



***DMR Repeater Back-to-Back***  
***Application Notes***



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# Preface

This section describes the conventions and revision history of this document.

## Conventions

### Icons

Icon	Description
 <b>Tip</b>	Indicates information that can help you make better use of your product.
 <b>Note</b>	Indicates references that can further describe the related topics.
 <b>Caution</b>	Indicates situations that could cause data loss or equipment damage.
 <b>Warning</b>	Indicates situations that could cause minor personal injury.
 <b>Danger</b>	Indicates situations that could cause major personal injury or even death.

### Notations

Item	Description
" "	The quotation marks enclose the name of a software interface element. For example, click "OK".
<b>Boldface</b>	The text in boldface denotes the name of a hardware button. For example, press the <b>PTT</b> key.
->	The symbol directs you to access a multi-level menu. For example, to select "New" from the "File" menu, we will describe it as follows: "File -> New".

## Revision History

Version	Date	Description
R2.0	September 2018	<ul style="list-style-type: none"><li>● Updated document outline.</li><li>● Add application scenario that repeater connects with mobile radio to realize Back-to-Back feature.</li></ul>
R1.0	January 2011	Initial release.

# 1. Overview

The Back-to-Back is a feature based on accessory pin. Two repeaters or one repeater and one mobile radio are connected through a pin cable to realize cross-band communication among analog and digital radios.

This document introduces how two repeaters or one repeater and one mobile radio perform the Back-to-Back feature.

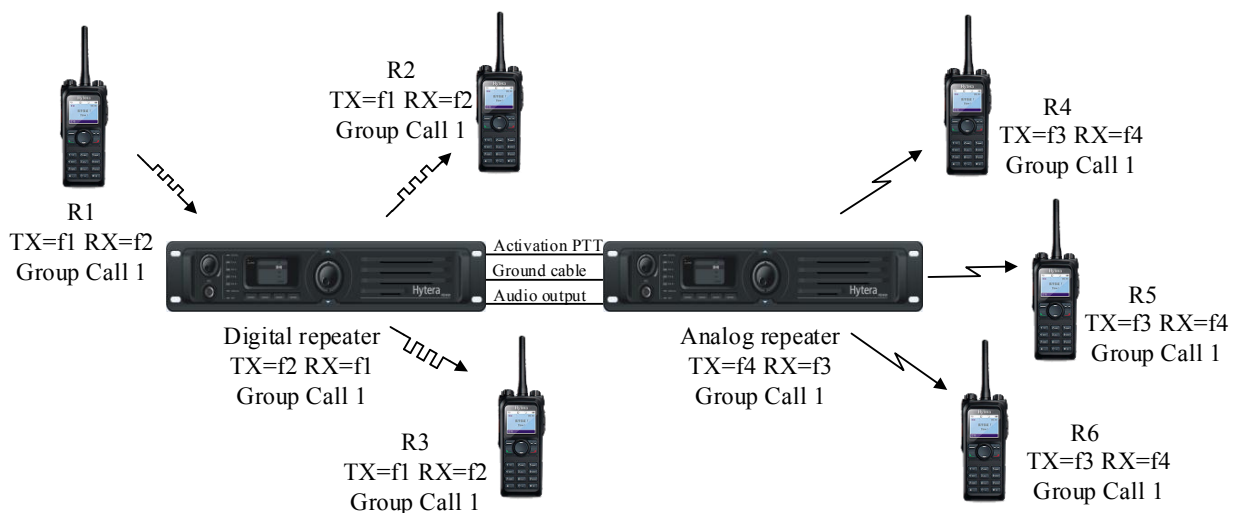
## 1.1 Principle

### 1.1.1 Working Principle

The Back-to-Back is realized through accessory pin features. For definition about involved accessory pin, see [1.1.2](#) and [1.1.3](#).

The following takes connection between the two repeaters for example to describe working principle.

- R1, R2, and R3 are digital portable radios. They work in the communication coverage of the digital repeater.
- R4, R5, and R6 are analog portable radios. They work within communication coverage of the analog repeater.
- The digital repeater and analog repeater are connected through the accessory pin cable



The following process describes communication from R1 to R4, R5, and R6.

**Step 1** R1 makes a group call.

**Step 2** The digital repeater repeats the audio signal to R2 and R3, transmits this signal to the analog repeater through the accessory pin, and activates the external Mic PTT of the analog repeater.

Because the digital repeater and analog repeater are connected through the cable, the audio transmission is not affected by operation mode (e.g. digital or analog mode) and frequency band.

**Step 3** The analog repeater starts transmission.

R4, R5, and R6 receives audio signal from the analog repeater. Finally, R1 can communicate with R4, R5, and R6.

The analog repeater also can transmit audio signal to the digital repeater through the accessory pin. In this case, portable radios within communication coverage of the two repeaters can communicate with each other.

### 1.1.2 Accessory Pin of the Repeater

On either analog channel or digital channel, the repeater starts or stops transmission through accessory pin, and samples the audio signals to be transmitted through the corresponding input pin.

#### Input

Item	Type	Applicable Mode	Definition
EXT Mic PTT (through external Mic PTT)	Programmable function	Analog and digital	When a valid level is input, the repeater will trigger its transmission circuitry, activate its external MIC PTT, and transmit the audio signal sampled from Codec. If the input level is invalid, the repeater will stop transmission.
TX Audio (for MIC signal input)	Fixed function	Analog and digital	When the external MIC PTT is enabled, the repeater will transmit the audio signals

#### Output

On either analog channel or digital channel, the repeater can output (in level form) the repeating request and its receiving status through accessory pin. The following table describes the pin definition.

Item	Type	Applicable Mode	Definition
Carrier Detect	Programmable function	Analog	<p>When an analog radio makes a call request, the repeater will output a valid level if detecting the matched carrier. When the analog radio stops transmission, the repeater will output an invalid level if no matched carrier is detected.</p> <p>Note: this feature is not applicable to repeaters with CTCSS/CDCSS enabled. The level indicates whether the repeater is working.</p>

Item	Type	Applicable Mode	Definition
CTCSS/CDCSS Detect	Programmable function	Analog	When an analog radio makes a call request, the repeater will output a valid level if the matched CTCSS/CDCSS signaling is detected. When the analog radio stops transmission, the repeater will output an invalid level if no matched CTCSS/CDCSS signaling is detected.  Note: this feature is applicable to repeaters with CTCSS/CDCSS enabled. The level indicates whether the repeater is working.
Rx Audio Output	Fixed function	Analog	When the repeater repeats audio signal, it will output such signal through accessory pin.
Voice Detect	Programmable function	Digital	When a digital radio makes a call request, the repeater will output a valid level if detecting the matched digital signaling. When the radio stops transmission, the repeater will output an invalid level.  This level indicates whether the repeater is working.
Audio Playback Slot-A, Audio Playback Slot-B	Fixed function	Digital	When the repeater repeats the audio signal, it will output such signal through accessory pin.

