Wolfgang Schneider, DD 2 EK

FM-ATV in the GHz Range
Part 1: 23 cm Transmitter

Owing to the advancing developments in the field of satellite television techniques, FM-ATV is becoming of increasing importance to the radio amateur. In addition to the use of ready-made industrial units, the modern semi conductors allow the home construction of complete FM-ATV transmitters and receivers, well into the GHz range, with the minimum effort. The following multipart article describes the construction of a transmitter/receiver for FM-ATV in the 23 cm band.

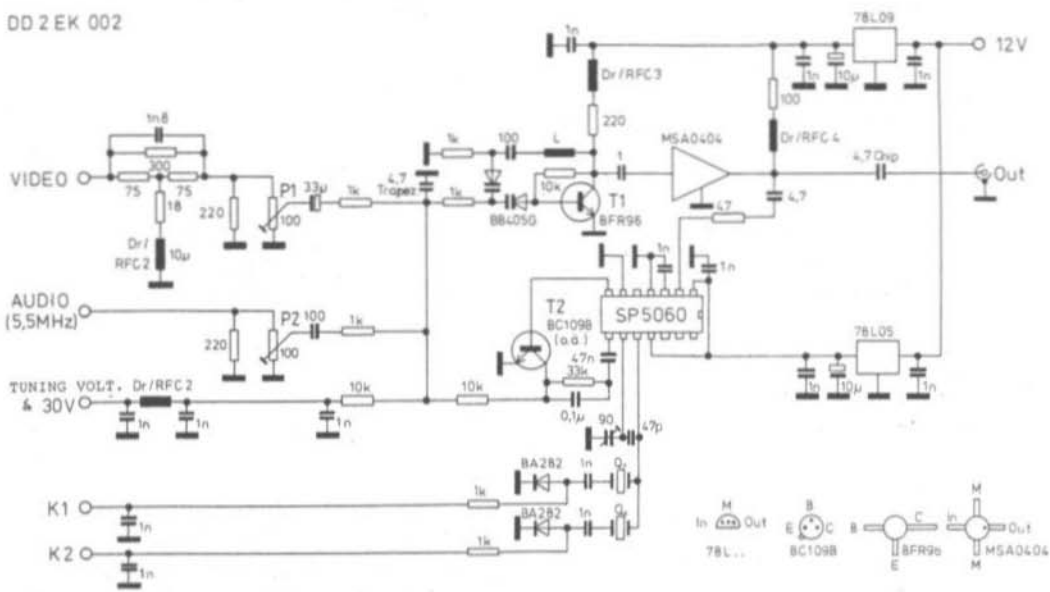

Fig. 1: 23 cm band FM-ATV transmitter

1. CIRCUIT DESCRIPTION

As may be seen from **fig. 1**, the 23 cm ATV transmitter displays no particular peculiarities. As may be expected, the heart of the transmitter may be regarded as the voltage-controlled oscillator (VCO) included in a phase-locked looped (PLL). This will now be examined in detail.

1.1. The Voltage-Controlled Oscillator (VCO)

The VCO (**fig. 2**) was developed using economical, but readily obtainable components. The varicap diodes are normal UHF types and the transistor is also a standard type.

The series resonant circuit comprises an inductor and two varicap diodes (BB405G) connected between the collector and the base of the oscillator transistor. A 100 pF capacitor serves to isolate the varicaps from the DC collector voltage but at the same time its connecting lead forms the series tuning-inductance. Other connections are kept as short as possible in order to prevent the introduction of uncontrolled reactances into the circuit.

The control of the transistor's working point and its quiescent current is achieved by the 10 kΩ resistor between collector and base and the 220 Ω resistor in the collector. A small inductance in series with the collector resistor prevents the tuned circuit from being loaded and ensures complete decoupling from the supply voltage.

The VCO, as described, is capable of working at 2.2 GHz. The inductor formed from the lead of the 100 pF capacitor determines the resonant frequency of this circuit. In the interesting frequency range around 1.2 GHz, a 0 - 24 volt tuning voltage will enable a spectrum of 500 MHz to be covered! An output power of about 12 mW is obtained at 1 GHz and 5 mW at 1.5 GHz (**fig. 3**).

