

## AP-16+ Audio Player

Version 1.0

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### DESCRIPTION

Professional prop builders know a secret: audio is more than half of the experience of a high-quality prop. Until now, most consumer-level audio boards lacked some real professional features -- features like quality amplification, stand-alone randomization of sounds, relay control for automated output while audio plays, and easy connections for manual and remote control. The AP-16+ is a high-quality, stereo WAV file player designed for serious prop builders of all levels. It's very easy to use, yet rich in features, and is easily integrated into props and displays.

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### PRODUCT APPLICATIONS

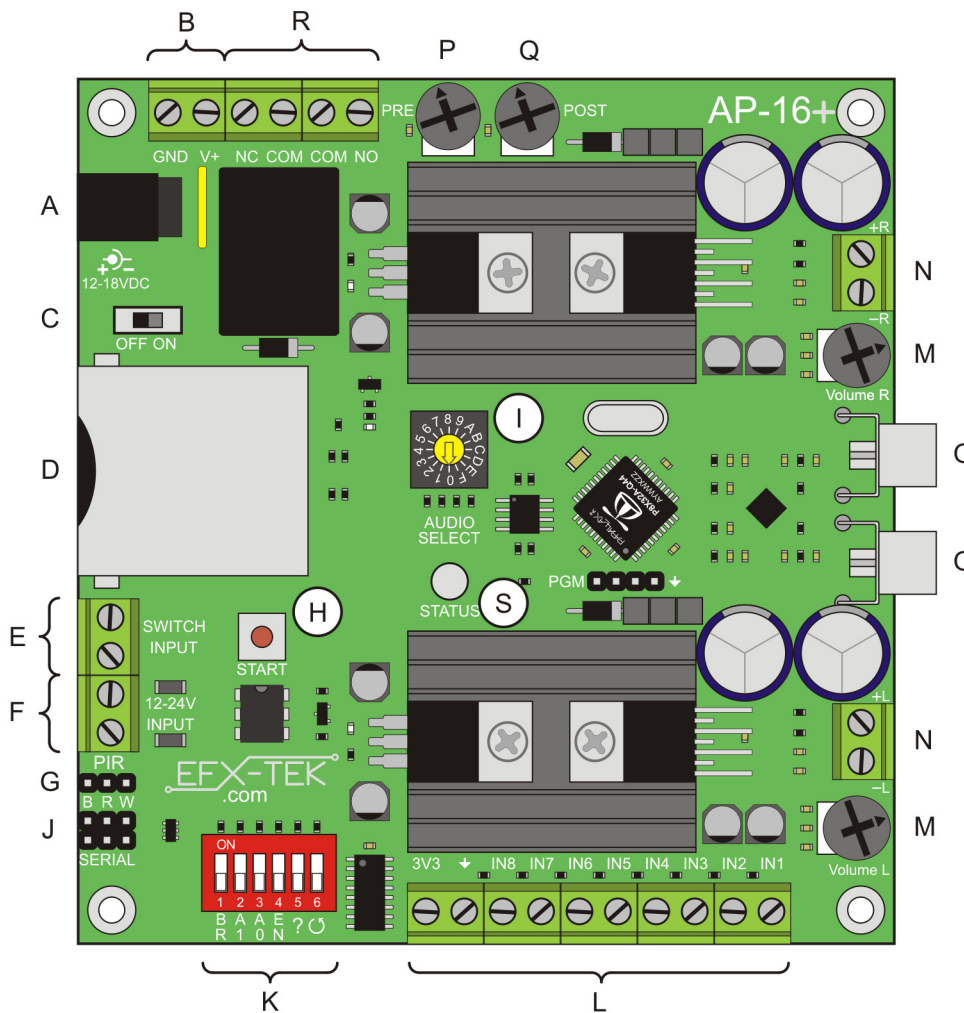
- Props and holiday displays
- Sophisticated audio annunciation for small-scale industrial control

