**Tim Brauner**
Product Line Manager
SLC & Thin Film Products

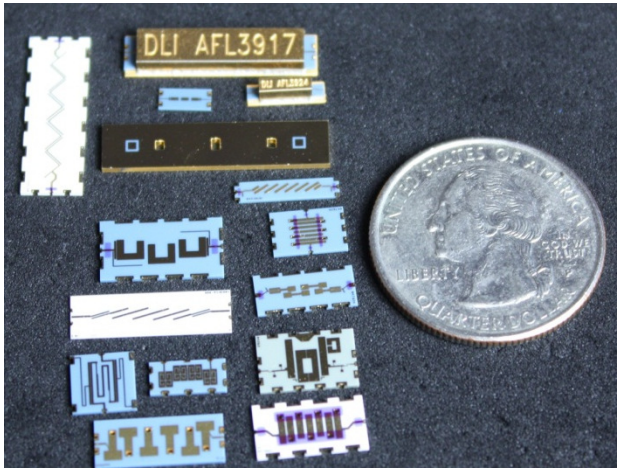
July 2017

# DLI Products
# What's New
# Thin Film Microwave Devices

# ‘Disruptive Component Technologies’ for RF & Microwave Systems

## *Miniature Microwave Thin Film Filters & Components*

- Custom Designs/ Hi-K Ceramics
- 300MHz ~50GHz
- SMT
- Chip & Wire



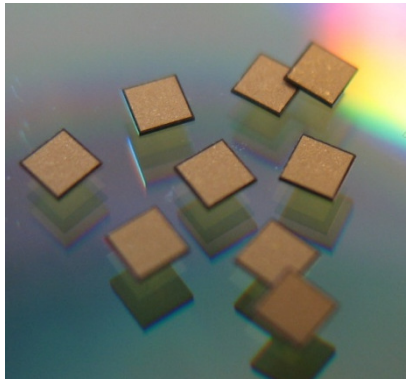

XTREME-Q

## *Thin Film Build to Print Fabrication*

- *Wide range of standard & DLI proprietary Ceramics 4<K<40,000*
- *Metallization: TiW, Pt, Ni, Cu, Au, TaN resistors*
- *Features to 0.5 mils*
- *Laser Vias / Filled Vias*
- *Polyimide Multi-layer, in R&D*
- *RF testing service/ Screening option*

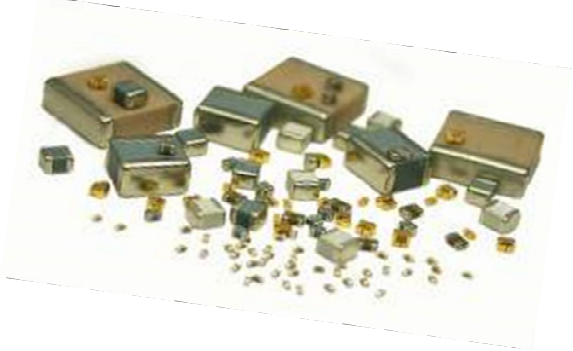
## *Single Layer Ceramic Capacitors*

- Widest selection of SLC’s
- 4<K40,000
- Temperature stable /Hi-Q matching
- Decoupling/ DC blocking
- Metallization , many options
- Microwave Modeling CAPCAD™
- Custom Solutions



## *Hi-Q MLC’s*

- 0402 ~3838 case sizes
- RF Power
- Broadband DC Blocks



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# Thin Film Microwave Technology

## Performance Advantages of DLI Thin Film Devices

- Strengths
  - Temp Stability
  - Repeatability
  - Reduced Size
- Wider Band
- Steeper Skirts
- Higher Frequency Advances
- Multi-Device Packaging

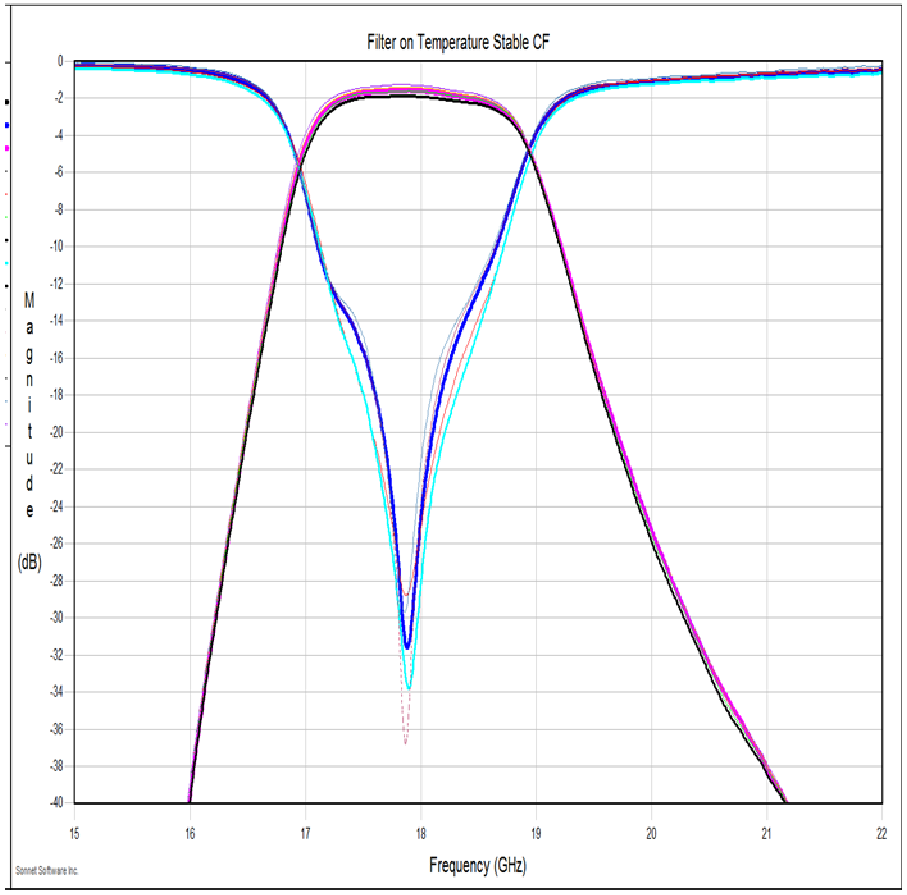
# DLI Filters, 5G Advantages


- Small size (footprint & height)
  - High dielectric constant, Hi-Q materials offer reduced size versus on PCB
  - Use K= 13, 23, 67 to shrink size (PCB typically 2-4); 3-10x reduction is size
- Temperature stable RF to (~3ppm/℃)
  - Smaller modules and higher power amplifiers (GaN) mean denser, higher temperature variation in packages. DLI filters are inherently temperature stable over wide temp range; -55 to 125°C
- Excellent RF repeatability
  - Using thin film manufacturing, we can guarantee repeatability on large batches of filters to offer more repeatable performance and lower cost of next level assembly – No Tuning!
- Repeatable SMT performance to 20GHz +
  - DLI has been building surface mount filter devices for >10 yrs and is excelling at higher frequency filtering for mounting in low cost printed wire board technology
- Wider band performance, steeper skirts
  - DLI Hi-Q, Hi-K, temp stable technology offers the ability for higher selectivity, wider bandwidth and lower loss filters than many competing tech for lower cost
- Higher Power
  - Using DLI, we can build components that withstand higher power than traditional chip technology. Devices can be designed to handle over 20 Watts of power.

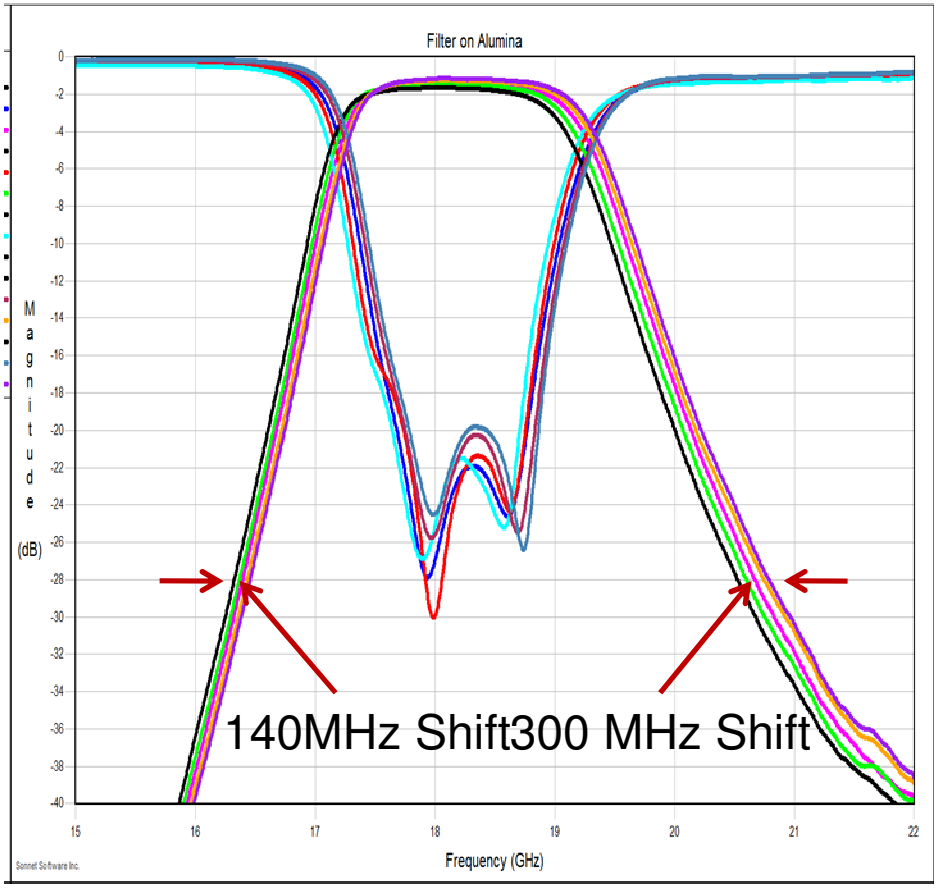
# Filter Temperature Stability

18 GHz Band-pass Filters (-55 to +125 ℃)

"CF"




99.6% Alumina




Most Systems Specify -40 to +85°C

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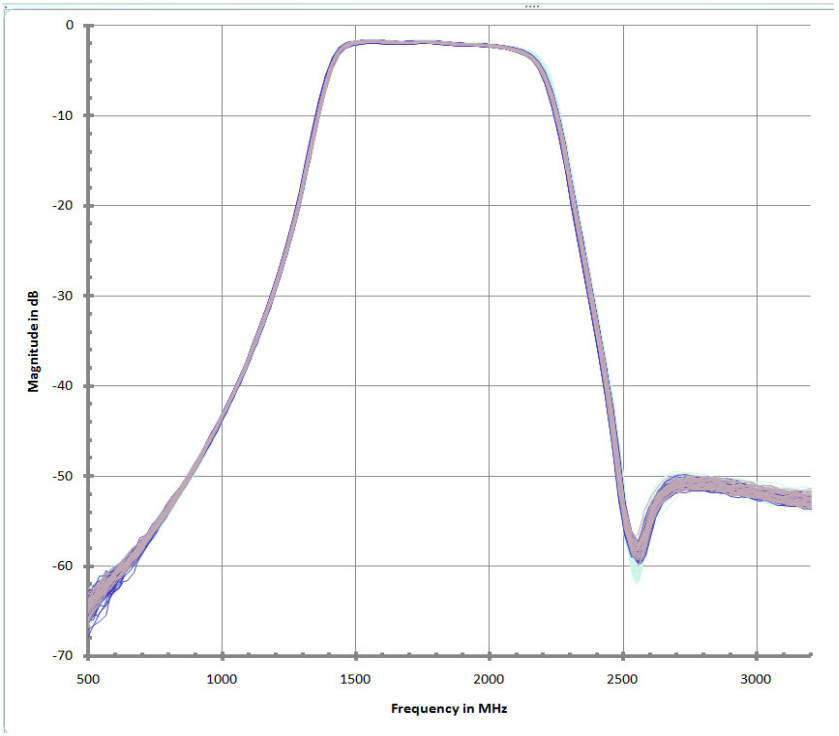
# Materials for Temperature Stability

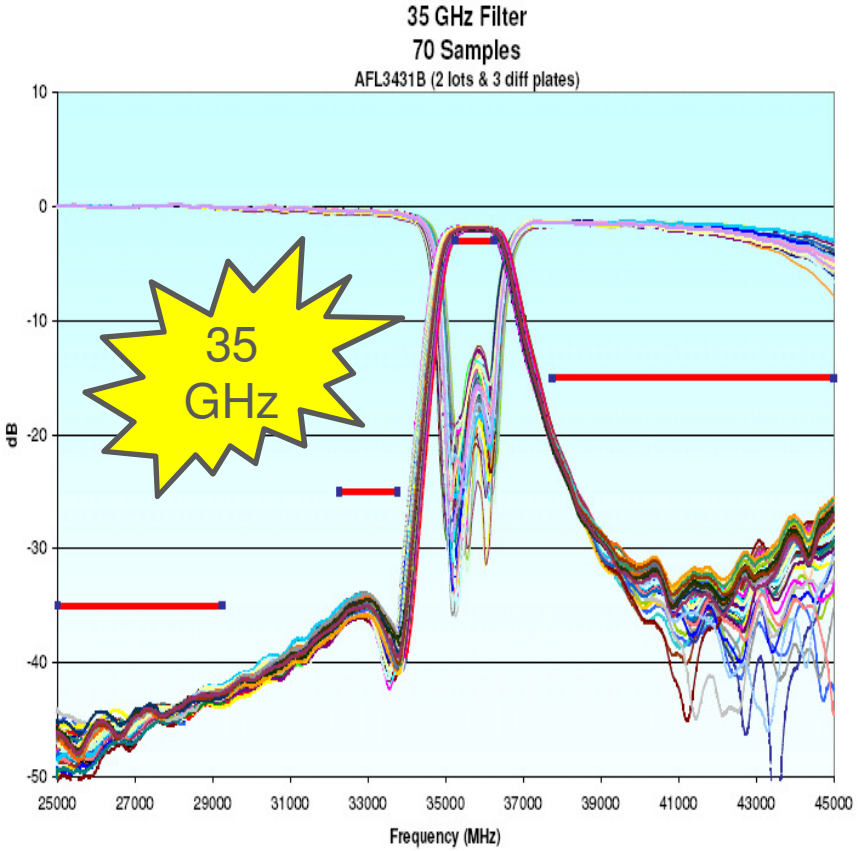
| Substrate Material | Dielectric Constant (Tolerance) | Typical Loss Tangent | Coefficient of Thermal Expansion (ppm/°K) | Temperature Coefficient of Capacitance (ppm/°C) | Surface Finish (m-inch) | Temp Stability |
|---|---|---|---|---|---|---|
| 99.6% Alumina (Al2O3) PI | 9.9 (± 0.15) @1MHz | 0.0001 | 6.5-7.5 | P120 ± 30 | <5 | Poor |
| **PG** | **13 (± 0.5)** | **0.0002** | **7.6** | **P22 ± 30** | **<5** | **Good** |
| **CF** | **25 (± 1)** | **0.0003** | **9.0** | **0 ± 15** | **<5** | **Excellent** |
| **CD** | **38 (± 1)** | **0.0004** | **5.8** | **N20 ± 15** | **<5** | **Good** |
| **CG** | **67 (± 3)** | **0.0008** | **9.0** | **0 ± 30** | **<5** | **Very Good** |

