

Table of Contents

1 Introduction

1.1 Purpose and Scope	1-1
1.2 Background Information	1-1
1.3 General Information	1-1
1.4 Organization	1-3
1.5 Requirements Terminology	1-4
1.6 Requirement Labeling Conventions	1-4
1.6.1 Numbering of Requirement and Related Objects	1-5
1.6.2 Requirement, Conditional Requirement, and Objective Identification	1-5

2 Overview

2.1 General	2-1
2.2 Powering ONUs in FITL System	2-1
2.2.1 Centralized Power Systems	2-2
2.2.2 Local Power Systems	2-3
2.3 Electrical Safety and Protection Issues	2-4
2.3.1 Electrical Safety in GR-1089-CORE	2-4
2.3.2 National Electrical Safety Code (NESC)	2-5
2.3.3 National Electrical Code (NEC)	2-6
2.3.3.1 Article 800	2-7
2.3.3.2 Article 820	2-7
2.3.3.3 Article 830	2-7
2.3.3.4 Class 3 Limit in NEC Article 725	2-9
2.3.4 Power Limitations in GR-1089-CORE	2-9
2.3.5 Listing Standards and Requirements	2-10
2.3.6 Electrical Surge Protection	2-10
2.3.6.1 Centrally and Locally Powered Systems	2-10
2.3.6.2 Coaxial Powered Systems	2-12
2.4 Powering Architectures	2-13
2.4.1 Centralized Power Systems Issues	2-13
2.4.1.1 Central Powering - Option 1	2-13
2.4.1.2 Central Powering - Option 2	2-14
2.4.2 Local Power Systems Issues	2-15
2.4.2.1 Local Powering – Option 1 for TLEs at Remote Sites	2-16
2.4.2.2 Local Powering – Option 2 for TLEs at Remote Sites	2-17
2.4.2.3 Local Powering – Option 3 for TLEs at Remote Sites	2-18
2.4.2.4 Local Powering – Option 4 for TLEs at Customer Premises	2-19
2.4.2.5 Local Powering – Option 5 for TLEs at Customer Premises	2-20
2.4.3 Powering Using Coaxial Cable Plant	2-21
2.4.3.1 DC Powered Systems	2-21
2.4.3.2 AC Powered Systems – Shared Battery	2-22
2.4.3.3 AC Powered Systems – Local Battery	2-23
2.4.4 Batteries	2-24
2.5 Power Alarm Capability and System Load Shedding	2-26

3 General, Electrical, and Physical Requirements

3.1	General Design Considerations	3-1
3.1.1	Implementation	3-1
3.1.2	Fail-Safe Design	3-1
3.1.3	Open Architecture	3-2
3.2	General Requirements	3-2
3.2.1	Sample Size and Test Procedure	3-2
3.2.2	Product Samples	3-2
3.2.3	Product Changes	3-3
3.2.4	Documentation	3-3
3.2.5	Training Requirements	3-3
3.2.6	Marking of Components	3-4
3.2.7	Sparing	3-4
3.2.8	Marking, Packaging, and Shipping	3-4
3.2.9	Paint	3-4
3.2.10	Materials	3-5
3.2.11	Quality	3-5
3.3	Engineering, Installation, and Maintenance	3-6
3.3.1	Code Compliance	3-6
3.3.2	Protection and Hazards	3-6
3.3.3	Fault Tolerance	3-7
3.3.3.1	Centralized Power Systems	3-7
3.3.3.2	Local Power Systems	3-7
3.3.4	Power Interruption	3-7
3.3.5	Toxic Materials	3-8
3.3.6	Powering System Reliability	3-8
3.3.6.1	Batteries	3-8
3.3.6.2	Centralized Power Systems	3-8
3.3.6.3	Local Power Systems	3-8
3.3.7	Human Factors	3-8
3.4	Physical Requirements	3-9
3.4.1	Temperature and Humidity	3-9
3.4.2	Shock During Transportation and Storage	3-9
3.4.3	Altitude	3-9
3.4.4	Heat Dissipation and Release	3-10
3.4.5	Fire Resistance	3-10
3.4.6	Equipment Handling	3-10
3.4.7	Earthquake, Office Vibration, and Transportation Vibration	3-10
3.4.8	Airborne Contaminants	3-10
3.4.9	Acoustic Noise	3-11
3.4.10	Enclosures	3-11
3.4.10.1	Centralized Powering Systems	3-11
3.4.10.2	Local Powering Systems	3-11
3.4.11	Equipment in Enclosures	3-11
3.4.12	Heating/Cooling	3-12
3.5	Electrical Requirements	3-12
3.5.1	Dielectric Withstand	3-12
3.5.2	Insulation Resistance	3-12
3.6	Electromagnetic Compatibility and Electrical Safety Criteria	3-13
3.6.1	Electrostatic Discharge	3-18

