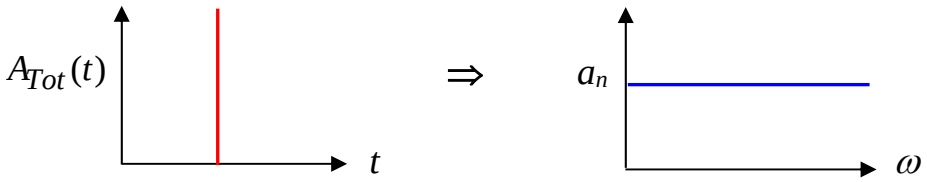
Example: A noise "spike" (of infinitely short duration) consists of a linear combination of ALL frequencies – with ***equal*** amplitudes!!

A noise ***spike*** in time has a ***flat*** frequency spectrum!



Human Perception of Tone Quality - "Subjective Tones"

The human ear/brain ***are*** systems with non-linear responses. For example, when two ***loud pure*** tones (frequency f_1 & f_2) are simultaneously sounded together, a third difference tone $|f_2 - f_1|$ can be heard!! (Actually two additional tones $(f_1$ & $f_2)$ and $|f_2 - f_1|$ can be heard). This can ***only*** happen if there exist non-linear response(s) in the human ear/brain!

Example: If one sounds two loud pure-tone notes together, one sound with frequency $f_1 = 300\ Hz$, the other with frequency $f_2 = 400\ Hz$ the human ear also hears $(f_1$ & $f_2)$ and $|f_2 - f_1|$ sum and difference tones:

Summation tone: $f_1 + f_2 = 300\ Hz + 400\ Hz = 700\ Hz \leftarrow$ *n.b.* harder to hear
Difference tone: $|f_1 - f_2| = |f_2 - f_1| = |300 - 400| = 100\ Hz$

These sum and difference frequencies arise solely due to non-linear response(s) of the human ear/brain. Linear sum and difference frequencies $(f_1$ & $f_2)$ and $|f_2 - f_1|$ arise primarily from quadratic non-linear response terms. Cubic, quartic, quintic, *etc*. (non-linear response) terms give high order frequency effects! *e.g.* $2f_1 - f_2, 3f_1 - 2f_2, 2f_1 + f_2, \ldots\ \}$. When many frequencies/harmonics are present, the non-linear response of the human ear/brain produces inter-modulation distortion (many such sum and difference frequencies) – giving rise to perception of a complicated set of combination tones. Please see/read UIUC Physics 406 Lecture Notes on Theory of Distortion I & II for more details…