



Aidan Williamson <aidan.d.williamson@gmail.com>

Capacitive Sensor

30 messages

Aidan Williamson <aidan.d.williamson@gmail.com>

Thu, Jul 3, 2014 at 2:42 PM

To: [email address withheld]

Hi,
Here is the part number: analog devices AD7747.

Here is a link to my code: [pastebin](#)

There are pictures of the construction of the board here: [trovebox](#)
Pin 2 was unused so I soldered a wire to it.

Here are my notes that I created as I went through this. [Google Drive](#) . Please comment if you see modifications to be made.

I study "electronics technology" at a community college so I'm by no means an EE. I have knowledge of analog and digital electronics. I have more experience programming PICs in assembly than using arduino... I found an example of someone else using this chip with an arduino online (link is at the top of my code) and based my code off their work.

Here is some other relevant information:

1. I do not have access to an oscilloscope
 1. Marcin wants me to buy a usb oscilloscope that displays on a PC. I am hesitant to do this because I think it will be a waste of money in the long run.
2. I don't have access to a logic analyzer
3. I'm simply running a jumper cable from the capacitance sense pin (middle of the 3 pin header) to a self-fabricated ring of steel and running a jumper from the GND on the arduino to another piece of steel. I thought about putting a known value of capacitance between these two lines (ceramic capacitor or similar) in order to see if it would "help" the chip determine some capacitance. I am shorting the Shield pins (straddle the capacitance sense pin) together because we don't have a low capacitance wire. (I wanted to ask why you chose a 3 pin header instead of a bnc connector or similar) I am holding the ring near the work and hoping for a result.

I wanted to wait until I had done more exhaustive troubleshooting before contacting you but Marcin suggested I contact you sooner rather than later. I'm glad you are willing to help!

attached is a picture of the current setup. I know it's janky but I don't really have a good place to work yet since arriving on Monday. I will try to claim some space here to create a good work station while I wait for your response.

Best,

[Aidan](#)

(the above link is to my OSE wiki log)



2014-07-03 14.37.53.jpg
1910K

Paul <[email address withheld]>
To: Aidan Williamson <aidan.d.williamson@gmail.com>

Thu, Jul 3, 2014 at 3:01 PM

Would you please forward the schematic and board layout. I no longer have them here.

Thank you,

Paul Neelands

Best,

[Aidan](#)

(the above link is to my OSE wiki log)

Paul <[email address withheld]>
To: Aidan Williamson <aidan.d.williamson@gmail.com>

Thu, Jul 3, 2014 at 4:06 PM

Your code addresses the AD7747 start byte at 0x48 whereas the data sheet page 12 indicates 0x90 for the start byte for a write operation. Lets try that first. It needs to be changed at several locations.

Paul

[Aidan](#)

(the above link is to my OSE wiki log)

Paul <[email address withheld]>
To: Aidan Williamson <aidan.d.williamson@gmail.com>

Thu, Jul 3, 2014 at 4:12 PM

In your loop code:

```
Wire.requestFrom(0x48,3); //reads data from cap DAC registers 1-3
while(Wire.available())
{
```

you are reading the AD7747 data at 0x48 whereas the data sheet indicates a read is to be done with an 0x91.

Paul

Aidan

(the above link is to my OSE wiki log)

Paul <[email address withheld]>
To: Aidan Williamson <aidan.d.williamson@gmail.com>

Thu, Jul 3, 2014 at 4:43 PM

Reasonably low capacitance coaxial cable like RG59U has a capacitance of 20.5 pf per foot. The maximum range of the AD7747 is basically 8.192 pf without using offsets. This severely limits the cable length. Three conductor cable is much lower in capacitance.

Paul

Aidan Williamson <aidan.d.williamson@gmail.com>
To: Paul <[email address withheld]>

Thu, Jul 3, 2014 at 4:47 PM

Hi Paul,
Thanks for responding so fast!
Your board and schematic can be found here: http://opensourceecology.org/wiki/Paul_Log

There is actually a reason for the address change.
Arduino does not use the last bit in the address sequence (the R/W bit). It specifies read/write in the command. We write Wire send or wire receive. So instead of an 8 bit address it's a 7 bit address. The datasheet address gets converted this way: Shift to the right and drop the last bit. See the note on this page: <http://www.arduino.cc/en/Reference/Wire>

-Aidan
[Quoted text hidden]

Aidan Williamson <aidan.d.williamson@gmail.com>
To: Paul <[email address withheld]>

Thu, Jul 3, 2014 at 5:01 PM

Ok, I see. Could you clarify how exactly you intended the sense connection to interface with the torch table?

