# VH2

Product Manual

## ABOUT COMREX

Comrex has been building reliable, high quality broadcast equipment since 1961. Our products are used daily in every part of the world by networks, stations and program producers.

Every product we manufacture has been carefully designed to function flawlessly, under the harshest conditions, over many years of use. Each unit we ship has been individually and thoroughly tested. Most items are available off the shelf, either directly from Comrex or from our stocking dealers.

Comrex stands behind its products. We promise that if you call us for technical assistance, you will talk directly with someone who knows about the equipment and will do everything possible to help you.

Our toll free number in North America is 800-237-1776. Product information along with engineering notes and user reports are available on our website at www.comrex.com. Our email address is info@comrex.com.

## WARRANTY AND DISCLAIMER

All equipment manufactured by Comrex Corporation is warranted by Comrex against defects in material and workmanship for one year from the date of original purchase, as verified by the return of the Warranty Registration Card. During the warranty period, we will repair or, at our option, replace at no charge a product that proves to be defective, provided you obtain return authorization from Comrex and return the product, shipping prepaid, to Comrex Corporation, 19 Pine Road, Devens, MA 01434 USA. For return authorization, contact Comrex by phone at 978-784-1776 or fax 978-784-1717.

This Warranty does not apply if the product has been damaged by accident or misuse or as the result of service or modification performed by anyone other than Comrex Corporation.

With the exception of the warranties set forth above, Comrex Corporation makes no other warranties, expressed or implied or statutory, including but not limited to warranties of merchantability and fitness for a particular purpose, which are hereby expressly disclaimed. In no event shall Comrex Corporation have any liability for indirect, consequential or punitive damages resulting from the use of this product.

## WHAT VH2 DOES

VH2 is a powerful hardware-based telephone system designed for broadcast on-air telephone management. Unlike legacy systems that interfaced to analog and digital dedicated phone lines, VH2 interfaces only to IP-based (VoIP or Voice-over-IP) telephone circuits. By this we mean that all phones lines are delivered virtually over a single Ethernet connection to the VH2.

The voice telephone industry has been moving toward IP voice service for many years already because it streamlines connections, enhances management, and reduces costs. IP-based voice carries these benefits for the broadcaster.

The VH2 (and VoIP in general) brings other advantages to broadcasters:

1. VoIP service is generally much less expensive than dedicated legacy phone lines.
2. VH2 implements a codec option (G.722) which delivers better fidelity (7KHz) than ordinary phone calls. This mode will be automatically selected when possible.
3. VH2 utilizes a VoIP protocol called SIP, which allows integration with existing and future VoIP gear (e.g. sharing lines and using extensions from PBXs).
4. VH2 can be easily interfaced to legacy PSTN, ISDN, T1 and E1 phone lines through the use of external gateway devices.

## ABOUT VH2 AUDIO PROCESSING

VH2's main function is to make your on-air phone calls sound great. From an audio perspective, it does this by:

- Making sure the caller you select is presented in the best possible audio quality to your console.
- Making sure that the caller can hear the studio host(s) clearly.
- Making sure if multiple callers are on-air, that they can hear each other clearly.
- Making sure callers with low or high levels are automatically equated (AGC).

A block diagram of VH2 audio connections is shown in **Figure 1** In this simple configuration, a feed of the station's program audio (pre-delay) is fed to the **HOLD AUDIO CH 1** port on the VH2. A studio "mix-minus" feed is attached to the **INPUT CH 1** port, and the caller(s) audio (for delivery to a single console fader) is available on the **OUTPUT CH 1** port.

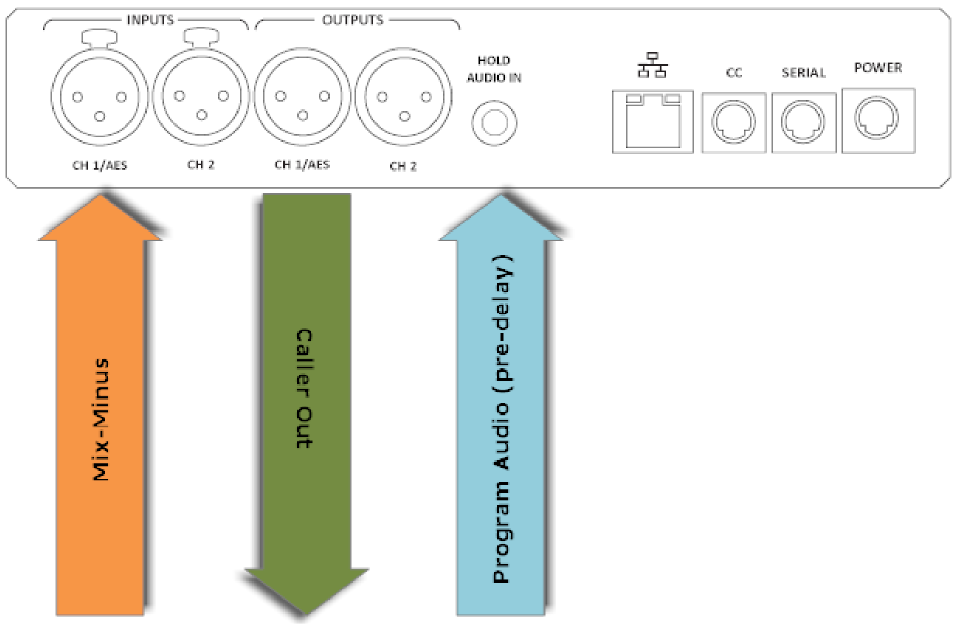



FIGURE 1 **VH2 SIMPLE AUDIO CONNECTIONS**

Many applications require that multiple callers be put on-air simultaneously. For this reason, VH2 contains two separate hybrids* that allow each caller to be presented on a different output from the VH2. This allows you to balance each caller on a separate console fader.

**Figure 2** shows this arrangement. Here, two caller outputs are used, but only a single mix-minus feed is applied to the **INPUT CH 1** port. This mix-minus must not contain any caller audio from either hybrid. An example of how to create this type of mix-minus is to use an auxiliary bus on your console, deselecting both telephone input ports from that bus.

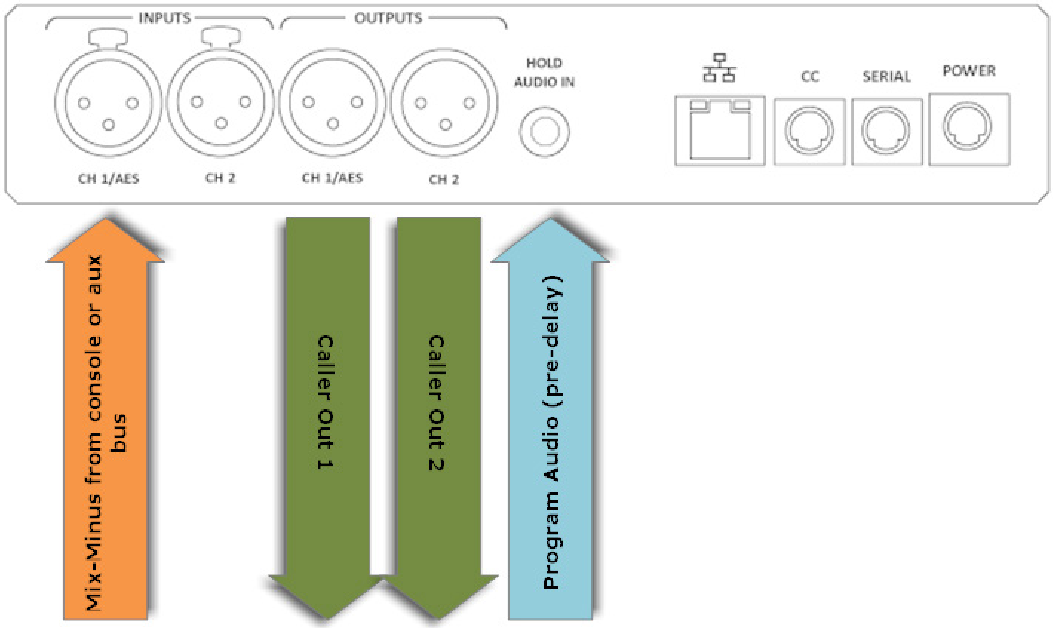



**FIGURE 2**

**The term Hybrid is a legacy from analog telephony products, which had the task of separating send and receive audio on the phone line. Since VoIP calls don't mix this audio, a Hybrid is technically not employed, but rather a conference is built for each output. For simplicity, we'll continue to use the legacy term for an on-air telephone channel.*

Some consoles have a dedicated "send" output for each fader associated with a caller. Often, the console will define these as "telephone busses" or "channels". In this case (**Figure 3**), each hybrid gets its own "send" audio from the console, each pre-configured with an appropriate mix-minus feed. These mix-minus feeds will be applied to the **INPUT CH 1** and (optionally) **INPUT CH 2** ports.

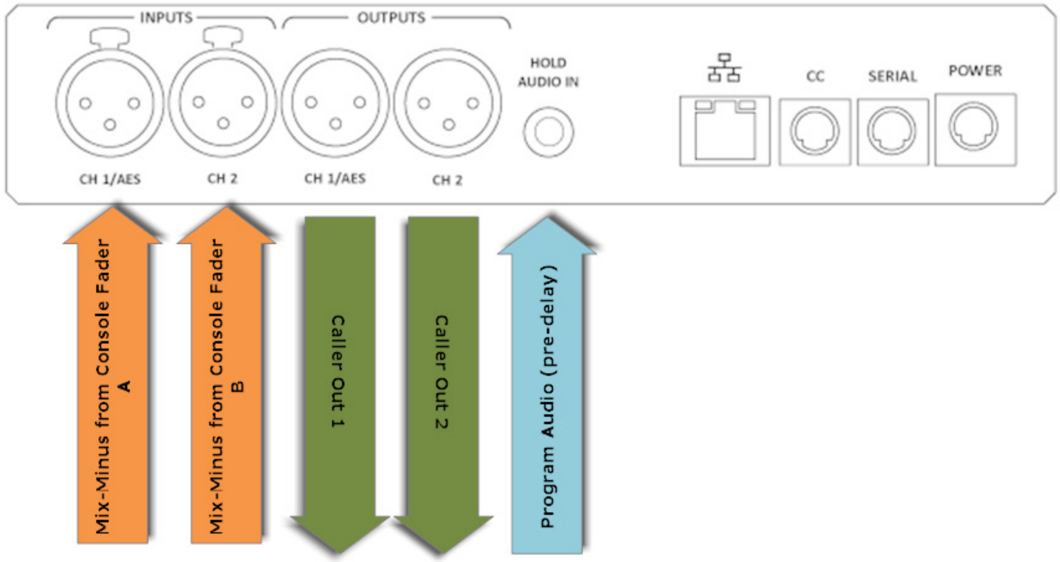



**FIGURE 3**

Finally, VH2 is capable of behaving like two, completely independent products for use in two, unrelated studios. This is shown in **Figure 4**.

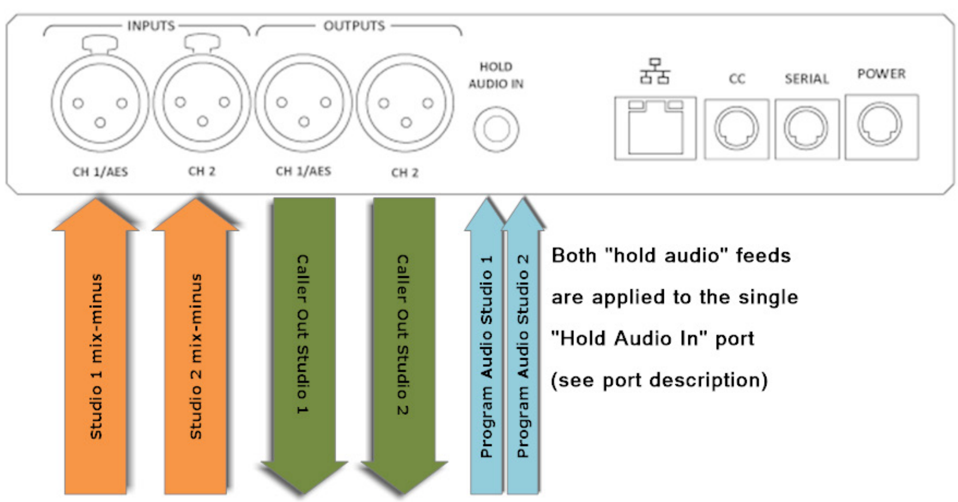



**FIGURE 4**

## ABOUT MIX-MINUS

Comrex support spends a lot of time discussing mix-minus, as it is not an obvious concept. In studio telephony integration, there is a golden rule:

***People connecting from outside the studio must never be sent their own audio back to themselves.***

If this rule is not followed, the result will be an unpleasant echo in the caller's ear. It is the responsibility of the studio tech to connect a feed to each return channel that is a mix of all important audio sources - in-studio mics, automation, carts, other remote sources, etc., minus the caller. Most modern consoles can do this easily. If not, other options exist and are discussed in the section "**Why Do I Hear Hear Myself Myself?**" (**Section XIV** in this manual).

Finally, when configuring and connecting for using both send inputs, the mix-minus feeds usually contains the audio from the opposite send channel. In instances where this is not the case, behavior can be configured to allow callers to hear each other within the VH2.

# II. SETTING UP VH2

## HARDWARE ATTACHMENTS

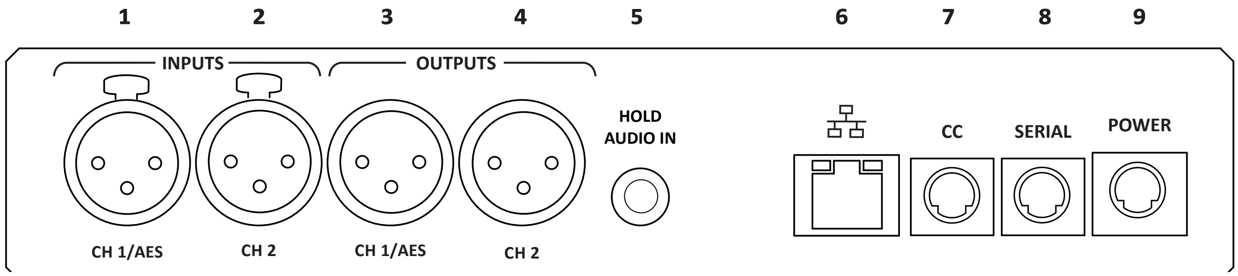



FIGURE 5 **VH2 REAR PANEL**

**Figure 5** shows the rear panel of VH2:

1 **CH 1 INPUT -** In analog mode, this XLR connector should be sent a balanced, 0dBu signal that is heard by callers when they are “on-air”. This is usually a “mix-minus” feed created on your studio console. In digital AES3 mode, both **CH 1 INPUT** and **CH 2 INPUT** are applied here (on left and right channel, respectively).

