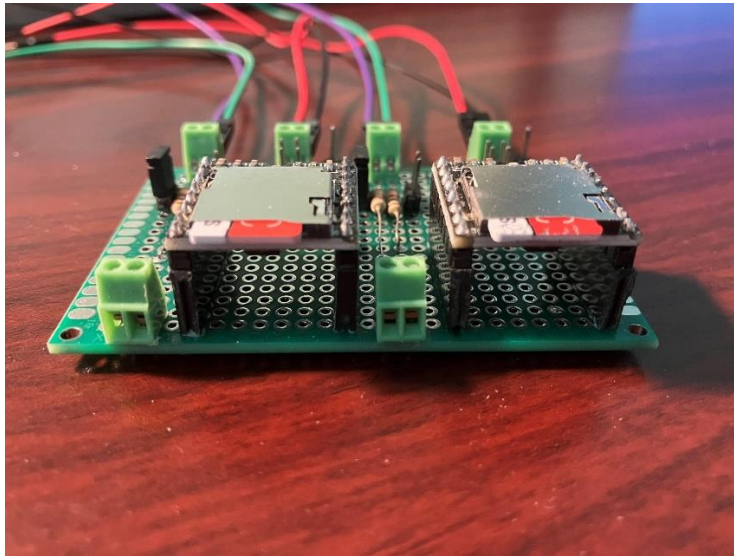


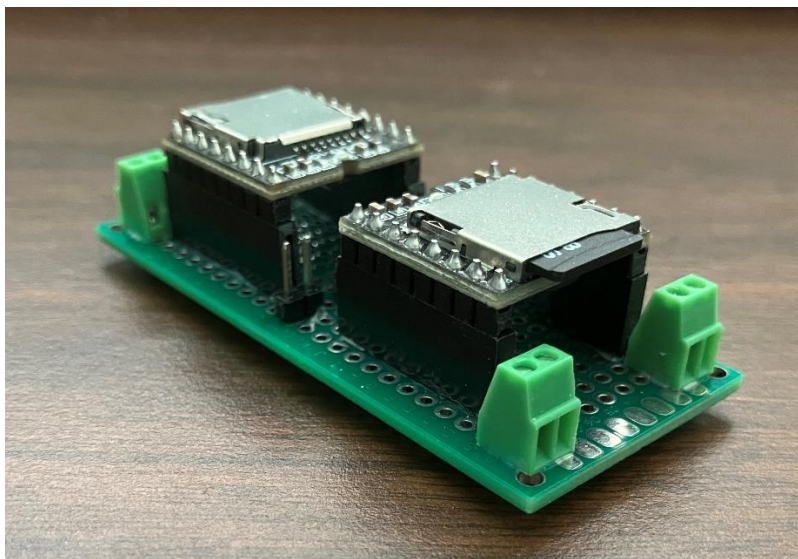
Three Ways to Add Sound Objects to a Model Railroad with DFPlayer

Using An Arduino Mega Running DCC-EX EX-Command Station
Or for Traditional Layouts, Incorporating Simple Switches and Relays

The DFPlayer Dual Caddy (MCU)



The DFPlayer Dual Caddy for All



DFPlayer USE Matrix

What happens if one wants more than two DFPlayers? Under DCC-EX EX-Command Station, serial port expansion is an option but requires the help of the I2C bus with several additional hardware considerations.

The DFPlayer has three operating modes;

Serial Communications

Direct I/O

Loop

Commonly available positive level triggered opto-isolated relay boards designed to be driven by MCUs can simulate both short and long momentary button depressions or a latching switch. Solid State Relays and sensors can also be employed.

Assuming the sound object requires only one or few different clips, operating the DFPlayer in either Direct I/O mode or Loop mode can be a viable alternative. There are instances where one or two clips is all that's necessary for a given detail. In Loop mode, a single audio clip playing the sound(s) of burning wood in concert with the respective associated campfire lighting detail can work well and save the MCU's serial ports for sound objects that require many clips, regardless of order and at a variety of volume levels.

	LOOP Mode	Direct I/O	Serial Communications
PROS	Simplest Works On Any Layout Operated by a Latching Power Switch MCU-Limited Only by the number of available Digital I/O Pins MCU-Uses 1 Digital I/O Pin per DFPlayer MCU-EX-Rail (Routes-Sensors-FastClock) Power Efficiency - No Idling Current	1 or more Clips Works On Any Layout Clip Selection and Volume by 2 MO Pushbuttons Limited Only by the number of available Digital I/O Pins MCU-Uses 2 Digital I/O Pins per DFPlayer EX-Rail (Routes-Sensors-FastClock) Good when only a few clips are needed for a sound object	1 or more Clips Volume Control - 30 Steps via Coding Clips Selected by Coding in any Order EX-Rail (Routes-Sensors-FastClock)
CONS	Only 1 Clip MCU-Relay Required for DFPlayer Power No Volume Control - Defaults to Max 30	MCU-Dual Relay Simulated Pushbuttons MCU-Fixed Long Depress Duration Sequential Clip and Volume Selection	MCU Limited to 2 Players on Mega w/o I2C Expansion Limited Number of DFPlayers even with Expansion
Notes	*Audacity - MP3 Import-Select All-Effects-Amplitude-Export		
	*1 Digital Pin Operation If Only One Clip and Previous and Volume Decrease is needed.		

Order

The file naming convention suggested is 0001xyz.mp3 , 0002abc.mp3, 0003def.mp3 and so on. While this is helpful in matching clips and how they are noted in code, technically the DFPlayer uses the order on which they were copied to the micro SD card. It is the sequential entry into the disk's FAT or File allocation table that dictates the physical clip order. Therefore, the first clip copied to the SD card is the first FAT entry, and so on. Important. Clips must be copied ONE at a time in sequential order. If you copy 0003def.mp3 before 0001xyz.mp3, 0003.mp3 IS THE First Clip as far as the DFPlayer is concerned! Remember, the Windows Copy command DOES NOT place the clips in order if multiple files are selected and copied to the SD Card at the same time.

File Naming and Order Example

Below shows the first three of the 26 Tower sound clips. They were copied one by one to a micro SD Card.

