Application Note #251115

Introduction

This application note is intended to provide design considerations for users to achieve more accurate attenuation characteristics when multiple DSAs are connected in cascade configuration in serial control mode.

Users generally employ multiple DSAs (Digital Step Attenuators) in various configurations when designing a system. Depending on the system RF budget, multiple DSAs may be connected directly in series, used with other components such as amplifiers inserted between DSAs, or implemented in separate system paths for independent path operation. However, due to space constraints, multiple DSAs are typically placed in close proximity within a limited area, sharing common lines such as DATA (SERIN), CLK (Clock), and VDD.

When using DSAs in this way, as the attenuation value increases, insufficient isolation between DSAs can cause crosstalk, which often leads to a rise in attenuation accuracy errors. To mitigate such crosstalk, careful attention to PCB layout and circuit design is required.

Causes of Crosstalk

The main flows through which crosstalk occurs can be defined as two types.
The first is **radiated leakage**, which occurs when insufficient shielding between DSAs results in spatial isolation that is smaller than the DSA attenuation value, leading to crosstalk. The second is **conducted leakage**, which refers to the leakage of RF signals through shared circuits between DSAs, such as VDD and DATA/Clock lines.

Both of these leakage types require careful attention during PCB layout and circuit design. The following section provides detailed solutions for each type of leakage.

1. Methods to reduce Radiated Leakage

Figure 1 illustrates the paths of radiated leakage when three DSAs are connected in a cascade configuration.

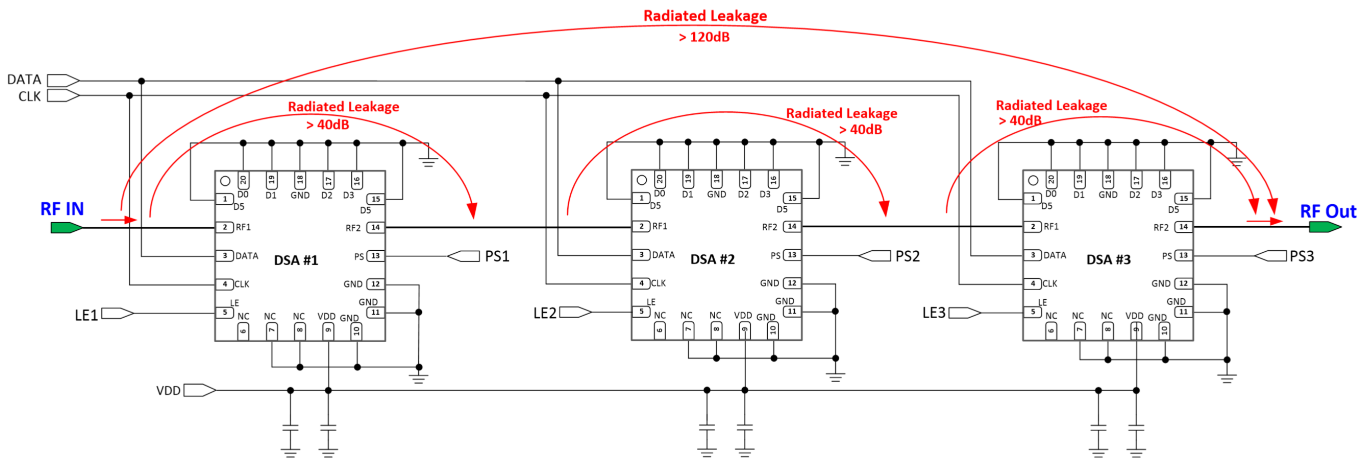

Figure 1. Radiated Leakage Flows — Serial Control Mode

RF input signals radiating through the air can couple at each DSA output and mix with the main signal, resulting in crosstalk. If the RF1 input signal of DSA #1 is transmitted to the RF2 output with a maximum attenuation of 31.5dB, the spatial isolation on the PCB layout should be at least 40dB to ensure stable attenuation performance without interference from radiated leakage signal. When three DSAs are cascaded, a total spatial isolation of at least 40dB × 3 = 120dB should be ensured.

