PROTECTION ENGINEERS GROUP

HUNTSVILLE, AL - MARCH 13-15, 2018

IEEE Wire-Line Subcommittee Update

Presented by:
John E. Fuller
Principal Design Engineer
AT&T Services
Technology Planning and Engineering

IEEE Wire-Line Subcommittee (WLS) Update-Overview

- Committee structure
- Scope
- Liaisons
- Recent publications
- Key changes to requirements
- Real-world implementation challenges

Current WLS Membership:

John Fuller, *Chair* **Ernie Gallo**, Vice-*Chair* **Joe Boyles**, *Secretary*

Dan Ashton	Jean De Sève	Dan Jendek	Henry Randolph
Ron Baysden	Ernest Duckworth	Del Khomarlou	Rudy Sadkowski
Steven Blume	Lurch Farley	Richard Knight	Mark Tirio
David Boneau	Russ Gundrum	Randall Mears	Thomas Vo
Timothy Conser	Dave Hartmann	Percy Pool	Larry Young
Bhimesh Dahal	Bob Heinlin		

Wire-Line Subcommittee – Hierarchy in IEEE

- Dielectrics and Electrical Insulation Society
- Industrial Electronics Society
- Industry Applications Society
- Power Electronics Society
- Power & Energy Society

Wire-Line Subcommittee - Hierarchy

Power & Energy Society (PES) has 17 Technical Committees, including

- Surge Protective Devices, SPD (Ron Hotchkiss, Chair)
- …
- Power System Communications and Cybersecurity Committee, PSCC (Mike Dood, Chair)

Wire-Line Subcommittee - Hierarchy

Power System Communications and Cybersecurity (PSCC)

- Power Line Carrier
- Cybersecurity
- Fiber Optic Communications
- Protocols and Architecture
- Wireless (two-way radio, microwave, etc.)

- **Wire Line Communications including all circuit types and facilities,**

a.k.a. Wire-Line Subcommittee, or WLS

Wire-Line Subcommittee – Scope

Wire-Line Subcommittee (SC-6) Scope and Mission:

Establish methods and suggest practices for the protection and use of all forms of single or multipurpose wire line communication systems which serve electric power systems or which are otherwise subjected to the influence of the power system or lightning. (Communications systems may be defined in this instance as the media, whether owned or leased, for the transmittal of any form of intelligence.)

Develop and maintain related Standards, Recommendations and Guides.

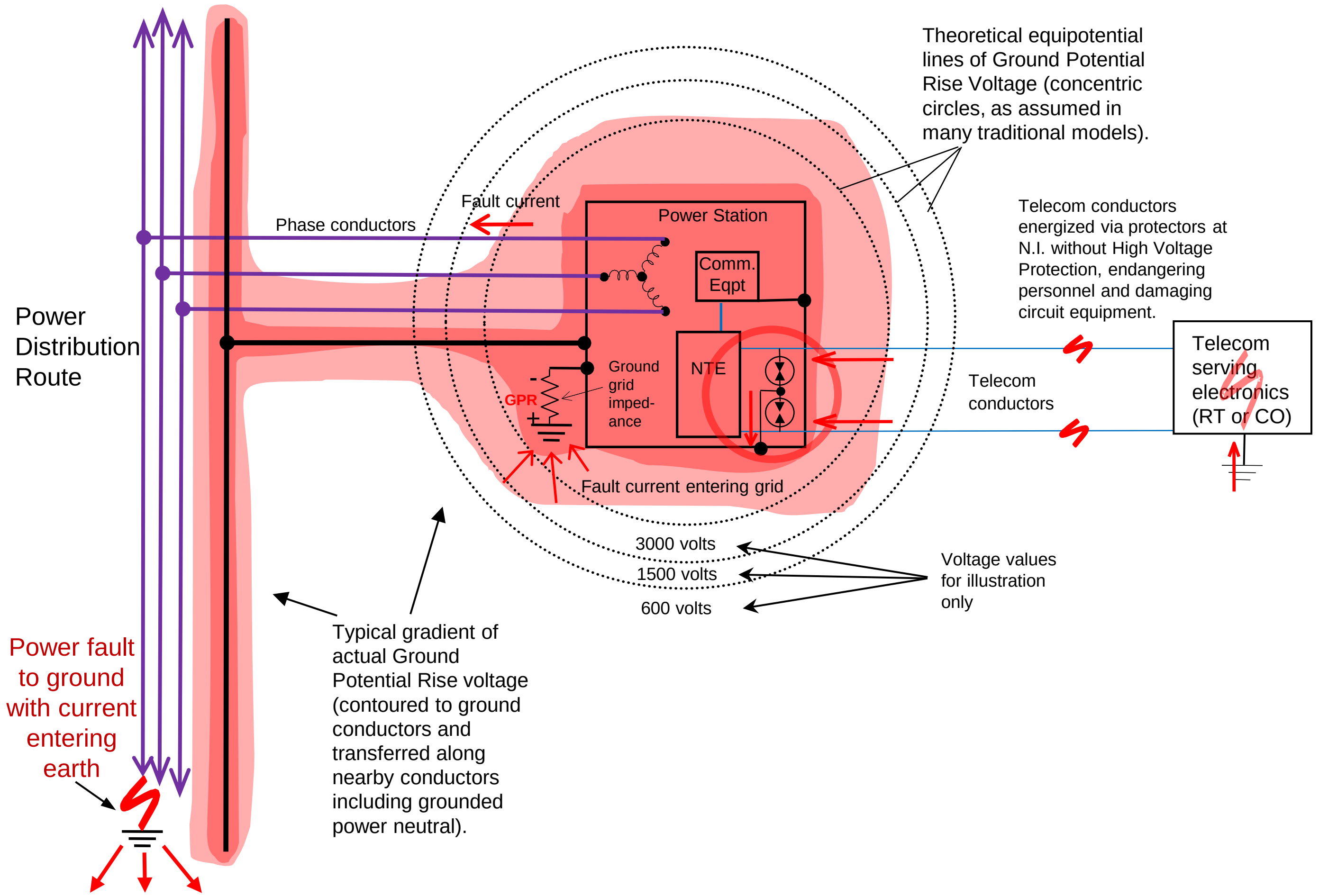
Coordinate with other technical committees, groups, societies and associations as required.

