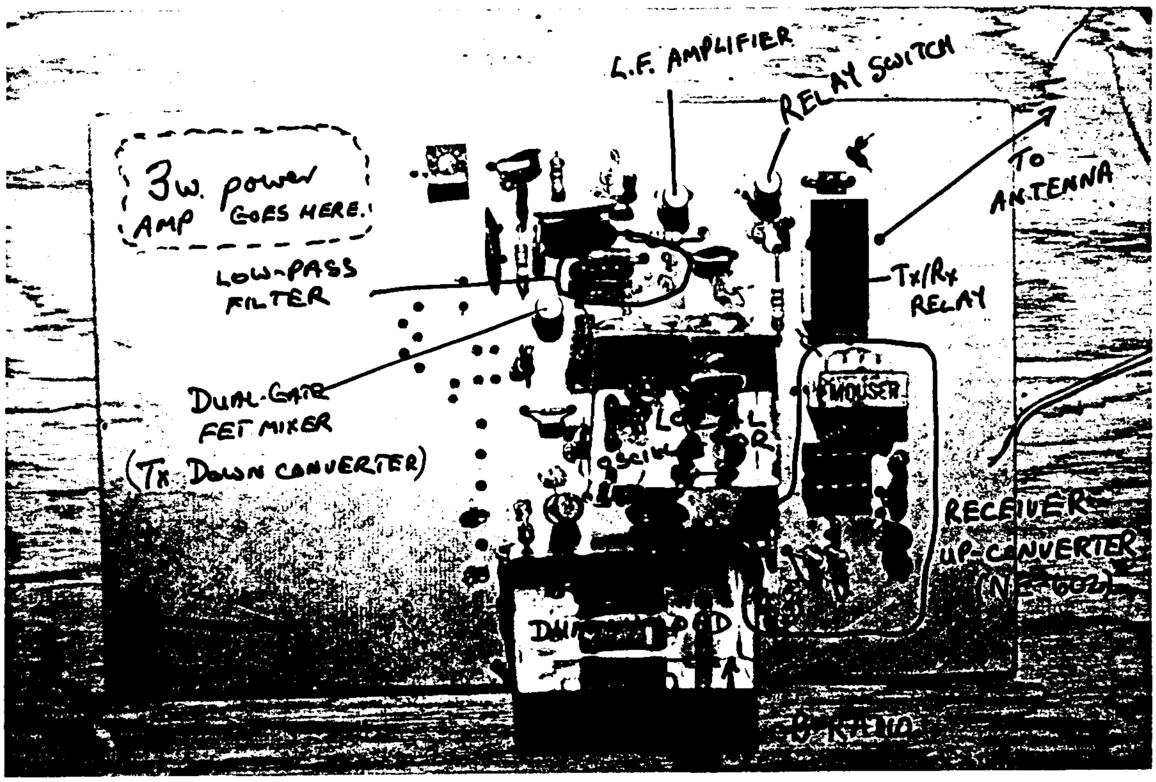
speleonics 19

volume V number 3

MAY 1993



Low-frequency transverter for SSB CB radio makes high-performance cave radio which is easy to build. See article by Ian Drummond.

* * *

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SPELEONICS 19

Volume V, Number 3 May, 1993

SPELEONICS is published quarterly (sometimes irregularly) by the Communication and Electronics Section of the National Speleological Society (NSS). Primary interests include cave radio, underground communication and instrumentation, cave-rescue communications, cave lighting, and cave-related applications of amateur radio. NSS membership is not required for newsletter subscription. Section membership, which includes four issues of SPELEONICS, is $6.00 in USA/Canada/Mexico, $8 overseas. Send subscriptions to section treasurer Joe Giddens at the address below (make checks payable to SPELEONICS.) If you have a ham-radio callsign or NSS membership number, please include them when subscribing.

Foreign subscriptions can be paid in U.S. "paper" dollars in the mail; an international money-order may cost as much as the subscription itself. Many members have sent cash without problems. (No foreign currency, please.)

Editorship rotates among the officers. Volunteers are encouraged to guest-edit or produce an issue. A technical session, followed by election of officers, is held annually during the NSS Convention.

Complimentary copies of SPELEONICS go to NSS offices and sections, the U.S. Bureau of Mines, U.S. Geological Survey, and the Longwave Club of America.

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EDITORIAL

Our frequency of publication has decreased rather drastically for the last few issues. I must take the blame. Although the editorship of SPELEONICS rotates, I usually do the work of assembling each issue and delivering it to the printer. Lifestyles, workloads and priorities change, and our publication has fallen victim to the disease all too common among caving newsletters and other publications produced by volunteer labor. We will discuss the matter at the NSS convention.

