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THE MITCHELL LEE AMPLIFIER

TWO TUNER IMPLEMENTATIONS

Mark Connelly -- WA1ION DX Labs -- 22 MAR 1985

My recent article, "DX Lab. Test of the Mitchell Lee Loop Amplifier" (dated 25 FEB 1985) described tests.done on an amplifier circuit first described in the LWCA "Lowdown" of May 1984.

The WA1ION DX Labs version of this amplifier, dubbed FE-C, has its schematic & layout drawings in the 25 FEB 1985 article. A big advantage of the circuit is good dynamic range (freedom from overloading-generated-"spurs"). Further testing has indicated that the low-impedance (hereafter low-Z) input used in conjunction with a series inductance-capacitance (hereafter LC) tank has inherently better Q (selectivity) than that of a high-Z input of an FET amplifier (e. g. FE-A card) used with the same L & C in a parallel configuration. Results demonstrate that the FE-C is very useful for urban DXing.

A disadvantage of the FE-C is that the gain is lower than that achievable with high-Z input FET amplifiers. Recent experimentation has shown that broadband-amplification of the output can more than make up for the gain difference. The dynamic range AND gain of the FE-C followed by the BBA-B broadband amplifier is usually better than that of the FE-A FET-input front-end card. (For FE-A schematic, see Article 1 of "RT-1 Remotely-Controlled Tuner" and for BBA-B schematic, see the "Mini-MWDX3 Phasing Unit" article.)

To minimise the possibility of overloading of the BBA-B broadband amplifier, a level pot should be placed between the FE-C RF-Out port and the BBA-B RF-In port.

Tests were done with two different tank-circuit implementations. The nature of these implementations and the pro's & con's of each are discussed later in this article.

Figure 1 shows the overall form of the tuner design using FE-C. RF from an antenna or another external (untuned or tuned) source is routed in through a DC-blocking capacitor to the arm of one section of a 3 or 4 pole/ 4-position rotary switch (the Mode / Length switch). The OFF/BYPASS position of this switch routes the tuner's RF input directly to the tuner's output. Another section of this switch disconnects battery power from the FE-C and BBA-B cards when in the OFF/BYPASS position.

The other three positions of the Mode / Length switch apply power to the two amp. cards, route the BBA-B output to the tuner's RF-Out jack, and route the RF input to the appropriate tank node. There are three tank-input nodes: one is intended for short aerials (such as a whip), another is intended for "normal" length aerials (e. g. between 33'/10 m. and 200'/60 m. at 1 MHz), and the third is for longer aerials such as Beverages. The low-Z output node of the tank goes to the input of the FE-C front-end.

The FE-C's output goes to the "top" (= CCW pin) of the 1K audio-taper Level Pot. The Level Pot's "bottom" (= CW pin) goes to the pot's built-in switch. This switch disconnects the pot's "bottom" from ground at the maximum-level (CCW) setting.

The arm of the Level Pot goes to the broadband amplifier card input. The BBA-B provides about 20 dB of gain. If overloading occurs (this is only really likely at urban sites), adjustment of the Level Pot can cure the problem.

/* OVERLOADING OF THE INPUT STAGE (FE-C) IS VERY UNCOMMON. */

If input-stage overloading does occur when using a wire antenna and when the Mode / Length switch is on SHORT or NORMAL, setting the Mode / Length switch to LONG will generally eliminate the spurious responses.

TANK IMPLEMENTATIONS

/* Implementation 1 */
Refer to Figure 2.

The high-Z tank node is at the stator of the tuning capacitor. This point coincides with the SH (short-length) tank-input node. The NM (normal-length) tank-input node is coupled to the high-Z node through 39 pF; the LG (long-length) tank-input node is coupled to the high-Z node through 10 pF.

The Q-switch selects high or low tank-circuit Q (selectivity). Low Q (using the 15K Q-spoiling resistor) is utilised ONLY IF THE TUNER IS BEING USED AS AN INPUT TUNER IN A PHASING SYSTEM. The Low-Q position causes considerable degradation of overall tuner gain.

