Use of ISL55016 as a Single-Ended to Differential Converter

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Introduction

The ISL55016 Silicon Bipolar amplifier can match a 75Ω single-ended source to a 100Ω differential load. This feature makes the ISL55016 ideal for a radios where the tuner chip has a differential input, such as Satellite TV. Here we will introduce the application circuit and discuss the advantages of this part. Specifically, the differential nature of the output removes the need for a balun, which improves both board area and frequency response.

The ISL55012 is a predecessor to the ISL55016. It has similar functions with the exception of the output, which is limited to single-ended operation. We will discuss using the ISL55016 to substitute for the ISL55012 with a balun structure.

Balun

A balun is a passive structure which converts between balanced and unbalanced electrical signals (Figure 1). Some normal balun structures include classical transformers, transmission line baluns and 180° power divider/combiners.

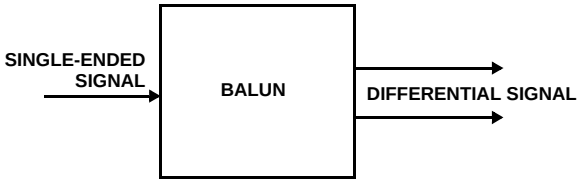

FIGURE 1. BLOCK DIAGRAM OF A BALUN

Typical Application Circuit

The ISL55016 is a true differential amplifier and doesn't need a balun. Figure 2 shows the typical application circuit of ISL55016.

The ISL55016 can be used as a single-ended input. Pin 2 and Pin 3 are equivalent. Either one can be used as the input; the other one needs to be connected to an AC Ground. The input is internally matched to 75Ω single-ended and the output is matched to 50Ω single-ended or 100Ω differentially.

The ISL55016 can be used as differential-in and differential-out as well since Pin 2 and Pin 3 are equivalent, balanced inputs.

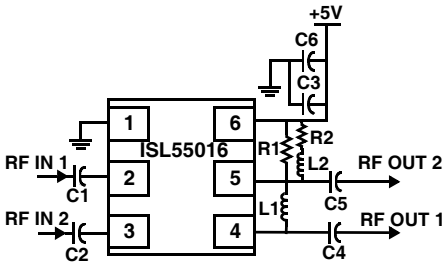

FIGURE 2. APPLICATION CIRCUIT

Impact of Balun on Layout

In contrast with the ISL55016 is its predecessor, the ISL55012. The amplifier will be followed with a Balun structure to transfer the single-ended signal to a differential tuner. The ISL55016 can be used to substitute the Balun Structure and LNA to save PCB space and components (Figure 3). The differential capabilities of the ISL55016 allow a reduction in excess of 50%.

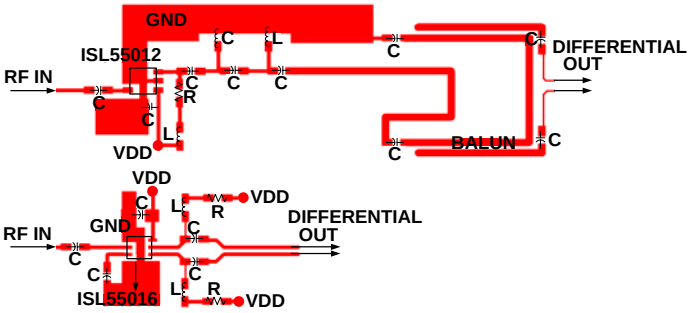

FIGURE 3. COMPARISON OF THE LAYOUTS OF HE ISL55012 WITH A BALUN AND THE ISL55016 (RELATIVE SIZE)

Figure 4 shows gain measured for the ISL55016 and ISL55012 with a transmission line balun on a customer board as shown in Figure 3. One of the design goals of the ISL55016 is to provide gain no less than the ISL55012 at 0.5GHz to 2GHz. Also the ISL55016 can be used at low frequency down to 50MHz, where the ISL55012 can not work well.

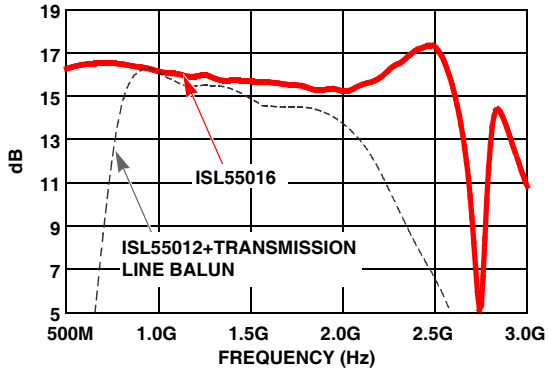

FIGURE 4. GAIN OF ISL55012 WITH A TRANSMISSION LINE BALUN vs ISL55016

The ISL55016 shows a little higher gain than the ISL55012 with balun structure. In this way, Figure 4 shows the realization of the ISL55016 as a single-ended to differential converter.

