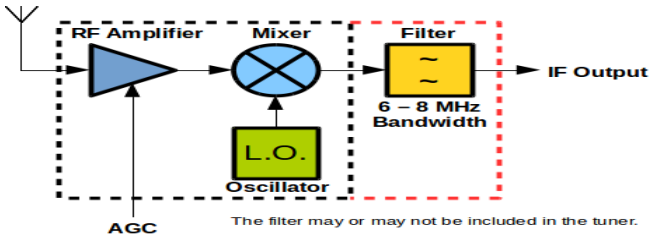
HOW TO IDENTIFY AN UNKNOWN RADIO TUNER

Radio frequency tuners can be found in a lot of devices, starting with TV sets, set top boxes and PC tuner cards. A tuner is a device that takes a ”chunk” of a frequency carrier of a bandwidth, amplifies it and then shifts it (usually by down-converting) into a fixed frequency that will be fed into a demodulator device. Tuners are difficult to build and a DIY tuner will never have the performance of one from a radio receiving device. The RF signal enters a baseband amplifier. Further, this signal is mixed with a local oscillator with variable frequency. The result exits the tuner as Intermediate Frequency (IF). Sometimes the tuner also contains a filter at the IF output. These functional blocks can be integrated into a super heterodyne receiver with ease (just add a detector). So, what can you do with a tuner? Keep reading.



The functional blocks of a tuner

What can it receive?

That really depends on the device it came from. Here are the usual bands a tuner can receive:

- air and cable TV tuner:
- 48 – 68 MHz aka. VHF-I, VHF-Lo, channels 2 – 4
- 105 – 174 MHz aka. Midband, channels S1 – S10
- 175 – 230 MHz aka. VHF-III, VHF-Hi, channels 5 – 12
- 231 – 300 MHz aka. Superband, channels S11 – S20
- 303 – 469 MHz aka. Hyperband, channels S21 – S41
- 471 – 605 MHz aka. UHF-IV, channels 21 – 37
- 607 – 861 MHz aka. UHF-V, channels 38 - 69
- satellite TV tuner: 950 – 2150 MHz (some of the analog STBs had the upper limit of only 1750 MHz)

Tuners receive more of the above mentioned bands, depending on the device:

- old analog CRT TV sets, including BW: VHF-Lo, VHF-Hi, UHF-IV
- newer analog CRT TV sets: VHF full, UHF full, Midband
- last manufactured CRT TV sets and analog tuner flat TV sets: full frequency range (all bands): 48 – 861 MHz

- devices with DVB-T(2) tuner: VHF-III and UHF full
- devices with DVB-C tuner: full frequency range or even more. Some tuners are able to receive as high as 1000 MHz

Obviously, the most useful tuners will be the ones that have full frequency range. CRT TV sets with this kind of tuners were advertised as Hyperband. There is no gap between VHF-I and Midband as all tuners can be pushed a little further from the mentioned limits. A tuner is by design an analog device. It doesn't matter if it came from a digital TV, it still can receive analog signals. To see what you can receive in these bands, I suggest reading your country's frequency assignments. In general, with a TV tuner you can pick up FM radio, AM aircraft communications and some HAM bands. With a satellite tuner you can pick up ADS-B aviation data.

Tuning methods

A tuner selects a desired frequency and down-converts it. The selection is determined by the local oscillator frequency. There are two methods of changing the local oscillator frequency. Actually three. The early TV sets with tubes used variable capacitors to change frequency. But they are out of discussion here.

Voltage Synthesis Tuning

The local oscillator is built with varicap diodes. The frequency is changed by varying the varicap reverse voltage. This makes a tuner very easy to change the frequency yet very hard to keep the frequency constant. That's why several methods were imagined. The simplest is to use a thermistor on the varicap voltage to compensate any drift caused by temperature. Another method is called Automatic Frequency Control (AFC) and it uses a fixed oscillator to compare the IF with. There is also a fake AFC method that locks the frequency to the strength of received signal. It works most of the times and it involves tweaking the varicap voltage with the received signal strength voltage.