The heart of any tank-circuit is the inductor / capacitor combination. This tank uses a series L-C configuration. The Freq. Range switch selects one of 11 internal moulded inductors or an external coil. The external coil can be a (ferrite or air-core) loophead intended to pick up signals on its own or it can be a non-signal-catching inductor used to provide wire-tuner operation on bands not covered by the internal inductors. The 11 internal inductors allow the tuning & amplification of signals from a wire or other external source over an approximate frequency range of 150 to 7500 kHz. The "APT-3 Regenerative Tuner" article (IRCA / NRC reprint) has a table giving approximate frequency ranges that can be expected with each inductor (as the APT-3 uses a similar Freq. Range switch).

The low-Z tank-output node is at the side of each inductor which does not go (via switch) to the tank's high-Z node.

Advantages of Tank Implementation 1

* Tuning capacitor has a grounded side. This simplifies mechanical design considerably. No hand capacitance occurs when the tuner is assembled in a metal box. (Rotor node is bolted to chassis box.)

* Inductive-division is not necessary: This permits the use of a 1-pole / 12-position rotary switch as the Freq. Range switch. As a result, 11 ranges (plus the external coil) may be accommodated. Frequency coverage with this scheme includes longwave, medium wave, and tropical bands.

Disadvantages of Tank Implementation 1

* Coupling via the LG (long) tank-input node is very loose and is, therefore, inefficient (lossy). Those using wires much longer than (75 / F (MHz)) ft. will realise considerably more tuner gain if they use Tank Implementation 2 (to follow) when the Mode / Length switch is set to LONG.

/* Implementation 2 */
Refer to Figure 3.

An important difference from Implementation 1 is that, rather than using fairly loose capacitive coupling to the high-Z tank node, Implementation 2 utilises a tighter coupling method for normal and long antennae.

Implementation 2 connects the rotor of the tuning capacitor to a low-Z NM & LG node tank-input (rather than directly to ground) when the Mode / Length switch is set to NORMAL or to LONG. An added (fourth) section of the Mode / Length switch is employed to set up a SHORT length condition of the Implementation 1 type, a NORMAL condition using a capacitive-divider approach, and a LONG length condition using an inductive-divider approach.

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The NORMAL condition shunts the antenna with 560 pF to compensate for a variety of antenna capacitances above 75 pF (the maximum suggested "SHORT" input capacitance). The LONG condition uses a L-divider with a ratio of approximately "Lmain" = 6 * "Ltap" to allow a medium degree of coupling of input sources having low to medium inductance or resistance. Resistive input loading is used if the Mode / Length switch is on LONG and if the External Coil is selected by the Freq. Range switch.

Q-spoiling (when needed for phasing applications) is accomplished by the same method used in Implementation 1.

In Implementation 2, neither side of the tuning capacitor is "hard-grounded". The rotor of an air-variable capacitor has a larger surface area than the stator; therefore, its inherent capacitance to ground is higher. For this reason, the rotor is connected to the lower impedance circuit point.

Five positions of the Freq. Range switch are used to select internal pairs of inductors. The values shown cover medium wave (450 to 2000 kHz). Longwave (140 to 640 kHz) coverage may be obtained by multiplying all inductor values by 10. Tropical-bands (1400 to 6400 kHz) coverage may be obtained by dividing the inductor values by 10. All inductors shown have standard industry values for miniature moulded inductors manufactured by Mouser, Dale, Delevan, Mytronics, JW Miller, Caddell-Burns, Coilcraft, and numerous other vendors.

Advantage of Tank Implementation 2

* Better performance (more efficient coupling) of aerials of medium to long length and of low-Z input sources. This is decidedly the better tank-circuit implementation for those using Beverages.

