The TDA7000 FM Receiver

My attention was first drawn to this IC when Elektor in December 1983 published a project called "Personal FM". Then in the late 1980's, Tandy were selling this IC for about $8. I didn't really take much notice of it until around that time when I was looking for simple VHF FM receiver designs, that would function better than super regen circuits. (*This was before I discovered the Pulse Counting receiver design*). I dug out the Elektor article and was intrigued at how this IC functioned and the lack of coils and alignment usually associated with superhet receivers. Looking at the Philips data with its mention of 1.5uV sensitivity also got my attention.

Taken from the 1989 Tandy catalog.

Background

What is unusual about this IC is how it operates. It is a proper FM superhet receiver, with the usual local oscillator, mixer, IF amplifier, limiter, and phase detector. The difference is that there's only one tuned circuit; the local oscillator. Like the Pulse Counting Receiver, the TDA7000 relies on a low IF so that ordinary Op Amp circuitry can take care of the gain and bandpass characteristics. Only 70Kc/s is used with the TDA7000. Now, you might remember that the deviation of a broadcast FM signal is +/- 75Kc/s. A fully modulated signal would therefore sound rather distorted. So, how can this IC work?
It's quite simple in that there is what Philips call a Frequency Locked Loop. Basically, the local oscillator is shifted in response to detector output so that the bandwidth of the mixer output is never more than +/- 15Kc/s. It is actually compressing the frequency range of the modulated signal.
The muting or squelch feature is novel to say the least. Although it performs as any other muting circuit does, the TDA7000 provides an artificial noise generator so that the receiver still sounds alive while tuned off station. If you don't need that feature, just remove the .022uF condenser at pin 3. Not all Philips data sheets show it, but connecting a 10K resistor from the supply to pin 1 will disable the squelch.

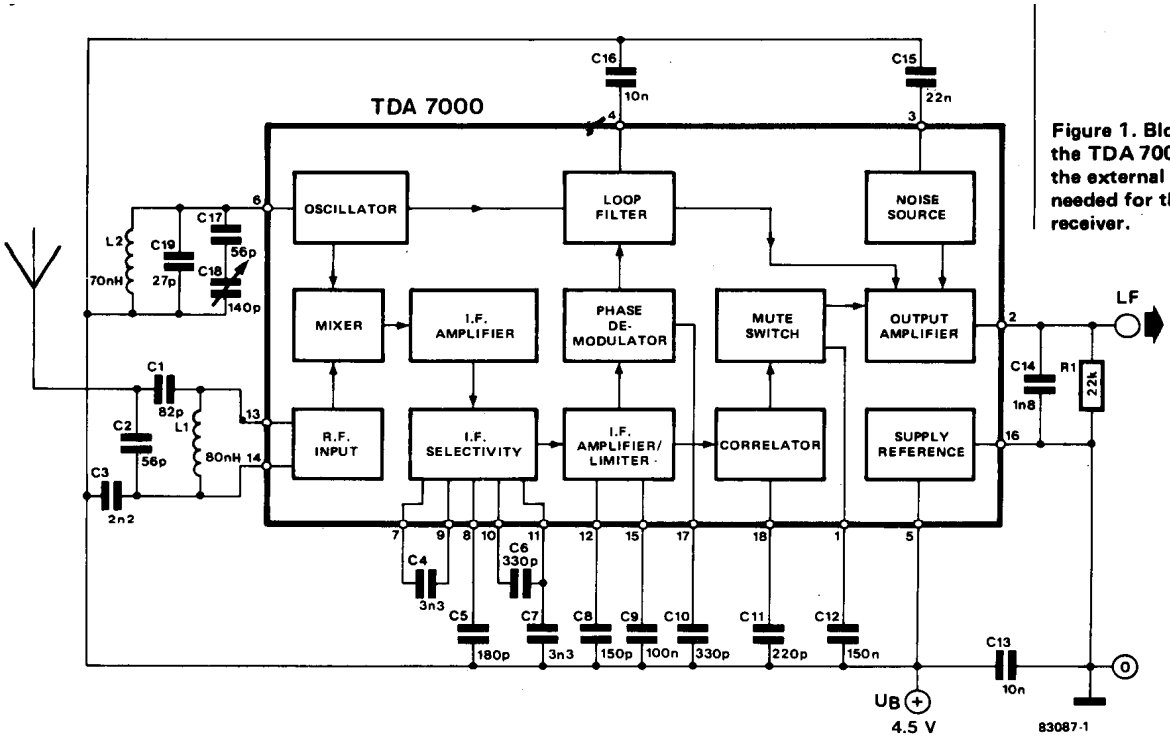


Figure 1. Block diagram of the TDA 7000 including the external components needed for the basic radio receiver.