3.6.2	Electrical Fast Transients (EFTs)	3-18
3.6.3	Electromagnetic Interference	3-19
3.6.4	Lightning and AC Power Faults	3-19
3.6.5	Steady-State Power Induction	3-20
3.6.6	DC Potential Difference	3-21
3.6.7	Electrical Safety	3-21
3.6.8	Corrosion	3-21
3.6.9	Grounding	3-21
3.7	Electrical Surge Protection for Centralized and Local Powering	3-22
3.7.1	Protector Reset	3-23
3.7.2	Option 1	3-23
3.7.3	Option 2	3-25

4 Centralized Powering Requirements

4.1	Power Source Subsystem Requirements	4-1
4.2	Standby Engine-Alternator Connection	4-3
4.3	Power Source Battery Requirements	4-6
4.3.1	CO Battery Requirements	4-6
4.3.2	Confined Location Battery Requirements	4-6
4.3.3	Uncontrolled Environment Battery Life Requirements	4-7
4.3.4	Low-Voltage Disconnect	4-7
4.3.5	Battery Charging Current Limit	4-7
4.3.6	Thermal Runaway Detection and Control	4-8
4.3.7	Reserve Requirements	4-8
4.3.8	Battery Heaters	4-8
4.4	Power Source Rectifier Requirements	4-8
4.4.1	CO Rectifiers	4-8
4.4.2	Confined Location Rectifiers	4-8
4.5	Power Source Converter Input Requirements	4-9
4.5.1	Input Voltage Requirements for Power Source Converter	4-9
4.5.2	Current Limit	4-9
4.5.2.1	Start Operation	4-9
4.5.2.2	Continuous Operation	4-10
4.5.2.3	Overload Current	4-11
4.5.3	Efficiency	4-11
4.5.4	Noise Returned by the Power Source Converter (Noise Emission)	4-11
4.5.4.1	Voice Frequency Noise Emission	4-12
4.5.4.2	Wideband Frequency Noise Emission	4-12
4.5.4.3	Broadband Noise Emission	4-12
4.5.5	Converter Power Input Noise Immunity	4-13
4.5.5.1	Voice Frequency Noise Immunity	4-13
4.5.5.2	Wideband Frequency Noise Immunity	4-14
4.5.5.3	Broadband Noise Immunity	4-14
4.6	Power Source Converter Output Requirements	4-14
4.6.1	Output Voltage Requirement	4-15
4.6.2	Output Power and Current Limitations	4-15
4.6.3	Output Noise Emission	4-16
4.6.3.1	Voice Frequency Noise Emission	4-17
4.6.3.2	Wideband Frequency Noise Emission	4-17
4.6.3.3	Broadband Noise Emission	4-17

- 4.6.4 Output Noise Immunity 4-18
 - 4.6.4.1 Voice Frequency Noise Immunity 4-18
 - 4.6.4.2 Wideband Frequency Noise Immunity 4-18
 - 4.6.4.3 Broadband Noise Immunity 4-19
- 4.6.5 Power Source Foldback Requirements 4-19
- 4.7 Power Source Fault Detection and Alarms 4-20
 - 4.7.1 Test Points 4-20
 - 4.7.2 Power Source Alarms 4-20
- 4.8 Additional Requirements for Parallel Power Architectures 4-23
 - 4.8.1 Dielectric Withstand and Insulation Resistance 4-30
 - 4.8.2 Power Limitation Requirement 4-31
 - 4.8.3 Electrical Safety Requirement 4-32
 - 4.8.4 Open Conductor Requirement 4-33
 - 4.8.5 Reverse Conductor Requirement 4-36

5 Local Powering Requirements

- 5.1 AC Interface Unit (ACIU) - General Description 5-3
 - 5.1.1 ACIU Input Requirements 5-3
 - 5.1.1.1 Input Voltage 5-3
 - 5.1.1.2 Efficiency 5-4
 - 5.1.1.3 Electrical Surge Protection at the AC Input of ACIU 5-4
 - 5.1.1.4 Lightning Surge Tests 5-5
 - 5.1.1.5 Overcurrent Protection 5-5
 - 5.1.2 ACIU Output Requirements 5-6
 - 5.1.2.1 Output Voltage 5-6
 - 5.1.2.2 Internal Overvoltage Shutdown 5-6
 - 5.1.2.3 Output Power and Current Limitations 5-6
 - 5.1.2.4 ACIU Output Noise Emission 5-7
 - 5.1.2.5 ACIU Foldback Requirements for Local Option 2 5-7
 - 5.1.3 Local Battery Requirements 5-9
 - 5.1.3.1 Battery Reserve 5-9
 - 5.1.3.2 Backup Power Source Reserve Time Demonstration 5-10
 - 5.1.3.3 Extended Outages 5-10
 - 5.1.3.4 Battery Recharge Time 5-10
 - 5.1.3.5 Battery Maintenance and Replacement 5-10
 - 5.1.3.6 Battery Safety 5-11
 - 5.1.4 ACIU Alarms and Indications 5-11
- 5.2 Network Termination Unit (NTU) Requirements 5-11
 - 5.2.1 General Requirements 5-12
 - 5.2.2 Electrical Surge Protection 5-12
 - 5.2.3 Surge Tests on NTU Powering Conductors 5-13
 - 5.2.3.1 First Level Surge Test 5-13
 - 5.2.3.2 Second Level Surge Test 5-14