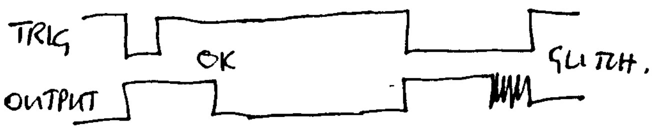
-- **Frank Reid**

LETTERS

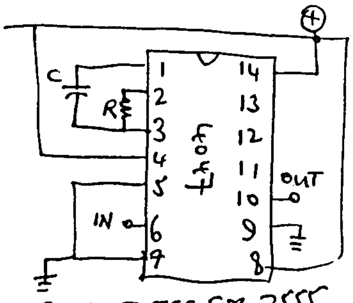
Dear Ian,

I am interested in counting cavers. At the moment we are having a lot of hassle from local residents who are complaining about the number of 'cavers.' We keep log-books in the 3 main (padlocked) caves and we know that annual figures are about 600, 600 and 1000 respectively because log books are kept in the caves. So it isn't us, as this divides down to not very many per average day. There is a fourth cave (un-gated and no logbook) which is used very heavily by scouts and outdoor pursuits courses. I want to know what the usage level is there relative to 'real cavers' in the other 3 caves.

I saw your 'caver counter' circuit in Speleonics 17 and have tried it both on breadboard and a pcb. It works so long as there is no light on the sensor when the CMOS 555-timed period ends, otherwise you get a bad glitch and a false reading then on the counter. Unfortunately, it is mandatory with 555 timers to condition the input such that the trigger pulse is shorter than the timed period:



You can get around this by substituting a 4047 monostable which does not suffer from the problem. Also by doing this you reduce the quiescent supply current from about 80 uA to 1 uA.



R = 1M } typically
C = 2µF }

SUBSTITUTES FOR 7555.

If I have got it wrong somewhere, then perhaps you can let me know, but I feel you must have seen this effect because of the caveats about using a long tube on the sensor, etc. If I am right, then I'll just leave it to you to publish and updated circuit in a future edition.

Yours sincerely,

Stuart France

The Smithy
Tretower
CRICKHOWELL
Powys NP8 1RD
Great Britain

--

Dear Stuart,

Thanks for the upgrade on the "Caver Counter." I was, as you suspected, aware that exposure to a continuous light caused not continuous counting, but collapse of the binary information. I was not aware of the cause of this, and I appreciate your suggestion for fixing it. I have sent the letter on to Frank Reid for his editorial attention. (It's nice to have several editors for Speleonics, not only gives you a rest, but allows some "arm's length dealing" with your own articles!)

The original counter was patched together one week-end as a result of comments in the bar by a Calgary caver doing a master's degree on recreational use of caves in the Rockies (I think!). He tested it fairly extensively in his basement and it spent a month or two, two weeks at a time, in a local cave where it counted a couple of hundred events, a reasonable number when checked against other estimates of visitors. He had plans to build a number of units and check for consistency between units, but I don't think that happened.

Please let me know if you deploy any modified counters. I would be interested to know the results.

Ian Drummond

Dear Frank:

I read with pleasure Speleonics 18, especially the article by Douglas Strait on High-Brightness LEDs. I'd like to add something based on everyday uses of LEDs that are plug-n-play.

Radio Shack has a relatively high output LED, part # 276-086, costing $4.99, which fits (with minimal work) into a Mini-Mag lite flashlite. All that needs to be done is:

1. Unscrew the knurled front end of the flashlight.
2. Remove the small incandescent lamp.
3. Cut the leads of the LED slightly longer than the leads of the incandescent lamp, as you have to approximate the leads of the LED closer together to fit in the two-pronged socket.
4. Insert the LED into the socket (n.b.-the LED is polarized and you have to rotate it to the correct position).
5. Reassemble the flashlight,leaving the plastic parabolic reflector OUT, and you're done!

Calculations, using Radio Shack data, and observed measurements:

Absolute Maximum Ratings	
forward current	30mA
forward voltage	2.5V
reverse voltage	4.0V
power dissipation	75.0mW

Electro-Optical Characteristics	
forward voltage	1.85V
peak emission	660 nM
luminous intensity	5000mCD

Approximate battery life of two AA nicads (500 mA-hours @ 1.2V) with the regular incandescent lamp is 1 hour; with the LED it ranges from 13 to 17 hours!

Approximate battery life of 2 alkaline AA cells ranges from 22 to 28 hours!

As Doug says in the article, alkaline cells obviously do not have the half-life of lithium cells: the advantage here is that the LED is almost a "drop-in" installation in a standard, unmodified, readily-available,dependable flashlight. This makes its use as "last-ditch" light very accessible.

Dr.Gregory Doria N2SEA
PO Box 280094
Brooklyn NY 11228-0002

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ERRATUM

In Speleonics 18 the formula on page 2, column 2, line 13 is correct in context but should more properly be written as %capacity = 100% (V-3.00)/3.00.

