3GPP TS 36.211 V17.2.0 (2022-06)

Technical Specification

3rd Generation Partnership Project;

Technical Specification Group Radio Access Network;

Evolved Universal Terrestrial Radio Access (E-UTRA);

Physical channels and modulation

(Release 17)

** 

The present document has been developed within the 3rd Generation Partnership Project (3GPP TM) and may be further elaborated for the purposes of 3GPP.   
The present document has not been subject to any approval process by the 3GPPOrganizational Partners and shall not be implemented.   
This Specification is provided for future development work within 3GPPonly. The Organizational Partners accept no liability for any use of this Specification.  
Specifications and reports for implementation of the 3GPP TM system should be obtained via the 3GPP Organizational Partners' Publications Offices.

Keywords

E-UTRA, radio, layer 1

***3GPP***

Postal address

3GPP support office address

650 Route des Lucioles - Sophia Antipolis

Valbonne - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Internet

http://www.3gpp.org

***Copyright Notification***

No part may be reproduced except as authorized by written permission.  
The copyright and the foregoing restriction extend to reproduction in all media.

© 2022, 3GPP Organizational Partners (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC).

All rights reserved.

UMTS™ is a Trade Mark of ETSI registered for the benefit of its members

3GPP™ is a Trade Mark of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners  
LTE™ is a Trade Mark of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners

GSM® and the GSM logo are registered and owned by the GSM Association

Contents

Foreword 9

1 Scope 10

2 References 10

3 Symbols and abbreviations 11

3.1 Symbols 11

3.2 Abbreviations 15

4 Frame structure 15

4.1 Frame structure type 1 16

4.2 Frame structure type 2 17

4.3 Frame structure type 3 18

5 Uplink 20

5.1 Overview 20

5.1.1 Physical channels 20

5.1.2 Physical signals 20

5.2 Slot structure and physical resources 20

5.2.1 Resource grid 20

5.2.2 Resource elements 22

5.2.3 Resource blocks 22

5.2.4 Narrowbands and widebands 22

5.2.5 Guard period for narrowband and wideband retuning 23

5.3 Physical uplink shared channel 25

5.3.1 Scrambling 25

5.3.2 Modulation 26

5.3.2A Layer mapping 27

5.3.2A.1 Layer mapping for transmission on a single antenna port 27

5.3.2A.2 Layer mapping for spatial multiplexing 27

5.3.3 Transform precoding 28

5.3.3A Precoding 28

5.3.3A.1 Precoding for transmission on a single antenna port 28

5.3.3A.2 Precoding for spatial multiplexing 28

5.3.4 Mapping to physical resources 31

5.4 Physical uplink control channel 37

5.4.1 PUCCH formats 1, 1a and 1b 38

5.4.2 PUCCH formats 2, 2a and 2b 41

5.4.2A PUCCH format 3 42

5.4.2B PUCCH format 4 44

5.4.2C PUCCH format 5 44

5.4.3 Mapping to physical resources 45

5.4A Short Physical Uplink Control Channel 48

5.4A.1 General 48

5.4A.2 SPUCCH formats 1,1a,1b 48

5.4A.2.1 Slot-SPUCCH 48

5.4A.2.2 Subslot-SPUCCH 49

5.4A.3 SPUCCH format 3 50

5.4A.3.1 Slot-SPUCCH 50

5.4A.4 SPUCCH format 4 50

5.4A.4.1 Slot-SPUCCH 50

5.4A.4.2 Subslot-SPUCCH 51

5.4A.5 Mapping to physical resources 51

5.5 Reference signals 55

5.5.1 Generation of the reference signal sequence 55

5.5.1.1 Base sequences of length  or larger 56

5.5.1.2 Base sequences of length less than  57

5.5.1.3 Group hopping 61

5.5.1.4 Sequence hopping 62

5.5.1.5 Determining virtual cell identity for sequence generation 62

5.5.2 Demodulation reference signal 63

5.5.2.1 Demodulation reference signal for PUSCH 63

5.5.2.1.1 Reference signal sequence 63

5.5.2.1.2 Mapping to physical resources 67

5.5.2.1A Demodulation reference signal for PUSCH with sub-PRB allocations 68

5.5.2.1A.1 Reference signal sequence using modulation schemes other than π/2-BPSK 68