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### FEATURES & BENEFITS

- Plays stereo WAV files (16-bit, PCM, up to 44.1kHz)
- Files stored on standard SD card (FAT or FAT32 format)
- 24 stand-alone files under manual control
- Optional, auto-playing ambient file (AMBIENT.WAV)
- Manual input via (normally-open) dry-contact, (optically isolated) 12-24 VDC input, or PIR sensor
- Eight, dry-contact auxiliary inputs
- Relay output active when file plays (N.O. and N.C connections provided)
- Pre- and post-play delay potentiometers (manual mode, only)
- Dual 20W amplifiers (one per channel)
- TTL serial control for connection to host microcontroller
  - unlimited files under serial control
- User-configured baud rate (2400 or 38.4k) for serial control
- User-configured address allows up to four AP-16+ boards on one serial connection
- Easily updated as new features become available – update loads from SD card
- Size: 4.25" x 4.50" (107.95mm x 114.30mm)
- Four, 0.135" (3.4mm) mounting holes

## AP-16+ Connections & Controls



- |  |   |
|--|---|
| <b>A.</b> Power input; 2.1mm barrel jack; 12 to 18 VDC | <b>K.</b> Option switches                     |
| <b>B.</b> Power input; terminal block; 12 to 18 VDC    | <b>L.</b> Auxiliary inputs (AUX files)        |
| <b>C.</b> Power switch                                 | <b>M.</b> Volume control (for speaker output) |
| <b>D.</b> SD card socket                               | <b>N.</b> Speaker output: 4Ω / 8Ω             |
| <b>E.</b> Start input: dry contact                     | <b>O.</b> Line level output                   |
| <b>F.</b> Start input: 12 to 24 VDC                    | <b>P.</b> Pre-play delay potentiometer        |
| <b>G.</b> Start input: PIR                             | <b>Q.</b> Post-play delay potentiometer       |
| <b>H.</b> Start input: manual button                   | <b>R.</b> Relay output terminals              |
| <b>I.</b> Audio Select switch (SFX files)              | <b>S.</b> Status LED                          |
| <b>J.</b> Serial input (Open-True TTL)                 |   |

## Power Input

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The AP-16+ is powered from 12 to 18 volts DC. DC power may be connected to via the 2.1mm power jack or through the V+ and GND terminals located just above the power jack.



**CAUTION:** Do not apply more than 18 volts DC to the power input; this is the maximum voltage allowed by the amplifier circuitry. Note, too, that for maximum volume the AP-16+ should be powered by 18 volts DC at 3 Amps.

## Audio Outputs

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The AP-16+ provides terminal outputs for 4Ω or 8Ω speakers. Be sure to select speakers of the appropriate wattage to handle the output, and always use enclosed speakers for the best fidelity. When not using the speaker output terminals you should rotate the speaker volume potentiometers fully counter-clockwise (lowest setting). If more volume is required the AP-16+ also provides line-level outputs that can be connected to an external, stereo amplifier.



**CAUTION:** When working in close proximity to the AP-16+'s speakers be very mindful of the volume settings – 20W per channel can be quite loud.

## AP-16+ Audio Files

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The AP-16+ plays PCM encoded, 16-bit, stereo WAV files at sample rates up to 44.1kHz. Monophonic files, or those with a different bit depth, will need to be converted.



**NOTE:** When converting files, especially from compressed formats (e.g., MP3), up-sampling is not recommended as it can lead to audio artifacts in the form of clicks, pops, and noise in the up-sampled file. It is best to maintain or even lower the sample rate when from compressed formats.

## AP-16+ Audio Files - Manual Mode

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The AP-16+ can work with up to 24 files in manual operation, as well as an optional “background” file that will play between selections (if enabled).

**AMBIENT.WAV** Background file that will play between other files when ambient loop switch (⤴) is set to ON. For best results this should be a “loopable” file and generally be at a lower level than other audio files.