--

NEWS, ANNOUNCEMENTS, RESOURCES

Tom Kaye (NSS News July 1992) suggested that CB channel 2 and 147.48 MHz as "cavers' frequencies." They worked well at the 1992 NSS Convention. **Gene Harrison** (WB4NGC) suggests that caver/hams using VHF or UHF FM transmit a CTCSS frequency so that those equipped with CTCSS decoders can "scan for cavers" while travelling or attending conventions. Gene recommends **203.5** Hz (Motorola PL code M1), a relatively high frequency which will pass through most repeaters.

Continuous Tone Coded Squelch System (CTCSS) is a common way of coding two-way radio gear to allow selective calling of radios in the same organization, or to key repeaters selectively. Units with the same CTCSS code will be able to communicate, others will not be heard. CTCSS is also known as PL ("Private Line") in Motorola equipment, "Channel Guard" (General Electric), and "Call Guard" in E.F. Johnson gear.

The transmitter generates a tone that is modulated along with the voice signal. The receiver detects the tone and opens the radio's squelch circuitry if the predetermined CTCSS frequency agrees. A high-pass filter removes CTCSS tone from the audio output.

In urban areas and on commercial frequencies there is usually more than one organization on an assigned frequency. CTCSS prevents he separate groups from hearing each others' traffic. If two groups key their radios at the same time and are geographically near each other, they will still cause interference.

--

CAVE RADIO & ELECTRONICS GROUP

BCRA

The Cave Radio & Electronics Group is one of the "special interest" groups of the British Cave Research Association. We publish a quarterly journal of communications, lighting & photography, surveying & computing, and geophysics & cave detection.

Members of the group receive a quarterly *newssheet* containing short articles, news and letters. Additionally members may subscribe to the *journal* which consists of over 20 A4 pages of theoretical and practical articles ranging from electromagnetic theory and cave detection methods to practical advice such as "How to lose the guarantee on your electric drill and related horror stories". Journal 10 includes a practical design for a high performance flashgun slave and a discussion on the design of power amplifiers.

We have also published a bibliography of underground communications containing over 300 references. New subscribers to the journal will receive an index to issues 6-9 listing the Abstract or Introduction to each article. (an index to issues 1-5 is in preparation). Enquiries and subscriptions should be sent to the secretary, David Gibson, at

12 Well House drive, LEEDS, Great Britain, LS8 4BX

● copy of December issue of the journal (#10)	£2.50
● Group membership (four quarterly newssheets)	£2.50
membership discount for BCRA members:	(£0.90)
● Four quarterly journals (group members only)	£5.00
● Bibliography of Underground Communications	£5.00
● Other publications and back issues are also available	

Prices include airmail postage worldwide. Payment should be in UK currency, by cheque drawn on a British bank, eurocheque, international money order, Visa or Mastercharge accounts. Alternatively you may send cash (US dollars or UK pounds) *at your own risk* (please add 20% to exchange rate). No other currency or credit cards please. Cheques should be made payable to *BCRA Cave Radio & Electronics Group.* If paying by credit card please send a formal authorisation to debit your account, quoting card number and expiry date.

-- Most highly recommended!

Book Review

Prolific writer and philosopher of electronics **Don Lancaster** sent a copy of his newest book, The Incredible Secret Money Machine II, about how to run your own small technical enterprise. It's not a sequel, but an expanded revision, reflecting technology not available when the original was written 15 years ago.

ISMM-II is pure, condensed, useful advice **not available in business schools.** It's available from Synergetics Press, Box 809, Thatcher, Arizona 85552. The International Standard Book Number (ISBN) is 1-882193-65-2.

Having found the publishing establishment increasingly bureaucratic and impenetrable even for one of his track record, Don now publishes and markets his own books. He offers invaluable advice in ISMM-II on doing so, with a discussion of "book on demand" technology.

Don is a caver, NSS member and reader of SPELEONICS.

CONVERTING CB RADIOS FOR USE AS LOW-FREQUENCY CAVE RADIOS

Ian Drummond

Design Philosophy.

Julian Coward and I started building the 3 Alberta Speleological Society (ASS) Cave Radios in 1980, following hand-written circuits from **Pete Hart** in the UK. The radios [described in Speleonics 5] have proved useful, robust, and have generally provided the range necessary for use in the mountains of Western Canada. Unfortunately in the intervening 12 years no-one (including ourselves) has built any further units. Indeed the circuits are daunting, containing many hand-wound inductors requiring individual tuning, and by now several key components are obsolete, requiring redesign work.