2 **CH 2 INPUT -** Use of **CH 2 INPUT** is optional. This analog input receives audio to be sent to callers on “hybrid 2” when “on-air”. This input is disabled when in AES3 mode or when configured for single “send” input.

3 **CH 1 OUTPUT -** This analog output will deliver the audio from callers who are sent to “channel 1” on air. Alternately, the system may be configured to present all caller audio on this single output. In digital AES3 mode, both **CH 1 OUTPUT** and **CH 2 OUTPUT** are delivered here (on left and right channel, respectively).

4 **CH 2 OUTPUT -** This analog output will deliver the audio from callers who are sent to “channel 2” on air. This output is disabled when in AES3 mode or when configured for a single “caller” output. Note special pinning of this 1/4” connector in the next section.

5 **HOLD AUDIO IN -** Analog only, route audio to this port that will be sent to callers “on-hold”.

6 **Ethernet Port -** Connect your network to this gigabit compatible Ethernet port.

7 **Contact Closure Connector -** This contains 4 contact closure input and output signals, for various remote control and tally functions as described further on.

8 **Serial Port -** This is an RS-232 connector that presents a serial port for future use.

9 **Power Supply input –** Apply the included AC desktop adapter output here. The power supply port requires 24VDC at 0.5A.

## AUDIO CONNECTIONS

All analog XLR audio inputs has a nominal level of 0dBu (full scale +20dBu).  When the input mode is changed (via DIP Switch #1) to AES3 mode, the AES3 output will rate lock to the input signal. Otherwise, AES3 output is 48KHz. AES3 inputs support 32, 44.1, and 48KHz sampling rates.

Analog input and output pinouts:

| | |
|---|---|
| Pin 1 | Ground |
| Pin 2 | Balanced audio + |
| Pin 3 | Balanced audio - |

AES3 input and output pinouts:

| | |
|---|---|
| Pin 1 | Ground |
| Pin 2 | Data + |
| Pin 3 | Data - |

The "**HOLD AUDIO IN**' port has a special pinout to be aware of. The 1/4" jack is designed to accept two signals, a "Hold" signal for channel 1 and channel 2. The inputs are unbalanced with a common ground.

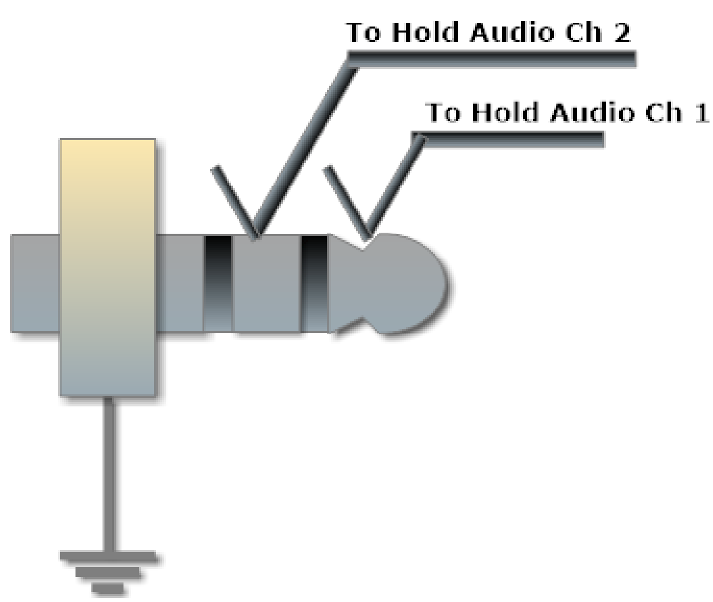
The pinout is:

Tip: Hold Audio in CH1

Ring: Hold Audio in CH2

Sleeve: Ground

Do not feed this port with actively balanced outputs, as it will ground one side of your active signal. If using only a single "Hold" audio source, connect the + side of the feed to Tip and Ring, and the Ground to Sleeve. If using two different "Hold" sources, connect CH 1 + to Tip, CH 2 + to Ring, and both grounds to Sleeve. Even though it's unbalanced, nominal level to this port is still 0dBu (+20dBu clip).



## CONTACT CLOSURES

Contact closure signals are available via the 9-pin mini-DIN connector.

The contact closure inputs parallel the action of the front panel buttons. The function of the output closures are set up in the behavior section of the configuration process, and can indicate different types of activity.

Inputs are triggered by shorting the respective input to Pin 9. Outputs consist of an open collector circuit which, when inactive, will offer a high-impedance path to Pin 9 and, when active, will offer a low-impedance path to Pin 9. These outputs are capable of sinking up to 200mA at a voltage up to 12V. Do not switch AC mains power using these contacts.

Contact Closure Pinouts:

| | | | | | |
|---|---|---|---|---|---|
| Pin 1 | Output #1 | Pin 4 | Output #4 | Pin 7 | Input #3 |
| Pin 2 | Output #2 | Pin 5 | Input #1 | Pin 8 | Input #4 |
| Pin 3 | Output #3 | Pin 6 | Input #2 | Pin 9 | Ground |

## MAKING CONNECTIONS

At a minimum, VH2 will need two audio connections and a network connection. Levels of all analog audio I/O is 0dBu (0.775V) nominal. This level will provide 20dB headroom before the clipping point. Input audio is reflected on the front panel LED based peak meters as indicated in **Figure 6**. Clipping is indicated by the red LED on these meters.

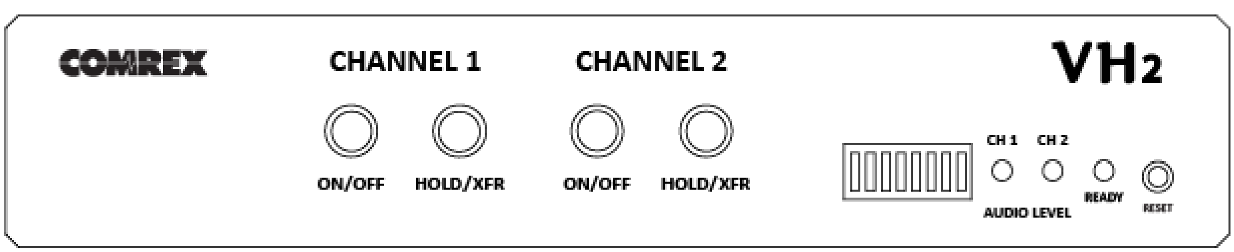



FIGURE 6 **VH2 FRONT PANEL**

VH2 needs a network connection to be useful. On VH2, network connections are made via a standard 1000Base-T Ethernet connection on an RJ-45 connector.

In most ways, VH2 will look like an ordinary computer to this network. In fact, VH2 contains an embedded computer with a Linux-based operating system and a full network protocol stack.

VH2 is perfectly capable of working over most LANs, but there may be situations where a LAN is heavily firewalled, subject to overloaded traffic conditions, or has security concerns. Better performance is possible if VH2 has its own Internet connection.

Since there may be bandwidth, firewall, and security concerns with installing VH2 on a managed LAN, it is recommended that your IT manager be consulted in these environments. The details that follow assume a working knowledge of IT topics and network configuration.

On VH2, the single Ethernet port handles connections to your phone lines and your web interface. IP addressing can be DHCP or Static, but if you are using the companion VoIP phone in your system, you will need to assign a Static IP address to the Ethernet port in order for the phone to find the VH2.

## ABOUT USING THE VH2 COMPANION PHONE

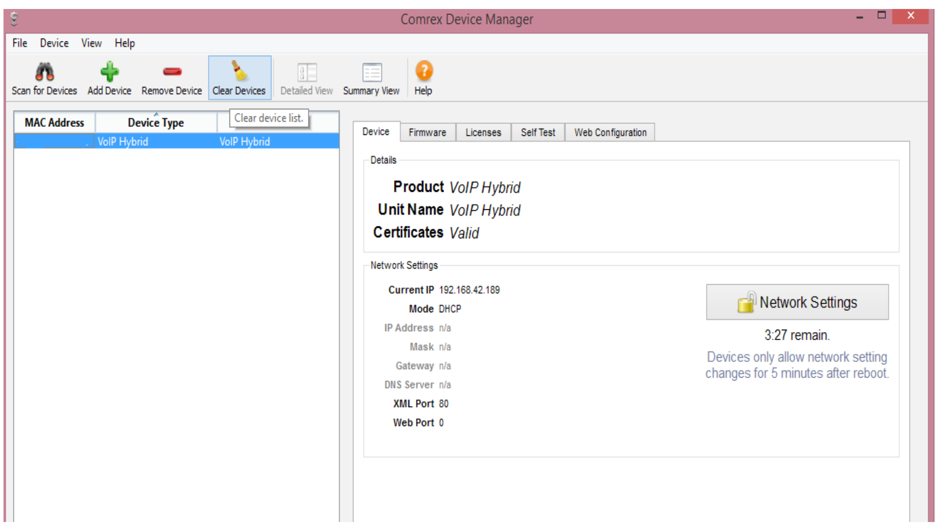
In a typical studio environment, it is convenient to be able to use a telephone set in conjunction with a telephone hybrid. This allows for outgoing calls to be placed, calls to be answered and screened, and for conversations to take place "off-air". VH2 supports this function with the approved VoIP companion phone (currently the **Polycom IP 331**). The VH2 can emulate the function of sharing a call between the hybrid and the phone, and "bouncing" a call between them with a single button push. The phone will require special settings (as outlined in section **IV. Configuring the VH2 Companion Phone**) to be configured as an extension of the VH2.

# III. CONFIGURING VH2 IP INFORMATION

VH2 is shipped from the factory set to DHCP mode, so it will find an address on your network if possible. The easiest way to find what that address is to use the Comrex **Device Manager** software, available on our website for both Windows and Mac platforms. You can also use **Device Manager** to upgrade the firmware on your VH2.

While it's not technically required for VH2 to have a static IP address, it is required for use with the companion phone, and if the DHCP address changes you'll need to find the new address in order to configure the VH2 via the Toolbox interface.

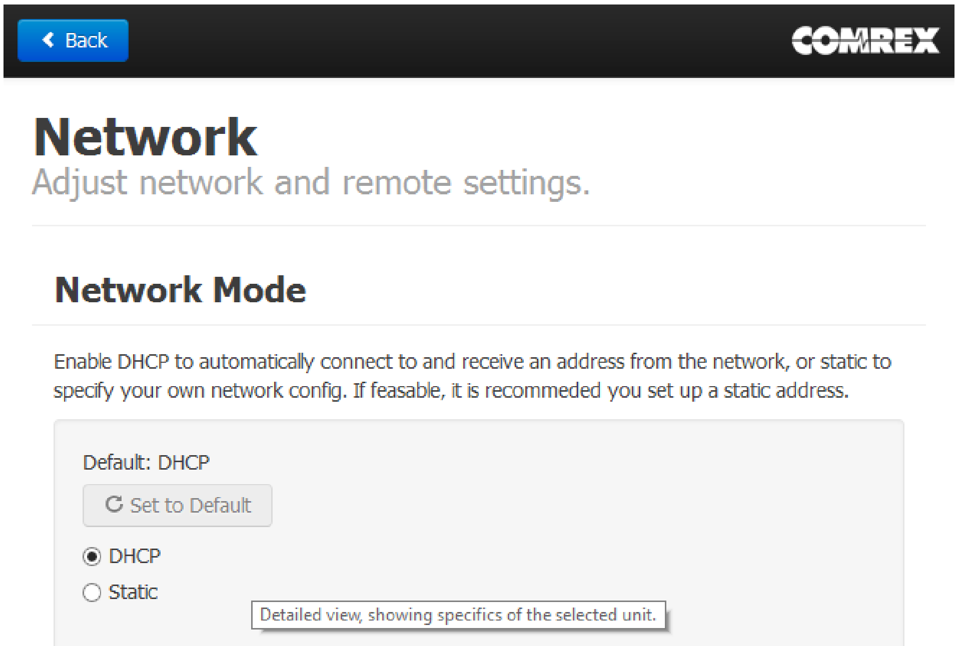
Install **Device Manager** on a computer on the same physical LAN as the VH2. Once installed and run, press the "**Scan for Devices**" button in the upper left corner to scan your network for Comrex products. The results should look like this:




There are two ways to set the static IP information using **Device Manager**. The "rescue" mode allows you to change parameters during the first five minutes of operation, and is initiated using the "**Network Settings**" button on the right pane. This mode is most useful if you've forgotten the unit password. The normal mode of changing any settings in VH2 is by clicking the "**Web Configuration**" tab in the right pane. This opens the unit's Toolbox interface. Toolbox is a web-based interface that allows you to set all relevant parameters of the product. Once you know the unit's IP address, Toolbox can also be accessed via a browser by going to **http://[ip-address]/cfg**.

Toolbox requires that you log on with a username and password. The default user name is “**admin**” and the default password is “**comrex**”. We recommend you change the default password, especially if your VH2 is exposed directly to the Internet.

Once logged in, choose the “**Network**” option. Under “**Network Mode**”, you’ll see the following options:




Change the mode to **Static**, and input the IP address, netmask, gateway and DNS information for your network. Click “**apply IP settings**” after all the information is correct. If you need to access Toolbox after this, you’ll need to rescan and log in again (or open a browser to the new IP address).

Alternately, to use the “Rescue Mode”, just click the **Network Settings** box on the right pane of **Device Manager**. If the 5 minute timer has not run out, a pop-up menu will appear allowing you to reconfigure the IP address, netmask, Gateway and DNS information and save it away. You will need to restart the VH2 for these changes to take effect.

# IV. CONFIGURING THE VH2 COMPANION PHONE

If you have the **Polycom 331 IP phone** for use with VH2, you'll need to set it up to be an extension of the VH2. The phone needs to be on the same physical LAN as the VH2, but it doesn't need a static IP address. You'll only need to program the static address of the VH2 into the phone.