Phase Locked Loop

This is what the VST tuners evolved into. The local oscillator is built the same way, with varicaps. The most important improvement is that a PLL circuit controls entirely the varicap voltage depending on the feedback from a phase comparator. The frequency is very stable and it is controlled indirectly by “talking” with the PLL circuit. The first PLL tuners were simple VST tuners fitted with a frequency output that was compared with a reference in an integrated circuit outside the tuner and the output was fed to varicaps.

The entire circuitry has been totally integrated into the tuner and so, today's tuners only “want” a microprocessor to tell them the frequency, most times via I2C bus.

Where is the tuner

I suggest you start by opening a radio frequency receiving device. Follow the antenna connector. Look for a metal box. That's the tuner. If there are more metal boxes on that PCB, usually the first one that the antenna enters into is the tuner. Start by taking out (desoldering) the tuner if it is possible (on modern devices, the tuner is built on the same PCB as the mainboard and a metal frame is around it – you don't have to desolder anything here; instead you'll cut the PCB – keep reading to see an example). I assume you desoldered the tuner. Don't hurry to throw away the board it came from. Look for any part number written on the tuner and look it up on the internet. Look for pinout information. Found nothing? Don't worry (yet)! Open the tuner case and look for IC capsules. Search their part numbers online. The ICs you will find may be one or more of these:

- frequency prescalers
- SAW drivers
- mixers
- PLL controllers

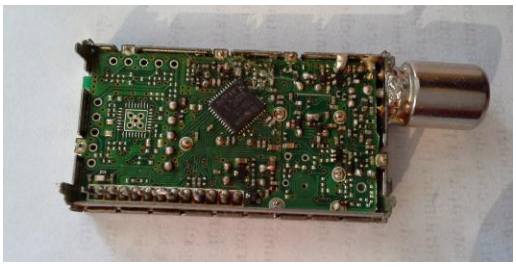
- complete tuners IC

  Nobody cares of a datasheet of the first three. If you can't find a datasheet of the fourth, the tuner cannot be controlled via I2C, but can be tweaked and turned into a VST tuner. If you can't find a datasheet of the fifth (the complete tuner IC) you have one last solution: look into the Linux kernel archives (the same applies for PLL controllers). Some of these ICs were also used in TV cards and open source drivers are available. Search the part number in the kernel sources. Found nothing? Give up that tuner. There's nothing you can do. You may eventually find out the pinout, but you'll never know how to control that tuner. Anyway, let's go back to tuners with no ICs or with ICs that have datasheets available. The only thing left here is to find the pinout. Remember I told you not to throw away the PCB where the tuner came from? Look there for any markings – some manufactures wrote pin functions on the PCB. Some don't. Yet it's still possible to figure out the pin functions. Look also for chassis number or any other writings on the PCB. Search them on the internet. Following are some practical situations with different tuner types.

  PLL with datasheet

  The tuner model is CDT-9ET222-42. Searching this online returns nothing. It came from a DVB-T receiver (Televes 7117) that can receive VHF-Hi and UHF.

It can probably receive even more but that will be determined after powering it and pushing the frequency limits. So I open the tuner box and look for part numbers. The PCB is marked as CDT-9ETP010-42. No results on this either. Looking further I notice that the manufacturer has written pin functions on the PCB.



In the first picture, there is a black capsule with the part number HD BF36A1Dc which is a SAW filter with the center frequency of 36.125 MHz and 8 MHz bandwidth. The integrated circuit in the second picture is called TUA6039F-2 and fortunately its datasheet is available. This IC contains both the PLL and the mixers. It has three mixers for three bands, but unfortunately the manufacturer didn't place the components for the VHF-Lo and Midband oscillator. The VHF-Hi oscillator probably covers Superband and even Hyperband too. That remains to be determined. Let's talk about the pinout these kind of tuners have.