Block diagram of the TDA7000 as used for a typical FM receiver. Audio output is around 75mv.

At this point I recommend you have a look at the Philips application notes. They give a good background to the design and use of this IC. For curiosity value, have a look here for the application notes regarding Narrow Band FM. In case you were thinking a low IF would be suitable for a NBFM receiver, you're right. Note that the TDA7000 is not suitable for feeding into a stereo decoder.
It is interesting to speculate as to why Philips didn't make this IC a pulse counting receiver. After all, the low IF is ideal, and pulse counting technology had been around for a while.

The TDA7000 starts a family!

Philips didn't stop with just the TDA7000 in its 18pin DIP package. Next came the TDA7010T which is the surface mount version. It comes in a 16pin SMD package. What of the other two pins? Well, the artificial noise generator has been dispensed with and so has the connection to one of the IF filter capacitors. The latter is a bit odd; I'm not sure if it could be dispensed with altogether or if they managed to fit it inside the chip. The data for both chips is the same apart from that.
Next comes the TDA7021T which is also surface mount but is stereo compatible. Lastly comes the surface mount TDA7088T which is mono only but has a search type tuning and works on 3V.
The TDA7000 is one of those IC's like the 555 that is a brilliant design with so many uses, but never really found its way into commercially made products. Instead it seems that it's kits and other homemade gear that have kept it going. I have never seen the TDA7010T or TDA7021T used in anything commercially made, or even a kit. The TDA7088T however does exist in some of those miniature keyring FM receivers that are popular of late.

R.I.P. TDA7000

Unfortunately as I write this in early 2004, the TDA7000 is no longer being produced having being withdrawn from manufacture, December 2003. Actually, it's a pretty long production run when you consider it is just over 20 years old. So, if you want to play around with this IC, keep in mind that there won't be any new stock. The last TDA7000's I bought a few months back were made in 1994, so I'd say there are ample stocks around for a while. Who knows; it might go the way of the ZN414 and be cloned by some other company.
However, all is not lost for the TDA7010T is electrically the same. It does mean you have to be able to make a PCB with tracks close enough together for surface mount. You could probably use it with existing PCB's by running fine wire to the pins, or even mounting the TDA7010T in an 18 pin header. This IC, the TDA7021T and TDA7088T are still current Philips production. The TDA7021T can also be used; you don't have to use it for a stereo receiver. And the TDA7088T can be used with a normal variable condenser if you want to.
Unfortunately it seems that Sony have dominated the market with their SMD chips for use in miniature radios. They use the boring kind of 10.7Mc/s IF circuit, however.

