



## Opal Manual

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### Introduction

The Comrex Opal is a Web Audio Gateway designed for studio use. The main function of Opal is to allow two-way delivery of audio both to and from remote guests, much like a telephone call-in system. However, Opal doesn't use phone lines. Opal receives web-based audio calls from users on computers and smartphones. There are two key advantages to using Opal:

- 1 Opal's web audio uses audio encoders and decoders that delivers high-fidelity, studio quality audio while maintaining the delay of a typical mobile phone
- 2 Opal is designed to be extremely simple for the remote guest - non-technical callers can easily use Opal

Opal has the capability of handling two web audio calls simultaneously, and provides two input and output channels on pro-level balanced XLR or AES3. In current firmware, internal conferencing is not supported.

Opal attaches to the Internet at the studio. It has special requirements regarding networks. But these requirements all allow for the call process to be extremely simple for the guest. All the complexities are on the studio side, and the remote guest needs no special gear or setup.

All connections to Opal are incoming - no functionality is provided make outgoing connections from Opal.

Once Opal is installed and configured, connections are made to it by sending an **Invite** to the remote guest, via IM, email, text, snail mail, publishing the **Invite**, or any other means. The **Invite** consists of an Internet link, much like a web page. The only responsibility of the guest is to have a compatible web browser or app, a mic and headphones, and be able to click or copy the **Invite**.

**Invites** are generated by logging into Opal from the studio side via a web browser using a special password protected "**Invite**" account. In current firmware, **Invites** can be manually enabled and disabled. In future firmware, **Invites** can be programmed to expire after time, usage, or not at all. Invites automatically route the call to one of the two Opal audio channels, designated when the **Invite** is created.

### Compatibility

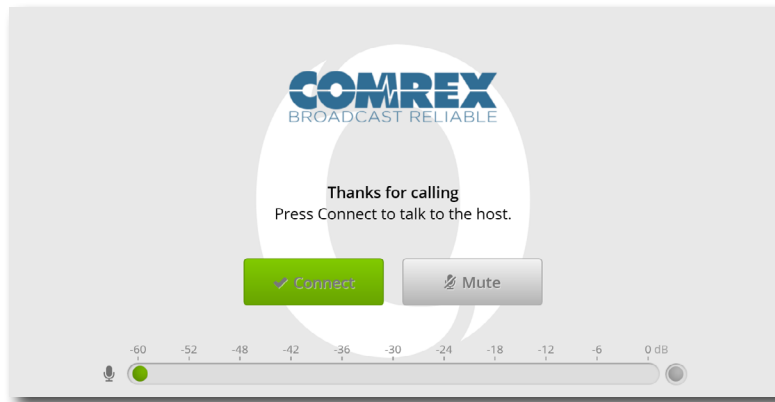
On the remote guest end, the caller should have access to a computer with a compatible web browser, and a microphone and headphone. Web browsers currently supported are **Edge**, **Chrome**, **Safari 11** for MACOS, **Opera** and **Firefox**. Opal is also compatible with **Chrome** and **Firefox** on Android devices, as well as **Safari** in **iOS 11**, but we have seen operational issues on current mobile browsers. We recommend the use of the Opal app on mobile devices, currently available on the **Apple iTunes** and **Google Play** stores for free.

For best audio quality, it is recommended that callers using a laptop or desktop computer utilize a headset and wired microphone rather than the computer's open speaker and built-in microphone. This is important not only with regard to noise but also with isolating the local microphone from the "return" audio, which will make a big difference in quality. For similar reasons, for smartphone users it's advised to use the phone as a handset, rather than a speakerphone. On smartphones, wired headsets will provide the best audio quality.

## How Opal Works

Opal is installed on the studio side's Internet connection. For best results, Opal needs a public, static IP address with a domain name assigned to it by a provider of domain names.

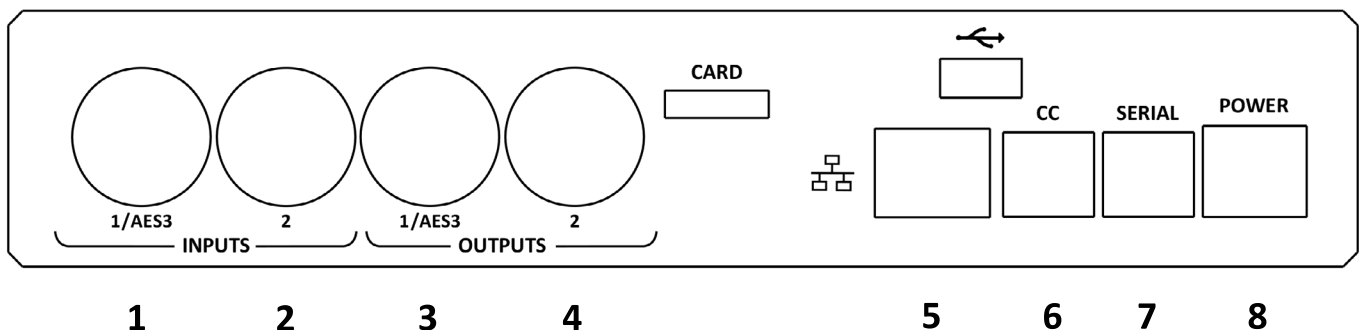
**Invites** are retrieved from Opal via the **Invite** web interface and transferred to the guest caller. The guest caller will click or copy the **Invite** in a compatible browser, and will see the Opal landing page with the **"Connect"** and **"Mute"** buttons.



Pressing **"Connect"** will create a high quality audio link to one of the two Opal channels. The connection will end when the caller presses the **"Disconnect"** button.

## Opal Hardware Attachments

The following figure shows the Opal rear panel.



