
A NEW FEED SYSTEM FOR ARRAYS
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NEW FEED SYSTEM FOR ARRAYS
▪ Arrays on Low Bands often have all elements fed
▪ Not necessarily: see N7JW
▪ What is the best feed method?
▪ Easiest, “plug and play”
▪ Most flexible (optimized results)
▪ How much better ?
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PHASING ANGLE & LINE LENGTH

- In the past: phase delay = cable length
- IS WRONG (in most cases)

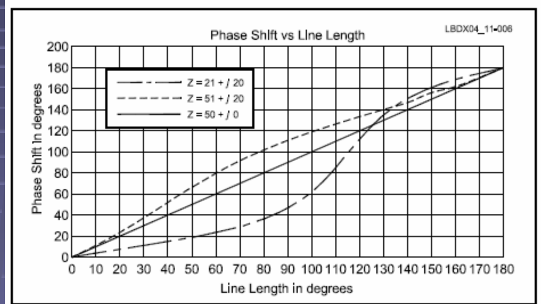


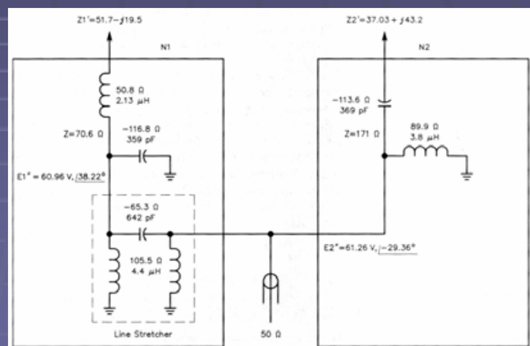
Fig 11-6—Graph showing the current phase shift in a 50-Ω line (RG -213, on 80 meters), as a function of the load impedance. The loads shown are those for a 2-element cardioid array. Note that the phase shift does *not* equal line length, except when the line is terminated in its own characteristic impedance!

BREAKTHROUGHS

- Forest Gehrke – K2BT- Ham Radio 1983
- W2CQH: the hybrid coupler QST Jan 1978

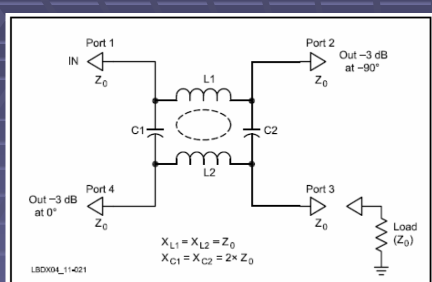
GEHRKE – K2BT METHOD

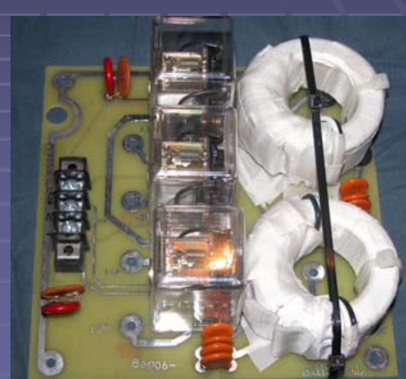
Gehrke, K2BT, has developed a technique that is fairly standard in the broadcast world.



Typical K2BT feed system for a 2-ement array

THE HYBRID COUPLER





(Commercialized by COMTEK)

OTHER SYSTEMS

- Many other systems e.g. **K3LC, W8JI (cross fire) etc.**

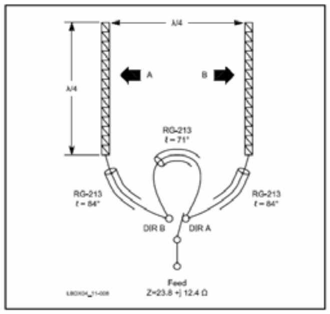


Fig 11-8—Christman feed system for the 2-element λ/4-spaced cardioid array fed 90° out-of-phase. Note that the two feed lines are 84° long (not 90°), and that the "90° phasing line" is actually 71 electrical degrees in length. The impedance at the connection point of the two lines is 23.8 + *j* 12.4 Ω (representing an SWR of 2.3:1 for a 50-Ω line), so some form of matching network is desirable.

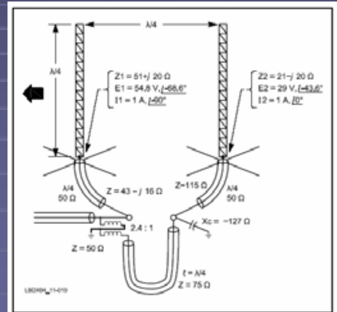


Fig 11-10—While all other feed methods feed the back element directly and provide phase delay via coaxial cable or a network to the front element, the cross-fire feeding system does the opposite. It makes uses of a 180° phase-inverter transformer to achieve a feed system that guarantees that the phase delay remain correct when the frequency is changed. See text for details.

W7EL's BREAKTHROUGH

- W7EL **current forcing**
  - Covered in great detail in ARRL Antenna book
  - Property of a quarter wave long feed line:

I(at ant) = E (at end line) / Zcable

  - I(at antenna) determines radiation (not E!)
  - E is easier to measure than I
  - So: measure E at the end of a ¼ wave line

NOW: FULL DESIGN FREEDOM

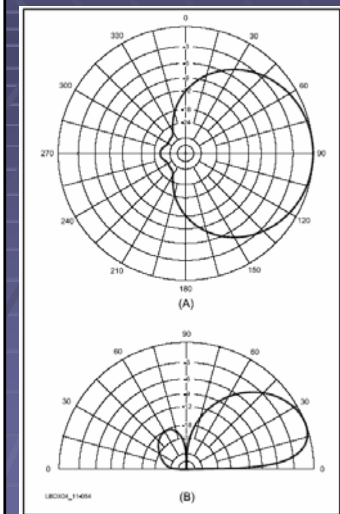
W7EL **L network** → **W1MK L network**

- Until now formulas available only for quadrature feed but with any feed current magnitude
  (Quadrature = in increments of 90 deg)
- **Now W1MK developed the mathematics that apply for any magnitude and phase angle**
- It really is a Gehrke equivalent (= FULL DESIGN FREEDOM) where all networks are combined in a single L network

WHY?

- Why do we want “any” magnitude and phase angle?
  - More design freedom for improved performance
  - Let’s analyze the well known 4-square array

OPTIMIZED VS. QUADRATURE

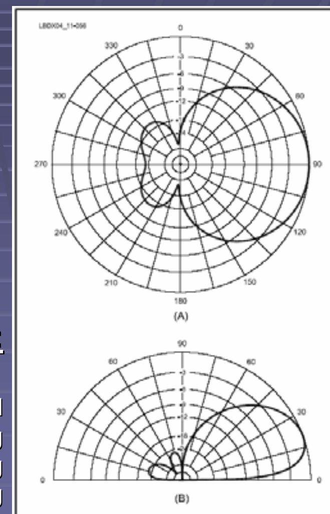


LEFT:

Quadrature feed with equal currents
Back:1A at 0 deg
Cntr: 1A at -90 deg
Frnt: 1A at -180 deg

RIGHT:

WA3FET feed
Back:1A at 0 deg
Cntr: 0.9A at -111 deg
Frnt: 0.872A at -218deg



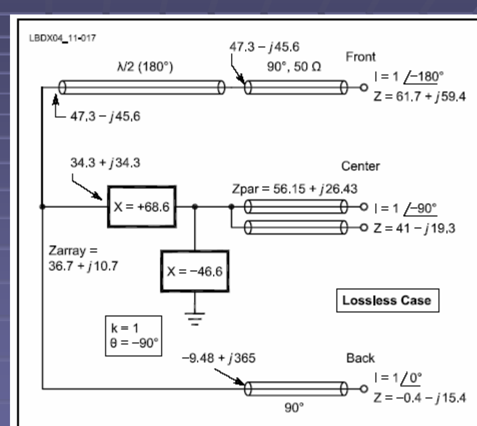
G = 6.7 dBi, RDF = 10.6 dB, DMF = 21.0 dB

G = 7.2 dBi, RDF = 11.4 dB, DMF 24.0 dB

QUADRATURE

Quadrature feed

Can be calculated with W7EL formulas from ARRL Antenna Book



Or you can use a hybrid coupler!

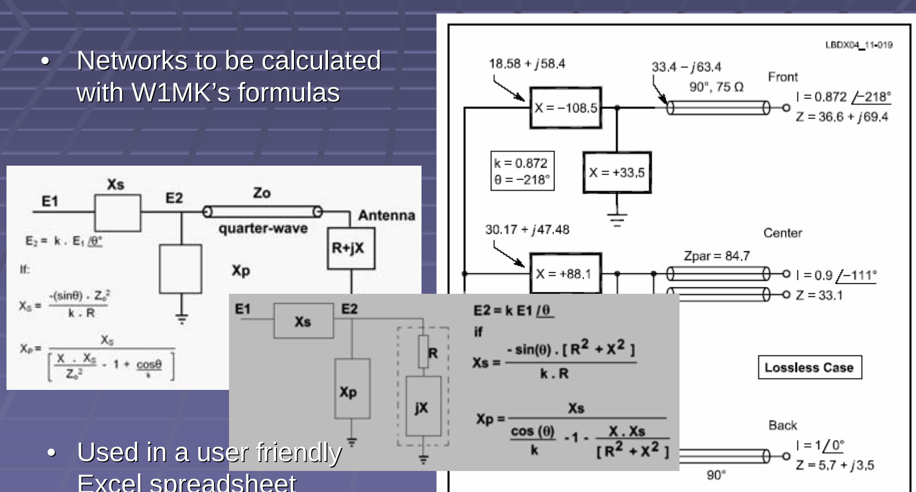
FULL FREEDOM

Odd phase angles (non quadrature)

- No calculation tool so far
- **Now the mathematics and a user tool are introduced by W1MK**

WA3FET OPTIMIZED FEED

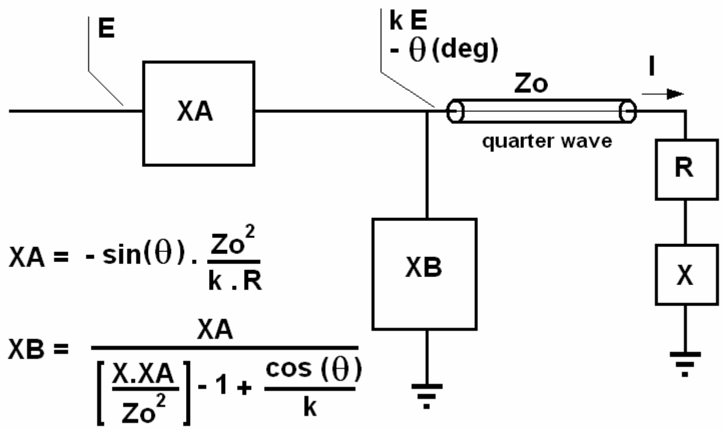
- Networks to be calculated with W1MK's formulas



- Used in a user friendly Excel spreadsheet

W1MK

EQUATIONS FOR ANY AMP/PHASE



$$XA = -\sin(\theta) \cdot \frac{Zo^2}{k \cdot R}$$

$$XB = \frac{XA}{\left[\frac{X.XA}{Zo^2}\right] - 1 + \frac{\cos(\theta)}{k}}$$

W1MK

COMPARISON

W7EL	General Solution (W1MK)
$k = 1$	k = variable (amplitude)
$\theta = -90$ deg	θ = variable (phase, degrees)
$XA = \frac{Zo^2}{R}$	$XA = -\sin(\theta) \cdot \frac{Zo^2}{k \cdot R}$
$XB = \frac{XA}{\left[\frac{X.XA}{Zo^2}\right] - 1}$	$XB = \frac{XA}{\left[\frac{X.XA}{Zo^2}\right] - 1 + \frac{\cos(\theta)}{k}}$

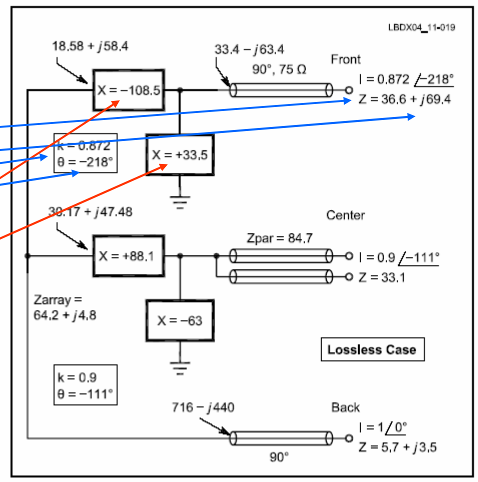
W1MK

THE SPREADSHEET TOOL (1)

