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Another silent key – the revered John D Kraus, W8JK ♦ A small four-arm antenna ♦ Another simple SSB generator ♦ PA0SE's 'sliding doors' transceiver

TT

ANTENNA ICON – JOHN KRAUS, W8JK, SK

Hardly had the September 'TT' item gone to press with the item 'A Sad Harvest' (noting the spate of deaths of a succession of amateurs and others who had contributed to home construction and audio engineering), than the Grim Reaper wielded his sickle once more. This time removing Dr John D Kraus, W8JK, antenna designer, radio astronomer and author of several classic engineering handbooks, aged 94. A legend in his lifetime and an icon to both amateurs and professionals.

At the age of 10, in 1920, he erected his first antenna, soon afterwards joining ARRL and, in 1926, becoming a licensed amateur (8AFJ, later W8JK). In 1933, he gained a PhD degree in Physics at the University of Michigan for a 5m (58MHz) research project (with Henry Muyskens who was also a licensed amateur). This was published in P*roc IRE,* September 1933 as 'Some Characteristics of Ultra-High-Frequency Transmission'. Using a 15W, 58.1MHz transmitter and National HFR receiver (predecessor to the One-Ten) mounted in a Studebaker touring car, they compiled a field strength contour map of Ann Arbor, Michigan. In an era when little commercial use was being made of the VHF spectrum they concluded *inter alia*: "A resonant [verti-

Fig 1
Major contributions to antenna engineering by John D Kraus, W8JK. (a) The first close-spaced flat-top arrays in early 1937. (b) The VHF/UHF corner reflector. (c) The axial-mode helix. (d) Codification of centre-fed multi-wire doublets including the 300ohm half-wave folded dipole (1939/40).

