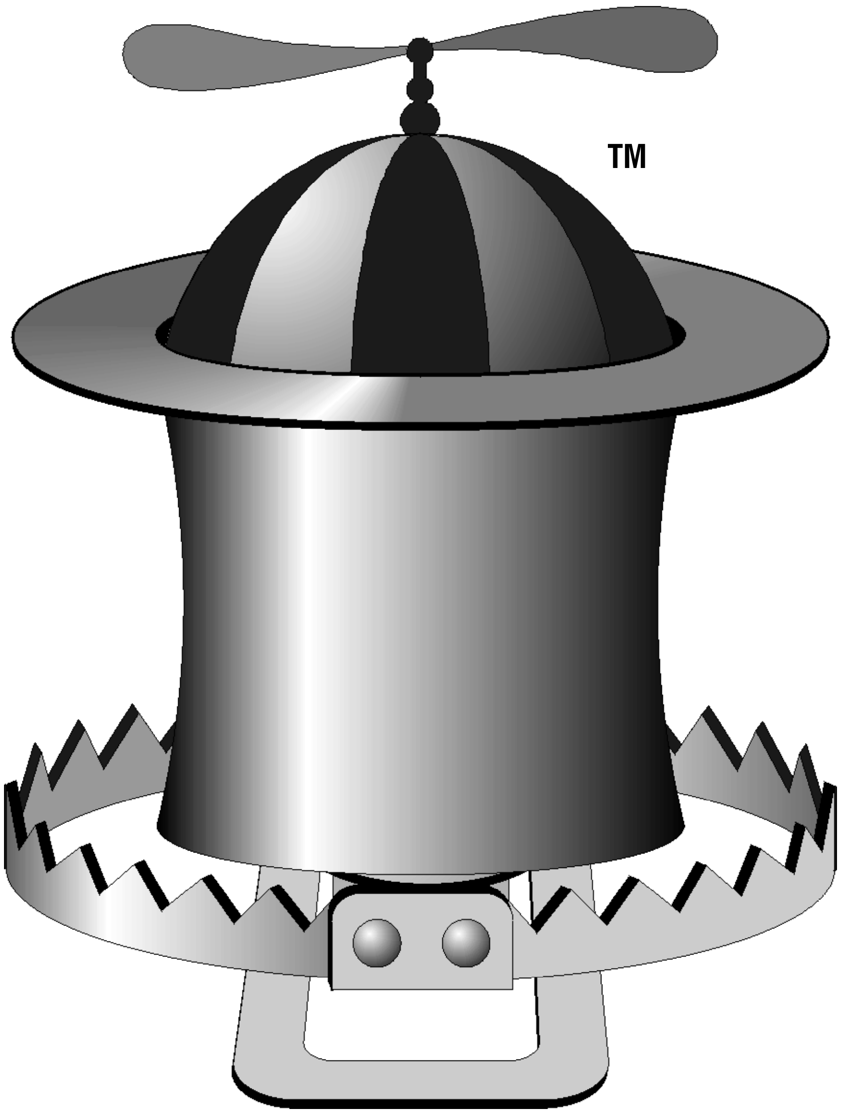
Propeller™ Tricks & Traps



Phil Pilgrim
Bueno Systems, Inc.

Version 2007.09.28

Introduction

This document is, and always will be, a work in progress. It's designed to be a compendium of tricks stumbled into and traps fallen into while learning to program Parallax's Propeller chip. At this early stage in my own learning curve, it may seem ruefully pretentious to produce such a document. But I wanted to get the information down while it was still fresh in my mind and to have a vehicle for recording my adventures and misadventures with the Propeller as they happened. I know if I wait, I'll forget both my discoveries *and* my mistakes and probably have to repeat them. Hopefully, this will be a time-saver for other programmers, as well, as they probe the Propeller's many wonders and mysteries.

As yet, this document is not organized by category but is, rather, just a jumbled potpourri of miscellania. As more stuff gets added, it may become apparent how better to organize it.

