

Propeller Backpack (#28327): *Video Terminal and A/V-enhanced Propeller Development Module*

General Description

The Propeller Backpack is a compact, multipurpose Propeller-based module that is optimized for audio and video applications. It is preprogrammed as an NTSC video character display for your BASIC Stamp® (or other compatible controller).

This module is also a fully capable Propeller™ microcontroller development platform, which you can program with Parallax's free "Propeller Tool" software. For expansion, it includes a socket to accommodate a daughterboard from Parallax's growing assortment of MoBo accessories.

Features and Specifications

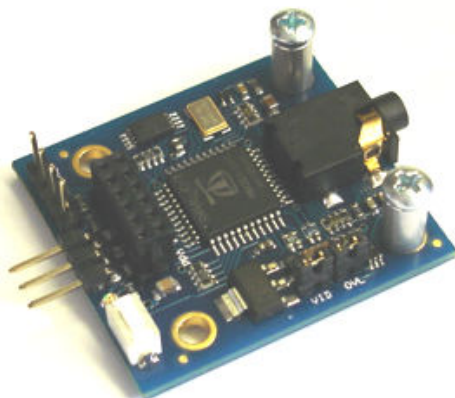
- Compact size: 1.5 x 1.35 in. (38.1 x 34.3 mm)
- Propeller P8X32A-Q44 chip and 10 MHz crystal for up to 80 MHz operation
- Sigma-delta analog input circuitry (2 channels)
- Onboard circuitry for video out, video sync in, video overlay switching, audio I/O, and push-to-talk (PTT)
- Double-size (64K x 8) EEPROM for programs and data
- External interface: 1/8" stereo phone jack for line-level A/V and PTT signals, 3-pin servo header for power and serial I/O, 4-pin Prop Plug header, 12-position daughterboard socket
- Power requirements: 4–6 V unregulated DC @ 20–150 mA, depending on application (5 V regulated DC is required when used with daughterboards.)

Applications

- Serial video terminal for BASIC Stamp
- Video character overlay (e.g. for GPS coordinates)
- Speech output
- Audio special effects
- Machine vision (with optional daughterboard)

Out of the Box

What's Included



**Propeller Backpack
Module with Screws,
Standoffs, and Jumpers
Installed.**

What You Need to Provide

For use as a video terminal from a BASIC Stamp or other micro, you will need a means to connect +5 V, ground, and a signal line to the Backpack. This can be accomplished either by plugging the Backpack directly into a solderless breadboard and making the required connections there, or by using a Parallax 3-wire Extension Cable with 3-pin Header (#805-00001 or #805-00002). See the "Installation" section for details.

For the video connection, a 1/8"-phone-to-RCA adapter, such as the one pictured below, can be obtained from RadioShack, along with a doubly-terminated RCA cable.



RadioShack #274-897

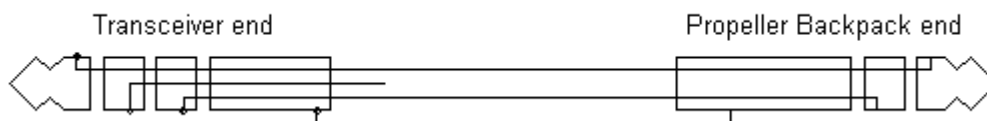
You can also use a monaural cable with a 1/8" phone plug at one end and an RCA plug at the other end.

For applications requiring two A/V connections, a stereo adapter like the one pictured below or a stereo cable with a 1/8" stereo phone plug at one end and a pair of RCA plugs at the other will be required.



RadioShack #274-883

Other applications may demand different—or even custom—cables, such as this one built to interface to a Yaesu handheld VHF transceiver. (Note the 4-conductor plug at one end.)



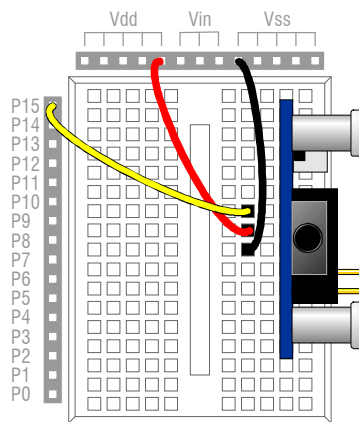
Quick Start

For a quick demo of the Propeller Backpack's video capabilities, connect it as shown in the "Installation" section below. Also connect a video monitor or TV that has a video input (*not* the antenna input), using an adapter or cable like those described above. Make sure a jumper is installed on the pair of pins marked "VID." The "OVL" jumper is not required, but you can leave it in place anyway to avoid losing it.

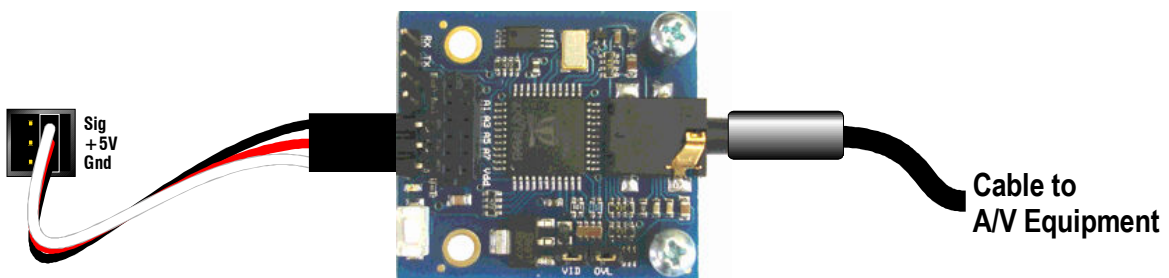
From the Propeller Backpack product page on the Parallax website, download the program, **PropBP_terminal_demo.bs2**, and run it. You should see an animated demonstration which begins, "This is a demo of the Propeller Backpack TV terminal."

Installation

The Propeller Backpack can be plugged into a solderless breadboard like so:



Or, by using a 3-wire F/F Extension Cable (Parallax#805-00001 or #805-00002), it can be plugged into a three-pin "servo" header, as shown here, along with the A/V cable:



With no daughterboard plugged into it, the supply voltage can be anywhere between +4 V and +6 V; but it is not recommended to go higher than that. When using a daughterboard, the supply voltage should be kept to a regulated +5 V.

Using the Pre-loaded TV Terminal Firmware

Introduction and Tutorial

As the above "Quick Start" demo shows, the Propeller Backpack can function as a video terminal driver out of the box, without requiring any Propeller programming. This feature makes it possible for a BASIC Stamp programmer to display text on an NTSC monitor in a variety of ways, without knowing anything about the Parallax Propeller. In this section, the various commands used to control the TV terminal from the BASIC Stamp are introduced tutorial-style. A subsequent section describes them in detail.

NOTE: Wherever you see a constant symbol (e.g. **SCRSIZ**, **USECLR**, etc.), it refers either to one of PBASIC's predefined DEBUG constants or to one of the constants defined in the demo program, **PropBP_terminal_demo.bs2**, cited above. You can copy and paste the constant block from this program into your own PBASIC code. This will make it easier to use these constants in command strings sent to the Backpack.

Communication with the Backpack video terminal program takes place using serial I/O, transmitting and receiving at 9600 baud, using a **non-inverted, open-drain** protocol. The Backpack includes a pullup resistor to +5 V, so you do not need to apply one externally. Because of the open-drain protocol, *the pin used to communicate with the Propeller Backpack should always be configured as an input, except when being driven low.*

The pin and baudmode settings for the BS2 on pin 15 at 9600 baud, for example, would be:

```
io    PIN 15
baud  CON 84 + 32768
```

When your PBASIC program first starts, it is a good idea to reset the Propeller Backpack before doing anything else. You do this by pulling the serial I/O pin low for 500 ms and releasing it. Do not hold it low for more than a second, though, as this will cause the Backpack to enter "programming mode" and not start the terminal program. Here's a typical startup sequence:

```
LOW io          'Reset the Propeller Backpack
PAUSE 500
INPUT io
PAUSE 2000      'Wait for it to come out of reset.
```

Once the terminal firmware resets, it will be configured as follows:

- Columns: **40**
- Rows: **13**
- Color: **0** (white foreground; black background)
- Current window: **0**
- Screen: **cleared**
- Cursor position: **0,0** (top left-hand corner)

Printing to the screen is as easy as sending it text. For example, to display "Hello, world!", just send it using a **SEROUT** command, like this:

```
SEROUT io, baud, ["Hello, world!"]
```

It will display as follows:

A terminal window with a black background. The text "Hello, world!" is displayed in a small, white, monospaced font at the top left of the window.

