The *Elektor* DSP radio

DSP world receiver with USB interface

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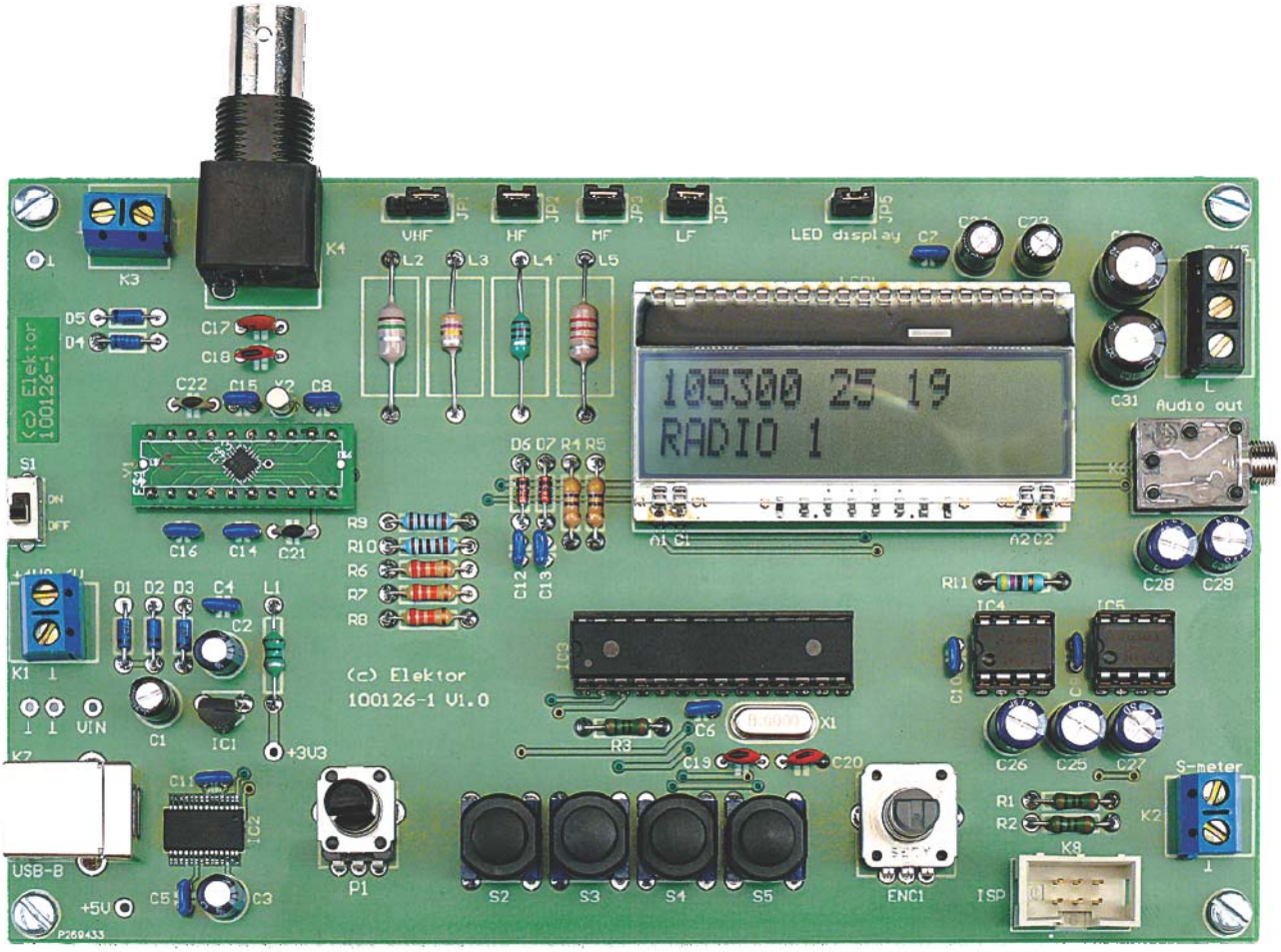

A world receiver that needs no set-up adjustments? It's possible using DSP technology. All the main functions are done in a Si4735 DSP radio IC measuring just 3 mm by 3 mm, with the help of an LCD-based user interface, a stereo audio amplifier and an interface that allows the receiver optionally to be controlled from a PC.

Many radio amateurs in practice use two receivers, one portable and the other a fixed receiver with a PC control facility. The Elektor DSP radio can operate in either capacity, with a USB interface giving the option of PC control. An additional feature of the USB interface is that it can be used as the source of power for the receiver, the audio output being connected to the PC's powered speakers. To allow portable 6 V battery operation the circuit also provides for an audio amplifier with one or two loudspeakers.

