# Full Train Public Address System Rebuild

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## Overview

There are several issues with the current system that need to be corrected, and some capabilities that should be considered for addition.

The most pressing issue is to have a connection-between-cars method that is mechanically tolerant of being pulled apart by the cable (when the connector is not properly disconnected), is reasonably weatherproof, and can accommodate having the car being in any position in the consist in any direction. Another issue is that the sound levels in the cars is inconsistent and depends upon the consist - with one amplifier feeding (almost) all of the speakers on the train in parallel, the position in the consist affects volume.

Events can have unique requirements for what audio is shared, and what is isolated - often requiring physical rewiring to accommodate that event - weekend train has all cars listening to the conductor's announcements from a coach - story time train has the dining car isolated from the rest of the train - pajama train has the diner as the audio source for music and story reading.  A simple way to adapt the configuration to consist and function is desirable.

It would be convenient for some events to have the announcements (and possibly music) limited to the local car rather than being broadcast to the train.  Currently, only one amplifier can be active, so the other cars cannot have local announcements.

## Concept

Since this project will require rewiring, there is the opportunity to improve the cable distribution system to one where any car on the train can be the master (and need not be in a specific location in the consist), which in turn will require that each car have it's own amplifier (the ADA would need to have an amplifier added).  Each car having it's own amplifier would also address the issue of uneven sound levels in the cars.

The audio distribution bus for the train will continue to use the 70V level which provides good noise immunity.  Currently, the PA system is wired to have one amplifier drive all the speakers on the train. This has been circumvented in the open air (501) car to allow it to have its own amplifier to independently power its own speakers.  The dining car also has its own amplifier, but the diner must be on the end of the train - it doesn't have external PA car-to-connection on the kitchen-end of the car. Even though both the 602 coach and the 603 coach have amplifiers, one must be turned off for the PA system to work - both on at once is the occasional cause of the "low volume" problem.  The cabling, inter-car connections, and in-car switching will be modified to form an audio bus, and each car can listen to the audio bus and will power its own speakers.

The audio bus can be configured with the entire train as a single segment, or can be divided into multiple independent segments.  Each segment will have one car as the master with other cars in the segment as repeaters of the master.  For example, the story time train usually has the ADA car next to the diner - they could form one segment.  The remaining cars on the train would form another segment.  The story

reading in the dining car could also be playing in the ADA car. For Pajama Train, the entire train was one segment, with the dining car as the master music and story reading for the entire train. Since each car will power its own speakers, an amplifier will need to be added to the ADA car. All other cars already have amplifiers. All amplifiers will be "PAGING" type - when there is local content, the amplifier automatically mutes the external content - for example, background music can be playing (possibly sourced from another car) but being interrupted when the Conductor makes an announcement.

To provide the ability to segment the train, each car will have a switch panel with two selection controls. One control will select whether the car is to be a TALKer (master) or a LISTENer. The second control will be a selection of which car(s) this car will associate with - the one to the LEFT, BOTH, or the one to the RIGHT. It will be the responsibility of the crew member establishing the configuration to ensure that there is only one master (TALKer) for each segment. If all cars in a segment are selected as LISTENers, then each car must provide its own audio content.

Now for some sensory overload for you readers. For the first example, lets assume a no-special-event Dining, 602, 501, 603, ADA consist. All of the cars will select BOTH cars for association (the audio bus becomes one end-to-end segment) and the Conductor selects one car to TALKer (ensures that the rest are LISTENers), can provide background music to the train, and interrupt the music to make safety announcements. For the second example, one of those cars (let's say the 602) is dedicated to a private party - the volume for the audio bus input can be turned down and private music and announcements for that car (602) can be provided without affecting the rest of the train. The third example with a Dining, ADA, 602, 501, 603 consist could be for story time when the reading in the dining car will also be played in the ADA car, and the Conductor provides announcements and background music from the 602. The Dining car would select RIGHT and TALK, the ADA car would select LEFT and LISTEN, the 602 would select RIGHT and TALK, the 501 would select BOTH and LISTEN, and the 603 would select LEFT and LISTEN.

