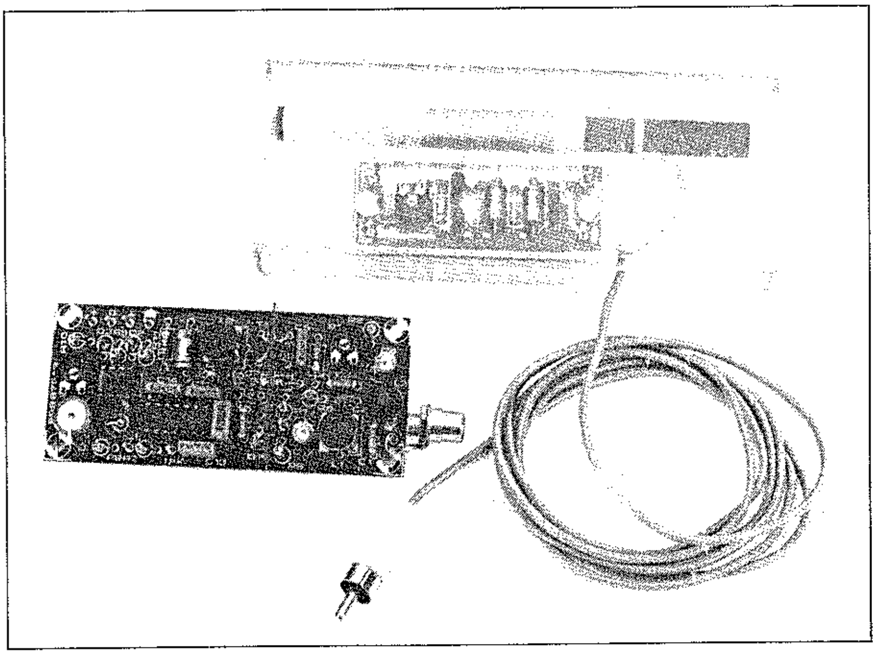
SIMPLIFIED TIME-SIGNAL RECEIVER

The automatic synchronization facility of many microprocessor-based clocks ensures reasonable long-term accuracy even when the relevant time-signal transmitter is received for only a couple of minutes each day. Obviously, this feature relaxes the design requirements of the receiver, which can be kept relatively simple. Such a receiver is described here: it has a digital pulse output, excellent sensitivity, and can be tuned to time-standard stations transmitting in the VLF band between 50 and about 100 kHz.

Time-signal transmitters such as Rugby MSF, HBF and DCF77 operate in the VLF (very low frequency) band, at frequencies between 50 and 100 kHz. The VLF band is characterized by very predictable propagation characteristics, but received signals often suffer from interference generated by electrical apparatus such as TV sets and dimmers. The receiver should, therefore, have good or very good selectivity. The frequency conversion principle (heterodyne receiver) must be dismissed, however, when the practical design is to remain as simple as possible.



Completed prototype of the simplified time signal receiver, connected to the associated active aerial.

Circuit description

Selectivity of the present VLF receiver is determined solely by the aerial and two tuned circuits. High-gain RF amplifiers are used, and a special, non-linear, demodulator extracts the time signals from the still relatively noisy RF input signal.

The circuit diagram of Fig. 1 shows that the RF signal from the transmitter is picked up by an active aerial circuit, whose output signal is filtered by tuned circuit L_1-C_2, and amplified by dual-gate MOSFET T_1. A further tuned circuit inserted in the drain line of this transistor ensures adequate receiver selectivity. The drain signal is rectified by D_1 to provide automatic gain control (AGC) on gate 1 of the MOSFET. The AGC has a relatively slow response because fading is generally slow on VLF.

