

CONTENT

| | |
|---|-----------|
| Content..... | 1 |
| Resum | 4 |
| RESUMEN..... | 4 |
| ABSTRACT..... | 5 |
| ACKNOWLEDGEMENTS..... | 6 |
| CHAPTER 1: Introduction | 7 |
| Chapter 2: Objectives..... | 9 |
| Chapter 3: Power quality..... | 11 |
| 3.1. Definition | 11 |
| 3.2. Price for the low power quality..... | 11 |
| 3.3. Voltage quality..... | 12 |
| 3.4. Classes of power quality problems..... | 12 |
| 3.4.1 Transients..... | 14 |
| 3.4.2 Impulsive transients..... | 14 |
| 3.4.3 Oscillatory transients..... | 14 |
| 3.4.4 Voltage sags (dips) | 15 |
| 3.4.5. Voltage swells..... | 16 |
| 3.4.6. Undervoltages | 16 |
| 3.4.7. Long-duration overvoltages..... | 17 |
| 3.4.8. Sustained Interruption..... | 18 |
| 3.4.9. Voltage unbalance..... | 18 |
| 3.4.10. DC Offset | 19 |
| 3.4.11. Current harmonics..... | 19 |
| 3.4.12. Voltage harmonics..... | 21 |
| 3.4.13. Interharmonics | 21 |
| 3.4.14. Notching | 21 |
| 3.4.15. Noise..... | 22 |
| 3.4.16. Voltage fluctuations (flicker) | 22 |
| 3.4.17. Power frequency variations..... | 22 |
| Chapter 4: Remote laboratories..... | 24 |

| | | |
|--|---|-----------|
| 4.1. | Introduction to the remote laboratories..... | 24 |
| 4.2. | A typology of Internet accessible labs | 25 |
| 4.2.1. | Real-Virtual labs | 25 |
| 4.2.2. | Architecture | 26 |
| 4.3. | Remote laboratories on the Internet | 26 |
| Chapter 5: Components of remote power quality laboratory..... | | 33 |
| 5.1. | Power supply | 33 |
| 5.2. | Automation platform, the 24 V power supply and network card,..... | 34 |
| 5.3. | Contactors..... | 35 |
| 5.4. | Measuring transformers..... | 36 |
| 5.5. | Measuring equipment..... | 37 |
| 5.6. | Web-cam..... | 38 |
| 5.7. | Illumination | 39 |
| CHEAPTER 6: Disturbance plants..... | | 40 |
| 6.1. | Linear load | 41 |
| 6.2. | Single Phase Bridge Rectifier..... | 44 |
| 6.3. | Three-Phase Bridge Rectifier..... | 47 |
| 6.4. | Energy-saving lights..... | 48 |
| 6.5. | PC power source..... | 52 |
| CHEAPTER 7: Upgrade of the laboratory..... | | 55 |
| 7.1. | Plug..... | 55 |
| 7.2. | Variable speed drives..... | 56 |
| 7.3. | Three-phase transformer..... | 58 |
| CHEAPTER 8: Configuration and programation..... | | 61 |
| 8.1. | Programming of the PLC..... | 62 |
| 8.2. | Programming in Ladder language. | 64 |
| 8.3. | Programming of the web interface..... | 66 |
| CHEAPTER 9: Measuring software | | 69 |
| 9.1. | SMS 1500..... | 69 |
| 9.2. | Web interface | 71 |
| CHEAPTER 10: Possible future upgrade..... | | 74 |
| CHEAPTER 11: Conclusions..... | | 76 |
| CHEAPTER 12: References..... | | 77 |
| 12.1. | Main references | 77 |
| 12.2. | Consulting references | 78 |

Annexes

- Annex A: Planes
- Annex B: Budget
- Annex C: PLC program in LD
- Annex D: Variables
- Annex E: UNE-EN 50160
- Annex F: Datasheet Altivar 21
- Annex G: I/O TSX Micro
- Annex H: Webpage code