Once the phone is on your LAN, it will get a DHCP address from the network. You can find what this is by pressing the menu button on the phone and navigating to the following using the direction cursor and enter key:

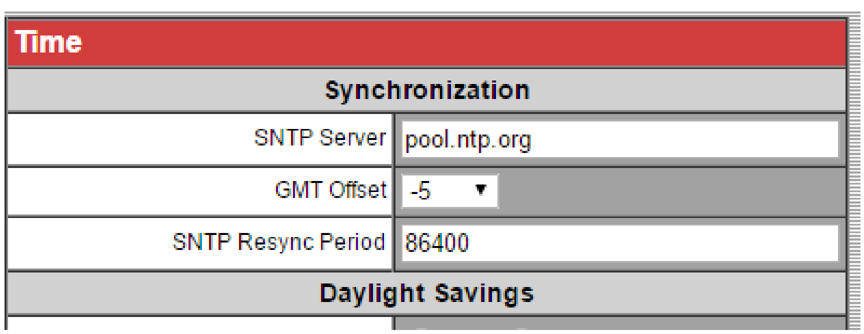
**2)Status-> 2)Network-> 1)TCP/IP Parameters**

Open a browser on your local computer and input the IP address of the phone into the URL bar. You will be prompted to log in to the phone's web interface. Default username is "**Polycom**" and default password is "**456**".

## TIME SETTING

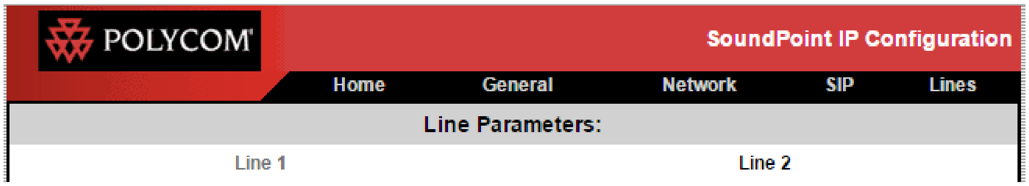
To stop the annoying time display from flashing an incorrect time and date, set a default SNTP server and time zone on the phone. Navigate to **General->Time** and set the fields to read the following:

**SNTP Server-> pool.ntp.org** (or any other SNTP server of your choosing)
**GMT Offset->** The offset of your time zone in hours from GMT (e.g. US Eastern = -5, US Pacific = -8)



## VH2 SETTINGS

To put the details of your VH2 into the phone, choose the **Lines** tab on the top menu of the configuration page:




Note the two sub-sections, **Line 1** and **Line 2**. You will need to program information into both of these pages.
On the Line 1 page, set the following fields:

Under *Identification*:

**Display Name -> 'Line 1'**

**Address-> '1100@<VH2_ip_address>'** (remove ' and <>)

**Authentication User ID -> '1100'**

**Authentication Password -> (default="456" - can be changed in Toolbox)**

**Label ->'Line 1'**

**Type->Private**

**Third Party Name->'none'**

**Number of Line Keys->1**

**Calls per Line->1**

Under *Server 1*:

**Address-><VH2_ip_address> (remove <>)**

**Port->5170**

**Transport->DNSnaptr**

**Expires->100**

**Register->1**

**Retry Timeout->0**

**Retry Maximum Count->3**

**Line Seize Timeout->30**

(leave the rest of the fields at default)

Your Line 1 Page should read like this (but with your VH2 IP address)

| Line 1 | |
|---|---|
| **Identification** | |
| Display Name | Line 1 |
| Address | 1100@192.168.42.15 |
| Authentication User ID | 1100 |
| Authentication Password | •••• |
| Label | Line 1 |
| Type | Private Shared |
| Third Party Name | none |
| Number Of Line Keys | 1 |
| Calls Per Line | 1 |
| **Server 1** | |
| Address | 192.168.42.15 |
| Port | 5170 |
| Transport | DNSnaptr |
| Expires | 100 |
| Register | 1 |
| Retry Timeout | 0 |
| Retry Maximum Count | 3 |
| Line Seize Timeout | 30 |

**Click Submit on the bottom of the page, then go to line 2**

On the Line 2 page, set the following fields:

Under *Identification*:

**Display Name -> ‘Line 2’**

**Address-> ‘1200@<VH2_ip_address>’ (remove ‘ and <>)**

**Authentication User ID -> ‘1200’**

**Authentication Password -> (default=”456” - can be changed in Toolbox)**

**Label ->’Line 2’**

**Type->Private**

**Third Party Name->’none’**

**Number of Line Keys->1**

**Calls per Line->1**

Under *Server 1*:

**Address-><VH2_ip_address> (remove <>)**

**Port->5170**

**Transport->DNSnaptr**

**Expires->100**

**Register->1**

**Retry Timeout->0**

**Retry Maximum Count->3**

**Line Seize Timeout->30**

(leave the rest of the fields at default)

Your Line 2 Page should read like this (but with your VH2 IP address)

| Line 2 | |
|---|---|
| **Identification** | |
| Display Name | Line 2 |
| Address | 1200@192.168.42.15 |
| Authentication User ID | 1200 |
| Authentication Password | •••• |
| Label | Line 2 |
| Type | Private Shared |
| Third Party Name | none |
| Number Of Line Keys | 1 |
| Calls Per Line | 1 |
| **Server 1** | |
| Address | 192.168.42.15 |
| Port | 5170 |
| Transport | DNSnaptr |
| Expires | 100 |
| Register | 1 |
| Retry Timeout | 0 |
| Retry Maximum Count | 3 |
| Line Seize Timeout | 30 |

**Click the Submit button on the bottom of the page.**

You are finished with the telephone setup.

# v. TELEPHONE CONNECTIONS

## INTRODUCTION TO SIP

SIP (Session Initialization Protocol) is the standard used by VH2 to talk to virtual phone lines. These lines must be created in some way externally before they are “applied” to VH2. “Applying” SIP lines to VH2 involves configuring the unit with certain information about the lines and the location of the server that delivers them. Then the unit can be allowed to register with the SIP server and automatically handle all of the interface with the virtual line.

The SIP line can be delivered from several sources:

1. A commercial telephony provider that delivers SIP-based lines over a public or private IP network.
2. A PBX that delivers telephony to extensions via SIP (in this case theVH2 is treated like a PBX extension).
3. A hardware gateway device designed to bridge legacy telephone services to SIP. These devices interface to the outside worlds via analog POTS/PSTN cables, T1/E1 circuits, or ISDN. They interface to VH2 via IP over Ethernet.

The setup and interface are identical for options 1 & 2 and similar for option 3.

The first step in setting up a SIP-based phone line is establishing an account with some kind of SIP-based provider or PBX. This process can’t be described here, but the result of this process is that you will have access to certain credentials for that account. These typically consist of:

**Server Domain** - The IP address or URL of the server to which you are being registered.

**Username** - The name that VH2 will use when logging into the service.

**Password** - The password associated with your account for security purposes.

In addition, several SIP providers require an **Authorization Username**, which is often defaulted to be the same as the username but sometimes is required to be different.

SIP is a complex protocol, and is based on Internet standards documents called RFCs. These documents are often subject to interpretation, and some PBXs, gateways, or telephony providers may have some obscure SIP settings requirements to work best with VH2. But most should work with just the credentials noted above.

Once VH2 is set up to work with a PBX or Internet Telephone Provider, it will automatically register with the correct server and maintain a connection to the server indefinitely. This way, the provider or PBX can notify VH2 of incoming calls to its phone number, as well as route outgoing calls correctly.

With hardware gateways, the process is reversed. VH2 will actually emulate a SIP server to the gateway device. The credentials will be entered into the gateway device. VH2 will only need to know the address of the gateway device

## SETTING UP A SIP PROVIDER OR PBX

SIP provider's info is entered using the web-based Toolbox Utility, accessible either by the **Comrex Device Manager** software (see **Network Settings**) or pointing a browser to **http://[ip_address]/cfg**. As a reminder, the default login credentials are **admin/comrex**.

In most arrangements, a SIP provider can deliver several telephone channels to you over a single account. When you subscribe to a SIP provider, make sure you understand how many simultaneous channels are provided with that account. These channels will act like a traditional telephone hunt group, so in the case of channel one being busy, calls will be routed to channel two, etc. You are only required to put in your credentials once for each account even if you have multiple channels.

Along with account credentials, you'll need a Direct Inward Dial (DID) number associated with your account. This is the "old fashioned" phone number users will dial to reach you. VH2 does not need to know this number - translation to the proper SIP channel happens behind the scenes at the SIP provider (although often the DID and SIP account name are the same).

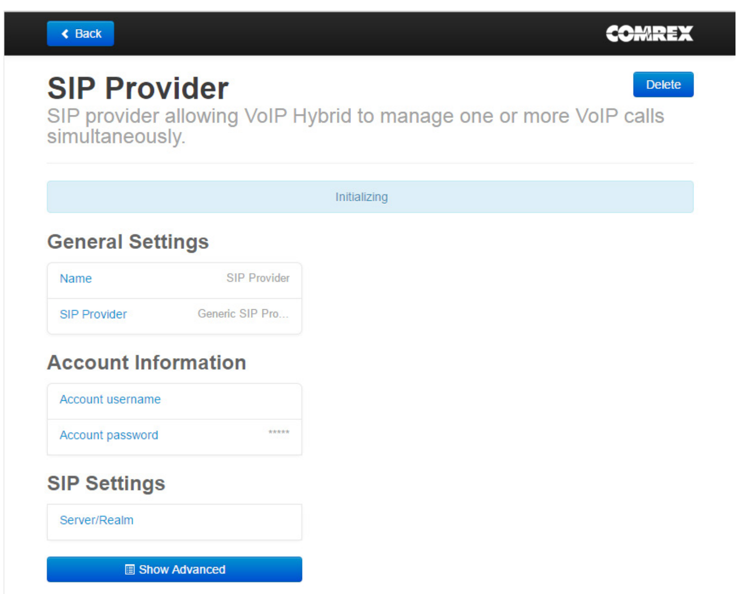



FIGURE 7

In Toolbox, navigate to **Channel Configuration->VoIP Providers->Add Provider-> SIP Provider**. The basic settings for a SIP provider are shown in **Figure 7**. First, you should give your provider a unique name in the "**Name**" field. This is used for reference only.

Under the SIP Provider entry, we've provided a list of commonly used providers. Using one of these profiles helps set up some of the more obscure settings that we've found necessary for these providers to work correctly. If your provider isn't on the list (or if you're setting up a SIP extension from a PBX) leave this set to "**Generic"**.

The next three fields are where you should enter your account credentials: **Account Username**, **Account Password**, and **Server/Realm**. These should have been provided to you by the SIP provider. **Account Username** is usually the name at the start of any SIP URI assigned. (More on that later). E.g., **username@sip_provider**. Make sure to enter only the username part.

The **Server/Realm** is the address of a registration server maintained by the provider. No web prefixes are needed here, just the address. E.g., **sip.comrex.com** or **iptel.org**. If you are programming a PBX extension here, this will be the IP address (or URL) of the PBX.

Under most circumstances this is all you should need. Setting these parameters, clicking **Back** then clicking **Restart** should start the process of VH2 registering with the provider or PBX. However, SIP registration can be tricky in some systems, and if registration fails you should check the required SIP settings carefully and use the **Advanced SIP** settings.

## ADVANCED SIP SETTINGS

By clicking **Show Advanced** in the **SIP Setup** menu, the list expands to include less used options:

### - UNDER ACCOUNT INFORMATION -

**Auth Username** - By default, this field is set internally to the same as the user.

**Name Entry** - Occasionally, SIP providers require this field be something different, and will outline that in their setup instructions.

## - CODEC SETTINGS -

Here is a list of the supported SIP codecs in VH2:

**G.711** - This is the same codec used in everyday normal telephone calls, and is the most common codec used in VoIP. When your SIP provider (or PBX) bridges incoming or outgoing calls to the legacy phone network, it will use this codec. So if you are using this mode primarily (e.g., not taking or making any wideband calls on this provider) this is often the best codec to use, so no transcoding needs to occur. The downside is that by modern standards, G.711 uses a lot of network data bandwidth (64kb/s). There are actually two flavors of G.711 (u-law and a-law) but VH2 automatically adapts between these.

**G.722** - This codec is the most common used in the “**HD Voice**” world to deliver wideband phone calls. It uses the same network bandwidth as G.711 (64kb/s), but delivers much higher fidelity (7KHz vs. 3KHz) sound.

The default behavior of the VH2 is the “normal” setting, where the unit will prefer wideband G.722 connections if possible, and drop to “telco quality” G.711 connections otherwise. Options are available to lock codec choice to G.722 or G.711 exclusively.

## - UNDER SIP SETTINGS -

**Outgoing Caller ID Name, Number** - If your provider or PBX allows changing the default name and number sent with outgoing calls, you can set these values in these two fields. Many providers will ignore this.

**Provider Binding Port** - This port is assigned by VH2 based on the number of providers you have assigned. Unless required, you should leave the default setting as is.

**Proxy Address** - Most providers use the same server address for incoming call registration and proxying SIP traffic. If your provider shows a different address for proxy, enter it here.

**Register Proxy Address** - Some providers require **REGISTER** messages be sent to a different server. If your provider has specifically required this, enter the address here.

**From Username** - SIP providers will usually automatically fill in the **From** field on an outgoing SIP call. If allowed, you can change the name used in this field by changing this entry.

**From Domain** - Likewise, the **From Domain** field is set automatically by the SIP provider for outgoing calls. If changeable, enter a desired name here.

**Expire Time, Retry Time** - These values determine how long to wait (without any communication) before the SIP provider will consider the registration connection lost, and once lost, how often to attempt to re-establish. The default values are usually best, unless strictly required to be changed by your provider.

**Register** - If you would like to save SIP provider entries for occasional use, you can set them to be disabled here by setting this value to “**No”**. No registration will be attempted until this setting is changed from “**No**” back to “**Yes**”.

**Register Transport** - Leave this set to “**UDP”** in all but very unusual circumstances.

**INVITE Contact Compatibility** - Optionally force extension to be sent in **Contact** field of **SIP INVITE**. This setting is required by **3Com NBX**.

**INVITE SDP Compatibility** - Optionally enable compatibility mode for **SIP INVITE lacking SDP**. This setting is required by **Cisco CUCM** and **3Com NBX**.

### - EXTRA SETTINGS -

**Outgoing Enabled** - Controls whether or not the line can make outgoing calls on this line using the companion VoIP phone.

## CONFIGURING FOR A PBX

In the case where you wish to set up incoming lines as extensions of an upstream PBX, the instructions are very similar. Your PBX will deliver channels to VH2 in the same way a SIP provider does, and you will need to set up the PBX and retrieve the proper credentials to program into the **SIP Provider** fields in VH2. IP PBX programming is usually very complex and is usually handled by the PBX vendor. Inform the vendor that you wish to set up an extension with “**x**” number of simultaneous channels and without additional features like conferencing, transfer, etc. (since VH2 doesn’t support these functions).