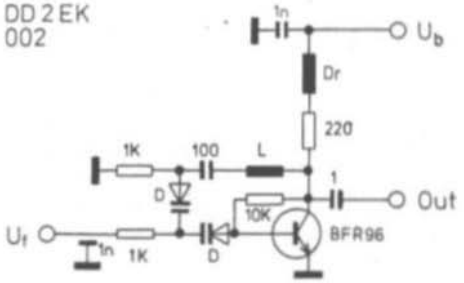

Fig. 2: The voltage-controlled oscillator

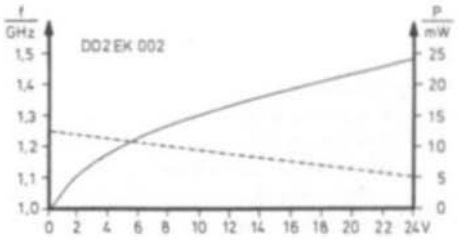

Fig. 3: The VCO frequency and the output power (dotted line) as a function of the tuning voltage

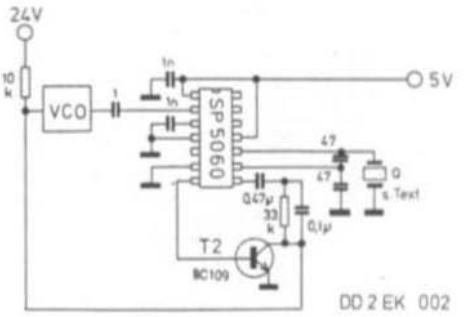

Fig. 4: The phase-locked loop

1.2. The Phase-Locked Loop

The SP 5060 forms, together with the VCO, a complete PLL frequency synthesizer (**fig. 4**) which is usable over the range 300 MHz to 2 GHz. The integrated circuit contains a pre-scaler together with a pre-amplifier and a frequency divider. The latter has a fixed division factor, the ratio between the synthesizer and the reference frequency being 256 : 1.

The phase comparator is supplied with an external, quartz-derived, reference frequency. The output of the comparator controls the varicap diode in the VCO via an external transistor (BC 109 or equiv.).

Owing to the fixed division factor in the SP 5060's divider, the reference frequency is obliged to be exactly a 256th of the synthesizer frequency. This means that for a desired output frequency, say 1270 MHz, a reference frequency of 1270/256 = 4.9609375 MHz is required.

2. CONSTRUCTION

The printed circuit board for the circuit described above, is constructed on a double-sided, 1.5 mm thick, epoxy-glass material and of dimensions 72 x 72 mm (**see fig. 5**). It fits into a proprietary tin-plate box 74 x 74 x 30 mm.

After trimming the board to size, it is cleaned and coated with rub-on silver plating – although this is not absolutely necessary. Then it is drilled. The broadband amplifier is fitted into a suitably cut hole in the board. Also, a slot (1 x 8 mm) is provided, at the appropriate place at the edge of the board, in order to accommodate the BNC socket inner connector spigot.

The board is then drilled for the other components; resistors, capacitors, the crystal etc. Care must then be taken to provide a countersink (using a 2.5 mm drill) around the ungrounded leads on the ground-plane, i.e. component side of the board, in order that the component leads are not inadvertently shorted to earth.

After this work is finished, the board can be treated with flux solution.

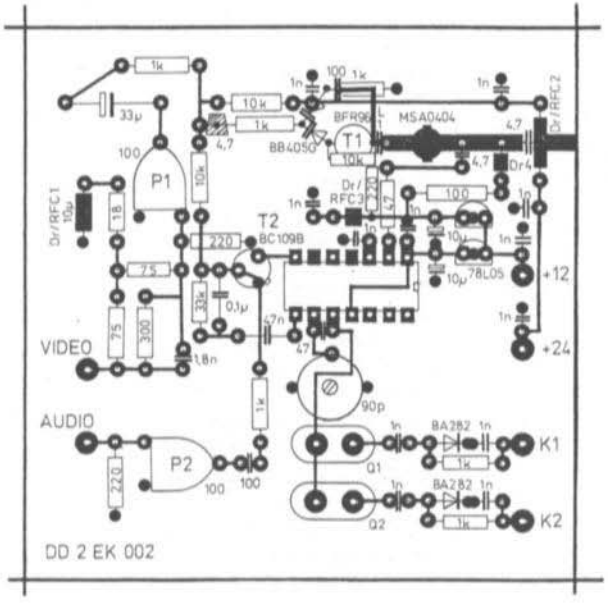

Fig. 5:
The tracks and components of the double-sided PCB DD 2 EK 002 for the circuit diagram of fig. 1

