a sound relationship
Russound

IPK-1

Single Gang IP Keypad

Software Functional Specification

Version 1.15

3/31/2021

Version History

Version	Author	Revision Date	Reason
1.0	Ed H	8/14/2020	Initial Draft
1.1	Ed H	8/18/2020	Internal Review
1.2	Ed H	8/19/2020	• For MBX-Series the Power button should result in a play status of STOPPED. • Added All Off on press and hold of the Power button
1.3	Ed H	8/21/2020	• Added Hold and Release section • Added Key Press Acknowledge section • Added note to Status LED Table for normal operation
1.4	Ed H	8/26/2020	• Added details on using private RIO WATCH for ledStatus. • Reference changed to RIO 1.16.00
1.5	Ed H	10/23/2020	• Changed Pairing packet port from 9800 to 9750 to avoid conflict with WebDAV • Changed RIO Client Service (_rioclient) to Russound Pairing Service (_russound-pairing) • Added several attributes to Russound Pairing Service TXT record • Removed GET command from Russound Pairing Service
1.6	Ed H	10/27/2020	• Added table for volume LEDs • Modified rules for illuminating volume LEDs • Specified how volume notifications are received by IPK-1 • Modified event for Power button
1.7	Ed H	12/7/2020	• Modified key-combo event key code to use ampersand instead of comma.
1.8	Ed H	12/18/2020	• Added a section on persistence
1.9	Ed H	12/21/2020	• Added a section on connectivity and updated the flowchart
1.10	Ed H	1/28/2021	• Added Test Plan with results for version 1.00.03.00001
1.11	Ed H	2/2/2021	• Added Product ID Table • Added several test cases to Test Plan base on requirements in spec.
1.12	Ed H	3/3/2021	• Added more details on Russound Pairing Service command support.
1.13	Ed H	3/15/2021	• Moved Test Plan to its own document • Added detail to 'Device Fault' in Status LED Table
1.14	Ed H	3/24/2021	• *Power* button no longer referred to as *Zone Off* • Changed "Not Paired" LED status to blinking yellow (2Hz)
1.15	Ed H	3/31/2021	• Added DHCP requirements to Connectivity section • Made the LED flash interval for Device Fault consistent with the requirement for ledStatus JSON (3 seconds).

Table of Contents

Overview

The IPK-1 keypad has 10 buttons specifically mapped to common user controls for easy operation of Russound MCA-Series and MBX-Series devices. The keypad requires POE and operates on the same LAN as the other Russound gear. A simple pairing sequence assigns the keypad to a specific zone, and an embedded client service allows for a single point of maintenance for all IPK-1 keypads on the network.

User Interface

RIO protocol will be used to execute the commands required to operate the IPK-1 keypad. The protocol also gives the UI the ability to monitor the status of the paired zone. The UI does not need to keep state since it receives status through the protocol using the private WATCH command:

WATCH C[c].Z[z]~ ON

Parameters required to connect to the paired zone are acquired using a pairing process detailed within this document.

The 10 button keypad has a Status LED that is driven by the status of the paired zone. There are also 7 LEDs used to display the current volume level.

Status LED

- See the Status LED Table for requirements.
- In certain circumstances the state of the Status LED will be driven by local system events such as booting, firmware update and factory reset.
- For normal operation, the Status LED will be driven by parameters received from the device.
    - Use the following private RIO WATCH to monitor LED status for normal operation:

      WATCH C[c].Z[z]~ ON

    - The IPK-1 will parse the JSON string returned in ledStatus.
        - "color" : ["none", "red", "green", "yellow", "blue", "violet", "cyan", "white"]
        - "blinkRate" : [0, 1, 2, 3, 4] – Integer values are in Hz – blinks per second.
        - "flashCount" : [0 – *n*] – Integer values – flash *n* times at blinkRate every 3 sec.
    - Example JSON
        - LED off: "{"color":"none","blinkRate":0,"flashCount":0}"
        - LED green: "{"color":"green","blinkRate":0,"flashCount":0}"
        - LED green and blinking 1Hz: "{"color":"green","blinkRate":1,"flashCount":0}"

- MCA-Series - The Status LED follows zone status. IPK-1 will parse JSON string for attributes.
    - The LED should be off when the the zone is OFF.
    - The LED should be green when the zone is ON.
- MBX-Series - IPK-1 will parse JSON string for attributes.
    - The LED should be on when audio is "playing".
    - The LED should blink when audio is "paused".
    - The LED should be off when audio is "stopped".
    - The LED should be blue when Bluetooth is selected.
    - The LED should be cyan when the Digital Input is selected.
    - The LED color should be violet when the device is grouped.
    - Otherwise the LED color should be green.