5.5.2.1A.2 Reference signal sequence using π/2-BPSK modulation scheme 69

5.5.2.1A.3 Group hopping 70

5.5.2.1A.4 Mapping to physical resources 71

5.5.2.2 Demodulation reference signal for PUCCH 71

5.5.2.2.1 Reference signal sequence 71

5.5.2.2.2 Mapping to physical resources 73

5.5.2.3 Demodulation reference signal for SPUCCH 74

5.5.2.3.1 Reference signal sequence 74

5.5.2.3.2 Mapping to physical resources 74

5.5.3 Sounding reference signal 76

5.5.3.1 Sequence generation 76

5.5.3.1.1 Sequence generation for basic SRS 76

5.5.3.1.2 Sequence generation for additional SRS 76

5.5.3.2 Mapping to physical resources 77

5.5.3.2.1 Mapping to physical resources for basic SRS 77

5.5.3.2.2 Mapping to physical resources for additional SRS 79

5.5.3.3 Sounding reference signal subframe configuration 80

5.6 SC-FDMA baseband signal generation 82

5.6A SC-FDMA baseband signal generation for PUSCH using sub-PRB allocations 83

5.6A.1 Modulation schemes other than π/2-BPSK 83

5.6A.2 Modulation scheme π/2-BPSK 83

5.7 Physical random access channel 84

5.7.1 Time and frequency structure 84

5.7.2 Preamble sequence generation 91

5.7.3 Baseband signal generation 96

5.8 Modulation and upconversion 97

6 Downlink 98

6.1 Overview 98

6.1.1 Physical channels 98

6.1.2 Physical signals 98

6.2 Slot structure and physical resource elements 99

6.2.1 Resource grid 99

6.2.2 Resource elements 100

6.2.3 Resource blocks 101

6.2.3.1 Virtual resource blocks of localized type 102

6.2.3.2 Virtual resource blocks of distributed type 102

6.2.4 Resource-element groups (REGs) 103

6.2.4A Enhanced Resource-Element Groups (EREGs) 104

6.2.4B Short Resource-Element Groups (SREGs) 104

6.2.5 Guard period for half-duplex FDD operation 104

6.2.6 Guard Period for TDD Operation 105

6.2.7 Narrowbands and widebands 105

6.2.8 Guard period for narrowband and wideband retuning 106

6.3 General structure for downlink physical channels 106

6.3.1 Scrambling 107

6.3.2 Modulation 108

6.3.3 Layer mapping 108

6.3.3.1 Layer mapping for transmission on a single antenna port 108

6.3.3.2 Layer mapping for spatial multiplexing 109

6.3.3.3 Layer mapping for transmit diversity 110

6.3.4 Precoding 110

6.3.4.1 Precoding for transmission on a single antenna port 110

6.3.4.2 Precoding for spatial multiplexing using antenna ports with cell-specific reference signals 111

6.3.4.2.1 Precoding without CDD 111

6.3.4.2.2 Precoding for large delay CDD 111

6.3.4.2.3 Codebook for precoding and CSI reporting 112

6.3.4.3 Precoding for transmit diversity 113

6.3.4.4 Precoding for spatial multiplexing using antenna ports with UE-specific reference signals 114

6.3.5 Mapping to resource elements 115

6.4 Physical downlink shared channel 116

6.4.1 Physical downlink shared channel for BL/CE UEs 118

6.4.2 Slot/subslot-basedphysical downlink shared channel 121

6.5 Physical multicast channel 123

6.6 Physical broadcast channel 123

6.6.1 Scrambling 123

6.6.2 Modulation 123

6.6.3 Layer mapping and precoding 124

6.6.4 Mapping to resource elements 124

6.6.4.1 PBCH repetition in the cell acquisition subframe 125

6.7 Physical control format indicator channel 126

6.7.1 Scrambling 126

6.7.2 Modulation 126

6.7.3 Layer mapping and precoding 127

6.7.4 Mapping to resource elements 127

6.8 Physical downlink control channel 127

6.8.1 PDCCH formats 127

6.8.2 PDCCH multiplexing and scrambling 127

6.8.3 Modulation 128

6.8.4 Layer mapping and precoding 128

6.8.5 Mapping to resource elements 128

6.8A Enhanced physical downlink control channel 129

6.8A.1 EPDCCH formats 130

6.8A.2 Scrambling 131

6.8A.3 Modulation 131

6.8A.4 Layer mapping and precoding 131

6.8A.5 Mapping to resource elements 132

6.8B MTC physical downlink control channel 133

6.8B.1 MPDCCH formats 133

6.8B.2 Scrambling 134

6.8B.3 Modulation 134

6.8B.4 Layer mapping and precoding 134

6.8B.5 Mapping to resource elements 134

6.8C Short physical downlink control channel (SPDCCH) 138

6.8C.1 SPDCCH formats 138

6.8C.2 Scrambling 140

6.8C.3 Modulation 140

6.8C.4 Layer mapping and precoding 140

6.8C.5 Mapping to resource elements 140

6.9 Physical hybrid ARQ indicator channel 142

6.9.1 Modulation 143

6.9.2 Resource group alignment, layer mapping and precoding 143

6.9.3 Mapping to resource elements 145

6.10 Reference signals 147

6.10.1 Cell-specific Reference Signal (CRS) 147

6.10.1.1 Sequence generation 147

6.10.1.2 Mapping to resource elements 148

6.10.2 MBSFN reference signals 150

6.10.2.1 Sequence generation 150

6.10.2.1.1 Sequence generation for 15 kHz and 7.5 kHz subcarrier spacing 150

6.10.2.1.2 Sequence generation for 1.25 kHz subcarrier spacing 151

6.10.2.1.3 Sequence generation for 2.5 kHz subcarrier spacing 151

6.10.2.1.4 Sequence generation for 0.37 kHz subcarrier spacing 151

6.10.2.2 Mapping to resource elements 151

6.10.2.2.1 Mapping to resource elements for 15 kHz and 7.5 kHz subcarrier spacing 151

6.10.2.2.2 Mapping to resource elements for 1.25 kHz 153

6.10.2.2.3 Mapping to resource elements for 2.5 kHz subcarrier spacing 153

6.10.2.2.4 Mapping to resource elements for 0.37 kHz subcarrier spacing 154

6.10.3 UE-specific reference signals associated with PDSCH 154

6.10.3.1 Sequence generation 155

6.10.3.2 Mapping to resource elements 156

6.10.3A Demodulation reference signals associated with EPDCCH, MPDCCH, or SPDCCH 163

