WARC Newsletter

The Monthly Newsletter of the Wantagh Amateur Radio Club, Wantagh, Long Island New York — December 2004

Meeting Notice: **The next monthly meeting of the Wantagh Amateur Radio Club will be held at 8:00 P.M. on Friday, December 10th, at the Wantagh Public Library. This will be our annual holiday party, which will commence immediately after the business meeting. Members are requested to bring cookies, cake, etc. to share with the participants.**

WARC GENERAL MEETING MINUTES – November 12th, 2004.

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Vic K2IY, president, opened the meeting at 8:20 PM.

Officers present:

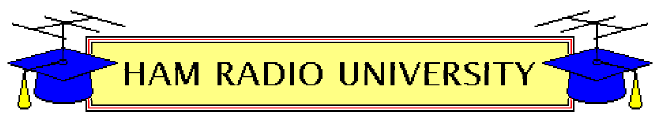
President:	**Vic**	**K2IY**
Secretary:	**Bill**	**N2RRX**
Treasurer:	**Chris**	**KC2FBW**
Directors:	**Vince**	**KD2EP**
	Frank	**N2RSO**

The minutes of the October meeting were accepted as read by the secretary, Bill N2RRX.

Treasurer's Report by Chris KC2FBW

Our current balance is $67.52

Continued on Page 2 ▸



FELLOWSHIP SERVICE KNOWLEDGE HRU 2005

Bethpage, New York - On Sunday, January 9, 2005 at 8AM, the doors of Briarcliffe College will open for the sixth annual Ham Radio University and the ARRL New York City/Long Island Section Convention. Ham Radio University 2005 is a day of education about Amateur Radio.

The event is being held at Briarcliffe College, 1055 Stewart Ave., Bethpage, NY. There will be special forums geared to the new ham as well as the experienced amateur radio operator. The focus will be "hands on" with many demon-strations.

Come to Briarcliffe College, Bethpage, Long Island, and learn about everything from satellite communications, low power operating using radios as small as a tuna tin and the latest in emergency communications. There will also be a VE session for those who would like to take an FCC exam and a Special Event Station set up and operational on HF.

Continued on Page 3 ►

INSIDE THIS ISSUE
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DX Report by Sid, K2LJH

Conditions generally continue to be poor. However, last weekend conditions were great for the contest. George Tranos, N2GA, gave a brief description of the band openings and the many contacts made over the weekend.

OLD BUSINESS:

Bellmore Fair Report

On Saturday morning our president, Vic, K2IY, and a few club members, set up a display table with printed materials from the ARRL for distribution. They also connected the "Rig-In-A-Box" and made several HF contacts using portable Hamstick dipole antennas. There were only a few passersby at the location, and our club was unable to achieve the publicity and interest that was expected. In future events, we plan to have several members on standby at their home QTHs, so that we can have an active demonstration with radio contacts as needed.

We then had a discussion about building up the club membership.

Nominating Committee Report

Ralph WP4KO reported the following slate of officers: Secretary, Treasurer, Vice-president and Director. Unfilled offices are President and two Directors. After much discussion, there were a few volunteers from the floor. The slate of officers as reported are: President – Vic, K2IY; Vice-President – Al, K2ES; Secretary – Bill, N2RRX; Treasurer – Chris, KC2FBW; Directors – Frank, N2RSO; Jack, KI2M; and Herman, W2TLC. A motion was made, seconded and passed to close nominations. The secretary was directed to cast one vote for each of the nominees, to which he complied.

Featured Speaker

Diane Ortiz, K2DO, the Public Information Officer for the ARRL, led a very informative interactive discussion on developing an information strategy to increase our club's membership. She had picked up our concerns during the meeting and used this as the focus of her presentation. She stated that we are doing some positive steps now, e.g., our website and newsletter are very good. We should now focus on our strengths: having an operational radio at meetings, and promoting interest in HF. She mentioned that assistance with flyers was available from ARRL. A more detailed report will follow next month.

NEW BUSINESS:

ANNOUNCEMENTS

Sid K2LJH reported that Lew, W2BIE, is much improved and hopes to be home by Thanksgiving. He also gave a brief overview of the new BPL regulations, which leave a lot of interference questions unanswered and unaddressed.

George Tranos, N2GA, briefly discussed Ham Radio University 2005, which will be held January 9th 2005 at Briarcliff College in Bethpage. He also distributed flyers for the event.

