Adam's Motor Manual

Adam Orin

February 17, 2006

1   Quick Reference

```
naf ACM 6 13         Enable ZAP to send requests to laser
naf ACM 12 13        Use TR encoder pulses and not internal clock
naf ACM 3 17 data    How many TR pulses after TR index before
                     laser fire (1-4096)
naf ACM 6 17 32768   Set diffuser divide ratio to 10
naf ACM 14 13        Enable diffuser logic
naf ACM 7 0          Read diffuser/TR phase (1-999)
naf ACM 13 13        Disable diffuser logic

naf ACM 6 17 40960+N
Speed diffuser; divide-by-9 N times; then revert div-by-10

naf ACM 6 17 43008+N
Slow diffuser; divide-by-11 N times; then revert div-by-10

naf ACM 6 17 data
data(16bit) = 10  1010  1000000000 = 43008 + 512 (to divide by 11 512 times)
             A    B        C
A: Normal divide by number
   10 = count 9 (div by 10), 01 = count 4, 11 = count 13, 00 = 0
B: Phase adjust count, 4 bit number
   (1010 = count 10 = div by 11)
   (1000 = count 8 = div by 9)
C: How many times to use phase adjust count before reverting to normal
   div by, 10 bit number (1000000000=512 times)

mot start Start the TR motor
mot stop Stop the TR motor
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! Booster must be powered on with 50MHz clock for ZAP to work!

Phase # = number of TR encoder pulses from the rising edge of TR index
          pulse and rising edge of diffuser index pulse
```

2   Introduction

Thank you for selecting the APOLLO motor setup to meet your diffuser-mirror rotating needs. We hope that you will find your experience with the APOLLO diffuser motor a most pleasant one. Enjoy!

The diffuser motor and TR motor are stepper motors. That means you tell them to take a step, and they move a specified amount of degrees. (However, the TR motor is smart enough that you tell it how fast to spin, and it figures out when to take steps on its own.) Each revolution is a certain number of steps.

The TR motor's encoder outputs 1000 pulses for every revolution. So, if it spins at 20 Hz, the TR motor outputs 20000 pulses per second (pps). The TR motor sends out 2 sets of encoder pulses, one 90 degrees out of phase of the other. If you XOR the two pulses together, you get out 2000 pulses per revolution.

The diffuser motor controller has two modes. In "full step" mode, there are 200 steps for every revolution. That means if you move the diffuser motor by one step, it rotates by 1.8 degrees. In "half step" mode, thre are 400 pulses per revolution.

Both motors output an 'index' pulse once every revolution.

When we are ranging, the TR mirror spins at 20 Hz. We want the diffuser to spin at 10 Hz, so every other fiducial pulse goes through the diffusing quadrant. We will use the TR encoder pulses to create diffuser step commands. The ACM has logic that will count TR encoder pulses and send diffuser step commands every nth TR encoder pulse, where n=10, 5, or 14.

Now, there are two modes of operation, one for the diffuser in full step mode, and one for the diffuser in half step mode.

2.1   Full Step Mode

In full step mode, to make the diffuser motor spin at 10 Hz, it needs to be given 2000 step commands per second. The TR outputs 20000 pps, and the diffuser wants 2000 pps. Therefore, we send one step command to the diffuser for every 10 encoder pulses from the TR.

We want to be able to change the relative phase between the diffuser and the TR. The phase is number of TR encoder pulses from the rising edge of TR index pulse and rising edge of diffuser index pulse. Thus, the phase is a number between 0 and X, where X is the number of TR encoder pulses per revolution. In full step mode, if the phase is 250, this means when the TR is at 12 o'clock, the diffuser is at 3 o'clock.

When we want to change the relative phase between the TR and the diffuser, we need the diffuser to spin faster/slower than normal for a little bit. To slow the diffuser down, you can have it divide by 11 instead of divide by 10. And to speed it up, you can have it divide by 9 instead of divide by 10.

So, we tell the ACM logic to divide by d_T instead of by the normal d N times. By how many TR encoder steps does the phase change? Phase changes by

$$N (d_T - d)$$

where negative is a CCW phase change, and positive is a CW phase change.

2.2   Half Step Mode

In half step mode, to make the diffuser motor spin at 10 Hz, it needs to be given 4000 step commands per second. If we use the XOR combination of the TR's two encoder sets, then we have 2000 TR encoder pulses per rev. With the TR spinning at 20 Hz, we get 40000 TR encoder pps. The TR outputs 40000 pps, and the diffuser wants 4000 pps. Therefore, we send one step command to the diffuser for every 10 encoder pulses from the TR. The same logic in the ACM works in both scenarios.