Zone Favorites [1-4]

- Buttons 1 through 4 are pressed to restore a previously saved zone favorite. The following RIO command should be sent to restore a zone favorite, where n = 1 - 4:
    - EVENT C[*c*].Z[*z*]!RestoreZoneFavorite *n*
- Press and hold a Zone Favorite button for 1.5 seconds to save the current selection as a favorite. This is valid only when zone is ON and play status is not STOPPED. The following RIO command should be sent to save a zone favorite, where n = 1 – 4:
    - EVENT C[*c*].Z[*z*]!SaveZoneFavorite "Favorite *n*" *n*

Previous/Next

- The following RIO command should be sent when the Previous button is pressed:
    - EVENT C[*c*].Z[*z*]!KeyRelease Previous
- The following RIO command should be sent when the Next button is pressed:
    - EVENT C[*c*].Z[*z*]!KeyRelease Next

Volume Up/Down

- RIO command: EVENT C[*c*].Z[*z*]!KeyPress VolumeUp
- RIO command: EVENT C[*c*].Z[*z*]!KeyPress VolumeDown

Volume LED Indicator

- Volume LEDs should illuminate linearly over full volume range [0-50].

	Volume Range							
LED	0	1-8	9-16	17-24	25-32	33-40	41-48	49-50
7	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON
6	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON
5	OFF	OFF	OFF	OFF	OFF	ON	ON	ON
4	OFF	OFF	OFF	OFF	ON	ON	ON	ON
3	OFF	OFF	OFF	ON	ON	ON	ON	ON
2	OFF	OFF	ON	ON	ON	ON	ON	ON
1	OFF	ON	ON	ON	ON	ON	ON	ON

- Volume LEDs should turn on and indicate the current volume after any button press.
- Volume LEDs should illuminate for 20 seconds following any event that turns them on.

- Volume LEDs should turn off when the Status LED color transitions from any color to “none”.
- Volume LEDs should turn on when the Status LED color transitions from “none” to any color.
- Use the private RIO WATCH to monitor changes in volume (example uses c=1 and z=1):

  WATCH C[1].Z[1]~ ON

  N C[1].Z[1].volume=”10”

Play/Pause Toggle

- RIO command: EVENT C[*c*].Z[*z*]!KeyRelease Pause
- Note: Pause command acts like a Play/Pause toggle.

Power

- RIO command: EVENT C[*c*].Z[*z*]!KeyRelease Power
- Note: On MCA-Series the Power command is an On/Off toggle. On MBX-Series it acts like Stop.
- Press and hold for 1.5 seconds to turn all zones off. RIO command: EVENT C[*c*].Z[*z*]!AllOff

Hold and Release Support

Single Key

There are several key hold features that the IPK-1 will support locally:

- Zone Favorites – Press and hold saves whatever is currently playing as a zone favorite.
- Power – Press and hold sends the AllOff event.
- Volume(+) – Press and hold sends the KeyPress VolumeUp every 150msec
- Volume(-) – Press and hold sends the KeyPress VolumeDown every 150msec

For other instances of a single key hold, the IPK-1 should send the KeyHold event once every 150msec for as long as the button is held with the respective hold-time parameter. When the button is released, a KeyRelease event must be sent to complete the hold operation. This applies to the following keys:

- Pause
- Previous
- Next

Example for Next key hold (c=1, z=1)