If the letters are too small, you can set a different screen size by sending the **SCRSIZ** command (\$1D), followed by a column and row count. For example, to double the font size, just halve the default screen size, like this:

```
SEROUT io, baud, [SCRSIZ, 20, 6, "Hello, world!"]
```

Now the screen will look like this instead:

A terminal window with a black background. The text "Hello, world!" is displayed in a larger, white, monospaced font at the top left of the window.

Whenever you change the screen size, the display resets and clears completely, and any windows or attributes (e.g. color) that you've set will be cleared as well. For this reason, setting the screen size is normally done only at the beginning of your program.

If you get bored with white-on-black, you can change the color of your text on the fly. For example, if you wanted "world" to be black on a blue background, you could do this:

```
SEROUT io, baud, [SCRSIZ, 20, 6, "Hello, ", USECLR, 10, "world", USECLR, 0, "!"]
```

This is how the screen would look (except a little blockier, since the font gets pixelated at larger scales):

A terminal window with a black background. The text "Hello, world!" is displayed in a white, monospaced font. The word "world!" is highlighted with a blue background, and the text "Hello, " is in white.

The screen can be divided into regions, called “windows”, which you can define and write to independently. There is one predefined window (number **0**), which encompasses the entire screen. When you create a new window, you define its position (left column and top row) and size (column count and row count). (Please note that column and row numbers start a location **0**, not location **1**.) For example, if you want a new window at location (5,5) that is 6 columns wide and 7 rows high, you’d define it thus:

```
SEROUT io, baud, [DEFWIN, 1, 5, 5, 6, 7]
```

Now **DEFWIN** doesn’t do anything except tell the Backpack that you have a window identified as number **1**, having the size and location given above. It doesn’t even let you start writing in that window. To do that, you invoke the **USEWIN** command:

```
SEROUT io, baud, [USEWIN, 1]
```

This tells the Backpack that subsequent text is to be written in window **1**.

But, so far, window **1** doesn’t look any different than window **0**, *i.e.* the entire screen. This is easily remedied by changing its color:

```
SEROUT io, baud, [CHGCLR, 12]
```

Unlike the **USECLR** command invoked in a prior example, **CHGCLR**, changes the color scheme for the entire window at once. Now, let’s put it all together:

```
SEROUT io, baud, ["Hello, ", USECLR, 15, "world", USECLR, 0, "!"]  
SEROUT io, baud, [DEFWIN, 1, 5, 5, 6, 7, USEWIN, 1, CHGCLR, 12]  
SEROUT io, baud, ["Text", CR, "in", CR, "window", CR, "1"]  
SEROUT io, baud, [USEWIN, 0, " I've arrived!"]
```

And this is what gets displayed:



Note that, after text was written in window **1**, the program changes back to window **0** and writes, “I’ve arrived!” and that it continues from where the text in that window left off. This demonstrates that each window keeps track of its current state, including cursor position and text color.

Unlike in a certain PC operating system of the same name, “windows” in the Backpack terminal program do not overlap, and there is no concept of “in front of” or “behind.” If two windows share character positions on the screen, the window that writes to those positions last gets to display its text (and colors) there. For example, look what happens if we add the following to the above example:

```
SEROUT io, baud, [USEWIN, 0, " I've arrived!", CRSRXY, 8, 5, "OOPS!"]
```

Here's the display:

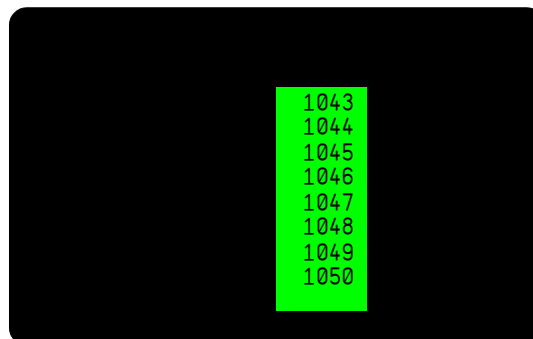


This example also shows how cursor positioning works. It's pretty much that same as it is with the DEBUG screen, except that the coordinates are relative to the upper left-hand corner of the current window, not to the entire screen.

When writing multiple lines to a window, once you get to the window's bottom line, additional lines will cause text in the window to scroll up, just as it would on a PC screen. This program fragment, for example, defines a window, and begins writing data into it, one line at a time:

```
SEROUT io, baud, [DEFWIN, 1, 20, 2, 7, 9, USEWIN, 1, CHGCLR, 12]  
FOR W0 = 1000 TO 1050  
  SEROUT io, baud, [" ", DEC W0, CR]  
NEXT
```

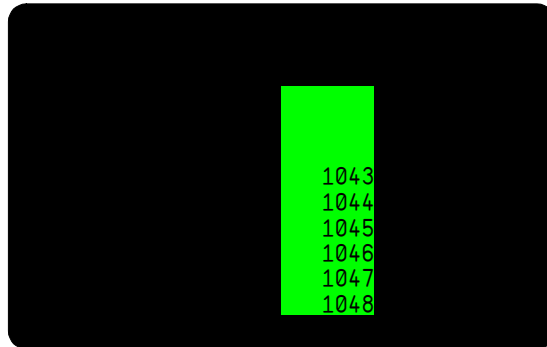
When it gets to the bottom line, the data scrolls upwards, leaving this on the screen when it has finished:



Scrolling can be done explicitly, as well. For example, let's add the following statement to the above code:

```
SEROUT io, baud, [SCRLDN, SCRLDN, SCRLDN, SCRLRT]
```

Here is what the screen looks like after those three scrolls down and one to the right:

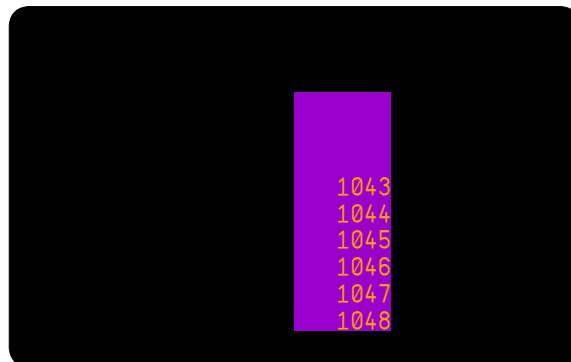


Notice that the Backpack doesn't keep track of the stuff that got scrolled out of the window. It just moves what's there and pads the vacated character positions with blanks.

Now, suppose we didn't like any of the default color schemes (i.e. color-on-black or black-on-color) and wanted something flashier, say, orange-on-purple. Any of the default colors can be altered. Since we're using color **12** in the above window, let's redefine it to the new color scheme, by adding the following to the above code:

```
SEROUT io, baud, [DEFCLR, 12, $AD, $0C]
```

This is how the display would look now:



It's important to note that any redefinition of a color scheme changes all instances of that scheme on the entire screen, not just in the current window.

Command Definitions

In this section, each command is given with both its defined constant name and its hexadecimal value. You can use either one in your **SEROUT** statements. PBASIC's predefined constant names are shown in **BLACK**; the Backpack's own constants, in **RED**. Where the term "cursor" is used, it refers to the position where the next character will be written. There is no visible cursor on the screen, however.

CLS	\$00	Clear the current window.
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Clear the current window, converting all character cells to the window's background color, and home the cursor to the window's top left-hand corner. If the current window is window **0**, the entire screen will be cleared.

HOME	\$01	Move cursor to the current window's home position.
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This command moves the to the top left-hand corner of the current window but does not change the window's contents.

CRSRXY, x, y	\$02, x, y	Move cursor to position (x,y).
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The two bytes following this command define the new position (column, row) of the cursor within the current window, starting from column zero, row zero in the window's home position. The contents of the window are unchanged.

CRSRLF	\$03	Move cursor one column to the left.
CRSRRT	\$04	Move cursor one column to the right.
CRSRUP	\$05	Move cursor one row up.
CRSRDN	\$06	Move cursor one row down.

Move the cursor in the direction indicated. Motion saturates (stops) at the current window's left, right, top, and bottom edges.

