

CONTENTS

Chapter 1 GENERAL BACKGROUND	1
1.1 Telephone networks	1
1.1.1 Historical	1
1.1.2 Transmission planning, standards of performance and methods of assessment	4
1.2 Transmission of information	14
1.3 Subjective assessment	19
1.4 Mathematics and statistics	26
Chapter 2 MECHANISM OF HUMAN COMMUNICATION	31
2.1 Speech	31
2.1.1 The production mechanism (including artificial mouths)	31
2.1.2 The specification of speech	43
2.1.3 Physical characteristics important in telephony	52
2.1.3.1 General	52
2.1.3.2 Amplitude structure	56
2.1.3.3 Time structure	69
2.1.3.4 Frequency structure	72
2.1.4 Acoustical descriptions relevant to recognition and synthesis	74
2.2 Hearing	77
2.2.1 The reception mechanism (including artificial ears)	77
2.2.2 Perception	81
2.2.3 Characteristics relevant to telephony	82

Contents

2.2.3.1	Steady state sounds	82
2.2.3.2	Transient sounds (including speech)	102
2.2.3.3	Use of both ears	103
2.3	Conversation	104
2.3.1	Introduction	104
2.3.2	Description of conversation	106
Chapter 3	METHODS OF MEASURING THE COMMUNICATION EFFICIENCY OF A SPEECH LINK	112
3.1	General	112
3.1.1	Definition of a speech link	112
3.1.2	Classifications and choice of assessment methods	114
3.1.3	Reference systems, transmission standards and representative connections	117
3.1.4	Rating scales and the impairment principle	125
3.2	Loudness rating	129
3.2.1	Aim	129
3.2.2	Principle and method	131
3.2.3	Use	145
3.2.4	Relationships between loudness ratings of speech paths and their absolute sensitivities	146
3.2.4.1	Theoretical basis for calculating loudness of speech	146
3.2.4.2	Determination of proper sensitivity/frequency characteristics	152
3.2.4.3	Calculation of reference equivalent	157
3.2.4.4	Alternative reference systems	159
3.3	Articulation	164
3.3.1	Aim	164
3.3.2	Principle	164
3.3.3	Method	166
3.3.4	Use	169
3.3.5	Relationships between articulation scores and certain physical particulars of speech paths	170
3.4	Listening methods using sentence material	173
3.4.1	Aims and principles	173
3.4.2	Methods	174
3.4.3	Use	180
3.4.4	Relationships between listening opinion scores and certain physical particulars of speech paths	180

Contents

3.5 Talking methods	184
3.5.1 Aim and principle	184
3.5.2 Methods	184
3.5.3 Use	194
3.6 Examination of conversations	195
3.6.1 Aim and principle	195
3.6.2 Methods	196
3.6.3 Use	207
3.7 Examination of participants during or after conversation	208
3.7.1 Aim and principle	208
3.7.2 Methods	208
3.7.3 Use	219
3.8 Methods based on instrumental measurements	220
 Chapter 4 EFFECTS OF SPECIFIC FACTORS	 224
4.1 Introduction	224
4.1.1 General	224
4.1.2 Composition of real telephone connections	232
4.1.3 Definitions of relative transmission levels	235
4.1.4 Laboratory representations of telephone connections	240
4.1.5 Choice of assessment criteria	243
4.2 Listening factors	248
4.2.1 Loss, noise and attenuation/frequency distortion	248
4.2.1.1 General theoretical framework	248
4.2.1.2 Listening assessment scores	256
4.2.1.3 Relationship between listening and conversation test results	268
4.2.1.4 Conversational assessment scores	274
4.2.1.5 Definition of an optimum telephone connection	278
4.2.1.6 Disturbing effect of noise in the absence of speech	290
4.2.2 Nonlinear distortion	293
4.2.2.1 Instantaneous nonlinearity	293
4.2.2.2 Nonlinearity involving storage	301
4.2.3 Group delay/frequency distortion	303

Contents

4.2.4 Combination of the effects of different listening factors	305
4.3 Talking factors	307
4.3.1 Sidetone	307
4.3.2 Talker echo	309
4.4 Conversational factors	311
4.4.1 Asymmetry	311
4.4.2 Propagation time	313
4.4.3 Voice operated devices	317
4.4.4 Handsfree telephony	319
4.5 Crosstalk	328
4.5.1 General	328
4.5.2 Linear crosstalk paths	334
4.5.3 Nonlinear crosstalk paths	340
4.6 Miscellaneous	343
 Chapter 5 TELEPHONE SETS	 349
5.1 Handset telephones	349
5.1.1 Handset dimensions	350
5.1.2 Microphone characteristics	355
5.1.3 Earphone characteristics	366
5.1.4 Sending and receiving losses of the electrical circuit	372
5.1.5 Sidetone suppression provided by the electrical circuit	379
5.1.5.1 Theoretical design of induction coils	379
5.1.5.2 Sidetone and line impedance	385
5.1.6 Miscellaneous requirements	395
5.1.7 Overall performance	396
5.2 Loudspeaking telephones	397
5.3 Headset telephones	403
 Chapter 6 LINE TRANSMISSION SYSTEMS	 404
6.1 Subscribers' lines and local telephone circuits	404
6.1.1 General	404
6.1.2 Sending and receiving sensitivities of local telephone circuits	415
6.1.2.1 Sending sensitivity	418
6.1.2.2 Receiving sensitivity	420

Contents

6.1.2.3 Example of calculating the sending sensitivity of a LTC	421
6.1.2.4 Receiving sensitivity example	425
6.1.2.5 Summary	426
6.1.3 Loudness ratings of local telephone circuits	426
6.1.4 Sidetone paths	429
6.1.5 Crosstalk paths	434
6.2 Junctions	436
6.3 Trunk circuits	448
6.4 Overall transmission loss of a connection	455
6.5 Economy systems	459
Chapter 7 PLANNING OF TELEPHONE NETWORKS	462
7.1 A look backwards	462
7.2 The network planning process	472
7.3 Notes on specific aspects of the network planning process	479
Chapter 8 TRANSMISSION PERFORMANCE OF TELEPHONE NETWORKS	487
8.1 Some estimates of the telephonic performance of the telephone network of the United Kingdom since 1905	487
8.2 Distribution of transmission losses	494
8.3 Frequencies of calls over various classes of connection	503
8.4 Estimation of future network transmission performance	506
APPENDIXES	521
1. Charts for determination of mismatch and return losses	521
2. International organisations	524
BIBLIOGRAPHY	529
INDEX	579