DESIGN EVOLUTION OF ANTENNA SYSTEMS FOR DTV MULTICHANNEL OPERATION

- 1.- An Improved Constant Impedance Channel Combiner for UHF TV (MCI)

- 2.- UHF CPOL/EPOL Panel antenna to ensure mobile-handheld reception (RYMSA)

An Improved Constant Impedance Channel Combiner for UHF TV

Presented by Frank Malanga

Micro Communications, Inc.
Merrimack, New Hampshire
A RYMSA Company

Agenda

- Review
  - Different types of channel combiners.
  - Constant-impedance channel combiner (CICC) fundamentals.
- Tutorial
  - The critical role of the hybrid in a CICC.
- New
  - Improved performance of a new 90° coax hybrid designed for wideband, high power channel combining.
  - An Improved Constant Impedance Channel Combiner for UHF TV

Various Types of Channel Combiners

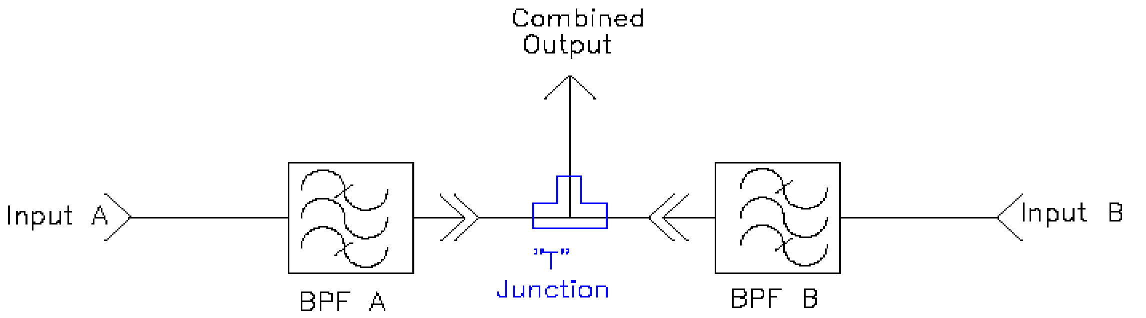
Tee-based Combiners

- Starpoint
- Manifold

Hybrid-based Combiners

- Constant Impedance

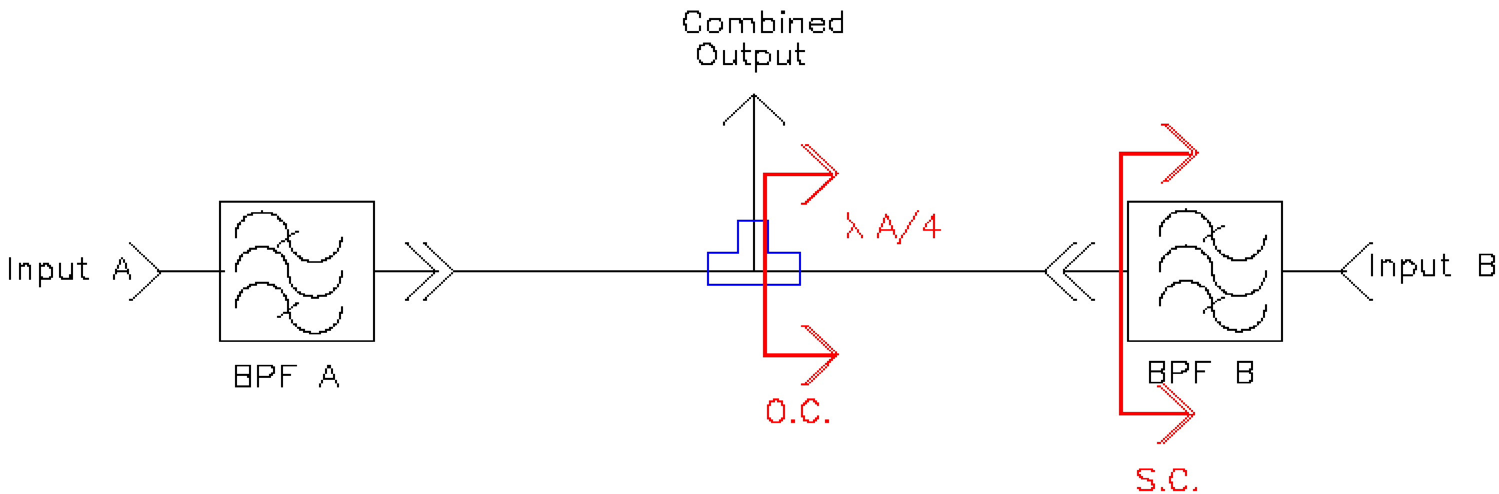
Tee-based Combiners



Unitary Tee-junction Combiner

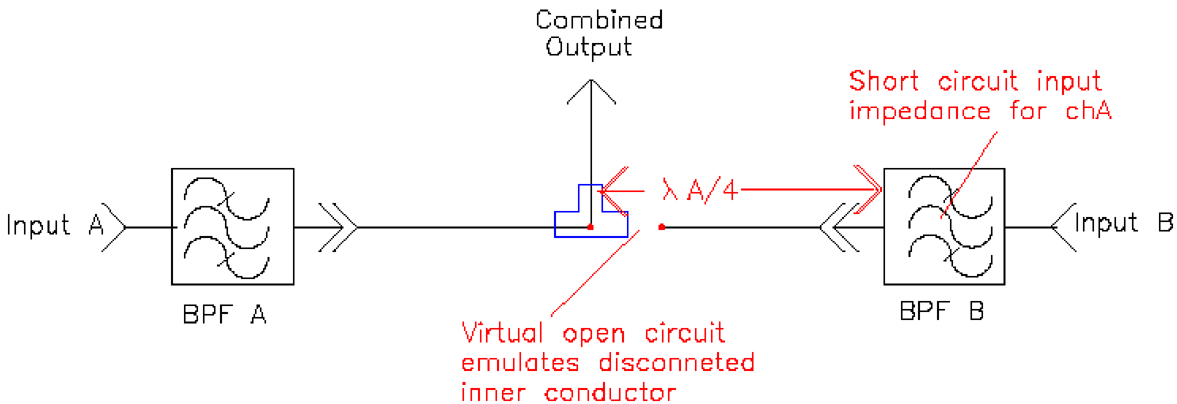
- Starpoint and manifold channel combiners are both composed of the unitary Tee-junction combiners.

Unitary Tee-junction Combiner Channel A Perspective



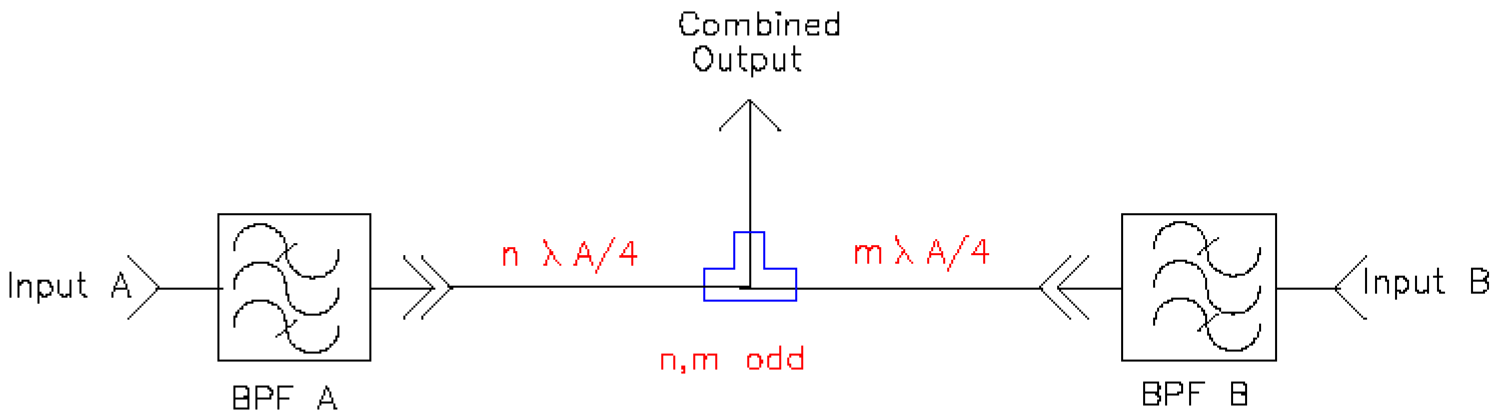
- BPF-B acts as a short-circuit to Channel A
- One-quarter wavelength before a short circuit is a virtual open circuit
- This open circuit condition effectively decouples the entire “B” branch of the circuit from the tee junction.