Features

Any radio receiver worth its salt should of course offer high-quality FM reception, preferably in stereo and with RDS station information display. The proof of the radio is in the hearing, and this receiver will not disappoint: it has very high FM sensitivity and sound quality. The Si4735 device that we use, unlike its less sophisticated sibling the Si4734, includes an RDS decoder. The Si4734 has recently been finding its way into an increasing number of portable radios.
The second requirement of a world receiver is that it should be able to tune in to distant

Features

- no set-up adjustments required
- Si4735 DSP receiver IC
- ATmega168 microcontroller
- USB interface using FT232R
- backlit 2 x 16 LCD panel
- battery voltage 4.8 to 6 V
- current consumption approximately 50 mA
- 3.3 V internal power supply
- power from PC over USB interface
- stereo audio output
- stereo audio amplifier (2 x LM386)
- RDS display
- AM from 153 kHz to 21.85 MHz
- automatic station search
- antenna signal strength indication in dBµV
- signal strength meter connection
- diode switching of AM band
- automatic tuning of AM resonant circuit
- switchable AM bandwidth
- optional PC control over USB
- tuning using rotary encoder
- four control pushbuttons
- station memory (30 AM presets and 30 FM presets)
- open-source firmware (free download)
- in-system programming interface
- printed circuit board available ready-populated and tested*

* see http://www.elektor.com/100126 and the Elektor shop pages at the back of this issue

AM transmitters. Here the receiver is in a class of its own, offering excellent shortwave reception. In particular it has very good sensitivity in the presence of strong nearby interfering signals, which allows the use of longer antennas. A highly effective automatic level control system brings the signal level into the optimal range, to the point where it can often be difficult to distinguish different antennas. Selectivity is also very high, and the receiver bandwidth can be adjusted in several steps, a feature previously reserved for only the most expensive equipment.

The DSP radio is also capable of receiving mediumwave and longwave signals, with the external antenna input allowing the connection of antennas for any frequency range. If a simple whip or other indoor antenna is used, it will often the the case that too much wide-band interference will be picked up. An alternative is the (optional) connection of a ferrite antenna.

SSB and DRM reception are, unfortunately, not possible. This is a result of the receiver structure. The radio IC uses an homodyne (that is, zero intermediate frequency) IQ mixer with configurable DSP-based filters and demodulator (**Figure 1**). For tuning a PLL is initially activated, and then the receiver locks on to the carrier of the AM signal.

The circuit

The circuit of the receiver (**Figure 2**) does not look, at first sight, much like a traditional RF design. This is because all the important functions are integrated into the Si4735. Only the antenna connection betrays the RF nature of the circuit: the antenna signal arrives at BNC socket K4 or at screw terminals K3 and passes through a diode limiter comprising D4 and D5. L2 is an FM coil with an inductance of 0.1 µH. In normal operation jumper JP1 is set to bridge pins 2 and 3, which connects the end of the FM coil to the AM input.

What is not visible from the circuit diagram is that in FM mode the receiver sets its internal AM 'variable capacitor' to 500 pF, which, as far as RF is concerned, shorts the end of the FM coil to ground. In AM mode, however, the signal from the antenna passes via L2, which now acts to increase the effective antenna length, to the AM resonant circuit comprising L3, L4, L5 and the automatically tuned 'variable capacitor' inside the Si4735 at pin 4 (AMI). Which of the fixed inductances is actually used is determined by IC3 using the switching circuit comprising 1N4148 diodes D6 and D7, which can effectively short a selected part of the inductance in the circuit to ground. In normal use jumpers JP2, JP3 and JP4 are closed; opening these jumpers allows the connection of alternative antenna input circuits or of a ferrite antenna. For example, a mediumwave ferrite antenna can be connected at JP3 or a shortwave loop antenna at JP2. If a whip antenna is to be used for FM reception only, set JP1 to bridge pins 1 and 2.

The stereo audio output of the Si4735 is taken to a stereo jack socket via C28 and C29, for connection to an external amplifier or powered speakers. The output is short-circuit proof, with an output impedance of 10 kΩ and an amplitude of about 80 mV_{eff}. Two LM386 ICs are also provided as a power amplifier, with loudspeakers connected at K5. The maximum output power into 8 Ω is around 300 mW. Surprisingly there is no stereo volume control potentiometer in the