There is a demand for Cave Radios; I have been contacted by people interested in using radios for improved communications in rescue work, in scientific studies, in administration of show caves, and in exploration of caves. Why then have no more been built? In talking to people, of the three resources needed (time, knowledge and money) it seems that time is the least available, followed by knowledge, while money is relatively the most abundant resource. (True! Speleonics has carried two adverts from people wishing to buy cave radio systems for cash, yet in talking to people knowledgeable enough to build them, most have preferred to spend their time with their families, caving, or doing something other than building radios in their basements.)

Thus the idea developed to create a cave radio system using where ever possible purchased sub-systems. Various sub-systems were considered, and finally a decision was made to build a system using a CB radio as the central building block. This would be followed by a "transverter" to provide frequency down-conversion on transmission, and up-conversion on reception. A loop antenna and battery would complete the system. A summary of the advantages and disadvantages of such a system was compiled.

I was greatly encouraged in this approach to a cave radio system by an article by **Pat Harrington** intitled "A Simple CB to Low Frequency Transverter" published in Northern Observer #13, October 1989, pp5-11. Pat's article described how he built a transmitter for the 160-190 kHz band, using similar concepts to the ones described here.

Advantages

- A big reduction in construction time.
- Repair services are widely available for CB radios.
- Many people are familiar with CB radio operation.
- The frequency of operation can be easily changed.
- The system can be upgraded and will not readily become obsolete.
- CB radios incorporate features such as squelch and noise-blanking.
- Optimized for 2-way speech communication.
- The known electrical performance of the CB radios provides more consistent performance of the communication system as a whole.
- Allows direct research on the effects of frequency and mode of transmission. [European CB is FM. Some countries also allow AM and SSB. See summary at the end of this article.]

Disadvantages

- The system is electrically inefficient (RF power from the CB is wasted).
- A non-optimum signal processing scheme is used.
- CB radios are not constructed to stand the cave environment.
- The system is awkward for transmission of tone signals.
- The automatic gain control's range and time-constant make null-finding more difficult in location work.
- There is a potential for interference between CB and cave radio frequencies. (Intense CB activity could interfere with a surface cave radio, or cave radio use could leak CB radio transmissions.)

Performance of completed units.

Two complete units have been made, the first by point-to-point wiring on a bread-board with a ground plane (Vector 8004). Building on that experience, a p-c board was etched for the second unit. The frequency and mode (114.28 kHz, upper sideband) was selected to match the ASS Cave Radios. tests in town between the second unit and the ASS radios over the surface gave a range for 2-way speech of 350m [~1150 ft], which exceeded the 300m [~1000 ft] achieved by the ASS radios only.

A similar test in the electrically quieter countryside had easily achieved a range of over 600m [~2000 ft] horizontally on the surface before heavy rain arrived to terminate the experiment.

There is no doubt that the communication was achieved at 114 kHz, not through 27 MHz CB frequency leakage, as the ASS radios are totally insensitive to CB frequencies.

CB leakage was tested by operating a 1.5w CB walkie-talkie (Radio Shack TRC-214) about 20m away. Unfortunately perfect 2-way speech was achieved, despite careful shielding and correct termination of the CB RF circuits. Further work is clearly needed to establish if this is a serious operational problem, both from aspect of CB noise interfering with cave communications, and from reduced security through transmission of cave communications in the the CB bands.

> In summary, these tests indicate that the CB cave radios will perform at least as well if not better than the ASS cave radios for voice communication.

Selection of a CB radio

The CB radio MUST be in a metal case to provide RF shielding. Early experiments using a plastic-case CB walkie-talkie (Radio Shack TRC-214) were terminated when it was found that the unit leaked so much RF radiation through the case when transmitting that it was impossible to make meaningful measurements on a circuit 2m away.

It is strongly recommended that the CB radio be capable of Single Side-Band (SSB) operation. While the cheaper, smaller AM units will certainly work for voice communication, they will be very electrically inefficient, and cannot receive CW (tone) signals for location work. A compromise might be to use a cheap AM unit underground and a SSB unit on the surface. Then the SSB unit can receive the tone needed for location work, and voice contact can be conducted via the AM mode.

The electrical quality of the CB radio certainly affects the performance of the system as a whole. The unit used in the tests mentioned above was a Radio Shack Realistic TRC-453 purchased during a clear-out sale in the USA for US$95.00. (A Uniden$^{(tm)}$ chassis is hiding inside the Realistic$^{(tm)}$ case.)

The most relevant specifications to determine selectivity and sensitivity of the receiver are as follows:

Receiver selectivity - adjacent-channel rejection 70 dB.
Sensitivity for 10 dB S/N, 0.5 microvolts AM, 0.25 uV SSB

Addendum

Since writing the original article, two more transceivers have been built using commercially-produced printed-circuit boards.

