RF signal generator

part 1: circuit descriptions

An RF signal generator is used for repairing radio/TV circuits, checking filters, aligning receivers, and for comparative sensitivity tests on all kinds of receivers, whether home-made, restored surplus or off-the-shelf. The generator described here has an output frequency range of 0.5 to 30 MHz, making it suitable for many applications.

Main specifications

- Frequency range: 0.5 MHz to 30 MHz
- Output level: 0 dBm down to –79 dBm in 1-dB steps
- Max. output level: $0.63V_{pp}$ into 50 Ω
- Output impedance: 50 Ω
- AM input
- FM input
- LCD readout
- Microprocessor controlled
- Optional serial interface

Design by Guido Brunner

A rock-solid RF signal with an accurately known frequency and level is a must for anyone seriously involved in repairing radio receivers and other communications equipment like filters and even antennas. In particular, receiver RF input and IF (intermediate frequency) sections can not be tested with any degree of certainty if a trustworthy RF signal generator is not to hand. Unfortunately, professional-grade RF signal generators (like the mighty Hewlett Packard 8640B in our design lab) cost an arm and a leg, even in the surplus trade. None the less, you will see at least one RF signal generator, home-made, thrown together from other bits and pieces, or ex-MOD, in the shack of the more advanced radio amateur, simply because this piece of test gear is as indispensable as the plain old multimeter.

The stability of the RF signal generator described in this article is such that it will meet the (moderate) demands of many amateurs. Offering a frequency range of 0.5 through 30 MHz and an output level down to –80 dBm, it is perfect for testing and aligning many receivers and their sub-circuits like RF/IF amplifiers, mixers and demodulators.

What requirements can be mentioned in relation to an RF signal generator? The answer is very simple indeed: you need to be sure of (1) the *frequency* and (2) the *level* of the signal you feed into the circuit (receiver) under test. If either of these is unreliable, all testing and comparing of receiver specs becomes meaningless. In the present design, frequency stability is assured by a PLL (phase-locked loop), while the output level is determined by a switched pi (pi) attenuator, all under the control of a microprocessor.

BLOCK DIAGRAM

Because the actual circuit diagrams of the four modules that make up the signal generator are a fairly complex lot when presented together, it was decided to draw and discuss them as separate blocks. The basic interaction of these blocks is illustrated in **Figure 1**. The block diagram shows that the heart of the circuit is a PLL synthesizer module keeping a VCO (voltage-controlled oscillator) in check. The VCO output signal is amplified and fed to the generator output as well to the synthesizer input and the input of the attenuator. The PLL obtains digital information on the target VCO frequency from a microprocessor module. The micro also takes care of the front-panel mounted user interface, which consists of 3 switches, a rotary encoder and an LCD (liquid-crystal display). It also controls the amount of attenuation at the generator output, across a range of –1 dB through –79 dB. An optional serial interface is available to enable the RF Signal Generator to be linked to a PC using an RS232 cable. Functionally, the instrument is completed by an internal power supply.

PLL BOARD

The circuit diagram of this first module to be discussed in detail is shown in **Figure 2**. It comprises three sub-circuits: VCO, synthesizer and output buffer. The VCO and the synthesizer together from the PLL.

VCO and buffers

The active element in the oscillator is a differential amplifier built around transistors T1, T2 and T3, whose gain depends on the current passed by T3. The actual resonating element in the oscillator is an L-C parallel tuned circuit connected to the input of the difference amplifier. The LC network consists of inductors L1-L5 in combination with variable-capacitance diodes (varicaps) D9 and D10. The other input of the oscillator is grounded for RF by capacitor C10. Depending on the desired frequency range, one or more inductors are switched into the oscillator. This is done by pulling the non-commoned terminals to RF ground using +5V control voltages on PIN diodes D2, D4, D6 and D8. In the highest frequency range, all inductors are effectively connected in parallel. This is necessary to make sure that the non-selected inductors and their parasitic capacitance can not form a series tuned circuit that would prevent the oscillator from operating at the desired frequency. All inductors are off-the-shelf miniature chokes. The frequency range switching takes place at 1.024 MHz, 2.304 MHz, 5.376 MHz and 13.056 MHz.

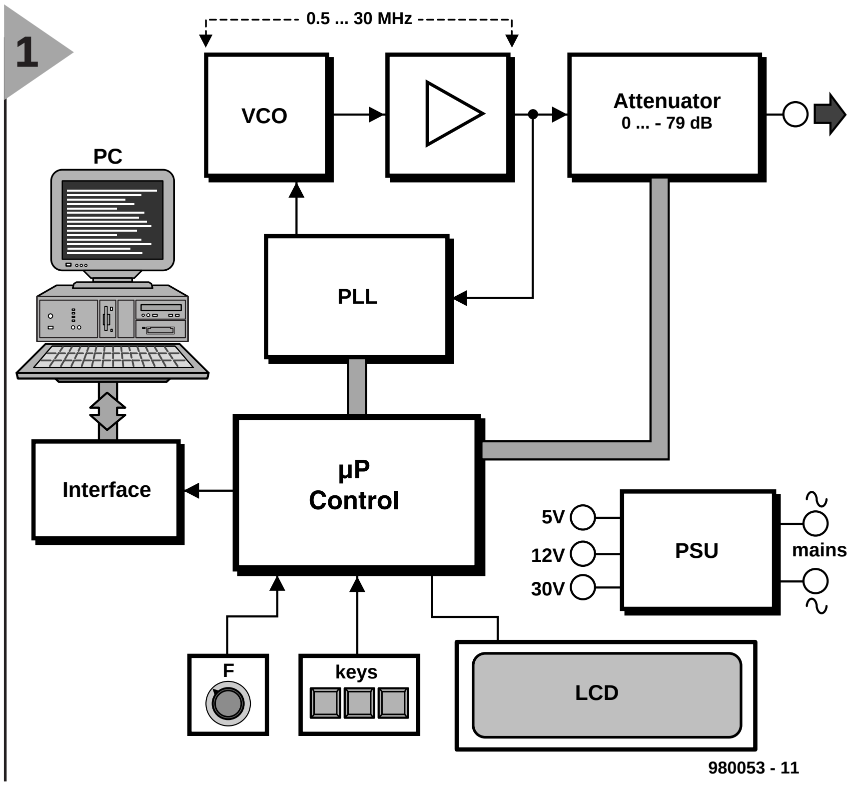

Figure 1. Block diagram of the RF Signal Generator. All intelligence is vested in a microcontroller.

Capacitor C8 provides the necessary amount of positive feedback in the oscillator. An AF signal may be applied to the emitter of T4 to effect amplitude modulation (AM). Frequency modulation (FM) is also possible by superimposing an AF signal onto the varicap tuning voltage. Although FM will cause the PLL to drop out of lock, the average frequency remains constant because the time constant of the control loop is not capable of tracking the 'instability' caused by the modulation signal.

To make sure it is not too heavily loaded, the oscillator signal is first buffered by a FET (field-effect transistor), T4. Next comes the real amplifier, IC1, a type NE592 which some of you may know from baseband-video amplifiers in satellite-TV receivers. The amplifier is biased at half the supply voltage by opamp IC3b, and its gain is defined by series network R26-L8. Because of the inductor action, the gain decreases at higher frequencies. Because the VCO strives to maintain a stable output level, less gain on the NE592 automatically more gain in the differential oscillator. This purposely-created effect is essential for reliable starting of the oscillator at higher frequencies.

