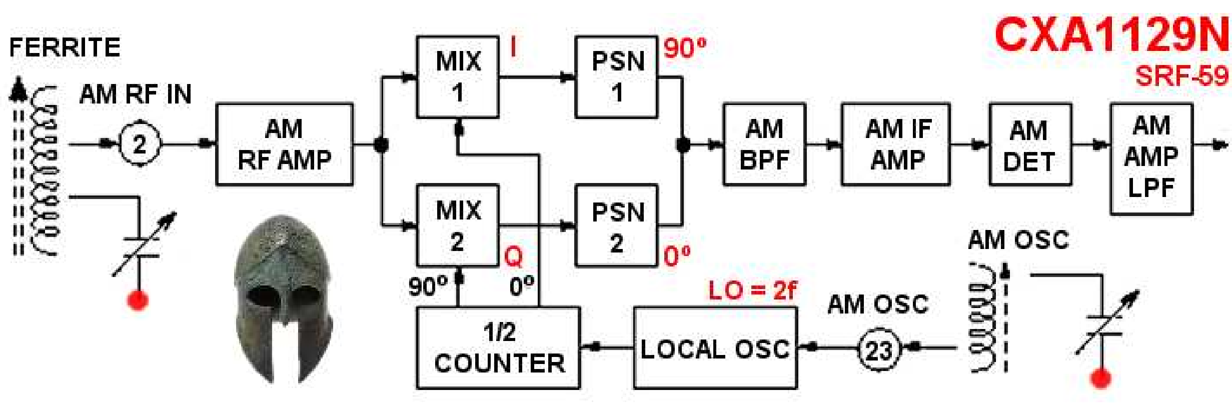
Hellenized SRF-59

$40 QRP Hartley image rejection low-IF shortwave receiver

VERSION 1 ©2009



The information below is not guaranteed to be free of errors.

1. INTRODUCTION

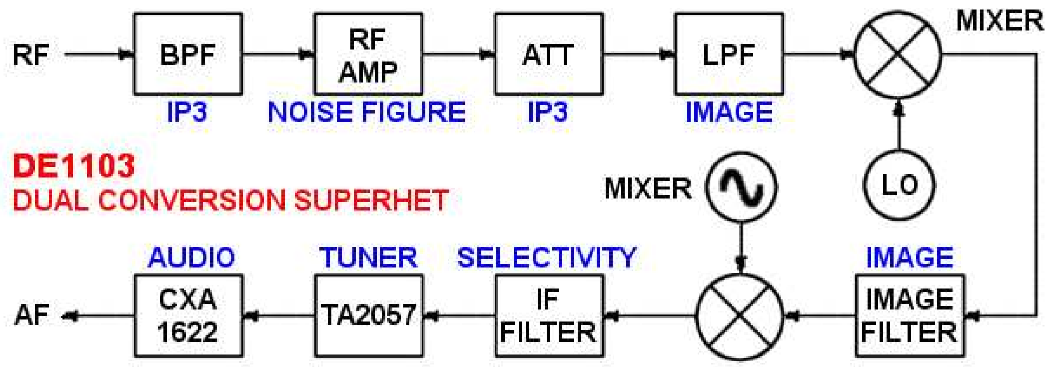
My 2003 article named **Sony ICF-S10MK2** proved an $11 radio with a $20 Radio Shack Loop heard, on average, 94% of what an ICOM R75 and Quantum QX Loop could [$780 total]. It found that half the missed stations were *faint* and half were *adjacent to* or *located at the images of* the strongest stations. This effort to quantify using a pocket radio for BCB DX fell on deaf ears. I was pleased to learn recently that *Gary DeBock* founded a new DX niche called UltraLight Radio [see *www.dxer.ca* for details]. Ironically, *Gary* labeled my trusty S10MK2 as a *turkey*… but it has long since been cooked! My S10MK2's fate was a conversion to shortwave, complete with fifteen element Murata filter. Since the Sony SRF-59 is acclaimed at BCB DX, I decided to study it, alter it, and finally do formal write ups. Read the companion article named **Hellenized ICF-S10MK2**.

My 2006 article named **Tuning Tricks Challenge SAM** explains two tuning "tricks" called **SIDEBAND-SELECTED AM** and **PRECISION ECSS** that negate the need for SAM or Synchronous AM detection. The conclusion was that slow-AGC and sideband suppression reduce carrier dropout related distortion. The article has relevance when studying the proprietary CXA1129N chip within the SRF-59. The article points out using an offset tuned filter to suppress a sideband and diminish fading distortion. Offset tuning, with its resultant increase in fidelity, can be done with an SRF-59.

