Technical Specification Manual

V-PLC9000 Series

Technical Specification Manual

Veesta - Universal PLC Communication System 9000 Series Product

Universal Power Line Carrier equipment designated for realization of telecommunication links and services over High Voltage Power Lines

VEESTA WORLD

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DOCUMENT HISTORY

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Chapter 1 - Introduction

1.1 General Information

This is technical information of design of V-PLC9000 the Universal Power Line Carrier Communication System 9000 Series from Veesta World Company for providing analogue and/or digital telecommunication channels on HV power lines. This document helps you to find technical specification and about how V-PLC9000 Series works and designed for your purpose.

In the continue you will see about VP-9PST device intended for transmission of protection commands through voice grade channels (from 300Hz to 3720Hz (3400Hz)) in command type teleprotection systems.

1.2 Veesta World Co

Veesta World Co is a leading company in automation field in Iran and specialized in design and installation of IT Network of wide area and local area, Automation control units, control rooms, DCS design, PLC and SCADA application installation and system integration. The main advantage of Veesta World's products is complying international standards and do customs basic design.

Veesta World Co is a dynamic company located in the Tehran, IRAN, whose main commitment is the customer's satisfaction. Business vision and its future evolution together with the proper combination of new and existing technologies are the main aspects considered in the solutions proposed by Veesta World Co. Owing to this, key issues like Scalability, the Return of Investment or the Total Cost of Ownership are carefully considered. Consequently, the solutions offered by Veesta World Co are able to cope with the requirements of a sustainable growth. Veesta World Co is a service-oriented company and the customer perspective is its action guide. An added value of the offer is the evaluation and Management of the risk. This issue is getting a major relevance in the changing environment in which new technologies have to be applied, particularly when profitability is a major concern.

The objective of Veesta World Co is focused on the creation of value for the customer through the proper business strategy alignment and the right combination of technologies. These principles, developed

under the Total Quality Management practice, allow Veesta World Co to offer, in a seamless approach, consultancy, engineering and training services. The founders of Veesta World Co are professionals with a large experience in the Telecommunication and Networking and Industrial fields. Veesta World Co is formed by a balanced team of professionals that gather knowledge in a wide range of technologies and specific know-how on how to apply these technologies in mission-critical control networks.

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Figure 1-1: Veesta World Co Logo and sign

Chapter 2 - V-PLC9000 System Overview

2.1 PLC Technology

Secure and cost effective supply of electricity is basis of every country's economy and of modern life generally. Complex power supply systems are built for that purpose. Dependable operation and supervision of such complex system is based on dependable and technologically up-to-date subsystems. Reliable information flow between sites of the power supply system (power plants, substations, control centers etc.) on the same hierarchical level and between hierarchical levels is of crucial importance for efficient control and manages of power supply system in order to achieve dependable and stable operation. The basis of reliable information flow is powerful and dependable private telecommunication (TC) system, which must be cost effective at the same time.

When building the private TC system standard TC technologies such as radio links, cables (typically fiber optic), satellite communication and others are used.

Specific TC technology used exclusively in Power Utility TC systems is **Power Line Carrier** (or **PLC** for short). **High Voltage (HV) power lines** are used as **transmission media** for telecommunication signals. This results in some interesting advantages:

- HV power lines form wide power transmission network connecting almost all sites of power supply system. Power Utility is the owner of power transmission network. So there is no need to obtain government approval or concession to use HV power lines as telecommunication transmission media. Consequently, use of transmission media is free of charge.
- Due to its important primary function of transmitting the energy, HV power lines are well maintained therefore HV power lines are reliable as TC transmission media as well.
- PLC links (especially analogue PLC channels) are highly dependable even in adverse operating conditions; high attenuation and low signal-to-noise ratio.
- In comparison with other TC technologies PLC links are cost effective especially in applications where low number of TC channels and specific TC services are required (Teleprotection signaling, redundant transmission of information, last mile access etc).

Due to the above mentioned facts answer to the question of usefulness of PLC in present times is "YES" in spite of the number of powerful modern TC technologies. PLC links are used as cost effective solution for dedicated communication services such as hot point–to-point dispatcher speech links, Teleprotection signaling, stand-by redundant telecommunication channels (redundancy on the level of transmission media) and connection of end-point installations of Power Utility to the telecommunication backbone (last mile access).

2.2 V-PLC9000 Family of Devices

V-PLC9000 Communication system is a family of devices intended for realization of PLC links and telecommunication services. Following devices are members of V-PLC9000 family:

- **VP-9UPT** Universal PLC terminal
- **VP-9ACT** Analogue Channel Terminal
- **VP-9PST**-A Protection Signaling Terminal Transmission in AF band
- **VP-9NBM** Narrow-Band FSK Modem
- **VP-9COD**-A, -B Coupling Device; versions A and B
- **VP-9TRD** Transit Device

2.2.1 VP-9UPT - Universal PLC Terminal

VP-9UPT **U**niversal **P**LC **T**erminal is intended for realization of PLC links with analogue and/or digital PLC channels anywhere (full programmability) within the extended HF frequency range from 20 kHz to 1,000 kHz, which may prove very useful in case of lack of free frequency space. Each channel may have integrated protection signaling function (transmission of protection commands) which characteristics are the same as of VP-9PST-A device.

2.2.2 VP-9ACT - Analogue Channel Terminal

VP-9ACT **A**nalogue **C**hannel **T**erminal enables extension of analogue PLC channels, multipurpose use of telecommunication channels (e.g. simultaneous transmission of speech, protection commands and standard or narrowband modem signals) and isolated extension of telephone subscriber lines. It includes universal (programmable) telephone interface, which ensures adaptability to different application requirements.

2.2.3 VP-9PST - Protection Signaling Terminal

VP-9PST **P**rotection **S**ignaling **T**erminal is intended for transmission of up to six (6) protection commands in AF band (from 300Hz to 3720Hz) in different transmission schemes and using pure F6 FSK modulation (only one single tone is transmitted at a time).

2.2.4 VP-9NBM - Narrow-Band FSK Modem

VP-9NBM **N**arrow-**B**and FSK **M**odem provides with fully transparent transmission of asynchronous data using robust FSK modulation and occupying relatively narrow part of AF band. Modem centre frequency is fully programmable in the range from 300 Hz to 3720 Hz. Data transmission rates from 50 bits/s to 2400 bits/s are supported (fully programmable).

