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SureCAL™ TECHNICAL NOTES

Technical Note TN ##

Creating or Modifying Cal Kit and Test Set Definition Files used in the SureCAL Power Sensor and RF Components Package

Overview:

This Technical Note describes the structure of Vector Analyzer Cal Kit (.CKD) and Test Set (.TSD) files used in the Power Sensor and RF Components Packages. Information is provided to assist in modifying existing files or creating new files.

Additional information on how .CKD and .TSD files are implemented within the Power Sensor and RF Components Packages can be found in SureCAL Technical Note 201001 February 2010. All Technical notes are available from the SureCAL website – SureCAL Calibration Software - Northrop Grumman.

Quantities for devices used in the .CKD files are provided by both the cal kit specifications and the cal kit definitions provided by the cal kit manufacturer. Quantities for the .TSD files are provided by both the test set specifications and typical cable specifications.

Dependent on the OEM, Cal Kit and Test Set characteristics may vary in presentation format. In simple cases, characteristics may require units of measure conversion for compatibility. In more complex cases, multiple characteristics may need to be combined to achieve the error term required for program implementation.

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IDENTIFICATION OF CAL KIT TYPE AND CHARACTERISTICS WITHIN THE .CKD FILE

The first four items in the .CKD file identify and provide the basic operational limits of the cal kit. Cal kit connector type, manufacturer model number, upper frequency limit of cal kit and upper limit of cal kit fixed terminations are identified. For consistency the model number identified in this file should agree with the file name.

```
N CAL KIT
85054D
18 GHz
18 GHz FIXED TERM
```

This section is populated with kit type, kit model number, upper frequency limit of cal kit and upper limit of fixed terminations.

```
ERROR TERMS & CAL COEFFICIENTS
ERROR TERM      FREQUENCY(GHz)      ERROR TERM VALUE(LINEAR)
=========================================================
DIRECTIVITY        0 TO 2         -    .0100000
                   2 TO 8         -    .0158000
                   8 TO 18        -    .0200000
LOAD MATCH         0 TO 2         -    .0100000
                   2 TO 8         -    .0158000
                   8 TO 18        -    .0200000
SOURCE MATCH       0 TO 2         -    .0119000
                   2 TO 8         -    .0232000
                   8 TO 18        -    .0367000
*********************************************************
   STANDARD
(TEST PORT SEX)      LENGTH          STRAY C/L         LOSS
=========================================================
FEMALE OPEN         57.993 (E-12)   *  89.939 (E-15)    .93
                    .0173860        *  2536.8 (E-27)
                                    * -264.99 (E-36)
                                    *    13.4 (E-45)
MALE OPEN           22.905 (E-12)   *  104.13 (E-15)    .93
                    .0068667        * -1943.4 (E-27)
                                    *  144.62 (E-36)
                                    *  2.2258 (E-45)
FEMALE SHORT        63.078 (E-12)   *  0.7563 (E-12)   1.1273
                    .0189100        *  459.88 (E-24)
                                    * -52.429 (E-33)
                                    *  1.5846 (E-42)
MALE SHORT          27.990 (E-12)   * -0.1315 (E-12)   1.3651
                    .0083912        *  606.21 (E-24)
                                    * -68.405 (E-33)
                                    *  2.0206 (E-42)
M-M ADAPTER         196.00 (E-12)                      2.2
                    .0587590
```

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DIRECTIVITY & LOAD MATCH

The .CKD values for both Directivity and Load Match are populated with specification values available for each calibration kit. These may be obtained from the cal kit operator's manual.

Directivity and Load Match are effectively equal to the return loss of the cal kit terminations. These values are normally presented in dB.