Tee-junction Combiner (Channel A perspective)



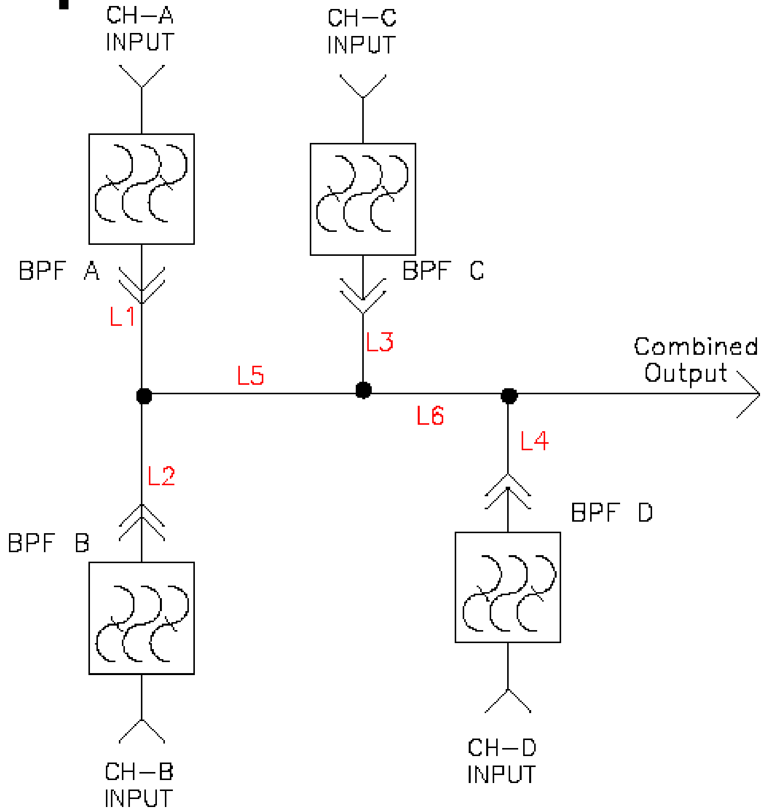
- A virtual open circuit condition (no current flow) precisely located at the tee junction is effectively similar to disconnecting the inner conductor that leads to filter BPF-B.
- Thus the tee junction with a properly phased reflective filter behaves like an elbow and all power flows to the common output port.

T-junction Combiner General Solution



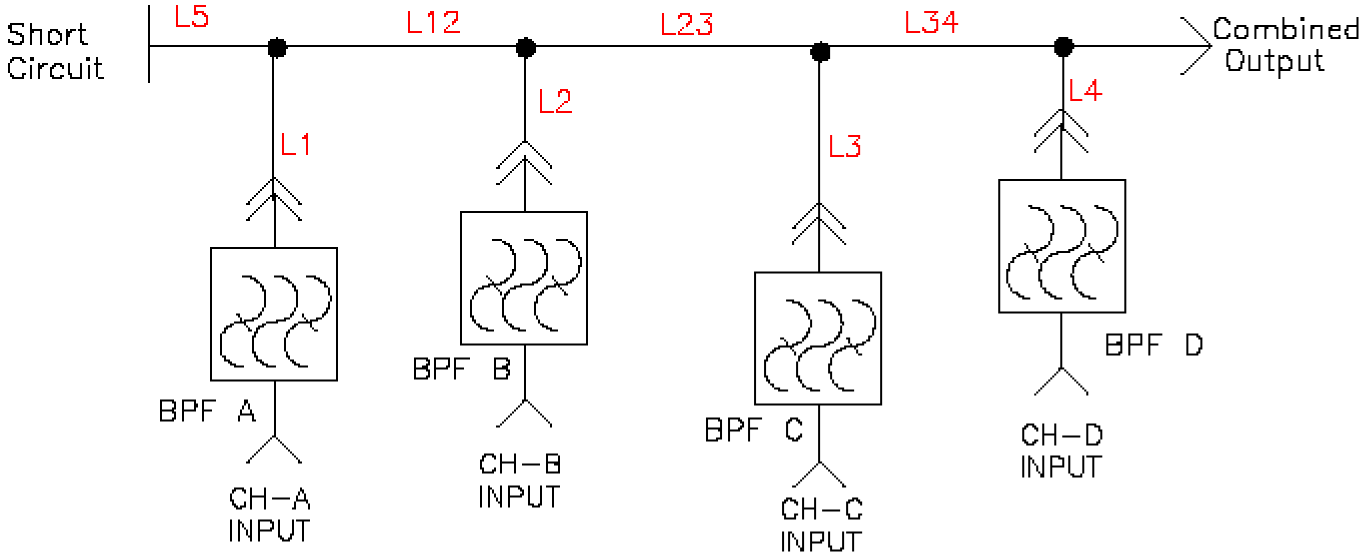
- The line length from BPF-A to the tee junction is critical to channel B and of no consequence to channel A.
- The line length from BPF-B to the tee junction is critical to channel A and of no consequence to channel B.
- Half wavelengths can be added to the phasing lines and the combiner will still work, but with reduced bandwidth. (The critical phasing lines are λ/4 long at only one center frequency).

Multichannel Tee-junction “Starpoint” Combiners



- Multiple channels can be combined in the same way using multiple tees and multiple phasing lines.