Constructing a TDA7000 receiver

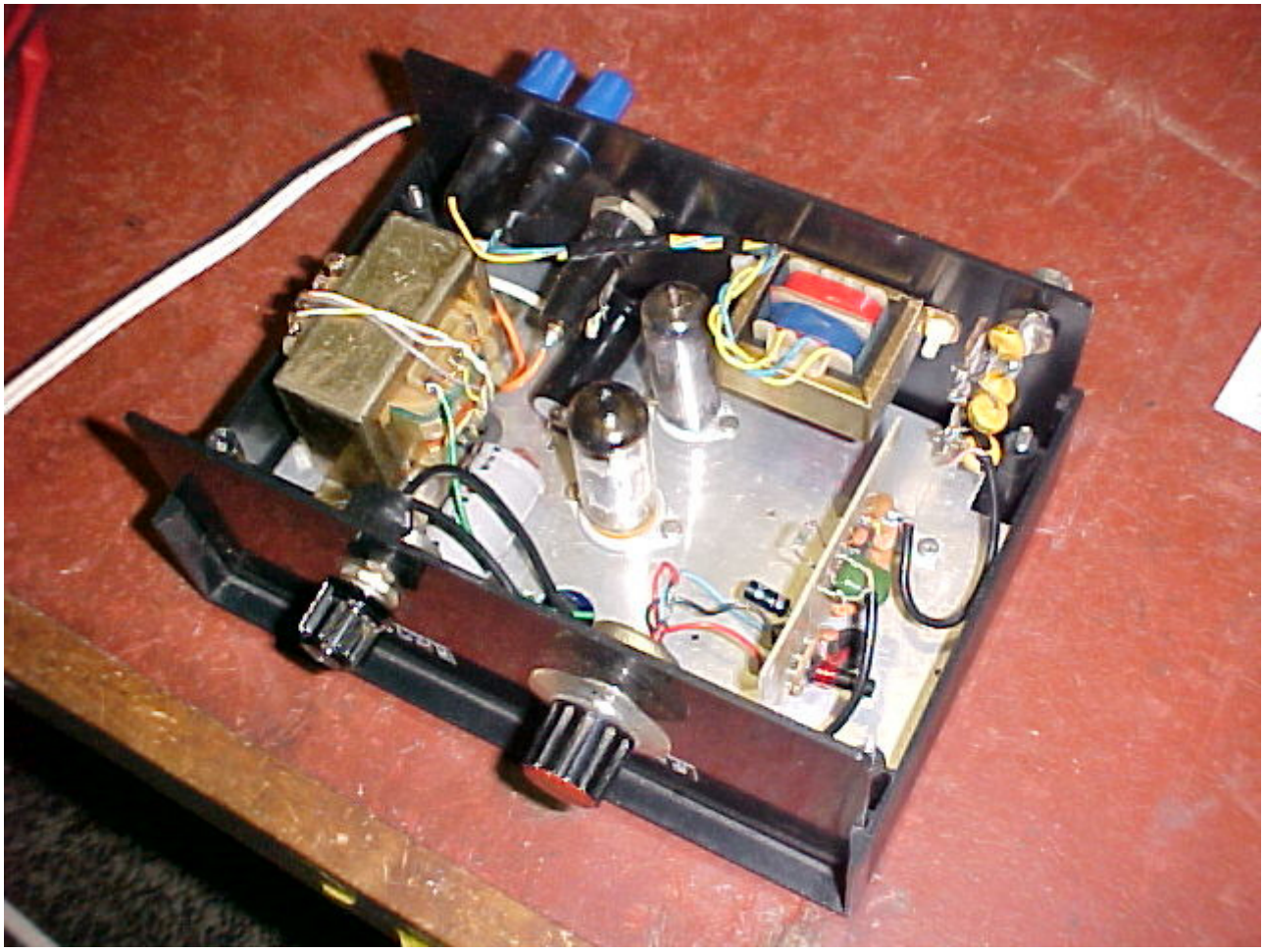
I bought my first TDA7000 IC in 1988 and tried to build up a receiver on a piece of matrix board. Here I learnt the first thing of importance. Layout and groundplanes are critical to using this IC. The Philips data gives a PCB layout and this should not be altered too much. Of course my matrix board receiver didn't work properly.

Bought from Tandy in Chatswood; like all their components, packaging was excessive. An abbreviated reprint of the Philips AN192 application notes was included.

Soon after, Electronics Australia did an article (June 1988) with a TDA7000 and LM386 for the audio. So, I purchased the PCB and constructed just the TDA7000 part. I didn't think much of the LM386 (and still don't) so I made a two transistor class A amplifier on another PCB instead. The other alteration was to use a BB809 varicap diode for tuning. I didn't like the idea of EA using a trimmer capacitor.
The receiver certainly worked but the "1.5uV" sensitivity seemed questionable. Also the way the squelch worked was a bit strange. Apart from that, the sound was very good.