# Repeatable Performance from DC to 50GHz

Excellent Repeatability
250 Samples. 3 Lots

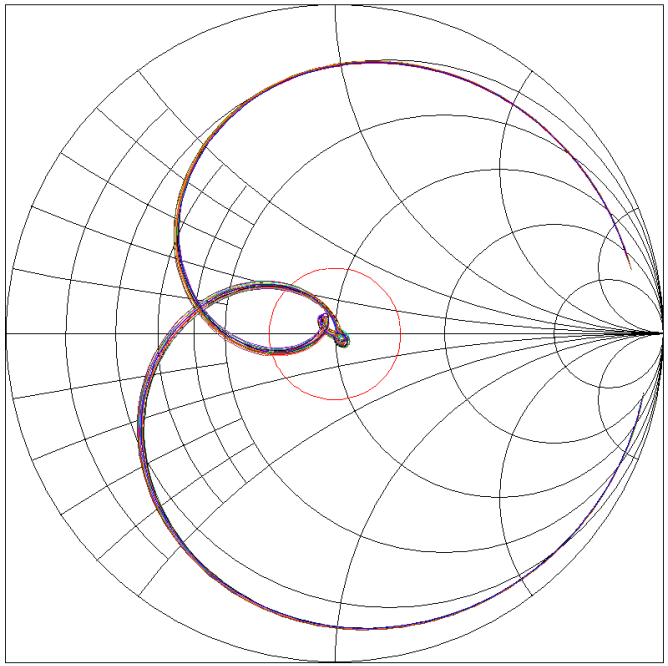


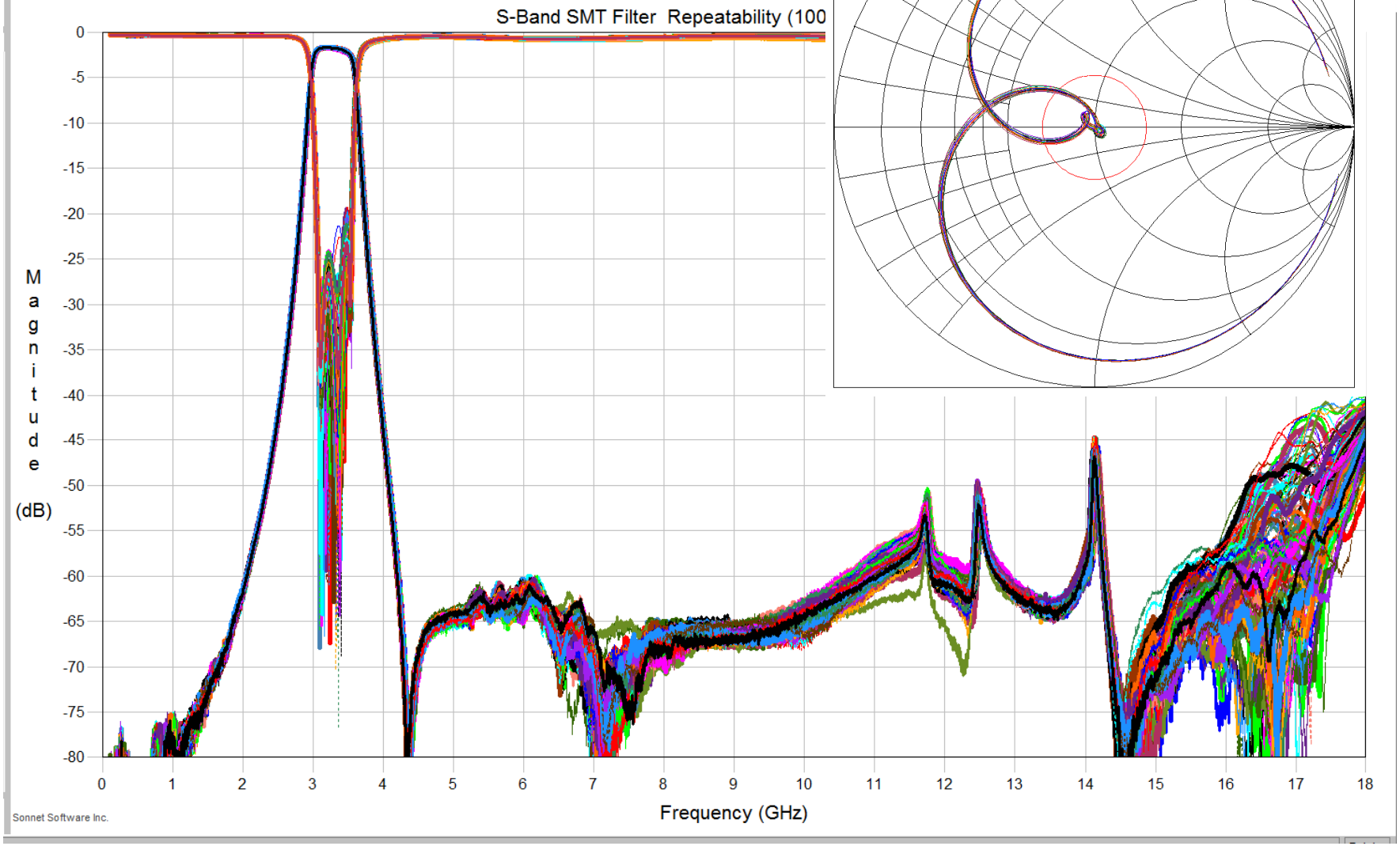

70 Samples from Multiple Substrates
- 10 mil CF (K23 ) material



# S-Band SMT Filters
# Repeatability 100 samples

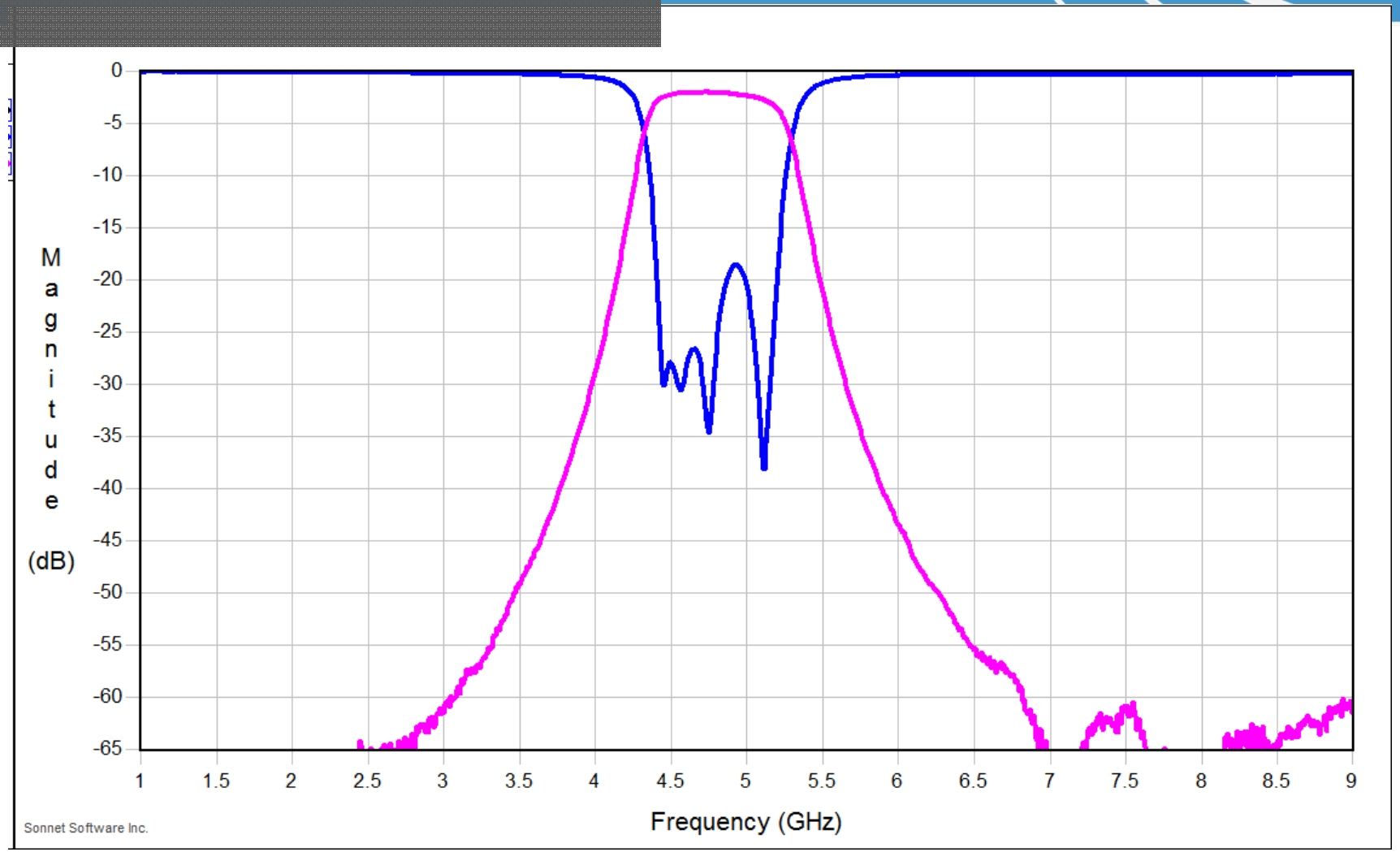
S11 Repeatability 20 Samples





# Miniature SMT 5 GHz BPF

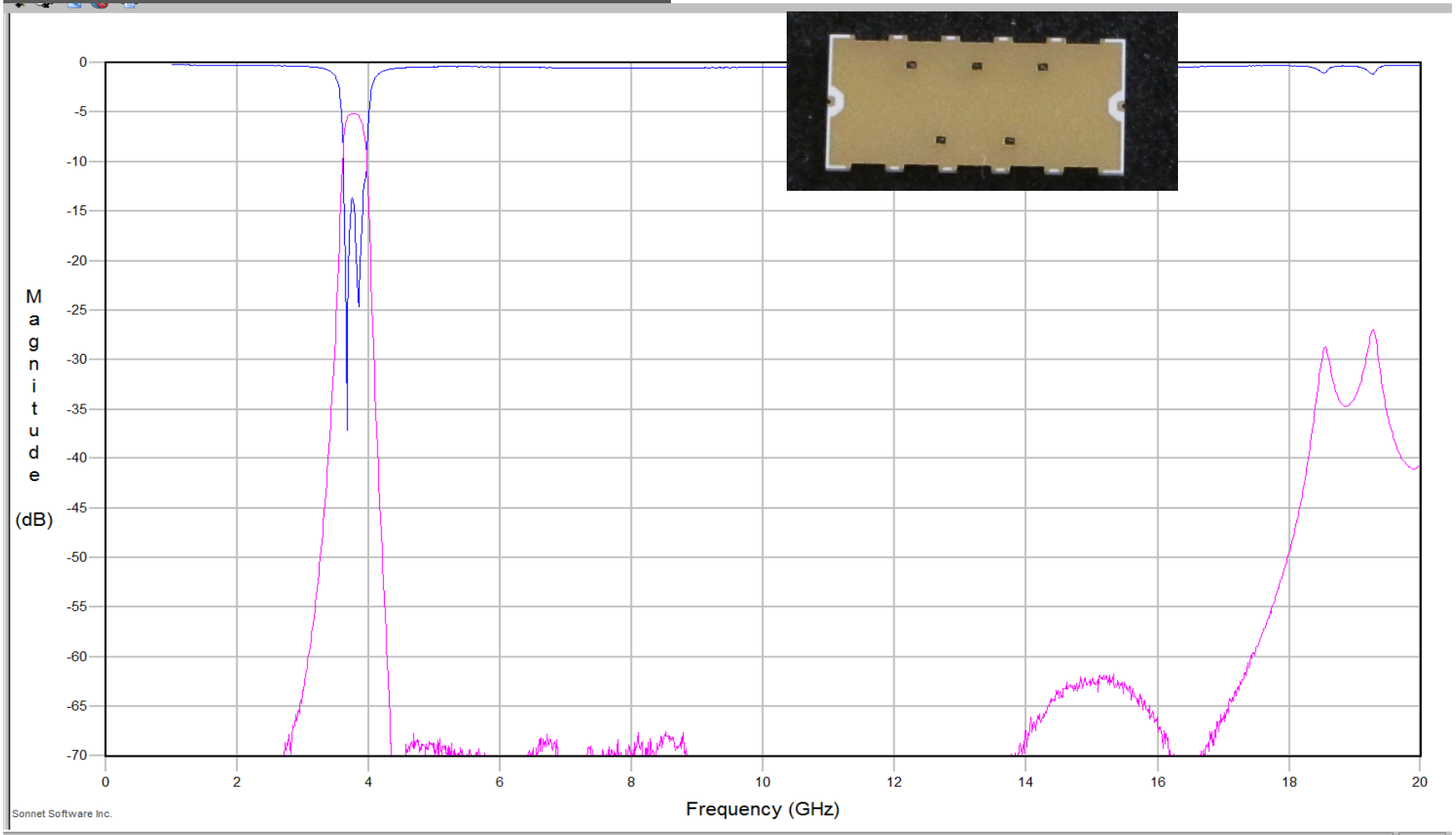
Size 0.4x0.18 inches [10.2x4.6mm], shield cover



# 3.7 GHz SMT Filter synthesizer LO chain

(500 x 240 mils) [12.7x6.1mm]
Exceptional stop-band Performance



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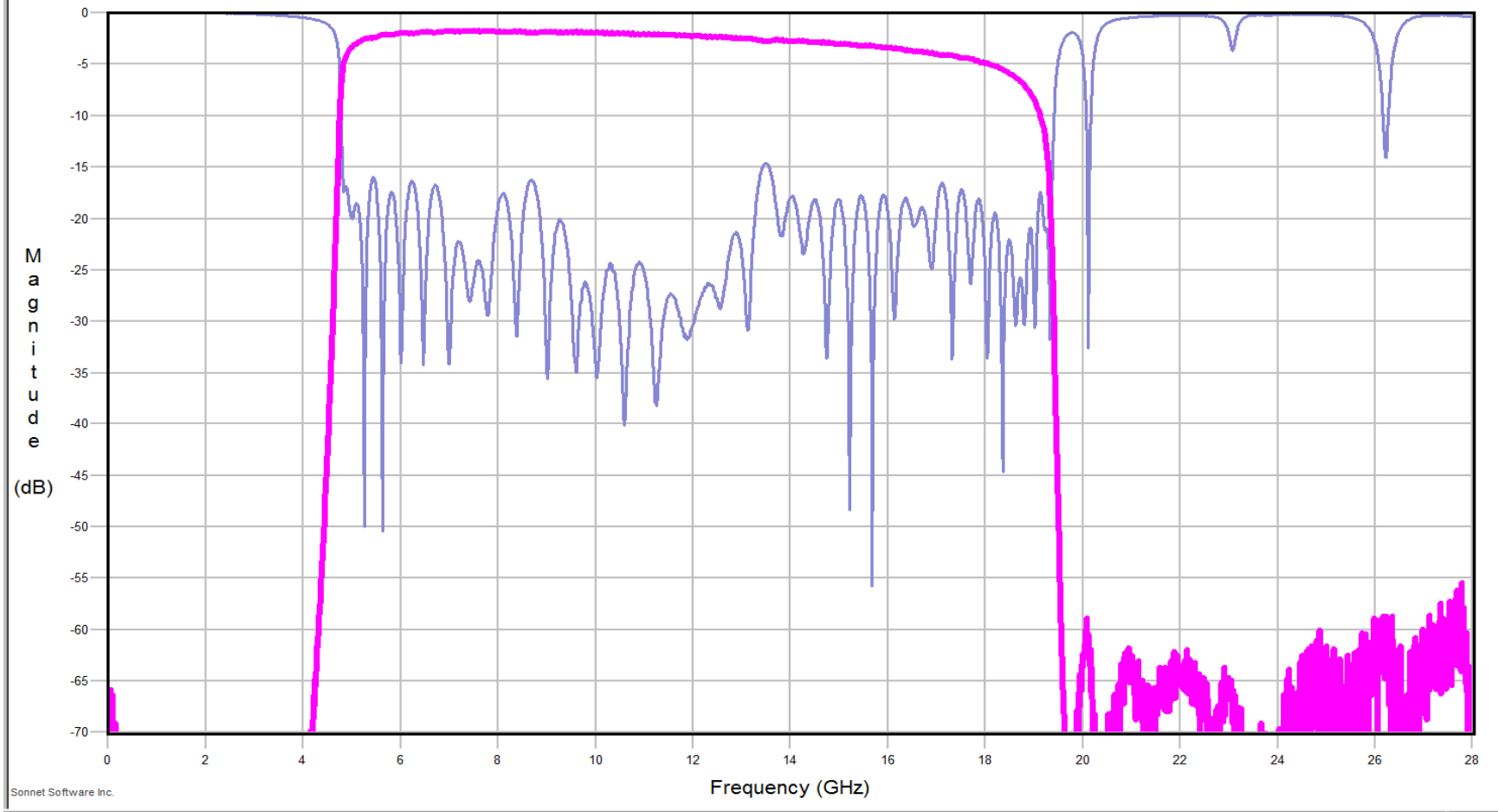
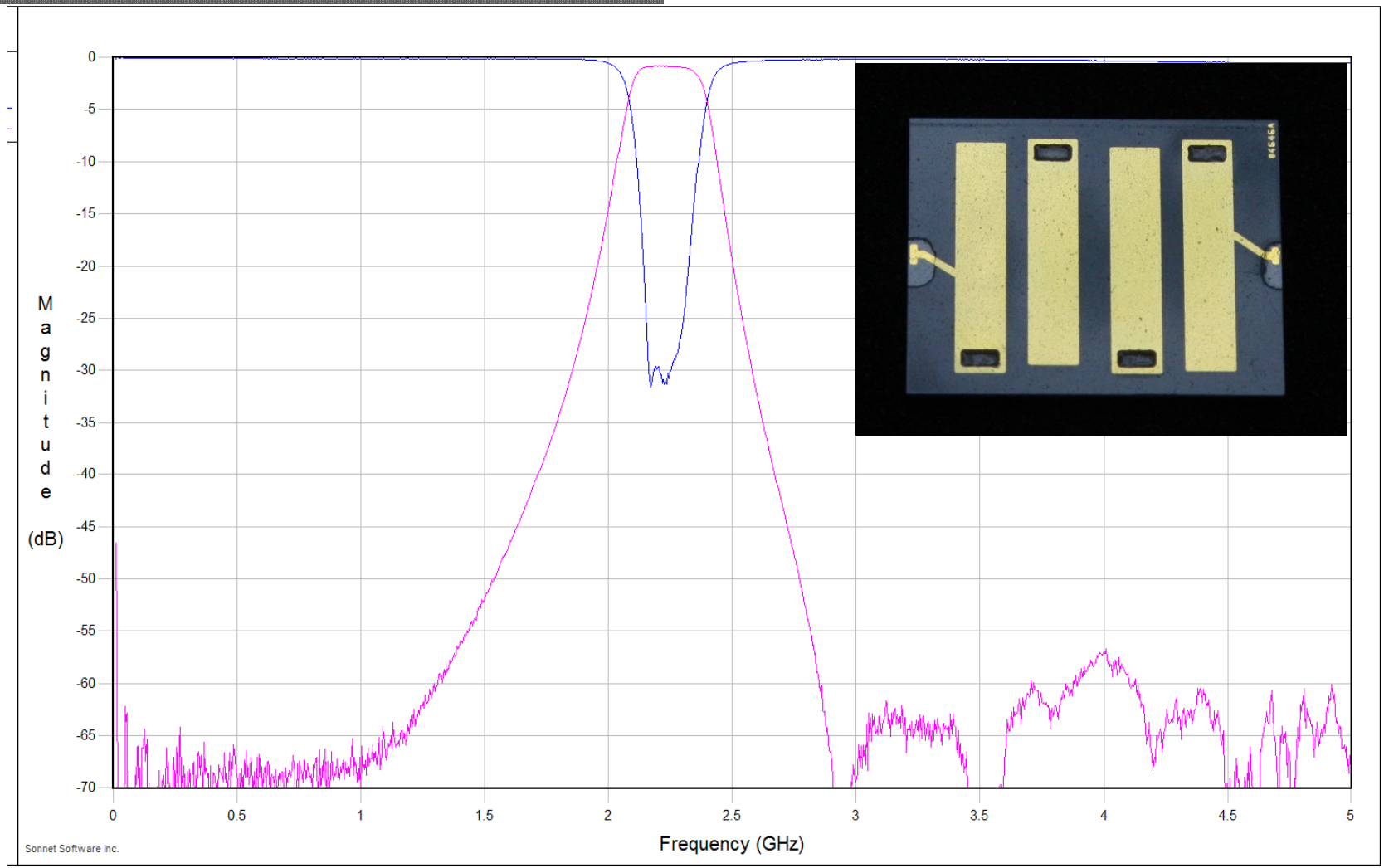
# Integrated High Pass & Low Pass Filters

