6.3 Simulation of a TDAF-based AVM system

In a CDMA system, the most common forms of interference includes background noise, multipath, and multiple access interference. However, for CDMA systems using the ISM band, interference may be due to other CDMA systems or from dissimilar modulation formats, such as FM. Also there may exist adjacent channel interference from other AVM systems or other FCC part 15 devices.

TDAF processing of DS-SS signals allows correlated spectral energy to be utilized, even when that correlated spectral energy is corrupted by dissimilar interference. The energy from undesired signals is discriminated because it is not spectral correlated with the desired DS-SS signal.

The simulations are presented for partially overlaying AVM systems, in which one system locates its main lobe over the sidelobe of a second system's spectrum. System parameters used in the simulation are listed in Table 6.2.

Table 6.2 System parameters for simulation

Modulation types:	BPSK and QPSK
Maximum Data Rate:	31.25 kbits/sec (BPSK), 62.5 kbits/sec (QPSK)
Chip Rate:	2 MHz
Sample Rate:	4 MHz
Processing Gain:	64 (18 dB)
Samples per chip	2
Code Repeat Rate:	2 MHz
Signature Sequence Length	64
Samples per data symbol	128
Training sequence length	300
Training time	9.6 ms
FFT size	128

The processing gain is chosen to be S=64, i.e., there are 64 chips per message baud. In order to maximize the performance of the conventional DS/SS demodulator, the 64 chip sequences employed in the simulations have characteristics similar to 63 chip Gold codes. The maximum measured cross-correlation between any two codes is 22, the

maximum autocorrelation sidelobe of any single code is 16. Thus, while the length 64 codes are not Gold codes in the strict sense, they have characteristics which are similar to length 63 Gold codes generated from preferred and non-preferred pairs of generating polynomials. The maximum data rate for BPSK is 31.25 kbits/sec or 62.5 kbits/sec for QPSK.

6.3.1 Adjacent channel interference scenarios

Given proper spectral shaping and equal power signals, the peak of the sidelobe leaking into channel is at least -25 dB down from the peak of the mainlobe in the primary channel, centered at 0 Hz. The power spectrum of both the primary and adjacent channels is shown in Figure 6.1.