Trade-off Between Power and OIP2

Once the signal is truly balanced, even order distortion drops to zero. The ISL55016 converts the signal to differential early in its signal path thus reducing second order distortion and boosting OIP2. Nevertheless, the ISL55016 does generate

some even order distortion because of the asymmetric loading of its input and improving the device linearity will improve OIP2. The values of R1 and R2 (Figure 1) have been characterized for two options, 27Ω and 0Ω. Decreasing the R1 and R2 value will increase the voltage across the output transistor leading to an increase in the dissipation power. At the same time, it will increase the amplitude of the compression and OIP2, OIP3. This allows a trade-off between the power dissipation and the distortion.

Matching at the Input and Output

In PCB layout design, a matching network is needed, especially at the input. The Figure 5 shows the matching network used for the ISL55016 Evaluation Board. 12mm of 100Ω trace and 8mm of 50Ω trace are used to form the input matching network while 4mm of 100Ωr trace forms the output matching network on the FR4 material.

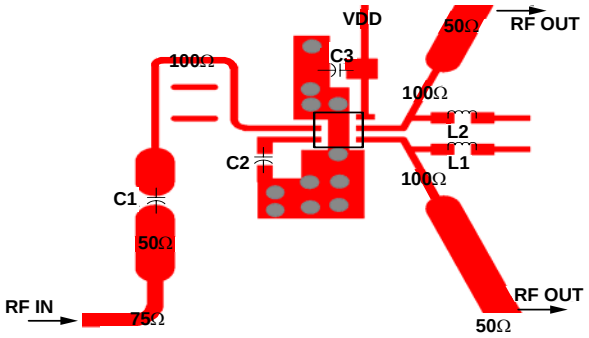

FIGURE 5. PCB LAYOUT OF MATCHING NETWORK

Figure 6 shows the improvement in input matching (S11) provided by this network of traces. At 2GHz, the input match is improved 3dB and remains below a -10dB level.

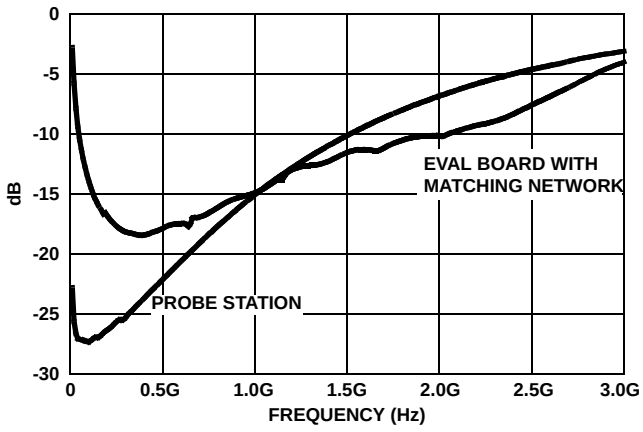

FIGURE 6. |S11| vs FREQUENCY

Thermal Management

The power dissipation of ISL55016 is about 500mW. The PCB layout shown in Figure 5 provides the good thermal connectivity between the device back plate and the main ground plane, hence the copper and vias holes are needed on either side of the chip. So via holes have two functions to perform, providing a good RF ground for C2, C3 and back plate and providing a low thermal conductivity to the ground plane which dispenses the heat.

Choices of Components

ISL55016 is designed for wide bandwidth Applications, 50MHz-3GHz. The decoupling and RF choke components should be chosen carefully for different frequency applications. Tables 1 and 2 list the component information for the Evaluation Board.

TABLE 1. LIST OF COMPONENTS (50MHz~300MHz)

FREQUENCY BAND	VALUE	DESCRIPTION/DIMENSIONS
C1, C2	2200pF	0603
C4, C5	2200pF	0603
L1, L2	2.2µH	Multilayer Ferrite/0603
C3	1nF	0603
C6	0.1µF	1206
R1, R2	27Ω/0Ω	0402

TABLE 2. LIST OF COMPONENTS (300MHz~3GHz)

FREQUENCY BAND	VALUE	DESCRIPTION/DIMENSIONS
C1, C2	100pF	0603
C4, C5	100pF	0603
L1, L2	100nH	Surface Mount/0402
C3	100pF	0603
C6	0.1µF	1206
R1, R2	27Ω/0Ω	0402