Using the standard manual start inputs (see below) the AP-16+ can play any of 16 files, named SFX00.WAV through SFX15.WAV. Note that the AUDIO SELECT switch (I) is hexadecimal-encoded using digits 0 through 9, and letters A through F for 10 through 15.

**SFX00.WAV** Corresponds to manual input when AUDIO SELECT switch is in position 0.  
**SFX10.WAV** Corresponds to manual input when AUDIO SELECT switch is in position A.  
**SFX15.WAV** Corresponds to manual input when AUDIO SELECT switch is in position F.

The AP-16+ inventories SFX files on power-up; there is no requirement for all 16 SFX files to be present.

Using the auxiliary manual inputs (IN1..IN8) the AP-16+ can play any of eight files, named AUX01.WAV through AUX08.WAV. Note that when the EN (audio stop enable) option switch is set to ON, IN8 will serve as

a stop input and AUX08.WAV will not play in manual mode.

**AUX01.WAV**                      Corresponds to manual input on IN1  
**AUX08.WAV**                      Corresponds to manual input on IN8 (when EN option is off)

## **AP-16+ Audio Files - Serial Control Mode**

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When using an external controller like the Prop-1, Prop-2, or Prop-SX, the AP-16+ can play any number of files that are stored on the SD card. The only requirement is that the files are named using DOS 8.3 naming convention, that is, the name of the file is eight characters or less, followed the the ".WAV" extension.

File naming examples:

**BELL.WAV**                      Good file name  
**TELEPHONE.WAV**              Bad file name – too many characters in name (9)  
**WOLF.MP3**                      Bad file name – extension is incorrect; format probably incorrect as well

## **Manual Control**

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An SFXnn.WAV file can be started by:

- ✓ Using a normally-open push-button/switch across the SWITCH INPUT terminals (E)
- ✓ Applying a 12- to 24-volt DC voltage to the 12-24V INPUT terminals (F)
- ✓ Connecting a PIR or compatible sensor to the PIR input header (G)
- ✓ Pressing the START button (H)

Manual control of an SFXnn.WAV file has two modes: 1) standard, and 2) random. The mode is controlled by the position of the Random (?) option switch. When the random option switch is set to OFF the file to be played is set by the AUDIO SELECT switch.

When the the Random (?) option switch is set to ON the AP-16+ will randomly select a file between SFX00.WAV and the file set by the AUDIO SELECT switch. For example, if the Random option switch is set to ON and the AUDIO SELECT switch is set to 7, the AP-16+ will play one of the files in the range SFX00.WAV through SFX07.WAV. Note that the Random option uses internal logic so that all files within the selected range are played before any is repeated, and the same file will not play back-to-back.

An SFXnn.WAV file will play until finished, even it another trigger input (dry contact, DC, sensor, or START button) is detected. To stop an SFXnn.WAV file in progress:

- ✓ With the EN (audio stop enable) option switch on, press a button connected between 3V3 and IN8
- ✓ Send an "X" command through the TTL serial link
- ✓ Start an AUXnn.WAV file using one of the INx inputs

An AUXnn.WAV file can be started by connecting a normally-open push-button/switch between the 3V3 terminal and an INx (IN1..IN8) terminal. Note that the auxiliary inputs will override the current file if the selection differs from the file presently playing, and are not subject to pre- and post-play delays (see below). For example, if AUX01.WAV is playing and a button connected to IN2 is pressed, the AP-16+ will immediately stop AUX01.WAV and start AUX02.WAV. If, while AUX02.WAV is playing, another input on IN2 is detected, this input will be ignored. When the audio stop enable (EN) option switch is ON, IN8 serves as an audio stop; AUX08.WAV – even if present – will not play under manual control

## **Pre-Play and Post-Play Delays**

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For stand-alone projects the AP-16+ includes potentiometers for setting pre- and post-play delays applied to

manually-started SFXnn.WAV files (AUXnn.WAV files are not affected). The pre-play delay, 0 to 30 seconds, is set by the PRE potentiometer (P). During this delay the STATUS LED will flash between yellow and green, and the AP-16+ will remain silent (AMBIENT.WAV will be stopped if it was playing).