Circuit IC_1 is a Type SO42P balanced mixer/oscillator from Siemens. In the present application, it functions as a four-quadrant multiplier, so that its output signal is proportional to the square of the input signal provided by T_1. The modulation frequency on DCF77 is relatively low, so that a single R-C network, R_8-C_{15}, is sufficient for removing the RF component from the rectified time signals. These are filtered and shaped in a further (active) rectifier, IC_{2a}, whose output signal is a measure of the instantaneous amplitude of the time signals. The discharge time of C_{16} is relatively long (P_2-R_{10}), so that the voltage on this capacitor is largely constant for the duration of the time pulses. Comparator IC_{2b} compares the instantaneous amplitude of the rectified voltage to a part of the absolute amplitude, set with P_2.

The output of the receiver supplies time pulses as they are modulated, i.e., a time pulse corresponds to a logic low level. This makes the present time signal receiver compatible with the Intelligent Time Standard published in Ref [2], but only if DCF77 is being received.

The circuit diagram shows the capacitor values needed for reception of DCF77 on 77.5 kHz. The tuned circuits can be modified for reception of, for instance, Rugby MSF at 60 kHz, by multiplying the value of C_2, C_7 and C_8 by a factor $(77.5/60)^2 \approx 1.67$, and using the closest practical capacitor value.

Construction and alignment

The receiver is composed of two boards: active aerial and receiver/demodulator. The active aerial is identical to that used for the DCF77 receiver and locked frequency standard (see Ref. [1]). The unit is constructed on the small printed circuit board shown in Fig. 2. The aerial, L_5, is formed by about 200 closewound turns of 0.2 mm dia enamelled copper wire on a 30 mm long cardboard or paxolin former. This is slid on to a 12-20 cm long ferrite rod of 10 mm diameter. The rod and associated former used for building the prototype receiver were parts salvaged from a discarded MW/LW radio.

Populating the receiver/demodulator board shown in Fig. 3 should not present problems. A 15 mm high tin plate or brass screen is fitted across T_1 as shown on the component overlay The screen has small clearances for T_1 and R_3, and is secured to the PCB with the aid of two soldering terminals. Note that a number of parts are fitted upright

Use one metre or so of screened microphone wire to connect the active aerial to the main receiver board.

First, concentrate on setting up the active aerial. Power up and check the DC settings at the points indicated in the circuit diagram. Set a sine-wave generator to the receiving frequency (e.g., 77.5 kHz), and connect a coupling loop and a series resistor to the output of the instrument. Wind the coupling loop on to the ferrite rod, and connect an AC-coupled oscilloscope to the output of the active aerial. Slide the former until the signal amplitude is a maximum. Reduce the output of the generator, and move the coupling loop away from the rod.

Again slide the former on the rod to find the resonance point. If this is found with the former partially off the rod, the number of turns of L_5 should be reduced. Experiment with the value of C_{44} and the setting of P_2 until the completed active aerial has a selectivity of about 10 kHz, and the former is about flush on the rod. When this cannot be achieved, the ferrite rod may have incorrect RF properties, and there is no alternative but to try out another type. After adjustment, the former is secured on the ferrite rod by means of wax or sellotape. Do not use a metal support for fixing the rod.

Switch off the generator, increase the sensitivity of the scope, and rotate the rod in the horizontal plane until the RF signal from the time signal station is observed on the oscilloscope screen. The signal is relatively small, but should have an amplitude between 5 and 50 mV_{pp}. Connect the probe to the drain of T_1, and carefully peak L_1 and L_2 for maximum amplitude. If clipping or oscillation occurs, reduce the gain of T_1 by adjusting P_1. Readjust the active aerial and the tuned circuits with a high-impedance voltmeter connected to pin 2 of IC_1

The time signals can be heard on high-impedance (600 Ω) headphones connected between the positive supply and test point TP2. Finally, mount the active aerial in a position well away from