2. CXA1129N and SRF-59

The CXA1129N is based off a 0.95 Volt bipolar chip designed by *Taiwa Okanobu* in 1992. To eliminate external 455 kHz filters, selectivity would be provided via active RC filters using MIS (Metal Insulator Semiconductor) capacitors on IC. Their Q (under 20) necessitates usage of a low 55 kHz IF: the problem is the image! The solution is to cancel the image using I/Q [Inphase and Quadrature] double-balanced mixers followed by a PSN (Phase Shift Network). Mixers are fed 90 degree phase shifted local oscillator (LO) signals. The two ~55 kHz PSN's [two 2nd order all-pass] outputs are added and the image is cancelled. Image rejection is ~40 dB [~60 dB with a ferrite]. Shortwave reception is possible in the prototype as mixer LO was specced up to 60 MHz. The LO is twice the receive frequency due to the ½ divider. The 55 kHz AM BFP [three 2nd order biquad] has specs of -20 dB at 5 kHz and -40 dB at 10 kHz. *Taiwa*'s test radio showed an AM (6 dB S/N) sensitivity of 3.16 µV [10 dBuV] or S5; S/N of 50 dB; and THD of 0.3%. The chip has three AGC lines: 1) AGC1 at pin 3 at the RF amplifier to limit the input level; 2) AGC2 at pin 9 post-detector as standard IF AGC; and 3) OL AGC at pin 25 post-mixers which is an overload AGC. The SRF-59 uses a fixed resistor off GAIN ADJ at pin 26. The prototype tunes mixer gain via a potentiometer, which maximizes image rejection. Tuning indication [pin 22 is TUN IND] and stereo FM indication [pin 15 is ST IND] can be added to a SRF-59. Sony's schematic contains an error: D2, one of the FM antenna input protection diodes, needs to be flipped so that its cathode is attached to ground.

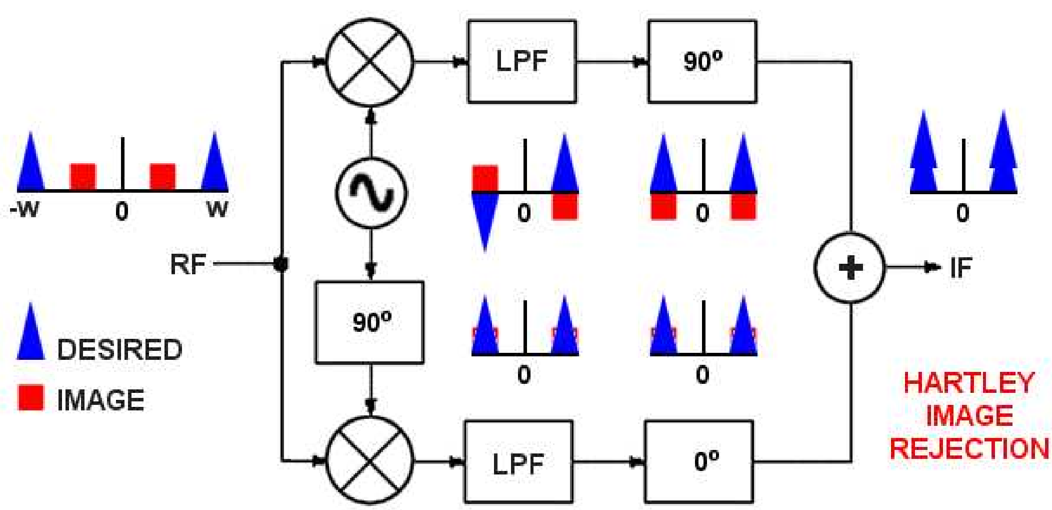
3. QRP ARCHITECTURE



In Phil's SW Radio Picks I recommended several portables including the DE1102, DE1103, and KA2100. These double-conversion PLL-synthesized portables have good image rejection and selectivity. They are also power hogs that supply an AM/FM tuner, CPU, PLL, and audio chips, as well as external mixers and LCD displays. The DE1103 using earphones and not backlit consumes 71.3 mA at 6 Volts or 428 mW of power. Four Duracell "AA" alkaline batteries will last ~40 hours. By comparison the low-power (QRP) SRF-59 uses 15.8 mA at 1.5 Volts or 24 mW of power. One Duracell "D" type battery *may* power the radio for 950 hours or 2.6 hours daily for an entire year.