Contributions

Anyone encountering this document who would like to contribute or make corrections to it is welcome to do so. Just leave a posting in the "Tricks & Traps" thread in Parallax's Propeller forum. I will include it as my time allows and as my sole editorial discretion deems it suitable. Credit will be given to contributors. Just make sure to include how you'd like to be credited.

Copyright

Disclaimer

Trademarks

Assembly Tricks & Traps

Immediate Addressing

Trick: You can use immediate addressing when your source operand is 9 bits or less. Just prepend the constant with a pound sign:

```
      MOV   Dest, #53
```

This statement loads the value **53** into **Dest**.

Immediate Addressing

Trap: Make sure, when using immediate addressing, that your operand doesn't exceed nine bits in length. If it does, only the least-significant nine bits will be used. The following code loads **Dest** with the value $1A5.

```
   MOV      Dest, #$A5A5A5A5
```

Thankss to André LaMothe

MOVI
MOVS
MOVD

Trick: You can use the **MOVI**, **MOVD**, and **MOVS** commands to load the Instruction (bits 31 .. 23) , Destination (bits 17 .. 9), or Source (bits 8 .. 0) fields of any writable memory destination. This technique is a handy way to achieve indirect addressing:

```
                  MOVS  :Indirect,Address
                  .. some other instruction(s) ..
   :Indirect      MOV   Dest,0-0
```

In this example, the contents of the memory at **Address** are stuffed into the source field of the **MOV** instruction at **:Indirect**. When the **MOV** instruction executes, the contents of the memory at *that* address will be loaded into **Dest**. (The **0-0** is just a way to indicate that something will be stuffed into that location from elsewhere.)

Indirect Addressing

Trap: Never modify the instruction following the one doing the modifying. If the prior example had been written:

```
                  MOVS  :Indirect,Address
   :Indirect      MOV   Dest,0-0
```

it would not have worked as expected. The reason is that the Propeller uses a two-stage pipeline. As one instruction is executing, the next one is being fetched. By the time the **MOVS** is finished executing, the **MOV** instruction *with its prior source field contents* will already have been loaded. Always insert at least one additional instruction between modifier and modified. Use a **NOP** if you have to.

Subroutine Parameters

Trick: You can use inline subroutine arguments to improve a program's readability and encapsulation:

```
                CALL  #Subroutine
                LONG  Arg1
                LONG  Arg2

                ..


Subroutine      MOVS  :GetArg1,Subroutine_ret
                ADD   Subroutine_ret,#1
:GetArg1        MOV   :Arg1,0-0
                MOVS   GetArg2,Subroutine_ret
                ADD   Subroutine_ret,#1
:GetArg2        MOV   :Arg2,0-0

                ..

                JMP   Subroutine_ret

:Arg1           LONG  0-0
:Arg2           LONG  0-0

Subroutine_ret RET
```

In this example, **Subroutine** is called with two arguments, having *values* **Arg1** and **Arg2**. When **Subroutine** is **CALL**ed, the address of **Arg1** is written into memory at **Subroutine_ret**. The first instructions in **Subroutine** use indirect addressing to retrieve **Arg1** and **Arg2** and place their values in **Subroutine**'s local variables, **:Arg1** and **:Arg2**, respectively. One advantage to this method is that you don't need to use global variables to pass parameters to a subroutine.

Notice that the **JMP Subroutine_ret** is an indirect jump. It jumps to the address *contained* in **Subroutine_ret**. We could have used immediate addressing, but that would have resulted in *two* jumps to exit the routine, rather than one.

This is an example of "call by value". You can also implement "call by reference", wherein **Arg1**, for example, might contain the *address* of the value you wish to pass. In this case, you would have to do the indirect addressing twice to get the value within the subroutine.

JMP Direct

Trap: It's *so* easy to forget that the source field of a **JMP** follows the same rules as any other instruction. If you're jumping directly to a location in memory, use immediate addressing:

```
                JMP   #Here
                ..
Here
```

Failure to include the pound sign (#) can be a frequent source of headaches.

