More

The amateur Programmer

Revitalizing old hard drive motors using Arduino

Hard drives use brushless motors (BLDC motors)
Brushless motors are more durable than ordinary carbon brush motors because they lack a commutator (which is a brush rubbing a pair of cyclic magnets to reverse the direction of current)

For brushless motors they use electronic switches to reverse the current.
In BLDC motors the coils are wrapped on the stator, while the rotor has a permanent magnet attached to it.

However, it should be noted that a brushless motor cannot be driven by ordinary Direct Current.

This article tries to demonstrate how to run a Hard drive scraped BLDC motors by using a microcontroller/ rapid prototyping board **Arduino**.

This method is based on this video
http://www.youtube.com/watch?v=CMz2DYpos8w

Principles
Use Arduino sends pulses to Darlington Transistors.
There are 3 phases in the motor. Each phase is controlled by one Arduino Pin.
For example,

---------time---------------->
phase1pin:100100100
phase2pin:010010010
phase3pin:001001001

where 1 = High signal in Arduino pin, causing Darlington Transistor to supply current to the motor.
Scraping hard drive motors
You need:

Torx screw drivers (especially T8)
common screw drivers

Technique: No special attentions needed. Just unscrew them all. Some screws may be hidden under the label.

(There is a ribbon connected to the drive; **DO NOT PULL** it off because there are very thin wires

Blog Archive

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About Me

Hermann M

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which are connected to the coils of the motor inside. I suggest soldering additional wires like the photo above)

Testing which lead is <u>common</u>
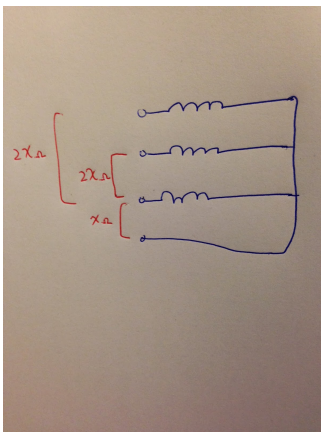
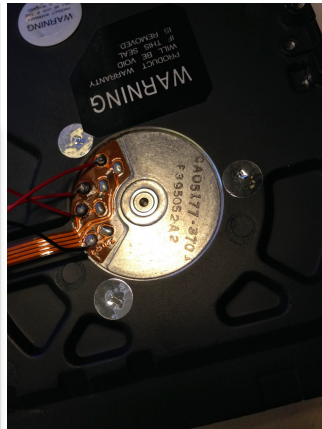Usu ally a hard disk BLD C is a 3-

Fig 2

Fig 1

phase BLDC, which has 3 phases + 1 common = 4 wires

Use a multimeter to test for resistance on those 4 points:

A common lead + coil = 1x ohm
A coil + a coil = 2x ohm (Fig.2)

Then solder extending wires. In Fig. 1, the common wire is in black color.

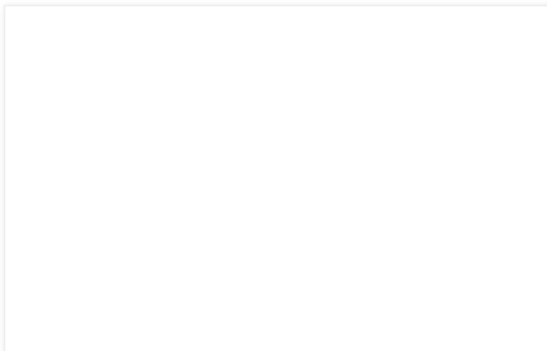### Connecting to Arduino
Arduino:
- We need 3 digital pins to send the signal, say pin 2,3,4

Breadboard components:
- 1k ohm resistors *3
- TIP122 darlington pairs *3
- diode 1N4004 *3
- battery power 5 to 12V