2.2.5 VP-9COD - Coupling Device

VP-9COD **Co**upling **D**evice allows PLC terminal(s) to be connected to HV power line. Primary task of coupling device is impedance matching between HV power line and the PLC terminal(s) enabling maximization of the transmit signal power actually transmitted to the transmission media. Important task of coupling device is protection of PLC terminals and maintenance personal against high voltage of HV power line.

2.2.6 VP-9TRD - Transit Device

VP-9TRD **Tr**ansit **D**evice serves to selectively transit PLC signals between HV power lines.

2.3 V-PLC9000 Unified Technological Platform

V-PLC9000 Communication System apart from being a common name for family of devices also signifies unified technological platform on which all devices are designed upon. Elements of unified platform are:

- standard 19-inch system in EMC version
- power supply system
- parametrising system
- diagnostic system
- technology

All devices, members of ***V-PLC9000 Communication System*** family, are built within the same mechanical system (19-inch rack) and have same power supply modules. Parametrising and supervision of all devices is performed through the same parametrising and diagnostic system. This feature is important as it lowers cost of spare parts and maintenance personnel training.

Devices **VP-9COD-A, -B** and **VP-9TRD** of course are exempted from the unified platform rule as their function requires specific robust design and specific technology and do not require power supply, parametrising and diagnostics.

All **V-PLC9000** devices are utterly programmable. Setting of majority of parameters value is performed by Personal Computer (PC) locally or remotely.

Construction of all devices is modular and very compact so more independent devices can be built into the single 19-inch rack.

Modular construction and unified technology enables simple and fast changes in equipment structure at any phase of equipment life cycle as well as quick clearance of eventual faults.

Special care in design has been taken to achieve appropriate Electro Magnetic Compatibility (**EMC**) of al devices, members of **V-PLC9000 Communication System** family.

Characteristics and construction of devices are in accordance with the relevant standards such as:

- IEC 60495 (1993-09),
- IEC 60834-1 (1999-10),
- IEC 60481 (1974),
- IEC 61000-4-xx,
- IEC 61000-3-xx,
- IEC/EN 60950, etc.

2.4 V-PLC9000 Application

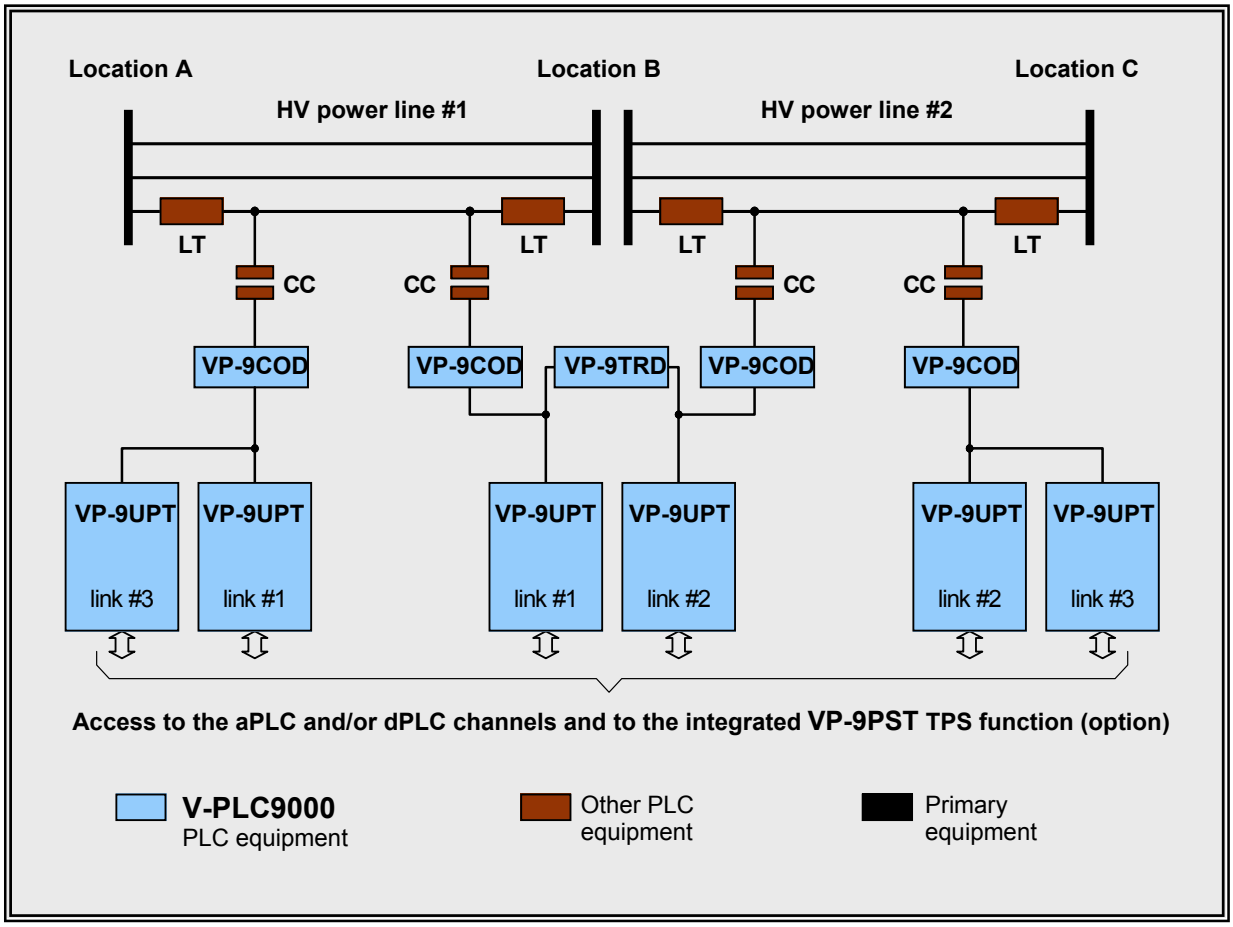

Figure 2-1: Building of the PLC links using V-PLC9000 Communication equipment

Figure 2-1 and Figure 2-2 show the application points of the **V-PLC9000** devices. Coupling devices **VP-9COD** and **VP-9TRD** together with Coupling Capacitor are connecting PLC terminal(s) to the HV power lines. **VP-9UPT** devices form PLC links with one or more analogue and/or digital PLC channels. **VP-9ACT** device is used to extend analogue PLC channel from location A to location D.