To convert to the required linear format perform the following calculation:

ERROR TERM VALUE (LINEAR) = 10^(-Return Loss in dB/20)

```
N CAL KIT
85054D
18 GHz
18 GHz FIXED TERM
ERROR TERMS & CAL COEFFICIENTS
ERROR TERM      FREQUENCY(GHz)      ERROR TERM VALUE(LINEAR)
=========================================================
DIRECTIVITY       0 TO 2        -     .0100000
                  2 TO 8        -     .0158000
                  8 TO 18       -     .0200000
LOAD MATCH        0 TO 2        -     .0100000
                  2 TO 8        -     .0158000
                  8 TO 18       -     .0200000
SOURCE MATCH      0 TO 2        -     .0119000
                  2 TO 8        -     .0232000
                  8 TO 18       -     .0367000
*********************************************************
   STANDARD
(TEST PORT SEX)      LENGTH           STRAY C/L          LOSS
=========================================================
FEMALE OPEN        57.993 (E-12)   *  89.939 (E-15)     .93
                   .0173860        *  2536.8 (E-27)
                                   * -264.99 (E-36)
                                   *    13.4 (E-45)
MALE OPEN          22.905 (E-12)   *  104.13 (E-15)     .93
                   .0068667        * -1943.4 (E-27)
                                   *  144.62 (E-36)
                                   *  2.2258 (E-45)
FEMALE SHORT       63.078 (E-12)   *  0.7563 (E-12)   1.1273
                   .0189100        *  459.88 (E-24)
                                   * -52.429 (E-33)
                                   *  1.5846 (E-42)
MALE SHORT         27.990 (E-12)   * -0.1315 (E-12)   1.3651
                   .0083912        *  606.21 (E-24)
                                   * -68.405 (E-33)
                                   *  2.0206 (E-42)
M-M ADAPTER        196.00 (E-12)                      2.2
                   .0587590
```

Populated with termination cal kit spec table values.

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SOURCE MATCH

The .CKD values for Source Match are approximated using the following formula:

Source Match = $\sqrt{((\text{Phase error short}/2) \times (3.14/180)^2) + ((\text{Phase error open}/2) \times (3.14/180)^2)}$ **+ Directivity Error**

The Open and Short phase errors are converted to a linear number, combined and added to the system directivity which is effectively the return loss of the calibration kit loads.

Although the source of the actual values for the devices is not stated, the Source Match may also be calculated using the Agilent 8510 System modeling software.

```
N CAL KIT
85054D
18 GHz
18 GHz FIXED TERM
ERROR TERMS & CAL COEFFICIENTS
ERROR TERM      FREQUENCY(GHz)      ERROR TERM VALUE(LINEAR)
=============================================================
DIRECTIVITY        0 TO 2         -     .0100000
                   2 TO 8         -     .0158000
                   8 TO 18        -     .0200000
LOAD MATCH         0 TO 2         -     .0100000
                   2 TO 8         -     .0158000
                   8 TO 18        -     .0200000
SOURCE MATCH       0 TO 2         -     .0119000
                   2 TO 8         -     .0232000
                   8 TO 18        -     .0367000
*************************************************************
   STANDARD
(TEST PORT SEX)      LENGTH           STRAY C/L          LOSS
=============================================================
FEMALE OPEN         57.993 (E-12)   *  89.939 (E-15)     .93
                    .0173860        *  2536.8 (E-27)
                                    * -264.99 (E-36)
                                    *    13.4 (E-45)
MALE OPEN           22.905 (E-12)   *  104.13 (E-15)     .93
                    .0068667        * -1943.4 (E-27)
                                    *  144.62 (E-36)
                                    *  2.2258 (E-45)
FEMALE SHORT        63.078 (E-12)   *  0.7563 (E-12)   1.1273
                    .0189100        *  459.88 (E-24)
                                    * -52.429 (E-33)
                                    *  1.5846 (E-42)
MALE SHORT          27.990 (E-12)   * -0.1315 (E-12)   1.3651
                    .0083912        *  606.21 (E-24)
                                    * -68.405 (E-33)
                                    *  2.0206 (E-42)
M-M ADAPTER         196.00 (E-12)                      2.2
                    .0587590
```