Name	Date modified	Type	Size
0001-WelMan.mp3	8/25/2025 1:51 PM	MP3 File	105 KB
0002-DXO-C.mp3	8/11/2025 2:37 PM	MP3 File	146 KB
0003-DXO-T.mp3	8/11/2025 2:38 PM	MP3 File	147 KB

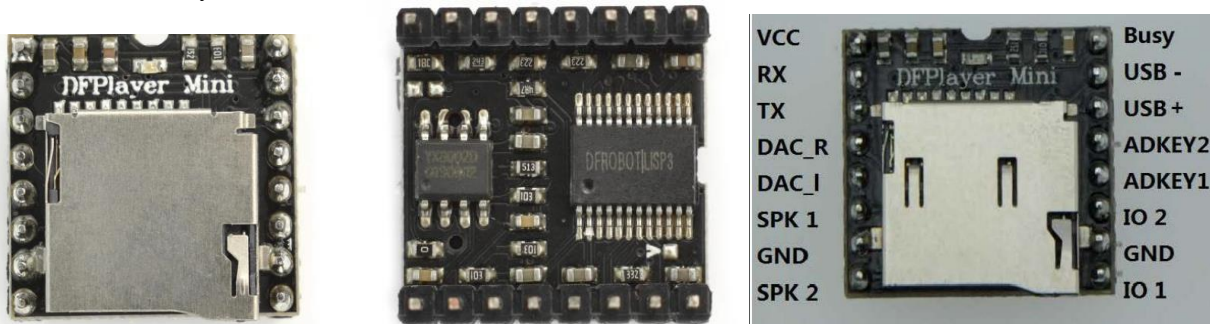
Some mp3 clips resident on the Station's DFPlay micro SD Card

0001-MainA.mp3	8/11/2025 5:59 PM	MP3 File	418 KB
0002-MainD.mp3	8/11/2025 5:59 PM	MP3 File	418 KB
0003-PennA.mp3	8/11/2025 5:59 PM	MP3 File	434 KB
0004-PennD.mp3	8/11/2025 5:59 PM	MP3 File	433 KB
0005-MonmA.mp3	8/11/2025 5:59 PM	MP3 File	453 KB
0006-MonmD.mp3	8/11/2025 5:59 PM	MP3 File	449 KB

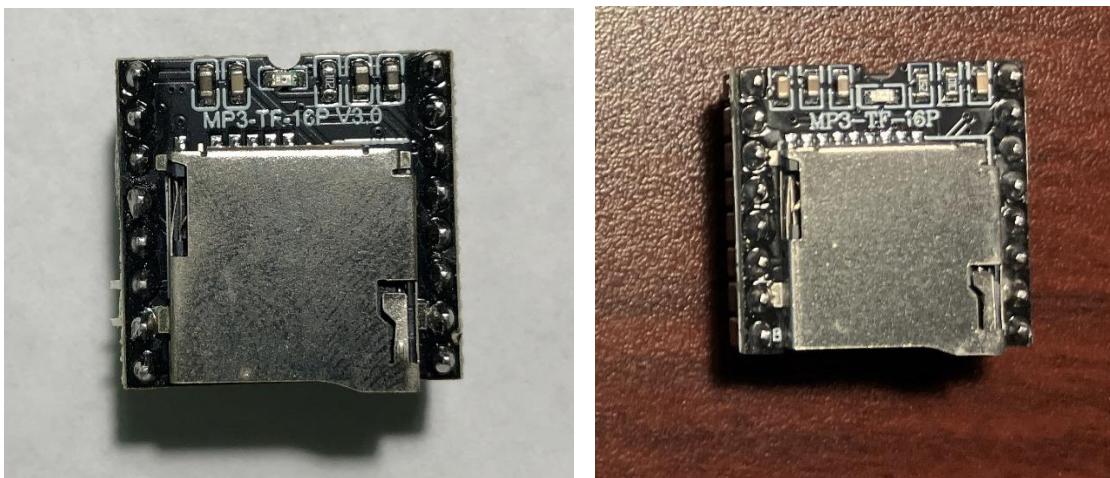
Introduction to the DFPlayer – An Overview

The DFPlayer is an inexpensive and simple device for incorporating sound objects or details on any model railroad. While many incorporate it in serial communications mode with a Microcontroller (MCU), the DFPlayer other two operating modes allow it to be easily added on traditional model layouts too!

The “Official” DFPlayer



DFRobot, DigiKey and a few other resellers of the official DFPlayer are great retailers for product purchase. A myriad of low cost DFPlayer versions are available from online retailers. Be careful. Many pictures do not show the actual MP3 decoder chip on the DFPlayer advertised. There are multiple “models” sold. Board silk screen printing shows either “DFPlayer Mini” (some with HW247A next to it) or MP3 FN-M16P or MP3-TF-16P. Photos of the first two DFPlayers purchased were manufactured with the MH2024K-24SS and the JL AB24CR9F35.1-74 mp3 decoder ICs.