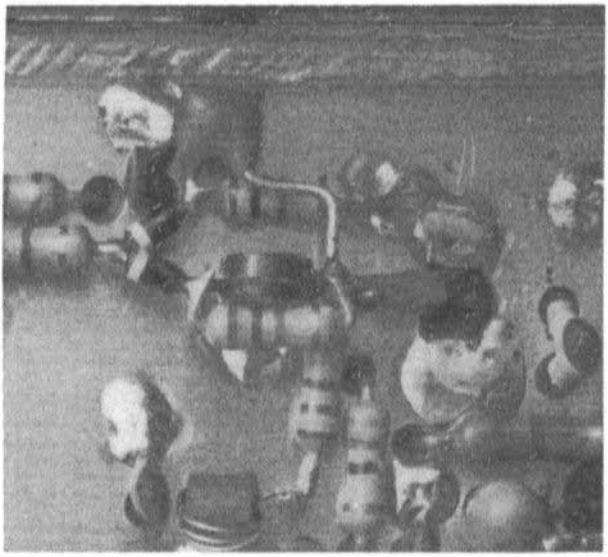

Fig. 6:
The VCO showing the self-supporting-in-air component mounting

When the board is dry, the through-plating contacts can be installed for the broadband amplifier IC. The BNC socket must be installed so that its flange fits to the appropriate place on the frame with its inner spigot in the slot provided on the PCB. The teflon shoulder on the socket may be removed with a sharp knife before mounting. Also, see to it that the module lid is not prevented from fitting when the crystal has been installed (think about this when the board is being soldered into its frame).

Following the correct soldering of the PCB into the box frame, the equipping of the board is carried out. The VCO is wired together "in air" (**see fig. 6**), the component leads being made as short as possible in order to minimize stray inductance effects. The series inductor in the VCO is formed from the collector-side lead of the 100 pF capacitor connected between base and collector of T 1. For the frequency of interest, about 1.2 GHz, this lead is trimmed to 9 mm and bent through 90°. This may be clearly seen in the photograph of fig. 6.

2.1. Components

1 BC109B, BC 413, BC 550 or equiv. low-noise NF types
1 BFR96
1 MSA0404 (Avantek)
1 SP5060 (Plessey)
1 78 L 09
1 78 L 05
2 Diode BB405G
2 Diode BA282
1 RFC 10 μH (Neosid)
1 6-hole ferrite core (Valvo)
2 RFC 4 turns 0.3 mm Cu-lac. wire on 3 mm ferrite bead
1 90 pF foil trimmer (red)
1 4.7 pF trapez. cap.
1 4.7 pF chip cap.
1 0.47 μF cap. (7.5 mm grid)
1 0.1 μF cap. (7.5 mm grid)
1 33 μF/35 V elko. (10 mm grid)
2 10 μF/16 V tant.
2 100 Ω preset pot. (10 mm grid)
1 100 Ω/0.3 W resistor
1 Tin-plate box 74 x 74 x 30 mm

1 BNC panel mounting socket UG290A/U
6 teflon feed-thro insulators

Ceramic disc capacitors (2.5 mm grid)
1 1 pF
1 4.7 pF
1 47 pF
2 100 pF
12 1 nF
1 1.8 nF

Resistors (fixed, 10 mm grid)
1 18 Ω
1 47 Ω
2 75 Ω
1 100 Ω
3 220 Ω
1 300 Ω
6 1 kΩ
3 10 kΩ
1 33 kΩ

Inductors see text.

Crystal
HC-18U or HC-25U (see text)

3. COMMISSIONING

The following test instruments should be available:

- Multi-purpose meter
- Frequency counter (to 1.3 GHz)
- Power meter (to 1.3 GHz)

Following the application of the 12 V supply voltage, the unit should immediately start

