


Nolan Engineering Project: Dryer Tunes



It's the final countdown!

Da-nah-na-nuuu, da-nah nuh-uh-
uhhh. 

Jim Nolan

2-July-2020 to 10-July-2020

totorodad@gmail.com

Source code and project are: Open Source

Problem/Solution/Cost:

- **Problem:** My dryer is older and does not play any sort of ending sound or tune when it completes its drying cycle.
- **Solution:** Create a current monitoring circuit that detects when the dryer has completed it's drying and then plays an audible tune (MP3) to let the user know when the dryer is done and needs to be attended to.
- **Cost:** estimated: \$200 (actual around \$160 using existing stock)
- **Labor:** Design and build about 5 days @ 6hrs/day. Build-again would be around 2 days @ 2-3 hours per day.

Warning: If you attempt this project make sure you know what you are dealing with around 220VAC hazardous voltages.

Architecture/Assumptions



- Current will be detected by using an in-line hall effect sensor
 - Use Allegro ACS758xCB type hall sensor. Use pre-mounted module from CZH-LABS, model: D-1085 (150Amp version).
 - The current sensor needs to read alternating current
- Only one phase of the split-phase 240VAC going to the dryer would be read. ~20amps per phase for 40amp dryer.
- The current sensor is biased at 2.5V and outputs .013V/amp. Note that a more sensitive current sensor might be better such as the 50 amp version (at .040V/amp).
- Peak current would be measured by an ADC connected to a Raspberry PI 4 in the form of a quasi-peak detector. The peak would be multiplied by .707 to calculate the RMS current:
 - $I(\text{Peak}) = \text{abs}([2.50\text{V} - V(\text{ADC})]) / 0.013$
 - $I(\text{RMS}) = I(\text{Peak}) * .707$
- The dryer would be detected as operating when the RMS current threshold > 10 amps.
- The dryer would be detected as done drying if the RMS current < 8 amps for 15 minutes.
 - 15minutes is needed as there are several periods where the dryer turns off the heater and just tumbles. This is true at the end
 - Of the cycle also where the heater is off for ~10 minutes.
- Python would be used (mostly to learn it form other real programming languages)
- NOOB 3.4 would be installed onto a 128GB SD card. See setup section for how this was setup.
- The ADC interface would be a WaveShare ADS1256 8ch 24-bit ADC (30ksps sample rate)

Interconnect

**Waveshare 24VADC
B0105DPYNO
\$34**

AUDIO-
Cable
\$7

**Raspberry Pi
4-2GB
B07V58CQGR
\$47**

- V(ADC)
- +5VDC
- GND

14,15 set
for 5V

**SanDisk
128GB
Micro SD
Card
\$22**

**Meanwell RS-15-5
AC/DC converter
+5V @ 3.0 Amps
\$13**

+5VDC
GND

DRYER PHASE 2 (HOT)
DRYER NEUTRAL

 $V(\text{ADC})$

**220VAC
Dryer Cord
SDRC-3W-50A
\$22**

DRYER PHASE 1 (IN)

DRYER PHASE 1 (OUT)

CZH-LABS
MD-D1085/150A
\$18

Interconnect (audio output)

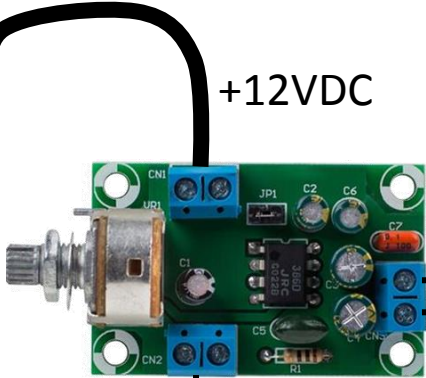
110VAC TO 12VDC
1-2 AMP
B0851DDXVG
\$12

DRYER PHASE 2 (HOT)
DRYER NEUTRAL



+12VDC

Volume knob

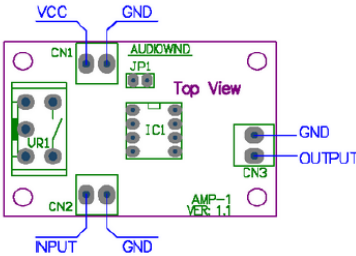


AUDIO
(left ch only)