USECLR, c	\$07, c	Change to color scheme c for the next character(s).
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This command changes the color scheme to one of the 16 (numbered **0** through **15**) available. Therefore, the byte **c** that follows **USECLR** must be less than or equal to **15**; otherwise, the results will be unpredictable. The default color schemes are shown below.

0	White on black	8	Black on white
1	Lavender on black	9	Black on lavender
2	Blue on black	10	Black on blue
3	Aqua on black	11	Black on aqua
4	Green on black	12	Black on green
5	Yellow on black	13	Black on yellow
6	Orange on black	14	Black on orange
7	Red on black	15	Black on red

Please note that, depending upon your monitor and its brightness and contrast adjustments, the colors you see may differ slightly from those shown here. This is normal.

BS	\$08	Backspace.
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Move cursor to the previous character position in the window and erase the character there.

TAB	\$09	Tab.
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Insert as many spaces as necessary to get to the next column position evenly divisible by eight in the current window.

LF	\$0A	Linefeed.
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Move cursor down one line in the current window. If cursor was in the window's bottom line, scroll window up by one line and clear the bottom line using the current background color.

CLREOL	\$0B	Clear to the end of the line.
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Clear the current line (row) in the current window from the current cursor position to the end of the line, using the current background color. The cursor position remains unchanged.

CLRDN	\$0C	Clear down.
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Clear the current window from the current cursor position to the end, using the current background color. The cursor position remains unchanged.

CR	\$0D	Carriage return.
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Clear to the end of the current line in the current window using the current background color, then perform a linefeed. Cursor is moved to the beginning of the new line.

CRSRX, x	\$0E, x	Move cursor to column x.
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Move the cursor to the column given by the next byte (**x**) within the current row in the current window. If **x** is greater than or equal to the width of the window, position the cursor in the last column.

CRSRY, y	\$0F, y	Move cursor to row y.
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Move the cursor to the row given by the next byte (**y**) within the current column in the current window. If **y** is greater than or equal to the height of the window, position the cursor in the last row.

DEFWIN, w, l, t, c, r	\$10, w, l, t, c, r	Define a new window.
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A new window identified by the next byte (**w**) with a value between **1** and **15** is defined at the screen position given by the next four bytes:

l – left-hand screen column, **t** – top screen row, **c** – width in columns, and **r** – height in rows.

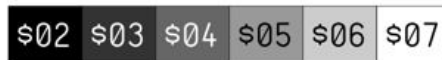
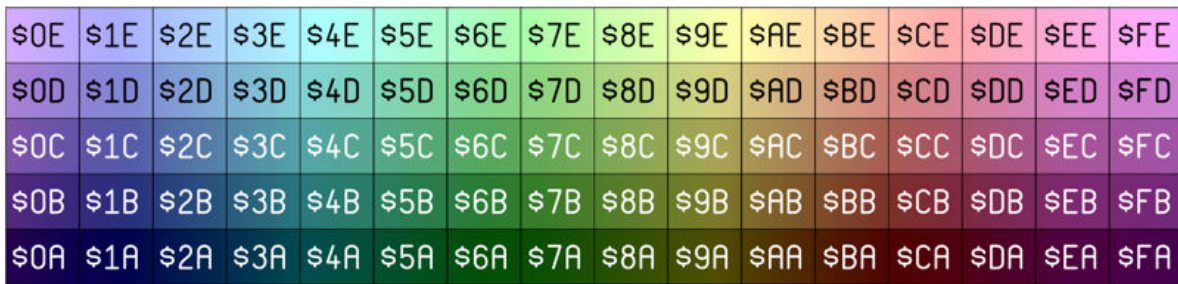
The cursor in the new window is moved to the home position, and the color scheme is set to **0**. The new window does *not* become the current window, however, nor are any changes made within the new window's confines.

USEWIN, w	\$11, w	Use a different window.
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Set the current window to the number indicated by the next byte (**w**), where **w** is less than or equal to **15**. Subsequent cursor, color, and character commands will be applied within the confines of the newly current window.

DEFCLR, c, f, b	\$12, c, f, b	Redefine a color scheme.
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Change the color scheme of the color given by the next byte (**c**), where **c** is less than or equal to **15**, to the foreground and background colors given by the next two bytes (**f** and **b**, respectively). Allowable choices for **f** and **b** are as follows (colors approximate):



Color numbers outside of these choices can produce an unstable display.

SCROLLF	\$13	Scroll window contents one column to the right.
SCRLRT	\$14	Scroll window contents one column to the left.
SCRLUP	\$15	Scroll window contents one row up.
SCRLDN	\$16	Scroll window contents one row down.

Scroll the characters in the current window in the direction indicated. Characters that scroll out of the window are lost forever. The cursor position does not change.

CHGCLR, c	\$17, c	Change color scheme for entire window to c.
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The color scheme for the current window is changed to the color scheme number indicated by the next byte (**c**), where **c** is less than or equal to **15**. This causes an instant change over the entirety of the current window.

SCRSIZ, c, r	\$1D, c, r	Change screen size to c columns by r rows.
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The overall size of the display screen is changed according to the next two bytes (**c** and **r**), where **c** (the column count) is less than or equal to **40**, and **r** (the row count) is less than or equal to **13**. This indirectly affects the font size, which will be made as large as possible for the number of rows and columns selected in order to fill the display area. In extreme cases, characters can become squashed either vertically or horizontally, so some discretion is required to preserve readability. When executed, the entire screen is blanked and reinitialized. An attached monitor may briefly lose sync, causing the picture to roll. Normally **SCRSIZ** is used only at the beginning of one's program.

CLRW	\$1E	Clear the current window.
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This command is identical to **CLS**. It's included here so it can be used in zero-terminated strings.

ESC, c	\$1F, c	Escape the next character.
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The Propeller's displayable character set includes characters in the range **\$00** to **\$1F**, which are commands for the Backpack. The **ESC** command allows you to display one of these characters by forcing the Backpack to ignore any special command significance the next character might have and to display it as-is. For example, sending **ESC, \$11** will cause the Greek letter pi (π) to be displayed. (See character chart below.)

ZERO	\$FF	Equals zero when used as a command argument.
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When sending zero-terminated strings, you can substitute **ZERO** for **0** when it's used as an argument for one of the above commands. *Do not use **ZERO** to substitute for **CLS**, though; use **CLRW** instead.*

Character	\$20 - \$FF	Clear the current window.
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Any character in the range shown, when sent where a command might be expected, is displayed in the current window.

Character Chart

The following chart illustrates the characters available to display on the video screen. The shaded characters numbered between **\$00** and **\$1F** must be preceded by an escape (**ESC**) command.

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
\$00 - \$1F	[Control characters: cursor, arrow, home, end, etc.]																															
\$20 - \$3F	! " # \$ % & ' () * + , - . / 0 1 2 3 4 5 6 7 8 9 : ; < = > ?																															
\$40 - \$5F	@ A B C D E F G H I J K L M N O P Q R S T U V W X Y Z [\] ^ _																															
\$60 - \$7F	` a b c d e f g h i j k l m n o p q r s t u v w x y z { } ~ [Symbol]																															
\$80 - \$9F	[Waveform symbols]																															
\$A0 - \$BF	↑ ↓ £ € ¥ ¤ × ÷ ← → [Math symbols]																															
\$C0 - \$DF	À Á Â Ã Ä Å Æ Ç È É Ê Ë Ì Í Î Ï Ð Ñ Ò Ó Ô Õ Ö × Ø Ù Ú Û Ü Ý Þ ß																															
\$E0 - \$FF	à á â ã ä å æ ç è é ê ë ì í î ï ð ñ ò ó ô õ ö ÷ ø ù ú û ü ý þ ÿ ∞																															

Loading New Firmware

For those users wishing to explore beyond the confines of the default video terminal, or those just wishing to install updates of the video terminal, there are three ways to upload new firmware:

1. Use the Propeller Tool and a Prop Plug (Parallax #32201).
2. Use the Propeller Backpack Loader program (downloadable from the Propeller Backpack product page) with a Prop Plug.
3. Use the Propeller Backpack Loader program with any member of the BASIC Stamp 2 family (**no Prop Plug required**).

Using the Prop Plug

If you use the Prop Plug to do your programming, just plug it into the Propeller Backpack, making sure that the **TX** and **RX** designators on the board align with those on the Prop Plug. You will still need to apply power via the three-pin header in order for programming to work.

