Programmable Attenuators for Wireless Products

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Programmable attenuators are widely used in communication test systems and instruments for a variety of applications. The most common use is in spectrum analyzers and test receivers to increase the dynamic range of the instrument or wireless subsystem. Another typical application is the use of programmable attenuators to simulate specific conditions in a wireless communication system such as the simulation free space loss or fading conditions. In either application, the incremental step size accuracy, total attenuation range, switching speed, and pack-

Weinschel Programmable Attenuators

aging requirements are important parameters in determining the most appropriate design configuration. Programmable attenuators are used throughout the electronics industry for signal level adjustment.

Programmable attenuators generally consist of a series of attenuation pads or cells, that are inserted into the signal path. The attenuation pads are usually in a sequence, giving extensive attenuation range, while also giving small incremental steps. Since this sequence is a binary sequence the unit is termed a binary programmable attenuator. The basic structure of a programmable attenuator is illustrated in Figure 1.

There are a number of ways in which the attenuator pads are switched in and out of the circuit. A very popular technique is to use electromechanical relays. Other versions of programmables using solid state switching techniques such as PIN and FET devices are used in specific applications. They are normally much faster in operation, sometimes by several orders of magnitude, but normally have limited frequency range. Mechanical switches work from true dc up to the full bandwidth of the device. PIN switched devices always have a lower frequency limit, and the isolation between control and through path with FET devices is nowhere near as good as with a mechanical switch.

Switching speed is the maximum time between applying the switching command to the cell and the cessation of contact bounce. The time is a function of switch structure and size.

There are two basic styles of operation; momentary or fail-safe, and latching. In momentary action the switch is only held in the one position as long as power is applied to the solenoid. As soon as power is

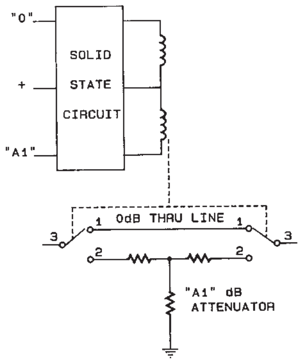

Figure 1. Typical Programmable Attenuators Cell

removed the switch reverts to its no-control signal or fail-safe state. Usually this state is the through state, i.e. no attenuation is in circuit. In the latching versions each cell has two controls. One control causes the switch to move in one direction, the other causes it to move in the other. There is usually a magnet involved to hold the switch stable in either position. There are advantages and disadvantages with both techniques. A non-latching switch requires constant power to the solenoid to hold the switch in the one position. This can cause unwanted heating of the switch. On the other hand the current required to effect switching is normally less as there is no permanent magnet to overcome.

The quoted life for mechanical switches is normally in the range from 5 million to 10 million switchings. This specification is per switch independent of the other switches in the attenuator. However, care must be taken to ascertain whether the switching is defined as movement one way or a complete cycle. For example in the Weinschel Model 3200 series the specification is 10 million cycles, i.e. one cycle is the switch moving in both directions. These specifications are based on the mechanical life of the switch. There are very often other criteria also involved. High power operation can have an adverse effect on the switch surfaces as they switch. This can reduce the overall life of the switch by causing the attenuator performance to go outside its electrical operational specification. A 0 dBm, 1 mW level is considered low power in this instance.

A term often used with respect to programmable attenuators is "monotonicity". A unit is considered monotonic if attenuation of the device always increases whenever an increase in attenuation is selected. This applies on a per frequency basis. For example it does not mean that the 20 dB setting at 1 GHz cannot be greater than the 21 dB setting at 18 GHz. It is largely a factor of the interrelationship between the SWR of cells as they combine to form values of attenuation other than that given by single cells. The addition of the indi-

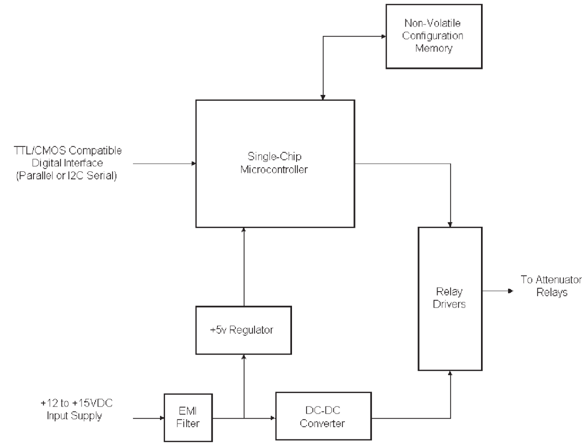

Figure 2. SmartStep Programmable Attenuator Block Diagram

vidual attenuation values of the cells also plays a big part. Another good example of when problems can occur is when a unit such as the 3200-1 goes from 63 to 64 dB. In doing so it switches from the 1, 2, 4, 8, 16, and 32 dB cells to the 64 dB cell alone. If each of the first cells is 0.1 dB high the combination could be 0.6 dB high. On the other hand the 64 dB cell could be 0.5 dB low. The unit would thus go from an actual 63.6 dB to 63.5 dB as the selected value goes from 63 to 64 dB. This would not be monotonic.

Controlling and communicating with a programmable attenuator is accomplished in a variety of ways. As the wireless systems become more complex, there is an increasing need to provide more sophisticated methods of driving the switch cells. In response to these requirements, Weinschel now offers a series of Smartstep™ programmable attenuators and communications interface units that greatly simplify the process of controlling these devices (Figure 2).

The SmartStep™ attenuators feature an internal microcontroller-based driver that provides a TTL-level digital interface for control of the attenuator relays (Figure 2). This card simplifies operation and interfacing requirements, while at the same time providing for greatly enhanced flexibility over past designs. User-selectable modes of operation include both parallel and serial I^2C bus. The parallel mode provides a simple, one-bit per relay on/off control with internal pullups for use primarily in single attenuator applications. This mode allows the attenuator to be controlled via a variety of methods, such as a TTL-level digital output port, or mechanical toggle switches. The I^2C mode provides a two-wire serial bus structure and protocol for connecting a number of devices to a single host control interface, suitable for use in larger system and sub-system applications. The SmartStep™ contains non-volatile configuration memory that is used to hold a wide variety of attenuator and driver-dependant parameters, including serial number, attenuator cell dB values, relay configurations, and switching requirements, which are all accessible via the I^2C interface. This frees the system designer from such low-level details, allowing faster integration. In either operational mode, the microcontroller enters an idle condition during periods of inactivity, turning off all on-board clocks, reducing EMI concerns, and lowering power consumption. On-board regulation for the digital circuitry allows the SmartStep™ to operate from a single input supply voltage.

The communications interface (Model 8210) provides a flexible, low cost solution for the operation of programmable step attenuators and other electromechanical devices under computer control. Designed to interface to Weinschel's new line of SmartStep™ programmable attenuators, the Model 8210 represents a new concept in device control applications for bench test and subsystem designs. The 8210 communications interface provides a high-level interface from various industry standard communications interfaces, including IEEE-488 and RS232/RS422/RS485, to the SmartStep's serial Driver Interface Bus.

A final point to make about programmable attenuators is that they have two types of attenuation; insertion loss and incremental. The former is the loss of the device itself with no attenuation settings selected. It usually has a slope with frequency reaching values of several dB at the high end. The latter concerns the performance of the individual cells relative to that innate insertion loss. Thus the performance of programmable attenuators is always given in incremental attenuation, with the insertion loss being considered part of the fixed performance of the system.