Wire-Line Subcommittee – Scope (cont'd)

Coordinate with other technical committees, groups, societies and associations as required:

- Liaison to Fiber Optic Subcommittee
- Coordinate Std. 525 *IEEE Guide for the Design and Installation of Cable Systems in Substations* update with Substations Committee D2
- Sponsor IEEE Principal seat for NFPA 70 (NEC) Code Making Panel 16
- Current Principal: Bill McCoy
  - Alternate Seat vacant

Wire-Line Subcommittee – Power GPR



Wire-Line Subcommittee Documents

Std.	Year	Title	Status
367	2012	Recommended Practice for Determining the Electric Power Station Ground Potential Rise and Induced Voltage from a Power Fault	Current
487	2015	Standard for the Electrical Protection of Communication Facilities Serving Electric Supply Locations - General Considerations	Current
487.1	2014	Standard for the Electrical Protection of Communication Facilities Serving Electric Supply Locations Through the Use of On-Grid Isolation Equipment.	Current
487.2	2013	Standard for the Electrical Protection of Communication Facilities Serving Electric Supply Locations Through the Use of Optical Fiber Systems.	Current
487.3	2014	Standard for the Electrical Protection of Communication Facilities Serving Electric Supply Locations Through the Use of Hybrid Facilities	Current
487.4	2013	Standard for the Electrical Protection of Communication Facilities Serving Electric Supply Locations Through the Use of Neutralizing Transformers	Current
487.5	2013	Standard for the Electrical Protection of Communication Facilities Serving Electric Supply Locations Through the Use of Isolation Transformers	Current

Wire-Line Subcommittee Documents (Continued)

Std.	Year	Title	Status
776	2008	Recommended Practice for Inductive Coordination of Electric Supply and Communication Lines	**Under Revision**
789	2013	Standard Performance Requirements for Communications and Control Cables for Application in High-Voltage Environments.	**Current**
820	2010	Standard Telephone Loop Performance Characteristics	**Current**
1137	1991	Guide for the Implementation of Inductive Coordination Mitigation Techniques and Application	**Under Revision**
1692	2011	Guide for the Protection of Communication Installations from Lightning Effects	**Current**

Std. 367-2012 Scope:

This standard provides guidance for the calculation of power station ground potential rise (GPR) and longitudinal induction (LI) voltages as well as guidance for their appropriate reduction from worst-case values for use in metallic telecommunication protection design. Information is also included for the determination of the following:

- The fault current and earth return current. (The probability, waveform, and duration of these currents and the impedance to remote earthing points used in these GPR and LI calculations as well as the effective X/P ratio are discussed).
- The zone of influence (ZOI) of the power station GPR.
- The calculation of the inducing currents, the mutual impedance between power and metallic telecommunication facilities, and shield factors.
- The channel time requirements for metallic telecommunication facilities where non-interruptible channels are required for protective relaying.

Std. 487-2015 Scope:

This standard presents general consideration for special high-voltage protection systems intended to protect telecommunication facilities serving electric supply locations. This standard contains material common to all of the 487-family including basic theory and fundamental electrical protection concepts and designs.

NOTE: This Standard was one document (487 only) prior to 2013

Std. 487 Considerations

Clause 9.6 ***Specific protection configurations***

Specific protection configurations are described in detail in other standards in the IEEE 487 family of standards:

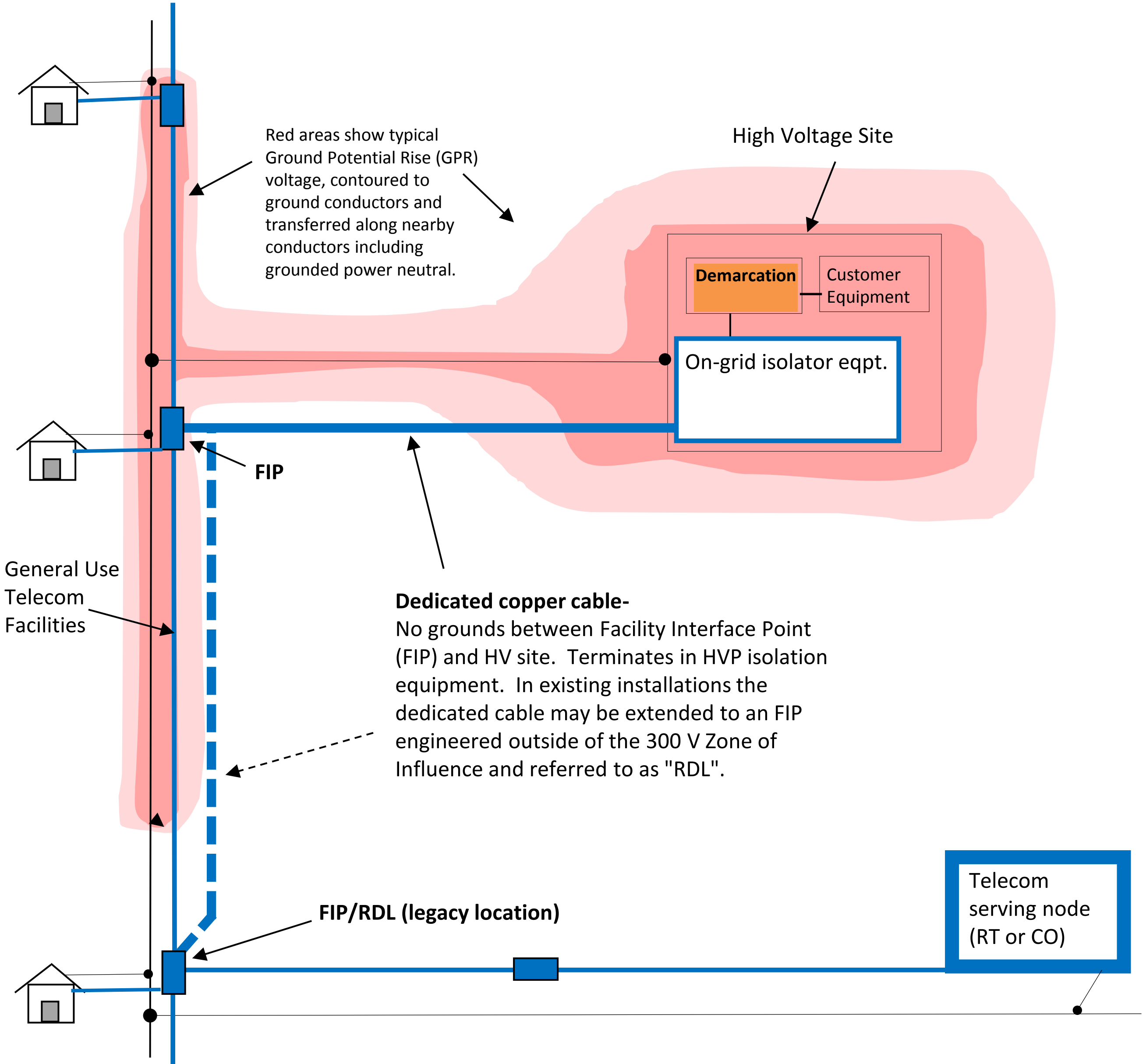
- *For protection configurations employing modular high-dielectric and modular optic isolators, refer to IEEE Std 487.1.*
- *For protection configurations employing hard-wire isolation transformers, refer to IEEE Std 487.5.*
- *For protection configurations consisting of both metallic cables and fiber cables, i.e., hybrid facilities (using metallic wire-line components in part of the telecommunications circuit and optical fiber systems in the remainder of the telecommunications circuit), refer to IEEE Std 487.3.*
- *For protection configurations consisting entirely of optical fiber cables, refer to IEEE Std 487.2.*

Std. 487.**1**-2014 Scope:

This standard presents engineering design procedures for the electrical protection of metallic wire-line communication facilities serving electric supply locations through the use of <u>on-grid</u> isolation equipment. Other telecommunication alternatives such as radio and microwave systems are excluded from this document.

NOTE: Applicable to modern isolation equipment such as Positron Teleline and SNC Lyte Lynx C-Line.