Using the Propeller Tool

If you are using the Prop Plug, programs can be uploaded in the normal way using the Propeller Tool downloadable from the Parallax website. There is one catch, however: any programs saved to EEPROM will overwrite the monitor and bootloader firmware that comes installed on the Propeller Backpack. Until this program is reloaded via the Propeller Tool and Prop Plug, it will not be possible to use the Propeller Backpack Loader program to upload programs via a BASIC Stamp. To restore this program, follow the directions given later in this chapter.

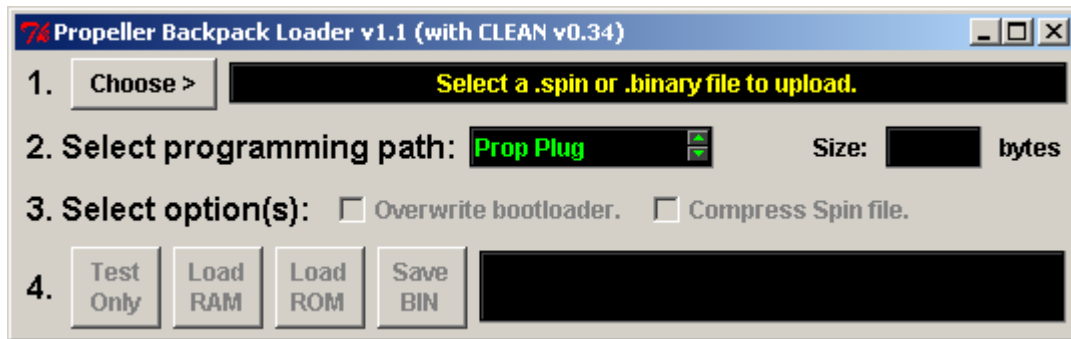
Using the Propeller Backpack Loader

The Propeller Backpack Loader (**PropBP_loader.exe**), downloadable in zip format from the Propeller Backpack product page, can be used to reprogram the Backpack without the need of a Prop Plug. All you need is any member of the BASIC Stamp 2 family and a connection from any of **P0** to **P15** to the three-pin header, along with power and ground. However, instead of a BASIC Stamp, you *can* use a Prop Plug with the loader instead.

To install the Backpack Loader:

1. Unpack the contents of the downloaded zip file into its own folder. You can then create a shortcut to **PropBP_loader.exe** (by right-clicking on it and selecting "Create Shortcut") and place it on your desktop or other convenient location, if you like. With the loader is included a special copy of **Propellent.exe**, which must remain in the same folder as the loader program.
2. If you are using the BASIC Stamp, you will also need to download and install the BASIC Stamp Editor from www.parallax.com/basicstampsoftware, if you haven't done so already.
3. Finally, if you plan to compile Spin programs that use library objects, or if you plan to write your own Spin programs, you will need to download and install the Propeller Tool from Parallax. (You can omit this step if you plan only to load canned firmware in the form of **.binary** files.)

To start the Propeller Backpack loader, just click on the **.exe** or its shortcut. You will see the following:



Step 1: **Select the file to upload.** This can be either a **.spin** or precompiled **.binary** file. Just click "Choose" to open a file dialog box.

Step 2: **Select programming path.** By flipping through the choices, you can choose either a Prop Plug or one of 16 pins (P0 – P15) on an attached BASIC Stamp.

Step 3: **Select option(s):**

Overwrite bootloader. If you are using the Prop Plug, you have the ability to overwrite the bootloader that comes preinstalled in your Propeller Backpack. Doing so will preclude further uploads via the BASIC Stamp, however, until the bootloader has been restored. (Instructions for restoring it appear below.)

Compress Spin file. If you are uploading from a Spin file, you have the option to compress it by removing all unused methods in order to make the resulting object file smaller. These selections are enabled only as appropriate, based upon those made in Steps 1 and 2.

Step 4: **Click a button** to select which action you wish to take. The available actions are:

Test Only: Compile a **.spin** file or examine a **.binary** file to check for errors and to measure its size. Assuming this operation is successful, the compiled code size (exclusive of **VARs**) will appear in the **Size:** box.

Load RAM: Load the Propeller chip's RAM with the selected program and begin execution.

Load ROM: Save the selected program in the onboard EEPROM, and reset the Propeller to begin execution.

Save BIN: If the selected file is a **.spin** file, compile it and save the compiled **.binary** file in the same directory.

During the activity you've selected, you will see a progress report in the lower window. If problems arise, you may be presented with one or more popup windows for a response.

Restoring the Original Firmware

If the bootloader firmware that comes preinstalled on the Propeller Backpack gets overwritten, it can be restored by downloading the file **prop_backpack_monitor.binary** from the Propeller Backpack product page and uploading it to the Backpack's EEPROM using a Prop Plug. If you are using the Backpack Loader program, of course, you will want to make sure **Overwrite bootloader** is checked.

To restore the TV terminal firmware, download the file **prop_backpack_TV_terminal.binary** from the Propeller Backpack product page and upload it using the Backpack Loader. *Do not use the Propeller Tool for this step!* Make sure to *uncheck* **Overwrite Bootloader** when you do this, and upload the file to EEPROM.

Software Considerations

The Propeller Backpack includes features and limitations that require special attention when writing software for it. Those are described here.

Crystal and Clock

The Propeller Backpack uses a 10 MHz crystal, instead of the more common 5 MHz frequency. Therefore, to run with an 80 MHz system clock, you will need the following pragmas in the **CON** section of your top-level program:

```
CON
    _clkmode      = xtall + pll8x
    _xinfreq      = 10_000_000
```

This is an easy step to forget. If you try to run code that uses a **pll16x** clock mode designator, it will not work.

EEPROM

The Backpack uses a 64Kbyte EEPROM, which is twice the size of a normal Propeller EEPROM. This can provide up to 32K of additional space for storage of extra data, beginning at address **\$8000**. However, if you are using the bootloader, the addresses from **\$8000** through **\$83FF** *must not be overwritten*, since they contain the first 1K bytes of the user program. (EEPROM bytes **\$0000** to **\$03FF** contain the monitor/bootloader.)

Monitor/Bootloader

The Propeller Backpack monitor/bootloader is invoked whenever pin **A31** (serial receive from Prop Plug header) or **A27** (serial I/O) is low when the Propeller comes out of reset. The included TV terminal program is designed to force such a reset when pin **A27** is held low for 10 ms or more (**BREAK** condition). Therefore, if **A27** is held low for around two seconds with the TV terminal firmware installed, the Propeller will reset and enter monitor mode, rather than restart the TV terminal program.

If you are writing applications for the Propeller Backpack, you may wish to incorporate this behavior into your own programs. The code fragment below is the serial input routine from the monitor program itself and gives an indication how this can be done (BREAK detection **highlighted**):

```

'-----[ serin ]-----
'Get one character serial input at 9600 baud. Leave inverted stop bit in bit 8.
serin          waitpeq  _0,inp_pin          'Wait for serial I/O pin to go low.
               mov      time,_9600baud    'Wait one-half bit time.
               shr      time,#1
               add      time,cnt
               waitcnt  time,_9600baud
               test     inp_pin,ina wz     'Is the pin still low?
if_nz          jmp      #serin            ' No: False alarm.

               mov      acc,#0            ' Yes: Valid start bit.
               mov      bitcnt,#9         'Initialize data byte and bit count.

:bitlp         shr      acc,#1            'Shift data right by one.
               waitcnt  time,_9600baud    'Wait for middle of next data bit.
               test     inp_pin,ina wz     'Is pin high?
if_nz          or      acc,#$100         ' Yes: Insert a "1" into result.
               djnz     bitcnt,#:bitlp     'Back for next bit.

               tjnz     acc,#serin_done    'Is data all zeroes?

               mov      time,break        ' Yes: Maybe a break condition.
               '        Get ready to time it.
:breaklp      test     inp_pin,ina wz     ' Is pin still low?
if_nz          jmp      #serin_done       ' No: Not a break.
               djnz     time,#:breaklp    ' Yes: Keep checking.

               clkset   reeboot           ' Timed out with pin low, so
               '        reset chip.

serin_done     xor      acc,#$100        ' No: Invert the stop bit. Framing
               '        error if that makes it a "1".

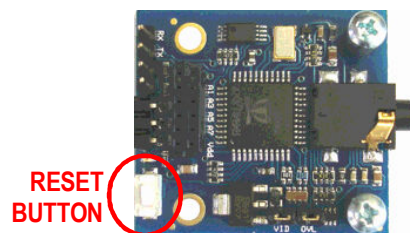
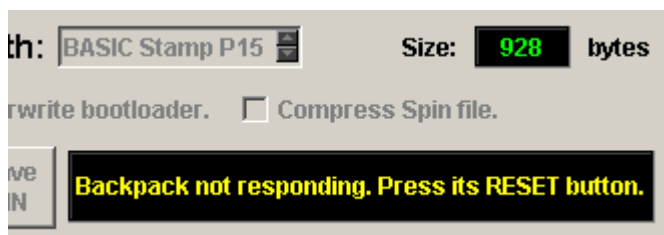
serin_ret      ret

_0             long    0
_9600baud      long    80_000_000 / 9600
break         long    50_000
inp_pin       long    1 << 31
reeboot       long    $80

acc           res     1
time         res     1
bitcnt       res     1

```

If you choose not to program this behavior in, that's okay, too. The only consequence is that the Backpack Loader will not be able to get the bootloader's attention from a BASIC Stamp without your help. When it sees that the Backpack is not responding, it will prompt you to press the Backpack's reset button, as shown below. Once you press reset (and it may take more than one try to sync with the BASIC Stamp's actions), the BASIC Stamp will be able to force entry into the monitor/bootloader.