### 1.1.3 Accessory Pin of the Mobile Radio

#### Input

On either analog channel or digital channel, the mobile radio starts or stops transmission through accessory pin, and samples the audio signals to be transmitted through the corresponding input pin.

Item	Type	Applicable Mode	Definition
EXT Mic PTT	Programmable function	Analog and digital	When a valid level is input, the mobile radio will trigger its transmission circuitry, activate its external PTT, and transmit the audio signal

Item	Type	Applicable Mode	Definition
			sampled from Codec. If the input level is invalid, the mobile radio will stop transmission.
TX Audio	Fixed function	Analog and digital	When the external MIC PTT is enabled, the mobile radio will transmit the audio signals.

## Output

On either analog channel or digital channel, the mobile radio can output (in level form) the audio signal and its receiving status through accessory pin. The following table describes the pin definition.

Item	Type	Applicable Mode	Definition
Speaker Open Detect	Programmable function	Analog and digital	When the mobile radio detects that the speaker unmutes, the mobile radio will output a valid level. After the speaker is muted, the mobile radio will output an invalid level.
Rx Audio Output	Fixed function	Analog and digital	When the mobile radio receives audio signal, it will output such signal through accessory pin.
Carrier Detect	Programmable function	Analog and digital	When the mobile radio detects matched carrier signal, it will output a valid level.

## 1.2 Versions

- R9.0: realized Back-to-Back via the mobile radio and repeater.
- R3.0: realized Back-to-Back via repeaters.

## 2. Device Requirements

- Back-to-back via the repeater: The firmware version of the repeater is V3.0 or later.
- Back-to-back via the mobile radio and repeater:
  - Repeater firmware: V9.00.08.508.iM or later.
  - Mobile radio firmware: V9.00.04.405.iM or later
- Accessory pin cable
  - Back-to-back via the repeater: PC49
  - Back-to-back via the repeater and mobile radio: POA147



### Note

For specific accessories about the repeater and mobile radio, refer to the related User Manual. For specific radio model, consult your dealer.

## 3. Connection

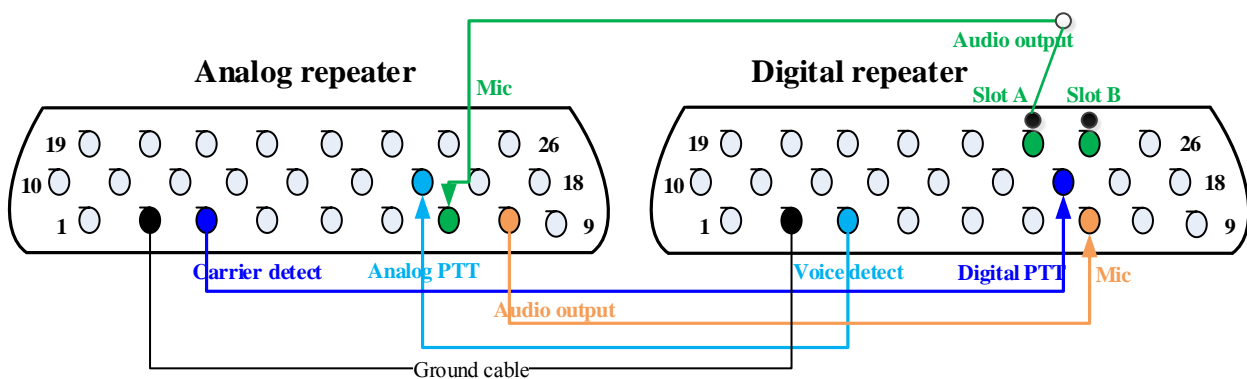
You can connect two repeaters or one repeater and one mobile radio through the accessory pin cable. For customized or expansion design, refer to the following pin position and features.

### 3.1 Connecting Two Repeater

#### Analog repeater and digital repeater

You can connect the analog repeater to the digital repeater according to the following figure.

Both Pin 3 and Pin 16 are programmable ports. Pin 3 can be replaced by Pin 12, Pin 20, and Pin 22. Pin 16 can be replaced by Pin 12, Pin 20, Pin 22, and Pin 23.



- **Ground cable**

Connects the Pin 2 of the analog repeater to the Pin 2 of the digital repeater.

- **Activation of digital repeater transmission**

Connects the Pin 3 of the analog repeater to the Pin 16 of the digital repeater.

- **Audio signal output of analog repeater**

- For analog repeater RD98XS: connects the Pin 24 to Pin 7 of the digital repeater.
- For other repeaters: connects Pin 8 to Pin 7 of the digital repeater.

- **Activation of analog repeater transmission**

Connects the Pin 3 of the digital repeater to Pin 16 of the analog repeater.

- **Audio signal output of digital repeater**

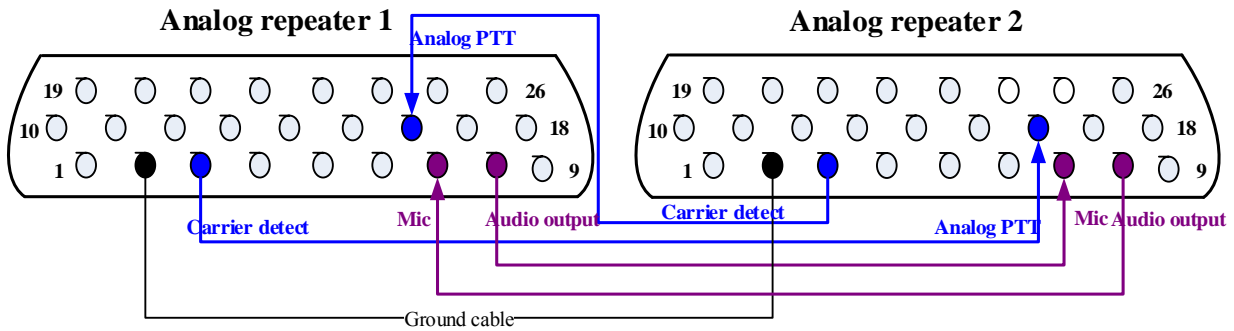
Connects the Pin 24 or Pin 25 of the digital repeater to the Pin 7 of the analog repeater.