FIG 1a © RADCOM 271

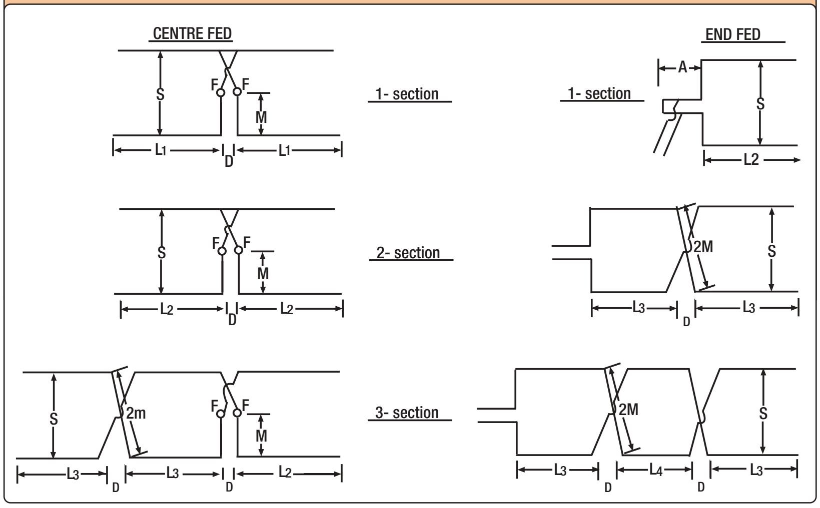


FIG 1b © RADCOM 278

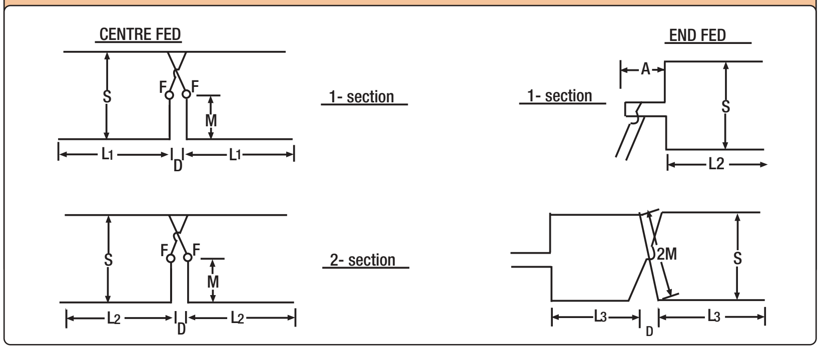


FIG 1c © RADCOM 274

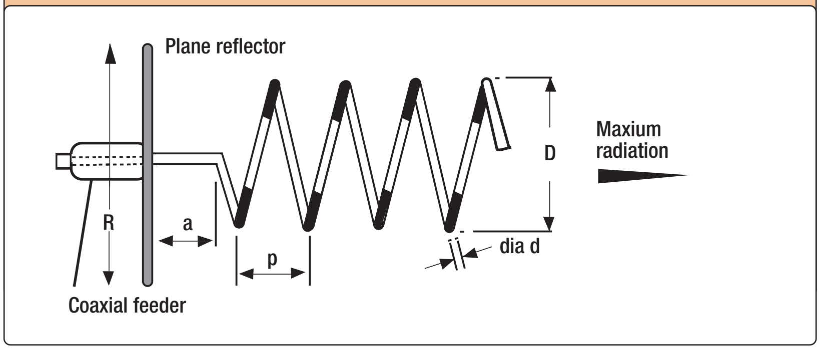
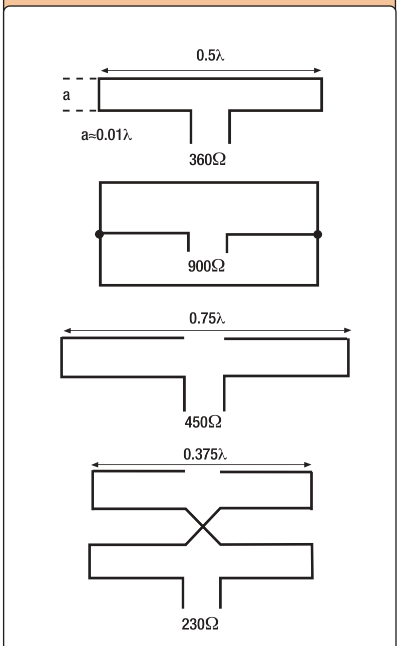


FIG 1d © RADCOM 272



cal] receiving antenna was shown to be of considerable value. Using an antenna of this type, good reception may be obtained for field strengths of about 50µV/m with even the comparatively-simple super-regenerative type of receiver. An area of about 150 square kilometres was covered with minimum field strength of about 50µV/m. *Such low power coverage would be admirably suited for certain types of local services as broadcast, television, police or local point-to-point communications. Likewise, due to the relatively small range under ordinary conditions, similar services in other centres could use the same frequencies without interference to each other*" (italics added).

His great skill was seeing, in the theoretical work of himself anf others, the potential for antennas of great practicality, not only to amateurs, but also to professionals. In 1937 he became the first to see in the classic paper of Dr George Brown (RCA) the tremendous importance of the close-spacing of antenna elements, a story recounted recently in 'TT' (March, 2004). He soon developed a series of effective fixed or rotary 'flat-top' bi-directional (W8JK) beams. His interest in amateur radio continued throughout his long professional life. In June 1982, he contributed an article 'The W8JK Antenna: Recap and Update' to *QST* (noted in 'TT', November 1982) showing how the antenna forms an effective multi-band antenna, with a single-section 14MHz array effective on all the higher HF bands (including the then new WARC bands) and less effectively on 10MHz (**Fig 1(a)**).

