3GPP TS 36.211 V15.14.0 (2021-09)

Technical Specification

3rd Generation Partnership Project;

Technical Specification Group Radio Access Network;

Evolved Universal Terrestrial Radio Access (E-UTRA);

Physical channels and modulation

(Release 15)

** 

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.

© 2021, 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 36

5.4.1 PUCCH formats 1, 1a and 1b 37

5.4.2 PUCCH formats 2, 2a and 2b 40

5.4.2A PUCCH format 3 41

5.4.2B PUCCH format 4 43

5.4.2C PUCCH format 5 43

5.4.3 Mapping to physical resources 44

5.4A Short Physical Uplink Control Channel 47

5.4A.1 General 47

5.4A.2 SPUCCH formats 1,1a,1b 47

5.4A.2.1 Slot-SPUCCH 47

5.4A.2.2 Subslot-SPUCCH 48

5.4A.3 SPUCCH format 3 49

5.4A.3.1 Slot-SPUCCH 49

5.4A.4 SPUCCH format 4 49

5.4A.4.1 Slot-SPUCCH 49

5.4A.4.2 Subslot-SPUCCH 50

5.4A.5 Mapping to physical resources 50

5.5 Reference signals 54

5.5.1 Generation of the reference signal sequence 54

5.5.1.1 Base sequences of length  or larger 55

5.5.1.2 Base sequences of length less than  56

5.5.1.3 Group hopping 60

5.5.1.4 Sequence hopping 61

5.5.1.5 Determining virtual cell identity for sequence generation 61

5.5.2 Demodulation reference signal 62

5.5.2.1 Demodulation reference signal for PUSCH 62

5.5.2.1.1 Reference signal sequence 62

5.5.2.1.2 Mapping to physical resources 66

5.5.2.1A Demodulation reference signal for PUSCH with sub-PRB allocations 67

5.5.2.1A.1 Reference signal sequence using modulation schemes other than π/2-BPSK 67

