A WEST COAST LIGHTWAVE PROJECT

Steve McDonald, VE7SL / Markus Hansen,VE7CA

With the growing popularity of Web blogs devoted to Amateur Radio, the Internet has become a wonderful source of technical topics. One such blog caught my interest this past summer, when I began to follow the daily postings of Roger, G3XBM, in the United Kingdom (see note 1).

I found Roger's notes describing his LED lightwave experiments to be particularly inspiring. Further searching led me to the UK Nanowave Group and a series of *Radcom* lightwave articles that I found difficult to resist (see note 2). It seemed that many of our UK counterparts were becoming very active in building and operating simple LED lightwave stations and appeared to be having far too much fun in the process!

Roger's notes and the *Radcom* articles were passed to Markus, VE7CA and to John, VE7BDQ, both ardent homebrewers, who also believed the concept of communicating with lightwaves would be an interesting challenge.

The project was soon broken into four basic requirements so that work could begin:

- a lightwave receiver
- a lightwave transmitter
- an optical system and enclosure for both RX and TX
- a CW tone modulator

RECEIVING

It wasn't long before construction began on a basic receiving system designed around the G3XBM receiver and additional information found at Clint Turner's (KA7OEI) website (see note 3).

The receiver we chose to build was a G3XBM modification of one designed many years ago by K3PGP for his laser experiments. It consisted of a small inexpensive PIN photodiode (BPW34) driving a JFET amplifier, followed by several stages of audio amplification (see Figure 1). The completed receivers are very compact as can be seen by the one shown here constructed by John, VE7BDQ (see Figure 2 on the next page).

There are numerous inexpensive photodiodes that will work very well in this circuit. Although the G3XBM receiver used an SFH213 photodiode, we used BPW34's. This particular diode works best in the IR region, but still performs suitably in the slightly higher deep-red light part of the visible spectrum where we planned to transmit (see Figure 3).

To increase the light-gathering capability of the system, inexpensive plastic Fresnel lenses were purchased in order to focus incoming light onto the photodiode's tiny cell as well as for use

IMPORTANT SIDEBAR

Canadian Amateurs operating a Lightwave Optical system should be aware of Transport Canada's / Canadian Aviation Regulations with regard to any Directed Bright Light (DBL) source and operate in accordance to these regulations.

DBL's are potentially hazardous and penalties do exist for their inappropriate use.

The Canadian Aviation Regulations (CAR) prohibit "projecting a bright light source" into airspace.

601.14

In this Division, "directed bright light source" means any directed light source (coherent or non-coherent), including lasers, that may create a hazard to aviation safety or cause damage to an aircraft or injury to persons on board the aircraft.

601.20

Subject to section 601.21, no person shall project or cause to be projected a bright light source into navigable airspace in such a manner as to create a hazard to aviation safety or cause damage to an aircraft or injury to persons on board the aircraft.