Respectfully submitted,

Bill N2RRX, Secretary ♦

HRU 2005 is sponsored this year by the Long Island Mobile Amateur Radio Club (LIMARC) in conjunction with the Briarcliffe College Amateur Radio Club and is a cooperative effort between over twenty clubs and organizations in the New York City- Long Island area. Besides the forums, there will be tables set up with information about different organizations and clubs including the Red Cross, Salvation Army, National Weather Service, Friends of Long Island Wireless, as well as ham radio classes, local FCC exam schedules, public service and other activities.

Join in for a day of fun and education for the whole family! Admission is open to all - donation is $2 per person. (Refreshments will be available)

For more information contact:
George Tranos N2GA, HRU 2005 Chairman / ARRL NYC-LI Section Manager
N2GA@arrl.org -or- by telephone at 631-286-7562

Check the website for updates and forum information: http://www.hudson.arrl.org/nli

Section Manager Election Results

In the New York City/Long Island Section, George Tranos, N2GA, of Bellport, was re-elected to a new term of office when he received 534 votes, and his opponent, Steve Barreres, K2CX, received 351. George Tranos has held the SM position since April 1998.

The Web Site of Adam Farson, VA7OJ/AB4OJ.

This month's "editor's choice" for the most interesting and informative ham radio web-site Is http://www.qsl.net/ab4oj, published by Adam Farson. Please visit his home-page for additional information.

The following article, "Automatic Antenna Tuners & Couplers" is reprinted with kind permission from the author, Mr. Adam Farson, VA7OJ/AB4OJ, from North Vancouver, BC, Canada. The original article appears on his web-site at http://www.qsl.net/ab4oj/ .

Mr. Farson, a retired telecom engineer, was First licensed as ZS1ZG in 1962 – (visit SARL site). His First steps in Ham Radio were with military surplus and homebrew equipment. He is active on HF: 80 through 10 meters SSB/CW ; 6m: SSB/FM - visit UKSMG site; and 2m/70cm: FM You can view his current shack at http://www.qsl.net/ab4oj/myhouse/myhouse.html#SHACK .

Automatic Antenna Tuners & Couplers

by Adam M. Farson VA7OJ/AB4OJ

1. Introduction and Purpose

The purpose of an automatic antenna tuner (auto-tuner) is to transform (match) a complex load impedance to 50Ω resistive, and to maintain the matched condition automatically as the operating frequency and load impedance vary.

This will assure optimum RF power transfer, correct transmitter LPF termination and best PA linearity *(Ref. 1)* over a reasonably wide range of transmit frequencies and load-impedance variations.

The automatic antenna tuner receives band/frequency information either from the associated transceiver, or by measuring the RF drive frequency. The actual tuning operation is controlled by detectors at the input to the matching network. These detectors provide information on the matching condition to the control electronics, which adjust the matching-network constants to achieve the required match.

Automatic antenna matching systems, once found exclusively in exotic military and commercial HF equipment, are now commonplace in affordable amateur-radio gear.

2. The two basic tuner types

- T-network tuner with limited matching range
- Π/L-network coupler with wide matching range

2.1 The T-network tuner: In its simplest form, this tuner consists of a T-network with capacitive (C) series arms and an inductive (L) shunt arm. The T-network tuner normally has a coaxial input and output, and is designed for connection to a coaxial feedline. Its matching range is usually limited to a maximum VSWR excursion of 3:1 (16 ~ 150Ω resistive) to 50Ω resistive.

2.2 The Π/L-network coupler: This type of tuner consists of a switchable Π-network with capacitive shunt arms and an inductive series arm. The input is connected via a 50Ω feedline to the transceiver, and the output via a short single-wire feeder to the feed-point of the radiator. To increase the matching range, the network can be switched from a Π to an L topology by switching out the output shunt capacitance.

This type of coupler is intended to match random-length radiators such as whips and long-wires to 50Ω resistive. It can accommodate complex loads with a very wide impedance range, from tens (λ/4) to thousands of ohms (near λ/2). The limiting case is λ/2.

3. T-network tuner considerations

3.1 Capabilities, limitations and expectations: As mentioned in 2.1, the T-network tuner is intended to match loads having a maximum VSWR excursion of 3:1 (16 ~ 150Ω resistive) to 50Ω resistive. It is designed to match near-resonant antennas such as LPDA's, multi-band verticals, tri-band beams etc. The T-network design does not have the matching range to accommodate random-length mobile whips or wire antennas, or non-resonant doublets fed via balanced line. We cannot simply connect our ladder-line-fed 80m doublet, 40m long, to a T-network auto-tuner via a 4:1 balun and expect it to tune all bands.

