u-Law Companders and A-Law Companders

Introduction

The HammerCores by Altera® u-Law and A-Law Compander macros are very efficient, high performance, full precision voice telephony macros. They are optimized for Altera® FLEX® 6000, FLEX 8000, and FLEX 10K devices.

Companders are widely used for voice compression in telecommunications systems. The word compander comes from the terms compressor and expander, and they generally work together. Voice data is sampled in a Pulse Code Modulation (PCM) format. The PCM data is then compressed for transmission, and is expanded, either for signal processing at some node, or at the receiver.

Voice companding is done to a logarithmic scale, so that low-amplitude signals are preserved accurately. Most voice information is at small signal levels, although information may exist over a wide dynamic range.

There are two common companding schemes in use -- u-Law for North American and Japanese standards, and A-Law, for European standards. The u-Law compander compresses a 14-bit signal down to an 8-bit signal, and expands it back to 14 bits. An A-Law compander compresses and expands a 13-bit signal to 8 bits, and back again.

Although smaller signals are compressed with more precision, there will often be a majority of '0' bits in the companded signal. For this reason, the code word is inverted prior to transmission. Inversion is not done in these companders, and must be added, if required.

u-Law Companders

The u-Law compander macro is comprised of separate compression, and expansion, components. The full precision standard, of 14 bits to 8 bits to 14 bits, is implemented. Both macros are purely combinatorial, and very compact. The specifications of the macros are in Table 1. Performance is given in total delay for a single instance in an EPF10K10LC84-3, including I/O. Actual performance on board a device may still be higher.

Table 1. U-Law Compander Specifications

	u-Law Compressor	u-Law Expander
Resources (LCs)	57 LCs	29 LCs
Performance	40 ns	25 ns

The u-Law standard (compression direction) is described by:

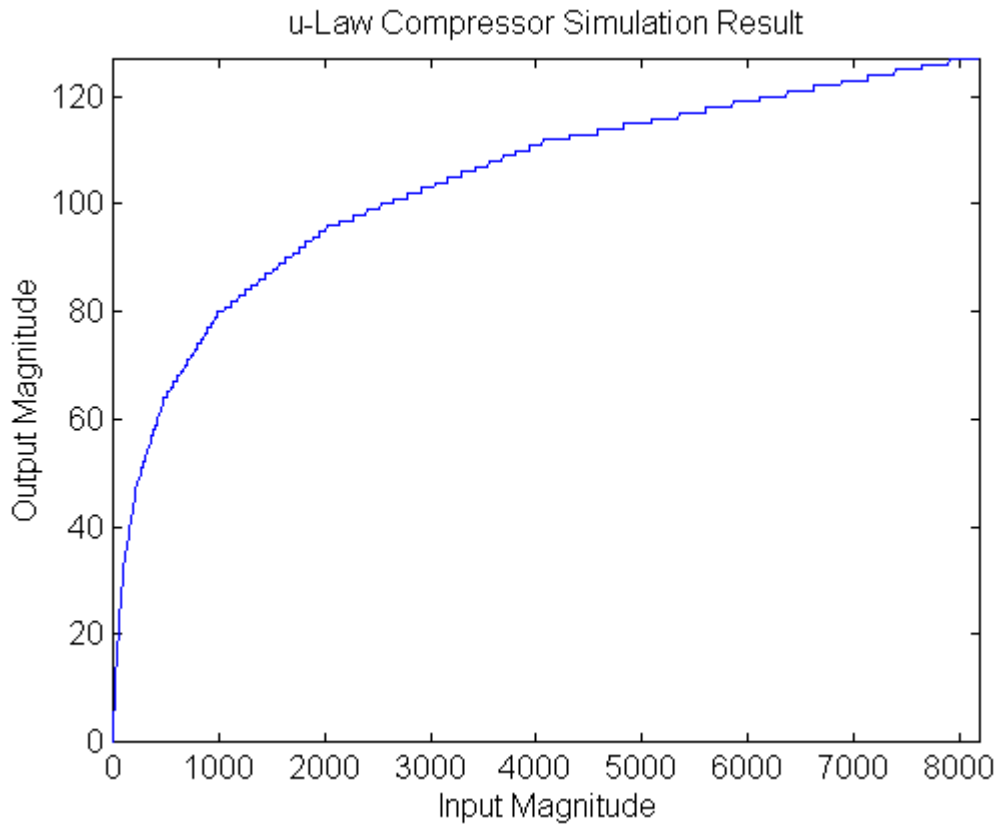
$$F(x) = \mathrm{sgn}(x)\frac{\ln(1+\mu|x|)}{\ln(1+\mu)}$$

Where μ is the compression parameter, which is set to 255 for the North American standard.