Manifold Combiners

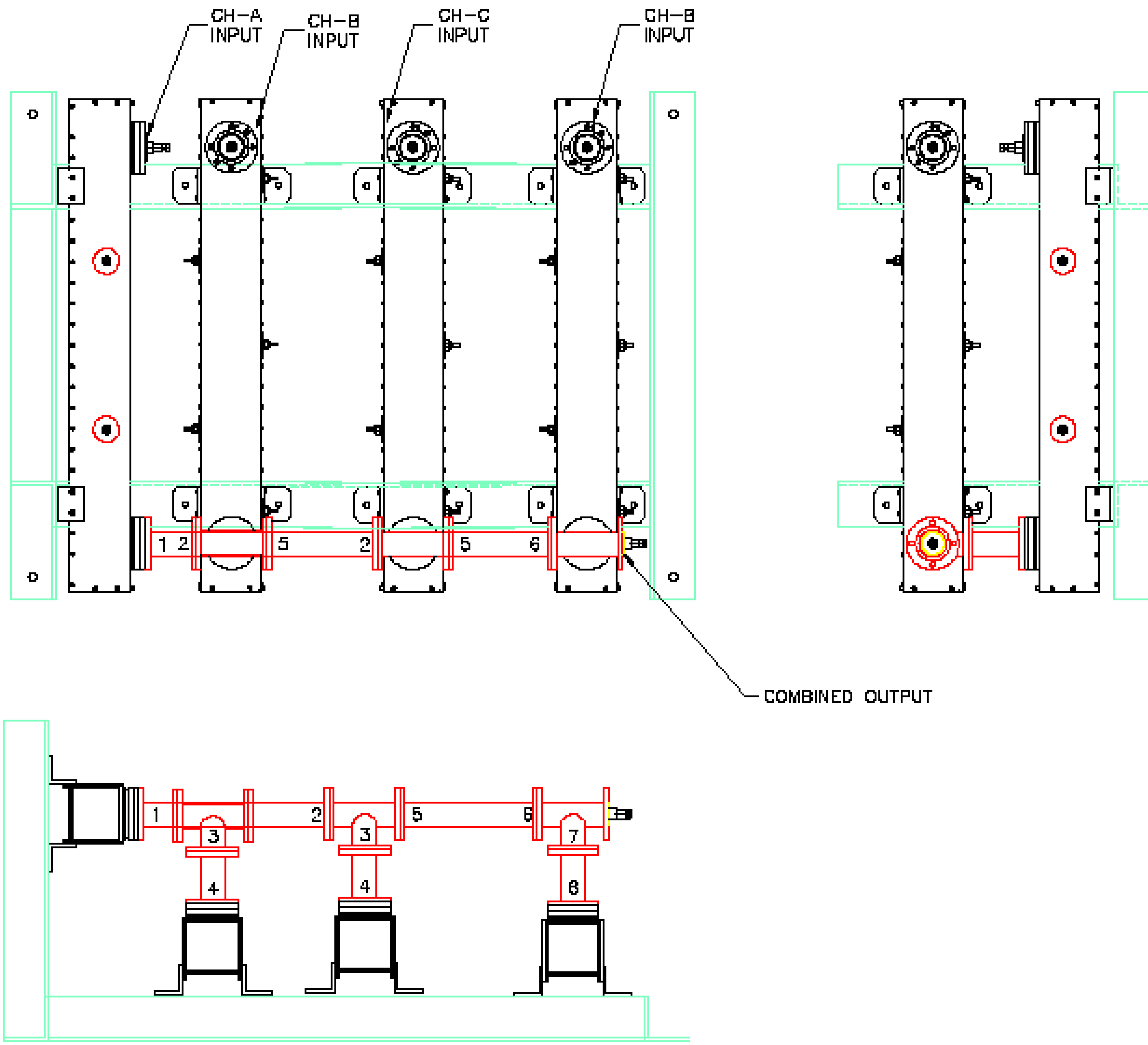


- A manifold combiner is simply a multi-channel tee-combiner with all of the tees lined up in a serial, collinear fashion.

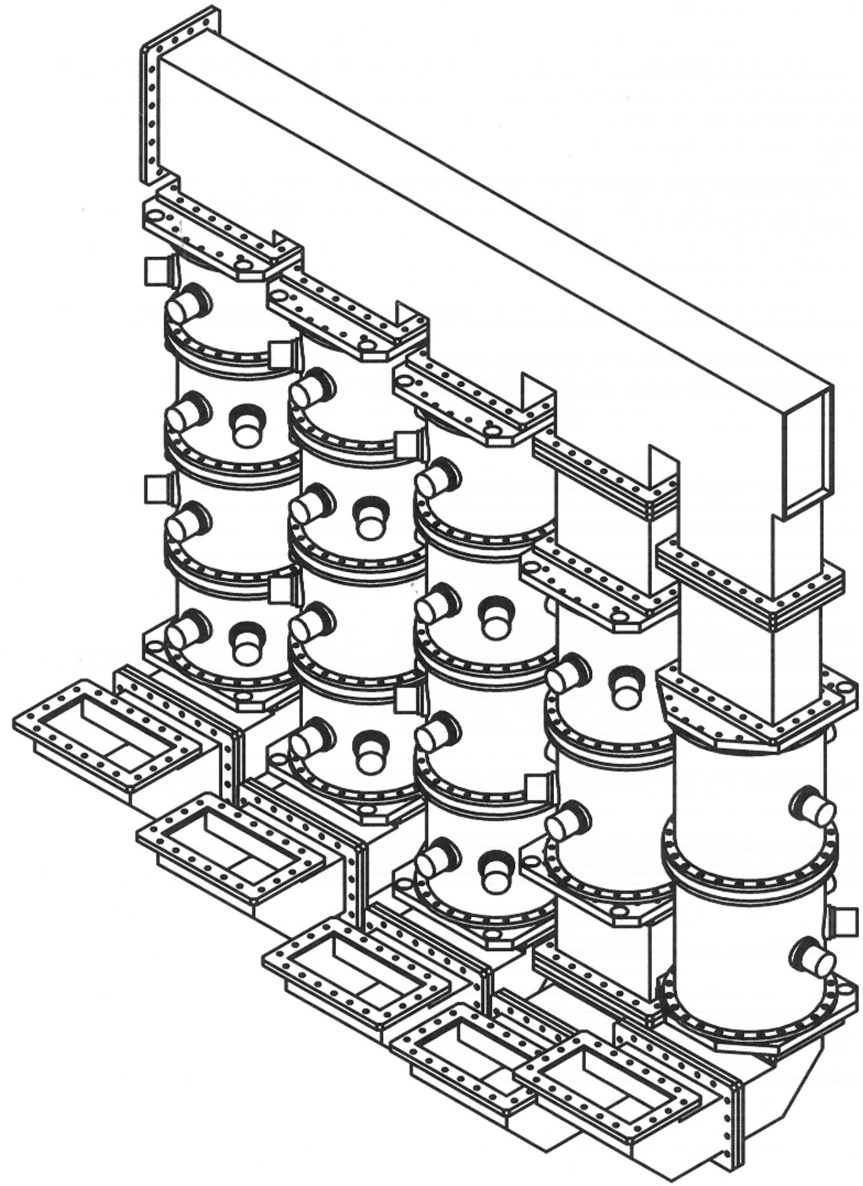
Manifold/Starpoint Combiners

- Can be very compact, with the least hardware for any type of channel combiner.
- Typically lower cost than constant impedance channel combiners.
- Will reflect out-of-band power back to each transmitter.
- Lowest VSWR for any type of channel combiner for multiple widely-spaced channels. (No hybrid)
- Complicated design, very hard to tune the prototype if it is not accurately designed.
- Not future-expandable. (But it can be fed into the wideband input port of a downstream constant-impedance channel combiner.

