COMPARISON OF 110 GHz SILICON (HL9439) AND CERAMIC (HL8439) DC BLOCKS

Jason Yoho, Ph.D., Madrone Coopwood

OVERVIEW

HYPERLABS has positioned itself as market leader in ultrabroadband components through their ever-expanding 110 GHz product line. Focusing on the broadest bandwidth devices with extremely flat insertion loss and high return loss, this product line can be employed in a wide variety of leading-edge technology including in 224 Gbps Serializer/Deserializer (SerDes) applications.

Our engineers have developed a proprietary transmission line topology that enables the development of a wide range of component offerings. In the realm of DC Blocking components, HYPERLABS released their initial 110 GHz offering, the HL9439, in Q2 2022. This initial DC Block is based on a silicon technology which has some trade-offs in comparison to ceramic technology, to be discussed and compared in this note. In Q1 2024, HYPERLABS is releasing the broadest bandwidth DC Block in the industry, the HL8439, a ceramic-based offering that boasts a bandwidth of 16 kHz to over 110 GHz, with a voltage rating of 10 V.

In system development, proper device selection and understanding of specific performance trade-offs pertaining to those choices are of utmost importance. To assist in making the best tradeoffs when using HYPERLABS' components, we will investigate the construction as well as the differences between ceramic-based capacitors versus silicon-based versions in this application note.

SILICON-BASED CAPACITORS

Silicon capacitor offerings have been increasing in recent years. These capacitors are constructed using a semiconductor Metal-Oxide-Silicon (MOS) process and incorporate 3-dimensional (3D) structures to create increased capacitance per footprint size in each device. Shown in *Figure 1* is a graphical image of a metal-insulator-metal, or MIM, type topology implemented on a semiconductor substrate. The dielectric of the substrate is usually silicon dioxide or silicon nitride material. The 3D structure is shown by round pockets embedded into the silicon substrates, but these shapes can be optimized to increase the surface area resulting in increased capacitance per area. If the 3D shape is flattened, it results in a structure resembling an extremely large single-layer capacitor.

Silicon capacitors have some significant advantages over ceramic based capacitors. First, these types of capacitors are very stable in terms of temperature and voltage. Silicon-based capacitors can handle significant temperature ranges with the capacitance value remaining stable over this wide temperature range as well. The voltage stability of the silicon capacitor results in the capacitance value not changing based on the bias voltage incident to the part. In terms of HYPERLABS' DC Blocks, this means the low frequency cut-off remains constant and independent of the bias voltage applied.

Another feature of silicon capacitors are high reliability, aging stability, and ultra-thin physical designs. These ultra-thin designs allowed HYPERLABS' engineering team to develop a proprietary transmission line structure that is packaged into 1.0 mm connectorized components.

One significant disadvantage of the silicon-based capacitor is that the capacitance is limited compared to its ceramic counterparts. The effects of the limited capacitance can be detected on the HL9439 low-frequency cutoff specification. The low frequency cutoff is 160 kHz or 280 kHz depending on the breakdown voltage rating of 11 V or 30 V, respectively. The low frequency can be extended with increased capacitance, which leads us to the discussion of ceramic based capacitors.

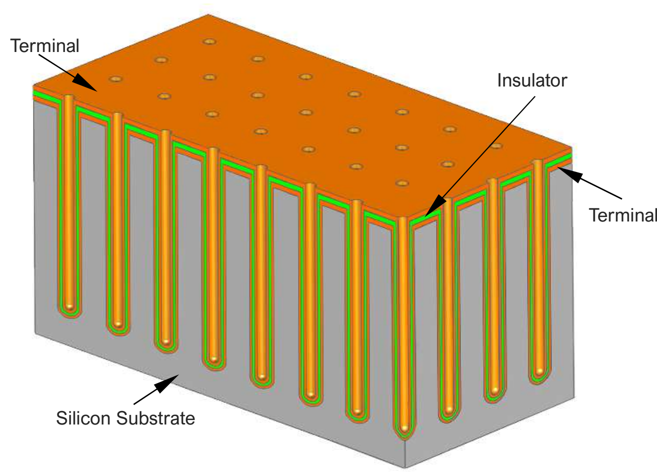

Figure 1: Silicon Capacitor Topology

CERAMIC-BASED CAPACITORS

Ceramic-based capacitors have been around for as long as one can remember. These capacitors achieve large values in extremely small packages using multi-layered technology. Multilayer ceramic capacitors (MLCC) can be described as single layer capacitors stacked on top of one another as shown in *Figure 2*. Current MLCC capacitors are as small as a 0.010” x 0.005” footprint.

