

June 27, 2012

Figure 1 shows the list of waveforms sources.

Summary

LeCroy's ArbStudio has great tools for creating simple waveforms.

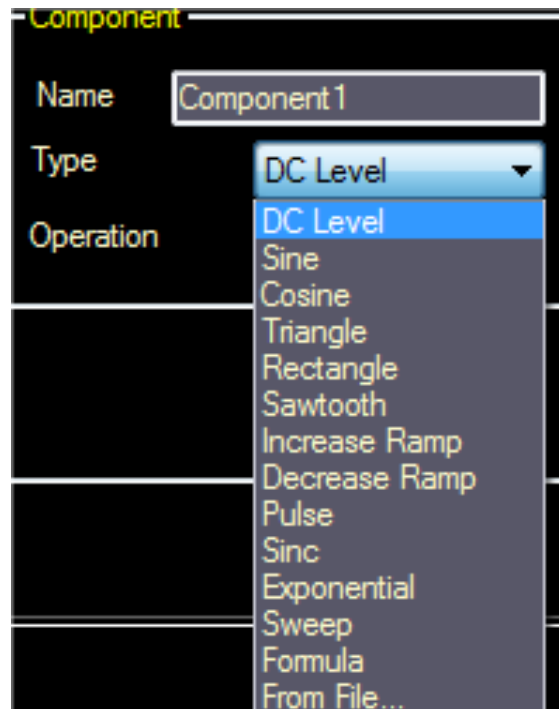


Figure 1: The list of component waveform sources in ArbStudio


While standard waveforms like sine and squarewave (rectangular) are commonly used, either alone or in combination with other waveshapes, there are many waveforms that cannot be created by a simple combination of these waveforms. In these cases, importing waveforms from a measurement instrument, file, or creating it analytically using equations or formulae are ideal methods. This paper will focus on creating waveforms using formula entry.

After creating or opening a workspace in ArbStudio double click on the Waveform Sequencer in the channel of your choice. This will bring up the Waveform Sequencer for the channel as shown in Figure 2.



Figure 2: Double clicking on the Waveform Sequencer under one of the channel will open the Waveform sequencer window



Press the  add advanced waveform button to add a component waveform. Double click on component 1 in the waveform manager to access the component definition window as shown in Figure 3.

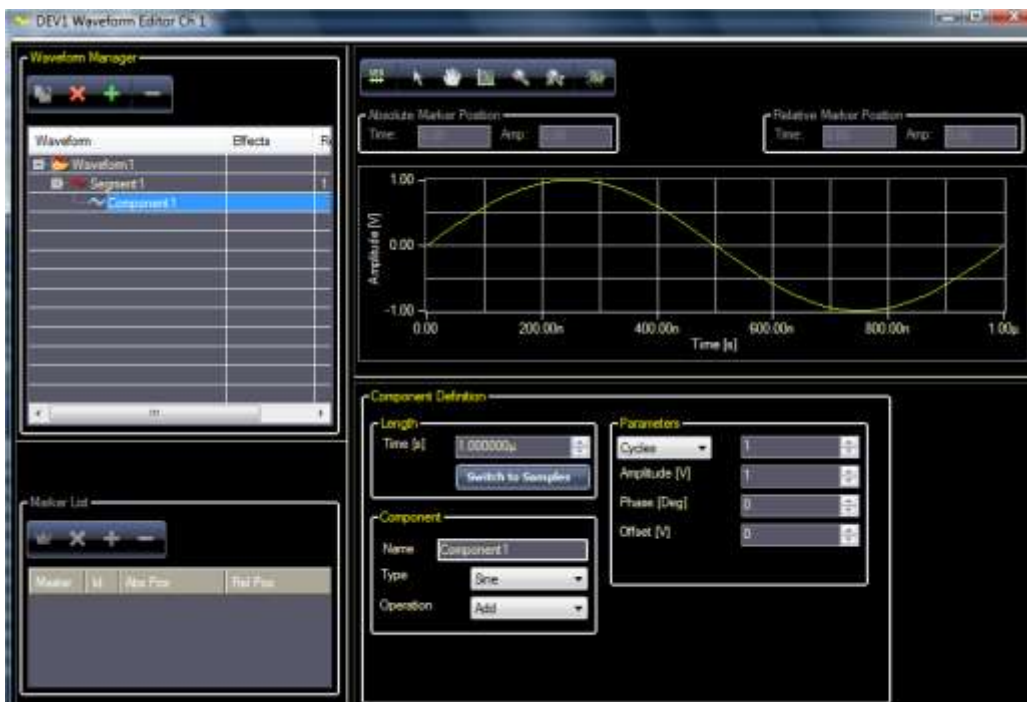


Figure 3: Selecting the component definition

Click on the Type scroll list in the component definition to show waveform sources. Select Formula to access the formula editor in Figure 5.