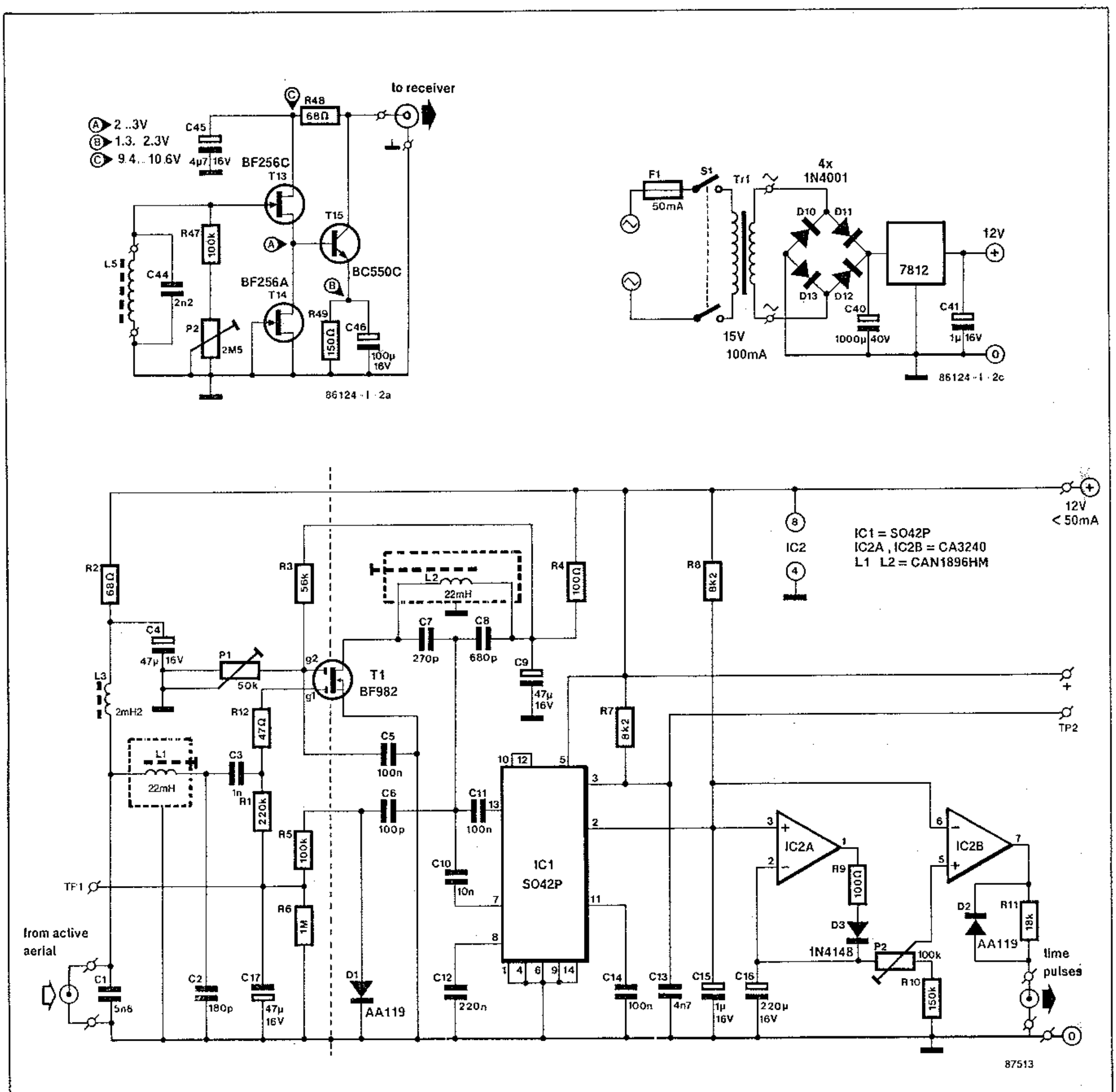


Fig. 1 Circuit diagram of the VLF time signal receiver.

sources of interference The length of the screened cable between the active aerial and the main receiver board should not exceed 15 m or so

References:
[1] DCF77 receiver and locked frequency standard. *Elektor Electronics* January 1988, p. 24-29.
[2] Intelligent time standard *Elektor Electronics* February 1988, p 22-30.

