RTCA Special Committee 186, Working Group 5

ADS-B UAT MOPS

Meeting #6

UAT Transmit Spectrum

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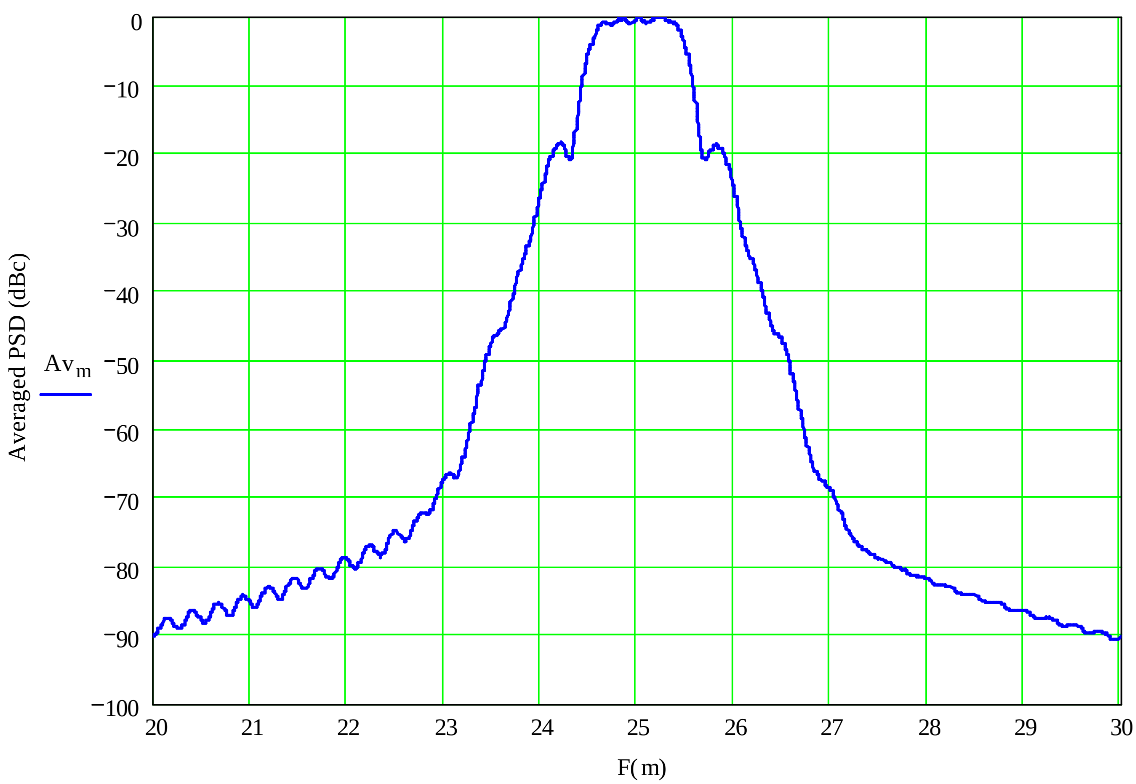
SUMMARY

UAT Transmit Spectrum Using Baseband Shaping vs IF Filtering

This short note adds to the on-going discussion of choosing a receive filter to minimize off-channel interference (from DME, MIDS), the potential for "degradation" in demodulating the received signal, and how all this relates to the spectral containment of the transmitted waveform to satisfy (FCC) "out-of-band" requirements and minimize interference to off-channel systems (e.g., DME). We focus on the originally conceived waveform design, as summarized by Warren Wilson in UAT-WP-5-11, wherein the transmitted baseband waveform is generated by passing the bit sequence through a Nyquist filter prior to the FM modulation process (referred to herein as CPM, Continuous Phase Modulation). By contrast, it is understood that the current transceiver design implements CPFSK ($\kappa = 0.6$) and includes an IF filter that is apparently utilized in both transmit and receive paths.

Figure 1.