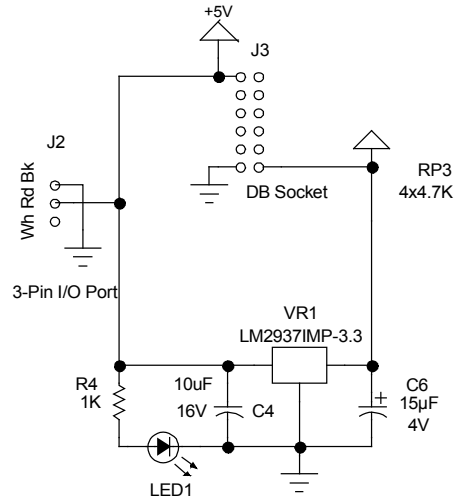


Hardware Description

The Propeller Backpack includes many unique features to make it adept at audio and video applications and to be compatible with other Parallax products. A complete schematic is provided at the end of this document. Certain portions of it will be described here.

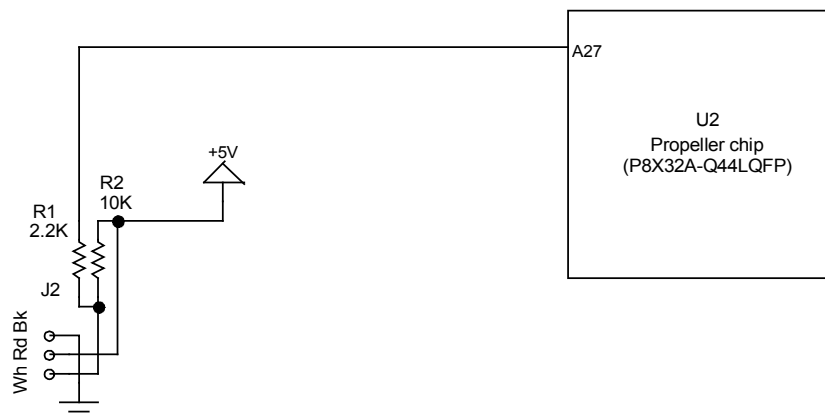
Power Input

The Backpack requires power in the range of 4–6 VDC. If a daughterboard is plugged in, the input voltage must be a regulated 5 V. Power may be fed from either the power (middle) pin on the 3-pin header or the +5V pin on the daughterboard connector. Here is a diagram of the Backpack's power input and regulation system:



Three-pin Header Serial I/O

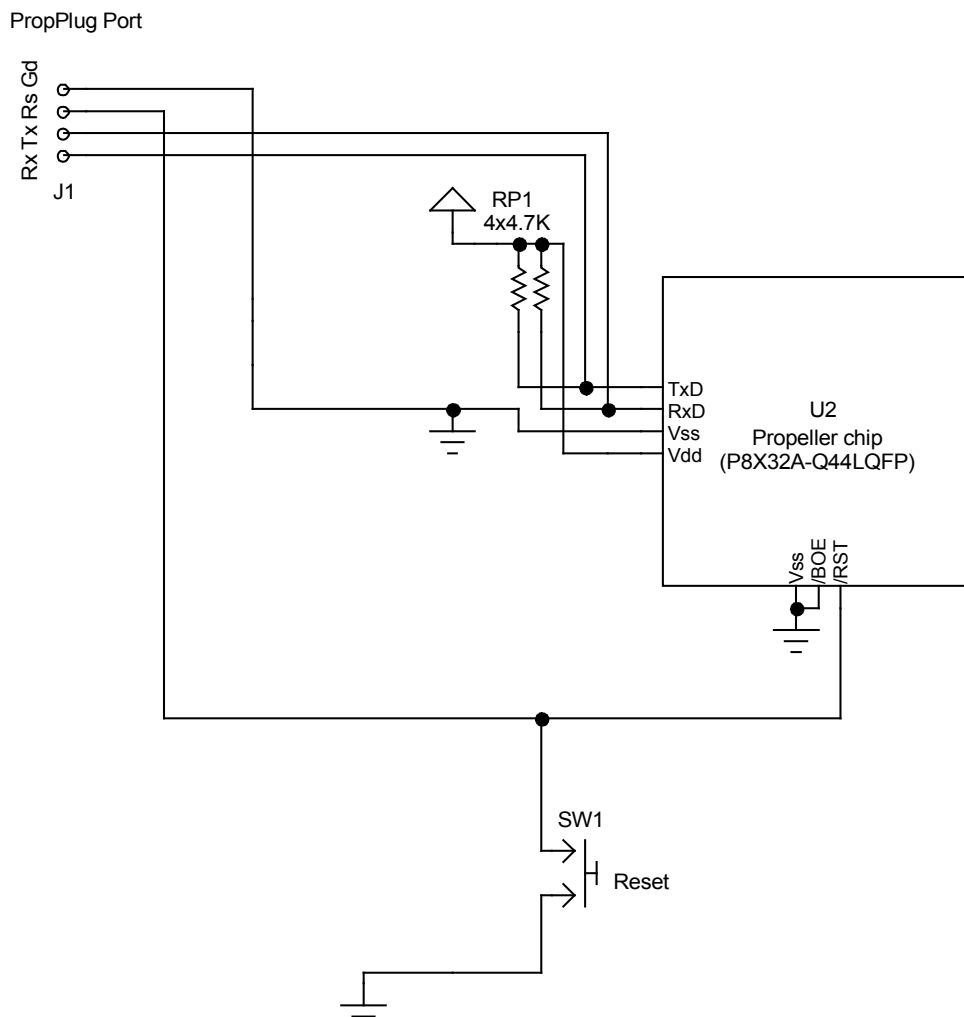
Besides power and ground, the three-pin header provides a communication pin. This pin is pulled up to +5V with a 10 k Ω resistor and is connected to the Propeller's **A27** pin through a 2.2 k Ω resistor. The series resistor provides protection to the Propeller in case the I/O pin is driven high to +5V. In normal operation, though, this pin must never be driven high, either by the Propeller or by an attached BASIC Stamp or other controller. On the BASIC Stamp side this is accomplished easily by making sure the **Open** bit (15) is set in the baud mode word. On the Propeller side, you can use the **basic_sio.spin** object, downloadable from the Propeller Backpack product page. This object has a special **start** method for the Backpack, which configures pin **A27** properly for bidirectional communication at 9600 baud. It also includes echo suppression so that characters sent from the Propeller on a single I/O pin don't also end up in the receive buffer. Here's the schematic fragment that deals with the Backpack's serial I/O circuitry:



Prop Plug Header I/O and Reset

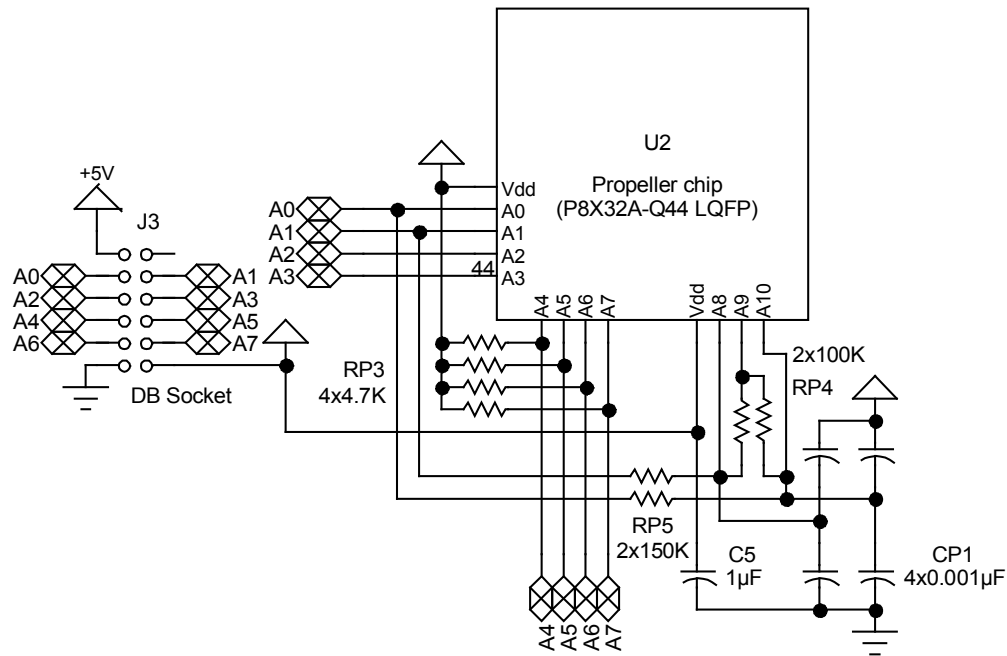
Although the Prop Plug header is provided mainly for programming, it can also be used for full-duplex serial I/O, either with an attached micro, or through the Prop Plug to a PC. Incoming signals connect to the Propeller's **A31** pin; outgoing signals, to **A30**. Signal levels on these pins must never go above +3.3 V or below 0 V. So, for interfacing to 5 V logic, 2.2 k Ω series resistors are recommended to protect the Propeller's input and output pins. Both pins are pulled up to +3.3 V via 4.7 k Ω resistors. This is done to ensure that a marking state is maintained on these pins during reset and/or in the absence of a Prop Plug. It will also help to alleviate the notorious multiple reset issue that can occur when the Prop Plug is plugged in without being connected to a PC.

This header also provides a direct connection to the Propeller chip's **/RST** pin. By pulling this pin low, the Propeller can be reset. The pin is pulled high internally to the Propeller chip itself, so it can be left floating in normal operation. Here's a schematic fragment of the Prop Plug circuitry:



Daughterboard Connector

The daughterboard connector is a 2x6 2mm header receptacle and is provided for compatibility with Parallax's growing family of daughterboards. In this sense, the Propeller Backpack can be thought of as a half motherboard, since it has one daughterboard socket instead of two. This connector brings Propeller pins **A0** through **A7** out directly, with **A4** through **A7** being pulled up to **Vdd** (3.3V) via 4.7 k Ω resistors. This is done to ensure compatibility with the daughterboard standard. Another standard that's adhered to is that the pins connected to **A0** and **A1** provide a means for analog input. This is done by connecting them further to a delta-sigma ADC input network on pins **A8** (from **A1**) and **A10** (from **A0**). The common feedback pin is **A9**. Rounding out the pin complement on this connector are **Vdd** (3.3V), **+5V**, and **Vss** (Gnd). The **Vin** pin is not connected, since there is no +5V regulator on board the Backpack. Here's a schematic fragment showing the daughterboard connections:



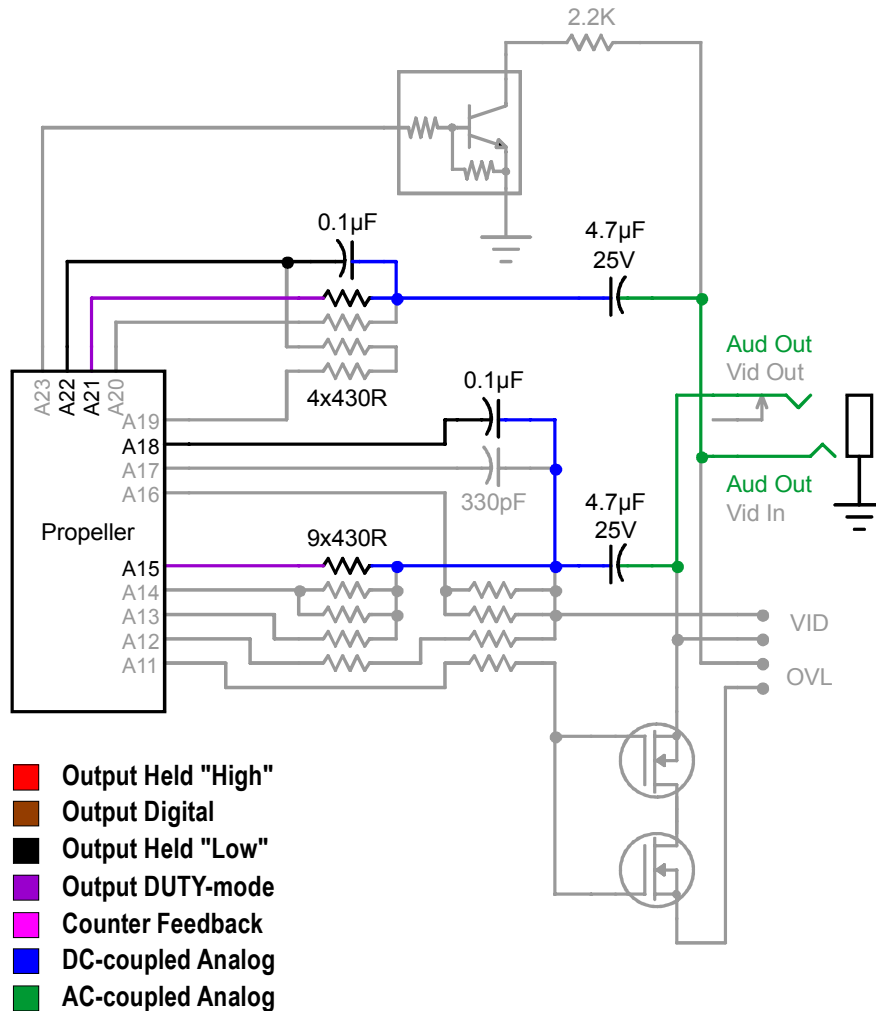
The common feedback pin has a consequence for analog to digital conversion: when switching from one analog input to the other (by changing the **CTRA** or **CTRB** register source field from **8** to **10**, or back), the program will need to wait for the capacitor network on the new input pin to recharge to **Vdd/2**. A 500 μ s "soak" time is adequate.

The fact that the analog inputs are connected to other Propeller pins (i.e. **A0** and **A1**) makes it possible for the Propeller to perform two-point self-calibration of the sigma-delta converter. Without a daughterboard plugged in, these pins can be asserted both high and low to provide **Vdd** and **Vss** references to the sigma-delta conversion routine.

The common feedback timing and calibration features are both provided by **prop_backpack_adc.spin**, which can be downloaded from the Propeller Backpack product page.