VP-9PST devices (integrated functions or self-standing devices) are used to perform protection commands transmission through the channels of PLC links.

VP-9NBM devices provide with data transmission in narrow part of analogue PLC channel.

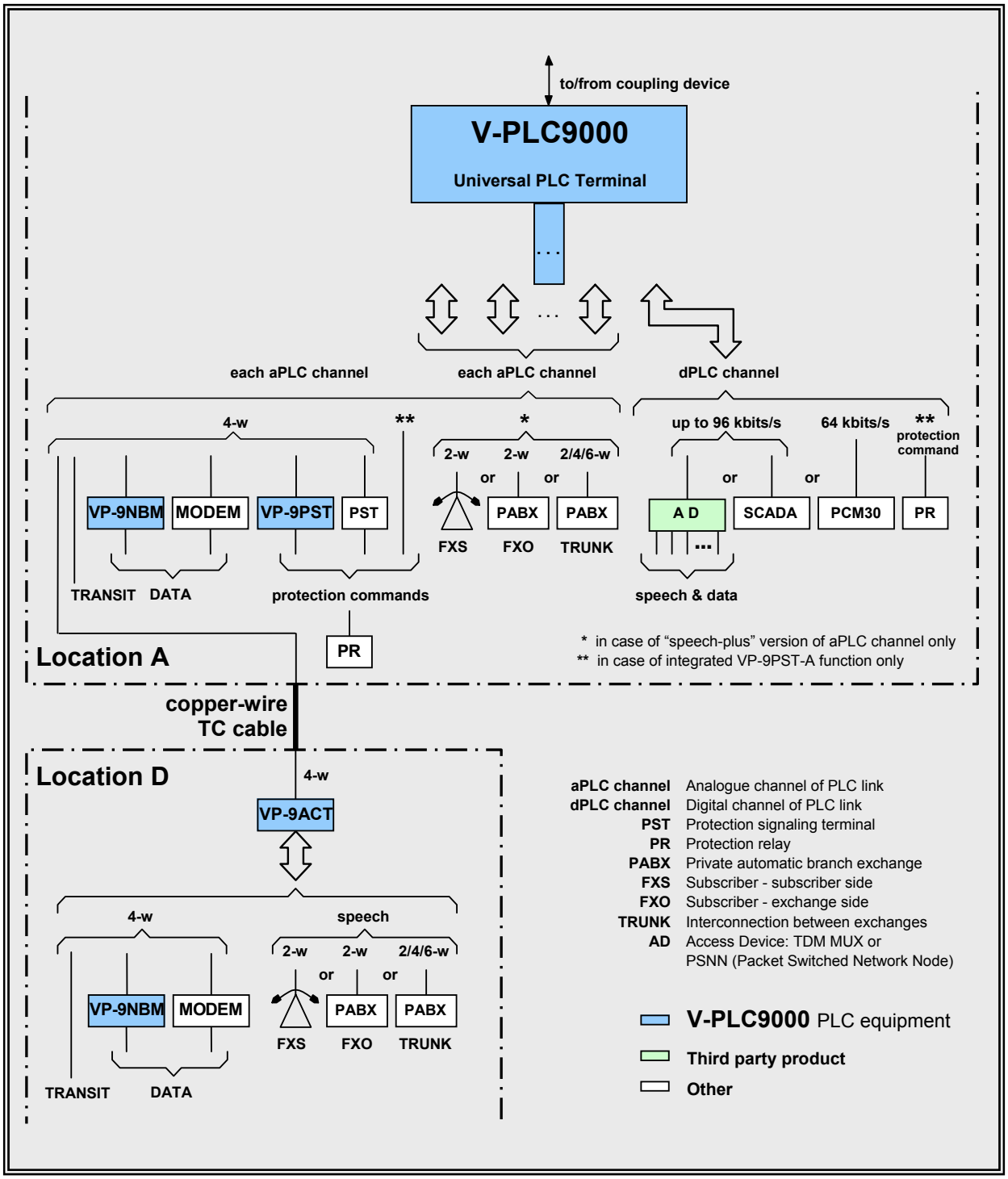

Figure 2-2: Possible ways of aPLC in dPLC channels utilisation in V-PLC9000

Chapter 3 - VP-9UPT, Universal PLC Terminal

3.1 VP-9UPT - Universality

Traditional PLC links offered telecommunication resources in form of 4 kHz wide analogue channels (gross). Modern trends in telecommunications have also resulted in field of PLC communications. Increased need for transmission of data, development of quality algorithms for compressing of digitalized speech and need to include PLC links into unified digital communication transmission network have resulted in emerging of digital PLC terminals or more precisely digital PLC channels. With emerging of digital PLC links analogue PLC links however did not loose their meaning. Analogue PLC channels are much more robust due to its high resistance to adverse operational conditions and are therefore suitable for realization of most important communication services (such as point-to-point dispatcher speech link, transmission of protection commands, redundant transmission of critical information using two different transmission media etc.).

Less resistant digital PLC channels on the other hand offer relatively high transmission capacity with regard to the frequency bandwidth used (n x 4kHz; n = 1, 2, 3, 4, …).

Major part of PLC terminal is same regardless of the channel type (analogue or digital). It is therefore sensible that the design of the PLC terminal is universal. Universal PLC terminal provides realization of analogue (aPLC) or digital (dPLC) channels or even combination of both.

PLC terminal VP-9UPT is typical universal PLC terminal in the market.

3.2 VP-9UPT - Main Characteristics and Features

1- **Universal design** provides realization of analogue (aPLC) and/or digital (dPLC) channels.

2- **Full programmability** without changing any hardware (modules) Value of most parameters is settable by PC locally or remotely.

3- **One-step modulation scheme** enables simple production of PLC terminals with different number and type of channels:

up to 6 aPLC channels or
1 dPLC channel or
aPLC channel(s) and 1 dPLC channel

4- **Modular design** enables optimal adjusting of the PLC terminal hardware structure to specific needs of particular application. User always buys only necessary hardware (modules). With adding (or removal) of modules structure of PLC terminal can be adjusted to new requirements: changing of number and type of channels, aPLC channels version (»standard« or »speech-plus«), output power (PEP), power supply source and possibility of later integration or removal of TPS function.

5- **Wide RF range** of operation from 20 kHz to 1,000 kHz; programmability without changing of hardware.

