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POWER AND GROUNDING FOR COLLOCATION

This paper describes an Incumbent Local Exchange Carrier (ILEC) perspective and approach to powering, protecting and maintaining a reliable network for the both the ILEC & the collocated service provider (i.e. leased space providers, competitive local exchange carrier, competitive access provider, etc.). Topics and sections in this paper are listed below:

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Introduction: Today there are many communication service providers of all sizes and shapes, competing to be the customer's preferred service provider for dial tone, long distance, Internet Services, and all manner of other high speed data and broadband wire line or wireless services. The point of interconnection for these services to the ILEC Telephone Switch is typically at the LEC central office. This results in a convergence of service providers collocating their equipment at the ILEC office facility or adjacent (outside) to the facility. (Note: in this paper the use of the word CLEC is used interchangeably with collocator – or any type of collocating service provider).

In order to drive greater competition, the FCC deregulation mandates have made it possible for competitive service providers (CLECs) to collocate and provide many services (those normally provided by the ILEC) to the traditional ILEC customer. This is easily done by leasing and using part of the ILECs network and facilities to reach the customer(s). Collocating has been primarily based on leasing and reselling the ILEC's service offerings, but today the collocator is also attracting customers to broadband and high tech service packages / offerings.

Historically the ILEC has owned, designed and maintained its own buildings and network facilities with a long track record of safety and reliability. In so doing, the ILEC facility's electrical, mechanical, and physical standards have been designed ONLY for ILEC purposes. Interconnecting the CLEC into the ILEC facilities

presents a significant challenge for the incumbent LEC - to maintain high levels of safety order and network reliability.

Types of Collocation:

There are several types / classifications of collocation. Discussed in general terms, here are the following:

Physical Collocation

- ☑ Caged: Walls, cages / fence, or other barriers
- ☑ Cageless
- ☑ Shared Caged (Note: shared cageless not provided)

Virtual Collocation

☑ Installed, maintained, and monitored by the ILEC. (Often is located in the ILEC equipment lineups). This type of collocation normally does not allow the CLEC access to the ILEC network facility.

Adjacent Collocation

☑ Located adjacent to and outside of the ILEC network facility (i.e. CEV, Tower, Hut). The collocator is located on the ILEC property but outside of the Central Office. This type of collocation is used when the Central Office is "out of space".

Competitive Rules for Collocation:

- ✓ The ILEC may not demand the Collocator meet a higher standard than the ILEC itself follows.

  Note: The ILEC may also use established industry standards, however, the ILEC could also demand a standard for itself that is higher than industry standards. In turn the ILEC may demand the CLEC to meet this standard.
- ✓ The ILEC will provide services to the CLEC at parity with ILEC parameters.
- ✓ The ILEC may hold the CLEC to NEBS level-1 compliance.
- ✓ The ILEC may hold the CLEC to the same safety and equipment standard that it has employed for itself.
- ✓ The ILEC may reserve floor space (for itself) based on engineering forecasts for the current year and the next (budget year). Note: This may vary from state to state and also in other ILECs.

Why the ILECs are providing the Power:

Floor loading design constraints – Telcordia GR 63

Ventilation – IEEE Stds 484 & 1187, & the Uniform Fire Code (UFC).

Hazmat & Fire concerns led the UFC to require acid containment and compartmentation of power (battery) rooms.

- VRLA's are thought to potentially overcome this, but have a very short service life and are susceptible to thermal runaway.

Maintenance Requirements for Power Equipment are high.

- IEEE Stds 450 & 1188 (battery maintenance) are examples.

The present Telecomm NEC exemption is at risk.

The ILEC owns the engine alternator and building AC systems.

ILECs may use either the existing DC plant(s) or build new ones to serve the CLEC(s).

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What Power Equipment can the CLECs Place?

The CLEC (or any collocation applicant) can place:

- AC and DC Fuse Panels
- Inverters, Rectifiers, and other power electronics. (Note: Batteries cannot be placed which negates the usefulness of placing rectifiers).
- Safety issues for equipment include NEC, U.L., NEBS Level 1, etc.
- The collocation space *may not* contain Chemical Storage Battery Systems.
- No UPS equipment will be placed in the collocation space (storage batteries, ventilation requirements, high maintenance, and synchronization issues with AC engine-alternators).