From your log:

The capacitive sensor board will need to be mounted on or near the torch with the capacitive sensor pickup ring surrounding the torch tip. A long 4 conductor flat flex cable extends from the I2C connector J1 on the capacitive sensor board to the I2C connector on the Ramps 1.4 board. A short (~6 in.) low capacitance shielded cable (RG6U Cable) extends from the capacitive sense input to the sensor ring. The shield of this cable connects to the Shield terminal of J2 pin 1 or 3, the inner conductor connects to the CapSense terminal of J2 pin 2

I thought a BNC connector would work better with the rg6u cable which is why I asked.

-Aidan
[Quoted text hidden]

Aidan Williamson <aidan.d.williamson@gmail.com>
To: Paul <[email address withheld]>

Thu, Jul 3, 2014 at 7:16 PM

What do you think of my settings of the configuration register? I just took a guess at some values. In the code I sent you the binary pattern in the comment doesn't match the hex in the command. this is because when I was troubleshooting I switched the hex without changing the comment. I don't really understand what's going on with table 18 of the datasheet (page 18)

Thanks,
-Aidan
[Quoted text hidden]

Paul <[email address withheld]>
To: Aidan Williamson <aidan.d.williamson@gmail.com>

Fri, Jul 4, 2014 at 11:55 AM

Oops! Ok for 0x48 then.

Paul
[Quoted text hidden]
[Quoted text hidden]

Paul <[email address withheld]>
To: Aidan Williamson <aidan.d.williamson@gmail.com>

Fri, Jul 4, 2014 at 12:18 PM

Have you checked the voltage at pin 13 to 14 on the on the AD7747? What are they?
For cheap scopes check Saelig.com the Rigol series has a good reputation. A 50 mhz one is \$329.
The next step is to hang a scope on pins 1 & 16 and see if the chip is being accessed via SCL & SDA.
For this to work you need a 2 channel scope at least.

Paul

On 14-07-03 05:47 PM, Aidan Williamson wrote:
[Quoted text hidden]

Aidan Williamson <aidan.d.williamson@gmail.com>
To: Paul <[email address withheld]>

Fri, Jul 4, 2014 at 6:09 PM

Hi Paul,
I am just checking my email now -- busy day.

There is a PowerCube workshop happening here which is taking up all my time right now.
I will have to get back to you on those readings. I believe I took them and they look good. 5v on vcc and 0v on ground.
i was reading 4.7v on the rdy pin.

Marcin wants to cheap out on the oscilloscope. could you give me a convincing reason not to go for usb? I mean, usb latency just doesn't sound right for a scope but I don't have the credentials to convince him.

Back to the workshop,

Aidan

[Quoted text hidden]

Aidan Williamson <aidan.d.williamson@gmail.com>

Sat, Jul 5, 2014 at 10:06 AM

To: Paul <[email address withheld]>

Actually, I take that back about usb scopes. What do you think of this one:

<https://www.saleae.com/logic16>

[Quoted text hidden]

Aidan Williamson <aidan.d.williamson@gmail.com>

Sat, Jul 5, 2014 at 10:12 AM

To: Paul <[email address withheld]>

i said scopes but i meant logic analyzers.

[Quoted text hidden]

Paul <[email address withheld]>

Sat, Jul 5, 2014 at 10:32 AM

To: Aidan Williamson <aidan.d.williamson@gmail.com>

Well you need some way of looking at SCL & SDA. At the very low end there are 4 bit logic analyzers that understand I2C for \$99.

Paul

[Quoted text hidden]

[Quoted text hidden]

Aidan Williamson <aidan.d.williamson@gmail.com>

Sat, Jul 5, 2014 at 2:56 PM

To: Paul <[email address withheld]>

Forwarding Marcin the section of your email that mentioned the Rigol did the trick. It's on the way.

For now, I have successfully gotten some data out of it! I spent this morning modifying my code

I need to study the datasheet more and also study capacitive sensors in general.

I will contact you when I feel like I am ready to proceed.

My current (working) code: <http://pastebin.com/tWrjfYCA>

I also was able to secure a workstation outside of the Mud Hut.

Best,

Aidan

[Quoted text hidden]

Paul <[email address withheld]>

Sat, Jul 5, 2014 at 6:07 PM

To: Aidan Williamson <aidan.d.williamson@gmail.com>

Looking at your code, I gather that readycheck() isn't fully formed. It isn't called anywhere at the moment. The if statement if(readybit = 0) uses the assignment operator instead of == and it has a recursive loop in that it calls itself which will result in an eventual stack overflow which should probably be a while loop.

On the other hand I'm happy that you are getting some results and a scope is coming. Good work.

Paul
[Quoted text hidden]

Aidan Williamson <aidan.d.williamson@gmail.com>

Sun, Jul 6, 2014 at 9:23
AM

To: Paul <[email address withheld]>

Thanks. I changed it and it gives me pretty much the same data. The data I get can't be very good, though.