3.2 T-network topology: It is not our intent to go into the mathematics of these networks; there is an excellent T-network tuner simulator on the Web, which displays L and C values (and insertion loss) for any combination of load impedance and frequency.

Typically, the capacitive (C) series arms are air-variable capacitors driven either by DC servomotors or by stepper motors. Relay-switched fixed capacitors are switched in parallel with the variable capacitors as required, to extend the matching range.

In some low-power portable designs, a series of relay-switched fixed capacitors arranged in a binary or 1,2,5 sequence takes the place of the motor-driven variable capacitors. To conserve primary power, latching relays are used throughout the tuner.

The inductive (L) shunt arm consists of a tapped inductor with a relay contact connected between each tap and chassis ground. Each relay closure corresponds to a particular band or frequency range, and shorts a part of the inductor (more turns shorted for higher frequency and vice versa.) The inductor usually consists of ferrite-cored toroids for the lower bands, and air-wound coils for the higher bands; the relay contacts are connected to the junctions between coils. Some designs utilise a motor-driven wafer-type rotary shorting switch instead of a series of relays. (Portable low-power equipment uses latching relays to conserve primary power.) A motorised roller-inductor is used in some higher-powered tuners.

3.3 Minimum practical match: Most modern solid-state transmitter PA's start to reduce output for load VSWR > 1.5:1. This feature is known as *foldback SWR protection.* Accordingly, the ability to match down to VSWR < 1.5:1 is a design objective of every automatic antenna tuner. Manufacturers' specifications usually state the minimum match point as VSWR < 1.2:1.

3.4 Tuning time: This varies with the design of the tuner; typical values are 1 ~ 5 sec. to reach the match point after selecting a new band, and < 1 sec. to rematch after an in-band QSY.

3.5 Internal and external (accessory) versions: Many modern solid-state HF amateur transceivers, and almost all current solid-state HF amateur linear amplifiers, incorporate an integral T-network auto-tuner. In addition, external T-network tuners are available as accessories for transceivers not fitted with an internal tuner. These units receive band-selection data from the associated transceiver. Some models cover HF and 6m.

3.6 Power rating, insertion loss and power dissipation: Typically, an internal auto-tuner as fitted to a transceiver or amplifier is rated at the parent equipment's output. An external accessory auto-tuner is rated at 100 to 150W CW or PEP. It is obvious that the network components in a tuner for a 1 kW amplifier will be much larger, and considerably more expensive, than those in a 100W transceiver's internal tuner. ***Note:*** *When transmitting into a load which presents VSWR > 2:1 to the auto-tuner, it may be necessary to de-rate the tuner to avoid overheating. This is especially true of "key-down" modes such as CW and RTTY.*

The insertion loss of the T-network when matched is typically 0.5 to 1 dB (6.25 to 12.5% of input power). The auto-tuner compartment of a solid-state HF amplifier is fitted with a cooling fan, as 0.5 dB insertion loss equates to 125W dissipation in the T-network at 1 kW output to the load.

The insertion loss when not matched will be higher; increased RF currents in the L and C elements, and higher RF voltages across capacitors, will yield higher losses. These will increase the power dissipation in the network. For this reason, the tuner should be designed (and allowed) to match as close as possible to unity VSWR.

3.7 The T-network tuner as receiver preselector: In most current HF amateur transceivers, the auto-tuner is in the RF signal path on receive as well as transmit. Furthermore, if the tuner in a solid-state amplifier is enabled, it will be in the RF signal path in operate and standby modes. The T-network will contribute some additional RF preselection to the receiver front end. This is especially true in the case of an amplifier; to reduce insertion loss, the inductor Q in the high-power auto-tuner is quite high. (Note: The transceiver's auto-tuner should always be disengaged when driving a solid-state amplifier.)

3.8 T-network tuner control methods: In an automatic T-network tuner, three RF circuit elements must be controlled; the shunt L arm and the two series C arms. As mentioned earlier, control of the L value is fairly simple in an amateur application; we select the correct L tap for the band in use. Band information from the transceiver is decoded to set the bandswitch or relay group to the correct tap. In some designs, the band information will cause fixed capacitance to be added to the C arms to cover lower bands.

A servo (feedback) loop controls the series C arms. A detector at the T-network input passes error voltages to the servo controller. The controller, in turn, drives the tuning –capacitor motors or capacitor-bank selection relays. The tuning process commences when initiated by the operator, or when VSWR > 1.5:1 (typically); it continues until the error-voltage outputs of the detector fall to zero. At this point, the servo controller stops the tuning process. The loop time constants are chosen for optimum damping without overshoot.