2.3   Things to be Aware of

- If you read the diffuser phase over and over, it semes to vary between 2 consecutive values (like 320,321) even when it's stable.

3   The Electric - Plugging it all in and powering it on

3.1   Diffuser Motor Setup

- The motor controller wants 12-35V DC. The lower the voltage you put in, the more current it will spit out to the motor to get it spinning. We typically run the diffuser with 20V DC.

- The motor has a full step mode and a half step mode. In full step mode, 200 steps is one revolution. In half step mode, 400 steps is one revolution. This is set by the little switchbox on the motor controller.

- The little switchbox on the motor controller also controls how much current is sent to the motor per phase. We have it set to one amp. See motor controller manual for details.

- Ther are several ways to wire up the motor leads. See the motor controller manual for details.
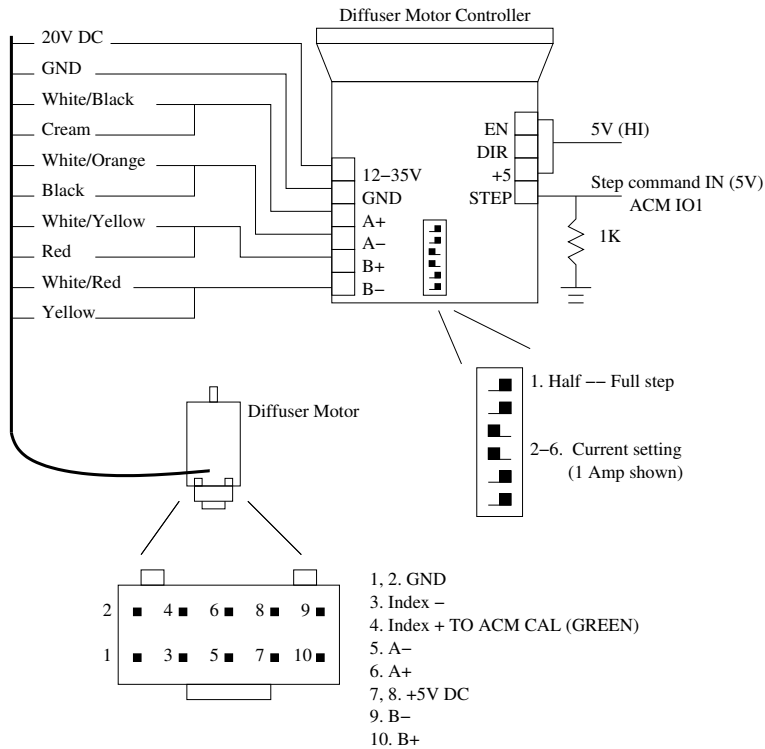
- See Figure 1

Diffuser Motor Controller

20V DC
GND
White/Black
Cream
White/Orange
Black
White/Yellow
Red
White/Red
Yellow

12–35V
GND
A+
A−
B+
B−

EN
DIR
+5
STEP

5V (HI)

Step command IN (5V)
ACM IO1

1K

Diffuser Motor

1. Half –– Full step

2–6. Current setting
(1 Amp shown)

2   4   6   8   9
1   3   5   7   10

1, 2. GND
3. Index −
4. Index + TO ACM CAL (GREEN)
5. A−
6. A+
7, 8. +5V DC
9. B−
10. B+

Figure 1: Diffuser motor wiring.

3.2   TR Motor Setup

- See Figure 2

- The TR motor has a male high density 15-pin D connector on the back. This is where the serial communications and digital I/O are available. Only 3 pins are dedicated to the serial port. A full 9 pins are for the digital I/O. The digital I/O is where the TR encoder and index output pulses are available.

- The TR motor has a male 3 pin thingy for the 48 V that powers the motor.

- The 48 V power has to go both into the large 3-pin connector and into the 15-pin connector.