6.10.3A.1 Sequence generation 164

6.10.3A.2 Mapping to resource elements 165

6.10.4 Positioning reference signals 167

6.10.4.1 Sequence generation 167

6.10.4.2 Mapping to resource elements 167

6.10.4.3 Positioning reference signal subframe configuration 169

6.10.5 CSI reference signals 170

6.10.5.1 Sequence generation 171

6.10.5.2 Mapping to resource elements 171

6.10.5.3 CSI reference signal subframe configuration 180

6.11 Synchronization signals 180

6.11.1 Primary synchronization signal (PSS) 180

6.11.1.1 Sequence generation 180

6.11.1.2 Mapping to resource elements 181

6.11.2 Secondary synchronization signal (SSS) 181

6.11.2.1 Sequence generation 181

6.11.2.2 Mapping to resource elements 183

6.11.3 Resynchronization signal (RSS) 184

6.11.3.1 Sequence generation 184

6.11.3.2 Mapping to resource elements 184

6.11A Discovery signal 185

6.11B MTC wake-up signal (MWUS) 186

6.11B.1 Sequence generation 186

6.11B.2 Mapping to resource elements 186

6.12 OFDM baseband signal generation 187

6.13 Modulation and upconversion 187

7 Generic functions 189

7.1 Modulation mapper 189

7.1.1 BPSK 189

7.1.2 QPSK 189

7.1.3 16QAM 189

7.1.4 64QAM 190

7.1.5 256QAM 192

7.1.6 1024QAM 193

7.2 Pseudo-random sequence generation 193

8 Timing 193

8.1 Uplink-downlink frame timing 194

9 Sidelink 196

9.1 Overview 196

9.1.1 Physical channels 196

9.1.2 Physical signals 196

9.1.3 Handling of simultaneous sidelink and uplink/downlink transmissions 196

9.2 Slot structure and physical resources 197

9.2.1 Resource grid 197

9.2.2 Resource elements 197

9.2.3 Resource blocks 198

9.2.4 Resource pool 198

9.2.5 Guard period 198

9.3 Physical Sidelink Shared Channel 198

9.3.1 Scrambling 198

9.3.2 Modulation 199

9.3.3 Layer mapping 199

9.3.4 Transform precoding 199

9.3.5 Precoding 199

9.3.6 Mapping to physical resources 199

9.4 Physical Sidelink Control Channel 200

9.4.1 Scrambling 200

9.4.2 Modulation 200

9.4.3 Layer mapping 200

9.4.4 Transform precoding 200

9.4.5 Precoding 200

9.4.6 Mapping to physical resources 200

9.5 Physical Sidelink Discovery Channel 201

9.5.1 Scrambling 201

9.5.2 Modulation 201

9.5.3 Layer mapping 201

9.5.4 Transform precoding 201

9.5.5 Precoding 201

9.5.6 Mapping to physical resources 201

9.6 Physical Sidelink Broadcast Channel 202

9.6.1 Scrambling 202

9.6.2 Modulation 202

9.6.3 Layer mapping 202

9.6.4 Transform precoding 202

9.6.5 Precoding 202

9.6.6 Mapping to physical resources 202

9.7 Sidelink Synchronization Signals 202

9.7.1 Primary sidelink synchronization signal 203

9.7.1.1 Sequence generation 203

9.7.1.2 Mapping to resource elements 203

9.7.2 Secondary sidelink synchronization signal 203

9.7.2.1 Sequence generation 203

9.7.2.2 Mapping to resource elements 203

9.8 Demodulation reference signals 203

9.9 SC-FDMA baseband signal generation 205

9.10 Timing 205

