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HIGH POWER MICROWAVE GENERATION WITH PULSE COMPRESSION

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"Chirp" was first used by Bernard Oliver in an internal Bell Lab memo, "Not with a Bang, but with a Chirp," in 1951. It describes how radar detection ranges are increased without loss of resolution or increase of peak power. Transmitted radar pulses, with long periods T and low peak power Chirp have Frequency Modulated (FM) carriers that sweep frequencies across bandwidth B during each period. The pulses are backscattered from buried ancient towns, buried water pipes, or other structures to radar receivers and compressed with matched filters into [sin X] / X with high peak powers (Bang). Pulse compression ratios are ratios of period T to collapsed pulse width (1/B), or BT. Typical BT ratios vary from values of 10 to 100,000. The product BT is the increase in peak power due to pulse compression. With BT equal to 20, 100 watts before compression increases to 2 kilowatts after compression. Chirped pulse compression is achieved in transmit modes with wideband antennas, such as log periodic dipole arrays (LPDA), where the matched filters are the antennas.

Computer generated curves of amplitude and phase spectra are presented for variable Chirp signal pulse width, reduced periods after compression, and frequency intervals during a period of the original pulse. Pulse compression ratios BT from 20 to 120, in increments of 20, are seen with one microsecond pulse periods T, and frequency bandwidths B of 20 to 120 megahertz in 20 megahertz increments. The compressed pulse period decreases from 50 nanoseconds (BT = 20) to 8 nanoseconds (BT = 120). Differences in these and previously published curves were found because use of more accurate computer generated Fresnel Integral values. The effect of Doppler frequencies on Chirped pulse waveforms is seen with +10 to -10 megahertz Doppler frequencies in 2 megahertz increments. This family of Doppler shifted outputs of the matched filter are like the ambiguity function for the linear FM signal.

Linear FM signals and pulsed waveforms are substantially distorted by LPDAs because of frequency dispersion in phase frequency and amplitude-frequency spectra. Frequency bandwidths B of these antennas are limited by the bandwidth ratio P, given by f_2 / f_1 (upper frequency/lower frequency), to 2.5 due to deterioration of input characteristics at low frequencies to antenna pattern distortion at high frequencies.[1] If LPDA antennas are modeled as filters, possessing both amplitude versus frequency and phase versus frequency responses, then their phase conjugate functions can be shown to produce pulse compression distorted by frequency dispersion. The technique for chirping is an application or matched filter design found in radar systems.[2]

The pulse distortion and FM frequency errors in LPDAs can be greatly reduced by three different techniques. The phase-frequency response of the LPDA can be corrected by changing the logarithm's periodicity to arithmetic periodicity, by altering only the equation of the change of coordinates and lengths of the dipoles. The disadvantage of this technique is that the "arithmetic" periodic dipole array (APDA) has a small deterioration in B in comparison with the LPDA. In this paper, a modulation technique is described which compresses ultra wideband (UWB) signals on conventional LPDAs.

Although the modulation technique applies only to linear FM signals, the same methodology can greatly reduce pulse distortion when pulse waveform is known.

The preceding applications of pulse compression is found with receive modes. In transmit modes, HPM applications are found with wideband transmitting antennas, such as log periodic dipole antenna arrays (LPDA), where the matched filters are the antennas. The strong phase dispersion usually encountered with LPDAs creates substantial distortion in the shape of wideband signals or pulses. This distortion is greatly reduced with either a change in the FM from linear to exponential or with a modification in the log periodicity of the array elements to a linear periodicity.

REFERENCES

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