GPS Interference Mitigation for Small UAV Applications

by

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Abbreviations

ADC: Analogue to Digital Converter

AGC: Automatic Gain Control

AJ: anti-jam/anti-jamming

AOA: Angle of Arrival

BPF: Band Pass Filter

CECOM: Communications-Electronics Command

CDMA: Code Division Multiple Access

C/No: Carrier to Noise Density Ratio

DAC: Digital to Analogue Converter

DLMS: Delayed Least Mean Square

DOA: Direction of Arrival

DSP: Digital Signal Processing

DSSS: Direct-Sequence Spread Spectrum

EMC: Electromagnetic Compatibility

FFT: Fast Fourier Transform

FIR: Finite Impulse Response

FPGA: Field Programmable Gate Array

GLONASS: Global Navigation Satellite System

GNSS: Global Navigation Satellite System

GPIB: General Purpose Interface Bus

GPS: Global Positioning System

IF: Intermediate Frequency

IP3: Third Order Interception Point

IIP3: Input IP3

INS: Inertial Navigation System

LMS: Least Mean Square

LNA: Low Noise Amplifier

LO: Local Oscillator

MDS: Minimum Detectable Signal

MSE: Mean Square Error

MVDR: Minimum Variance Distortionless Response

NF: Noise Figure

NLMS: Normalised Least Mean Square

OIP3: Output IP3

PCB: Printed Circuit Board

RBW: Resolution Bandwidth

RF: Radio Frequency

SFAP: Space Frequency Adaptive Processing

SFDR: Spurious Free Dynamic Range

SIR: Signal to Interference Ratio

SMA: Sub-Miniature A (type of RF connector)

SNR: Signal to Noise Ratio

STAP: Space Time Adaptive Processing

UAV: Unmanned Aerial Vehicle

VCO: Voltage Controlled Oscillator

VHDL: VHSIC (Very High Speed Integrated Circuit) Hardware Description Language

WGN: White Gaussian Noise

Abstract

The vulnerability of GPS to interference has been a major concern for both military and civilian applications, including small UAVs. Various signal processing techniques have been developed to improve the reliability of GPS receivers against different types of interference. Among these techniques, null steering is recognized as an effective method to protect GPS against both narrowband and broadband interference. However, due to the requirement of multiple antenna channels, it has mainly been implemented for large platform applications.

This thesis examines the suitability of null steering techniques for small UAV applications and determines the practically achievable anti-jamming ability by implementing a two-element miniaturized adaptive antenna array.

The adaptive antenna array is tested against a 2MHz broadband jamming signal under both laboratory testing conditions and a real jamming environment. Approximately 40dB anti-jamming range was achieved in the laboratory testing conditions. 38dB and 42dB were obtained in a real jamming environment with different antenna configuration. The likely performance limitations and possible further performance enhancements are also outlined in this thesis.

Publications

J. Li & M. Trinkle, “Miniaturized GPS interference canceller for UAV application”, presented at IGNSS-07, December 4-6, 2007. Awarded for “*Best Academic Paper*”.

Statement of Originality

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the test.

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