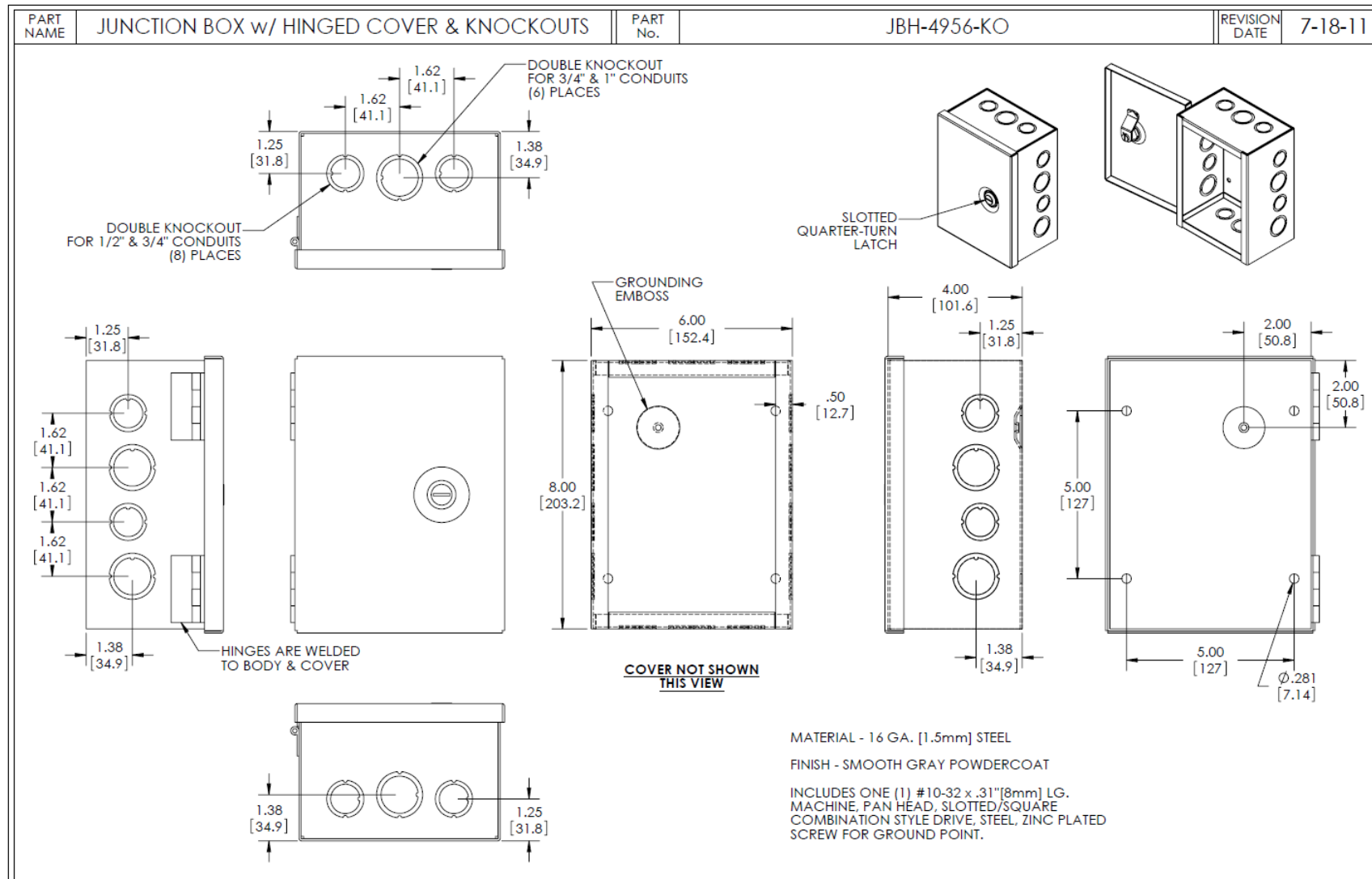
NJM386D
7545884950
Audio AMP
\$10



3Watt (4 o 8 ohm speaker)
B01CHYIU26
\$10



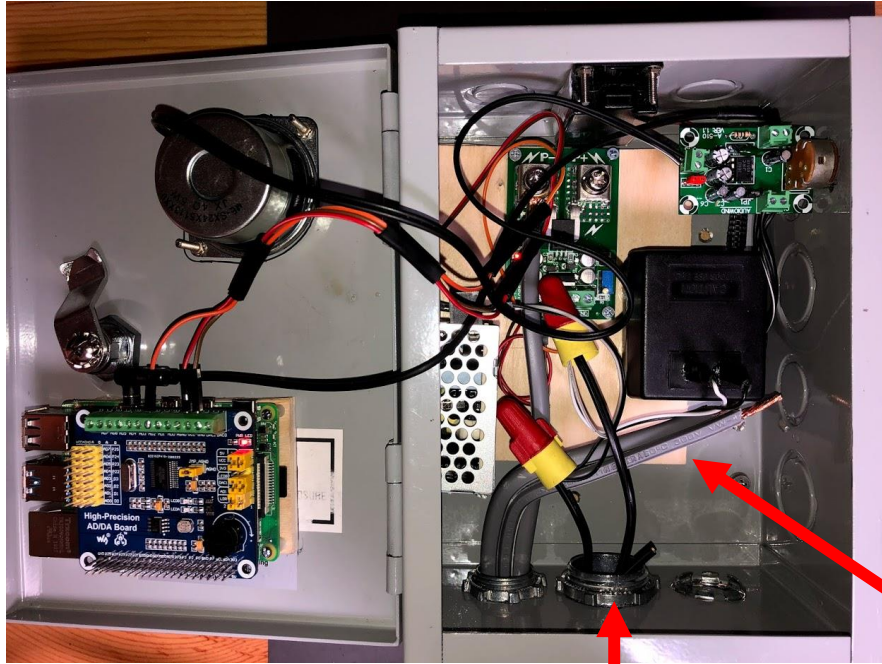
Box: (Bud Industries: JBH-4956-KO \$16)



BOM

Project: Dryer Tunes					
BOM					
10-Jul-20					
Rev 0					
Item#	Qty	Description	Cost	Extended Cost	URL
1	1	Raspberry PI 4 (2GB)	47.00	47.00	https://www.amazon.com/Vilros-Raspberry-USB-C-Adapters-Quickstart/dp/B07V58CQGR/ref=sr_1_1?dchild=1&keywords=B07V58CQGR&qid=1594420194&sr=8-1
2	1	Bud Box 6"x8"x4" Non-sealing with latching lid	16.00	16.00	https://www.amazon.com/BUD-Industries-JBH-4956-KO-Knockout-Hinged/dp/B005UP9YYI/ref=sr_1_1?dchild=1&keywords=JBH-4956-KO&qid=1594419965&sr=8-1
3	1	24BIT ADC board (fits on Raspberry PI 3 and 4	34.00	34.00	https://www.amazon.com/waveshare-Raspberry-High-Precision-AD-Board/dp/B0105DPYNO/ref=sr_1_1?dchild=1&keywords=B0105DPYNO&qid=1594420234&sr=8-1
4	1	150 Amp hall effect current sensor board with terminals	21.00	21.00	https://www.amazon.com/Electronics-Salon-100Amp-Current-Sensor-Module/dp/B016M63GTM/ref=sr_1_2?dchild=1&keywords=MD-D1085%2F150A&qid=1594420265&sr=8-2&th=1
5	1	4 foot cord 220VAC Dryer Cord SDRC-3W-50A	22.00	22.00	https://www.amazon.com/Supplying-Demand-Compatible-Whirlpool-Frigidaire/dp/B075962XDG/ref=sr_1_1?dchild=1&keywords=SDRC-3W-50A&qid=1594420371&sr=8-1&th=1