The post-delay potentiometer (Q) can be used to prevent immediate re-triggering of audio; this is especially useful when using the AP-16+ for stand-alone audio and prop control. The post-play delay, 0s to 3 minutes, is set by the POST potentiometer (Q). During this delay the STATUS LED (S) will flash between red and green, and if the ambient Loop switch (U) is set to ON, AMBIENT.WAV will be re-started during the post-play delay.

## Relay Control Output

The AP-16+ has an on-board relay with normally-open and normally-closed contacts (R). The relay is automatically activated when an audio is played. The relay is not activated for AMBIENT.WAV, or during the pre- and post-play delay periods.



**NOTE:** Rev A and Rev B PCBs have the relay terminals mis-marked; the correct marking for the relay outputs is shown below.



## Configuration Switches

The 6-position configuration switch controls many aspects of the AP-16+ behavior; the table below describes the function of each switch.

<b>BR</b>	Sets the baud rate for serial control (see below). When OFF, the baud rate is 2400 (Prop-1); when ON the baud rate is 38400 (Prop-2, Prop-SX).
<b>A1</b>	Controls the upper bit of the AP-16+ address for serial commands (see below).
<b>A0</b>	Controls the lower bit of the AP-16+ address for serial commands (see below).
<b>EN</b>	When ON, the EN option switch converts IN8 from a manual control input (for AUX08.WAV) to a “audio stop” input for any file (except AMBIENT.WAV when playing). When enabled the Audio Stop function will stop the file regardless of state: pre-play delay, playing, or post-play delay.
<b>?</b>	When ON, the ? switch activates random mode for SFX files. The file played will be from SFX00.WAV through the file indicated by the AUDIO SELECT switch.
<b>U</b>	When ON, the ambient Loop switch causes AMBIENT.WAV (if on the SD card) to be played while the AP-16+ is idle.

## Serial Protocol

The AP-16+ serial connection conforms to the Parallax AppMod bi-directional communications protocol, which operates at TTL (0 to 5 VDC) using “open-true” baud mode to enable daisy-chaining devices. All exchanges are initiated by the host controller. The format of host communications to the AP-16+ is as follows:

```
"!AP16", address, command { , data }
```

...where "!AP16" is the preamble that allows the AP-16+ to exist on the same communications line as other devices (e.g., DC-16, FC-4, RC-4), *address* is the board address set with configuration switches A1 and A0, *command* is a single-character command designator, and *data* is any value(s) that may be required by command.

AP-16+ Address settings for remote commands.

	OPTION A1	OPTION A0
Address = %00 (0)	OFF	OFF
Address = %01 (1)	OFF	ON
Address = %10 (2)	ON	OFF
Address = %11 (3)	ON	ON



**NOTE:** Valid addresses are in the range of %00 (0) to %11 (3). Commands that do not generate a response to the host will also work with the global address, \$FF (255).

The baud rate for serial communications is set with the BR option switch. When the BR option is set to OFF the AP-16+ uses 2400 baud (e.g., Prop-1); when the BR option is set to ON the AP-16+ uses 38.4k baud (e.g., Prop-2, Prop-SX).

The following section details the serial commands for the AP-16+.

**"X" :: Reset**

Syntax:   "!AP16", *address*, "X"  
 Reply:    None

The "X" (reset) command stops a file that is presently playing (via "P" command only, AMBIENT.WAV is not affected). If the ambient loop switch (⌋) is closed and AMBIENT.WAV is on the SD card, it will restart when the "X" stops another file.

Prop-1 Example

```
SEROUT Sio, OT2400, ("!AP16", %00, "X")
```

In this example a file that was previously started, either manually or using a "P" command, will be stopped and the random play list will be reset. Note that the reset command sets the channel levels and playback speed to 100%.