Disadvantages of Tank Implementation 2

* Tuning capacitor must "float" (= neither side is permanently grounded). This increases the difficulty of assembling the tuner and it increases the size of the chassis box to be used.
* Greater susceptibility to input-stage overloading at urban sites.
* A double-wafer (4-pole / 4-position) switch must be used for the Mode / Length switch.
* Only 5 frequency ranges plus the external coil may be accommodated with a normal-size single-wafer rotary switch. A double-wafer (2-pole / 12-position) and 22 (rather than 11) inductors would be required to obtain the same frequency coverage as that of Implementation 1.

CONCLUSION

The Mitchell Lee amplifier, adapted & modified to be the FE-C card, is a very useful front-end design because of its high dynamic range and lack of inherent Q-spoiling. When followed by a level pot and the BBA-B Broadband Amplifier card, a tuner of considerable merit results.

Numerous tank-circuit implementations may be used -- two have been presented in this article. The tank design should be optimised for the DXer's specific needs. Tank design is largely governed by the most-frequently-used type of input (e. g. shortwire, longwire, output of another tuner, etc.) and by the operating frequency range desired.

-end-

(Figures 1, 2, & 3 to follow)

FIGURE 1 GENERAL FORM OF TUNER

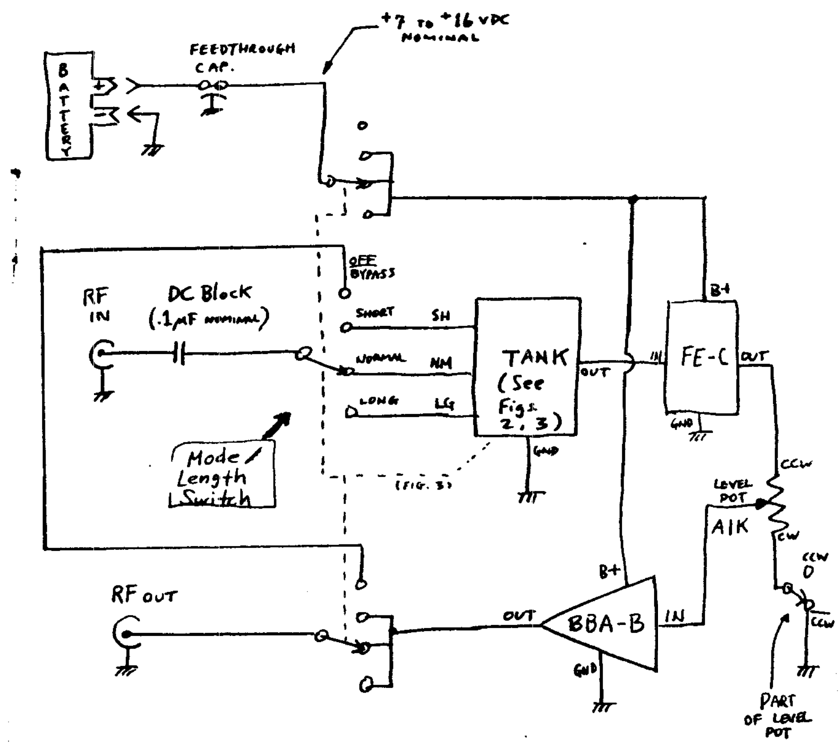

FIGURE 2 TANK : "IMPLEMENTATION 1"