On-Grid Architecture



Std. 487.1 Considerations

- "RDL" vs. "FIP"
- "Remote Drainage Location" designated grounding point for drainage devices (Clause 6.4.2, *Remote drainage protection*)
- Facility Interface Point- New Definition appears in Std. 487.3 Clause 3.1 Definitions:

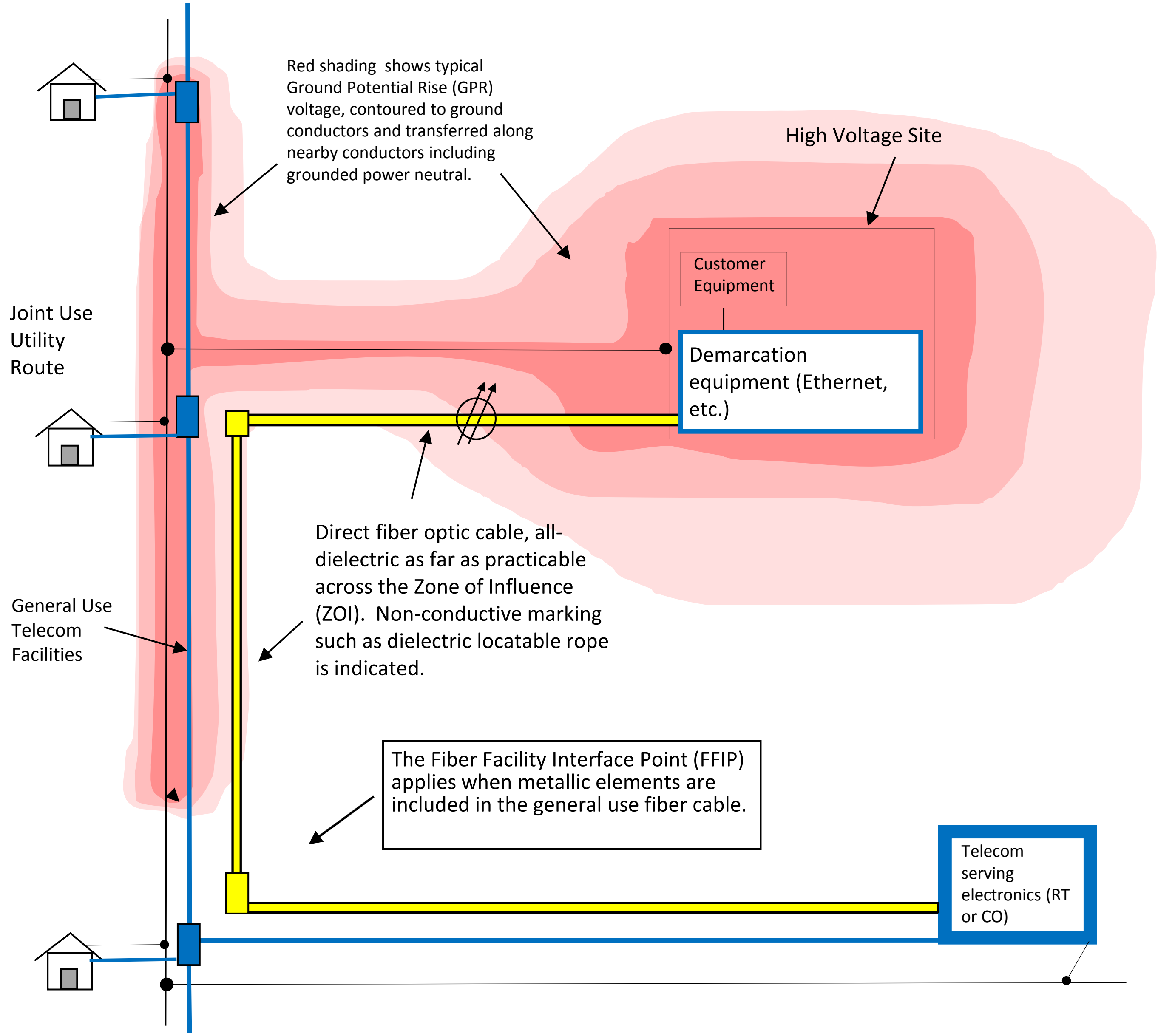
  Facility Interface Point (FIP)- *The splice point for general use cable to dedicated cable. The FIP may be located anywhere in the circuit.*

Std. 487.**2**-2013 Scope:

This standard presents engineering design procedures for the electrical protection of communication facilities serving electric supply locations through the use of optical fiber systems for the entire access facility. Other telecommunication alternatives such as radio and microwave systems are excluded from this document.

NOTE: This standard, together with 487.3-2014, replaces Std. 1590-2009 in its entirety.

Direct Fiber Architecture



Std. 487.**3**-2014 Scope:

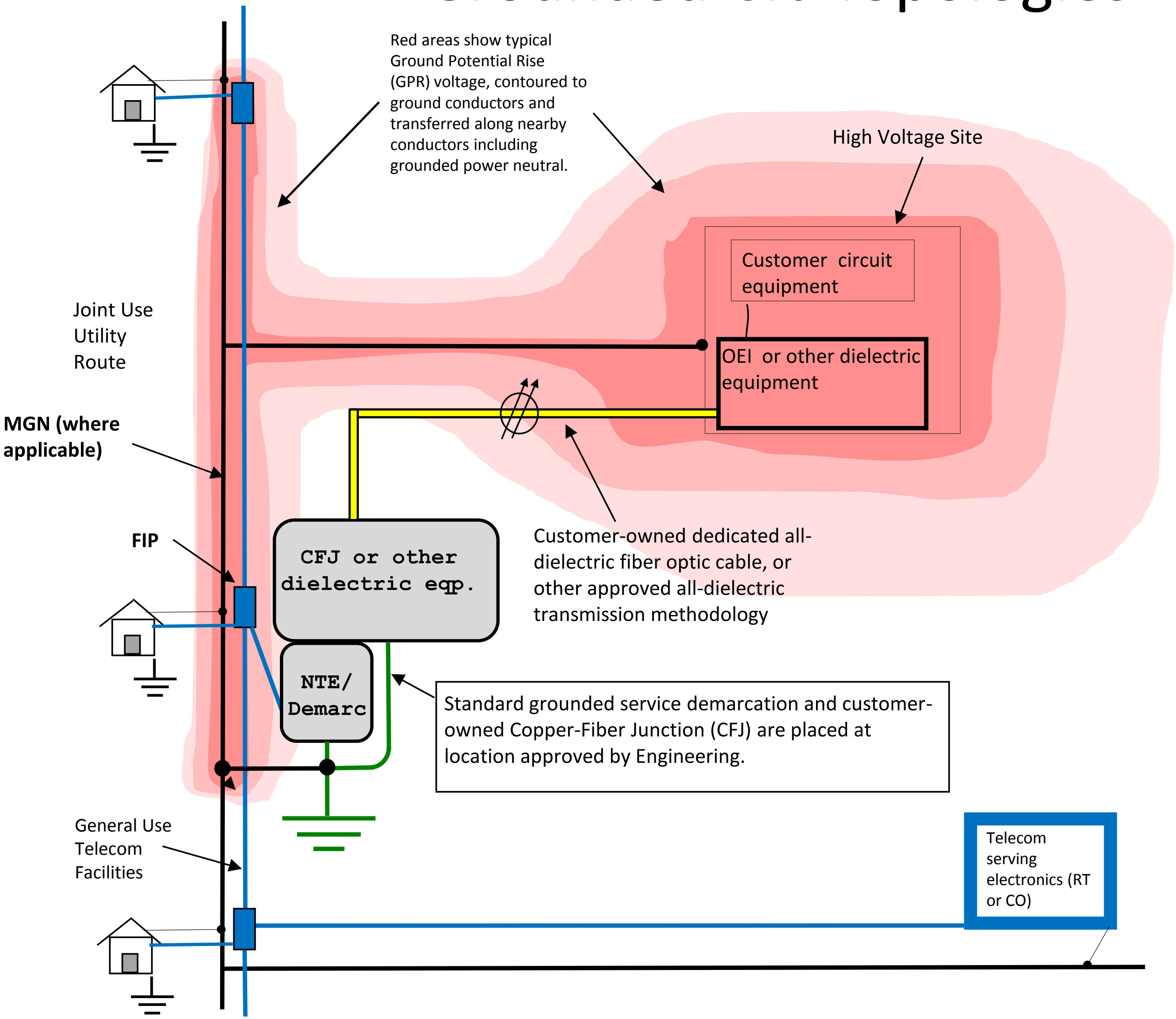
This standard presents engineering design procedures for the electrical protection of communication facilities serving electric supply locations through the use of metallic wire-line components in part of the communication circuit and optical fiber systems in the remainder of the communication circuit. Other telecommunication alternatives such as radio and microwave systems are excluded from this document.