Both the input and the output are in signed magnitude format i.e. the MSB is the sign bit, followed by the magnitude. The actual operation of the compressor results in 13 bits of dynamic range compressed down to 7 bits. The sign bit remains the same.

The operation of the compressor is graphically described by Figure 1. The steps in the curve show the quantization steps.

Figure 1



A-Law Companders

As with the u-Law compander, the A-Law macro is comprised of separate compression, and expansion, components. The full precision standard, of 13 bits to 8 bits to 13 bits (as compared to the u-Law macro, with 14 bits of precision in the uncompressed sample), is implemented. Both macros are purely combinatorial, and very compact. The specifications of the macros are in Table 2. Performance is given in total delay for a single instance in an EPF10K10LC84-3, including I/O. Actual performance on board a device may still be higher.

Table 2. A-Law Compander Specifications

	A-Law Compressor	A-Law Expander
Resources (LCs)	30 LCs	26 LCs
Performance	23 ns	24 ns

The A-Law standard (compression direction) is described by:

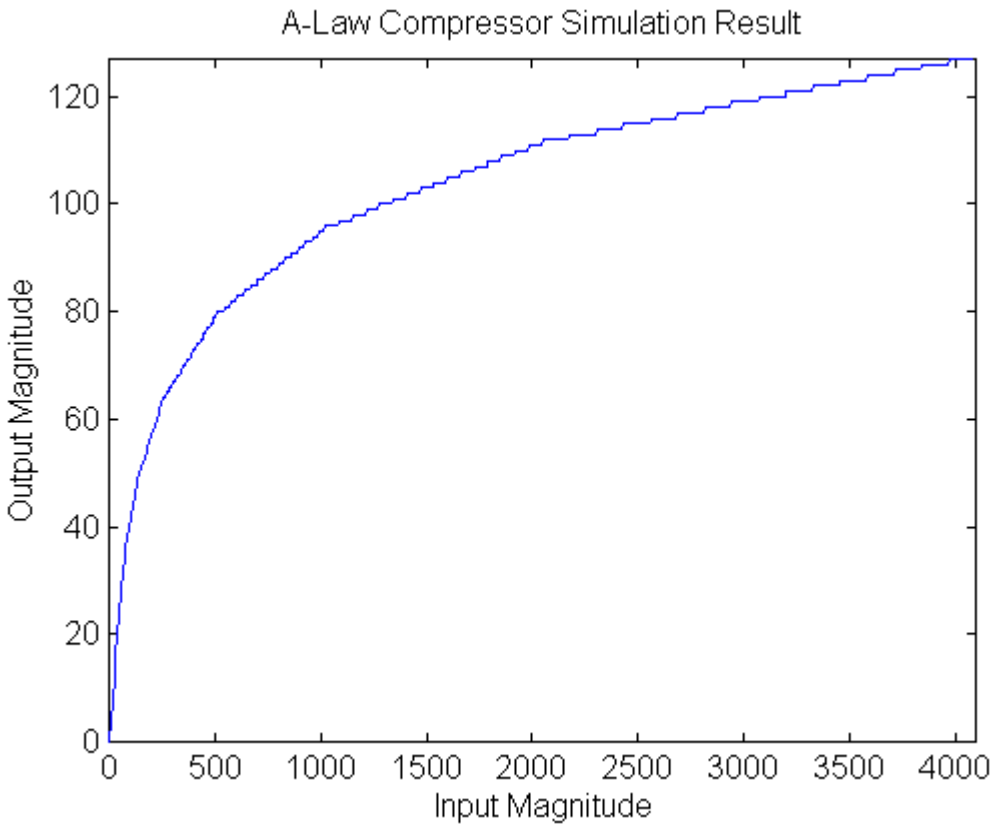
$$F(x) = \mathrm{sgn}(x)\frac{A|x|}{1+\ln(A)} \quad \text{for } 0 \le |x| < \frac{1}{A} \text{ , and}$$

$$F(x) = \mathrm{sgn}(x)\frac{\left(1+\ln\left(A|x|\right)\right)}{1+\ln(A)} \quad \text{for } \frac{1}{A} \le |x| \le 1$$

Both the input and the output are in signed magnitude format i.e. the MSB is the sign bit, followed by the magnitude. The actual operation of the compressor results in 12 bits of dynamic range compressed down to 7 bits. The sign bit remains the same.

The operation of the A-Law compressor is graphically described by Figure 2. The steps in the curve show the quantization steps.

Figure 2



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