6- **Compact design:** Regardless of output power (10W, 20W, 40W or 80W) and of number of channels, PLC terminal VP-9UPT occupies standard 19 inch rack of 6U (266mm) height and 295mm depth.

7- **Powerful diagnostic system** generates lists of diagnostic data (alarms, operational parameters, events) which enable supervision of a device condition locally or remotely.

8- **Modern technology:** Intensive use of DSP (Digital Signal Processing) and CPLD (Complex Programmable Logic Device).

9- **Compliance with the relevant standards and recommendations:** IEC 60495 (1993-09), document »Report on Digital Power Line Carrier« (CIGRE WG 35.09, April 2000) and relevant standards on EMC (IEC 61000-4-xx; Electro Magnetic Compatibility) and safety.

3.3 VP-9UTP - aPLC channel

Each aPLC channel is a telecommunication resource in a form of usable AF band from 300 Hz to 3.720 kHz (4 kHz gross) intended for a transmission of analogue signals, carrying information. aPLC channels are very robust. They operate with sufficient dependability even at adverse operational conditions (e.g. bad weather) represented by high attenuation of transmission path and high level of noise and interferences which result in low Signal-to-Noise ratio (SNR) at the receiver input.

Two versions of aPLC channel are available: **»standard«** and **»speech-plus«**. Interface of each »standard« aPLC channel includes three (3) 4-wire analogue channel ports and input for control signal »BOOST«. AF channel port #1 can perform transit function for analogue signals (activation of transmit and/or receive transit filter), AF channel port #2 can serve for connection of external TeleProtection Signaling terminal. »Speech-plus« aPLC channel additionally includes universal (programmable) telephone interface providing possibility for different telephone applications such as remote subscriber (interface on subscriber side (FXS) or telephone exchange side (FXO)) or TRUNK connection between telephone exchanges (2-w/4-w, E&M interface).

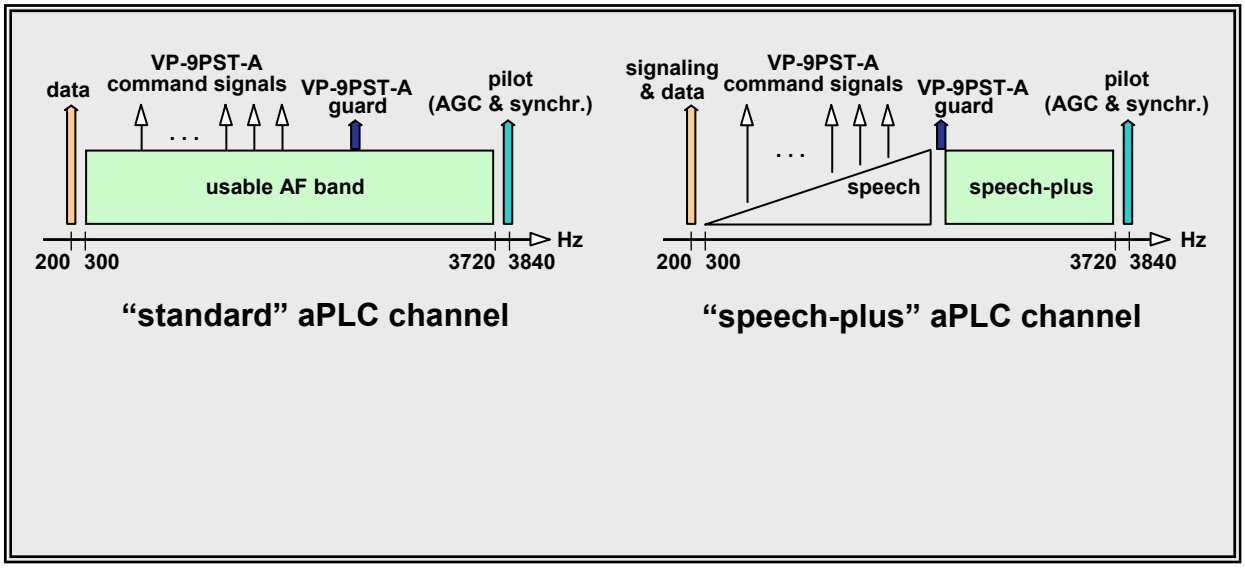

Figure 3-1: aPLC »standard« and »speech-plus« channels utilisation

Each aPLC channel can have integrated function for transmission of protection commands (TPS function) which characteristics are the same as of **VP-9PST-A** TPS terminal. In such case suitable number of interface modules for connection to protection relay is built into the rack; VP-9PRIA, VP-9PRIB and/or VP-9PRIC module(s).

3.4 VP-9UTP - dPLC channel

Each dPLC channel is a telecommunication resource in a form of transmission capacity expressed in kilobits-per-second (kbps). Transmission capacity of dPLC channel of universal PLC terminal VP-9UPT is programmable in the range from 9.6kbps to 96kbps. Frequency bandwidth occupied by dPLC channel is also programmable in the range n x 4kHz; n = 1, 2, 3 or 4. dPLC channel enables transmission of information in digital form. dPLC channel is more sensitive to adverse operational conditions but it provides more efficient use of frequency band intended for PLC communications. Whole transmission capacity of dPLC channel may be used for transmission of only one digital signal and this is called *single-purpose* use of dPLC channel. In that case source/sink of digital signal is connected directly to digital channel interface of dPLC channel. dPLC channel may be equipped with digital interfaces of different type.

Several applications require transmission of many individual digital signals over single dPLC channel (data and/or speech) and this is called multi-purpose use of dPLC channel. In this case external digital access multiplexer (AMUX like V-MUX9000 or V-COM2000 Products Series from Veesta World) is connected to the digital channel interface of dPLC channel. Basic function of AMUX is digitization and compression of analogue speech signals and time division multiplexing of data and digitized speech signals to single digital signal suitable for transmission over dPLC channel. AMUX structure is modular which enables insertion of different data and speech (telephone) interfaces and with that coverage of many different applications requirements.