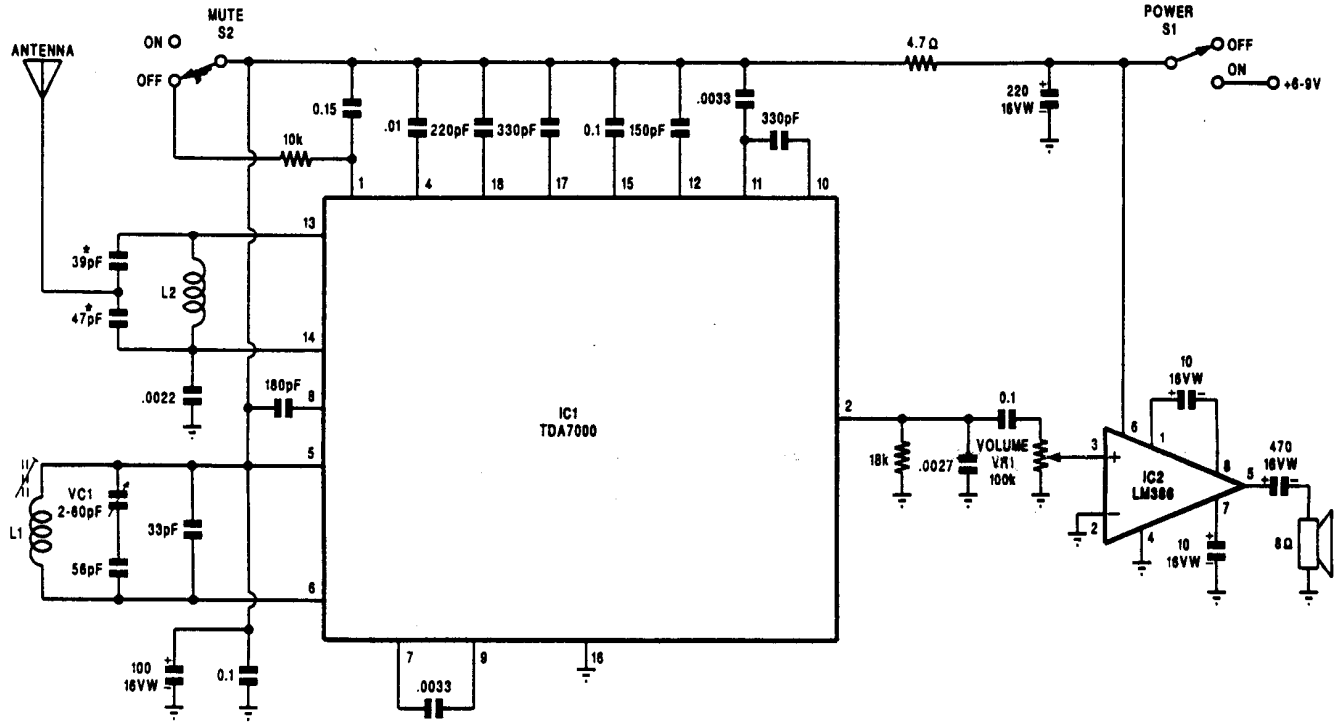
Mains operated TDA7000 receiver

Around November 1990, I built my mains operated TDA7000 receiver. This used the EA PC board but fed a 6AV6 and 6DX8 amplifier in a plastic box. A 6X4 half wave rectified the mains with heaters powered off my original DSE2155 transformer. Of course being a live chassis set, precautions were taken. External screws were nylon, a mains rated transformer was used for the output transformer, and 400V isolating condensers were used to connect the aerial. A few years ago I removed the 6AV6 stage as the audio gain was much higher than needed. I had originally acquired the 5V supply for the TDA7000 and varicap diode from the 6DX8 pentode cathode. However, drift was a problem and found that the 6DX8 cathode current being only about 20mA was only just enough to power the 7805 regulator, leaving the TDA7000 barely functional. I simply half wave rectified the 6.3V heater supply to fix that one.

