# Contents

Declaration by Guide................................................................. ii  
Declaration by Student............................................................... iii  
Certificate................................................................................ iv  
Acknowledgement........................................................................ v  
List of contributions.................................................................... vii  
Abstract....................................................................................... ix  
List of symbols and abbreviation............................................... x  
List of Figures and tables............................................................ xiv  
Contents...................................................................................... xviii  

1. Introduction................................................................................. 1  
   1.1 Basic functionalities of watermarking schemes......................... 4  
      1.1.1 Perceptibility............................................................... 4  
      1.1.2 Level of reliability..................................................... 5  
      1.1.3 Capacity................................................................. 6  
      1.1.4 Speed................................................................. 6  
      1.1.5 Statistical undetectability................................. 6  
      1.1.6 Asymmetry.......................................................... 6  
   1.2 Evaluation of Schemes........................................................... 7  
      1.2.1 Perceptibility............................................................. 8  
      1.2.2 Robustness............................................................. 8  
      1.2.3 Capacity.............................................................. 10  
      1.2.4 Speed.............................................................. 10  
      1.2.5 Statistical undetectability...................................... 11  
   1.3 organization of thesis............................................................ 11  

2. Literature Survey........................................................................... 13  
   2.1 Spread spectrum audio watermarking...................................... 13  
   2.2 Methods using patch work algorithm..................................... 16  
   2.3 Methods implemented in time domain.................................... 17
### 2.4 Methods implemented in transform domain

2.5 Other recently developed algorithms

2.6 Audio watermarking techniques against time scale modifications

2.7 Papers studied on performance analysis and evaluation of watermarking Systems

2.8 Watermark attacks

2.9 Research problems identified

2.10 Concluding remarks

### 3. Research problem

3.1 Summary of chapter

### 4. High capacity covert communication for Audio

4.1 Overview of the properties of HAS

4.2 Discrete wavelet transform

4.2.1 Conditions for perfect reconstruction

4.2.2 Classification of wavelets

4.2.2.1 Features of orthogonal wavelet filter banks

4.2.2.2 Features of biorthogonal wavelet filter banks

4.3 Audio watermarking for Covert Communication

4.4 Results of high capacity covert communication technique

4.4.1 Subjective Listening test

4.4.2 Robustness test

4.5 Summary of chapter

### 5. Spread Spectrum Audio watermarking algorithms

5.1 Conventional spread spectrum method of watermarking

5.2 Adaptive SNR based non blind watermarking technique in wavelet domain

5.3 Proposed adaptive SNR based blind watermarking using DWT/Lifting wavelet transform

5.3.1 Watermark embedding

5.3.2 Watermark extraction

5.3.3 Experimental results
5.3.4 Selection criteria for value of SNR in computing $\alpha(k)$ and selection criteria for segment length N .......................... 67
5.4 Proposed adaptive SNR based spread spectrum scheme in DWT-DCT ................................................................. 68
  5.4.1 Watermark embedding................................................. 69
  5.4.2 Watermark extraction.................................................. 70
  5.4.3 Experimental results.................................................. 71
5.5 Proposed SNR based blind technique using cyclic coding ........... 74
5.5 Summary of chapter.......................................................... 75
6. Adaptive watermarking by GOS modification............................. 77
  6.1 Introduction to audio watermarking technique based on GOS modification in time domain........................................ 78
    6.1.1 Rules of watermark embedding.................................... 79
    6.1.2 Watermark extraction............................................... 79
  6.2 Proposed adaptive watermarking using GOS modifications in transform domain...................................................... 80
    6.2.1 Proposed blind watermarking using GOS modification in DWT domain......................................................... 81
    6.2.2 Proposed blind watermarking using GOS modification in DCT domain......................................................... 86
    6.2.3 Proposed blind watermarking using GOS modification in DWT-DCT domain................................................... 90
  6.3 Proposed GOS based blind technique using cyclic coding........... 92
  6.4 Comparison of proposed method with well known watermarking algorithms......................................................... 94
  6.5 summary of chapter........................................................ 97
7. Intelligent encoder and decoder modeling ................................ 98
  7.1. Basic model of watermarking......................................... 98
  7.2 Method-1: Proposed Intelligent encoder and decoder model for robust and secure audio watermarking based on Spread Spectrum 102
  7.3 Method-2: Proposed Intelligent encoder and decoder model for robust and secure audio watermarking based on GOS modification 106
  7.4 Summary of chapter....................................................... 108
8. Discussion and Conclusion.................................................. 110
8.1 Discussion and conclusion......................................................... 110
8.2 Main contribution of the present research.............................. 115
8.3 Future scope........................................................................... 115
9. References.............................................................................. 117-124
Appendix....................................................................................... 125