JMP Indirect

Trick: Indirect **JMP** addressing *can* come in handy for implementing things like state machines, though. Here's an example of a three-state loop, whose state variable is the address contained in the source field of memory location **StateMachine**:

```
Init            MOVS  StateMachine,#State1
                JMP   StateMachine

State1          do state1 stuff
                MOVS  StateMachine,#State2
                JMP   #Common

State2          do state2 stuff
                MOVS  StateMachine,#State3
                JMP   #Common

State3          do state3 stuff
                MOVS  StateMachine,#State1
                JMP   #Common

                ..

Common          common post-state code
                ..

                JMP   StateMachine

                ..

StateMachine    RES   1
```

Of course, more complicated state machines can be designed by choosing the next state based on some condition. But this simple example should be enough to get started with.

Thanks to M. Park for suggesting improvements to this example.

Comparing and testing

Trap: The Propeller has a **TEST** instruction that lets you set flags based on the outcome of ANDing the instruction's source and destination arguments. *But be sure to tell it which flags to set* using **WZ** and/or **WC**. This doesn't happen automatically, just because it's a test instruction. The same applies to the compare instructions (**CMP**, **CMPS**, **CMPSX**, and **CMPX**).

Comparing and testing

PAR
CNT
INA
INB
PHSA
PHSB

Trap: You can use the compare and test instructions to test port input bits. *But beware statements like the following:*

```
                TEST  INA,#%0010        WZ
```

It just won't work. Why? Because **INA** is *read-only*. And you can't use read-only locations in the destination field of an instruction. You will have to do the following instead:

```
                TEST  Mask,INA          WZ
                ..
Mask            LONG  %0010
```

The read-only locations include **PAR**, **CNT**, **INA**, and **INB**. **PHSA** and **PHSB** should also not be used in the destination field of these instructions.

Multi-cog Shared Labels

Trap: The **DAT** section of a .spin file can contain assembly code for more than one cog. Each cog, when loaded, gets 512 longs from hub memory, beginning at the address given in **COGNEW** or **COGINIT**. The beginning of each cog's assembly code should begin with an **ORG** statement. This resets the assembler's address counter so that subsequent addresses will be correct when the code beginning at the **ORG** is loaded into its cog for execution. Now, you may be tempted to share code and data among different **ORG**ed sections, as in the following example:

```
                ORG
Cog1            CALL  #Common
                ..

                ORG
Cog2            CALL  #Common
                ..

Common          common subroutine
                ..
Common_ret
```

But resist the temptation. Even though **Common** may be included with **Cog1** when it loads, the address computed for it by the assembler will be relative to the beginning address of **Cog2**, because of the subsequent **ORG**. And it's *that* (incorrect) address that gets assembled into Cog1's **CALL** statement.

WRBYTE
WRWORD
WRLONG

Trap: In Propeller assembly code, the usual direction of data transfer is from source to destination. The **WRBYTE**, **WRWORD**, and **WRLONG** are exceptions to the rule. These statements all write data *from* cog memory at **from_cog** *to* hub memory at **to_hub**:

```
               WRBYTE      from_cog,to_hub
               WRWORD      from_cog,to_hub
               WRLONG      from_cog,to_hub
```

Thanks to Paul Baker

RES
LONG

Trap: Be sure to place **RES** statements *at the end* of any **ORG** segment that uses them. The following example does it *wrong*:

```
               MOV         Time,CTR
               ADD         Time,Offset
               ..

Time           RES         1
Offset         LONG        230
Other_value    LONG        123

               ORG
Another_cog    ..
```

In this example, **Offset** will get clobbered when **CTR** is copied to **Time**, and **123** will get added to it instead of **230**. Why? Because when the assembler encounters a **RES**, it reserves space in cog memory, but not in hub memory where the program is stored. Consequently, **230** will occupy **Time**'s address in hub memory, and **123** will occupy **Offset**'s. Do this instead:

```
               MOV         Time,CTR
               ADD         Time,Offset
               ..

Offset         LONG        230
Other_value    LONG        123
Time           RES         1

               ORG
Another_cog    ..
```

In this example, whatever's assembled at **Another_cog** will get loaded into **Time** when the first cog loads. But we don't care, since **Time** will get written over anyway.