<user presses key>
<150msec time delay>
EVENT C[1].Z[1]!KeyHold Next 150
<150msec time delay>
EVENT C[1].Z[1]!KeyHold Next 300
<150msec time delay>
EVENT C[1].Z[1]!KeyHold Next 450
<150msec time delay>
EVENT C[1].Z[1]!KeyHold Next 600
<150msec time delay>
EVENT C[1].Z[1]!KeyHold Next 750
<150msec time delay>
EVENT C[1].Z[1]!KeyHold Next 900

<150msec time delay>
EVENT C[1].Z[1]!KeyHold Next 1050
<user releases key>
EVENT C[1].Z[1]!KeyRelease Next

Key Combination

There are several combination key hold features that the IPK-1 will support locally:

- Pairing: Press and hold *Favorite 1* and *Favorite 2* together for 2 seconds.
- Check for Firmware Update: Press and hold *Previous* and *Next* for 5 seconds.
- Reboot: Press and hold *Volume (-)* and *Power* for 5 seconds.

For the key hold combinations listed below, the IPK-1 should send the KeyHold event once every 150msec for as long as the button is held with the respective hold-time parameter. When the buttons are released, a KeyRelease event must be sent to complete the hold operation. This applies to the following key combinations (event key code):

- Favorites 1 and 3 (Favorite1&Favorite3)
- Favorites 1 and 4 (Favorite1&Favorite4)
- Favorites 2 and 3 (Favorite2&Favorite3)
- Favorites 2 and 4 (Favorite2&Favorite4)
- Favorites 3 and 4 (Favorite3&Favorite4)

Example for a Favorite 3 and Favorite 4 combination key hold (c=1, z=1)

<user presses key>
<150msec time delay>
EVENT C[1].Z[1]!KeyHold Favorite3&Favorite4 150
<150msec time delay>
EVENT C[1].Z[1]!KeyHold Favorite3&Favorite4 300
<150msec time delay>
EVENT C[1].Z[1]!KeyHold Favorite3&Favorite4 450
<150msec time delay>
EVENT C[1].Z[1]!KeyHold Favorite3&Favorite4 600
<150msec time delay>
EVENT C[1].Z[1]!KeyHold Favorite3&Favorite4 750
<150msec time delay>
EVENT C[1].Z[1]!KeyHold Favorite3&Favorite4 900
<150msec time delay>
EVENT C[1].Z[1]!KeyHold Favorite3&Favorite4 1050
<user releases key>
EVENT C[1].Z[1]!KeyRelease Favorite3&Favorite4

Key Press Acknowledge

- Any key press should be acknowledged by turning the Status LED off for 125msec when the Status LED is on, or turning the Status LED on for 125sec when it is off.
- When pressing and holding a Zone Favorite button to save a favorite the Status LED should acknowledge the hold was detected by Flashing the LED one time (see Status LED Table)

  ON -> [HOLD] -> OFF[500m] ON[250m] OFF[500m] -> ON

Pairing – Zone Assignment

A simple method for pairing the keypad to a specific zone is desired. An installer will simply initiate pairing from the MCA-Series or MBX-Series web page then complete the pairing by pressing and holding favorite buttons 1 and 2 together for 2 seconds.

The IPK-1 will be configured with the MCA-Series or MBX-Series hostname, protocol name and controller/zone assignment. Hostname is used instead of IP address since DHCP reservations or static Ips may not used.

The IPK-1 will rely on the results of an MDNS query for the RIO service (_rio._tcp.local) to obtain the device IP address and port number required to establish a RIO connection. The keypad should send out MDNS queries continuously according to the service record's TTL (see RFC-6762) and maintain a table of hosts that support RIO. This table will be required to resolve the IP address and port number when paired.

- MDNS Query from IPK-1
    - Pointer record
        - Name: _rio._tcp.local
        - Type: PTR (Domain name pointer)
        - "QU" question: False (request multicast response "QM")
- Example MDNS Answer from MBX-AMP
    - Pointer record
        - Name: _rio._tcp.local
        - Type: PTR (Domain name pointer)
        - Domain Name: MBX-AMP-9434 RIO 0._rio._tcp.local
    - Text record
        - Name: MBX-AMP-9434 RIO 0._rio._tcp.local
        - Type: TXT (Text strings)
        - **hostname=MBX-AMP-9434**
        - localName=Office Speaker
        - **productId=89**
        - productType=2
        - version=01.05.03.96179
    - Service record
        - Service: MBX-AMP-9434 RIO 0
        - Protocol: _rio
        - Name: _tcp.local
        - Type: SRV (Service location)
        - Cache flush: True
        - TTL: 2 minutes
        - **Port: 9621**
    - Address record
        - Name: MBX-AMP-9434.local
        - Type: A (Host address)
        - **Addr: 192.168.1.139**
- Pairing Packet from MBX-Series or MCA-Series