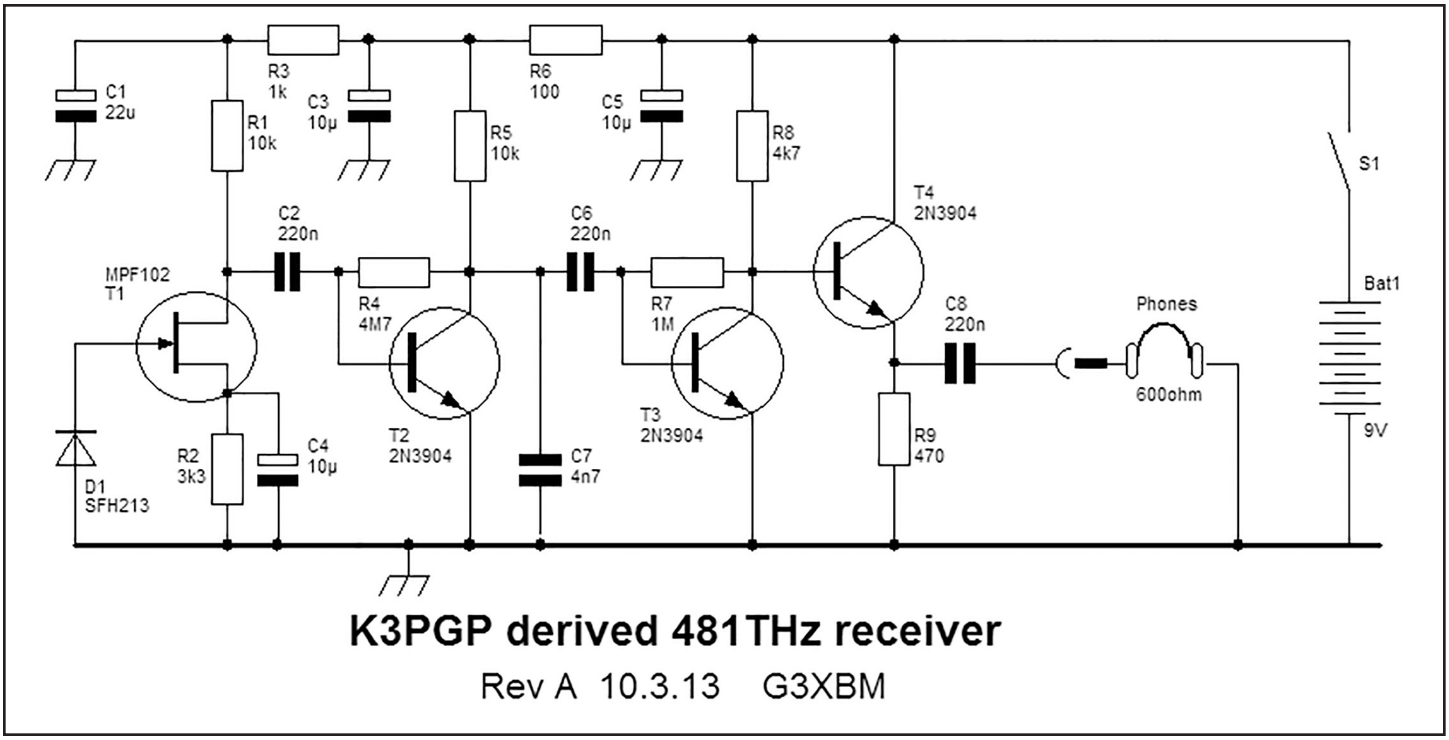


Figure 1: Schematic diagram of the basic lightwave receiver used at both stations; courtesy of G3XBM.

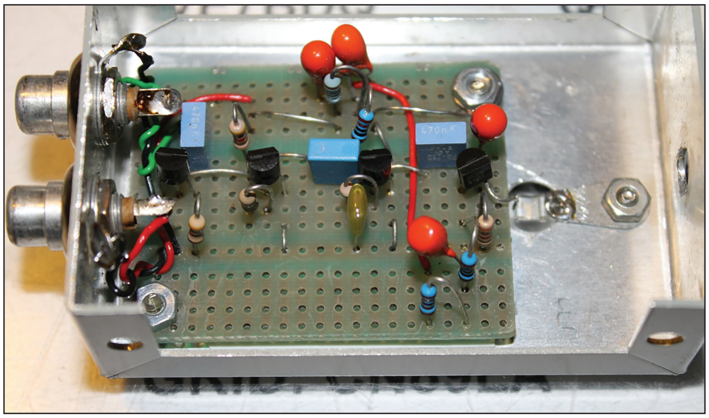


Figure 2: One of the finished receivers built by John, VE7BDQ.

in the transmitter (see note 4). John devised a brilliantly simple mounting support for the receiver using the split shaft locking collet removed from an old potentiometer. The mount allowed for easy three-axis movement (forward/backward, up/down, left/right) and precise positioning of the photodiode at the Fresnel's focal point. A similar mount was constructed for the transmitter's LED as well (see Figure 4).

The finished receivers turned out to be exceptionally sensitive. Initial nighttime listening tests revealed an unexpected abundance of interesting signals! One of the first signals heard was a repetitive low frequency "thump-thump", which turned out to be the audio signature of flashing strobe lights from various aircraft, both near and far.

The receiver could easily detect the jet aircraft strobes from incoming planes heading for Vancouver International while they were still over 70 miles away above the coastal mountains on their descent and still above 10,000 feet.

From my receiving location on the eastern shore of Mayne Island, in the middle of Georgia Strait, I could hear many different signals as I panned the receiver along the mainland's southern coast. Many sounded like radar sweeps and others like strobes, and all with different timing cycles and modulation rates. Some sounded rough and growly while others were pure and "T9".

Attesting to the receiver's sensitivity, most of the signals showed no visible sign of their presence to my eyes, even when scanning with binoculars to find the source. Once the receiving systems were working well, construction of the transmitters began.

