

## Applications

- 2G / 3G / 4G wireless systems
- LTE transceivers
- UHF/VHF public safety bands
- Macro base stations
- Micro base stations
- Pico base stations
- Femto base stations
- GSM, UMTS, multistandard transceivers
- Test and measurement instrumentation
- Military communication

## Features

- Low insertion loss
- High attenuation accuracy
- Excellent return loss
- High IP3
- Broad frequency response
- Flat attenuation
- Monotonic step response
- Performance out to 4 GHz
- Power control at IF applications
- SPI control
- Parallel control
- Power up options
- Addressable
- Small QFN lead (Pb)-free, RoHS-compliant packaging



## Digital Attenuators with High Attenuation Range and Accuracy

### Select Digital Attenuators Available from Stock for Prototype or High Volume Production

Skyworks Solutions offers a select group of digital attenuators from our broad product portfolio that are in stock now and ready for immediate design into your demanding applications.

Skyworks' extensive portfolio of RF microwave products includes solutions for wireless communications infrastructure systems, such as 4G / LTE macro and micro cellular base stations, high power WLAN access points, land-mobile radio systems, point-to-point radio links, and more. Skyworks' solutions attenuate signals in both receive and transmit signal paths, are controlled by serial or parallel interfaces, and offer attenuation bit accuracy as great as 0.25 dB.

Select attenuators include the most popular GaAs 1-, 2-, 3-, 4-, 5-, 6-, and 7-bit RF and IF attenuators, readily available to ship from stock. These devices provide excellent performance and value for applications such as Tx/Rx power control in transceiver blocks. All attenuators are designed using Skyworks' state-of-the-art Pseudomorphic High Electron Mobility Transistor (pHEMT) process. Some designs incorporate CMOS controllers to generate negative bias to extend frequency response down to 50 MHz for IF applications. These designs do not require DC blocking capacitors on the RF lines. The use of CMOS in the package also provides the functionality of serial port interface (SPI) control as well as decode logic functions. The CMOS designs draw very little bias control current when compared to integrating the decode functions on a GaAs design. Select attenuators have been fully characterized for low-frequency applications, covering the UHF and VHF ranges.

The performance characteristics of the attenuators include: broadband operation (VHF to 4 GHz); attenuation range from 0.25 dB to 31.75 dB; low insertion loss; excellent attenuation accuracy; monotonic step size; excellent phase performance; fast switching; and, excellent IIP3 performance. All attenuators are absorptive in 50  $\Omega$  environments and therefore easily cascable – impedance matching is not required between attenuators.










Our lead (Pb)-free, RoHS-compliant and Green™ products are fabricated in our high volume GaAs pHEMT facility. All attenuators are packaged in industry-standard, plastic surface-mount packages. These attenuators leverage the extensive design knowledge, technical leadership, manufacturing expertise, and superior quality of Skyworks.


A select list of Skyworks digital attenuators is provided in Table 1. Evaluation boards are available.

An application engineering team is available to assist you with your design efforts.

Application notes and block diagrams are accessible on Skyworks' Web site: [www.skyworksinc.com](http://www.skyworksinc.com)

**Table 1. Select Digital Attenuators for IF/UHF/VHF and Broadband RF Applications**

Part Number New Products	Frequency Range (GHz)	Number of Bits	Least Significant Bit (dB)	Control Interface	Maximum Attenuation (dB)	Typical Insertion Loss (dB)	Typical IIP3 (dBm)	Package (mm)
AA103-72LF	LF–2.5	1	10	Parallel	10	0.3–0.4	41	SOT-23 5L 2.8 x 2.9 x 1.18
 SKY12406-360LF	0.05–0.6	1	12	Parallel	12	0.3	46	QFN 8L 2 x 2 x 0.9
AA116-72LF	0.004–2.0	1	15	Parallel	15	0.35–0.4	41	SOT-23 5L 2.8 x 2.9 x 1.18
AA104-73LF	LF–2.5	1	32	Parallel	32	0.8–1.0	41	SOT-23 6L 2.8 x 2.9 x 1.18
 SKY12407-321LF	0.05–0.6	2	12	Parallel	12 (100 $\Omega$ Differential I/O)	0.3	48	QFN 12L 3 x 3 x 0.75
SKY12324-73LF	0.3–3.0	2	4	Parallel	12	0.9–1.3	43	SOT-23 6L 2.8 x 2.9 x 1.18
 SKY12338-337LF	0.35–4.0	2	6	Parallel	18	0.55–1.3	45	QFN 12L 3 x 3 x 0.75
SKY12325-350LF	0.5–6.0	3	1	Parallel	7	0.7–1.3	47	QFN 16L 3 x 3 x 0.75
 <b>SKY12348-350LF</b>	0.1–3.0	4	1	Parallel	15	0.8–1.2	45	QFN 16L 3 x 3 x 0.75
 SKY12340-364LF	0.3–2.0	5	0.5	SPI	15.5	1.4–1.8	45	QFN 32L 5 x 5 x 0.9
SKY12322-86LF	0.5–4.0	5	0.5	Parallel	15.5	1.4–3.0	45	MSOP 10L 4.9 x 3 x 0.96
SKY12323-303LF	0.5–3.0	5	1	Parallel	31	1.4–2.3	48	MSOP 10L 4.9 x 3 x 0.96
SKY12328-350LF	0.5–4.0	5	0.5	Parallel	15.5	1.1–2.3	42	QFN 16L 3 x 3 x 0.75
 SKY12339-350LF	0.4–3.0	5	1	Parallel	31	1.2–2.0	39	QFN 12L 3 x 3 x 0.75
 SKY12345-362LF	0.7–4.0	5	0.5	SPI	15.5	1.2–2.0	42	QFN 24L 4 x 4 x 0.9
 <b>SKY12347-362LF</b>	LF–3.0	6	0.5	SPI or Parallel	31.5	1.2–2.0	50	QFN 24L 4 x 4 x 0.9
 <b>SKY12343-364LF</b>	0.01–4.0	7	0.25	SPI or Parallel	31.75	1.8–1.9	50	QFN 32L 5 x 5 x 0.9