  - **Broadcast packet – UDP port 9750**
  - Three keypad pairing broadcast packets are transmitted one second apart
  - IPK-1 will always listen on UPD port 9750 for the pairing packets
  - Each packet identifies the protocol, device hostname, controller number and zone number (JSON or KVP). Each packet will also have a packet number.

Key-Value Pair	*JSON*
p=_rio._tcp.local h=MBX-AMP-9434 c=1 z=1 n=[1-3]	{ “protocol” : “_rio._tcp.local”, “host” : “MBX-AMP-9434”, “controller” : “1”, “zone” : “1”, “number” : [1-3] }

  - IPK-1 will always use the last pairing information it has when the pairing is acknowledged with the key combination (last in wins).
- An installer will navigate to the controller web configuration and select *Keypad Pairing* from either the MCA-Series Zone Setup page or the MBX-Series Setup page.
- All IPK-1 keypads will enter the pairing mode for up to 60 seconds when a pairing packet is received.
- The Status LED will blink green at 2Hz while in pairing mode.
- **Key-Combo**: Pairing is completed by pressing and holding favorite buttons 1 and 2 on the keypad for 2 seconds within the 60 second pairing window.
  - The keypad looks up the hostname in the RIO service hosts table and uses the device IP address and port to open a RIO connection.
  - The keypad also determines the product id from the RIO TXT record (productId)

Russound Device	*Product ID*
MCA-66	81
MCA-88	82
MCA-88X (discontinued)	83
MBX-AMP	89
MBX-PRE	90

  - All commands are directed to the controller number and zone number specified in the pairing packet.
- Any keypress other than the pairing key-combo will result in the keypad exiting out of pairing mode.
- Keypads that are not paired are always in pairing mode.

Factory Reset

- Factory Reset button on back
  - Hold down Factory Reset button for 10 seconds
  - All settings/configuration/data are deleted and device reboots
  - Zone becomes unassigned as a result

Soft Reboot

- **Key-Combo**: Hold *Volume-* and *Power* buttons for 5 seconds
- See EVENT Key Table for the RIO Client *reboot* command

Firmware Update

- Latest firmware will reside on the Russound HTTP server. Requires DNS for server name lookup.
- The keypad will use HTTP GET to download a text file that contains information for the update:
    - Text file: http://updates.russound.com/updates/id_92/current/swupdate.txt
    - File contents:
        - version: Firmware version available
        - url: URL to firmware file (HTTP GET)
        - forcedUpdate: Forced update flag (true or false)
- Check for update
    - **Key-Combo**: Hold *Previous* and *Next* buttons for 5 seconds
    - See EVENT Key Table for the RIO Client *firmwareUpdate* command
    - If available version is greater than the running version then perform the update
- Forced update
    - Keypad must regularly check if a forced update is required
    - Check is done every 24 hours of runtime.
- Active and inactive partitions
    - The keypad must handle loss of power during firmware update.
        - New firmware is written to an inactive partition
        - After a successful download, the inactive partition becomes the active partition
        - Boot loader always boots from the active partition
- Manufacturer/Service level firmware load
    - The onboard interface used for initial firmware load should be made accessible from the back or side panel of the keypad.
    - This would preferably be micro-USB (USB update).
- Debug
    - The Manufacturer/Service level firmware load is the only way to load firmware for debug.
- Back Rev
    - The Manufacturer/Service level firmware load is the only way to back rev firmware.