Thanks to Beau Schwab

CALL #:Local

Trap: The Propeller assembler won't let you **CALL** a subroutine with a local label. For example, the following is not allowed:

```
                MOV   :Arg, #1
                CALL  #:Subr
                ..

:Subr           TEST  :Arg, #%101
                ..

:Subr_ret       RET

:Arg            LONG  0-0
```

But there *is* a work-around. Just use **JMPRET** instead:

```
                MOV    :Arg, #1
                JMPRET :Subr_ret,#:Subr
                ..

:Subr           TEST   :Arg, #%101
                ..

:Subr_ret       RET

:Arg            LONG   0-0
```

It's not as elegant-looking as a **CALL**, but it *does* work.

PAR

Trap: The **PAR** register's bits 1..0 *always* read as zero. This is okay as long as you're passing a long address to a newly-created cog via **COGNEW** or **COGINIT**. But if you use **PAR** to pass any other kind of parameter, you will need to shift it left by two to avoid getting its two LSBs zeroed, then shift it back in the assembly routine:

```
COGNEW(@new_cog, arg << 2)
..

DAT

  new_cog       MOV   my_arg,PAR
                SHR   my_arg,#2
```

Also, because the upper 16 bits of the 32-bit parameter field are ignored, this effectively limits argument size to 14 bits.

Thanks to Raymanand BradC for pointing out that bits 31 .. 16 are not passed.

@Address

Trap: The "@" prefix can be used in both Spin code and assembly to denote the address of some memory location. But the same expression, **@Address**, can mean two different things, depending on where it's used. Here's an example:

```
VAR

  LONG  var_begin

PUB start

  var_begin := @begin
  COGNEW(var_begin, 0)

DAT

begin          JMP      #begin

my_begin       LONG     @begin
```

In the Spin code**, @begin** refers to the actual location of **begin** in hub memory, and **var_begin** will be assigned that value. In the assembly code, one might expect **my_begin** to hold the same value, but it does not. What it contains is the *offset* of **begin** from the beginning of the current object, and that will not be the same as its location in hub memory. The rule is this (quoting the manual):

> *"It is important to note that this is a special operator that behaves differently in variable expressions than it does in constant expressions. At run-time, ... it returns the absolute address of the symbol following it. This run-time, absolute address consists of the object's program base address plus the symbol's offset address.*
>
> *"In constant expressions, it only returns the symbol's offset within the object. It can not return the absolute address, effective at run-time, because that address changes depending on the object's actual address at run-time."*

Hub address of assembly label

@@Addr

Trick: Suppose we want to start a new cog from an assembly program. To do so, we need the hub address of that program, so we can pass it to **COGINIT**. But in the prior **trap**, we discovered that **@program** won't give us that address. What to do?

Here's where the **@@** notation comes to the rescue. This notation, prepended to an address (**@@addr**), means, "Return the value obtained from adding the current object's base address in the hub, to **addr**'s offset from that base address: in other words, **addr**'s hub address. By this logic, then, **@@0** will refer to the hub address of the beginning of the object. We can use that to advantage:

```
CON

  _clkmode      = xtal1 + pll16x
  _xinfreq      = 5_000_000

PUB start

  COGNEW(@begin, @@0)

DAT

              ORG
begin         ADD       :new_cog,PAR
              SHL       :new_cog,#2
              OR        :new_cog,#%1000
              COGINIT   :new_cog
              COGID     :self
              COGSTOP   :self

:new_cog      LONG      @new_begin
:self         RES       1


              ORG
new_begin     MOV       dira,#1

:loop         XOR       outa,#1
              JMP       #:loop
```

The code at **begin** receives the object's base address in hub memory (**@@0**) in **PAR**. It adds this to **@new_begin**, the offset of **new_begin** from the begging of the object, to get its hub address. It then constructs the rest of the argument to **COGINIT**, which is used to start **new_begin** running in a new cog. Finally, it stops its own cog.