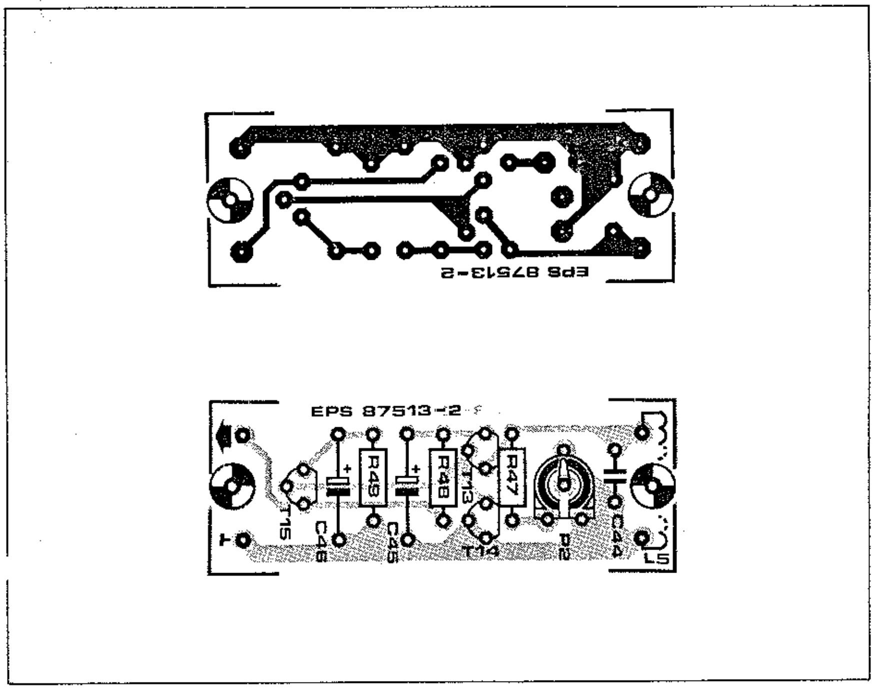


Fig. 2. Printed circuit board for the active aerial.

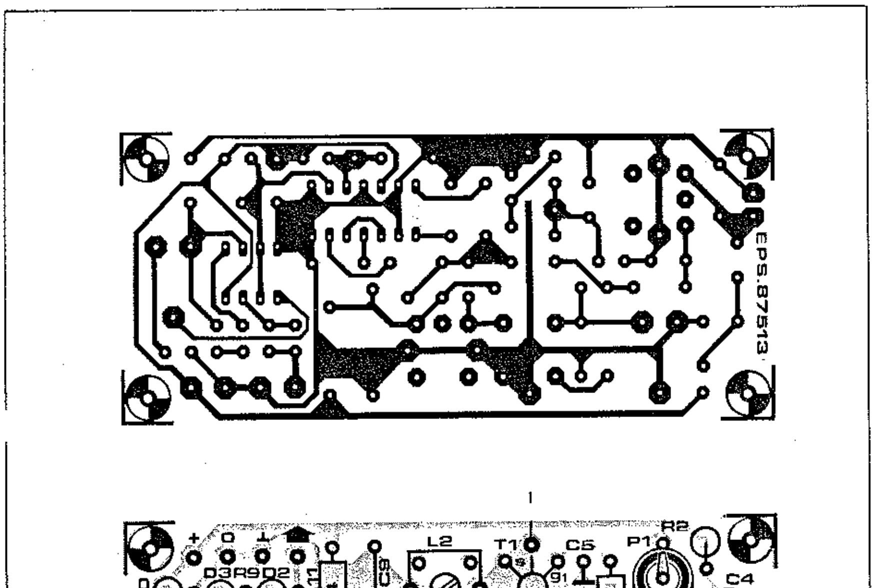


Fig. 3. Printed circuit board for the time signal receiver/demodulator.