**"V" :: Get AP-16 Version Number**

Syntax:   "!AP16", *address*, "V"  
 Reply:    3-byte (ASCII) version string

Prop-1 Example:

```
SEROUT Sio, OT2400, ("!AP16", %00, "V")
SERIN  Sio, OT2400, id0, id1, id2
DEBUG "AP-16 Version ", #@id0, #@id1, #@id2, 13
```

## "G" :: Get AP-16 Status

Syntax: `"!AP16", address, "G"`

Reply: Single byte that indicates the AP-16+ status. See below.

AP-16+ status byte:

Bit	When 1	When 0
7	AP-16 is playing	AP-16 is idle (or ambient)
6	Playing looped mode	Playing single-shot mode
5	Playing named WAV file	Playing SFX or AUX file
4	Playing AUX file	Playing SFX file
3	BIT3 of file #	
2	BIT2 of file #	
1	BIT1 of file #	
0	BIT0 of file #	

Prop-1 Example:

```
SEROUT Sio, OT2400, ("!AP16", %00, "G")
SERIN Sio, OT2400, ap16Status
```

## "PS" :: Play SFX##.WAV File

Syntax: `"!AP16", address, "PS", #, loops`

Reply: None

The "PS" (play SFX) command is used to play a specific SFX##.WAV file (0 to 15). The *loops* parameter is used to specify the number of times to play the file (0 to 255); typically once (1). To continuously repeat the specified file until another play or reset command, use zero (0) as the *loops* parameter.

Prop-1 Example

```
SEROUT Sio, OT2400, ("!AP16", %00, "PS", 1, 1)
```

In this example, the AP-16+ at address %00 will play SFX01.WAV one time. If the ambient Loop switch (⏮) is closed and AMBIENT.WAV is on the SD card, it will restart when SFX01.WAV has finished playing.

## "P?" :: Play Random SFX##.WAV File

Syntax: `"!AP16", address, "P?", #, loops`

Reply: None

The "P?" (play random SFX) command is used to play a random SFX##.WAV file (00 to 15). The # parameter limits the file selection, which always begins with zero (SFX00.WAV). For example, to randomly play one of the files from SFX00.WAV through SFX04.WAV, the # parameter would be set to four (4). As with the "PS" command, the *loops* parameter specifies the number of times to repeat the file.

Note that the AP-16+ maintains an internal play list so that – if using the same limit # in the "P?" command – no file will be repeated until all within the range have played.

## Prop-1 Example

```
SEROUT Sio, OT2400, ("!AP16", %01, "P?", 7, 1)
```

In this example, the AP-16+ at address %01 will play one of the files in the range SFX00 through SFX07.WAV one time. If the ambient Loop switch (⌚) is closed and AMBIENT.WAV is on the SD card, it will restart when SFXnn.WAV has finished playing.

### "PA" :: Play AUX##.WAV File

Syntax: `"!AP16", address, "PA", #, loops`  
Reply: None

The "PA" (play SFX) command is used to play a specific AUX##.WAV file (1 to 8). The *loops* parameter is used to specify the number of times to play the file (0 to 255); typically once (1). To continuously repeat the specified file until another play or reset command, use zero (0) as the *loops* parameter.

## Prop-1 Example

```
SEROUT Sio, OT2400, ("!AP16", %10, "PA", 7, 1)
```

In this example, the AP-16+ at address %10 will play AUX07.WAV one time. If the ambient Loop switch (⌚) is closed and AMBIENT.WAV is on the SD card, it will restart when SFX01.WAV has finished playing.