6	1	5V 15Watt ACDC Meanwell Power Supply: RS-15-5	13.00	13.00	https://www.amazon.com/MEAN-WELL-RS-15-5-Supply-Single/dp/B005T6UJBU/ref=sr_1_1?dchild=1&keywords=rs-15-5+meanwell&qid=1594420651&sr=8-1
7	1	Sigma Electric ProConnex 49663 NM/SE Clamp Type Connector 1-Inch	5.00	5.00	https://www.amazon.com/Sigma-Electric-ProConnex-49663-Connector/dp/B000GATQEU/ref=sr_1_5?dchild=1&keywords=3%2F4+box+wire+clamp&qid=1594420433&sr=8-5
8	1	Audio amplifier board: NJM386D 7545884950	10.00	10.00	https://www.amazon.com/Electronics-Salon-Battery-Supply-Amplifier-NJM386D/dp/B0155X6IRK/ref=sr_1_1?dchild=1&keywords=7545884950&qid=1594420859&sr=8-1
9	1	110VAC brick 12VDC 2amp B0851DDXVG	12.00	12.00	https://www.amazon.com/Switching-Adapter-Transformer-Charger-100-240V/dp/B0851DDXVG/ref=sr_1_1?dchild=1&keywords=B0851DDXVG&qid=1594420765&sr=8-1
10	1	Hubbell-Raco 2863B5 Clamp Type for Oval or Round Cable Connector, 3/4-Inch, Zinc, 5-Pack	2.40	2.40	https://www.amazon.com/Hubbell-Raco-2863B5-Connector-4-Inch-5-Pack/dp/B00719W9RI/ref=pd_bxgy_img_3/139-1666694-6795428?encoding=UTF8&pd_rd_i=B00719W9RI&pd_rd_r=4bf66c07-fd75-4b56-84c1-d40cc3fbf008&pd_rd_w=s35e7&pd_rd_wg=fci8Q&pf_rd_p=ce6c479b-ef53-49a6-845b-bbbf35c28dd3&pf_rd_r=2P5NEGSB8QFJWXHM9CNS&psc=1&refRID=2P5NEGSB8QFJWXHM9CNS
11	1	Misc (wood, wire nuts, wire, fasteners, glue)	10.00	10.00	
Total:				192.40	