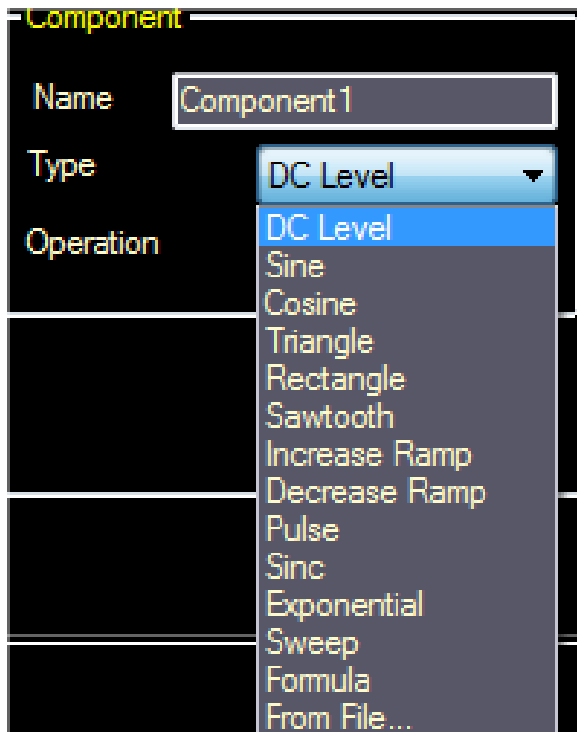


Figure 4: the list of component waveform sources in ArbStudio

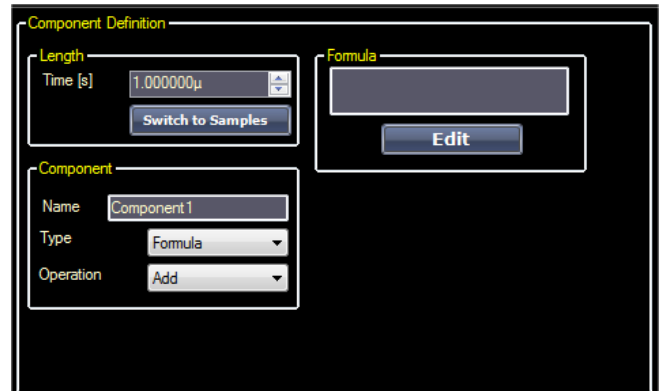


Figure 5: The formula editor

Pressing the Edit key in the Formula box of the Component definition will open the formula editor shown in Figure 6.



Figure 6: The formula editor allows you to build a waveform analytically using equations. Equation can be based on time (t) or samples (x)

Equations can be based on the functions Sine, Cosine, Log base 2, Log Base 10, raise to a power (^), Square Root, Sign, Tan, Natural Log (Ln), Abs, Exp, Integer, ArcSine, Arc Cosine, Arc Tan, Ceiling and Floor along with the basic arithmetic operations addition (+), subtraction (-), multiplication (*), and division (/).

Numeric values can be entered from the keypad along with multipliers (nano, micro, milli, kilo, Mega, and Giga).

The preview key will compile your formula and display the results graphically above the Component definition box, as shown in Figure 7. When you are completed with all the edits pressing Confirm will save the equation and exit the editor.

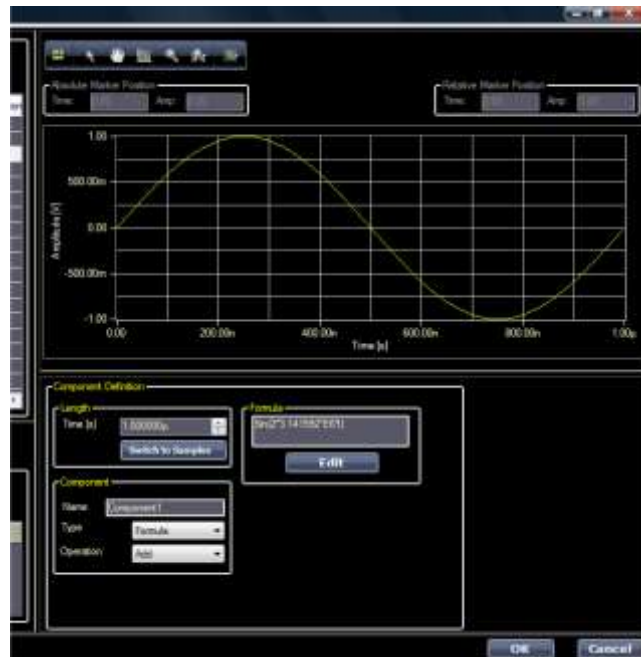


Figure 7: Previewing the results of the formula

Once you have completed work on this component you can move on to additional components or choose to add this component to the sequencer and output the waveform from the ArbStudio.

The balance of this application note will show some typical formula based waveforms.

Exponentially Decaying Sine wave

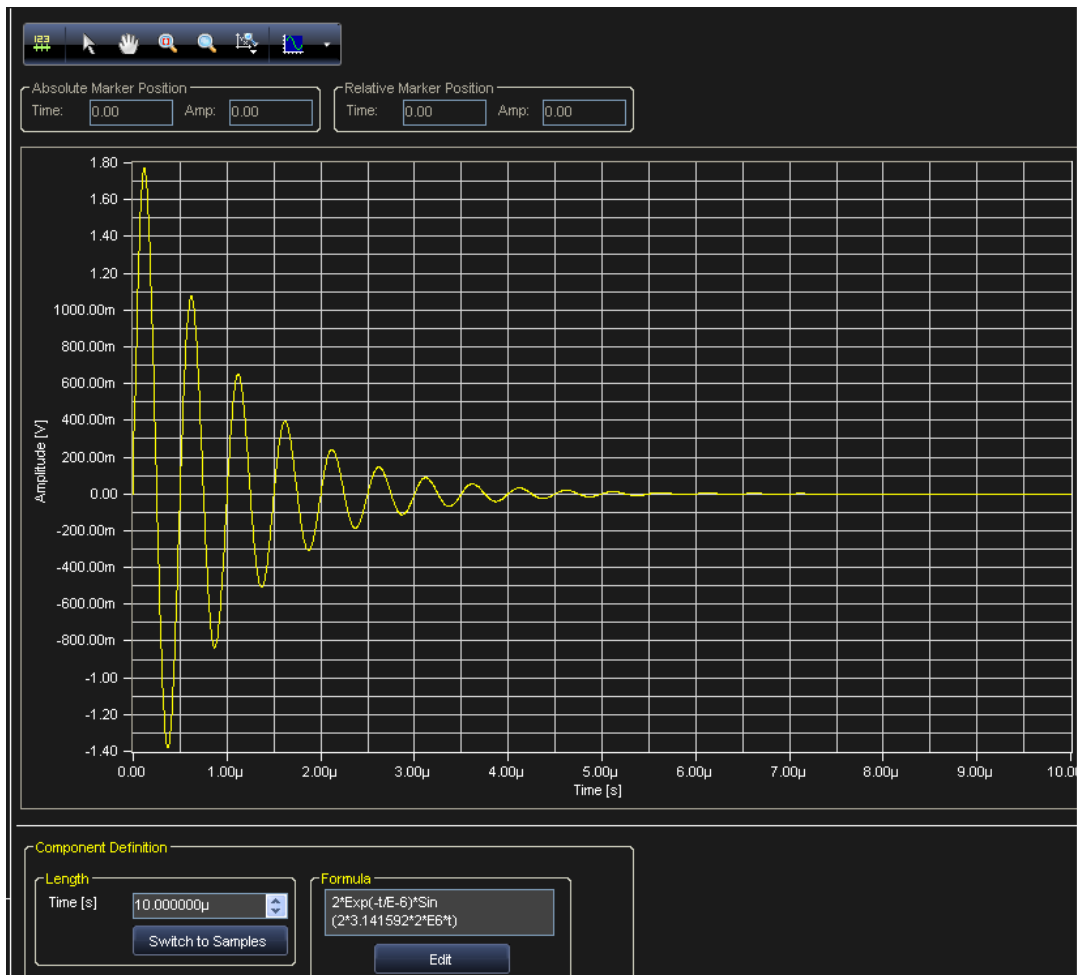


Figure 8: Exponentially Decaying 2 MHz sine wave $2 \cdot \text{Exp}(-t/E-6) \cdot \text{Sin}(2 \cdot 3141592 \cdot 2 \cdot E6 \cdot t)$

