1 SSB Transmitter

An analytic signal is defined as $s_+(t) = s(t) + j\hat{s}(t)$, where $\hat{s}(t) = s(t) \otimes (1/\pi t)$ is the Hilbert transform of $s(t)$. The Hilbert transform is a special kind of non-causal filter with impulse response $1/\pi t$ that shifts each sinusoidal component of $s(t)$ by 90 degrees.

A single sideband signal $s(t) = m(t)\cos 2\pi f_c t - \hat{m}(t) sin 2\pi f_c t$ can be written as

$$s(t) = \mathrm{Re}\{a(t)e^{j\phi}e^{j2\pi f_c t}\} = \mathrm{Re}\{[m(t) + j\hat{m}(t)]e^{j2\pi f_c t}\}$$

Thus the complex envelope $a(t)e^{j\phi} = m(t) + j\hat{m}(t)$ is an analytic signal created from the (real) message $m(t)$. To create an SSB signal at f_c using these equations, we can:

1. Take the Hilbert transform $\hat{m}(t) = m(t) \otimes (1/\pi t)$ of the message.
2. Create the analytic signal $\tilde{m}(t) = m(t) + j\hat{m}(t)$.
3. Upconvert it to the desired carrier frequency by multiplying by $e^{j2\pi f_c t}$
4. Take the real part.

The upconversion to a radio frequency (RF) wave at f_c (steps 3 and 4) is the function of the *USRP Sink* block. Thus an SSB signal is generated by a USRP sink block (standard IQ transmitter) with inputs $i(t) = m(t)$ and $q(t) = \hat{m}(t)$

2 SSB Receiver

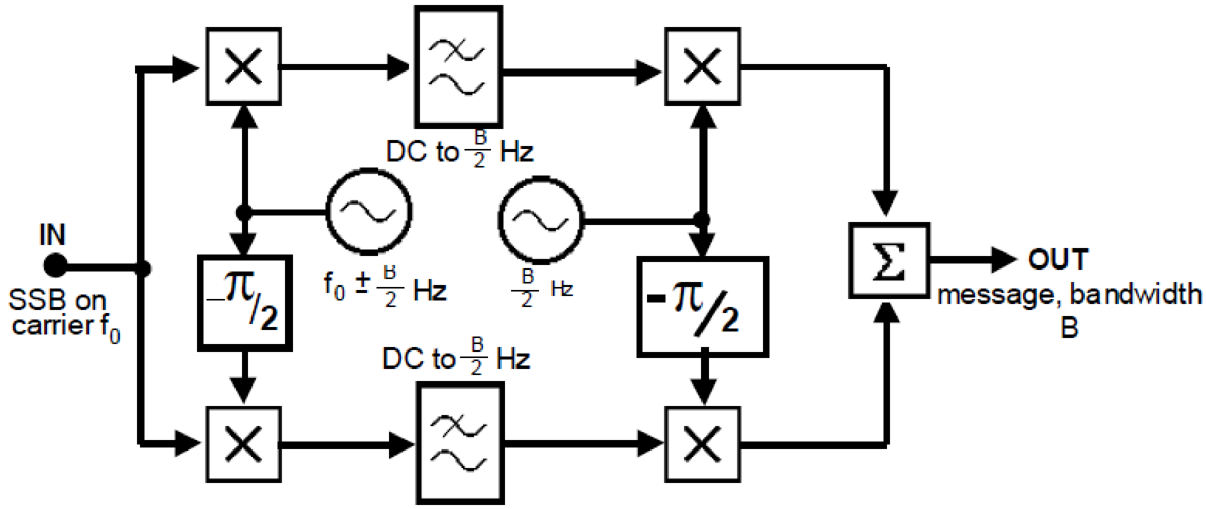
We consider two SSB receiver architectures.

1. multiply the real SSB signal by $\cos 2\pi f_c t$ and low pass filter to get $m(t)$ This is done in analog receivers.

2. Weaver demodulator: downconvert the real SSB signal $s(t) = m(t)\cos 2\pi f_c t - \hat{m}(t) sin 2\pi f_c t$ to $i(t) + jq(t)$ using the USRP source block, but with a frequency offset f_1 relative to f_c [thus in this case $i(t) \neq m(t)$ and $q(t) \neq \hat{m}(t)$]. Then implement $i(t)\cos 2\pi f_1 t + q(t)\sin 2\pi f_1 t$ where $f_1 = B/2$ is a frequency in the approximate middle of the message bandwidth, e.g. 1500 Hz for a 300-3000 Hz voice signal.

$$\begin{array}{ccccccc} m(t) \rightarrow & \otimes & \rightarrow LPF(f_1) \rightarrow & \otimes & \rightarrow \\ & \uparrow & & \uparrow & \\ & e^{-j2\pi(f_0 \pm f_1)t} & & e^{j2\pi f_1 t} & \end{array}$$

In real notation



USRP downmixer GNURadio mixer