Power & Grounding Connection Issues:

All power equipment systems and materials used by a Collocator will be *ILEC - Approved for Use, and NEBS Level 1 compliant. U.L. Certification will also be required for some equipment.*

Fuses and Breakers are both valid devices for providing over current protection to the circuit feed.

The CLEC should provide one or more secondary fuse / circuit breaker panels within the physical space.

A & B feeds are assumed for each DC circuit ordered - unless specified otherwise.

Order the Feeds at the highest ampacity required:

- Because it is very costly to retrofit cabling
- Fuse size can be smaller to start and will be charged on that usage rate.

Physical Collocation will typically need a ground bus bar (extension of the ILEC Floor Ground Bar).

Virtual and cage less equipment is grounded similar to ILEC lineups.

- In non-isolated Transmission Relay Rack (RR) lineups, connect #6 frame ground to 2/0 stringer.
- Floor isolation of RR required / not required on per office basis.
- CLEC equipment using frame return (common with battery return) *will not* be qualified for locating in an IGZ.

Note: Collocated switches may require an isolated ground plane. This can be setup independently without connection to the ILEC ground window.

Power & Grounding Cost Recovery:

Each AC and / or DC circuit provided to the CLEC will reduce the existing power infrastructure by eating into the remaining power capacity. This can become a problem when the incumbent needs to add equipment and the capacity may not be there. Shown in the diagram below, are shaded components that represent a loss of capacity to the existing power system or new components added to compensate for the additional capacity needed.

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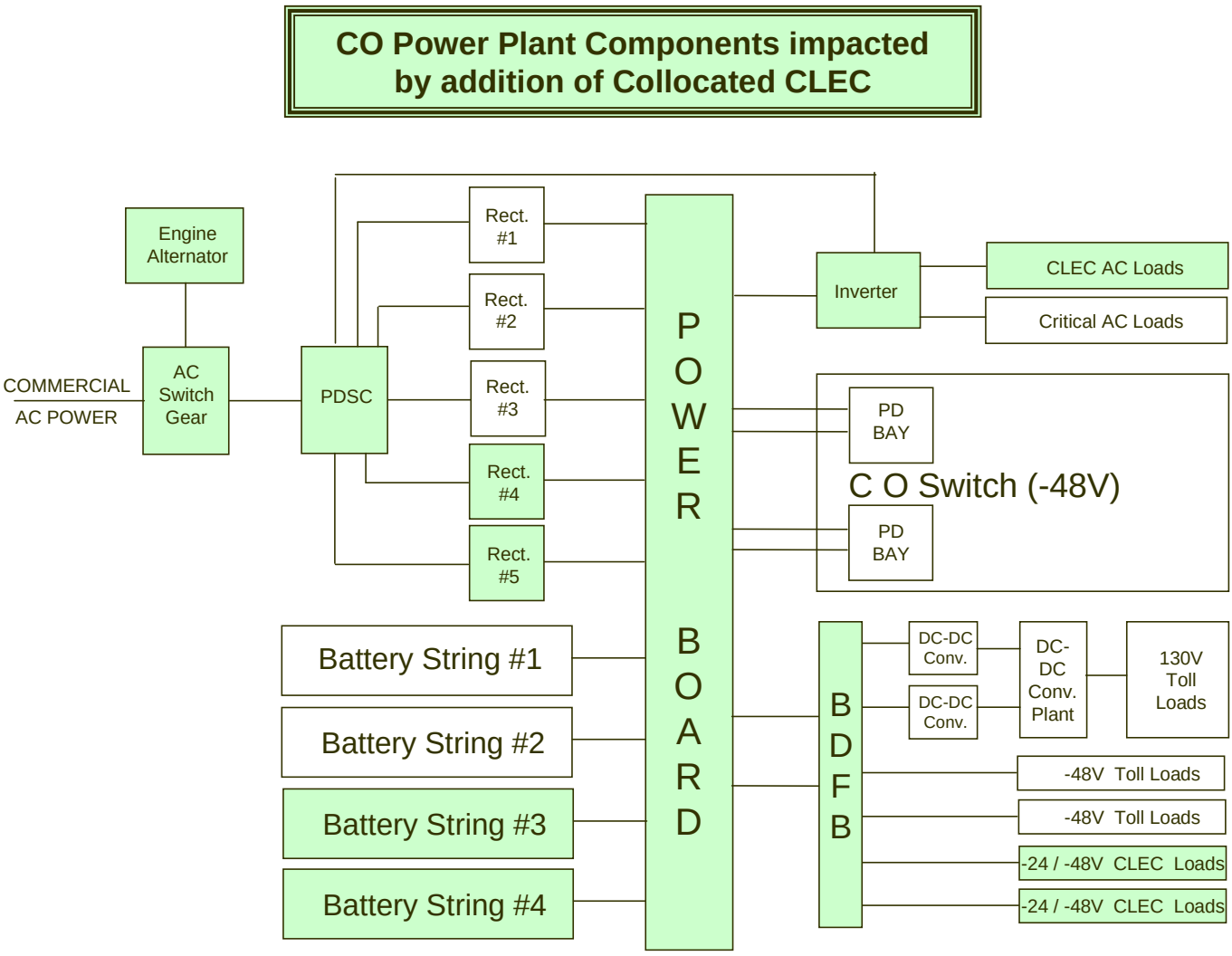