- 1 CH 1 INPUT** - In analog mode, this XLR connector should be sent a balanced, pro-level signal that is heard by callers when they connect to Opal on **Channel 1**. This is usually a "mix-minus" feed created on your studio console. In digital AES3 mode, both **CH 1 INPUT** and **CH2 INPUT** are applied here (on left and right channel, respectively).
- 2 CH 2 INPUT** - This analog input receives audio to be sent to callers on **Channel 2**. This input is disabled when in AES3 mode.
- 3 CH 1 OUTPUT** - This analog output will deliver the audio from callers who connect to Opal **Channel 1**. 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 connect to Opal **Channel 2**. This output is disabled when in AES3.

- 5 **Ethernet Port** - Connect your network to this gigabit compatible Ethernet port.
- 6 **Contact Closure Connector** - This contains 4 contact closure input and output signals, for various remote control and tally functions as described further on.
- 7 **Serial Port** - This is an RS-232 connector that presents a serial port for future use.
- 8 **Power Supply Input** - Apply the included AC desktop adapter output here. The power supply port requires 24VDC at 0.5A.

The following figure shows the Opal front panel.



- 1 **DIP Switches** - See DIP Switch Settings below
- 2 **Channel 1 Audio Indicator** - Show the level of incoming or outgoing audio (selectable) on channel 1
- 3 **Channel 2 Audio Indicator** - Show the level of incoming or outgoing audio (selectable) on channel 2
- 4 **Ready/Status Indicator** - Shows network and call status
- 5 **Reset Button** - Reset to factory defaults (See Factory Reset section for full process)

*Level indicators* will light green when input /output (depending on dip switch setting) level is detected, red when clipping.

*Ready/Status -*

**Red** - No network detected

**Amber** - Network OK/No certificates

**Flashing Green** - Loading internal systems (booting)

**Off** - Network OK/Idle

**Green** - Call active

## DIP Switch Settings

| DIP Switch | Function                      | Default (down) |
|------------|-------------------------------|----------------|
| 1          | Analog/AES3 Input Select      | Analog         |
| 2          | Analog/AES3 Output Select     | Analog         |
| 3          | Future Use                    |                |
| 4          | Level Indicators Send/Receive | Send           |
| 5-6        | AES3 Sample Rate Select       | 48KHz          |
| 7-8        | Factory reset                 |                |

## AES3 Sample Rate select

Opal supports I/O sampling rates of 48KHz, 44.1KHz, and 32KHz. The input and output sampling rate must always be the same. Opal locks the output AES3 Clock to the input clock. At rates other than 48KHz, it's always necessary to have AES3 input active in order to use AES3 output.

Set the expected AES3 using Dip Switch 5 & 6

| DIP Switch 5 | DIP Switch 6 | Sample Rate |
|--------------|--------------|-------------|
| Down         | Down         | 48KHz       |
| Down         | Up           | 44.1KHz     |
| Up           | Down         | 32KHz       |

Reboot Opal after changing the AES3 sampling rate settings. In analog mode, the AES3 DIP switches are ignored.

NOTE: If you plan on using both analog and AES3 simultaneously, (i.e., Analog Input, AES3 output) AES3 must be set to 48KHz.

## Factory Reset

To factory reset your device using dip switches, follow these steps:

- 1 Put dip switch 7 & 8 up.
- 2 Press the Reset button once. Wait until the **Channel 1**, **Channel 2** and **Network/Status** indicators flash red and green. (About 40 seconds.)
- 3 Put dip switch 7 & 8 down.
- 4 Press the Reset button once.

## About Mix-Minus

Comrex support spends a lot of time discussing mix-minus, as it is not an obvious concept. Regarding studio connections to outside sources, 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 "send" channel that is a mix of all important audio sources - in-studio mics, automation, 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 at the end of this manual, **"Why Do I Hear Hear Myself Myself?"** Finally, it's important to remember the mix-minus feeds must contain the audio from the opposite send channel. Opal does not provide any in-box conferencing options.

## Audio Connections

All analog XLR audio inputs have a nominal level of 0dBu (full scale +20dBu). When the input mode is changed (via DIP Switch #1) to AES3 mode, the system expects a 48KHz AES3 input. When the output mode is changed (via DIP Switch #2), a 48KHz signal will be output. To change the sampling rate to either 44.1KHz or 32KHz, refer to the section on the previous page, AES3 Sample Rate Select.

### Analog input and output pinouts:

- 1 Ground
- 2 Balanced audio +
- 3 Balanced audio –

### AES3 input and output pinouts:

- 1 Ground
- 2 Data +
- 3 Data –

## Contact Closures

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

In current firmware, only contact closure outputs 1 & 2 are supported. Contact closure #1 is active when a call is active on channel 1, and contact closure #2 is active when a call is active on channel 2.

Contact Closure inputs perform the following functions:

- #1** - Disconnect active call on Channel 1
- #2** - Disconnect active call on Channel 1 and disable invite
- #3** - Disconnect active call on Channel 2
- #4** - Disconnect active call on Channel 2 and disable invite

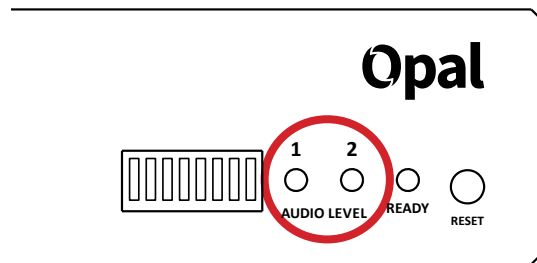
Inputs are triggered by shorting the respective input to Pin 9. Outputs consist of an open collector circuit which, when inactive, will offer a high-impedance path to Pin 9 and, when active, will offer a low-impedance path to Pin 9. These outputs are capable of sinking up to 200mA at a voltage up to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

### Contact Closure Pinouts:

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

## Attachment Details

At a minimum, Opal 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 the following figure. Clipping is indicated by the red LED on these meters.



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

In most ways, Opal will look like an ordinary computer to this network. In fact, Opal contains an embedded computer with a Linux-based operating system and a full network protocol stack. Opal is perfectly capable of working over most LANs, but there are special considerations outlined below for Opal to work its best.