CALCULATION L-NETWORK FOR LEWALLEN / LAHLUM FE

For system using current forcing

INPUT DATA			
n elem	1		n-elem: if si
Zo	75.00	ohm	Zk of curren
R	36.60	ohm	resistive par
X	69.40	ohm	reactive par
k	0.87		current mag
theta	-218.00	deg	Theta = pha
freq	1.83	MHz	frequency
RESULTS			
X-Series	-108.51	ohm	reactance of
X-Par	33.46	ohm	reactance of
Series elem	801.9	pF	
Par elem	2.9	uH	
Rpar	202.12	ohm	Resistive pa
Xpar	-64.31	ohm	Reactive pa
Rser	18.58	ohm	Resistive pa
Xser	-58.40	ohm	Reactive pa

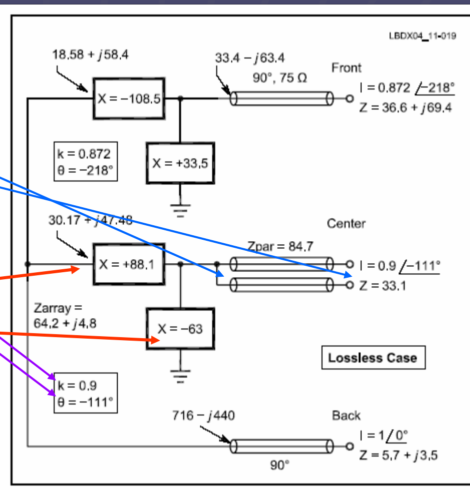


THE SPREADSHEET TOOL (2)

CALCULATION L-NETWORK FOR LEWALLEN / LAHLUM FE

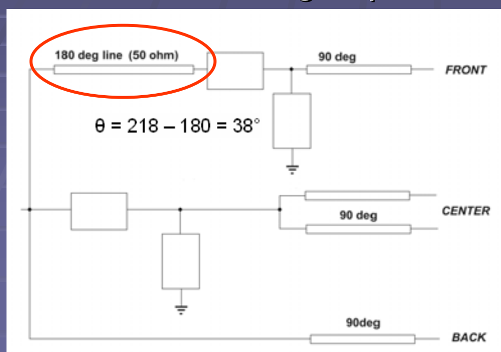
For system using current forcing

INPUT DATA			
n elem	2		n-elem: if sin
Zo	75.00	ohm	Zk of current
R	33.10	ohm	resistive part
X	0.00	ohm	reactive part
k	0.90		current magn
theta	-111.00	deg	Theta = phas
freq	1.83	MHz	frequency
RESULTS			
X-Series	88.14	ohm	reactance of
X-Par	-63.04	ohm	reactance of
Series elem	7.7	uH	
Par elem	1380.3	pF	
Rpar	104.90	ohm	Resistive par
Xpar	66.65	ohm	Reactive part
Rser	30.17	ohm	Resistive par
Xser	47.48	ohm	Reactive part



THE 180 DEGREE LINE

You can also feed the front element through a 180 (half wave) line, in which case The L network will add 218 - 180 = 38 deg of phase shift



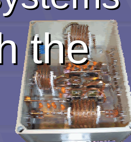
INPUT DATA		
n elem	1	
Zo	75.00	ohm
R	36.60	ohm
X	69.40	ohm
k	0.87	
theta	-38.00	deg
freq	1.83	MHz
RESULTS		
X-Series	108.51	ohm
X-Par	87.34	ohm
Series elem	9.4	uH
Par elem	7.6	uH
Rpar	202.12	ohm
Xpar	346.84	ohm
Rser	150.88	ohm
Xser	87.93	ohm

GETTING PRACTICAL

After the PAPERWORK, let's DO it.

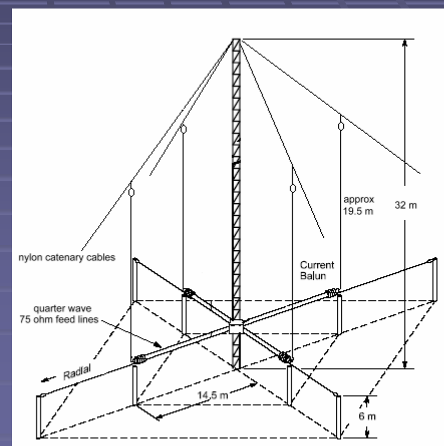
- Our goal:
  - Rebuild the ON4UN 4-square (80m)
  - Install a hybrid coupler system
  - Develop, build and test a Lewallen/Lahlum system
  - Measure current and phase on both systems
  - Assess and evaluate results of both systems

Thank you Jay, WX0B, for helping with the one of your 4-square boxes boxes

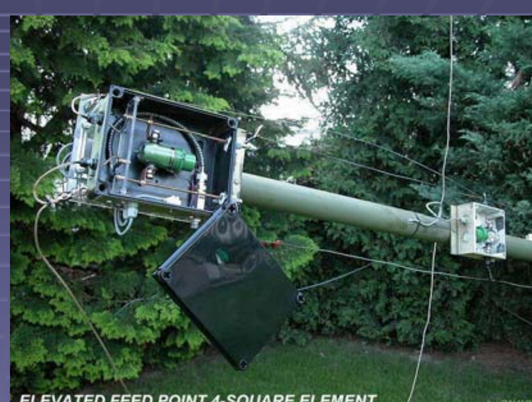


EXPERIMENTS AT ON4UN

- **Rebuild the 4-square**
  - New elements
  - New feed points
  - New quarter-wave feed lines
  - Switcheable to 3.505 or 3.795 MHz



THE ON4UN 80M 4-SQUARE

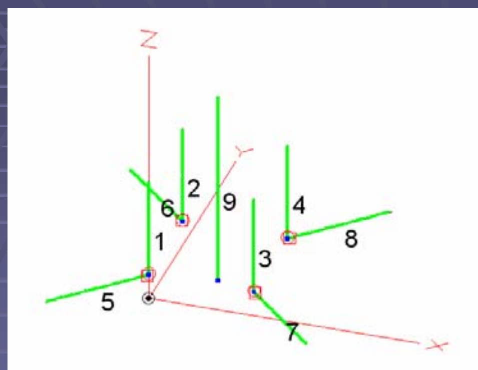


THE ON4UN 80M 4-SQUARE

DESIGNING THE NETWORK

- **Calculating the Lahlum-Lewallen network**
  - Model the array (Eznec)
  - Build the array
  - Resonate the elements
  - Measure the Z = R at resonance for each element (should be close)
  - Model a single element
  - Add Rloss (as a series R at the feed point) to obtain same feed impedance as measured
  - Remodel the array with these loss resistors
  - Plug in the Z obtained Z-values in the Lahlum spreadsheet tool

THE MODEL




```
Source 1        Voltage = 20.78 V. at 29.08 deg.
                Current = 1 A. at 0.0 deg.
                Impedance = 18.16 + J 10.1 ohms
                Power = 18.16 watts
                SWR (50 ohm system) =  2.881  (75 ol

Source 2        Voltage = 32.36 V. at -111.71 deg.
                Current = 1.11 A. at -111.0 deg.
                Impedance = 29.15 - J 0.3587 ohms
                Power = 35.92 watts
                SWR (50 ohm system) =  1.715  (75 ol

Source 3        Voltage = 32.36 V. at -111.71 deg.
                Current = 1.11 A. at -111.0 deg.
                Impedance = 29.15 - J 0.3614 ohms
                Power = 35.92 watts
                SWR (50 ohm system) =  1.715  (75 ol

Source 4        Voltage = 103.6 V. at -174.94 deg.
                Current = 1.666 A  at -218.0 deg.
                Impedance = 45.44 + J 42.46 ohms
                Power = 126.1 watts
                SWR (50 ohm system) =  2.383  (75 ol
```

Sources

Source

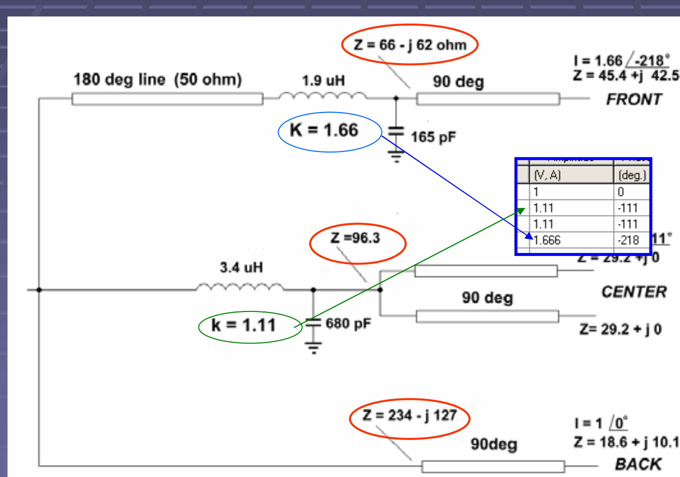
Sources							
No.	Specified Pos.		Actual Pos.		Amplitude	Phase	Ty
	Wire #	% From E1	% From E1	Seg	(V, A)	(deg.)	
1	1	0	1.66667	1	1	0	I
2	2	0	1.66667	1	1.11	-111	I
3	3	0	1.66667	1	1.11	-111	I
4	4	0	1.66667	1	1.666	-218	I

Loads (R + j X)

Load Other

Loads						
No.	Specified Pos.		Actual Pos.		R	X
	Wire #	% From E1	% From E1	Seg	(ohms)	(ohms)
1	5	0	1.66667	1	10	0
2	6	0	1.66667	1	10	0
3	7	0	1.66667	1	10	0
4	8	0	1.66667	1	10	0

FEED SYSTEM AFTER MODEL



WORK IN THE WORKSHOP

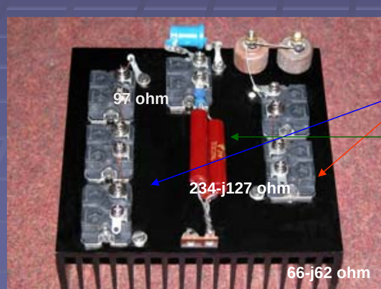
WHY?

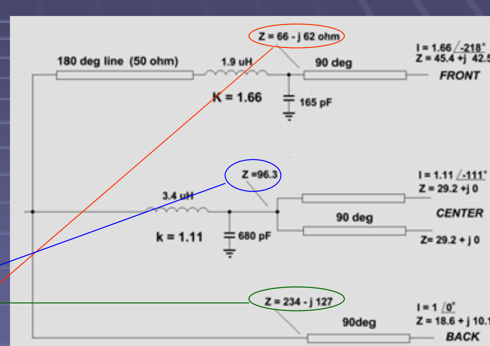
- Verify the feasibility of the L-networks approach
- Develop an appropriate test and measurement method, to adjust the values of the L networks
- Evaluate the test method

In a first iteration this was done on dummy loads
(also to stay out of the rain…)

THE DUMMY LOADS

Build dummy loads representing the complex impedances at the end of the quarter-wave feed lines

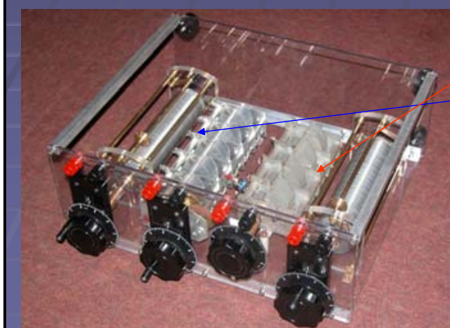


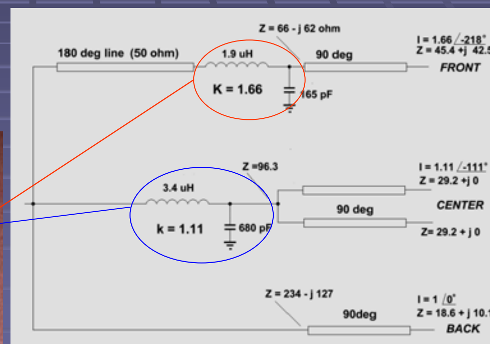


The loads are capable of dissipating hundreds of Watts.

