EMI Filter and Filtered Connector Options for your application

By Bob Ydens

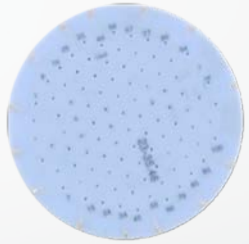
President

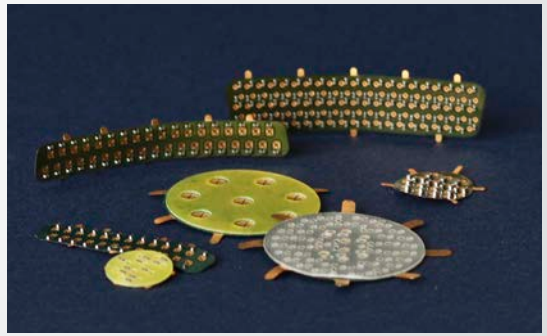
EMI Solutions Inc

Types of Filters

Filter inserts:

Press in filters added to an existing system, providing decoupling capacitors on each pin.





Filtered connectors:

Filtering being built into the already selected connector

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Types of Filters

Feed Through Filters:

Simple implementation used when the signal or power passes through a bulkhead without any connectors.

- Press In/Threaded
- Solder In
- Power

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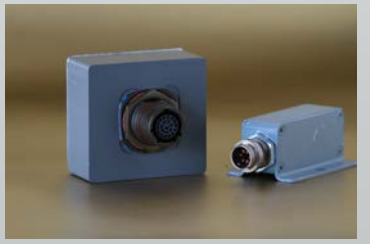
Types of Filters

Filter Modules:

Common filtering devices with various forms of filters and transient suppression built into a module as opposed to a single connector.

- Standard AC Filters

- High Power Filters (AC and DC)



- Custom Filtering

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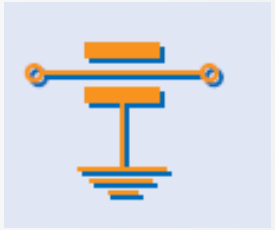
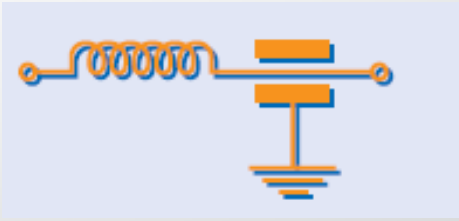
Types of Low Pass Filters

C filters - pure capacitive filter

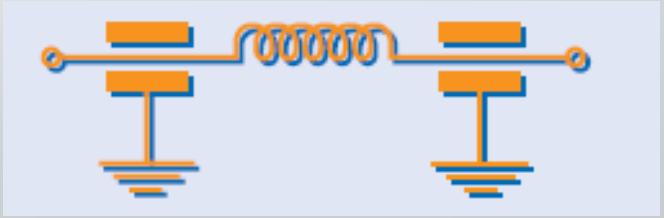
- Chip Capacitor
- Discoidal / Feed thru
- Planar Array



CL/LC filters - combined inductance and capacitance filtering



Pi filters – Capacitive and Inductive filtering, named due to the shape resembling the pi symbol, π



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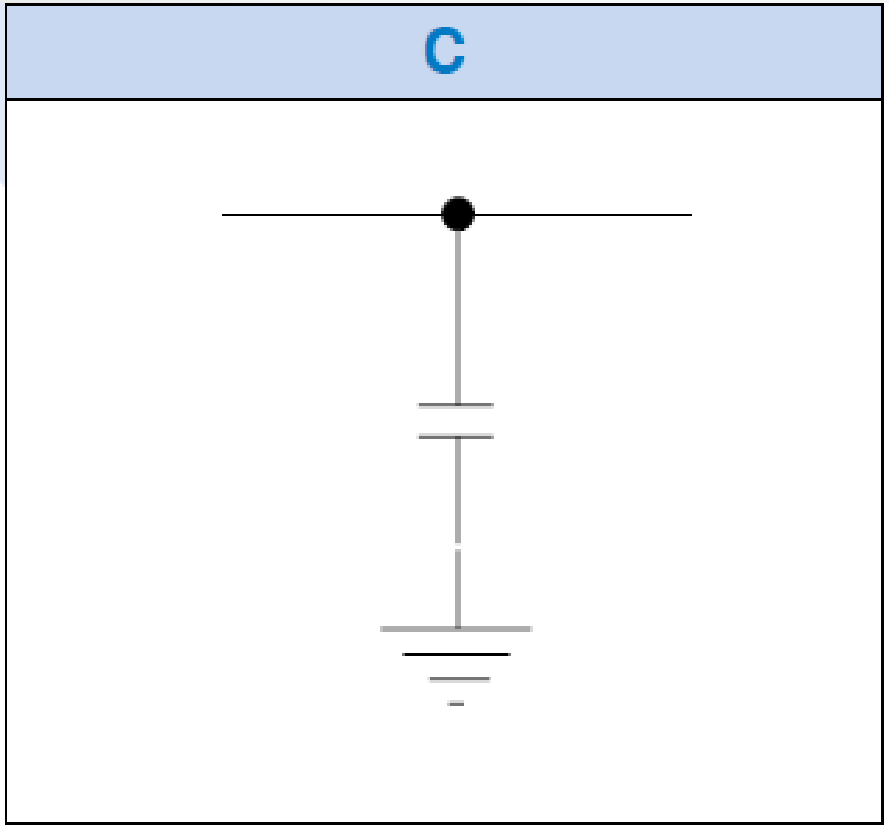
When to use a C Filter



"C" filters involve a single capacitor. This simple, cost efficient design excels at low frequency performance which often exceeds the performance of multiple-component configurations.

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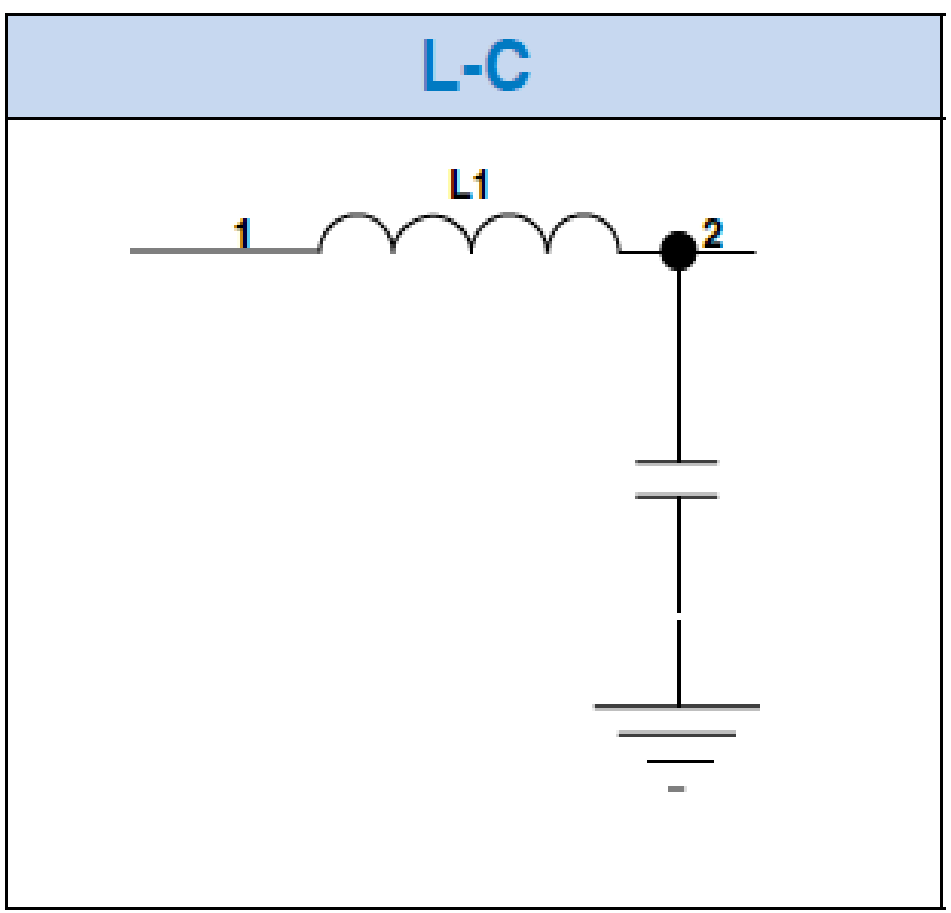
When to use a L-C Filter