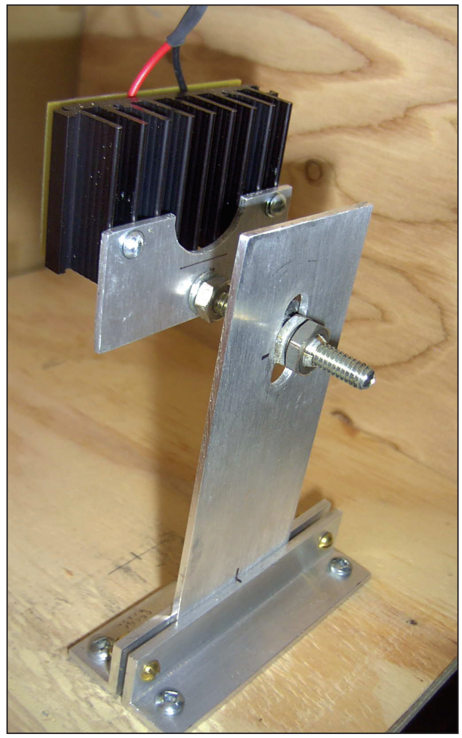


Figure 4: The adjustable mounting system used for alignment of the LED and the receiver.

TRANSMITTING

The heart of the transmitter is a single Luxeon Red Rebel LED (see Figure 5 on the next page) mounted on a small heatsink.

The tiny LED operates at 2.4V @ 700ma while producing light in the deep-red

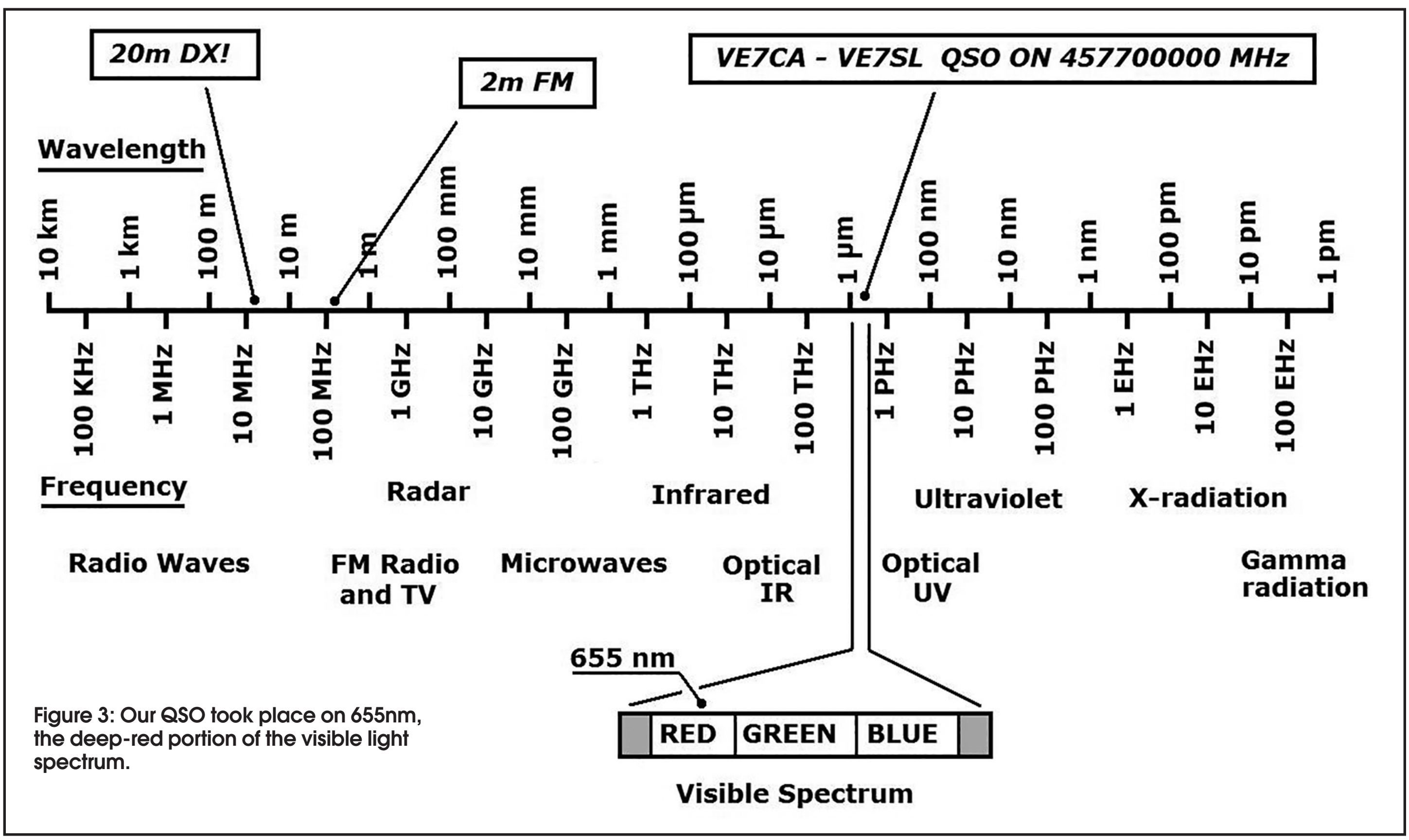
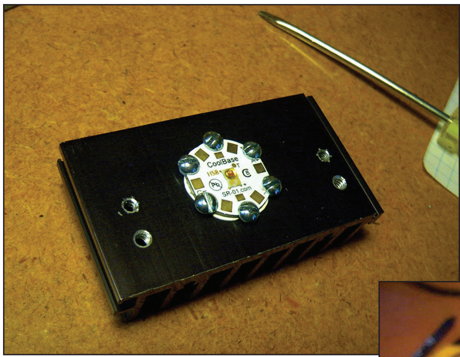