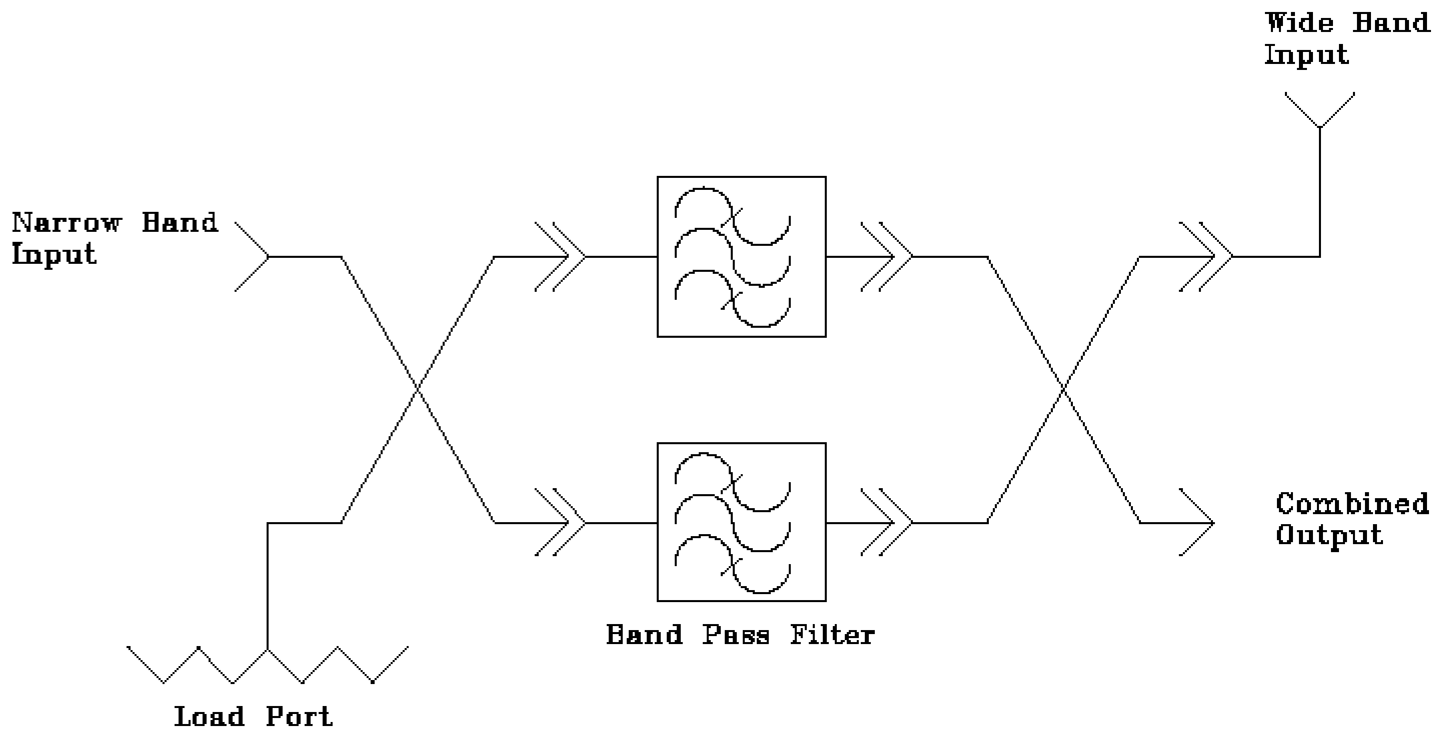
Four-Channel Starpoint Combiner



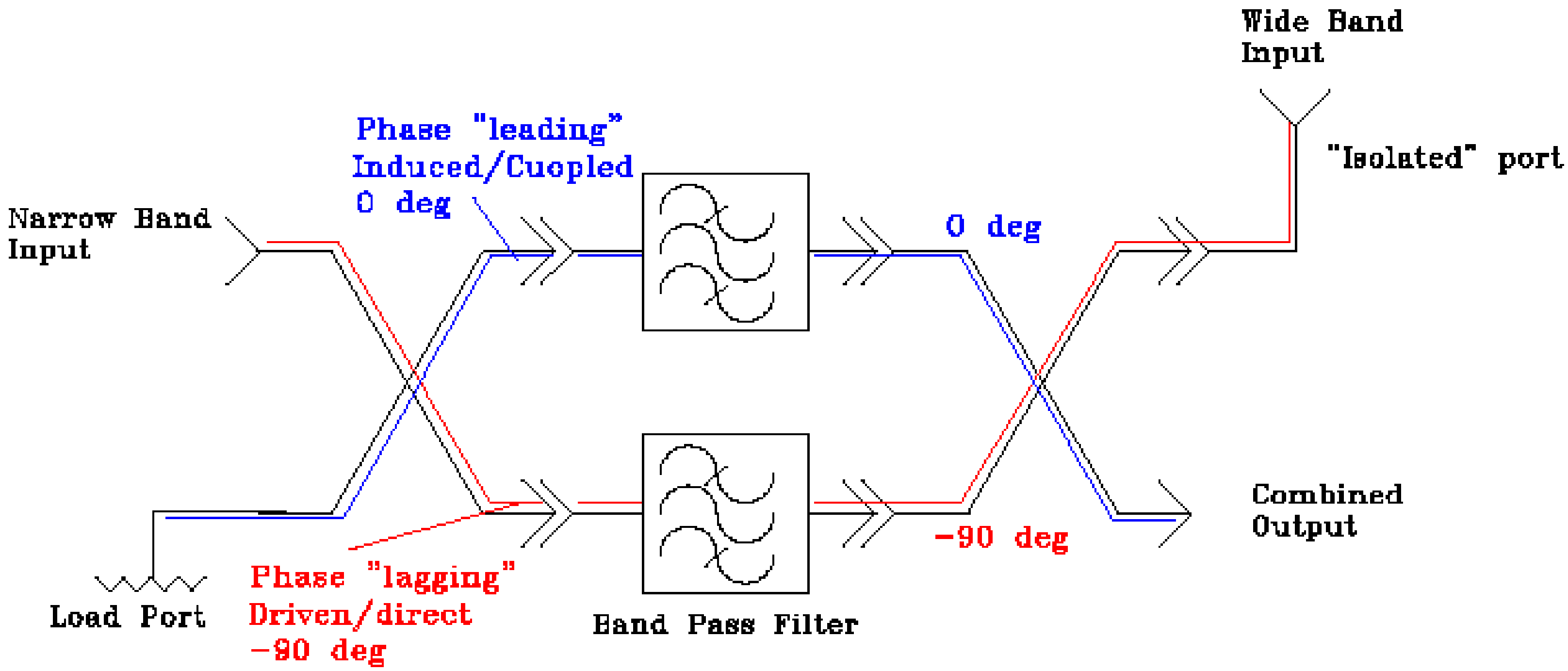
Five-channel Manifold Combiner



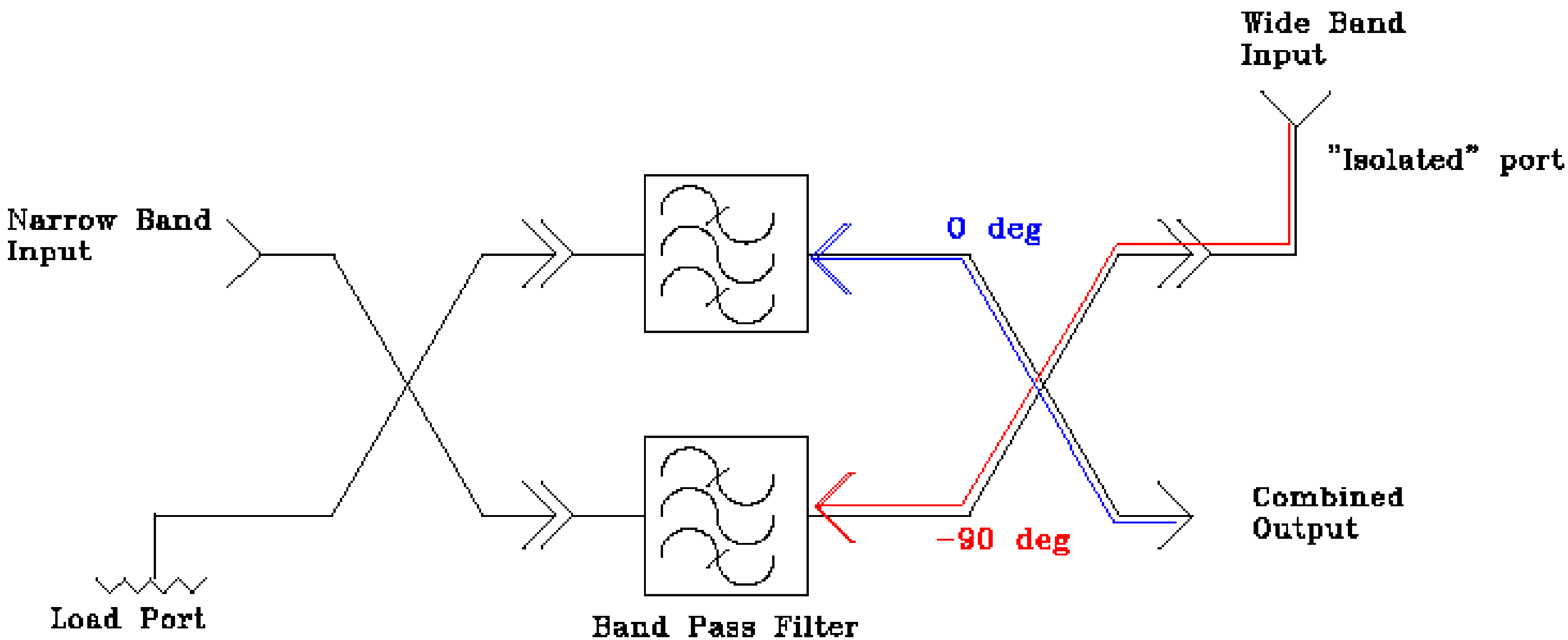
Constant Impedance (Balanced) Channel Combiners