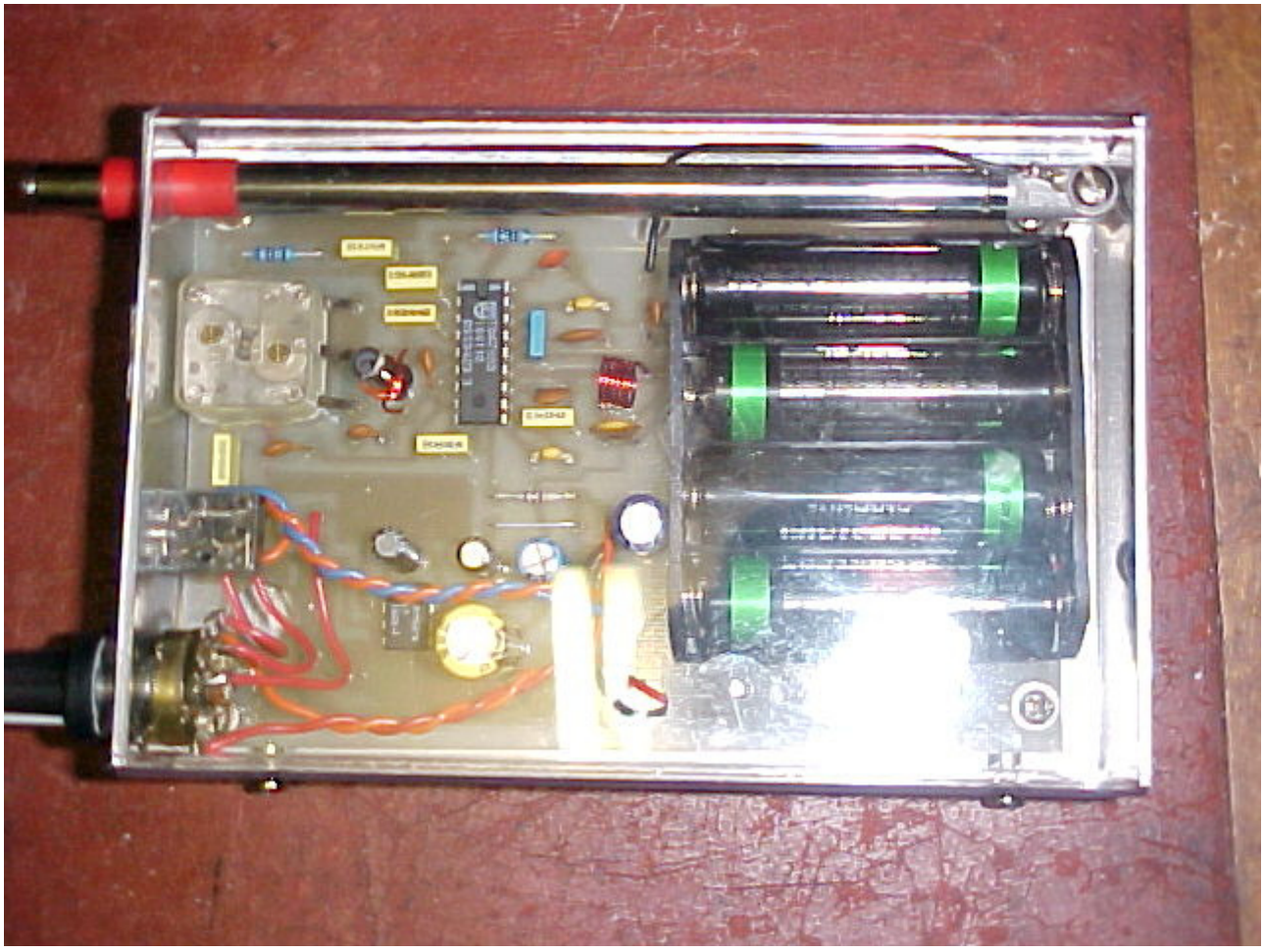


Very bland looking but functional. At left is the heater transformer, middle is the output transformer, and at the right is the PCB with the TDA7000. Note also the yellow ceramic aerial isolating condensers.

The Silicon Chip November 92 TDA7000 receiver



I built this receiver during 1995 and used it on the train for a few years. The circuit is very typical using an LM386 for the audio stage. The LM386 is a very noisy IC and I'm certainly not fond of it.
Originally I built it in a plastic box with speaker, but wanting to make it smaller, I built a new enclosure out of aluminium, with a lexan cover. (January 2004). I didn't bother including the speaker as I seldom used it. However, once I'd done this, the performance seemed very poor. Sensitivity was really bad. Eventually I noticed that it seemed like some sort of spurious oscillation was going on. Bridging the negative battery terminal straight to the case brought up a huge improvement, and a permanent cure was made by connecting the PCB groundplane to the chassis directly, not just relying on the headphone socket. It just goes to show how finicky things are at VHF.



I mounted 4xAA cells on the PCB where Silicon Chip intended the speaker to be placed. The squelch switch was not used; instead the squelch is permanently disabled. The telescopic aerial extends to 75cm which is a quarter wavelength.