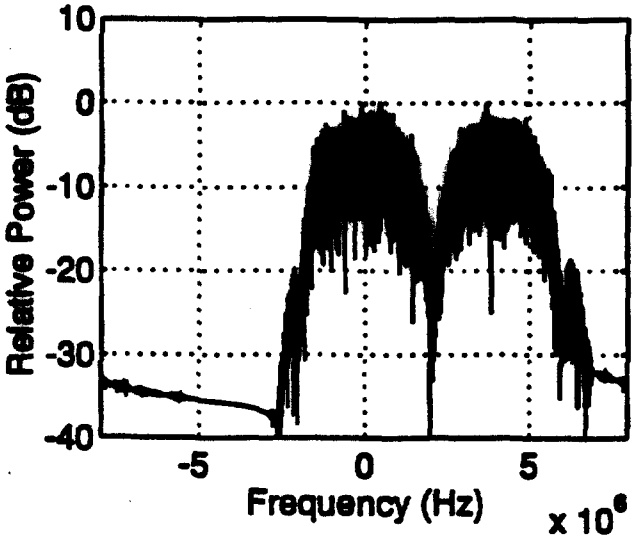

Figure 6.1
Power spectrum of primary and adjacent channel

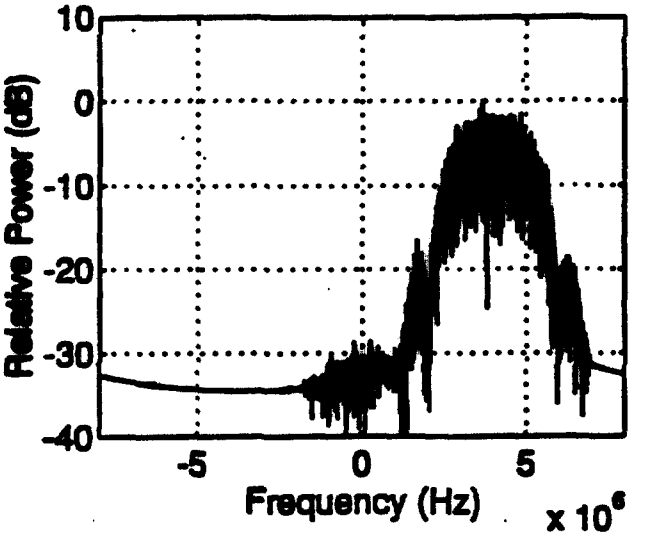

Figure 6.2
Strong adjacent channel interference scenario

RF propagation loss varies greatly from one user to another. Therefore the relative power between the primary and adjacent channel can be large. Universal power controls on all users for different systems are not practical. Thus, as calculated earlier, the maximum near-far power difference could be as high as 50 dB. Therefore, 50 dB dynamic range of adjacent channel interference should be taken in count. The power spectrum plot of primary channel and adjacent channel for the worst scenario is shown in Figure 6.2. In Figure 6.2, there is only one user in the current channel. It is assumed that there are 40 users in the adjacent channel, and the power of these users is 50 dB stronger than the user in the primary channel.

Figure 6.3 shows an enlargement of the power spectrum of the primary channel. It is assumed that the spreading codes used in the adjacent channel are total independent, instead of coordinated. Because of the extremely high power of the adjacent system, the primary channel signals are masked by the interference signals as seen in Figure 6.3. The Signal-to-interference ratio (SIR) is -19.9 dB for this case..

The 18 dB processing gain of the DS/SS signal is clearly insufficient to combat such high levels of interference. However, TDAF processing can effectively reject adjacent channel interference. Figure 6.4 is the power spectrum of output signal after TDAF processing. It can be seen that TDAF processing the can remove nearly all the narrowband interference from the spectrum.