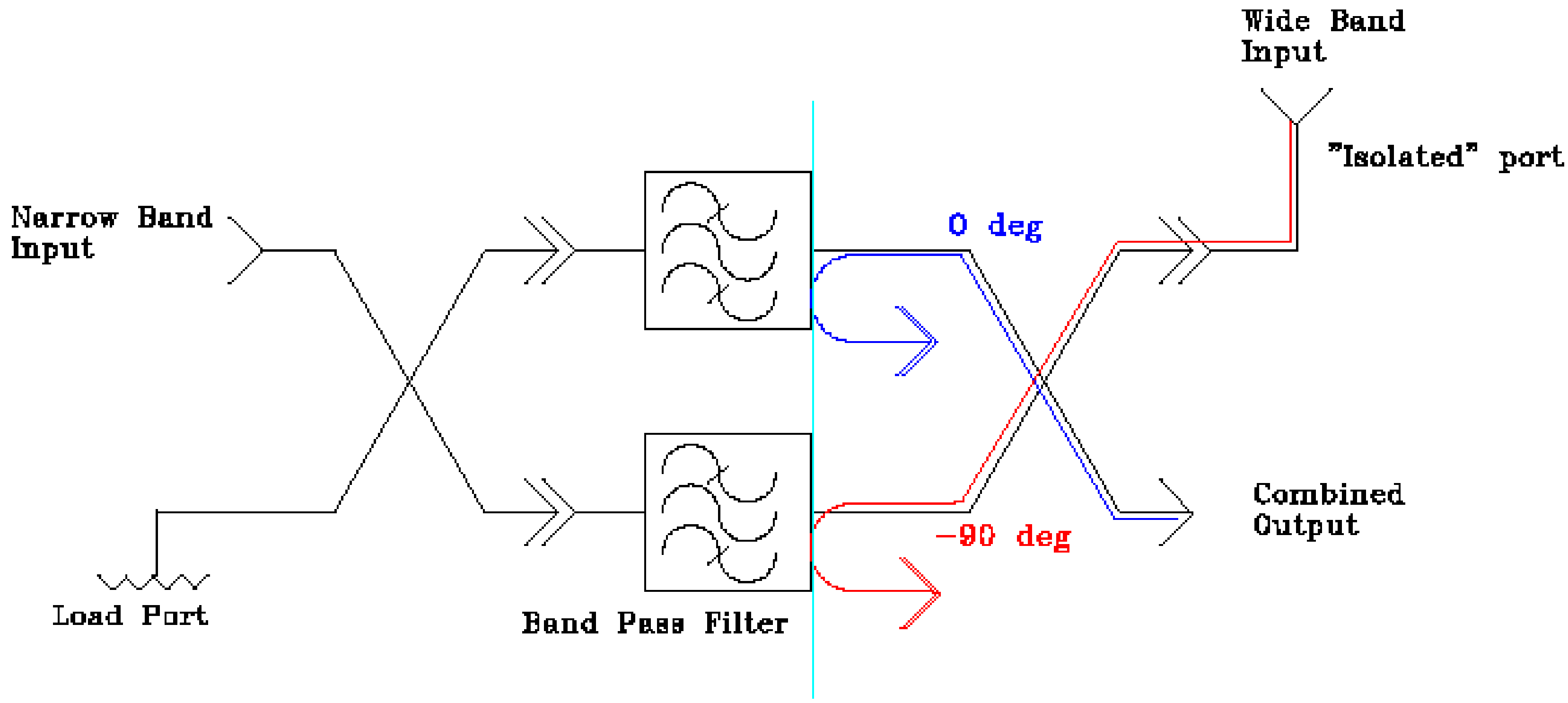
CICC Narrowband Signal Flow



CICC Wideband Flow to Filters



CICC Wideband Flow off Filters



Constant Impedance (Balanced) Channel Combiners

- CICCs present wideband *matched* impedances at both the narrowband and wideband inputs.
- Each CICC module adds a single new channel to a pre-existing multiplex of channels.
- CICCs are modular and can be cascaded with other CICC modules.

The Role of the Hybrid in a Constant Impedance Channel Combiner

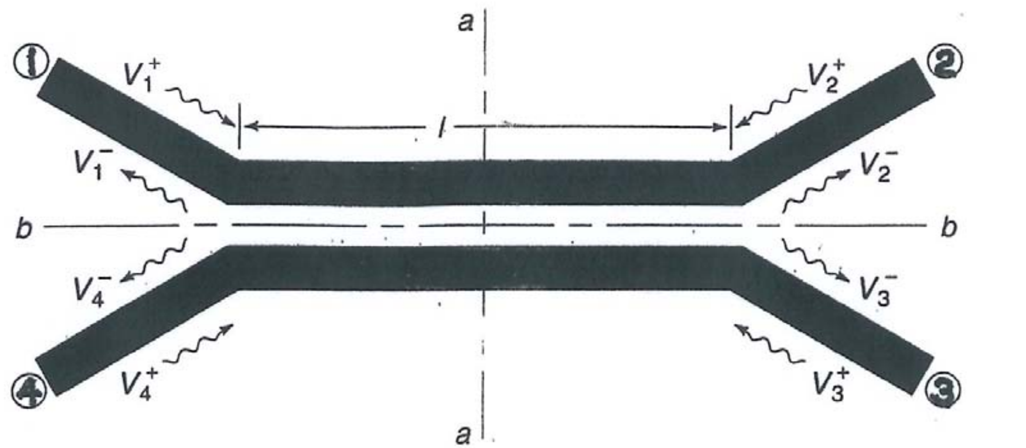
The Role of the Hybrid in a Constant Impedance Channel Combiner

- Splitting signals with a hybrid.
- Combining equal-power “half-signals” with a hybrid.
- The “short-circuit” VSWR of a hybrid as an estimator of combiner VSWR at the wideband input port.