General form of the formula:

$$V \cdot \text{Exp}(-t/T_c) \cdot \text{Sin}(2 \cdot \pi \cdot t \cdot F_s)$$

Where F_s – Sine wave frequency in Hertz

T_c – Time Constant in seconds

V – Signal amplitude in Volts peak

Ramp

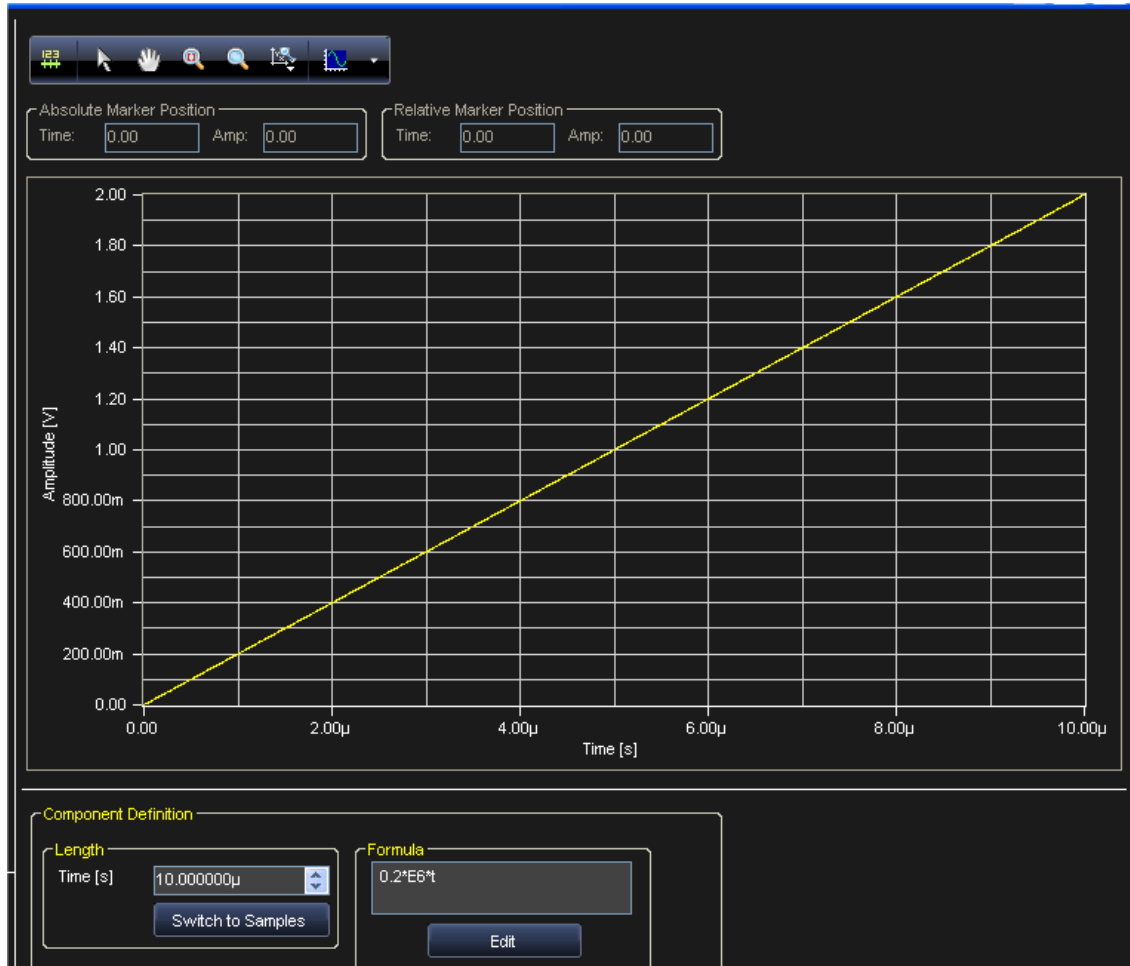


Figure 9: Ramp $0.2 \cdot E6 \cdot t$

General form of the formula:

$A \cdot t$

Where A– Slope of the ramp in Volts/second

Rising Exponential

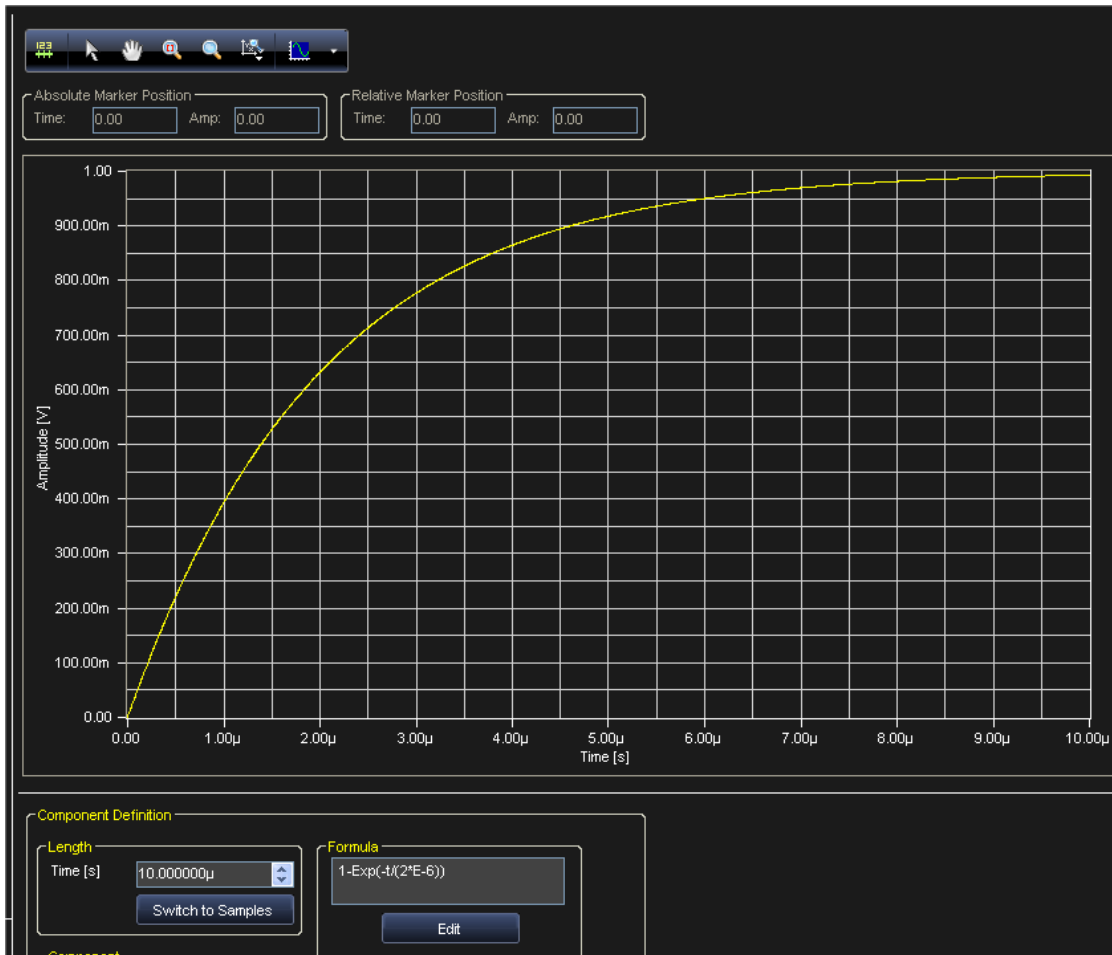


Figure 10: Rising Exponential $1-\text{Exp}(-t/2 \cdot E-6)$

General form of the formula:

$$1-\text{Exp}(-t/T_c)$$

Where: T_c – Time Constant in seconds

Decaying Exponential

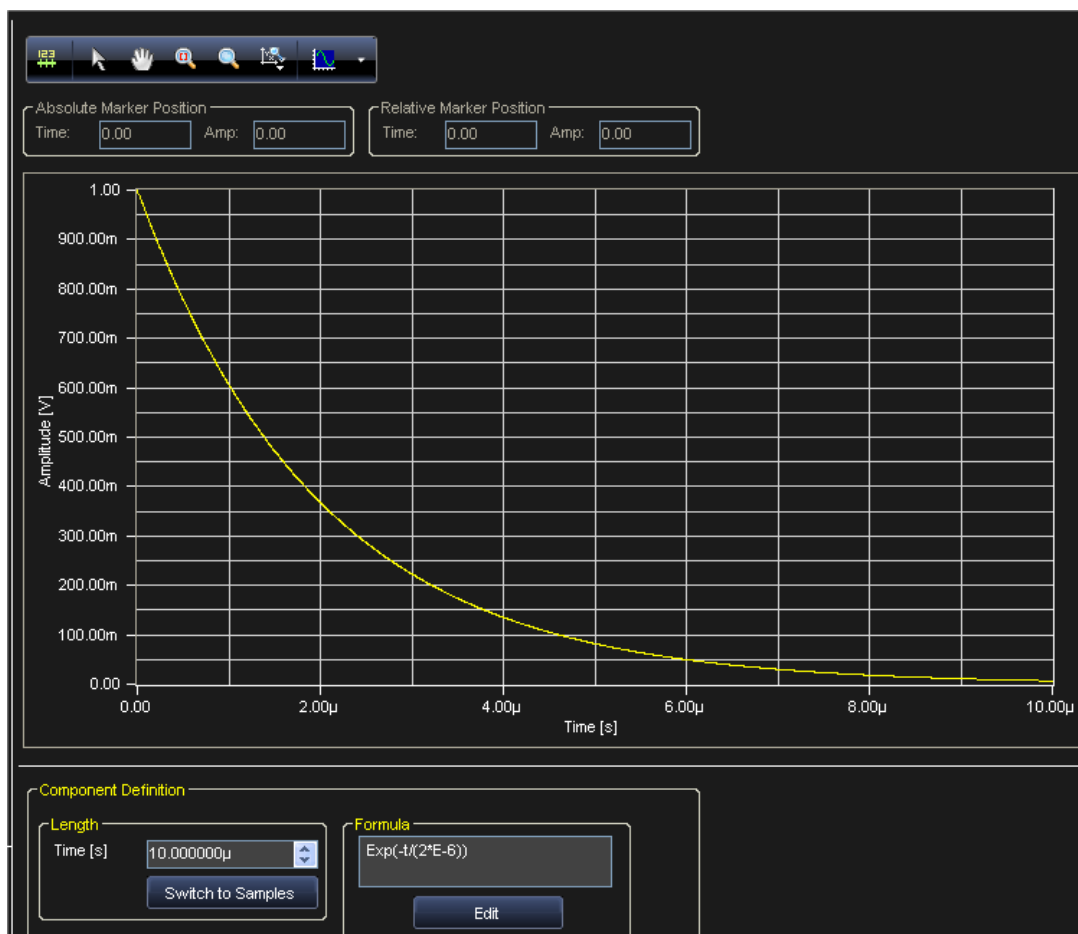


Figure 11: Decaying Exponential

$$\text{Exp}(-t/(2*E-6))$$

General form of the formula:

$$\text{Exp}(-t/T_c)$$

Where: T_c – Time Constant in seconds

Sine



Figure 12: $\text{Sin}(2*3.141592*2E6*t)$

General form of the formula:

$$V*\text{Sin}(2*\text{pi}*t*F_s)$$

Where F_s – Sine wave frequency in Hertz

V – Signal amplitude in Volts peak

Linear Amplitude Sweep of a Sine

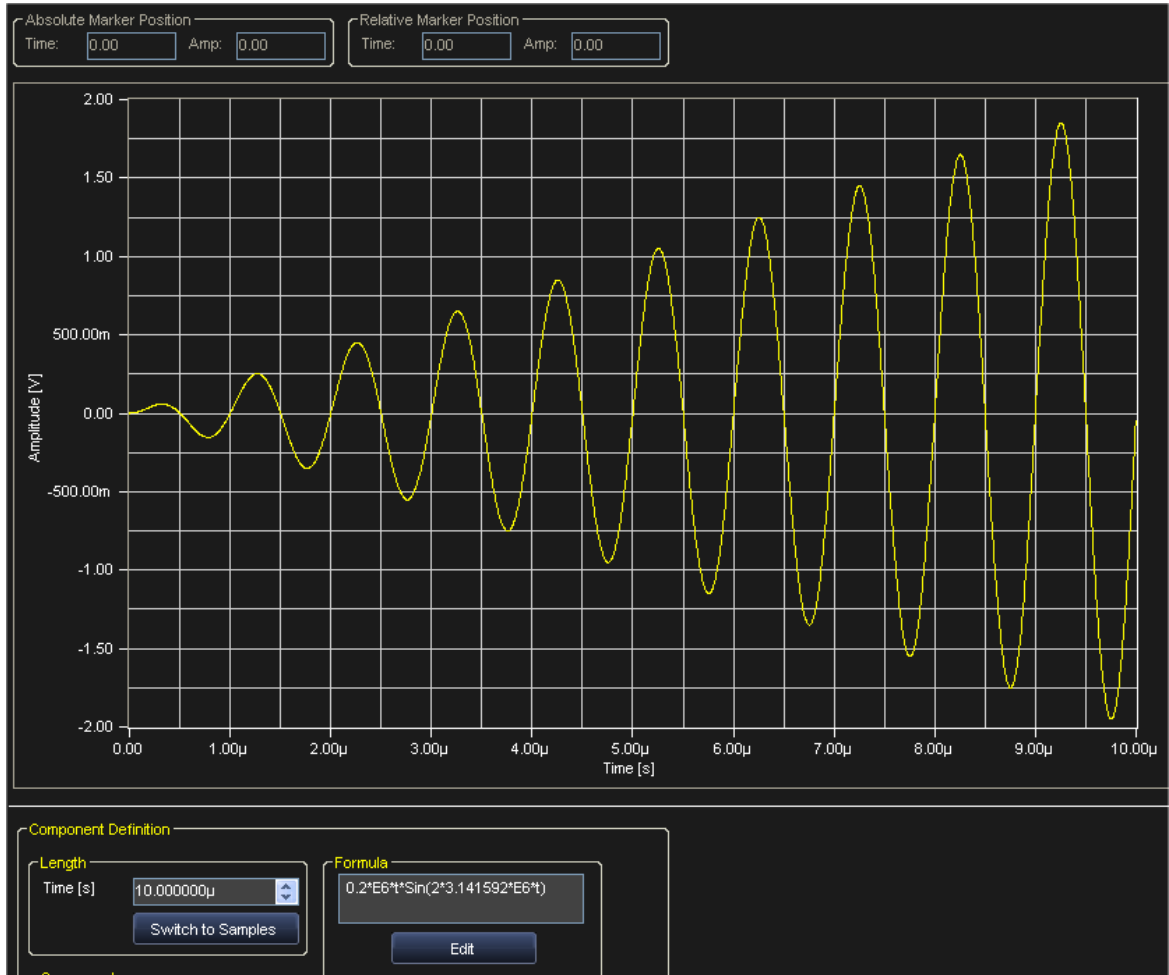


Figure 13: Linear Amplitude Sweep of a 1 MHz Sine $0.2 \cdot E6 \cdot t \cdot \sin(2 \cdot 3.141592 \cdot E6 \cdot t)$

General form of the formula:

$$(A \cdot t) \cdot \sin(2 \cdot \pi \cdot t \cdot F_s)$$

Where F_s – Sine wave frequency in Hertz
 A -slope of the ramp in Volts/second

Frequency Modulation (FM)

Note, the ArbStudio, operating in Direct Digital Synthesis (DDS) mode can create both frequency and phase modulation. This example shows how to create FM by formula.



Figure 14: Frequency Modulation

$$\text{Sin}(2 \cdot 3.141592 \cdot 2 \cdot E6 \cdot t + 2 \cdot \text{Cos}(2 \cdot 3.141592 \cdot 0.4 \cdot E6 \cdot t))$$

General form of the formula

$$\text{Sin}(2 \cdot \pi \cdot t \cdot F_c + (F_D / F_M) \cdot \text{Cos}(2 \cdot \pi \cdot t \cdot F_M))$$

Where : F_c - Carrier frequency in Hertz

F_D – Frequency deviation in Hertz

F_M – Modulation frequency in Hertz

Phase Modulation (PM)

Note, the ArbStudio, operating in Direct Digital Synthesis (DDS) mode can create both frequency and phase modulation. This example shows how to create PM by formula.



Figure 15: Phase Modulation

$$\text{Sin}(2 \times 3.141592 \times 2 \times 2 \times 10^6 t + (3.141592 \times \text{Sin}(2 \times 3.141592 \times 0.4 \times 10^6 t)))$$

General form of the formula

$$\text{Sin}((2 \times \pi \times t \times F_c + K \times \text{Sin}(2 \times \pi \times t \times F_M))$$

Where : F_c - Carrier frequency in Hertz

K - Peak phase excursion in radians

F_M - Modulation frequency in Hertz

Linear Frequency Sweep

Note, the ArbStudio, operating in Direct Digital Synthesis (DDS) mode can create both frequency and phase modulation. This example shows how to create a linear frequency sweep by formula.