To reduce crosstalk caused by radiated leakage, the following methods should be considered during the design phase.

- Place the DSAs as far apart as possible.
- Inserting other components, such as amplifiers, between DSAs can also be helpful.
- When multiple DSAs are placed in a confined space, achieving adequate spatial isolation can be challenging. In such cases, it may be necessary to separate them using walls or shield cans to ensure proper isolation.
- To further enhance shielding effect, add as many ground vias as possible around the DSAs and along the RF lines. Strengthening the ground in this way helps improve isolation. Figure 2 shows an example of ground via placement

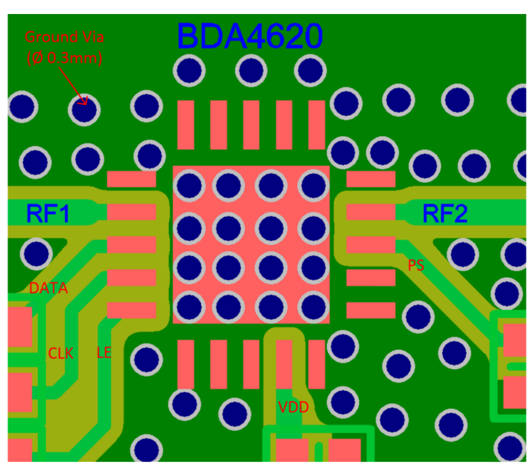

Figure 2. BDA4620 PCB layout (Serial mode)

2. Methods to reduce Conducted Leakage

The figure below shows the flow of conducted leakages when three DSAs are used in a cascade configuration.

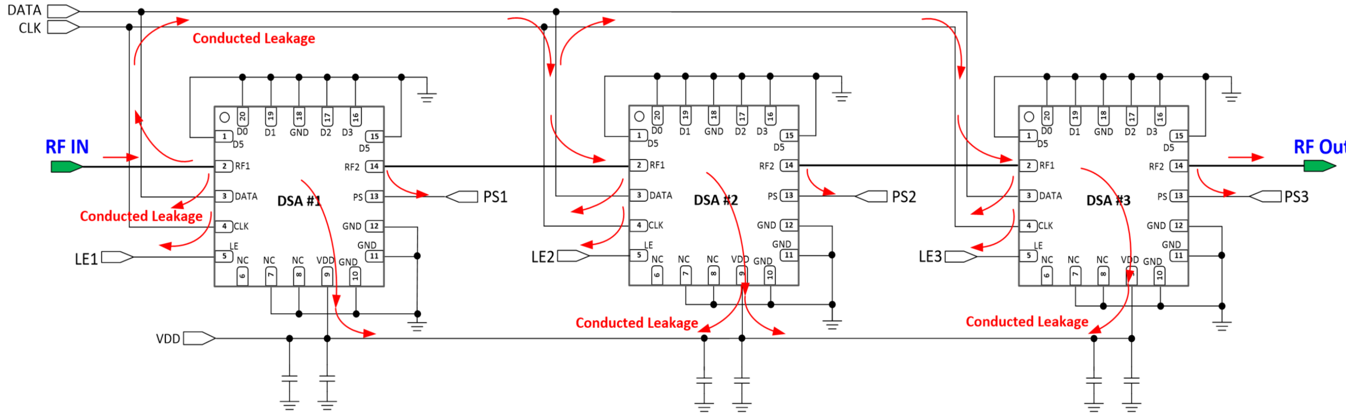

Figure 3. Conducted Leakage Flows — Serial Control Mode

These conducted leakage occur through the lines shared between DSAs, most commonly through the DATA, CLK, and VDD lines as shown in the figure 3. (LE pin may also be shared at some products, in which case crosstalk can occur through the LE line as well.) This leakage signal can also affect each DSAs, potentially causing degradation in attenuation accuracy.

In particular, coupling through the pin located closest to the RF line generates relatively larger crosstalk.

To reduce crosstalk caused by conducted leakage, the following methods should be considered during the design phase.