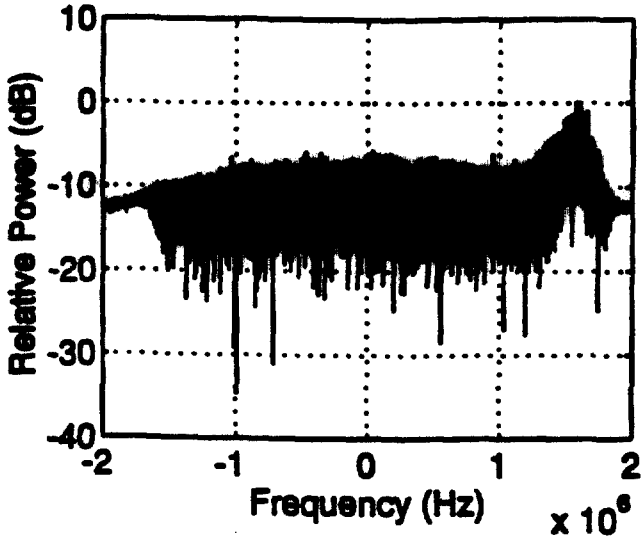

Figure 6.3
Power spectrum of signal corrupted by adjacent channel interference

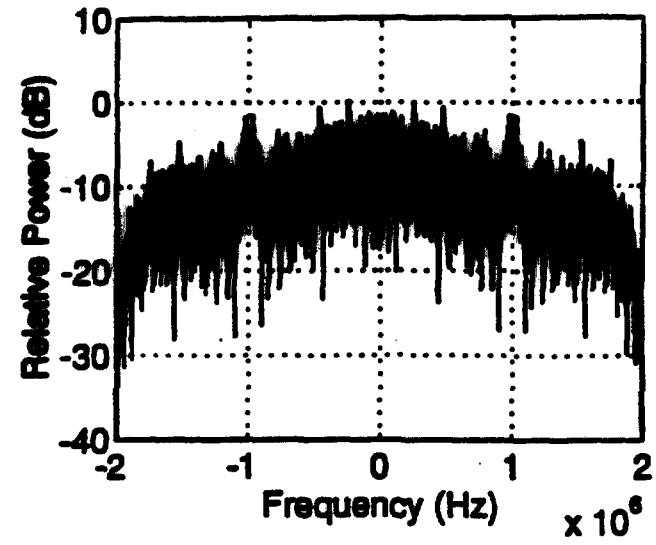

Figure 6.4
Power spectrum of output signal after TDAF processing

For comparison, both the conventional matched filtered signal and TDAF processed signal are presented. Figure 6.5 shows the constellation diagram after conventional matched filter processing. Figure 6.6 shows the constellation diagram for output signal after TDAF processing. The SNR for matched filter processing is 6.79 dB. For TDAF processed signal, the SNR is 34.42 dB. Simulation results show that using TDAF processing can effectively increase the narrowband interference tolerance of CDMA overlay systems.

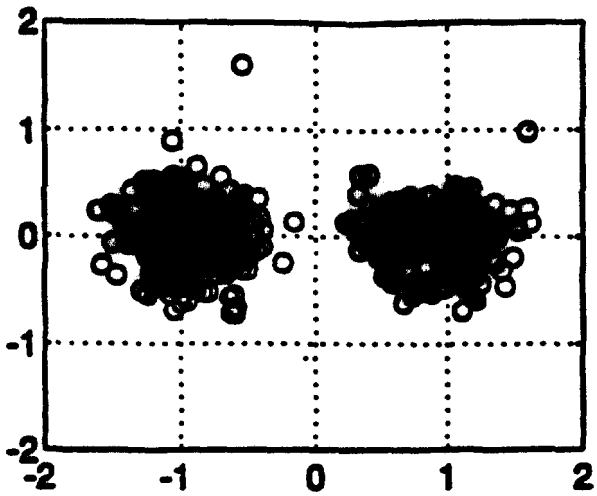

Figure 6.5
Constellation diagram for output signal
after conventional matched filter processing

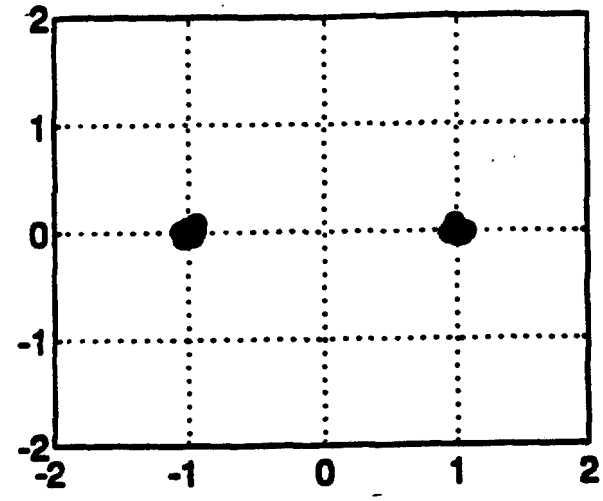

Figure 6.6
Constellation diagram for output signal
after TDAF processing

6.3.2 Interference from dissimilar modulation

TDAF processing of DS/SS signals allows correlated spectral energy to be utilized, even when the correlated spectral energy is corrupted by dissimilar interference, such as FM. In the ISM band, the DS/SS signal will have not only undergo multiple access interference but also narrowband interference from low-power Part 15 devices.

