



# UNDER THE HOOD OF THE SOUNDSTATION VTX 1000™

## WHITE PAPER

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## **Preface**

Since its introduction a short time ago, interest in the Polycom SoundStation VTX 1000 has been intense. In many respects, it is a revolutionary product. It is the first integrated audioconferencing system to provide wideband audio capabilities over the public telephone network; this alone makes it a major advance over the existing state of the industry. But there are numerous other firsts in the SoundStation VTX 1000. Some of these will be helpful to those who are using, selling, or considering a purchase of the system, and some may just be interesting to know. The purpose of this paper is to give a peek inside the SoundStation VTX 1000, to help you understand just why this system is so extraordinary.

## **Capabilities and Characteristics**

Some of the capabilities of the SoundStation VTX 1000 relate directly to its current features, while others may be more fully utilized in the future (yes, its software is upgradeable; more about that later), or in specific installations. Here are some of its internal characteristics and capabilities.

*Digital Architecture.* The SoundStation VTX 1000 operates on the TriMedia processor core, running at 200 MHz. This is a multiprocessing DSP that runs five execution units simultaneously, producing an aggregate of over 1000 million operations per second (MOPS), and more than 800 million floating point operations per second (MFLOPS). In calculation capacity, this can be compared to a one-GHz Pentium IV. Program and ringtone storage is 4 MB, operating memory is 16 MB. This is over 100 times the processing power of the SoundStation, one thousand times the available memory.

*Software Architecture.* The SoundStation VTX 1000 contains six independent 14kHz audio processing input channels: one for each of the three internal mics, two external mics, and the auxiliary input channel. Each of these performs a complex set of algorithms in both time and frequency domains, at some points operating on internal representations of the audio signals which are broken into 320 separate frequency sub-bands. By comparison, the SoundStation Premier has three input channels, each processing eight sub-bands.

Tone Controls: Two tone controls, one treble and one bass, can be accessed through the keyboard. Each of these is implemented as a double biquad IIR digital filter, acting on the audio path that leads to the loudspeaker.

PSTN Interface. The telephone interface resides in the *Palomod* (a name combined from the Unimod of SoundStation and SoundStation Premier, and the name that the project team gave the SoundStation VTX 1000 while we were developing it, *Palomino*). This is a special circuit with extremely low distortion that is configured and controlled (no more DIP switches for worldwide flexibility) by a local microprocessor. It is also controllable to present a wide range of real and complex impedances to the attached telephone line, which is helpful in achieving an optimal match to minimize line reflections while meeting individual country requirements. This interface controller is commanded and the software is updated via the cable that connects it to the SoundStation VTX 1000 console.

Power Subsystem. The main power supply is a full-range (100 - 264VAC, 50/60 Hz) switching supply integrated into the Palomod. 22VDC is sent to the console, where it is converted to five lower voltages by local linear and switching regulators. The 22 VDC is highly regulated and conditioned to maintain very low noise in the analog sections of the phone.

Narrowband Communication Protocols. When connected to a far end in narrowband mode, audio is carried over the twisted-pair phone line via conventional analog techniques.

Wideband Communication Protocols. Wideband audio is transmitted by first compressing the near-end audio signal with a high-bandwidth codec selected according to call requirements from a menu including G.722.1, G.722.2, Siren14, and proprietary codecs, and communicating it via a proprietary modem which is designed to optimize latency, connect time, bidirectional data rate, and link reliability.

Sampling rate and inherent bandwidth. The basic audio sampling rate is 48 kHz (which gives a higher theoretical bandwidth limit than even the 44.1 kHz used by Compact Disks). The inherent hardware bandwidth (not including speaker and mics) within the SoundStation VTX 1000 is consequently greater than 22 kHz. Internal mics and speaker are certified to 14kHz. Interfaced to an external Vortex, the system can operate to 22 kHz.

Microphone Configuration. Three cardioid mics provide consistent frequency and sensitivity through a 14 kHz frequency range, around the entire 360 degree coverage pattern. This compares to the cardioid and hypercardioid patterns of Polycom's earlier systems, all of which were limited to 3.3 kHz.

The internal microphones can be disabled via the user interface, which can be very useful in some special situations.

Speaker configuration. Acoustic suspension speaker in an isolated enclosure, bandwidth to 14 kHz (the internal speakers in SoundStation and SoundStation Premier are limited to a top end of 3.3 kHz.). The internal speaker can be disabled via the user interface, which can be very useful in some special situations.

External I/O. The SoundStation VTX 1000 has separate line-level input and output (AUX IN and AUX OUT) for interfacing with external systems. This is different from the SoundStation and SoundStation Premier, in which only one connection is available and must be switched between input and output.

AUX IN. The Auxiliary Input, AUX IN is configurable for external microphone, wireless microphone, or sound systems (such as CD players). Additionally, AUX-IN allows use of Polycom's Vortex™ Installed Voice system with external (table or ceiling mounted) microphones.

AUX OUT. The Auxiliary Output, AUX OUT can be keyboard-configured to operate with an external subwoofer, external PA system, or external recorder. Additionally, AUX OUT is used to drive external speakers via Polycom's Vortex Installed Voice system with external speakers.