Performance

Of late, with designing a radio for my Model T Ford, I have been giving the TDA7000 some thought so my interest in this IC has been rekindled in the last few months. Although I have been considering the 12AT7 super regenerative receiver, the TDA7000 has better sound quality and does not need a regeneration control.
At this point in time I have decided to use the TDA7000 for the front end of my new car radio. For one thing, the tuning of a pulse counting or super regenenerative receiver is too distracting while driving a car. Adjusting regeneration and tuning controls that interact with each other requires concentration best left to the controls of the car itself. Also, the TDA7000 is a proper FM receiver and has better interference supression, unlike super regen sets which are AM receivers. This is important in the Model T environment where ignition interference is severe. Finally, the sensitivity is better, meaning less fading of FM stations whilst driving around.
So, I have been paying a lot of attention to this receiver to learn of it's limitations as well as its virtues.
How does it perform? For strong local stations it works very well, with excellent sound quality. Sensitivity is good...I would hesitate to agree with Philips claim of 1.5uV...more inclined to agree with Elektor's 7uV. I should mention that the Elektor article did include an RF amplifier which supposedly increased the sensitivity to .5uV.
The first notable limitation is the very wide capture range due to the AFC circuit. It's quoted as +/- 300Kc/s. That makes it impossible to receive weaker stations close in frequency to strong ones. For example, at home where I have 2ONE on 96.1Mc/s about 5 km away, I cannot receive 2WL on 96.5Mc/s which is about 90 km away.

Nova on 96.9Mc/s from Sydney (50 km away) just makes it worse.
The worst feature by far is on weak signals. Instead of just being noisy, there is an awful disortion present. The super regen and pulse counting receivers are much easier to listen to on weak signals.
Tuning the receiver is critical, despite what Philips say in their application notes. It is actually better to have the squelch enabled when tuning as you will only hear a signal when the receiver is correctly tuned.

Highly Recommended

The mention of these limitations is in no way meant to be a negative criticism. All receivers eventually are limited in some way; I'm merely determining how the TDA7000 performs. The average listener is not going to use a receiver the same way I do. In this regard, the TDA7000 performs no worse than most commercially made portable FM radios. In fact it performs a lot better than some I have tried.
My recommendation is that you gear down the tuning control with a reduction drive, or use a pot with varicap diode. Leave the squelch enabled, or at least have a switch if you want to disable it. And don't expect it to perform as a Super DX receiver. As with all kinds of receiver, give it a decent aerial!
I highly recommend this IC for where non technical users are involved and where sound quality is important. For what it is, and the simplicity of use, it makes an excellent FM receiver.