John Kraus 'invented' the corner reflector antenna (**Fig 1(b)**), much used in the USA for TV reception, the high-gain axial-mode helix antenna (**Fig 1(c)**), widely used in space communications and radio-astronomy, and was the first to describe in detail the 300ω folded-dipole, the related family of multi-wire doublets (**Fig 1(d)**), and the three-eighth-wave vertical (**Fig 2)**, first in the US amateur magazine *Radio* in May/June1939 (copy kindly provided by G3UUR), and then in *Electronics* (April 1940). A spin-off was the 'T-Match' antenna, described in *QST* (September, 1940) from which was later developed the gamma match.

In *IEEE Antennas & Propagation Magazine* (April 1995), Dr Kraus, at the age of 84 years, was still developing new forms of his axial-mode helical beam antenna. As I noted in 'TT' (August 1995), he showed that the large ground-plane reflector could be replaced by one or more loops with little effect on performance. **Fig 3** shows his experimental 10-turn 1680MHz helix antenna which has a gain of about 15dBi and half-power beamwidth of 34°

He was author of classic handbooks *Antennas* and *Electromagnetics*, both of which ran to more than one edition, as well as an autobiographical book *Big Ear*, named after the large radio astronomy antenna he built as Director of the Ohio State University Radio Observatory. He also wrote a popular book, *Cosmic Universe* (1980).

FIG 2a © RADCOM 276

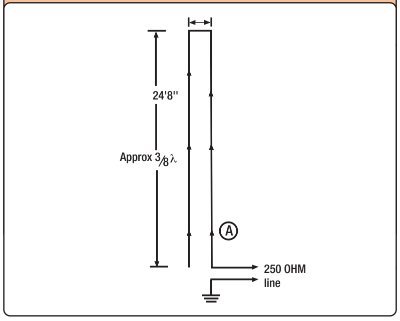


FIG 2b © RADCOM 279

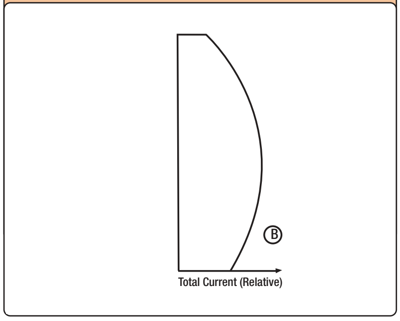


Fig 2
The two-wire 3λ/8 vertical antenna with a resistive feed-point of about 250Ω, as described by W8JK in his articles on multi-wire dipoles (Radio, June 1939 and Electronics, May 1940). Dimensions shown in (a) are for 14MHz with the total current distribution shown in (b). This antenna has been featured several times in 'TT' but appears to be seldom used.

Brian Austin, G0GSF, points out that one book contains a list of the 146 papers Kraus published between 1933 and 1995, including three survey papers on antennas in 1982, 1985 and 1989. G0GSF adds that of his four books with seven editions, he has six, two being signed copies from the author himself! "He was a great man and a giant in the world of applied electromagnetics". To G3UUR also, he was one of his technical heroes. Amateur radio owes him a great debt!

SMALL FOUR-ARM CSL ANTENNA

These days, the professional antenna designers have largely shifted their attention away from HF or even VHF antennas, and mostly have as their objective ever smaller UHF antennas for handheld mobile telephones and related equipment. With a quarter-wavelength at 900MHz only 22mm, there might seem little need to strive to produce electrically-small UHF antennas. Nevertheless, as mobile terminals are shrinking in size, there are increasing demands for antennas whose maximum dimension is only a fraction of a wavelength, despite fundamental limitations in efficiency and bandwidth.

Paul Hallbjörner of Ericsson AB (and postgraduate student at Chalmers University of Technology, Göteborg, Sweden) in 'Electrically Small Unbalanced Four-Arm Wire Antenna' (*IEEE Trans on Antennas & Propagation*, June 2004, pp1424 – 28), presents a novel CSL (capacitance-inductance (Swedish) -loaded) antenna, tunable with a selected capacitance-value over a wide frequency range and with an instantaneous bandwidth of about 3%. A good match to 50Ω coaxial feed without a matching network is ensured by the 50Ω load resistor. The non-inductive resistor has to absorb the residual transmitter power, and this will vary with the radiation efficiency of the antenna, requiring approximately absorption of the full transmitter output at the lower frequency end of its range.