"L-C" filters excel when the source impedance is less than the load impedance, often outperforming "PI" filters at frequencies lower than 10MHz

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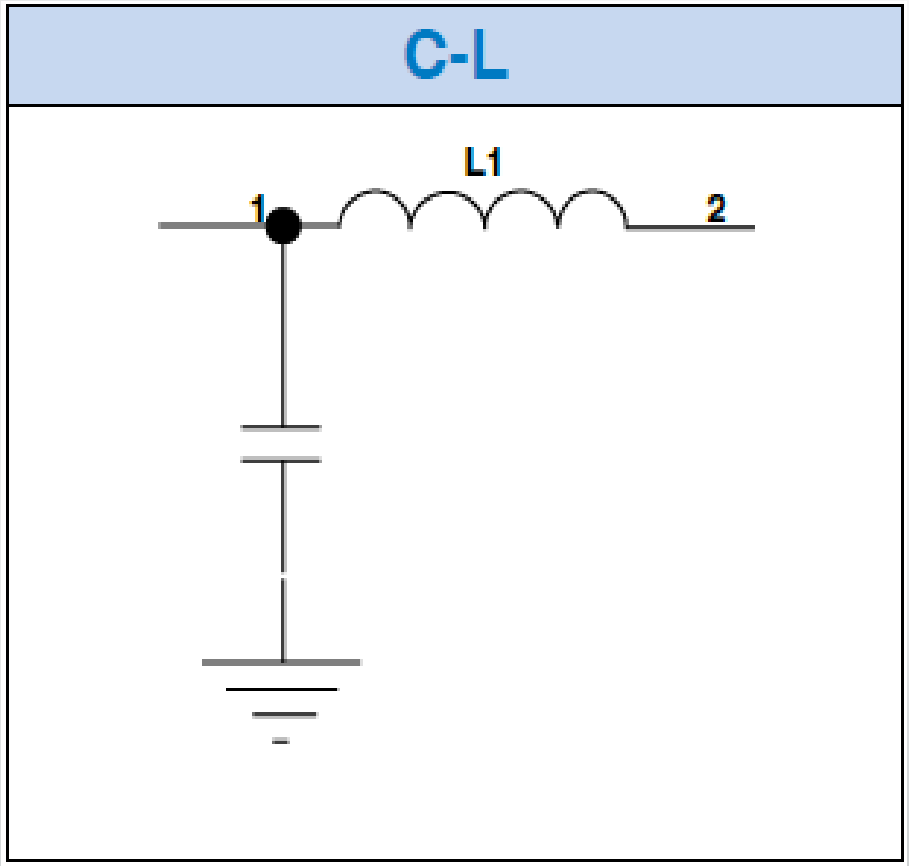
When to use a C-L Filter



"C-L" filters are the inverse of "L-C" filters, performing best when the source impedance is greater than the load impedance

Noise Filtering vs Frequency

Low Pass Filters

- Identify the capacitance of the filter to operate in the correct frequencies
- Select the capacitance so that it doesn't interfere with designed signals
- Determine the type of filter (Notch or Broadband) that meets the frequency spectrum required in your application
- Choose optimum capacitance based on **-3dB Cutoff Frequency** of the filter

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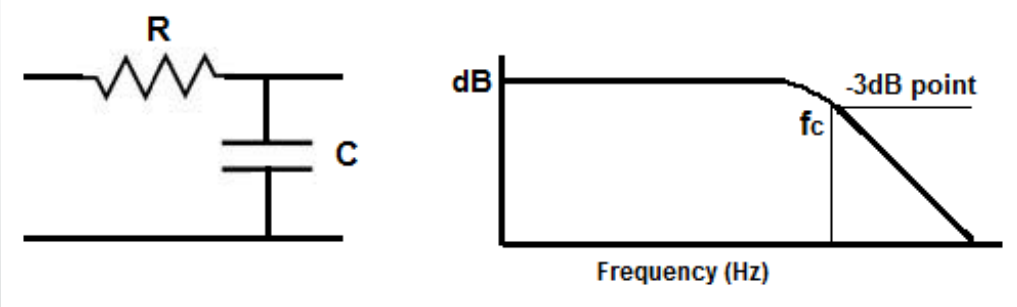
Understanding the -3dB Cutoff Frequency

- Formula for Cutoff Frequency

$$f_c = \frac{1}{2\pi RC}$$

- Equivalent Circuit and Performance vs Frequency



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Calculated Cutoff Frequency Data

Capacitance	470 pF	10,000 pF
C	0.000470	0.010
2*P	6.28	6.28
R	0.000022	0.000022
Fc	15,399,967	723,798

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Industry Data

ALWAYS DO A SANITY CHECK!!

Benchmark calculations

vs

published industry data!*

Chart A - Typical Insertion Loss (dB), No Load. 50 ohm system

Capacitance	0.01MHz	0.1MHz	1MHz	10MHz	100MHz	1GHz
10pF						4
15pF						7
22pF						10
33pF						12
47pF					1	15
68pF					2	18
100pF					4	22
150pF					7	25
220pF					10	29
330pF					13	33
470pF				1	16	35
680pF				2	19	39
1nF				4	23	41
1.5nF				7	26	45
2.2nF				10	30	50
3.3nF				13	33	52
4.7nF			1	16	36	55
6.8nF			2	19	39	57
10nF			4	22	41	60
15nF			7	25	44	62
22nF			10	29	46	65
33nF			13	33	48	68
47nF		1	16	35	50	70
68nF		2	19	39	54	70
100nF		4	22	41	57	70
150nF		7	25	45	60	70
220nF		10	29	49	62	70
330nF		13	33	52	66	70
470nF	1	16	35	55	68	70
680nF	2	19	38	58	70	70
1µF	4	22	41	61	70	70
1.5µF	7	25	45	64	70	70
2.2µF	10	29	48	66	70	70