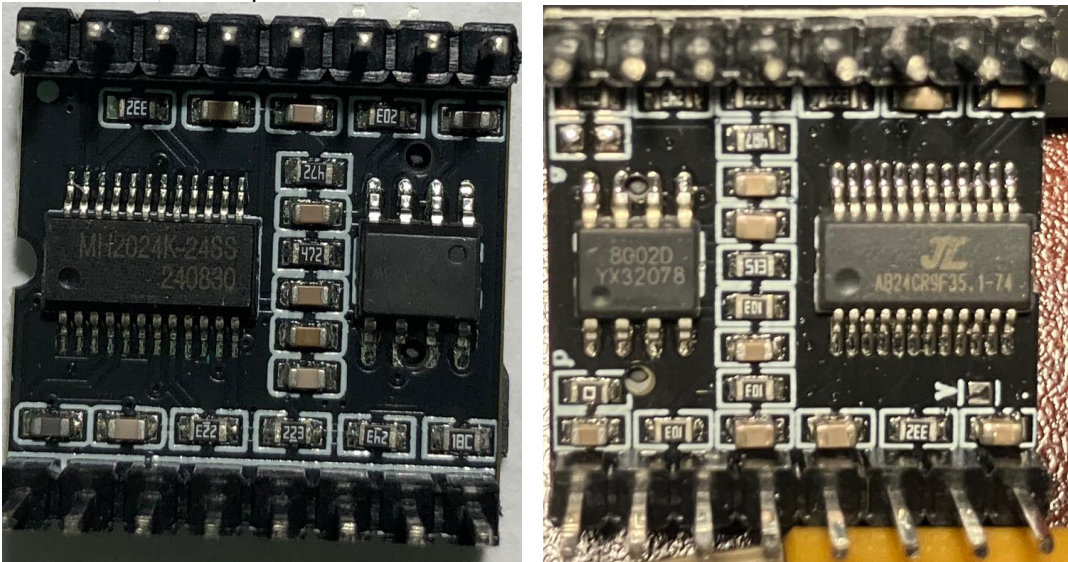


Two ICs are found on the DFPlayer module board; a mp3 decoder chip and an 8002 class AB amplifier. Class AB amplification is less efficient than the newer and more widely used class D amplifier resulting in a relatively high idling or quiescent current. Some clones suffer from an undesirable tone on power up. The idling current drawn from the power supply for a DFPlayer is typically between 20-30mA. The total supply current of approximately 45mA was measured during testing two concurrently idling DFPlayer modules, one of each of the two mp3 decoder types purchased.

Excluding the official DFRobot DFPlayer, there seems to be consensus that the YX5200 mp3 decoder chip is most compatible to the mp3 decoder on the DFRobot DFPlayer. The MH-ETLive is another common clone mp3 decoder IC. There are many copies...Expect the Unexpected.

While the official DFRobot DFPlayer has not been tested, it should work without any problems. Sometimes it is best to buy a branded product rather than a knockoff when adopting a new device however since adding sound is not “mission critical” and there is about a 5 to 1 difference in cost, it was decided to first explore a couple of cheaper DFPlayer clones.

Two versions; the 24 pin MH2024K-24SS and the JL AB24CR9F35.1-74



Some of the differences and defects observed or reported elsewhere.

MH2024K-24SS

Red operating light Slide in SD Card Hum on 3.3V None at 5V Inconsistent library support.

JL AB24CR9F35.1-74

Blue Operating Light Spring Card loader Lower volume at max Inconsistent I/O actions.

Two issues in testing for the planned use were discovered but reasonable solutions found;

MH2024K-24SS -- Does not play on cold boot (from power down) but does upon a warm boot (MCU reset button, via EX tools in Engine Driver or in the Arduino IDE serial monitor). The current drawn from the 5V supply was slightly higher with this chip. The fix - Swap with the JL AB24CR9F35.1-74 version. Trigger Port Pins I/O 1 and I/O 2, and ADDKEY work on the MH2024K-24SS based DFPlayer.

JL AB24CR9F35.1-74 – A short <1 second “squeal” sound upon cold boot. A board modification of the similar MH-ETLive DFPlayer mp3 decoder addresses the issue however the board differences between it and the JL AB24CR9F35.1-74 requires additional re-work. It was decided to delay any modification until either or both the YX5200 or official DFPlayer mp3 decoders are evaluated. More testing will be performed regarding reported inconsistent reaction to I/O actions – I/O 1, I/O2 and ADDKey. Sound checks from both JL AB24CR9F35.1.74 DFPlayers on the Dual Caddy were tested via I/O 1 and performs as defined.

Both Versions

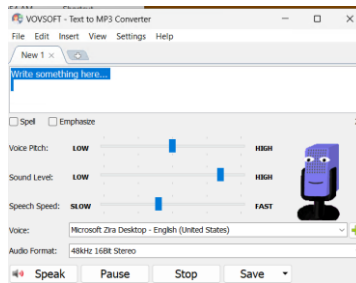
Hum and motorboating noise heard when an external amplifier was connected to the DAC L and R audio outputs. Amplified 2 channel or stereo is unneeded, however it was discovered that hum and motorboating marginally improved by free wiring the DFPlayer module instead of breadboarding it. A significant reduction occurred when the 2nd ground, pin 10 of the DFPlayer was connected solely to the signal ground of the audio amplifier.

Perhaps the greatest disadvantage to implement the DFPlayer is how to mount it. There are no holes for mounting and its double sided physical layout with pre-soldered pins adds to the challenge. One of the reasons the Dual Caddies were created.

MP3 Sound Files – Creation and Ordering

Perhaps the most time consuming task is developing and organizing the sound clips. Three open source programs, VOVSOF's Text to MP3 converter, VLC and Audacity played important parts in the making the clips. Be cognizant of copyright laws and regulations.

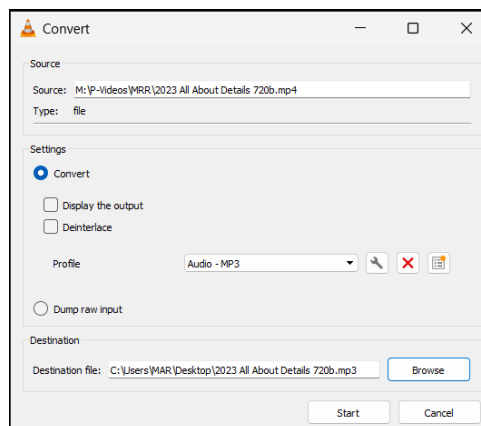
The Tower and Station human communications were written in a text editor or MS Word. The text was copied into the Text to MP3 converter and saved as a mp3. The mp3 was then imported into Audacity for clip modification such as adding reverb, adjusting volume and any other effects desired and lastly, exported as an mp3.



Audacity is a wonderful program. One can easily spend a lot of time and fun by adding a variety of effects. The graphic equalizer is very helpful in compensating for speaker deficiencies, eg Increasing emphasis on the lower to mid audio frequencies and decreasing the upper frequencies for small 10-15mm speakers better balances the sound reproduced. There are only several essential steps. Eg Adding reverb. Import mp3 into Audacity, Select Entire Clip, Go to Effect, Select Delay and Reverb, Reverb, Apply, Test via the Play button and if satisfied, Export to MP3. Long clips can be shortened if needed.



