|  |  |
| --- | --- |
| **The "Mighty Midget" Audio Amplifier Module**  **It's based on a Philips class-H audio amplififer IC and can deliver 36W RMS OR 70W music power, all from a 13.8V supply.**  By Rick Walters |  |
|  |



Our new Mighty Midget Amplifier can really pack a punch - around 36W RMS continuous into a 4-ohm load when using a 13.8V supply. However, it's the 70W of output power that it can deliver during dynamic (music) signal conditions that really make you sit up and take notice.

As can be seen from the photos and the circuit diagram, the Mighty Midget uses just a handful of parts. It's built on a PC board that measures just 104mm x 39mm but while its size may be modest, these's nothing at all modest about its power output. And the noise and distortion figures are pretty good too.

At the heart of the circuit is the TDA1562Q IC, described by Philips as a "monolithic integrated Bridge-Tied Load (BTL) class-H high-efficiency power amplifier". It comes in a 17-pin "DIL-bent-SIL" plastic package and is not only designed for use in car audio and portable PA work but for mains applications as well; eg, mini/midi audio components and TV sound.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| PERFORMANCE   |  |  | | --- | --- | | **Output power:** | 36W RMS into 4Ω | | **Music power:** | 70W into 4Ω | | **Frequency response:** | -1dB down at 28Hz and 55kHz | | **Input sensitivity:** | 130mV RMS (for 36W into 4Ω) | | **Harmonic distortion:** | typically 0.2% (see graphs) | | **Signal-to-noise ratio:** | 95dB unweighted (22Hz to 22kHz) | |

Specifications  
   
Fig.1 block diagram of the TDA1562Q class-H audio amplifier IC.The "Lift Suppy" stages drive external capacitors(C1 & C2) to boost the supply rails when needed.The specifications panel and the accompanying graphs show the performance of our prototype, as measured on our Audio Precision test gear. Note that the total harmonic distortion is typically less than 0.2% at 1kHz for output powers up to about 16W RMS, while the signal-to-noise ratio is better than 95dB unweighted (22Hz to 22kHz).  
  
The frequency response is virtually ruler flat from 28Hz to 55kHz.  
  
Pumping it out  
So how does it achieve such high output powers when powered from a 13.8V rail? Well, it employs a few clever tricks. Let's take a closer look.  
  
First, the TDA1562Q chip actually incorporates two power amplifiers in its package and these are operated in bridge mode to boost the available output power. Fig.1 - the block diagram of the TDA1562Q IC - shows the general idea.  
  
Normally, if we have just one amplifier stage operating from a 13.8V supply, the maximum power that can be delivered into a 4Ω load is about 6W. The reason for this is that the maximum voltage "swing" possible from a 13.8V supply is 6.9V in the positive direction and 6.9V in the negative direction. This is equivalent to about 4.88V RMS (ie, 6.9/1.4142).  
  
From there, the mathematics is simple enough - the power output is equal to the square of the RMS voltage divided by the load resistance; ie, P = V&sup2;/R. This means that we get 4.88 x 4.88/4, or about 5.95W RMS.  
  
However, this is a theoretical maximum and is never realised in practice. The actual output power is likely to be closer to 4.5W RMS due to losses in the output devices of the amplifier.  
  
   
Fig.2: the circuit uses a phase splitter based on IC1a & IC1b to drive the inputs of IC2 in anti-phase.One way of obtaining more power is to wire two identical power amplifiers in "bridge" mode, with each amplifier essentially a "mirror" of the other. One amplifier drives one side of the loudspeaker in a positive voltage direction, while the other drives the other side of the loudspeaker in a negative voltage direction. As a result, the voltage across the loudspeaker is effectively doubled compared to the voltage delivered by a single power amplifier.  
  
This doesn't just double the power output, though. Instead, as shown by the above formula, doubling the voltage swing effectively quadruples the output power! So if we use two amplifiers which on their own can deliver only about 4.5W into 4Ω, we can expect to obtain about 18W RMS into the same load when they are connected in bridge mode.  
  
And 18W RMS is a "helluva" lot better than 4.5W RMS.  
  
Jacking up the supply  
   
Fig.3: total harmonic distortion (THD) vs. frequency at 12W (measurement bandwidth 10Hz-80kHz). The dip at 100Hz is due to cancellation with supply ripple.That's by no means the end of the story, though. As previously stated, the TDA1562Q is capable of delivering 36W RMS and up to 70W of music power.  
  