As shown in **Fig 4**, it is an unbalanced antenna, consisting of four wire arms arching over a ground-plane in shapes that may vary from semicircular to rectangular, etc. One of the wire ends is the feed, and the other three are connected to the ground-plane, one via a variable capacitance, one as a direct connection, and the other via a load resistor (the order in which these connections are made is important). The ends of the four wires are connected to the ground-plane roughly as a square, although making it slightly rectangular fine-tunes the input impedance. The crossover point of the arms is electrically connected. The resonance of the antenna is set by the value of the capacitance (fixed or variable). With a variable capacitance, the antenna can be resonated over a range of several octaves, with a 3dB bandwidth of roughly 3% at any given frequency.

The Swedish paper describes a miniature CSL for UHF/VHF applications with a copper ground-plane measuring only 30mm by 30mm with semicircular 0.8mm copper wires reaching 19mm above the ground-plane. All four wires connections to the ground-plane are located about 2 – 3mm from the respective edges, thus forming a square of 25 x 25mm (roughly an inch square). This tunes from 1585MHz with zero capacitance to 310MHz with 6.8pF capacitance (intended for maximum efficiency at 900MHz).

I came across this paper at the IEE Library and was struck by the possible application of scaled-up models at HF as an alternative to the tunable transmitting loop for mobile operation etc. I wrote to Dr Brian Austin, G0GSF, who in the past investigated and developed a vehicle NVIS loop (see 'TT', August 1995 etc).

He writes: "This CSL antenna is certainly a novel idea and lends

FIG 3 © RADCOM 273

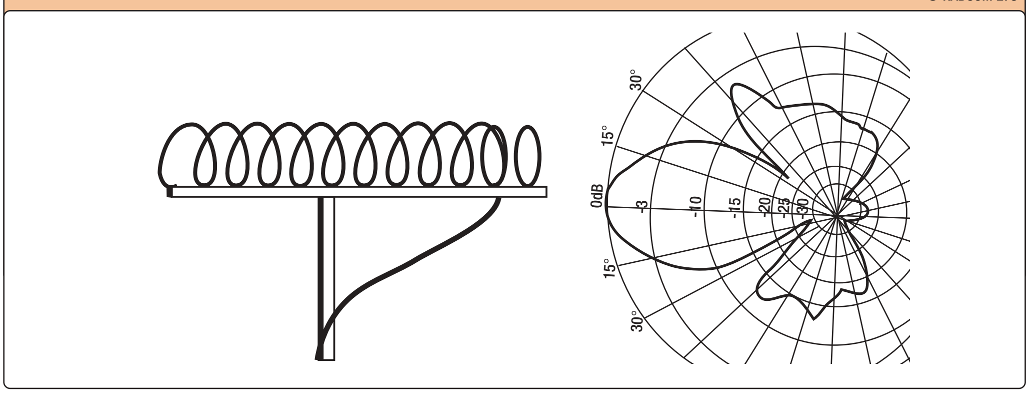


Fig 3
In his eighties, W8JK continued to develop new antennas until the mid-90s. This new form of his helical-beam antenna appeared in 'TT' December 1995, in which the ground-plane reflector is replaced by one or more loops. It has less wind-resistance, is well suited to pole mounting, and of less obtrusive appearance, but this 10-turn 1.7GHz version provided a gain of some 15dBi.