10 Narrowband IoT 206

10.0 General 206

10.0.1 Frame structure 206

10.0.1.1 Frame structure type 1 206

10.0.1.2 Frame structure type 2 206

10.1 Uplink 207

10.1.1 Overview 207

10.1.1.1 Physical channels 207

10.1.1.2 Physical signals 207

10.1.2 Slot structure and physical resources 207

10.1.2.1 Resource grid 207

10.1.2.2 Resource elements 208

10.1.2.3 Resource unit 208

10.1.3 Narrowband physical uplink shared channel 209

10.1.3.1 Scrambling 209

10.1.3.2 Modulation 209

10.1.3.3 Layer mapping 210

10.1.3.4 Transform precoding 210

10.1.3.5 Precoding 210

10.1.3.6 Mapping to physical resources 210

10.1.4 Demodulation reference signal 212

10.1.4.1 Reference signal sequence 212

10.1.4.1.1 Reference signal sequence for  212

10.1.4.1.2 Reference signal sequence for  212

10.1.4.1.3 Group hopping 214

10.1.4.2 Mapping to physical resources 214

10.1.5 SC-FDMA baseband signal generation 215

10.1.6 Narrowband physical random-access channel 216

10.1.6.1 Time and frequency structure 216

10.1.6.2 Baseband signal generation 219

10.1.7 Modulation and upconversion 220

10.2 Downlink 220

10.2.1 Overview 220

10.2.1.1 Physical channels 220

10.2.1.2 Physical signals 220

10.2.2 Slot structure and physical resource elements 220

10.2.2.1 Resource grid 220

10.2.2.2 Resource elements 221

10.2.2.3 Guard period for half-duplex FDD operation 221

10.2.2.4 Guard period for TDD operation 221

10.2.3 Narrowband physical downlink shared channel 221

10.2.3.1 Scrambling 221

10.2.3.2 Modulation 221

10.2.3.3 Layer mapping and precoding 221

10.2.3.4 Mapping to resource elements 222

10.2.4 Narrowband physical broadcast channel 223

10.2.4.1 Scrambling 223

10.2.4.2 Modulation 223

10.2.4.3 Layer mapping and precoding 224

10.2.4.4 Mapping to resource elements 224

10.2.5 Narrowband physical downlink control channel 224

10.2.5.1 NPDCCH formats 224

10.2.5.2 Scrambling 225

10.2.5.3 Modulation 225

10.2.5.4 Layer mapping and precoding 225

10.2.5.5 Mapping to resource elements 225

10.2.6 Narrowband reference signal (NRS) 226

10.2.6.1 Sequence generation 229

10.2.6.2 Mapping to resource elements 229

10.2.6A Narrowband positioning reference signal (NPRS) 231

10.2.6A.1 Sequence generation 231

10.2.6A.2 Mapping to resource elements 232

10.2.6A.3 NPRS subframe configuration 233

10.2.6B Narrowband wake up signal (NWUS) 234

10.2.6B.1 Sequence generation 234

10.2.6B.2 Mapping to resource elements 234

10.2.7 Synchronization signals 235

10.2.7.1 Narrowband primary synchronization signal (NPSS) 235

10.2.7.1.1 Sequence generation 235

10.2.7.1.2 Mapping to resource elements 235

10.2.7.2 Narrowband secondary synchronization signal (NSSS) 236

10.2.7.2.1 Sequence generation 236

10.2.7.2.2 Mapping to resource elements 236

10.2.8 OFDM baseband signal generation 237

10.2.9 Modulation and upconversion 238

Annex A (informative): Change history 239