Thanks to Chip Gracey

<=
>=

Trap: Beware the “<=” and “>=” operators. In many computer languages, these mean “less than or equal to” and “greater than or equal to”, respectively. Not so in Spin. Here, these are assignment operators and work like this:

```
a <= b    is equivalent to   a := a < b
a >= b    is equivalent to   a := a > b
```

For “less than or equal to”, use “=<”; for “greater than or equal to”, “=>”.

Thanks to Beau Schwab

waitcnt

Trap: Failure to account for the clock speed can lead to program lockup, especially with spin code. For example, the following snippet out of **serialDemo.spin** (in the Tips & Traps forum thread) will lock up if the baud rate is set too high for the selected clock frequency. Here is the offending code:

```
t = cnt
repeat 10                    '10 bits.
  waitcnt(t += bittime)      'Time for next bit edge: +=
                             'is short for t := t + bittime
  outa[tx] := (b >>= 1) & 1  'Get the next bit.
```

The trap there is that the value of the system counter, **cnt** is captured in the variable **t** before entering this routine. The idea then is that serial bits will be sent out at regular times, **t + bittime**, **t + 2 * bittime**, **t + 3 * bittime**, etc. However, the spin code in the line following the **waitcnt** instruction, plus the **repeat** loop overhead, can take longer than **bittime**. If that happens, **cnt** will already have passed **t + bittime** when it hits the **waitcnt** instruction, and it will have to wait there for the whole cycle of 32 bits to roll back to the value, for each bit. This limits the baud rate to 19200 for an 80 MHz clock (5 MHz crystal , plus 16x PLL), or 1200 baud with a 5 MHz clock. Of course assembly code is faster, but this is still a trap for fast actions that use repeated **waitcnt**.

Thanks to Tracy Allen

Hyperterminal

Trap: Code does not run as expected when using Hyperterminal. As with the BASIC Stamp, the DTR line resets the Propeller; and when reset, the code stored in EEPROM will be loaded, replacing whatever code was previously in the Propeller RAM. Hyperterminal brings DTR high when it connects and returns it low when it disconnects. With the FDTI programming adapter at least, the Propeller resets when DTR goes from high to low.

A better option is to use the DEBUG window in the Stamp IDE, since DTR is not automatically set. Here, you can manipulate DTR manually through the DTR checkbox to see the effect of a reset on the Propeller.

Thanks to Tracy Allen

Stack Size

Trick: When a Spin cog is started with **COGNEW**, you have to give it the address of an array in hub RAM to use as a stack. But how big does this array have to be? The answer to that depends on the Spin code in the cog and how deeply it nests procedure calls. To get an empirical idea how big to make the stack area, you can use the following Spin object:

```
CON
  filler = $5aa5a55a

VAR
  word  my_stack[32]

PUB start(addr, size)
  longfill(addr, filler, size)
  return cognew(monitor(addr, size), @my_stack) => 0

PUB monitor(addr, size) | used, i
  dira := $FF0000
  outa := 0
  repeat
    used := 0
    repeat i from addr to addr + size * 4 step 4
      used -= long[i] <> filler
    outa := used << 16
```

The procedure **start** should be called from your top-level program *before* you call **COGNEW** and launch your Spin cog. It takes two arguments: the address of the stack array used by your cog, and its size in **LONG**s. It then fills this area with a pattern before it launches its own cog that does the monitoring. This cog will continuously examine the stack array, counting the number of **LONG** locations in which the pattern has been changed. It then displays this number on the development board's LEDs in binary. You can then use this number, *padded appropriately for safety*, as the dimension of your stack array.

Pre-initialized DAT arrays

Trick: You want to define an array in the **DAT** area, initialized to a certain value. How do you go about it? Use the following array constructor:

```
CON
  MySize = 64

DAT
  MyVar    LONG    $AA55[MySize]
```

This defines a block of **MySize LONG**s in cog memory, initialized to **$AA55** (assuming it's part of an assembler program that gets its own cog). But, perhaps more interestingly, it also defines a single instance of an array in hub RAM, initialized to **$AA55**, that can be shared by multiple instances of the defining object -- or anyone else, for that matter, if they know its address.