- The TR motor has two encoder outputs. Both are 1000 pulses per revolution, but one is 90 degrees phase shifted with respect to the other. So, ENC1 XOR ENC2 = 2000 pulses per revolution, with a 50 percent duty cycle.
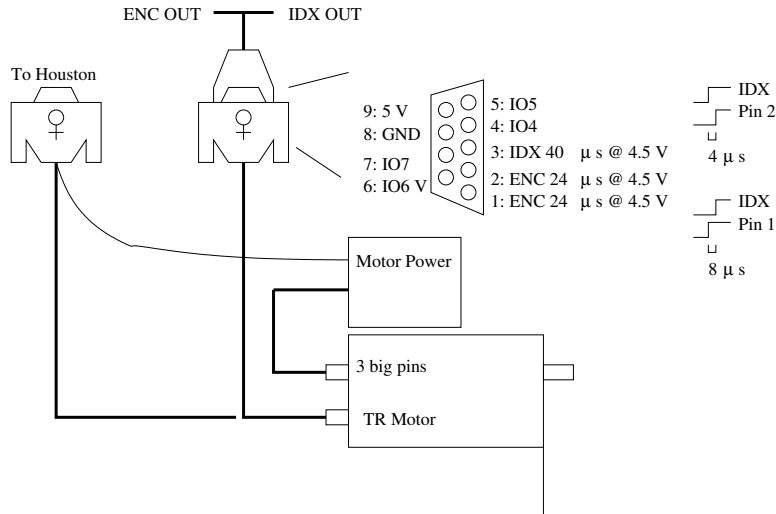
- The table below is available in the Silvermax manual.

4

ENC OUT — IDX OUT

To Houston

9: 5 V
8: GND
7: IO7
6: IO6 V

5: IO5
4: IO4
3: IDX 40 μ s @ 4.5 V
2: ENC 24 μ s @ 4.5 V
1: ENC 24 μ s @ 4.5 V

IDX
Pin 2

4 μ s

IDX
Pin 1

8 μ s

Motor Power

3 big pins

TR Motor

Figure 2: TR motor wiring.

TR output pin	Description	Serial	Digital IO
1	+48V in		
2	TX	2	
3	5V, 100mA supply out		9
4	I/O 3 (IDX)		3
5	I/O 6		6
6	48V GND in		
7	+48V power		
8	Logic GND	5	8
9	I/O 2 (ENC2)		2
10	I/O 5		5
11	48V GND in		
12	RX	3	
13	I/O 1 (ENC1)		1
14	I/O 4		4
15	I/O 7		7

3.3   ACM (APOLLO Command Module)

The ACM has programmable logic devices that have been instructed to both listen and shout at the diffuser motor. You don't need the 50 MHz clock or One Pulse Per Second inputs if you don't plan on having the laser (ZAP) work.

- I/O 1: This is the step command *output* to the diffuser motor. It is a TTL signal.

- CAL: This is the index *input* from the diffuser motor.

- IDX: This is the index *input* from the TR motor.

- ENC: This is the encoder *input* from the TR motor.

4   The Digital

4.1   TR Motor

Houston commands the TR motor through the serial port. There is a program called "mot" to run the thing.

- mot: This will bring up a list of options.

- mot start: This starts the motor a-going.

- mot stop: This stops the motor.

- mot speed '#': This will change the speed of the motor (# = revs/sec). Don't change the speed while it is running!

4.2   Diffuser Motor

The APOLLO Command Module is what is sending out the diffuser step commands to the diffuser. And we set up the AMC via NAF commands.

naf ACM 14 13
This command will enable the ACM's diffuser logic.

naf ACM 13 13
This command will disable the ACM's diffuser logic.

naf ACM 7 0
This command will read out the diffuser/TR phase. The phase is the number of TR encoder pulses between the TR motor index and the diffuser motor index. Thus, the phase is a number between 0 and 999. If the phase is 250, this means when the TR is at 12 o'clock, the diffuser is at 3 o'clock.

naf ACM 6 17 data
This is the important command. This lets you set the normal divide-by, the temporary divide-by , and the number of times to use the temporary divide-by. The data you send is a 16 bit number:

```
data(16bit) = 10  1010  1000000000
              A    B       C
```

```
A: (2 most significant bits) The normal divide-by.
   10 = count 9 TR steps and send diffuser step command
        on the 10th TR step (divide by 10),
   01 = count 4 (divide-by-5)
   11 = count 13 (divide-by-14)
   00 = don't send diffuser step requests

B: (next 4 significant bits) The temporary divide-by.  Simply the
   number of TR steps to count, in binary.
   1001 = count 9 TR steps then send diffuser command (divide-by-10)

C: (10 least significant bits) How many times to use temp divide-by.
   1000000000 =5 12 use temporary divide-by 512 times
```

So, for normal divide-by-10 operation:
data = 10 0000 0000000000 = 32768

To divide-by-9 n times, then resume to divide-by-10:
data = 10 1000 n = 40960 + n

To divide-by-11 n times, then resume to divide-by-10:
data = 10 1010 n = 43008 + n