* Table courtesy of Syfer

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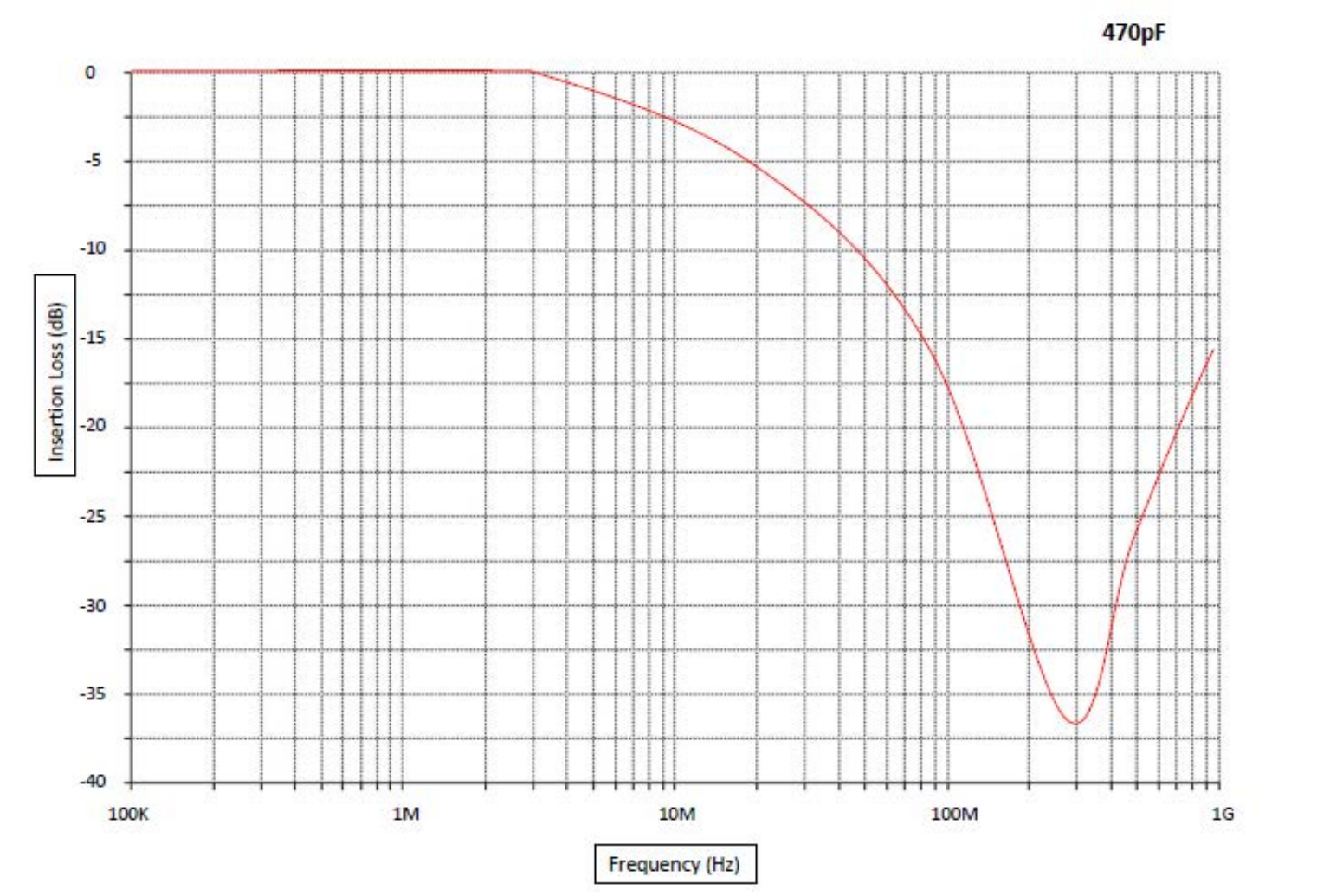
Actual Measured Chip Capacitor Data – 470pF



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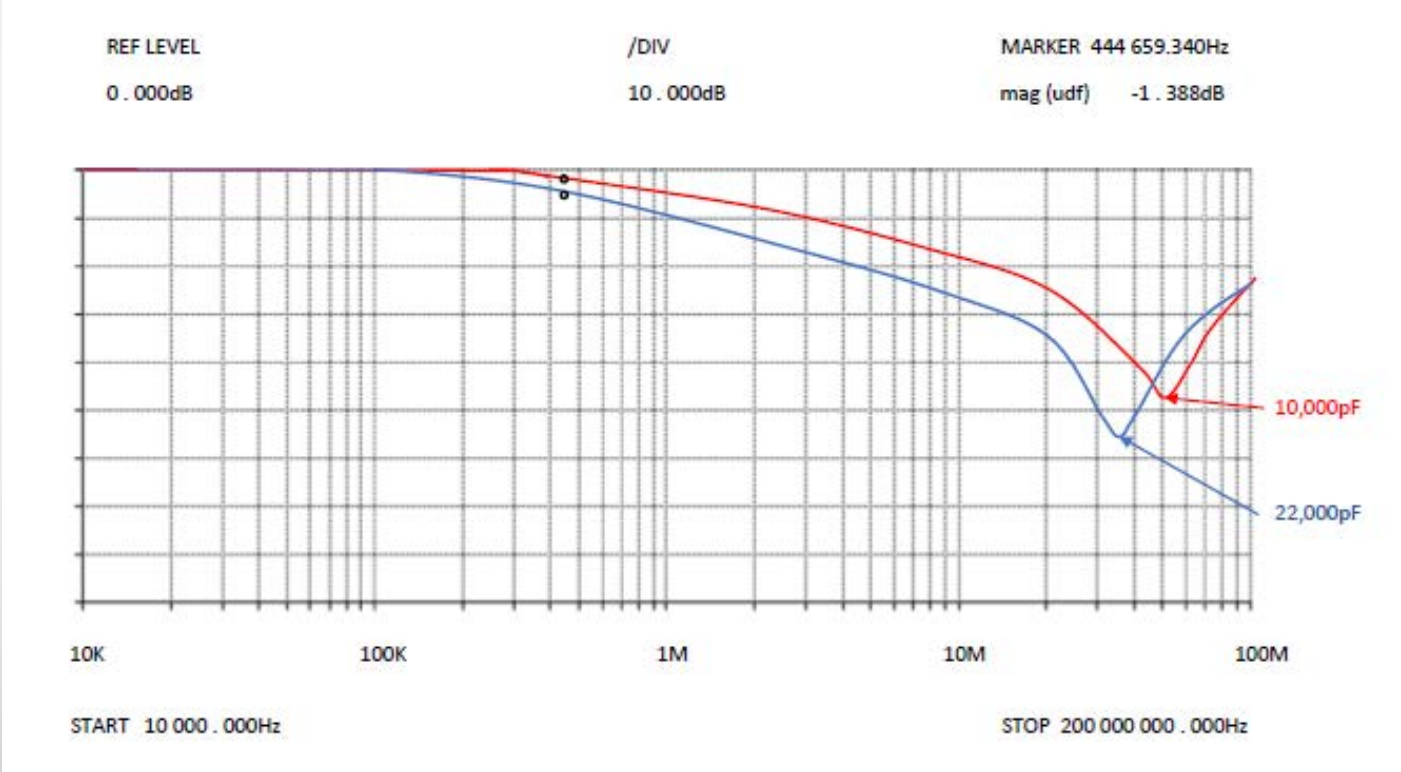
Actual Measured Data