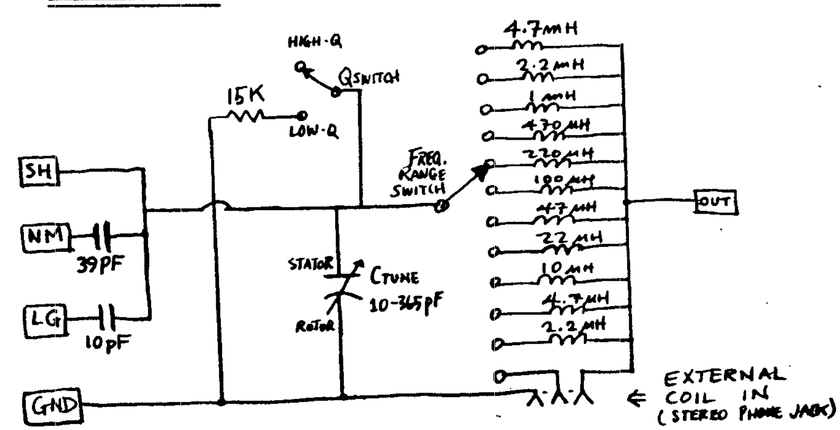

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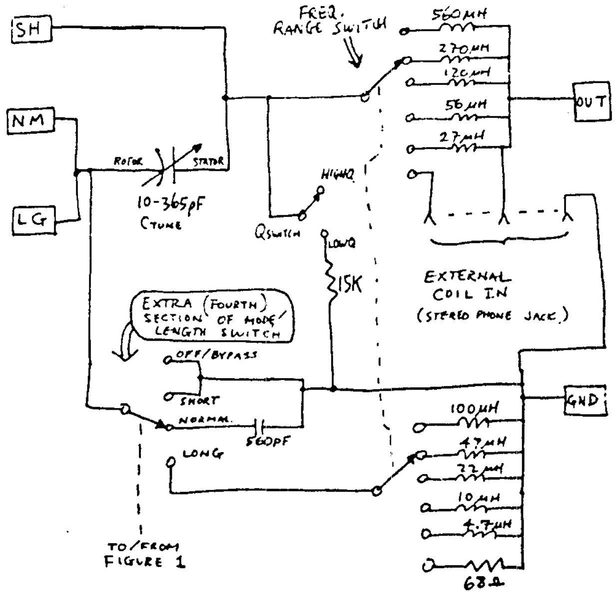
FIGURE 3 TANK: "IMPLEMENTATION 2"



Book Reviews

25 Simple Tropical and MW Band Aerials

25 Simple Shortwave Broadcast Band Aerials

by E.M. Noll

These two pocket sized books contain quite a bit of antenna theory. Indoor and outdoor antennas are covered in detail. A general purpose introduction gives Time Zone information, tips for antenna tuner use, reception patterns, band frequencies, wavelength calculations, grounding schemes and impedance values. The first book is intended for BCB and the 49/60/75/90/ and 120 meter bands and contains the following: quarter wave dipole, quarter wave vertical, inverted dipole, cross-inverted dipole, unlike-segment dipole, longwire vertical helix, longwires, three-quarter wavelength, vee-beam, MW vertical ladder, closed horizontal loop, open horizontal loops, double open-loop, little squared Rhombic, space saving dipole, indoor tropical longwire, indoor tropical open loops, MW quarter wave aerials, MW and LW longwires, basic Beverage, MW attic ladder and active aerials. The second book describes: dipole, quarter wave verticals, sloping dipole, uneven-leg sloper, inverted dipole, uneven-leg inverted dipole, inverted vee three halves wavelength, helical vertical, random wire and tuner, end-fed wavelength aerial, cheap quarter wave vertical, umbrella vertical, 11 and 13 meter quarter wave special, triangles, tilted three halves wavelength, vee-beam areials, two in-phase verticals, end-fire 180 degree verticals, end-fire 90 degree vertical, dipole and parasitic reflector, parasitic director, and Ed Noll's Australia/Spain Special antenna.
These handy references can be obtained from the author at the address below for just $5.00 for each book (which includes first class postage, PA residents must add state tax).
Edward Noll, Box 75, Chalfont, PA 18914.