FIG 4a © RADCOM 267

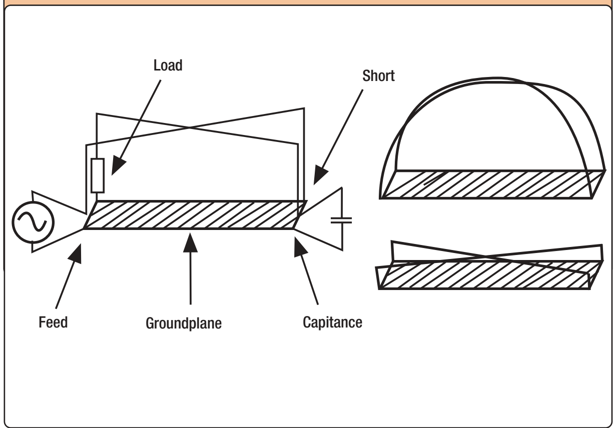


FIG 4b © RADCOM 268

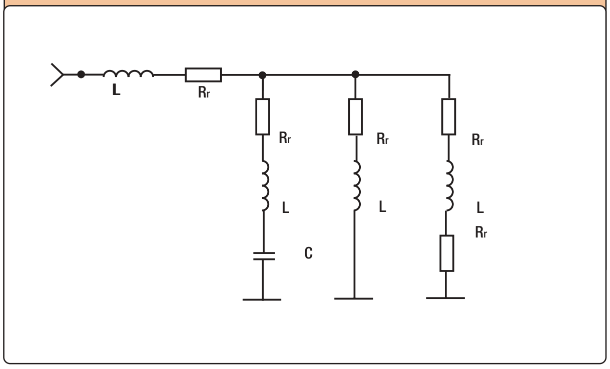


Fig 4
(a) The new Swedish CSL electrically-small unbalanced four-wire antenna developed for mobile telephones. On the left, its four-wire connections: feed, capacitance, short and load (in that order). On the right, alternative shapes. The wires are electrically connected where they cross in the middle. (b) Equivalent circuit for the CSL antenna.

itself well to modelling with *NEC*. To simplify the process, I used a rectangular configuration rather than his semi-circular one with a height of 19mm to compare my results with those given in the paper. As one would expect, the 50Ω resistor determines the input impedance at discrete frequencies and obviously consumes power, so the radiation efficiency is further impaired as a consequence. However, the idea is clever and the antenna certainly deserves a place alongside those other resistively-loaded configurations where gain is traded for bandwidth.

"The best match occurs at the parallel resonance formed by the lumped capacitor, transferred to the feed-point, and the distributed inductances of the wires, especially the short-circuited one – a stub. Allowing for the slight difference in geometry between my model and his, the agreement between them was good.

"I then scaled my antenna down to HF by keeping the reactance of the capacitor the same as his and merely changing the side lengths in proportion (from mm to m): see **Fig 5.** As scaled with 25mm copper tubing, the antenna would be too large to be mounted on a conventional motor car but would not look too out of place on a ship! I was particularly interested in its NVIS properties. With a 1000pF variable capacitor, it will tune between about 1.5MHz and 9MHz – certainly useful for NVIS. The VSWR (50Ω) is very good (as the resistor ensures), being better than 1.5:1 everywhere except at the very top of the band when the capacitance is made up only of strays. Now to the important bit – the gain towards the zenith varies between -3dBi at 9MHz and -23dBi at 1.8MHz. Naturally, the radiation efficiency is very low (<1%) at the lowest frequency, but approaches 60-70% at the top end of the tuning range and, of course, no additional impedance matching network is required. These figures assume an ideal, perfectly conducting ground plane beneath the loop. In practice, this won't be realised, and so there will be a consequential decrease in gain due to increased ground losses. On board a ship at sea, things should be much better.

"The scaled-up dimensions I used produce an antenna that is not really electrically small above about 5MHz, since the loop perimeter (including that part within the ground plane) is of the order of λ/3 at 5MHz. Above that frequency, the current distribution is no longer uniform and the so-called dipole-mode begins to dominate the small loop mode (terms that have received airing in 'TT' over many months!). The onset of this is immediately evident as a flattering of the lobe in the zenithal direction with maximum radiation now beginning to appear broadside to the loop instead of in the plane of the loop. However, the effect is not too severe and this antenna would still be a useful radiator for NVIS service at the top of the band. I have not tried changing the dimensions to produce a 'car top' version but, no doubt, this could be done."