Costs: The *additional up front and ongoing costs* the ILEC expends in providing power - must be recovered. The four main types of costs the ILEC must recoup are:

- One time cabling cost (including engineering & installation) to connect power feeders to the primary or secondary distribution panel (i.e. at the collocation space).
- The portion or percentage of the power infrastructure (batteries, rectifiers, power board, primary cabling, engines, transfer switch, AC entrance capacity, and building AC) being used by the CLEC.
- The CLEC's portion of the maintenance and monitoring costs.
- The operating costs of electricity used, and the cost of energy used to cool the heat radiated by the CLEC equipment.

In comparison to power costs, the grounding costs are much lower. For physical collocation the recovery of grounding costs will be for:

- Collocation Ground Bar (CGB)
- Horizontal equalizer extension from the FGB to the CGB.
- Grounding of the Cage or metallic walls, structures and frames.

For virtual and cageless collocation:

- CLEC's portion of the stringer and frame grounding connections.

Power System Provisioning Timelines:

The ILEC, in accordance with states and/or interconnection agreement terms, must act very quickly (90-day target) to provision services (power, space, interconnection, etc) to the bona-fide collocation applicant. However, there are significant difficulties in engineering, acquiring and installing the necessary equipment in this time frame, which result in timelines greater than 90 days.

Items with industry timelines which may cause overruns of the 90-day target:

- New BDFB (3 months)
- Additional Battery Charger / Rectifier (3 months)
- Additional Battery String(s) – (4-5 months)
- New Engine-Alternator (6-8 months)
- New DC Power Plant (6 months)
- New AC service entrance / switch gear (9-10 months)

Note: Today many collocators are demanding / expecting 90 days from request approval to interconnect.

ILEC Procedures for Collocation:

Facility Access: ILEC access to the CLEC cage or physical enclosure (i.e. room) is regulated by terms and conditions stated in the collocation agreement(s) negotiated between the CLEC and ILEC. These contracts typically allow access to the CLEC's cage given proper notification, or immediate and unconditional access - in the event of an emergency. (Note: Also established in the contracts are terms to regulate and control the access of personnel installing and maintaining CLEC equipment).

The chosen methods and procedures presented (below) are designed to optimize the powering and protection for both the ILEC and collocated CLEC. These provisos, methods and procedures represent *basic and minimum* requirements. *State and local jurisdiction may determine additional requirements, with which collocation applicants will abide.*

In each collocation scenario, efforts shall be made to establish an *Independent* physical collocation wherever possible; i.e., segmented from the ILEC equipment in a separate physical space. This is always the first choice. The physical separation of equipment promotes discrete powering and grounding to the collocated service provider, reducing the risks of network interruptions during faults originating in either ILEC or CLEC equipment. If there is NO VIABLE means to maintain physical separation for the collocated service provider, only then will the ILEC consider placement of said provider into and amongst the ILEC equipment lineups. This type of collocation shall be managed by ILEC engineers to insure that ILEC grounding practices and procedures are followed.