How does it do this? Well, according to Philips, at low output powers, up to 18W, the device operates as a normal BTL amplifier. However, when a larger output voltage swing is required, the internal supply voltage to the power amplifiers is "jacked up" by using the "Lift-Supply" stages to switch in two external electrolytic capacitors - see Fig.1.  
  
There are no details in the specifications as to how the "Lift-Supply" stages work but we assume it's a type of boot-strapping circuit whereby each of the two power amplifiers in the bridge circuit actually "jacks up" an external 4700μF capacitor to increase the effective supply voltage.  
  
   
Fig.4: total harmonic distortion vs. frequency at 36W (measurement bandwidth 10Hz-80kHz). It's less than 0.5% for frequencies from 30Hz to 10kHz.Normally, the external electrolytic capacitors are switched across the 13.8V supply and charge to about 12.8V (ie, about 1V less than the supply rail). When extra power is required, these capacitors are boosted up by the respective power amplifiers so that ultimately, the supply voltage is almost doubled.  
  
As a result, the amplifier module can briefly deliver much greater output power - up to 70W of music power or up to 36W RMS (ie, continuous power) as previously mentioned. Of course, it cannot maintain 70W of output power for long. The two external capacitors immediately begin to discharge when the amplifier is delivering this sort of power and so the supply rails quickly falls again.  
  
On practical music signals, however, this isn't normally a problem, as the electrolytic capacitors are quickly switched out and charged again between the signal peaks.  
  
Class-H or Class-G?  
   
Fig.5: total harmonic distortion vs. power output at 1kHz (measurement bandwidth 22Hz-22kHz).Philips refer to this scheme for operating the power amplifiers as class-H operation. In class-H operation, the input signal is monitored and the supply rail is constantly adjusted to provide just enough voltage for optimum operation of the output devices.  
  
By contrast, class-G operation involves monitoring the input signal and switching the output stage between two different supply rails, as required. In this scheme, the (class-AB) output stage is normally connected to the lowest rail and automatically switches to the higher rail for large signal peaks.  
  
So which of the two schemes is it? Philips label the TDA1562Q as a class-H amplifier and we are inclined to agree with this although we still don't know the exact mechanism of the "Lift Supply" circuitry. No matter - which ever label is used, it's very effective at boosting the output power.  
  
   
Fig.6: the frequency response at 1W. It's just 1dB down at 28Hz and 55kHz.Another advantage of class-H (or class-G) operation is that it reduces dissipation in the output stages by about 50%. That's because the output stages operate at low voltage for most of the time when the amplifier is driven by music signals. This means that the heatsink size can be greatly reduced.  
  
By the way, all switching from class-AB to class-H operation (and vice versa) takes place at zero crossing points of the input signal. This is done to eliminate switching artefacts, which could otherwise cause distortion in the output signal. It's a very effective technique - we could find no traces of switching noise whatsoever.  
  
A rugged device  
Another good thing about the TDA1562Q is that it is virtually indestructible (within limits). It's output stage is short-circuit proof (either to ground, the supply rail or across the load) and it features thermal overload protection, good supply ripple rejection and static discharge protection.  
  
There are also no switch-on or switch-off plops and the output is automatically muted if the supply voltage drops below the minimum operating level. The thermal overload protection works by automatically switching the device from class-H to class-AB operation if its case temperature exceeds 120&deg;C. This basically disables the high-voltage supply and thus limits the output power to less than 20W.  
  
Circuit description  
   
Fig.7: follow this layout diagram when installing the parts on the PC board. Make sure that all polarised parts are correctly oriented.Refer now to Fig.2 for the complete circuit details of the Mighty Midget Amplifier. Apart from the TDA1562Q itself (IC2), there is a dual op amp IC (IC1), two air-cored inductors and a few resistors and capacitors.  
  
Op amps IC1a and IC1b together function as a phase splitter. These stages are necessary to provide a differential input to the amplifiers in IC2, both of which have their inputs at pins 1 & 2.  
  
As shown, the input signal is fed to pin 3 of IC1a. This functions as a non-inverting amplifier with a gain of 2.4, as set by the 47kΩ and 33kΩ feedback resistors (ie, Gain = 1 + 47/33). Its output is AC-coupled to pin 2 of IC2 via a 0.1μF capacitor and drives IC1b which is wired as an inverting unity gain amplifier.  
  