VLC can extract the audio content from a mp4 to create an MP3 when the sound clip desired is from a video. Audacity can be used if sound clip modification, such as length, if desired. The convert screen ready to extract the audio track



Caddy Wiring Schematic

The schematic below depicts the MCU option for operating the DFPlayer in Loop Mode. For traditional non-MCU layouts, the relay NO and COM pins 1 and 2 are simply replaced with a SPST latching switch to turn on player and start playing the sound clip. The DFPlayer ADKEY1 pin 12 is permanently connected to DFPlayer ground pin 10 which instructs the DFPlayer to function in Loop mode and play the clip on powerup.



While the wiring schematic illustrates connection for MCU driven layouts, sound clips are selected, Previous or Next, when either I/O 1 or I/O 2 respectively, is momentarily connected to ground by a relay or normally open momentary switches. A longer momentary depression on I/O 1 decreases volume. Volume can be increased when I/O 2 is subject to a longer depression. Swap the relay with a push button connected between I/O 1 pin 9 and ground and another pushbutton between I/O 2 and ground to operate the DFPlayer without a microcontroller.



The DFPlayer Dual Caddy for ALL.

Development

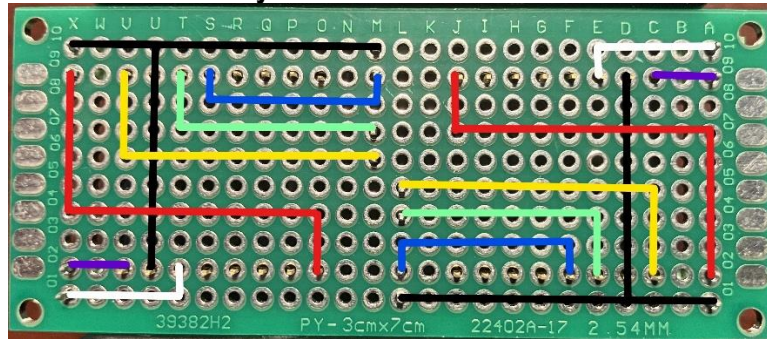
Bottom Interconnect Wiring

Breakable male and female headers were selected for their adaptability to mount different components and minimize parts. Extra space between the SD card and layout bottom side, compared to an IC socket, facilitates SD card swaps.

Separate Voltage In connections incorporating 2 pole screw terminals allow flexibility for powering each DFPlayer.

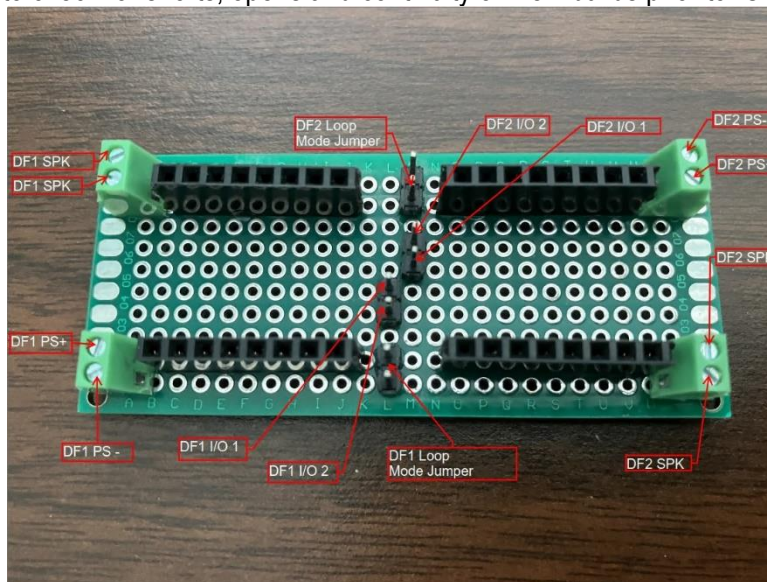
I/O Trigger Port 1 and I/O Trigger Port pins are wired to separates single male Dupont header pin.

Caddy Bottom Interconnect Side



Caddy Layout and Connections

It is HIGHLY recommended to check for shorts, opens and continuity on new builds prior to IC insertion and applying power.



Power-Speaker-Triggering Ports and ADKEY1.

The dual DFPlayer board features an independent power option for each DFPlayer. The separate power inputs allow for additional options.

Speakers DF1 Speaker and DF2 speaker. Output connections from each DFPlayer to respective speaker. The DFPlayer's single channel audio power IC, the 8002, is rated at 3W @ 3 ohms, 2.65W @ 4 ohms and 1.8W @ 8 ohms.

Loop Mode Jumper Blocks and Direct I/O Mode)

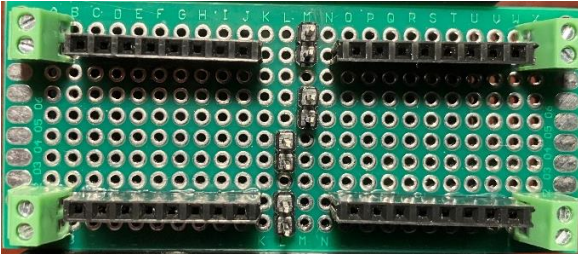
A jumper block for operating the player in Loop Mode. The ground side can be used for MCU or relay ground. Triggering port pins I/O 1 and I/O 2 access from single header pins.

Construction Photos

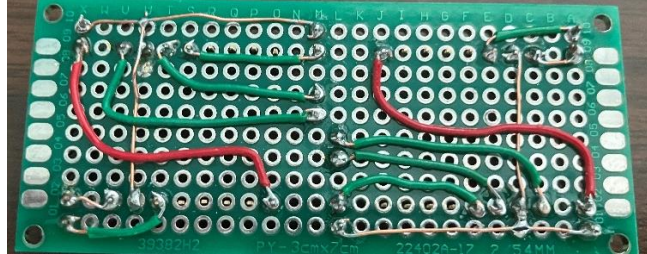
Assembly was straightforward and perhaps the most difficult aspect was maintaining flush top side component mounting when soldering the interconnections while the Caddy is bottom side up. A very light coat of Elmer's Glue All on the bottom of the pieces provided sufficient support until the parts were soldered.

After gathering the parts, spent a little time positioning several times before the outcome. Component arrangement selected to minimize perf board area and minimize lengths of the interconnections.