- GND – may or may not exist as a pin. Just connect the GND to the tuner case.
- +VCC – use a continuity tester to find which pin matches the power pin of the IC.
- +VT – this is the varicap voltage, Usually needs a low current 30 – 33 V supply.
- AGC – the automatic gain control pin needs voltage between 0 V (lowest gain) and 70% to 100% of +VCC (highest gain).
- I2C – two or three pins: SDA, SCL, ADDR.
- IF – one pin if unbalanced or two pin if balanced output.

This is the standard pinout. Now let's see how this tuner's pinout differs and what it has in addition:

1. ANT – power supply for an antenna amplifier.
2. RFAGC – AGC for RF. Used only when disabling this function on IC.
3. VT – just for testing here. The 33 V are generated inside the IC.
4. +5V – the IC voltage
5. AS – I2C address
6. SCL
7. SDA
8. IF – unbalanced IF output. Not passing through the SAW!

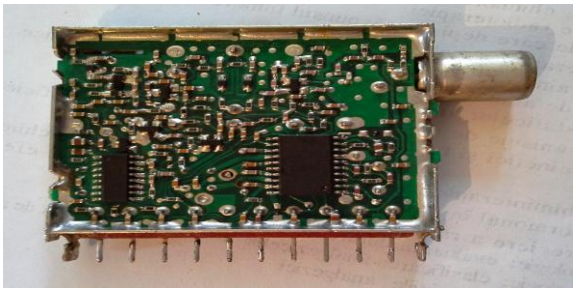
9. CVBS – demodulated analog video output. It has no function here because the tuner doesn't contain the demodulator. The PCB is common to multiple tuners.
10. IFAGC – AGC for the IF. The demodulator controls it.
11. DIF – probably stands for Digital IF. Anyway is just a balanced IF output, filtered by SAW device.
12. DIF – same as 11.

Before powering up there are some things to do. Connect pull-ups to the I2C pins and connect the tuner to an I2C bus. Read the datasheet to know the correct address. Connect one or both IF outputs to the demodulator. Make a voltage divider with a potentiometer and connect its output to the AGC pin (IF AGC here, because RF will be controlled by the IC). Set it to about 60 – 70 %. Connect the antenna. Power it. Talk to it via I2C (it's up to you how you do that: Arduino, other microcontroller, PC adapter or whatever you have). This PLL IC supports reading data from it. And that data holds one important bit called frequency lock. As long as the tuner locks, it can be pushed from the specified frequency limits. This one was easy.

PLL turned to VST

The tuner number is 29504-201.73 and it came from a Grundig TV with dual tuner (cable and satellite).

Can't get any information about its part number, but if I look up the TV chassis, CUC7300, on ElektroTanya several results show up. One of them contains the tuner schematic.