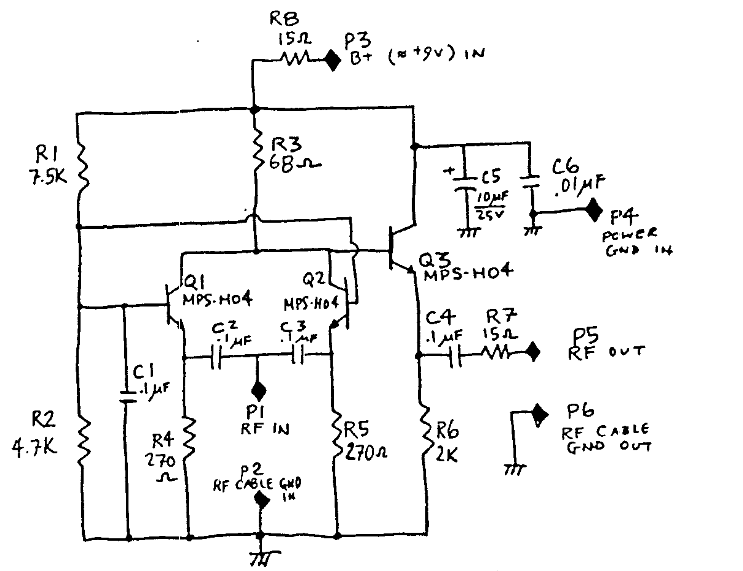
EQUIPMENT REVIEW

DX Lab. Test of the Mitchell Lee Loop Amplifier
(with comparison to a high-Z FET-input front-end)

Mark Connelly -- WA1ION DX Labs -- 25 FEB 1985

The May 1984 issue of "Lowdown" contained an article by Mitchell Lee on a low-impedance-input 3-transistor amplifier designed to be used for series-tuned loops. The main advantage of this design was stated to be good dynamic range (freedom from overloading / spurious-signal generation). A slightly-modified version of this design was built here at Billerica. It's been dubbed FE-C (Front-End card, version C). FE-A is the FET-input amp. (used in the RT-1 Remote Tuner project) against which FE-C was compared; FE-B is the regenerative front-end used in the APT-3 regen. tuner. Figure 1 (schematic) and Figure 2 (component roadmap) illustrate the FE-C version of Mitchell Lee's loop amplifier.

Figure 1: FE-C schematic



The purpose of the testing was to judge the low-Z input FE-C's performance against that of the FE-A (which uses the traditional high-Z-FET-input / parallel L-C tank approach). Factors considered included gain, noise, and spurious signal occurrences in the presence of potent local stations WRKO - 680, WHDH - 850, WBZ - 1030, and WMRE - 1510. In addition to loop operation, the use of each front-end in random-wire-tuning applications was evaluated. The schematic of the FE-A card is included in Figure 3 for reference.

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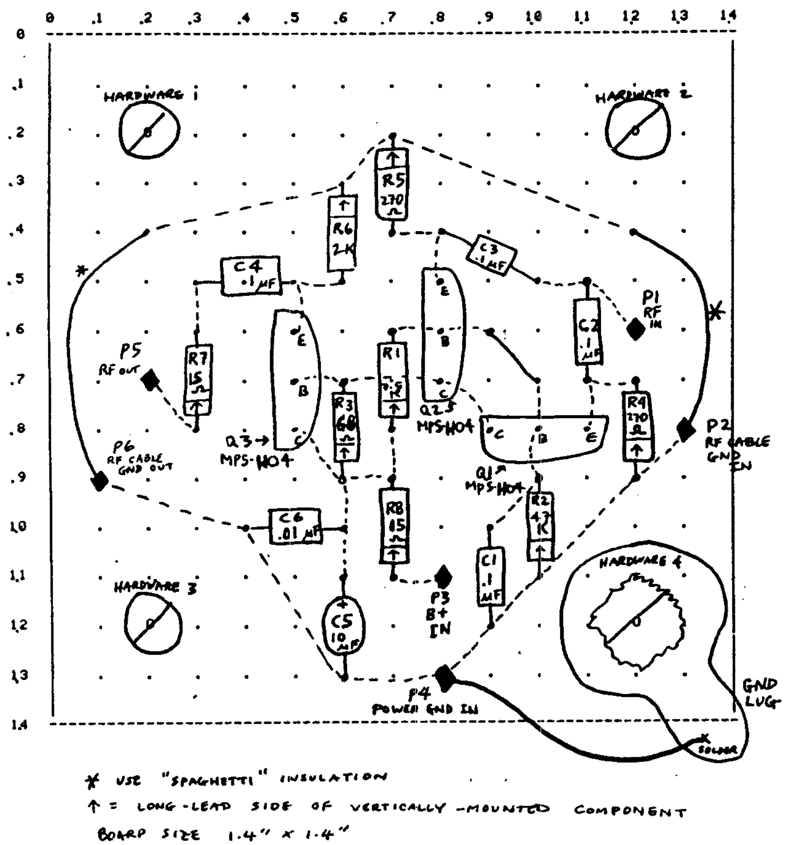
Figure 2: FE-C component roadmap