**Preliminary Design**

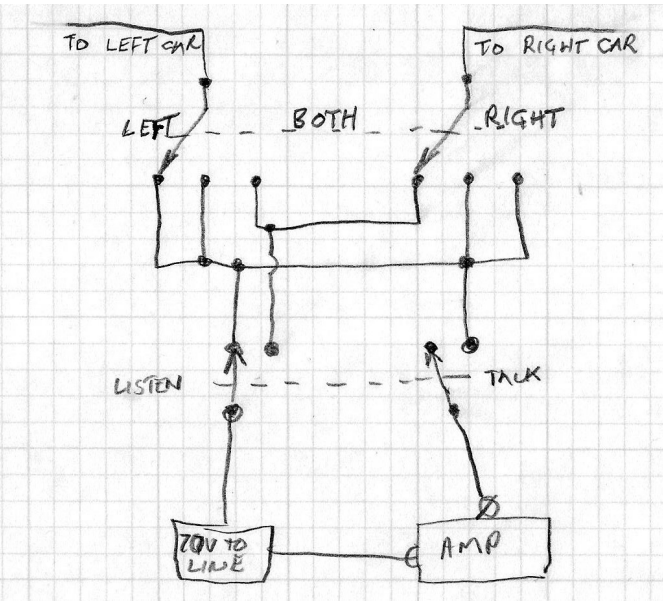
The connectors tentatively selected are pre-molded two-pin waterproof IP65, are AWG18, and are used for outdoor LED wiring. They come with a 8" cable stub, so must then be spliced into the overall cable system. These connectors do have a securing (threaded nut type) ring available, but it doesn't need to be used.

Each amplifier will have an adapter that converts the 70V audio bus level either to the amplifier's 1V line input level (RCA style connector) or microphone input level (XLR style connector) depending on the amplifier. They will be transformer-isolated to prevent audio ground problems.

To add an amplifier to the ADA car, a lockable electrical cabinet can be added to the wall opposite the door. The overhead already has access to 120VAC power - since the light is not switched, that power can be brought to the electrical cabinet. The speaker and audio bus wiring will need to be routed from the overhead in the vestibule, and an audio line needs to be run from the cabinet to the inter-car connection the far end of the car. An XLR microphone input needs to be added outside the bathroom, probably next to the door. It might also be advisable to add a small circulating fan since most amplifiers are convection cooled .

The small open air cars (502 and 503) will eventually have a booster amplifier, but for this phase they

will appear on the bus as additional speaker to be driven by whatever car has been selected as master.




The segment switching will be accomplished using a multi-pole rotary switch. In the LEFT position or the RIGHT position, the audio bus is isolated between the left and right cars. In the BOTH position, the left and right cars are connected to each other. In the BOTH position, this car can: 1) LISTEN to the audio bus (some other car is bus master); or 2) this car can TALK to all cars that are connected to this segment of the bus. In the LEFT or RIGHT position: 1) this car will LISTEN only to the selected car, or; 2) this car can TALK to the selected car, but will be listening to the opposite car (this is the configuration used for Pajama Train where the music and story reading was fed to the whole train from the dining car, but the conductor only talked to the following cars).

**Work Summary**

Before making any changes, "rationalize" the existing wiring. Go through each car that has an amplifier and establish which wire in the inter-car connections corresponds best to that amplifier's COMMON - color code the inter-car connectors. I suspect that in one or more cars, the existing wiring doesn't separate COMMON from GROUND, and could be the cause of some audio feedback/feed-through problems For the ADA, check if either speaker wire has been grounded - if not, color coding of the speaker wires is arbitrary. Ensure that the audio bus COMMON is not physically grounded.

Where feasible, eliminate the old 5-pin XLR car-to-car connections and add "home-run" cables from the new segement-switch boxes to the inter-car connectors (leave lots of recoverable slack).

