Audio Math

Fundamental Signal RMS Voltage

The RMS voltage is calculated one of two ways. For time domain data it's just the RMS definition

$$V_{RMS} = \frac{\sqrt{\left(\sum_{t=0}^{T} V_t^2\right)}}{n}$$

For frequency data it's a bit different since frequencies values are like densities.

$$V_{RMS} = \frac{\sqrt{\left(\sum_{fmin}^{fmax} V_f^2\right)}}{ENBW(windowing)}$$

ENBW is the equivalent noise bandwidth of the fft windowing method. In some ways it's a measure of how much the signal is smeared into adjacent channels. It can be calculated by

$$ENBW = \frac{\sqrt{\left(\sum_{t=0}^{T} W_t^2\right)}}{\left(\sum_{t=0}^{T} W_t\right)}$$

Where W_t is the fft weight at time *t*. Note this is scale-independent of the weights.

Intermodulation Distortion

CCIF style math for IMD

When close together fundamentals (**f_H/f_L < 2**) use the 2nd order CCIF2 or 3rd order CCIF3. QA40xPlot uses CCIF3.

CCIF2 uses a single value

CCIF2 IMD = $\frac{V_{f_H - f_L}}{V_{f_H} + V_{f_L}}$

CCIF3 uses a different single value

CCIF3 IMD = $\frac{\sqrt{V_{f_H - f_L}^2 + \left(V_{2f_L - f_H} + V_{2f_H - f_L}\right)^2}}{V_{f_H} + V_{f_L}}$

SMPTE/DIN IMD (or MOD IMD)

When the fundamentals are far apart (**f_H/f_L > 7**) use SMPTE/DIN math

SMPTE/DIN IMD = $\frac{\sqrt{\left(V_{fH-fL}+V_{fH+fL}\right)^2+\left(V_{fH-} \quad +V_{fH+2fL}\right)^2}}{V_{fH}}$

RMS Power IMD

Finally, when **2 < f_H/f_L < 7** use IMD RMS power methods using RMS addition

POWER IMD = $\frac{\sqrt{V_{fH-f}^2 \quad +V_{fH+fL}^2+V_{fL-2f}^2 \quad +V_{fL+2f}^2 \quad +V_{fH-2f}^2 \quad +V_{fH+2f}^2}}{\sqrt{V_{fH}^2+V_{fL}^2}}$