### "PW" :: Play Named WAV File

Syntax: `"!AP16", address, name, {CR}, loops`  
Reply: None

The "PW" (play named WAV file) command is used to play a WAV file by name (which must conform to the DOS 8.3 file naming convention). When using the "PW" command, the ".WAV" file extension is optional, but the file name must be terminated with a carriage return (13). As with the other play commands, the *loops* parameter is used to specify the number of times to play the file (0 to 255); typically once (1). To continuously repeat the specified file until another play or reset command, use zero (0) as the *loops* parameter.

## Prop-1 Example

```
SEROUT Sio, OT2400, ("!AP16", %11, "PW", "WOLF", 13, 2)
```

In this example, the AP-16+ at address %11 will play WOLF.WAV two times, back-to-back. If the ambient Loop switch (⌚) is closed and AMBIENT.WAV is on the SD card, it will restart when WOLF.WAV has finished playing both loops.

Note that if an invalid name is specified while the ambient file is playing, the ambient file will be restarted. The AP-16+ must stop AMBIENT.WAV in order to search and verify the file specified in the "PW" command.



**NOTE:** Any "P" command will always stop audio that is playing. Use the "G" command (get status) to check on the AP-16+ if you do not desire this behavior



## "L" :: Set Channel Volume Levels

Syntax: `"!AP16", address, "L", left, right`  
Reply: None

The "L" (set levels) command is used to set the volume levels (0% to 100%) for each of the WAV channels.

### Prop-1 Example

```
SEROUT Sio, OT2400, ("!AP16", %00, "L", 50, 50)
```

In this example, the AP-16+ at address %00 will change both the left and right channel levels to 50%.

## "S" :: Set Playback Speed

Syntax: `"!AP16", address, "S", speed`  
Reply: None

The "S" (set speed) command is used to set the playback speed (50% to 200%). Note that the maximum sample rate is 44.1kHz so a 44.1kHz file cannot be made to play faster.








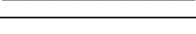
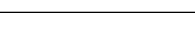
### Prop-1 Example

```
SEROUT Sio, OT2400, ("!AP16", %00, "S", 75)
```

In this example, the AP-16+ at address %00 will change the playback speed for subsequent files to 75%. This will cause the pitch to be lower and the playback duration to be longer.

## Status LED

The AP-16+ uses a multi-color status LED (S) to provide information regarding the operational state. The table that follows illustrates steady and blinking patterns that you will see from the status LED under various operational conditions.

	Ready
	Pre-play delay in progress (manual mode, SFX files only)
	Playing
	Post-play delay in progress (manual mode, SFX files only)
	Selected file not on SD card
	Invalid serial command or command time-out
	SD card not mounted (not inserted at power-up)
	Updating firmware from SD card (see below)
	Firmware update failure (may require cable and Prop-Plug to update)

## SD Card

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The AP-16+ can use any standard SD card that is FAT or FAT32 formatted, up to 4G in size. For best performance you should only put those files actually used by the project onto the SD card.



**NOTE:** Always switch off power before removing or inserting the SD card. Failure to do so could result in one or more corrupted files.

## Firmware Updates

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From time-to-time EFX-TEK may release firmware updates to add to or improve the features of the AP-16+. These updates will be provided free-of-charge. To install the update you will download an update file from EFX-TEK that will have the form:

AP16\_vXYY.EEPROM

...where X is the major version number and YY is the minor version number.