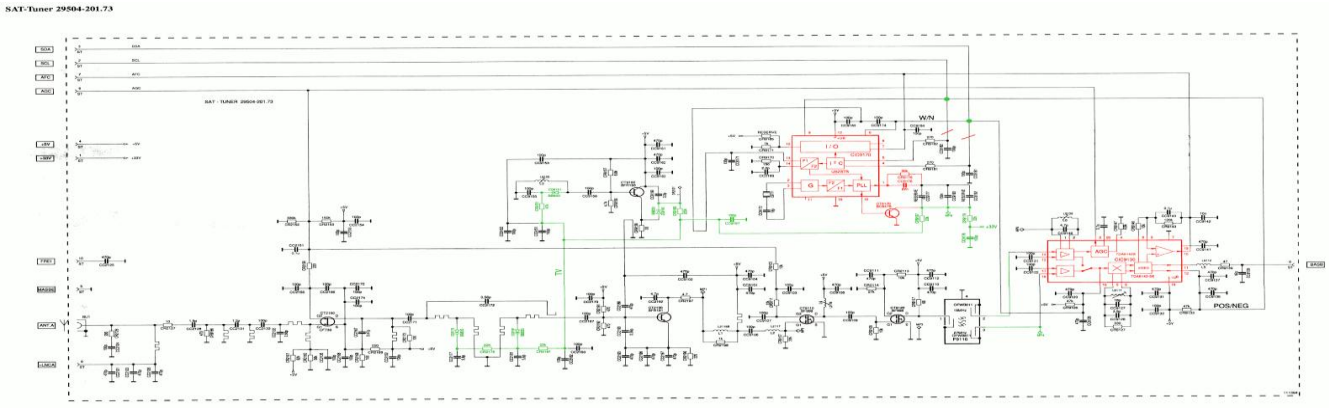


In the first picture a SAW filter can be seen. The part number, however is not readable. In the second picture two ICs make the tuner. The left one is the PLL, U6237B and there is no datasheet for it and it doesn't seem to be compatible with the similar U6239B or U6225. The other IC is an analog satellite FM video demodulator. It is useless today, so it may probably get desoldered. The IF of these tuners is usually between 480 to 495 MHz.

The pinout is somehow similar to the above PLL tuner with the exception that it has no IF output, instead it has wideband CVBS output.

The IF bandwidth, as dictated by the SAW filter is either 18 or 27 MHz. Because I have no datasheet of the PLL IC, I will desolder it.

Next I must identify all its functions, the most important being the varicap voltage output which may be a variable voltage or a variable PWM signal fed into a charge pump. The tuner schematic helps a lot. The SAW filter is OFW G611 and has a center frequency of 479.5 MHz. Does that seem to high to demodulate? What stops us from connecting the IF output of this tuner to a cable TV tuner and setting it to receive 479.5 MHz? In this way, we'll have a 36 MHz second IF, but with a narrower bandwidth. Anyway, the modification of this tuner requires disabling the chargepump by removing CT9170 transistor. After that, the +33V input can be used directly for feeding varicaps. Note that when directly controlling varicaps avoid voltages above 30 - 31 V. **For some diodes, the 33 V represents an absolute maximum rating.** If, for whatever reason, I would like to use the included FM demodulator, I will remap the control signals to unused pins. For example the bandwidth selection pin can be mapped to SDA and positive / negative demodulation control can be assigned to SCL.



The ICs get removed. +33V becomes +VT. The IF is available at the SAW filter pins.

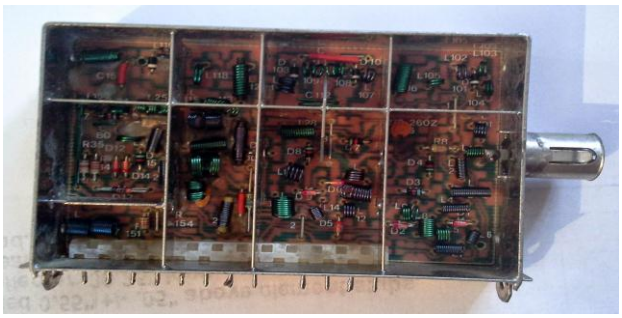
This schematic has been down sampled. You can see the full size schematic here and how it looks after removing unnecessary ICs and one transistor (you don't really have to remove everything. It's enough to cut ICs power and remove anything that's in your way - the chargepump transistor CT9170 in my example).

Assuming you don't have a schematic or datasheet, you would apply a 15 – 20 V to the negative pole of each varicap and you would try to see where the voltages applied to different varicaps converge.

