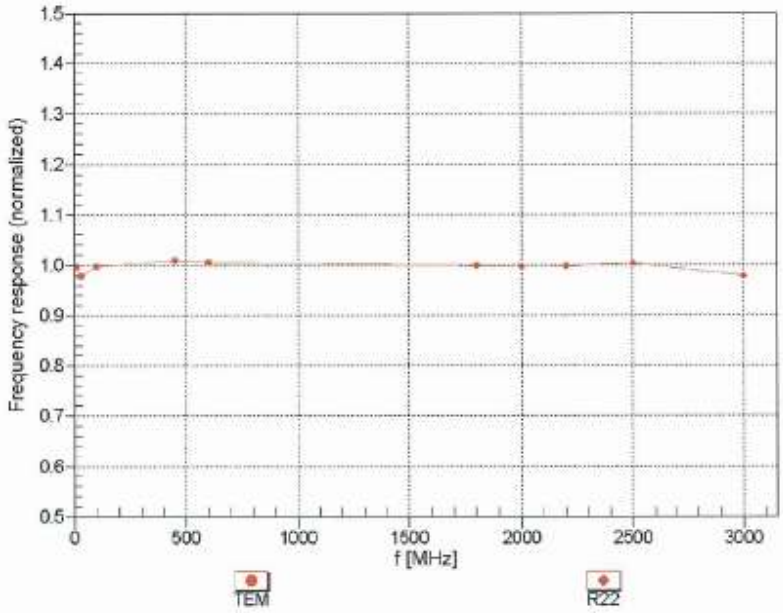
## Frequency Response of E-Field
(TEM-Cell:ifi110 EXX, Waveguide: R22)




Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)

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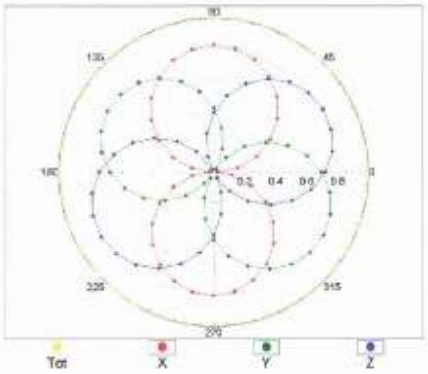
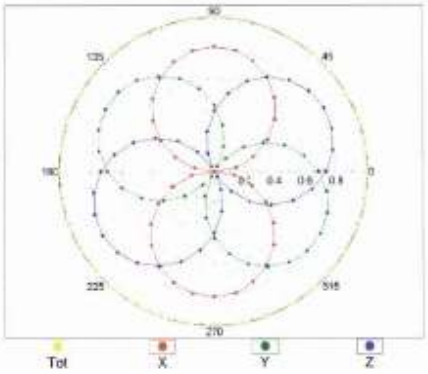
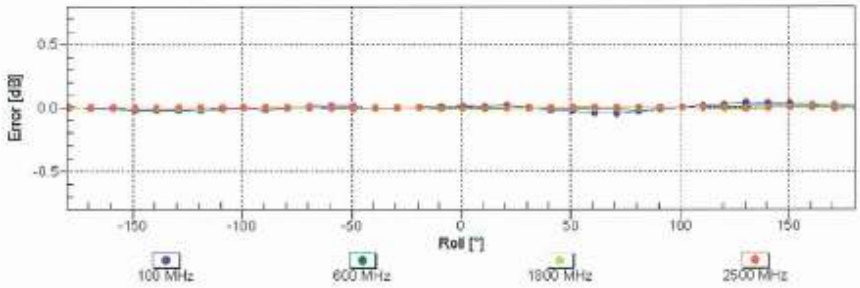
## Receiving Pattern (ϕ), ϑ = 0°

f=600 MHz,TEM




f=1800 MHz,R22




**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

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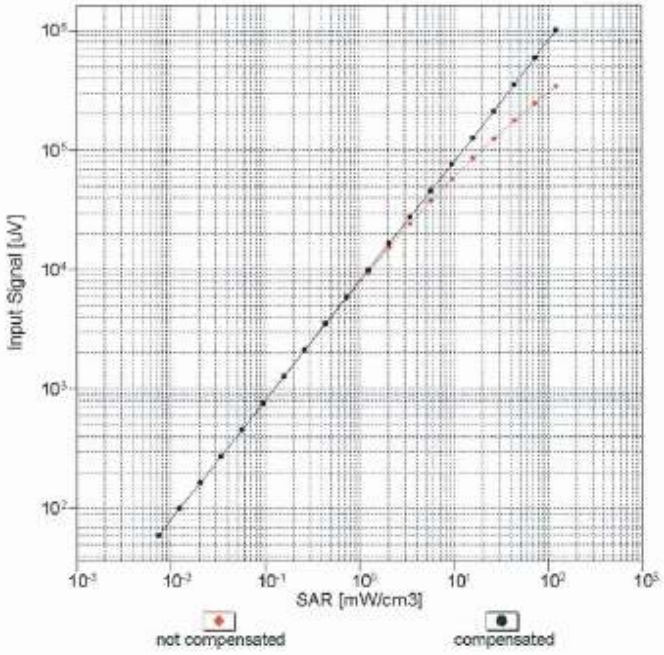
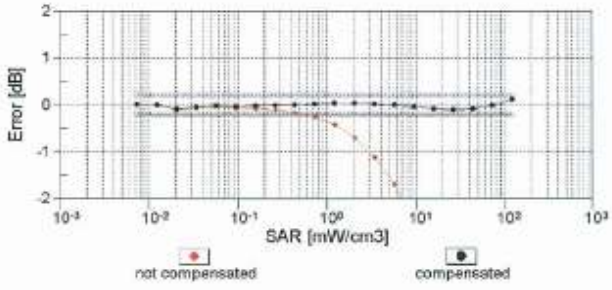
## Dynamic Range f($SAR_{head}$)
(TEM cell , $f_{eval}$= 1900 MHz)




**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**

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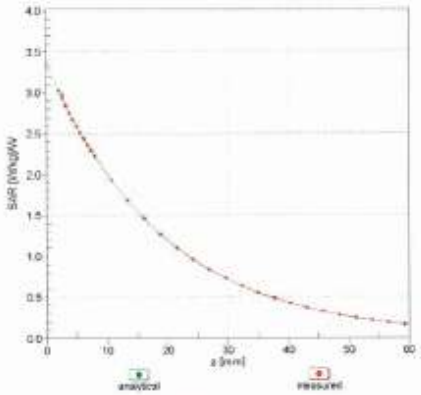
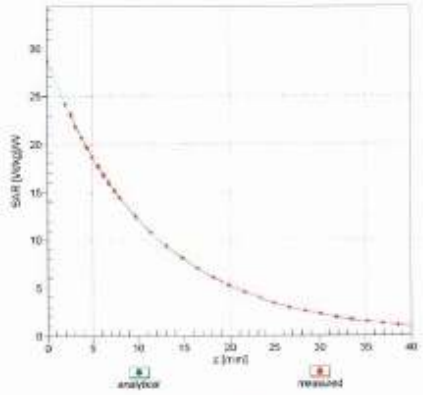
## Conversion Factor Assessment

f = 835 MHz,WGLS R9 (H_convF)

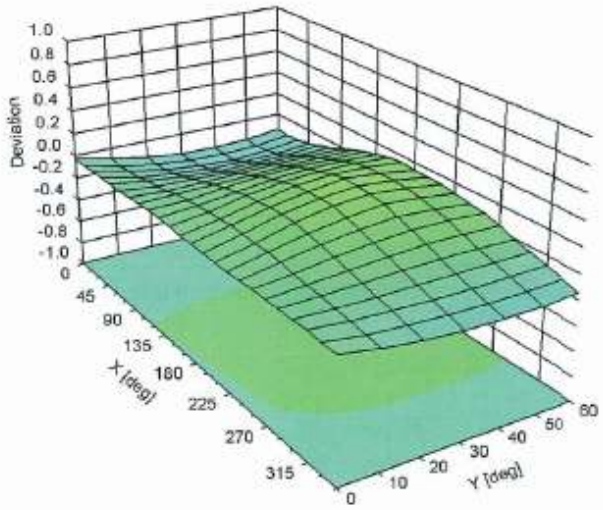



f = 1900 MHz,WGLS R22 (H_convF)




## Deviation from Isotropy in Liquid

**Error (ϕ, ϑ), f = 900 MHz**





**Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)**

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3260

### Other Probe Parameters

| | |
|---|---|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | -79.1 |
| Mechanical Surface Detection Mode | enabled |
| Optical Surface Detection Mode | disabled |
| Probe Overall Length | 337 mm |
| Probe Body Diameter | 10 mm |
| Tip Length | 10 mm |
| Tip Diameter | 4 mm |
| Probe Tip to Sensor X Calibration Point | 2 mm |
| Probe Tip to Sensor Y Calibration Point | 2 mm |
| Probe Tip to Sensor Z Calibration Point | 2 mm |
| Recommended Measurement Distance from Surface | 3 mm |

**Calibration Laboratory of**
Schmid & Partner
Engineering AG
**Zeughausstrasse 43, 8004 Zurich, Switzerland**

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
**The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates**