The NE592 being a differential amplifier, it has two inputs, but also outputs. Both are used here. The signal at the first output (pin 7) is applied to emitter follower T5 which supplies the actual generator output signal at an impedance of 50 Ω (the standard in RF test equipment). The other output signal supplied by the NE592 is used to drive two sub-circuits. One branch goes to the PLL chip via C23 and R33, the other is used to drive a voltage rectifier/doubler, D11-D12 which in turn drives amplitude-control opamp IC3a. The desired highest output amplitude may be set using preset P1. The author used a setting where 0 dBm (decibel-

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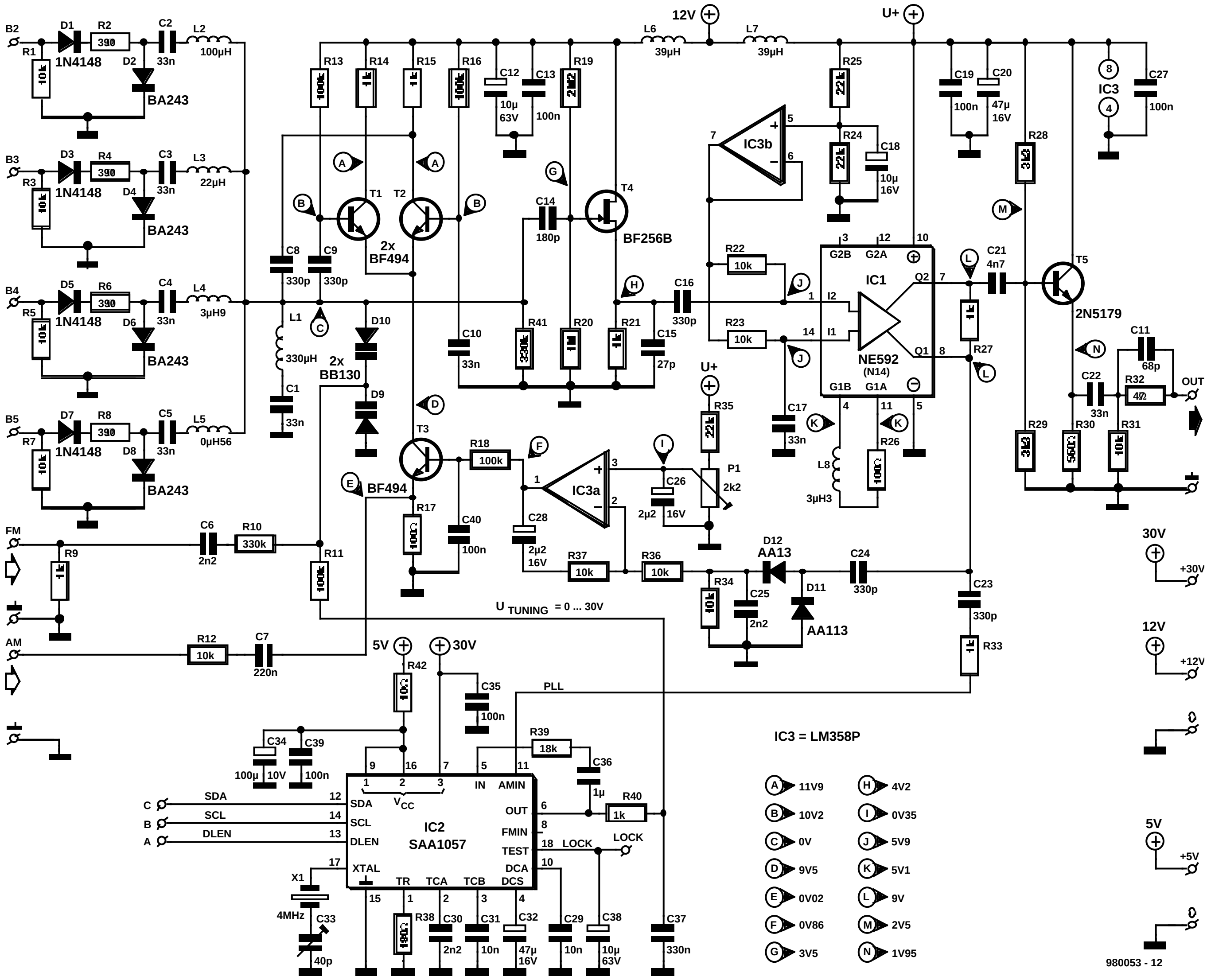

B2
B3
B4
B5
D1 1N4148
D3 1N4148
D5 1N4148
D7 1N4148
D2 BA243
D4 BA243
D6 BA243
D8 BA243
R1 10k
R2 390
R3 10k
R4 390
R5 10k
R6 390
R7 10k
R8 390
C2 33n
C3 33n
C4 33n
C5 33n
L2 100µH
L3 22µH
L4 3µH9
L5 0µH56
L1 330µH
C1 33n
C8 330p
C9 330p
R13 100k
R14 1k
R15 1k
R16 100k
T1
T2
2x BF494
C12 10µ 63V
C13 100n
R19 2M2
C14 180p
T4 BF256B
12V
L6 39µH
L7 39µH
U+
R25 22k
R24 22k
C18 10µ 16V
IC3b
R22 10k
R23 10k
IC1 NE592 (N14)
G2B G2A G1B G1A
I2 I1 Q2 Q1
C16 330p
C21 4n7
T5 2N5179
R27 1k
C19 100n
C20 47µ 16V
IC3
C27 100n
R28 3k3
C11 68p
C22 33n
R32 47Ω
OUT
R29 3k3
R30 560Ω
R31 10k
D10
2x BB130
D9
C10 33n
R41 330k
R20 1M
R21 1k
C15 27p
C17 33n
L8 3µH3
R26 100Ω
R35 22k
P1 2k2
T3 BF494
R18 100k
IC3a
C26 2µ2 16V
R17 100Ω
C40 100n
C28 2µ2 16V
R37 10k
R36 10k
D12 AA13
C24 330p
D11 AA113
R34 10k
C25 2n2
C23 330p
R33 1k
FM
C6 2n2
R10 330k
R9 1k
R11 100k
U TUNING = 0 ... 30V
AM
R12 10k
C7 220n
5V
30V
R42 10Ω
C35 100n
PLL
C34 100µ 10V
C39 100n
R39 18k
C36 1µ
R40 1k
C
B
A
SDA
SCL
DLEN
IC2 SAA1057
VCC
IN
AMIN
OUT
FMIN
TEST
DCA
DCS
XTAL
TR TCA TCB
LOCK
X1 4MHz
C33 40p
R38 180Ω
C30 2n2
C31 10n
C32 47µ 16V
C29 10n
C38 10µ 63V
C37 330n
IC3 = LM358P
A 11V9
B 10V2
C 0V
D 9V5
E 0V02
F 0V86
G 3V5
H 4V2
I 0V35
J 5V9
K 5V1
L 9V
M 2V5
N 1V95
30V +30V
12V +12V
5V +5V
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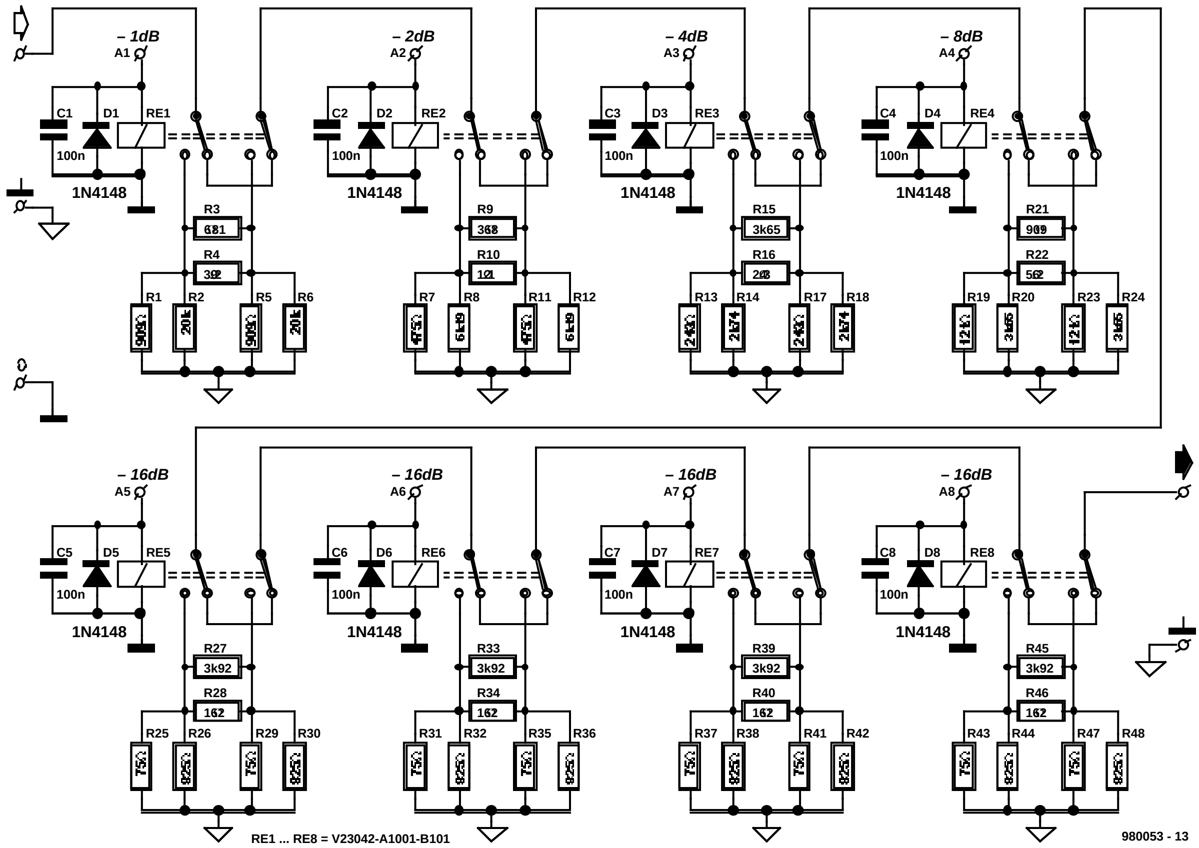