Line Level Audio Output

Audio output is but one of the functions provided by the multi-purpose A/V stereo phone jack. Because of its multiple uses, much of the passive analog filtering circuitry is not hard-wired but, rather, controlled by Propeller pins. Therefore, in order to output audio, for example, it is necessary to make sure that the filter cap in the low-pass RC network is grounded. This is done by driving the "ground" pin low. Here's a schematic fragment showing the analog circuitry configured for stereo output:



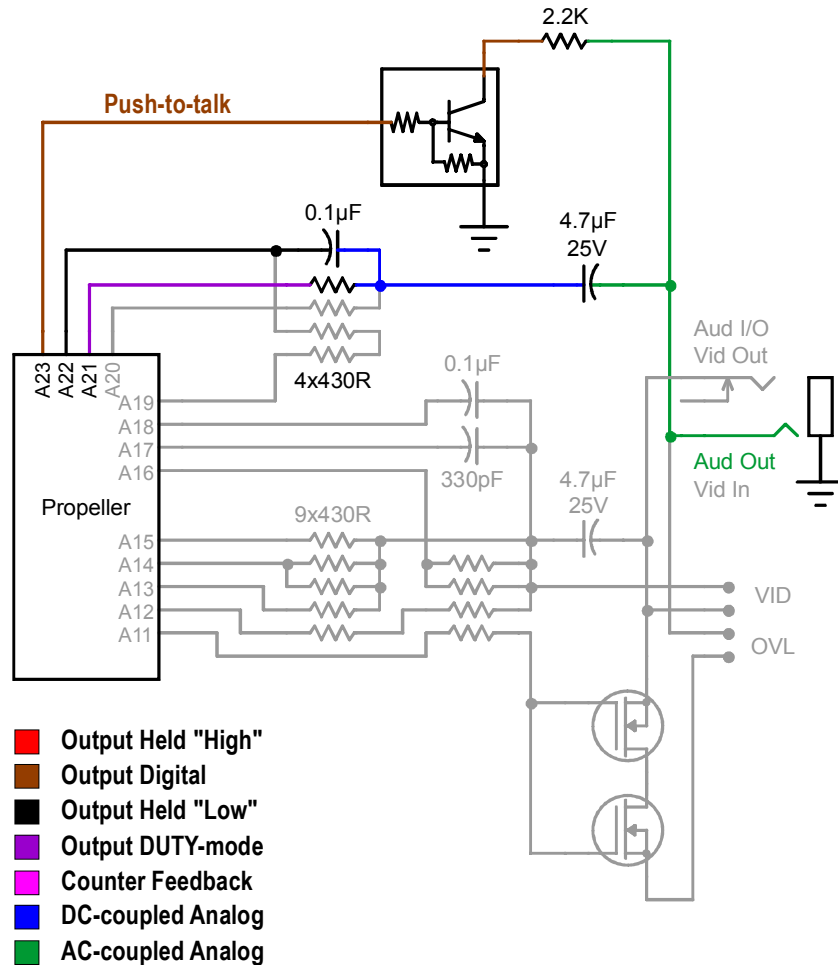
The left channel audio is provided by a DUTY mode output from pin **A15** and filtered by an RC network consisting of a 430-ohm resistor and a 0.1µF cap. Because the "ground" end of the cap is not hardwired to **Vss** but, rather to pin **A18**, this pin must be configured as an output and pulled low to make the filtering effective. Otherwise, that end of the cap will simply "flop around", electrically speaking, and not provide any filtration. Once filtered, the output is capacitively coupled to the center pin (tip) of the phone jack.

The right channel is similarly connected to the outside (ring) pin of the phone jack, being driven from **A21**, with **A22** asserting ground for the filter cap.

NOTE: When outputting audio, make sure that the **VID** and **OVL** jumpers are removed from their respective headers.

Audio Output with Push-to-Talk

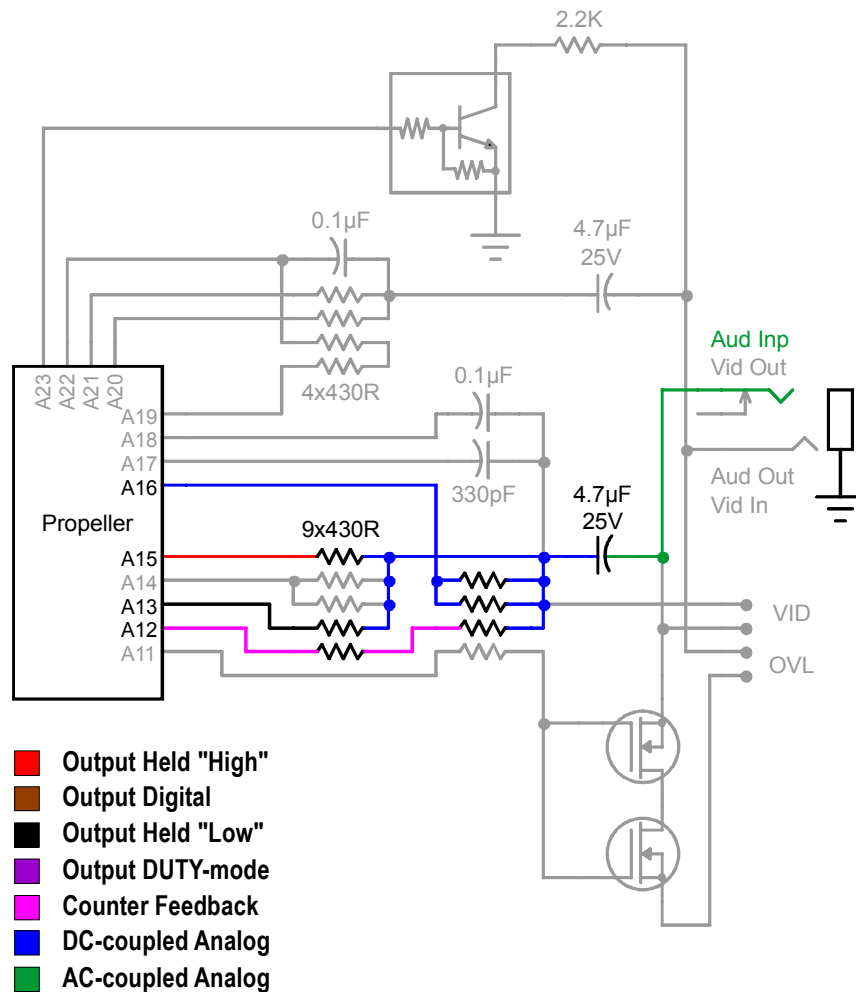
The right channel audio circuitry includes a push-to-talk activator that will work with many radio transceivers. Such transceivers will switch to transmit when the microphone input is biased to ground through a 2.2 kΩ resistor. The Propeller backpack provides such a switchable bias, in order to change from receive to transmit. This makes it possible for the Propeller to transmit data using, for example, the Bell 202 modem software from the Propeller object exchange (OBEX) with a ham radio transceiver (license required). It is also possible to provide synthesized voice response. (This feature was actually used to provide wind speed information from an anemometer to paragliders equipped with two-way radios having a "call" feature.) The following diagram shows how this feature is implemented:



To activate push-to-talk, pin **A23** is asserted high, which causes the transistor to conduct and bias the audio output to ground through the 2.2 kΩ resistor. The audio itself is provided as before.

Line Level Audio Input

The left audio output channel can also be configured for low-impedance (line level) audio input. This is done by configuring the RC network as a simplified delta-sigma input, as shown below:

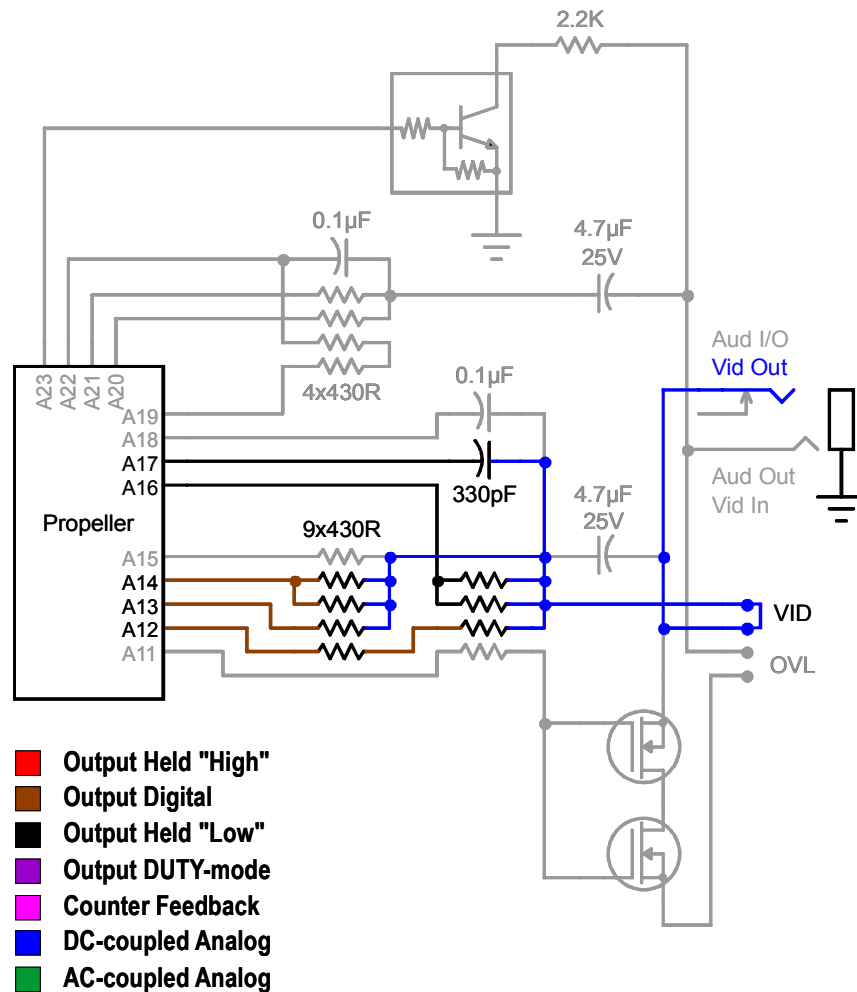


With **A15** asserted high and **A13** asserted low, a voltage divider is formed that biases the incoming (capacitively-coupled) audio to $V_{dd}/2$. This biased audio is fed to pin **A16** through paralleled 430 Ω resistors. This pin is the sigma-delta input. The feedback for this arrangement comes from pin **A12**, through two 430 Ω resistors connected in series.