AC Powering – Non-Adjacent Collocation (Within the ILEC office facility):

AC Power without Standby Generator backup: The ILEC furnishes the requested AC circuits to the physical collocation space, *without connection* to an AC generator transfer switch.

AC Power with Standby Generator backup: The ILEC furnishes the requested AC circuits to the physical collocation space, *with connection* to an AC generator transfer switch.

AC Circuit Distribution Panel: After ILEC approval, the collocator may provision an AC circuit distribution panel within the *physical collocation* space (to be sub fed from an ILEC AC power panel).

Protected AC Power: After ILEC approval, the collocator may provision DC-AC Inverted Power conversion equipment within the *physical collocation* space.

Inverted DC Power (AC): The ILEC *will not* furnish protected AC inverted power circuits (i.e., the ILEC *will not* provide a connection to any existing DC-AC inverted power conversion equipment and also *will not* provision new DC-AC inverted power conversion equipment to serve the collocation space).

Uninterruptible Power Supplies: The ILEC *will not* provision uninterrupted power supply (UPS) circuits to the collocator (i.e., the ILEC will not provide connections to existing UPS power conversion equipment, and also *will not* provision new UPS power conversion equipment to serve the collocation space).

AC Power Transfer Switch: The collocator *may not* provision an AC power transfer switch.

AC Standby Generator: The collocator *may not* provision an AC standby generator.

DC Powering – Non-Adjacent Collocation (Within the ILEC office facility)

DC Power Circuit Feeds: The ILEC furnishes the requested DC power circuits to the collocation space up to the capacities available. (Note: ILEC personnel will determine maximum DC circuit capacities available to the collocator).

Battery Reserve: The ILEC furnishes the collocator with DC battery reserve at parity with the ILEC and in accordance with ILEC Standard practices (up to or above 3 hours at sites with stationary generators; up to or above 8 hours at sites without stationary generators.*)*

Electro-Chemical Stationary Batteries: The collocator *may not* place *Electro-Chemical Storage Batteries* of any type inside the physical collocation space.

DC-DC Power Conversion Equipment: After ILEC approval, the collocator may provision DC-DC power conversion equipment within the physical collocation space.

DC Secondary Distribution: After ILEC approval, the collocator may provision DC-DC power conversion equipment and DC distribution equipment within the *physical collocation space.*

NOTE: The CLEC use of AC-DC power conversion equipment (i.e. rectifiers) inside the collocation space is strongly discouraged (no battery backup).

Grounding – Non-Adjacent Collocation (Within the ILEC Central Office Facility):

The collocation applicant will submit plans to the ILEC for connecting and grounding the collocated equipment. After approval, the ILEC will also inspect the installation for proper and safe grounding prior to turning-up the interconnection between collocator and ILEC. The ILEC is also responsible for connecting the Collocation ground bus bar to the *designated* ILEC office grounding system (see Figure B).

The ILEC will establish a separate Collocation Ground Bus Bar, which is dedicated to the Physical Collocation space(s) alone. The collocation ground bus bar is the single ground reference point and connection for the

collocated equipment. The collocation ground bus bar should be positioned and located outside the physical collocation space such that it may serve as the Collocation Ground connection point for any other additional collocation spaces in the immediate area. Any powered equipment, electronic equipment, equipment racks, chain link fences/metallic cages and other miscellaneous equipment within the collocation space will be safety grounded and bonded to the designated Collocation Ground Bus Bar. Note: AC circuits serving the physical collocation space will be grounded in accordance with ILEC practices.

Isolated Ground Zones: The Isolated Ground Zone (IGZ) is that area in the central office environment where all designated equipment is grouped into a specific ground plane(s) or zone(s). All equipment within this isolated zone is installed in such a manner to eliminate any unintentional references and/or conductive paths to ground. This definition applies to both switching and non-switching environments.