ANOTHER SIMPLE SSB GENERATOR

Paul Fellingham, G7FJC, writes: "The simple SSB generator by P M Prabhu ('TT', August, 2004, p44, Fig 2 from *Electronics World*) struck a chord, as I have recently developed a very similar design as one section of a transceiver (incomplete as yet) for the lower HF bands: **Fig 6.** There is nothing new or specialised about it; it is just a cheap, simple SSB generator that is easy to build and set up.

"The generator is built around a filter using readily-available 4.433MHz colour TV crystals. Three of these filters have been built and tested using different makes of crystal. All three had similar responses, provided that all the crystals were closely matched in frequency. This ladder filter has an excellent response on the high-frequency side, but the roll-off and ultimate attenuation (~42dB) are rather poor on the low-frequency side. The poor low-frequency response, corresponding to the high-frequency end of the audio input signal, can be improved by the use of audio filtering prior to the modulator. These ladder filters are unsuitable for generating upper-sideband signals.

"The LSB generator includes a microphone amplifier based around a TL071 op-amp with HF roll-off provided by the 680pF capacitor. This is followed by a low-pass filter, using two transistors, that removes the high frequencies insufficiently attenuated by the crystal filter. A single-transistor high-pass filter removes low audio frequencies.

"As in the Prabhu design, an NE602 is used as oscillator and balanced modulator, with the double-sideband signal fed directly to the home-brew crystal filter that removes the upper sideband. A 4dB attenuator helps to terminate the filter and also reduces the signal level to that needed by an NE602 transmit mixer (not shown) To terminate the crystal filter properly, the following circuit requires a 1.5kΩ input impedance. This remains true if the attenuator is omitted."

PA0SE's now-completed and operational home-built HF transceiver featuring 'sliding doors' variable selectivity with constant shape factor, Cohn RF filters and a National PW (HRO-type) tuning dial.

PA0SE's 'SLIDING DOORS' TRANSCEIVER

'TT' June 2002, pp 61-2 reported that Dick Rollema, PA0SE, was in course of constructing a new HF transceiver incorporating a 'sliding doors' variable-selectivity IF filter. This filter is a modified form of the multi-mixer system originally developed by Rohde & Schwarz for their EK-07-80 receiver and described in 'TT' December, 1969. R/S used two high-slope 10kHz low-pass filters and was shown in Fig 2 of the June 2002 'TT' and also in several editions of *Amateur Radio Techniques*. The PA0SE filter, unlike the R/S original (Fig 2, June 2002), can be adjusted to provide an LSB, USB or symmetrical response, each of continuously-variable bandwidth, without degrading the shape factor even at the narrow CW settings. He was also incorporating a National PW (HRO) dial recovered from a German wartime receiver and Cohn filters as described in 'TT' April, 1997 (*TTS 1995-1999*, pp147/48).

In June this year, he writes: "My new home-made transceiver has been in use for several months now, and I am entirely satisfied with it. The 'sliding doors' are very convenient and at least as useful as the combination of selectable bandwidth plus pass-band tuning incorporated in my former valve receiver. I have not measured its large-signal behaviour but it must be very good, as judged from an operational point of view. During evening hours on 7MHz there is no trace of intermod, not even with the 12dB RF pre-amplifier switched on as a test only, since the amplifier is intended only for possible use on 24 and 28MHz. The attractive appearance of this unique transceiver is shown in the photograph.