I am reading the three CDC register bytes in decimal form. the serial only really changes when I touch the shield wires with my finger or short them to the C+ input. If I connect a jumper to the sense pin and short it to ground I get no change. Actually, if I connect a jumper to the sense pin my readings go to 7, -1, -1. If I remove the jumper I read a value around 7, -39, -53. The first digit, 7, drops to two for one reading at a seemingly constant frequency.

My understanding so far is that you designed this board to work in singled ended mode using the C+ input pin (i'll call it c+) which measures capacitance between its input and ground on a range from 0 to ~8pf. The shield wires on either side of the Capacitance input pin are driven to the same potential as C+so that little parasitic capacitance can interfere. The real inner workings of the chip are not really touched upon in the datasheet except for the mention that it uses a sigma-delta adc (something I have yet to understand).

I was wondering if you had any ideas on how I should set myself up for testing the linearity of the device? I am thinking that I will need a precise way to move up/down and measure my displacement. Then I should collect my data and capacitance vs distance in order to extrapolate a transfer function. Does this sound like I'm on the right track? Then, when I find this I can install it on the torch table and modify the offset and gain registers to compensate for the fact that the whole machine is pretty much at ground since it's all made of metal. It would be nice to be able to insulate the y axis (the axis that moves the head along the width of the table) from the rest of the table...

Before I do any of this, though, I should make sure that I am actually getting the right kind of data. When we are measuring the capacitance to ground, which ground is this? The chip's ground, right? So why does nothing change even when I short sense to ground? I should read more about capacitive sensor theory.

In the datasheet the image of the sense wire is always a coaxial cable. I wonder if I might ask you again, because I still don't understand, why the flat-flex wire jumper cable is suitable? I know nothing, but I thought that the best noise cancellation occurs when you have a conductor encased 360 degrees by a shield.

I attached some pictures and a video. The pictures show the way it's laid out on the desk and the data it gets in the configuration shown in the picture.

This video : <http://youtu.be/t2xOkvoXIOk> shows activity when I move my body near it.

Best,
Aidan
[Quoted text hidden]

2 attachments



DSC01256.JPG
2720K



DSC01255.JPG
1510K

Aidan Williamson <aidan.d.williamson@gmail.com>
To: Paul <[email address withheld]>

Sun, Jul 6, 2014 at 9:49 AM

By the way, and out of curiosity, would you be interested in visiting Factor E Farm sometime this summer? Yann Lischetti (sp?) of the Velocar project is currently on-site to build a prototype of his product and there are a few other things happening. I ask mainly out of my own desire to work in person with someone with your level of understanding.

[Quoted text hidden]

Paul <[email address withheld]>
To: Aidan Williamson <aidan.d.williamson@gmail.com>

Sun, Jul 6, 2014 at 11:05 AM

With a 3 conductor flex cable the center conductor is actually quite well shielded and it has much lower parasitic capacitance than coax.

For a test capacitance a 3 x 3 cm parallel plate capacitor spaced 1cm has a capacitance of 0.797 pf. Spaced 1 mm it has a capacitance of 7.97 pf. Put various insulators like paper or cardboard between the plates and use that for testing. Measure the thickness of the paper/cardboard with a caliper. Alternatively use plastic between the plates. Slip in additional pieces to vary the capacitance. The formula for air parallel plate capacitance is:

$C = (8.854 \cdot \text{area}^2) / \text{gap}$ capacitance in pf, area and gap in meters.

Yes. it uses single ended mode. The workpiece should be at chip ground. Shorting the sense pin is not recommended.

With this code

```
Wire.beginTransmission(0x48); //begins transmission again
Wire.write(0x09);           //address pointer for capacitive channel excitation register
Wire.write(0x0F);           //This will vary depending on your setup. See page 17 of datasheet
the converter will be running at the extremes of its range. You might change that to:
Wire.write(0x0E);
to use 1/8 to 7/8 of its range.
```

Paul

[Quoted text hidden]
[Quoted text hidden]

Aidan Williamson <aidan.d.williamson@gmail.com>

Sun, Jul 6, 2014 at 1:26 PM

To: Paul <[email address withheld]>

What kind of material do you recommend using for the plates? Does it matter if they are dissimilar?

I get this data in three bytes and I am not sure how combine them. I have to add the incoming twi stack right? Do you have a suggestion as to how to go about doing this in my code? And when I combine them, how does the data correspond to farads... or does that even matter? Do I have to discover this myself? I need to do two things: 1 is to make sure the ad7747 is functioning properly in this experimental circuit; 2 is to find out how the data corresponds to

nevermind it doesn't necessarily matter how it corresponds to units of farads because it only matter how it corresponds to distance - per our application... right?

thanks for your patience,
Aidan

[Quoted text hidden]

Aidan Williamson <aidan.d.williamson@gmail.com>

Sun, Jul 6, 2014 at 1:29 PM

To: Paul <[email address withheld]>

I will set up your recommended test jig tonight and take plenty of pictures/ record the data.