#### Analog repeater and analog repeater

You can connect the two analog repeaters according to the following figure.

Both Pin 3 and Pin 16 are programmable ports. Pin 3 can be replaced by Pin 12, Pin 20, and Pin 22. Pin 16 can

be replaced by Pin 12, Pin 20, Pin 22, and Pin 23.



- **Ground cable**

Connects Pin 2 of the analog repeater 1 and Pin 2 of the analog repeater 2.

- **Activation of analog repeater transmission**

- Connects the Pin 3 of the analog repeater 1 to the Pin 16 of the analog repeater 2.
- Connects the Pin 3 of the analog repeater 2 to the Pin 16 of the analog repeater 1.

- **Audio signal output**

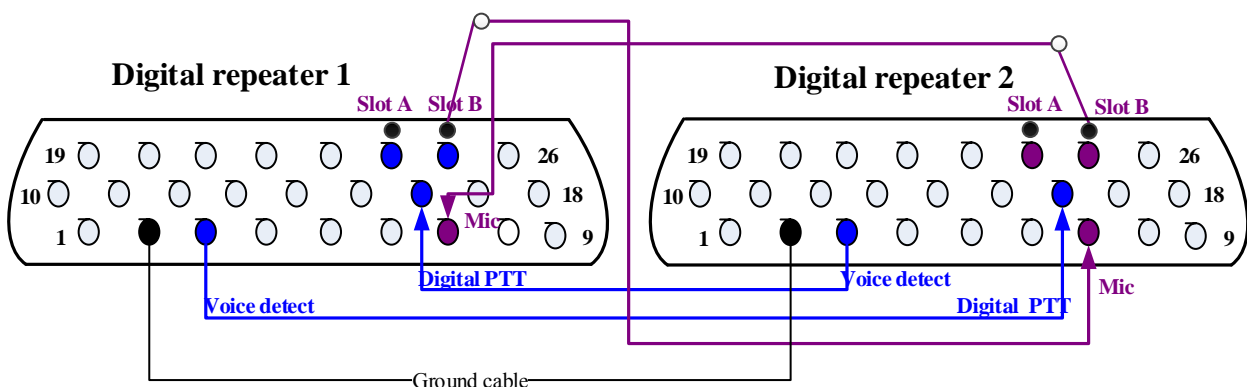
- Connects the Pin 8 of the analog repeater 1 to the Pin 7 of the analog repeater 2.
- Connects the Pin 8 of the analog repeater 2 to the Pin 7 of the analog repeater 1.

For the analog repeater RD98XS, connect the Pin 24 to the Pin 7 of the analog repeater.

### Digital repeater and digital repeater

You can connect the two digital repeaters according to the following figure.

Both Pin 3 and Pin 16 are programmable ports. Pin 3 can be replaced by Pin 12, Pin 20, and Pin 22. Pin 16 can be replaced by Pin 12, Pin 20, Pin 22, and Pin 23.



- **Ground cable**

Connects the Pin 2 of the digital repeater 1 to the Pin 2 of the digital repeater 2.

- **Activation of repeater transmission**

- Connects the Pin 3 of the digital repeater 1 to the Pin 16 of the digital repeater 2.
- Connects the Pin 3 of the digital repeater 2 to the Pin 16 of the digital repeater 1.

- **Audio signal output**

- Connects the Pin 24 or Pin 25 of the digital repeater 1 to the Pin 7 of the digital repeater 2.
- Connects the Pin 24 or Pin 25 of the digital repeater 2 to the Pin 7 of the digital repeater 1.

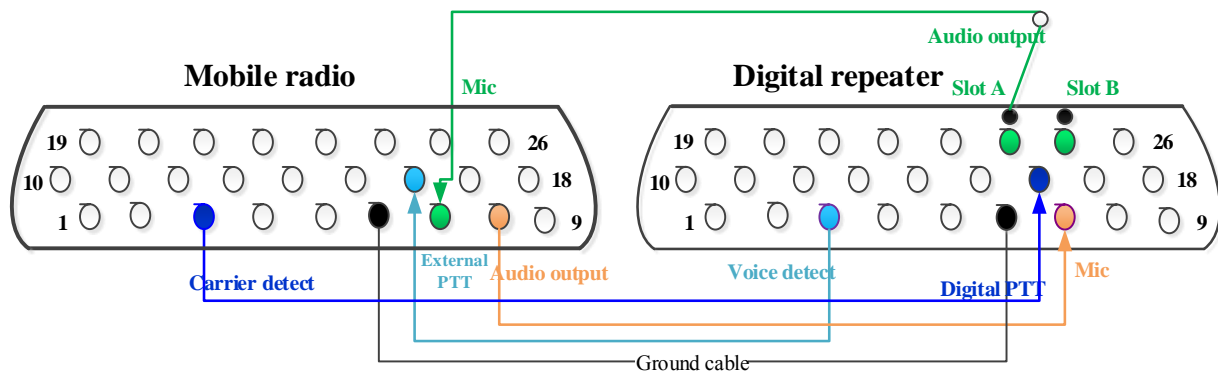
## 3.2 Connecting the repeater and mobile radio

### Digital repeater and mobile radio

You can connect either the analog mobile radio or digital mobile radio to the digital repeater according to the following figure.

Both Pin 3 and Pin 16 on the digital repeater radio are programmable ports. Pin 3 can be replaced by Pin 12, Pin 20, and Pin 22. Pin 16 can be replaced by Pin 12, Pin 20, Pin 22, and Pin 23.

Both Pin 3 and Pin 16 on the mobile radio are programmable ports. They can be replaced by Pin 12, Pin 20, Pin 22, and Pin 23.



- **Ground cable**

Connects the Pin 6 of the digital repeater to the Pin 6 of the mobile radio.

- **Activation of digital repeater transmission**

Connects the Pin 3 of the mobile radio to the Pin 16 of the digital repeater.

- **Audio signal output of mobile radio**

Connects the Pin 8 of the mobile radio to the Pin 7 of the digital repeater.

- **Activation of mobile radio transmission**

Connects the Pin 3 of the digital repeater to the Pin 16 of the mobile radio.