Connect them as shown in Fig. 3 and Fig 4

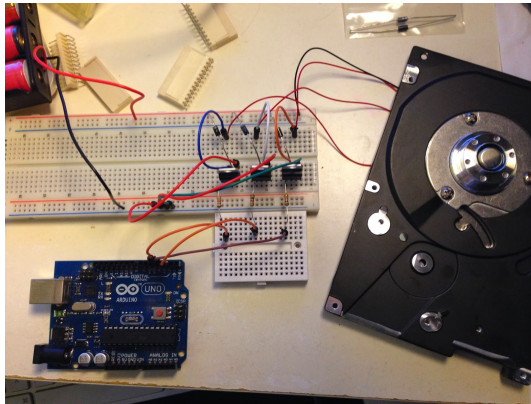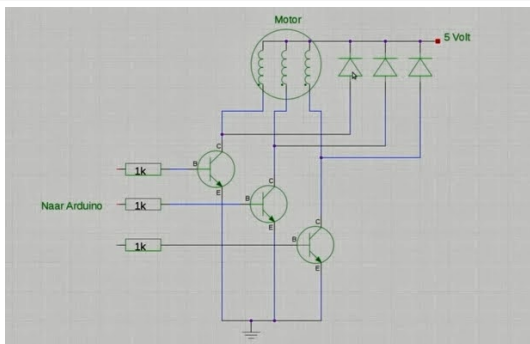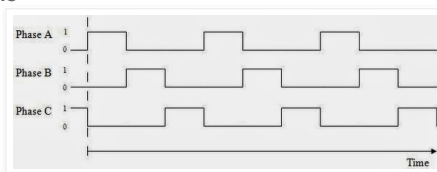Fig 3

Fig 4

Coding Arduino

Simple switching

```
const int phase1pin = 2;
const int phase2pin = 3;
const int phase3pin = 4;
const int delayTime = 6000; // microsecs

void setup(){
  Serial.begin(9600);
```

```
    pinMode(phase1pin, OUTPUT);
    pinMode(phase2pin, OUTPUT);
    pinMode(phase3pin, OUTPUT);
}

void loop(){
  switchStep(1);
  switchStep(2);
  switchStep(3);
}

void switchStep(int stage){
  switch(stage){
    case 1:
      digitalWrite(phase1pin, HIGH);
      digitalWrite(phase2pin, LOW);
      digitalWrite(phase3pin, LOW);
      delayMicroseconds(delayTime);
      break;
    case 2:
      digitalWrite(phase1pin, LOW);
      digitalWrite(phase2pin, HIGH);
      digitalWrite(phase3pin, LOW);
      delayMicroseconds(delayTime);
      break;
    case 3:
      digitalWrite(phase1pin, LOW);
      digitalWrite(phase2pin, LOW);
      digitalWrite(phase3pin, HIGH);
      delayMicroseconds(delayTime);
      break;
  }
}
```
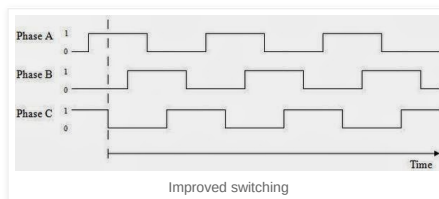
Improved version
The phases overlap with the previous phase by 1/4 cycle to improve the rotation transition.
In this version the motor is slowly accelerating to the max speed.

Improved switching

```
const int phase1pin = 2;
const int phase2pin = 3;
const int phase3pin = 4;
float holdTime = 50000; // microsecs
const unsigned long minHoldTime = 1300;

unsigned long p1start,
              p1end,
```

```
                p2start,
                p2end,
                p3start,
                p3end;

void setup(){
  Serial.begin(9600);
  pinMode(phase1pin, OUTPUT);
  pinMode(phase2pin, OUTPUT);
  pinMode(phase3pin, OUTPUT);
  p1start = micros();
  digitalWrite(phase1pin, HIGH);
}


void chkP1(){
  unsigned long currentTime = micros();
  unsigned long td = currentTime - p1start;
  unsigned long refractory = 2.25*holdTime;
  if(digitalRead(phase1pin)){
    if(td > holdTime){
      digitalWrite(phase1pin, LOW);
      p1end = currentTime;
    }
  }else if(td > refractory){
    digitalWrite(phase1pin, HIGH);
    p1start = currentTime;
  }
}

void chkP2(){
  unsigned long currentTime = micros();
  unsigned long td = currentTime - p1start;
  if(digitalRead(phase2pin)){
    if(td > 1.75*holdTime || td < 0.75*holdTime){
      digitalWrite(phase2pin, LOW);
      p2end = currentTime;
    }
  }else if(td > 0.75*holdTime && td < 1.75*holdTime){
    digitalWrite(phase2pin, HIGH);
    p2start = currentTime;
  }
}

void chkP3(){
  unsigned long currentTime = micros();
  unsigned long td = currentTime - p1start;
  if(digitalRead(phase3pin)){
    if(td > 0.25*holdTime && p3start < p1start){
      digitalWrite(phase3pin, LOW);
      p3end = currentTime;
    }
  }else if(td > 1.5*holdTime){
    digitalWrite(phase3pin, HIGH);
    p3start = currentTime;
  }
}

void loop(){
```

```
  chkP1();
  chkP2();
  chkP3();
  delayMicroseconds(100);
  if(holdTime >= minHoldTime){
    holdTime -= 0.5;
  }
}
```