THE LC NETWORKS

Build an LC box with two variable L's and two variable C's





THE ALIGNMENT TOOL

THE SCOPE PROCEDURE

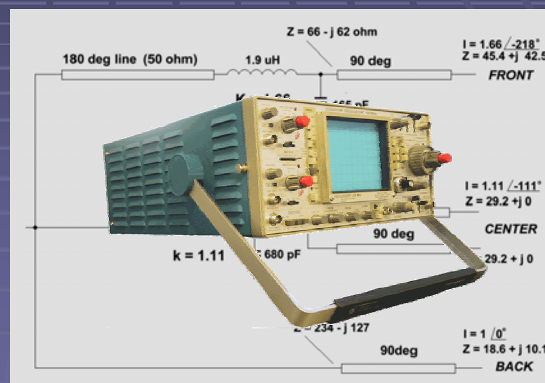
- Use a multi channel oscilloscope
- Simultaneously visualize the voltages at the end of the quarter-wave feed lines
- Voltage = antenna feed current x Zcable plus 90 degree phase delay

THE MULTI CHANNEL SCOPE

We used a 5 channel 100 MHz scope (Kikusui - model COS6100M)

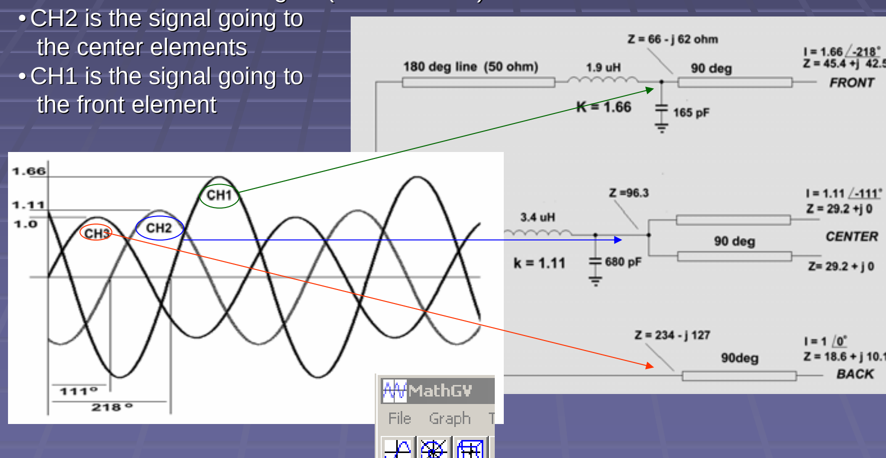
Available on Ebay for approx. $200

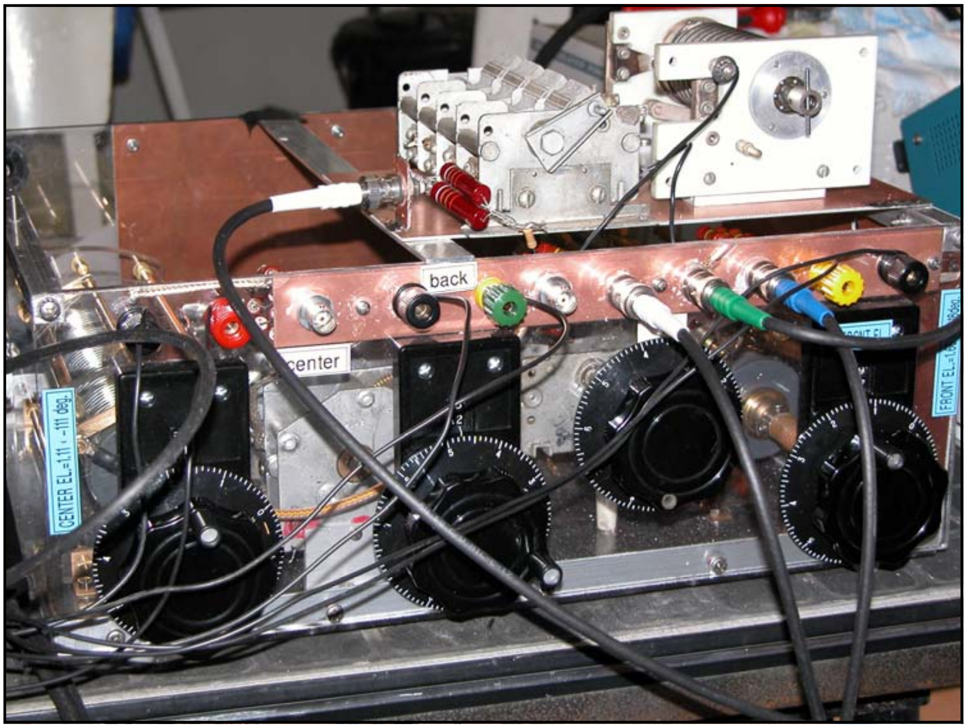
A 3 channel scope is really all you need …



THE SCOPE PATTERN

- CH3 is the reference signal (back element)
- CH2 is the signal going to the center elements
- CH1 is the signal going to the front element





THE VOLTAGE SAMPLING

Samplers:

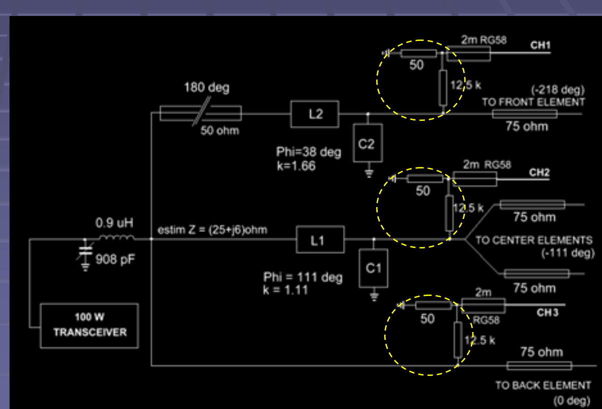
Zload = 12.5 k, attenuation is 12500/25 = 500 = - 54 dB

Channel 3: the reference signal going to the back element (no network)

Channel 2: the measured signal at the output of LC network going to the center elements

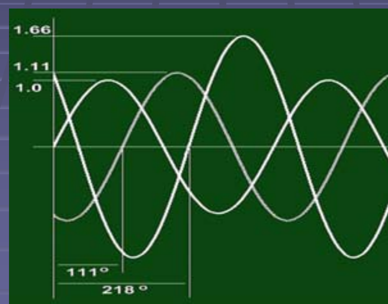
Channel 1: the measured signal at the output of LC network going to the front element

The LC components are tuned until the required phase shift and voltage are achieved.



THE SCOPE PATTERN

Just a drawing …



MADE WITH

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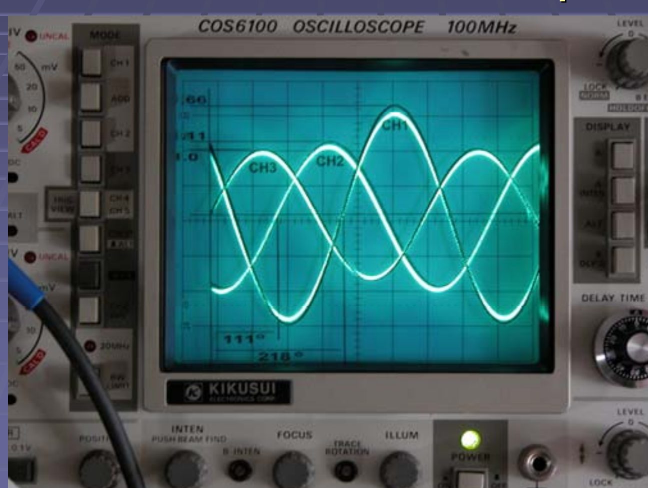
THE SCOPE PATTERN

On the multi-channel scope



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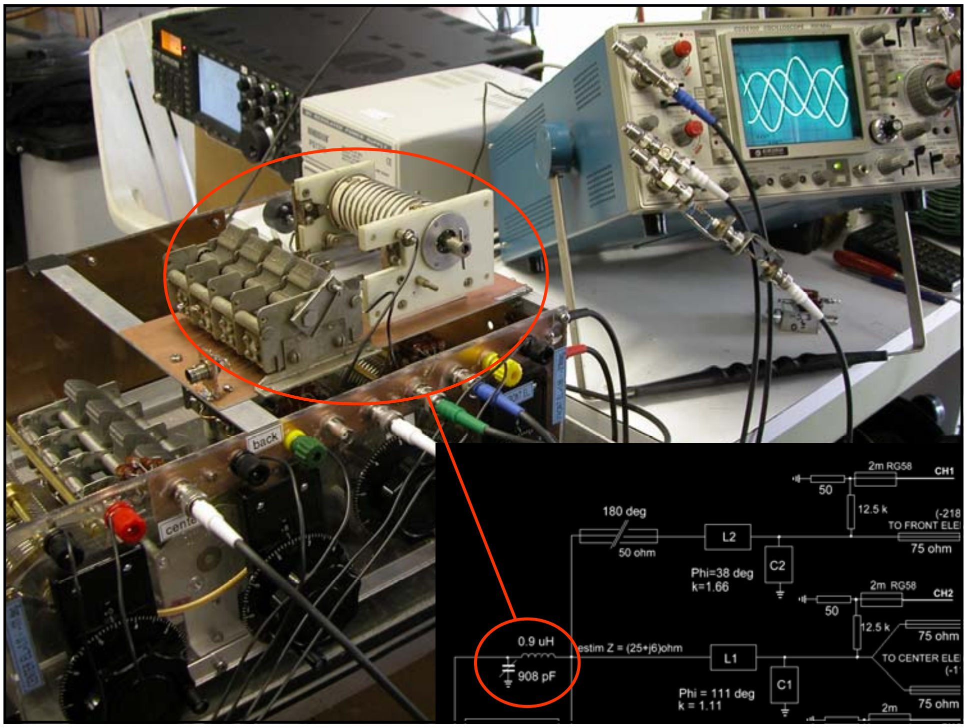


SCOPE PROCEDURE

- Dummies: 230 – j 120, 97 and 66 – j 62 ohm
- L1, C1: to center elements, L2, C2 to front element

	model	dummy
L1(ser)	3.4 uH	3.4 uH
C1 (par)	680 pF	818 pF
L2 (ser)	1.9 uH	1.4 uH
C2 (par)	165 pF	530 pF

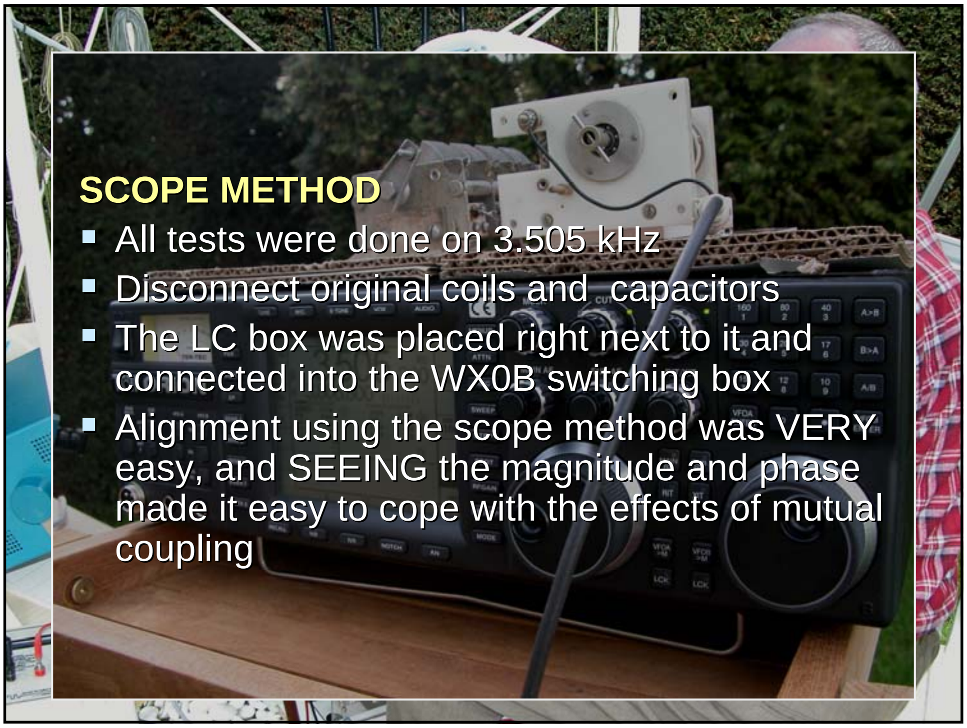
- Feed impedance: 19.7 + j 8 ohm

A CONCLUSION

- ALIGNMENT PROCEDURE WAS VALIDATED
- ALIGNMENT EASY BUT CRITICAL (TOUCHY)