NOTE: This standard, together with 487.2-2013, replaces Std. 1590-2009 in its entirety.

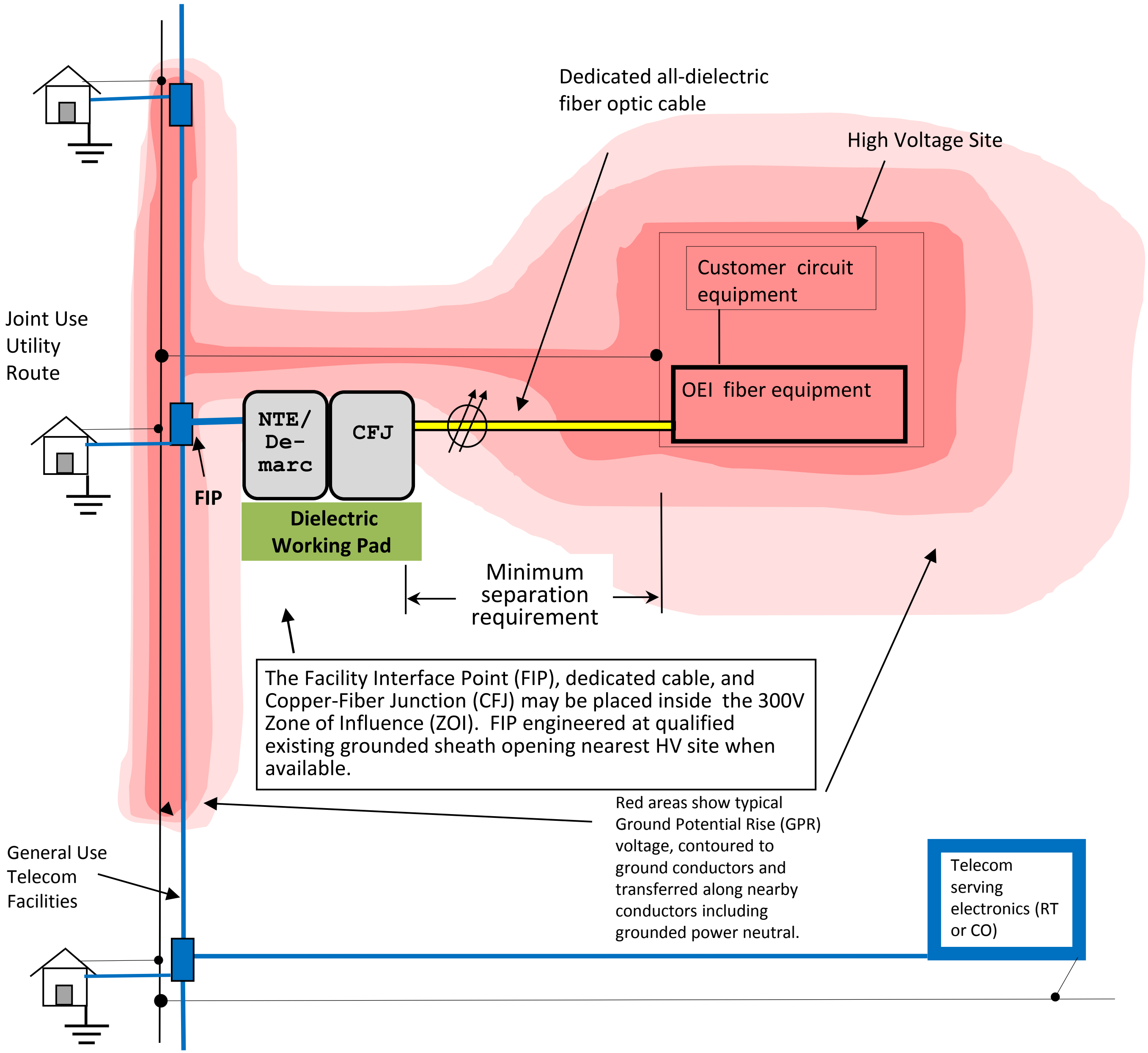
Std. 487.3 Considerations

- Grounded CFJ topologies (legacy)
- Ungrounded CFJ topologies

Grounded CFJ Topologies



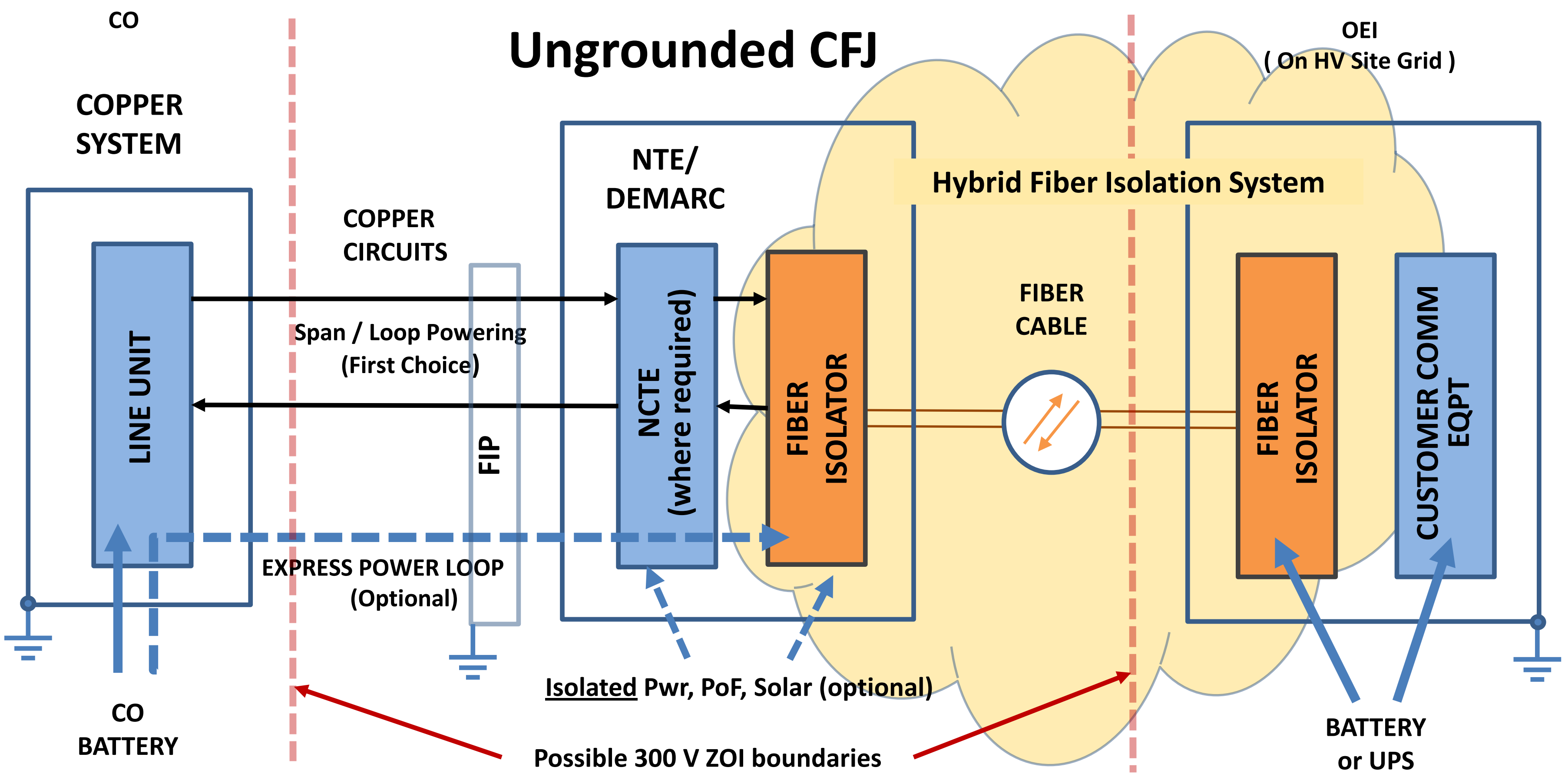
Ungrounded CFJ Topologies



Std. 487.3 Considerations

CFJ Powering options
- Solar power
- Isolation transformers
- Express Power
- No power station-referenced power

IEEE Std. 487.3-2014 CFJ Powering Options



Std. 487.**4**-2013 Scope:

This standard presents engineering design procedures for the electrical protection of communication facilities serving electric supply locations through the use of neutralizing transformers. Other telecommunication alternatives such as radio and microwave systems are excluded from this document..

NOTE: No substantive changes from the legacy 487 version (editorial items only).

Std. 487.**5**-2013 Scope:

This standard presents engineering design procedures for the electrical protection of communication facilities serving electric supply locations through the use of isolation transformers. Other telecommunication alternatives such as radio and microwave systems are excluded from this document.

NOTE: Discrete isolation transformers only (contrasted with 487.1). No substantive changes from the legacy 487 version (editorial items only).

IEEE P776d5 Scope:

This recommended practice addresses the inductive environment that exists in the vicinity of electric power and wire-line telecommunications systems and the interfering effect that may be produced thereby; guidance is offered for the control or modification of the