10,000pF and 22,000pF chip capacitor



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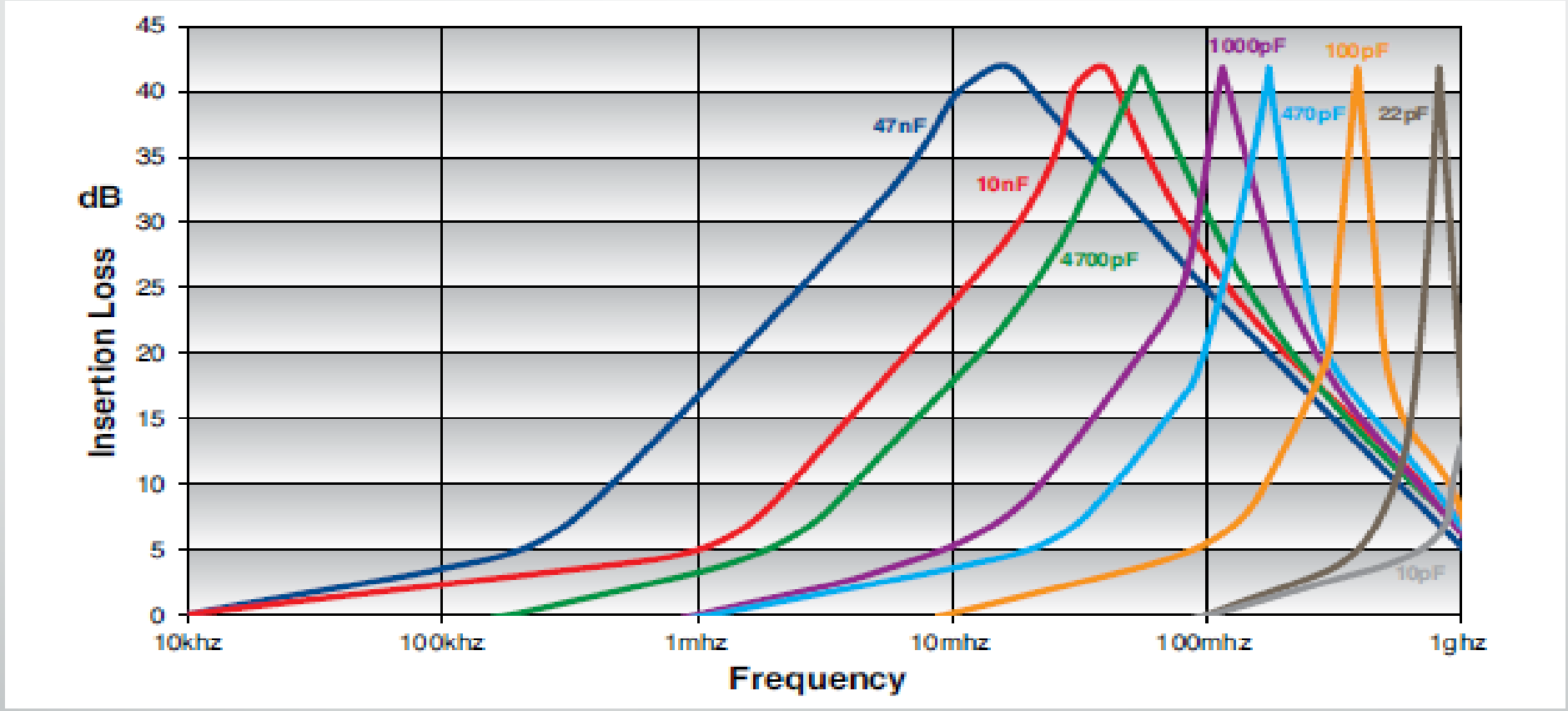
Chip Capacitor Filter Performance



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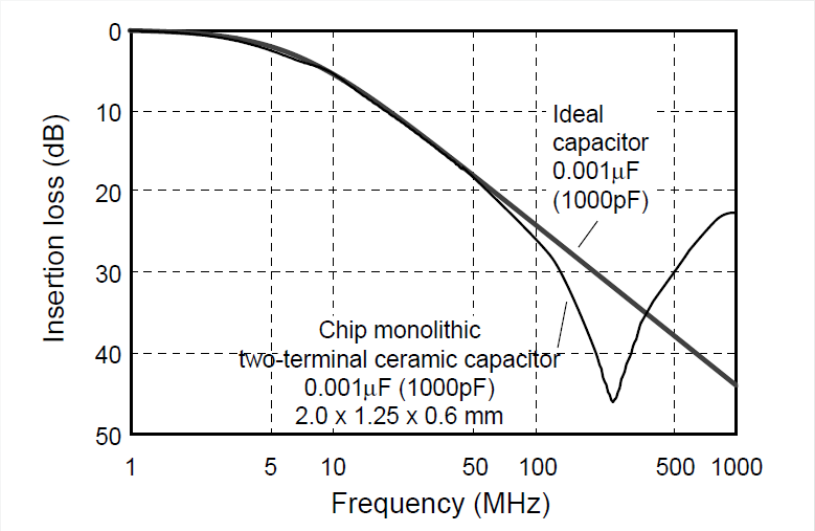
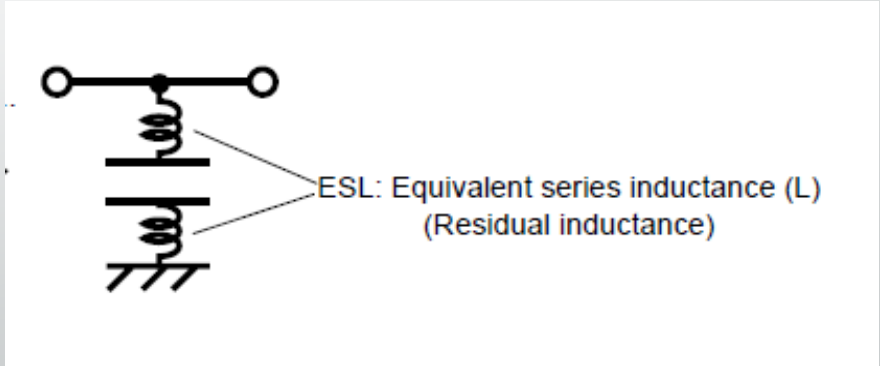
Self-Resonance

- Inherent to chip capacitors
- **GREATLY** impacted by mechanical packaging
- Creates "Notch Filter"
- Little to no high frequency performance