In the last of couple decades, there has been a focus to try to get the most bandwidth possible out of ceramic capacitors, such as adding a single layer capacitor within the package along with the MLCC to extend the higher range bandwidth. Another idea that has been implemented in the past was to parallel a MLCC on top of the single layer capacitor in a “piggy-back” topology. In today’s offerings, the advancements in ceramic capacitor technology are producing record capacitance values in the smallest of packages. One of these leading-edge capacitors was used to make the newly-released HL8439 DC Block boasting almost seven decades of bandwidth starting at 16 kHz and extending beyond 120 GHz. This is the broadest bandwidth offering on the market at the writing of this note.

Based on the description above, where the silicon-based capacitor falls short, the MLCC capacitor succeeds, but the inverse is also true. Ceramic-based capacitors do not have the same desirable characteristics as silicon-based capacitors in terms of capacitance stability versus voltage and temperature. The HL8439 uses X6S ceramic materials derived from a barium titanate base that is temperature and voltage sensitive.

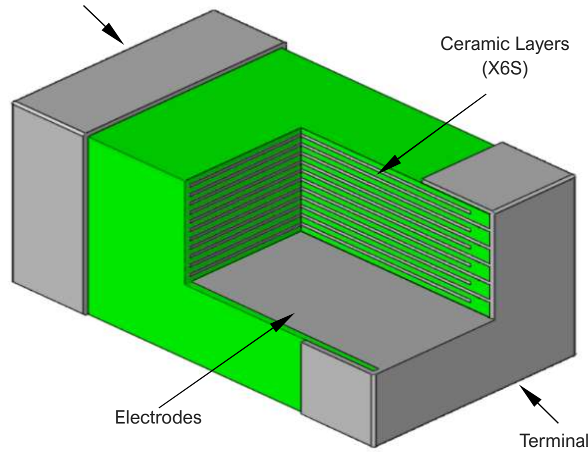

Figure 2: MLCC Topology

CONCLUSION

To summarize, HYPERLABS has given our customers the choice between the broadest-bandwidth ceramic-based DC Block on the market, the HL8349, and the voltage and thermally stable silicon-based DC Block, the HL9349.

Table 1 reviews the performance characteristics of HYPERLABS’ offerings to assist our customers in making the best tradeoffs when using HYPERLABS components.

Table 1: Performance Comparison of HYPERLABS’ 110 GHz DC Block Offerings

Parameter	HL9439-11	HL9439-30	HL8439-100
Material	Silicon	Silicon	Ceramic (X6S)
Capacitance Value	10 nF	5.6 nF	100 nF
Low Frequency Cutoff[1]	160 kHz	280 kHz	16kHz[3,4]
High Frequency Cutoff[2]	110 GHz	110 GHz	> 110 GHz
Breakdown Voltage	11 V	30 V	10 V
Thermal Stability	YES[3]	YES	NO[3]
Voltage Stability	YES[4]	YES	NO[4]
Connectors	1.0 mm	1.0 mm	1.0 mm

1 – LFC > -3dB; 2 – HFC > -2dB typ.; 3 - See Figure 4; 4 - See Figure 5

Figure 4 and *Figure 5* show examples of the thermal and bias voltage dependencies. Depending on the operating temperature and the bias voltage applied to the HL8439-100, the low frequency will adjust accordingly. Please reach out to info@hyperlabs.com with any questions you may have about the use of our 110 GHz DC Blocks.