The input tuning configurations tested are shown in Figures 4a through 4g. The tuning capacitor's rotor, indicated by the curved line, is grounded (whenever possible) or is tied to a low-Z point so that hand-capacitance-detuning is eliminated, even in high-Q tuning usages. Each figure has accompanying text describing its purpose. In each figure, two points are identified by a number within a diamond; we'll call them Node 1 and Node 2.

The RF input pin (P1) of the FE-C card was tied to Node 2 of each figure for its test. Node 1 did not connect directly to the card; rather, as each figure shows, it was connected via the main tank coil to Node 1.

For FE-A card tests, FE-A card input pin P1 was tied to Node 1 of each figure; Node 2 was connected to ground.

If these tuning configurations were to be used as passive tuners, Node 2 would be tied to the receiver (or broadband-amp.) input and also to the "top" of an added tap (inductive-divider) coil of inductance approximately 15 % of that of the main tank coil. The "bottom" of the added coil would be grounded. (Passive tuner tests were not done in this evaluation project.)

Figure 3: FE-A schematic

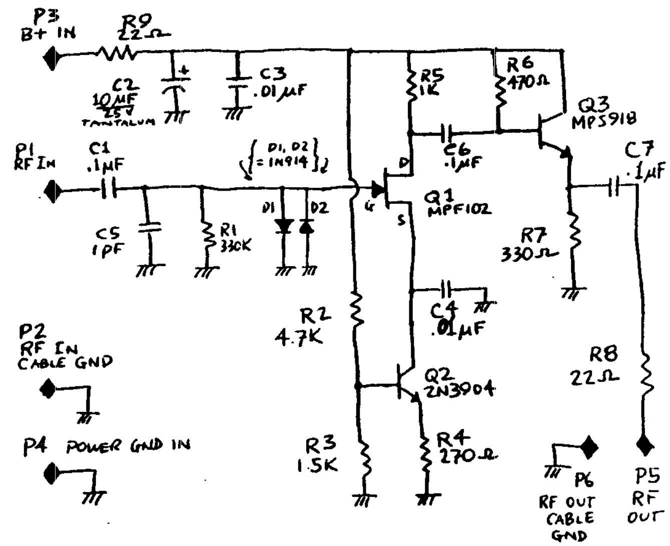


Figure 4a

Loop

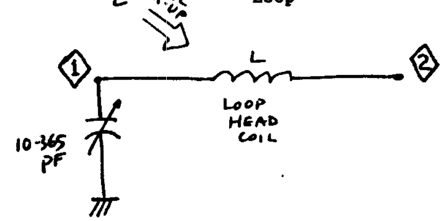
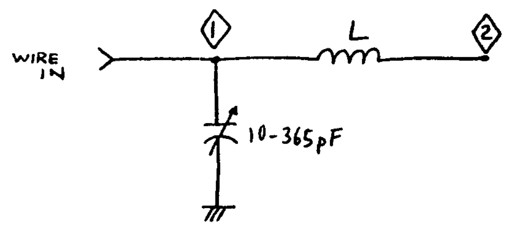


Figure 4b

Wire Tuner for antennae having effective capacitance less than 50 pF or effective inductance greater than 4*L (where L is the value of the main tank coil). /* TYPICAL "SHORTWIRE" TUNER */