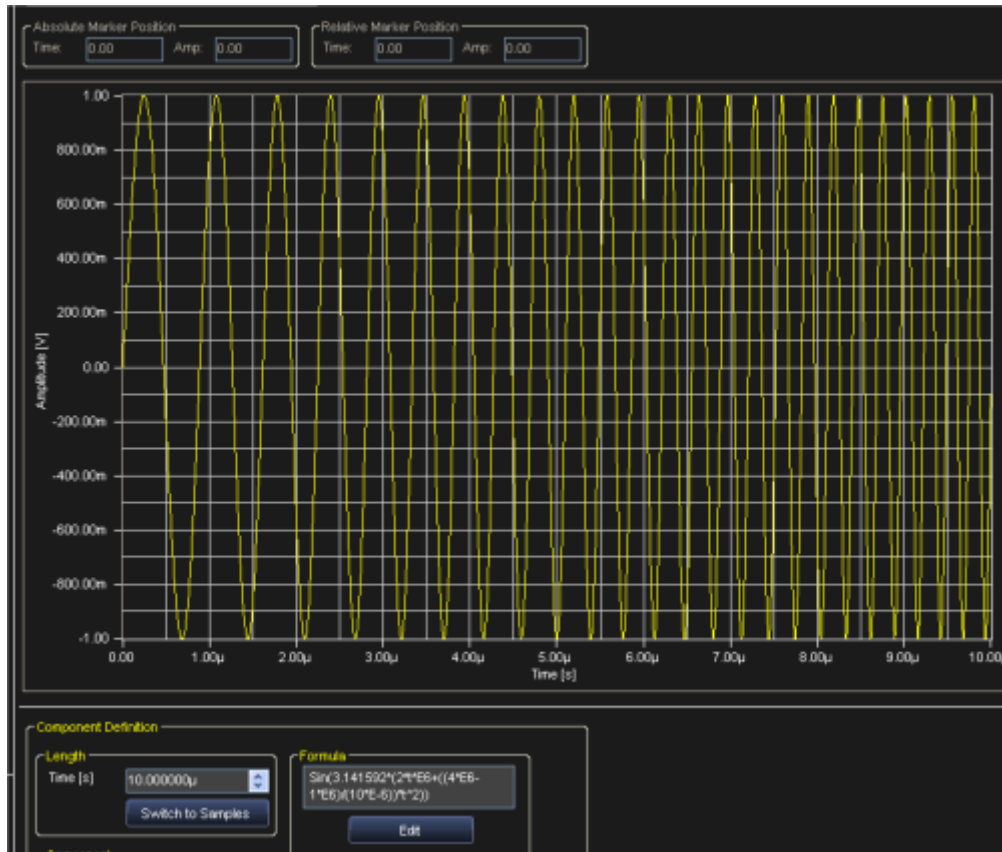


Figure 16: Linear Frequency Sweep $\text{Sin}(3.141592*(2*t*E6+((4*E6-1*E6)/(10*E-6))*t^2))$

General form of the formula

$$\text{Sin}(\pi*(2*t*F_s+((F_E-F_s)/T_s)*T^2))$$

Where : F_s - Start frequency in Hertz
 F_E – End frequency in Hertz
 T_s – Sweep duration in seconds