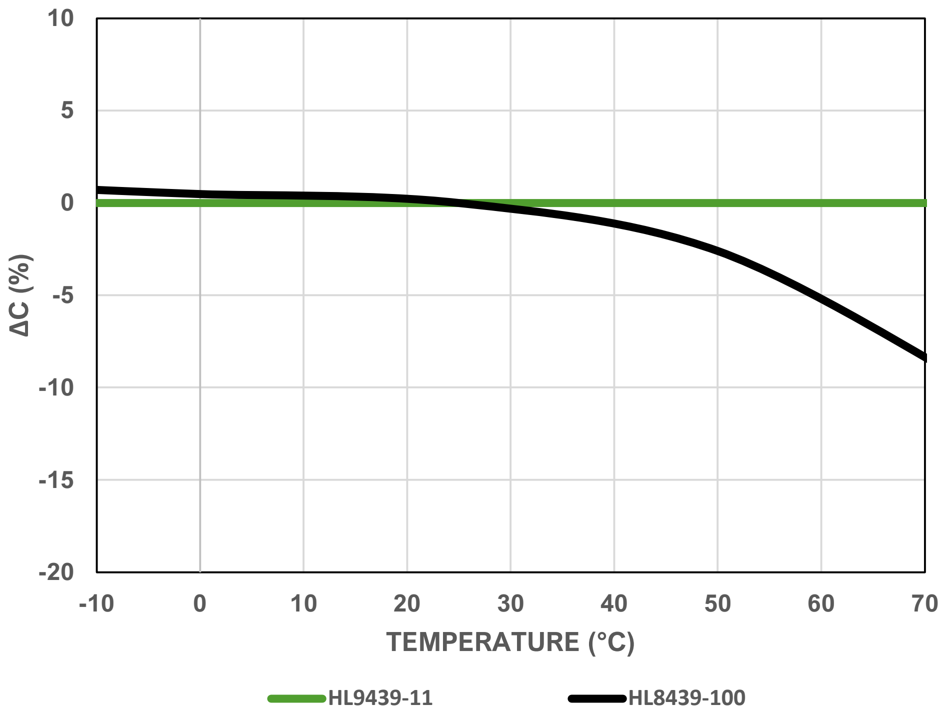

Figure 4: HL8439-100 Capacitance vs. Temperature (25 °C normalization)

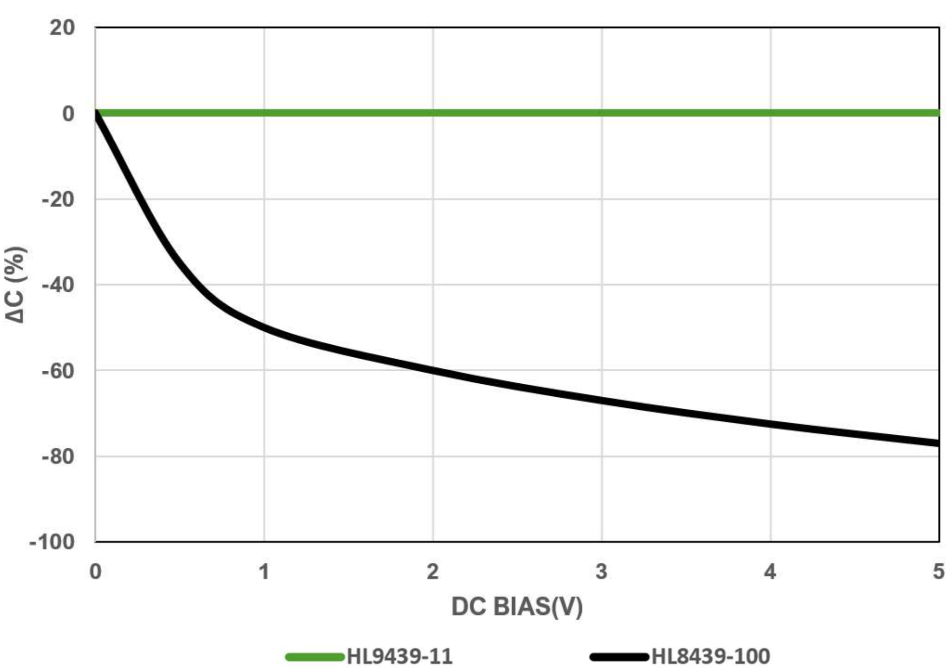

Figure 5: HL8439-100 Capacitance vs. Bias Voltage