Hostname

The IPK-1 will advertise a hostname in the following format:

IPK1-XXXXXX

Where XXXXXX are the last 6 digits of the MAC address

Status LED Table

Condition	LED Color	LED Pattern
Booting	Yellow	Solid
Network Error (no link, no IP)	Yellow	Blink 1Hz – Steady
Factory Reset	Red	Blink 2Hz – 4 times then Booting color
Pairing Mode	Green	Blink 2Hz – While mode is active
Not Paired	Yellow	Blink 2Hz
Firmware Update	Green	Blink 4Hz
Device Fault	Red	Flash n: Repeat every 3 seconds as long as condition exists. Example flashCount=3, blinkRate=2Hz • Save LED state • OFF[500m] • ON[250m] [1] • OFF[250m] • ON[250m] [2] • OFF[250m] • ON[250m] [3] • OFF[500m] • Restore LED state
Favorite Saved	Current state	Flash 1: • OFF[500m] • ON[250m] [1] • OFF[500m]
Pairing Accepted	Green	Flash 2: • OFF[500m] • ON[250m] [1] • OFF[250m] • ON[250m] [2] • OFF[500m]
Key press indication	Current state	Off for 125msec when pressed

Normal Operation*			
Product	Status	LED Color	LED Pattern
MCA-Series	Zone Off	Off	
	Zone On	Green	Solid
MBX-Series	Stopped	Off	
	Playing	See MBX Mode	Solid
	Paused	See MBX Mode	Blink 1Hz
MBX Mode	Bluetooth	Blue	
	SPDIF	Cyan	
	Grouped	Violet	
	Standard	Green	

*Use **WATCH C[c].Z[z].~ ON** to observe zone ledStatus. IPK-1 will be given color, blink rate (Hz), and flash count in a JSON string.

Russound Pairing Service

We anticipate that installers will want to check the firmware version of keypads throughout a household and perform firmware updates for a centralized UI. We propose that each IPK-1 advertise itself to have a *Russound Pairing Service* (_russound-pairing._tcp.local) and be able to response to queries for that service.

The Russound Pairing Service will provide details of its configuration and support several case insensitive commands to facilitate easy maintenance.

Advertisement

The IPK-1 will respond to queries for the russound-pairing service. The answer provided by the IPK-1 will provide details of its configuration.

MDNS Query

- MDNS Query from MCA or MBX
    - Destination: 224.0.0.251:5353
    - Pointer record
        - Name: _russound-pairing._tcp.local
        - Type: PTR (Domain name pointer)
        - "QU" question: False (request multicast response "QM")

MDNS Answer

- Example MDNS Answer from IPK-1
    - Destination: 224.0.0.251:5353
    - Pointer record
        - Name: _russound-pairing._tcp.local
        - Type: PTR (Domain name pointer)
        - Domain Name: IPK1-123456 RUSSOUND-PAIRING 0._russound-pairing._tcp.local
    - Text record
        - Name: IPK1-123456 RUSSOUND-PAIRING 0._russound-pairing._tcp.local
        - Type: TXT (Text strings)
        - **hostname=IPK1-123456**
        - productId=92
        - productType=3
        - version=01.00.00.99999
        - pairedHost=none (paired hostname when set. Example: MBX-AMP-9876)
        - pairedCid=0 (paired controller id when set [1-8])
        - pairedZid=0 (paired zone id when set [1-8])
        - pairedProtocol=none (paired protocol when set [RIO])
    - Service record
        - Service: IPK1-123456 RUSSOUND-PAIRING 0
        - Protocol: _russound-pairing
        - Name: _tcp.local
        - Type: SRV (Service location)
        - Cache flush: True
        - **Port: 9629**

- Address record
  - Name: IPK1-123456.local
  - Type: A (Host address)
  - **Addr: 192.168.1.101**

Commands

The IPK-1 will provide a Russound Pairing Service that supports several case-insensitive commands for maintenance. The Russound Pairing Service is accessed by making a raw TCP/IP connection to the IPK-1 on port 9629. The syntax is simply "EVENT [key]" (see EVENT Key Table). All commands must be terminated with <CR> (0x0D hex). All responses are terminated with <CR><LF> (0x0D 0x0A hex). Responses are either "S" for success or "E" for error. The reason for error should be provided as well.