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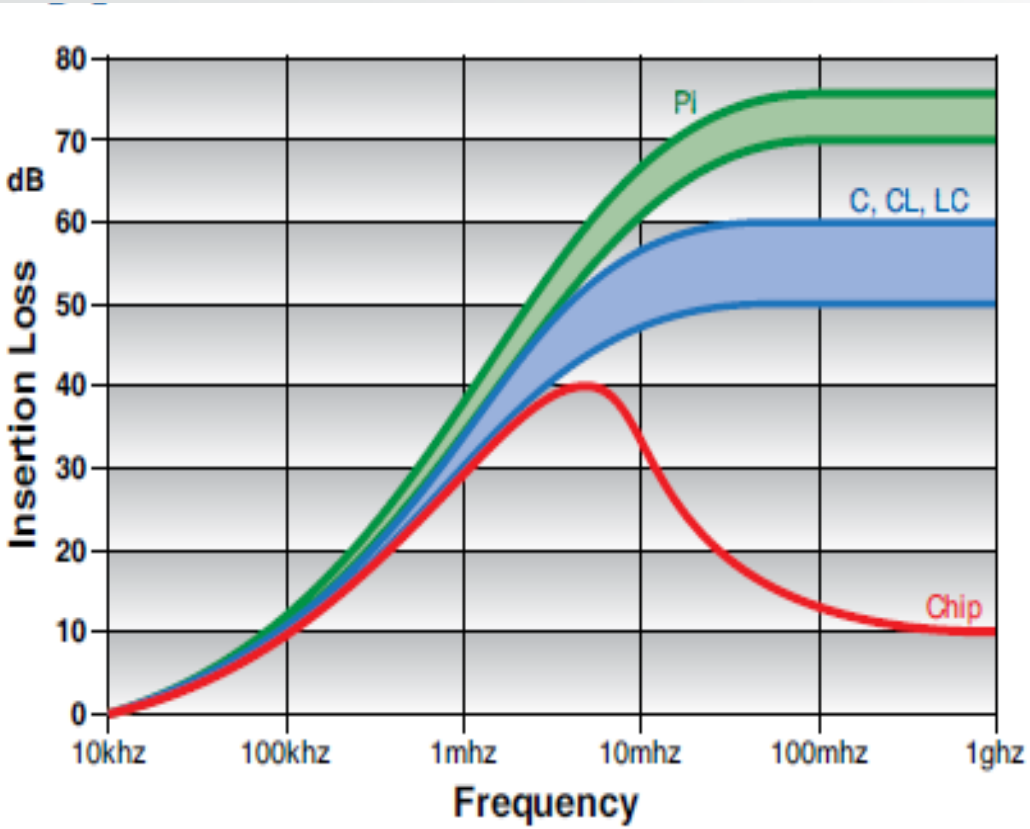
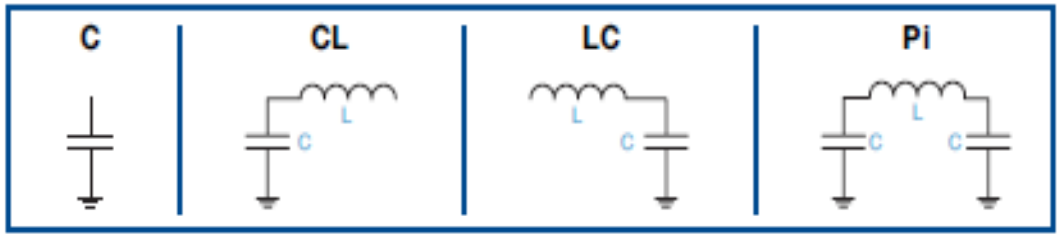
Filter Connector Performance Comparison



	Capacitance Options	Filter Performance
Chip Capacitor	3 pF – 47,000 pF+	>40 dB
Discoidal Capacitor (C)	470 pF – 40,000 pF+	50 – 60 dB
Planar Array (CL & LC)	100 pF – 1 uF+	50 – 60 dB
Pi with Planar Arrays	100 pF – 1 uF+	70+ dB
Pi Tubes	47 pF – 12,000 pF	70+ dB



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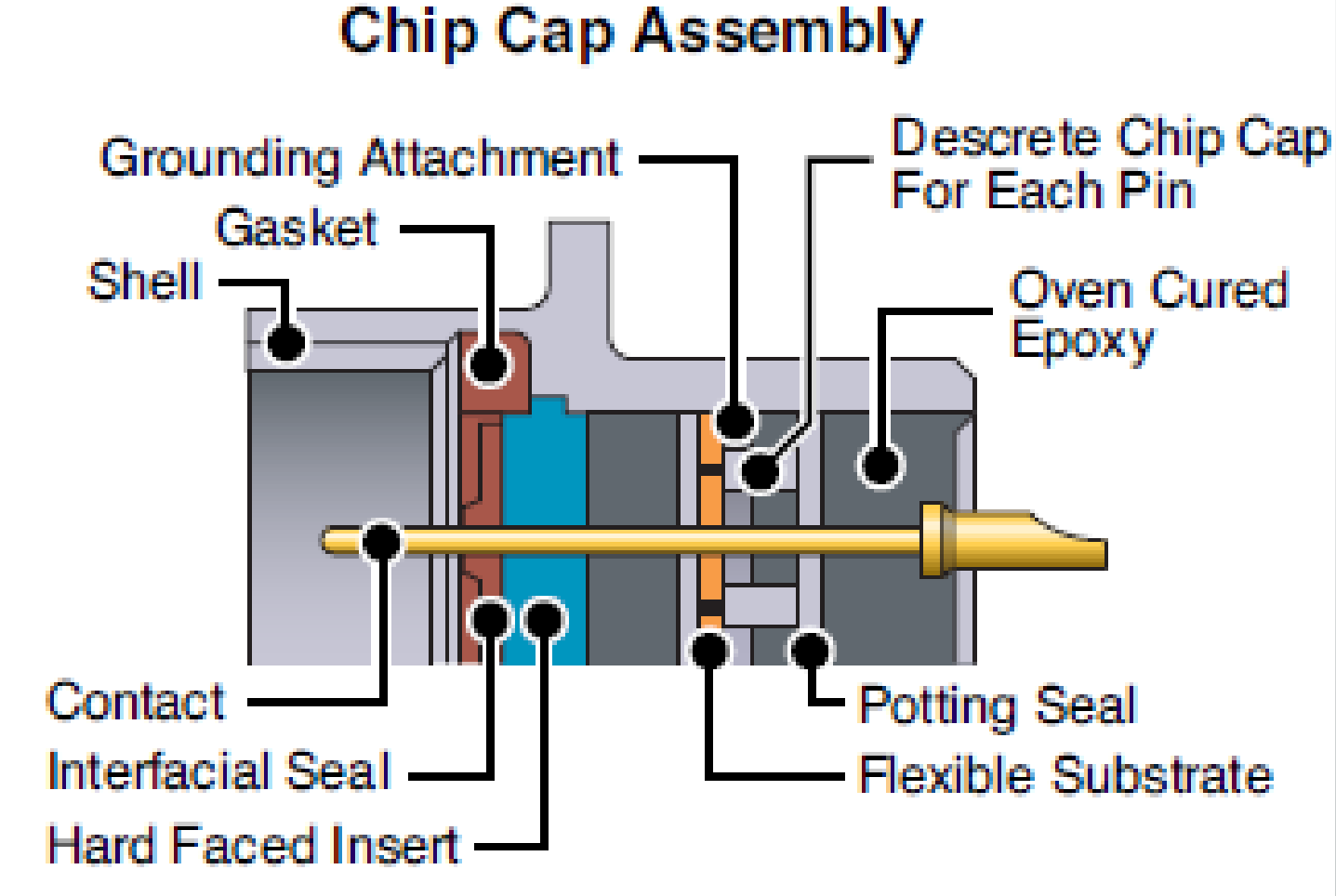
How chip cap filtered connectors are made