   
Fig.8: this full-size etching pattern for the PC board (code 01203021).IC1b in turn drives pin 1 of IC2 via a 0.1μF capacitor. As a result, the signal on pin 1 is inverted (180&deg; out of phase) compared to the signal on pin 2 and so we get true differential drive to IC2, with a gain of 2.4 for each input. The input impedance for each pin is 75kΩ (with respect to Vref) and so the low-frequency rolloff with 0.1μF input capacitors is about 20Hz.  
  
Bias for IC1a & IC1b is provided by a voltage divider consisting of two 10kΩ resistors. The resulting half-supply voltage (Vcc/2) is then filtered using a 100μF capacitor and is directly connected to pin 5 of IC1b. It also biases pin 3 of IC1a via a 47kΩ resistor and this ensures that pin 1 swings symmetrically about Vcc/2.  
  
IC2 operates with a nominal fixed gain of 20 or 26dB. Its two internal amplifiers amplify the signals on pins 1 & 2 and in turn provide out-of-phase (mirror image) signals to drive the bridge tied load (BTL). This BTL consists of a loudspeaker which is fed via two Zobel networks, each consisting of a 2.2Ω resistor and a parallel 880nH inductor.  
  
   
This close-up view shows the prototype PC board. The final version (Fig.7) has been amended to include a screw-terminal block for the supply connections and also features improved component spacing (especially near the inductors).The Zobel networks present a resistive load to the amplifier at high frequencies and ensure stability. They also help reduce transient and RF interference, which can be picked up by the loudspeaker leads, from being fed back into the early stages of the amplifiers via the feedback paths.  
  
The two external capacitors for the "Lift Supply" blocks each have a value of 4700μF. This value determines the low-frequency power roll-off.  
  
Pins 4 and 16 of IC2 have been tied high in this circuit. Pin 4 (Mode) must be tied high for normal operation - tying it low places IC2 into "standby" mode (effectively switching it off), while leaving it open circuit mutes the output by suppressing the input signal.  
  
Pins 8 (Diag) and 16 (Status) are normally used in conjunction with a microcontroller to monitor various parameters. For example, the "Dynamic Distortion Detector" inside the TDA1562Q can detect the onset of clipping and this information is fed to the diagnostic output. It could then be processed to drive a DC-volume control to attenuate the input signal accordingly and so limit the distortion.  
  
Similarly, the diagnostic output can indicate various short-circuit and temperature conditions. It can either be left open-circuit or tied to the +12V rail via a 10kΩ resistor. The Status pin (pin 16) is tied high to ensure that the amplifier operates in class-H mode.  
  
Table 1: Resistor Colour Codes  
No. Value 4-Band Code (1%) 5-Band Code (1%)   
2 47kΩ yellow violet orange brown yellow violet black red brown   
1 33kΩ orange orange orange brown orange orange black red brown   
4 10kΩ brown black orange brown brown black black red brown   
2 2.2Ω red red gold brown red red black silver brown   
   
  
PC board assembly  
   
The TDA1562Q is secured to the heatsink using two 15mm x 6BA machine screws, nuts & washers. This also provides sufficient support for the PC board.All the parts for the Mighty Midget Amplifier are accommodated on a PC board measuring 104mm x 39mm and coded 01203021. Fig.7 shows the assembly details.  
  
Before mounting any parts, first check your PC board for etching defects or undrilled holes by comparing it with the published pattern (Fig.8). This done, you can start the assembly by fitting the wire links, the resistors and the MKT capacitors. The two 100μF capacitors can then go in, taking care with their polarity.  
  
Table 1 shows the resistor colour codes but it's a good idea to also check them using a multimeter. That's because some of the colours can be difficult to decipher.  
  
The next step is to wind the two inductors that are used in the Zobel networks. These are made by winding 20 turns of 1mm enamelled copper wire onto a 5mm former (eg, a 5mm or 3/16-inch drill). Note that you will have to wind the last five or six turns back over the winding, so that the inductor leads line up with the board mounting holes.  
  
Because of space restrictions, the inductors are mounted proud of the PC board, so that they sit clear of the 2.2Ω resistors. Clean and tin the ends of the leads before soldering them in position. That done, fit the screw terminal block for the supply connections, followed by PC stakes for the signal input and loudspeaker terminals.  
  