HERE & THERE

In respect of low-voltage valves ('TT' January & August, 2004) Richard Hawkins, G7RVI, draws attention to the Collins high-performance communications vehicle receiver, type R-392 widely used by the US Army in the 1950s and 1960s.This ran directly from 28V DC vehicle batteries with no form of DC conversion to provide HT. He points out that it was a simplified, compact, ruggedised version of the famous R-390 designed by Collins about 1950. It provided 31 1MHz-wide bands, with dual-conversion above 8MHz and triple-conversion below that, with a 1st IF of 9 – 18MHz, tunable 2nd IF of 3 – 2MHz and 3rd IF of 455kHz, and used the classic Collins permeability tuning, giving a linear tuning dial. Despite the low 'HT' rail of 28V, it used typical US types such as the 26A6, 6AJ5 and 12AU7. Full details can be found at www.roveroresearch.com/r392/r392.html

In respect of the True antenna matcher (July 2004), John Pegler, G3ENI, notes that there was an article in *CQ* (January 1962) by David T Geiser, WA2ANU, about a phase detector using the same principles. He acknowledged Hay's article.

Michael O'Beirne, G8MOB, draws attention to an item in the 'Home Forum' feature of *The Times*, July 7, 2004, which provides an answer to the question: "How can I remove white deposits caused by batteries leaking in my camera flash after being left in too long? The answer given would be widely applicable: 'To remove battery deposits, sprinkle baking soda on the affected areas. Using a cotton bud dipped in vinegar, carefully swab out the baking soda and the deposits underneath. Take care not to damage the battery terminals." ♦

FIG 5 © RADCOM 269

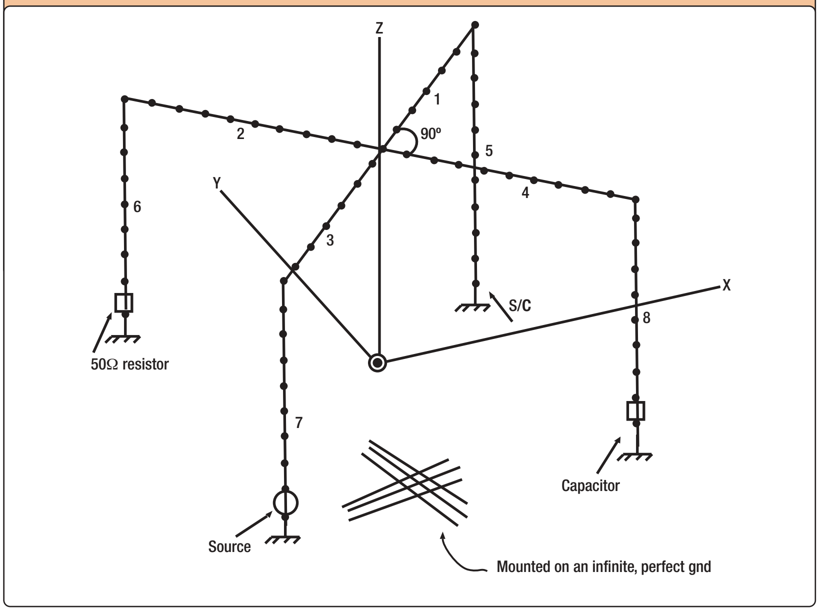


Fig 5
G0GSF scaled-up the CSL antenna EZNEC simulation for HF coverage by using metres rather than millimetres and 25mm copper tubing in place of the wires. Dimensions: 1, 2, 3, 4 each 3.15m. 5, 6, 7, 8 2.8m. The capacitor is variable, thereby allowing continuous tuning across the band. The Xc values in the original paper translate to 39pF required at 6.5MHz rising to 909pF at 1.75MHz. In practice, the size could be reduced if 1.8MHz coverage was not required and the antenna was mounted on a car etc.

