

Content

FOREWORD	6
INTRODUCTION	9
IMPEDANCE CONCEPT	13
0.1. General consideration of an impedance concept	13
0.2. Introduction of quantum wave impedance concept	14
0.3. Impedance concept for an electrical transmission line and an analogy with quantum wave impedance	17
0.4. Advantages of an impedance concept	19
0.5. Application of quantum wave impedance	21
0.6. A non-linear differential equation for quantum wave impedance	25
0.7. Scattering case	27
0.8. Transmission and reflection coefficients	29
0.9. Bound states case	32
1. APPLICATION OF QUANTUM WAVE IMPEDANCE FOR A PIECEWISE CONSTANT POTENTIAL	35
1.0. Solution for a constant value of potential energy	35
1.1. Piecewise constant potential	37
1.2. Scattering case for a piecewise constant potential	39
1.3. Bound states case for a piecewise constant potential	40
1.4. Tunelling through a single rectangular barrier. Quantum wave impedance approach	41
1.5. Tunnelling through a single rectangular barrier. Classical approach	44
1.6. Tunnelling through a single rectangular barrier. Transfer matrix approach	45
1.7. System of two symmetric barriers. An iterative approach	47
1.8. System of two symmetric wells. Quantum wave impedance function approach	50
1.9. Quantum capacitance for a single well	51

2. APPLICATION OF QUANTUM WAVE IMPEDANCE FOR SYSTEMS WITH SINGULAR ZERO-RANGE POTENTIALS	57
2.0. Singular zero-range potentials	57
2.1. Matching condition for quantum wave impedance in a case of δ -potential	59
2.2. Bound states case for a single δ -well	59
2.3. Scattering case for a single δ -barrier	61
2.4. Scattering case for a double δ -barrier potential	62
2.5. Bound states case for a double δ -well potential	63
2.6. Matching condition for quantum wave impedance in a case of a $\delta - \delta'$ -potential	65
2.7. Bound states case for a $\delta - \delta'$ potential	66
2.8. Scattering case for a $\delta - \delta'$ potential	68
2.9. Quantum wave impedance for an arbitrary combination of a piecewise constant potential and δ -potentials	69
3. APPROXIMATE CALCULATIONS AND QUANTUM WAVE IMPEDANCE	73
3.0. Approaches for approximate calculations	73
3.1. Relation between an iterative method and an equation for quantum wave impedance	75
3.2. Numerical calculations of quantum wave impedance using an iterative method	76
3.3. Characteristic and input impedances in a case of a δ -potential	77
3.4. Single parabolic barrier. Numerical technique of an iterative calculation	79
3.5. Calculation of quantum wave impedance for an arbitrary potential	82
3.6. Example of a double barrier system with a complicated geometry	85
3.7. Analytical representation of an approximate iterative calculation of quantum wave impedance	88
3.8. Double barrier/well systems. Analytical method	92
3.9. Quantum capacity for a double-well system	93
4. INFINITE PERIODIC SYSTEMS	99
4.0. Quantum wave impedance for infinite periodic media	99
4.1. Infinite Dirac comb	100
4.2. Wave functions of the Dirac comb	102
4.3. Infinite $\delta - \delta'$ comb	104
4.4. Kronig-Penney model	108

4.5. Kronig-Penney model. Classical approach	109
4.6. Kronig-Penney model. Transfer matrix approach	110
4.7. Semi-infinite systems	111
4.8. Existence condition for surface states	113
4.9. Semi-infinite system with a deformed edge	115
5. FINITE PERIODIC SYSTEMS	119
5.0. Relation between a transfer matrix and quantum wave impedance	119
5.1. Relation between a scattering matrix and a quantum wave impedance	123
5.2. Quantum wave impedance for a finite cascade of constant potentials	125
5.3. Finite periodic systems	128
5.4. Finite Dirac comb	129
5.5. Finite Dirac comb. Transfer matrix approach	132
5.6. Finite $\delta - \delta'$ comb	133
5.7. A $\delta - \delta'$ comb. Classical approach	135
5.8. Wave functions of surface states of a finite $\delta - \delta'$ comb	138
5.9. Surface states in a finite $\delta - \delta'$ comb. Classical approach . . .	139
6. DIFFERENT APPROACHES FOR FINDING ENERGIES AND WAVE FUNCTIONS OF BOUND STATES	143
6.0. The model for a comparison of different approaches	143
6.1. Relation between a Green's function and quantum wave impedance	144
6.2. Nonsymmetric well of a finite depth. Classical approach . . .	146
6.3. Nonsymmetric well of a finite depth. Transfer matrix approach	147
6.4. Nonsymmetric well of a finite depth. Quantum wave impedance approach	148
6.5. Wave functions of bound states. Classical approach	149
6.6. Wave functions of bound states. Quantum wave impedance approach	151
Conclusions	153
Bibliography	156