6 Coaxial Powering Requirements

- 6.1 DC Powered Coaxial System 6-1
 - 6.1.1 AC Input Power Sources 6-1
 - 6.1.1.1 Standby Engine-Alternator Connection 6-2
 - 6.1.1.2 Power Source Battery Requirements 6-5
 - 6.1.1.3 Power Source Rectifier Requirements 6-7



- 6.1.1.4 Power Plant Capacity 6-8
- 6.1.2 DC Input Power Sources 6-8
 - 6.1.2.1 Input Voltage Requirements 6-8
 - 6.1.2.2 Current Limit 6-8
 - 6.1.2.3 Efficiency 6-10
 - 6.1.2.4 Noise Returned by the Power Source 6-11
 - 6.1.2.5 Wideband Frequency Noise Emission 6-11
 - 6.1.2.6 Broadband Noise Emission 6-12
- 6.1.3 Power Source Output 6-12
 - 6.1.3.1 Output Voltage Requirements 6-13
 - 6.1.3.2 Output Power and Current Limitations 6-13
 - 6.1.3.3 Power Source Foldback Requirements 6-14
 - 6.1.3.4 Power Source Fault Detection and Alarms 6-16
- 6.2 Shared Battery AC Power System-Coaxial Cable 6-18
 - 6.2.1 Power System Requirements 6-19
 - 6.2.2 Battery Requirements 6-20
 - 6.2.3 Power Plant and Feeder Capacity 6-20
- 6.3 Local Battery AC Power System - Coaxial Cable 6-20
 - 6.3.1 AC Input Voltage 6-21
 - 6.3.2 Electrical Surge Protection at the Input of Transformer 6-21
 - 6.3.3 Lightning Surge Tests 6-21
 - 6.3.4 Overcurrent Protection 6-22
 - 6.3.5 Stepdown and Control 6-22
- 6.4 Electrical Surge Protection on Coaxial Cable System 6-23

Appendix A: References

Appendix B: Acronyms

Requirement-Object Index

List of Figures

Figure 2-1	Generic FITL System	2-2
Figure 2-2	Generic FITL System With Centralized Powering	2-3
Figure 2-3	Generic FITL System With Local Powering	2-4
Figure 2-4	Electrical Protection and Grounding of Centralized Powering System	2-12
Figure 2-5	Generic Centralized Powering System: Option 1 - Single 100 VA Source	2-14
Figure 2-6	Centralized Powering — Option 2, Parallel Powering	2-15
Figure 2-7	Local Powering: Option 1 – Power From Customer's Premises	2-17
Figure 2-8	Local Powering: Option 2 – Power From Utility Pole	2-18
Figure 2-9	Local Powering: Options 3 and 5 – AC Direct to TLE	2-19
Figure 2-10	Local Powering: Option 4 – AC From Branch Circuit Direct to TLE	2-20
Figure 2-11	DC Powering on Coaxial Cable	2-22
Figure 2-12	AC Power on Coaxial Cable – Shared Battery	2-23
Figure 2-13	AC Power on Coaxial Cable – Local Battery	2-24
Figure 2-14	Temperature Zones for Battery-Life Requirement	2-26
Figure 3-1	Interface Classification for the Centralized Power Source	3-15
Figure 3-2	Interface Classification for the TLE Using the Parallel Power Option	3-16
Figure 3-3	Interface Classification for the Local Power Source (ACIU)	3-16
Figure 3-4	AC Interface Unit Grounding and Protection	3-22
Figure 3-5	Test Procedure for Option 1 Protector Reset	3-25
Figure 4-1	Generic Centralized Powering System: Option 1—Single 100 VA Source	4-1
Figure 4-2	Example of a Centralized Power Source Architecture	4-2
Figure 4-3	Centralized Powering—Option 2, Parallel Powering (Generic View)	4-3
Figure 4-4	Alternate Engine-Alternator as a Separately-Derived System (Only single phase is shown for simplicity)	4-5
Figure 4-5	Alternate Engine-Alternator as a Non-Separately-Derived System (Only single phase is shown for simplicity)	4-6
Figure 4-6	Short-Circuit Tests on Converter Output	4-10
Figure 4-7	Quantities Related to Noise Emission	4-13
Figure 4-8	Typical Overcurrent Foldback Curve	4-19
Figure 4-9	Test Circuit for Determining Volt-Amperes Characteristics	4-20
Figure 4-10	Alarm Voltage States	4-22
Figure 4-11	Example of Parallel Power Architecture — Independent Power Supply Approach	4-25
Figure 4-12	Example of Parallel Power Architecture — Single Power Supply With a Separate PIDE Approach	4-26
Figure 4-13	Example of Parallel Power Architecture — Single Power Supply With an Integrated PIDE Approach	4-27
Figure 4-14	Example of Parallel Power Architecture — Independent Load Converters Approach	4-28
Figure 4-15	Example of Parallel Power Architecture — Single Load Converter With a Separate PICE Approach	4-28