Zero Intermediate Frequency (Zero-IF or Direct Conversion) receivers have no image and are QRP. Unfortunately Zero-IF suffers from DC offset (parasitic LO coupling to the antenna, LNA, and mixer), flicker ($1/f$) noise, LO antenna leak, and even order distortion. Zero-IF receivers are also notorious for problems with dynamic range, AC hum, microphonics, and weak audio output.

4. HARTLEY IMAGE REJECTION



Sony's engineers knew just how to get good overall performance under low-power. They combined a low-IF architecture, which does not suffer from much DC offset or flicker noise, with Hartley image rejection. Although phase and amplitude mismatches limit this image rejection to 40 dB the rest can be made up with a tuned antenna. This is a perfect symbiosis: low-IF suffers from images which Hartley (1928) architecture addresses [Weaver produces secondary images].

Unlike others, Sony has the engineering power to make their own *low external parts* chip. The SRF-59 contains no ceramic IF filters; and no power-using tuning LED or DSP IF. A separate LA4537M headphone power amplifier was used to prevent the need for balanced amplifiers inside the CXA1129N. This avoids feedback of audio, and its harmonics, into the RF amplifier or mixers.

5. MODIFICATIONS

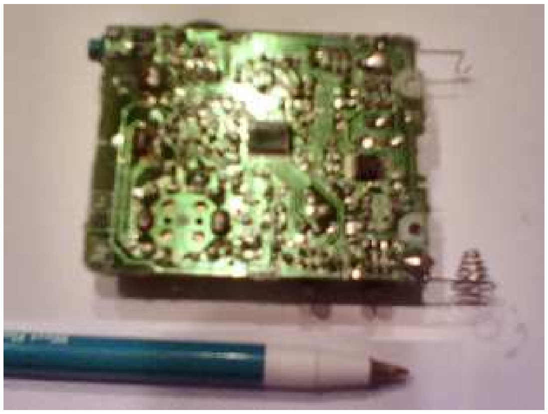
The conversion of an analog tuned radio from BCB to SW must address changing the local oscillator (LO) and antenna. The LO tank inductor may be replaced with a red type-2 iron powder toroid. The LO tank variable capacitor may be swapped for an air-variable capacitor with vernier drive or varactor diodes with a 10-turn potentiometer. The BCB ferrite antenna must be replaced. Untuned antennas can be used; but tuned loops reduce various mixer artifacts and can be rotated to attenuate local noise. Magnetic loops can be made using a tank with long connections between the capacitor and toroidal inductor [copper tubing can be used]. Statistically 4.7 MHz to 10.0 MHz covers ~**89.6%** of all evening English broadcasts beamed to America [by hours of programming]. Analog oscillators with tuned inputs have no CPU or synthesizer noise and low stray mixer energy.