EVENT Key Table

Event Table			
Key	Description	Data 1	Data 2
firmwareUpdate	Check for firmware update	N/A	N/A
reboot	Reboot device	N/A	N/A

Example:

```
EVENT reboot
S

EVENT firmwareUpdate
S
```

Error Handling

The Russound Pairing Service should return an indication of error if a command is not recognized.

Example:

```
EVENT rebot
E InvalidKey
```

Persistence

The IPK-1 will save the pairing configuration and restore it after a reboot or power cycle. The following configuration should be saved:

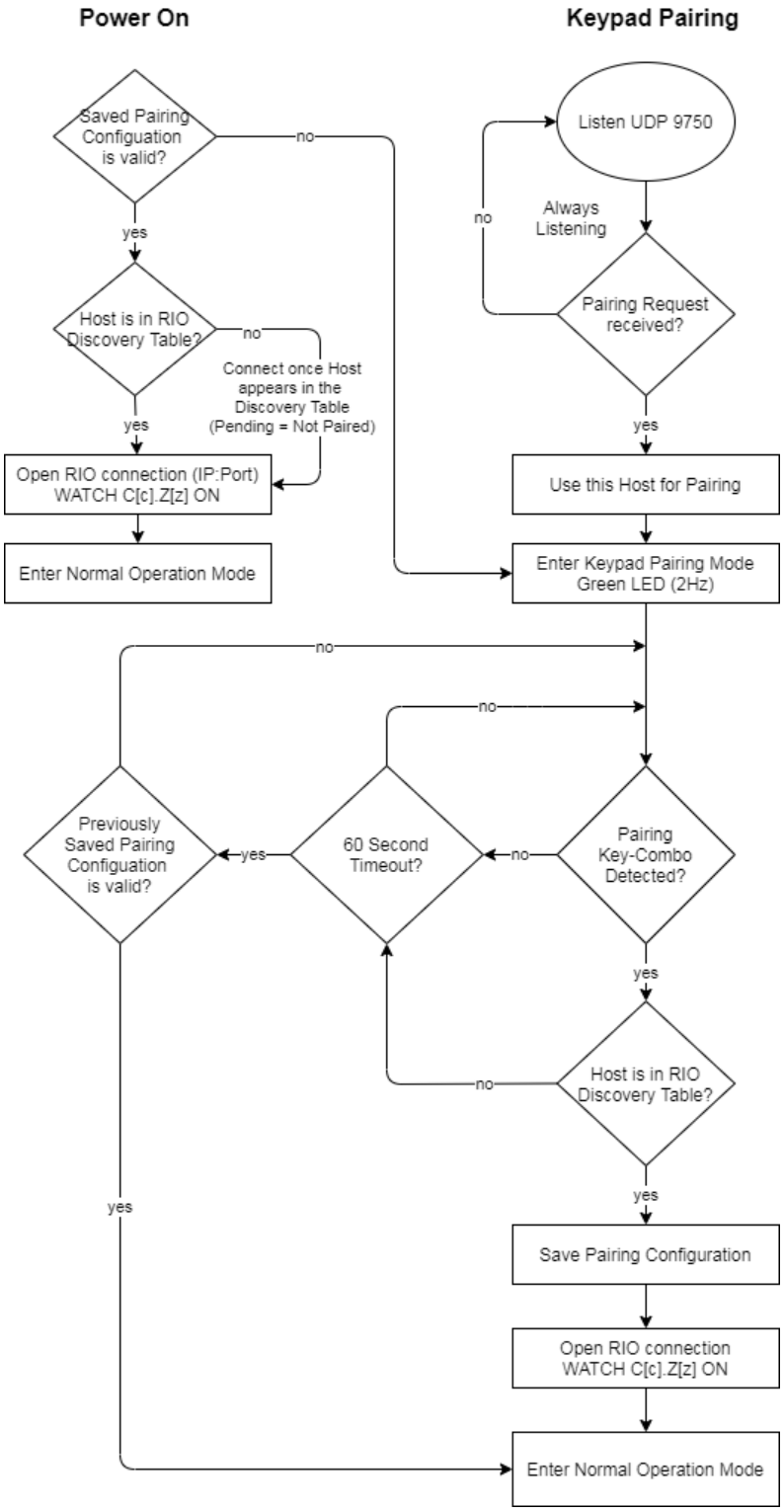
- Paired hostname (save hostname instead of IP address since IP address could change)
- Paired controller id
- Paired zone id
- Paired protocol

Connectivity

Once the IPK-1 is paired to a device, it will continue to use the pairing configuration until a user decides to pair it to another device. The IPK-1 will maintain the RIO session and must attempt to reconnect in the event of a disconnection due to a device reboot or network issue.