– 1dB A1
– 2dB A2
– 4dB A3
– 8dB A4
– 16dB A5
– 16dB A6
– 16dB A7
– 16dB A8
C1 100n D1 1N4148 RE1
C2 100n D2 1N4148 RE2
C3 100n D3 1N4148 RE3
C4 100n D4 1N4148 RE4
C5 100n D5 1N4148 RE5
C6 100n D6 1N4148 RE6
C7 100n D7 1N4148 RE7
C8 100n D8 1N4148 RE8
R3 681
R4 392
R1 909Ω R2 20k R5 909Ω R6 20k
R9 368
R10 121
R7 475Ω R8 6k49 R11 475Ω R12 6k49
R15 3k65
R16 243
R13 243Ω R14 2k74 R17 243Ω R18 2k74
R21 909
R22 562
R19 121Ω R20 3k65 R23 121Ω R24 3k65
R27 3k92 R28 162
R25 75Ω R26 825Ω R29 75Ω R30 825Ω
R33 3k92 R34 162
R31 75Ω R32 825Ω R35 75Ω R36 825Ω
R39 3k92 R40 162
R37 75Ω R38 825Ω R41 75Ω R42 825Ω
R45 3k92 R46 162
R43 75Ω R44 825Ω R47 75Ω R48 825Ω
RE1 ... RE8 = V23042-A1001-B101
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igure 2. Circuit diagram of
e VCO/PLL board. The heart
f the PLL is an I²C-controlled
ynthesizer chip type
AA1057.

milliwatt) into 50 Ω equals 0.63 V_{pp} at the generator output.

Synthesizer

The circuit of the synthesizer largely follows the Application Note for the SAA1057 as supplied by Philips Semiconductors. Some component values in the control loop had to be modified a little to optimise the behaviour of the PLL. The ‘LOCK’ output is only provided for test purposes. The SAA1057 receives its control information in I2C format via its SDA, SCL and DLEN inputs. These lines are connected to a microcontroller. Basically, the SAA1057 compares the frequency of the VCO with that of a reference signal derived from the external 4-MHz quartz crystal. For this purpose the VCO signal is internally divided by a factor determined by the microprocessor. The frequency difference produces an error signal which is converted into a corresponding varicap control voltage. This control voltage is integrated by R40-C37 and has a range of 0-30 V. Remarkably, the SAA1057 does not require an external level converter for the varicap control voltage — a special amplifier is included on the chip for this purpose, as well as a direct connection for +30 V (pin7).

Trimmer C33 allows the generator output frequency to be calibrated against a frequency standard.

The VCO/PLL board requires three supply voltages: +5 V for the synthesizer, +12 V for the VCO, and +30 V for the varicap voltage.

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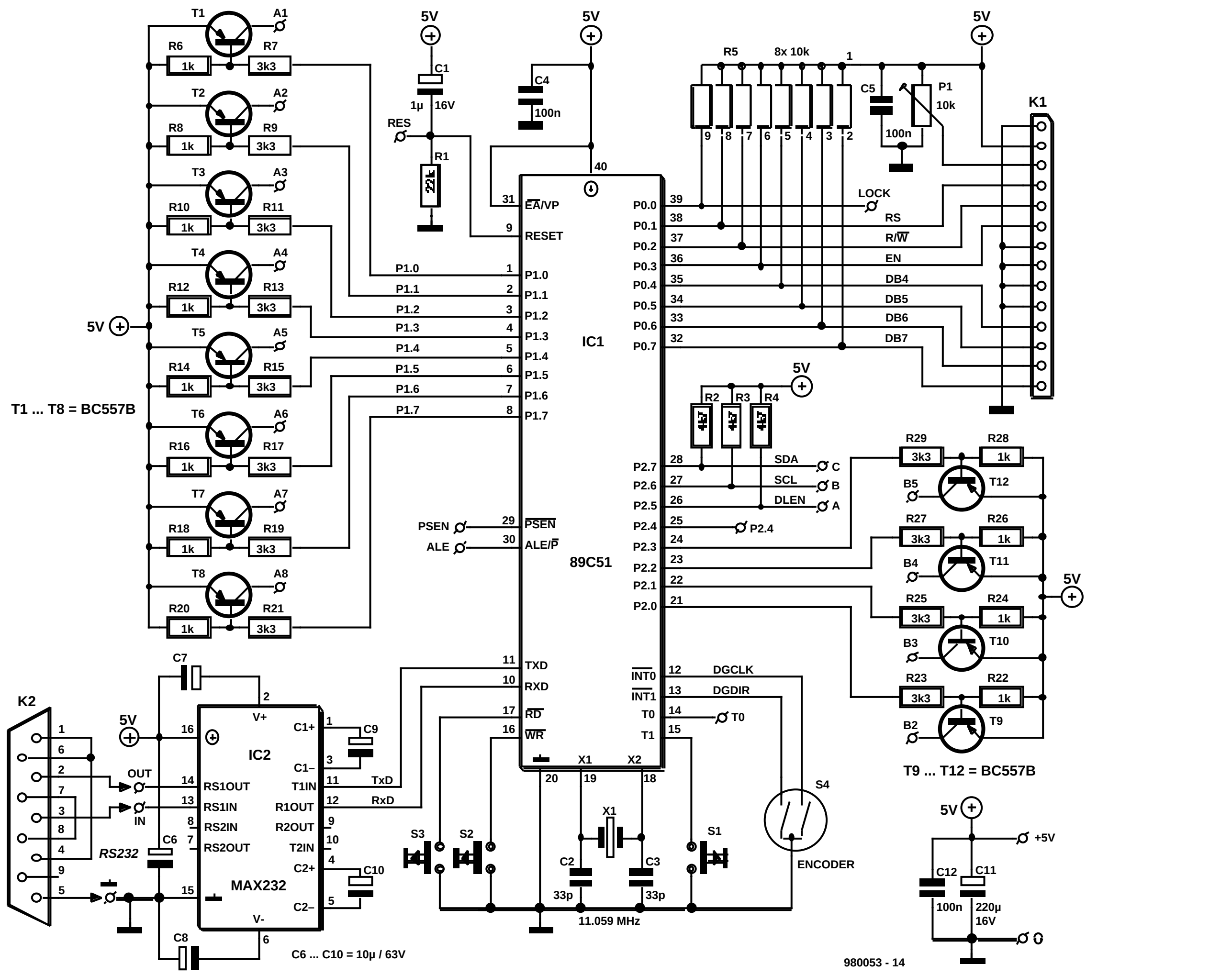

igure 3. Circuit diagram of
e digitally controlled attenu-
tor. Range is –1 dB to –79 dB
1-dB steps.

Figure 4. Circuit diagram of the controller board. An 89C51 sits between a number of input and output devices.

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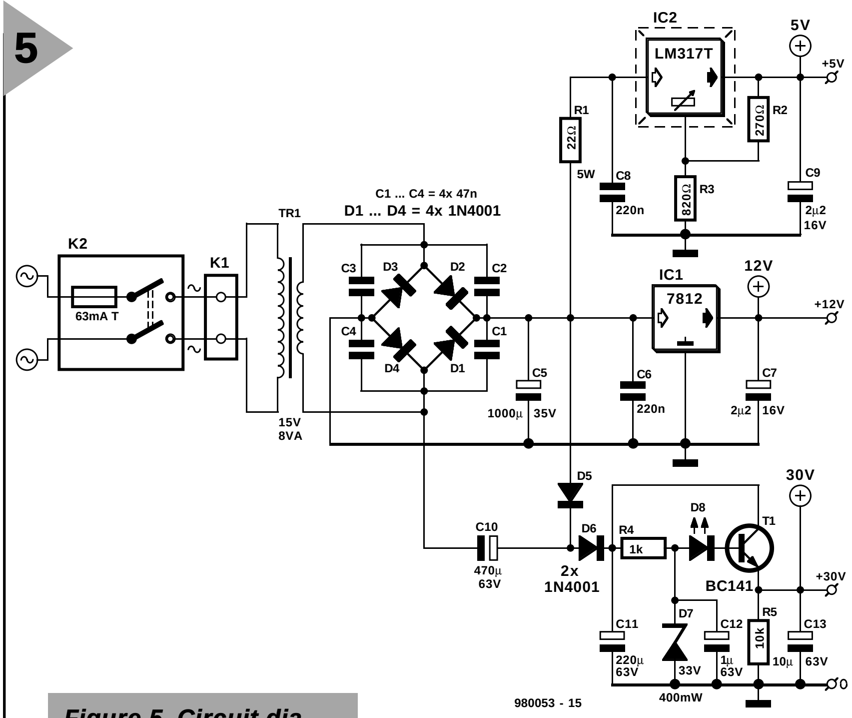

Figure 5. Circuit diagram of the power supply. Three voltages from one transformer!