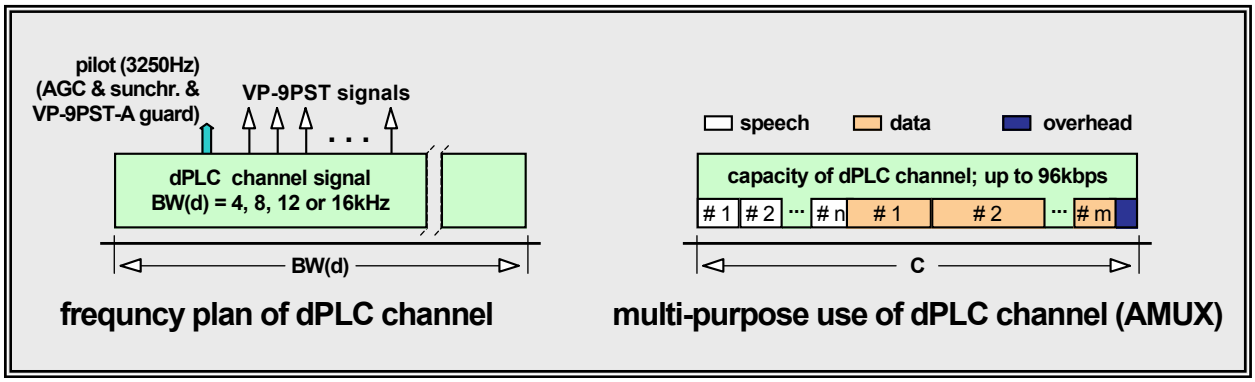

Figure 3-2: dPLC multi-purpose channel utilisation

For AMUX in PLC terminal VP-9UPT, Veesta World Company offers AMUX product from **V-MUX9000** for voice & data multiplexer product series and from **V-COM2000** for data purpose usage of multiplexer series which are modular, have quality algorithms for speech compression and high efficiency of multiplexing (low »overhead«) and is on very high technological level.

dPLC channel may have integrated function for transmission of protection commands (TPS function) which characteristics are the same as of VP-9PST-A TPS terminal. In such case suitable number of interface modules for connection to protection relay is inserted into the rack; VP-9PRIA, VP-9PRIB and/or VP-9PRIC module(s).

3.5 VP-9UPT - Principle Block Diagram

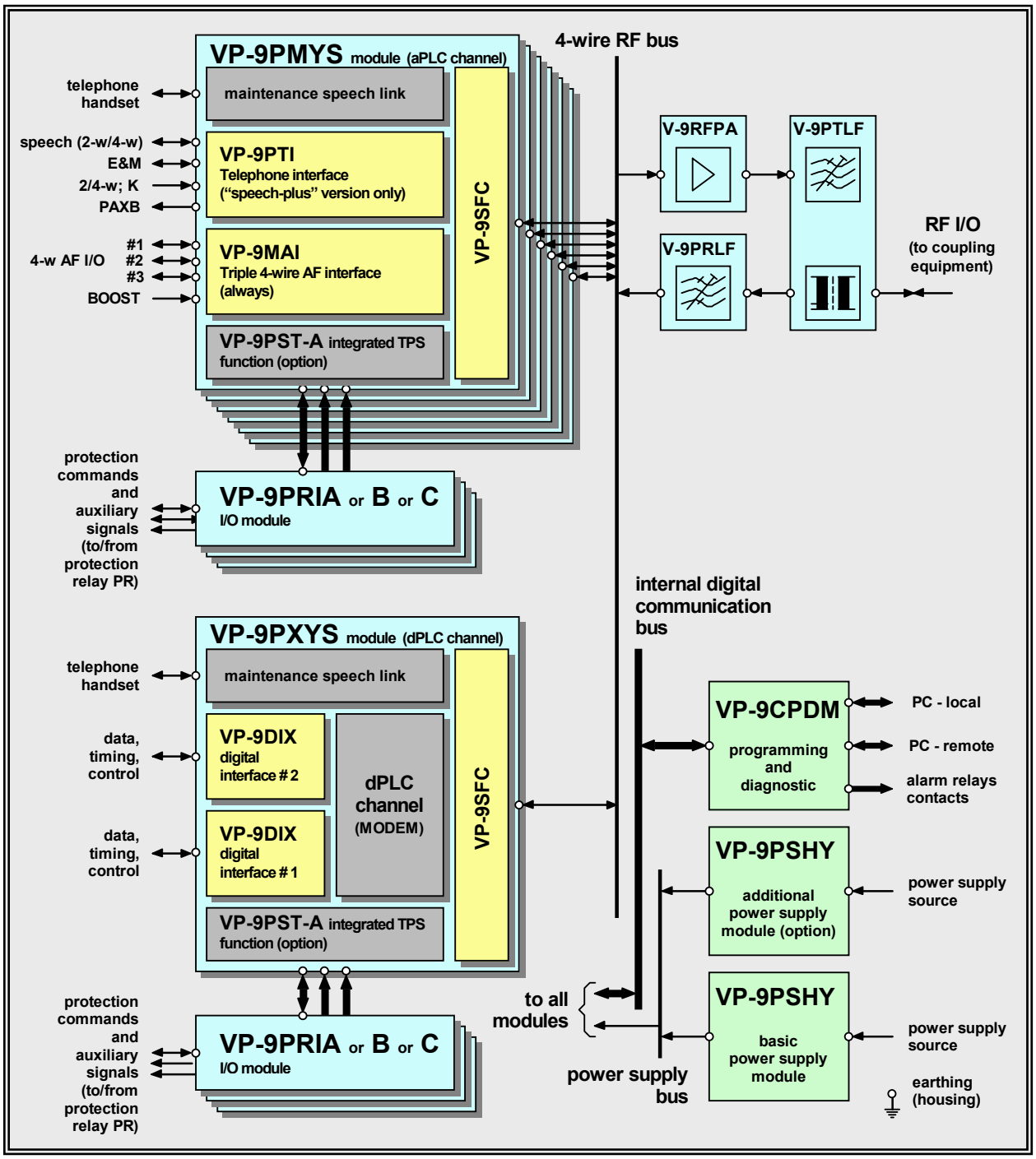

Figure 3-3: VP-9UPT principle block diagram

3.6 Technical Data

3.6.1 General Characteristics

1. **PLC Terminal type:** VP-9UPT

2. **Modulation type :** Single step AM (amplitude modulation)

3. **Transmission mode :** SSB (single side band) with suppressed carrier

4. **Operating mode :** Duplex

5. **Number of aPLC channel :** From 0 to 6

6. **Number of dPLC channel :** 0 or 1

7. **Basic frequency band of aPLC channel:** 4 kHz

8. **Basic frequency band of aPLC channel:** 4 kHz, 8 kHz, 12 kHz or 16 kHz

9. **Tx and Rx bandwidth:**
   1) adjacent Tx and Rx band: 4 kHz, 8 kHz or 12 kHz
   2) non -adjacent Tx and Rx band: 4 kHz, 8 kHz, 12 kHz, 16 kHz or 24 k
   NOTE: Tx bandwidth and Rx bandwidth are always the same!