 Skyworks Green™ products are compliant to all applicable materials legislation and are halogen-free. For additional information, refer to Skyworks Definition of Green™, document number SQ04-0074.

All parts are lead (Pb)-free and RoHS-compliant.

## Digital Attenuator Fundamentals

Skyworks utilizes the same process to fabricate RF switches as our digital attenuators, with an additional thin film resistor layer to create highly accurate attenuation structures. The thin film resistors are configured in either a  $\pi$  or a T-type configuration in order to provide the best attenuation accuracy and impedance match versus frequency. The  $\pi$  or T configured resistors are switched into or out of the signal path to either “click in” or “click out” the attenuation bit. (See Figure 1) .

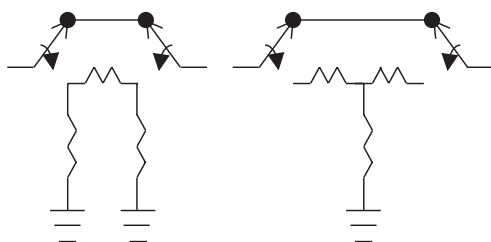


Figure 1.  $\pi$  and T Configured Attenuators

Multiple bits can be cascaded to increase attenuation range. Typically the bit values are binary weighted. The smallest value, which is the least amount of attenuation the attenuator can produce, is called the least significant bit (LSB). The largest value, or highest attenuation bit, is called the most significant bit (MSB). The individual bits can be switched into or out of the signal path to produce the desired total attenuation versus control signal(s) resulting in a transfer function which resembles a stair step function when plotted. The physical placement of the attenuator stages on the GaAs substrate is optimized to maintain the best match throughout the entire attenuation range. The control lines are routed on the chip to make it easy for the user to bias and control the attenuator in a logical, effective way.

Some attenuators also contain a CMOS decoder/driver die which may perform several functions. (See Figure 2).

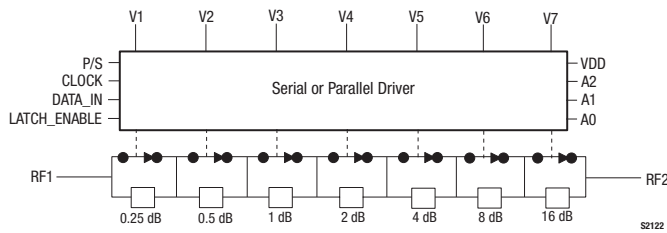


Figure 2. SKY12347-364LF Example of 7-Bit Attenuator

The use of CMOS provides several advantages. Functions such as negative voltage generators (NVG), serial port interface (SPI) and logic decoders are readily implemented in a CMOS process. When using an NVG, the user applies a positive supply voltage from which circuitry on the CMOS chip generates a negative voltage to bias the GaAs attenuator. Since the GaAs pHEMT Field-Effect Transistors (FETs) are depletion mode devices, they must be biased with a negative voltage at the gate with respect to the voltage at the drain/source. The use of an NVG also precludes the need for DC blocking capacitors on the RF lines and allows the GaAs attenuator bits to be connected directly to ground without an RF bypass cap. These design techniques are employed for most IF attenuators.

An alternate method to extend the frequency response down to UHF/VHF frequencies is to float the attenuator with an external capacitor. (See Figure 3).