ATTENUATOR BOARD

Figure 3 shows the circuit diagram of a digitally controlled 8-section pi RF attenuator with a range of –1 dB to –79 dB in 1-dB steps. The resistor combinations we need to realize each of the 79 discrete attenuation levels are connected into the circuit by means of relay contacts. The associated relays are actuated and de-actuated by microprocessor drive signals that form 8-bit combinations at the control inputs marked A1-A8.

The theoretical values of the resistors in the attenuator are realized by means of parallel combinations of 1% resistors from the E96 series.

Each relay coil is shunted by a back-emf suppressor diode and a decoupling capacitor.

MICROCONTROLLER BOARD

All the intelligence we need to implement a man/machine interface, i.e., establish communication between the user on the one hand, and the PLL and the attenuator on the other, is packed in a microcontroller type 89C51. This controller executes a program written by the author and burned into the internal program memory by the Publishers. The 89C51 is available ready-programmed from the Publishers or certain kit suppliers advertising in this magazine.

The 89C51 accepts information and supplies information. Microcontroller freaks call this 'I/O' for input/output. Well, the input devices are a rotary shaft encoder, S4, which is used for the frequency setting, a small keyboard, S1-S2-S3, the SDA line of the I^{2}C bus and (optionally) the RxD line of the MAX232 serial interface. The output devices to control are the LCD connected to port P0, the attenuator on port P1), the VCO inductors on port line P2.0 through P2.3 and, of course, the synthesizer chip, by way of the DDA and SCL lines (P2.6 and P2.7). Actually, the I^{2}C bus is modified into a so-called CBUS by the addition of P2.5 (DLEN) and its pull-up resistor, R2.

The 89C51 is clocked at 11.0592 MHz by an external quartz crystal, X1. This frequency was chosen because it allows standard baud rates to be used on the serial interface.

A classic power-on reset network, R1-C1, completes the microcontroller circuit.

This board requires only +5 V to operate, the MAX232 having on-chip step-up converters for +10 V and –10 V.

POWER SUPPLY BOARD

As you can see from the circuit diagram in Figure 5, the power supply for the RF signal generator is entirely conventional.

The 30-V varicap supply is based on a simple combination of a zener diode and a series transistor. Current drain on the 30-V rail will be very small, so extensive regulation is not necessary. None the less, a fair number of decoupling capacitors is used to keep the varicap voltage as clean as possible. After all, all hum, noise etc. on this rail will cause frequency modulation on the output signal. The input voltage for the 30-V regulator is supplied by a voltage doubler, C10-D5-D5.

The 5-V and 12-V supplies are based on two old faithfuls, the 7805 and the LM317 respectively. These ICs and their usual 'satellite' components have been used so many times in our published circuits that no further description will be necessary.

A single mains transformer rated at 15 V, 8VA, supplies all the necessary alternating voltages. The mains voltage at the primary side is applied via a double-pole switch and a fuse, both built into a Euro-style appliance socket.

NEXT MONTH

In next month's second and concluding instalment we will be discussing the construction of the instrument on four printed circuit boards. The article will be concluded with notes on the operation of the RF Signal Generator, miscellaneous matters and optional extras.

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RF signal generator

part 2 (final): construction, operation and adjustment

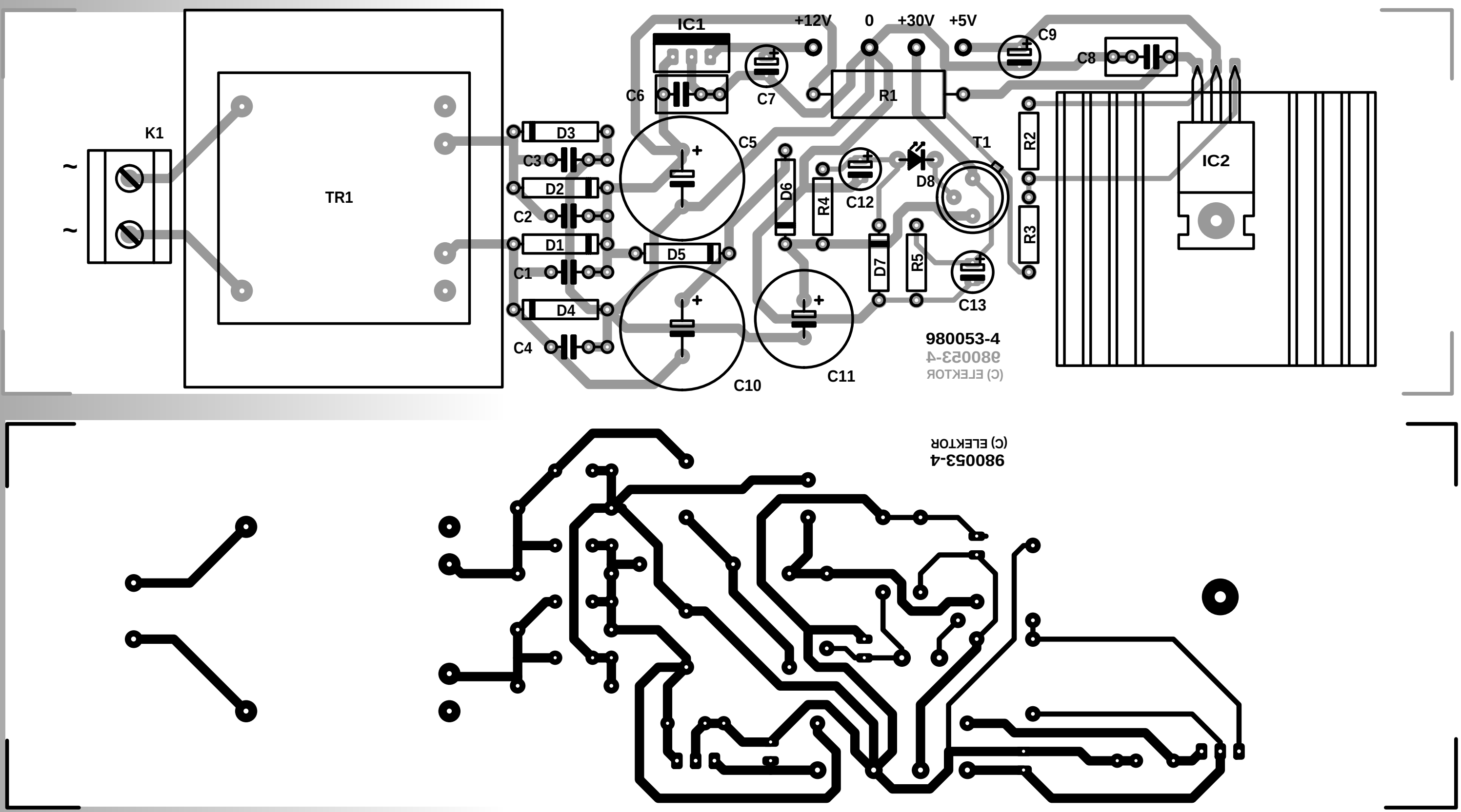

Figure 6. Copper track layout and component overlay of the power supply board.

Although the main subject of this month's second and final instalment is 'all matters constructional', there's also information on adjusting the instrument and, of course, on how to use it!

Design by G. Brunner

The RF signal generator is a quite complex instrument, and we should really advise beginners not to attempt to build this project without the help or guidance of someone with considerable experience in building RF and microcontroller circuits.

There are no fewer than four boards to build up, and each of these boards contains a fair number of components. Add to that the mounting of the four boards in a case and the inter-board

COMPONENTS LIST

POWER SUPPLY BOARD

Resistors:
R1 =22Ω 5W
R2 =270Ω
R3 =820Ω
R4 =1kΩ
R5 =10kΩ

Capacitors:
C1-C4 =47nF
C5 =1000μF 35V radial
C6,C8 =220nF MKT
C7,C9 =2μF2 16V radial
C10 = 470μF 63V radial
C11 = 220μF 63V radial
C12 = 1μF 63V radial
C13 = 10μF 63V radial

Semiconductors:
D1-D6 = 1N4001
D7 = 33V 400mW zener diode
D8 = LED, red, high efficiency
T1 = BC141
IC1 = 7812
IC2 = LM317T

Miscellaneous:
TR1 = mains transformer, 15V 8VA, Monacor/Monarch type VTR8115
K1 = PCB terminal block, 2-way, raster 7.5mm
K2 = mains socket, integral switch and fuseholder, with fuse 63mAT
Heatsink type SK59 37.5mm (Fischer, Dau Components)
PCB, order code 980053-4 (see Readers Services page)

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Figure 7. Finished PSU board (prototype).

wiring, and you are looking at a project which should take even advanced hobbyists several hours, winter evenings or rainy Sunday afternoons to complete.