Construction



Existing Dryer
power cord goes
in here (plug
removed)



Wood backing
plate to hold
components or
box



220VAC
from Wall

220VAC to
Dryer

Raspberry PI setup

- Format SD card for FAT32
- Download latest NOOB from here:
 - <https://www.raspberrypi.org/downloads/noobs/>
- Unzip NOOB to SD CARD.
- Insert SD CARD into PI 4 and connect HDMI monitor/display to HDMI 0 port on PI 4. Connect keyboard and Mouse to PI 4. Connect Power supply. Power on PI 4.
- Install NOOB and follow the setup to setup to US Keyboard and English. Setup wifi as directed.
- Reboot

Raspberry PI setup (cont.)

- Run command prompt
- Run sudo raspi-config
 - If you did not setup wifi then Turn on the SPI port
 - Set default audio to headphone
 - Turn on VNC (google and install vnc viewer to get to your PI 4 without a display or keyboard thru your wifi)
 - Set a new master password for you PI 4. The current password is: raspberry
- follow the online instructions to log your PI 4 into your local router. It's a lot like logging your laptop into your router. Click on the wifi antenna symbol on the top right of the x-window environment. Select your SSID and enter you password.

Raspberry PI setup (cont.)

- Run command prompt. Assumes you have internet access now (check by typing: ping google.com)
 - Type: `sudo apt-get install mpg123`
 - Type: `sudo pip3 install GPIO`
 - Type: `sudo pip3 install spidev`
- Download dryer.shl (python3 code and driver):
 - <https://drive.google.com/file/d/1QNUw8jS5Pak5rhmnnoNCKbsck5GauOTI2/view?usp=sharing>
- Extract the dryer code/sounds in your /home/pi folder with: `unzip dryer.zip`
- Test if the ADC can be ready by running: `sudo python3 main.py`
- You should see analog values of the input channels. Channel 2 (dryer current meter) should read about 2.5V
- Make dryer.shl executable by typing: `sudo chmod +x dryer.shl`
- Now you can run dryer.shl by typing: `./dryer.shl`
 - The audio should say: "System Ready"
 - When drying current (heaters on) is detected there will be a slight ding sound.
 - When the dryer is not demanding current (after current demand is detected) for at least 15 minutes the `dryer_done_sound.mp3` will be played from the dryer/sounds folder. This is currently set to a couple of seconds of the final countdown song.