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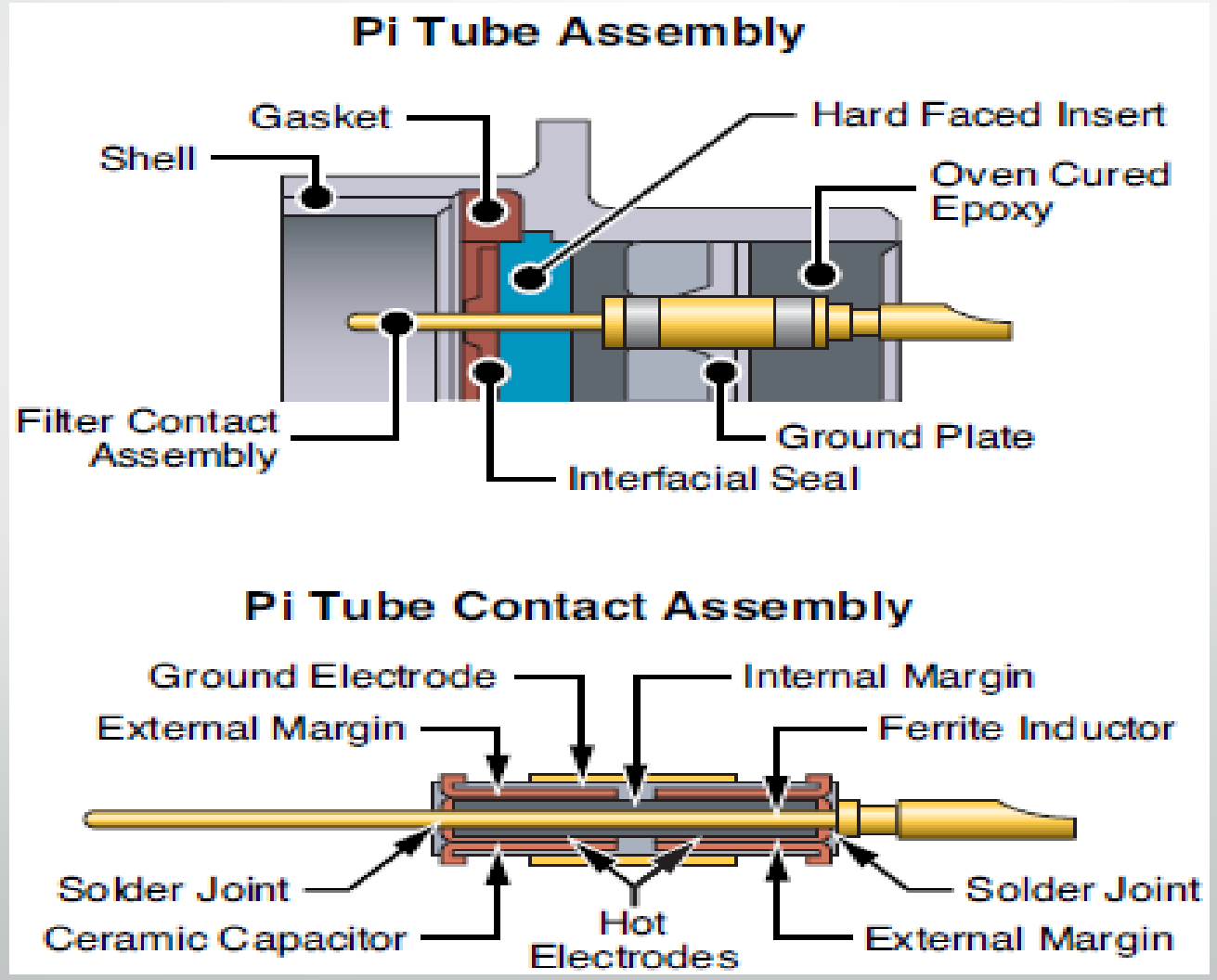
How Pi filtered connectors are made



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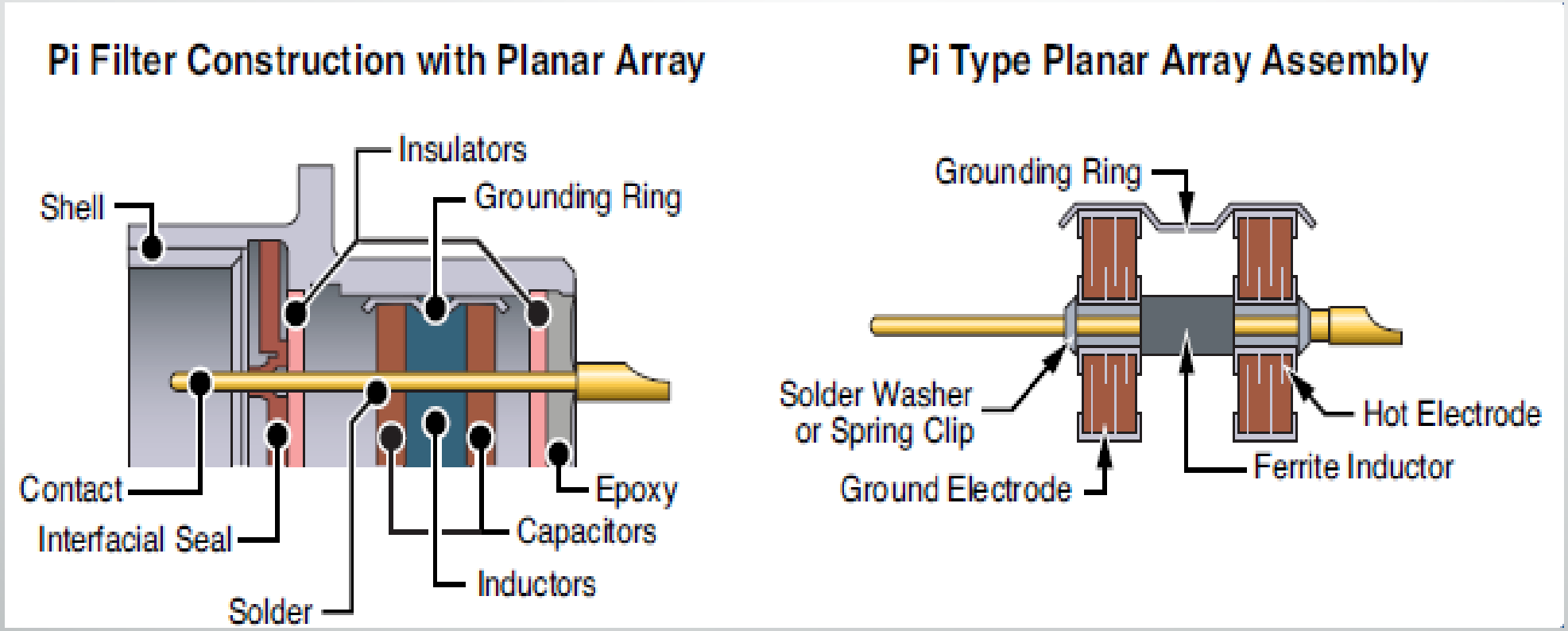
How planar filtered connectors are made



Voltage Considerations

Working Voltage: What voltages are your signals?

Rated Voltage: What voltage rating do you need for safety margin?

Dielectric Withstand Voltage: What voltage should the ceramics be able to withstand for 5 seconds?

Transient Voltage: Is your system susceptible to transient voltages?

Lightning: Is the system exposed to lightning? If so, what level?

Additional Options

- Grounding
- Lightning protection
- TVS protection
- Combo filters
- Double Pi filters

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Using Filter Inserts for Debugging

Free Filter Insert Samples!