Some automatic T-network tuners support dynamic tuning (re-matching automatically when load VSWR exceeds 1.5:1 or 2:1); other designs require the operator to initiate a new tuning cycle (static tuning).

3.8.1 Detectors: Most T-network auto-tuners employ a reflectometer (VSWR detector) and a phase detector *(Ref. 2)* at the network input. Each detector supplies an error voltage. The optimum matching point (both error voltages zero) corresponds to VSWR = 1.0:1 and RF voltage & current in phase. One design uses a reflectometer and a return-loss bridge. It initiates coarse tuning with the reflectometer, and then switches in the return-loss bridge for fine tuning. An HF discriminator embodying |Z| and phase detectors is also encountered. (Ref. 2, p. 595-6).

A minimum RF power input is required to ensure that the detectors develop a sufficiently high error voltage to allow accurate matching. This is typically 5 ~ 10W for a 100W auto-tuner, and at least 75W for a 1 kW tuner.

4. The Π/L-network coupler

4.1 Capabilities, limitations and expectations: As mentioned in 2.1, this type of coupler is intended to match random-length radiators (such as whips and long-wires) to 50Ω resistive. It can accommodate complex loads with a very wide impedance range, from tens (λ/4) to thousands of ohms (near λ/2). The limiting case is λ/2; in fact, the coupler will not match an exact half-wavelength or multiple thereof.

The Π/L automatic antenna coupler is designed to be installed in close proximity to the feed-point of the antenna radiator, and connected to that point via a short single-wire feeder*. It is not intended to match a near-resonant antenna fed via a coaxial feedline. The coupler can also be configured to match symmetrical antennas such as non-resonant doublets fed via balanced line. This will require floating the coupler above RF ground, and decoupling its RF feedline and power/control cables using RF chokes.

When a Π/L coupler feeds an asymmetrical random-length antenna, it is imperative that the coupler's "cold" (RF ground) terminal be connected to a good ground or counterpoise system. In vehicular, shipboard or aeronautical installations, the ground terminal must be bonded to the chassis or to a substantial metallic part of the structure.

Note: As the feeder forms part of the radiator, it must be as short as practicable.

4.2 Π/L network topology: Typically, the input and output shunt C arms consist of a series of relay-switched fixed capacitors; the series L arm is a tapped inductor with relay-switched taps. The relay contacts short out one or more sections of the inductor as required. The inductor is often made up of ferrite-cored toroids for the lower frequency range, and air-wound coils for the upper frequency range; the relay contacts are connected to the junctions between coils. The network covers the entire 1.8 ~ 30 MHz HF range continuously; some designs cover 1.8 to 60 MHz. High-power couplers often incorporate a motorised roller-inductor.

To extend the frequency coverage and impedance-matching range, either the input or the output shunt C arm can be switched out, thus reconfiguring the Π network as an L network. In a typical design (the SGC SG-230), a total of 26 network-component selection relays provide a network having 64 values of input shunt C, 32 values of output shunt C and up to 256 values of series L. *(Ref. 3, p.40)* View the block diagram of a typical SGC coupler.

4.3 Minimum practical match: Manufacturers' specifications usually state the minimum match point as VSWR < 2:1. Read these antenna-coupler FAQ's.

4.4 Matching time: Random set time (key-up to "Tuned" signal): 2 ~ 4 sec. Recurrent set time (rematch): < 10 msec.

4.5 Power rating, insertion loss and power dissipation: Π/L automatic couplers are available from various manufacturers with power ratings ranging from 5W to 500W. The insertion loss of the matching network when matched is typically 1 dB.

The insertion loss when not matched will be higher; increased RF currents in the L and C elements, and higher RF voltages across capacitors, will yield higher losses. These will increase the power dissipation in the network. For this reason, the coupler should be designed (and allowed) to match as close as possible to unity VSWR.

The Icom AH-4 inserts an attenuator ahead of the matching network, to prevent "hot-switching" of the network relays and minimise radio interference during tuning. This coupler also shuts down its microprocessor when tuning is complete, to eliminate EMC problems.