The four boards are built up one by one in the order indicated by the text to follow. As usual, great care should be taken to fit each and every part in the right position on the board. The component overlays and associated parts list should guide you through the process of assembling the boards. Particularly with the 1% resistors in the attenuator section, you should (1) ascertain the value and (2) look up the position on the board, before (3) fitting *any* resistor.

POWER SUPPLY BOARD

This board is the simplest to build. Populating it should be straightforward, using the relevant Components List and the component overlay shown in **Figure 6**. Resistor R1 may run fairly hot and should not touch the circuit board. The LM317T voltage regulator may be mounted directly on to the heatsink — an insulating washer is not required. The 'power on' LED is not fitted directly on the board — instead, it is connected up via a pair of thin wires with an length of about 20 cm.

This board is simple to test by provisionally connecting it to the mains and using a voltmeter to check the indicated output voltages: +5 V, +30 V and +12V. The finished PSU board is shown in **Figure 7**. Check your work against this photograph!

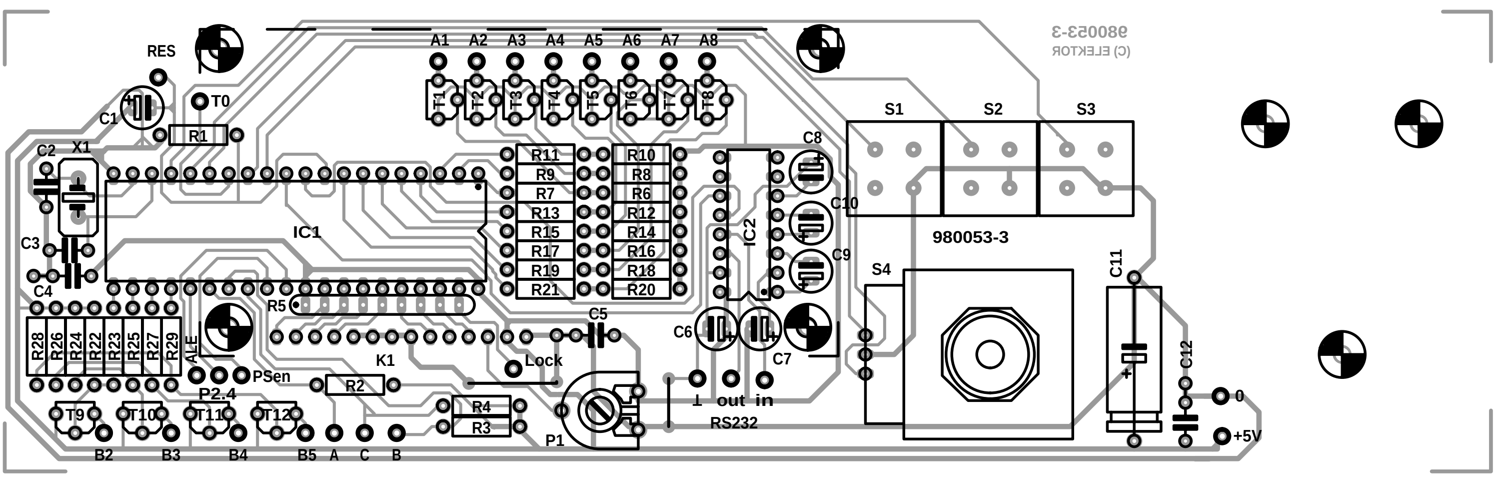
CONTROLLER BOARD

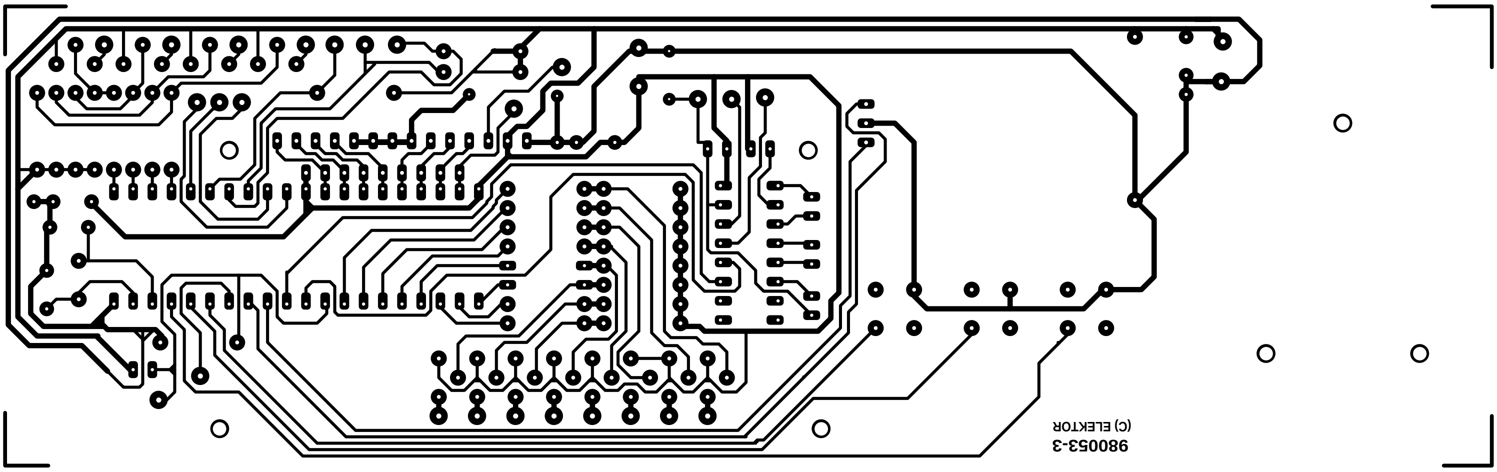
The controller board shown in **Figure 8** is far more densely populated than the PSU board. Hence, great care and precision is required when it comes to soldering the parts in place.

Start with the two wire links on the board — you'll find them near preset P1. Next, fit the components, the best order is probably from low-profile parts (resistors, IC sockets) to upright mounted parts (crystal, transistors, radial electrolytic capacitors).

The three push-buttons, S1, S2 and S3, are not mounted directly on to the board. Their pins are inserted in socket strips or stacked IC sockets so that their height can be adjusted a little. Alternatively, their pins are 'lengthened' using pieces of stiff wire. This is necessary to enable the cap tops to protrude a little through the front panel. The same mounting method is used for LCD. As with the push-buttons, the height of the LCD

Figure 8. Controller board artwork.





COMPONENTS LIST

CONTROLLER BOARD

Resistors:
R1 = 22kΩ
R2,R3,R4 = 4kΩ7
R5 = 10kΩ 8-way SIL array
R6,R8,R10,R12,R14,R16,R18,R20,R22,R24,R26,R28 = 1kΩ
R7,R9,R11,R13,R15,R17,R19,R21,R23,R25,R27,R29 = 3kΩ3
P1 =10kΩ preset, H

Capacitors:
C1 =1µF 16V radial
C2,C3 =33pF
C4,C5,C12 =100nF ceramic
C6-C10 =10µF 63V radial
C11 = 220µF 16V

Semiconductors:
T1-T12 = BC557B
IC1 =AT89C51-20PC or SC87C51CCN40 (order code 986515-1)
IC2 = MAX232

Miscellaneous:
X1 = 11.059MHz crystal
S1,S2,S3 = pushbutton, 1 make contact, ITT type D6-R-RD; cap type D6Q-RD-CAP (Eurodis)
K1 =14 way SIL pinheader
K2 =9-way sub-D socket (female)
S4 = rotary encoder, Bourns type ECW1J-B24-AC0024 (Eurodis)
LCD, 2x16 characters, Sharp type LM 16A211 (Eurodis)
PCB, order code 980053-3 (see Readers Services page)

above the controller board may need to be adjusted later, so do not mount it securely as yet. The rotary switch encoder, S4, is mounted directly on to the board, but its spindle is not yet cut off. Later, rectangular clearances are cut in the front panel to allow the LCD to be viewed, and the push-buttons to be pressed.