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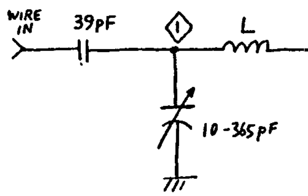
Figures 4c and 4d

Wire Tuners for antennae having effective capacitance between 50 pF and 500 pF. /* TYPICAL "MEDIUM-LENGTH WIRE" TUNERS */

4c



4d

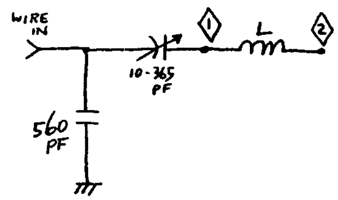
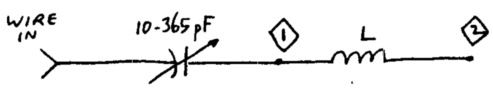


Figure 4e

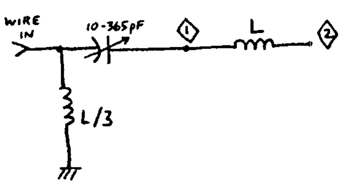
Wire Tuner for antennae having effective capacitance greater than 500 pF or effective inductance less than L/4 (where L is the value of the main tank coil).



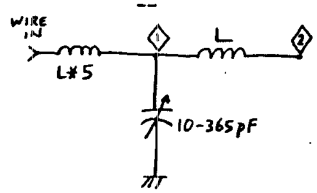
Figures 4f and 4g

Wire Tuners for antennae having effective inductance between L/4 and L*4 (where L is the value of the main tank coil).

4f



4g



Note: In figures 4a through 4g, Q-spoiling for phasing applications may be effected by switching in a 15K fixed resistor (or 25K pot) from Node 1 to ground. This is independent of the type of amplifier used.

Test Results

GAIN

The FE-A card gave consistently greater output level (approx. 10 to 15 dB in most cases). The output level of the FE-C still was substantially better than the level obtained by connecting the test longwire directly to the 50-ohm-terminated receiver input. The higher

gain afforded by the FE-A was sometimes unusable at this suburban QTH, however, because of spurious responses (see next item).

DYNAMIC RANGE

The FE-C amplifier clearly outshone the FE-A in this realm. It could handle a good deal more signal before producing spurious (off-channel) responses than the FE-A could.

NOISE

The FE-C was somewhat quieter than the FE-A; however, in light of the FE-C's lower gain, actual signal-to-noise on both front-end cards was about the same.

MISCELLANEOUS CONSIDERATIONS

The FE-C performed in a more stable manner with high-Q L-C tanks than the FE-A did: high-Z-input FET amplifiers are more likely to go into oscillation. Use of a pot of about 250 K or 500 K would cure the FET's tendency to oscillate (CCW of pot to Node 1, arm of pot to P1 input of FE-A, CW of pot to ground).

It seems that the FE-C is less likely to be "blown" during nearby thunderstorms.

FE-A has a slightly lower current draw (hence, longer battery life) than FE-C. FE-C operation at 8 to 9 volts DC did not appreciably differ from operation at the 12 volt DC level originally specified in Mitchell Lee's article.

Conclusions

In situations demanding high gain (e. g. physically small loop, short wire, or remote location far from cities), the FE-A would be the front-end card of preference. At urban locations and/or when a loop of efficient (high-pickup / high-Q) design is available, use the FE-C: chances are that the diminished gain will be more than offset by a welcome freedom from spurious signals. Extra gain, if required, can be supplied by a "crunchproof" broadband amplifier using a Motorola MHW- or MWA-series or TRW CA-series amplifier of the sort used in CATV line-amp. applications. These amplifiers require a "beefy" power supply (e. g. 24 V, > 60 mA); portable operation is unlikely. An amplifier suitable for use after either the FE-A or FE-C Front-End card is shown in Figure 5.

Figure 5

BBA-C High-Signal-Level Broadband Amplifier