## GATEWAYS

Gateways allow you to use VH2 with traditional analog phone lines, as well as T1, BRI and PRI ISDN, and other legacy telephone trunks. Gateways will convert these telephone channels to SIP-style virtual phone lines. You will need to find gateways that deliver FXO style channels on their telco side - the ports on the gateway are designed to point toward the telephone service (and not interface with telephones and PBXs, like an FXS port does).

Setup of gateway devices can be quite complex. Comrex maintains some basic instructions on how to set the gateways we prefer on our website. **www.comrex.com**

Gateways deliver their virtual SIP lines differently than SIP providers. With gateways, VH2 becomes the "provider" and the gateways register with it. This means the credentials you set up on VH2 will be generated by you, and they will need to be mirrored into the gateway. To use a gateway, both the gateway and the VH2 must have Static IP addresses so they can find each other.

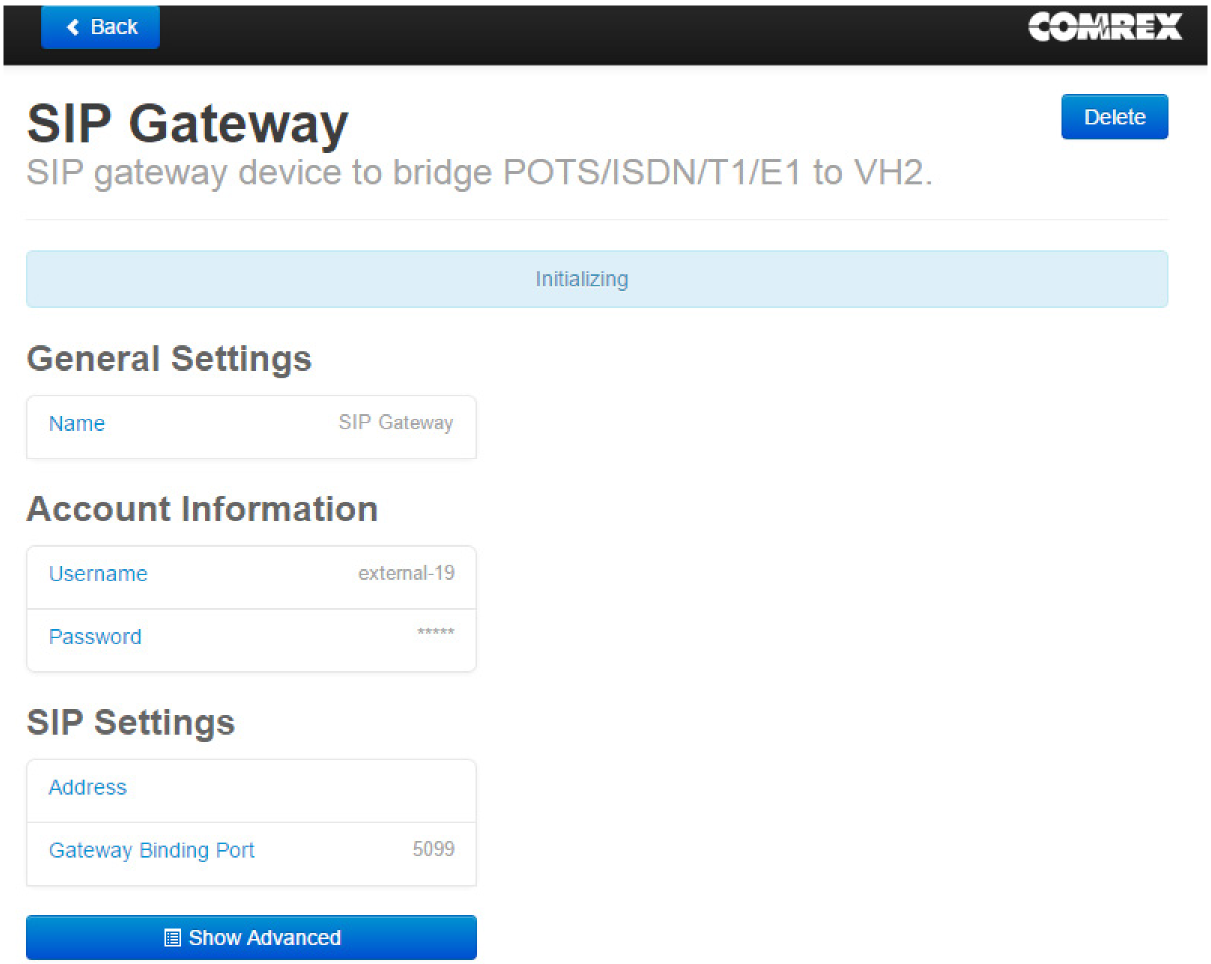



FIGURE 8 **NEW SIP GATEWAY**

**Figure 8** shows the settings for gateways (**Line Configuration > VoIP Providers > Add Providers > SIP Gateway Device**). Many of the settings are populated automatically by VH2, but can be changed to any value you wish.

**- GENERAL SETTINGS -**

**Name** - Give your gateway a unique name.

**- ACCOUNT INFORMATION -**

Username and Password - Locally generated values that the gateway will use to register to VH2

**- SIP SETTINGS -**

**Address** - The IP address of the gateway.

**Gateway Binding Port** - Automatically populated with an unused port. Must be mirrored into the **Gateway Settings**.

## ADVANCED GATEWAY SETTINGS

### DIAL PREFIX

Some Gateways require a certain prefix be dialed in order to select a particular legacy port for outgoing calls. If this is required for your Gateway (e.g. 991) enter it here.

### OUTGOING ENABLED

Allow outgoing calls on channels using this Gateway using the VoIP companion phone.

## SIP TRUNKS

SIP trunks differ from normal SIP providers in several ways. Rather than having VH2 “pull” the SIP channel from a provider, a SIP trunking provider will “push” the channel to a specific IP address of the user. This means in order to support SIP trunking you need a public, Static IP address, and no other devices can be utilizing the SIP ports at that address. Unlike normal SIP providers, only a single SIP trunk is supported on each VH2.

Most SIP trunk providers do not require registration information. Security is provided by the fact that they have initiated the SIP channel to the user’s address.

The setup of a SIP trunk is simpler than a normal provider. The option to add a new trunk is located in **Channel Configuration-> VoIP providers-> Add Provider -> SIP Trunk**. Once a new trunk is created, there will be no option to create another.

Although the settings menu for SIP trunking appears the same as for a normal provider, only a few of them are meaningful. You should put your trunking provider’s name into the **Name** field, choose your codec options (see normal provider settings) and set the correct SIP Port value (usually **5060**). If the trunk is active on your network, VH2 should sync with it automatically.

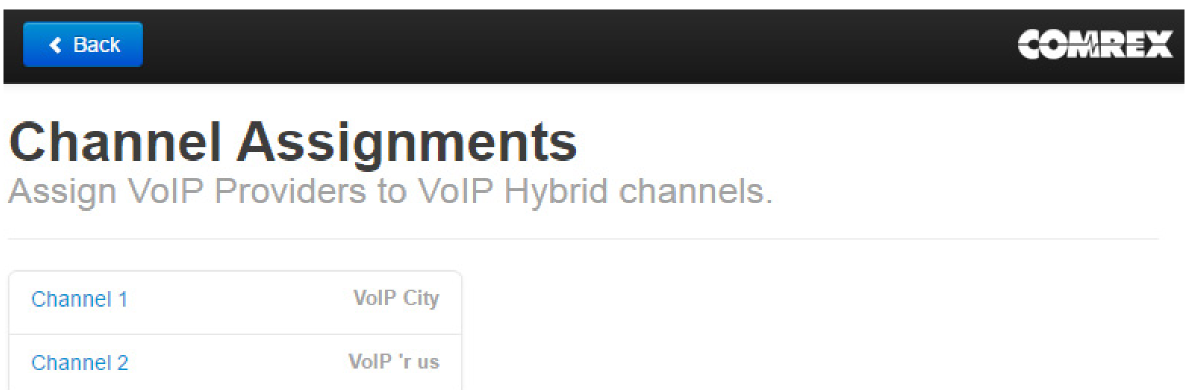
Very little feedback can be delivered on the status of SIP trunks by VH2. Trunks will show as “**registered**” as soon as they are created, regardless of actual status.

### LINE ASSIGNMENTS

Once you’re registered with at least one provider, gateway, or PBX, you can assign the VH2’s “channels” to that provider.

**Important: Simply registering is not enough. VH2’s channel(s) must be assigned to your provider(s) before you can use it.**

You can have up to two providers, and each provider can be assigned to one or both channels. Channel assignment is done in Toolbox via **Channel Configuration->Channel Assignments**.




The figure shows each channel assigned to a different provider. Each channel could also be assigned to the same provider, and the usual behavior is for calls to “hunt” between the channels (first call on channel 1, second on 2).

# VI. SYSTEM BEHAVIOR

Back at the main Toolbox page, selecting **System Behavior** allows you to set how the VH2's audio I/O interacts with your studio. The options are:

## AUTO-ANSWER

You can individually set each channel to auto-answer or not. If set to auto-answer, you can choose whether each channel puts each call to "on-air" state or "on-hold" state.

## STUDIO AUDIO I/O

Here you can select how many input and output audio ports are used on the VH2. The choices are:

a. **Single In/Single Out** - Only the **CH 1 INPUT** and **CH 1 OUTPUT** are used. All callers hear **CH 1 INPUT** and all callers audio is output on **CH 1 OUTPUT**.
b. **Single In/Dual Out** - The **CH 1 INPUT** is used, but both **CH 1 OUTPUT** and **CH 2 OUTPUT** are used. Caller audio appears separately on these channels (to be sent to two separate console faders, for example). Both callers hear audio sent to the **CH 1 INPUT**.
c. **Dual In/Dual Out** - Both **CH 1 INPUT** and **CH 2 INPUT** as well as **CH 1 OUTPUT** and **CH 2 OUTPUT** are used. Caller 1 hears **CH 1 INPUT** and appears on **CH 1 OUTPUT**. Caller 2 hears **CH 2 INPUT** and appears on **CH 2 OUTPUT**.

Note that none of these settings has any effect on whether callers hear each other. That function is chosen in the next option.

## ABOUT MIX-MINUS

When we refer to "send" audio to the caller, we're talking about the feed that is attached to the VH2 **CH 1 INPUT and CH 2 INPUT**. This is the audio that the caller hears when "on-air". It is essential that these feeds are specially mixed so that the caller output is not part of that mix. Many consoles provide for a special audio bus especially for this function. On some other consoles, you can use the secondary or audition bus (with callers deselected) to create this feed. But under no circumstances must incoming callers hear themselves sent back, or they will experience an annoying echo.

## CALLER MIX

Determines whether the callers can hear each other in the "conference" built within the VH2. If your console provides individual mix-minus for telephone channels, this should be off, as the mix will be done in your console. If the console doesn't handle this, and you are using a single mix-minus for both channels, turn this function on so the callers will be conferenced within the VH2.

## AGC

Selects whether VH2 applies AGC to the caller outputs, helping minimize large level changes between calls.

## CALLER DUCKING

Selects whether VH2 applies an algorithm to the caller audio to reduce it when the host voice is detected. This allows the host to "dominate" the conversation. Ducking, if enabled, has three choices (**Low**, **Medium**, **High**) that allows selection of how much the caller is reduced when the host speaks.

## CALLER ON-AIR TONE

Selects whether the caller hears a short "beep" when put "on-air". This is sent to the caller only and is not heard "on-air".

## CONTACT CLOSURES

The VH2 has four input and four output contact closures available.

**Outputs** -This entry determines the function of the four outputs. The choices are:

1. **No Function**
2. **Call On Air** - Closed when a call has been put "on-air" on any line.
3. **Call On Air 1 & 2** - A call has been placed "on-air" and is active on either the **CH 1 OUTPUT** or **CH 2 OUTPUT** specifically.
4. **Call Ringing** - An incoming call is ringing on any configured line.

**Inputs - Momentary/Latching**

The four contact closure inputs parallel the four front panel **On/Off** and **Hold Xfr** buttons. Since these buttons act as "momentary" toggles, this is the default action of the contact closures as well (e.g. a momentary closure on cc input 1 engages the On/Off CH 1 function, and a secondary closure disengages it). Some remote control systems can only deliver "latched" signals (closed for on, open for off). Changing this setting to "**Latching**" allows the VH2 to be remote controlled in this way. It does not have any effect on how the front panel buttons operate.

Note that the "**Xfr**" function on the "**Hold/Xfr**" button requires a momentary "long press" of the button to operate. Because this can't be supported in "latched" mode, the "**Xfr**" function is not available by remote control in latched mode.

## TEST MODES

These options are used for diagnostics or demo purposes only and will interfere with normal operation when enabled. Make sure all test modes are off before operating VH2 normally.

- **Audio Test** - These options provide for specific audio paths to be enabled (e.g., **CH 1 INPUT** to **CH 1 OUTPUT**). These are used in unit production tests and can also be used to troubleshoot general hookup issues. Modes are also offered that generate a tone from the caller out ports.
- **Contact Closure Test** - Likewise, enabling this option puts the contact closure feature in "loopback" mode with inputs directly driving outputs (e.g., **CH 1 INPUT** to **CH 1 OUTPUT**).
- **LED Test Mode** - tests the function of the front panel button and LED indicators

# VII. NETWORK CONFIGURATION PAGE

The **Network Configuration** page is shown in **Figure 9**. The settings in this section determine the IP settings of the Ethernet port, along with which network services are active on the VH2.