Embedding Array Pointers

Trick: Instead of using a separate pointer variable in assembly language array indexing, you can embed the pointer right into the code, *viz*:

```
          movd :loop, #buffer
          mov  :i, #BufferSize

:loop     mov  0-0, ina
          add  :loop, :d_inc
          djnz :i, #:loop

          ...

:d_inc    long 1 << 9       'LSB of destination field.
:i        res  1
:buffer   res  BufferSize
```

The loop is first initialized by writing the buffer address into the destination field of the **mov** instruction at **:loop**. (The “0-0” just signifies that something will be written into that field.) The loop then copies the value of **ina** to the next position of the buffer. The **add** instruction increments the destination field of the **mov** instruction, effectively advancing the pointer into the buffer.

Thanks to Paul Baker

Shifts and Rotates

Trap: In working with the Propeller, the biggest trap of all is the set of preconceived notions brought to bear from work with other microcontrollers. That this is particularly true of the Propeller's shift and rotate instructions (**shl, shr**, **sar**, **rol**, **ror**, **rcl**, and **rcr**) is an understatement. The trap here is the handling of the carry flag. In most micros, the carry flag is handled as an extension of the register being shifted or rotated. Right shifts/rotates treat the carry simply as a less-significant bit than the LSB of the register; left shifts/rotates, as a more significant bit than the MSB of the register. And rotates *through* the carry treat it as just another bit linking the register's LSB and MSB in a continuous loop. For the Propeller, however, this is not a useful model to keep in mind. In fact it will be more hindrance than help. Granted, shifts/rotates of a single bit position will behave just like they do on other micros. But that's where the similarity ends. This is because, no matter how many positions are shifted, the carry (if written) always gets the *initial* value of bit 0 for right shifts/rotates or bit 31 for left shifts/rotates. Here's an illustration of each instruction, starting with the following configuration in **Data** and **Carry**, and showing the result of each given command:

```
                  Data: abcdefghijklm------nopqrstuvwxyz  Carry: C

shl Data,#4  wc         efghijklm------nopqrstuvwxyz0000         a

shr Data,#4  wc         0000abcdefghijklm------nopqrstuv         z

sar Data,#4  wc         aaaaabcdefghijklm------nopqrstuv         z

rol Data,#4  wc         efghijklm------nopqrstuvwxyzabcd         a

ror Data,#4  wc         wxyzabcdefghijklm------nopqrstuv         z

rcl Data,#4  wc         efghijklm------nopqrstuvwxyzCCCC         a

rcr Data,#4  wc         CCCCabcdefghijklm------nopqrstuv         z
```

Note especially the **rcl** (rotate carry left) and **rcr** (rotate carry right) instructions. These are not actually rotates at all, but shifts, in which the initial value of the carry bit (instead of 0) fills the vacated positions.

Averaging Signed Numbers

Trick: You can use the **rcr** instruction to advantage when averaging signed numbers, thus:

```
            mov   average, value0
            add   average, value1   wc
            rcr   average, #1
```

rcr, in this case, acts like **sar** but with 33 bits instead of 32, the "sign" bit being the carry.

Sign Extension

Trick: You can extend the sign from any bit position in both Spin and Assembly by doing two shifts. For example, suppose you have a 24-bit number whose MSB (bit 23) is the sign, and you want to create a 32-bit signed value from it. In Spin, do this:

```
   Value := Value << 8 ~> 8
```

In assembly, the equivalent would be:

```
            shl   Value,#8
            sar   Value,#8
```

In each case, **Value** is first shifted left to get its sign bit into bit 31 of the long. Then an arithmetic right shift propagates the sign into the 8 MSBs.

Thanks to Chip Gracey via Jon Williams

Note: In Spin, two sign extension operators are pre-defined. To extend the sign from bit 7 (byte), do this:

```
   ~Value
```

And to extend from bit 15 (word), do this:

```
   ~~Value
```

Thanks to M. Park