Such an input configuration is entirely sufficient for receiving AFSK data from a ham radio transceiver or ring signals from an FRS transceiver to initiate voice response. The input impedance is too low, however, for directly connecting a microphone, necessitating a preamp for such high-impedance signals.

Baseband Video Output

NTSC or PAL video output is effected by using pins **A12** through **A14** and the 430 Ω resistor network as follows:



Pin **A16** is pulled low to complete the resistor network and set the output levels and impedance to their proper values. Unlike many of the video DAC circuits published for the Propeller, this one not only provides the requisite 1 V peak-to-peak signal to a 75 Ω load, but it does so with the correct 75 Ω source impedance.

Pin **A17** is pulled to ground to provide a slight amount of low-pass filtering to the video output. This is to accommodate any gray-level output that's provided by DUTY modulating pin **A12**. This filtering is not severe enough to remove the video's chroma information, however.

NOTE: When outputting video, make sure a jumper is installed on the **VID** header pair. This will bypass the 4.7 μ F output cap, providing the necessary low-frequency response into a 75 Ω load.

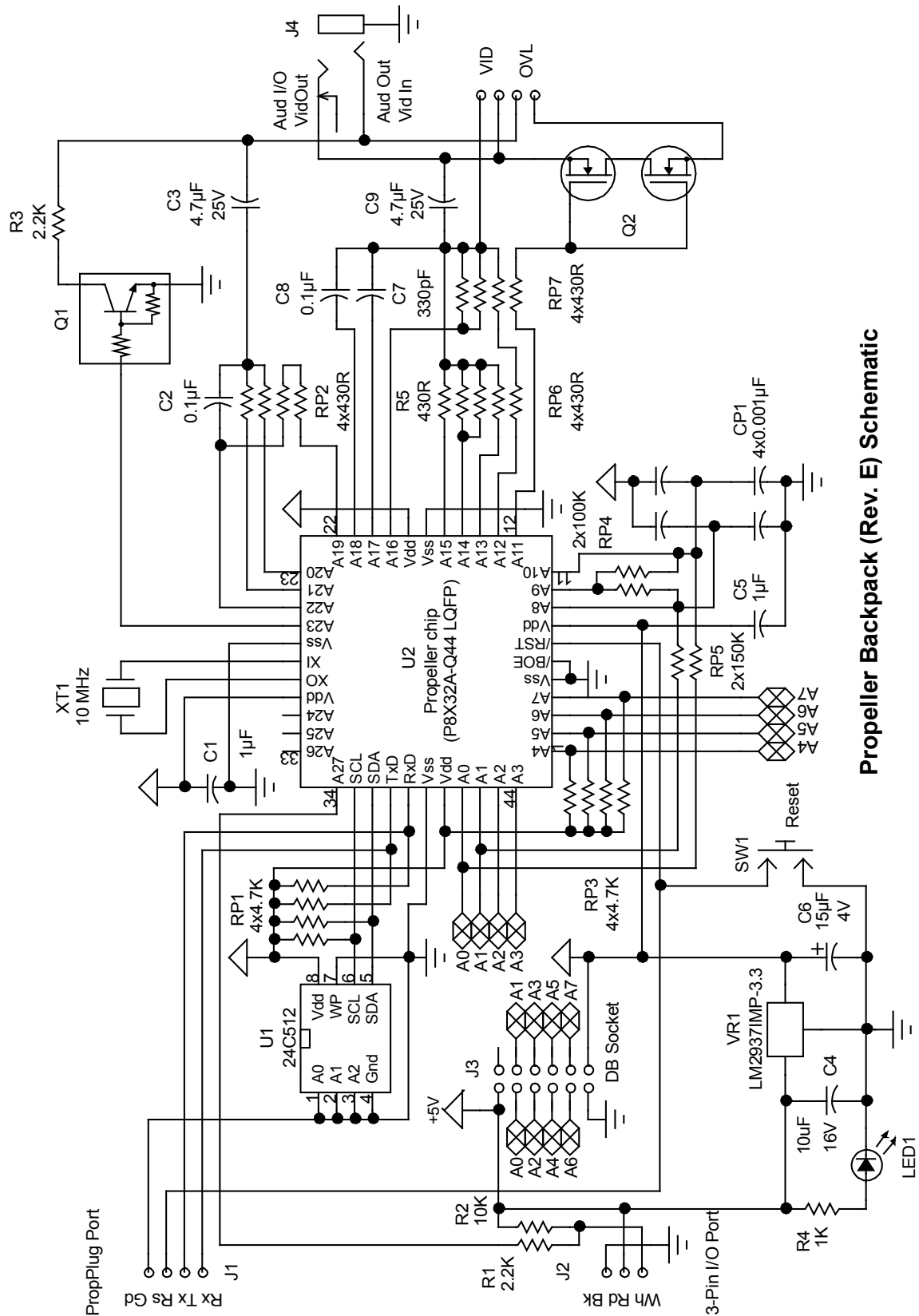
such as an LM1881 from National Semiconductor. But this is not necessary with the Propeller. It's possible to extract the video's composite sync with a programmable clamp circuit, as shown in the upper part of the above diagram. The incoming video is capacitively coupled through a series combination of 4.7 μ F and 0.1 μ F, which is approximately the same as if the larger cap were not present. This signal is input to pin **A22**. Whenever a low (i.e. a sync level) is detected on this pin, the Propeller program can cause pin **A19** to output a DUTY mode signal that clamps this pin just below the **Vdd/2** input threshold. (The DUTY mode output is filtered by means of the two series resistors from **A19** and the coupling capacitance.)

Now this is an obvious chicken-and-egg situation: you have to know when the input is at sync level to know when to provide the DUTY-mode clamp, and you have to provide the clamp at the right time to detect the sync signal. Fortunately, this is a pretty simple operation to bootstrap and consists of randomly sampling the video input and applying the opposite bias until sync is achieved. Once sync has been obtained, maintaining it is a simple matter of timing and application of the clamping signal at the proper times.

There is one caveat to observe, however. If the sync tips are clamped to 1.5 V, say, and the input signal exceeds 2.4 V peak-to-peak, the Propeller's body diodes will clamp the peak values to 3.9 V, which will push the signal too far down for accurate sync detection. But why would this ever happen? Aren't video signals supposed to be 1V peak-to-peak? Well, no, not always. Without a 75 Ω load, a video signal with the correct 75 Ω source impedance will be 2 V peak-to-peak. It only drops to 1 V when the load is applied. In the overlay circuitry, the input signal may not see a load if the MOSFET switch is not conducting (i.e. when opaque characters or backgrounds are being generated). But 2 V is still well below the 2.4 V maximum. Unfortunately, not every video source is well-behaved in this regard. While it may drive a 75 Ω load okay at a 1 V peak-to-peak level, this signal level may be a lot higher than 2 V without a load, because the source impedance is too high. The "standard" Propeller video DAC is an example. Its output without a load is 3.3 V peak-to-peak, even though its peak output level is 1 V with a 75 Ω load. Some cheap video "board" cameras also exhibit this tendency. In such cases, it will not be possible to provide full opacity to overlaid characters, since the MOSFET switch will have to be at least partially "on" to provide the incoming video with a load. But that's okay. It will still be possible to generate very readable overlays with a partially transparent background.

A fully operational and documented video overlay object is available in an App Note, downloadable from the Propeller Backpack product page.

Schematic



Propeller Backpack (Rev. E) Schematic