- **Audio signal output of digital repeater**

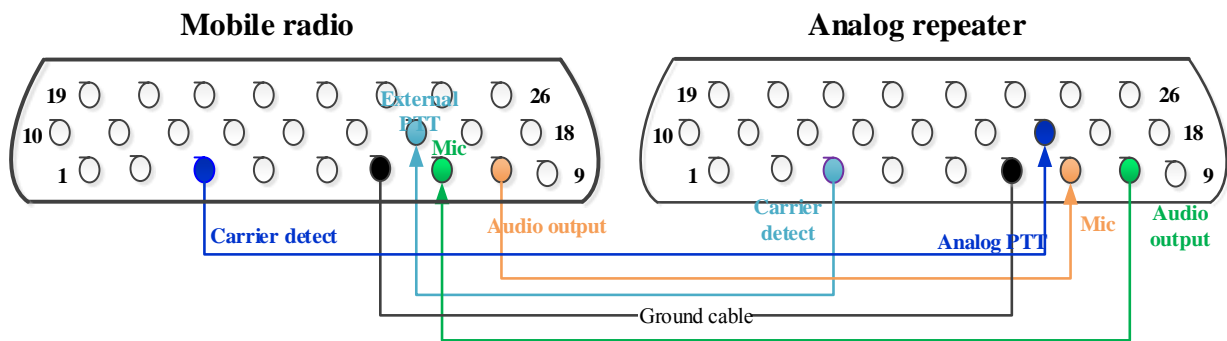
Connects the Pin 24 or Pin 25 of the digital repeater to the Pin 7 of the mobile radio.

### Analog repeater and mobile radio

You can connect either the analog mobile radio or digital mobile radio to the analog repeater according to the following figure.

Both Pin 3 and Pin 16 on the analog repeater are programmable ports. Pin 3 can be replaced by Pin 12, Pin 20, and Pin 22. Pin 16 can be replaced by Pin 12, Pin 20, Pin 22, and Pin 23.

Both Pin 3 and Pin 16 on the mobile radio are programmable ports. They can be replaced by Pin 12, Pin 20, Pin 22, and Pin 23.



- **Ground cable**

Connects the Pin 6 of the analog repeater to the Pin 6 of the mobile radio.

- **Activation of analog repeater transmission**

Connects the Pin 3 of the mobile radio to the Pin 16 of the analog repeater.

- **Audio signal output of mobile radio**

Connects the Pin 8 of the mobile radio to the Pin 7 of the analog repeater.

- **Activation of mobile radio transmission**

Connects the Pin 3 of the analog repeater to the Pin 16 of the mobile radio.

- **Activation of analog repeater transmission**

- For the analog repeater RD98XS: connects the Pin 24 to Pin 7 of the mobile radio
- For other analog repeaters: connects Pin 8 to Pin 7 of the mobile radio.

## 4. Configuration

This chapter describes how to configure the Pin port and other parameters of the digital and analog channel through the customer programming software (CPS).

### 4.1 Tools

- CPS V3.0 or later: applicable to back-to-back via the two repeaters.
- CPS V9.0 (9.00.07.712.iM or later): applicable to back-to-back via the mobile radio and repeater.

### 4.2 Back-to-back via the repeaters

The section describes how to configure the repeaters through the CPS.

#### For an analog repeater

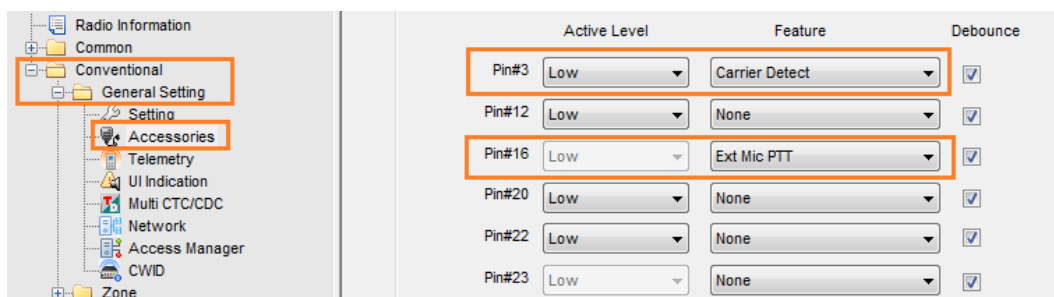
**Step 1** Open the CPS and read the existing configuration data from the analog repeater.

**Step 2** Go to "Conventional > General Setting > Accessories".

**Step 3** In the "GPIO Pins" box, set Pin 3 and Pin 16.

- Pin 3: If the repeater repeats the voice with CTCSS or CDCSS signaling, you must select "CTCSS/CDCSS Detect" from the "Feature" drop-down list. Otherwise, select "Carrier Detect" from the "Feature" drop-down list.
- Pin 16: select "Ext Mic PTT" from the "Feature" drop-down list

For details, refer to the CPS Help.



**Step 4** In the "Priority control" box, set "Path Priority" to "PTT Request", and set "PTT Priority" to "External PTT".

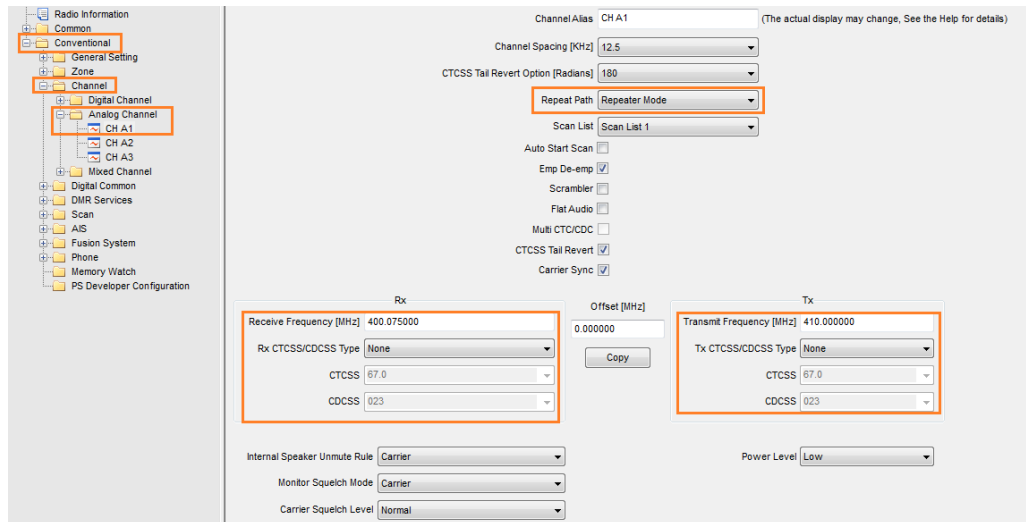


**Step 5** Go to "Conventional > Channel > Analog Channel".

**Step 6** Select the analog channel, set "Repeat Path" to "Repeater Mode", and set other parameters.

For details, refer to the CPS Help.