environment and the susceptibility of the affected systems in order to maintain an acceptable level of interference. An acceptable level is defined as an amount of steady-state or surge induced longitudinal voltage or current that does not cause a personnel or public safety hazard, damage to cable or equipment, and/or circuit degradation or failure.

To aid the user of this recommended practice in calculating induction between power and telecommunication lines, the concept of an interface is developed. This recommended practice permits either party, without need to involve the other, to verify the induction at the interface by use of a probe wire. This recommended practice does not apply to railway signal circuits.

IEEE P776d5 Revisions:

- Builds on historical revisions (1992) by members of the Longitudinal Induction Working Group, including Dick Nelson, Harold Held, Bill McCoy, Charlie Nelson, Chrys Chrysanthou, and David Boneau.
- Includes revised Scope for clarity of application
- Revisions for clarity to probe wire voltage threshold tables
- Corrections to Annex B, Example Calculations
- Proposed revisions to Clause 5 to explain application of probe wire voltage tables.
- New reference, *Basics of Noise Reduction* (8-pages), referenced in 776 introduction and moved to new Annex in P1137
  - ➢ Provides mitigation basics to be applied before probe wire testing.

IEEE P776d5 Revisions (cont'd):

- Recognized need for revised modeling of exposure.
- Default and buried cable geometries are shown in the following illustrations.

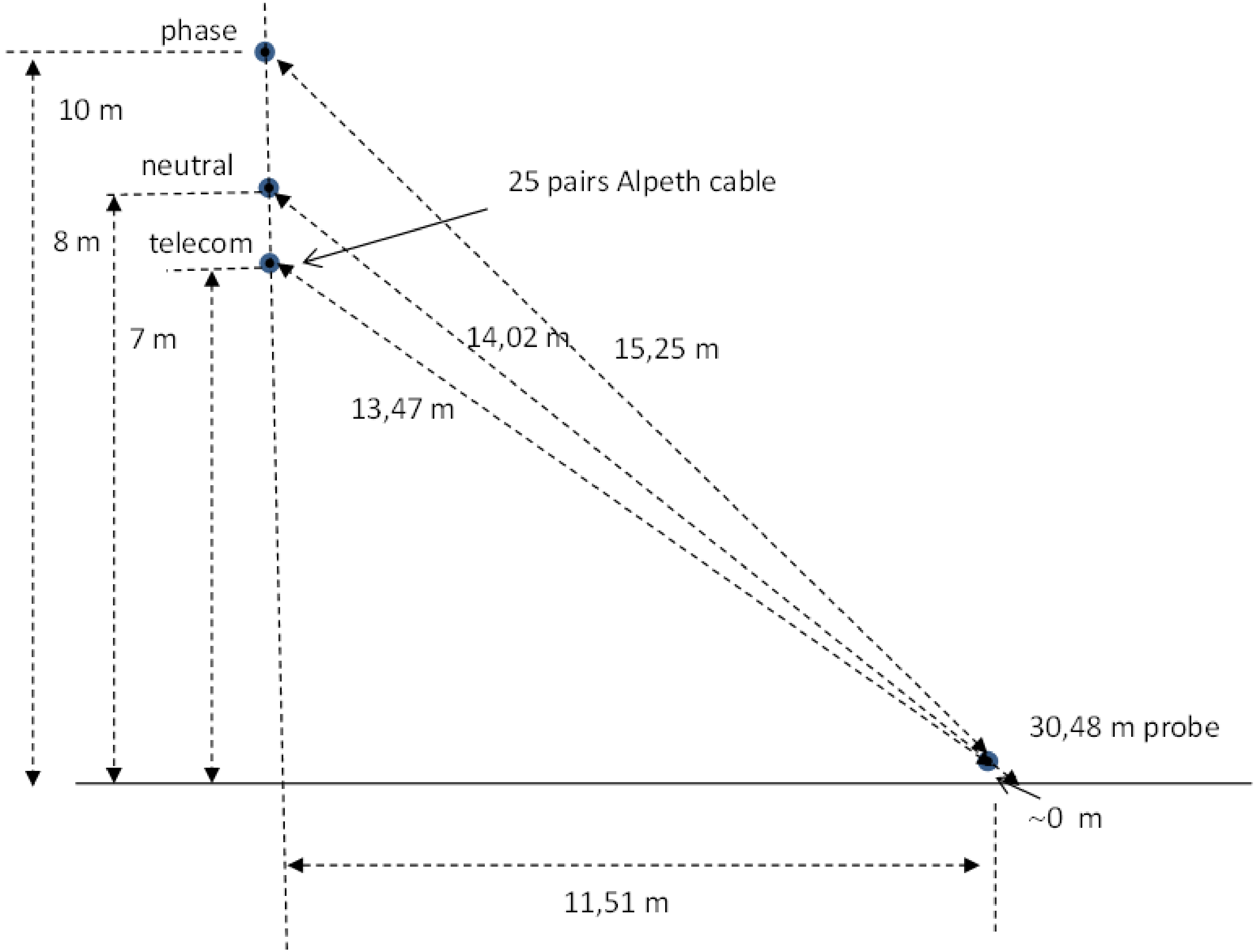


Figure 1a- Default Probe Wire Geometry (6/2017 Jean De Sève, Hydro-Québec)