The units were matched with antennas tuned to 185 kHz, with the result that CB channel 11 gives the appropriate frequencies. The unit is essentially a 2-channel voice unit, as upper sideband operations covers frequencies from 185.3 kHz to approximately 188 kHz, and lower sideband operation covers 182 to 184.7 kHz. Interferences that are prominent in one sideband are unnoticeable in the other. Unfortunately, I have not been able to devise a simple method of matching the antenna to the transceiver units for a wider variation in frequency.

The PC boards were made by Alberta Printed Circuits who provide a prototype service for small numbers of boards (even numbers, 2 to 12). The cost of two prototype boards (11.4 x 9.5 cm [4.5" x 3.75"]) was approximately $80 Canadian.

One attractive feature of dealing with APC is that they have a bulletin board and it is possible to download "Easytrax" software. Easytrax is a previous generation of professional design software which is fully capable of designing the 2-sided board, with ground information and drill tables that APC need.

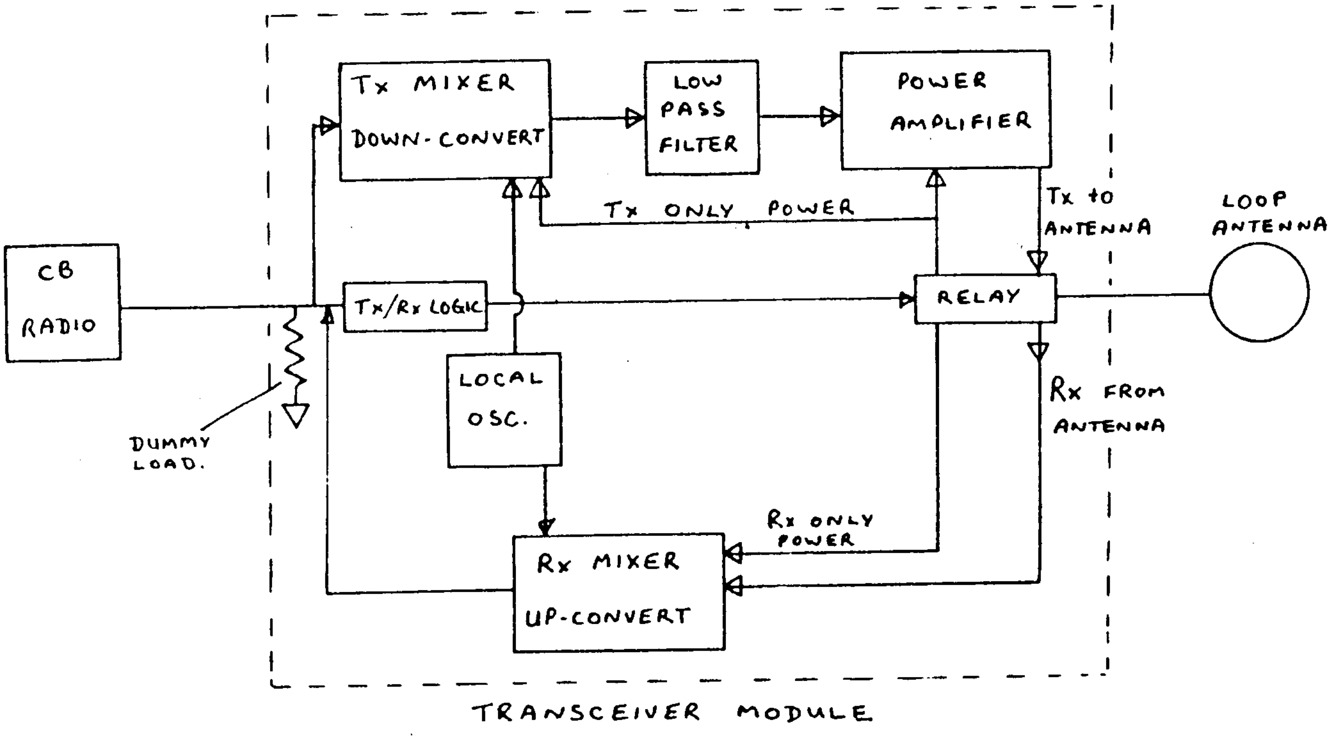
The whole production can be done by modem from a home computer (and not a very fancy unit either; I am running a Tandy 1000 SX with a 20-Meg hard drive and monochrome CGA graphics, but I do have a mouse which is nearly essential for the application). It is possible to download the software, design the board, upload the data files, and have APC make the boards, put them in the mail, and bill your credit card, all by modem over the phone lines.

This software is by far the best deal I was able to locate anywhere in North America. The process is to log-on and download a file called "newuser.exe" which gives all the details needed. Alternatively, they will send the software on a diskette for a $10 handling charge.