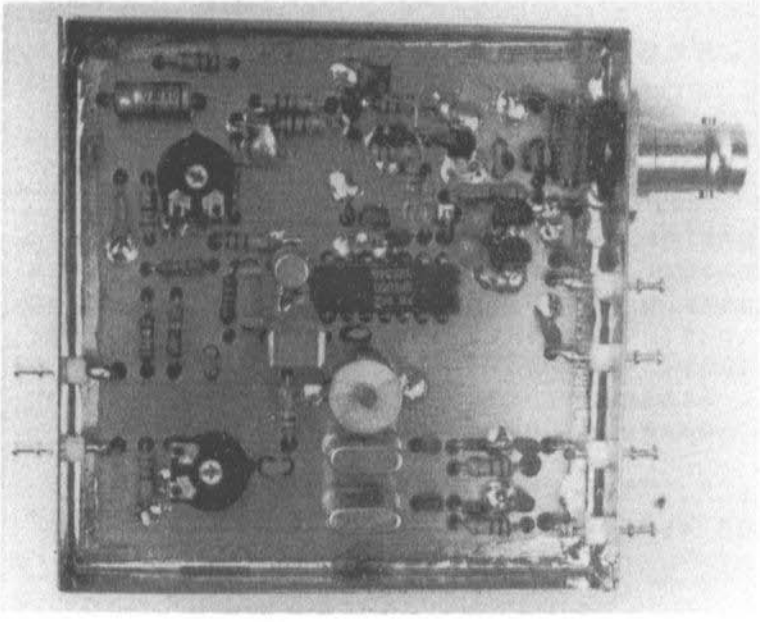

Fig. 7: The completed FM-ATV transmitter module

working, delivering some 20 mW to the power meter. The VCO, however, is not yet locked on to one of the two crystal-determined frequencies but is oscillating at its lowest frequency. The tuning voltage (max. 30 V) is now connected and one of the two crystals put into operation by applying 12 V to the appropriate point. The oscillator is now oscillating, locked at the desired frequency, and if not, it is working outside of the PLL's capture range. This may be corrected either by altering the inductance L or by an adjustment of the control voltage. A small test circuit, which will be described in the second part of the article, will produce an adjustable control voltage from the available 12 V supply voltage.

After the synthesizer has been set-up correctly, the video camera and a frequency-modulated, 5.5 MHz sound carrier can be connected and the unit put into operation. It only remains now to set the frequency deviation with the two preset resistors.

4. LITERATURE

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(2) Sattler, Günter:
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(3) Hirschelmann, Klaus:
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Wolfgang Schneider, DD 2 EK

FM-ATV in the GHz Range
Part 2: Sound-Carrier Circuits and Tuning-Voltage DC Converter

Part 1 of this article about FM-ATV in the GHz range (1) described an FM-ATV transmitter for the 23 cm band. This second, supplementary article, introduces the sound-carrier circuitry and also a DC converter to generate the tuning voltage from a 12 volt source for application to the varicap diodes.

1. THE SOUND-CARRIER CIRCUITS

In order to convey speech information over an ATV link, a frequency-modulated sound carrier at 5.5 MHz is required. This sound subcarrier is modulated together with the video signal in the FM-ATV sender's VCO. The simple circuit suitable for this purpose is shown in **fig. 1**.

1.1. Circuit Description

The sound signal from the microphone is taken via a single-stage pre-amplifier on to a gain-controlled stage using a μA 741 integrated circuit amplifier. At the output of this IC, a portion of the signal is capacitively taken off to a diode rectifier. The DC voltage is then filtered and amplified and is used as the control voltage for the AF amplifier.

The heart of the sound-carrier circuit is the VCO which is a voltage-tuned colpitts oscillator