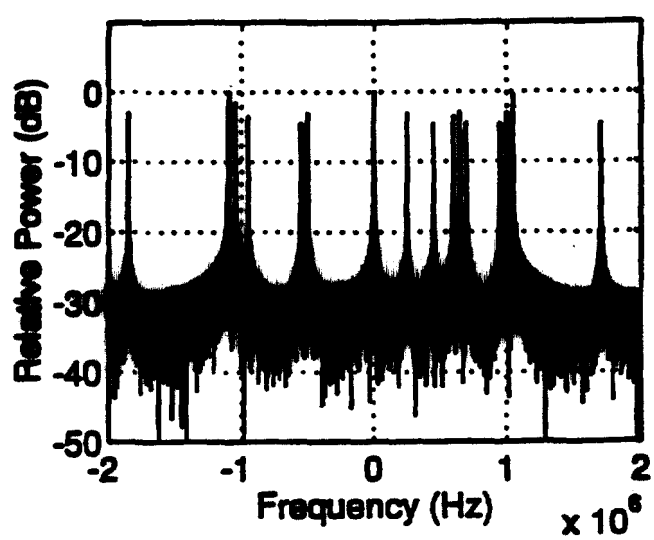

Figure 6.7 Power spectrum of signal corrupted by FM types interference

Although the FCC requires these narrowband signals to have low power, the RF propagation loss for CDMA may allow these narrowband signals to jam the CDMA signals. For example in Figure 6.7, the DS/SS signal with the previously defined parameters is corrupted by 20 narrowband FM signals. The bandwidth of these FM signals is 5 kHz, and the carrier-to-noise-ratio (CNR) is 30 dB for each of the twenty users. The total SIR for the DS/SS signal before despreading is -43.6 dB and the Signal-to-noise ratio (SNR) is 0 dB.

The results shown in the constellation diagram of Figure 6.8 were processed using conventional matched filter processing. The constellation diagram shows the signal is completely corrupted. However, if TDAF processing is employed to do interference rejection, the FM interference has little impact on the CDMA system performance. Figure 6.9 shows the constellation diagram for output after the TDAF processing. The SNR at output is 25.14 dB.

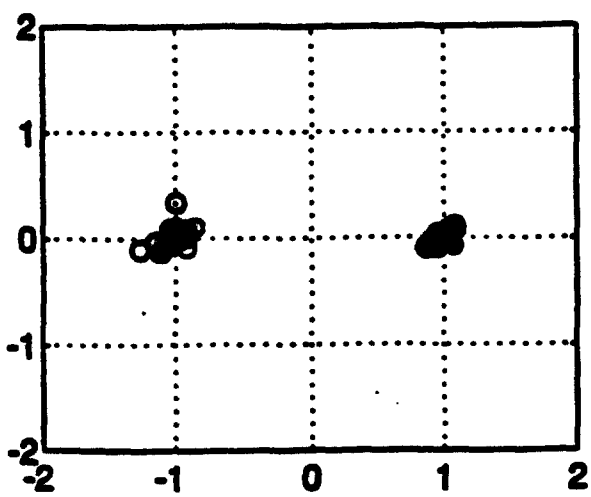

Figure 6.8
Constellation diagram for output signal after conventional matched filter processing

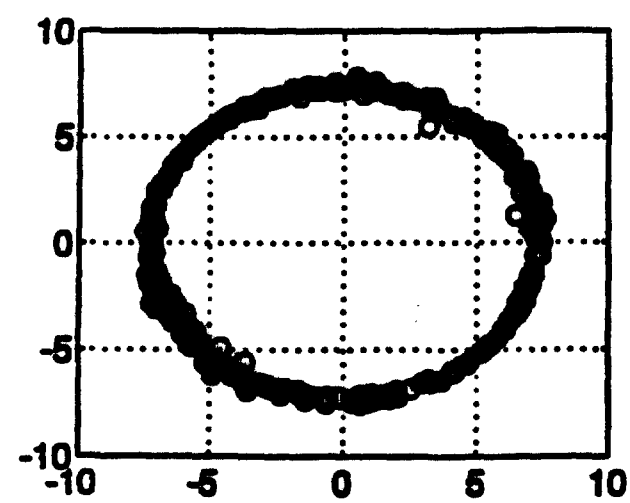

Figure 6.9
Constellation diagram for output signal after TDAF processing

6.4 Summary

A large number of interference rejection techniques are now becoming available for use in mitigating interference between systems. One particularly practical and promising technique is the use of Time Dependent Adaptive Filtering. TDAF processing of DS/SS signals represents a source of potential gain for many CDMA systems. First, time dependent filtering is able to mitigate many different forms of interference common to the mobile channel. Second, time-dependent filtering requires no knowledge of the other users in the system in order to produce marked increases in user capacity. The simulations

presented here have shown that TDAF processing exhibits significant improvement over conventional matched filter processing in interference environments which are dominated by dissimilar modulation formats. It is also very effective in adjacent channel interference rejection. These features make the TDAF highly attractive for AVM systems in the ISM band.

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