Splitting Signals With a Hybrid

Input, 100%, 0°

Direct Output, 50%, -90°



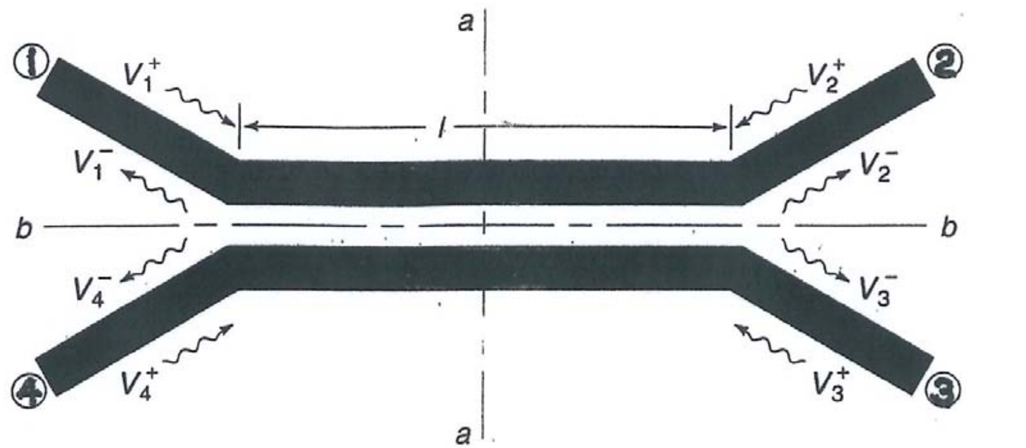
Coupled Output, 50%, 0°

Isolated Port

Combining Signals With a Hybrid

Isolated Port

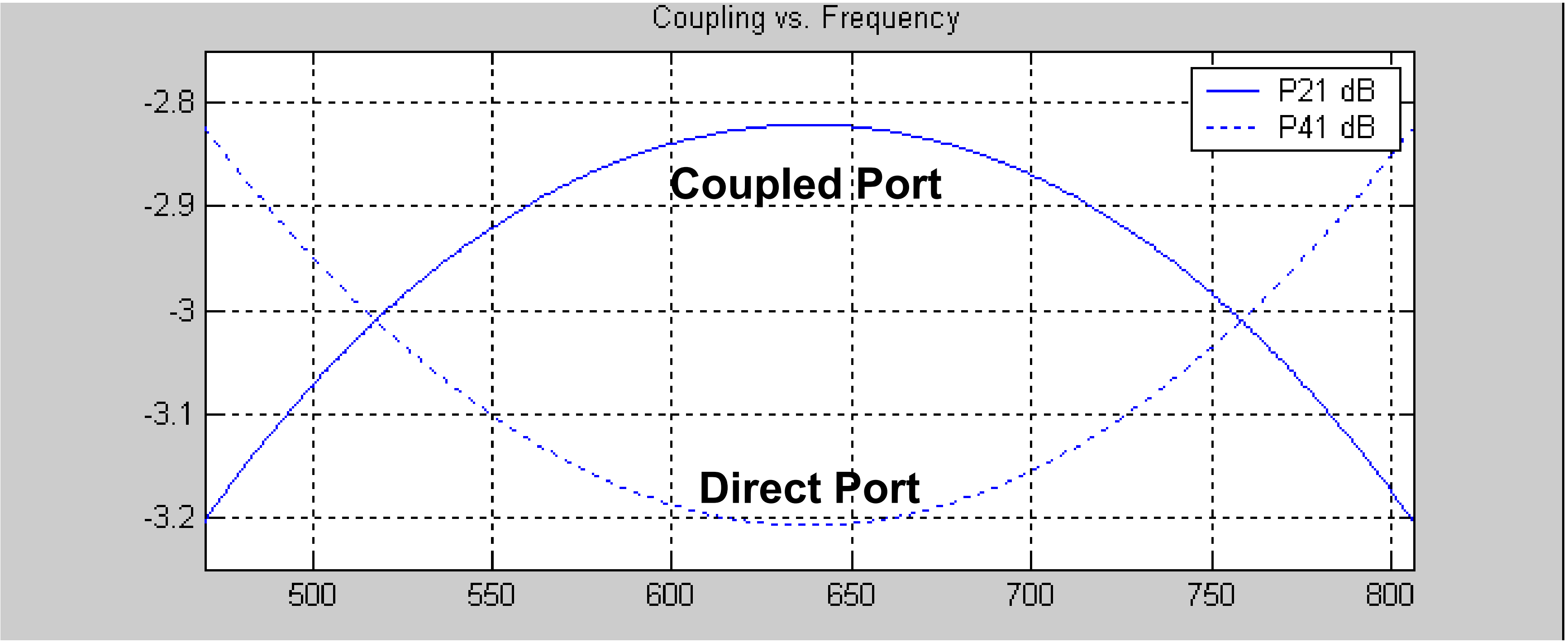
Input 50%, -90°



Input, 50%, 0°

Output 100%, -90°

Hybrid Amplitude Split and its Frequency Dependence



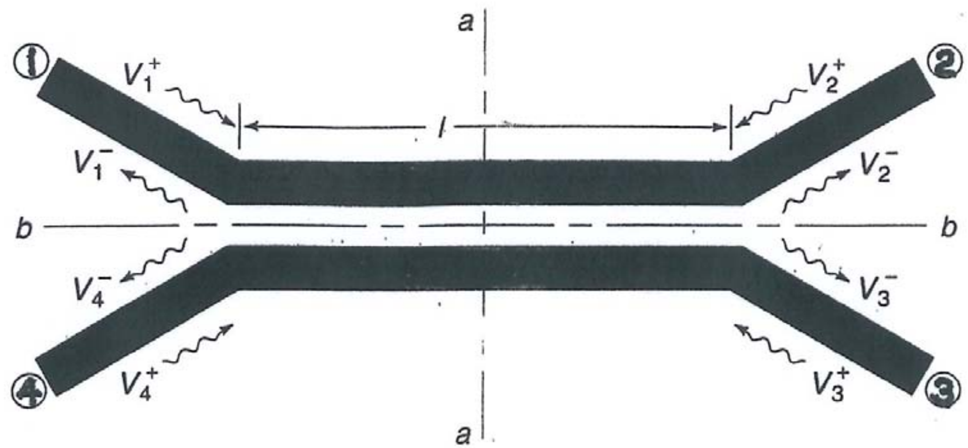
- Broadband coupling of a quarter-wave hybrid
- The amplitude-imbalance is equalized across the band.

Short Circuited, Over-coupled Hybrid

47.8%, -90°, reflected back

100% Input Power
Reflected 2.2%
16.5 dB RL
1.35 VSWR

S.C.



S.C.

52.2%, 0°, reflected back

Output ?

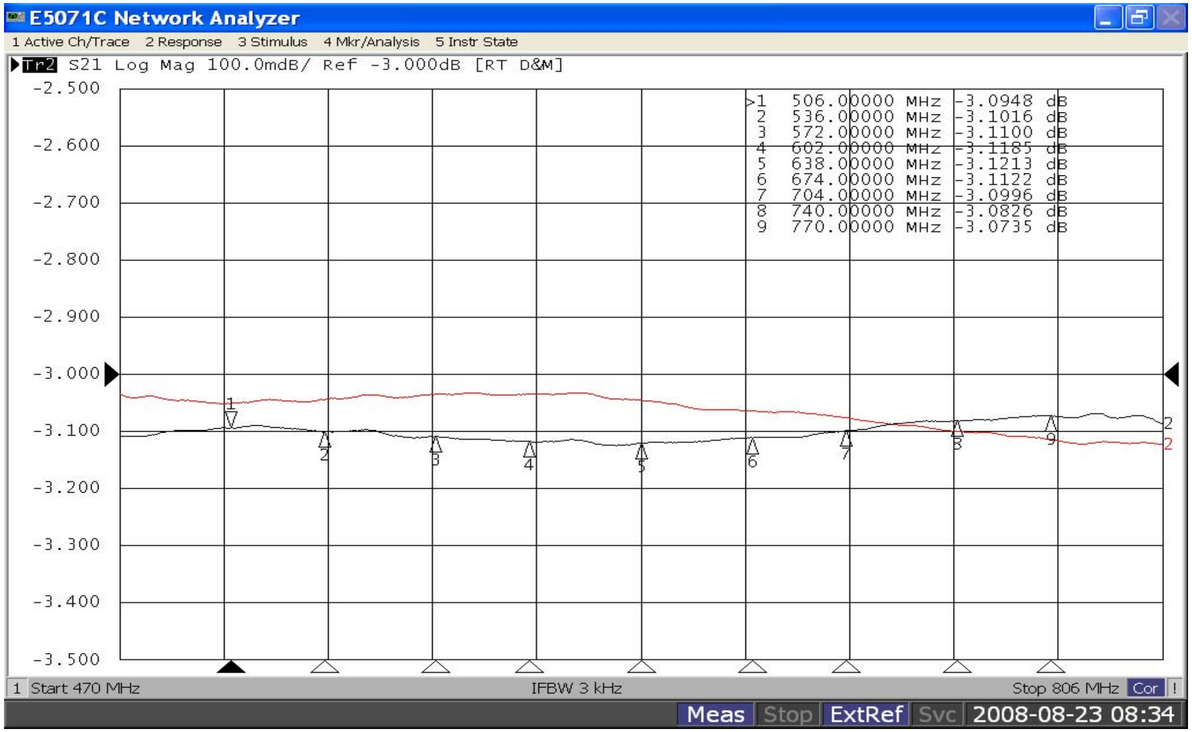
“Short Circuit” VSWR

- Wideband signals entering a CICC are reflected by the filter and are recombined by the wideband hybrid.
- If the amplitude split of the hybrid is not a perfect -3.01 dB, then there will be some reflected power at the wideband input.
- This is essentially the same as the short-circuit VSWR of the hybrid, assuming filters are well matched.
- Thus, having a flatter amplitude split will lead to a CICC with better wideband input VSWR.