FIG 6 © RADCOM 270

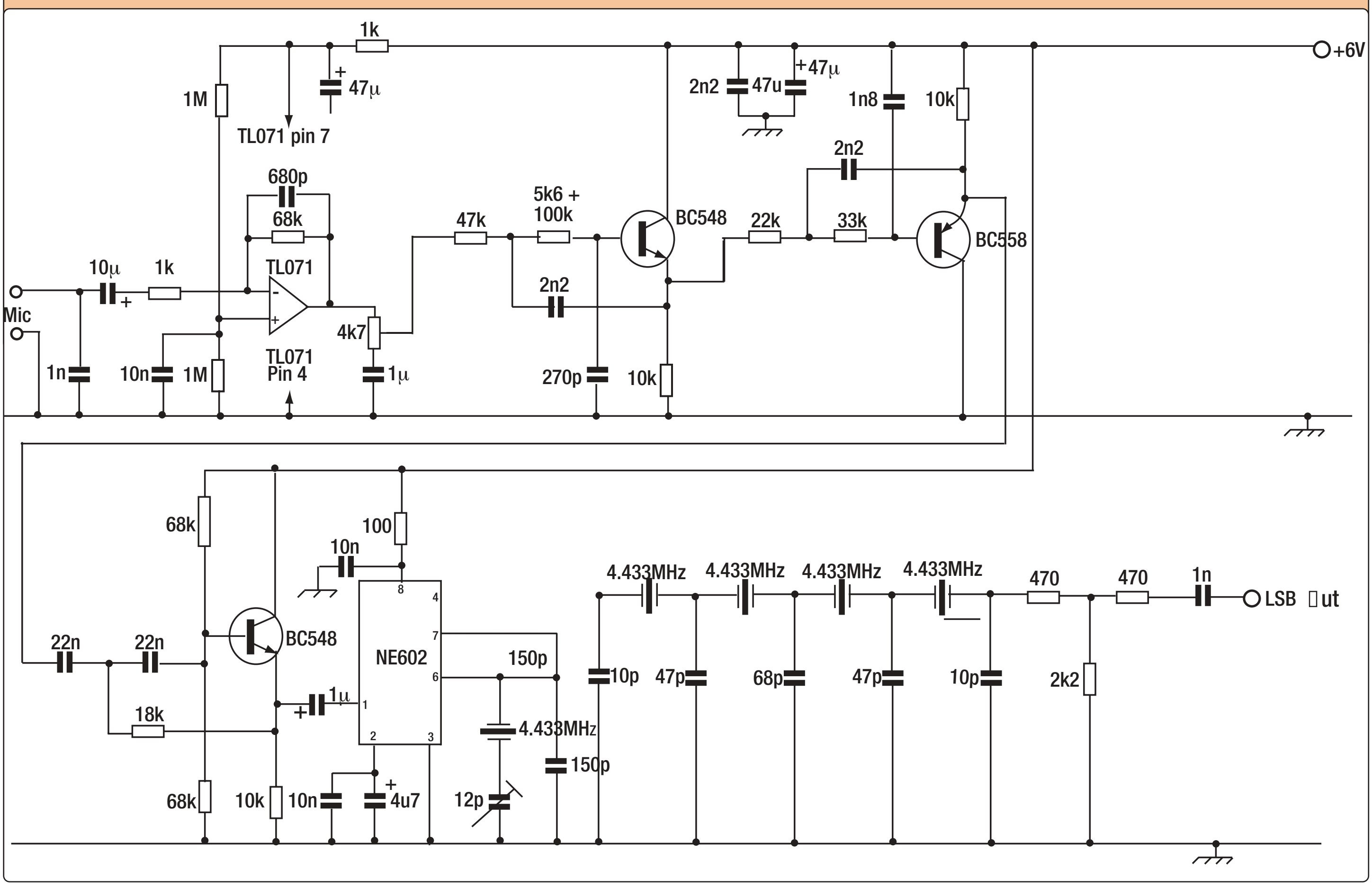


Fig 6
Simple 4.43MHz SSB generator including audio- as well as crystal-ladder filtering developed by G7FJC.