- Crosstalk and noise occurring through VDD(or PS) can be mitigated by adding big bypass capacitors in shunt for each DSA. In some cases, adding a low-pass filter (LPF : Cutoff frequency below 100MHz) can also help improve performance.
- For DATA, CLK, or LE lines, adding shunt capacitors or LPF to the lines can be considered as a mitigation method. However, this approach may distort the control signals, so there are limitations in applying a bypass capacitor or filter. Therefore, a more reliable way to eliminate crosstalk is to insert series resistors into each line, which significantly reduces the strength of interfering signals traveling along the lines. It is recommended to use resistors with a value of 1 kΩ or higher.
- As with radiated leakage, reinforcing the ground around the DSA can effectively reduce conducted leakage. Therefore, during PCB design, ground vias should be added as extensively as possible around the DSA bottom and along the RF lines to maximize ground reinforcement. (See the Figure 2)

Figure 4 and Figure 5 show the recommended circuits for reducing conducted leakage:

A. Apply 1 kΩ series resistors on the DATA, CLK, and LE lines.
B. Apply shunt bypass capacitors of 100nF and 100pF on the VDD line as close to pin as possible.
C. Apply a 100nF bypass capacitor on the PS pin.
D. Low Pass Filter for RF signal suppression : apply only if additionally required.