Since there may be bandwidth, firewall, and security concerns with installing Opal 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.

## Opal Network Requirements

The key to Opal is simplicity for the guest caller. In order to provide this, Opal has some special requirements on the studio side regarding its network configuration.

Opal requires the ability to accept unsolicited data from the public Internet. The easiest way to allow this is for Opal to be connected directly to the Internet, without any routers or firewalls in its path. All Opal functions are password protected, and it's highly recommended the user change the passwords from the default.

Often it's not possible for Opal to reside on the public Internet, and a router or firewall must be used. In this case, forwarding of several ports is required within the router/firewall. This is outlined in the **"For IT managers"** section towards the end of this manual.

Opal requires the configuration of a static IP to be used correctly. This IP address must be directly addressable from the public Internet, and not just a local LAN address. Static IPs are usually available from your Internet Service Provider, or from your IT department in larger facilities.

## Opal Domain Name

Finally, Opal needs a domain name associated with its static IP address. A domain name may be leased from any domain provider. Domain names are required to enable the SSL/TSL security certificates Opal uses for connections. Browsers require these certificates in order to engage the underlying technology that makes Opal work. Otherwise, the guest caller will need to click through multiple security warnings (if the browser even allows unsecured connection at all).

Some users may want to use a domain name they already own. This will probably not work, because Opal requires several ports that may be in use on your domain, including **TCP 80**, **TCP 443**, and **TCP 8082**. Alternatively, you can register a subdomain like **opalcallers.mystudio.com**.

If you do not have a domain name, Comrex recommends you do a web search on “Domain Names”. There are lots of low cost registrars out there. You’ll just need your Static IP to give them. Of course, your chosen name must be available, and you must renew it before it expires. There’s no need to get a “.com” domain, any suffix like .info or .ninja should work.

Unless you need it for other services, there’s no need to buy SSL certificates or any other security upgrades for your Domain Name from the registrar. Opal handles all that.

Opal works via sending and clicking links, and the Domain Name will be automatically put into the links, so it’s not that important that your name be simple or easy to remember.

**Tip:** Register both mystudio.com and **www.mystudio.com** to cover all your bases (most registrars will do this by default).

**Another Tip:** Make sure your domain is registered as a **real/ DNS A Record** pointing directly at your IP address and not a domain “forwarding” service. The security certificates required will not work if your domain provider is forwarding or proxying traffic from their domain.

**Last Tip:** **Dot.tk** is a free domain provider that offers **DNS A Records** to names within their .tk domain. There are some limitations that may affect long-term use, but for testing they are recommended.

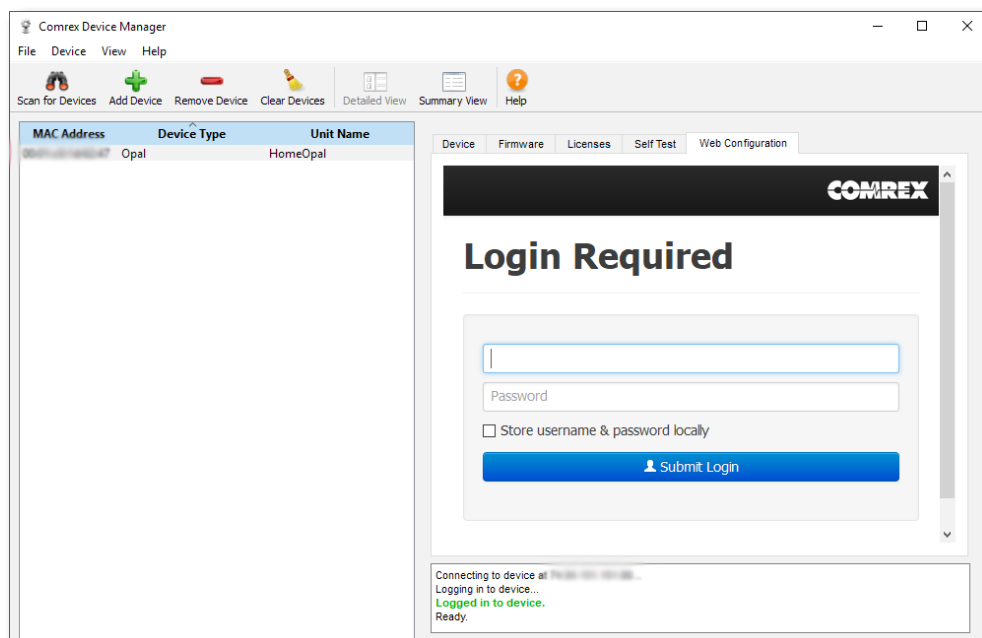
## Opal Configuration

At a minimum, you’ll need to configure Opal’s static IP address and its domain name.