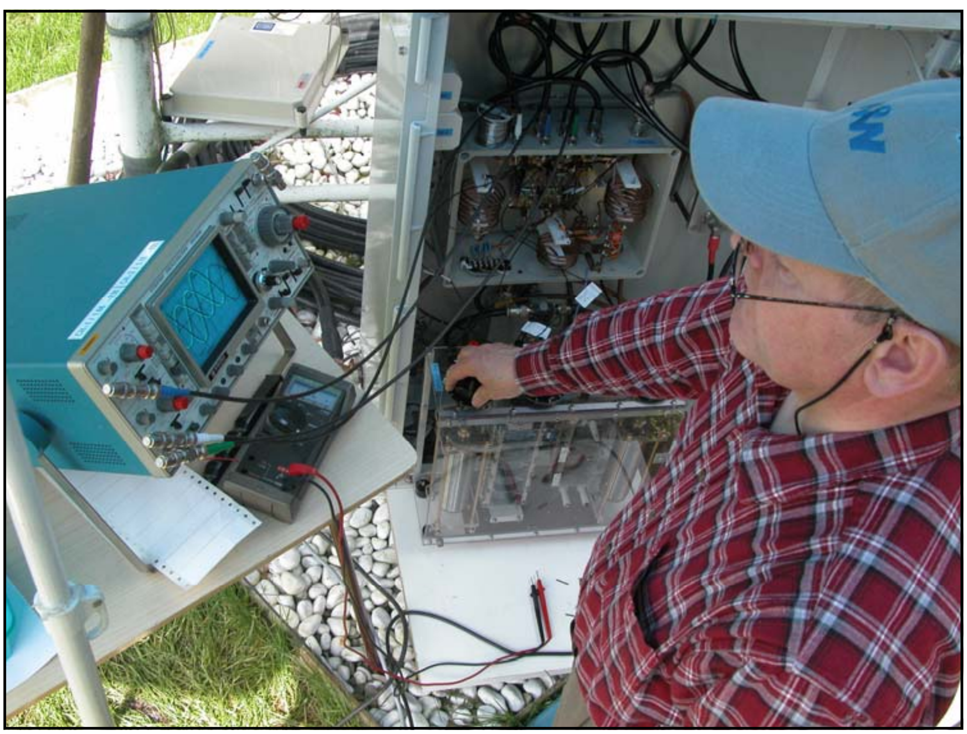
NEXT STEP:

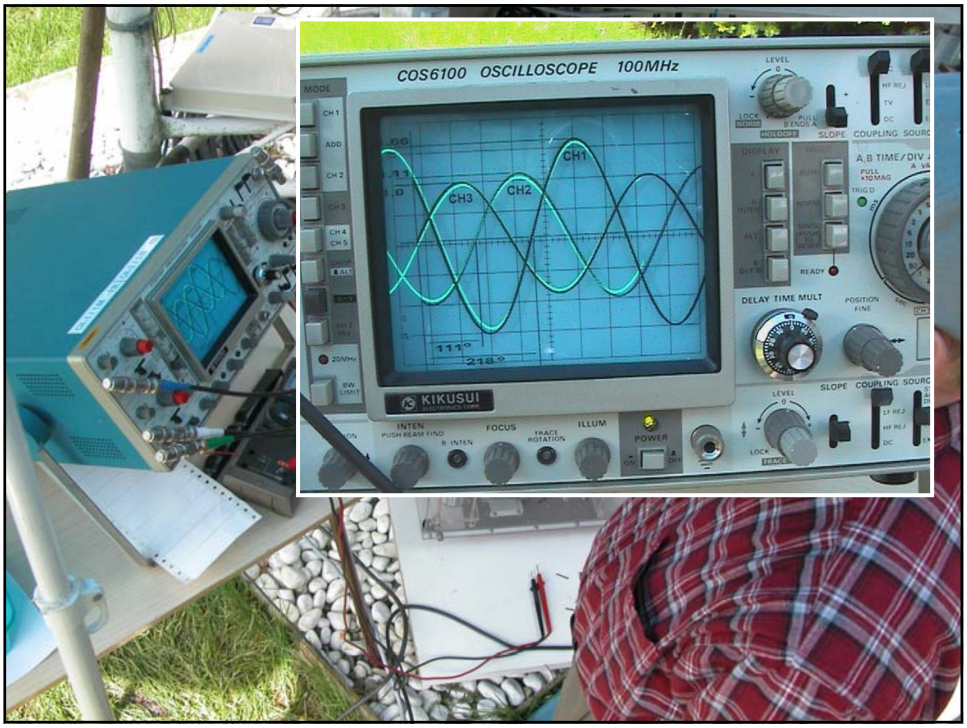
WAIT FOR BETTER WX AND GO OUT IN THE FIELD



SCOPE METHOD

- All tests were done on 3.505 kHz
- Disconnect original coils and capacitors
- The LC box was placed right next to it and connected into the WX0B switching box
- Alignment using the scope method was VERY easy, and SEEING the magnitude and phase made it easy to cope with the effects of mutual coupling





LC NETWORK DIAL SETTINGS

	C1	L1	C2	L2
NW	31.66	25.63	17	32.83
SE	30.94	25.31	19	35.16
NE	29.90	26.11	17	34.69
SW	31.29	25.28	16	33.13

FINAL	30.83	25.66	17.5	34.22
VALUES	3.3 uH	283 pF	867 pF	1.6 uH

VARIATIONS IN AMP AND PHASE

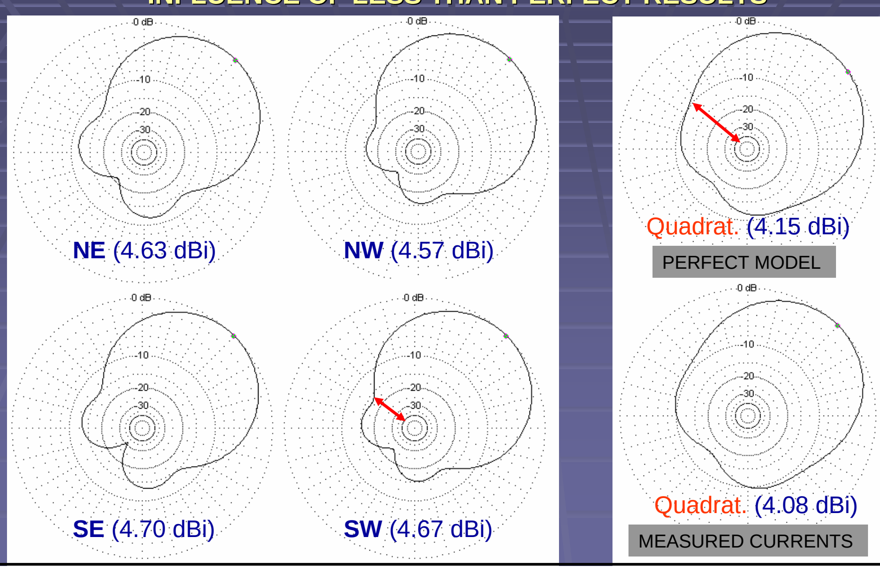
TARGET	1.11	-111º	1.66	-218º

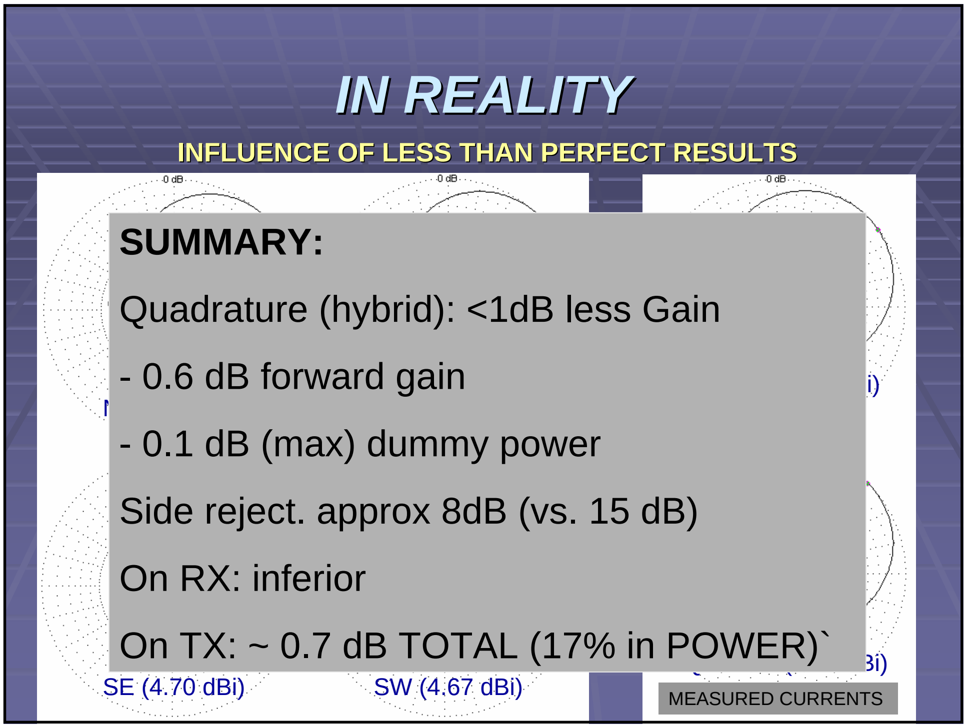
	K1	φ1	K2	φ 2
NW	1.01	-115º	1.52	-210º
SE	1.15	-111º	1.68	-222º
NE	1.19	-111º	1.66	-222º
SW	1.08	-118º	1.69	-218º

Accuracy: phase +/- a few degrees, amplitude +/- 2 %

IN REALITY

INFLUENCE OF LESS THAN PERFECT RESULTS




IN REALITY
INFLUENCE OF LESS THAN PERFECT RESULTS
SUMMARY:
Quadrature (hybrid): <1dB less Gain
- 0.6 dB forward gain
- 0.1 dB (max) dummy power
Side reject. approx 8dB (vs. 15 dB)
On RX: inferior
On TX: ~ 0.7 dB TOTAL (17% in POWER)`
SE (4.70 dBi)
SW (4.67 dBi)
MEASURED CURRENTS


MORE TESTS WERE DONE
TO ASSESS OPERATIONAL BANDWIDTH
… AND SWR BANDWIDTH

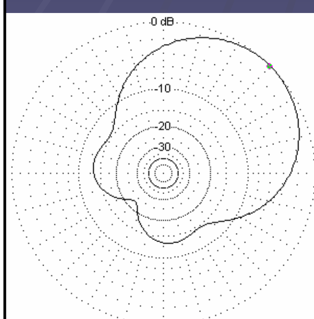
OPERATIONAL BANDWIDTH

	K1	φ1	K2	φ2
3.500	1.15	-102°	1.6	-210°
3.520.000	1.11	-111°	1.66	-218°
3.540	1.05	-120°	1.70	-230°

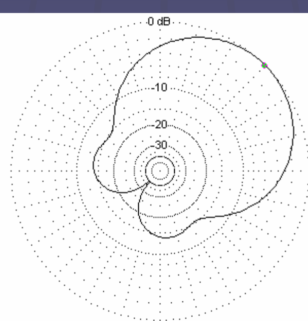
- OPERATIONAL BW: ~ 50 kHz
- SWR = 1/1 OVER APPROX. 100 kHz
- SWR BW IS NO VALID PERFORMANCE CRITERION

OPERATIONAL BANDWIDTH

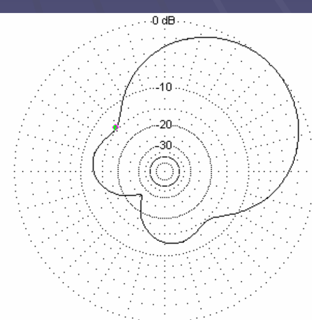
PATTERNS VS. FREQUENCY



3500 Khz (4.64 dBi)



3520 kHz (4.62 dBi)



3540 KHz (4.61 dBi)

CONCLUSION ON SCOPE PROCEDURE

- HIGH DRIVING POWER REQUIRED (100 W) BECAUSE OF "LOW" SCOPE SENSITIVITY
- EXCELLENT HUMAN INTERFACE (YOU SEE WHAT YOU DO)
- SUFFICIENT ACCURACY IN VIEW OF DIFFERENCES BETWEEN DIRECTIONS (SLIGHT DIFFERENCES IN ELEMENT SELF AND MUTUAL IMPEDANCES)

MORE CONCLUSIONS

- L NETWORK COMPONENTS MUST BE CONTINUOUSLY ADJUSTABLE
- ARRAY ELEMENTS ARE NOT "IDENTICAL"
- ACCURACY OF ALIGNMENT METHOD SHOULD NOT BE "MUCH" BETTER THAN VARIATION IN ELEMENT IMPEDANCES (don't measure a mile with a micrometer)

BUILDING A NEW HIGH POWER SYSTEM

- CONTINOUSLY VARIABLE CAPS: VACUUM VARIABLES
- CONTNUOUSLY VARIAB
  VERY BULKY FOR HIGH
- THE SOLUTION:

  IS IN "THE BOOK" :

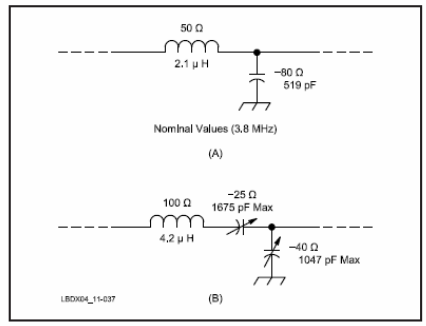


Fig 11-37—To make the Lewallen L-network continuously adjustable, replace the coil with a coil of twice the required value and connect a capacitor in series. The net result will be a continuously variable reactance. With the values shown, the nominal +50-Ω reactance is adjustable from +75 to +25 Ω (and less). The two capacitors can be motor driven to make the phase-shift network remotely controllable.