That's it.

For my 5400rpm hard disk motor, I used 3.7*3 = 11.1V
The min cycle period = 1.3ms
i.e. it takes about 1.3*2.25*2 = 5.85ms for 1 rev
=> about 10k rpm

Any further decrease in cycle period leads to an halt.

Increasing voltage allows shorter cycle period (prabably due to a stronger torque => higher rotation speed)

Addition info:
I dismantled / disassembled one of the BLDC motor, shown below:

The 4 wires were accidentally broken by me. So I punched the center of the axle to separate the rotor

Please ignore the bearing in the middle. It is totally irrelevant and it belongs to my other projects.

Posted by Hermann MK at 5:13 AM

30 comments:

Python February 27, 2014 at 2:06 AM

Hello, I was looking how to run old HDD stepper motor. Yesterday I found your article, build up the circuit, but something going wrong after 20 sec. Stepper motor stops spinning and I don't know what to do. Also stepper motor works only with second code. I wonder can you help me, because I don't know where to look for a problem.

Reply

▼ Replies

Unknown August 19, 2014 at 6:10 AM

Hey, I tried the second code (the first code needs some modification to work) and i got the same errors and u did. The motor got locked after some 20s. To correct this this, like Hermann MK said, we have to determine the "optimum signal interval" (Kudos! Hermann MK for the article). To do that try increasing the value of "minHoldTime", until your motor starts running smoothly without locking. (in my case it was 2400us).

Furthermore, if you want to increase/decrease the acceleration to reach the optimum speed, you can increase/decrease the signal hold interval shortening time. That is the final section of the code.
E.g (holdTime -=1; shortens the signal hold interval by 1us for every loop of 100us).

Reply

Hermann MK February 28, 2014 at 4:55 AM

Hi. The second code is actually instructing the motor to spin faster and faster
(as you can see in the main Loop, holdTime -= 0.5; i.e. For every 100us loop, the signal hold interval shortens by 0.5us).

However, there are different limits for different motors. Since we dont have a hall sensor, we cant sense the position of the rotor. If the signal pulses are given too fast but the rotor cannot keep up with the speen, it will be stuck. So I think we have to determine the "optimum signal interval" by experience.

Reply

Kormoran September 11, 2015 at 5:16 AM

Stepper motors have usually a critical speed (or more than one) that resonate mechanically. At that speed the motor can stop with very small resistant couple, or even stop without any mechanical load connected. I guess this is not a problem for an HD cause they run at fixed speed, but for other uses this can be a problem

Reply

Blogger September 24, 2015 at 9:57 PM

This comment has been removed by the author.

Reply

Blogger September 24, 2015 at 9:57 PM

good job dude... and thanks for explaining everything :)

Reply

Emanuel1989 February 15, 2016 at 12:52 AM

This comment has been removed by the author.

Reply

Unknown March 10, 2016 at 3:29 PM

Hello, but ir you use a push pull output stage obtain better response, you don't need center star coil connection, if you want use it center star use dual symmetrical power supply for power push pull stage and the center of star connected to GND power l, it improve full power at motor start better acceleration.