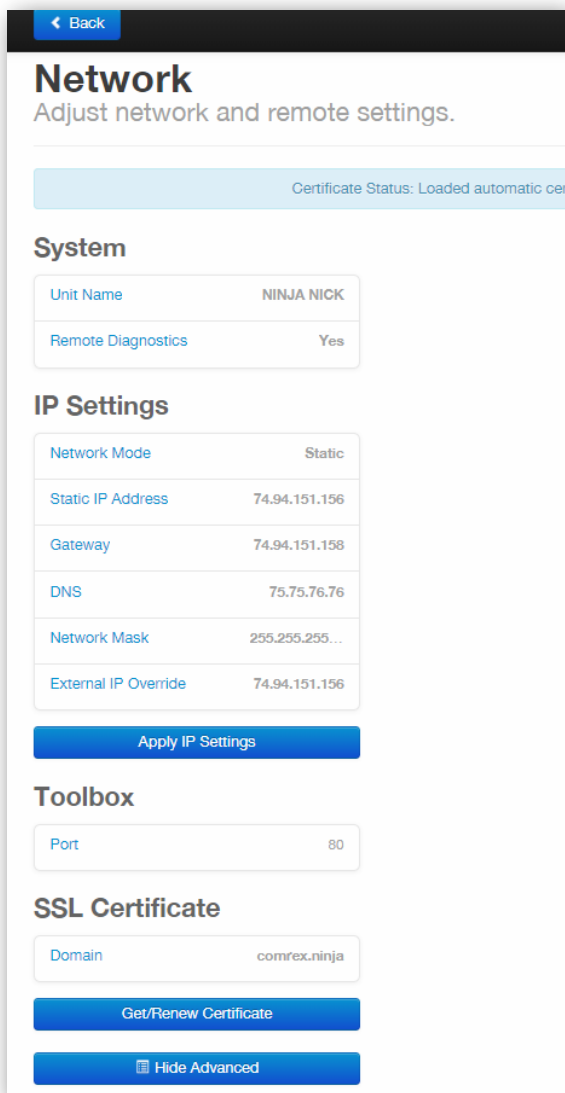
### Static IP address

Opal 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** utility, available on our website for both Windows and Mac platforms. You can also use **Device Manager** to upgrade the firmware on your Opal.

Install **Device Manager** on a computer on the same physical LAN as the Opal. Once installed and run, press the “**Scan**” 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 Opal 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](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. Once logged in, choose the “**Network**” option. Under “**Network Mode**”, you’ll see the following options:



The screenshot shows the 'Network' configuration page in the Toolbox interface. At the top, there is a 'Back' button. The main heading is 'Network' with the subtitle 'Adjust network and remote settings.' Below this, a status bar indicates 'Certificate Status: Loaded automatic cer...'. The page is divided into several sections: 'System' with fields for 'Unit Name' (NINJA NICK) and 'Remote Diagnostics' (Yes); 'IP Settings' with fields for 'Network Mode' (Static), 'Static IP Address' (74.94.151.156), 'Gateway' (74.94.151.158), 'DNS' (75.75.76.76), 'Network Mask' (255.255.255...), and 'External IP Override' (74.94.151.156); a blue 'Apply IP Settings' button; 'Toolbox' with a 'Port' field set to 80; 'SSL Certificate' with a 'Domain' field set to comrex.ninja; a blue 'Get/Renew Certificate' button; and a blue 'Hide Advanced' button at the bottom.

| System             |            |
|--------------------|------------|
| Unit Name          | NINJA NICK |
| Remote Diagnostics | Yes        |

| IP Settings          |                |
|----------------------|----------------|
| Network Mode         | Static         |
| Static IP Address    | 74.94.151.156  |
| Gateway              | 74.94.151.158  |
| DNS                  | 75.75.76.76    |
| Network Mask         | 255.255.255... |
| External IP Override | 74.94.151.156  |

Apply IP Settings

| Toolbox |    |
|---------|----|
| Port    | 80 |

| SSL Certificate |              |
|-----------------|--------------|
| Domain          | comrex.ninja |

Get/Renew Certificate

Hide Advanced

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).

**Note:** **External IP Override** is an advanced option that most users will leave blank. In the unusual circumstance where Opal cannot find its own IP address via **DNS lookup**, you may need to enter the public IP of Opal here.

## Domain name

Once you can log into Opal from your correct static IP address, you can set the Domain in the same “**Network**” option of **Toolbox**.

The screenshot shows the Opal configuration interface. On the left, the 'System' section includes 'Unit Name' (My Opal) and 'Remote Diagnostics' (Yes). Below it, 'IP Settings' includes 'Network Mode' (Static), 'Static IP Address' (192.168.1.102), 'Gateway' (192.168.1.1), 'DNS' (192.168.1.1), and 'Network Mask' (255.255.255...). An 'Apply IP Settings' button is at the bottom of this section. The 'Network' section has a 'Port' (80). The 'SSL Certificate' section has a 'Domain' field and a 'Get/Renew Certificate' button. On the right, the 'Domain' section has a text input for the domain name (example: www.your-domain.net) and a 'Set to Default' button. Below the input is a text field containing 'newengland.hfc.comcastbusiness.net'. At the bottom right are 'Cancel' and 'Save Setting' buttons.

No **HTTPS** or **//** is required here, just the domain (e.g. **comrex.com**). If you registered a domain with a “**www.**” prefix, make sure it’s included in the domain name.

Once the **Domain** entry is set correctly, press the button labeled “**Get/Renew Certificate**”. Opal will reach out to its certificate server and install the required security certificates automatically.

## Accounts

So far, we’ve dealt with the **Admin** account on **Toolbox**, which allows full configuration of Opal as well as generating **Invites** (explained below). This account is always active and cannot be removed. It’s possible to create “sub accounts” on **Toolbox** with their own passwords and capabilities. The most common reason for this is to create an “operator” sub account. Operators are not allowed to change settings on Opal, but can only generate/delete and enable/disable **Invites**, and disconnect currently active calls via **Toolbox**.

Create an additional account on Opal using the **Security->Accounts** option. Set a username and password, and whether the user has **Admin** or **Operator** privileges.

## Invites

Opal screens incoming calls by generating **Invites**. These take the form of URL-style links that can be copied and pasted, then delivered to guests.