The parameters in "Rx" and "Tx" box can specify the conditions for receiving and transmitting.



#### Note

Do not select "Flat Audio". Otherwise, the audio signal will be interrupted during repeating.

### For a digital repeater

**Step 1** Go to "Conventional > General Setting > Accessories".

**Step 2** In the "GPIO Pins" box, set "Slot1 Audio Output" and "Slot2 Audio Output".

For details, refer to the CPS Help.

- To output the audio signal from Pin 24, select "Slot1 Audio Output".
- To output the audio signal from Pin 25, select "Slot2 Audio Output".

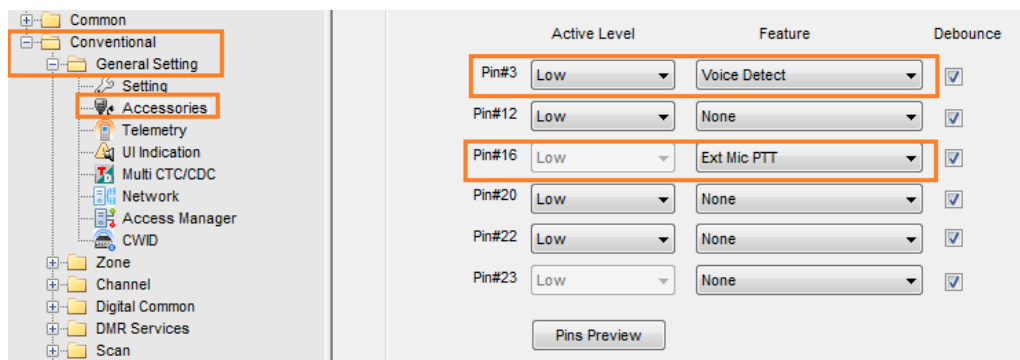


#### Note

The digital repeater can use only one Pin to output audio signal. If you select "Slot1 Audio Output" and "Slot1 Audio Output" at the same time, only the Pin (e.g. Pin 24 or Pin 25) connected to Pin 7 on the mobile radio can output audio signal.

**Step 3** In the "GPIO Pins" box, select "Voice Detect" from the "Feature" drop-down list for Pin#3, and select "Ext Mic PTT" from the "Feature" drop-down list for Pin#16.

For details, refer to the CPS Help.

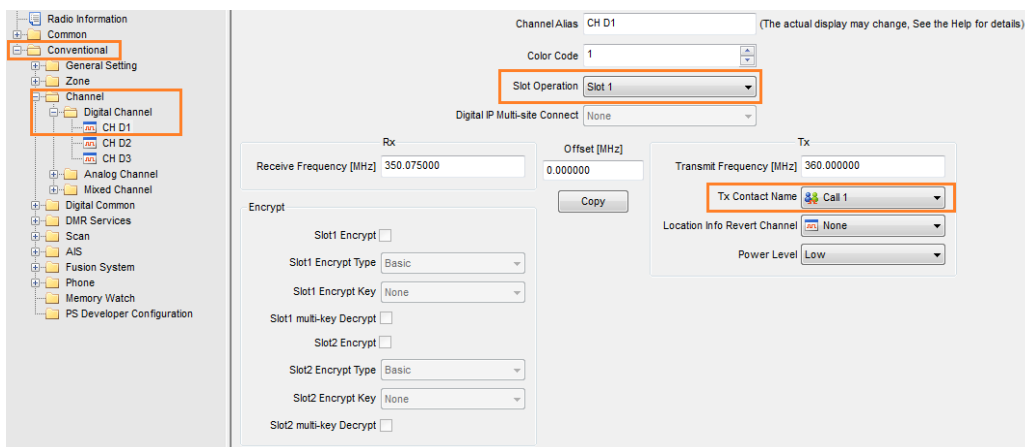


**Step 4** Go to "Conventional > Channel > Digital Channel".

**Step 5** Select the digital channel on which the digital repeater works, and set "Slot Operation" and other parameters in "Rx" and "Tx" box.

For details, refer to the CPS Help.

- To output the audio signal from Pin 24, set "Slot Operation" to "Slot 1".
- To output the audio signal from Pin 25, set "Slot Operation" to "Slot 2".



#### Note

The "Tx Contact Name" in the "Tx" box can be a group call contact or an all call contact. This contact will be used for repeater reception and transmission.

## 4.3 Back-to-back via the mobile radio and repeater

This section describes how to configure the mobile radio and repeater through the CPS.

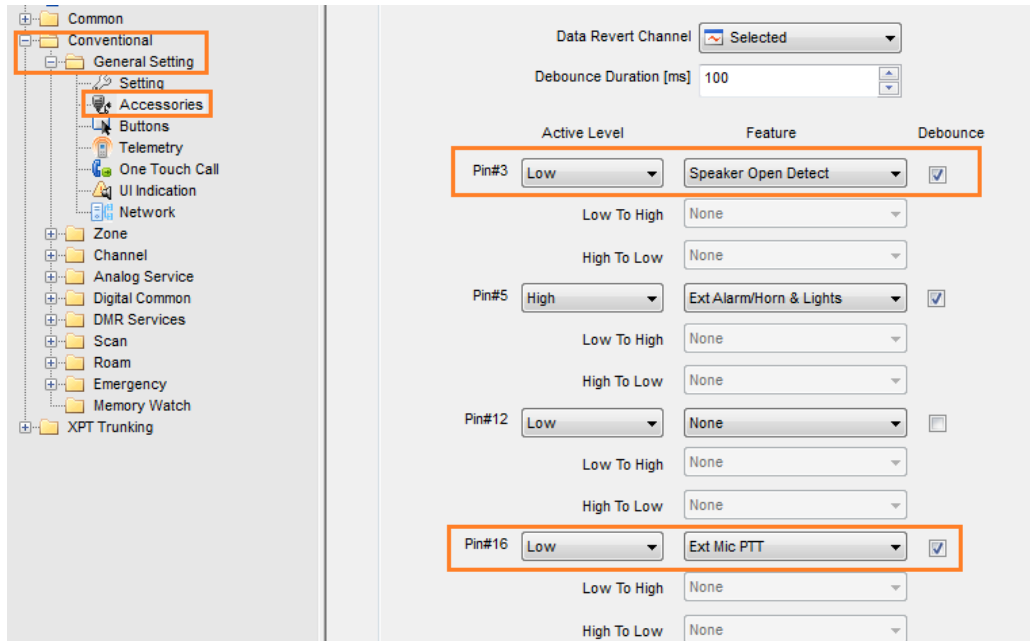
### For repeaters

- For details about configuring an analog repeater, see [For an analog repeater](#).
- For details about configuring a digital repeater, see [For a digital repeater](#).