The Isolated Ground Zone (IGZ), as applied by this ILEC is centered on the use of a Single Point Ground (SPG) reference. Depending on the hardware involved, the switching manufacturer's philosophy, and office physical constraints, the SPG point of connection for IGZ equipment will either be the designated SPG (Ground Window Bar), or the Master Ground Bar (sometimes used as the designated SPG in small offices).

The ILEC will determine if and when it is technically feasible for the Collocator to locate equipment within the Sprint designated IGZ. More specifically, if collocated equipment is not SPG compliant (i.e. 48VDC battery return common with chassis ground), or if said equipment is AC powered, stray current(s) would then be present on frame/chassis ground conductors creating "current loops" in & out of the IGZ. This equipment will not be allowed as this would nullify and compromise the concept of Single Point Grounding.

NOTE: If an ILEC decision is made to locate Non–Isolated CLEC equipment within an IGZ, special treatment for this equipment would have to be employed & monitored accordingly during installation. This would include the use of insulated mounting materials, bushings and non-metallic hardware. Additions of any SPG *compliant* CLEC equipment will have to be monitored as well.

Grounding – Adjacent Collocations (Collocation outside the ILEC Facility):

For any adjacent collocation scenario the ILEC will review and approve the collocator's grounding (earthing) design. The ILEC ensures that external grounding (earthing) is accomplished in accordance with ILEC specifications and standards. The ILEC is responsible for insuring that this has been properly completed.

Example: The collocation is **external** to the building or central office complex; and a Wireless installation (with cabinets) and associated monopole + antenna is present. The collocator is required to bond to the ILEC's external ground system (i.e., Made Ground Field).

Powering – Adjacent Collocations (Collocation outside the ILEC Facility):

The ILEC will provision AC and DC power for the Adjacent collocated or leased space, which is physically external or located outside of the ILEC network facility, in accordance with the following proviso's:

AC Power to the Adjacent Collocation Space: The Adjacent Collocation applicant may receive Commercial AC Power to the adjacent collocation space ONLY from the same Commercial AC Power Provider serving the ILEC facility and premises. *An Alternate AC utility provider is not allowed*.

AC Power from the ILEC to the Adjacent Collocation Space: If requested the ILEC will provision AC power to the adjacent location *only* if technically feasible – as determined by the ILEC.

AC Surge Protection: Branch AC circuits emanating from the ILEC facility serving the adjacent collocation space shall be provisioned with AC Surge Protectors -- at the point of exit from the ILEC facility.

AC Standby Generator: If available the ILEC will provide AC standby generator connection to the adjacent external location, when technically feasible as determined by the ILEC. The Collocator *may not* provide its own AC standby generator.

AC-DC, DC-DC, and/or DC-AC Power Conversion Equipment: The Collocator may provision ILEC approved power conversion equipment within its adjacent collocation space including UPS.

Electro Chemical Stationary Batteries: The Collocator may use Electro-Chemical Storage Batteries, *If And Only If* the Collocation facility is physically located outside the Sprint network facility, and the storage batteries are integral to the communications equipment and housed in a sealed cabinet or sealed structure.

Uninterruptible Power Supplies: The ILEC *will not* provide UPS powering to an adjacent/external location.

DC Power from the ILEC to the Adjacent Collocation Space: The ILEC *will not* provision DC power from within its facility to the adjacent/external collocation space. Some reasons for this are listed:

(a) Loss of control over the powering loads and voltage drops in feeder cables.

(b) The ILEC generally does not provision DC power to adjacent locations - for its own operations.

(c) New cable exposures and grounding issues place the ILEC (and CLEC) network at higher risk of service instability and network failure.

(d) NESC issues and other safety risks arising from the routing of power carrying conductor(s) outdoors.

(e) Extending DC Power beyond it's immediate technical floor space is not cost effective as compared to costs for installing a separate power plant at the adjacent location. (Note: this item is economics only and does not play into the technical feasibility of providing power).

(f) ILEC personnel are not trained (today) to provision DC power circuits from the C.O. to adjacent locations.