10. **RF range:** from 20 kHz to 1000 kHz

11. **Channel positioning in RF range:** programmable in whole RF range in 1 kHz step

12. **Channel polarisation (Tx and Rx) in RF range:** normal (always)

13. **Allocation of Tx and Rx band in RF range:**
    1) configuration with dPLC channel: non-adjacent (always)
       (only dPLC channel)

    2) all other configurations: adjacent or non-adjacent
       (only aPLC channel(s) or mix (aPLC channel(s) + dPLC ch.))

15. **Frequency accuracy in RF range:**
    1) f_{RF} = from 20 kHz to 500 kHz: ≤ +/- 10 Hz
    2) f_{RF} = from 500 kHz to 1000 kHz: ≤ +/- 20 Hz

16. Output Peak Envelope Power of PLC terminal - PEP:

1) output power of PLC terminal (PEP): 0 W, 20 W, 40 W or 80 W
2) output power of PLC terminal with regard to Tx band position in RF range:
   f_{RF} = from 20 kHz to 500 kHz: PEP
   f_{RF} = from 500 kHz to 750 kHz: PEP / 2
   f_{RF} = from 750 kHz to 1000 kHz: PEP / 4

17. Spurious emission: in accordance with IEC 60495; clause 5.2.4, figure 7 and figure A.2

18. RF line port:

1) output impedance: 50, 75, 125 or 150 Ohms
2) input impedance: same as output impedance (nominal) or high (applicable in case of non-adjacent Tx/Rx bands only)
3) configuration: balanced, unbalanced or 2 x 75 Ohms unbalanced, differential-phase
4) return loss: > 12 dB
5) balance to ground (balanced configuration only); f = 50Hz (60Hz) > 40 dB
6) RF connector: two (2) unbalanced (coaxial) N type connectors or two (2) balanced (symmetrical) connectors (on request only)

19. Receiver selectivity :

1) tested according to the IEC 60495; clause 5.3.1.5 COMPLY

3.6.2 Channel Part, Analogue (aPLC) Channel

1. Bandwidth (kHz): 4 (gross)

2. Usable AF band (Hz): 300 – 3.720

3. Channel versions: »standard« or »speech-plus«

4. AF channel interface: 3 x 4-wire port & BOOST

5. Transit filter: YES (in Tx and Rx direction)

6. Telephony interface: Universal; FXS, FXO, 2-/4-wire, E&M (TRUNK)

7. Receiver sensitivity: pilot level ≥ -30dB (PEP/channel = 10W: line attenuation ≤ 51dB)

8. **AGC range:** ≥ 40dB

9. **Synchronization:** YES; »master – slave«

10. **Integrated functions:** maintenance speech ch.
TPS function VP-9PST-A (option)

3.6.3 Channel Part, Digital (dPLC) Channel

1. **Digital modulation:** MC OFDM QAM

2. **Adaptive equalizer:** YES

3. **Nominal channel Capacity (kbps):** 9.6, 14.4, 19.2, 24, 28.8, 32, 48, 56, 64, 72 or 96

4. **Bandwidth used (kHz):** 4, 8, 12 or 16

5. **Utilization methods:** single-purpose use or multi-purpose use (AMUX)

3.6.4 Mechanical Design (Rack VP-9R1P)

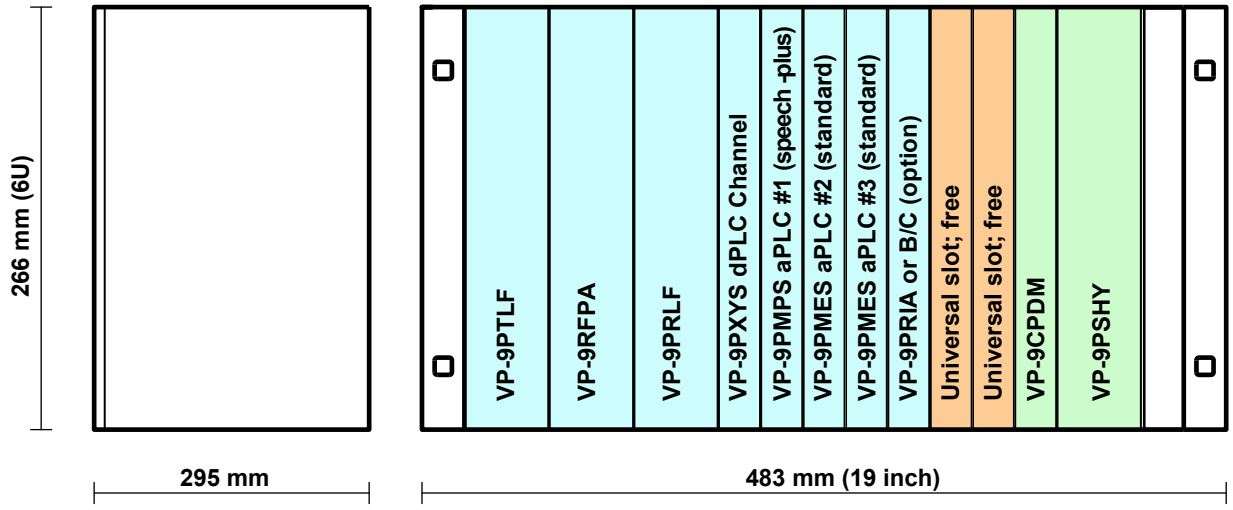

Figure 3-4: V-PLC9000 sub rack design for VP-9UPT

Chapter 4 - VP-9PST, Protection Signaling Terminal

4.1 General

Transmission of information for teleprotection systems is one of the most important telecommunication services that power utility private telecommunication system must provide. Information between Protection Relays (PRs) in teleprotection systems of command type is transmitted in the form of protection commands. Protection relays are located at ends of HV power lines. Commands are used in several applications: direct trip, permissive trip and (de)blocking. Each protection relay can handle the required protection operations also without information from the opposite side of HV power line. However fast, secure and dependable transfer of protection commands between two protection relays ensures *faster and/or more selective operation* of protection system. Important parameters of protection commands transmission are transmission time, security against unwanted commands and dependability of command transmission.