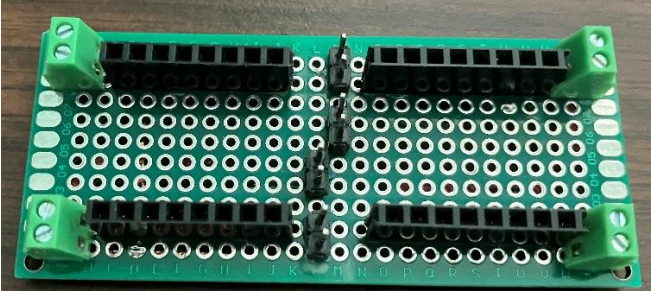
Glued Parts – Pre-Solder



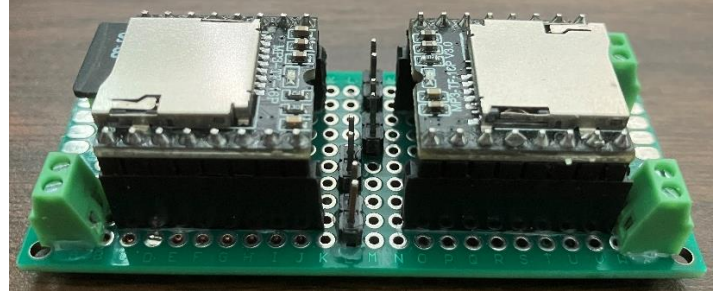
Completed Caddy Interconnect



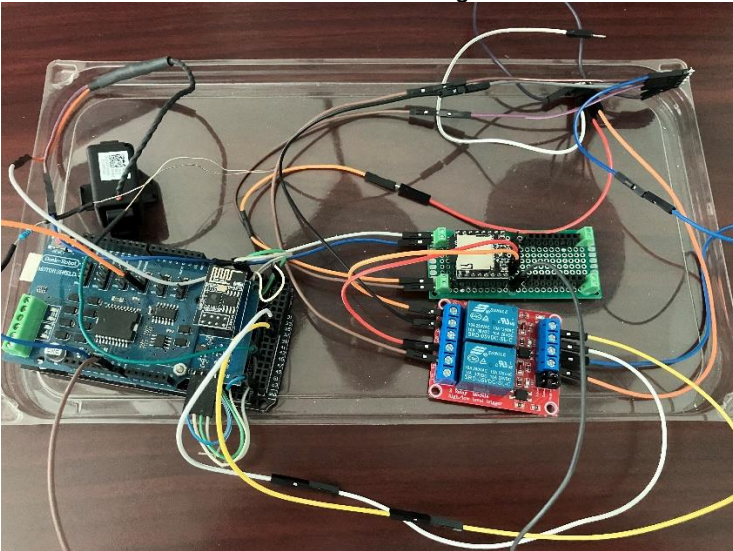
Checking For Continuity, Shorts and Opens



Ready for Testing



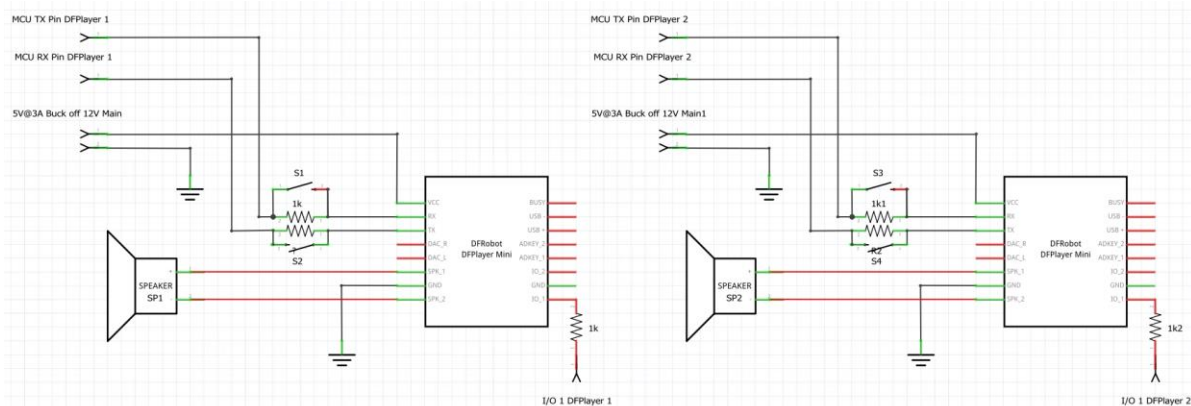
Direct I/O Mode Testing



The Dual Caddy DFPlayer (MCU)

Caddy Wiring Schematic

The Dual DFPlayer Caddy for MCU schematic or half of it is essentially the same circuit as shown on the DCC-EX website with a few exceptions and convenience additions. Two DFPlayers, separate power supply inputs and taps plus I/O 1 access for the most part, differentiates the two.



The current drawn by a single DFPlayer module at max volume can easily exceed 200mA. It is best to add a separate power supply when using DFPlayers. A ground connection between the MCU and the DFPlayer is needed when powering the DFPlayer by a separate power supply and operated in Serial Communications mode.

Other simple enhancements include Multi-Voltage MCU Support that includes or bypasses the 1k ohm resistors in series with the RX/TX inputs of the DFPlayer depending on whether a 5V or 3.3V MCU is controlling the DFPlayer. Access to the DFPlayer I/O 1Trigger, Pin 9, is accessible via a male Dupont Pin. It is good for testing the certain DFPlayer functions. Or, for limited manual control if desired.

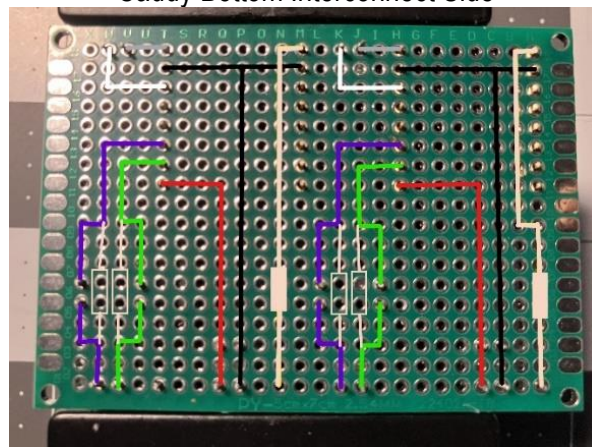
Caddy Development

A DFPlayer Dual Caddy seemed to make most sense, not just economically, but a Wifi equipped Arduino Mega leaves only 2 available serial RX/TX ports, without I2C expansion, for adding serial controlled devices e.g. DFPlayer. Breakable male and female headers were selected for their adaptability to mount different components and minimize parts. Extra space between the SD card and layout bottom side, compared to an IC socket, facilitates SD card swaps.