TURNING A C INTO AN L

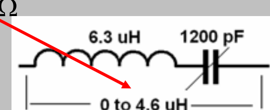
Center elements:

target L: 75 ohm or 3.4 uH

Top of tuning range = 4.6 uH → 100 Ω

1200 pF = -38 Ω

Coil: 100 + 38 = 138 ohm → 6.3 uH



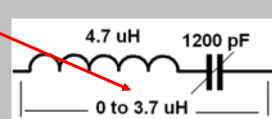
Front element

Target L: 35 ohm or 1.6 uH

Top of tuning range = 3 uH → 65 Ω

1200 pF = -38 Ω

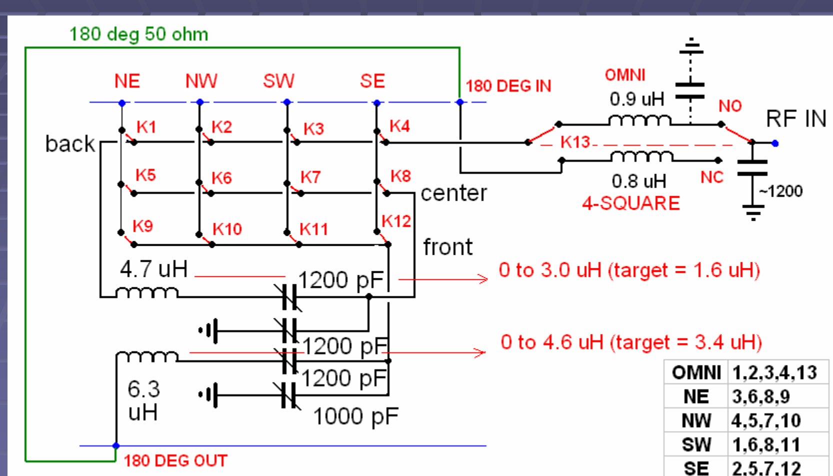
Coil = 65 + 38 = 103 Ω → 4.7 uH

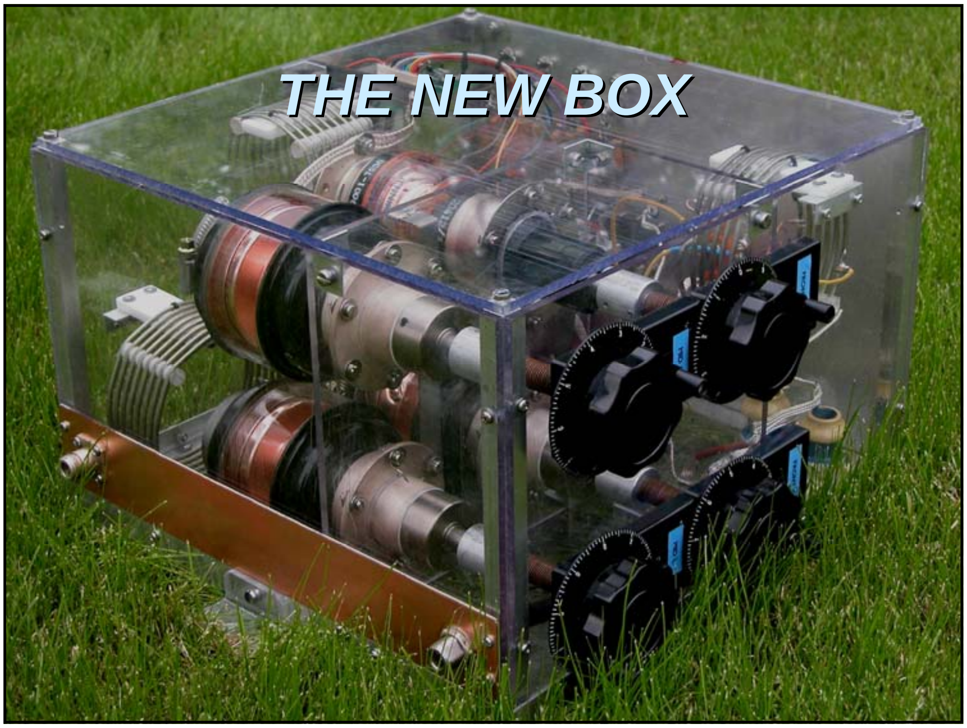


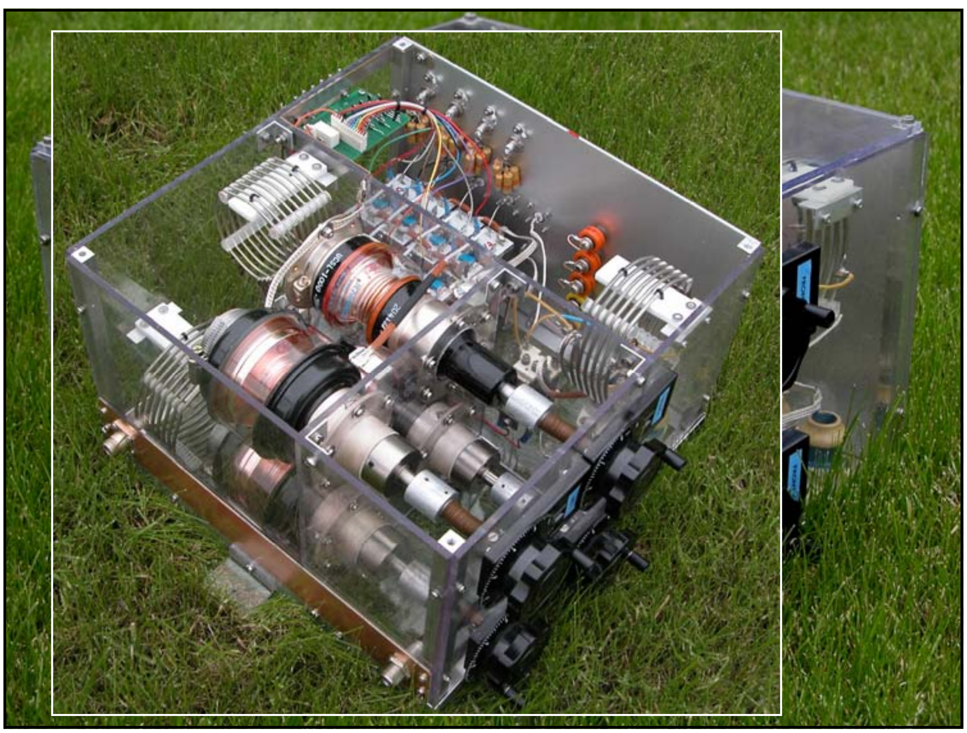
THE NEW FEED BOX

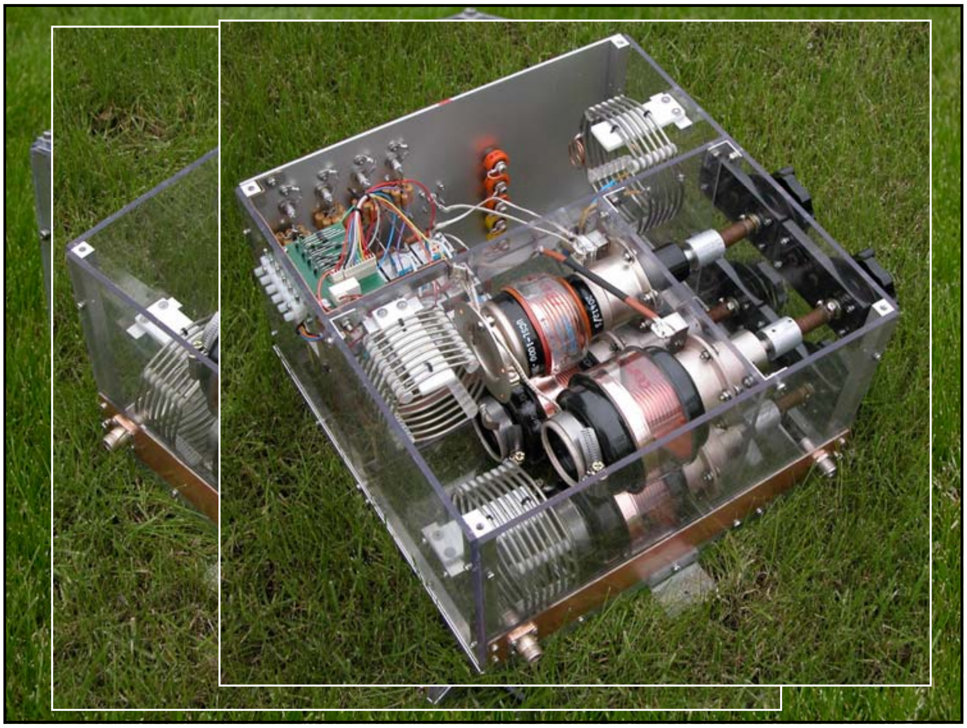
- USING FOUR 1200 pF VACUUM VARIABLES EQUIPED WITH TURN COUTERS
- VACUUM VARIABLE C IN SERIES WITH AN "OVERSIZED" COIL TO FORM A VARIABLE L
- RELAY MATRIX SWITCHING TO PROVIDE MAX. SYMMETRY AND FLEXIBILITY
- SEPARATE INPUT MATCHING L- NETWORKS FOR 4-SQUARE AND OMNIDIRECTIONAL