Parts list

ACTIVE AERIAL:

Resistors (± 5%):
R_{47} = 100K
R_{48} = 68R
R_{49} = 150R P_2 = 2M5 preset H

Capacitors:
C_{44} = 2n2
C_{45} = 4µ7; 16 V; radial
C_{46} = 100µ; 16 V; radial

Semiconductors:
T_{13} = BF256C (Cricklewood)
T_{14} = BF256A (Cricklewood)
T_{15} = BC550C

Inductor:
L_5 = see text Ferrite rod: e.g Cirkit Type FRA (stock number 35-14147)

Miscellaneous:
PCB Type 87513-2 (see Readers Services page)

MAIN RECEIVER BOARD:

Resistors (± 5%):
R_1 = 220K
R_2 = 68R
R_3 = 56K
R_4;R_9 = 100R
R_5 = 100K
R_6 = 1M0
R_7;R_8 = 8K2
R_{10} = 150K
R_{11} = 18K
R_{12} = 47R
P_1 = 50K preset H
P_2 = 100K preset H

Capacitors:
C_1 = 5n6
C_2 = 180p
C_3 = 1n0
C_4;C_{17} = 47µ; 16 V; radial
C_5;C_{11};C_{14} = 100n
C_6 = 100p
C_7 = 270p
C_8 = 680p
C_9 = 47µ; 16 V; axial
C_{10} = 10n
C_{12} = 220n
C_{13} = 4n7
C_{15} = 1µ0; 16 V; radial
C_{16} = 220µ; 16 V; radial

Inductors:
L_1;L_2 = 22mH variable; Toko 10PA series Type CAN1896HM (Cirkit stock number 35-18960)
L_3 = 2mH2 radial choke; Toko Type 181LY-222 (Cirkit stock number 34-22202)

Semiconductors:
D_1;D_2 = AA119
D_3 = 1N4148
T_1 = BF982 (C-I Electronics)
IC_1 = SO42P (Bonex; C-I Electronics; Universal Semiconductor Devices Ltd.)
IC_2 = CA3240

Miscellaneous:
PCB Type 87513-1 (see Readers Services page)

Note: PCB Types 87513-1 and 87513-2 are supplied as a set and cannot be ordered separately sources of interference. The length of the screened cable between the active aerial and the main receiver board should not exceed 15 m or so.