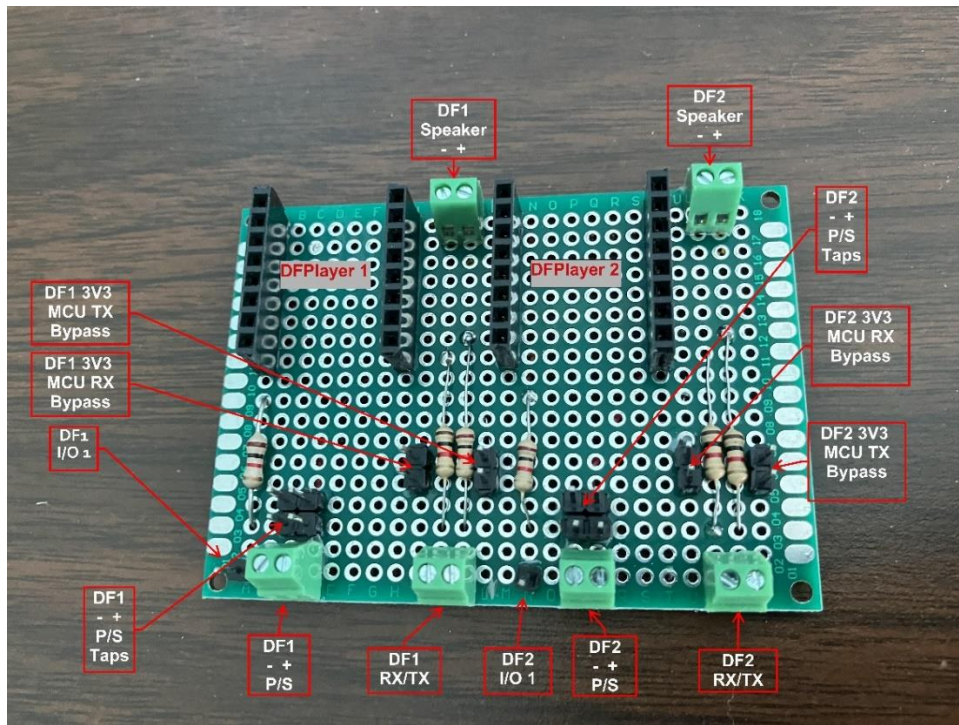
Separate Power In connections allow flexibility for powering each DFPlayer. A 2-pole screw terminal along with 4 male Dupont terminals can be implemented in several ways such as daisy chaining power or access to ground.

I/O Trigger Port 1 pin is wired to a mounted single Dupont male header pin.

Caddy Bottom Interconnect Side



Caddy Layout and Connections



Power-Speakers-RX/TX

Power DF1 - + P/S and DF2 - and +

The dual DFPlayer board features an independent power option for each DFPlayer. Power supply taps are provided for bridging a single power supply connection from either DF power input to the other. The separate power inputs enable additional options. Some clone DFPlayers may function better when power is fed to each separately.

Speakers DF1 Speaker and DF2 speaker.

Output connections from each DFPlayer to respective speaker. The DFPlayer's single channel audio power IC, the 8002, is rated at 3W @ 3 ohms, 2.65W @ 4 ohms and 1.8W @ 8 ohms.

Communication Ports DF1 R/X and DF2 RX/TX

Screw terminal blocks provide connection from the RX/TX pins of the module. 1k ohm resistors are in series with both RX/TX lines to protect the DFPlayer from excess voltage from 5V MCUs such as the Arduino Mega. Some reported that a few of the DFPlayer clones function only when both RX/TX lines include a 1k ohm series resistor.

ByPass Jumper Blocks and I/O Pin Access (Testing + Direct I/O Mode)

DF 3.3V MCU RX/TX By-Pass Jumper Blocks

Lower operating voltage MCUs such as the Nucleo, function at safe voltage levels for the DFPlayer thus eliminating the need for the 1k ohm RX/TX level protection resistors.

I/O Pin Access DF1 I/O 1 and DF2 I/O 2

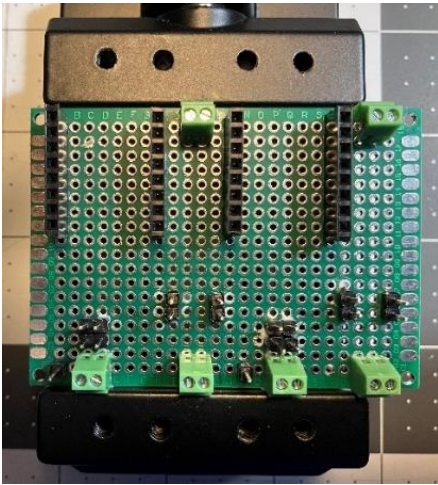
The triggering port pin I/O 1 can be used as a basic diagnostic tool. A momentary contact to ground instructs the DF player to play the previous mp3 at the default volume. If there is only one mp3 saved on the SD card, it would be played. A longer momentary contact will decrease volume. The I/O control pin overrides whatever the DFPlayer was doing previously. The ability to play a sound in this manner allows one to test basic functionality and isolate if an issue exists. Typically, if the DFPlayer produces sound when I/O 1 is momentarily grounded, then most likely the problem is either in RX/TX, grounding-MCU, code etc. A momentary push button connected between I/O 1 and ground does a fine job for both short and long depressions too.