### For an analog mobile radio

- Step 1** Go to "Conventional > General Setting > Accessories". In the "GPIO Pins" box, select "Speaker Open Detect" from the "Feature" drop-down list for "Pin#3", and select "Ext Mic PTT" from the "Feature" drop-down list for "Pin#16".

For details, refer to the CPS Help.

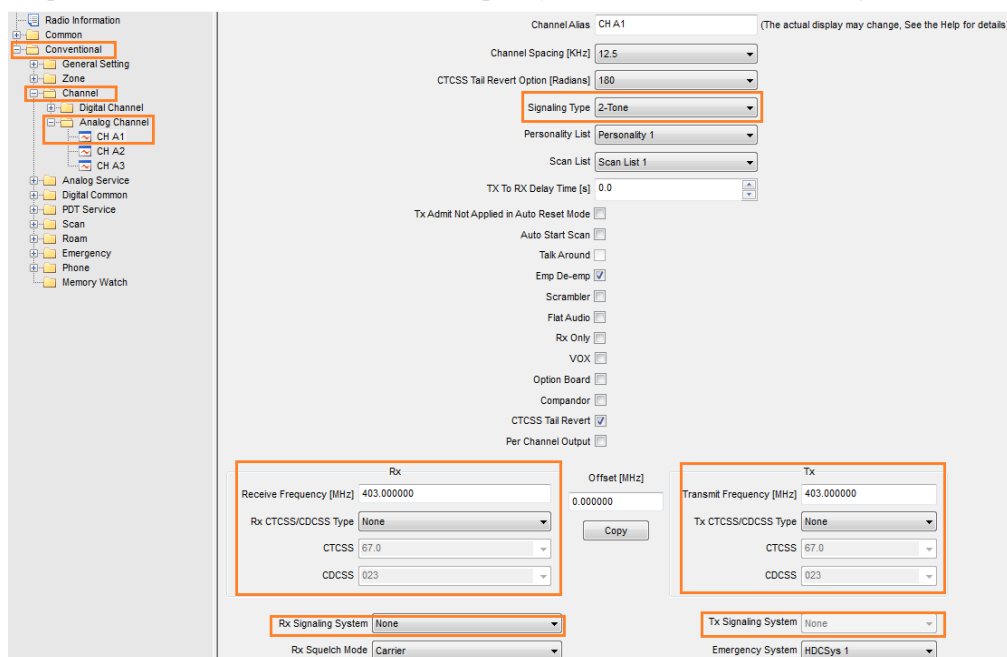


- Step 2** Go to "Conventional > Channel > Analog Channel".

- Step 3** Select the analog channel on which the analog mobile radio works, and set the signaling type and other parameters.

For details, refer to the CPS Help.

The parameters in "Rx" and "Tx" box can specify the conditions for receiving and transmitting.



### For a digital mobile radio

**Step 1** Select "Speaker Open Detect" from the "Feature" drop-down list for "Pin#3".

For details, see Step 1.

**Step 2** Go to "Conventional > Channel > Digital Channel".

**Step 3** Select the digital channel on which the digital mobile radio works, and set other parameters.

For details, refer to the CPS Help.

The "Rx Group List" defines the groups that can be responded (not required for private call and all call), and the "Tx Contact Name" defines the destination address.

Radio Information  
Common  
Conventional  
General Setting  
Zone  
Channel  
Digital Channel  
CH D1  
CH D2  
CH D3  
Analog Channel  
Analog Service  
Digital Common  
PDT Service  
Scan  
Roam  
Emergency  
Phone  
Memory Watch

Channel Alias: CH D1 (The actual display may change, See the Help for details)  
Color Code: 1  
Slot Operation: Pseudo Trunk  
Pseudo Trunk Designated TX: None  
Scan List/Roam List: Scan List 1  
Auto Start Scan: ☐  
Talk Around: ☐  
Rx Only: ☐  
IP Multi-site Connect: ☐  
Auto Start Roam: ☐  
VOX: ☐  
Option Board: ☐  
Priority Interrupt Encode: ☐  
Priority Interrupt Decode: ☐  
Reliable Priority Interrupt Transmit: ☐  
Enhanced Channel Access: ☐  
Per Channel Output: ☐  
Over the Air Encrypt Type: None  
Only Receive Encrypt Air: ☐  
Over the Air Encrypt Key: None

Rx  
Receive Frequency [MHz]: 403.000000  
Rx Group List: Rx Group List 1  
Emergency Alarm Indication: ☐  
Emergency Alarm Ack: ☐  
Emergency Call Indication: ☐  
Encrypt: ☐

Offset [MHz]: 0.000000  
Copy

Tx  
Transmit Frequency [MHz]: 403.000000  
Tx Contact Name: Call 1  
RRS Revert Channel: None  
Emergency System: DigitalSys 1  
Phone System: None  
Power Level: Low

## 5. Application Scenarios

This chapter describes how the back-to-back feature realizes cross-band communication among analog and digital repeater.

In addition, the Back-to-Back feature (via repeater and mobile radio) can work with IP Multi-site Connect feature to further expand the communication range.

### 5.1 Analog-digital Communication

This section takes communication between the analog portable radios and digital portable radios through the back-to-back feature for example.