**Accreditation No.: SCS 108**

Client **Cetecom USA**

**Certificate No: ES3-3323_Jun13**

# CALIBRATION CERTIFICATE

Object ES3DV3 - SN:3323

Calibration procedure(s) QA CAL-01.v8, QA CAL-23.v4, QA CAL-25.v4
Calibration procedure for dosimetric E-field probes

Calibration date: June 12, 2013

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter E4419B | GB41293874 | 04-Apr-13 (No. 217-01733) | Apr-14 |
| Power sensor E4412A | MY41498087 | 04-Apr-13 (No. 217-01733) | Apr-14 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 04-Apr-13 (No. 217-01737) | Apr-14 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 04-Apr-13 (No. 217-01735) | Apr-14 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 04-Apr-13 (No. 217-01738) | Apr-14 |
| Reference Probe ES3DV2 | SN: 3013 | 28-Dec-12 (No. ES3-3013_Dec12) | Dec-13 |
| DAE4 | SN: 660 | 31-Jan-13 (No. DAE4-660_Jan13) | Jan-14 |
| | | | |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| RF generator HP 8648C | US3642U01700 | 4-Aug-99 (in house check Apr-13) | In house check: Apr-15 |
| Network Analyzer HP 8753E | US37390585 | 18-Oct-01 (in house check Oct-12) | In house check: Oct-13 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Leif Klysner | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: June 12, 2013

**Calibration Laboratory of**
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

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Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

## Glossary:

| | |
|---|---|
| TSL | tissue simulating liquid |
| NORMx,y,z | sensitivity in free space |
| ConvF | sensitivity in TSL / NORMx,y,z |
| DCP | diode compression point |
| CF | crest factor (1/duty_cycle) of the RF signal |
| A, B, C, D | modulation dependent linearization parameters |
| Polarization φ | φ rotation around probe axis |
| Polarization ϑ | ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis |

## Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005

## Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the $E^2$-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConvF*.
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- *PAR:* PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z: A, B, C, D* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- *ConvF and Boundary Effect Parameters:* Assessed in flat phantom using E-field (or Temperature Transfer Standard for f ≤ 800 MHz) and inside waveguide using analytical field distributions based on power measurements for f > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to *NORMx,y,z * ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- *Spherical isotropy (3D deviation from isotropy):* in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *Sensor Offset:* The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.

# Probe ES3DV3

## SN:3323

Manufactured: January 10, 2012
Calibrated: June 12, 2013

Calibrated for DASY/EASY Systems
(Note: non-compatible with DASY2 system!)

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3323

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm ($\mu V/(V/m)^2$)[A] | 1.12 | 1.12 | 0.77 | ± 10.1 % |
| DCP (mV)[B] | 104.9 | 106.5 | 101.1 | |

## Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB√μV | C | D dB | VR mV | Unc[E] (k=2) |
|---|---|---|---|---|---|---|---|---|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 147.2 | ±2.7 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 194.2 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 152.6 | |
| 10011-CAA | UMTS-FDD (WCDMA) | X | 3.22 | 66.3 | 18.0 | 2.91 | 114.8 | ±0.5 % |
| | | Y | 3.12 | 66.3 | 18.0 | | 112.3 | |
| | | Z | 3.15 | 65.3 | 17.2 | | 123.8 | |
| 10012-CAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps) | X | 3.00 | 68.3 | 18.2 | 1.87 | 117.5 | ±0.5 % |
| | | Y | 3.24 | 70.3 | 19.1 | | 114.1 | |
| | | Z | 2.84 | 66.6 | 17.0 | | 125.4 | |
| 10021-DAA | GSM-FDD (TDMA, GMSK) | X | 21.19 | 94.6 | 26.6 | 9.39 | 145.5 | ±1.7 % |
| | | Y | 29.76 | 99.6 | 27.6 | | 142.9 | |
| | | Z | 13.12 | 87.2 | 24.0 | | 136.8 | |
| 10024-DAA | GPRS-FDD (TDMA, GMSK, TN 0-1) | X | 45.18 | 99.6 | 25.0 | 6.56 | 111.0 | ±1.4 % |
| | | Y | 50.15 | 99.8 | 24.5 | | 111.8 | |
| | | Z | 26.31 | 94.6 | 24.1 | | 116.2 | |
| 10027-DAA | GPRS-FDD (TDMA, GMSK, TN 0-1-2) | X | 52.37 | 99.1 | 23.5 | 4.80 | 121.7 | ±1.4 % |
| | | Y | 67.49 | 99.8 | 22.9 | | 122.2 | |
| | | Z | 11.90 | 82.8 | 19.1 | | 128.2 | |
| 10028-DAA | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3) | X | 62.99 | 99.9 | 22.7 | 3.55 | 132.7 | ±1.9 % |
| | | Y | 76.36 | 99.6 | 21.9 | | 128.9 | |
| | | Z | 18.38 | 87.2 | 19.4 | | 136.0 | |
| 10080-CAA | CDMA2000 (1xEV-DO, 153.6 kbps) | X | 4.27 | 66.0 | 18.3 | 4.22 | 112.4 | ±0.7 % |
| | | Y | 4.20 | 66.1 | 18.3 | | 110.5 | |
| | | Z | 4.17 | 65.1 | 17.6 | | 117.3 | |
| 10081-CAA | CDMA2000 (1xRTT, RC3) | X | 3.83 | 65.4 | 18.0 | 3.97 | 110.3 | ±0.7 % |
| | | Y | 3.72 | 65.2 | 17.9 | | 108.2 | |
| | | Z | 3.78 | 64.6 | 17.3 | | 115.2 | |
| 10100-CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 6.30 | 67.0 | 19.3 | 5.37 | 124.4 | ±1.2 % |
| | | Y | 6.25 | 67.1 | 19.4 | | 122.2 | |
| | | Z | 6.41 | 66.9 | 19.1 | | 130.9 | |
| 10103-CAB | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 10.92 | 75.7 | 25.5 | 9.29 | 122.3 | ±2.7 % |
| | | Y | 11.01 | 76.5 | 26.2 | | 117.5 | |
| | | Z | 10.27 | 73.8 | 24.5 | | 126.9 | |

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| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10108-CAB | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 6.23 | 66.7 | 19.2 | 5.80 | 124.3 | ±1.4 % |
| | | Y | 6.19 | 66.9 | 19.4 | | 121.5 | |
| | | Z | 6.33 | 66.7 | 19.1 | | 130.3 | |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 10.40 | 75.1 | 25.4 | 9.28 | 118.5 | ±2.7 % |
| | | Y | 10.61 | 76.4 | 26.3 | | 113.8 | |
| | | Z | 9.79 | 73.3 | 24.4 | | 123.1 | |
| 10154-CAB | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 5.95 | 66.3 | 19.0 | 5.75 | 121.7 | ±1.4 % |
| | | Y | 5.89 | 66.4 | 19.2 | | 119.7 | |
| | | Z | 6.04 | 66.2 | 18.9 | | 127.3 | |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 5.19 | 67.5 | 19.9 | 5.73 | 148.4 | ±0.9 % |
| | | Y | 5.16 | 67.8 | 20.2 | | 146.1 | |
| | | Z | 4.76 | 65.2 | 18.5 | | 110.4 | |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 9.80 | 79.7 | 27.7 | 9.21 | 126.5 | ±2.5 % |
| | | Y | 11.35 | 84.7 | 30.3 | | 131.0 | |
| | | Z | 8.91 | 77.3 | 26.6 | | 137.1 | |
| 10175-CAB | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 5.14 | 67.2 | 19.8 | 5.72 | 143.0 | ±0.9 % |
| | | Y | 5.08 | 67.5 | 20.0 | | 140.2 | |
| | | Z | 4.76 | 65.2 | 18.6 | | 110.6 | |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 6.18 | 66.5 | 19.1 | 5.81 | 119.1 | ±1.4 % |
| | | Y | 6.14 | 66.6 | 19.3 | | 117.2 | |
| | | Z | 6.37 | 66.7 | 19.2 | | 130.4 | |

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

[A] The uncertainties of NormX,Y,Z do not affect the $E^2$-field uncertainty inside TSL (see Pages 6 and 7).
[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

ES3DV3– SN:3323 June 12, 2013

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3323

## Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha | Depth (mm) | Unct. (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 41.9 | 0.89 | 6.57 | 6.57 | 6.57 | 0.37 | 1.65 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 6.28 | 6.28 | 6.28 | 0.23 | 2.18 | ± 12.0 % |
| 900 | 41.5 | 0.97 | 6.22 | 6.22 | 6.22 | 0.49 | 1.41 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 5.24 | 5.24 | 5.24 | 0.80 | 1.13 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 5.04 | 5.04 | 5.04 | 0.51 | 1.46 | ± 12.0 % |
| 1950 | 40.0 | 1.40 | 4.87 | 4.87 | 4.87 | 0.80 | 1.17 | ± 12.0 % |
| 2300 | 39.5 | 1.67 | 4.76 | 4.76 | 4.76 | 0.54 | 1.52 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 4.48 | 4.48 | 4.48 | 0.63 | 1.44 | ± 12.0 % |
| 2550 | 39.1 | 1.91 | 4.28 | 4.28 | 4.28 | 0.80 | 1.24 | ± 12.0 % |