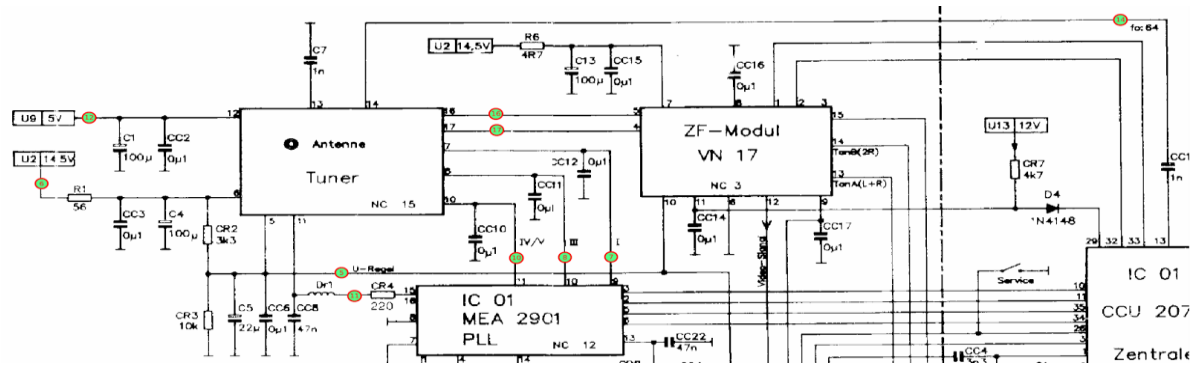
VST with external PLL

These kind of tuners were controlled with PLL circuitry. The tuner contains a frequency prescaler that outputs the local oscillator frequency divided by a (sometimes programmable) factor.

They are controlled through VST and the output from the prescaler can be fed into a frequency meter. The tuner I will talk about has no markings on it.



When opening it I can find two ICs: a prescaler, U813B, and a SAW filter driver, U4744B (not too much info about it). The prescaler is powered at 5V and I could find its VCC pin connected to a pin of the SAW driver. This is how I found the +5 V supply pin of the tuner. But I forgot it came from a Schneider TV with DTV1 chassis. Great! Now I got its complete pinout.



Part of the TV schematic showing tuner and its pinout

These kind of tuners have the following pins:

- supply voltage. Mine needs +5 V for the prescaler and driver and +12 V for the actual tuner
- AGC (called "U-Regel" in the above schematic)

- VT - the varicap tuning voltage (look at the signal coming out of the PLL IC and has an inductor on it)
- band selection pins (a high level with regard to the tuner voltage that is 12 V here) selects a different local oscillator corresponding to TV channels bands
- IF outputs
- prescaler frequency output (guessed by the fact that enters CPU and has a label "fo:64" which makes me think the scale factor is 64)
- prescaler division factor selection pin

To power up a tuner like this, you need a 30 V voltage divider's output connected to VT. To receive anything connect the antenna and power the AGC pin via a voltage divider with 60 - 70 % of the tuner's supply voltage. Apply the supply voltage to a band selection pin (only one at once) and if you connected a demodulator start rotating the potentiometer for VT. You should start picking up something.

Further searching lead me to a catalog of tuners manufactured by SIEL and my tuner was a perfect match with their UV616S equivalent. You are probably wondering what's that yellow wire. The prescaler had a fixed division factor of 64 because the manufacturer left its control pin floating. I connected a wire between that pin and an unused pin of the tuner so I can control the prescaler from outside the tuner. In this way I can change the division factor between 64, 128 and 256.

Tuner IC

Obviously these are PLL tuners. The IC contains everything, from the baseband amplifier, oscillators, mixers and even DC-DC converter for integrated oscillator. They are common in digital receivers and PC cards. The example here is MxL5007T. A Google search returns no datasheet (only a product brief), but Linux drivers source code. All that is left is to identify relevant pins.

The processes of identification as well as control software taken from Linux kernel are shown in *MxL5007T Tuner Radio* post.

Conclusion

Most of the times, even if you don't have a tuner's datasheet, you are able to find out enough information to get it working for your project. The most useful resources for schematics are ElektroTanya.com and FreeServiceManualswhile for software Linux kernel source and en.PUDN.com can be useful. It is very important that you gather as much information as possible from the device that contained the tuner.

Source: http://onetransistor.blogspot.in/2015/01/how-to-identify-unknown-radio-tuner.html