5~18 GHz pass band ~140% Bandwidth



# 2.2 GHz High Power Filter
# 50 Watt CW

Protection from RF Breakdown, Condensation & altitude

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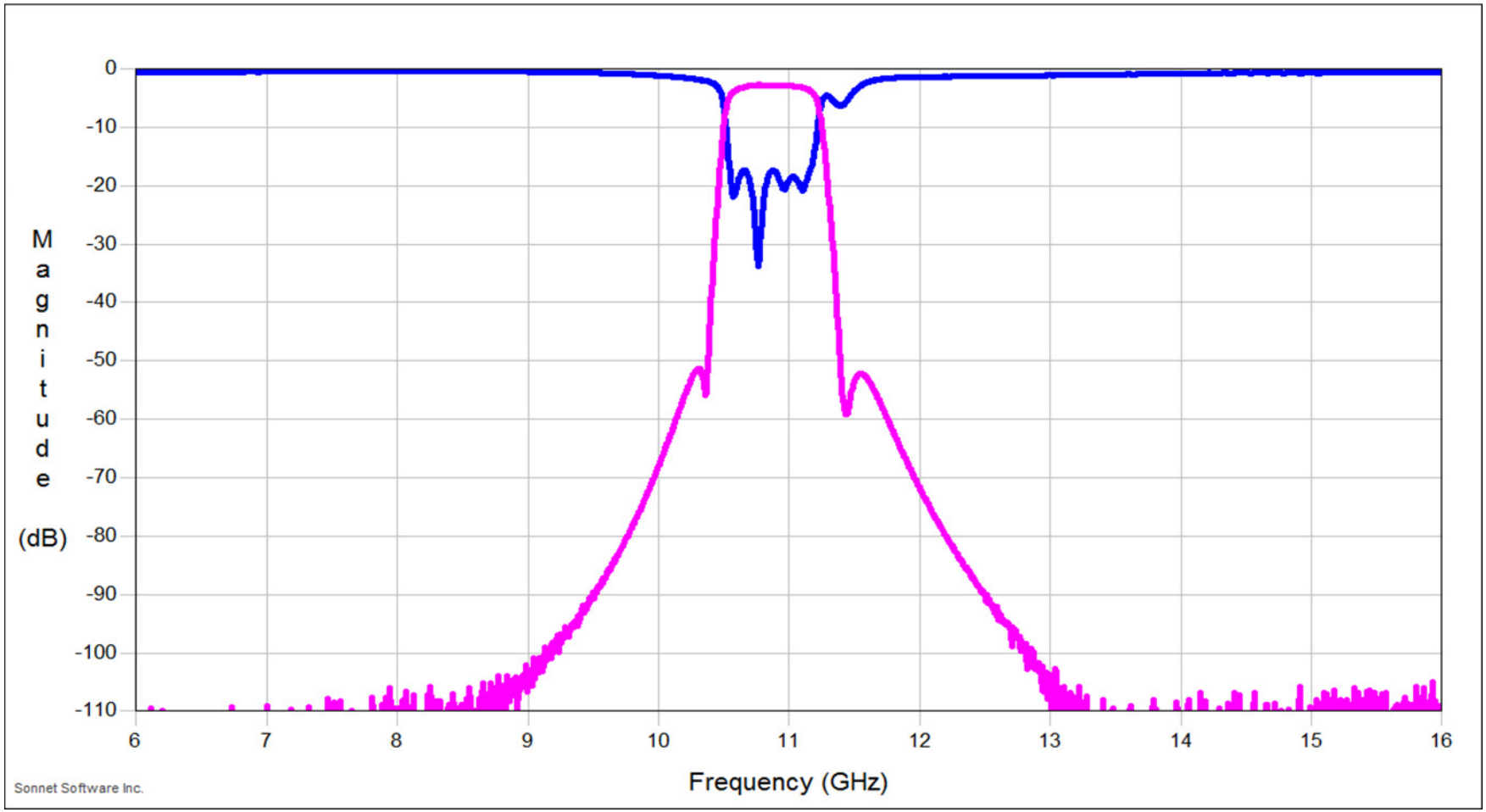
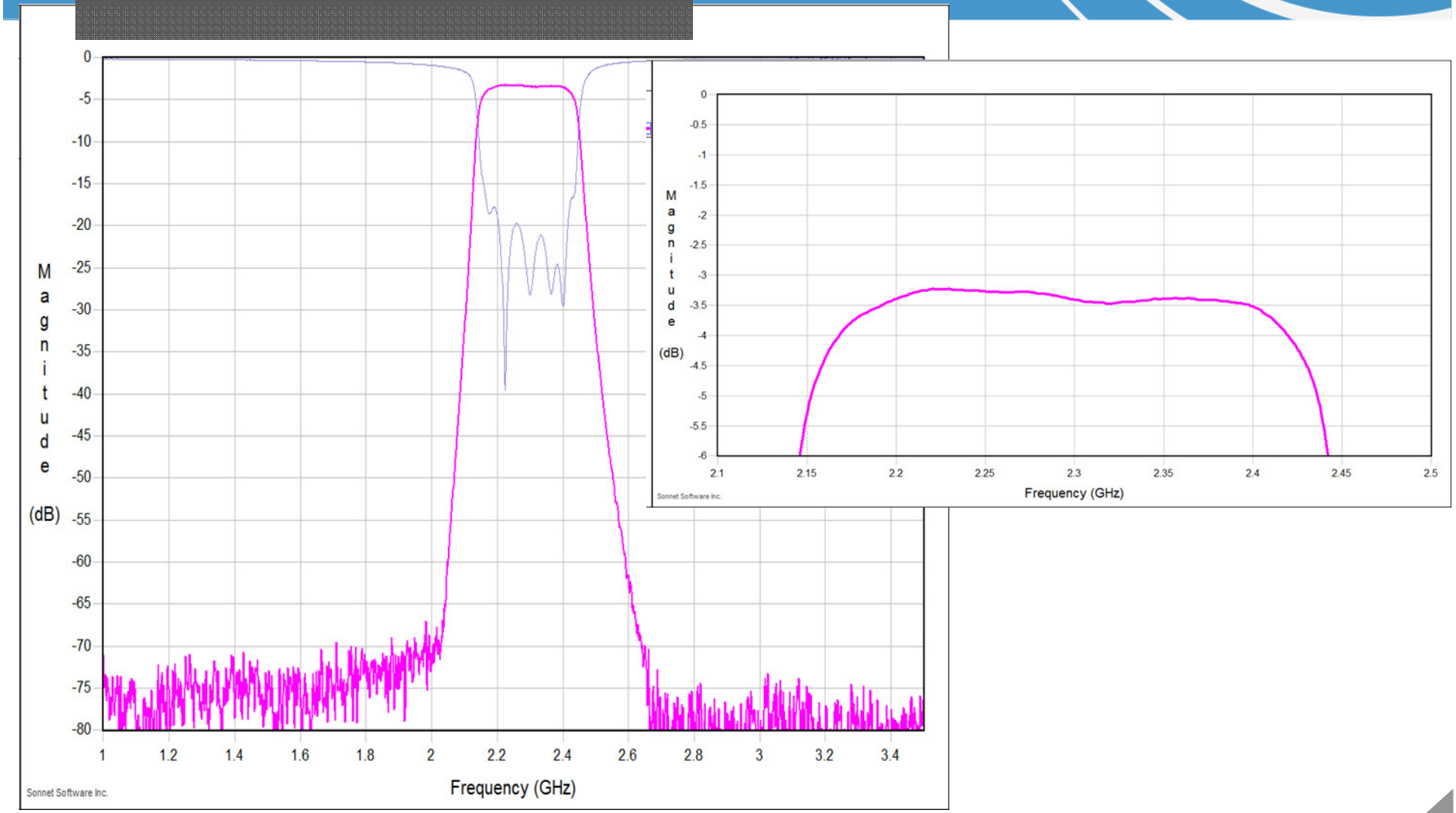
# Outstanding Rejection Possible

Shielded sample w/connectors



# Advanced Passband Flatness Techniques

8 Pole Filter with 0.25dB p-p Flatness (Thin Film Resistor networks incorporated)

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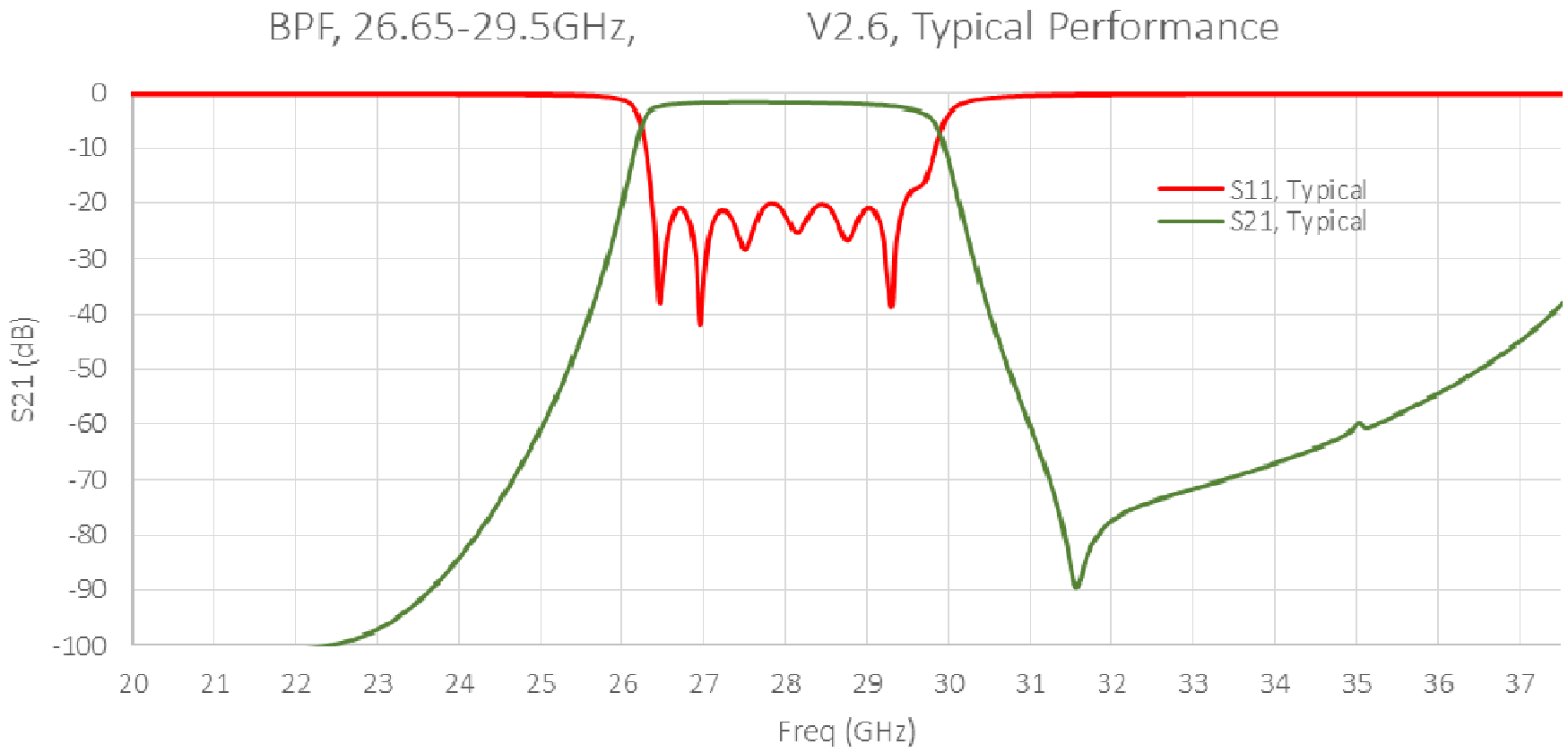
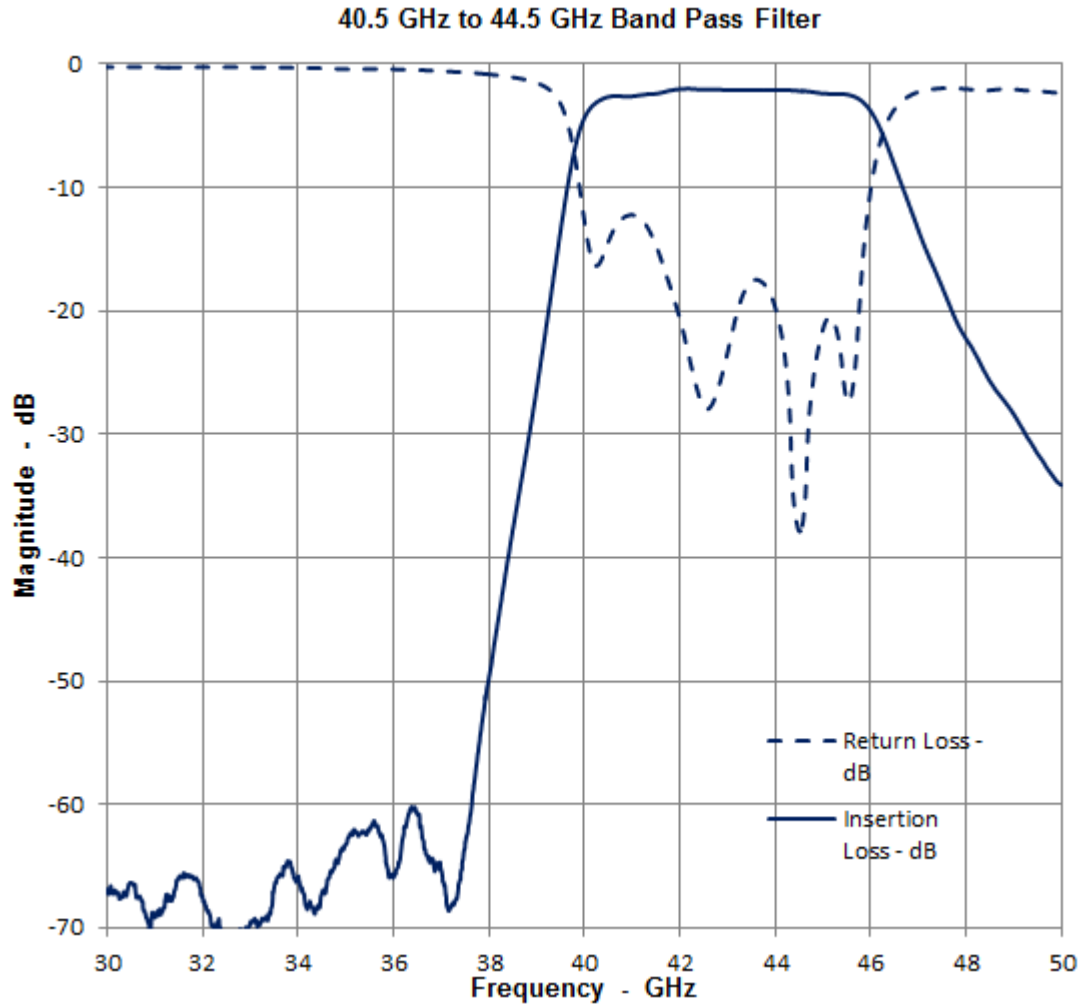
# 28 GHz Bandpass Filter