TDA7088T Receiver

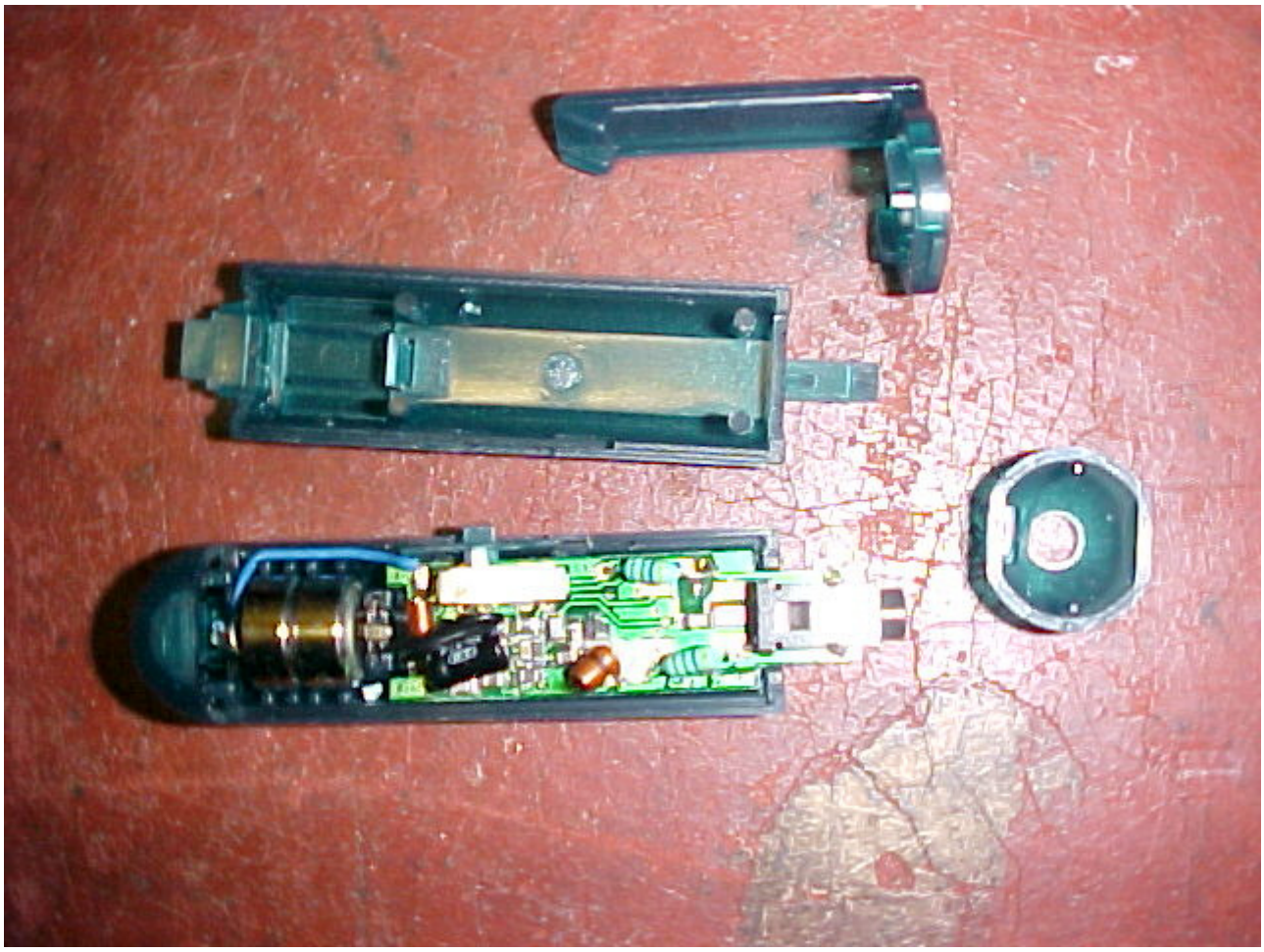
I found this in a $2 box at the Jaycar stall at the Wyong amateur radio field day 2004. When I realised what it was I had to have it. So how did I know it contained a TDA7088T? First thing that gives away this IC is the "scan" and "reset" buttons. Through the tinted plastic case I could see it ran off 3V (another TDA7088T characteristic), and just the lack of peripheral components (ceramic filters/IF tansfromers) around the surface mount IC.

Those earphones are awful.

This tiny receiver is not much bigger than an AA cell. It is powered off two LR44 button cells, which are expensive and I assume wouldn't last terribly long. I'll be on the lookout for LR44's at the markets and $2 shops now that I've got this radio! As with all these sorts of radios, the headphone lead functions as the aerial. Supplied with this receiver were a pair of those awful "in-the-ear" type of miniature type earphones. Apart from the appalling sound quality, they are insensitive, unhygenic and dirty, fragile, and do not block out external sounds.

So, I use the normal kind of headphones instead.