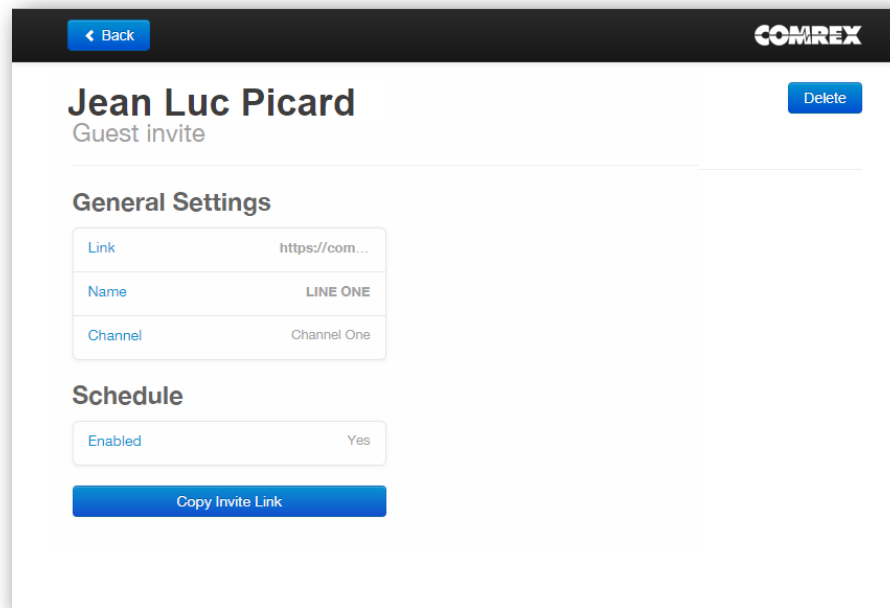
When an incoming caller attempts to connect to Opal, the **Invite** is checked against its internal database. If the **Invite** is valid, connection proceeds. If not, the user receives an error message.

Some users may want to bypass the screening provided by **Invites**. In this case, simply create a universal Invite for all users. This can even be published to the public, and will remain valid until you change it in **Toolbox**.

In current firmware, **Invites** can be generated, deleted, enabled and disabled. In future firmware, **Invites** can be set to expire after a time limit, a date, or number of connections.

To generate an Invite, log into Opal **Toolbox** with **Device Manager** or by pointing a browser at: [http://\[opal\\_ip\\_address\]/cfg/](http://[opal_ip_address]/cfg/)

Use your admin or operator user name and password to access **Toolbox**, then choose “**Invites**”. Choose “**Add Invite**” to create a new Invite. You will be offered the following options:



**Link** - This is the **Invite** you will copy and send to the guest(s). You can also copy it to your computer’s clipboard using the “copy” button at the bottom of the list.

**Name** - Name your **Invite** something familiar like “**Crazy Larry**” so you can reference who is calling.

**Channel** - Choose whether this caller will appear on Opal hardware port 1 or 2, or whichever is available.

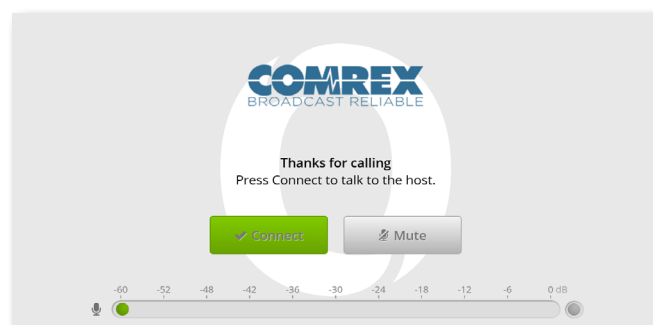
**Enabled** - Set to “**yes**” by default, this option allows you to disable this **Invite** without deleting it.

Once your **Invite** is set, you can click “**Copy Invite Link**” and your browser will copy the **Invite**, so you can paste it into a browser, email, text message, etc.

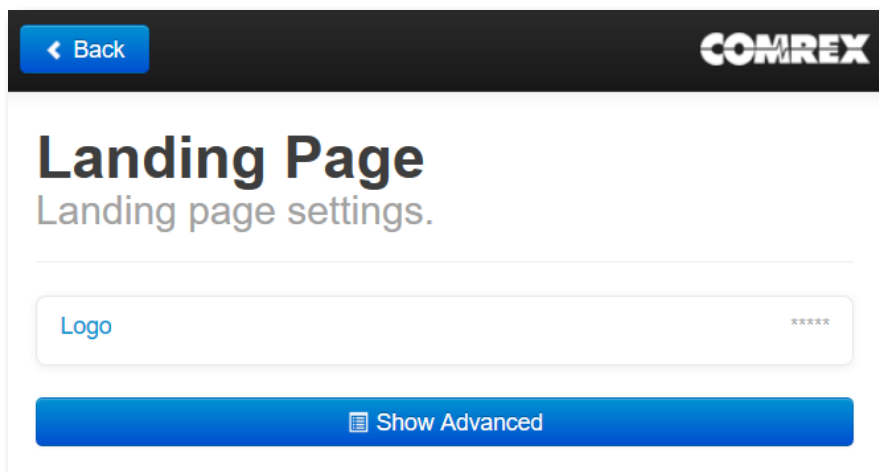
You can return to the **Toolbox Invite** page any time to disable or delete Invites you’ve created in the past.

## Uploading your Studio Logo to Opal

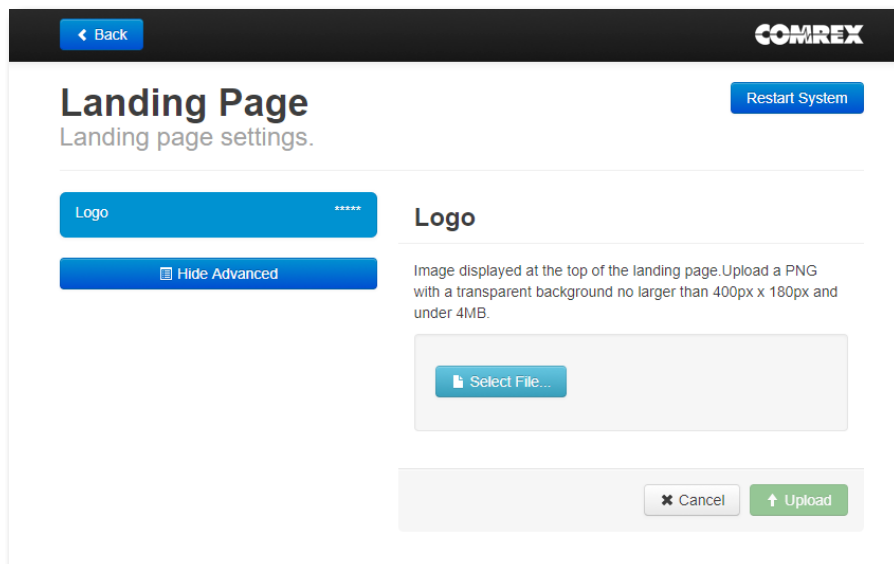
When guests use Opal with a web browser or an app, they’ll be looking at the Opal “Landing Page” as shown below:



It's possible to replace the top Comrex logo with one of your own, so that guests see exactly who they are calling. The following operation requires a web browser since it is not supported in Device Manager. Log in to the Opal **Toolbox** interface with your IP address <ip address/cfg>. You'll need a company graphic in **.png** format with a resolution up to 400 pixels wide x 180 pixels tall (and preferably with a transparent background). Your file must be 4MB or less in size. No other formats or resolutions are supported by Opal, and applying other style or resolution graphics can cause landing page distortion or inability to load. You can upload your graphic using the **Toolbox** "Landing Page" option.



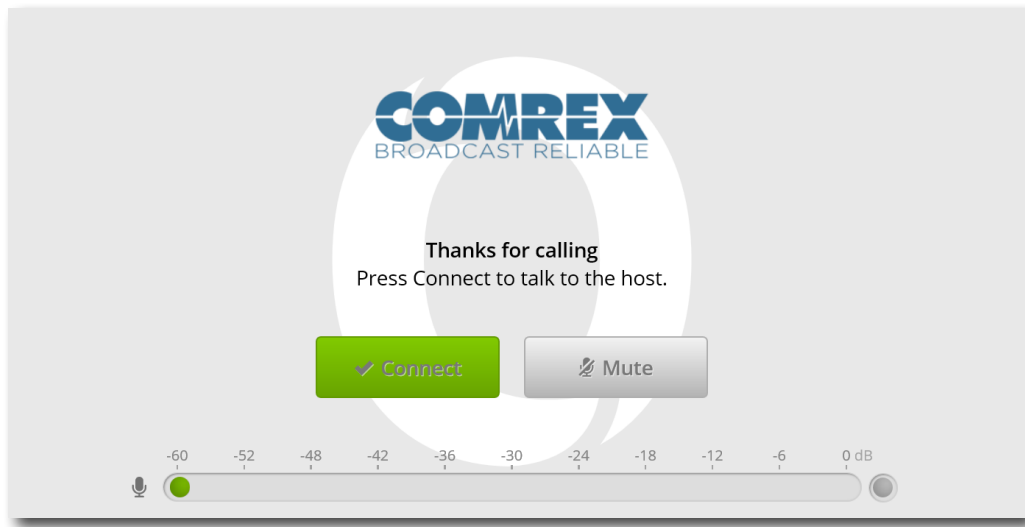
Choose "Select File" and a browse box will open on your computer.



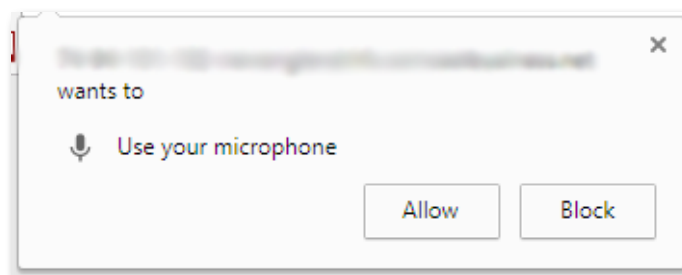
Choose the file to upload and then select "Upload" to send the graphic file to Opal.

## Making a Call to Opal

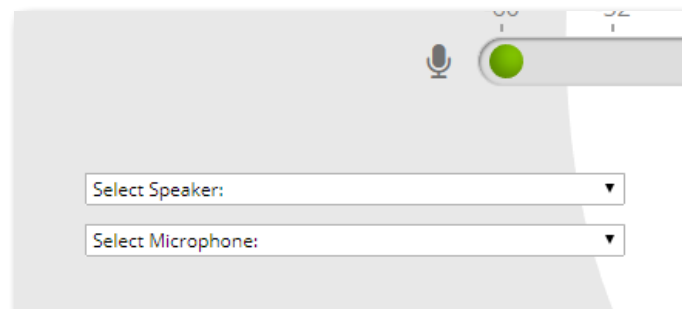
Your guest will need to open the **Invite** link in a compatible browser (**Chrome**, **Edge**, **Safari** [iOS 11 or higher], **Opera**, or **Firefox**). They should see the Opal landing page:



The first time the guest connects, they will be asked to authorize the Opal page to use their microphone. The guest must choose **"Allow"** for the connection to work.



On devices that have multiple microphones and speaker arrangements (e.g. a laptop with built-in mic/speaker but also a headset), the Opal page will offer a pull-down menu for the guest to choose which device to use.

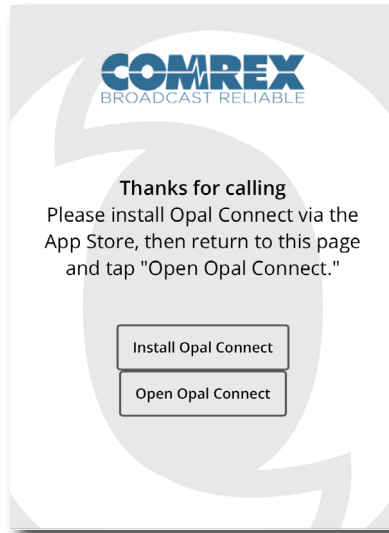


The guest should then see the microphone audio meter move when speech is detected. If this doesn't happen, their browser cannot connect to Opal.