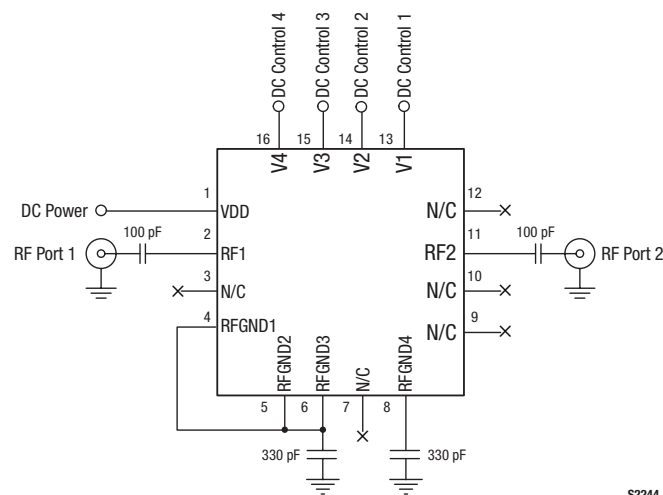


Figure 3. SKY12338-337LF Example of Externally Floated 2-Bit Attenuator

This technique allows a larger value floating capacitor to be used than what is practical to include on the attenuator die to float the attenuator above ground potential. Adding large value DC blocking capacitors to the RF input and output allows the gates of the FETs to be biased directly with positive voltage and is a good option for single bit or low bit count attenuators that do not require complicated biasing. One limitation to this design technique is that the usable bandwidth is somewhat reduced since the impedance of the blocking capacitors is composed of capacitive reactance as well as the reactance of the capacitors' parasitic inductance, thus making resonances possible. For RF applications, the value of the floating capacitors is much lower and so it is practical to incorporate them onto the GaAs die. (See Figure 4).

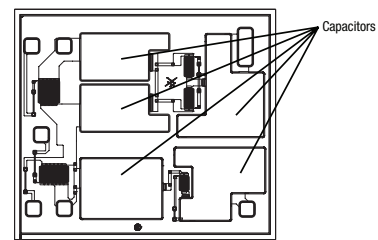


Figure 4. Capacitors Incorporated onto the Die for RF Applications. (SKY12338-337LF)

By including the floating caps on die, the only additional inductance added to the RF ground path is the bond wire from the chip to the exposed paddle of the QFN package. Typical capacitor values commonly used in this manner limit the lower frequency response of the attenuator to approximately 600–700 MHz. Making the capacitors larger in value adds significantly to the size of the chip, which increases cost.

Skyworks' portfolio of attenuators includes single bit devices up to a fully integrated designs with 7 bits. The 7 bit attenuator provides discrete 0.25 dB steps up to 31.75 dB. For applications requiring more dynamic range, higher total attenuation can be achieved by placing attenuators in cascade. In these high dynamic range applications, the use of two separate packaged attenuators is the best way to achieve higher levels of attenuation. In such cascades, it can be difficult to maintain monotonicity over very large dynamic ranges and broad bandwidths. Good step size monotonicity is more realizable if the LSB is 1 dB and IF the bandwidth is narrow. An example of a cascaded architecture is shown in Figure 5. This combines a 5 bit digital attenuator with a single bit attenuator to achieve 63 dB of potential dynamic range.

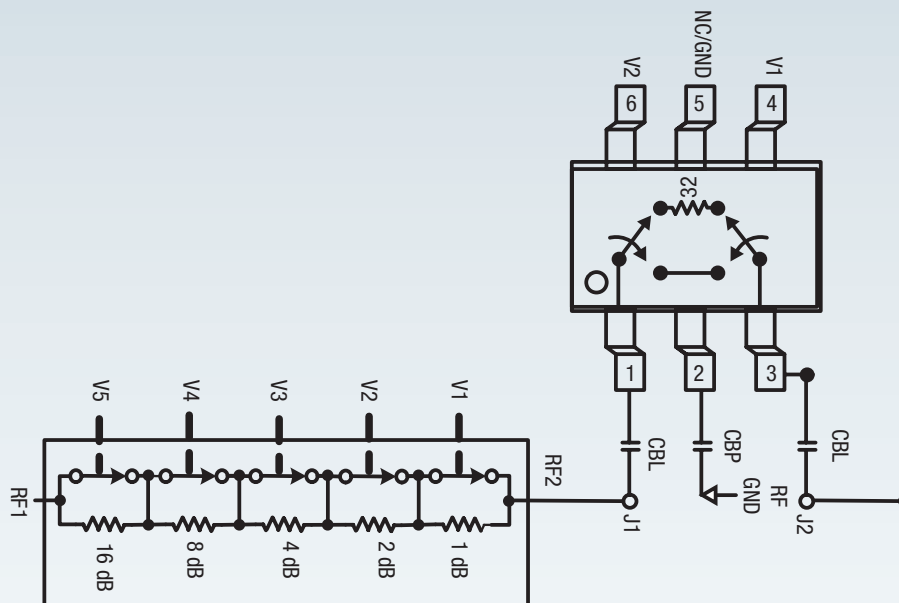


Figure 5. Multiple Attenuators Cascaded to Increase Dynamic Range (SKY12339-350LF cascaded with AA104-73LF).



Through our Green Initiative™, we are committed to manufacturing products that comply with global government directives and industry requirements.

Skyworks is continuously innovating RF, analog, and mixed-signal ICs. For the latest product introductions and information about Skyworks, visit our Web site at [www.skyworksinc.com](http://www.skyworksinc.com)

For additional information on our broad overall product portfolio, please contact your local sales office or email us at [sales@skyworksinc.com](mailto:sales@skyworksinc.com)

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