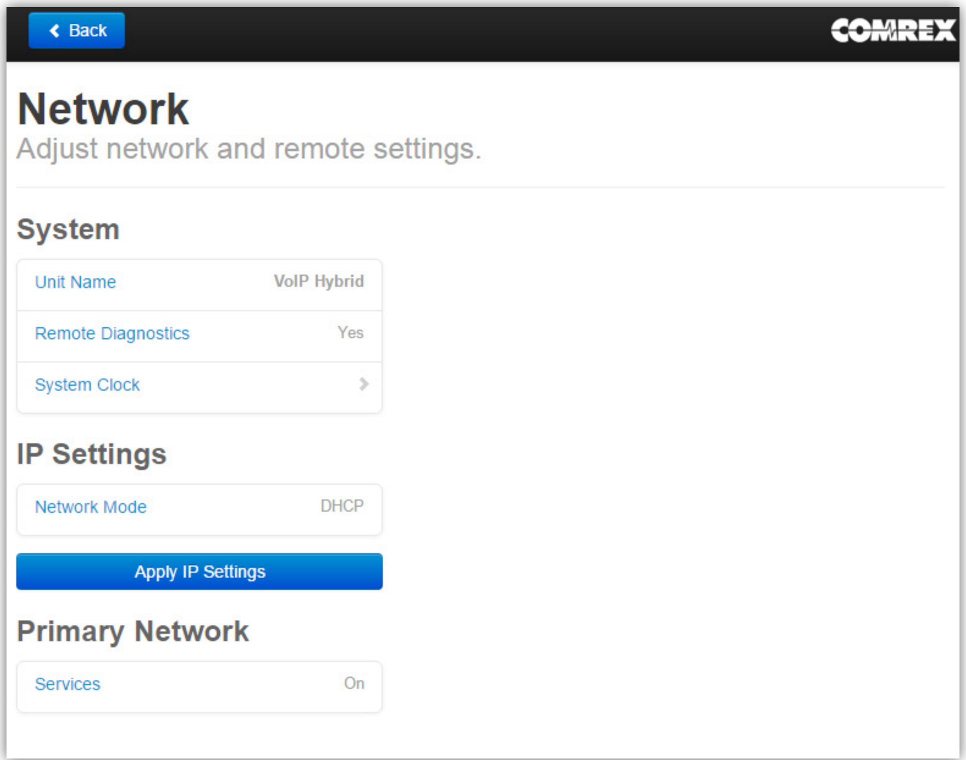



FIGURE 9

## - SYSTEM -

**Unit Name** - Giving your VH2 a unique name will help you identify it on the network.

**Remote Diagnostics** - Comrex support has the ability to connect to your VH2 via the SSH protocol to troubleshoot issues. This requires a private keypair that we don't provide. If you have security concerns about SSH, you can disable it by setting this option to "**No**".

**System Clock** - VH2 maintains a network connection to an NTP server that delivers the time-of-day information for use by system logs. The specifics of that function can be changed here. The default settings allow for a pool of public servers to be used.

## - IP SETTINGS -

As described in the previous section "**Configuring VH2 IP Information**", this is where you set the static IP address of the VH2's main Ethernet port.

## - PRIMARY NETWORK -

**Services** - Using this option, you can secure VH2 so that the Toolbox interface is no longer delivered via the Ethernet port. Note that once this is turned off, no further configuration of VH2 is possible. To change any setting you must first apply a factory reset to the VH2, which will wipe all its settings, including all your VoIP account info and static IPs. Turning services off also disables your VH2's ability to sync with the Comrex Device Manager (until a factory reset is performed).

# VIII. SECURITY AND USER ACCOUNTS

Security settings are available in the Toolbox web-based configuration page under **Security**.

The following options will be available under **Security**:

### HANDSET SIP PASSWORD

The VoIP companion phone available for the VH2 requires a password login in order for VH2 to communicate with it. The default password is “**456”**. This is also the password used to gain access to the full configuration of the phone via the web or the keys on the phone. If you wish to change this password from the default, you can let VH2 know the new value in this field. Comrex recommends changing this password.

### CHANGING THE PASSWORD ON THE ADMIN ACCOUNT

It is highly recommended to change the password on VH2 to prevent undesired configuration changes. This is done under **Security->Accounts->Admin** in Toolbox. Note that once the password is changed, it must be known to access Toolbox from a web browser or the **Device Manager** software. If the password is forgotten, a full factory reset will be required, clearing all settings including static IP and telephone provider settings.

# IX. FACTORY RESET

## FACTORY RESET

VH2 can be restored to factory settings, clearing all IP, behavior and provider info, two ways:

1. If the password is known, use the **Device Manager** software to login to VH2. Select **Device->Reset to Factory Defaults** to issue the reset command.
2. If the password is not known, you must issue a hardware factory reset. This is done via the following sequence:
    1. Put dip switch 7 & 8 up.
    2. Press the reset button once, wait until the **CH 1 CH 2** and **Power** LED flash red and green.
    3. Put dip switch 7 & 8 down.
    4. Press the reset button once.

## DIP SWITCH SETTINGS

The front panel DIP switches have the following function:

1 Analog in (down) / AES3 in (up)

2 Analog out (down) / AES3 out (up)

3 Unused

4 Level Indicators reflect Send audio (down)

Level Indicators reflect Caller audio (up)

5, 6 Unused

7, 8 Factory Reset (see previous section)

## ON/OFF BUTTON (CH 1 AND 2)

This is a toggle which determines if the call is active on the selected channel. When pressed, an incoming call will be answered. This button will also “grab” a currently active call on the companion telephone and place it on the desired channel. Calls selected this way are considered “on-air” and caller audio is routed via the selected behavior settings. Pressing this button when a call is active drops the call, whether “on-air” or “on-hold”.

## HOLD/XFR (CH 1 AND 2)

This is a toggle that places an active call “on-hold” from the “on-air” state. The caller will be removed from the main audio ports, and hear only the audio presented to the VH2 “on-hold” input. Pressing this button while an incoming call is ringing will send the caller directly to “on-hold” state. Pressing this button while a call is “on-hold” will send the call back to “on-air” state.

If a call is active (either “on-hold” or “on-air”) a long press of this button (over two seconds) will transfer the call to the companion telephone set. The set will ring, but the call will remain in its previous state (“on-hold” or “on-air”) until the handset is answered.

## INDICATIONS

The ON/OFF and HOLD/XFR buttons are lit to indicate the state of each particular channel

| ON/OFF | HOLD/XFR | Function |
|---|---|---|
| Off | Off | Idle-registered and ready for call |
| Blink Green | Off | Ringing |
| Green | Off | On-Air |
| Green | Green | Hold |
| Blink Green | Blink Green | On Handset |
| Red | Off | Auto-Answer |
| Red | Red | No Provider Assigned |
| Blink Red | Off | Provider Assigned, but not registered |

The “Ready” Indicator is used to signal the overall network condition. Its states are:

**Off** - System is starting up

**Fast Blink** - Loading application

**Red** - No Internet connectivity detected

**Green** - System has IP address on network

## GENERAL OPERATION

### INCOMING CALLS

Calls will ring the handset (if used) and blink the **ON/OFF** indicator for the channel with the incoming call. Calls can be answered via the handset, or placed directly “on-air” or “on-hold” via the front panel button. Calls on the handset can be put “on-air” or “on-hold” via the same buttons.

### OUTGOING CALLS

Place calls on either channel 1 or 2 via the handset. Place them “on-air” or “on-hold” with the appropriate channel buttons.

### TRANSFERRING TO HANDSET

From “on-air” or “on-hold”, long press the **HOLD/XFR** button. The handset will ring. Answer it and the call will be transferred (note the call is still in the current state until handset is answered).

### ENDING CALLS

From “on-air” or “on-hold” state, press the **ON/OFF** button to end the call. From the handset, simply hang up.

# XI. ABOUT SIP

**NOTE: This section is taken directly from our VoIP Primer. You can view and download the primer at www.comrex.com.**

## Introduction

At Comrex, it's our job to keep ahead of new and intriguing technologies that we can leverage for our customer, the broadcaster. But it's important that as we ride the wave of new tech, we don't forget about the people in our industry who have "stuff to get done", and can't afford to spend hours reading about all the newest developments.

We've found this to be the case in recent years with the introduction of ISDN, POTS codecs, and IP audio codecs. In each case, we decided to put together a "primer" for those who wished to gain the knowledge needed to use these tools effectively, but were short on time. The goal was to put together all the vital information in a booklet that could be consumed in under an hour. The feedback we've received has proven these efforts to be worthwhile.

A new disruptive technology is taking hold, and it's now time to cut another primer. Due to cost and necessity, broadcasters are finding they need to learn about Voice over IP (VoIP), and they need to learn fast.

**This booklet provides some basics about VoIP in an easily digestible form.**

VoIP provides a way for computer networks and other devices to emulate traditional phones and phone lines. Most modern business PBX systems have migrated to VoIP already. In some circumstances, legacy phone lines (PSTN or POTS) are no longer available and VoIP is the only choice.

Like a traditional line, a VoIP link consists of a service provider and an end user who owns a telephone instrument. But in this case, the provider is based in the "cloud". Alternately, the VoIP lines can be delivered from an upstream PBX. The end-user gear is a specialized VoIP telephone, or software running on a PC or mobile device that performs the same functions.

The Comrex STAC VIP is a sample of a device designed to interface with VoIP service. It can handle six or twelve calls simultaneously and provide the typical screening, audio processing, and control functions expected of broadcast call-in systems. For users with less call volume, the VH2 Hybrid is a dual-channel VoIP-to-studio interface. In addition, all Comrex IP codecs like ACCESS and BRIC-Link can communicate over standard VoIP protocols.

## IP Concepts you need to know

If you're already an expert on IP networking concepts in general, feel free to skip to the next section about RTP. But here are a few basic concepts you'll need to master to continue learning. This is much less than a complete overview of IP networking--only concepts directly relevant to VoIP are covered.

### IP basics

IP is short for Internet Protocol, but it doesn't always pertain to the Internet (as in, the public version). In a nutshell, IP networking involves creating packets of data, attaching certain headers to specify contents and assign addresses, and applying them in sequence to some kind of network capable of transmitting them. Physically, the network is usually Ethernet, although it may be Wi-Fi, 3G, satellite, or lots of other mediums.

## Addressing

Devices connected to an IP network are dealt an "IP Address". Under the IPv4 protocol (the most widely implemented), this address consists of a 32-bit numeric value. Putting on your "binary thinking cap", this can also be thought of as four 8-bit bytes. A byte can have a value from 0-255, so IP addresses are usually written as a sequence of four decimal numbers (separated by dots) like 192.168.0.23 with each integer having an upper limit of 255.

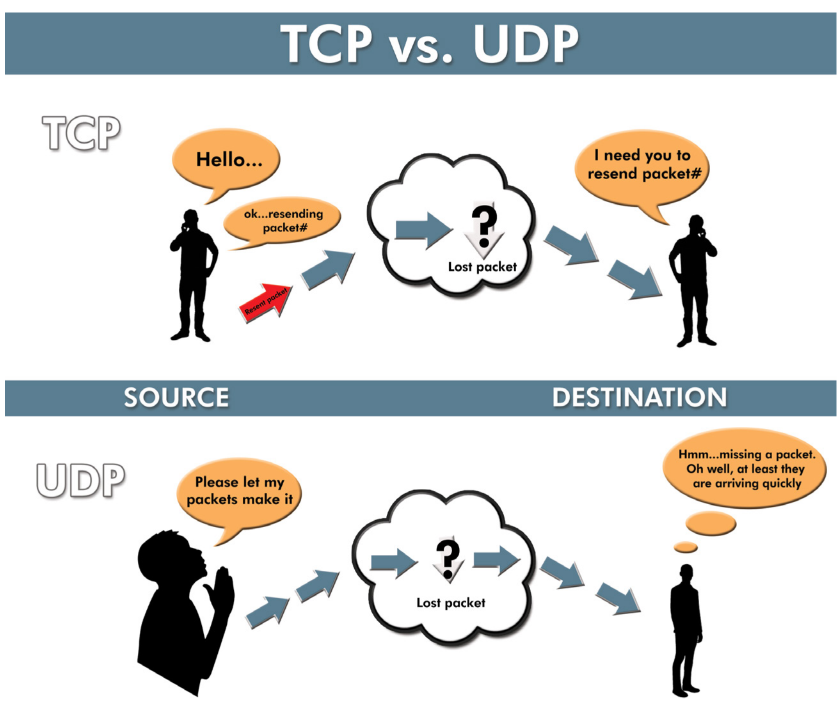
## Ports

The IP address is the main identifier used to specify a destination to send packets to within a network. But since IP compatible devices can make simultaneous connections for different reasons (e.g. web surfing and email), a scheme is used to designate a specific "port" on a machine, which is essentially a 16-bit sub-address contained within the header of the packet. These ports are usually written as simple decimal values (e.g. 80, 5060), and traffic sent to a specific port on a machine can only be accessed by a program or service "listening" on that port.

## TCP vs. UDP

The most common types of IP traffic fall in two sub-categories, TCP/IP and UDP/IP. The difference is important. Most web-related traffic travels via TCP, which has built in mechanisms for integrity checking and error-correction. This means that if the TCP "stack" within a machine has delivered a packet from the network, the packet is guaranteed to be correct, and if lost will be resent.It might surprise you to know that it's not TCP that's used for most real-time media on the web. This is because TCP has quite a bit of overhead in terms of data, and can easily add time delays if packets get corrupted.

VoIP and other real-time communication protocols use UDP, which is a much simpler delivery method. There is no error correction or resending available at the native UDP layer. UDP is sometimes referred to as the "send and pray" method, since the network provides no guarantees of delivery of any kind. In it's simplicity, UDP is a better choice for real-time communications because higher-level applications can be designed to make smart choices about error protection vs. delay.



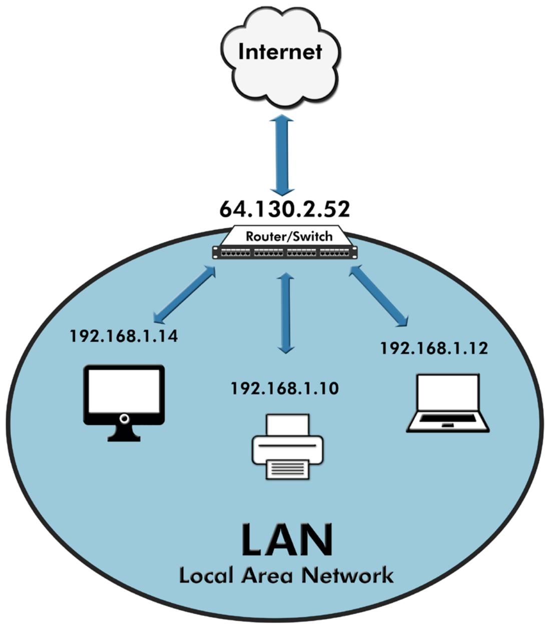
Packets sent on IP networks will include a destination IP address/port combination, and a source IP address/port combination. These act like the destination and return address on an envelope, and allow the packets to be responded to over the network.

The destination port is the most important to IT people, as it's the one that they need to be sure is open to receiving communications. When IT folks refer to a service as "running on port x" they are referring to the destination port.

We designate an IP connection via its protocol, destination IP address, and port combination in this form: **<protocol> <destination address:port>** e.g. **UDP 192.168.0.7:5060**

## LAN vs. Internet

Most of the networking you'll be dealing with will exist within your LAN (Local Area Network) and connections between devices within the LAN follow ordinary rules to send packets between each other. But in the situation where you wish to connect to a device outside the LAN (which is most common) special rules need to be followed.