Connections are made by pressing the **"Connect"** button, and waiting for it to turn green. Disconnect using the same button (now labeled **"Disconnect"**). If at any time the guest wants to mute the local microphone, pressing the **"Mute"** button will accomplish this. Audio to the guest will not be affected.

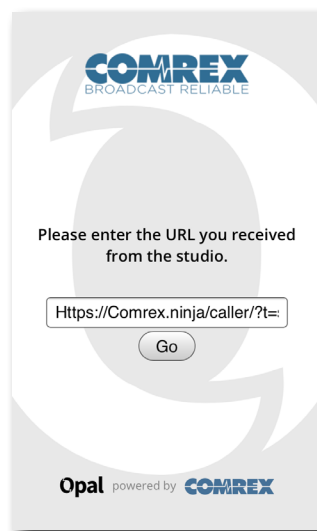
## Making a call to Opal from a Mobile Browser

When Opal detects the guest is using a mobile browser, it behaves differently. Opal will display options to the user, encouraging them to install or (if already installed) launch the free Opal app for Android or iOS\*.

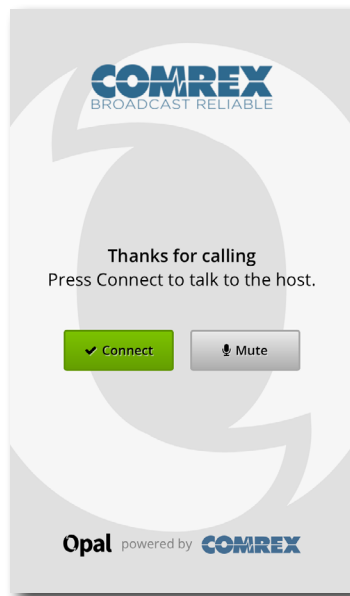


At this time, although mobile browsers support the Opal protocols, there are still issues that can arise. We recommend use of the Opal apps at all times on Android and iOS. Opal will display two options to mobile users:

- 1 **Install Opal Connect** - User will be taken to the app store and offered the chance to download and install the free Opal app.
- 2 **Open Opal Connect** - User should choose this option if the Opal app is already installed. The **Invite** will be automatically populated in the app when opened.



When **Opal Connect** is launched from a browser, the Invite will be shown in the URL bar of **Opal Connect**. If **Opal Connect** is launched independently from the browser, it will offer the last **Invite** used (if applicable) or a blank URL entry bar. It's possible to manually paste or enter an **Invite** into the URL bar. When the "Go" button is pressed, the app will display the Opal landing page.



**Opal Connect** offers an experience nearly identical to users on browsers. The main difference is that **Opal Connect** does not offer a mic level meter. **Opal Connect** does not operate in "background mode" on mobile phones or tablets. If the app is running and sent to background (via "home" button or other means) the current call will disconnect. But since **Opal Connect** maintains and offers the last **Invite** when brought back up, it's a simple and quick reconnect process.

For subsequent calls, guests can simply launch the **Opal Connect** app directly on their phones, without using the browser at all. The last **Invite** used will be offered as the connect option.

## Calling Opal on your iPhone with Safari

Using Safari to call Opal is possible, but with some restrictions:

- You must be running **iOS11** or higher. (If you are running an earlier version, you will only be able to use the Opal app to make the call.)
- You cannot use your phone's earpiece. You will have to use speakerphone (not recommended) or a wired headset (recommended).

## Disconnecting Calls from Opal

While calls cannot be *made* from the Opal **Toolbox** page, they can be *ended* from there. Under the "Control" option, (available in both admin and operator modes), an active call can be disconnected on either channel using the "Drop Call" for that channel. In addition, the call can be dropped and the **Invite** disabled simultaneously using the "Drop Call and Disable Invite" button.

### Options for Connecting to Opal with an iPhone

**Below iOS 11 - Must use Opal App**



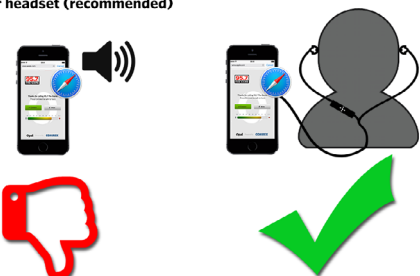
**iOS 11 or higher - Safari or Opal App**  
Option presented to user



**With Safari (iOS 11 or higher) -**  
Handset Earpiece cannot be used



**With Safari (iOS 11 or higher) -**  
Can only use speakerphone (not recommended)  
or headset (recommended)



## For IT Managers

The following ports are required by Opal to be open for incoming connections

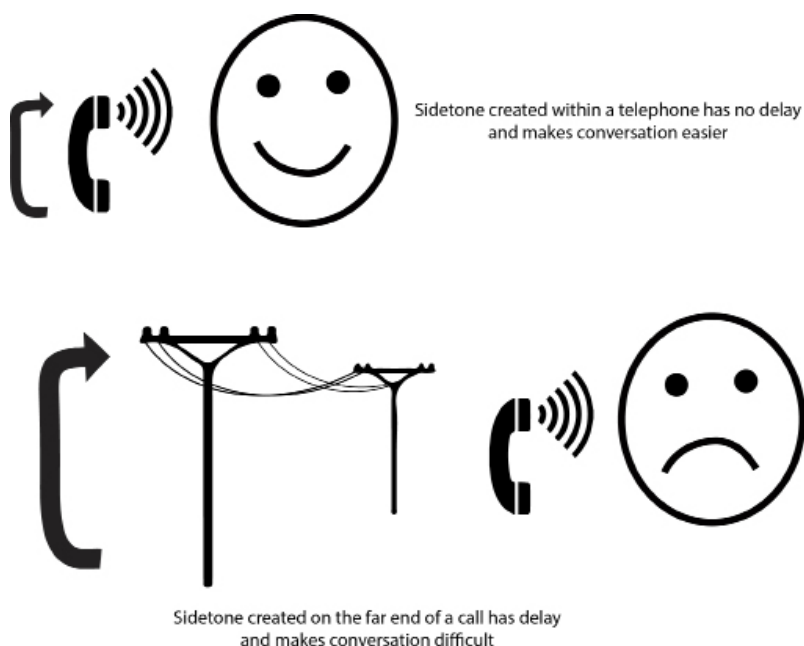
|                 |                                                    |
|-----------------|----------------------------------------------------|
| TCP 80          | HTTP users will be redirected to TCP 443 for HTTPS |
| TCP 443         | HTTPS server                                       |
| TCP 8082        | Signalling                                         |
| UDP 16390-16393 | Audio RTP                                          |