Figure 3: Our QSO took place on 655nm, the deep-red portion of the visible light spectrum.



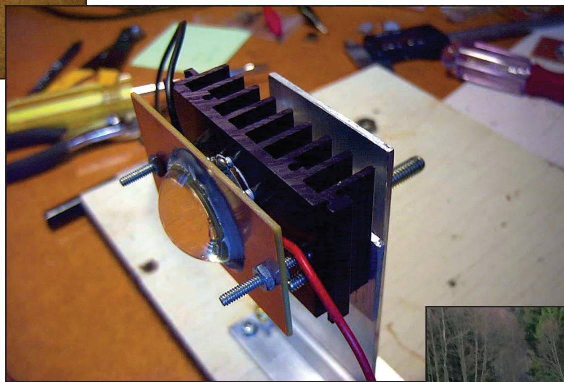


Figure 5 (top): The Red Rebel LED mounted on its Star Base and heatsink.

Figure 6 (right): The collimating lens and LED module on adjustable mount.

Figure 7 (far right): The VE7CA lightwave station ready to go.

portion of the visible spectrum at 655nm or approximately 460THz (see the box at the top right). The LED is mounted directly behind an inexpensive 30mm glass collimating lens in order to have its light fully illuminate the Fresnel lens without any power-wasting "spillover" (see note 5). The collimating lens, along with the LED and heatsink, are all mounted on a sliding carrier similar to the one used in the receiver so that it can be precisely aligned behind the larger Fresnel lens (see Figure 6).

In order to keep the system as simple as possible and to give us a better chance of success, we chose to CW modulate the lightwave signal with a 600 Hz keyed tone. Several simple transmitting schemes can be found on Roger's (G3XBM) blog where further details are available (see note 1).

A single 556 IC (dual 555's) was employed as the tone source as well as for a dual-tone "beacon-mode" signal. The output from the 556 was used to drive a power MOSFET (IRF540) which controlled current to the LED (see Figure 8).

Both the transmitter and the receiver boxes, along with their respective lenses, were mounted side by-side to ensure that both were pointing at the same target as shown here by the VE7CA station ready to go (see Figure 7).

The final task was to ensure that the LED was accurately positioned with relation to the Fresnel. This required aiming the transmitter at a flat surface at least 150 feet away and finetuning the focus carriage. Once the correct position was found, it was possible to see the actual LED die and its two tiny connecting wires on the distant target image.

ON THE AIR

Since two complete stations had now been built, we anxiously waited for a break in the west coast rain for an initial "on-air" test.

When the weather eventually broke, a test QSO was scheduled on a clear but cold evening. Markus, along with Jim, VE7BKX, set up his equipment near West Vancouver's Cypress Provincial Park enroute to the ski hills, giving him a clear line-of-sight path to my front yard location on Mayne Island, 54 kilometres away on the far side of Georgia Strait (see Figure 9 on the next page).

