Examples of Modulated Signals

1. DSB-AM-SC:

\[ s(t) = m(t)\cos(\omega_c t) \]

Note that the carrier, which takes on values between \( \pm 1 \), is multiplied by \( m(t) \), so \( s(t) \) lies within the envelope formed by \( \pm m(t) \).

2. DSB-AM-LC:

\[ s(t) = [1 + k_a m(t)]\cos(\omega_c t) \]

Note that the carrier, which takes on values between \( \pm 1 \), is multiplied by \( [1 + k_a m(t)] \), so \( s(t) \) lies within the envelope formed by \( \pm [1 + k_a m(t)] \).

3. PM:

\[ s(t) = \cos(\omega_c t + k_p m(t)) \]

Note that the phase of \( s(t) \) is \( \omega_c t + k_p m(t) \). If \( m(t) \) has discontinuities, so does the phase.

4. FM:

\[ s(t) = \cos\left(\omega_c t + k_f \int_{-\infty}^{t} m(t') dt'\right) \]

Note that the phase of \( s(t) \) is \( \omega_c t + k_f \int_{-\infty}^{t} m(t') dt' \). Even if \( m(t) \) has finite discontinuities, the phase is continuous. The “instantaneous frequency” is \( \omega(t) = \frac{d}{dt}\left(\omega_c t + k_f \int_{-\infty}^{t} m(t') dt'\right) = \omega_c + k_f m(t) \).

In the following examples: \( \omega_c = 4\pi \text{ rad/s} \), \( k_a = 0.4 \), \( k_p = 3\pi/4 \text{ rad} \), \( k_f = 3\pi \text{ rad/s} \).
Message

Carrier, $\omega_c = 12.5664$

DSB–AM–SC

DSB–AM–LC, $k_a = 0.4$

PM, $k_p = 2.3562$

FM, $k_f = 9.4248$
Message

$\sin(t) = m(t) \cos(\omega_c t)$

Carrier, $\omega_c = 12.5664$

$\cos(\omega_c t)$

DSB–AM–SC

$s(t) = m(t) \cos(\omega_c t)$

DSB–AM–LC, $k_a = 0.4$

$s(t) = [1 + k_a m(t)] \cos(\omega_c t)$

PM, $k_p = 2.3562$

$s(t) = \cos(\omega_c t + k_p m(t))$

FM, $k_f = 9.4248$

$s(t) = \cos(\omega_c t + k_f \int_{-\infty}^{t} m(t') dt')$
Message

Carrier, $\omega_c = 12.5664$

DSB–AM–SC

DSB–AM–LC, $k_a = 0.4$

PM, $k_p = 2.3562$

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