Verify:

- Grounding
- Capacitance
- Filter Frequency Band

Broadband filter

Upgraded voltage

Customize (grounds, resistors, diodes, overall configurations)

High performance filtered connector

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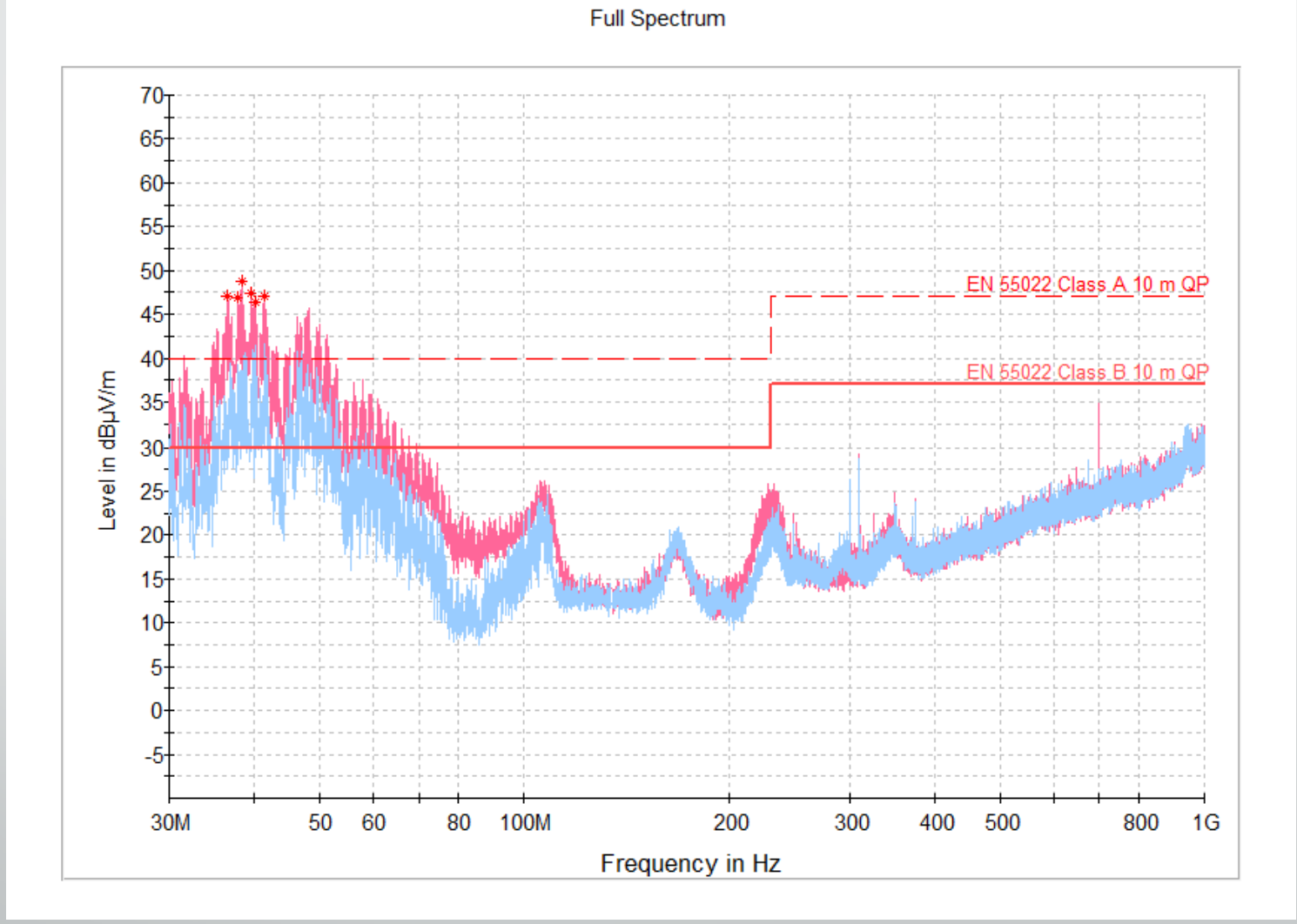
Real Life Example



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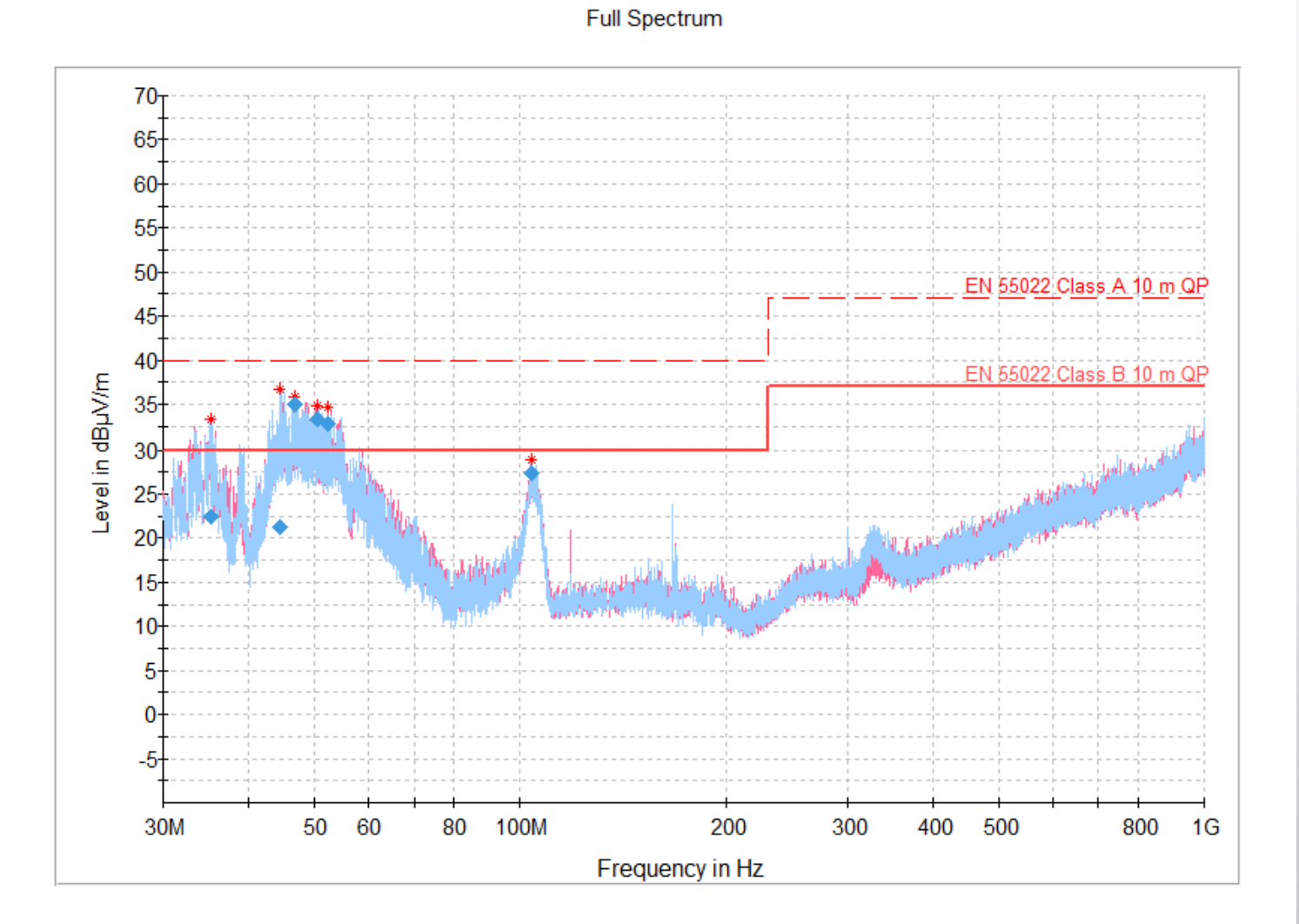
10,000pF Chip Capacitor Insert