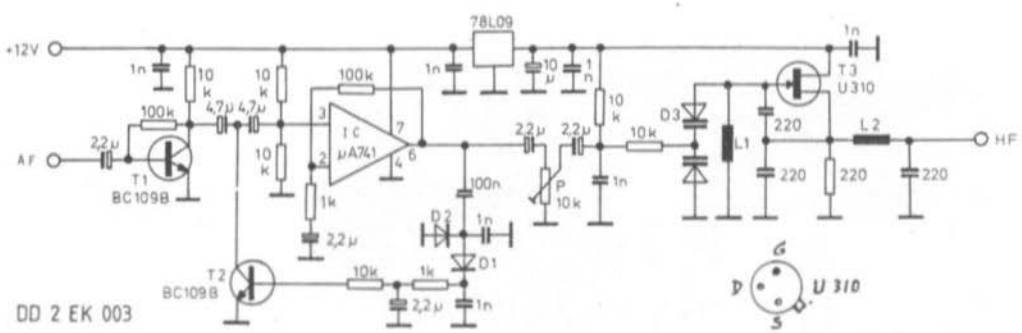

Fig. 1: Circuit schematic of sound carrier

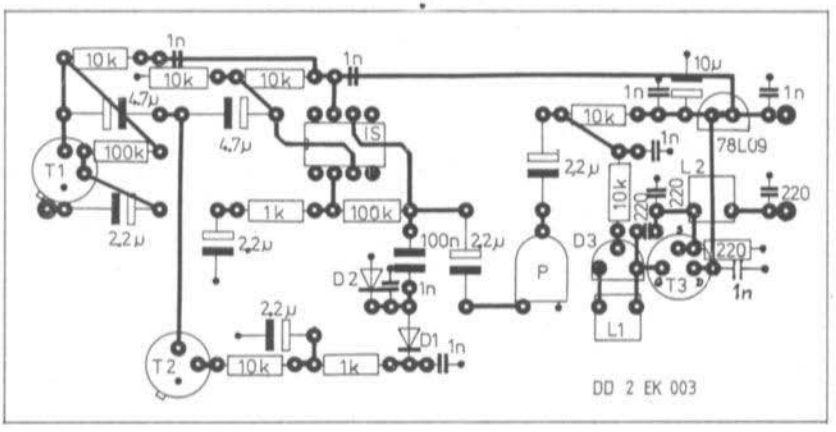

Fig. 2: Component layout of sound-carrier board DD 2 EK 003

working at 5.5 MHz. The frequency-determining parallel tuned-circuit consists of an 8 µH inductor and a double tuning-diode BB 204 B. Owing to the BB 204 B's constructional characteristics (two back-to-back diodes in a single encapsulation), the necessary large capacity variation range is produced and the otherwise capacitive separation of the tuning voltage and the AF signal from the rest of the oscillator circuit, is rendered superfluous.

Both diodes are DC-referenced to a fixed voltage of + 9 V. The amplified signal is applied at this point. The potentiometer serves to adjust the frequency deviation of the ATV sub-carrier sound.

An U 310 is used for the oscillator transistor. At the FET's source the modulated 5.5 MHz signal is taken, via a low-pass filter, to the output at a power of some 3 mW.

1.2. Construction

The printed circuit board DD 2 EK 003 consists of a two-sided 1.5 mm thick epoxy-glass material

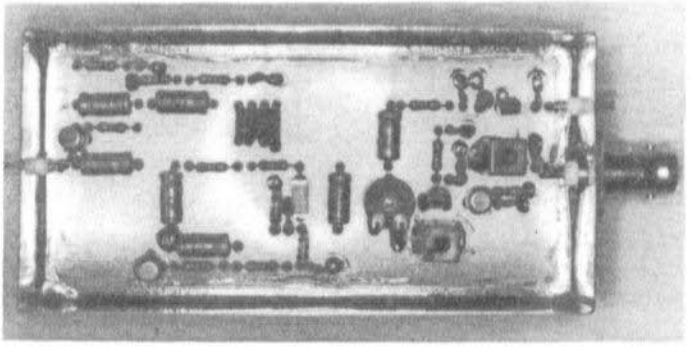

Fig. 3: The completed sound-carrier unit

and of dimensions 53.5 x 108 mm which fits into a proprietary 111 x 55.5 x 30 tin-plate box. After the holes for the small components have been drilled, the component side holes, which are not passing ground leads, are slightly counter-sunk in order that the copper plating is removed from around the circumference of the hole.

When these preparations are ready, the board can be sprayed with anti-corrosion solution. The board is equipped with components only after it has been soldered into the enclosure. **Figure 3** shows the prototype unit.

1.3. Components

T1, T2:	BC 109 B, BC 413, BC 550 or equiv.
T3:	U 310 (Siliconix)
IC:	µA 741
D1, D2:	AA 119 or equiv.
D3:	BB 204 B
L1:	8 µH inductor (Neosid BV 5800, gn/rd)
L2:	1 µH inductor (Neosid BV 5048 ye/gn)
1 x	voltage regulator 78L09
5 x	Elko 2.2 µF/25 V (10 mm grid)
2 x	Elko 4.7 µF/25 V (10 mm grid)
1 x	tantalum pearl cap. 10 µF/25 V
1 x	100 nF (7.5 mm grid)
1 x	10 kΩ preset (10 mm grid)
1 x	tin-plate box 111 x 55.5 x 30
1 x	BNC panel skt. UG-290A/U
2 x	PTFE feed-through