Construction Photos

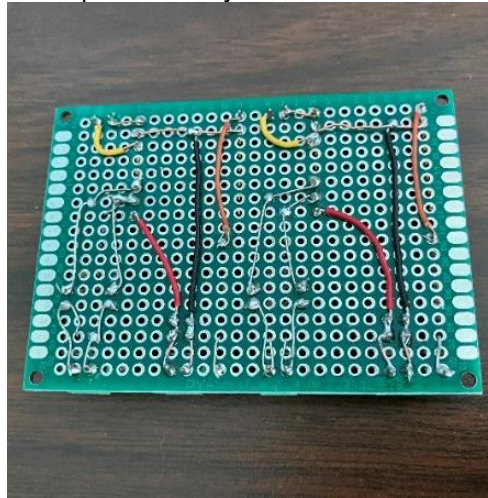
Assembly was straightforward and perhaps the most difficult aspect was maintaining flush top side component mounting when the Caddy is bottom side up when soldering the interconnections. A very light coat of Elmer's Glue All on the bottom of the pieces provided sufficient support until parts were soldered.

After gathering the parts, spent a little time positioning several times before the outcome. Component arrangement selected to minimize perf board area and minimize lengths of the interconnections. However, the board is slightly larger than necessary to allow for adding future enhancements such as male Dupont header pins for I/O 2, ADDKEY or other unassigned function pins.

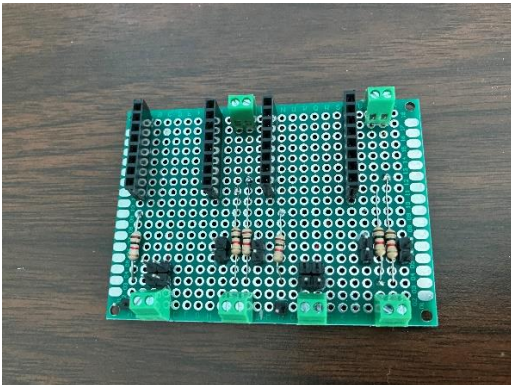
Glued Parts – Pre-Solder



Completed Caddy Interconnect



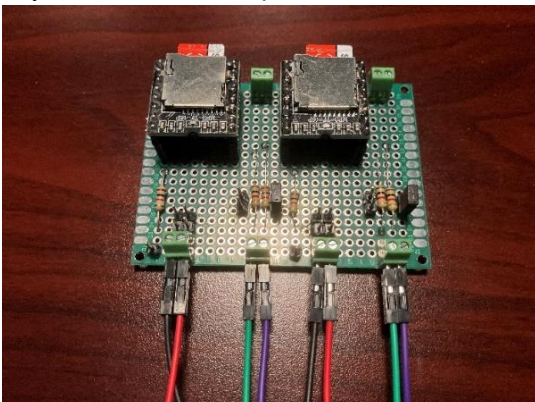
Checking For Continuity, Shorts and Opens



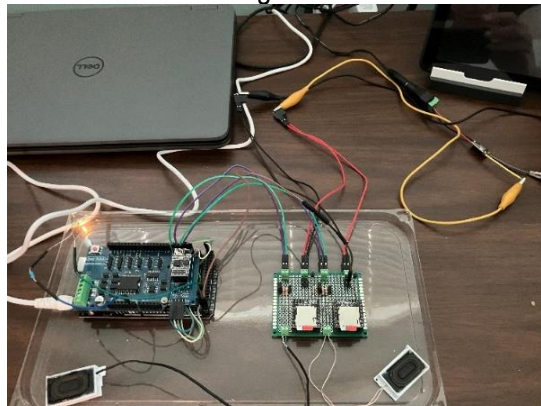
Ready for Testing



Layout Installation Preparation



Final Testing



DFPlayer Serial Communication Mode

DCC-EX EX-Command Station EX-CS combined with EX-Rail is a powerful way to control the DFPlayer. The EX-Rail programming illustrated in the examples below are intended for demonstrating the use and it is suggested to review the EX-Rail Command Summary in addition to related information.

HAL Hardware Abstraction Layer Coding.

There are two methods for defining DFPlayer hardware that enable usage in EX-CS; myHal.cpp and myAutomation.h.

myAutomation

```
HAL(DFPlayer, 1000, 16, Serial2)
```

```
HAL(DFPlayer, 1100, 15, Serial3)
```

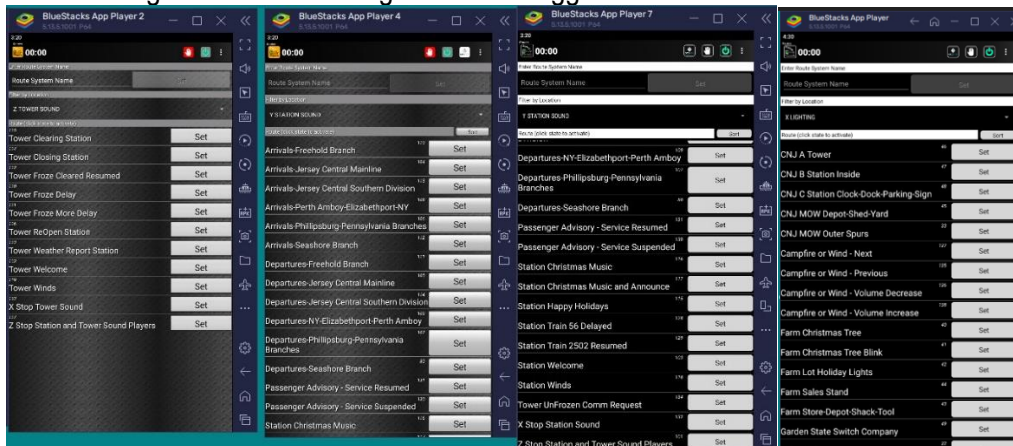
myHal.cpp

```
#include "IODevice.h"
```

```
#include "IO_DFPlayer.h"
```

```
void halSetup() {  
    DFPlayer::create(1000, 16, Serial2);  
    DFPlayer::create(1100, 15, Serial3);  
}
```

The first, second, and third Engine Driver screenshots represent the Tower and Station sounds. The fourth screen shot is the Lighting Routes screenshot. Besides manual control via buttons, the tower “speaks” whenever a turnout state changes or a locomotive automation begins or ends. Adding sensors to trigger sounds is an alternative to route buttons.