Surface Mount Device for 5G applications



# SMT 40~43 GHz Filter




Demonstrated Excellent Performance in Surface Mount Form

4 Pole Filter

Size: 0.275 x 0.080 in
7.0 x 2.0 mm

# Thin Film Technology

What's New

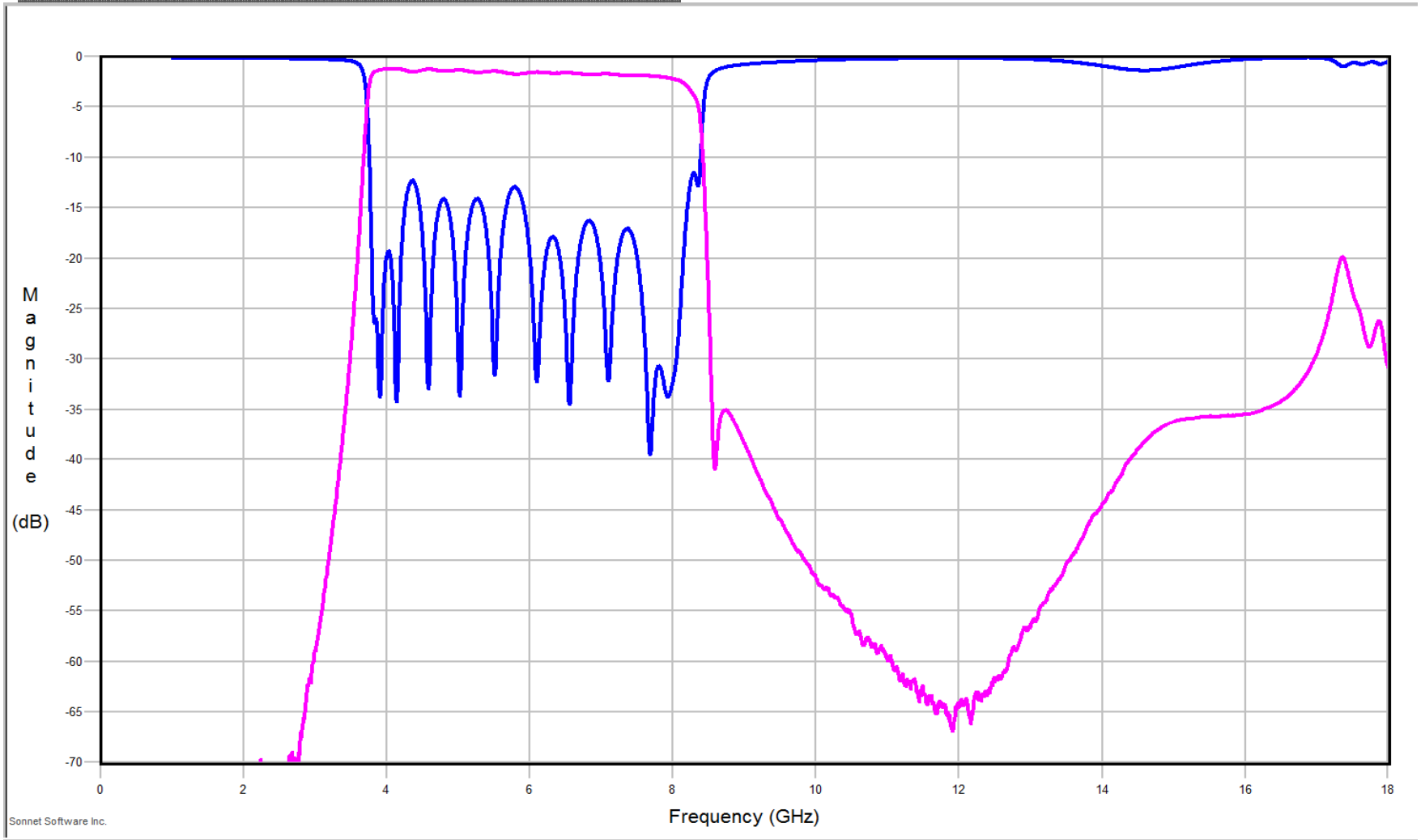
- Catalog Products
  - Bandpass Filters
  - Lowpass Filters
  - Highpass Filters
  - Power Dividers
  - Couplers, 10 & 20dB BIT
  - Gain Equalizers

# DLI SMT Filter Technology Made Easier


| Part Number | Center Frequency | Passband | Insertion Loss (@Fc) | | Length Inches (mm) | Width Inches (mm) | Height Inches (mm) |
|---|---|---|---|---|---|---|---|
| | | | @ 25°C | -40°C to +85°C | | | |
| B012MD5S | 1.227 GHz | 1.22 to 1.23 GHz | 3.5 dB | 4.2 dB | 0.670 (17.02) | 0.600 (15.24) | 0.100 (2.36) |
| B016MD5S | 1.575 GHz | 1.57 to 1.58 GHz | 3.5 dB | 4.2 dB | 0.670 (17.02) | 0.600 (15.24) | 0.100 (2.36) |
| B028RF2S | 3 GHz | 2 to 4 GHz | 2.5 dB | 3.0 dB | 0.450 (11.43) | 0.400 (10.16) | 0.113 (2.87) |
| B033ND5S | 3.3 GHz | 3.1 to 3.5 GHz | 2.0 dB | 3.2 dB | 0.393 (9.98) | 0.353 (8.97) | 0.128 (3.25) |
| B057MD7S | 5.7 GHz | 5.5 to 6.1 GHz | 2.3 dB | 2.8 dB | 0.475 (12.1) | 0.275 (7.00) | 0.103 (2.62) |
| B056RC4S | 6 GHz | 4 to 8 GHz | 3.0 dB | 3.5 dB | 0.450 (11.43) | 0.230 (5.84) | 0.100 (2.54) |
| B060NC5S | 6 GHz | 5.5 to 6.5 GHz | 2.0 dB | 3.0 dB | 0.500 (12.7) | 0.200 (5.08) | 0.088 (2.24) |
| B080MB5S | 8 GHz | 7.5 to 8.5 GHz | 2.0 dB | 3.0 dB | 0.500 (12.7) | 0.180 (4.57) | 0.100 (2.54) |
| B096QC2S | 10 GHz | 8 to 12 GHz | 2.5 dB | 3.0 dB | 0.400 (10.86) | 0.180 (4.57) | 0.100 (2.54) |
| B120MB1S | 12 GHz | 11.5 to 12.5 GHz | 2.0 dB | 3.0 dB | 0.525 (13.34) | 0.225 (5.72) | 0.090 (2.27) |
| B148QF0S | 15 GHz | 12 to 18 GHz | 3.6 dB | 4.2 dB | 0.550 (13.97) | 0.150 (3.81) | 0.098 (2.49) |
| B161LA0S | 16 GHz | 15.5 to | 4.0 dB | 6.0 dB | 0.695 | 0.250 | 0.093 |

# Catalog Filter P/N: B056RC4S

4~8 GHz Band Pass
Size: 0.45 x 0.23 inch
[12.1 x 7.0 mm]



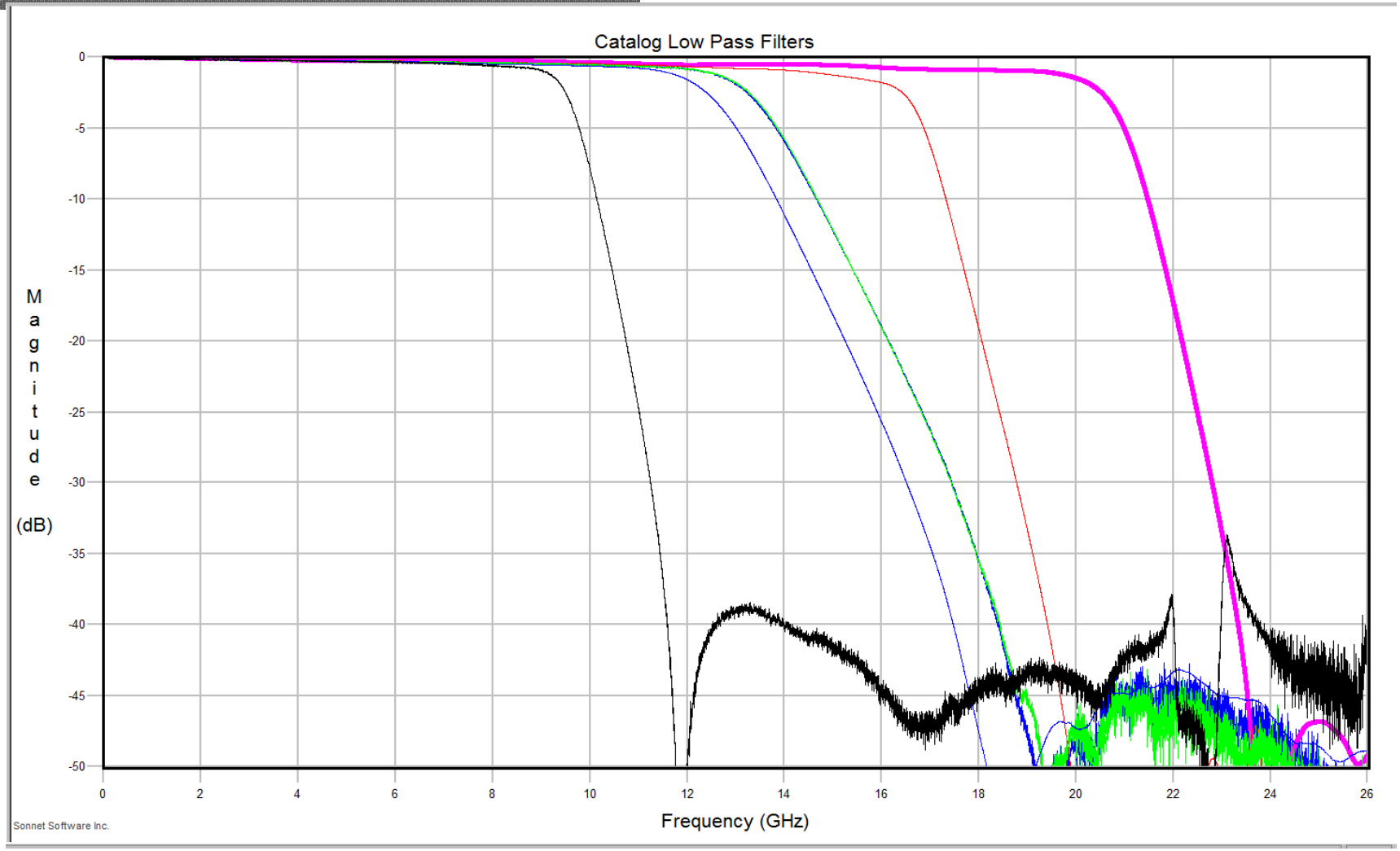
# Lowpass Filters

## SMD, Typically >35dB Rejection

| Part Number | 3 dB Cutoff | Passband | Max Insertion Loss in Passband | Min VSWR in Passband | Length Inches (mm) | Width Inches (mm) | Height Inches (mm) |
|---|---|---|---|---|---|---|---|
| L050XF9S | 5 GHz | DC - 4 GHz | 1 dB | 1.288:1 | 0.220 (5.58) | 0.180 (4.57) | 0.103 (2.62) |
| L065XG9S | 6.5 GHz | DC - 6 GHz | 1.3 dB | 1.22:1 | 0.220 (5.58) | 0.180 (4.57) | 0.103 (2.62) |
| L095XG9S | 9.5 GHz | DC - 9 GHz | 1.3 dB | 1.12:1 | 0.220 (5.58) | 0.140 (3.56) | 0.103 (2.62) |
| L117XH4S | 11.7 GHz | DC - 11 GHz | 1 dB | 1.43:1 | 0.220 (5.58) | 0.140 (3.56) | 0.103 (2.62) |
| L128XH4S | 12.8 GHz | DC - 12 GHz | 1.2 dB | 1.38:1 | 0.220 (5.58) | 0.140 (3.56) | 0.103 (2.62) |
| L157XG3S | 15.7 GHz | DC - 15 GHz | 2.2 dB | 1.3:1 | 0.220 (5.58) | 0.140 (3.56) | 0.103 (2.62) |
| L185XF4S | 18.5 GHz | DC - 18 GHz | 2.2 dB | 1.4:1 | 0.220 (5.58) | 0.140 (3.56) | 0.098 (2.49) |
| L204XF4S | 20.4 GHz | DC - 20 GHz | 1.8 dB | 1.43:1 | 0.220 (5.58) | 0.140 (3.56) | 0.098 (2.49) |
| L254XF3S | 25.4 GHz | DC - 25 GHz | 1.4 dB | 1.3:1 | 0.220 (5.58) | 0.140 (3.56) | 0.098 (2.49) |