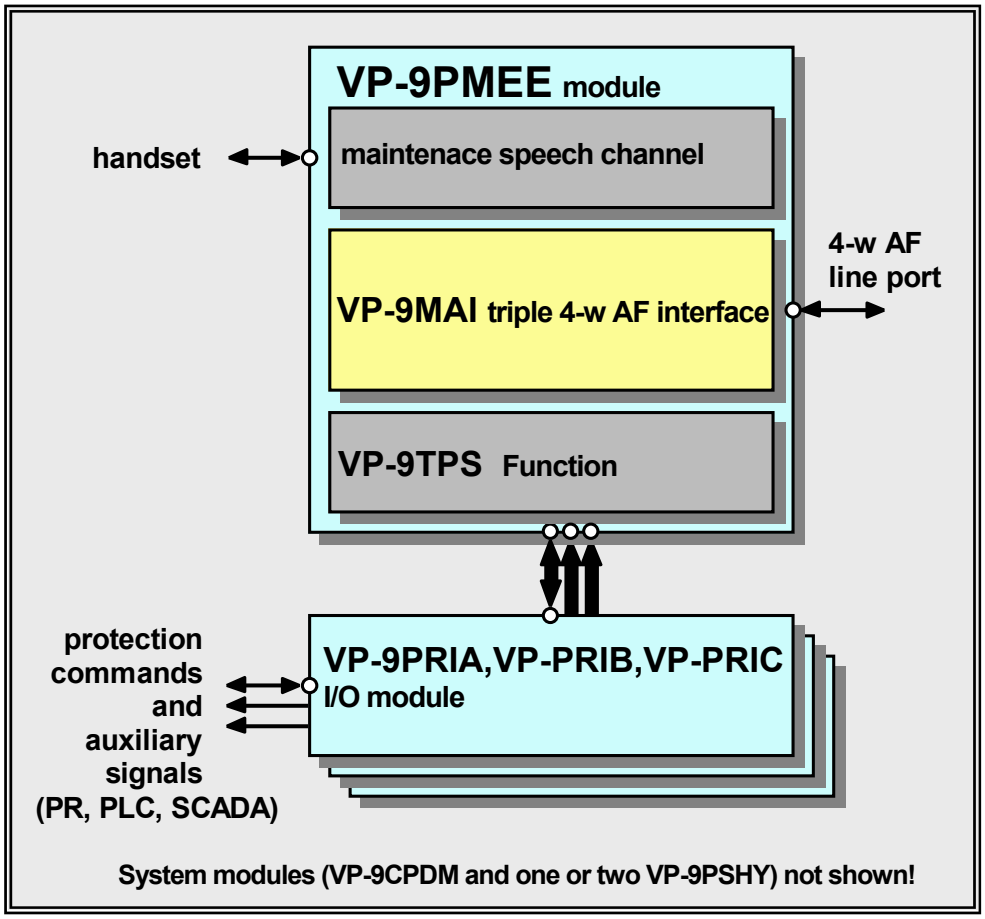

Figure 4-1: VP-9PST principle block diagram

VP-9PST-A TeleProtection Signaling terminal (TPS terminal) is designed for full duplex transmission of protection commands. Transmission of protection commands between two PRs is performed with two VP-9PST-A terminals located at the ends of HV power line together with PRs. Between two VP-9PST-A terminals a telecommunication link must exist. VP-9PST-A TPS terminal enables transmission of protection commands through »analogue« (voice grade) telecommunication channels in point-to-point configuration. »Analogue« means that the telecommunication channel is suitable for transfer of analogue signals within basic frequency band from 0Hz to 4kHz gross. Type of telecommunication technology used has no influence. It is however important that the telecommunication channel provides minimal delay. Considering that, most suitable technologies are copper or fiber optic cables, PLC links and radio links. Satellite or switched links are not suitable for such application.

VP-9PST-A fully programmable TPS terminal enables transmission of up to eight (8) protection commands in different priority schemes. Transmission parameters for each protection command are determined by chosen command application. Allocation of signals in AF band is also programmable.

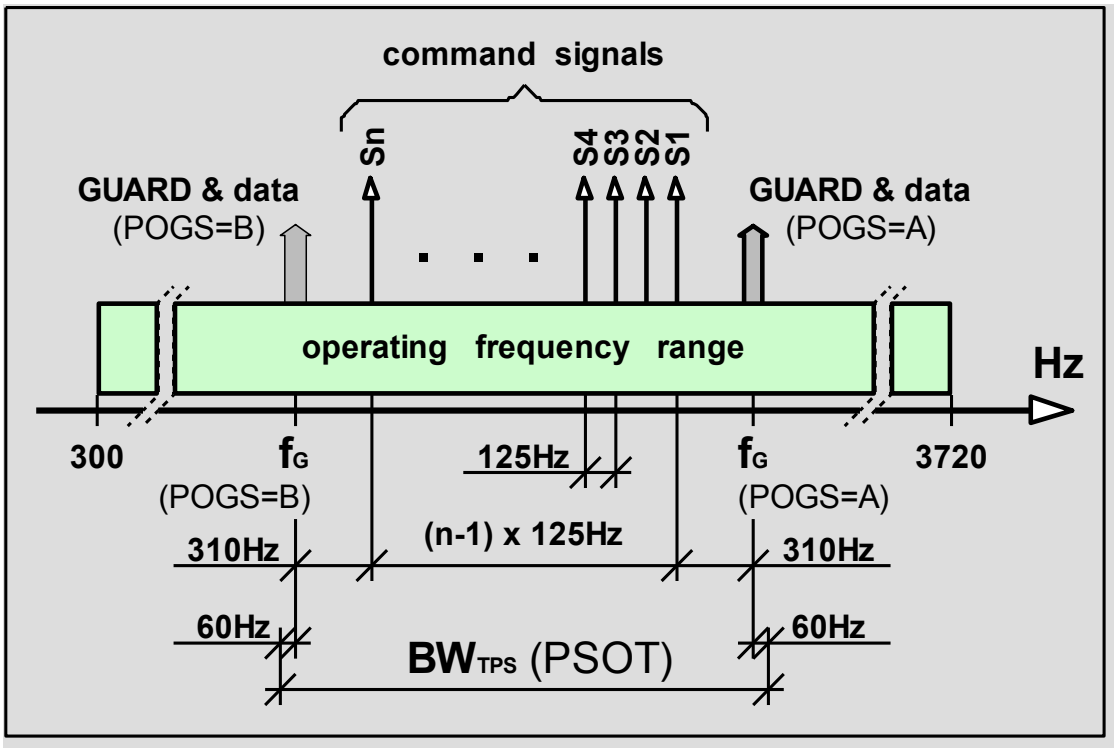

Figure 4-2: VP-9PST programmable Teleprotection Terminal

VP-9PST-A consists of processing DSP module VP-9PMEE and adequate number (1, 2 or 3) of interface modules VP-9PRIA, VP-9PRIB and/or VP-9PRIC. Interface modules provide interconnection between VP-9PST-A terminal and PR, supervision system (SCADA) and PLC terminal (BOOST-OUT). All modules are of the same dimensions: 25,4mm (width; 5HE) x 233,35mm (height;