In addition, Opal will make outgoing connections to the following ports:

|                |                           |
|----------------|---------------------------|
| UDP 123        | NTP                       |
| TCP 80, 443    | SSL Certificate retrieval |
| TCP and UDP 53 | DNS lookup                |

## Mix-Minus and Eliminating echo (Why do I hear hear myself myself?)

Studio integration with outside sources like telephones, codecs and Opal is a two-way process. The guest 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 remote studio voice integration 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.



But for several reasons, 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've found that any delay over 10mS starts to create an effect called "slapback" where the speaker is unable to maintain conversation and begins to halt and stutter.

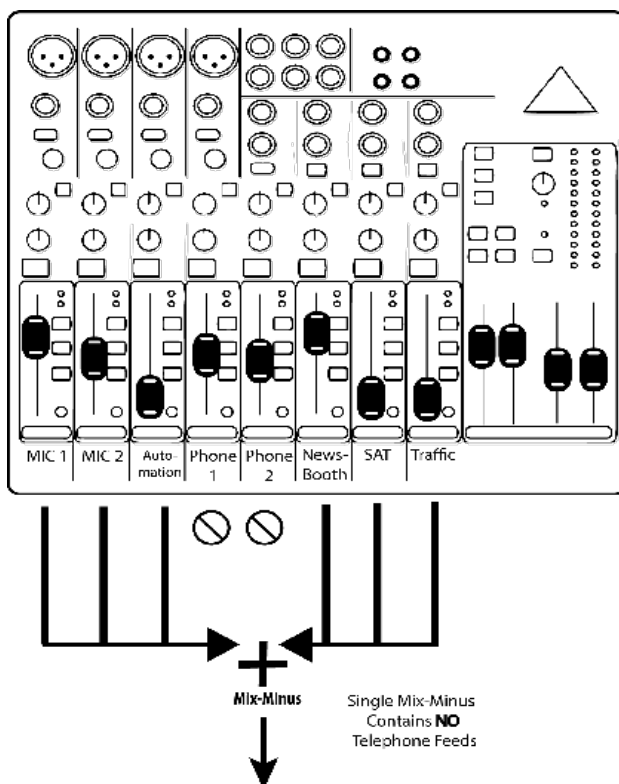
Even in "old-fashioned" analog telephone circuits, it's possible to create a 10mS round-trip delay on a long distance call. Now add in the requirement that modern VoIP-based or web audio systems have inherent windowing and buffer delays, and it's easy to pile up over 100mS round-trip on a call. A delay 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.

Many users installing a studio-based remote audio 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.

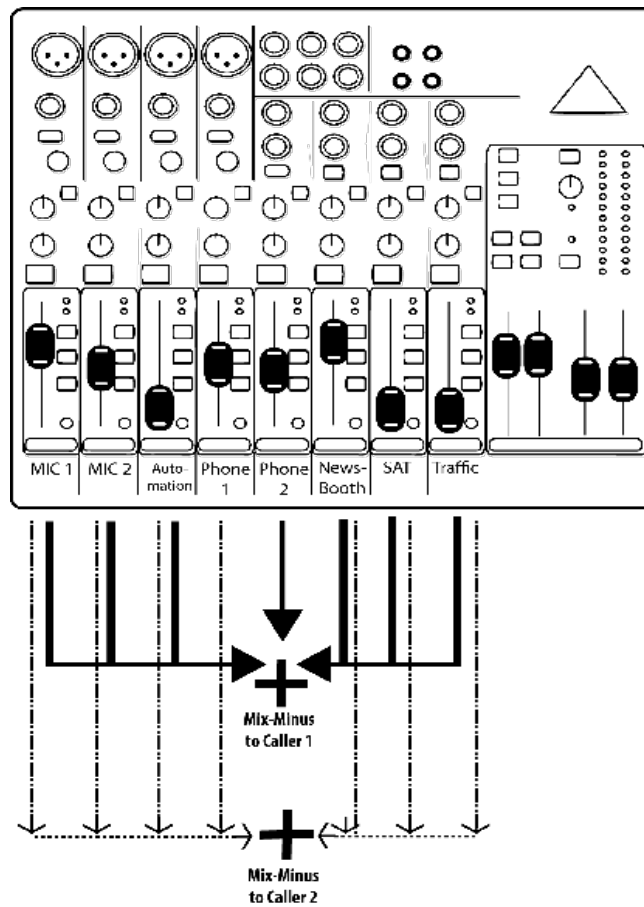
The solution here is mix-minus - a term used for a special mix of audio that explicitly excludes one source - the audio coming from the place the mix-minus is being sent. To put it another way, mix-minus is the entire studio mix minus one audio source.

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, ISDN or codec 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 fader tied to the caller's output, you can do this easily. The following figure shows the block diagram of a single mix-minus feed being generated on a mixing console.



The use of Opal complicates things a bit because it requires a pair of mix-minus feeds if both channels are to be used in the same studio. This is because Opal does not conference the two callers it receives, and each caller needs a custom mix-minus in order to hear the other, along with the studio-generated audio. This is shown in the following diagram:



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```
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## LESSER GNU PUBLIC LICENSE VERSION 2.1

sysfsutils

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Version 2.1, February 1999

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