5.5.2.1A.2 Reference signal sequence using π/2-BPSK modulation scheme 68

5.5.2.1A.3 Group hopping 69

5.5.2.1A.4 Mapping to physical resources 70

5.5.2.2 Demodulation reference signal for PUCCH 70

5.5.2.2.1 Reference signal sequence 70

5.5.2.2.2 Mapping to physical resources 72

5.5.2.3 Demodulation reference signal for SPUCCH 72

5.5.2.3.1 Reference signal sequence 72

5.5.2.3.2 Mapping to physical resources 73

5.5.3 Sounding reference signal 75

5.5.3.1 Sequence generation 75

5.5.3.2 Mapping to physical resources 75

5.5.3.3 Sounding reference signal subframe configuration 78

5.6 SC-FDMA baseband signal generation 79

5.6A SC-FDMA baseband signal generation for PUSCH using sub-PRB allocations 80

5.6A.1 Modulation schemes other than π/2-BPSK 80

5.6A.2 Modulation scheme π/2-BPSK 80

5.7 Physical random access channel 81

5.7.1 Time and frequency structure 81

5.7.2 Preamble sequence generation 89

5.7.3 Baseband signal generation 94

5.8 Modulation and upconversion 95

6 Downlink 96

6.1 Overview 96

6.1.1 Physical channels 96

6.1.2 Physical signals 96

6.2 Slot structure and physical resource elements 97

6.2.1 Resource grid 97

6.2.2 Resource elements 98

6.2.3 Resource blocks 99

6.2.3.1 Virtual resource blocks of localized type 100

6.2.3.2 Virtual resource blocks of distributed type 100

6.2.4 Resource-element groups (REGs) 101

6.2.4A Enhanced Resource-Element Groups (EREGs) 102

6.2.4B Short Resource-Element Groups (SREGs) 102

6.2.5 Guard period for half-duplex FDD operation 102

6.2.6 Guard Period for TDD Operation 103

6.2.7 Narrowbands and widebands 103

6.2.8 Guard period for narrowband and wideband retuning 104

6.3 General structure for downlink physical channels 104

6.3.1 Scrambling 105

6.3.2 Modulation 106

6.3.3 Layer mapping 106

6.3.3.1 Layer mapping for transmission on a single antenna port 106

6.3.3.2 Layer mapping for spatial multiplexing 107

6.3.3.3 Layer mapping for transmit diversity 108

6.3.4 Precoding 108

6.3.4.1 Precoding for transmission on a single antenna port 108

6.3.4.2 Precoding for spatial multiplexing using antenna ports with cell-specific reference signals 109

6.3.4.2.1 Precoding without CDD 109

6.3.4.2.2 Precoding for large delay CDD 109

6.3.4.2.3 Codebook for precoding and CSI reporting 110

6.3.4.3 Precoding for transmit diversity 111

6.3.4.4 Precoding for spatial multiplexing using antenna ports with UE-specific reference signals 112

6.3.5 Mapping to resource elements 113

6.4 Physical downlink shared channel 113

6.4.1 Physical downlink shared channel for BL/CE UEs 115

6.4.2 Slot/subslot-basedphysical downlink shared channel 118

6.5 Physical multicast channel 120

6.6 Physical broadcast channel 120

6.6.1 Scrambling 120

6.6.2 Modulation 120

6.6.3 Layer mapping and precoding 120

6.6.4 Mapping to resource elements 120

6.7 Physical control format indicator channel 122

6.7.1 Scrambling 122

6.7.2 Modulation 122

6.7.3 Layer mapping and precoding 123

6.7.4 Mapping to resource elements 123

6.8 Physical downlink control channel 123

6.8.1 PDCCH formats 123

6.8.2 PDCCH multiplexing and scrambling 123

6.8.3 Modulation 124

6.8.4 Layer mapping and precoding 124

6.8.5 Mapping to resource elements 124

6.8A Enhanced physical downlink control channel 125

6.8A.1 EPDCCH formats 126

6.8A.2 Scrambling 127

6.8A.3 Modulation 127

6.8A.4 Layer mapping and precoding 127

6.8A.5 Mapping to resource elements 128

6.8B MTC physical downlink control channel 129

6.8B.1 MPDCCH formats 129

6.8B.2 Scrambling 130

6.8B.3 Modulation 130

6.8B.4 Layer mapping and precoding 130

6.8B.5 Mapping to resource elements 130

6.8C Short physical downlink control channel (SPDCCH) 133

6.8C.1 SPDCCH formats 133

6.8C.2 Scrambling 135

6.8C.3 Modulation 135

6.8C.4 Layer mapping and precoding 135

6.8C.5 Mapping to resource elements 135

6.9 Physical hybrid ARQ indicator channel 137

6.9.1 Modulation 137

6.9.2 Resource group alignment, layer mapping and precoding 138

6.9.3 Mapping to resource elements 140

6.10 Reference signals 142

6.10.1 Cell-specific Reference Signal (CRS) 142

6.10.1.1 Sequence generation 142

6.10.1.2 Mapping to resource elements 143

6.10.2 MBSFN reference signals 145

6.10.2.1 Sequence generation 145

6.10.2.1.1 Sequence generation for 15 kHz and 7.5 kHz subcarrier spacing 145

6.10.2.1.2 Sequence generation for 1.25 kHz subcarrier spacing 145

6.10.2.2 Mapping to resource elements 146

6.10.2.2.1 Mapping to resource elements for 15 kHz and 7.5 kHz subcarrier spacing 146

6.10.2.2.2 Mapping to resource elements for 1.25 kHz 147

6.10.3 UE-specific reference signals associated with PDSCH 148

6.10.3.1 Sequence generation 148

6.10.3.2 Mapping to resource elements 149

6.10.3A Demodulation reference signals associated with EPDCCH, MPDCCH, or SPDCCH 157