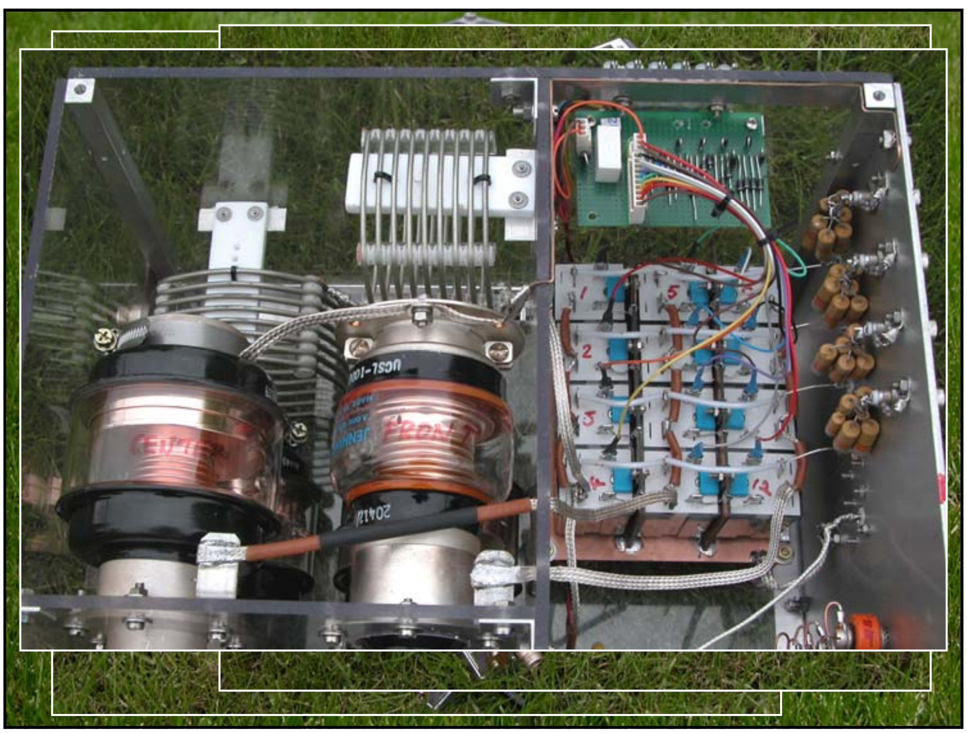
THE NEW BOX SCHEMATIC

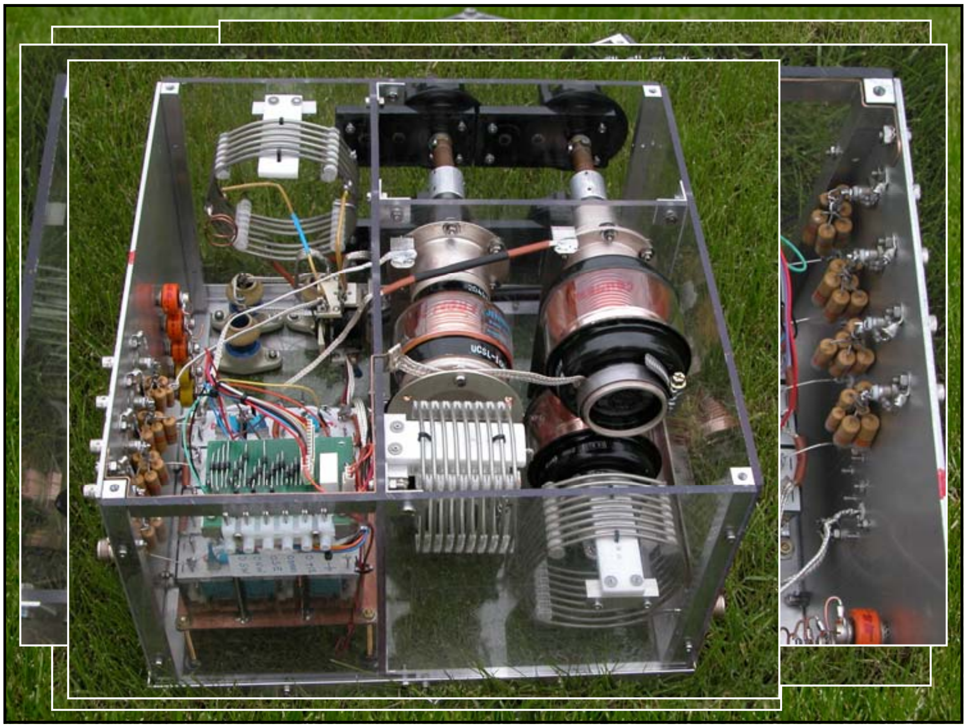


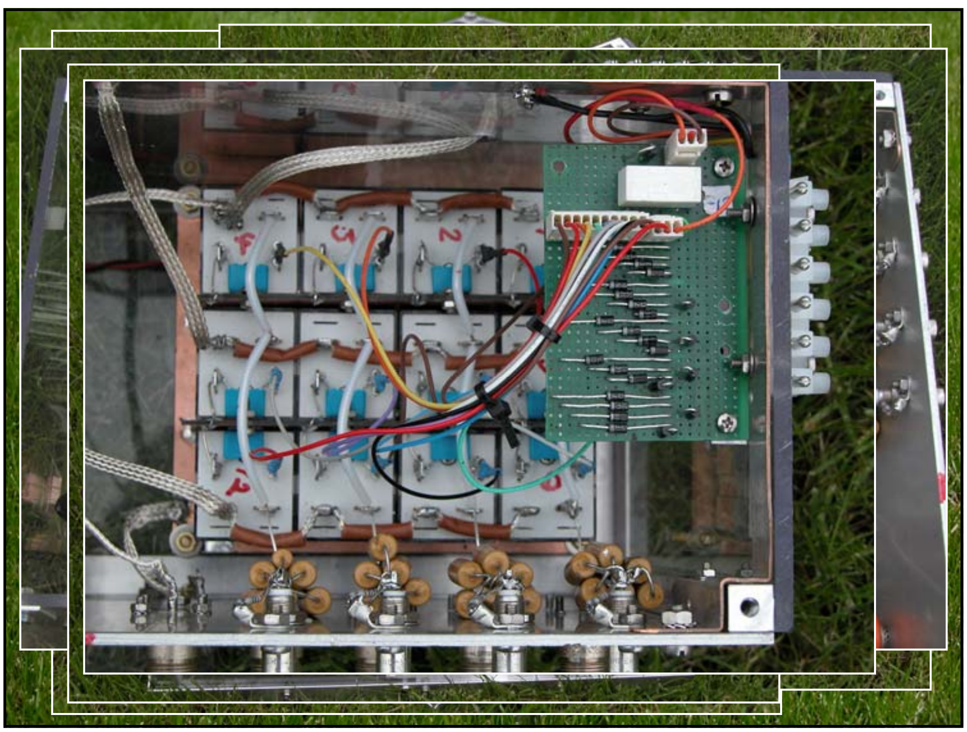

THE NEW BOX

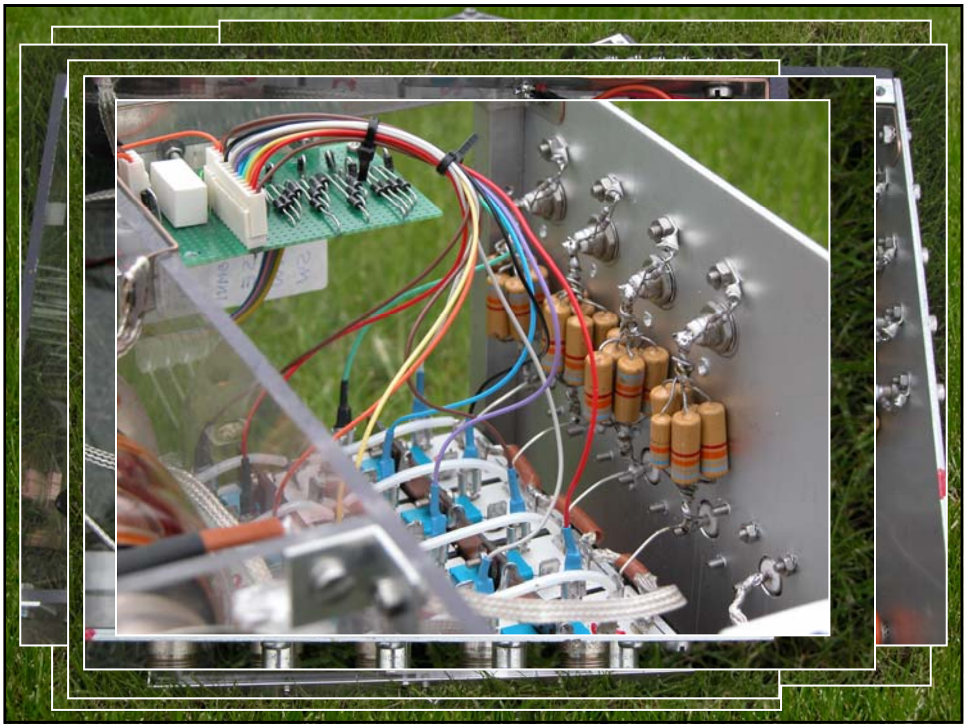




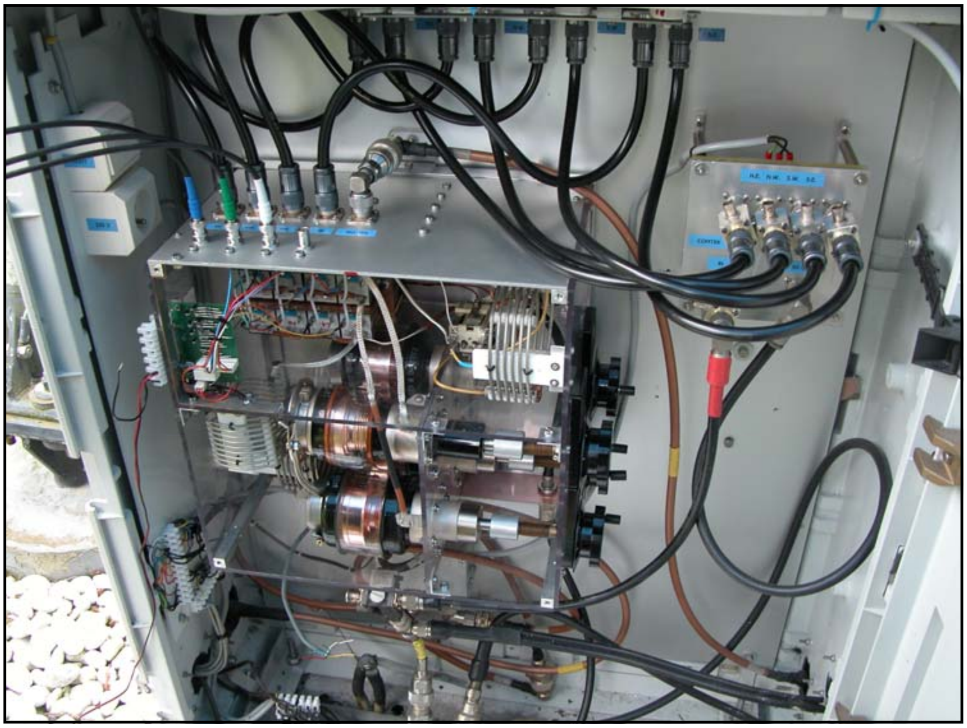


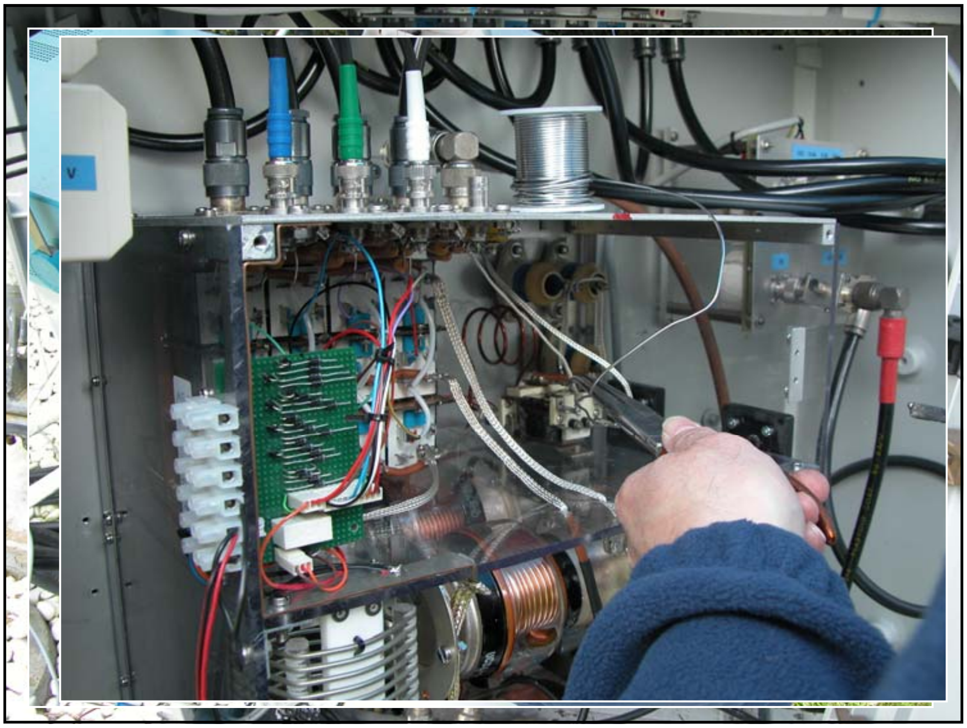


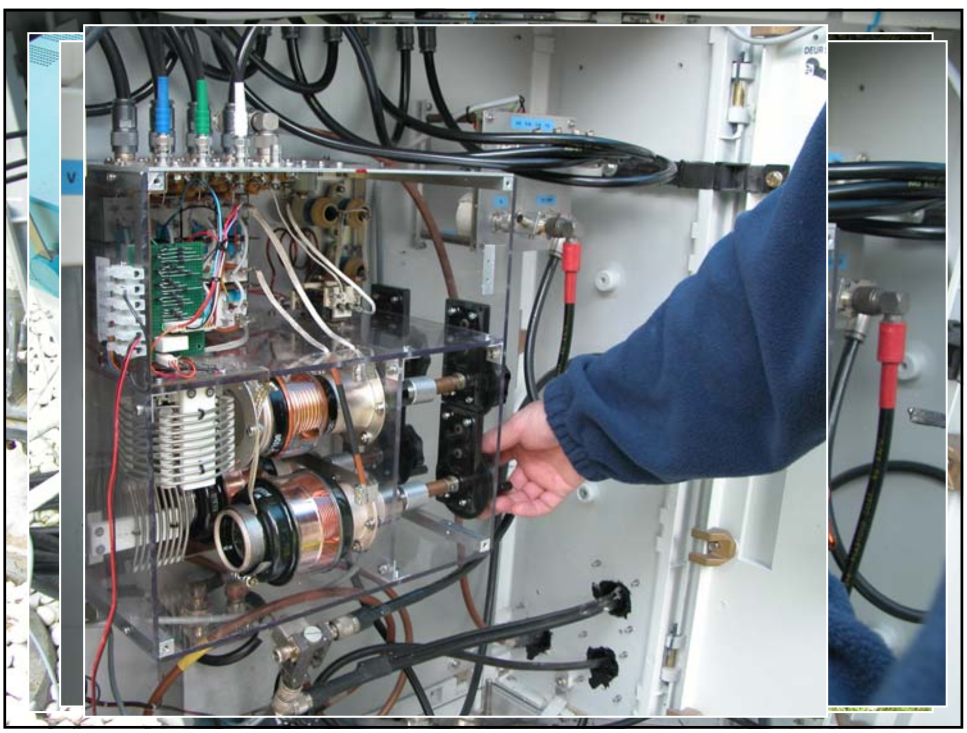




INSTALLING AND TUNING







MEASURED WITH NETWORK ANALYZER

TARGET	1.11	- 111 º	1.66	- 218 º

ON 3.5 MHz

	K1	φ1	K2	φ 2
NW	1.08	-116 º	1.69	- 226 º
SE	1.3	- 108 º	1.75	- 225 º
NE	1.2	- 103 º	1.72	- 223 º
SW	1.16	- 109 º	1.69	- 226 º

Accuracy: phase +/- 1º, amplitude +/- 1 %

Measurements done using an HP network analyzer

IMPORTANT !