Raspberry PI setup (headless mode)

- To make the PI boot without HDMI display attached (headless mode).
- Go to a command prompt and type: `sudo nano /boot/config.txt`
- Change the `#hdmi_force_hotplug=1` by removing the '#' in front of the line.
- Reboot

Raspberry PI setup (autoboot dryer.shl)

- Open command prompt
 - Type: `sudo nano /etc/xdg/lxsession/LXDE-pi/autostart`
 - Add the following line to the second to last line:
 - `@lxterminal --command "/home/pi/dryer/dryer.shl"`
 - Reboot
-
- This will execute a lxterminal upon bootup with the dryer.shl code running.

Raspberry PI setup (mDNS)

- RaspberrianOS (any most likely your PC if you have Itunes/or other apple products installed because they install Apple's version of mDNS called Bonjour) already support multi-cast DNS so you can get to you PI by using the address raspberry.local instead of the full IP address that is assigned to your PI by your house router.
- To change your mDNS name to dryer.local for instance edit and change the keyword raspberry in your /etc/hosts and /etc/hostname file with `sudo nano /etc/hosts` and `sudo nano/etc/hostname`. Then reboot. You can now access your PI 4 via VNC or SSH via the local mDNS name: dryer.local

Python code: (open source and freeware)

```
#!/usr/bin/python
# -*- coding:utf-8 -*-

import time
import ADS1256
import RPi.GPIO as GPIO
import os
import time

def dryer_done_sound():
    os.system('mpg123 -q /home/pi/dryer/sounds/dryers_done.mp3')

def system_up_sound():
    os.system('mpg123 -q /home/pi/dryer/sounds/system_up.mp3')

def armed_sound():
    os.system('mpg123 -q /home/pi/dryer/sounds/armed.mp3')

try:
    ADC = ADS1256.ADS1256()
    ADC.ADS1256_init()

    #this calibration assume no current used
    ADC_Value = ADC.ADS1256_GetAll()
    offset = ADC_Value[2]*5.0/0x7ffff
    print("Calibration: %1f" % offset)
    offset = 2.4422 # value based on the above read calibration

    system_up_sound()

    peak_detect_time = 4
    peakc = 0.0
    window_time = peak_detect_time+time.time()
    armed = False
    upper_current_threshold = 10.0
    lower_current_threshold = 8.0
    maxc = 50.0 #max current allowed to avoid inrush values
    volts_per_amp = 0.0133
    shutoff_detect_count = 225 # (15*60) / peak_detect_time
    shutoff_counter = shutoff_detect_count

    while(1):
        ADC_Value = ADC.ADS1256_GetAll()
        inc = abs((offset-(ADC_Value[2]*5.0/0x7ffff))/volts_per_amp)
        rmisc = inc * .707

        if rmisc > peakc and rmisc < maxc:
            peakc = rmisc
            # print("peak found: %1f" % peakc)

        if time.time() > window_time:
            print ('2 ADC = %1f' % peakc)
            window_time = peak_detect_time+time.time()
            # If the current is flowing to the dryer to heat the clothes
            # arm the dryer sound output
            if peakc > upper_current_threshold and armed == False:
                armed = True
                print("armed")
                armed_sound()

            # If armed and still high current then reset the shutdown counter
            if peakc > upper_current_threshold and armed == True:
                shutoff_counter = shutoff_detect_count

            # When the dryer output sound is armed and the current is low
            # start counting down ever read cycles (about 4s)
            if peakc < lower_current_threshold and armed == True:
                shutoff_counter = shutoff_counter - 1
                print("shutoff_counter: %d" % shutoff_counter)

            # When the dryer sound is armed and has been low current for
            # shutoff detect count cycles then play sound and
            # disarm the sound making until the next high current draw is seen.
            if shutoff_counter <= 0 and armed == True:
                dryer_done_sound()
                armed = False
                shutoff_counter = shutoff_detect_count

        peakc = 0 # reset for the next quasi-peak detect

except :
    GPIO.cleanup()
    print ("\r\nProgram end ")
    exit()
```