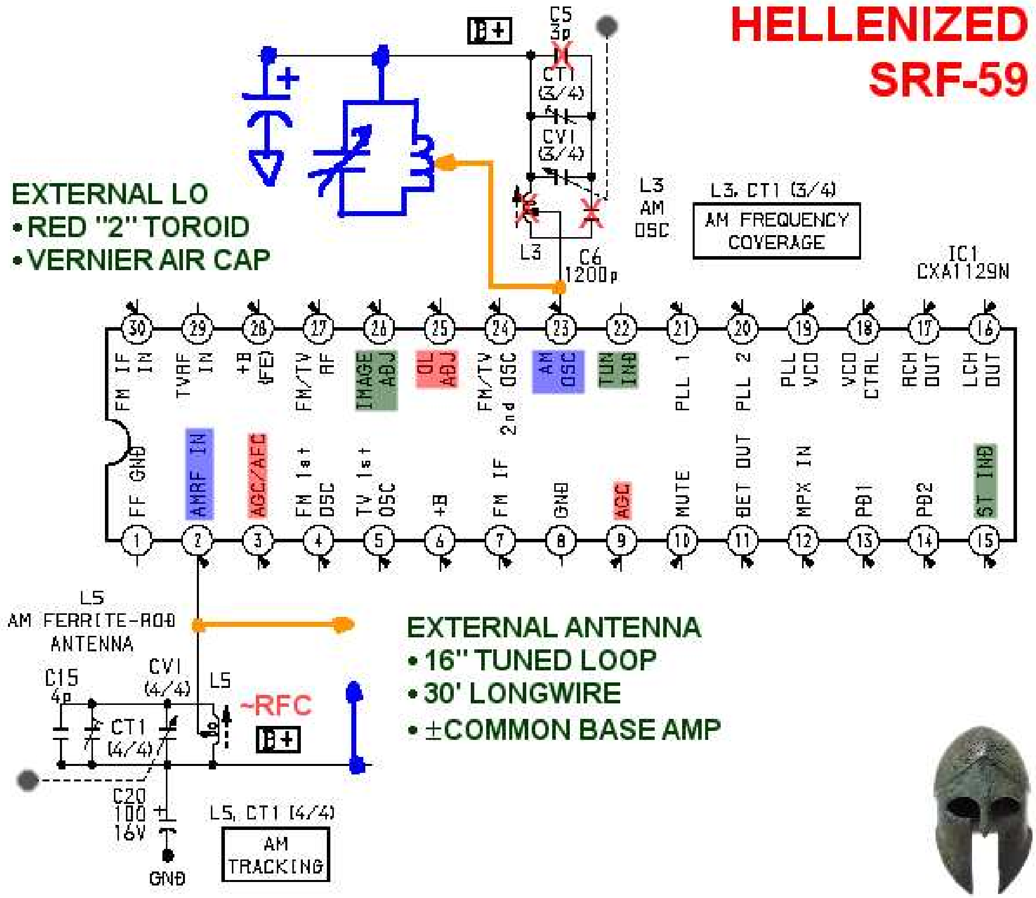
Advanced radio alterations include changing the external AGC capacitor: reducing it during band scanning and increasing it (ex. ~220 uF) for listening [switch selects]. The latter can reduce selective fading distortion. On the audio end a speaker, audio amplifier (TDA7052 or LM386), and audio filtration (passive **RC** or two-pole low-pass op-amp) make good additions. Comfortable $13 Koss Sparkplug earbuds are my favorite [112 dB SPL per mW]. Please note that modifying radios might result in their damage. To learn more about soldering to IC pins see **Phil's Soldering 101**.

WARNING: PLEASE wear **EYE PROTECTION** when performing modifications.

6. HELLENIZED SRF-59

I do NOT recommend modifying your SRF-59: the radio is easily ruined. This description is for amusement purposes. The tank's variable capacitor was rendered inoperable by removing two capacitors. The tank's inductor was removed. Four taps were created: *oscillator, antenna, ground,* and *power*. An old Heathkit Signal Generator was used for its tuning dial, vernier, and air-variable capacitor. An Amidon toroid was used for an inductor. The antenna pictured is a tuned loop: input via the ferrite's tap feeds 1.5 V to pin 2. The ferrite at SW acts as resistance for the chip's internal RF amplifier. Soldering was difficult (easily lifted lines). Superior circuits are being tested. The top pictures illustrate the size of the SRF-59 and its internals; bottom pictures are of the SW test unit.





7. DISCUSSION

The Hellenized SRF-59 rivals $4000 receivers in architectural complexity. Shortwave is a niche market: engineering muscle is concentrated in the lucrative BCB/FM consumer market. As hackers we can convert MW designs to shortwave and get a taste of the new technology without the high cost. Degen is using Silicon Lab's Si4734 AM/FM/SW/LW receiver IC with DSP IF in their $70 DE1123. Sony is using their CXA1376AS receiver IC with SAM in their $146 ICF-SW7600GR. Choices are obviously limited in the low-cost high-tech shortwave marketplace. The swapping of dual-conversion and ceramic filters for I/Q image-rejecting mixers and RC filters has merit when considering QRP usage. The Hellenized SRF-59 has a unique sound: warm, clean, and bass filled.

The Hellenized SRF-59 does great at program listening with a tuned loop (±RF amplifier): images were rare. The audio is tight, with fidelity being increased by offset-tuning. Sony did well with the AGC. DX tests and circuit optimization are ongoing. A SRF-59 displaces 9.7 cubic inches. The Hellenized SRF-59 represents a lot of shortwave listening "***bang for the buck***". You can now build a QRP Hartley image rejection low-IF shortwave radio with tuned loop antenna for $40. QRP amateurs, AM (LW/MW/SW) aficionados, and FM DXers may find use in modifying Sony's SRF-59.

Want to DX with less radio? My 2008 article named **Angelodyne** describes a new vacuum tube detector called a *regenerative plate detector*. Hear the world using a single frame-grid triode, modern 16-ohm earbuds, and non-lethal plate voltages. For details see the reference link below.

REFERENCE

just_rtfm@<NOSPAM>yahoo.com
http://home.comcast.net/~phils_radio_designs

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