Conclusions:

Collocation is a fast and ever growing business. Since the collocator has no network infrastructure investment to support, it is not difficult for the collocator to target specific types of customer needs and deliver cost effective high tech services to said customer(s). Collocation is also big business for the ILEC. The ILEC must be careful to properly plan, power, protect, and recover it's costs when hosting the collocator on it's property and in it's facilities. The provisioning, operation, maintenance, and monitoring of backup power systems are extremely important to both companies. Neglect of these powering issues (mentioned in this paper) can delay collocation, lead to network failures, cause hard feelings, and lead to litigation.

Some New Challenges:

- DC Power requirements in the C.O. are increasing without bound. Office infrastructure is exhausting.
- Higher power density: Equipment is smaller, faster, operates at lower voltages (higher currents).
- Relay Rack equipment bay powering loads are reaching 100 Amps (DSL equipment uses approximately 3-5 times greater power per line – as compared to POTS). Note: How to feed DC power to RR lineups?
- DLEC's: Data local exchange carriers (ISPs using the local loop).
- Line Sharing of ILEC and CLEC (or multiple CLECs) on a single twisted copper pair.
- Outside Plant Cabinet collocation (different equipment in same cabinet operating at different levels of power).

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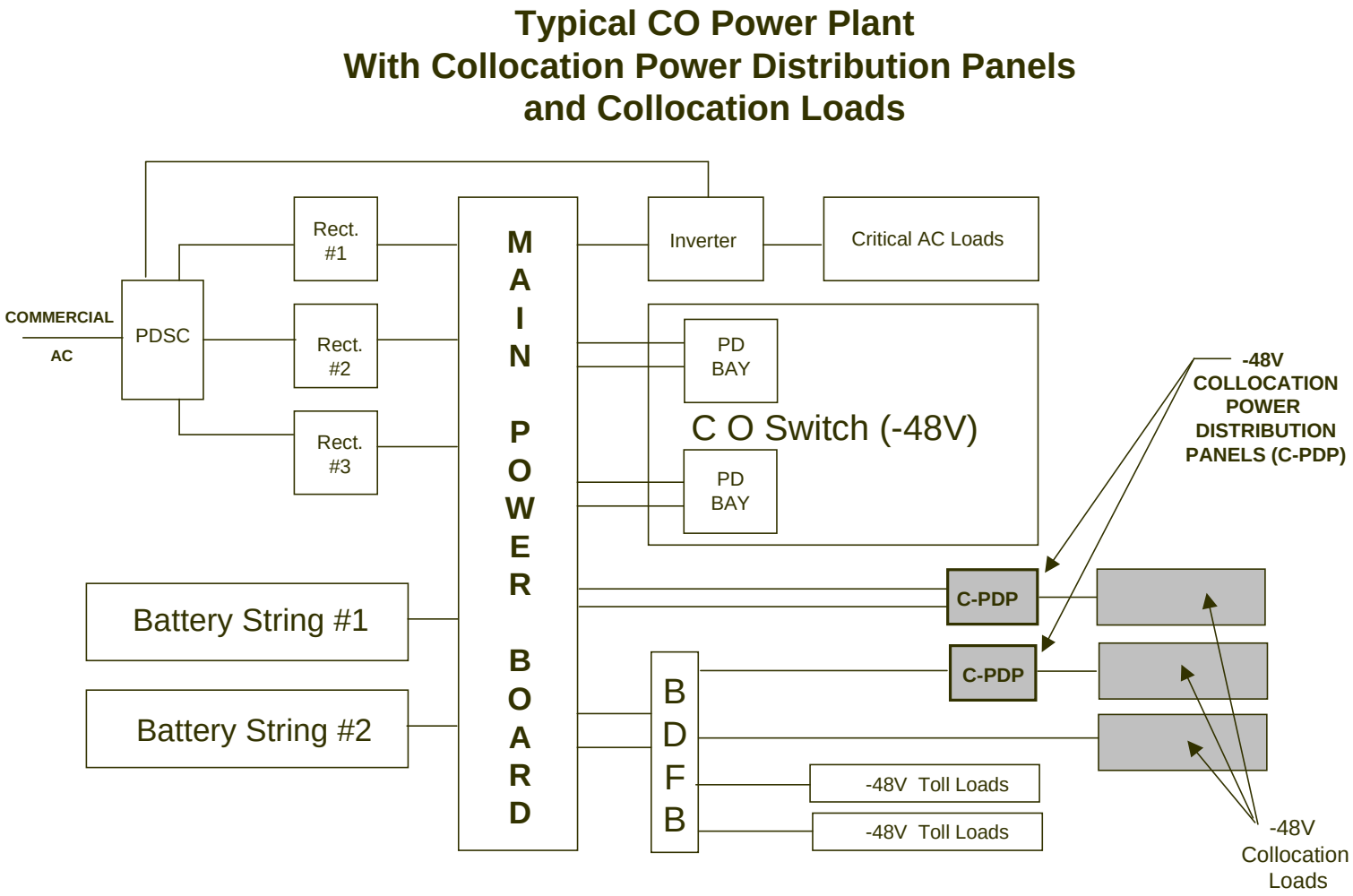
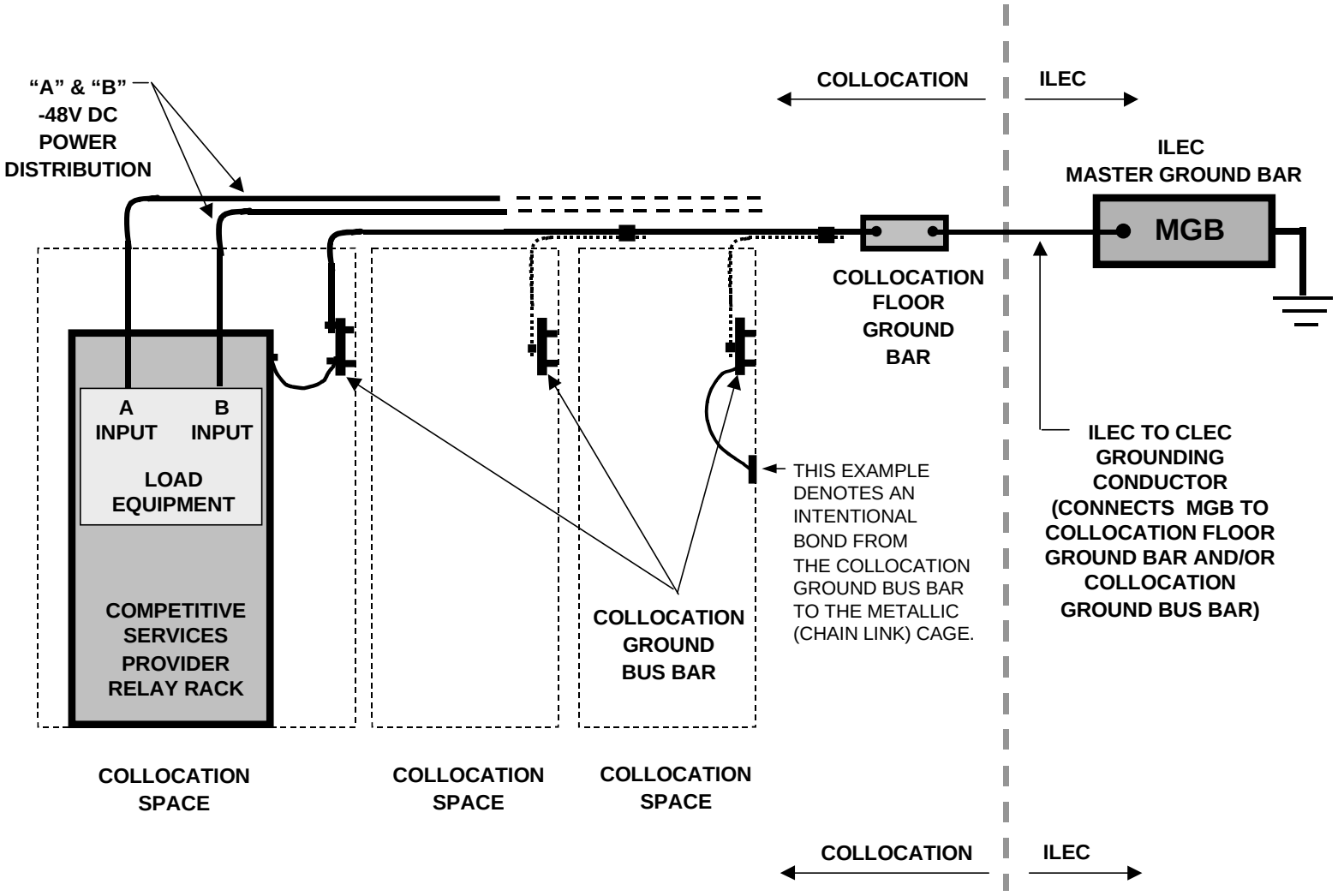
FIGURE A: -48V DC POWER DISTRIBUTION TO THE COLLOCATION SPACE