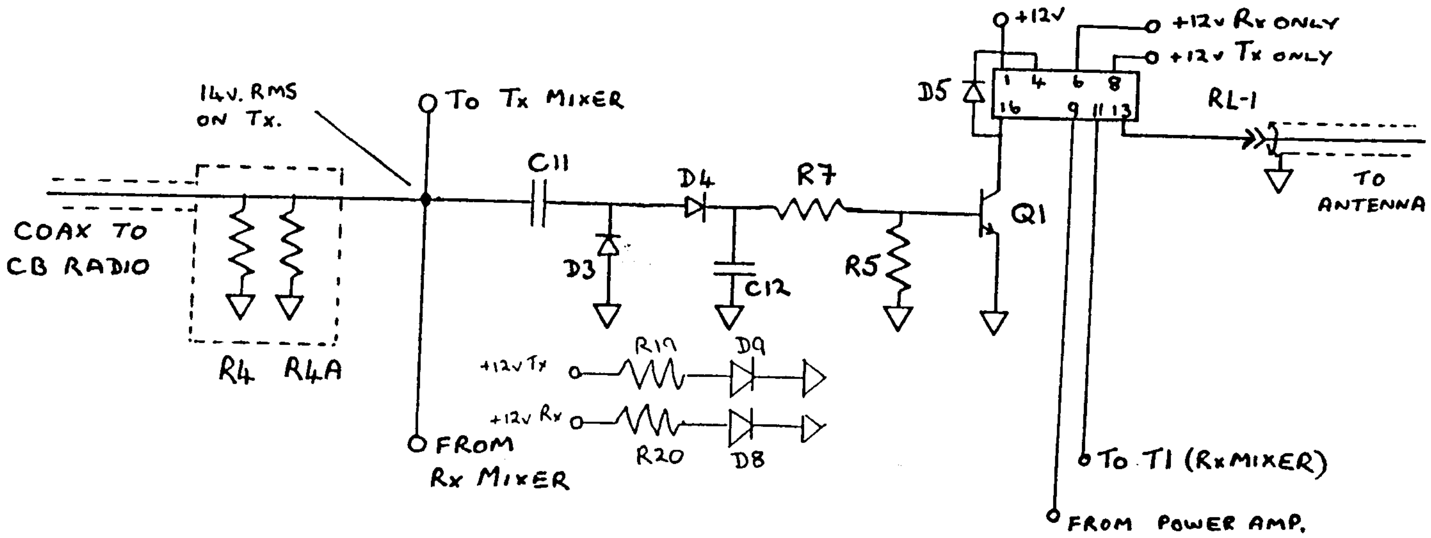
Alberta Printed Circuits, Bay 14, 3650-19 St. NE,
CALGARY, Alta
Computer (403 291-9342; voice (403) 250-3406

If you are interested in the PC boards used in this project, send Ian Drummond a letter (address in the front of Speleonics).