THz

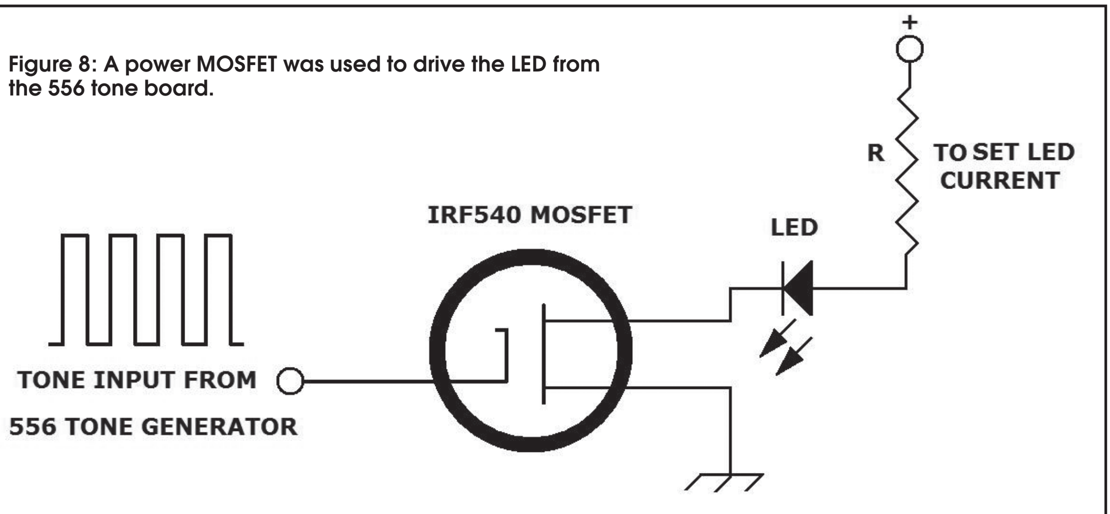
"THz" is the abbreviation used for "terahertz", the unit of electromagnetic wave frequency equal to one trillion hertz (10^12 Hz). It is mostly used to express the frequencies used for infrared (IR), visible and ultraviolet (UV) radiation. 1THz has a wavelength of .3mm.

Shortly before dusk, I pointed towards Markus's location and activated my transmitter in the beacon-mode. Markus heard me almost immediately and, after refining his alignment, replied by activating his beacon signal. Not knowing what to expect in the way of signal levels, we were all astounded at the strength of our signals – a true 599 or better!

Switching to straight CW and exchanging signal reports and grid square information made the contact "official", allowing us to then have a nice 20 minute CW ragchew before it became too cold on our fingers to continue (see note 6).

Interestingly, we were able to work full break-in style (QSK) as the transmitters did not interfere with the continuously running receivers, a nice surprise.

Figure 8: A power MOSFET was used to drive the LED from the 556 tone board.



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Our next goal is to move further afield and try to complete a QSO at a much further distance.

We are also considering adding voice modulators to the system and possibly shifting to the IR range for better efficiency.

In addition, John is interested in trying some "non-line-of-sight" (NLOS) experiments to see if it is possible to bounce signals across Georgia Strait from the cloud layer bottoms. One of the project's major goals is to try to encourage similar activity amongst Canadian Radio Amateurs and to encourage the joy of homebrewing your own station equipment.

If you intend to operate an LED lightwave system you must:

1) pay proper attention to where the system is deployed. Such a system must not be operated near airports or pointed towards aircraft and there are severe penalties for doing so (please read the sidebar for more information)

2) treat an LED light system with care. Although not physically damaging like laser light, modern LEDs are very bright and should never be looked at directly.

3) Be aware of other nearby activity. Although not physically damaging, a bright LED light can cause momentary distraction to automobile drivers or onlookers.

We hope that you will check out some of the references and links provided and get in on the fun as well. See you on 460THz!