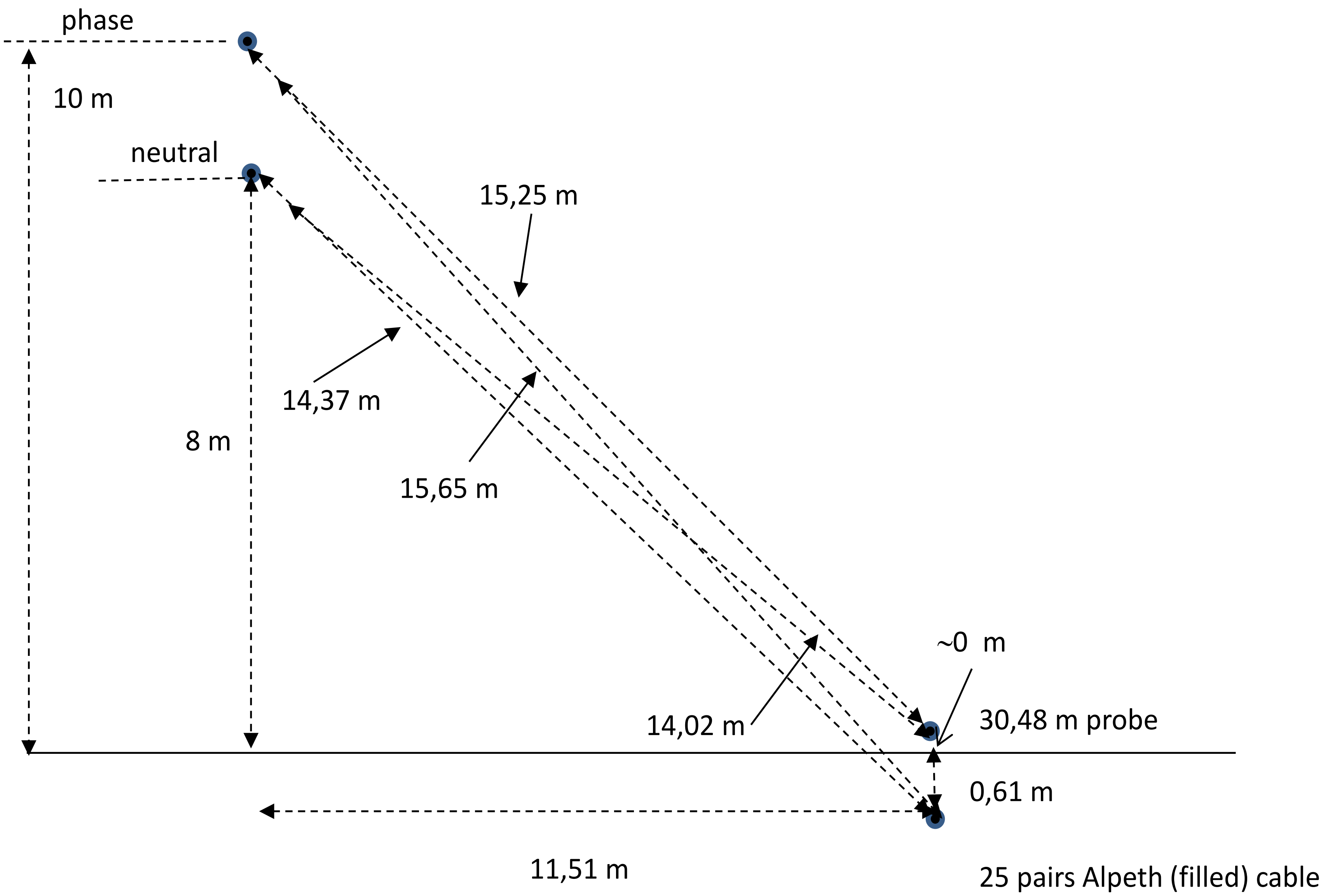
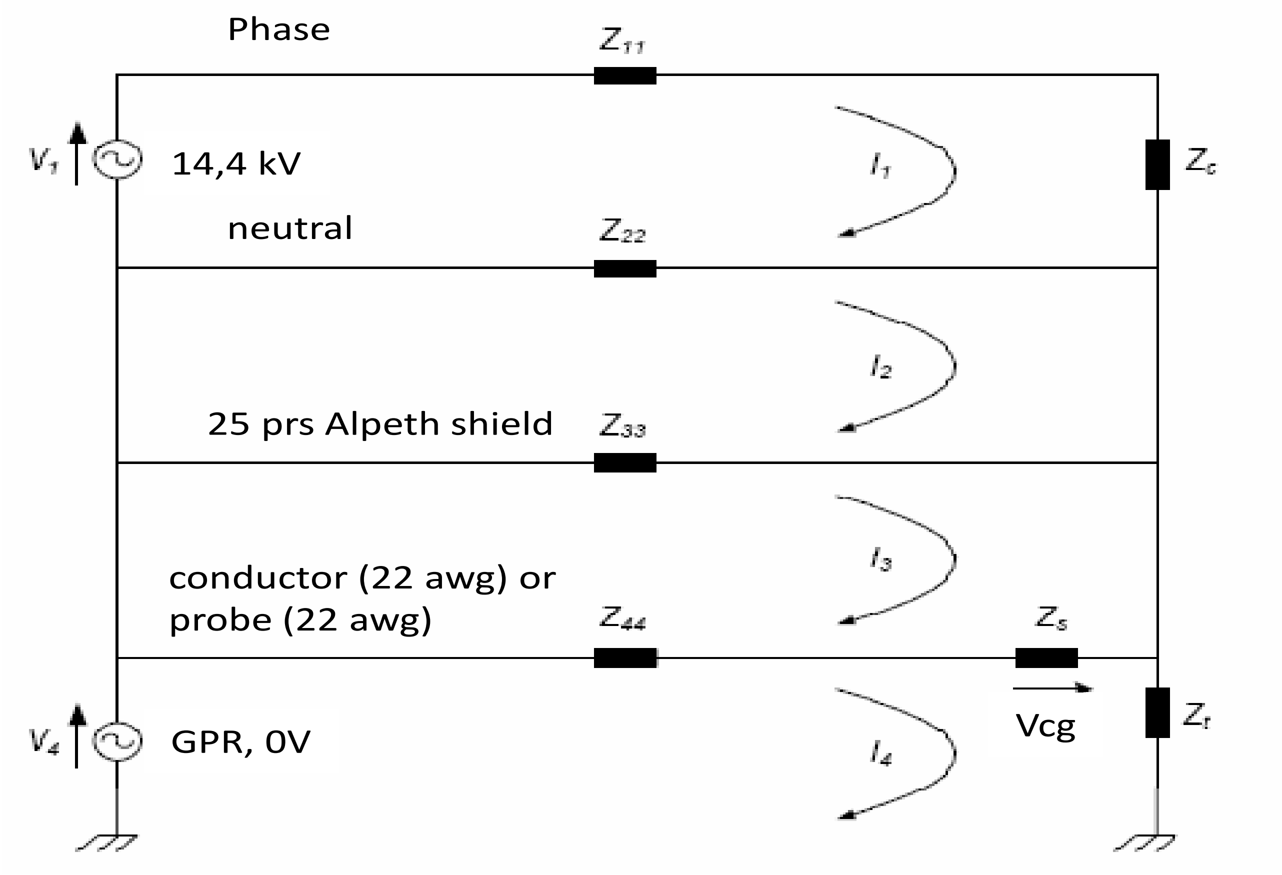