Coding Examples – Located in the parent myAutomation.h or a child such as mySounds.h.

PLAYSOUND = ANOUT = SET

Important- Without additional coding, if a clip is being played and the DFPlayer is instructed to play another, the first clip stops and the new clip begins. The WAITFOR(abcd) or AT(-abcd) where abcd is the port assigned to the DFPlayer, tells the DFPlayer to finish the playing the current clip before proceeding to play the next.

A suggestion to the DCC-EX team is to implement use of the undefined 3rd parameter as a Flag in PLAYSOUND and/or ANOUT;

none = If instructed to play a clip while currently playing one, the currently playing clip stops and the 2nd clip plays.

a= Argument to direct the DFPlayer to finish playing the current clip before proceeding (Instead of a separate command)

b= Argument to tell DFPlayer if interrupted, return to the clip after playing the 2nd clip.

Throttle Routes button – First Button Leftmost Screen

```
ROUTE(125, "Z TOWER SOUND: Tower Clearing Station")  
PLAYSOUND(1000, 25, 25, 0)  
DONE
```

whereas 1000 (Tower DFPlayer) hardware port defined earlier for the DFPlayer, play the 25th clip at volume 25/30

A Routes button example for the Station shown on the 2nd screen.

```
ROUTE(106, "Y STATION SOUND: Arrivals-Phillipsburg-Pennsylvania  
Branches")  
PLAYSOUND(1100, 3, 20, 0)  
DONE
```

whereas 1100 (Station DFPlayer) hardware port defined earlier. Play the 1st clip at volume 20/30

The tower also reports any change in turnout status. Located in myTurnouts.h,

```
ONCLOSE(1)
  GREEN(22)
  MESSAGE( "Crossover Is Closed-Stay on Mainline Or Service
Loop" )
  PLAYSOUND(1000,2,18,0)
| DONE
```

Note:The MESSAGE command pushes a text message window on every throttle connected to EX-CS

When the layout is powered on, the Tower and then the Station, welcomes all. Turnouts are set to their default position.

```
HAL(DFPlayer, 1000, 16, Serial2)
HAL(DFPlayer, 1100, 15, Serial3)

AUTOSTART
SET(46)
DELAY(5000)
PLAYSOUND(1000,1,18,0)
AT(-1000)
PLAYSOUND(1100,13,18,0)
WAITFOR(1100)
|THROW(1)
DELAY(9000)
THROW(2)
DELAY(9000)
CLOSE(3)
DELAY(9000)
THROW(4)
DONE

#include "myRoster.h"
#include "myShuttle.h"
#include "myLights.h"
#include "myDistricts.h"
#include "myTurnouts.h"
#include "mySounds.h"
```

Routes button example for Loop Mode “Tunnel Winds.”

After the left most screen shot was taken, a button was added for “Tunnel Winds.” The howling Tunnel Winds clip is located on a SD card in a dedicated DFPlayer operated in Loop Mode with a speaker located in the tunnel. It was arbitrarily placed on the Tower screen. The button functions as a latching switch.

```
ROUTE(139, "Z TOWER SOUND:Tunnel Winds")
  IF(200)
    RESET(39)
    UNLATCH(200)
  ELSE
    SET(39)
    LATCH(200)
  ENDIF
DONE
```

Whereas 39 is the Arduino Mega's Digital I/O pin connected to the respective relay input. 200 is an available Latch.

Routes button example for Direct I/O Mode “Campfire - Winds.” (The rightmost Engine Driver screenshot)

The Campfire lighting detail is complimented by campfire sounds. Or, it can play howling wind sounds. (Both the Tower and Station DFPlayer can also play the howling wind clip). The route buttons are set to function as momentary switches.

```
ROUTE(135, "X LIGHTING:Campfire or Wind - Previous")
  SET(37)
  DELAY(500)
  RESET(37)
  DONE

ROUTE(136, "X LIGHTING:Campfire or Wind - Volume Decrease")
  SET(37)
  DELAY(1000)
  RESET(37)
  DONE

ROUTE(137, "X LIGHTING:Campfire or Wind - Next")
  SET(38)
  DELAY(500)
  RESET(38)
  DONE

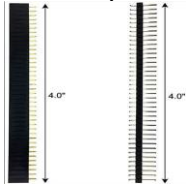
ROUTE(138, "X LIGHTING:Campfire or Wind - Volume Increase")
  SET(38)
  DELAY(1000)
  RESET(38)
  DONE
```

Mega Digital I/O Pins 37 and 38 connect to separate relay inputs that momentarily place I/O 1 or I/O 2 at ground. Two routes each and another two simulating short and long depressions. Short Contact or Depression = 500mSec and Long Depression = 1000mS.

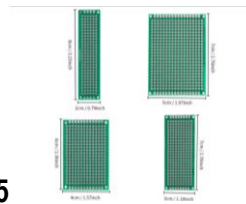
Parts List (Prices from AliExpress as of 250907

-- DFPlayers and micro SD cards (Up to 32GB) -- DFPlayer Clones start from \$1.50. The Official DF MSRP \$5.90

---2.54mm Breakable Headers Male and Female Single Row 40 Pin Pair 10 pack-\$2.17 (Jumper Blocks from Females)



---KF128 2P 2.54mm Plug-In PCB screw terminal block connector 26-18 AWG -- \$3.16



---4 Piece Equivalent (Elegoo) Small Perf Boards Set -- \$1.65

-1k ¼W Carbon Film Resistors and extras for wiring. Buy an assortment for about \$4 or a single pack of 1k ohm resistor for about \$1.50. Uninsulated bottom board interconnecting wire is from rarely installed values of resistors. Insulated bottom board wires are extra Dupont breadboard wires with ends cutoff. M-M, F-F and M-F packs are around \$1.50 each.

---5V 3A Buck Converter \$2.99. The Buck output USB connector was cut off and is a female USB A power pigtail for another project.



---DFPlayer Power Distribution Barrier Strip- \$1.47 -- Cut in half for 6P. Make bridging wire for each 6P block.



---Relay (2 or 4 or 8 Channel Positive/Negative Level Triggered Optoisolated) \$2.25-\$6.30
(Both Loop and Direct I/O Req. Positive Level)



---Speakers- The choice is yours.