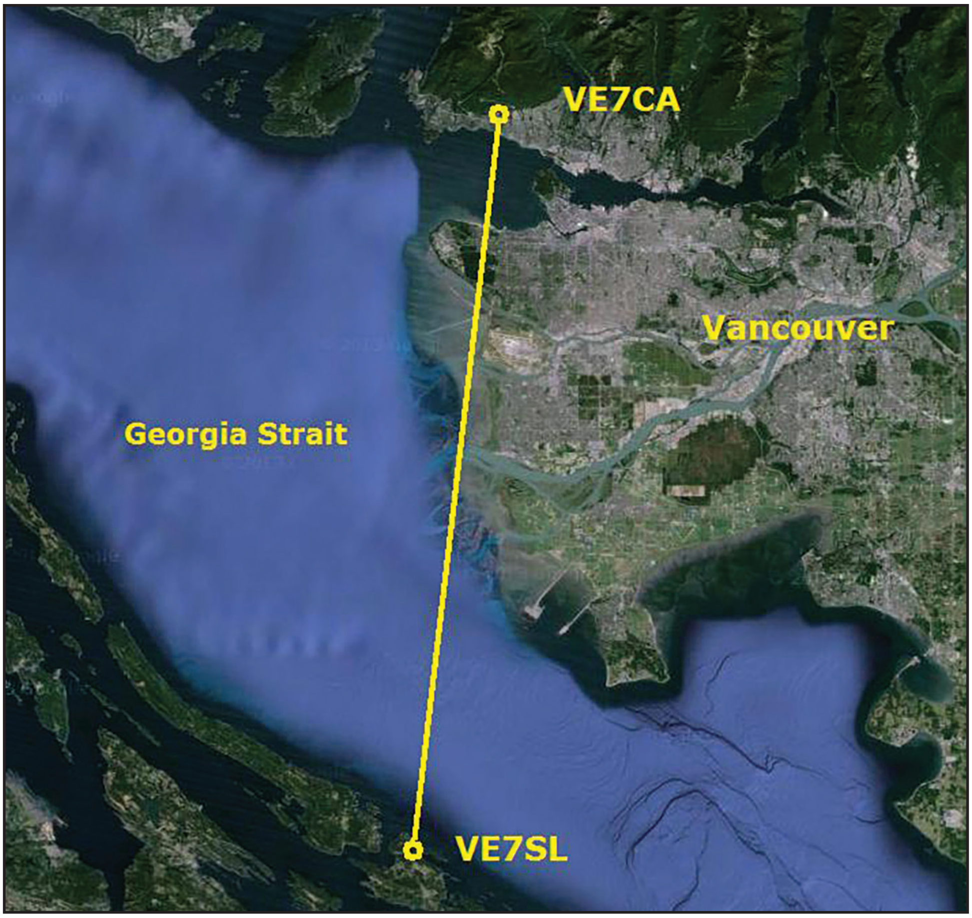

Figure 9: The 54 kilometreoptical path between Mayne Island and West Vancouver; courtesy of Google Maps.

NOTES

1) Several pages of Roger's optical adventures can be found online at: http://g3xbm-qrp.blogspot.ca/search/label/optical

2) The four-part *Radcom* article, "Adventures In Optical Communication" can be downloaded from http://groups.yahoo.com/neo/groups/UKNanowaves/info. It is well worth joining the group just to read this excellent series.

3) Probably the Web's best overall source of Amateur optical communications information can be found at: http://modulatedlight.org/optical_comms/optical_index.html

4) The Fresnel lens model A260 was purchased at: http://www.3dlens.com/shop/largefresnellens.php

5) The inexpensive 30mm PMN collimating lens was purchased at: http://www.surplusshed.com/

6) To see a short cellphone video of signals received near Cypress Park by VE7CA, visit YouTube and search for "VE7SL LW".

Steve McDonald, VE7SL, was first licensed as a teenager in 1963 (VE7ANP). He is now retired on Mayne Island, BC, after teaching high school Tech-Ed for 35 years. "My radio time is spent homebrewing and DXing, with a focus on 6m, LF and our new 630m band. I maintain my 'VE7SL Radio Notebook' website at: http://members.shaw.ca/ve7sl/ as well as a new Blog at http://ve7sl.blogspot.ca/ Please stop by."

Markus Hansen, VE7CA, has been an Amateur since 1959. He is now retired and enjoying a little more time for experimenting. Markus has had several articles published by the ARRL and one by RAC describing different antenna projects and his homebrew HBR-2000, a 160 to 6 metre full-fledged transceiver. He continues to be active on 160 to 6 metres mostly operating CW and some AM on 15 metres with a restored Viking Range and Collins 51j-4. Markus maintains a website at ve7ca.net describing many of his ham-related experiments and restoration projects.

TCA