[C] Frequency validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3323

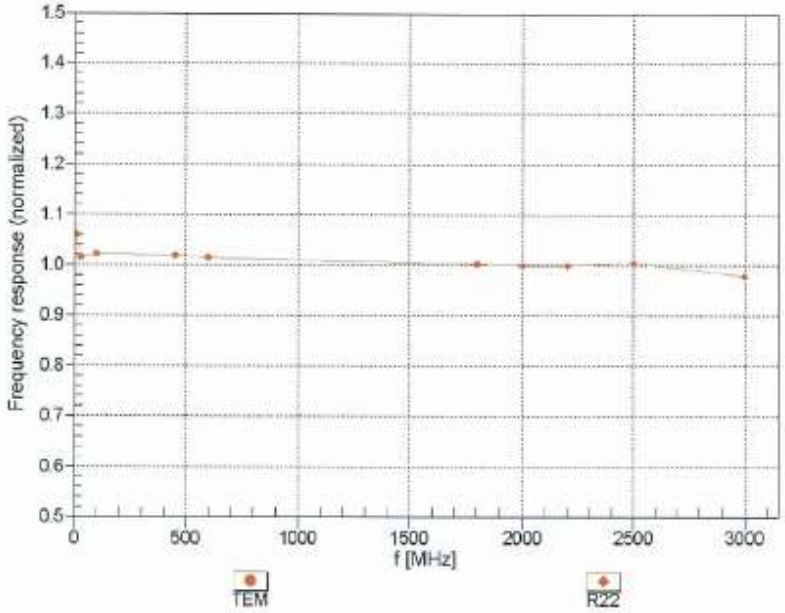
## Calibration Parameter Determined in Body Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha | Depth (mm) | Unct. (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 55.5 | 0.96 | 6.45 | 6.45 | 6.45 | 0.42 | 1.64 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 6.39 | 6.39 | 6.39 | 0.58 | 1.37 | ± 12.0 % |
| 900 | 55.0 | 1.05 | 6.30 | 6.30 | 6.30 | 0.40 | 1.67 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 5.01 | 5.01 | 5.01 | 0.65 | 1.36 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 4.77 | 4.77 | 4.77 | 0.80 | 1.28 | ± 12.0 % |
| 1950 | 53.3 | 1.52 | 4.86 | 4.86 | 4.86 | 0.60 | 1.47 | ± 12.0 % |
| 2300 | 52.9 | 1.81 | 4.51 | 4.51 | 4.51 | 0.80 | 1.23 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 4.31 | 4.31 | 4.31 | 0.80 | 1.10 | ± 12.0 % |
| 2550 | 52.6 | 2.09 | 4.23 | 4.23 | 4.23 | 0.74 | 1.09 | ± 12.0 % |

[C] Frequency validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

ES3DV3– SN:3323 June 12, 2013

## Frequency Response of E-Field
(TEM-Cell:ifi110 EXX, Waveguide: R22)

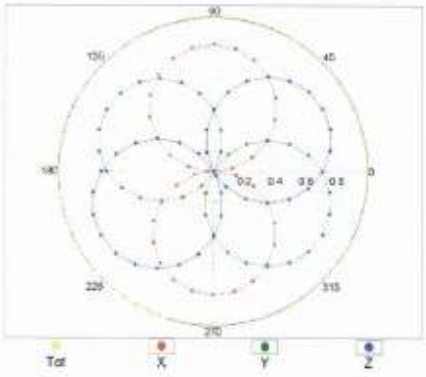



Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)

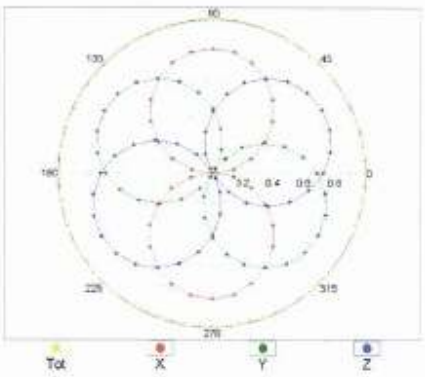
ES3DV3– SN:3323 June 12, 2013

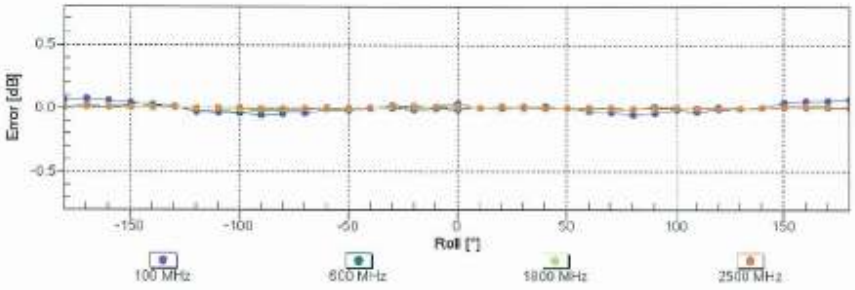
## Receiving Pattern ($\phi$), $\vartheta$ = 0°

f=600 MHz,TEM




f=1800 MHz,R22

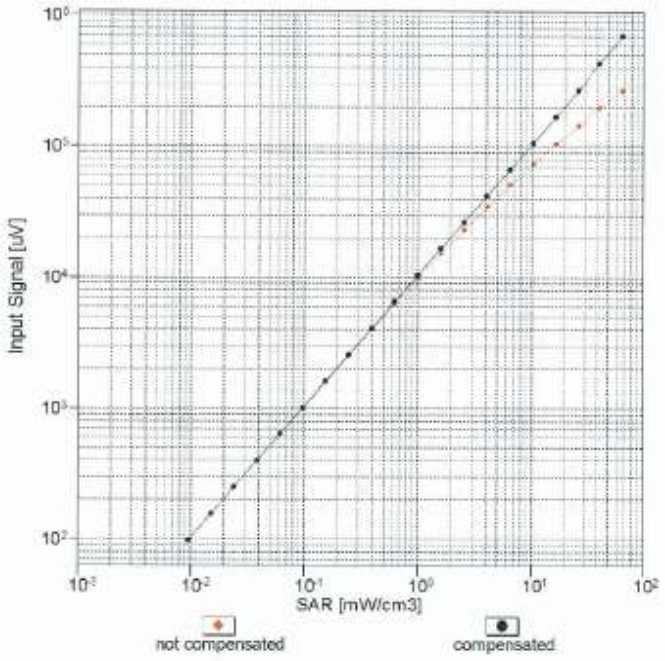


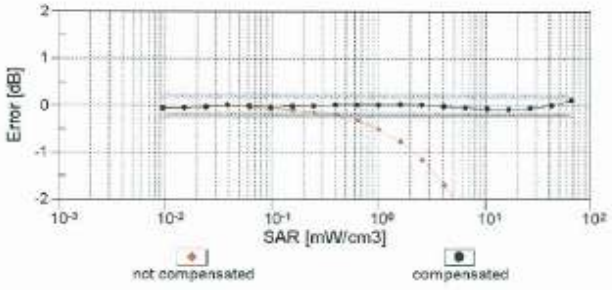




**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

ES3DV3– SN:3323 June 12, 2013

## Dynamic Range f($SAR_{head}$)
(TEM cell , f = 900 MHz)



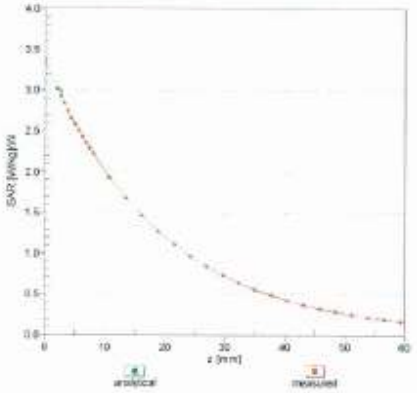




Uncertainty of Linearity Assessment: ± 0.6% (k=2)

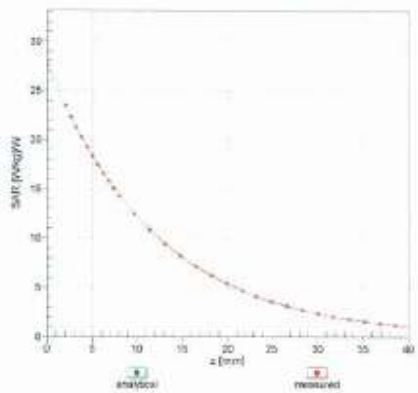
ES3DV3– SN:3323 June 12, 2013

## Conversion Factor Assessment

f = 835 MHz,WGLS R9 (H_convF)

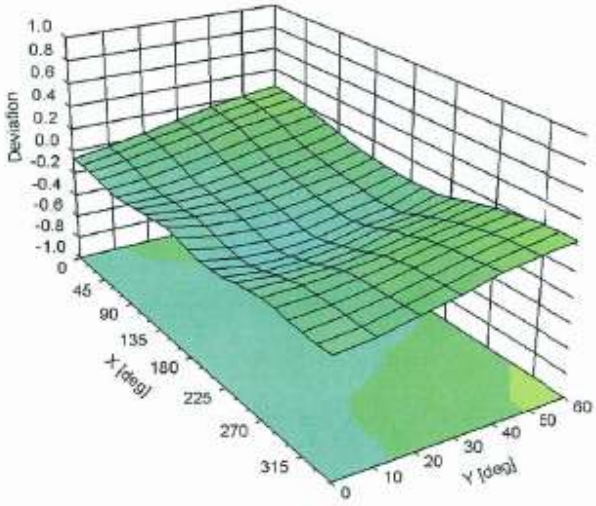


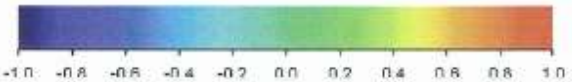

f = 1900 MHz,WGLS R22 (H_convF)