6.10.3A.1 Sequence generation 157

6.10.3A.2 Mapping to resource elements 158

6.10.4 Positioning reference signals 160

6.10.4.1 Sequence generation 160

6.10.4.2 Mapping to resource elements 161

6.10.4.3 Positioning reference signal subframe configuration 163

6.10.5 CSI reference signals 163

6.10.5.1 Sequence generation 164

6.10.5.2 Mapping to resource elements 164

6.10.5.3 CSI reference signal subframe configuration 173

6.11 Synchronization signals 173

6.11.1 Primary synchronization signal (PSS) 173

6.11.1.1 Sequence generation 173

6.11.1.2 Mapping to resource elements 174

6.11.2 Secondary synchronization signal (SSS) 174

6.11.2.1 Sequence generation 174

6.11.2.2 Mapping to resource elements 176

6.11.3 Resynchronization signal (RSS) 177

6.11.3.1 Sequence generation 177

6.11.3.2 Mapping to resource elements 177

6.11A Discovery signal 178

6.11B MTC wake-up signal (MWUS) 179

6.11B.1 Sequence generation 179

6.11B.2 Mapping to resource elements 179

6.12 OFDM baseband signal generation 179

6.13 Modulation and upconversion 180

7 Generic functions 182

7.1 Modulation mapper 182

7.1.1 BPSK 182

7.1.2 QPSK 182

7.1.3 16QAM 182

7.1.4 64QAM 183

7.1.5 256QAM 185

7.1.6 1024QAM 186

7.2 Pseudo-random sequence generation 186

8 Timing 186

8.1 Uplink-downlink frame timing 187

9 Sidelink 189

9.1 Overview 189

9.1.1 Physical channels 189

9.1.2 Physical signals 189

9.1.3 Handling of simultaneous sidelink and uplink/downlink transmissions 189

9.2 Slot structure and physical resources 190

9.2.1 Resource grid 190

9.2.2 Resource elements 190

9.2.3 Resource blocks 191

9.2.4 Resource pool 191

9.2.5 Guard period 191

9.3 Physical Sidelink Shared Channel 191

9.3.1 Scrambling 191

9.3.2 Modulation 192

9.3.3 Layer mapping 192

9.3.4 Transform precoding 192

9.3.5 Precoding 192

9.3.6 Mapping to physical resources 192

9.4 Physical Sidelink Control Channel 193

9.4.1 Scrambling 193

9.4.2 Modulation 193

9.4.3 Layer mapping 193

9.4.4 Transform precoding 193

9.4.5 Precoding 193

9.4.6 Mapping to physical resources 194

9.5 Physical Sidelink Discovery Channel 194

9.5.1 Scrambling 194

9.5.2 Modulation 194

9.5.3 Layer mapping 194

9.5.4 Transform precoding 194

9.5.5 Precoding 194

9.5.6 Mapping to physical resources 194

9.6 Physical Sidelink Broadcast Channel 195

9.6.1 Scrambling 195

9.6.2 Modulation 195

9.6.3 Layer mapping 195

9.6.4 Transform precoding 195

9.6.5 Precoding 195

9.6.6 Mapping to physical resources 195

9.7 Sidelink Synchronization Signals 196

9.7.1 Primary sidelink synchronization signal 196

9.7.1.1 Sequence generation 196

9.7.1.2 Mapping to resource elements 196

9.7.2 Secondary sidelink synchronization signal 196

9.7.2.1 Sequence generation 196

9.7.2.2 Mapping to resource elements 196

9.8 Demodulation reference signals 197

9.9 SC-FDMA baseband signal generation 199

9.10 Timing 199

10 Narrowband IoT 200

10.0 General 200

10.0.1 Frame structure 200

10.0.1.1 Frame structure type 1 200

10.0.1.2 Frame structure type 2 200

10.1 Uplink 201

10.1.1 Overview 201

10.1.1.1 Physical channels 201

10.1.1.2 Physical signals 201

10.1.2 Slot structure and physical resources 201

10.1.2.1 Resource grid 201

10.1.2.2 Resource elements 202

10.1.2.3 Resource unit 202

10.1.3 Narrowband physical uplink shared channel 202

10.1.3.1 Scrambling 203

10.1.3.2 Modulation 203

10.1.3.3 Layer mapping 203

10.1.3.4 Transform precoding 203

10.1.3.5 Precoding 203

10.1.3.6 Mapping to physical resources 203

10.1.4 Demodulation reference signal 205

10.1.4.1 Reference signal sequence 205

10.1.4.1.1 Reference signal sequence for  205

10.1.4.1.2 Reference signal sequence for  206

10.1.4.1.3 Group hopping 207

10.1.4.2 Mapping to physical resources 208

10.1.5 SC-FDMA baseband signal generation 208

10.1.6 Narrowband physical random-access channel 209

10.1.6.1 Time and frequency structure 209

10.1.6.2 Baseband signal generation 212

10.1.7 Modulation and upconversion 213

10.2 Downlink 213

10.2.1 Overview 213

10.2.1.1 Physical channels 213

10.2.1.2 Physical signals 213

10.2.2 Slot structure and physical resource elements 213

10.2.2.1 Resource grid 213

10.2.2.2 Resource elements 214

10.2.2.3 Guard period for half-duplex FDD operation 214

10.2.2.4 Guard period for TDD operation 214

10.2.3 Narrowband physical downlink shared channel 214

10.2.3.1 Scrambling 214

10.2.3.2 Modulation 214

10.2.3.3 Layer mapping and precoding 214

10.2.3.4 Mapping to resource elements 215

10.2.4 Narrowband physical broadcast channel 216

10.2.4.1 Scrambling 216

10.2.4.2 Modulation 216

10.2.4.3 Layer mapping and precoding 216

10.2.4.4 Mapping to resource elements 216

10.2.5 Narrowband physical downlink control channel 217

10.2.5.1 NPDCCH formats 217

10.2.5.2 Scrambling 217

10.2.5.3 Modulation 217

10.2.5.4 Layer mapping and precoding 218

10.2.5.5 Mapping to resource elements 218

10.2.6 Narrowband reference signal (NRS) 219

10.2.6.1 Sequence generation 221

10.2.6.2 Mapping to resource elements 221

10.2.6A Narrowband positioning reference signal (NPRS) 223

10.2.6A.1 Sequence generation 223

10.2.6A.2 Mapping to resource elements 224

10.2.6A.3 NPRS subframe configuration 225

10.2.6B Narrowband wake up signal (NWUS) 226

10.2.6B.1 Sequence generation 226

10.2.6B.2 Mapping to resource elements 226

10.2.7 Synchronization signals 227

10.2.7.1 Narrowband primary synchronization signal (NPSS) 227

10.2.7.1.1 Sequence generation 227

10.2.7.1.2 Mapping to resource elements 227

10.2.7.2 Narrowband secondary synchronization signal (NSSS) 227

10.2.7.2.1 Sequence generation 227

10.2.7.2.2 Mapping to resource elements 228

10.2.8 OFDM baseband signal generation 229

10.2.9 Modulation and upconversion 229

Annex A (informative): Change history 231