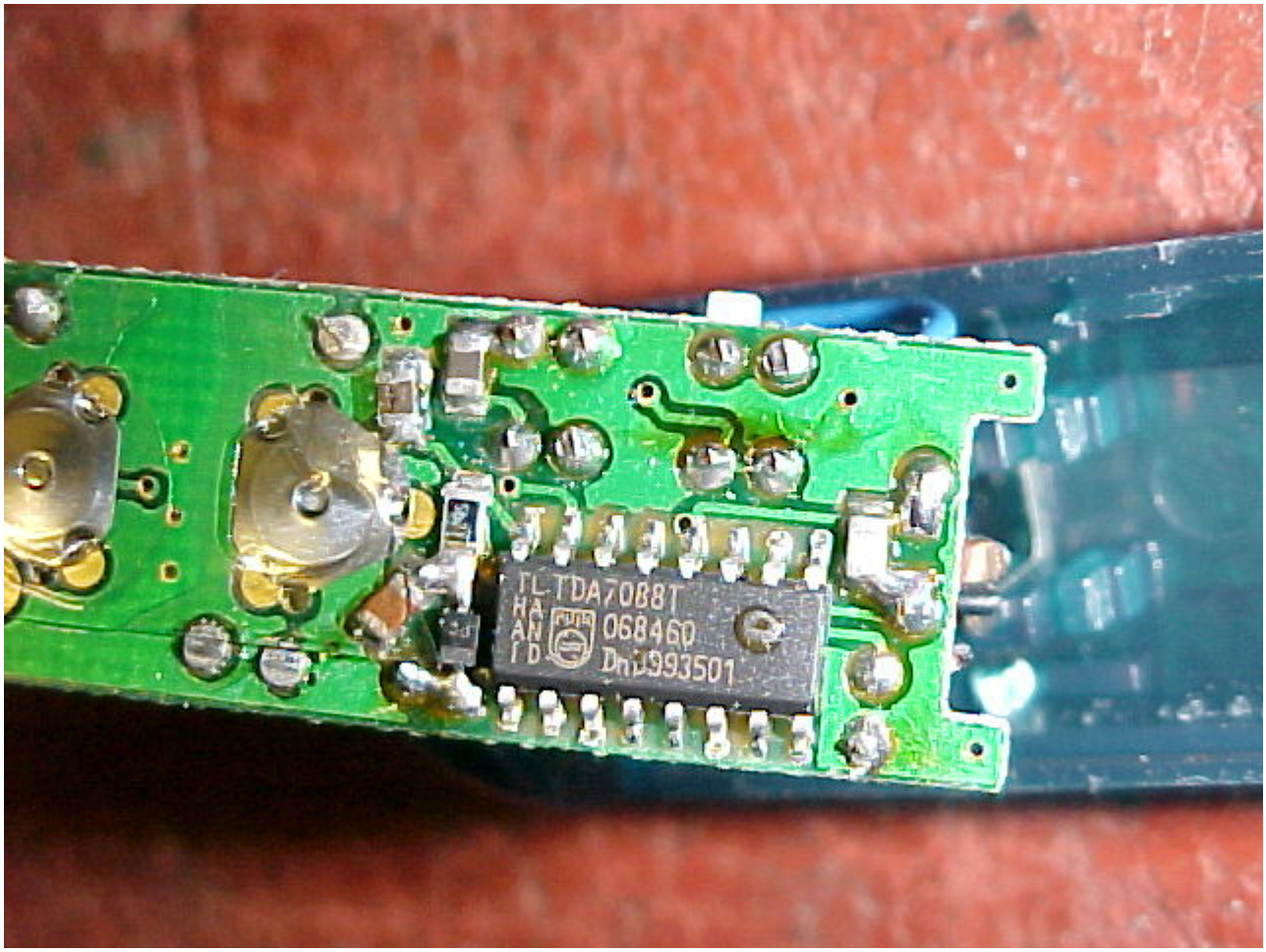
The enclosure is all clipped together, and once I'd opened it, sure enough, a TDA7088T was visible.
The audio amp appears to be one transistor; ie. single ended class A. I don't know what current it's drawing so I can't say whether it's consuming much more battery current than a class B amp would. In any case I would prefer AAA cells rather than the LR44's.



Opened up, this shows two LR44 cells, the switch and headphone socket. Note the two RF chokes to allow the headphones lead to be used as the aerial. The TDA7088T is on the other side of the PCB.

The power switch is a minature slide switch on the side, which has an extra position for volume. This is obviously done to avoid a space consuming potentiometer. So, we have only two levels of volume; full and something a bit less.

How well does it work? Quite well actually. Performance is the same as the TDA7000 IC in terms of sensitivity and sound quality. However, the TDA7088 has the mute permanently enabled so some weaker stations that could otherwise be received with a TDA7000 or TDA7010T cannot be received on the TDA7088T. Also, the headphone lead aerial is not as efficient as a 75cm telescopic aerial so this needs to be taken into account.



Close up of the TDA7088T. The scan and reset switches are to the left.

The scanning circuit works very well, there is virtually no waiting for the radio to find the next occupied frequency. Once you have reached the 108Mc/s limit, you have to press "reset" to get back to the 88Mc/s end of the band. It does not automatically do this like a PLL type of circuit would.
These TDA7088 receivers seem to be common at the moment for under $10. They're well worth collecting, but use a decent pair of headphones!