4.6 Π/L automatic coupler control methods: In a Π/L automatic coupler, three RF circuit elements must be controlled; the input and output shunt C arms and the series L arm. As the coupler does not receive explicit frequency data from the transceiver, the coupler's microprocessor controller counts the frequency of the RF signal applied to the input. The frequency information, and error signals from detectors at the network input, are passed to the controller. The controller, in turn, sets the L and C selection relays in the matching network, configuring it in Π or L as required. *It also controls the roller-inductor drive motor (if fitted).*

The tuning process commences when initiated by the operator, or when VSWR > 2:1 (typically). The controller sets up successive L/C combinations in accordance with a matching algorithm, as a function of RF signal frequency. This process continues until the error-voltage outputs of the detectors fall to zero. At this point, the servo controller stops the tuning process, and signals the operator that tuning is complete. These settings are held pending subsequent changes in frequency and/or load parameters.. For a more complete description, read *Ref. 3*, p. 41.

When RF is re-applied to the coupler in a new transmission, the coupler checks the frequency and load parameters, and initiates a new tuning cycle if required.

4.6.1 Detectors: As well as a frequency counter, a typical Π/L automatic coupler utilises a reflectometer (VSWR detector), an impedance bridge (load impedance detector) and a phase detector *(Ref. 2)* at the matching-network input. Each detector supplies an error voltage to the controller. The optimum matching point (both error voltages zero) corresponds to VSWR = 1.0:1, 50Ω resistive load impedance and RF voltage & current in phase.

4.7 Physical construction and installation of Π/L coupler: As the Π/L automatic antenna coupler is designed to be installed in close proximity to the antenna feed-point, its electronics are enclosed in a weatherproof, high-impact plastic housing. The housing is sealed with watertight cover gaskets and cable-entry fittings; in some cases, an internal desiccant pack is provided. The RF output terminal is mounted in a large, ribbed ceramic insulator. ***Very high RF voltages can appear at the coupler output, particularly when feeding radiators whose electrical length approaches λ/2.***

The output terminal is connected to the antenna feed-point via a single-wire feeder. This feeder forms part of the radiating system, and should thus be as short as practicable and kept clear of any metallic object. The 50Ω coaxial feedline and power/control cable are brought back to the transceiver location. Ferrite RF chokes may be fitted to the cables at the coupler end, as required.

For further protection from a hostile environment, manufacturers recommend mounting the coupler undercover - for example, under a hood, in the trunk of a car, or on an inside bulkhead closest to the antenna feed-point in marine applications.

Ref. 3 offers a wealth of installation information. Although SGC-oriented, much of the material is applicable to any coupler.

5. Tuner control schemes

5.1 Historical development: Early automatic T-network antenna tuners used analogue circuits (operational amplifiers, comparators and servomotor driver amplifiers) to translate the error signals received from the VSWR and phase detectors into variable voltages which drove the two tuning-capacitor motors. Starting at a default setting initially preset by the operator, the motors turned until the correct matching point was reached (error-signal voltages = 0). Any change in frequency (within a band) or load impedance initiated retuning. Band selection was accomplished by manual bandswitching, or via band data received from the transceiver. The band data set the band-selection relays, or the third (bandswitch) motor, to the correct inductor tap. Examples of this type of tuner are the Icom AT-150 and AT-500.

An automatic antenna-selection switch, programmable by band, was an attractive feature of many of these auto-tuners.

Early Π/L-network couplers, initially developed for military applications, employed servomotor-driven vacuum variable capacitors and roller-inductors, controlled by analogue circuitry receiving error signals from a reflectometer and phase detector at the coupler input, as discussed in Section 4 above.

5.2 Microprocessor control: The next step was to replace the analogue controller with a microprocessor. The detector error signals drove analogue/digital converters (ADC's) which, in turn, fed data to the processor. Digital/analogue converters (DAC's) converted digital output data from the processor into analogue signals which drove the servomotors. (Example: Icom IC-765). In later and current designs, stepper motors and their associated drivers have replaced the DAC/motor driver/DC motor combination. The microprocessor also translates band data from the transceiver into coil-tap relay settings. (Example: Yaesu VL-1000 HF/6m amplifier). The processor stores each new match point in memory, and retunes the tuner settings to the match point closest to the selected frequency range.

5.3 Internal vs. external tuners: Most popular amateur HF transceivers are now fitted with an internal automatic T-network tuner. As a result, the demand for external tuners has declined in recent years. Despite this, many excellent external units are available on the used market.

An internal tuner receives DC power, RF drive and band data from the transceiver in which it is mounted. An external tuner requires 12V DC (or mains) power, RF drive and band data from the transceiver to which it is connected. The band data protocol is proprietary; Icom uses a 0 ~ 8V analogue band-setting voltage, whilst Yaesu and Kenwood use a 4-bit binary code.