IMPORTANT TO REMEMBER:

- YOU MUST MODEL YOUR ANTENNA AS PRECISELY AS POSSIBLE
- THIS WILL GIVE YOU APPROXIMATE L-NETWORK VALUES
- YOU NEED TO ADJUST THOSE IN THE FIELD
- **CONTINUOUSLY** ADJUSTABLE L AND C ELEMENTS ARE A MUST
- A 3 CHANNEL SCOPE IS A GOOD TOOL

ALTERNATIVE ALIGNMENT PROCEDURE

W1MK HYBRID ALIGNMENT SETUP

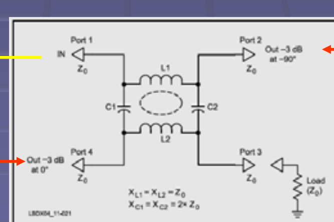
This setup is used in conjunction with the W1MK detector / power meter

- A null method (bridge method)
- Using a hybrid coupler network

To NULL DETECTOR

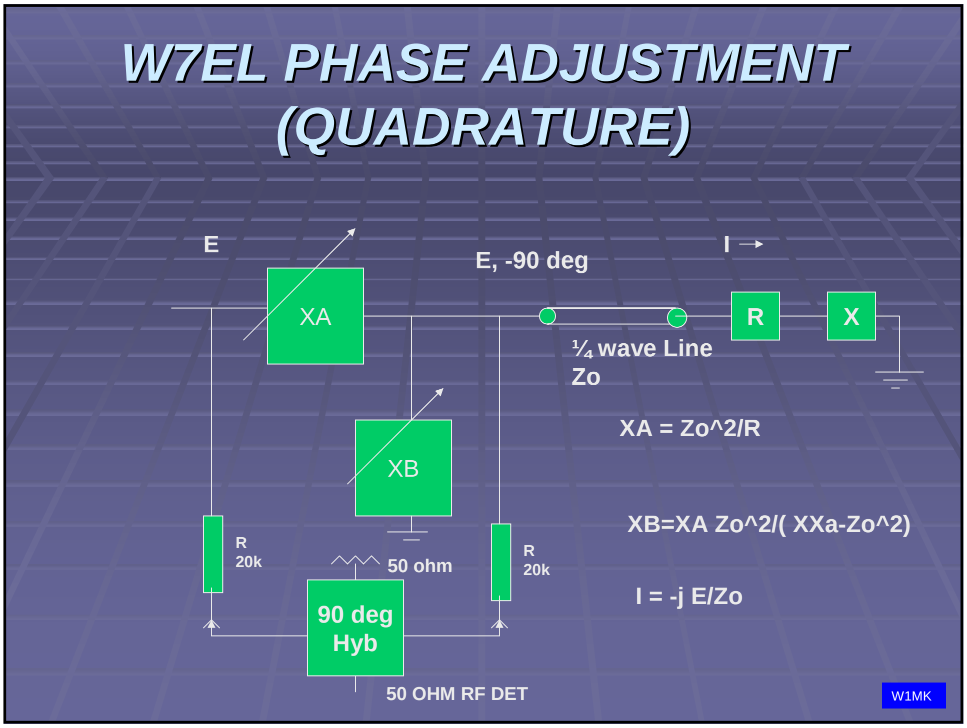
FROM ELEMENT 2

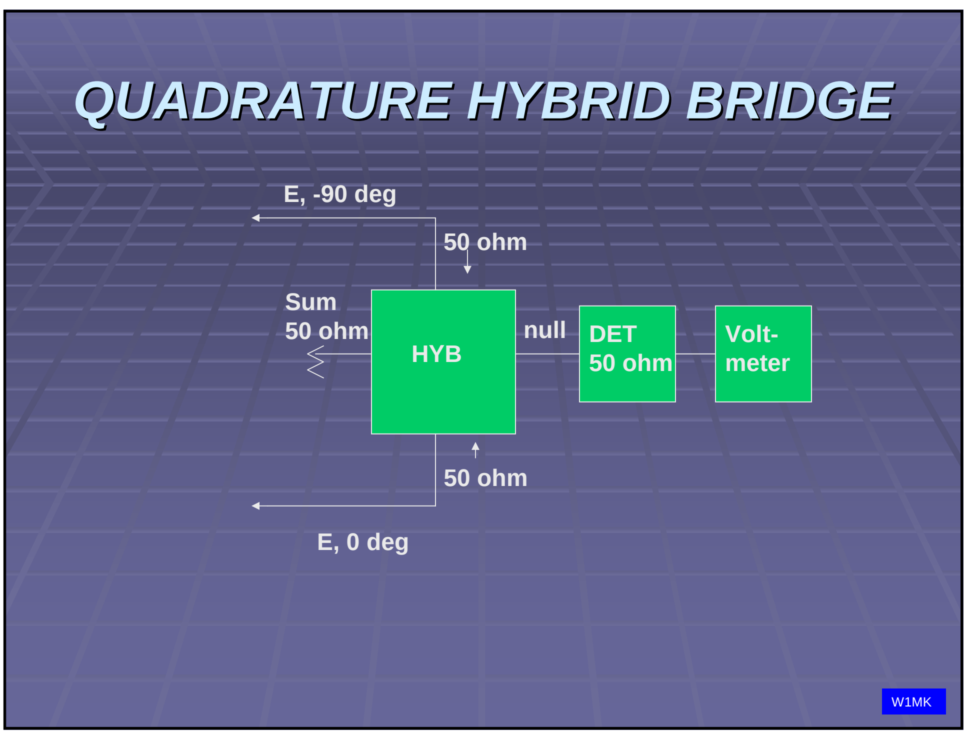
FROM ELEMENT 1



Already described in edition 3 of Low Band Dx-ing

W1MK


W7EL PHASE ADJUSTMENT (QUADRATURE)
E
E, -90 deg
I →
XA
R
X
¼ wave Line
Zo
XA = Zo^2/R
XB
XB=XA Zo^2/(XXa-Zo^2)
R
20k
50 ohm
R
20k
I = -j E/Zo
90 deg
Hyb
50 OHM RF DET
W1MK


QUADRATURE HYBRID BRIDGE
E, -90 deg
50 ohm
Sum
50 ohm
HYB
null
DET
50 ohm
Volt-
meter
50 ohm
E, 0 deg
W1MK

ERROR PLOT

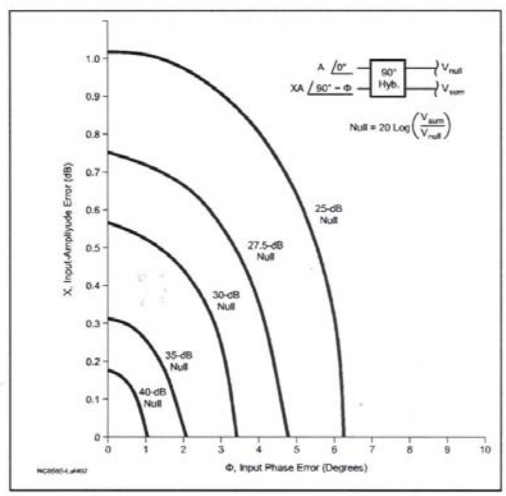
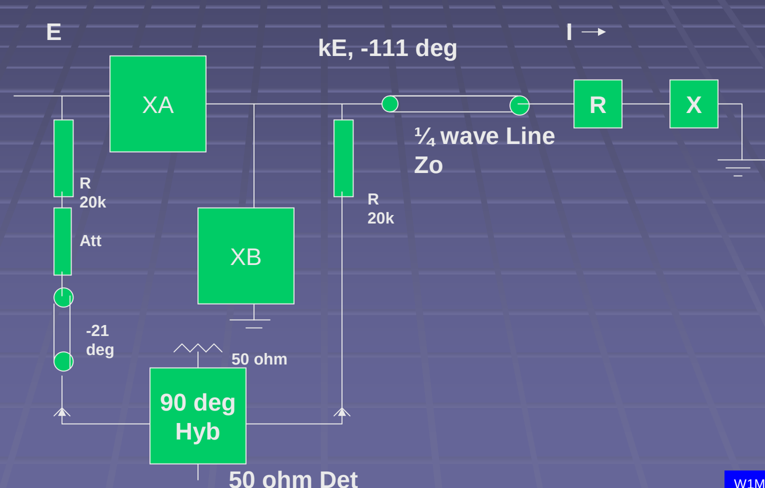


Figure 2—Amplitude and phase errors for various amounts of null.