Gaussian Pulse

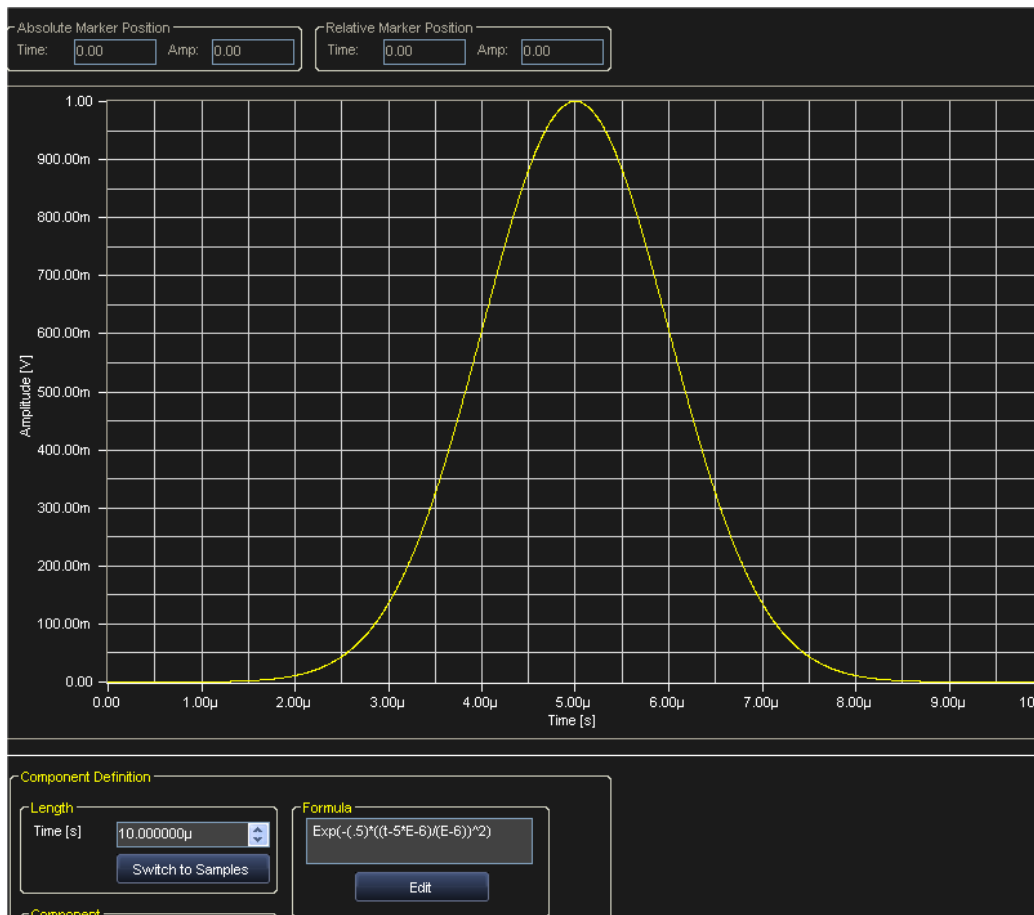


Figure 17: Gaussian Pulse $\text{Exp}(-0.5)*((t-5*E-6)/(E-6))^2$

General form of the formula

$$\text{Exp}(-1/2)*((T-T_M)/T_\sigma)^2$$

Where : T_M - Time location of the mean of the Gaussian pulse

T_σ - Half width point of Gaussian pulse corresponds to the standard deviation σ

Lorentzian Pulse

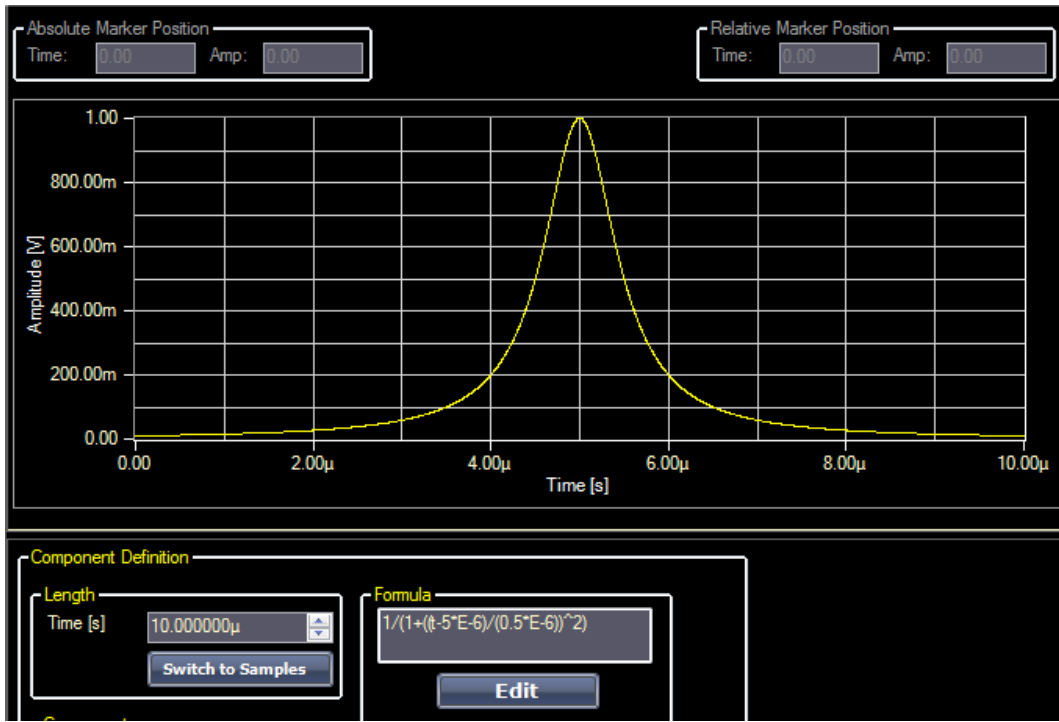


Figure 18: Lorentzian Pulse $1/(1+((t-5*E-6)/(0.5*E-6))^2)$

General form of the formula

$$1/(1+((t-5*T_D)/(T_W))^2)$$

Where : T_D - Time delay in seconds

T_W - Half width point of the Lorentzian pulse @ 50% amplitude

Amplitude Modulated Sine

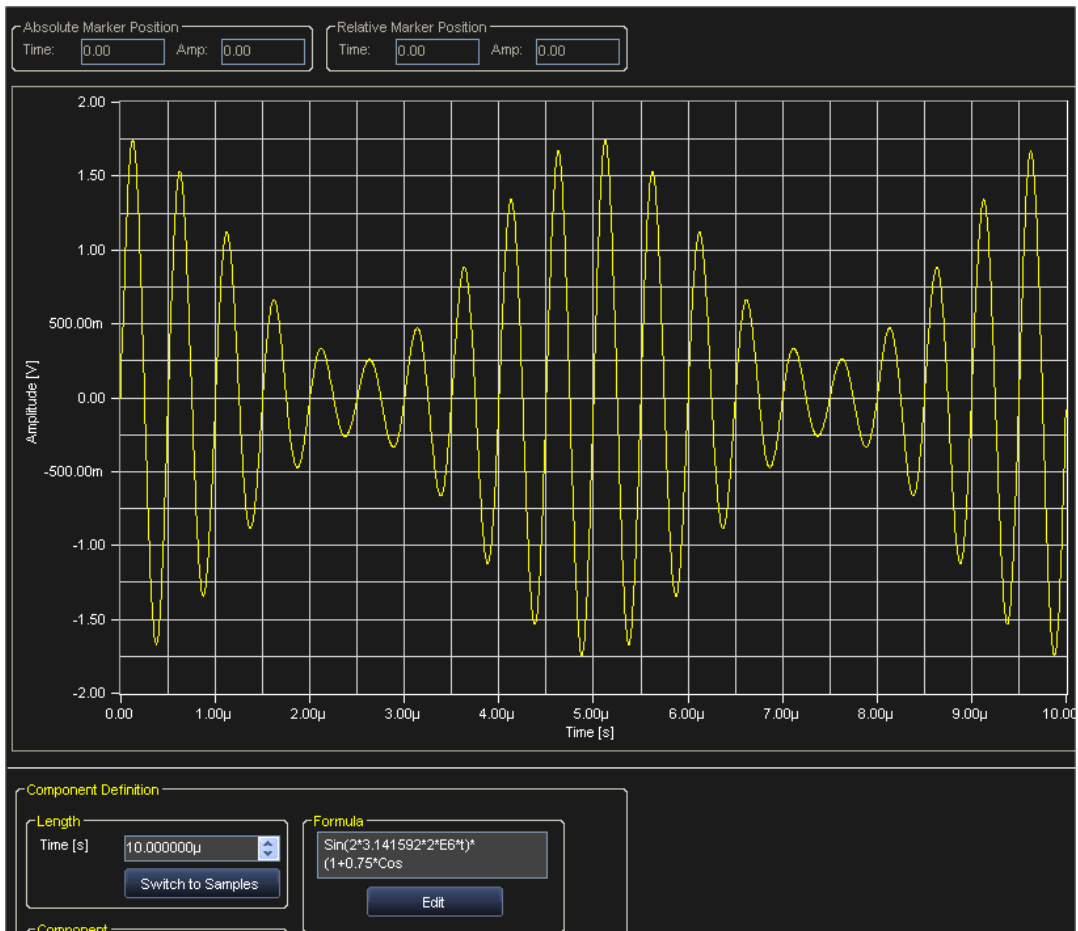


Figure 19: Amplitude Modulated 2 MHz Sine $\text{Sin}(2 \cdot 3.141592 \cdot 2 \cdot E6 \cdot t) \cdot (1 + 0.75 \cdot \text{Cos}(2 \cdot 3.141592 \cdot 0.2 \cdot E6 \cdot t))$