# Lowpass Filters
## Rejection 3 Harmonics

Mouser Stocking
Demo Boards Avaliable



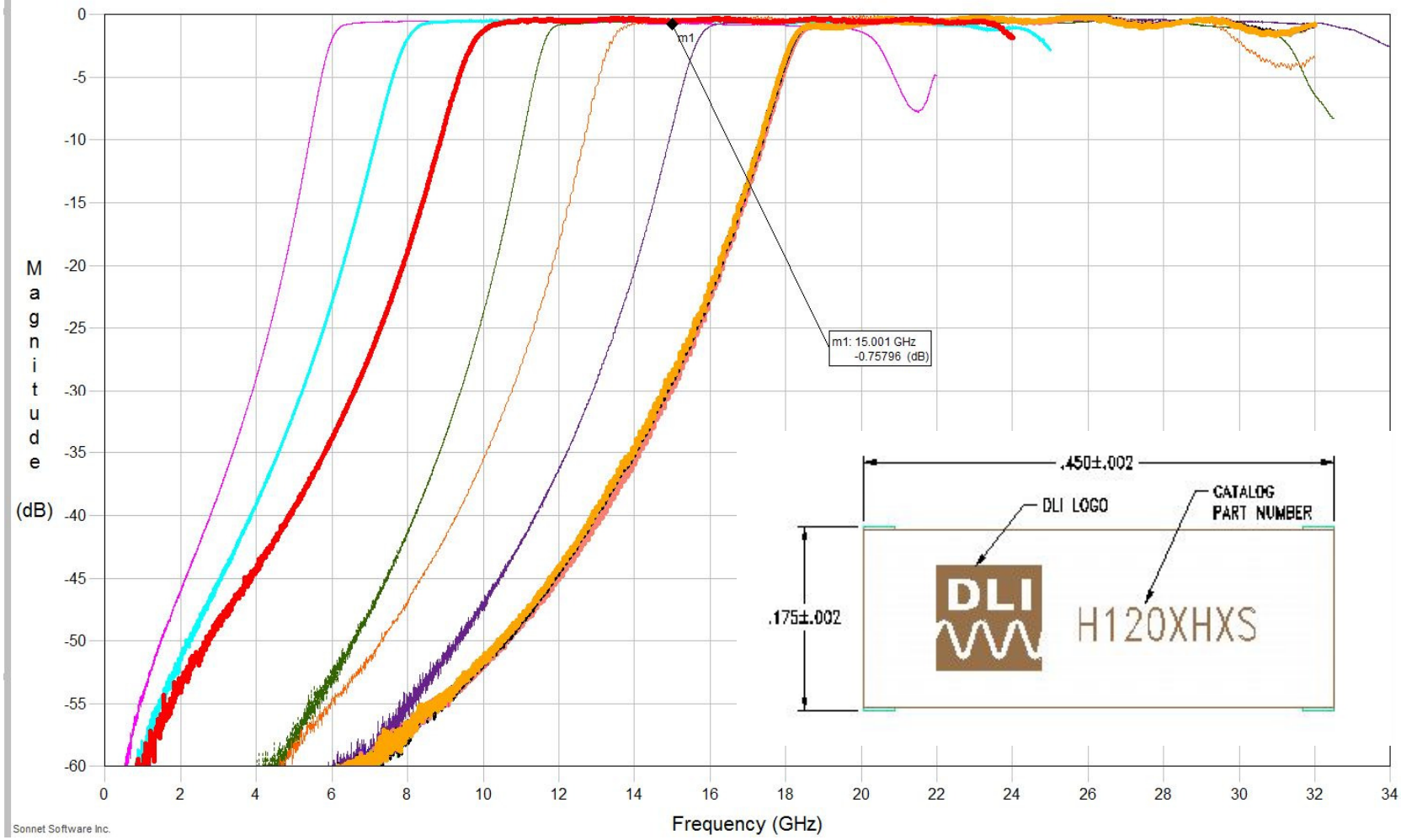
# **New** *Catalog Highpass Filters*

Chip & Wire Hybrid versions available also!

| Part Number | 3dB cutoff | Passband | Typical Insertion Loss in Passband | Minimum VSWR in Passband | Length inches (mm) | Width inches (mm) |
|---|---|---|---|---|---|---|
| H060XHXS | 6 GHz | 6.5 - 20 GHz | 1dB | 1.43 : 1 | 0.450 (11.43) | 0.200 (5.08) |
| H080XHXS | 8 GHz | 8.5 - 22 GHz | 1dB | 1.43 : 1 | 0.450 (11.43) | 0.200 (5.08) |
| H100XHXS | 10 GHz | 10.5 - 23 GHz | 1dB | 1.43 : 1 | 0.450 (11.43) | 0.175 (4.445) |
| H120XHXS | 12 GHz | 12.5 - 30 GHz | 1dB | 1.43 : 1 | 0.450 (11.43) | 0.175 (4.445) |
| H140XHXS | 14 GHz | 14.5 - 28 GHz | 1dB | 1.43 : 1 | 0.450 (11.43) | 0.175 (4.445) |
| H160XHXS | 16 GHz | 16.5 - 32.5 GHz | 1dB | 1.43 : 1 | 0.450 (11.43) | 0.175 (4.445) |
| H182XHXS | 18.2 GHz | 18.75 - 28 GHz | 1dB | 1.7 : 1 | 0.450 (11.43) | 0.175 (4.445) |

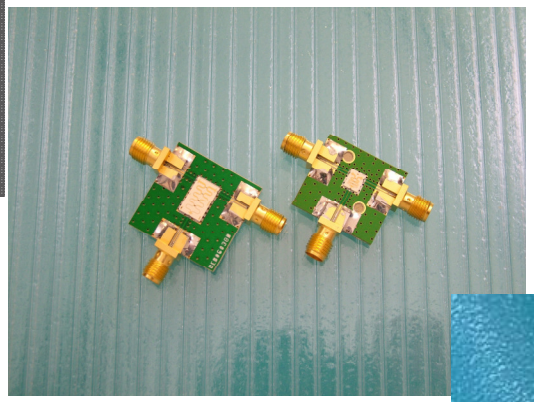
# Highpass Filters GHz

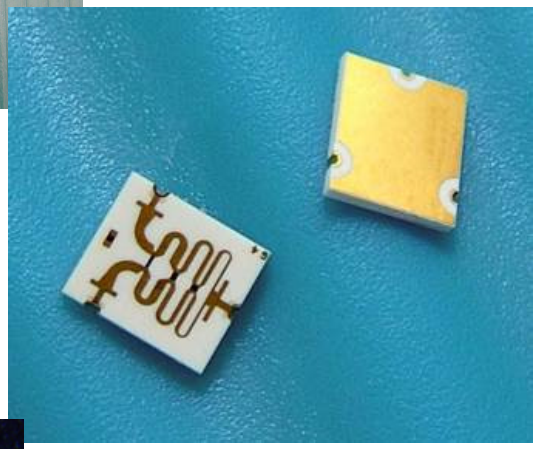
*Corner frequencies: 6, 8, 10, 12, 14, 16, and 18*

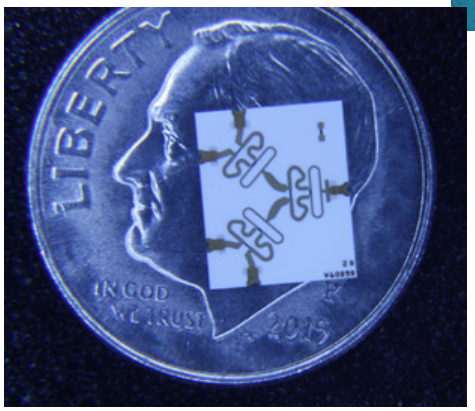


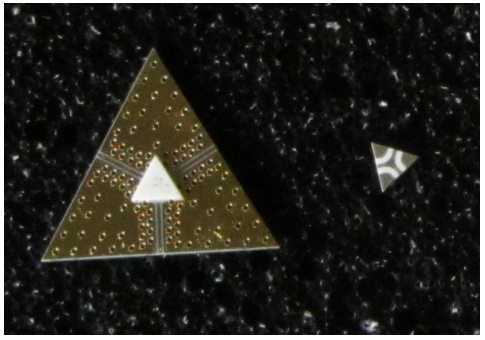
# *Thin Film in Phase Power Dividers*

- SMT & Wire-bond versions
- Frequency Range: DC to 50 GHz
- Resistive Dividers
- Multi-section Wilkinson Dividers
- Thin Film Benefits:
  - Excellent amplitude & phase characteristics
  - Excellent unit to unit repeatability
  - Integrated Thin Film Isolation resistors
    - Superior power handling
    - Superior isolation

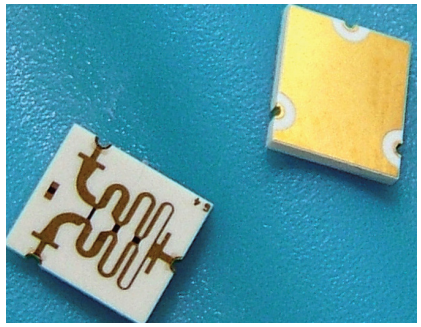






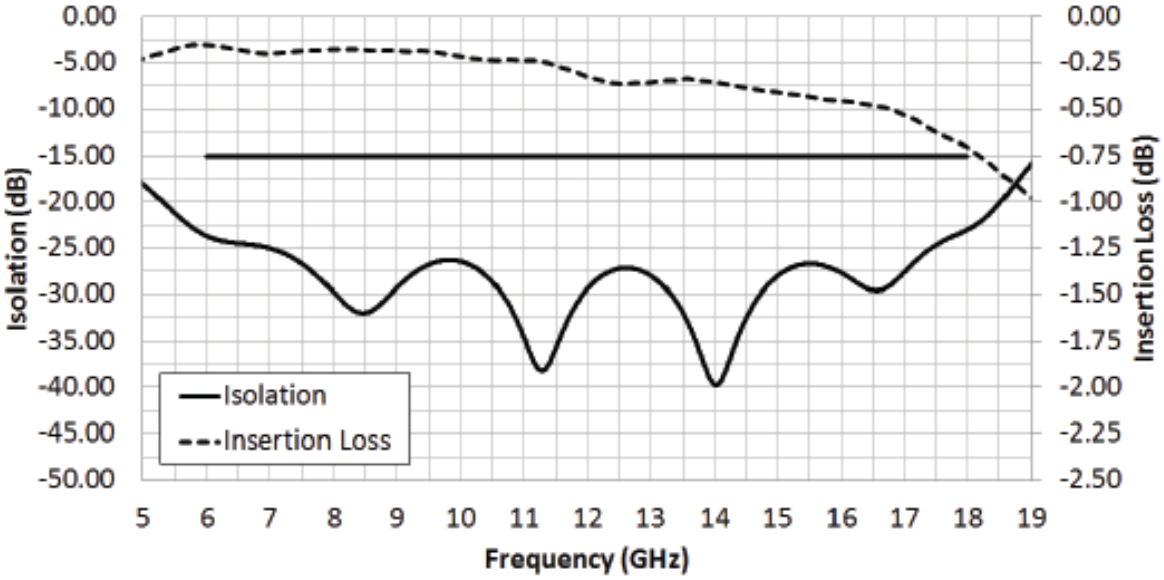



# 6-18 GHz Wilkinson Power Divider



Features:

- Broadband performance
- Compact SMT Package utilizing DLI Hi-K materials
- 0.185 x 0.180 x0.020 inches
- 4.70 x 4.57 x 0.51 mm
- Excellent Phase and Amplitude Balance




## Electrical

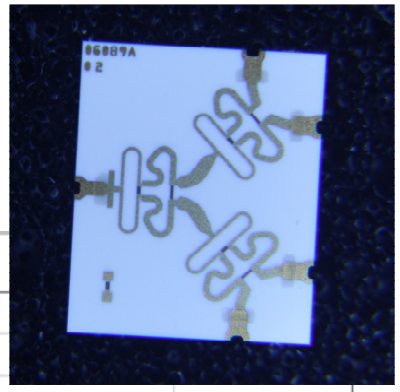
| | |
|---|---|
| **Frequency Range (GHz)** | |
| 6 to 18 | |
| **Nominal Power Splitting (dB)** | |
| 3.0 (typical) | |
| **Nominal Phase Shift (degrees)** | |
| 0.0 (typical) | |
| **Amplitude Balance (dB)** | |
| ±0.025 max. | |
| **Phase Balance (degrees)** | |
| ±3.0 (max.) | |
| **Excess Insertion Loss (dB)** | |
| 0.7 (typical) | |
| **Return Loss (dB)** | |
| 20 (typical) | |
| **Isolation (dB)** | |
| 20 (typical) | |

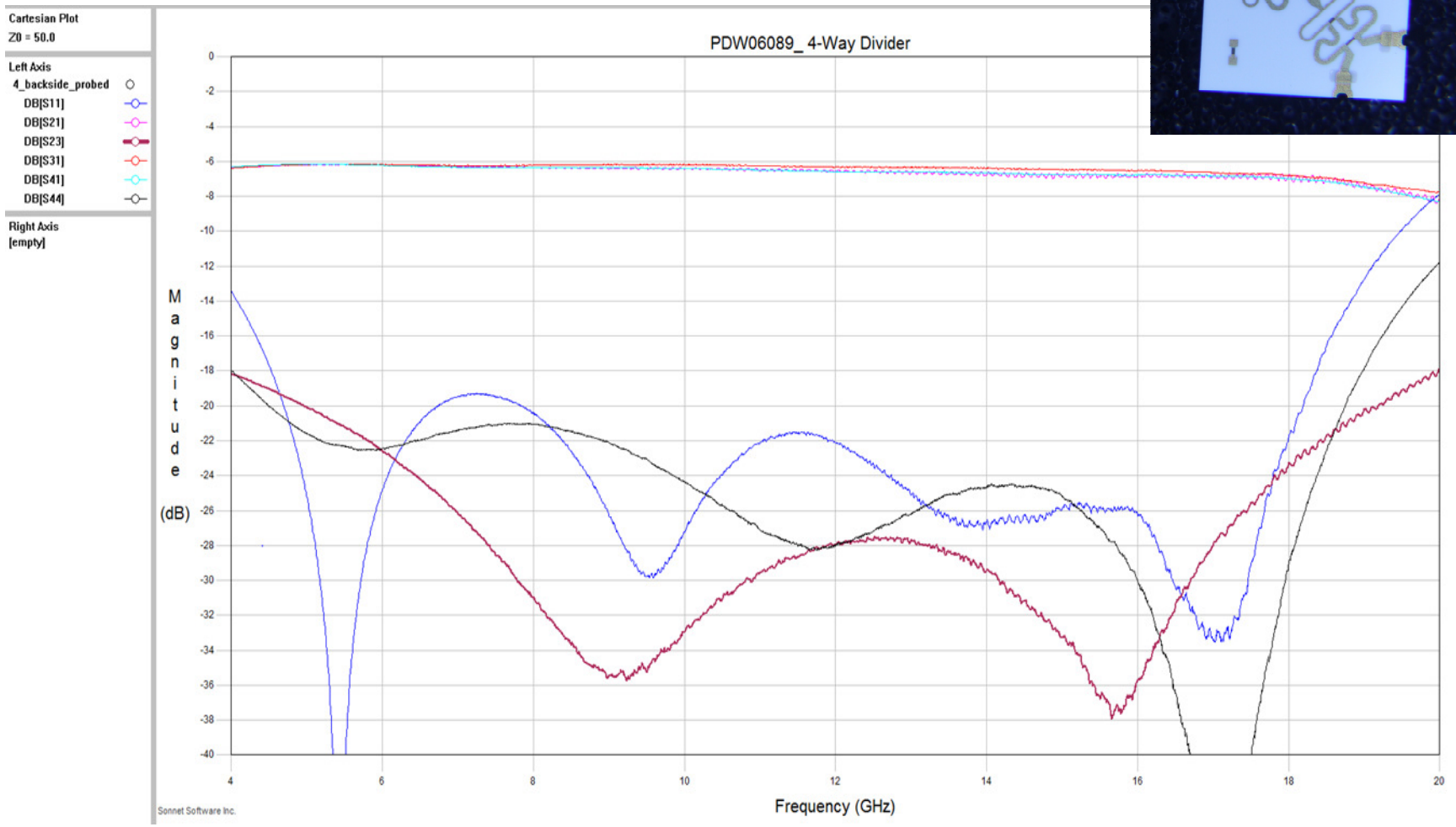
# 6-18 GHz 4-Way Wilkinson Power Divider: PDW06089

## Compact SMT Package utilizing DLI Hi-K materials

Footprint: 0.25 x 0.30 in [6.35 x 7.62 mm]