## Deviation from Isotropy in Liquid

Error (ϕ, ϑ), f = 900 MHz




Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3323

**Other Probe Parameters**

| | |
|---|---|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | -29.7 |
| Mechanical Surface Detection Mode | enabled |
| Optical Surface Detection Mode | disabled |
| Probe Overall Length | 337 mm |
| Probe Body Diameter | 10 mm |
| Tip Length | 10 mm |
| Tip Diameter | 4 mm |
| Probe Tip to Sensor X Calibration Point | 2 mm |
| Probe Tip to Sensor Y Calibration Point | 2 mm |
| Probe Tip to Sensor Z Calibration Point | 2 mm |
| Recommended Measurement Distance from Surface | 3 mm |

**Calibration Laboratory of**
Schmid & Partner
Engineering AG
**Zeughausstrasse 43, 8004 Zurich, Switzerland**

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
**The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates**

**Accreditation No.: SCS 108**

Client **Cetecom USA**

**Certificate No: EX3-3739_Mar14**

# CALIBRATION CERTIFICATE

Object EX3DV4 - SN:3739

Calibration procedure(s) QA CAL-01.v9, QA CAL-14.v4, QA CAL-23.v5, QA CAL-25.v6
Calibration procedure for dosimetric E-field probes

Calibration date: March 18, 2014

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter E4419B | GB41293874 | 04-Apr-13 (No. 217-01733) | Apr-14 |
| Power sensor E4412A | MY41498087 | 04-Apr-13 (No. 217-01733) | Apr-14 |
| Reference 3 dB Attenuator | SN: 55054 (3c) | 04-Apr-13 (No. 217-01737) | Apr-14 |
| Reference 20 dB Attenuator | SN: 55277 (20x) | 04-Apr-13 (No. 217-01735) | Apr-14 |
| Reference 30 dB Attenuator | SN: 55129 (30b) | 04-Apr-13 (No. 217-01738) | Apr-14 |
| Reference Probe ES3DV2 | SN: 3013 | 30-Dec-13 (No. ES3-3013_Dec13) | Dec-14 |
| DAE4 | SN: 660 | 13-Dec-13 (No. DAE4-660_Dec13) | Dec-14 |
| | | | |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| RF generator HP 8648C | US3642U01700 | 4-Aug-99 (in house check Apr-13) | In house check: Apr-16 |
| Network Analyzer HP 8753E | US37390585 | 18-Oct-01 (in house check Oct-13) | In house check: Oct-14 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Jelon Kastrati | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: March 20, 2014

**Calibration Laboratory of**
Schmid & Partner
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Zeughausstrasse 43, 8004 Zurich, Switzerland

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Accreditation No.: SCS 108

## Glossary:

| | |
|---|---|
| TSL | tissue simulating liquid |
| NORMx,y,z | sensitivity in free space |
| ConvF | sensitivity in TSL / NORMx,y,z |
| DCP | diode compression point |
| CF | crest factor (1/duty_cycle) of the RF signal |
| A, B, C, D | modulation dependent linearization parameters |
| Polarization φ | φ rotation around probe axis |
| Polarization ϑ | ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis |
| Connector Angle | information used in DASY system to align probe sensor X to the robot coordinate system |

## Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005

## Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the $E^2$-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConvF*.
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- *PAR:* PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z: A, B, C, D* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- *ConvF and Boundary Effect Parameters:* Assessed in flat phantom using E-field (or Temperature Transfer Standard for f ≤ 800 MHz) and inside waveguide using analytical field distributions based on power measurements for f > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to *NORMx,y,z * ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- *Spherical isotropy (3D deviation from isotropy)*: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *Sensor Offset*: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- *Connector Angle*: The angle is assessed using the information gained by determining the *NORMx* (no uncertainty required).

# Probe EX3DV4

## SN:3739

Manufactured: February 15, 2010
Calibrated: March 18, 2014

Calibrated for DASY/EASY Systems
(Note: non-compatible with DASY2 system!)

# DASY/EASY - Parameters of Probe: EX3DV4 - SN:3739

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm ($\mu V/(V/m)^2$)[A] | 0.37 | 0.48 | 0.28 | ± 10.1 % |
| DCP (mV)[B] | 101.5 | 101.8 | 107.6 | |

## Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB√μV | C | D dB | VR mV | Unc[E] (k=2) |
|---|---|---|---|---|---|---|---|---|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 157.0 | ±3.3 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 157.2 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 136.8 | |

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

[A] The uncertainties of NormX,Y,Z do not affect the $E^2$-field uncertainty inside TSL (see Pages 5 and 6).
[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

EX3DV4– SN:3739 March 18, 2014

# DASY/EASY - Parameters of Probe: EX3DV4 - SN:3739

## Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unct. (k=2) |
|---|---|---|---|---|---|---|---|---|
| 2450 | 39.2 | 1.80 | 7.23 | 7.23 | 7.23 | 0.39 | 0.76 | ± 12.0 % |
| 5200 | 36.0 | 4.66 | 5.04 | 5.04 | 5.04 | 0.40 | 1.80 | ± 13.1 % |
| 5300 | 35.9 | 4.76 | 4.79 | 4.79 | 4.79 | 0.40 | 1.80 | ± 13.1 % |
| 5500 | 35.6 | 4.96 | 4.76 | 4.76 | 4.76 | 0.40 | 1.80 | ± 13.1 % |
| 5600 | 35.5 | 5.07 | 4.51 | 4.51 | 4.51 | 0.40 | 1.80 | ± 13.1 % |
| 5800 | 35.3 | 5.27 | 4.59 | 4.59 | 4.59 | 0.40 | 1.80 | ± 13.1 % |

[C] Frequency validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

EX3DV4– SN:3739 March 18, 2014

# DASY/EASY - Parameters of Probe: EX3DV4 - SN:3739

## Calibration Parameter Determined in Body Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unct. (k=2) |
|---|---|---|---|---|---|---|---|---|
| 2450 | 52.7 | 1.95 | 7.18 | 7.18 | 7.18 | 0.73 | 0.57 | ± 12.0 % |
| 5200 | 49.0 | 5.30 | 4.55 | 4.55 | 4.55 | 0.45 | 1.90 | ± 13.1 % |
| 5300 | 48.9 | 5.42 | 4.35 | 4.35 | 4.35 | 0.45 | 1.90 | ± 13.1 % |
| 5500 | 48.6 | 5.65 | 4.00 | 4.00 | 4.00 | 0.50 | 1.90 | ± 13.1 % |
| 5600 | 48.5 | 5.77 | 3.85 | 3.85 | 3.85 | 0.50 | 1.90 | ± 13.1 % |
| 5800 | 48.2 | 6.00 | 4.08 | 4.08 | 4.08 | 0.50 | 1.90 | ± 13.1 % |

[C] Frequency validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

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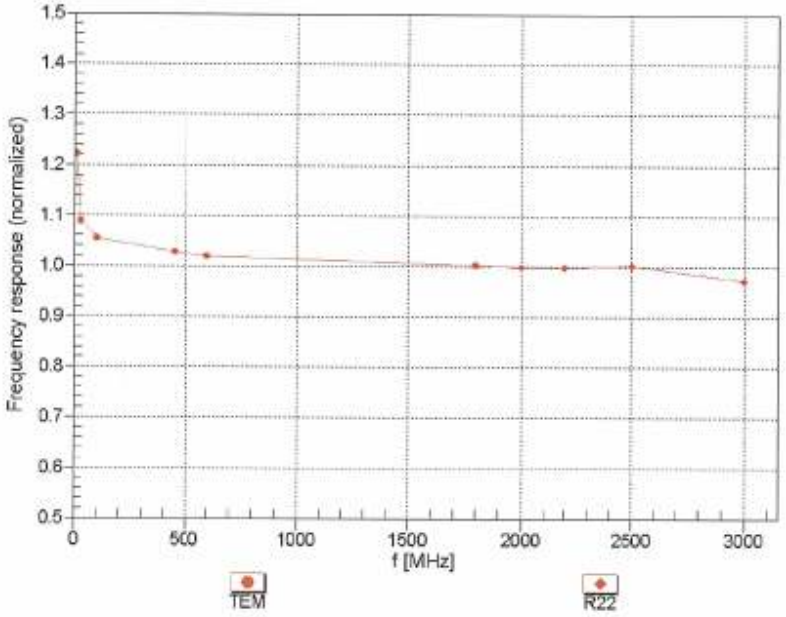
## Frequency Response of E-Field
**(TEM-Cell:ifi110 EXX, Waveguide: R22)**




**Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)**

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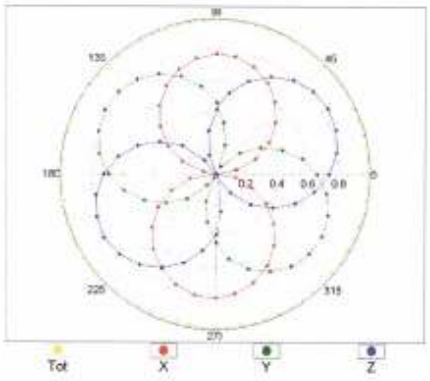
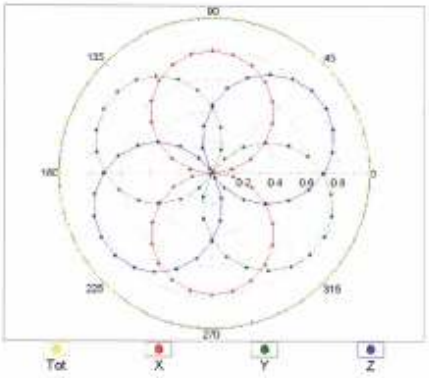
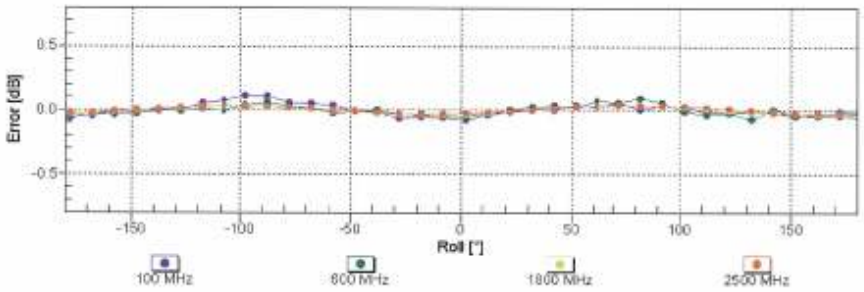
## Receiving Pattern (ϕ), ϑ = 0°

f=600 MHz,TEM




f=1800 MHz,R22

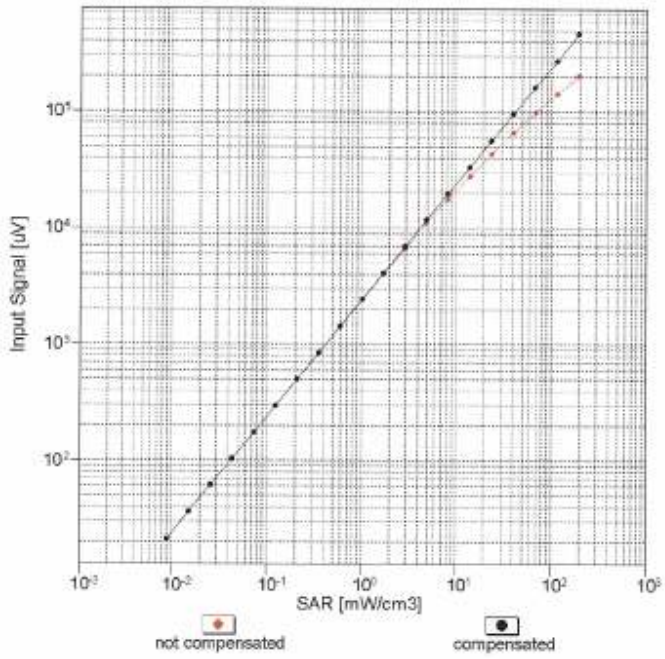


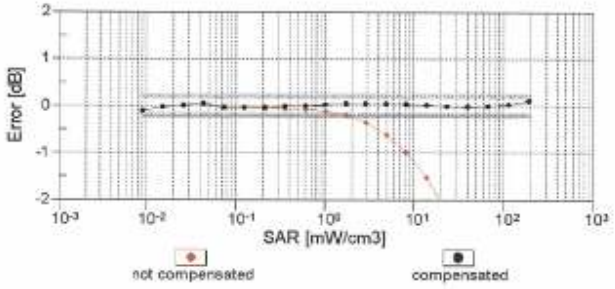




**Uncertainty of Axial Isotropy Assessment: ± 3.5% (k=2)**

EX3DV4– SN:3739 March 18, 2014

## Dynamic Range f($SAR_{head}$)
(TEM cell , $f_{eval}$= 1900 MHz)




Uncertainty of Linearity Assessment: ± 0.6% (k=2)

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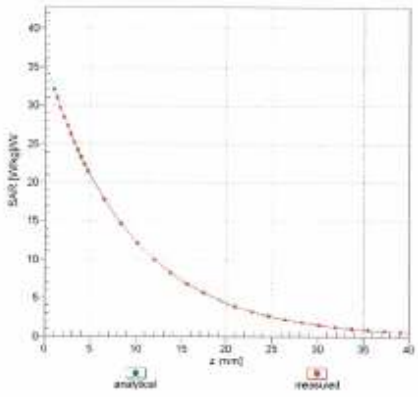
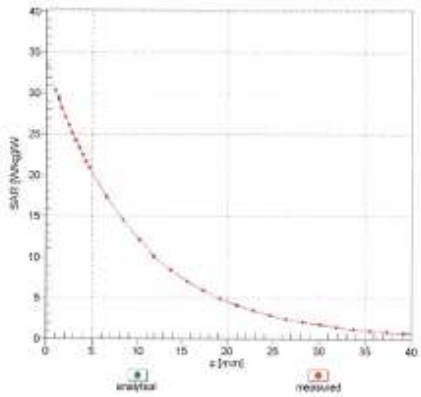
## Conversion Factor Assessment

f = 2450 MHz,WG_S R22 (H_convF)

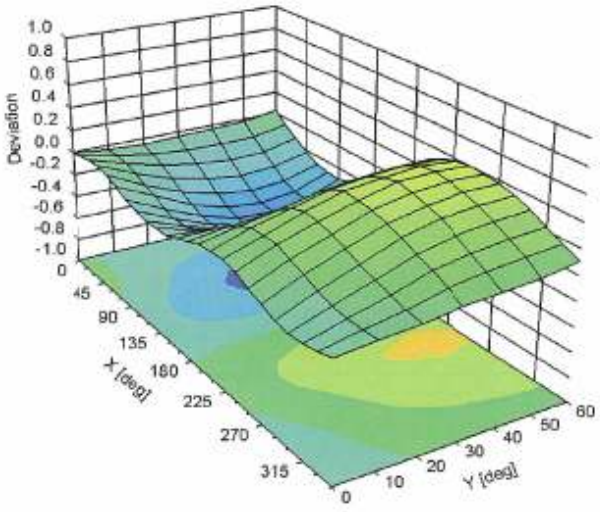


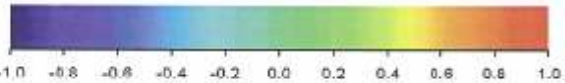
f = 2450 MHz,WGLS R22 (M_convF)



## Deviation from Isotropy in Liquid

**Error (ϕ, ϑ), f = 900 MHz**




**Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)**

# DASY/EASY - Parameters of Probe: EX3DV4 - SN:3739

**Other Probe Parameters**

| | |
|---|---|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | -127.8 |
| Mechanical Surface Detection Mode | enabled |
| Optical Surface Detection Mode | disabled |
| Probe Overall Length | 337 mm |
| Probe Body Diameter | 10 mm |
| Tip Length | 9 mm |
| Tip Diameter | 2.5 mm |
| Probe Tip to Sensor X Calibration Point | 1 mm |
| Probe Tip to Sensor Y Calibration Point | 1 mm |
| Probe Tip to Sensor Z Calibration Point | 1 mm |
| Recommended Measurement Distance from Surface | 2 mm |

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**Accreditation No.: SCS 108**

**Client** Cetecom USA **Certificate No: EX3-3771_Jun13**

# CALIBRATION CERTIFICATE

Object: EX3DV4 - SN:3771

Calibration procedure(s): QA CAL-01.v8, QA CAL-14.v3, QA CAL-23.v4, QA CAL-25.v4
Calibration procedure for dosimetric E-field probes

Calibration date: June 14, 2013

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter E4419B | GB41293874 | 04-Apr-13 (No. 217-01733) | Apr-14 |
| Power sensor E4412A | MY41498087 | 04-Apr-13 (No. 217-01733) | Apr-14 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 04-Apr-13 (No. 217-01737) | Apr-14 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 04-Apr-13 (No. 217-01735) | Apr-14 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 04-Apr-13 (No. 217-01738) | Apr-14 |
| Reference Probe ES3DV2 | SN: 3013 | 28-Dec-12 (No. ES3-3013_Dec12) | Dec-13 |
| DAE4 | SN: 660 | 31-Jan-13 (No. DAE4-660_Jan13) | Jan-14 |
| | | | |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| RF generator HP 8648C | US3642U01700 | 4-Aug-99 (in house check Apr-13) | In house check: Apr-15 |
| Network Analyzer HP 8753E | US37390585 | 18-Oct-01 (in house check Oct-12) | In house check: Oct-13 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Israe El-Naouq | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: June 15, 2013

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Accreditation No.: SCS 108

## Glossary:

| | |
|---|---|
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| NORMx,y,z | sensitivity in free space |
| ConvF | sensitivity in TSL / NORMx,y,z |
| DCP | diode compression point |
| CF | crest factor (1/duty_cycle) of the RF signal |
| A, B, C, D | modulation dependent linearization parameters |
| Polarization φ | φ rotation around probe axis |
| Polarization ϑ | ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis |

## Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005

## Methods Applied and Interpretation of Parameters:

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- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConvF*.
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- *PAR:* PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z: A, B, C, D* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- *ConvF and Boundary Effect Parameters:* Assessed in flat phantom using E-field (or Temperature Transfer Standard for f ≤ 800 MHz) and inside waveguide using analytical field distributions based on power measurements for f > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to *NORMx,y,z * ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- *Spherical isotropy (3D deviation from isotropy):* in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *Sensor Offset:* The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.