Figure 4-16 Example of Parallel Power Architecture — Single Load Converter With an Integrated PICE Approach 4-29

Figure 4-17 Definition of a Remote Power Circuit 4-30

Figure 4-18 Test Circuit for Power Limitation for Parallel Power Architecture 4-32

Figure 4-19 Test Circuit for Source Limits 4-33

Figure 4-20 Test Circuit for Open Conductor Requirement 4-34

Figure 4-21 Test Circuit for the Transient Source Test 4-35

Figure 4-22 Test Circuit for the Transient Source Test 4-37

Figure 5-1 Local Powering: Option 1 - Power From One Customer's Premises 5-1

Figure 5-2 Local Powering: Option 2 - Power From Utility Pole 5-2

Figure 5-3 Local Powering: Option 4 - AC From Branch Circuit Direct to TLE 5-3

Figure 5-4 Typical Overcurrent Foldback Curve 5-8

Figure 5-5 Test Circuit for Determining Volt-Amperes Characteristics 5-9

Figure 5-6 Impulse Reset Test Circuit 5-13

Figure 5-7 Circuit for Surge Test With Short-Circuited Subscriber End 5-15

Figure 5-8 Circuit for Surge Test With Open-Circuited Subscriber End 5-15

Figure 6-1 DC Powering on Coaxial Cable - AC Input 6-2

Figure 6-2 DC Powering on Coaxial Cable - DC Input 6-2

Figure 6-3 Alternate Engine-Alternator as a Separately-Derived System (Only single phase is shown for simplicity) 6-4

Figure 6-4 Alternate Engine-Alternator as a Non-Separately-Derived System (Only single phase is shown for simplicity) 6-5

Figure 6-5 Short-Circuit Tests on Converter Output 6-9

Figure 6-6 Quantities Related to Noise Emission 6-12

Figure 6-7 Typical Overcurrent Foldback Curve 6-15

Figure 6-8 Test Circuit for Determining Volt-Amperes Characteristics 6-15

Figure 6-9 Alarm Voltage States 6-17

Figure 6-10 AC Power on Coaxial Cable - Shared Battery 6-19

Figure 6-11 AC Power on Coaxial Cable - Local Battery 6-20

List of Tables

Table 1-1	AC Voltage Requirements for Class B Systems	1-2
Table 1-2	DC Voltage Requirements for Class A and AB Systems	1-2
Table 2-1	Limitations for Network-Powered Broadband Communications Systems	2-8
Table 2-2	NEC Class 3 Limits for DC Voltages for Inherently Limited Sources	2-9
Table 2-3	Surge Protective Devices for LEC Use at TLE for Option 2	2-11
Table 3-1	Electrical Isolation - Test Voltages	3-12
Table 3-2	Applicable GR-1089 Criteria to the Whole Power System Equipment	3-13
Table 3-3	Applicable GR-1089 Criteria for Power System Equipment Ports	3-17
Table 4-1	Battery Life for Each Latitude Zone	4-7
Table 4-2	Input Voltage Limits	4-9
Table 4-3	Power Source Output Voltage Requirements	4-15
Table 4-4	Output Power and Current Limitations	4-16
Table 4-5	Alarm Terminations	4-20
Table 4-6	Alarm Requirements	4-22
Table 5-1	Output Voltage Requirements of the ACIU	5-6
Table 5-2	Output Power and Current limitation of the ACIU	5-7
Table 5-3	ACIU Alarms and Indications	5-11
Table 5-4	First Level Surge Test Values	5-14
Table 5-5	Second Level Surge Test Values	5-14
Table 6-1	Battery Life for Each Latitude Zone	6-6
Table 6-2	Input Voltage Limits	6-8
Table 6-3	Power Source Output Voltage Requirements	6-13
Table 6-4	Output Power and Current Limitations	6-14
Table 6-5	Alarm Terminations	6-16
Table 6-6	Alarm Requirements	6-18