6U) x 220mm (depth). Two fully independent VP-9PST-A terminals can be installed into one VP-9R22 type 19 inch rack. Each terminal includes necessary system modules: one or two (redundant power supply) power supply modules VP-9PSHY and parametrising/ diagnostic module VP-9CPDM.

TPS function with identical characteristics may be integrated into any aPLC or dPLC channel of VP-9UPT universal PLC terminal and into VP-9ACT analogue channel terminal.

VP-9PST-A fully complies with relevant international standard IEC 60834-1 (1999-10).

4.2 Technical Data

4.2.1 General Characteristics

1.	**AF band:**	0 – 4kHz gross; 300 – 3720 (3400) Hz net		
2.	**Operating mode:**	4-wire, full duplex		
3.	**Number of commands:**	from 1 to 8		
4.	**Transmission mode:**	guard tone/command(s) tone (F6 modulation)		
5.	**Command application:**	direct trip, permissive trip or (de)blocking		
6.	**Priority schemes:**	3I, 4I, 6P (1+1+1+1+1+1), 22 (2+2) in 42 (2+2+2+2)		
7.	**Frequency plan:**	programmable		
8.	**Nominal transmit time (ms):**	**direct.** <20	**permiss.** <15	**block.** <10
9.	**Probability of an unwanted Command P_{uc} (security);** (noise = white noise bursts)	$<10^{-7}$	10^{-5}	10^{-3}
10.	**Probability of a missing com P_{mc} (dependability) / T_{ac} (ms);** (S/N = +6dB)	$<10^{-4}$/40	$<10^{-4}$/20	$<10^{-3}$/15

4.2.2 AF Line interface (4-wire)

1. **Impedance:** 600Ω; balanced
2. **Return loss:** ≥ 20dB
3. **Balance to ground:** ≥ 40dB
4. **Nominal / max. Tx level:** 0dBm / +9dBm (command)
5. **Receiver sensitivity:** -30dBm (command)

4.2.3 Binary Input

1. **Number of inputs:** module VP-9PRIA: 2x IN
module VP-9PRIB: 4x IN
module VP-9PRIC: 6x IN
2. **Input technology:** Optocoupler
3. **Electrical characteristics:** Uin = from 24V to 250V DC
(Iin = const. = 5mA)
4. **Function (setting):** transmit (Tx) command or
BOOST-IN (from PR)

4.2.4 Binary output

1. **Number of Outputs:** module VP-9PRIA: 6x OUT
module VP-9PRIB: 4x OUT
module VP-9PRIC: 2x OUT
2. **Output technology (setting):** MOSFET or relay contact
3. **Electrical characteristics:** Umax = 250V
Imax = 2A (MOSFET)
Imax = 5A (relay contact)
4. **Function (setting):** receive (Rx) command,
BOOST-OUT (to PLC),
ALARM, PR deblocking,
Tx command control
5. **Command counters:** Each command; Tx and Rx
6. **Test:** YES; Manula or Automatic

4.2.5 Other Characteristic

1. **Integrated function:** maintenance speech channel
2. **Power Supply - mains:** 115 / 230 V AC
3. **Power Supply - battery:** 24, 48, 60, 110 or 220 V DC
4. **Temperature range (°C):** 0 - 45 (55)
5. **Compliance:** IEC 60834-1 (1999-10)

4.2.6 Mechanical Design (Rack VP-9R1P)

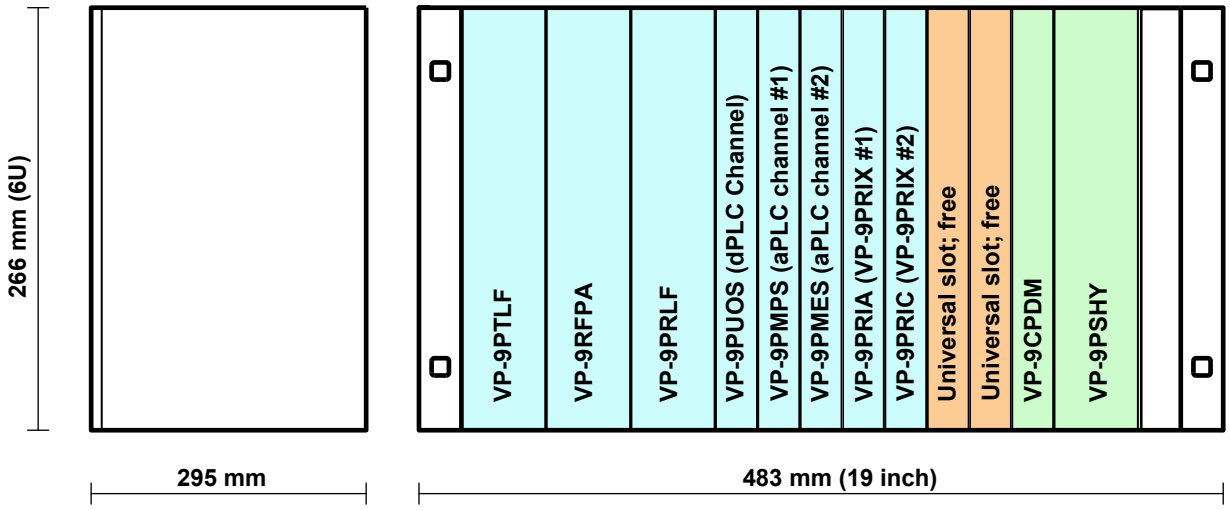

Figure 4-3: V-PLC9000 sub rack design for VP-9PST

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