# Probe EX3DV4

## SN:3771

Manufactured: March 29, 2011
Calibrated: June 14, 2013

Calibrated for DASY/EASY Systems
(Note: non-compatible with DASY2 system!)

EX3DV4- SN:3771 June 14, 2013

# DASY/EASY - Parameters of Probe: EX3DV4 - SN:3771

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm ($\mu V/(V/m)^2$)[A] | 0.56 | 0.56 | 0.58 | ± 10.1 % |
| DCP (mV)[B] | 98.9 | 100.7 | 95.4 | |

## Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB√µV | C | D dB | VR mV | Unc[E] (k=2) |
|---|---|---|---|---|---|---|---|---|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 172.1 | ±3.3 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 169.7 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 173.8 | |
| 10062-CAA | IEEE 802.11a/h WiFi 5 GHz (OFDM, 6 Mbps) | X | 10.29 | 68.8 | 21.5 | 8.56 | 128.0 | ±2.5 % |
| | | Y | 10.43 | 69.6 | 22.2 | | 135.2 | |
| | | Z | 10.42 | 69.1 | 21.7 | | 133.4 | |

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

[A] The uncertainties of NormX,Y,Z do not affect the $E^2$-field uncertainty inside TSL (see Pages 5 and 6).
[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

EX3DV4– SN:3771 June 14, 2013

# DASY/EASY - Parameters of Probe: EX3DV4 - SN:3771

## Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha | Depth (mm) | Unct. (k=2) |
|---|---|---|---|---|---|---|---|---|
| 5200 | 36.0 | 4.66 | 5.22 | 5.22 | 5.22 | 0.30 | 1.80 | ± 13.1 % |
| 5300 | 35.9 | 4.76 | 4.99 | 4.99 | 4.99 | 0.30 | 1.80 | ± 13.1 % |
| 5500 | 35.6 | 4.96 | 4.88 | 4.88 | 4.88 | 0.30 | 1.80 | ± 13.1 % |
| 5600 | 35.5 | 5.07 | 4.79 | 4.79 | 4.79 | 0.30 | 1.80 | ± 13.1 % |
| 5800 | 35.3 | 5.27 | 4.56 | 4.56 | 4.56 | 0.40 | 1.80 | ± 13.1 % |

[C] Frequency validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

EX3DV4– SN:3771 June 14, 2013

# DASY/EASY - Parameters of Probe: EX3DV4 - SN:3771

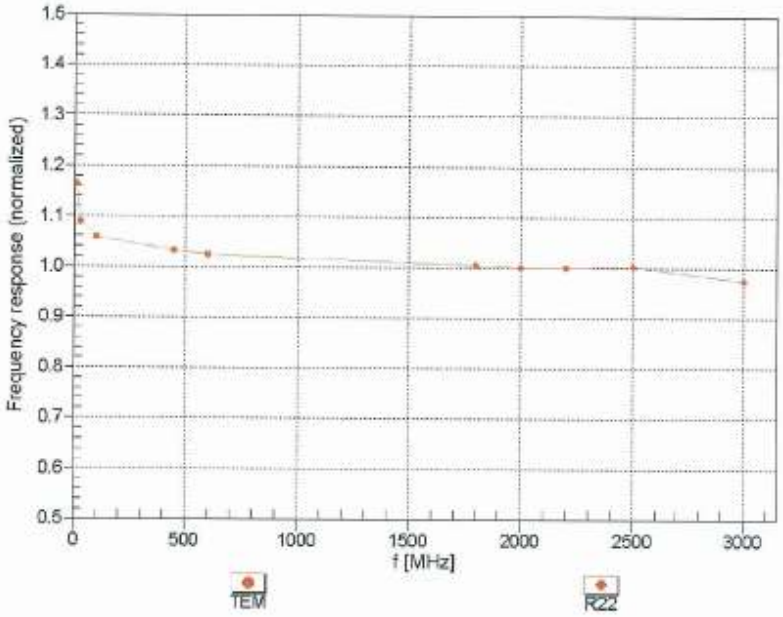
## Calibration Parameter Determined in Body Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha | Depth (mm) | Unct. (k=2) |
|---|---|---|---|---|---|---|---|---|
| 5200 | 49.0 | 5.30 | 4.59 | 4.59 | 4.59 | 0.40 | 1.90 | ± 13.1 % |
| 5300 | 48.9 | 5.42 | 4.45 | 4.45 | 4.45 | 0.40 | 1.90 | ± 13.1 % |
| 5500 | 48.6 | 5.65 | 4.06 | 4.06 | 4.06 | 0.45 | 1.90 | ± 13.1 % |
| 5600 | 48.5 | 5.77 | 3.96 | 3.96 | 3.96 | 0.40 | 1.90 | ± 13.1 % |
| 5800 | 48.2 | 6.00 | 4.27 | 4.27 | 4.27 | 0.45 | 1.90 | ± 13.1 % |

[C] Frequency validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

EX3DV4– SN:3771 June 14, 2013

## Frequency Response of E-Field
(TEM-Cell:ifi110 EXX, Waveguide: R22)

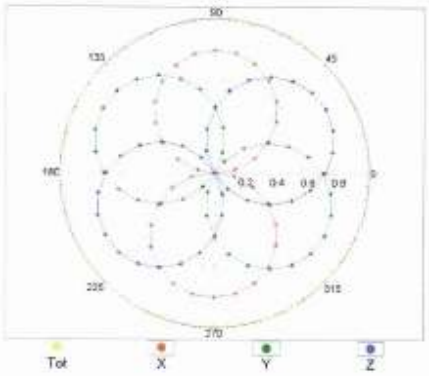



Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)