I want to modify my code so that it only updates the serial monitor when the data changes.

[Quoted text hidden]

Paul <[email address withheld]>

Sun, Jul 6, 2014 at 1:32 PM

To: Aidan Williamson <aidan.d.williamson@gmail.com>

The plates need to be conductive. Anything from aluminum foil to steel.

Paul

[Quoted text hidden]

[Quoted text hidden]

Aidan Williamson <aidan.d.williamson@gmail.com>

Sun, Jul 6, 2014 at 1:42 PM

To: Paul <[email address withheld]>

haha yeah i figured that one out!

I was wondering if I would get better results with specific materials

[Quoted text hidden]

Paul <[email address withheld]>

Sun, Jul 6, 2014 at 2:33 PM

To: Aidan Williamson <aidan.d.williamson@gmail.com>

```
unsigned char hi,mid,lo;
long val;
float pf;
hi=Wire.read();
mid=Wire.read();
lo=Wire.read();
val=hi<<16+mid<<8+lo-0x800000;
pf=(float)val/(float)0x800000*8.192f;
```

Paul

On 14-07-06 02:26 PM, Aidan Williamson wrote:

8.1957159042,
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[Quoted text hidden]

Aidan Williamson <aidan.d.williamson@gmail.com> Thu, Jul 10, 2014 at 8:03 AM

To: Paul <[email address withheld]>

<https://www.youtube.com/watch?v=NZqa3A80I5Q>

Data is not changing no matter where the plates are relative to each other. I think there may be some parasitic capacitance that is drowning out my data. I will try to do some offsetting. It would be nice if I had a capacitance meter so that I could measure various points on your board.

Current code: <http://pastebin.com/TjEysF9B>
is the 0x800000 in the pf equation for setting the zero scale?

I tried reading right from the CAP DAC A register (page 19) and I am getting 0x02 which occasionally jumps to 0x07 seemingly randomly.

Could be that the chip is bad?

Saelig failed to inform us that the scope we bought was out of stock. So i'm pushed back another week on that end.

-Aidan

[Quoted text hidden]

Paul <[email address withheld]> Fri, Jul 11, 2014 at 6:59 AM
To: Aidan Williamson <aidan.d.williamson@gmail.com>

Remove readycheck() and try something along these lines:

```
void loop(){  
    Wire.beginTransaction(0x48); //talking to chip  
    Wire.write(byte(0x00));      //status register address
```

```

Wire.endTransmission();
Wire.requestFrom(0x48,1); //request status register data
ready=Wire.read();
if((ready&0x1)==0){ // ready?
Wire.beginTransmission(0x48); //arduino asks for data from ad7747
Wire.write(0x01); //set address point to capacitive
DAC register 1
Wire.endTransmission(); //pointer is set so now we can
read the data
Wire.requestFrom(0x48,3); //reads data from cap DAC
registers 1-3
while(Wire.available()){
unsigned char hi,mid,lo; //1 byte numbers
long capacitance; //will be a 3byte number
float pf; //scaled value of capacitance
hi=Wire.read();
mid=Wire.read();
lo=Wire.read();
capacitance=(hi<<16)+(mid<<8)+lo-0x800000;
pf=(float)capacitance*-1/(float)0x800000*8.192f;
Serial.print(pf, DEC); //prints the capacitance data in
decimal through serial port
Serial.print(",");
}
Serial.println();
}
delay(100);
}

```

Aidan Williamson <aidan.d.williamson@gmail.com>

Fri, Jul 11, 2014 at 8:48 AM

To: Paul <[email address withheld]>

Same deal. Prints the maximum value of capacitance (8.192pf). I added some serial prints scattered about to make sure it's executing the entire program before looping.

I think we either have a problem of parasitic capacitance of a greater value than the sense to ground capacitance or the chip needs to be replaced after a week of being roughed around.

I have taken the following readings (with a cheap DMM while we wait for the scope to show) :

Vcc: 4.7v

Vsense to Vshield: ~30mv max

V sense to gnd: ~2.5v

If i disconnect the sense and shield cable then my reading does this:

```

Data Ready
Data Incoming
8.1920013427pF
Loop Done

Loop Done

Loop Done

Data Ready

```

Data Incoming
8.2018308639pF
Loop Done

On page 19 there is the CAP DAC A register description. The value of Cin that we get will be equal to the capacitance between sense and ground minus the value of this register - if I have understood the datasheet correctly.



So maybe I have to give that register the value that I am reading with nothing connected?

Thanks for your help so far it's been invaluable to me good sir,
Best
Aidan

[Quoted text hidden]