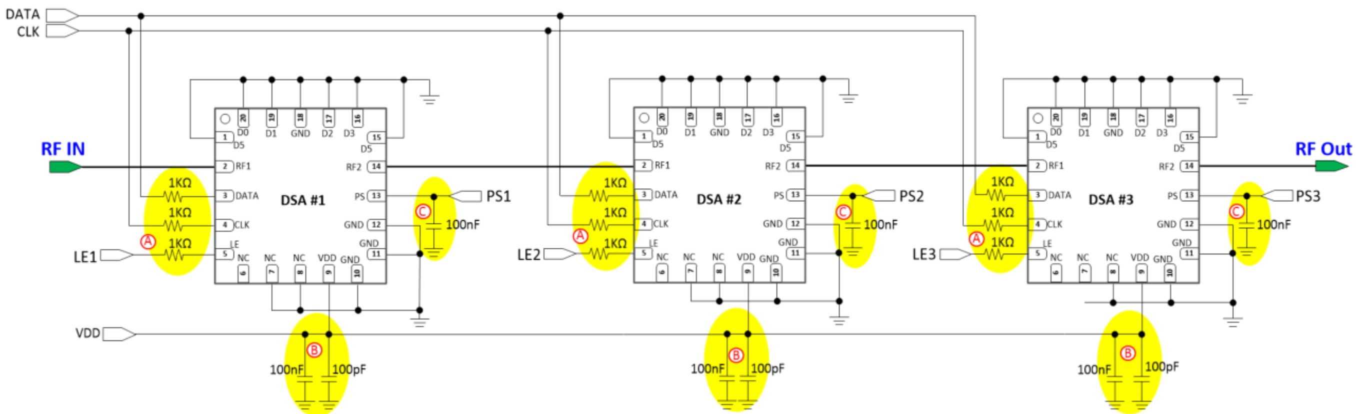

Figure 4. Recommended Circuits for Cascaded DSAs — Serial Control Mode

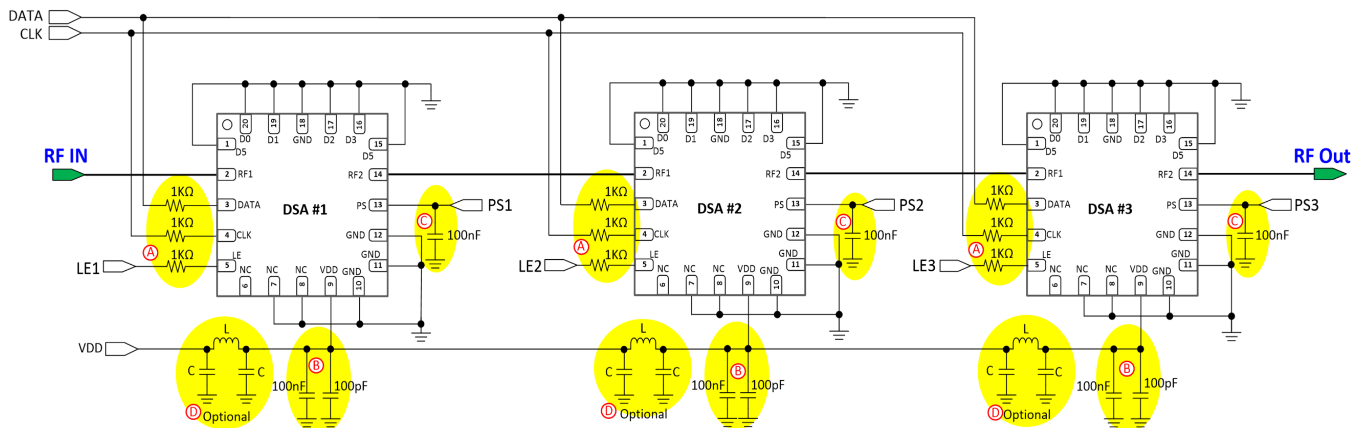

Figure 5. Recommended Circuits with Filter for Cascaded DSAs — Serial Control Mode

3. BeRex Product List with DSA

Table 1 summarizes the BeRex products for which crosstalk-improvement applications should be considered in multi-chip configurations.

Part name	Type	Configuration	ATT Range	ATT Step	Control Mode	PIN Shareability
BDA4601	DSA	DSA	31.5dB	0.5dB	Serial/Parallel	DATA, CLK, VDD, PS
BDA4620	DSA	DSA	31.5dB	0.5dB	Serial/Parallel	DATA, CLK, VDD, PS
BDA4630	DSA	DSA	31.5dB	0.5dB	Serial Addressable/Parallel	DATA, CLK, LE, VDD, PS
BDA4700	DSA	DSA	31.75dB	0.25dB	Serial/Parallel	DATA, CLK, VDD, PS
BDA4710	DSA	DSA	31.75dB	0.25dB	Serial Addressable/Parallel	DATA, CLK, LE, VDD, PS
BDA4730	DSA	DSA	31.75dB	0.25dB	Serial Addressable/Parallel	DATA, CLK, LE, VDD, PS
BDA4710V	DSA	DSA	31.75dB	0.25dB	Serial Addressable/Parallel	DATA, CLK, LE, VDD, PS
BVA303C	DVGA	DSA+AMP	31.5dB	0.5dB	Serial/Parallel	DATA, CLK, VDD, PS
BVA304C	DVGA	DSA+AMP	31.5dB	0.5dB	Serial/Parallel	DATA, CLK, VDD, PS
BVA305C	DVGA	DSA+AMP	31.5dB	0.5dB	Serial/Parallel	DATA, CLK, VDD, PS
BVA1621	DVGA	DSA+AMP	31.5dB	0.5dB	Serial Addressable/Parallel	DATA, CLK, LE, VDD, PS
BVA2140B	DVGA	AMP+DSA+AMP	31.5dB	0.5dB	Serial/Parallel	DATA, CLK, VDD, PS
BVA7202C	DVGA	AMP+DSA+AMP	31.5dB	0.5dB	Serial/Parallel	DATA, CLK, VDD, PS
BVA1761	DVGA	DSA+AMP	31.75dB	0.25dB	Serial Addressable	DATA, CLK, LE, VDD, PS
BVA2761	DVGA	AMP+DSA+AMP	31.75dB	0.25dB	Serial Addressable	DATA, CLK, LE, VDD, PS
BVA1762	DVGA	DSA+AMP	31.75dB	0.25dB	Serial Addressable	DATA, CLK, LE, VDD, PS
BVA2762	DVGA	AMP+DSA+AMP	31.75dB	0.25dB	Serial Addressable	DATA, CLK, LE, VDD, PS
BVA3144C	DVGA	AMP+DSA+AMP+AMP	31.75dB	0.25dB	Serial	DATA, CLK, VDD, PS
BVA7242	DVGA	AMP+DSA+AMP	31.75dB	0.25dB	Serial	DATA, CLK, VDD, PS

Table 1. BeRex Products with DSA(Digital Step Attenuator)