Figure 1b- Parallel underground cable model (6/2017 Jean De Sève, Hydro-Québec)



Zii : Self impedance
Zij : mutual impedance

Calculated as specified in IEEE-367-2012
(Carson's equation)

$$\begin{bmatrix} V_1 \\ 0 \\ 0 \\ V_4 \end{bmatrix} = \begin{bmatrix} Z_{11}+Z_{22}-2Z_{12}+Z_C & Z_{12}-Z_{22}-Z_{13}+Z_{23} & Z_{13}-Z_{23}-Z_{14}+Z_{24} & Z_{14}-Z_{24} \\ Z_{12}-Z_{22}-Z_{13}+Z_{23} & Z_{22}+Z_{33}-2Z_{23} & -Z_{33}+Z_{23}-Z_{24}+Z_{34} & Z_{24}-Z_{34} \\ Z_{13}-Z_{23}-Z_{14}+Z_{24} & -Z_{33}+Z_{23}-Z_{24}+Z_{34} & Z_{33}+Z_{44}-2Z_{34}+Z_S & Z_{34}-Z_{44}-Z_S \\ Z_{14}-Z_{24} & Z_{24}-Z_{34} & Z_{34}-Z_{44}-Z_S & Z_{44}+Z_S+Z_T \end{bmatrix} \bullet \begin{bmatrix} I_1 \\ I_2 \\ I_3 \\ I_4 \end{bmatrix}$$

Figure 2- Mutual Impedance Calculations (6/2017 Jean De Sève, Hydro-Québec)

IEEE P776d5 Revisions (cont'd):

Self (Zii) and mutual impedance (Zij) were calculated using Carson's equation as specified in IEEE-367-2012.

The model illustrated is used to calculate combined effects of induction and power station GPR. In this case the GPR (V4) was set to 0V.

V1 represents phase to ground voltage of the distribution power line and was set to 14.4kV (25 kV phase to phase).
Zt represents ground impedance between the substation and the fault point of a distribution line. This value is used to evaluate the GPR between the substation and the fault point of a distribution line. For modeling a steady state condition (not a fault condition), Zt was set to 0 ohm.

Zc is used to control the current in the phase conductor (I1). The phase current was set to induce 50 V on the telephone conductor (Vcg).

Zs is set to 1MΩ, to isolate the conductor (probe wire or cable conductors) in order to calculate the induced voltage on this conductor.

Calculation was done for a 25 pair 22 AWG Alpeth cable.

IEEE P776d5 Revisions (cont'd):

Problem: All modeling to date assumes aerial distribution power lines and either aerial or buried copper communications cables.

Consider the following recent real-world installation:

Underground HV transmission line and communications cable

IEEE P776d5 Revisions (cont'd):

Remaining challenge: How can higher voltage transmission lines closely paralleling underground communications be modeled?

What is the effect of the HV lines' E-field on the 100' probe wire or the paralleling cable?

- 5-10' separation
- Impact of soil resistivity

Std. 789-2013 Scope:

This standard applies to wires and cables, used principally for power system communications and control purposes, which are located within electric supply locations or are installed within the zone of influence (ZOI) of the power station ground potential rise (GPR), or which may be buried adjacent to electric power transmission and distribution lines. This standard covers the appropriate design requirements, electrical and mechanical parameters, the testing requirements, and the handling procedures for cables that are to be installed and operated in high voltage environments where they may be subjected to high voltages either by conduction, or induction coupling, or both. Coaxial and fiber optic cables, except for those used in Ethernet applications, are specifically excluded from this standard.

NOTE: Minor content and editorial changes from previous versions.

Std. 789 Considerations

- Prescribed communications cable parameters include 20 kV core-to-shield dielectric strength.
- Expense associated with ANAW and CMAW cables (double sheath)
- From 487.1 Clause 5.1: ***…In the case of leased (rented) telecommunications facilities, the use of a high dielectric dedicated cable from the electric supply location to a point outside the influence of the electric supply location ground grid shall also be considered and agreed upon if the dielectric value of a general-use type cable is determined to be inadequate.***

Selected OSP Communications Cable Properties

Recommended for HVP service / Not recommended for HVP service	AWG	Manuf.	Part/ Product Number	Core-shield Dielecric Strength (kV, as stated by mfr.)	Cond-cond Dielecric Strength (kV, as stated by mfr.)	Outer Jacket Dielectric Strength (kV, <1.29" O.D. cables)			Construction/ Sheath
						ASTM D-149 Min.	Industry Range per Polymer Encycl. Reference	Minimum per stated Manufactr. Material Properties	
BURIED CABLES									
ANAW	22	Gen. Cabl	6987572	10	3.6	34.3	21 - 47	23.5	Filled ASP/ Polyethylene
ANAW	22	Sup. Essx	22-062-83	10	3.6	34.3	21 - 47	N/A*	Filled ASP/ Polyethylene
ANMW	24	Gen. Cabl	6987705	10	3	34.3	21 - 47	23.5	Filled ASP/ Polyethylene
ANMW	24	Sup. Essx	22-097-83	10	3	34.3	21 - 47	N/A*	Filled ASP/ Polyethylene
CMAW	22	Sup. Essx	21-062-48 (Custom Ordered)	20	5	34.3	21-24	N/A*	Filled ASP/ Polyethylene
CMAW	22	Gen. Cabl	Custom Manufactured	20*	5*	34.3	21-24	23.5	Filled ASP/ Polyethylene
AERIAL CABLES									
BHAH	22	Gen. Cabl	7503543	15	5	34.3	21 - 47	23.5	PASP/ Polyethylene
BHAH	22	Sup. Essx	20-062-05	20	4	34.3	21 - 47	N/A*	PASP/ Polyethylene
BKMH	24	Gen. Cabl	7503659	15	4	34.3	21 - 47	23.5	PASP/ Polyethylene
BKMH	24	Sup. Essx	20-097-05	20	3	34.3	21 - 47	N/A*	PASP/ Polyethylene
BURIED DROPS									
BW AF 2-pair	22	Sup. Essx	25-062-86	15	5	N/A	6.3-10	N/A*	Filled corrugated 6 mil aluminum/ PVC
BW AF 5-pair	22	Sup. Essx	25-154-86	15	5	N/A	6.3-10	N/A*	Filled corrugated 6 mil aluminum/ PVC
BW GDJ 2-pair	19	Sup. Essx	25-020-79	20	7	N/A	>6.3	N/A*	Filled polyeth inner jkt, flooded corrg. armor/ PVC
BW GDJ 5-pair	22	Sup. Essx	25-553-79	20	5	N/A	>6.3	N/A*	Filled polyeth inner jkt, flooded corrg. armor/ PVC

* - Manufacturers assert compliance to Telcordia GR-421-CORE or GR-3163-CORE . Outer jacket thickness depends upon cable size.