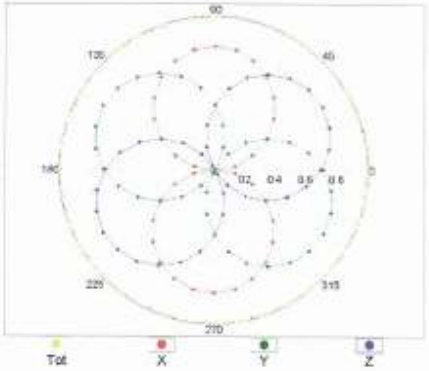
EX3DV4– SN:3771 June 14, 2013

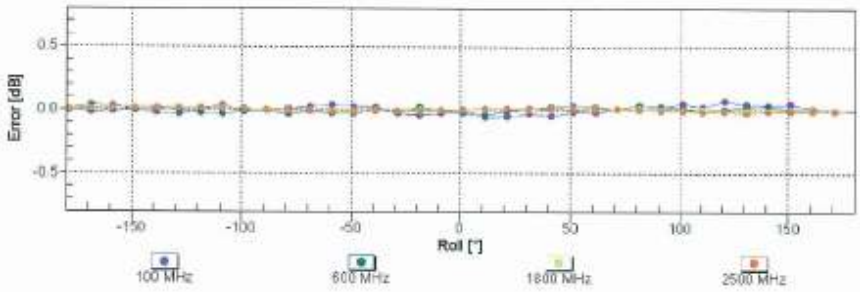
## Receiving Pattern (ϕ), ϑ = 0°

f=600 MHz,TEM




f=1800 MHz,R22

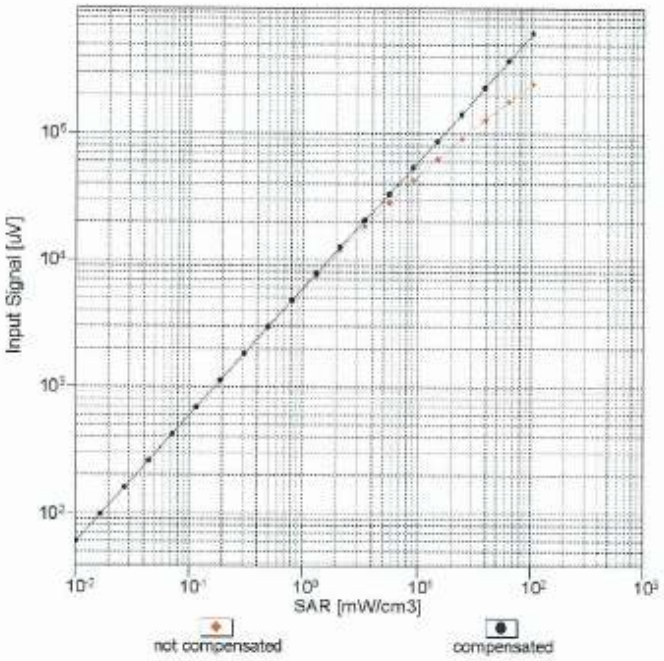


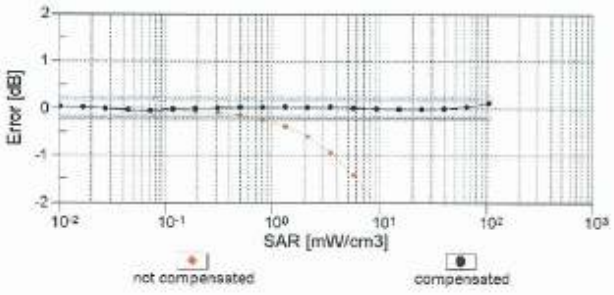




**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

EX3DV4– SN:3771 June 14, 2013

## Dynamic Range f($SAR_{head}$)
(TEM cell , f = 900 MHz)



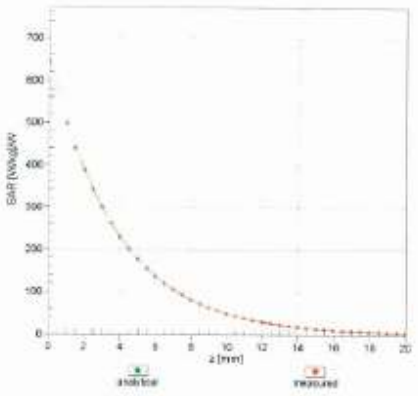




**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**

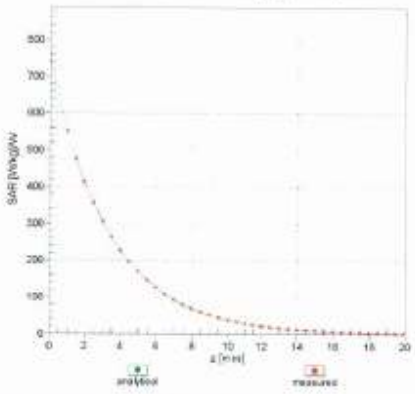
EX3DV4- SN:3771 June 14, 2013

## Conversion Factor Assessment

f = 5200 MHz,WGLS R58 (H_convF)-SCS

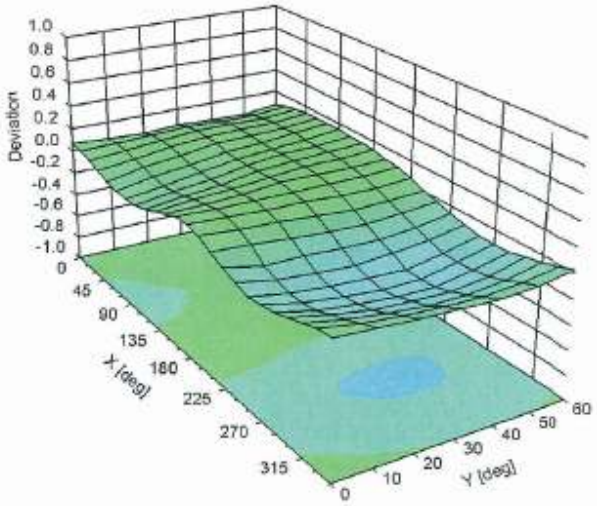


f = 5800 MHz,WGLS R58 (H_convF)-SCS



## Deviation from Isotropy in Liquid

Error (ϕ, ϑ), f = 900 MHz





Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)

# DASY/EASY - Parameters of Probe: EX3DV4 - SN:3771

## Other Probe Parameters

| | |
|---|---|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | -98.7 |
| Mechanical Surface Detection Mode | enabled |
| Optical Surface Detection Mode | disabled |
| Probe Overall Length | 337 mm |
| Probe Body Diameter | 10 mm |
| Tip Length | 9 mm |
| Tip Diameter | 2.5 mm |
| Probe Tip to Sensor X Calibration Point | 1 mm |
| Probe Tip to Sensor Y Calibration Point | 1 mm |
| Probe Tip to Sensor Z Calibration Point | 1 mm |
| Recommended Measurement Distance from Surface | 2 mm |

**Calibration Laboratory of**
Schmid & Partner
Engineering AG
**Zeughausstrasse 43, 8004 Zurich, Switzerland**

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**The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates**

**Accreditation No.: SCS 108**

Client **Cetecom USA** Certificate No: **EX3-3771_Mar14**

# CALIBRATION CERTIFICATE

Object EX3DV4 - SN:3771

Calibration procedure(s) QA CAL-01.v9, QA CAL-14.v4, QA CAL-23.v5, QA CAL-25.v6
Calibration procedure for dosimetric E-field probes

Calibration date: March 18, 2014

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter E4419B | GB41293874 | 04-Apr-13 (No. 217-01733) | Apr-14 |
| Power sensor E4412A | MY41498087 | 04-Apr-13 (No. 217-01733) | Apr-14 |
| Reference 3 dB Attenuator | SN: 38054 (3c) | 04-Apr-13 (No. 217-01737) | Apr-14 |
| Reference 20 dB Attenuator | SN: 35277 (20x) | 04-Apr-13 (No. 217-01735) | Apr-14 |
| Reference 30 dB Attenuator | SN: 35129 (30b) | 04-Apr-13 (No. 217-01738) | Apr-14 |
| Reference Probe ES3DV2 | SN: 3013 | 30-Dec-13 (No. ES3-3013_Dec13) | Dec-14 |
| DAE4 | SN: 360 | 13-Dec-13 (No. DAE4-660_Dec13) | Dec-14 |
| | | | |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| RF generator HP 8648C | US3642U01700 | 4-Aug-99 (in house check Apr-13) | In house check: Apr-16 |
| Network Analyzer HP 8753E | US37390585 | 18-Oct-01 (in house check Oct-13) | In house check: Oct-14 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Jeton Kastrati | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: March 20, 2014

**Calibration Laboratory of**
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The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 108

## Glossary:

| | |
|---|---|
| TSL | tissue simulating liquid |
| NORMx,y,z | sensitivity in free space |
| ConvF | sensitivity in TSL / NORMx,y,z |
| DCP | diode compression point |
| CF | crest factor (1/duty_cycle) of the RF signal |
| A, B, C, D | modulation dependent linearization parameters |
| Polarization φ | φ rotation around probe axis |
| Polarization ϑ | ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis |
| Connector Angle | information used in DASY system to align probe sensor X to the robot coordinate system |

## Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005

## Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the $E^2$-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConvF*.
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- *PAR:* PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z: A, B, C, D* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- *ConvF and Boundary Effect Parameters:* Assessed in flat phantom using E-field (or Temperature Transfer Standard for f ≤ 800 MHz) and inside waveguide using analytical field distributions based on power measurements for f > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to *NORMx,y,z * ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- *Spherical isotropy (3D deviation from isotropy)*: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *Sensor Offset*: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- *Connector Angle*: The angle is assessed using the information gained by determining the *NORMx* (no uncertainty required).

# Probe EX3DV4

## SN:3771

Manufactured: March 29, 2011
Calibrated: March 18, 2014

Calibrated for DASY/EASY Systems
(Note: non-compatible with DASY2 system!)

EX3DV4– SN:3771 March 18, 2014

# DASY/EASY - Parameters of Probe: EX3DV4 - SN:3771

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm ($\mu V/(V/m)^2$)[A] | 0.56 | 0.56 | 0.58 | ± 10.1 % |
| DCP (mV)[B] | 96.9 | 99.4 | 94.0 | |

## Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB√μV | C | D dB | VR mV | Unc[E] (k=2) |
|---|---|---|---|---|---|---|---|---|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 150.6 | ±3.5 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 154.3 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 153.8 | |

The reported uncertainty of measurement is stated as the stancard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

[A] The uncertainties of NormX,Y,Z do not affect the $E^2$-field uncertainty inside TSL (see Pages 5 and 6).
[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

EX3DV4– SN:3771 March 18, 2014

# DASY/EASY - Parameters of Probe: EX3DV4 - SN:3771

## Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unct. (k=2) |
|---|---|---|---|---|---|---|---|---|
| 2450 | 39.2 | 1.80 | 7.21 | 7.21 | 7.21 | 0.31 | 0.89 | ± 12.0 % |
| 5200 | 36.0 | 4.66 | 5.02 | 5.02 | 5.02 | 0.40 | 1.80 | ± 13.1 % |
| 5300 | 35.9 | 4.76 | 4.86 | 4.86 | 4.86 | 0.40 | 1.80 | ± 13.1 % |
| 5500 | 35.6 | 4.96 | 4.73 | 4.73 | 4.73 | 0.40 | 1.80 | ± 13.1 % |
| 5600 | 35.5 | 5.07 | 4.53 | 4.53 | 4.53 | 0.40 | 1.80 | ± 13.1 % |
| 5800 | 35.3 | 5.27 | 4.57 | 4.57 | 4.57 | 0.40 | 1.80 | ± 13.1 % |