It is recommended to use sockets for IC1 and IC2. All holes in the PCB with a label printed near it (like A1, T0, Psen, Lock, etc.) are for inter-board wires. Solder pins are not strictly necessary — direct wire connections to the board are also fine. As with the PSU board, check your work against our fully working prototype. This time, refer to the photograph in **Figure 9**. The board is fitted vertically behind the metal front plate (which has to be purchased separately). It is held in position by a pair of slots moulded on the bottom plate of the case. Several slots are available, and the pair you actually choose to use should ensure that the metal frame around the face of the LCD is pressed firmly against the inside of the front panel. The three type 'D6' push-buttons should then protrude a little from the front panel.

The holes marked 'In', 'Out' and 'ground' to the right of preset P1 are for an *optional* 3-wire RS232 link to a PC. If you do not require PC control, the MAX232 may be omitted. The practical use of the RS232 interface will be reverted to further on.

VFO/PLL BOARD

As you can see from the PCB artwork in **Figure 10**, this is the board with the highest component density of all four. Care and precision are essential if you want to avoid a tedious faultfinding session. Identify and check each part before fitting it, and double-check its value and position using the Components List and the component overlay.

As usual, start with the wire links (there are three), so they are not forgotten or overlooked. Then follow the low-profile parts and, finally, the vertically mounted parts. IC sockets should *not* be used for the NE592 and the SAA1057 on this board.

The value of the inductors is usually printed on these parts in the form of colour bands (like resistors) or dots.

The PLL/VFO board is fitted in a tinplate enclosure from Teko. After the solder work, inspect the board, and compare yours with our prototype shown in **Figure 11**.

Figure 9. Finished controller board (prototype).

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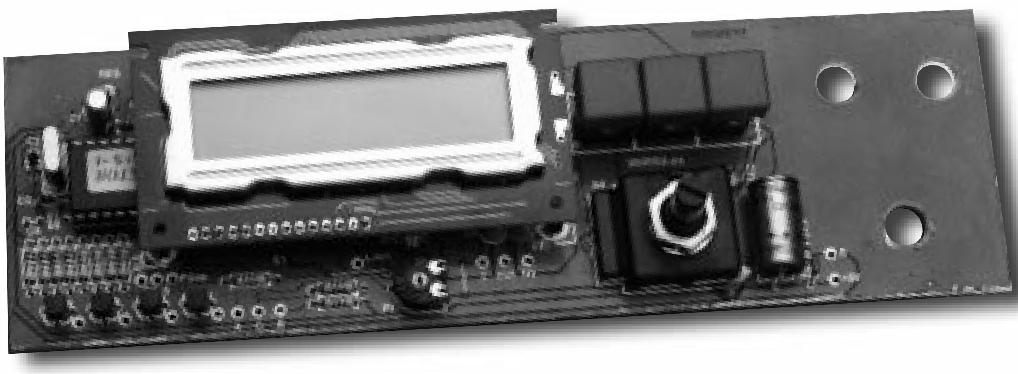

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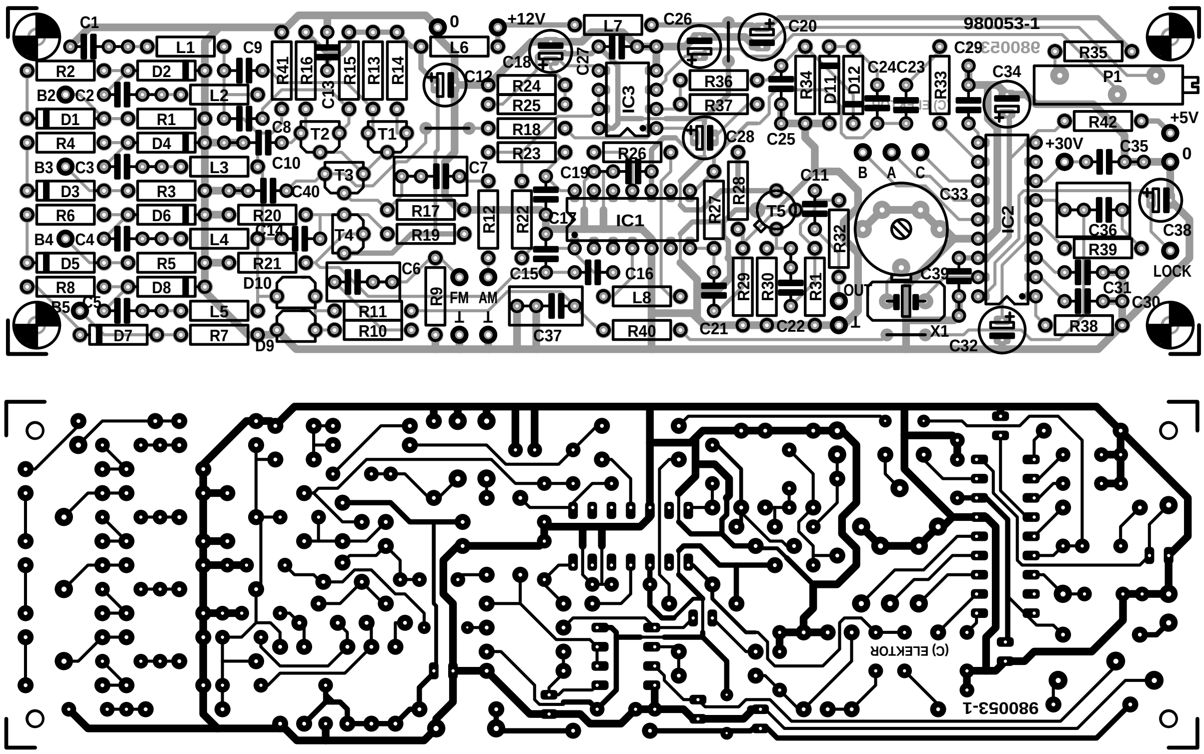


Figure 10. VFO/PLL PCB design.

ATTENUATOR BOARD

The main point to mind about assembling the attenuator board (**Figure 12**) is that each close-tolerance (1%) resistor goes to the right position on the board. One error in this respect may cause wrong attenuation levels later, with possibly difficult to explain behaviour of some of the radio equipment you may be aligning! Our advice is, therefore: read the Components List carefully, check the colour code, use a DMM to measure the value of each resistor, and then check its position on the board.

The attenuator board has relatively large copper areas to assist in screening and preventing unwanted signals from being generated and picked up by the circuit. The attenuator board is shown in **Figure 11**, together with the VFO/PLL board. For RF screening purposes, both boards are fitted in Teko tinplate cases.

ADJUSTMENT

The boards may be wired up experimentally for an initial test and a few adjustments.

To begin with, set the two presets and the trimmer to the centre of their travel. It is assumed that the power supply board has been tested already (with good results, of course).

After applying power, the first thing to do is set the LCD contrast with preset P1. Next, use an oscilloscope to check that the VFO/PLL board supplies an RF signal to the attenuator board.

The output frequency supplied by the generator may be checked with a calibrated frequency meter, a frequency standard (off-air Rugby MSF or similar) or a calibrated SW receiver (zero-beat). The relevant adjustment is trimmer capacitor C33.

