

TABLE OF CONTENTS

INTRODUCTION	9
1 BROADCASTING NETWORKS CHARACTERISTICS	21
1.1 Introduction	21
1.2 DRM digital broadcasting system audio path qualitative characteristics	22
1.3 Coverage radii in AM and DRM modes comparison	32
1.4 Different frequency bands broadcasting efficiency	40
1.5 International DRM standardization	47
1.5.1 Transmitter output signal spectral characteristics requirements	47
1.5.2 Transmitter output signal modulation error ratio requirements	50
1.5.3 DRM system standards	52
1.6 Conclusion	53
2 DRM TRANSMITTERS	56
2.1 DRM transmitters requirements	56
2.2 High efficiency broadcast transmitters	58
2.2.1 HF broadcast transmitters	58
2.2.2 HF communication transmitters	62
2.2.3 LF and MF broadcast transmitters	66
2.2.3.1 RF path	67
2.2.3.2 PWM modulator transmitters	69
2.2.3.3 Digital transmitters	72
2.2.3.4 Digital transmitters with outphasing	74
2.3. Transmitters performance requirements development	78
2.3.1 Choice of analysis method	79
2.3.2 Set-up to investigate the DRM transmitter non-linearities effect on the output signal MER value	80
2.3.3 Transmitting device characteristics nonlinearity influence on the output DRM signal MER and spectrum: analysis results	84
2.4. Development of performance requirements for envelope elimination and restoration transmitters	88
2.5. Development of performance requirements for digital transmitters	91
2.6. Development of performance requirements for outphasing transmitters	92
2.6.1 Outphasing transmitter principle of operation	93
2.6.2 Mathematical model development	95

2.6.3 DRM mode outphasing transmitter out-of-band emissions investigation	98
2.6.4 DRM mode outphasing transmitter channel signals admissible asymmetry requirements development	101
2.7 Conclusion	101
3 FEATURES OF USING TRANSMITTERS ANTENNA-FEEDER DEVICES IN DRM MODE	104
3.1 Requirements for the antenna systems VSWR in AM and DRM modes	104
3.2 LF band antenna systems LC-matching potential possibilities analysis	105
3.3 Frequency extension circuits principles of construction	108
3.3.1 LF antenna systems using RLC matching circuits	108
3.3.2 Frequency extension circuits constructing in series and parallel configurations	109
3.4 Frequency extension circuits calculation methodology and energy efficiency	111
3.4.1 Frequency extension circuits designing methodology development	111
3.4.2 Frequency extension circuits energy efficiency analysis depending on the antenna system parameters	113
3.4.3 Frequency extension circuits various variants according of technical feasibility and economic efficiency criteria analysis	115
3.4.4 Frequency extension circuits losses in different transmitter operation modes	118
3.5 Antenna-matching circuits designing algorithm development	119
3.5.1 Low-pass filter transformers designing	120
3.5.2 Antenna-matching circuits engineering tools development	121
3.5.3 Antenna-matching circuits for LF range simulcast mode designing example	124
3.6 Practical applicability and expected economic effect	126
3.7 Conclusion	127
4 DRM RECEIVING EQUIPMENT REQUIREMENTS DEVELOPMENT	128
4.1 Introduction	128
4.2 DRM receiver samples sensitivity measurements	129
4.2.1 DRM receivers sensitivity measuring at the external antenna input port	130
4.2.2 DRM receivers sensitivity measuring by electromagnetic field strength	132
4.3 Providing the required sensitivity of DRM LF and MF ranges consumer receivers possibility analysis	137
4.4 DRM receiving equipment parameters requirements development	140
4.4.1 Basic performance requirements	141
4.4.2 Requirements for basic RF parameters	143
4.5 DRM receiving equipment radio frequency parameters measuring methods development	146