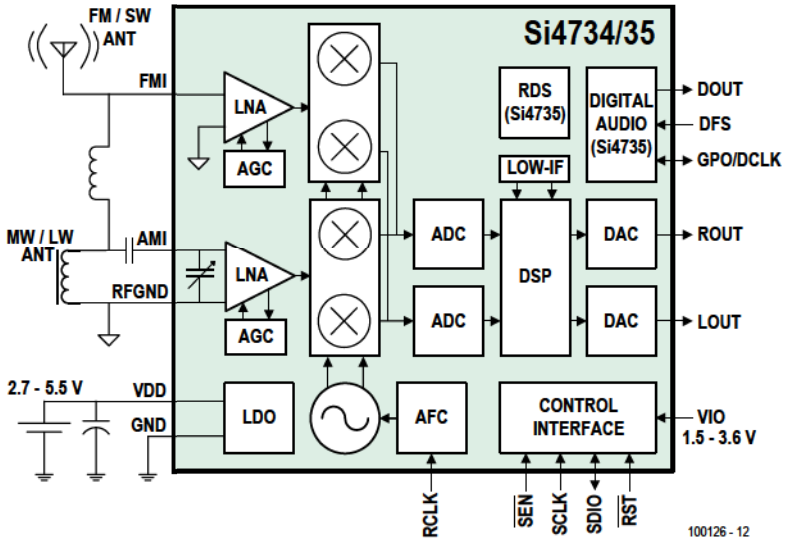

Figure 1. Block diagram of the Si4735 DSP radio IC (courtesy http://www.silabs.com)

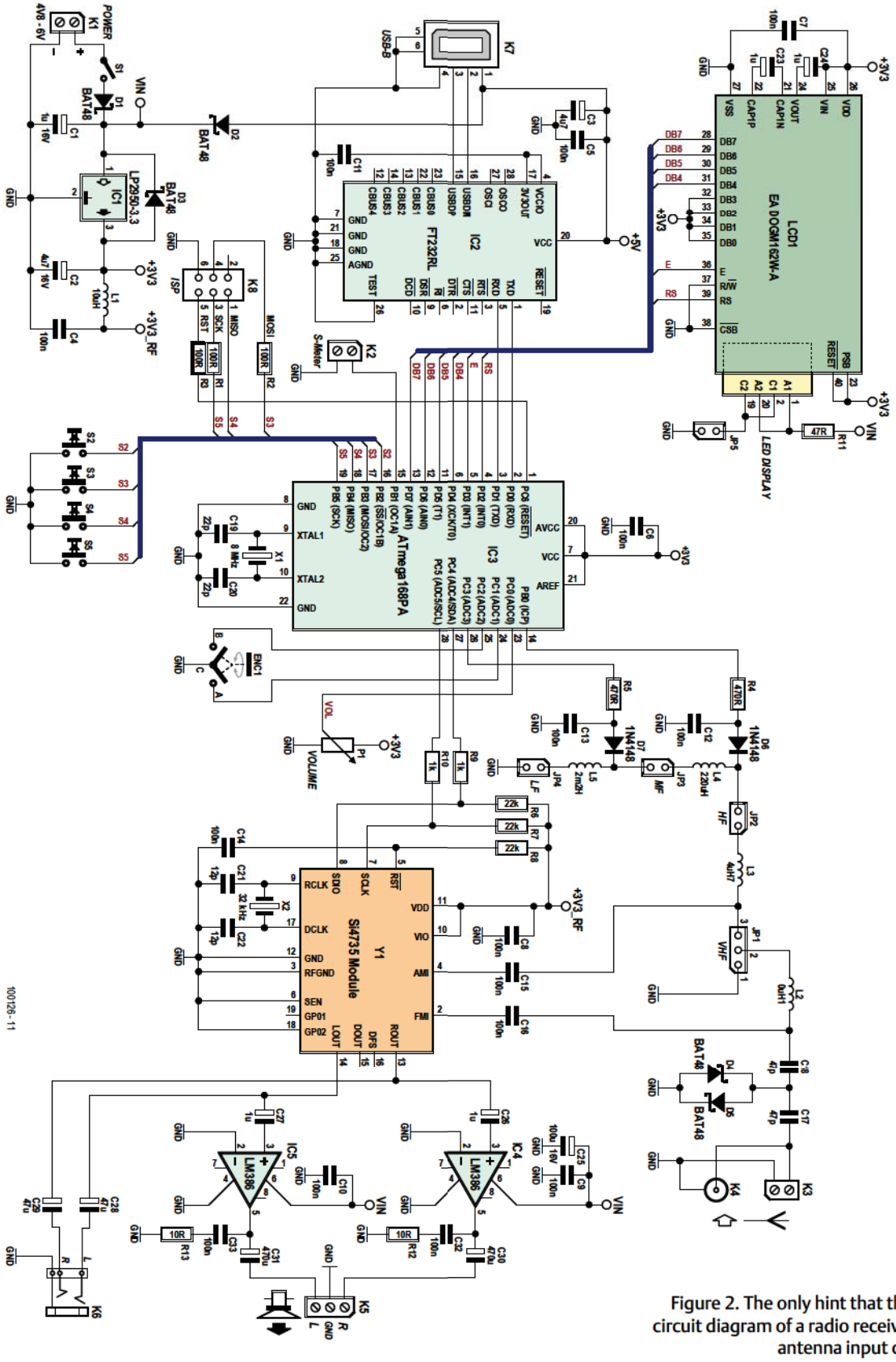

Figure 2. The only hint that this is the circuit diagram of a radio receiver is the antenna input circuitry.