COMPONENTS LIST

VFO/PLL BOARD

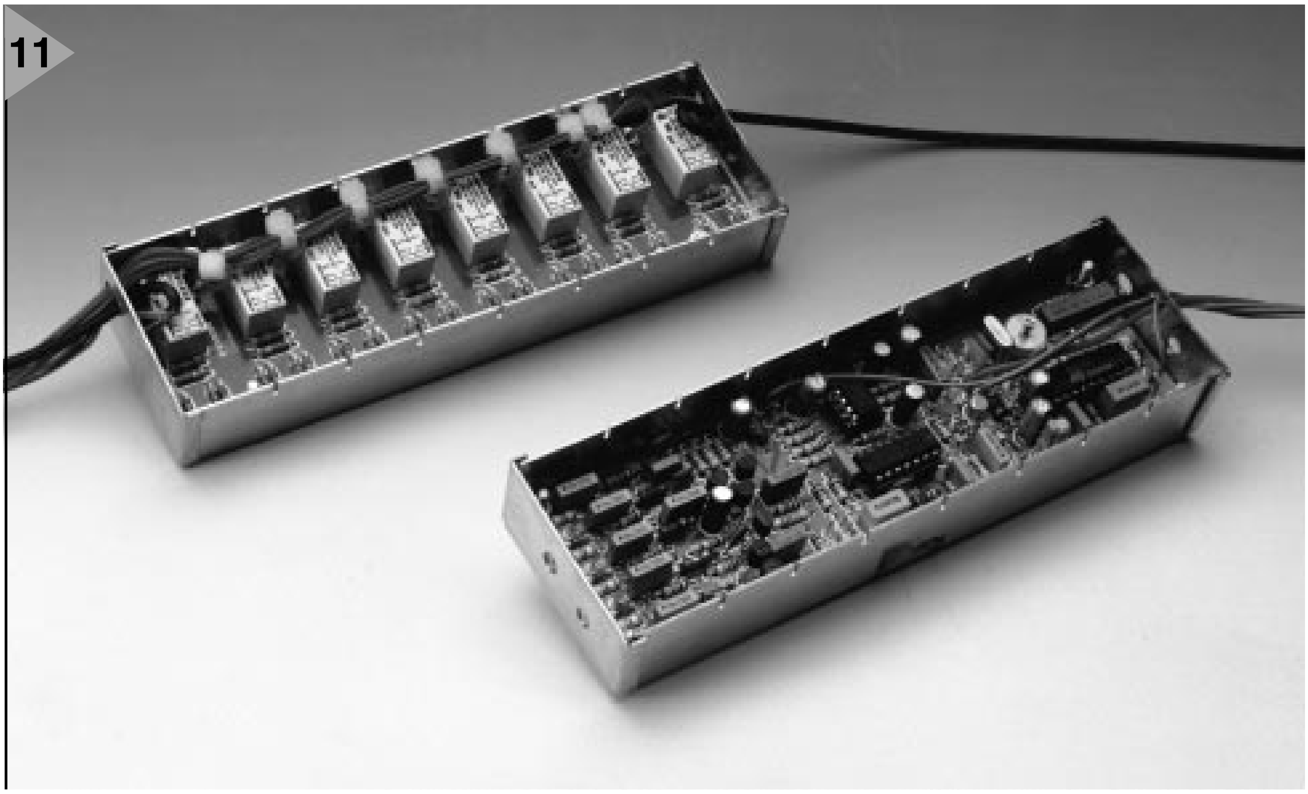
Resistors:
R1,R3,R5,R7,R12,R22,R23,R31,R34,R36 ,R37 = 10kΩ
R2,R4,R6,R8 = 390Ω
R9,R14,R15,R21,R27,R33,R40 = 1kΩ
R10,R41 = 330kΩ
R11,R13,R16,R18 = 100kΩ
R17,R26 = 100Ω
R19 = 2MΩ2
R20 = 1MΩ
R24,R25,R35 = 22kΩ
R28,R29 = 3kΩ3
R30 = 560Ω
R32 = 47Ω
R38 = 180Ω
R39 = 18kΩ
R42 = 10Ω
P1 = 2kΩ multiturn preset, H

Capacitors:
C1-C5,C10,C22 = 33nF ceramic
C6,C25,C30 = 2nF2 ceramic
C7 = 220nF MKT
C8,C9,C16,C23,C24 = 330pF ceramic
C11 = 68pF ceramic
C12,C18,C38 = 10µF 63V radial
C13 =100nF ceramic 5mm
C19,C27,C35,C39,C40 =100nF ceramic
C14 = 180 p ceramic
C15 = 27 p ceramic
C17 = 33n ceramic 5mm
C20,C32 = 47µF 16V radial
C21 = 4n7 ceramic
C26,C28 = 2µF2 16V radial
C29,C31 = 10nF ceramic
C33 = 40pF trimmer
C34 = 100µF 10V radial
C36 = 1µF MKT
C37 = 330nF MKT

Inductors:
L1 = 330µH
L2 = 100µH
L3 = 22µH
L4 = 3µH9
L5 = 0µH56
L6,L7 = 39µH
L8 = 3µH3

Semiconductors:
D1,D3,D5,D7 = 1N4148
D2,D4,D6,D8 = BA243
D9,D10 = BB130
D11,D12 = AA113
T1,T2,T3 = BF494
T4 = BF256B
T5 = 2N5179
IC1 =NE592N (N14)
IC2 = SAA1057 (Philips)
IC3 = LM358P

Miscellaneous:
X1 = 4MHz
Tinplate case, Teko, size 160x25x49mm
Case, Bopla type Ultramas UM52011 (size 224x72x199mm)
Front panel type FP50011 or FPK50011
PCB, order code 980053-1 (see Readers Services page)



Adjustment of the RF signal level is only possible if you have an accurate and calibrated RF voltmeter. With the attenuation set to 0 dB, preset P1 may be adjusted for an output level of 630 mV_{pp} into 50 Ω at the generator output. Failing the necessary test equipment, you may leave the multi-turn preset at mid-travel.

Figure 11. Finished PLL/VFO board (below) and attenuator board (above), both fitted in 'Teko' ready-made tinplate cases.

WIRING AND MECHANICAL WORK

Although there are quite a few wire connections between the boards, there are no special precautions in this respect. The RF signal connection between the PLL/VFO board and the attenuator board must, of course, be made in coax cable. The same goes for the connections between the AM and FM inputs on the PLL/VFO board and the associated BNC sockets on the front panel. If you can get hold of it, use the 3-mm dia. type RG174/U, else, the much thicker RG50/U or /CU is a good alternative.

All other inter-board connections are made in light-duty flexible wire or flatcable, although slightly thicker wire should be used for the 0-V, 5-V and 12-

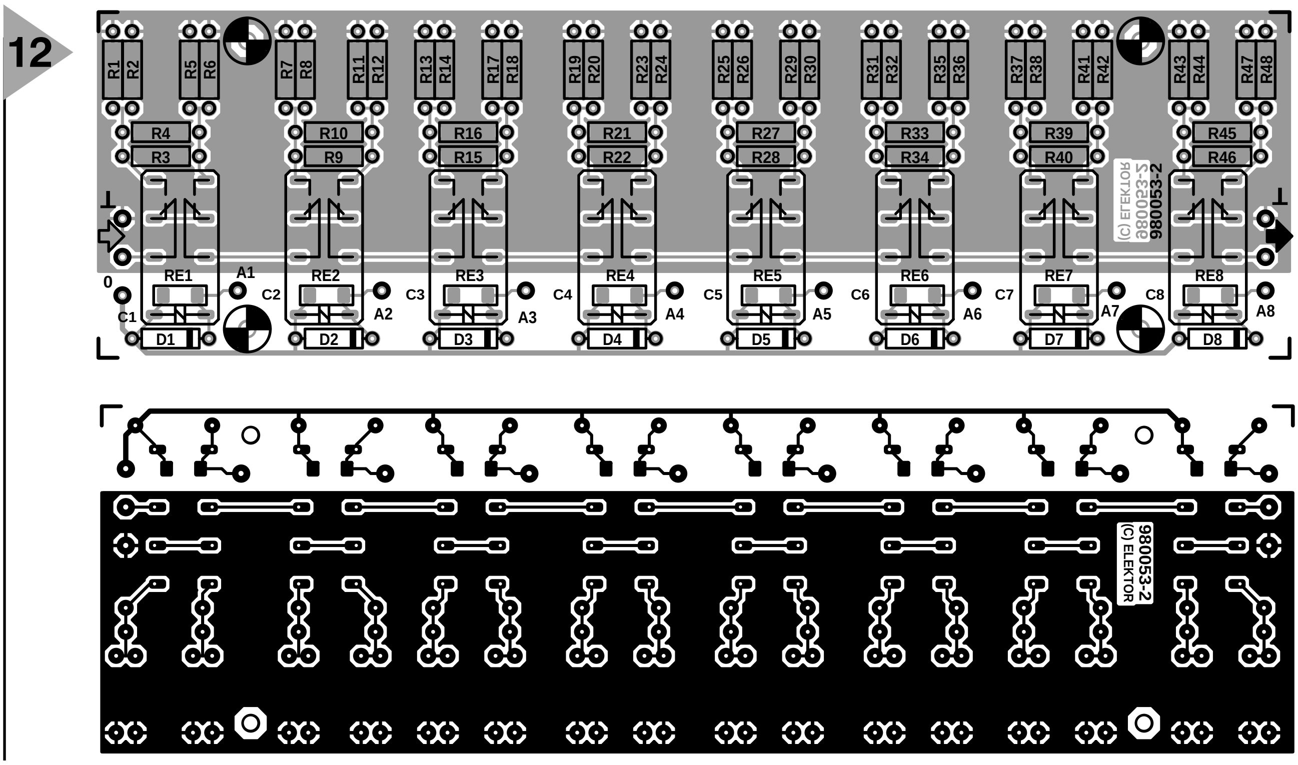


Figure 12. Attenuator PCB artwork.