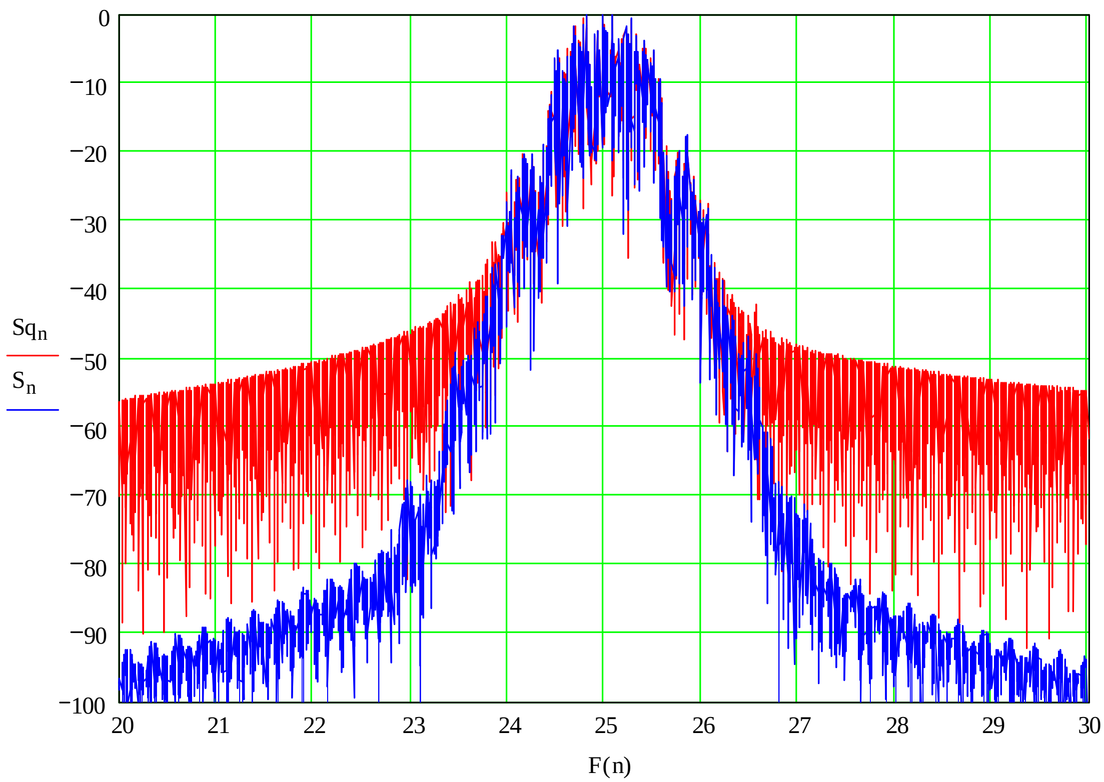


Frequency, in MHz

(100 KHz RBW)

Figure 1 shows the averaged power spectrum of the CPM waveform which was derived by passing a pseudo-randomly generated 250 bit sequence (plus 4 "idle" bits on either side of the burst) through the truncated raised cosine Nyquist filter ($\alpha = 0.5$) which then modulates the IF waveform using a modulation index of $\kappa = 0.6$; the resulting time domain burst is then shaped using a trapezoidal ramp over the 4 idle bits on both edges and FFT'ed (3.05 KHz/sample resolution). This PSD is summed over a sliding window of 33 samples to emulate something close to a 100 KHz resolution bandwidth with the final plot obtained by averaging the spectra of 10 such randomly generated sequences. For completeness, the corresponding PSD of a single 250 bit burst is shown in Figure 2 as the "blue" plot, where the only difference between the two plots is that the "red" (poor roll-off) plot has no edge shaping of the RF burst.

Figure 2.



Frequency, in MHz

These results indicate that no further filtering of the transmitted shaped CPM waveform should be needed. That is, not only is 99% of the total transmitted power contained within a 1.23 MHz bandwidth, all the "information" to preserve the attractive ISI properties of the Nyquist filter is contained within this bandwidth. Therefore, if a (1.2 MHz) filter is inserted in the transmit and/or receive path (for additional spectral containment), it should introduce negligible distortion of the "Eye Pattern."

Conversely, if a 1.2 MHz filter is used on the CPFSK realization of the waveform to achieve a comparable spectral roll-off, a significant distortion of the waveform is likely to result. [Evidence to support this view exists in the rather poor "Eye Pattern" results obtained using the 1.2 MHz receive filter and an even worse result when a 0.8 MHz filter is used; a similar inference can be drawn from the Spectrum Analyzer (SA) plots presented by UPSAT during UAT MOPS Meeting #6 -- *note that the above plots have been scaled to overlay the UPSAT plots fairly well*.] Moreover, separate analyses on CPFSK modulated waveforms indicate that edge shaping of the burst has noticeably less effect on the spectral roll-off than the rather dramatic effect seen in Figure 2 and thus, transmit filtering would still be required. In a related issue, it is believed that any "burst artifacts" that were expunged from the UPSAT SA plots will not disappear if the message burst is conditioned by RF edge shaping prior to transmission -- however, without seeing a non-retouched plot, their possible origins cannot be opined.