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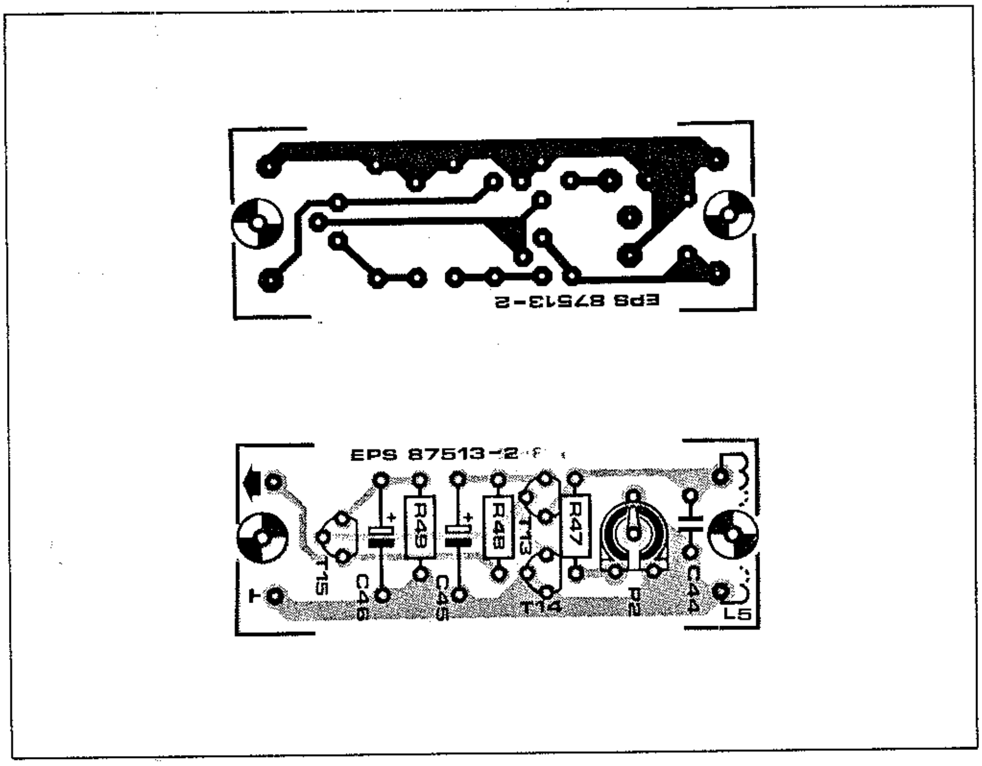
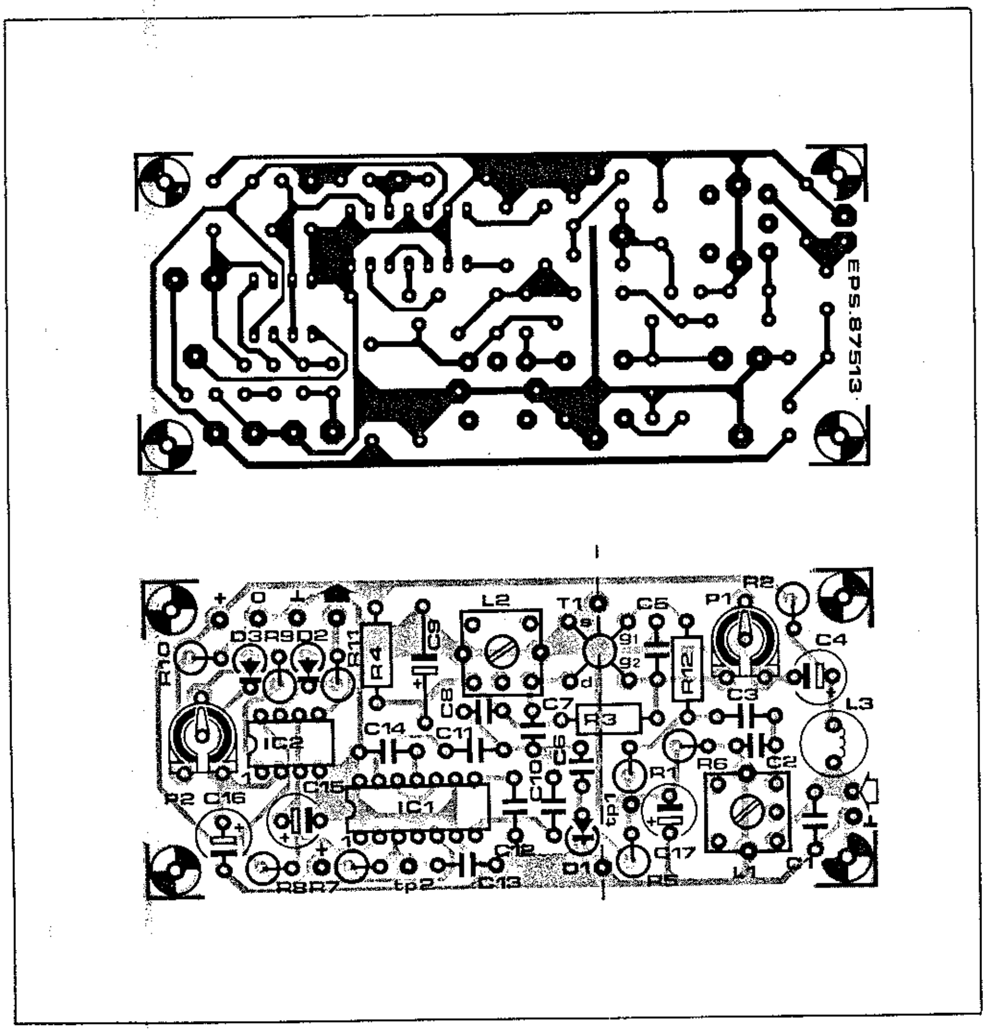


Fig. 2. Printed circuit board for the active aerial.



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C_{12} = 220n
C_{13} = 4n7
C_{15} = 1μ0; 16 V; radial
C_{16} = 220μ; 16 V; radial

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