BLOCK DIAGRAM

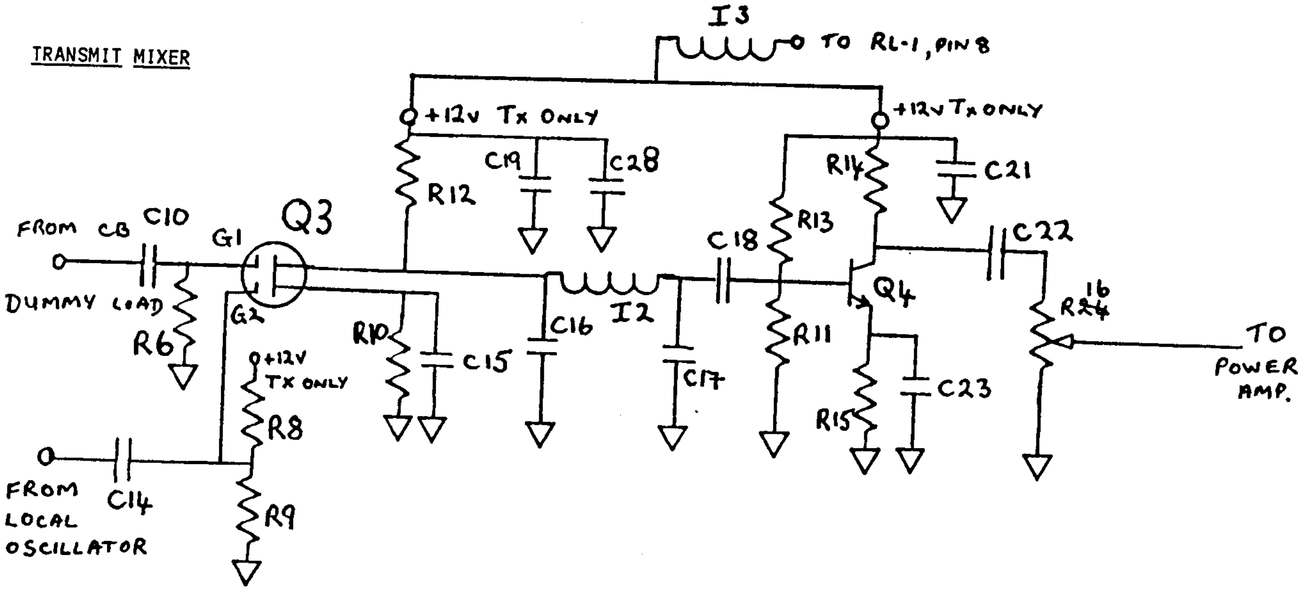


Tx/Rx LOGIC CIRCUITS



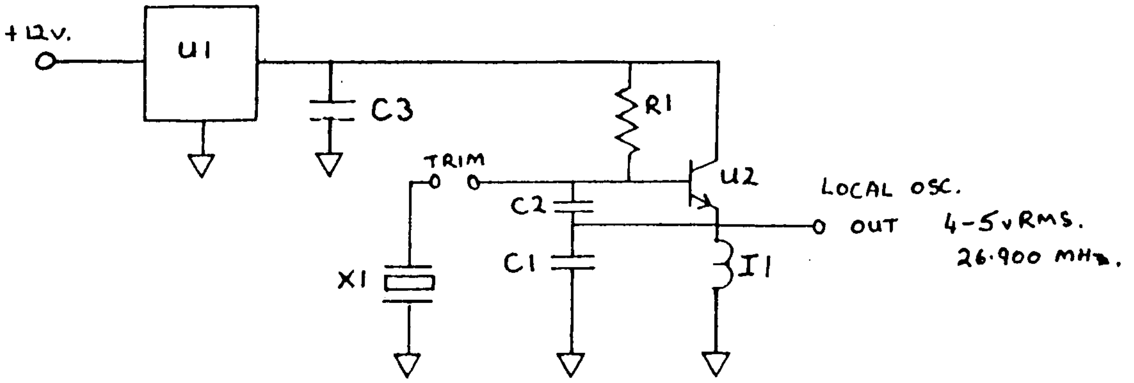
Notes -
1. Adjust C12 to change the 'hang' of the switch after releasing the CB radio transmit switch.
2. Adjust C11 to change the 'attack' of the switch on keying the CB radio.
3. R4 and R4A must present a matched load to the CB radio. Use an SWR meter to check and adjust R4 as necessary.
4. The values given are for a 4w CB transmitter.

TRANSMIT MIXER



Notes -
1. Values are for a 4w CB transmitter. Adjust R6 for other powers.
2. Design is based on 1982 Radio Amateur's Handbook (ARRL), page 8-17.
3. I3 provides power supply isolation from the power amplifier.
4. R12, C16 and 17, I2 and R11 form a low-pass filter with cutoff approx. 500 kHz.