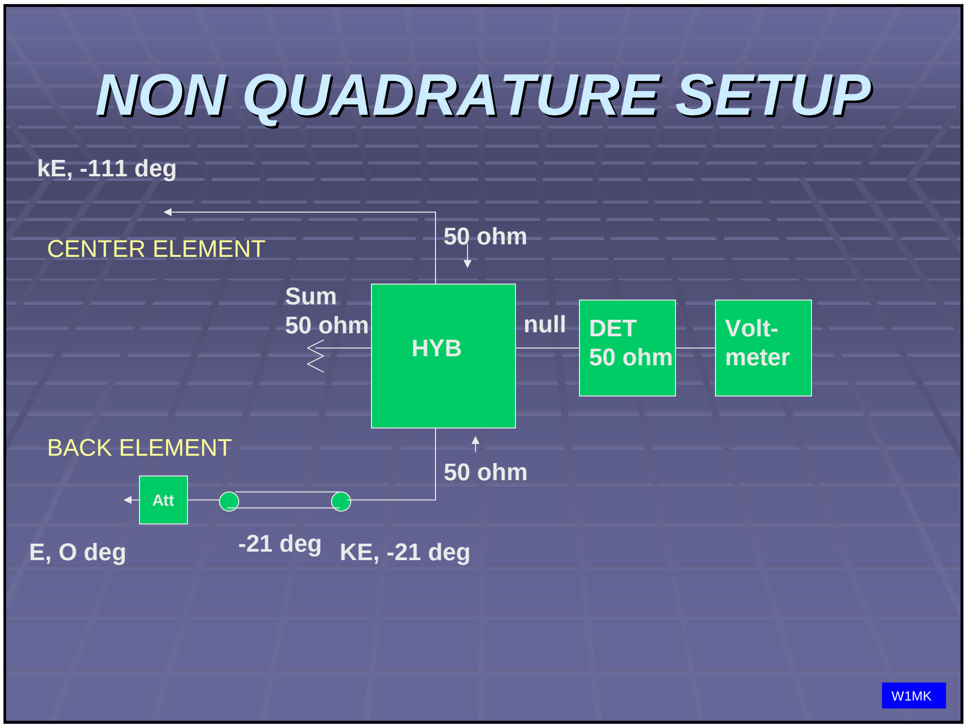
W1MK

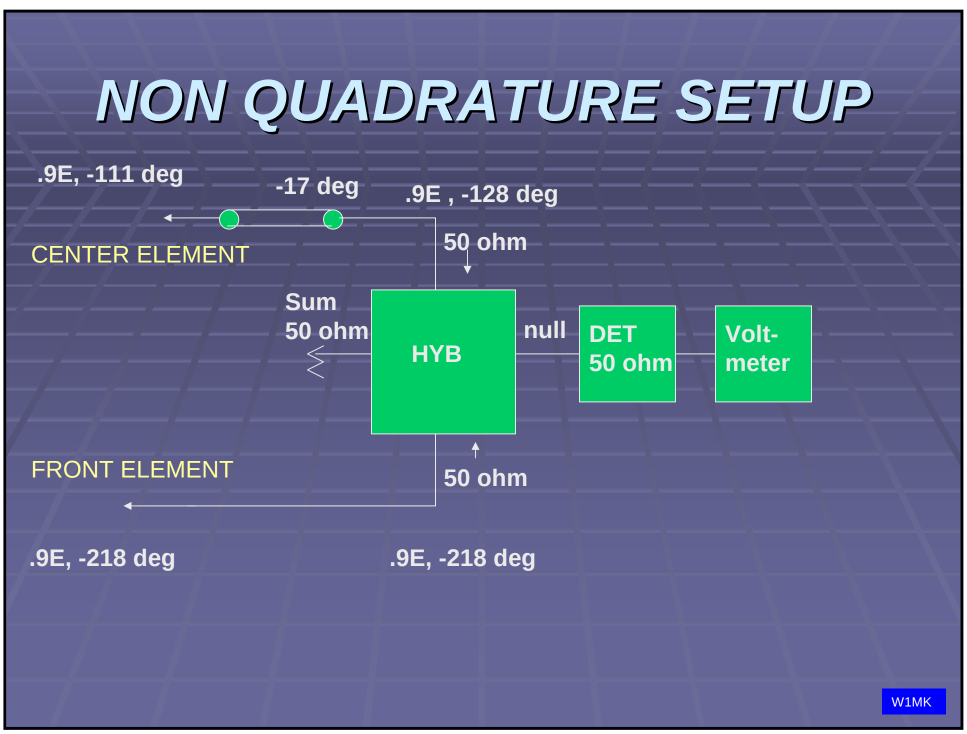
NON QUADRATURE SETUP

WA3FET -111 DEG PHASE ANGLE

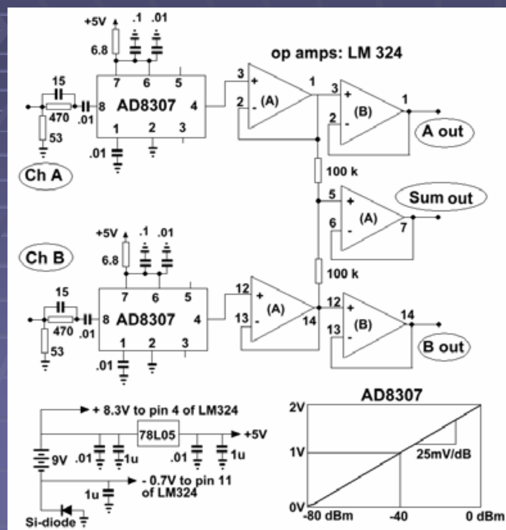


W1MK


NON QUADRATURE SETUP
kE, -111 deg
CENTER ELEMENT
50 ohm
Sum
50 ohm
HYB
null
DET
50 ohm
Volt-
meter
BACK ELEMENT
50 ohm
Att
E, O deg
-21 deg
KE, -21 deg
W1MK


NON QUADRATURE SETUP
.9E, -111 deg
-17 deg
.9E , -128 deg
CENTER ELEMENT
50 ohm
Sum
50 ohm
HYB
null
DET
50 ohm
Volt-
meter
FRONT ELEMENT
50 ohm
.9E, -218 deg
.9E, -218 deg
W1MK

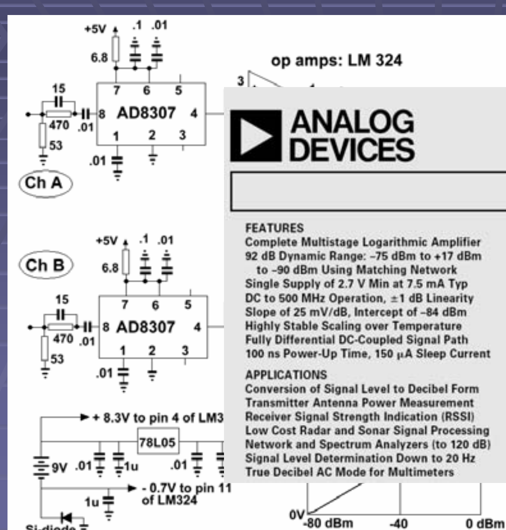
W1MK DUAL POWER METER-DETECTOR



per W7ZOI

W1MK

W1MK DUAL POWER METER-DETECTOR



per W7ZOI

ANALOG DEVICES

Low Cost DC–500 MHz, 92 dB Logarithmic Amplifier

AD8307

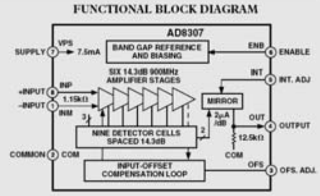
FEATURES

Complete Multistage Logarithmic Amplifier
92 dB Dynamic Range: –75 dBm to +17 dBm
  to –90 dBm Using Matching Network
Single Supply of 2.7 V Min at 7.5 mA Typ
DC to 500 MHz Operation, ±1 dB Linearity
Slope of 25 mV/dB, Intercept of –84 dBm
Highly Stable Scaling over Temperature
Fully Differential DC-Coupled Signal Path
100 ns Power-Up Time, 150 μA Sleep Current

APPLICATIONS

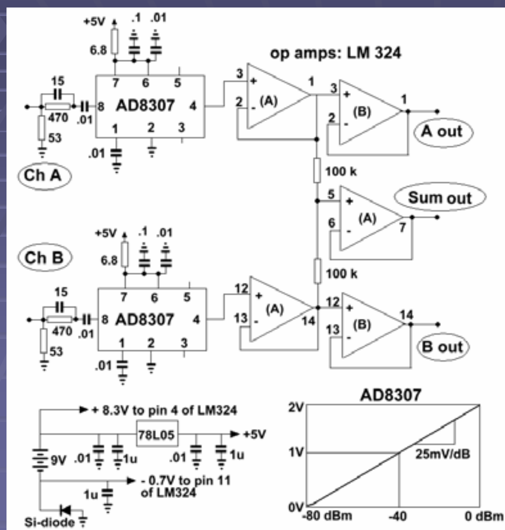
Conversion of Signal Level to Decibel Form
Transmitter Antenna Power Measurement
Receiver Signal Strength Indication (RSSI)
Low Cost Radar and Sonar Signal Processing
Network and Spectrum Analyzers (to 120 dB)
Signal Level Determination Down to 20 Hz
True Decibel AC Mode for Multimeters

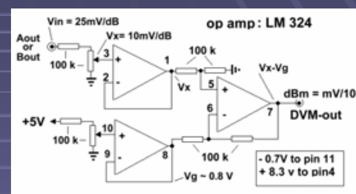
FUNCTIONAL BLOCK DIAGRAM



W1MK

W1MK DUAL POWER METER-DETECTOR





Direct dBm converter (per N3NHI)

W1MK

W1MK ALIGNMENT SETUP

ADVANTAGES

- SMALL DRIVING POWER REQUIRED (1 W)
- BATTERY POWER OPERATED
- INEXPENSIVE TEST/MEASURING EQUIPMENT
- NULL METHOD = INCREASED ACCURACY

W1MK

W1MK ALIGNMENT SETUP

DRAWBACKS

- VISUALLY “LESS INSTRUCTIVE”

CONCLUSION

- SCOPE AND NULL-METHOD IN REALITY HAVE COMPARABLE ACCURACY

W1MK

BACK TO OUR ARRAY

WHAT IS IMPORTANT

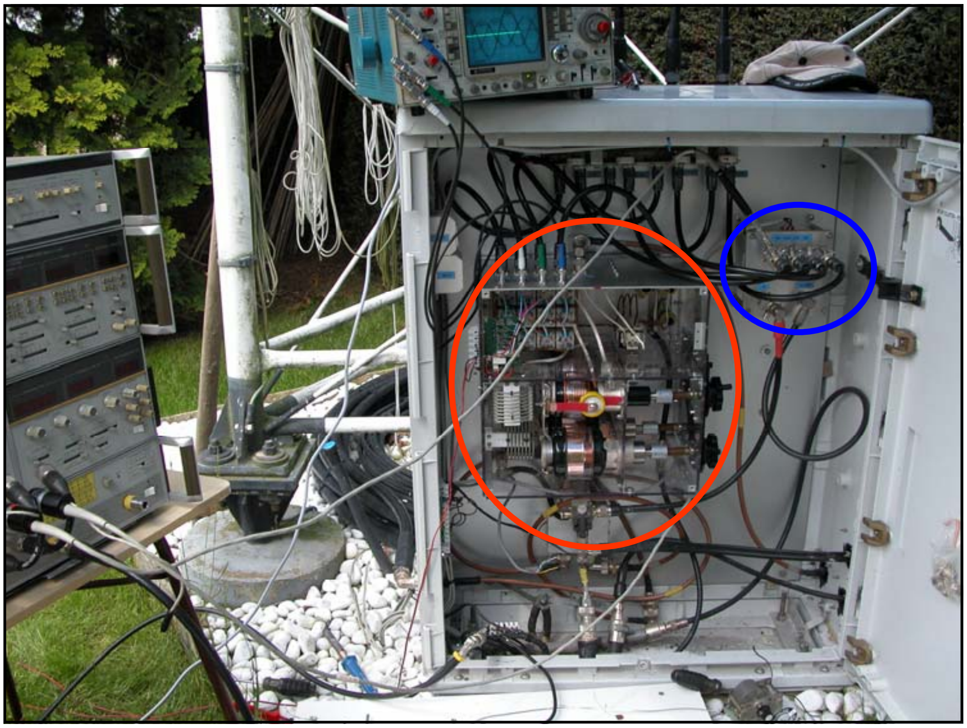
- IDENTICAL ELEMENTS
  - AVOID COUPLING WITH OTHER ANTENNAS
  - ERECT THE ARRAY IN THE CLEAR
- QUARTER WAVE LINES MUST BE $\lambda/4$ (AT BOTH BAND ENDS)
- BUILD THE ARRAY WITH GREAT CARE
- CAREFULLY ADJUST L NETWORK USING SCOPE OR W1MK HYBRID SETUP

COMPARING

THE HYBRID (COMTEK)

AND

THE LAHLUM SYSTEM



THE HYBRID COUPLER

TARGET	1.0	-90º	1.0	-180º

ON 3.5 MHz

	K1	φ1	K2	φ 2
NW	1.02	-106 º	1.0	- 186 º
SE	1.01	- 96 º	1.03	- 188 º
NE	1.0	- 93 º	1.02	- 187 º
SW	1.0	- 100 º	1.0	- 186 º

Accuracy: phase +/- 1 degree, magnitude +/- 1 %

Measurements done using an HP network analyzer on a Comtek unit

THE HYBRID COUPLER

TARGET	1.0	-90º	1.0	-180º

ON 3.8 MHz

	K1	φ1	K2	φ 2
NW	1.2	- 92	1.02	- 192 º
SE	1.0	- 92	1.07	- 192 º
NE	1.24	- 86	1.07	- 193 º
SW	1.07	- 93	1.06	- 194 º

Accuracy: phase +/- 1 degree, magnitude +/- 1 %

Measurements done using an HP network analyzer on a Comtek unit

THE HYBRID COUPLER

OPERATIONAL BANDWIDTH

- OPERATIONAL BW: > 300 kHz (on 80m)
- SWR BW > 300 KHz
- POWER IN DUMMY LOAD: < 80 W on 3.5 MHz and < 25 W on 3.8 MHz (for 1.5 KW input)

… IF ELEMENTS AND QUARTER-WAVE FEED LINES ARE ALTERNATIVELY TUNED TO LOW END (CW) OR HIGH END (SSB) OF THE BAND

THE HYBRID COUPLER

(Comtek unit)

- "PLUG AND PLAY"
- BROADBAND (CW and Phone on 80m if quarter wave feed lines are "retuned")
- RELIABLE
- NOT EXPENSIVE
- NO NEED FOR ALIGNMENT

…. BUT QUADRATURE ONLY

THE LAHLUM SYSTEM

- POTENTIAL FOR 0.7 dB MORE GAIN AND IMPROVED DIRECTIVITY
- FAIRLY NARROW OPERATIONAL BANDWIDTH:

  CW AND PHONE ON 80: NEED TO "TUNE" THE QUARTER-WAVE FEED LINES AND ADJUST THE L-NETWORKS!

- REQUIRES ALIGNMENT IN THE FIELD

… BUT FULL DESIGN FREEDOM (ANY ANGLE AND MAGNITUDE) and THE ONLY SOLUTION FOR MANY ARRAYS OTHER THAN 4-SQUARES

NEW FEED SYSTEM FOR ARRAYS

WRAP UP

- W1MK DEVELOPED THE MATHEMATICS GIVING FULL DESIGN FREEDOM (ANY MAGNITUDE/PHASE)
- THE LAHLUM FEED SYSTEM WAS APPLIED TO ON4UN'S 4-SQUARE
- SUITABLE ALIGNMENT METHODS WERE DEVELOPED AND DOCUMENTED
- A NEW FULLY FLEXIBLE FEED BOX WAS DESIGNED AND CONSTRUCTED
- TESTING WAS DONE ON BOTH QUADRATURE (HYBRID) AND LAHLUM (OPTIMIZED AMP/PHASE) CONFIGURATION
- CONCLUSIONS WERE DRAWN

NEW FEED SYSTEM FOR ARRAYS

THANK YOU,..

ROGER, ON6WU

AND

ROBYE, W1MK

NEW FEED SYSTEM FOR ARRAYS

THANK YOU

FOR YOUR KEEN INTEREST

By John Devoldere, ON4UN
Robye Lahlum, W1MK
Roger Vermet, ON6WU