General form of the formula:

$$\text{Sin}(2 \cdot \pi \cdot t \cdot F_s) \cdot (1 + K \cdot \text{Cos}(2 \cdot \pi \cdot t \cdot F_M))$$

Where F_s – Sine wave frequency in Hertz
 F_M – Modulation frequency in Hertz
 K - Modulation index, $0 < K < 1$

Full Wave Rectified Sine

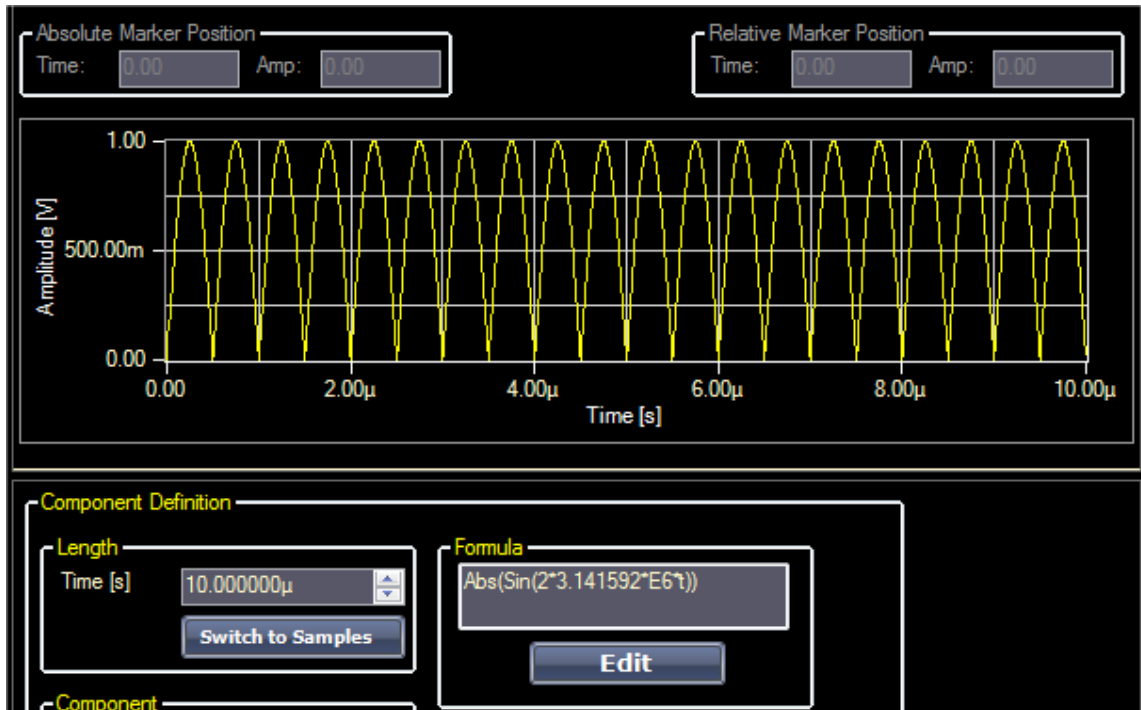


Figure 20: Full Wave Rectified Sine $Abs(Sin(2*3.141592*E6*t))$

General form of the formula:

$$Abs(Sin(2*3.141592*F_s*t))$$

Where F_s – Sine wave frequency in Hertz

Half Wave Rectified Sine

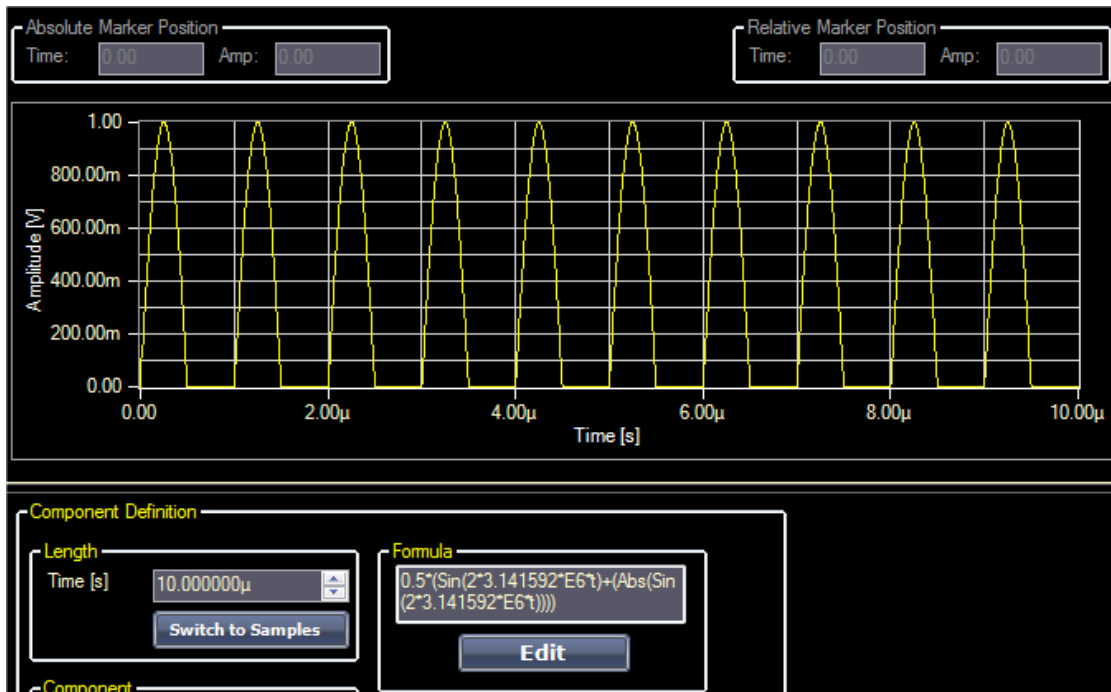


Figure 21: Half Wave Rectified Sine $0.5*(\text{Sin}(2*3.141592*E6*t)+(\text{Abs}(\text{Sin}(2*3.141592*E6*t))))$

General form of the formula:

$$0.5*(\text{Sin}(2*3.141592*F_s*t)+(\text{Abs}(\text{Sin}(2*3.141592*F_s*t))))$$

Where F_s – Sine wave frequency in Hertz