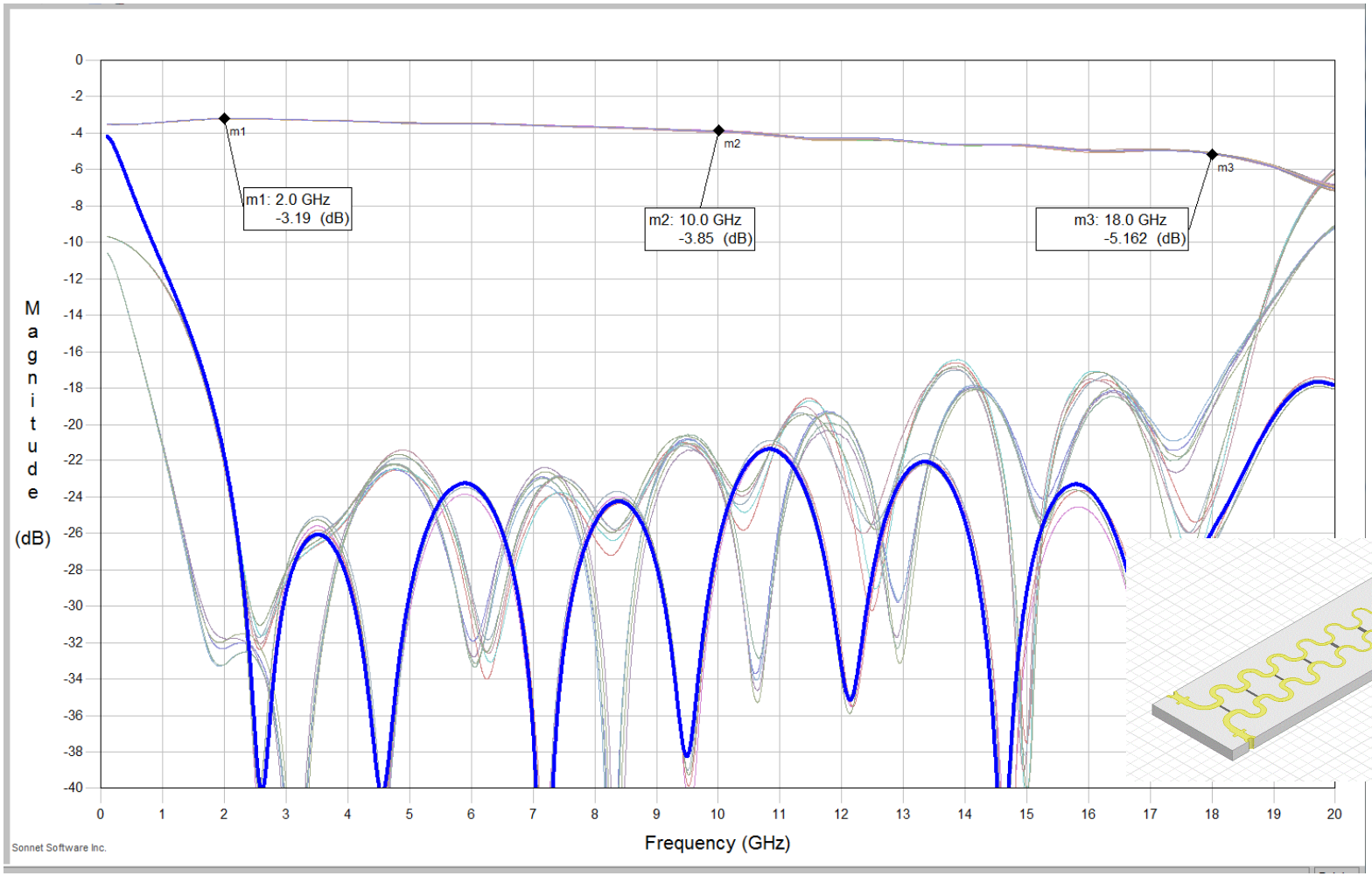
Low Loss Broadband performance  Excess loss:  0.7dB Typ.





# 2-18 GHz
# 2:1 SMT Power Divider

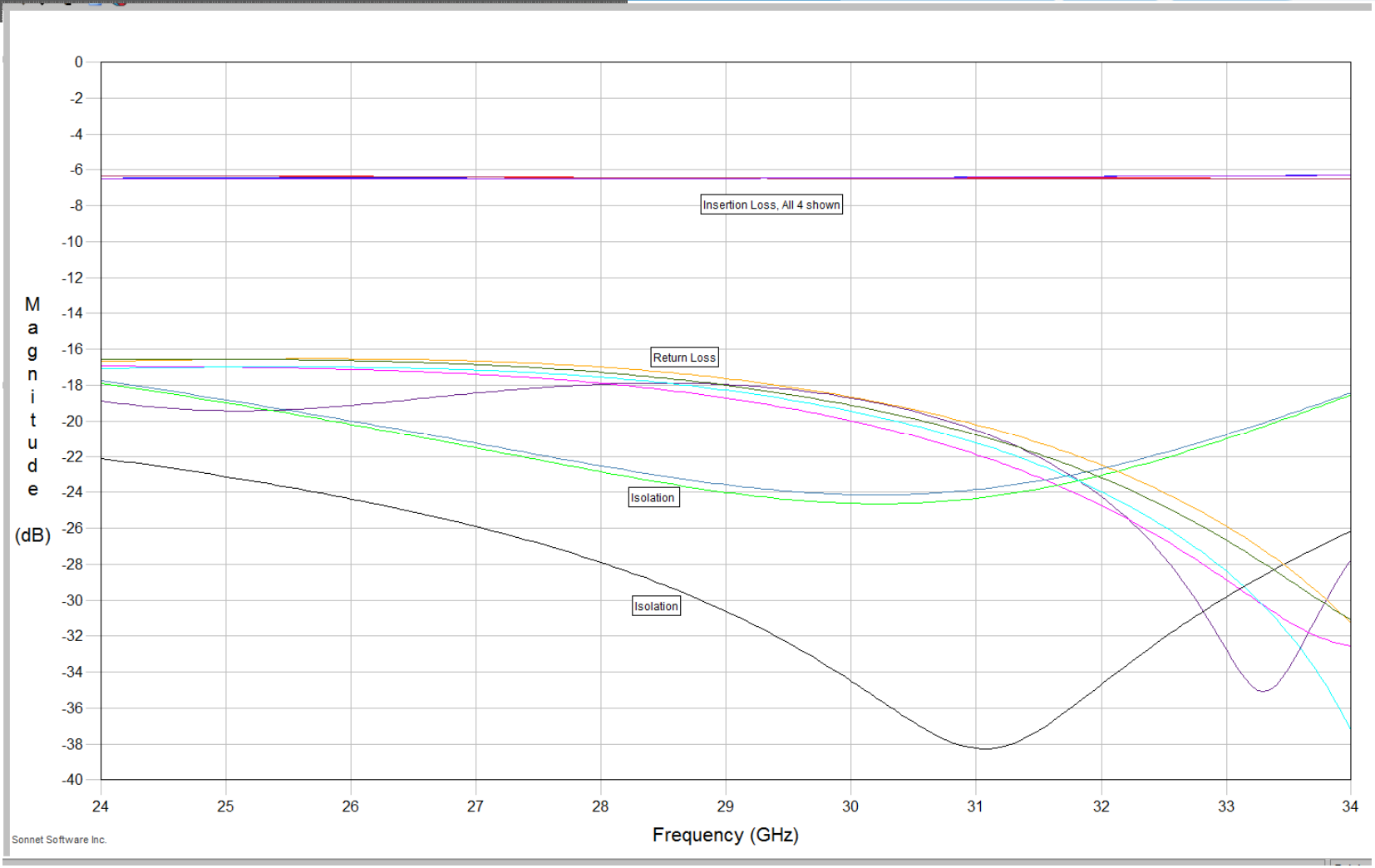
- 8 section Wilkinson (In-Phase)
- Blue curve is Isolation, S23
- Excellent RF Repeatability




Excellent RF Repeatability (5 parts graphed)

# “5G” 28 GHz 4-Way Power Divider

Footprint: 0.220 x 0.130 in
(5.5 x 3.25mm)
Ideal for Patch Antenna Arrays

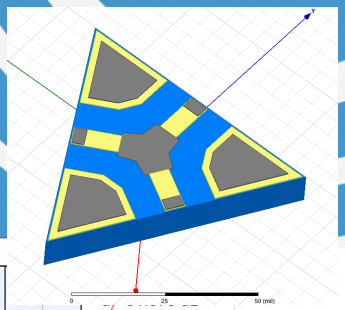


# Resistive Power Dividers Selection Chart

| Description | Packaging | | Frequency Range | | | | | | | | | | | Package Size (mils) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SMT | Wirebond | DC | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | |
| 2-Way (1 sec) | PDR06380 | | | | | | | | | | | | | 75 Triangular |
| 2-Way (1 sec) | PDR06390 | | | | | | | | | | | | | 75 x 70 |

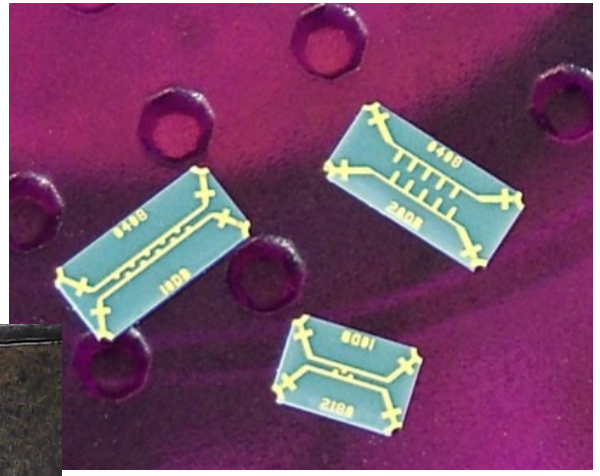
# 2 Way Resistive Power Divider

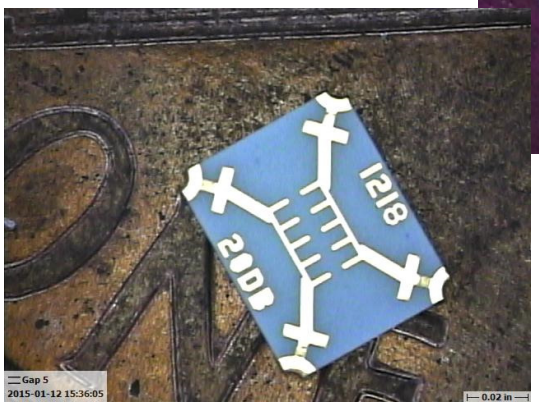
DC to 40 GHz

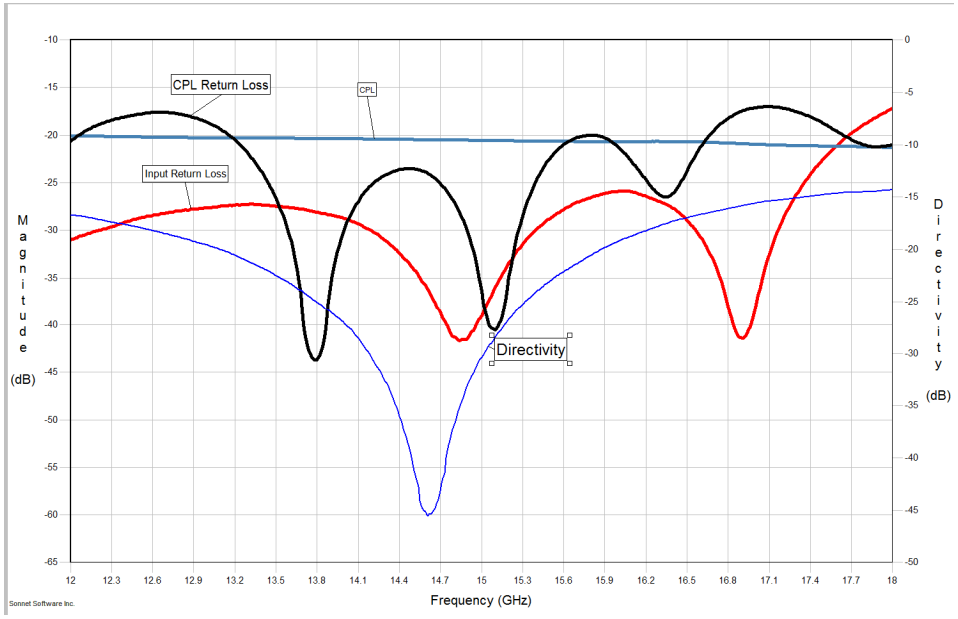


# Directional Couplers

- Benefits
  - Extremely small size
  - High Frequency, Ka Band offering
  - Surface Mount
  - Chip & Wire
  - Extreme repeatability
  - High Directivity
  - Operating Temp: -55 to 125°C



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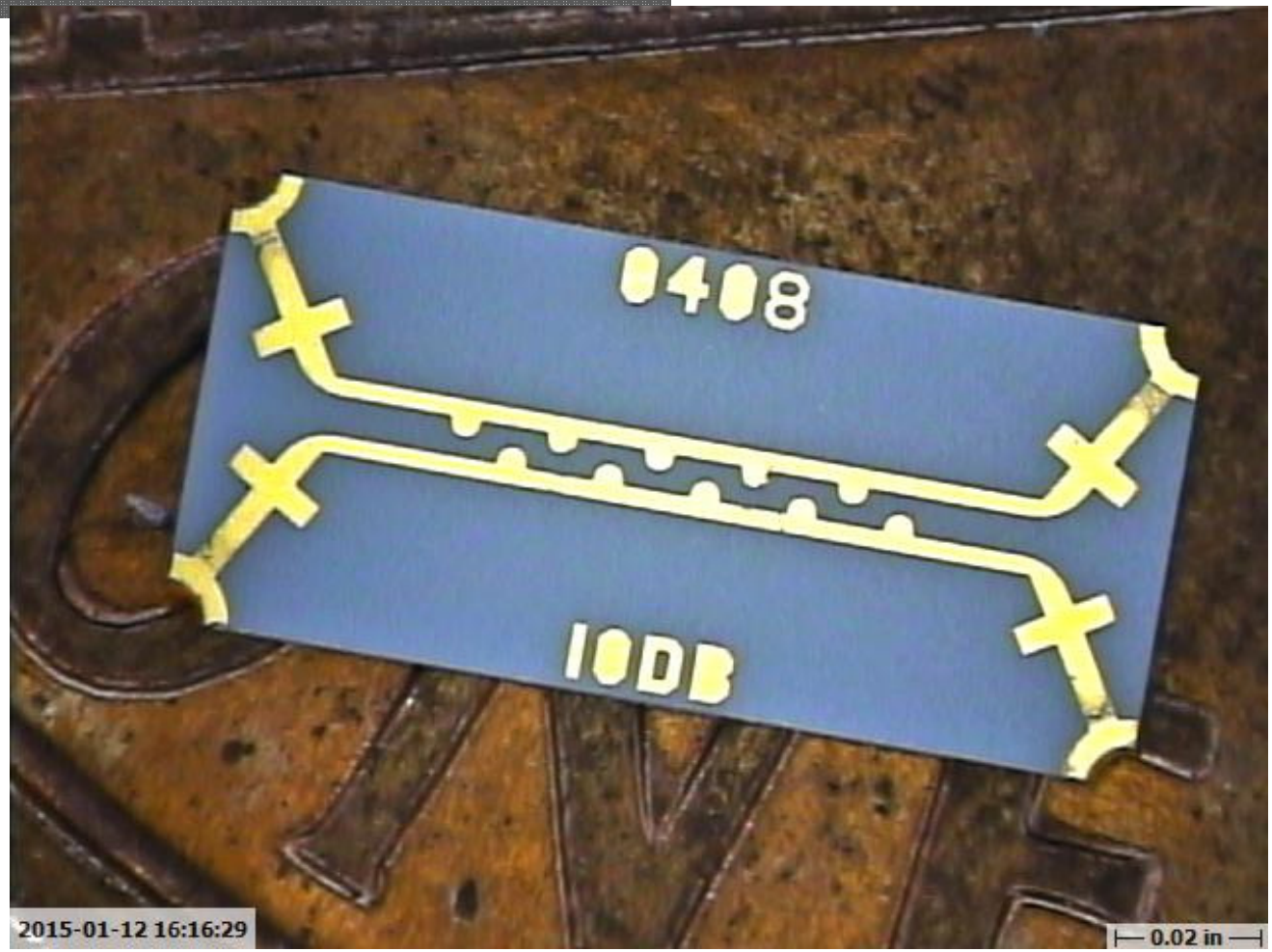
# Couplers for BIT

| Part Number | Frequency Range (GHz) | Mean Coupling Value (dB) | Passband Coupling Variation Typ. (dB) | Insertion Loss Typ. (dB) | Return Loss Typ. (dB) | Isolation Typ. (dB) | Directivity Typ. (dB) |
|---|---|---|---|---|---|---|---|
| FPC06073 | 4 to 8 | 10 | ± 1.5 | 0.3 | 20 | 30 | 20 |
| FPC06076 | 4 to 8 | 20 | ± 1.5 | 0.3 | 20 | 40 | 20 |
| FPC06074 | 8 to 12 | 10 | ± 1.0 | 0.3 | 14 | 25 | 15 |
| FPC06077 | 8 to 12 | 25 | ± 1.0 | 0.3 | 15 | 30 | 10 |
| FPC06075 | 12 to 18 | 10 | ± 0.5 | 0.3 | 15 | 25 | 14 |
| FPC06078 | 12 to 18 | 20 | ± 1 | 0.3 | 15 | 35 | 14 |
| FPC07181 | 20 to 40 | 20 | ± 1.5 | 0.3 | 20 | 25 | 20 |
| FPC07182 | 20 to 40 | 10 | ± 1.5 | 0.3 | 20 | 25 | 15 |
| FPC07183 | 24 to 33 | 3 | ± 1.0 | 0.3 | 15 | 25 | 20 |
| FPC06700 | 5.9 to 6.5 | 3 | 1 | 0.5 | 15 | 20 | 20 |
| FPC06701 | 10.7 to 12.75 | 3 | 1 | 0.5 | 15 | 20 | 20 |
| FPC06633 | 8.5 to 11 | 3 | 1 | 0.5 | 15 | 20 | 20 |
| FPC06913 | 6 to 18 | 20 | 1 | 0.3 | 15 | 20 | 20 |
| FPC06719 | 6 to 18 | 10 | 1 | 0.3 | 15 | 20 | 20 |
| FPC07180 | 2 to 18 | 20 | 4.5 | 0.8 | 15 | 20 | 20 |
| FPC06881 | DC to 40 | 20 | NA | 0.5 | 15 | 20 | 20 |
| FPC06882 | DC to 40 | 30 | NA | 0.5 | 15 | 30 | 30 |