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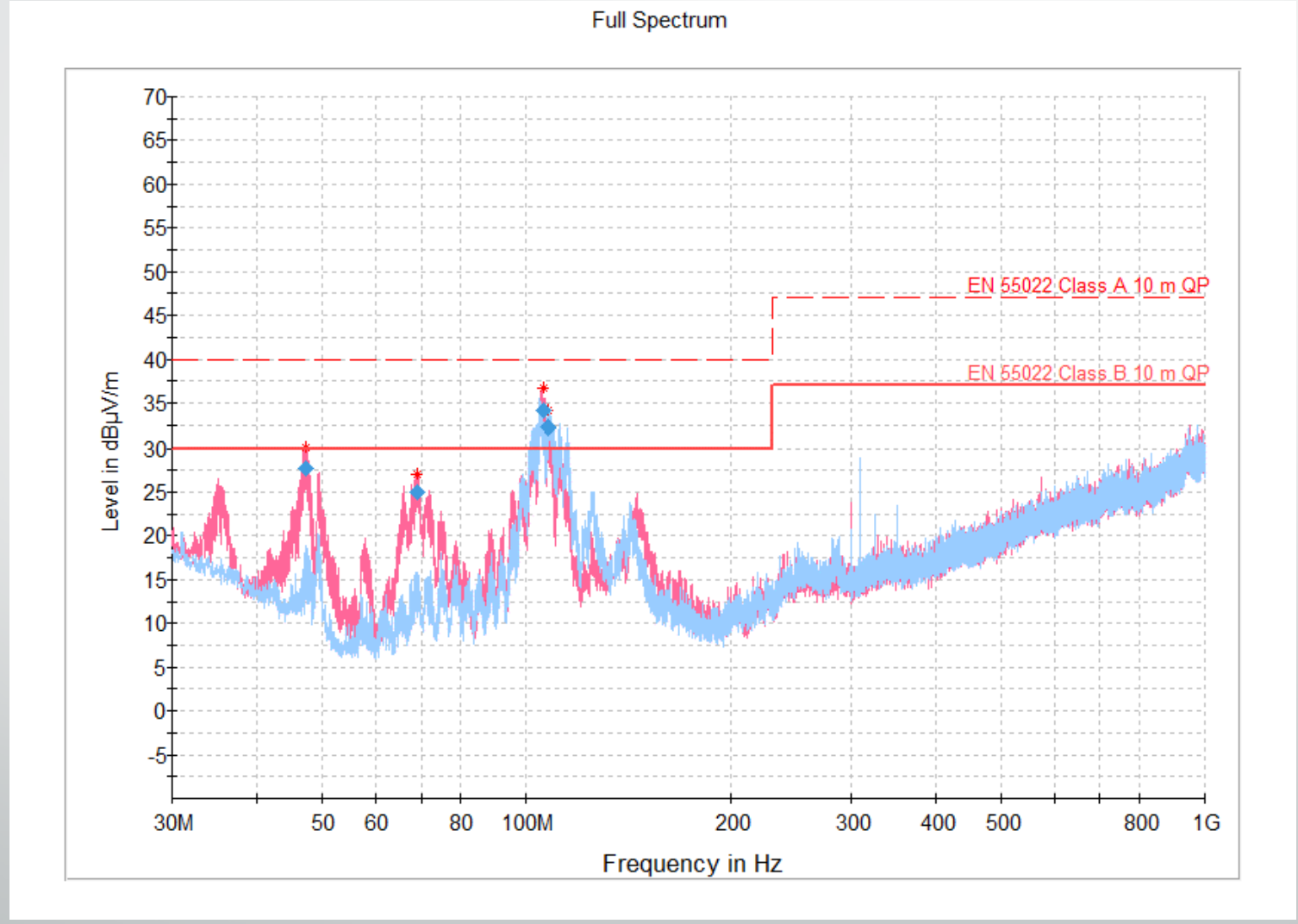
22,000pF Chip Capacitor Insert



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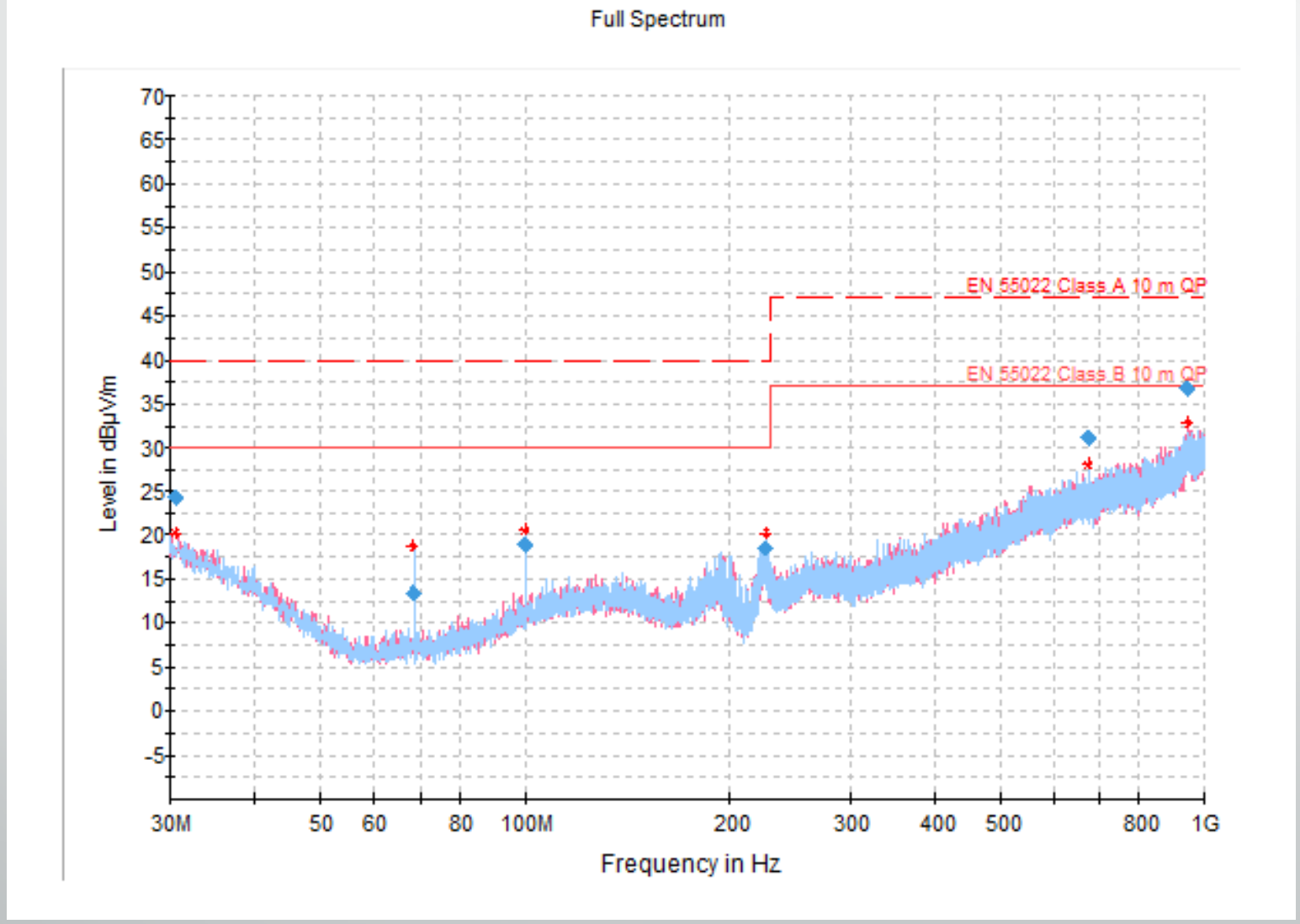
22,000pF *FlexFilter* Insert



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Thank you!

Questions?

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