COMPONENTS LIST

ATTENUATOR BOARD

Resistors (all 1%):
R1,R5,R21 = 909Ω
R2,R6 = 20kΩ
R3 = 6Ω81
R4 =39Ω2
R7,R11 = 475Ω
R8,R12 = 6kΩ19
R9 = 368Ω
R10 = 12Ω1
R13,R17 = 243Ω
R14,R18 = 2kΩ74
R15,R20,R24 = 3kΩ65
R16 = 24Ω3
R19,R23 = 121Ω
R22 = 56Ω2
R25,R29,R31,R35,R37,R41,R43,R47 = 75Ω
R26,R30,R32,R36,R38,R42,R44,R48 = 825Ω
R27,R33,R39,R45 = 3kΩ92
R28,R34,R40,R46 = 162Ω

Capacitors:
C1-C8 = 100nF SMD

Semiconductors:
D1-D8 = 1N4148

Miscellaneous:
RE1-RE8 = relay, 2 x change-over, type V23042-A1001-B101 or V23042-A2001-B101 Siemens (Eurodis, ElectroValue)
PCB, order code 980053-2 (see Read-

V supply wiring. Do not make any of the wires longer than necessary to prevent digital noise being picked up from the controller board.

The wires and the coax cables to and from the PLL/VFO board and the attenuator board should pass through holes drilled in the short side panels of the Teko tinplate cases. Once these boards are fully operational, the top covers are fitted for optimum RF screening.

Guidance for mounting the four boards into the Bopla enclosure may be obtained from the photographs in this article, and in particular, **Figure 13**. Note that the solder side of the power supply board is protected by a perspex cover plate cut to roughly the same size as the board. The VFO/PLL and attenuator boards are screened by tinplate boxes, and mounted horizontally on to the bottom plate of the enclosure. As already mentioned, the PSU board is fitted vertically, using a pair of the moulded PCB slots towards the back panel. The three holes at the 'empty' right-hand side of the controller board are drilled to a diameter of about 8 mm to allow the coax cables to the three front-panel mounted BNC sockets to pass.

The mains voltage is switched on and off by a double-pole switch integrated into a mains socket fitted onto the plastic rear panel of the enclosure. The wires between the mains socket/switch combination and the PCB terminal block on the PSU board should be mains-rated and properly isolated. At the PCB side in particular, the 'live' and 'neutral' wires should not be stripped longer than strictly necessary, and they should be inserted into the clamps right up to the insulation. Finally, once the wires are connected, the terminals on the mains socket/switch combination must be insulated using heat-shrink sleeving.

The metal front panel is cut, drilled and lettered using the template shown in **Figure 13**. This front panel foil is not available ready-made.

In the (ABS plastic) back panel, you have to cut rectangular clearances for the mains socket/switch combination and, optionally, for the RS232 connector (a 9-pin sub-D type).

Figure 13. A look inside our prototype of the RF Signal Generator. The covers of the tinplate cases of the VFO/PLL board and the attenuator board were removed for this photograph.

13

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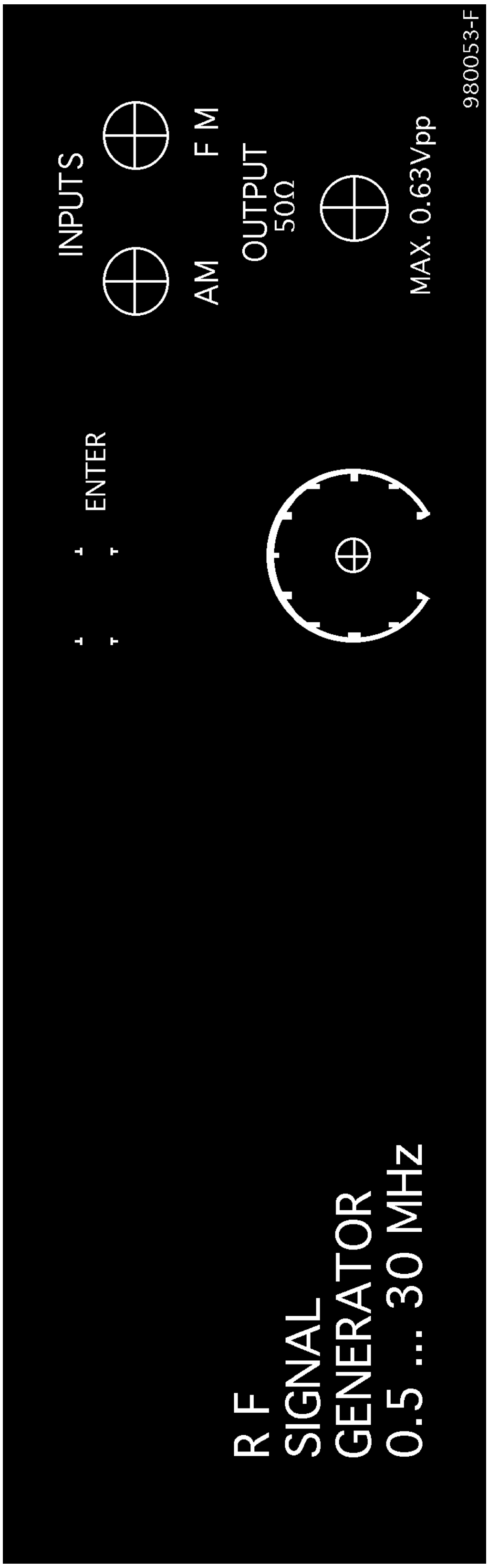

Figure 14. Suggested front-panel layout. Use it as a template to drill the metal front panel of the instrument, and apply the lettering/symbols.

OPERATION

The instrument is controlled by means of three pushbuttons and a rotary encoder, all accessible on the front panel. The instrument communicates with you via an LCD with two lines of 16 characters.

The functions of the 'left' and 'right' pushbuttons are self-evident, we reckon, because they move the cursor on the LC display in the direction indicated by the arrows on the front panel

From the starting position (cursor on 'MHz'), the cursor may be moved to the left on to any of the post-decimal positions of the frequency. The number at which the cursor arrives may then be changed by turning the rotary encoder. The frequency set in this way is however not actually generated until you press the 'Enter' pushbutton (asynchronous operation, this is indicated in the upper right-hand corner of the display). After any frequency change, the PLL status is indicated by 'lock' in the left-hand bottom corner of the readout.

From the initial position to the right, the cursor jumps to 'M0' (memory 0). This indicates two memories, M0 and M1, in which frequency and attenuator settings may be stored. You press the Enter key to change between these memories. In this way, you can quickly change between two previously stored settings, which may be useful, for example, for aligning a filter. Alternatively, you may use the same frequency twice, but with two different attenuator settings. This facility is useful for adjusting, say, a receiver AGC (automatic gain control).

Moving further to the right, the cursor jumps on 'asy'. Here you can switch to asynchronous operation by pressing 'Enter'. In synchronous mode, any frequency change requested by way of the rotary encoder is immediately passed on to the VFO/PLL unit. In this mode, the RF output frequency is continuously adjustable, but only within the selected range (one of five). If you turn the encoder to a frequency outside a certain range, the PLL will drop out of lock, and the 'lock' indication will disappear from the LCD. By pressing any key, the PLL is returned to asynchronous mode, and the last selected frequency is automatically restored. If you then move the cursor to a decimal digit of the frequency readout, and press the Enter key, the generator changes to the relevant frequency range, allowing you to change to synchronous mode again and continue 'tuning' again using continuous frequency variation.

One more position to the right, the cursor reaches the 'dB' position, indicating the currently valid attenuation. The desired attenuation may be set with the aid of the rotary encoder. As with the frequency setting, the desired attenuation becomes effective only when you press the Enter key. This is done to reduce wear and tear on the relays.

OPTIONAL RS232 INTERFACE

The RS232 interface on the controller board is an optional extension whose function has not been fully developed out by the author/designer. Basically, it was designed into the circuit to enable the generator frequency and output signal attenuation to be controlled by a PC.

The communication parameters are as follows: 9600 bits/s, 8 data bits, 1 stop bit. The communication works with character strings, and is easily tested with the aid of a terminal program. To set the frequency you have to send an 'F' (for 'frequency'), then five numbers for the frequency in kilohertz, and, finally, a carriage-return (CHR$(13)). An additional Line-Feed (CHR$(10)) will be ignored. If everything is correct (first character is 'F', a total of 6 characters and the frequency in the right range), the controller returns a 'D' (for 'done'), followed by a CR-LF sequence, otherwise, an 'E' (for 'error') and a CR-LF.

The attenuation is set by sending an 'A', two numbers and CR. Again the controller answers as described. The main purpose of the serial interface was to create a basis for using the generator in an environment like LabView™.

(980053-2)