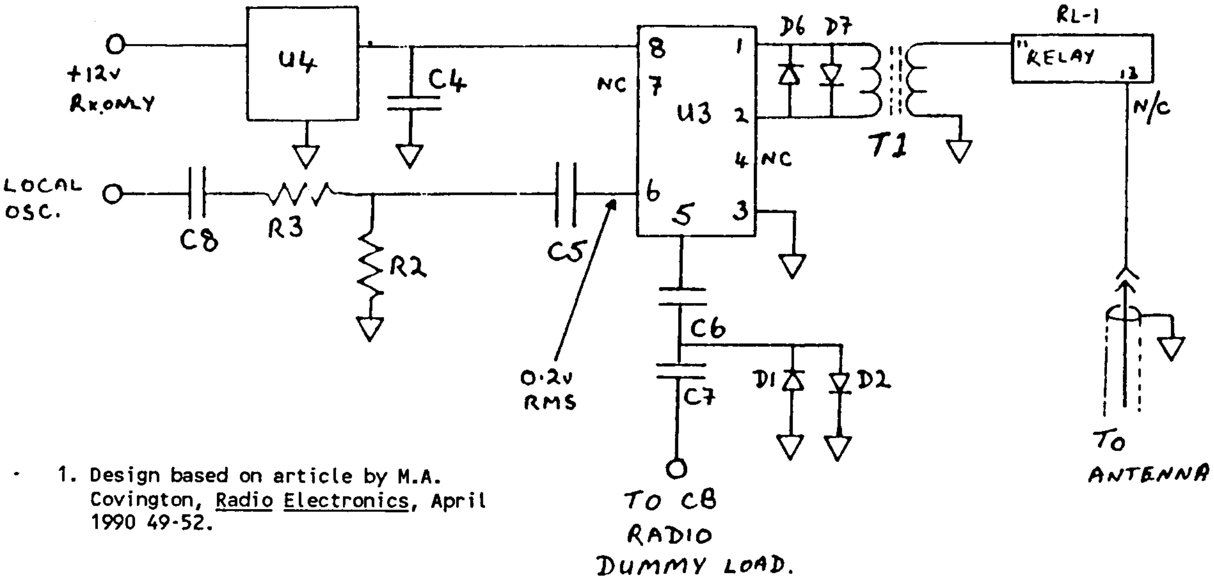
LOCAL OSCILLATOR



Notes -

1. I1/C1 values are critical. Feedback is <1 at fundamental and >1 at 3rd overtone, so X1 resonates at 3rd overtone.
2. U2 must be a high frequency, high gain transistor. Substitutions can significantly change both output voltage and frequency of oscillation.
3. Do not increase the operating voltage, as power dissipation in the crystal could become excessive.
4. Trim = capacitor or inductor to trim frequency up or down (or short).
5. Design details from Crystal Oscillator Circuits by R.J. Matthys, Wiley & Sons, 1983. ISBN 0-471-87401-9.

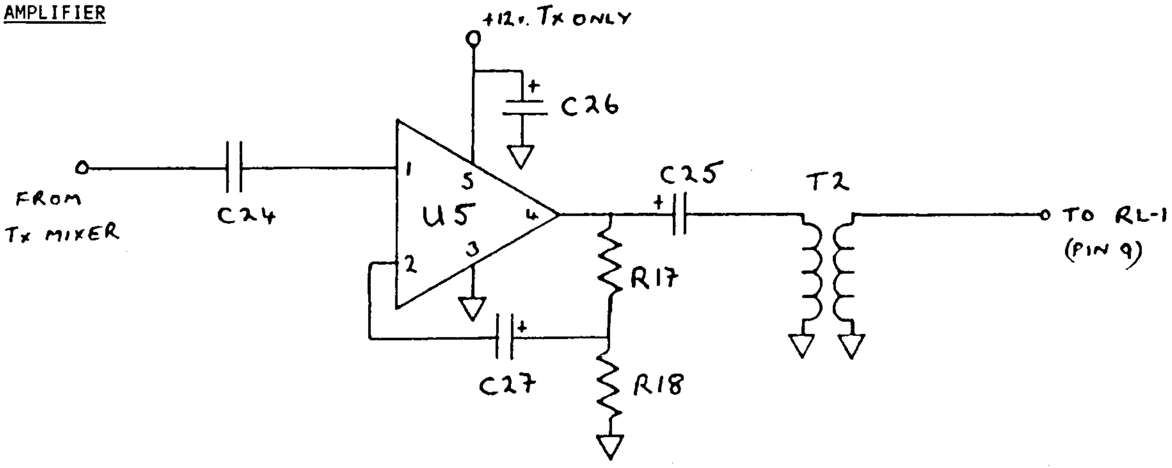
RECEIVER MIXER (up converter)



Notes -

1. Design based on article by M.A. Covington, Radio Electronics, April 1990 49-52.

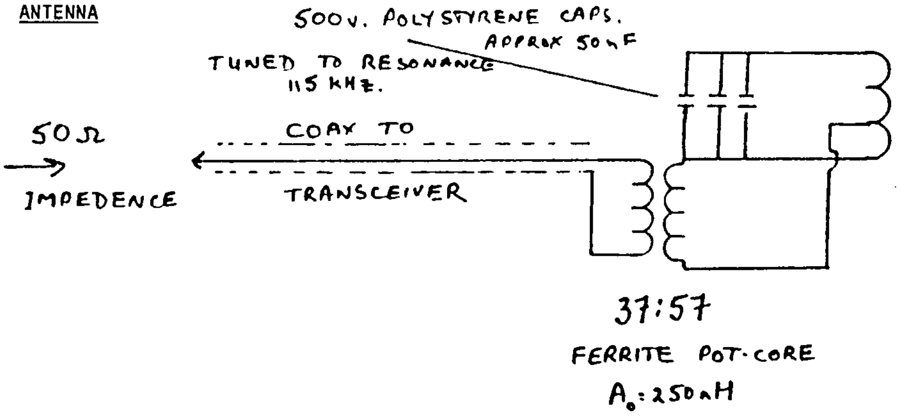
POWER AMPLIFIER



Notes -

1. Heat sink for 5w needed. Pin 3 is ground and case, so no need to isolate chip from sink electrically.
2. TDA2002A provides useful gain to 300 kHz.
3. Power delivered to 50 ohm load is approx. 2.5w.
4. Output at pin 4 cannot exceed 9.5v peak-to-peak.
5. Gain is adjusted by R18. Balance gain in preamp and power amp. to avoid oscillation problems. System is sometimes ok with dummy load but oscillates with antenna connected. Put electronics in metal box to cure!

ANTENNA



Notes -

1. Square frame, 1.42m across diagonal. Coil is 1 turn of 16/3 outdoor cable connected in series to give 3 electrical turns, tapped at 1 turn.