Reply

▼ Replies

Emanuel1989 March 11, 2016 at 2:51 PM

Could you please send a link to Fritzing diagram of your solution?

Thanks in advance,

Kamil

Pradeep Salve April 8, 2016 at 4:29 AM

I tried the Push Pull (complete electronics Noob here, understanding things slowly as I learn from the net)
Example: 3 TIP127 (High Side) (triggered on off by 3 TIP122) 3 TIP 122 Low Side. Used the proper sequence after testing the motor. Commutations are A-B, B-C, C-A. Applied the same through Arduino code. Doesn't work.
Could you please elaborate your concept.

Reply

Unknown April 6, 2016 at 5:43 AM

Hi ... Motor how many KV ? How many rpm ?

Reply

Unknown April 6, 2016 at 5:58 AM

http://www.pilottr.com/urun/iflight-ibm1811-13-2000kv-model-motor.html?srt=UP This engine is okay to use , is that it works with arduino code ?

Reply

Pradeep Salve April 8, 2016 at 4:04 AM

I took out the motor out of a 14 year old Seagate Barracuda (7200rpm/blown up SMOOTH controller). It has only 3 wires (no center tap). I tried this circuit a month ago. Didn't Work. Had been banging my head for the entire month. Got a 30A ESC and Servo Tester. The Motor only WALTZed no matter what settings I tried. Even tried 3 TIP127 High Side Switches (controlled through 3 TIP122) coupled with 3 TIP122 Low Side Switches (through Arduino UNO).Didn't Work. Yesterday I decided to give this circuit another go. After Watching the video carefully, I connected one extra wire from Positive Rail directly to one of the leads of the motor. Now, the first code works but with slow speed. The second Shorts out as someone said, 20 seconds in.

SO i used the code in the video (http://bartvenneker.nl/schemas/Code_arduino_hdd.txt) and kept on adjusting the "minStepLength". With the platter on, motor speeds up and maintains speed if value is above 4000. With no load, I could go down to 1600 with really good high rpm (supply of 12V).

Problem: This is just a temporary solution and the TIP122 to whose Outgoing lead the Positive input is connected gets hot and is hotter than the other two. It still hasn't blown up though. Plus with this configuration I can hear a ticking sound from the motor. Most probably because it is not meant to be run this way and I think it will damage the windings in the long run.

Can someone please, please suggest a work around??!!

Reply

▼ Replies

Player3 February 1, 2017 at 8:40 AM

Based on the measurements I took on one I have with a 3-pin motor, I believe it's 3 coils and no common pin. I don't know that this design will work without the common lead.

I'm no electrical engineer, but it looks like the power for the motor is carried on the common pin and then flows through the coils as each transistor is pulled to ground.

Based on that, I think you'd have to run power to each of the 3 pins and not just to the one pin you had it wired to.

Reply

Unknown April 16, 2016 at 1:05 PM

This comment has been removed by the author.

Reply

Unknown April 16, 2016 at 2:39 PM

This comment has been removed by the author.

Reply

Unknown May 27, 2016 at 1:23 PM

Hi, can i use a flip flop like 4047b with 3 different square waves to spin the motor?

Reply

Unknown January 13, 2017 at 12:46 PM

Hi can anyone write that code to a pic in mikroc pro please

Reply

Unknown January 23, 2017 at 4:46 PM

Hi, Im having the same problem as an above user. I only have 3 pins and no ground, suggestions? both codes are giving vibrations or very jerky motor movement

Reply

Player3 February 1, 2017 at 8:58 AM

I'm curious about something before I go to try any build this myself.... What are the 1K resistors between the Arduino and the bases on the transistors?

Reply

Unknown February 8, 2017 at 5:15 AM

I tried running a 5400rpm motor with the same circuit as you gave and the improved code but the motor is heating up like hell! i tried running it at lesser rpm also, but still the motor keeps heating up. Can you help me out?

Reply

Unknown February 14, 2017 at 3:17 PM

I am currently working on a spin coater and stumbled across this blog. Using a wall plug as a 12v source instead of the batteries will work right? I would think they would be the same since they are both 12V DC source?