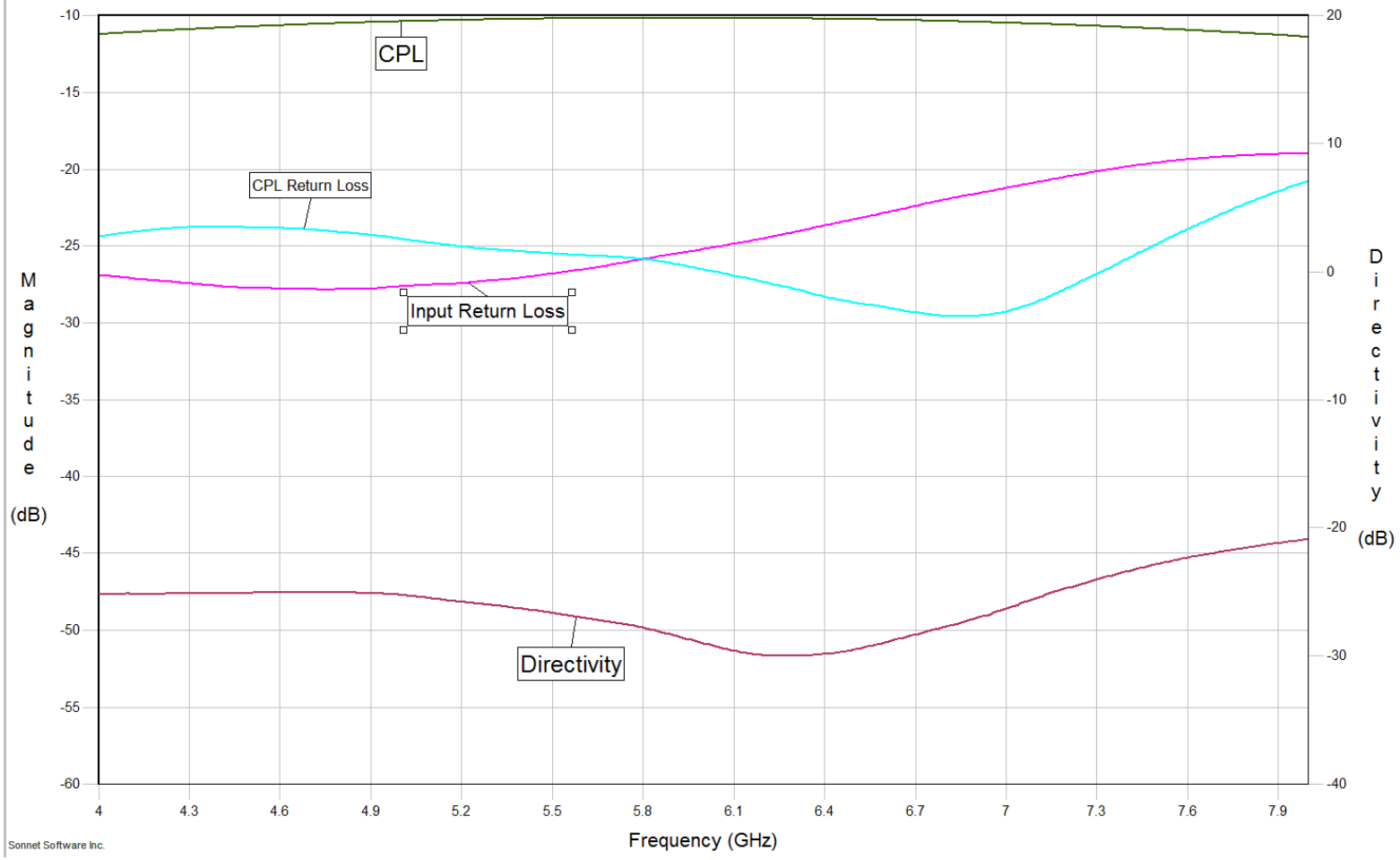
# 4-8GHz 10dB Directional Coupler

FPC06073 (10dB) / FPC6076 20dB
Package size: 0.170 x 0.080 in
4.32 x2.03 mm



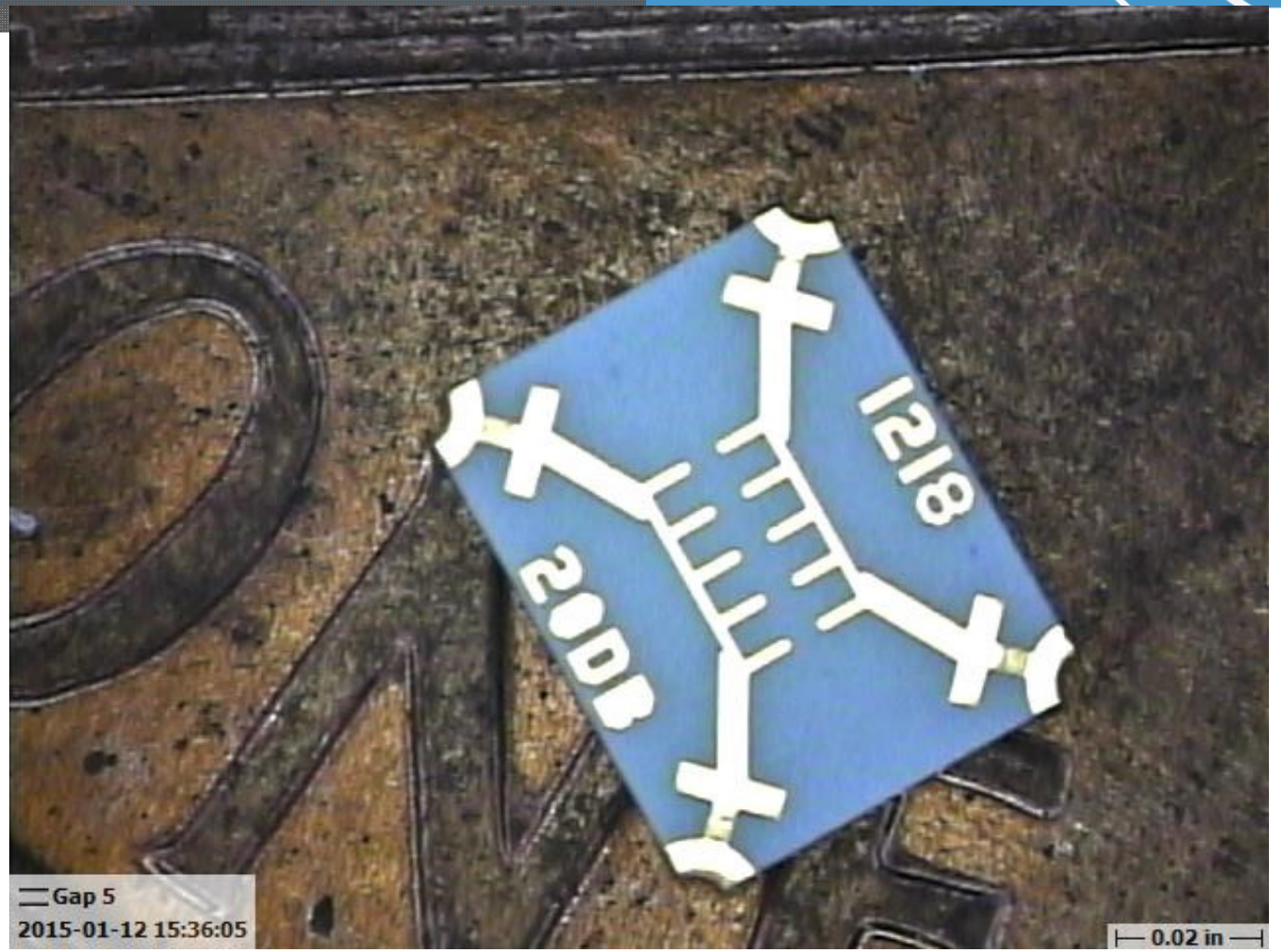
# 4-8GHz 10dB Coupler Performance

Measured on 10mil RO4350



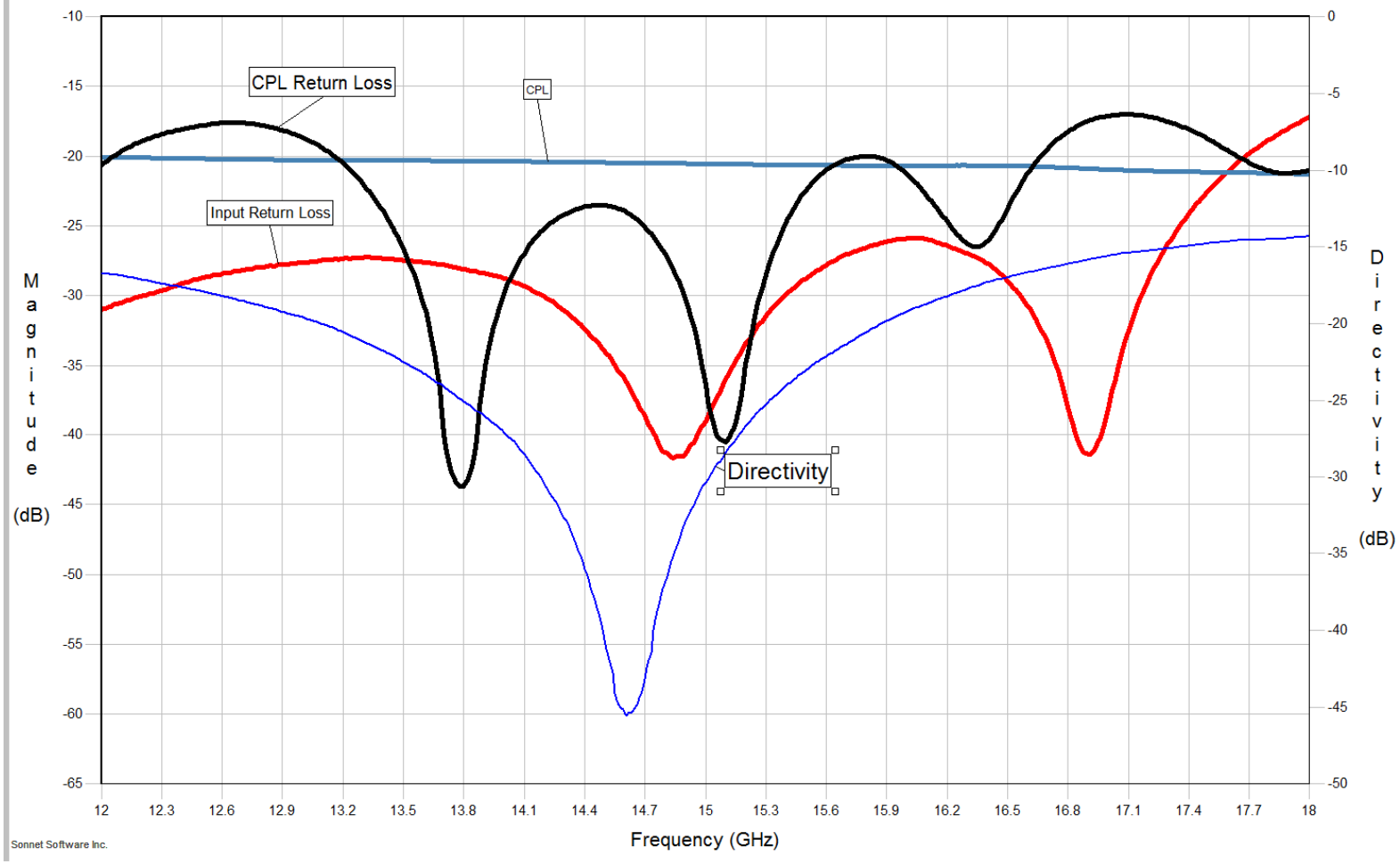
# 12-18GHz 20dB Directional Coupler

FPC06075 (10dB) / FPC6078 20dB
Package size: 0.100 x 0.080 in
2.54 x 2.03 mm



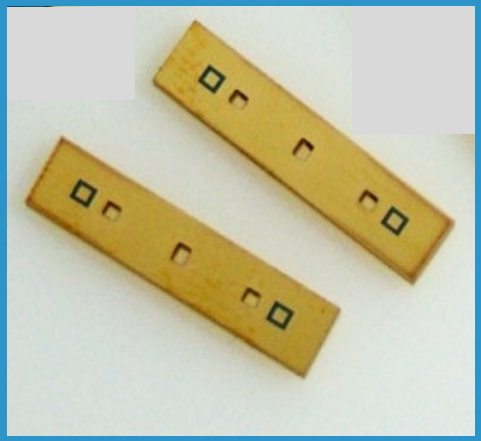
# 12-18GHz 20dB Coupler Performance

Measured on 10mil RO4350



# Cavity Filters

Mounting Options:
- SMT to Stripline
- SMT to Microstrip (Filter supplied on PWB interposer)
- Epoxy & Wire-Bond

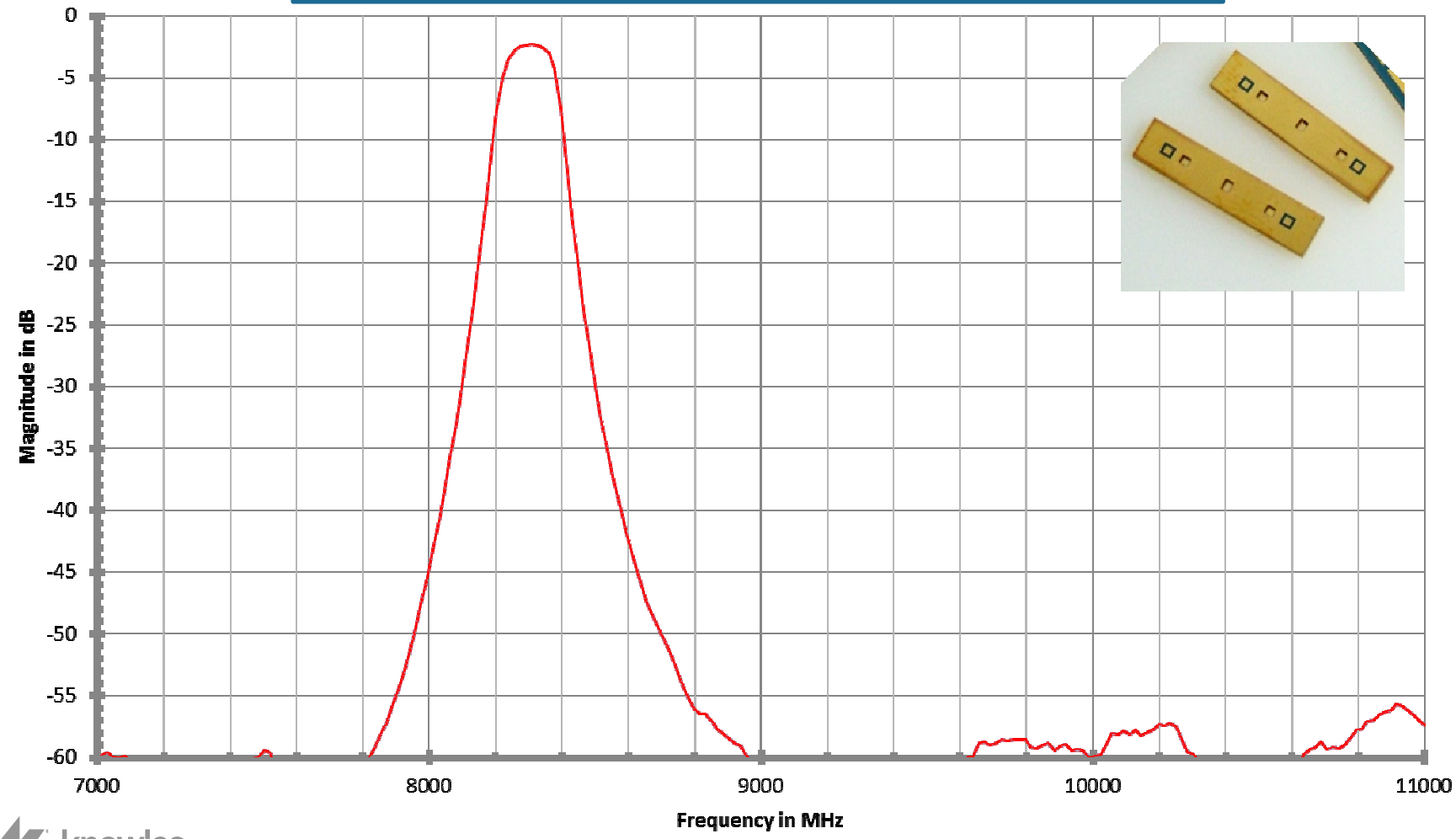


- Scalable from: ~6 to 15 GHz
- Bandwidths: 1 to 5%
- Resonator Q: 600 to 1200
  - Depending on:
    - Frequency
    - Ceramic material
    - Thickness
- Excellent for:
  - Narrowband
  - low pass band insertion loss
  - Completely Shielded –good isolation