Three Methods of provisioning ILEC -48V DC Power to the Collocator::
a. Power directly from BDFB to Collocation Space;
b. Power from BDFB to Collocation Power Distribution Panel (C-PDP);
c. Power from Main Power Board to Collocation Power Panel (C-PDP).

FIGURE B: GROUNDING THE COLLOCATION SPACE



TERMS / DEFINITIONS

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AC Power: The electrical power, which is measured when an alternating current (AC) Voltage source causes AC current to flow in a completed circuit. The circuit is made complete by inserting the electrical power consuming equipment (called the load) into the circuit. The measured amount of AC Volts multiplied by AC Amps is equal to the AC Power usually expressed in Watts.

DC Power: Electrical power, which is expressed by multiplying the direct current (DC) Voltage by the DC amperage. This is measured by sensing the DC Volts and DC Amps and is normally expressed in Watts. Note: Telecommunications equipment uses DC power to operate.

ILEC: Incumbent Local Exchange Carrier.

Inverted Power: AC power, which is derived from DC power. The input of the inverter normally uses DC power, and the "inverted" output waveform is AC power. Some inverter models are able to operate off commercial AC (input) and "switch" to the DC input (for true inversion) when needed. An inverter that operates 100% of the time from DC power is sometimes referred to as protected AC power. Note: An inverter can provide varying degrees of isolation between the input and output (useful for operating sensitive equipment).

Isolated Ground Plane. Also commonly called the Isolated Ground Zone equipment, the isolated ground plane is a set of interconnected frames that are intentionally grounded by making only one single connection to the given ground reference (the Ground Window Bar). This plane, taken as a conductive unit with all of its metallic surfaces and grounding wires bonded together, is insulated from contact with any other grounded metal work in the building.

Isolated Ground Zone (IGZ). A dedicated zone within a central office having specified physical boundaries, and containing sensitive electronic components (the isolated ground plane). All equipment located within the isolated ground zone must be electrically insulated from all external grounds except through a single connection at the Ground Window Bar.

Isolated Ground Zone Equipment. Communications equipment in which the circuit ground and battery conductors are deliberately insulated from the equipment framework and building connections.

Load: The term used to indicate the Equipment that requires electrical power (AC or DC) to operate. Interchangeably called load, or load equipment.

Physical Collocation Space: The space in the ILEC facility, which is contracted and/or leased to the collocating company (CAP, CLEC, Leased Space Provider, Competitive Service Providers, etc). The designated space contains the collocated company's equipment. Physical locations on ILEC property can include but are not limited to the following: enclosed and fenced in area(s), room(s), relay racks (amongst the ILEC lineups, or physically separate), outdoors, CEVs, cabinets, manholes, conduits, cables, other.

Protected AC Power: This refers to AC power that is uninterrupted at all times regardless of what happens to the commercial supply of AC power. This can be achieved by the use of an Inverter or an Uninterruptible Power Supply (UPS).

Uninterruptible Power Supply (UPS): A device using commercial AC power at the input which is converted to DC power, and then Inverted (see inverter) to AC power for the operation of AC powered equipment. The UPS also has a standby battery plant, which provides a short term DC power reserve (which is needed during commercial AC failures). The DC energy from the battery plant allows the inverter to continue the uninterrupted output of AC power to the load.