Reply

PMerchant May 25, 2017 at 1:18 PM

I have just disassembled a HDD to see if I can use the motor as a generator. But reading the comments above I have my doubts. But my real comment is to consider the coils as being in Delta format, not star. That would only require 3 pins. But each pin would have dual roles. If I was going further with this i would try and reverse engineer teh PC board that attached to the motor.

Reply

DIAC September 8, 2017 at 3:30 AM

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Reply

LOIS February 5, 2018 at 9:11 AM

hello , nice work what the name is those specific transistors ?
and if so what is there name or the number on it ?

Reply

Jat April 14, 2018 at 2:13 PM

any TTL level mosfet over 5 amps will do the job, I used overkill IRLZ44 but any IRL series
MOSFET will work... then I acheived x2 speed with a smoother accel with this code :

```
void loop(){
chkP1();
chkP2();
chkP3();
//delayMicroseconds(50);
if(holdTime >= minHoldTime){
if (previousup+200<micros()){
previousup=micros();
holdTime -= 0.5;
if(holdTime< 2400){previousup +=20000; holdTime += 0.25;}

// Serial.println(holdTime);
}
}
}
```
cheer's!

Reply

▼ Replies

Jat April 14, 2018 at 2:14 PM

sorry here is the full code :
```
const int phase1pin = 2;
const int phase2pin = 3;
const int phase3pin = 4;
float holdTime = 50000; // microsecs
const unsigned long minHoldTime = 1600;//1300;

unsigned long p1start,
p1end,
p2start,
p2end,
p3start,
p3end;

unsigned long previousup=0;

void setup(){
Serial.begin(9600);
pinMode(phase1pin, OUTPUT);
pinMode(phase2pin, OUTPUT);
pinMode(phase3pin, OUTPUT);
p1start = micros();
digitalWrite(phase1pin, HIGH);
}


void chkP1(){
unsigned long currentTime = micros();
unsigned long td = currentTime - p1start;
unsigned long refractory = 2.25*holdTime;
if(digitalRead(phase1pin)){
if(td > holdTime){
digitalWrite(phase1pin, LOW);
p1end = currentTime;
}
}else if(td > refractory){
digitalWrite(phase1pin, HIGH);
p1start = currentTime;
}
}
```

```
void chkP2(){
unsigned long currentTime = micros();
unsigned long td = currentTime - p1start;
if(digitalRead(phase2pin)){
if(td > 1.75*holdTime || td < 0.75*holdTime){
digitalWrite(phase2pin, LOW);
p2end = currentTime;
}
}else if(td > 0.75*holdTime && td < 1.75*holdTime){
digitalWrite(phase2pin, HIGH);
p2start = currentTime;
}
}

void chkP3(){
unsigned long currentTime = micros();
unsigned long td = currentTime - p1start;
if(digitalRead(phase3pin)){
if(td > 0.25*holdTime && p3start < p1start){
digitalWrite(phase3pin, LOW);
p3end = currentTime;
}
}else if(td > 1.5*holdTime){
digitalWrite(phase3pin, HIGH);
p3start = currentTime;
}
}

void loop(){
chkP1();
chkP2();
chkP3();
//delayMicroseconds(50);
if(holdTime >= minHoldTime){
if (previousup+200<micros()){
previousup=micros();
holdTime -= 0.5;
if(holdTime< 2400){previousup +=20000; holdTime += 0.25;}

// Serial.println(holdTime);
}
}
}
```

Reply

DIAC June 22, 2018 at 12:31 AM

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Reply

Unknown September 19, 2018 at 4:33 AM

The facts confirm that fenced in areas were accessible at the time, however for reasons unknown buyers were not utilizing them all the time. A few walled in areas can be extremely hard to utilize in light of the fact that they expect screws to be loosened before a drive is even embedded. Discuss badly designed. Best hdd docks

Reply

Rj Maan May 17, 2020 at 1:45 AM

Thank you very for such an impressive and informative article. I thought that you might be interested in purcahasing a cheap and affordable hard drives as well.

Reply

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Comment as: ikarus512@yar ⌄

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