EX: An Amplitude Modulated (AM) signal, x_{AM}, is created by multiplying a signal, $x(t)$, by a pure sinusoidal carrier sinusoid of higher frequency, f_0, than the signal.

$$x_{\mathrm{AM}}(t) = x(t)\cos(2\pi f_0 t)$$

This creates copies of the signal's spectrum shifted to + and − the carrier frequency. The first three lines of Fig. 1 show the Rosetta Stone method applied to a bandwidth-limited signal turned into an AM signal of a higher frequency. To avoid aliasing, f_0 must be at least twice the highest frequency in the signal, $x(t)$. Here, $f_0 = 2$ avoids aliasing.

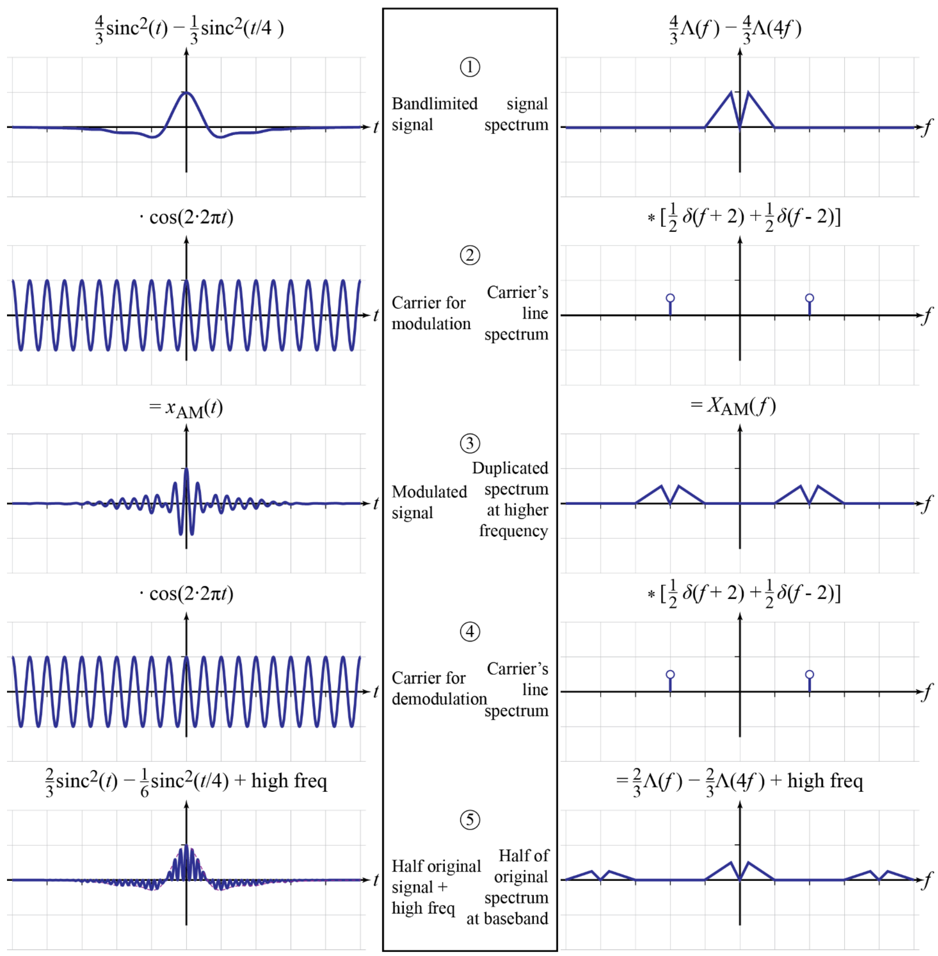

Fig. 1. Rosetta Stone view of AM modulation.

We may demodulate an AM signal by multiplying again by a sinusoid at the carrier frequency, f_0, shown in line 4, and then low-pass filtering to extract the baseband spectrum (not shown). Because the original signal is multiplied by the carrier sinusoid twice, the result (before low-pass filtering) may be written in terms of the identity for cosine squared.

$$x_{\mathrm{H}} = x(t)\cos^2(2\pi f_0 t) = x(t)\left[\tfrac{1}{2} + \tfrac{1}{2}\cos(2\cdot 2\pi f_0 t)\right]$$

The 'H' subscript is for "Heterodyne". We observe that the heterodyned signal is a copy of the original signal, $x(t)$, at half amplitude, plus a copy of the original signal AM modulated to *twice* the carrier frequency. If we low-pass filter the heterodyned signal, we remove the higher-frequency signal and recover the original signal. Before low-pass filtering, the envelope of the heterodyned signal has the same amplitude as the original signal. When low-pass filtered, however, the amplitude will be half. The peaks and valleys of the heterodyned signal average out to half the original height.