   
Fig.9.: the top trace shows the continuous output from the amplifier terminals at 36W into 4W. The lower two traces show the individual amplifier outputs which add to give the final BTL output.IC1 & IC2 can now be installed and the PC board fitted to the heatsink. Make sure that IC1 is installed the right way around, with pin 1 adjacent to the 47kΩ resistor. IC2 can only go in one way, so there's no chance of confusion here.  
  
The next job is to drill two holes in the heatsink to match the mounting holes at either end of the TDA1562Q. That done, deburr the heatsink mounting holes using an oversize drill and smear the mating surface of the TDA1562Q with heatsink compound. The assembly can then be bolted together using two 15mm x 6BA machine screws, nuts and washers.  
  
You can now complete the assembly by fitting the three large electrolytic capacitors but watch their polarity - electrolytic capacitors have a nasty habit of exploding if installed the wrong way around. These capacitors are all left until last to avoid accidental damage and, in the case of the centre 4700μF unit, to ensure access to the lefthand mounting screw for the TDA1562Q.  
  
Note that pin 4 (Mode Select), pin 8 (Diag) and pin 16 (Status I/O) have been brought out to vacant pads. These are not used in this circuit.  
  
Testing  
   
Fig.10: the same test conditions as for Fig.9 but with a music-power signal at 70W into 4W.To test the amplifier module, you will need a regulated power supply with an output of 12-15V DC (eg, a car battery or a 12V SLA battery). Be sure to connect it to the terminal block with the correct polarity.  
  
Note: a car battery charger can NOT be used as a DC supply for this amplifier module. That's because battery chargers deliver significantly more than 12V (they have to in order to charge) and also because they don't include any filtering.  
  
Initially, you should connect your multimeter - set to a DC current range - in series with one of the supply leads. This done, switch on and check that the current consumption is somewhere in the range of 110-150mA. If you don't get this, switch off immediately and check for wiring mistakes.  
  
After that, it's simply a matter of connecting the loudspeaker and feeding in an audio signal to confirm that it works.  
  
Note that if you are using a mains power supply to drive the module, it may lack sufficient output current capability for the amplifier to deliver full power during transients. In fact, a low-current supply could even activate the muting circuit in the TDA1562Q, due to the supply rail falling below about 8V.  
  
In practice, to drive the amplifier to full power, the power supply will need to be able to deliver at least 6A.  
  
Note too that car electrical systems normally don't run at 12V. Instead, most run at 13.8-14.4V when the motor is running. The Mighty Midget Amplifier is designed to handle this but don't push the supply voltage beyond about 16V - you'll exceed the ratings of the 4700μF electrolytic capacitors if you do.  
  
Speaker requirements  
You can use a huge variety of speakers with this module - even low-power speakers can be used as long as long you don't wind the wick up to far!  
  
The main thing to note is that the TDA1562Q is designed for use with 4Ω speakers and will deliver maximum power into 4W. Most car audio speakers are rated at 4Ω for this very reason. Of course, the amplifier will also quite happily drive an 8W loudspeaker. The drawback is that you will only get half the power output compared to driving a 4Ω speaker.  
  
Finally, there is a common misconception that large speakers require more power to drive than small speakers. This is not usually the case - large speakers are usually more efficient than small speakers of similar rating and will therefore sound louder when driven by the same amplifier.  
  
Table 2: Capacitor Codes  
Value IEC Code EIA Code   
0.33μF 330n 334   
0.22μF 220n 224   
0.1μF 100n 104   
   
  
Parts List  
1 PC board, code 01203021, 104 x 39mm   
1 1-metre length of 1mm-dia. enamelled copper wire   
1 heatsink (eg, Jaycar HH-8566 & HH-8572; DSE H-3460;   
Altronics H-0560 & H-0522)   
2 2-way PC-mount screw terminal block (5.08mm pitch)   
4 PC stakes   
2 15mm x 6BA machine screws   
2 6BA nuts   
4 6BA washers   
Heatsink compound   
Semiconductors   
1 TL072 dual FET op amp (IC1)   
1 TDA1562Q BTL power amplifier (IC2)   
Capacitors   
2 4700μF 16VW PC-mount electrolytic   
1 2200μF 16VW PC-mount electrolytic   
2 100μF 25VW PC-mount electrolytic   
2 0.22μF MKT polyester   
4 0.1μF MKT polyester   
Resistors (0.25W 1%)   
2 47kΩ 4 10kΩ   
1 33kΩ 2 2.2Ω 1W