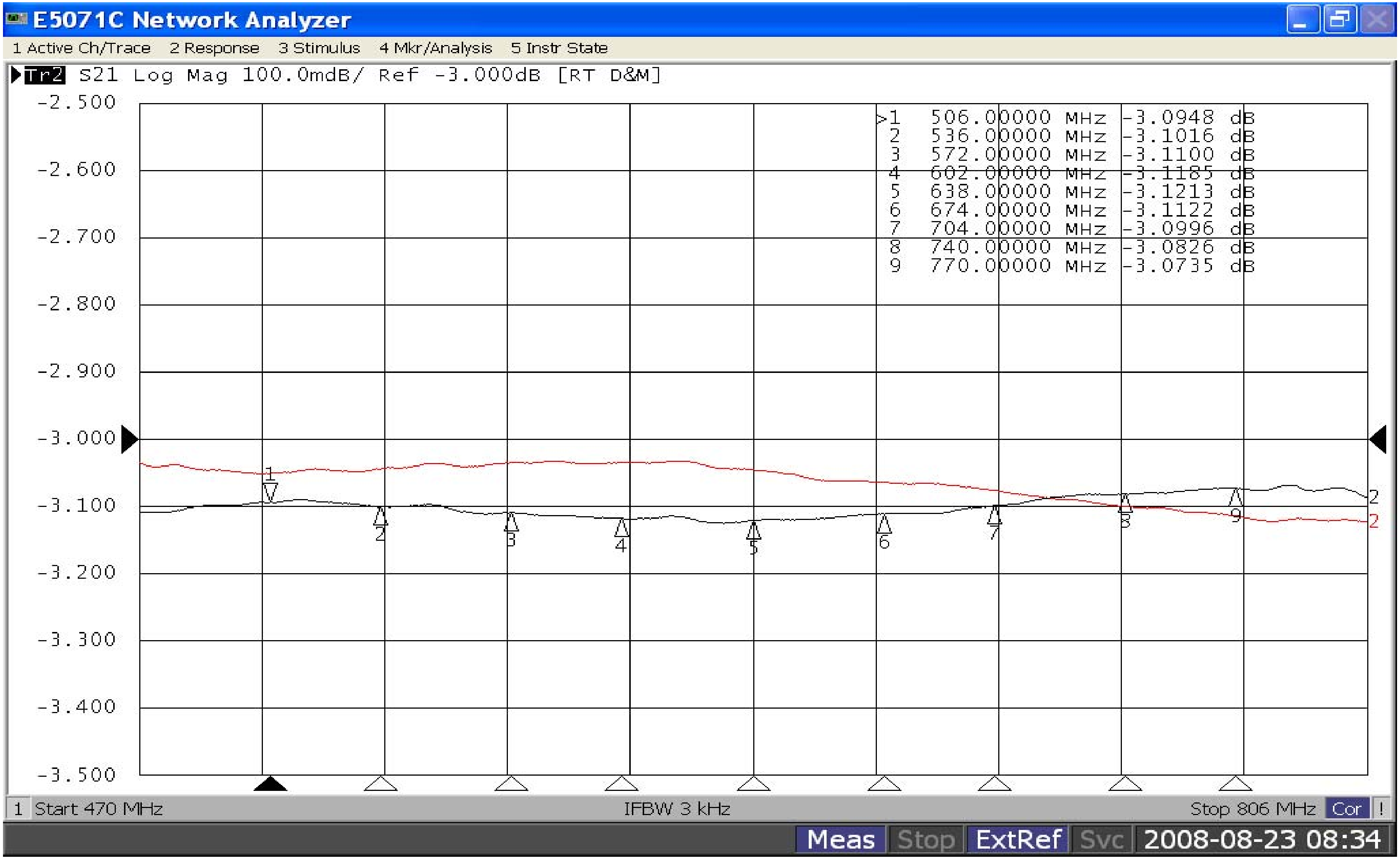
An Improved Hybrid

- The limitation of the quarter wave hybrid is its amplitude split versus frequency which is always the same cosine-squared shape.
- MCI has developed a multi-step hybrid that has flatter amplitude split and thus lower short-circuit VSWR

Amplitude Split of Super-hybrid (multi steps) 470-806 MHz



- **Only 0.08 dB maximum imbalance compared with 0.40 dB with a quarter-wave hybrid.**
- **This indicates 0.5% reflected power in short-circuit conditions, 23 dB RL,**
- **1.15 VSWR as compared with 16.5 dB RL and 1.35 VSWR for standard hybrid.**