LANs have IP addressing conventions that allow a range of addresses to be reused within the network, and prohibit those addresses not to be used again on the public internet. This allows for many devices to site behind a router, which has a single internet (publicly addressable) IP address, and each LAN device to have a private, reusable IP address. By convention the address ranges start with the digits 192.168.x.x, 172.16.x.x, or 10.0.x.x. So, for example, if a machine tries to connect to another at an address of 10.0.0.75, it is necessarily trying to send packets only within its LAN. The range of addressable LAN addresses is called a subnet, and must be programmed into each machine using a subnet mask entry.

If a machine on a LAN wishes to send packets outside the subnet, it must communicate with a gateway (usually a router) at a fixed IP address.

### Network Address Translation

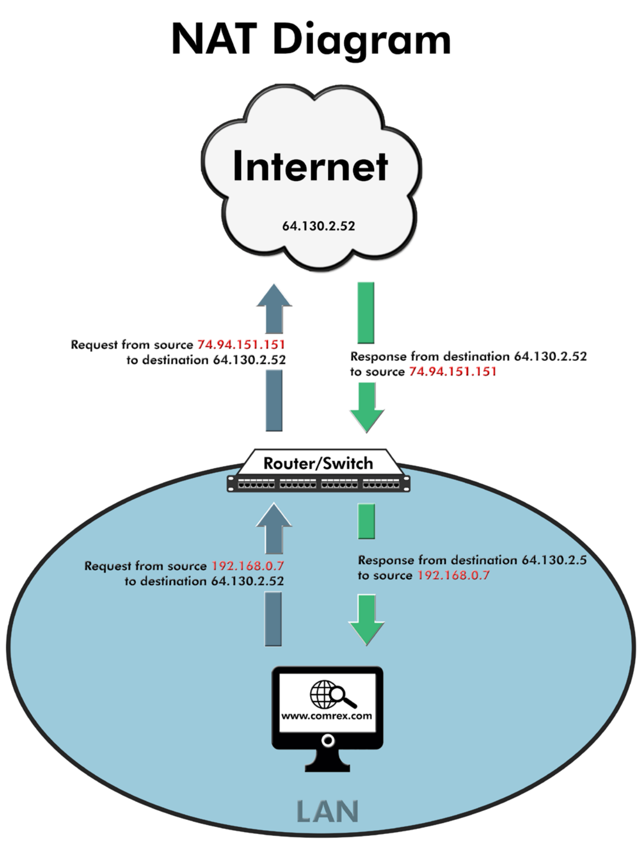
The concept of how a gateway router provides translation services to the Internet is extremely important in the field of VoIP, if only because it causes so many headaches. Known as Network Address Translation (NAT), it's easiest to use a diagram to illustrate a typical gateway scenario describing a user on a LAN accessing a web page at comrex.com. For this illustration, we'll ignore the concepts of DNS and URLs (which aren't particularly useful for VoIP) and live the fantasy that the user is accessing the comrex.com page via its public IP address, which is (as of this writing) 64.130.2.52. In our scenario, the user has a laptop on a LAN using the popular 192.168.0.x subnet addressing scheme, and specifically has the address of 192.168.0.42 assigned to it.

The user will input the web page address into his browser, and the computer will recognize the address as outside the subnet it has been programmed to work on. So it will form a packet, whose payload consists of a request to view the web page, and hand it to the gateway router, which is located at the local address programmed into the laptop (192.168.0.1).

Because the router is acting as a gateway, it actually has two IP addresses. The LAN address (192.168.0.1) is used by devices on the LAN. The WAN address (74.94.151.151) is the address assigned by the Internet Service provider. This address is public, in that it is addressable by every device on earth that is connected to the Internet.

The router will record the source address of the packet (192.168.0.7), change it to the public IP of the router (74.94.151.151), and send it along to the destination IP address. This is so the web site knows the correct address to which to respond.

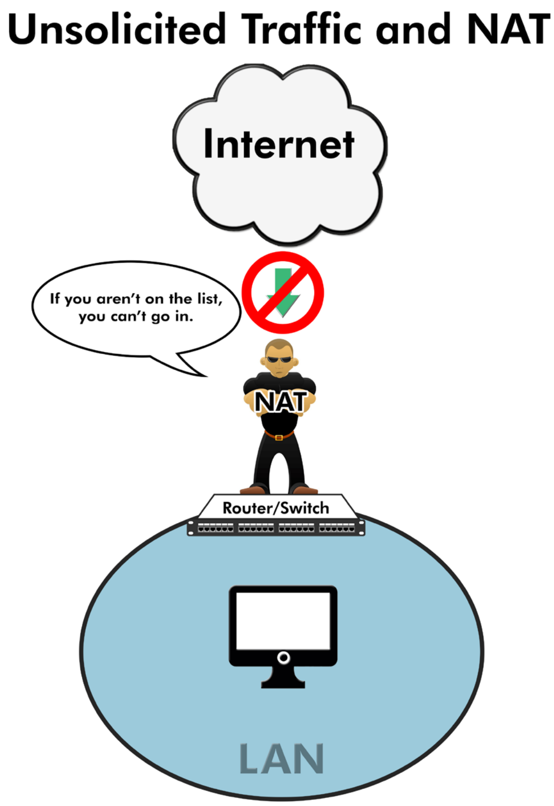
The router will now wait for the response from the web site (it's smart enough to know to expect something from the destination address of the packet it sent). It will then change the destination address of the packet to the private IP address of the laptop before sending it along to the LAN.



In reality, NAT is more complex than this, changing port numbers as well, but we've kept the concept to the bare basics to outline why NAT hurts VoIP.

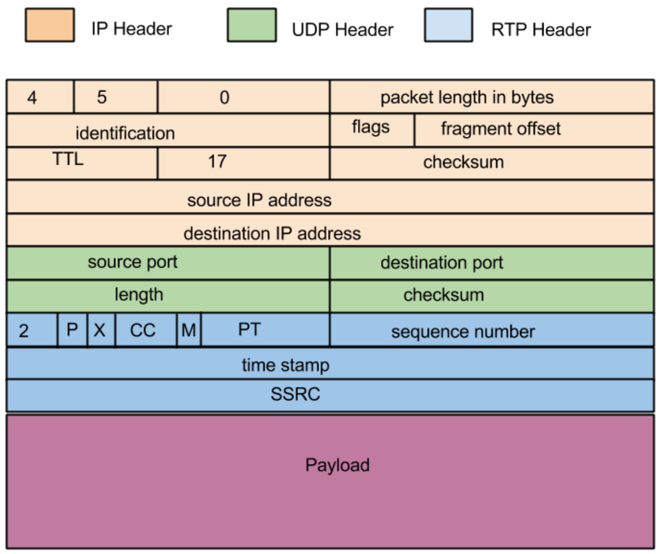
NAT provides for many benefits, including address reuse and basic security. This security exists because packets that arrive from the public Internet without being requested from within the LAN will be discarded. But it's this security element that makes VoIP difficult when using NAT. The concept of placing a VoIP call to a device behind a NAT requires that the NAT deliver unsolicited packets from the Internet to the VoIP device.

This is a complex topic, and as we'll see later on, NAT traversal can cause all sorts of trouble for VoIP.



## Real Time Protocol

A fundamental building block of VoIP is the Real-Time Protocol (RTP). This is a protocol layer that exists within a UDP packet specifically designed to transfer audio (and video) media with low delay. RTP consists of a header that is applied directly after the UDP header in the packet, followed by a media "payload" which consists of the actual encoded audio of a VoIP call.

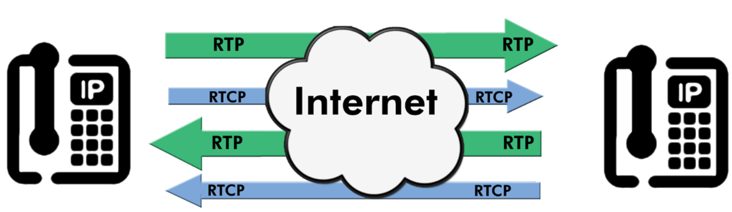



The primary responsibility of the information in the RTP header is to allow the decoder to find the proper playout sequence of the media contained in the packet. RTP doesn't contain any intelligence about what is actually contained in the payload--this has to be handled by other means.

An RTP stream is unidirectional. If a duplex stream is required, an additional independent RTP stream must be initiated in the reverse direction (This function is handled by the Session Initialization Protocol (SIP) layer discussed later).

Finally, an RTP stream (or session, as it's called) has a companion stream that is initiated and travels alongside it for the duration of its life. It's called RTCP and is sent to the same IP address as the RTP stream, but at one port higher. It's used for RTP stream quality statistics but doesn't carry any actual audio, so it uses a small amount of data. But it's important to know about if you're troubleshooting firewall or NAT issues.

**RTP Diagram**



RTP alone can be the basis of a very primitive VoIP call. If each end of the call knows in advance information about encoders used, no NAT routers are involved, and the call can be manually initiated and answered on each end, RTP streams can be "pushed" between the destinations and will provide the path for VoIP. Of course, real-world VoIP involves much more, so we need to add complexity to the system.

## Encoders

Broadcasters who've used POTS, ISDN or IP audio products are familiar with the concept of encoding compression. This is the choice of encoder within the system used to compress digital audio so it uses less network capacity. Encoders like MP3 and AAC are common in that world.

You'll see the VoIP industry use the term "codecs" for this function. But because broadcast transmission devices are also termed "codecs", we'll reserve it to describe hardware, and use "encoders" to describe compression algorithms.

VoIP has its own spectrum of useful encoder choices. VoIP encoders require very low delay and reasonable computational complexity. The RTP protocol has definitions for how to fit all popular encoder payloads into a session.

### G.711

The lowest common denominator encoder in VoIP is the same one that has been used by digital telephone networks for decades, defined as G.711. It's a simple way to compress audio, resulting in a network utilization of 64 Kb/s per channel in each direction, a compression of about only 30% from the original uncompressed stream. This is considered the highest amount of allowable data for a single call by modern standards, and it can add up quickly as multiple calls are handled on the same network. To its benefit, the encoder requires virtually no computer power to compress or decompress.

G.711 is limited in terms of audio fidelity by the choice of its audio sampling rate. Calls using this encoder usually provide only 300 Hz-3 KHz audio response, resulting in the familiar thin sound of phone call, especially when put "on the air".

G.711 actually has two variants, one used mostly in North America ($\mu$-law), and another used elsewhere (a-law). These are defined by the names of the tables used within the encoders to compress. All Comrex codecs and VoIP devices support G.711.

### G.729a

Because G.711 is a bit old and primitive, an encoder has been developed to deliver equivalent audio quality while using a fraction of the network bandwidth. G.729a implements a more aggressive compression algorithm, resulting in network usage of around 8 Kb/s per channel, or about 1/8th the data of G.711. This can be very helpful for avoiding excessive network congestion. Of course, equivalent audio means the same limited fidelity as G.711.

This encoder is sometimes simply referred to as G.729 (without the a), but is equivalent to the user. Another variant, G.729ab, is sometimes available that can detect when voice is present and squelch the data stream during periods of silence, further conserving network bandwidth. Comrex STAC VIP supports G.729a.

### G.722

Familiar to ISDN broadcasters, G.722 is an encoder designed to increase the audio fidelity of phone calls. Using the same network bandwidth as G.711 (64 Kb/s each way), G.722 more than doubles the audio spectrum conveyed by the call, making the caller sound much more natural and identifiable. The 7 KHz spectrum carried by G.722 covers the majority of human voice energy, excluding only the most sibilant sounds in speech.

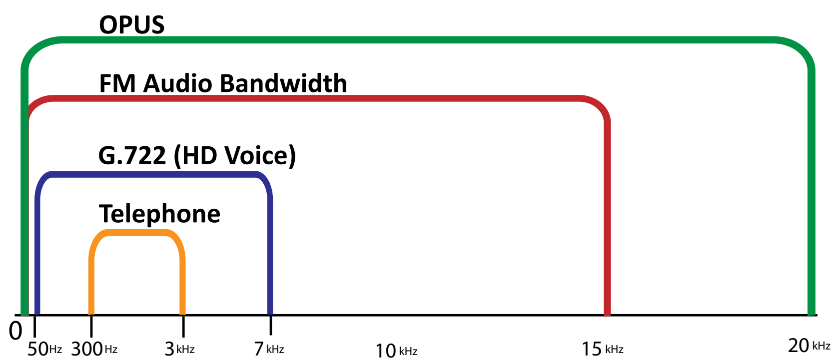
G.722 is the most common encoder for calls that are classified as "HD Voice" in the VoIP world. All Comrex codecs and VoIP devices support G.722.

### Opus

Efforts are increasing at combining the worlds of VoIP and web services. Many web audio services have standardized on Opus, an encoder that delivers near-CD quality audio with low delay. As these efforts continue, users can expect to find more support for the Opus codec in VoIP devices and networks. All Comrex codecs and the STAC VIP phone system support Opus.

### Other encoders

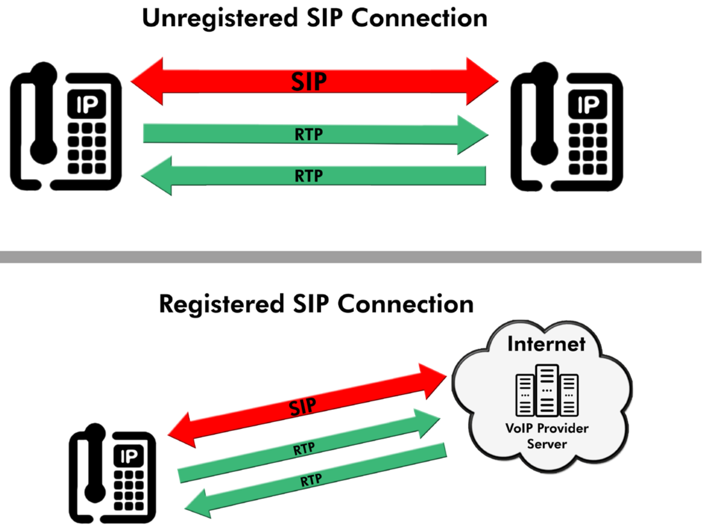
A large spectrum of VoIP-ready encoders have been introduced in the past decades, each having proponents and particular advantages for certain applications. These include iLBC, iSAC, G.722.1, G.722.2, G.726, VMR-WB, SILK and AMR-WB+. For the most part, we expect the industry to support only the four encoders outlined above in most equipment and networks.