4.6 Conclusion	148
5 PROTECTION RATIOS AND DIGITAL BROADCASTING NETWORK OPERATION IN THE TRANSITION PERIOD	150
5.1 Introduction	150
5.2 Protection ratios refinement	151
5.3 Protection ratios for the DRM signal with arbitrary number of interfering signals simultaneous exposure	156
5.4 Conditions investigation of the use of DRM digital radio broadcasting in Simulcast mode, taking into account existing consumer radio receiving equipment parameters	165
5.4.1 International experience analysis of the DRM Simulcast mode broadcasting in the LF, MF ranges	165
5.4.2 AM reception in Simulcast mode qualitative parameters investigation	170
5.5 Transition period analog and digital signals power ratio recommendations development	173
5.5.1 Power ratio when an analog signal is replaced by a digital signal	173
5.5.2. Power characteristics and coverage areas in Simulcast mode	174
5.6 Conclusion	177
6 TECHNICAL FOUNDATIONS DEVELOPMENT FOR THE FREQUENCY AND TERRITORIAL PLANNING OF THE LF AND MF BANDS DRM BROADCASTING NETWORKS	180
6.1 Introduction	180
6.2 Analysis and systematization of available publications and international experience on the topic of work	182
6.2.1 Analysis of international documents (Resolutions, Recommendations) related to digital broadcasting	184
6.2.2 Analysis of the experimental studies of DRM standard broadcasting in the LF, MF ranges results	184
6.3 Parameters and criteria used in the DRM digital radio broadcasting coverage area calculation	188
6.3.1 Ground wave field strength variations	189
6.3.2 Ground wave field strength variation reference point	192
6.3.3 Sky wave field strength variations	194
6.3.4 Atmospheric noise and industrial interference field strength	195
6.3.4.1 Man-made interference field strength	195
6.3.4.2 Maximum atmospheric radio noise field strength estimation	197
6.3.4.3 Distribution of atmospheric radio noise over the territory of the Earth	198

6.3.4.4 Atmospheric radio noise accounting procedure	201
6.4 DRM broadcasting networks in the LF and MF ranges coverage areas experimental studies	204
6.4.1 LF range DRM transmitter coverage area experimental studies	205
6.4.1.1 Necessary equipment preparation for the LF range experimental broadcasting	206
6.4.1.2 Coverage area calculation	207
6.4.1.3 Measurement methodology development and measurement points on the ground selection	210
6.4.1.4 Coverage area experimental measurements	212
6.4.2 Measurement of the radio noise level in populated areas and interference from various electrical and radio equipment in the LF range	215
6.4.2.1 Measurement of atmospheric radio noise and impulse noise in various types of settlements	215
6.4.2.2 Measurement of radio noise levels from various electrical and radio equipment	217
6.4.3 MF range DRM transmitter coverage area experimental studies	222
6.4.3.1 Equipment for MF range coverage area measurements	223
6.4.3.2 Coverage area calculation	224
6.4.3.3 Day time coverage areas measurements	228
6.4.3.4 Night time coverage areas measurements	231
6.4.4 Investigation of DRM digital broadcasting in the MF band fading zone	233
6.4.5 Mobile reception in various landscape conditions - lowlands, under power lines, tunnels	240
6.5 Conclusion	242
7 DRM DIGITAL RADIO BROADCASTING GLOBAL COVERAGE NETWORK: TOPOLOGY DEVELOPMENT	246
7.1 Introduction	246
7.2 Preferred frequencies and service area radii for different regions	249
7.3 Benefits of using the LF band for DRM at high latitudes	255
7.4 Solving the night time problem	256
7.5 Features of building single-frequency DRM networks	262
7.5.1 Method for calculating the synchronism zone	264
7.5.2 Considering possible scenarios for the transmitters location	265
7.6 Digital radio broadcasting network in the Arctic region architecture development example	272
7.7 Conclusion	277

CONCLUSION	279
BIBLIOGRAPHY	284
APPENDIX A DRM-30 receiver (for DRM digital radio broadcasting system in the frequency ranges below 30 MHz). General specifications (Basic specifications. Services provided)	301
APPENDIX B DRM-30 receiver (for DRM digital radio broadcasting system in the frequency ranges below 30 MHz). Methods of electrical high-frequency measurements	316
APPENDIX C Modeling the influence of interference from the DRM component to AM signal reception in the Simulcast system	333