Std. 820-2005 (R2010) Scope:

This standard covers the general parameters and characteristics associated with telephone loops from the subscriber signaling and analog voice frequency interface to the local Class 5 switch interface. It includes only those business and residential lines in the North American public switched network where no special performance requirements are involved. This standard provides common denominators for subscriber line performance, independent of facility types, construction processes or equipment, and circuit provisioning methods.

IEEE P1137d4 Scope:

This Recommended Practice offers users assistance in controlling or modifying the inductive environment and the susceptibility of affected wire-line telecommunications facilities in order to operate within acceptable levels of steady-state or surge induced voltage of the environmental interface (probe wire) defined by IEEE Std 776. The methodology, application, and evaluation of results for mitigative techniques or devices in general are addressed for all Specific Type A and Specific Type B coordination methods also defined by IEEE Std 776.

IEEE 1692-2011 Scope:

This Guide presents engineering design guidelines for the prevention of lightning damage to communications equipment within structures.

NOTE: This document contains significant content regarding protection at sites with tower installations.

Document Maintenance:

IEEE-SA requires that SC / WG review their documents every 10 years and determine if they need to be:

- Revised
- Reaffirmed
- Withdrawn

NOTE: Documents may be opened at any time for a maintenance review.

Document Maintenance (cont'd):

Priority	Year Due	Document
1	2018	776-1992 (R2008)
2	2018	1137-1991 (R2008)
3	2020	820-2005 (R2010)
4	2021	1692-2011
5	2022	367-2012
6	2023	789-2013

Document Maintenance (cont'd):

Priority	Year Due	Document
7	2023	487.5
8	2023	487.4
9	2023	487.2
10	2024	487.3
11	2024	487.1
12	2025	487

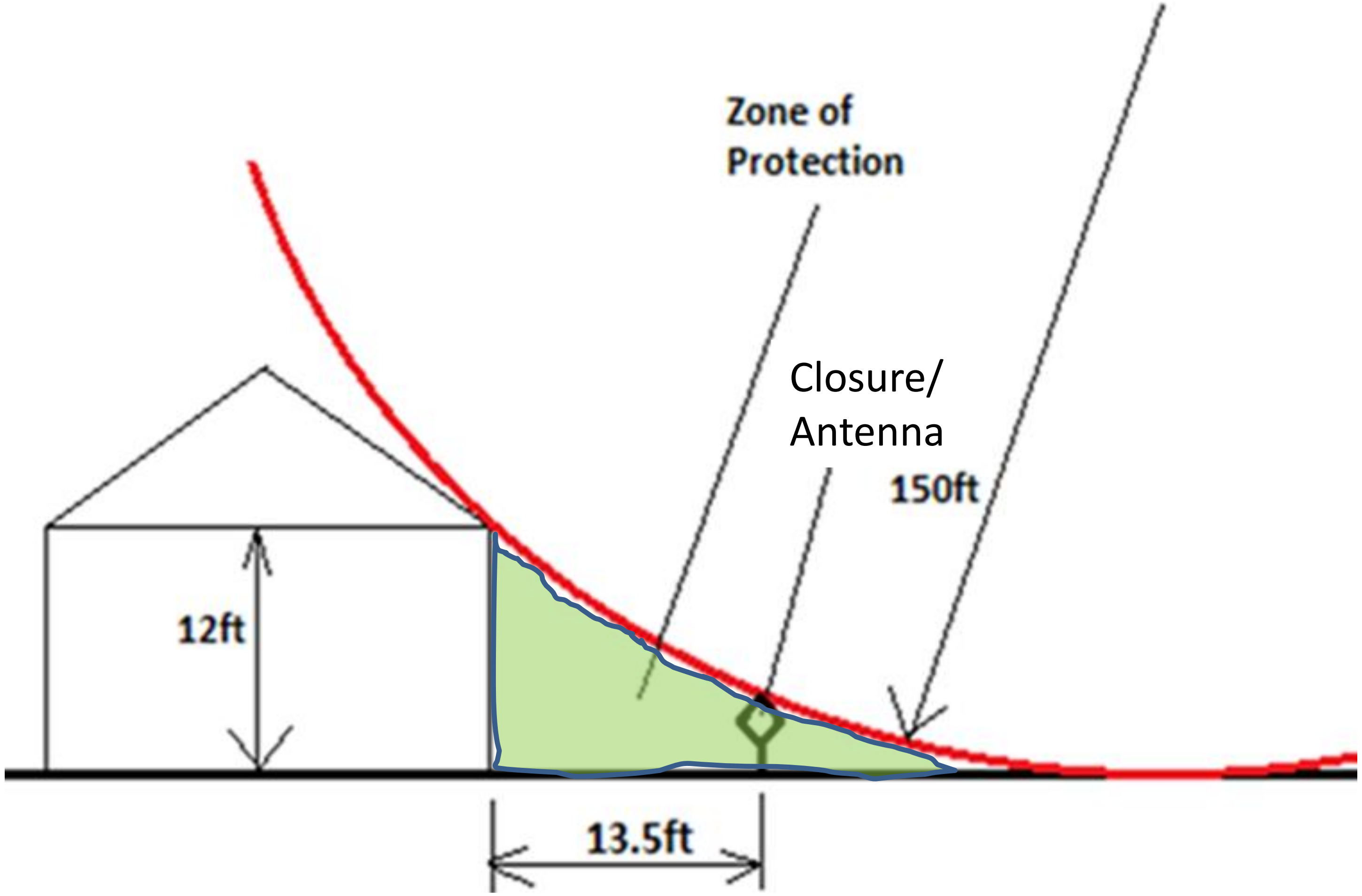
Near-term Action Items:

- Complete and publish revision of 776 (Inductive Coordination)
- Complete and publish revision of 1137 (Inductive Coordination Techniques), including Corrigendum 1

(Target balloting for above June 2018, with Comment Resolution 7-8 August 2018 @ Portland, OR face-to-face meeting)

- Pursue reaffirmation of 820 (Telephone Loop Performance Requirements)
- New Project Proposed- Develop and publish power Ground Potential Rise and Zone of Influence calculation tools
- Ongoing NEC liaison support
  - Reverse powering
  - Rolling sphere of protection exceptions (Chapter 8)
  - Nominal vs. Rated vs. Average current (Chapter 8)
- Meetings are typically 2-hour virtual, once a month when projects are active.

"Rolling Sphere" Exceptions:



QUESTIONS, COMMENTS?…

Contact:

John E. Fuller , P.E.
Principal Design Engineer
Network EMC, Electrical & High Voltage Protection Support

AT&T Services
Technology Planning and Engineering
Email jf2307@att.com
Ofc. 404-853-2092