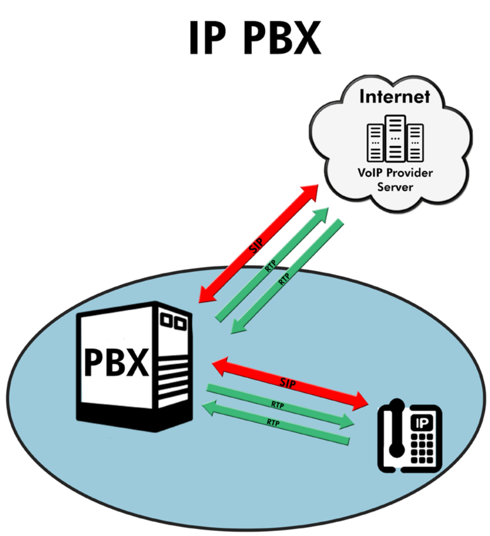

## Session Initialization Protocol

The piece that ties RTP sessions and encoders together, and gives VoIP its telephone-like qualities, is another completely separate connection between devices called the SIP. You'll see the term SIP thrown around in place of VoIP in many places (SIP Phones, SIP PBXs). It's a very powerful specification and is being used for an increasing number of applications besides VoIP, like compatibility standards between broadcast IP hardware codecs, studio-style AoIP installations, and real-time web audio and video. It's becoming such a vital element of so much new technology, it's a very valuable thing to be expert in.

SIP connections can be made in two primary ways--registered and unregistered. In unregistered mode, a SIP channel is opened between devices at the time a call is placed. In registered mode, a SIP channel is constantly maintained between a SIP client (like a studio talkshow system) and a SIP server (like that at an Internet Telephone Provider). Most VoIP users will only use registered mode, so that's what we'll focus on going forward.

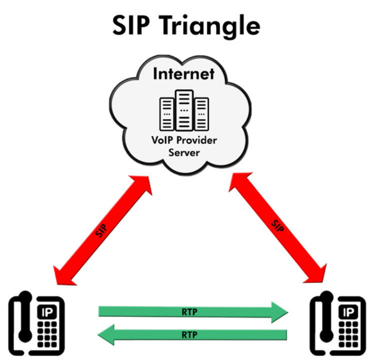



The SIP protocol can be used in more than one link in a VoIP chain. The best example would be a purely IP PBX. In this case, the PBX maintains a SIP channel to an Internet Telephone provider on its WAN port. It also maintains several SIP connections over its LAN to telephone extensions. Because the protocol used in these links is identical, it provides for a lot of flexibility. For example, if need be, the telephone extensions could register directly with the provider, bypassing the PBX entirely.

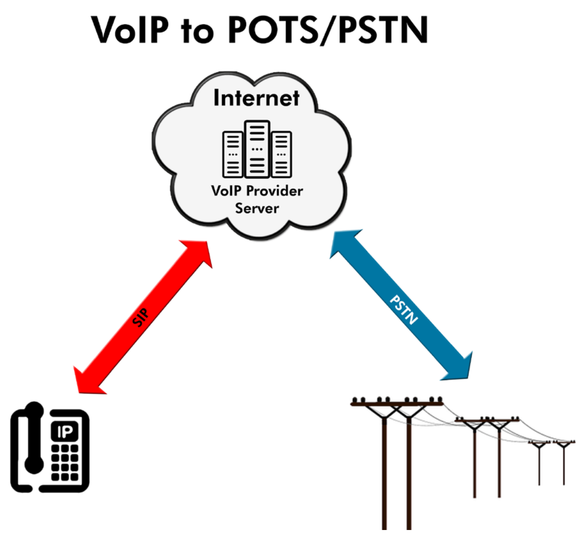



It's important to understand that the SIP protocol does not carry any actual voice between devices-- it simply instructs devices to create separate RTP sessions in each direction. RTP streams are created and destroyed based on commands contained in SIP messages when calls are made or received.

Sometimes the SIP channel is connected to a server that is removed from the RTP sessions entirely. This would likely be the case when two SIP devices are registered to the same (or sometimes even different) providers. The SIP channel would instruct the devices to create RTP sessions between them, rather than to the provider. This is known as the "SIP Triangle".




But more commonly, a SIP device is interested in making and receiving calls to and from the "old fashioned" public switch telephone (PSTN) or "plain old telephone" (POTS) network, whether wired or cellular. In this case both the SIP channel and the RTP sessions are made to a server at the Internet Telephone Provider, and the provider acts as a gateway for the voice call to the "legacy network". The user would be delivered a "real" phone number (DID for Direct Inward Dial) and the provider would handle all the necessary VoIP <-> PSTN conversions. We'll focus on this scenario from here on.



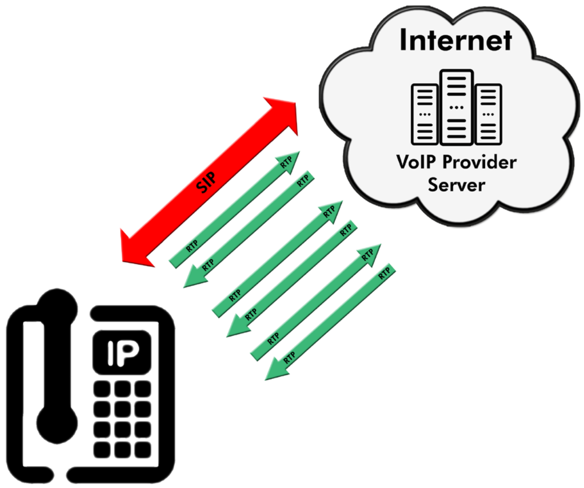

## SIP Details

The technical details of SIP are widely available on the web for further research. But essentially, commands and formats are provided to invite users to a call, accept calls, end them, and reject them. SIP also provides a mechanism to register and authenticate with a server.

Another useful function in SIP is encoder negotiation. The SIP protocol can inform users of which encoders are supported on each end of a session and in which priority. In this way, it's easy to make decisions about which encoder to choose that will be in common with both ends, and to reject calls if no common encoder is found.

Like RTP sessions, the SIP channel utilizes the UDP protocol by default. There is a specific port defined, 5060, as the default "well-known" port over which SIP operates, although it can usually be configured to be different.

A single SIP channel can manage multiple RTP sessions simultaneously. In this way, only a single account needs to be registered with the Internet Telephone Provider and a single SIP channel maintained, but multiple VoIP calls can be run simultaneously. Whenever a call is initiated or dropped, a pair of RTP sessions is created or destroyed on the fly for each call.




## Challenges with SIP/RTP

To summarize the previous sections, most VoIP connections involve a continuously active SIP channel initiated from the user device to a service provider over port UDP 5060. Using this channel, the two ends negotiate calls and create and destroy RTP sessions (each consisting of one RTP and one RTCP) in each direction. Like the SIP channel, these sessions also run between the end-user and provider, so the provider can bridge them to the legacy phone network. The SIP channel also negotiates which encoders will be used on the RTP channels.

So what can possibly go wrong? Almost every issue can be run down to NAT-based routers or blocking firewalls.

### Issues with the SIP channel

The SIP channel generally has the fewest issues, since it's usually originated from the user end of the link. This means NAT routers on the user end will generally allow this outgoing traffic to pass, and allow the response traffic (from the provider) back in. But if a network is heavily firewalled in a way that blocks outgoing access to UDP 5060, this channel will never be created and the user cannot register with the provider.

Also, although we have described the SIP connection as "always active", there are periods of inactivity on the link when no calls are being set up or ended. In order to receive information about new incoming calls from the provider, the user end must keep the SIP connection (or "binding") open through the NAT router to prevent it from terminating the binding and blocking incoming traffic. It does this by sending periodic updates even when no changes are being made to any calls. The interval of these updates is usually adjustable, but must be shorter than the timeout value the router takes to shut down any unused bindings.

### Where am I?

According to the SIP standard, the user device will inform the provider of its IP address (over the SIP signaling connection), and the provider will "push" the RTP session containing the incoming voice to that address. But devices on LANs often don't know what their "public" address is, only the private one assigned to them on the LAN. If the provider tries to initiate a stream to that address, it will go nowhere.

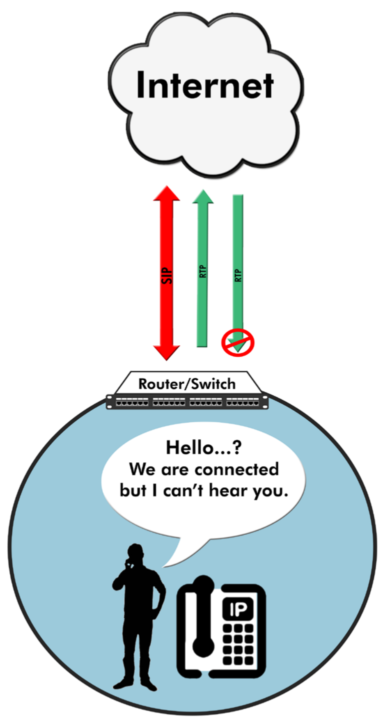
Many VoIP providers install a "cheat" here that will look at the user's IP address and determine if it looks "private". If so, they will ignore it and send the RTP stream to the destination address of the RTP session they receive.

If the cheat isn't implemented, user devices have a way of looking up their public IP address via a protocol called STUN. This protocol can usually be enabled within the user's equipment configuration. If enabled, the device will look to a STUN server out on the public Internet, and query its own address. It will then use that public address to populate the "from" field in the SIP handshake.

### Don't block me, bro!

Even if the provider gets the correct IP address of the user, there's plenty that can go wrong. Remember, SIP involves creating extra RTP "channels" in each direction to carry the actual voice. The ports used on each end are negotiated over the SIP signaling channel for each call. There aren't any "standard well-known" ports used for these connections. And there can be many of them active on different ports if lots of simultaneous calls are happening.

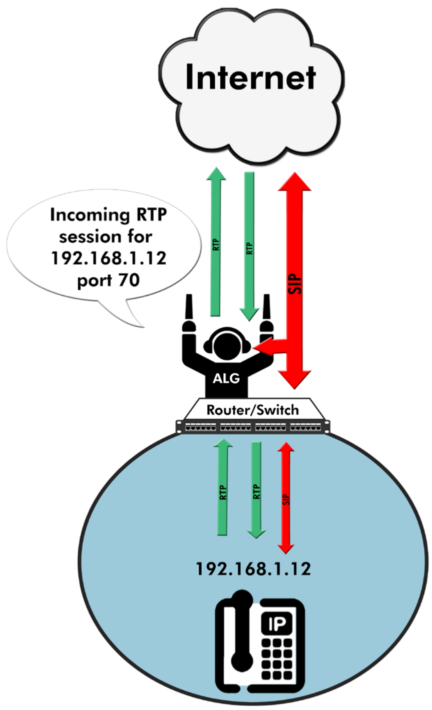
As far as the user's router or firewall is concerned, a new RTP session is trying to make it through its security layer. It's not aware this session has been requested, so it's blocked by default. This usually results in a one-way connection, where no audio can be heard on the SIP user end of the call.



### ALG to the rescue

This scenario has become common enough that router and firewall manufacturers have started to address it. The solution is called SIP ALG (for application layer gateway) and has been built into the firmware of most modern devices. It may be on or off by default. And the quality of how it functions may vary--early implementations sometimes did more harm than good.

But a properly functioning ALG will listen to your SIP channel, and gain an understanding of which RTP sessions are being created on which ports. It will then allow the incoming session through.




In reality, an ALG may often take quite a bit of license with your SIP connection. It can rewrite many of the SIP fields in order to comply with its rules, so the IP and port information getting to the service provider may actually be completely different than those sent by the device. As long as it has the intelligence to open the proper ports, this will usually work fine.

It's even possible that your SIP connection is being processed by more than one ALG, as in the instance of a separate router and firewall on the connection. Of course in this scenario, the possibilities for errors compound. Sometimes it's best to disable unnecessary ALGs in the link. Unfortunately, diagnosing these issues require analyzing packet captures. Luckily, SIP is a well-known protocol that can be easily deciphered by packet capture systems.

## Summary

The important elements of SIP are as follows:

1. An independent connection stays open on UDP 5060 between the user and the service provider
2. Separate and multiple RTP sessions are established in each direction for calls
3. Routers and firewalls interfere with these RTP sessions by design, but ALGs built into these devices can help.

## PBXs

So far we've discussed SIP connections to outside or "cloud" VoIP providers. But many times, the user already has a SIP PBX on premises, which already connects to the public telephone network by VoIP or legacy means, like analog lines or T1s. Since most modern PBXs talk SIP to their extensions, they just need to tie a SIP-compatible device (like a codec or hybrid) to the PBX, and allow the PBX to decide how to route calls to the device.

As mentioned before, the SIP protocol used in this scenario is the same. The device will register and maintain a SIP connection to the PBX, and the PBX will inform the device of incoming calls. RTP channels will be created when required between the SIP device and the PBX. This will usually be successful, since the LAN environment is less reliant on routers, subnets and firewalls to block the RTP channels.

## Registering with a SIP Server or PBX

The process of registering a device to a SIP provider, whether it's in the "cloud" or at your location, is usually simple. Much like registering an email client with a mail server, the VoIP client (the VoIP hardware) must know the location of the server, and a username/password combo with which to register. The server location can be in the form of an IP address, or a URL.

Some servers with more complex arrangements may require more information to help choose options. There may be separate settings for your SIP Proxy server, your SIP domain, and your SIP registration server. There may be choices for encoder support, auth username (an additional credential used for authentication), and caller ID options. For the most part, any essential info that needs to be programmed will be delivered from your provider (or in the case of a PBX, your Telco department) and you can set your VoIP device with the parameters that match, and ignore the others.

## Making and Receiving calls

Once registered correctly with a SIP server, incoming calls will be routed to your SIP device based on the calling plan set up with your provider or PBX. Whether it's the DID line(s) assigned to you by the provider, or an incoming trunk attached to your PBX, a "ring" on the line will trigger the server to notify your device of a call request using the SIP protocol. Your device can accept or reject the call. If you accept the call, an RTP channel is created to your device each way.

Outgoing calls just reverse the process. The SIP device sends an outgoing call request to the server, which attempts to complete the call. Call progress messages will be sent to your SIP device from the server, which may translate them to familiar tones like ringing and busy. On call completion, the server will create the RTP channels in the same way as for incoming calls.

## Hunting

Of particular interest to broadcasters who take lots of calls simultaneously is hunting behavior, or the way the system behaves toward simultaneous incoming calls. Keep in mind, when an incoming call is in the "ringing" state, there are only status messages exchanged over the SIP connection--no actual audio is being transferred. The RTP audio channels are only created after the call is answered.