External accessory automatic tuners for the Icom IC-706 series (IC-AT180), Kenwood TS-50 (AT-50) and Yaesu FT-100D (FC-20) are current products.

5.4 Protective features: In a solid-state HF linear amplifier with internal T-network automatic tuner, a reflectometer is sometimes fitted at the tuner output. This circuit reports the VSWR at the interface to the feedline. If VSWR > 3:1 (as in the case of a sudden antenna failure), the reflectometer will force the amplifier off-line, thus preventing any possible damage.

6. Conclusion

6.1 When should I use an automatic antenna tuner or coupler? A T-network automatic tuner is appropriate when the antenna system's maximum VSWR excursion in any band is 3:1 or less. A Π/L-network automatic coupler, mounted at the antenna feed-point, is ideal for automatic matching of random-length (non-resonant) wire or vertical antennas over a wide frequency range (1.8 ~ 30 MHz).

6.2 When am I best off with a manual antenna tuner? A manual T-network tuner may be most suitable when matching a non-resonant wire antenna such as a doublet or loop with a balanced-line feeder (open-wire or ladder line) over a wide frequency range. A balun is required to interface the balanced line to the unbalanced T-network output; a balanced tuner is an alternative.

6.3 Cascading internal and external tuners: a “no-no”! A transceiver's or amplifier's internal auto-tuner ***must be disengaged*** when using an external tuner. Cascading tuners can reflect high reactance values back into the auto-tuner and/or LPF bank. As a result, dangerously high RF voltages can appear across capacitors in these networks, leading to component failure.

6.4 Do I need to use the transceiver's tuner when driving my amplifier? The answer is: "That depends..." When driving a solid-state amplifier or many grounded-cathode tube amplifiers, the exciter's internal auto-tuner should be disengaged. It is not needed, as these amplifiers almost always have a frequency-independent 50Ω resistive input impedance.

When driving a grounded-grid tube amplifier, the transceiver's auto-tuner will often yield a better match to the amplifier's tuned input networks, especially when operating an older "non-WARC" linear on 17 or 12 metres. As a general rule, the exciter's auto-tuner should be engaged if VSWR > 1.5:1 at the amplifier input.

6.5 Common misconceptions and problems surrounding automatic tuners:

- "I have connected a single-wire-fed inverted-L to my antenna socket, and my tuner won't tune." No, it won't; please remember the VSWR < 3:1 limitation referred to above.
- "I don't need to use the tuner, because my VSWR is only 2:1." Wrong, on 2 counts; firstly, the PA is folding back the output significantly when it sees a 2:1 VSWR*. Secondly, *Ref. 1* is quite emphatic about a 50Ω resistive load as a precondition for good PA linearity.
- "I installed my IC-706 Mk IIG and AT-180 in my van, and ran the coax back to a 102-in. whip at the rear. It doesn't tune." Wrong tuner type. You need to install an AH-4 in the rear of the vehicle, close to the antenna base, and remove the AT-180.
- "I have just engaged the tuner , but now my receiver is deaf as a post." Try pressing the [TUNE] button, or making a brief transmission to set up a match point at the frequency in use. You may be surprised at the result.

***In the unlikely event that the PA lacks SWR foldback protection, let's see a 2-tone test at full power into a 2:1 VSWR load on our spectrum analyser!*

7. References:

1. *"HF Radio Systems & Circuits", Chapter 12, Sabin & Schoenike, editors. Noble, 1998. View excerpt*
2. *"HF Radio Systems & Circuits", Chapter 15.*
3. *"SG-230 Smartuner Installation & Operations Manual", SGC Inc. Download Mirror*

8. Links

- Home
- Icom FAQ
- Icom America
- Yaesu USA
- Kenwood USA
- LDG Electronics Inc.
- SGC, Inc.

9. Acknowledgements

- *I am indebted to my good friend Matt Erickson KK5DR for encouraging me to write and post this article.*

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The WARC Newsletter, an official publication of The Wantagh Amateur Radio Club, is edited and published monthly by Frank Porcaro, N2RSO.

The Wantagh Amateur Radio Club meets on the second Friday of each month at the Wantagh Public Library. Directions to the library, along with notices of meeting changes, invited speakers, demonstrations, etc. can be found at the club's website at http://www.qsl.net/w2va/home.htm . Visitors, both hams and other persons interested in amateur radio, are invited to attend. Coffee tea and doughnuts usually are served after the business meeting and before any presentations from guest speakers.

Frank Porcaro, N2RSO, Editor