#### Analog repeater and digital repeater

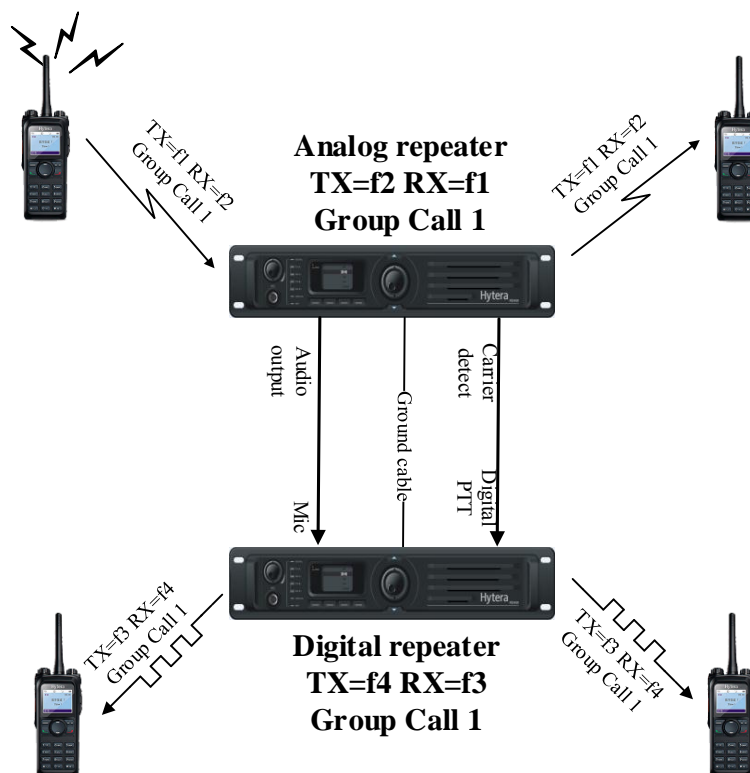
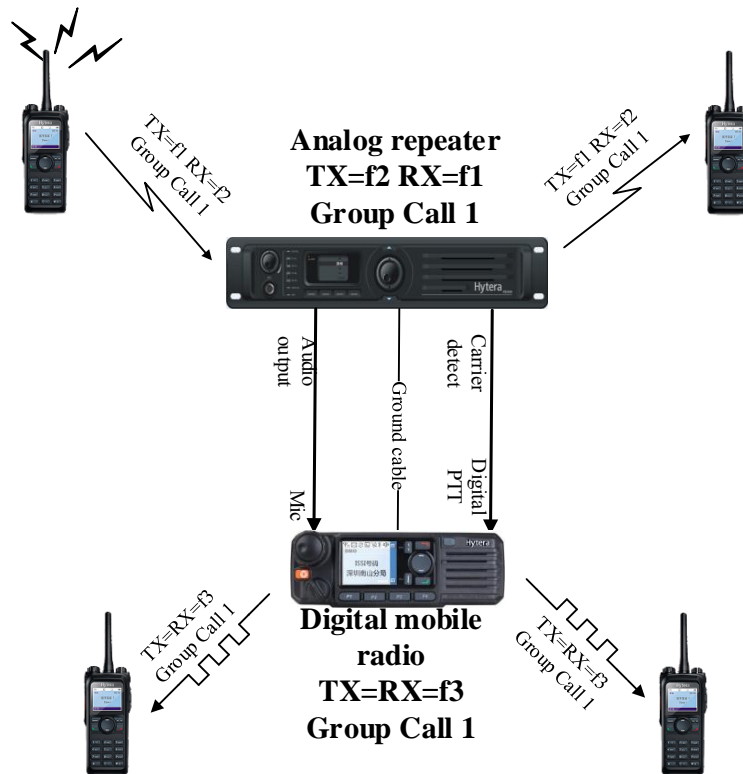


Figure 5.1-1 Analog-Digital Communication 1

**Analog repeater and digital mobile radio****Figure 5.1-2 Analog-Digital Communication 2**

## 5.2 Digital-digital Communication

### Digital repeater and digital repeater

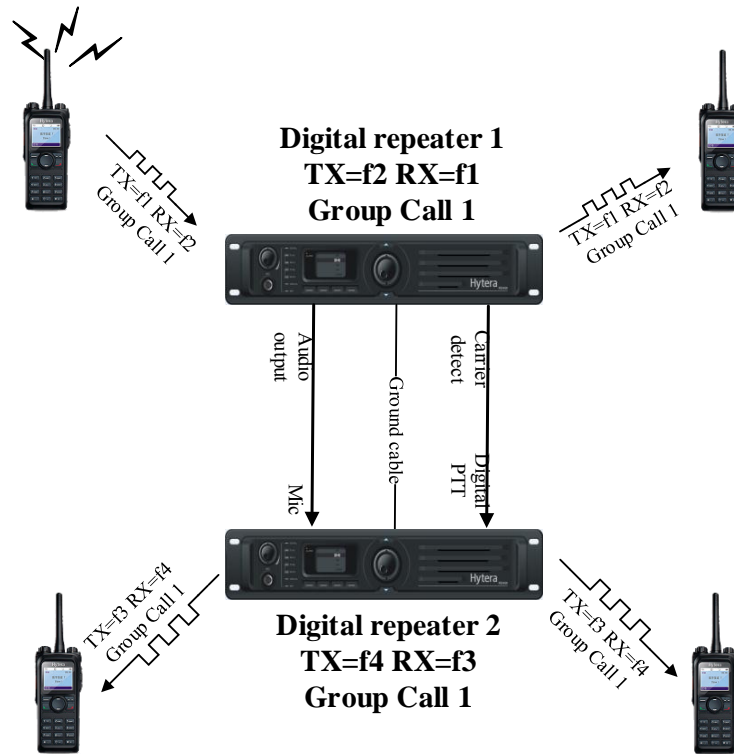
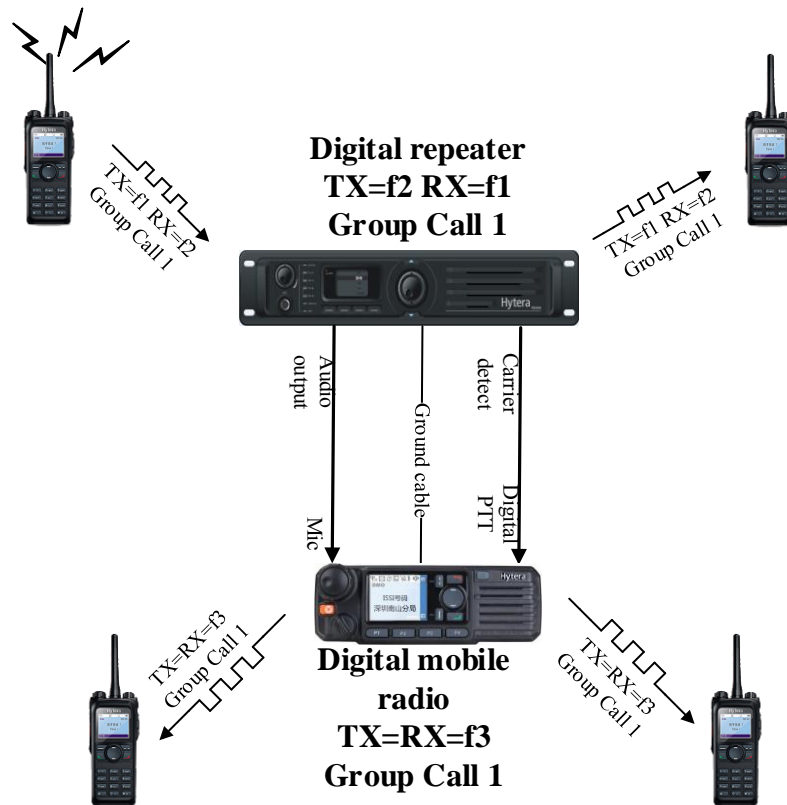