Ceramic disks, 2.5 mm grid:
3 x 220 pF; 7 x 1 nF

Resistors (10 mm grid):
1 x 220 Ω; 2 x 1 kΩ, 6 x 10 kΩ, 2 x 100 kΩ

2. THE DC-DC CONVERTER

2.1. Circuit Description

The circuit in **fig. 4** represents that of a DC-DC converter which supplies the VCO varicap diode with a tuning voltage of about 24 V. The circuit functions with an oscillator frequency of 40 kHz which is determined by the external circuitry to an NE 555. The following high-speed switching transistor drives the storage inductor L1. This inductor has an air-grapped pot-core (A_L = 250) wound with 70 turns of 0.2 mm lacquered copper wire (CuL). The 40 kHz output waveform is rectified and filtered and then applied to a preset potentiometer. The maximum voltage output is limited by the zener diode D1 to 30 V.

2.2. Construction

The DC-DC converter is, as all the other boards in the FM-ATV transmitter, mounted on a two-sided epoxy-glass PCB, DD 2 EK 004, with dimensions 53.5 x 72 x 1.5 mm (**fig. 5**).

The preparation and drilling follows the lines of the sound-carrier board. The board is drilled etc. and then mounted in its housing. The components are then mounted and soldered in. **Fig. 6** shows the prototype of the DC-DC converter.

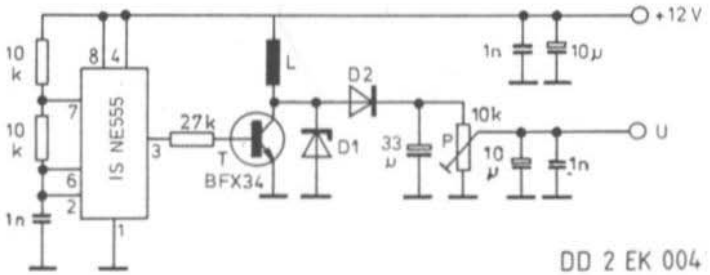

Fig. 4: Circuit schematic of DC-DC converter

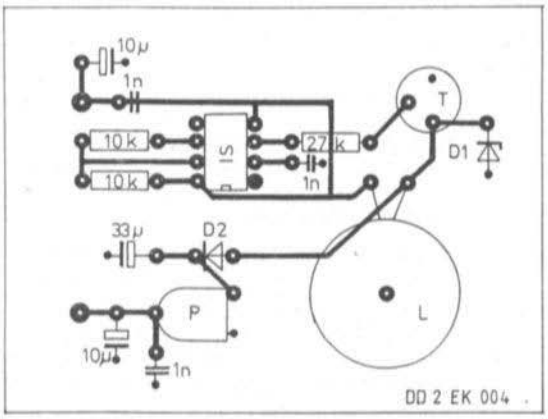

Fig. 5:
Component layout of DC-DC converter DD 2 EK 004

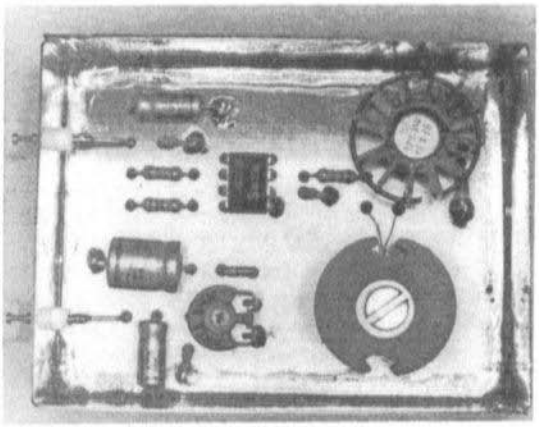

Fig. 6:
The completed DC-DC converter unit

2.3. Components

T1: BFX 34 or equiv.
IC: NE 555
D1: zener diode 30 V/1.3 W
D2: diode 1N 4148
L1: inductor: 70 turns, 0.2 CuL on pot-core 21 Ø x 13 mm (A_L = 250)
1 x Elko 33 µF/40 V (10 mm grid)
2 x Elko 10 µF/40 V (10 mm grid)
1 x preset 10 kΩ (10/5 mm grid)
2 x resistor 10 kΩ (10 mm grid)
1 x resistor 27 kΩ (10 mm grid)
3 x ceramic capacitor 1 nF (2.5 mm grid)
1 x tin-plate box 74 x 55.5 x 30
2 x PTFE feed-through

3. REFERENCES

(1) Schneider, W., DD 2 EK:
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Part 1: 23 cm Transmitter
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