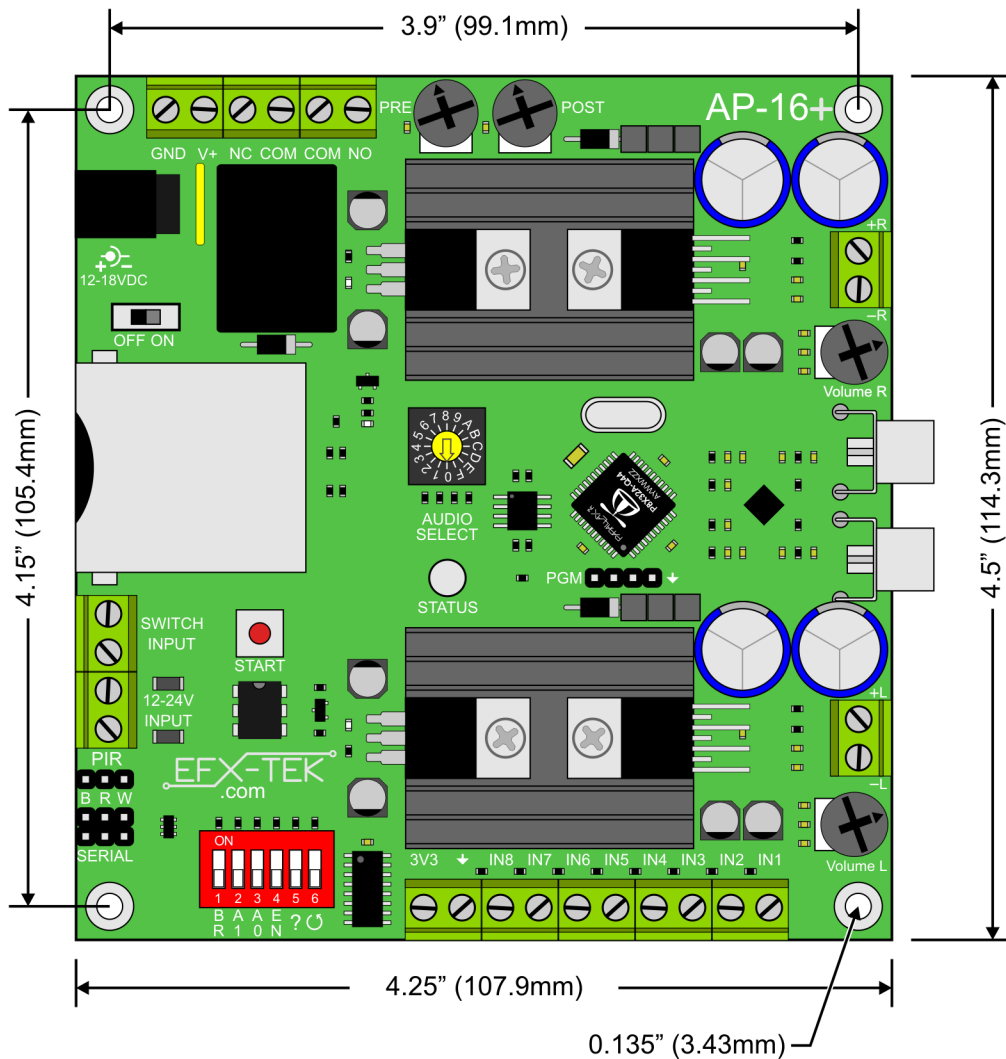
If you have a Parallax Prop-Plug and the Propeller Tool Software you may load this file and download it into the AP-16+; the programming connection is right below the large IC (Propeller chip) on the PCB. Once the file is download, power-down, remove the Prop-Plug, and then power back up.

A programming cable is not required. You may copy the above file to the SD card and rename it as follows:

AP16.PGM

Insert the SD card and power-up. Once the the AP-16+ is initialized it will look for this file; if detected the update will commence and the Status LED (S) will flash. The update takes about 15 seconds. Once the new firmware is installed the AP-16+ will restart itself and be ready to run with the new features.

## Mechanical Specifications



## Electrical Specifications

Parameter	Symbol	Specification			Unit
		Min.	Typical	Max.	
Supply Voltage	$V_{IN}$	12		18	VDC
Supply Current	$I_{IN}$	150			mA
Output Power (@18VDC) - 4 $\Omega$	$P_O$	18	20		W
Output Power (@18VDC) - 8 $\Omega$	$P_O$	10	12		W
Output Power (@12VDC) - 4 $\Omega$	$P_O$		13		W
Output Power (@12VDC) - 8 $\Omega$	$P_O$		8		W

Output power rating is per channel.