Figure 5.2-1 Digital-digital Communication 1

**Digital repeater and digital mobile radio****Figure 5.2-2 Digital-digital Communication 2**

## 5.3 Analog-analog communication

### Analog repeater and analog repeater

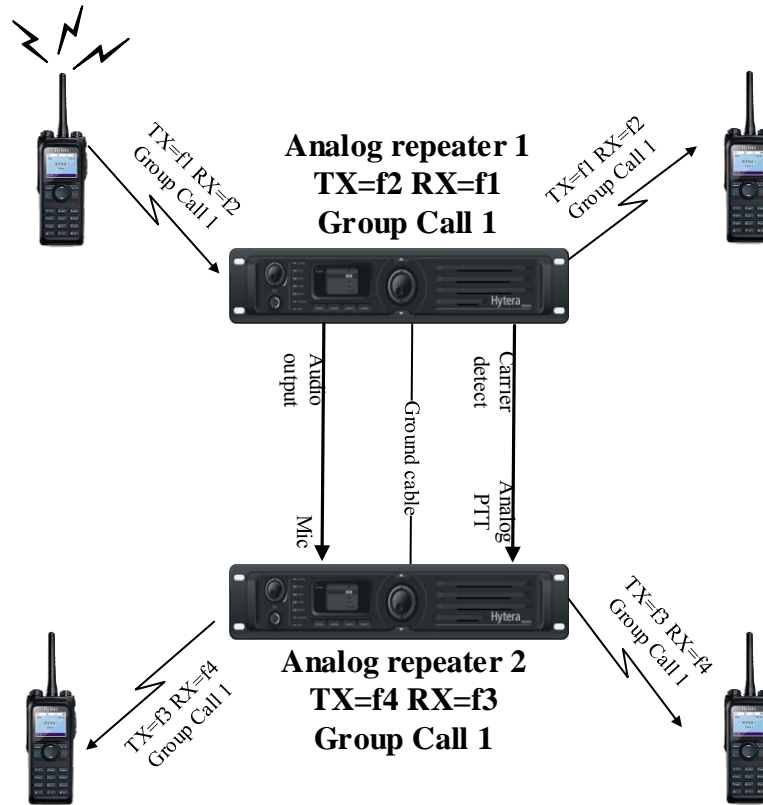


Figure 5.3-1 Analog-Analog Communication 1

### Analog repeater and analog mobile radio

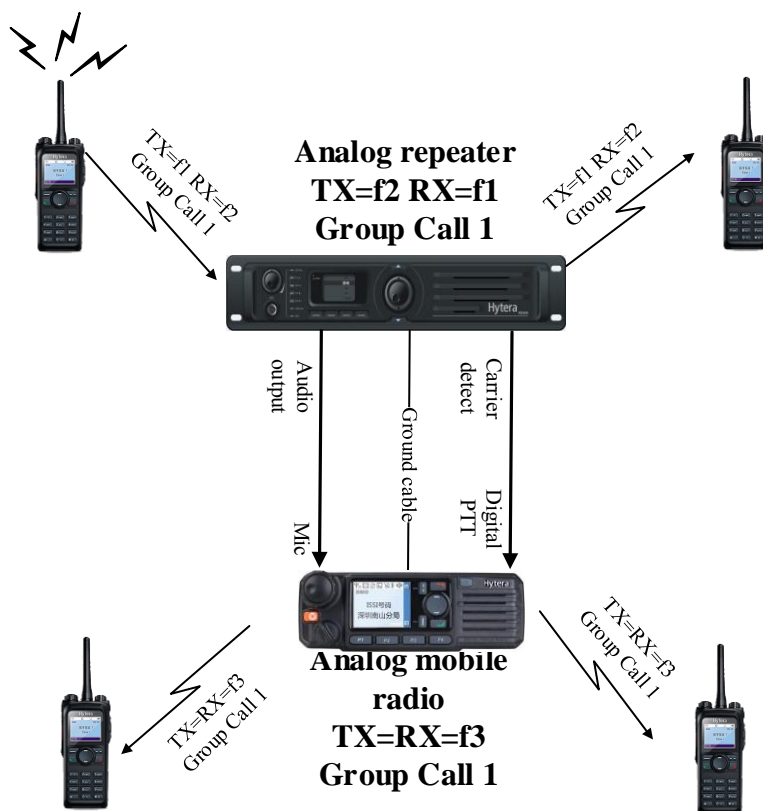


Figure 5.3-2 Analog-Analog Communication 2

## **6. FAQ**

### **6.1 How many repeaters and mobile radios can be connected in the back-to-back way?**

Only two repeaters or one repeater and one mobile radio. This ensures an optimal performance.

### **6.2 Can the repeater use the same frequency to realize A/D communication?**

No. It is recommended to use different frequencies to avoid signal interference.

### **6.3 Is there any suggestion for configuring the frequency?**

To ensure better communication, it is suggested to maintain the frequency space at 100 kHz or more.

### **6.4 Is there any requirement on the bandwidth?**

The bandwidths of two repeaters can be different. For example, the bandwidth of a digital repeater is 12.5 kHz and the bandwidth of an analog repeater is 12.5 kHz, 20 kHz, or 25 kHz. The bandwidth difference does not affect the back-to-back performance.

### **6.5 How long is the accessory pin cable?**

One meter at most.

### **6.6 Why does the prompt “Service rejected” appear frequently when the radio is transmitting?**

The reason is that the mobile radio or repeater is transmitting through the external Mic PTT. However, the mobile radio or repeater will not receive such prompt if the option “Tx Admit” is set to “Always Allow”. Therefore, it is recommended to set the option “Tx Admit” to “Channel Free”. In this case, the mobile radio will alert “Channel Busy!” instead when transmitting through the external Mic PTT.

### **6.7 How to deal with back-to-back function failure?**

To solve the back-to-back failure, do as follows:

1. Check whether the accessory pin cable is connected properly;
2. If the cable gets loose, reconnect it;
3. Restart the repeater or mobile radio;
4. If the above steps do not help, please contact your dealer.



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