External subwoofer. The wideband operation of the SoundStation VTX 1000 extends not only upward to 14 kHz, but down to 80 Hz. The internal speaker is effective down to about 250 Hz. Below that, an external subwoofer (shipped as part of the system) takes over. This allows the tabletop console to remain compact, while not compromising overall sound quality. Incidentally, the system still operates without this subwoofer attached; it's just the very lowest frequencies that are absent.

Console Interface. The console is connected to the Palomod via an enhanced 8-wire P8 bus, similar to that in the SoundStation Premier, which provides power, analog signaling, and RS-232

signaling. The console also has a 32 Mbps serial digital interface for future expansion.

EX MICs. Two enhanced EX mics are supported. Each has a uniform cardioid pattern across the 14 kHz frequency band (as compared to the 3.3 kHz EX mics in both SoundStation and Premier systems). *Note: The SoundStation VTX 1000 EX mics are not compatible with those in the SoundStation or SoundStation Premier.*

High Fidelity Ringtones. Ringtones are stored as part of the program image, and can hence be downloaded along with new software. These are stored in the Siren 7 compressed audio format for memory efficiency, optimized for music quality.

LCD: The LCD display is a 60 x 240 high-resolution monochrome LCD. It is backlit by an LED array for long life.

Software Upgrading Facilities. The program memory, ringtones, and user parameters are stored in an internal flash memory. This can be upgraded by any of three paths: by calling an unmodified V.34 modem over the phone line, by a connection to a compatible host system over the 32 Mbps digital link, or by RS-232 feed via the P8 bus. (The latter two paths are only supported for factory use at present).

Security. Security of three kinds is of interest.

a. Phone line interception. Narrowband calls over the SoundStation VTX 1000 have the same sensitivity to interception (wiretapping) as those of any standard analog phone. Wideband calls are considerably more resistant, as the connection sounds like white noise to the casual listener, and meaningful interpretation requires active participation in the line probing process at the beginning of the call, which would disrupt the call and so alert the participants to the interception attempt. Simply listening to the call would be useless to any but an extremely sophisticated interceptor. Current software versions do not support additional encryption of the data, although this would certainly be possible in the future.

b. Software upgrade and user configuration security. Remote or local software upgrade and system configuration are enabled after the entry of a three-digit key from the unit keyboard. Without this key set, a remote call attempting to contact the unit will not be able to establish the basic V.34 modem connection. In the initial release, a unit can only be

upgraded by calling out to a server, so there is no ability to call in and disrupt the software.

c. Radiated data. The system complies with the requirements of FCC Part 15 Class B and CISPR 55022 Class B. Consequently, its radiated energy is within very low limits.

### Connection Protocol and Implications

The SoundStation VTX 1000 operates as both a narrowband and wideband audioconferencing system. When first connecting to a far end, it makes a determination of what kind of system is at the far end and decides what to do next based on this determination. When both ends are VTX-compatible, the dialogue works like this.

a. The answering device begins the dialogue by generating a *ding* (a sound with specific characteristics). This *ding* has the meaning, "I am a VTX-compatible device, and I have just answered this call. Are you a VTX-compatible device? Do you want to convert this call to wideband voice mode?" *Ding* is a narrowband signal, audible to any calling telephone.

b. The calling device listens for the presence of the *ding*, and responds with a similar *dong* sound. *Dong* means, "I recognize that you are a VTX-compatible device. I am also VTX-compatible, and I want to convert this call to VTX Wideband mode."

c. The two units initiate a brief capabilities exchange session. This confirms the identify of the units as VTX-compatible, and also determines whether the line probing will be done using a *short train* (6 seconds) or *long train* (12 seconds) sequence. Each unit has a set preference through its user interface. Training will use long train, which provides the highest possible data rate on connection, unless both are set to prefer short train.

d. During the line probing procedure, the nature of line echoes, channel frequency response, and noise statistics are quantified. With the line characterized, the VTX-compatible devices then establish a digital link to each other. This process determines the line quality and will allow the phone to maximize voice quality and bandwidth. If the line quality is poor (too much noise or signal loss) the phones will automatically reduce audio bandwidth, until

at very low line qualities they will revert to normal 3.3 kHz analog mode.

e. Over the digital link an audio channel is opened, codecs are engaged, and two-way simultaneous wideband speech begins.

Note that a connection between two systems is only wideband when both ends are VTX-compatible and are operating in this mode. A VTX-compatible system communicating with another VTX-compatible system is probably operating in the VTX mode, and will communicate with wideband audio. However, a VTX-compatible system communicating with a SoundStation Premier, for example, will be constrained by the fact that the Premier is not VTX-compatible, so it will operate in its conventional narrowband mode. However, even the narrowband performance and features of the SoundStation VTX 1000 are superior to those of the Premier.

This also means that for a bridged, or multipoint, call to operate in VTX wideband mode, the bridge must support this mode. This is because for each endpoint, the bridge itself is the "other end;" data transfer is not possible directly through the bridge; the data channel is too sensitive to handle bridge processing directly (this is the same reason that computer modems cannot communicate through a multipoint bridge call). The bridge must demodulate the data, and remodulate it on the other participating ports. However, as more than 70 percent of all business calls today are point to point and so can support VTX wideband, this is not a serious disadvantage.

### **Compatibility**

The SoundStation VTX 1000 is compatible with many Polycom products via direct connection, including the following:

- Polycom Lavalier Wireless Microphone
- Vortex Installed Room Conferencing System
- iPower™ Video Conferencing System
- ViewStation® Video Conferencing System



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