Only one SIP connection needs be open for multiple voice channels to be created. Your VoIP provider or PBX will be programmed to allow a designated number of simultaneous voice channels, and any further incoming calls will be rejected there. By default, most multi-channel VoIP gear will "hunt" any second, third etc. call to the next "line" on the device. In this way hunting is inherent. If more than the supported number of calls is requested to the VoIP device, it will reject them in the same way as the provider does, and no RTP channel will open for these excess calls.

Alternately, it's possible to set up a separate SIP account for each "line" on the SIP device, and this account should be capable of creating only one "channel" at a time. In this case, it's the responsibility of the provider or PBX to sort the hunting arrangement and notify the proper account about incoming calls.

## Choke Lines

Another topic of interest to broadcasters is choke lines, the specially conditioned telephone trunks designed not to fail under loads of thousands of incoming calls (e.g. for contests). In the PBX scenario, choke lines can easily be used as the trunks that feed the PBX, and very little changes.

When using a cloud provider, it's important to notify them about potential peak call volume to avoid overloading their systems. But cloud providers are usually equipped to provide service to high-volume nationwide call centers, so they can usually implement techniques to throttle large amounts of calls without impacting overall service.

# XII. INFORMATION FOR IT MANAGERS ABOUT VH2

VH2 is an embedded Linux-based device with dual 10/100/1000Base-T Ethernet ports. The device contains an optimized version of the **Linux kernel** (at this writing, **3.12**). The IP parameters are set using an internal web server that hosts a configuration page on **TCP 80**.

Alternately, during the first five minutes of power up, the IP parameters may be set by a PC on the local LAN using a proprietary broadcast UDP protocol. Comrex provides the **Device Manager** software to perform this function on the local PC. After five minutes of operation, this function is disabled.

The device runs several services on different ports, outlined here:

## INCOMING SERVICES

The device hosts a combined HTTP/XML service on **TCP 80**. If this service is needed outside the firewall, the port will need to be routed to the VH2.

Firmware updates to the device are installed using the **Device Manager**. This update process is password protected and done via XML over **TCP port 8080**. In addition to the password protection, the update data itself must have a valid cryptographic signature from Comrex, or else it is rejected. In order for the unit to be remotely updated, **TCP port 8080** must be forwarded to the device. Alternately, updates can be initiated from any local PC using the **Device Manager**.

The device can support connection to a SIP trunking service, which would require incoming service on a single **UDP SIP port** (usually **5060**) and two **UDP RTP ports** in the range of **16384-16432**.

The device can support connection to a registered SIP service. In this case, the **UDP** SIP connection will be outgoing and the two **UDP RTP ports** will be incoming in the range of **16384-16482**.

Typically, SIP services rely on the presence of a SIP ALG within the firewall to open RTP ports.

If Comrex support is required, we may ask for access to the SSH host on the VH2 on **TCP 22**. SSH service is protected by a private keypair which is not delivered to customers. SSH service can be disabled in the setup menu.

## OUTGOING SERVICES

As described above, the VH2 will make outgoing connections to register with SIP providers (usually to port **UDP 5060**) combined with incoming and outgoing RTP in the range of **UDP 16384-16432**.

An NTP client is implemented by default to **UDP 123**.

**Comrex Corporation**
**19 Pine Road**
**Devens, MA 01434**
**USA**

Technical Support is available Monday-Friday 8:30AM-5PM EST.

**1-800-237-1776 (North America)**
**1-978-784-1776 (International)**
**1-978-784-1717 (FAX)**

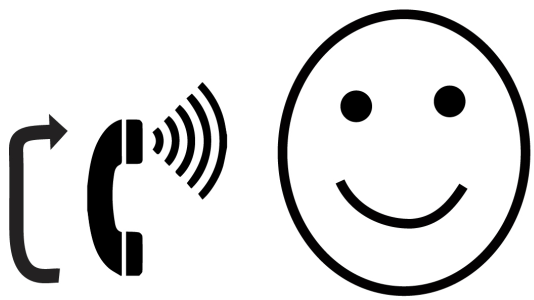
**email techies@comrex.com**

**Product manuals and firmware updates available on the web at:**
**http://www.comrex.com**

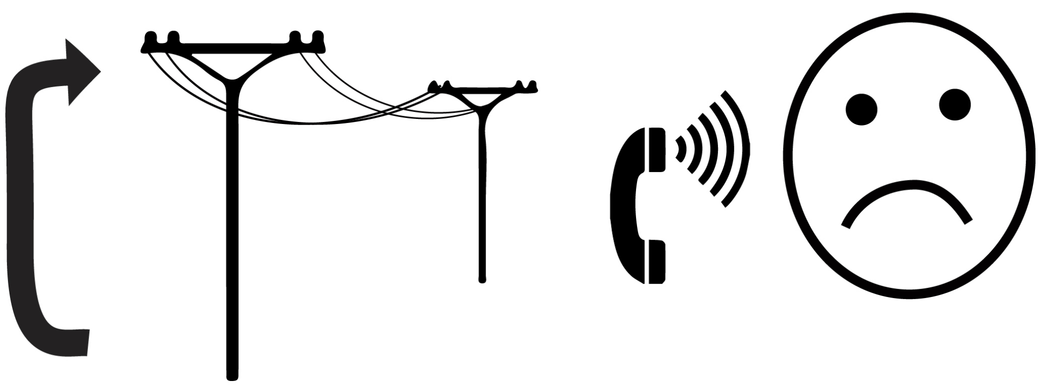
# XIV. WHY DO I HEAR HEAR MYSELF MYSELF?

## MIX-MINUS AND ELIMINATING ECHO

Studio telephone integration is a two-way process. The caller must send his audio to the studio, but also receive a return feed that allows him to interact with other sources, like a host. An important element of voice telephony involves allowing a speaking party to hear his own voice in his own earpiece.  This sidetone provides a speaker the comfort of knowing his voice is getting through, and makes two-way communication flow more easily.



Sidetone created within a telephone has no delay
and makes conversation easier



Sidetone created on the far end of a call has delay
and makes conversation difficult

But for several reasons, telephone sidetone is always generated locally within the speaker's equipment, rather than on the far end of the call. This is because humans have a very hard time handling even the smallest delay in this sidetone signal. In testing, we find that any delay over around 10mS starts to have an effect called “slapback” where the speaker is unable to maintain conversation and begins to halt and stutter.

Even in “old-fashioned” analog telephone circuits, it’s possible to create a 10mS round-trip delay on a long distance call. Now add in the requirement that modern VoIP-based systems have inherent windowing and buffer delays, and its easy to pile up over 100mS round-trip on a call. A delay of this length will typically not impede interactive conversation, but will certainly create an intolerable “slapback” environment if the caller hears his own voice delayed.

The telephone network employs digital echo cancellers at various nodes along the path of a phone call to avoid this scenario. And when they malfunction or are “untrained” at the start of a call, the effect is a dramatic echo in the caller’s ear.

Many users installing a studio-based phone system for the first time make the mistake of applying audio to the outgoing “send’ port that contains the main program feed - the same audio used to feed the transmitter or webstream. Since this mix contains the caller’s own audio, and there’s an inherent delay in modern digital systems, the “slapback” effect is immediate.

The solution here is mix-minus-- a term used for a special mix of audio that explicitly excludes one source--the audio coming from the place the mix-minus is being sent. To put it another way, mix-minus is the entire studio mix minus one audio source.

So how do we create this special audio mix? On modern studio systems, this is usually well defined and easy to do. Many consoles feature channels dedicated to telephone interface, and part of the channel is an automatically-created mix-minus output.

In less full-featured consoles, a mix-minus can often be created with an auxiliary or “audition” bus function. By selecting all relevant incoming sources on the bus except for the telephone fader, you can do this easily. Figure 10 shows the block diagram of a single mix-minus feed being generated on a mixing console.

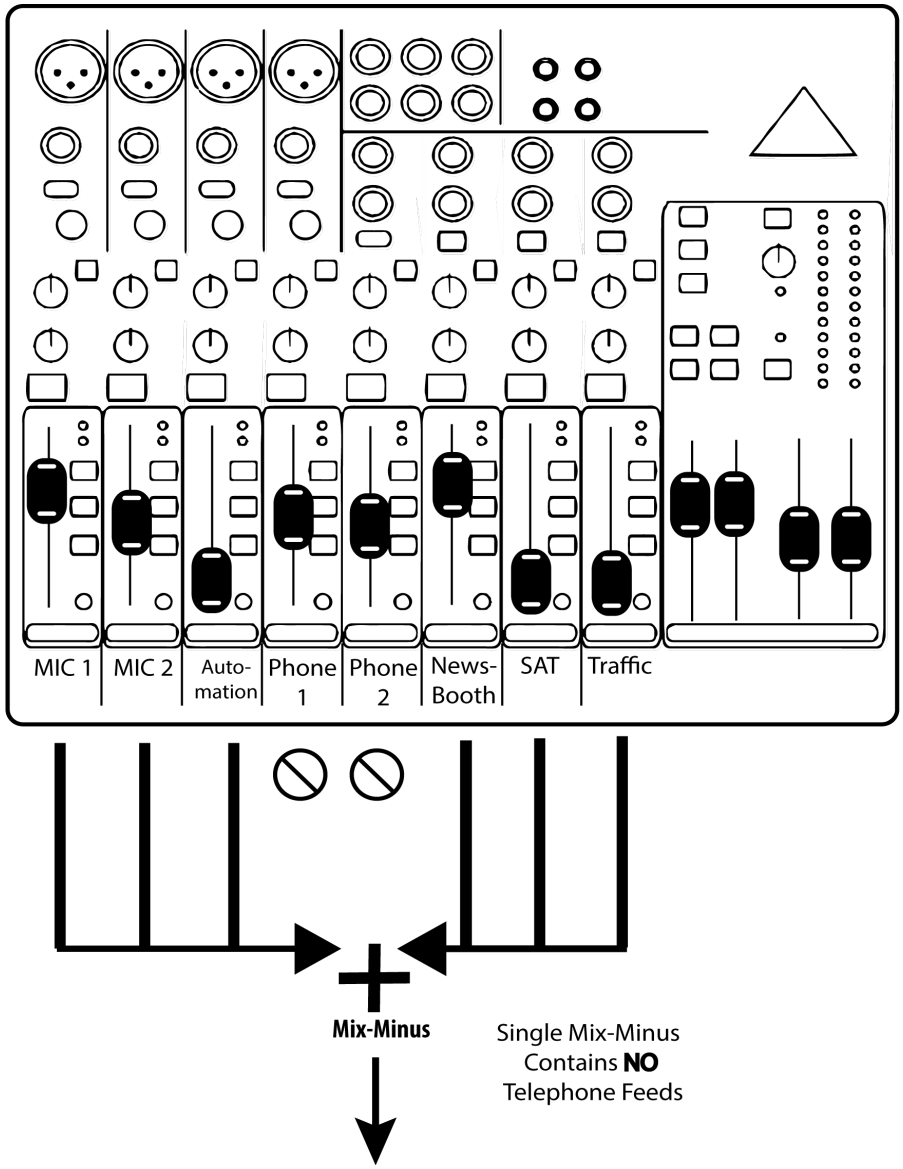



FIGURE 10 **SINGLE MIX-MINUS NO TELEPHONE FEEDS**

In some environments, it's only important that the caller hear the in-studio host, and less urgent that the on-air caller be able to hear automation, news reports, codecs etc. It's possible that simply routing an amplified version of the studio microphone signal to the "send" input will meet those needs.

Some studio telephone systems, like Comrex VH2, allow telephone callers to appear on one of two outputs (and therefore on two, separate console faders). In this circumstance, you often have a choice of delivering a single mix-minus with neither of the telephone audio sources present, or two distinct mix-minus feeds. In the case of two feeds, it's important to note that mix-minus A must include the caller audio B and vice-versa. Figure 10 illustrates this concept. Many consoles with dual telephone channels are designed to work this way, and should deliver the correct set of mixes automatically.

Finally, if you're stuck in a studio where you need to create multiple mix-minus feeds with no resources to do so, investigate the Comrex **Mix-Minus Bridge** product. It's an easy way to deliver up to six distinct mix-minus feeds (e.g. for two telephone channels, two audio codecs, a two-way radio system and an RPU return channel) simultaneously while sacrificing only one console auxiliary bus.

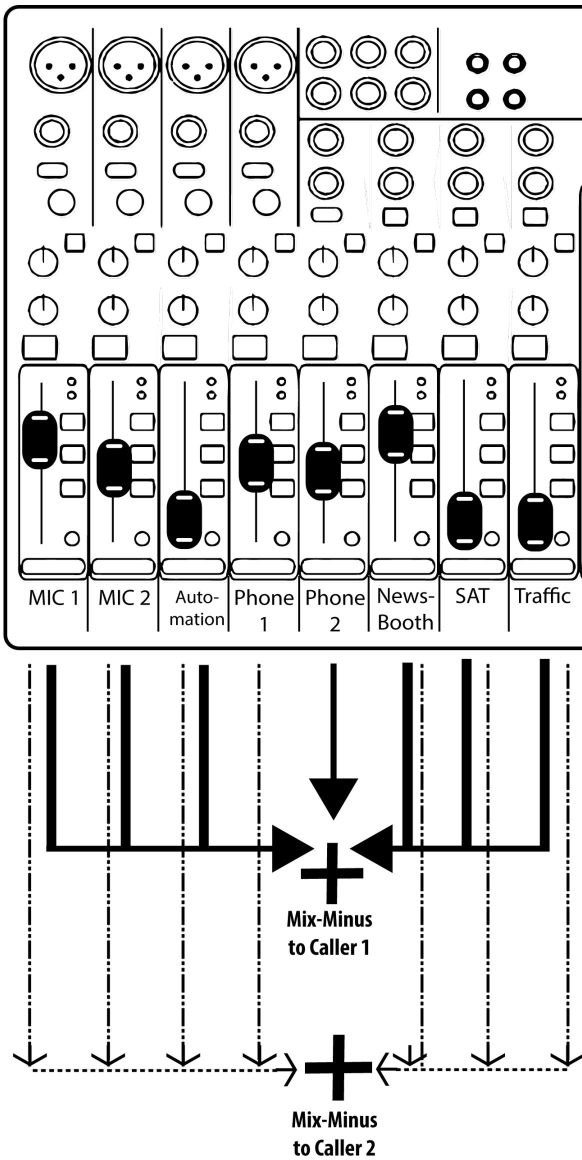



FIGURE 11 **TWO MIX-MINUS FEEDS**

# xv. SOFTWARE LICENSES

VH2 contains both proprietary and open source software. All proprietary portions are 

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