Dining car:

1) Modify the interior of the Porter's cabinet: to accommodate wiring passages between the upper and lower shelves, and access to hallway for new inter-car connection to kitchen end. Elevate and secure CD player, put A/C and signal wiring through the new access hole.
2) Add exterior box and conduit and route cable from the kitchen-end of the car to the Porter's cabinet - use new exterior connector.
3) Remove existing amplifier for use in ADA car, install new paging amplifier, verify that the existing audio feed-through has been eliminated
4) Fabricate and install switch panel
5) Fabricate and install new 70V-to-Mic adapter
6) Install new exterior connector on entry-end of the car, provide a temporary pigtail to the old-style inter-car connector
7) When feasible, add new exterior inter-car wiring on kitchen-end.

602 Coach:

1) Run a new cable from the car end opposite the conductor-closet-end into the conductor's closet, evaluate running new "home run" cable from the exterior connections on the conductor's-closet-end to eliminate spices in the old 5-pin XLR junction box (see item 4).
2) Fabricate and install switch panel, secure amplifier and CD player (? Need shock/vibration mount?)
3) Fabricate and install new 70V-to-Mic adapter
4) Install new exterior connector on conductor-closet-end of the car, provide a temporary pigtail to the old-style inter-car connector

603 Coach:

1) Run a new cable from the car end opposite the conductor-closet-end into the conductor's closet
2) Fabricate and install switch panel, secure amplifier and CD player (? Need shock/vibration mount?)
3) Fabricate and install new 70V-to-Mic adapter
4) Install new exterior connector on conductor-closet-end of the car, provide a temporary pigtail to the old-style inter-car connector

501 Open Air:

1) Fabricate and install switch panel, make wall mounting for the amplifier
2) If the existing adapter is not transformer isolated, fabricate and install new 70V-to-Line adapter
3) Install an XLR microphone input
4) Eventually change the amplifier to a paging amplifier
5) Install new exterior connectors on both ends of the car
6) Keep, but secure, the additional cables that can feed the 502/503 for future use
7) If convenient, add light inside the closet
8) The closet would be more useful if the door opened outward

604 ADA:

1) Create the equivalent of the 602/603 conductor's closet in a cabinet - has A/C power, has cable from all of the speakers, has cable from bathroom-end exterior, has new cable from opposite end exterior, has new cable from local microphone XLR
2) Fabricate and install switch panel
3) Install paging amplifier from Dining car
4) Fabricate and install 70V-to-Line adapter
5) Install new exterior connectors

502 and 503 Open Air:

1) Add conduit and J boxes to accommodate new wiring
2) Install new exterior connectors
3) Plan a location for a booster amplifier in the 503
4) Bring a tap from the audio bus to the speakers (verify that the speakers have 70V operation selected), keep in mind that there may be a booster amp inserted in the future (so might be able to wire the speakers to the TALK switch)

**Key Purchases**

Waterproof connector pairs
Audio cable
Paging amplifier
Segment switch components
    Enclosure and mounting
    Rotary switches
    Toggle switches
    Adapter (70V to Line) components
Enclosure for ADA amplifier, power wiring
Wiring supplies

**Test Set Kit**

During the building/remodeling of the PA system, it would be handy to have a kit of modules that can act like a car, but that has a few extra features.

New waterproof connector set (one male, one female), and two pair (male and female) of pigtails to old-style connectors - a universal adapter among the connectors used, and also can provide connection between the cars.

An amplifier, 8 ohm to 70V transformer, a 70V-to-Line-level adapter, and a speaker. In a passive mode, the speaker (via transformer) can receive directly from the audio bus. In active (A/C power available) listening mode the amplifier can receive from the 70V-to-Line adapter and directly drive the speaker. In active talk (master) mode, the amplifier can use the transformer to drive the bus - with input either from a microphone or a tone generator.

Need to have a method to detect and display connector polarity - could be as simple as a battery, clip leads, and a multimeter - or could use a supply from the A/C power. Goal is to “rationalize” the wiring to be consistent on the audio COMMON and the grounding.