[C] Frequency validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

# DASY/EASY - Parameters of Probe: EX3DV4 - SN:3771

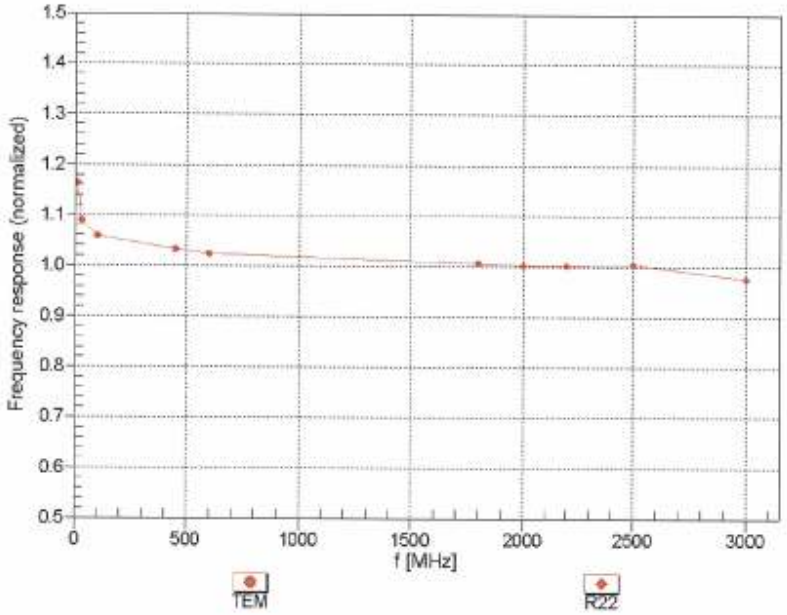
## Calibration Parameter Determined in Body Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unct. (k=2) |
|---|---|---|---|---|---|---|---|---|
| 2450 | 52.7 | 1.95 | 7.21 | 7.21 | 7.21 | 0.70 | 0.61 | ± 12.0 % |
| 5200 | 49.0 | 5.30 | 4.72 | 4.72 | 4.72 | 0.40 | 1.90 | ± 13.1 % |
| 5300 | 48.9 | 5.42 | 4.53 | 4.53 | 4.53 | 0.40 | 1.90 | ± 13.1 % |
| 5500 | 48.6 | 5.65 | 4.24 | 4.24 | 4.24 | 0.40 | 1.90 | ± 13.1 % |
| 5600 | 48.5 | 5.77 | 3.96 | 3.96 | 3.96 | 0.50 | 1.90 | ± 13.1 % |
| 5800 | 48.2 | 6.00 | 4.25 | 4.25 | 4.25 | 0.50 | 1.90 | ± 13.1 % |

[C] Frequency validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

EX3DV4– SN:3771 March 16, 2014

## Frequency Response of E-Field
(TEM-Cell:ifi110 EXX, Waveguide: R22)

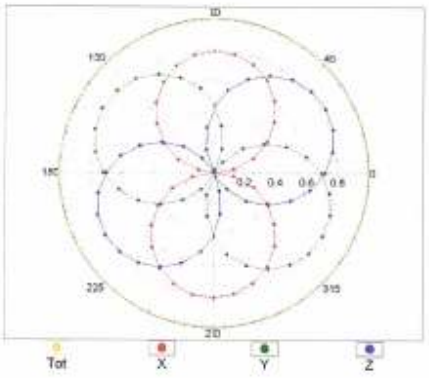



**Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)**

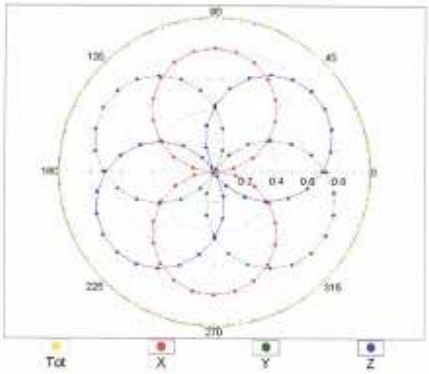
EX3DV4– SN:3771 March 18, 2014

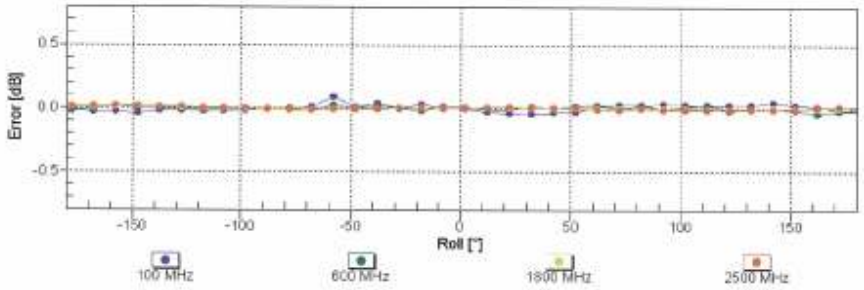
## Receiving Pattern (ϕ), ϑ = 0°

f=600 MHz,TEM




f=1800 MHz,R22

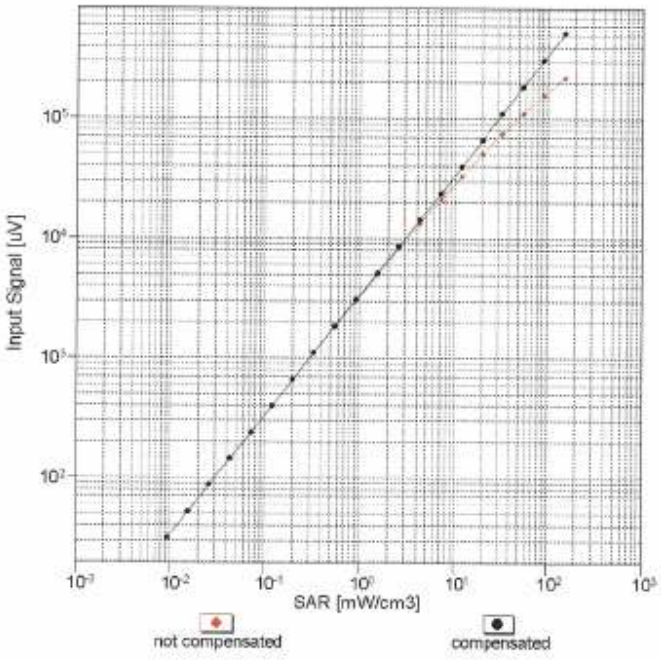


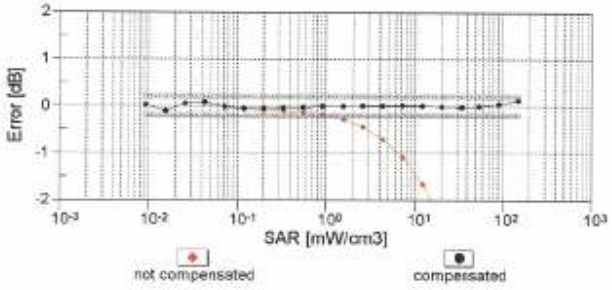




**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

EX3DV4– SN:3771 March 16, 2014

## Dynamic Range f($SAR_{head}$)
(TEM cell , $f_{eval}$= 1900 MHz)



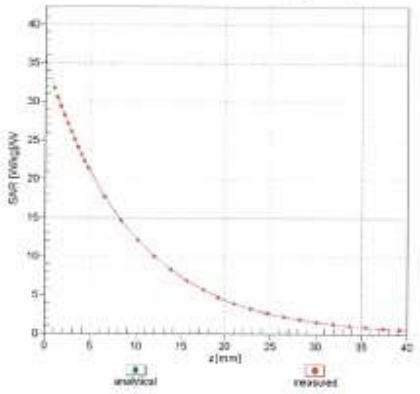




Uncertainty of Linearity Assessment: ± 0.6% (k=2)

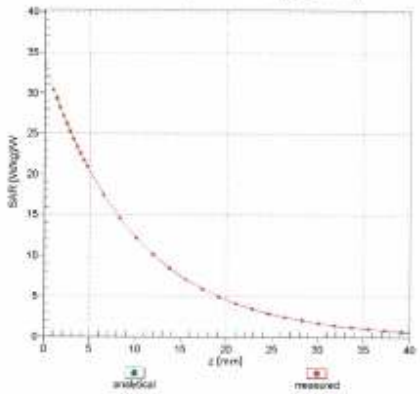
EX3DV4– SN:3771 March 18, 2014

## Conversion Factor Assessment

f = 2450 MHz,WGLS R22 (H_convF)

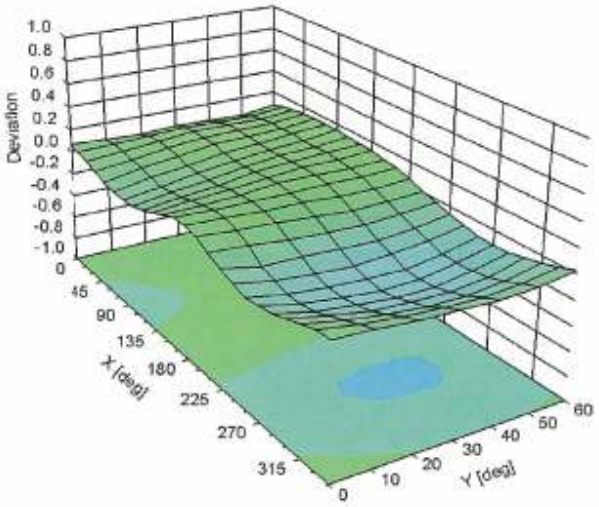



f = 2450 MHz,WGLS R22 (M_convF)




## Deviation from Isotropy in Liquid

Error (ϕ, ϑ), f = 900 MHz





Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)

# DASY/EASY - Parameters of Probe: EX3DV4 - SN:3771

**Other Probe Parameters**

| | |
|---|---|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | -97.9 |
| Mechanical Surface Detection Mode | enabled |
| Optical Surface Detection Mode | disabled |
| Probe Overall Length | 337 mm |
| Probe Body Diameter | 10 mm |
| Tip Length | 9 mm |
| Tip Diameter | 2.5 mm |
| Probe Tip to Sensor X Calibration Point | 1 mm |
| Probe Tip to Sensor Y Calibration Point | 1 mm |
| Probe Tip to Sensor Z Calibration Point | 1 mm |
| Recommended Measurement Distance from Surface | 2 mm |