# 4 Pole Cavity Filter
# 8300 MHz

1.5% Bandwidth

Cavity High Q Enables Low Loss Narrow band Filter



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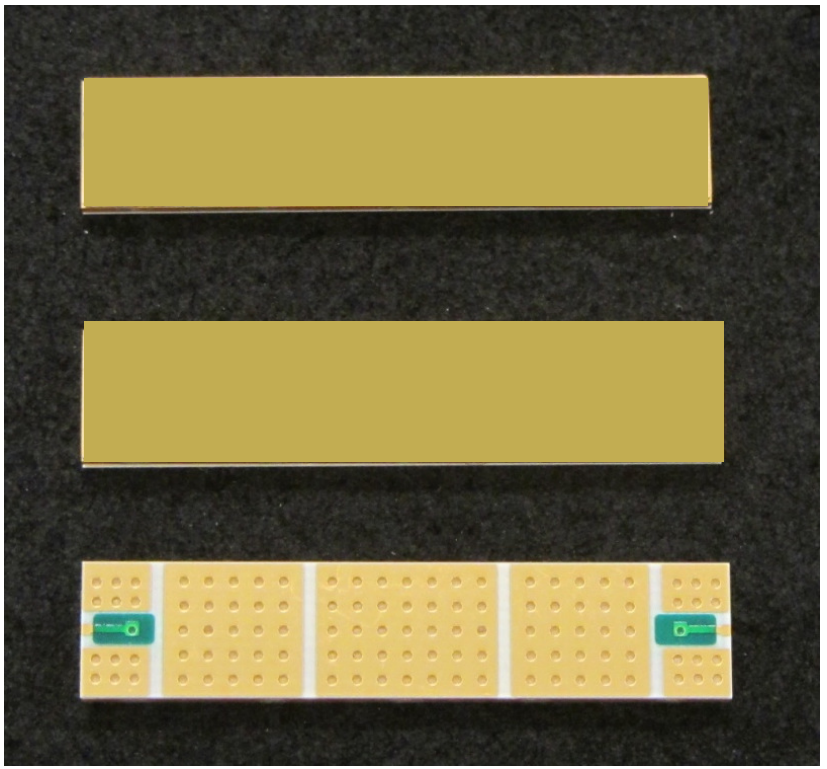
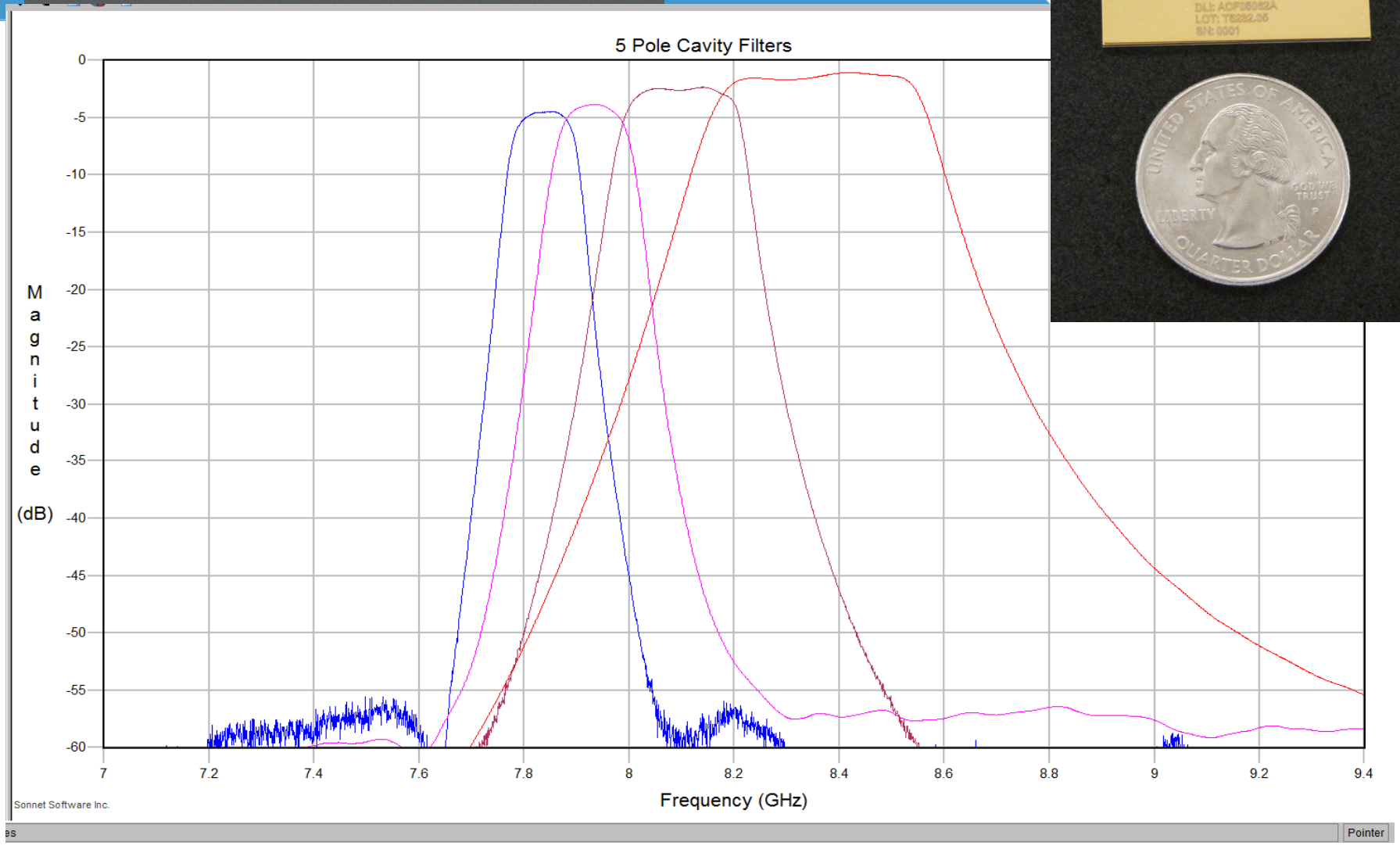
# Cavity Filter Advances

- ~ 30% better Q, ~800 @ 8GHz
- Improved Frequency precision
  - Improved material screening & models
  - Laser trim method developed ~0.1%
- Solder Surface Mountable
  - Interposer board matched to your board



# 4 Cavity Filters

Synthesizer Switched Filter Bank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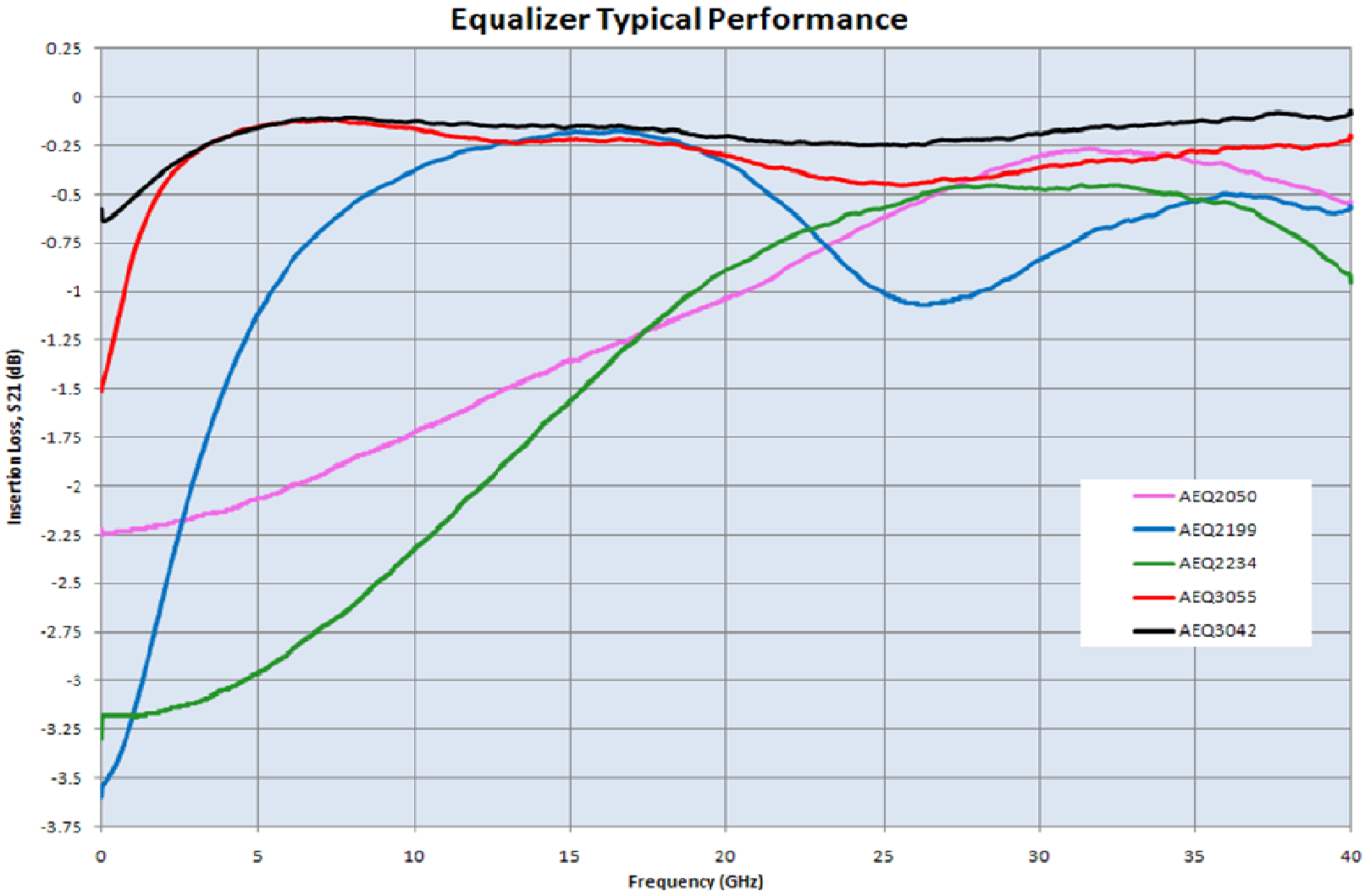
# Gain Equalizers

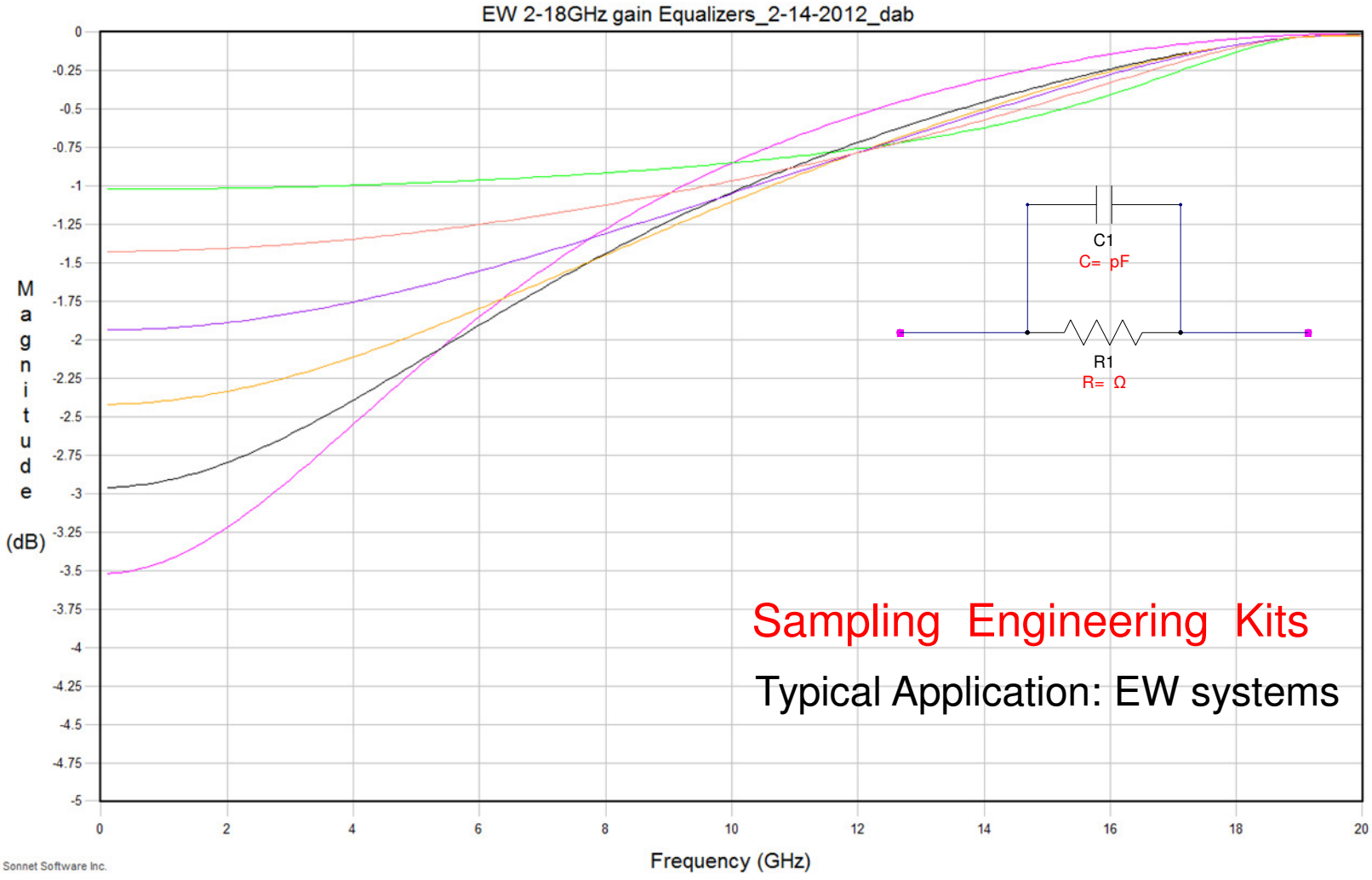

- Thin Film ‘R-C’ network
- Can be very small (0302 case)
- Flattens Amplifier Gain response
  - Positive Gain Slope
- Customization:
  - Low frequency loss
  - Minimum loss frequency
- Applications:
  - 10, 20 & 40 Giga-bit SONET
  - EW & Military Radars

# Gain Equalizer



# Gain Equalizer EW Series

DC~18GHz
1 to 3.5dB slopes, 0302 Case size




Sampling Engineering Kits

Typical Application: EW systems

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THANK YOU