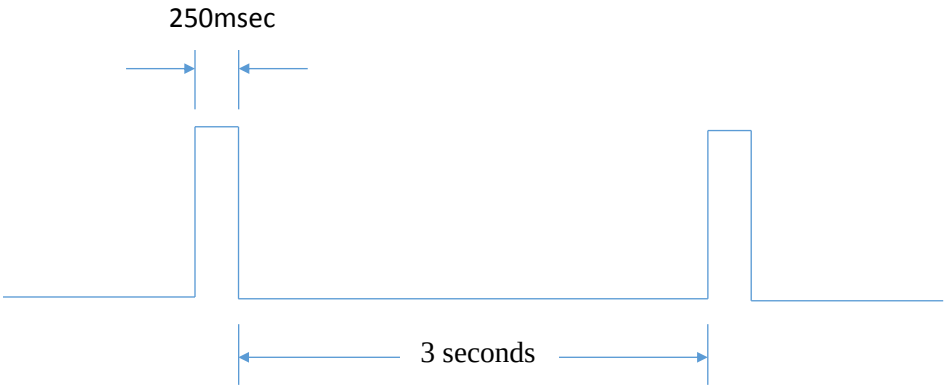
The IPK-1 will use DHCP to acquire an IP address, and renew the lease accordingly. In the event the renew request fails, the IPK-1 will broadcast a DHCP discover. In all circumstances the IPK-1 must maintain the connection to the paired device.

Flowcharts

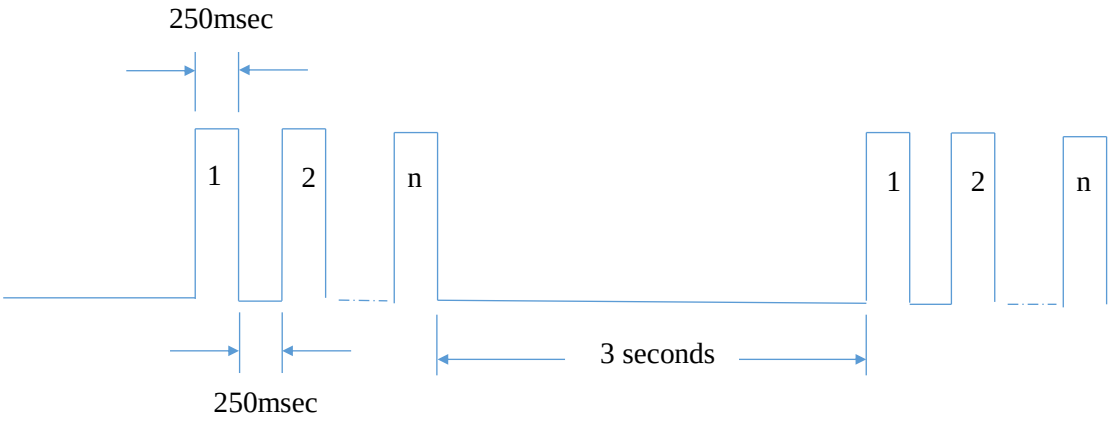


Flash Count

Flash 1 (2Hz)



Flash n (2Hz)



References

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2. MBX-AMP - Wi-fi Streaming Zone Amplifier, Installation Guide, 3.11.19 Rev. 19
3. MBX-PRE - Streaming Media Player, Installation Manual, 3.12.19 Rev. 22
4. MCA-88X – 8 Source, 8 Zone Controller Amplifier, Installation Manual, 02.08.17 Rev 3
5. RFC 6762 – Multicast DNS
6. RCC 6763 – DNS-Based Service Discovery
7. IPK-1 Test Plan, Revision 1.0