Derived from open and short errors and combined with system directivity

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ELECTRICAL LENGTH & DELAY

The cal kit opens, shorts and adapters are further defined by capacitance, inductance, loss, delay and electrical length. Characteristics for opens are stray capacitance, loss, delay and electrical length. Characteristics for shorts are stray inductance, loss, delay and electrical length. Characteristics for adapters are delay and electrical length. Values for capacitance, inductance, loss and delay are available in the cal kit operator's manual. The electrical length is calculated from the delay.

```
N CAL KIT
85054D
18 GHz
18 GHz FIXED TERM
ERROR TERMS & CAL COEFFICIENTS
ERROR TERM      FREQUENCY(GHz)      ERROR TERM VALUE(LINEAR)
=========================================================
DIRECTIVITY        0 TO 2         -     .0100000
                   2 TO 8         -     .0158000
                   8 TO 18        -     .0200000
LOAD MATCH         0 TO 2         -     .0100000
                   2 TO 8         -     .0158000
                   8 TO 18        -     .0200000
SOURCE MATCH       0 TO 2         -     .0119000
                   2 TO 8         -     .0232000
                   8 TO 18        -     .0367000
*********************************************************
   STANDARD
(TEST PORT SEX)      LENGTH          STRAY C/L         LOSS
=========================================================
FEMALE OPEN         57.993 (E-12)   *  89.939 (E-15)   .93
                    .0173860        *  2536.8 (E-27)
                                    * -264.99 (E-36)
                                    *   13.4 (E-45)
MALE OPEN           22.905 (E-12)   *  104.13 (E-15)    .93
                    .0068667        * -1943.4 (E-27)
                                    *  144.62 (E-36)
                                    *  2.2258 (E-45)
FEMALE SHORT        63.078 (E-12)   *  0.7563 (E-12)   1.1273
                    .0189100        *  459.88 (E-24)
                                    * -52.429 (E-33)
                                    *  1.5846 (E-42)
MALE SHORT          27.990 (E-12)   * -0.1315 (E-12)   1.3651
                    .0083912        *  606.21 (E-24)
                                    * -68.405 (E-33)
                                    *  2.0206 (E-42)
M-M ADAPTER         196.00 (E-12)                     2.2
                    .0587590
```

Loss in G/Ω

Stray Capacitance

Delay (pS) Calculated Length

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IDENTIFICATION OF TEST SET TYPE AND CHARACTERISTICS WITHIN THE .TSD FILE

The first three items in the .TSD file identify and provide the basic operational limits of the test set. Frequency range, model number and maximum frequency limit of test set are identified. For consistency the model number identified in this file should agree with the file name.

```
.01-50GHz TEST SET
N5230A_50
50 GHz
```

This field is populated with frequency range, test set model number and maximum frequency capability

```
ERROR TERMS
ERROR TERM      FREQUENCY(GHz)      ERROR TERM VALUE(LINEAR)
=============================================================
REFL TRACKING      .01 TO 2          -     .0024000
                   2 TO 20           -     .0032000
                   20 TO 40          -     .0046000
                   40 TO 50          -     .0066000
TRAN TRACKING      .01 TO 2          -     .0045000
                   2 TO 20           -     .0093000
                   20 TO 40          -     .0173000
                   40 TO 50          -     .0270000
ISOLATION          .01 TO 50         -     .0000100
NOISE FLOOR        .01 TO .5         -     .0000316
                   .5 TO 8           -     .0000032
                   8 TO 20           -     .0000100
                   20 TO 31.25       -     .0000178
                   31.25 TO 40       -     .0000316
                   40 TO 50          -     .0001000
```

```
REF: PNA HELP
HP85133F CABLE SET ERRORS INCLUDED
ASSUME 1 Deg SHIFT IN TRACKING ERRORS
```

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REFLECTION AND TRACKING ERRORS

Reflection and Transmission Tracking error terms are derived from the test set specifications and are converted to linear values by performing the following calculation:

TRACKING ERROR TERM VALUE (LINEAR) = 1- (10^(Tracking Error in dB/20)

```
.01-50GHz TEST SET
N5230A_50
50 GHz
ERROR TERMS
ERROR TERM      FREQUENCY(GHz)      ERROR TERM VALUE(LINEAR)
============================================================
REFL TRACKING      .01 TO 2          -     .0024000
                   2 TO 20           -     .0032000
                   20 TO 40          -     .0046000
                   40 TO 50          -     .0066000
TRAN TRACKING      .01 TO 2          -     .0045000
                   2 TO 20           -     .0093000
                   20 TO 40          -     .0173000
                   40 TO 50          -     .0270000
ISOLATION          .01 TO 50         -     .0000100
NOISE FLOOR        .01 TO .5         -     .0000316
                   .5 TO 8           -     .0000032
                   8 TO 20           -     .0000100
                   20 TO 31.25       -     .0000178
                   31.25 TO 40       -     .0000316
                   40 TO 50          -     .0001000
============================================================
REF: PNA HELP
HP85133F CABLE SET ERRORS INCLUDED
ASSUME 1 Deg SHIFT IN TRACKING ERRORS
```

Populated with specification for test set reflection and tracking errors

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ISOLATION

The isolation error term is derived from the test set dynamic range specification. This value is typically presented in dB and may be converted using the following formula:

ISOLATION ERROR TERM VALUE (LINEAR) = (10^(Dynamic Range in dB/20)

```
.01-50GHz TEST SET
N5230A_50
50 GHz
ERROR TERMS
ERROR TERM      FREQUENCY(GHz)      ERROR TERM VALUE(LINEAR)
=========================================================
REFL TRACKING      .01 TO 2          -     .0024000
                   2 TO 20           -     .0032000
                   20 TO 40          -     .0046000
                   40 TO 50          -     .0066000
TRAN TRACKING      .01 TO 2          -     .0045000
                   2 TO 20           -     .0093000
                   20 TO 40          -     .0173000
                   40 TO 50          -     .0270000
ISOLATION          .01 TO 50         -     .0000100
NOISE FLOOR        .01 TO .5         -     .0000316
                   .5 TO 8           -     .0000032
                   8 TO 20           -     .0000100
                   20 TO 31.25       -     .0000178
                   31.25 TO 40       -     .0000316
                   40 TO 50          -     .0001000
=========================================================
REF: PNA HELP
HP85133F CABLE SET ERRORS INCLUDED
ASSUME 1 Deg SHIFT IN TRACKING ERRORS
```

Populated with test set dynamic range specification

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NOISE FLOOR

The noise floor error term is derived from the test set noise floor specification. This value is typically presented in dB and may be converted using the following formula:

NOISE FLOOR ERROR TERM VALUE (LINEAR) = (10^(Dynamic Range in dB/20)

```
.01-50GHz TEST SET
N5230A_50
50 GHz
ERROR TERMS
ERROR TERM      FREQUENCY(GHz)      ERROR TERM VALUE(LINEAR)
============================================================
REFL TRACKING      .01 TO 2          -     .0024000
                   2 TO 20           -     .0032000
                   20 TO 40          -     .0046000
                   40 TO 50          -     .0066000
TRAN TRACKING      .01 TO 2          -     .0045000
                   2 TO 20           -     .0093000
                   20 TO 40          -     .0173000
                   40 TO 50          -     .0270000
ISOLATION          .01 TO 50         -     .0000100
NOISE FLOOR        .01 TO .5         -     .0000316
                   .5 TO 8           -     .0000032
                   8 TO 20           -     .0000100
                   20 TO 31.25       -     .0000178
                   31.25 TO 40       -     .0000316
                   40 TO 50          -     .0001000
============================================================
REF: PNA HELP
HP85133F CABLE SET ERRORS INCLUDED
ASSUME 1 Deg SHIFT IN TRACKING ERRORS
```

Populated with test set noise floor specification