E5071C Network Analyzer
1 Active Ch/Trace
2 Response
3 Stimulus
4 Mkr/Analysis
5 Instr State
Tr2 S21 Log Mag 100.0mdB/ Ref -3.000dB [RT D&M]
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-2.600
-2.700
-2.800
-2.900
-3.000
-3.100
-3.200
-3.300
-3.400
-3.500
>1 506.00000 MHz -3.0948 dB
2 536.00000 MHz -3.1016 dB
3 572.00000 MHz -3.1100 dB
4 602.00000 MHz -3.1185 dB
5 638.00000 MHz -3.1213 dB
6 674.00000 MHz -3.1122 dB
7 704.00000 MHz -3.0996 dB
8 740.00000 MHz -3.0826 dB
9 770.00000 MHz -3.0735 dB
1 Start 470 MHz
IFBW 3 kHz
Stop 806 MHz
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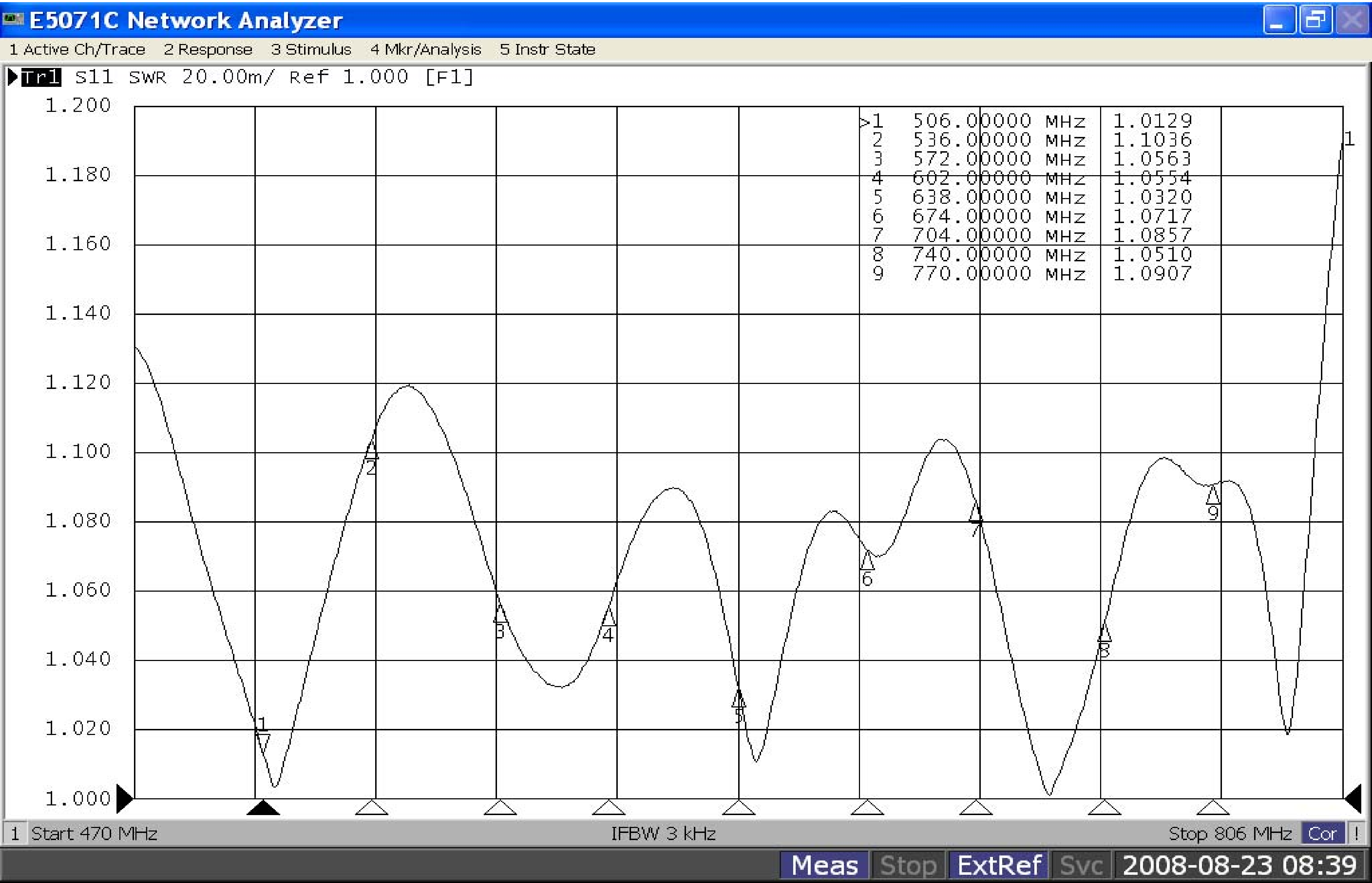
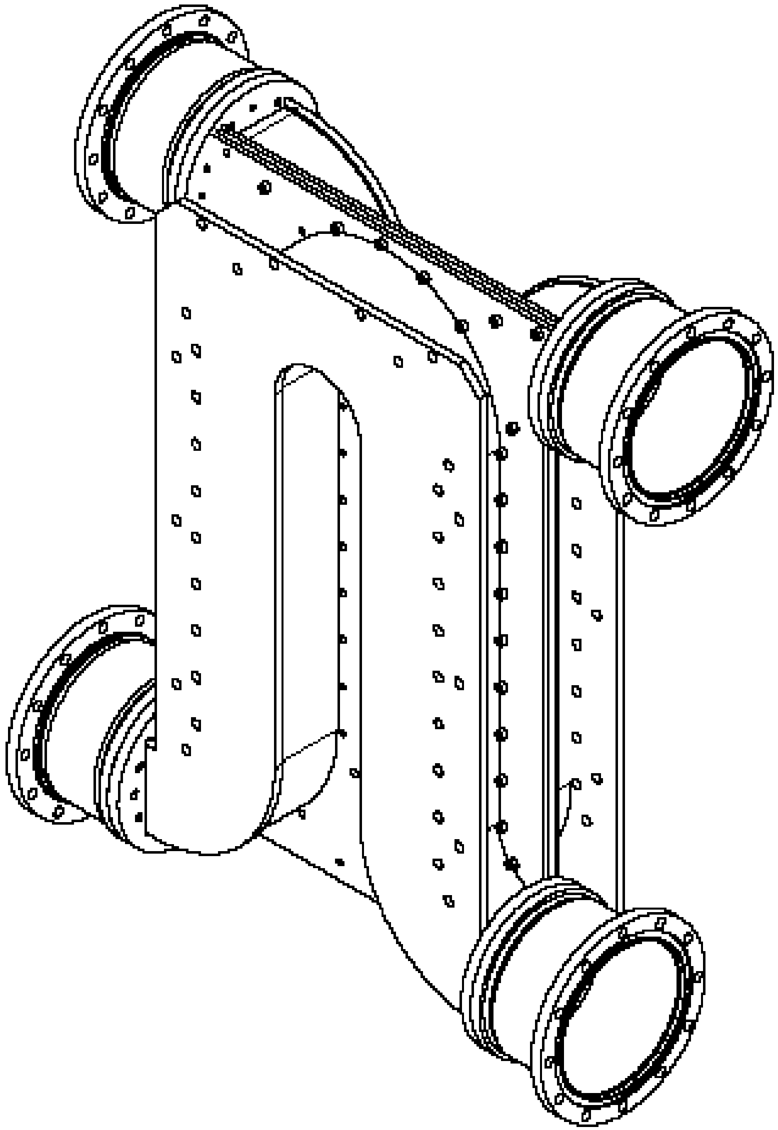
S.C. VSWR of Super-Hybrid



MCI new Superhybrid



We have used our new Superhybrid with great results on three high power projects.

→ IonMedia Combiner, NB=ch22 at 48KW

WB = ch42, 54 & 55 at 15KW

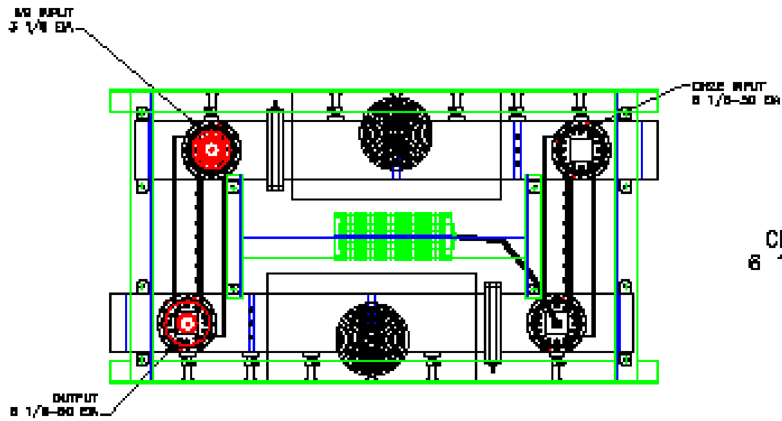
→ VTC Combiner, NB=ch39 at 34KW

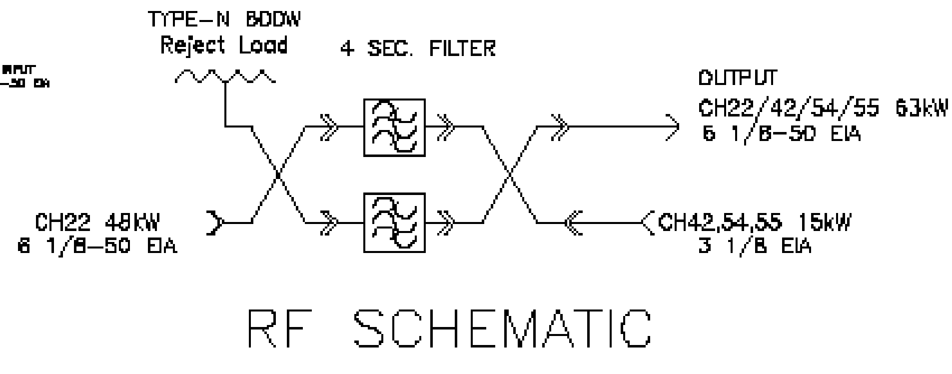
WB = ch33,34,38, 54, 60 & 61 at 65KW

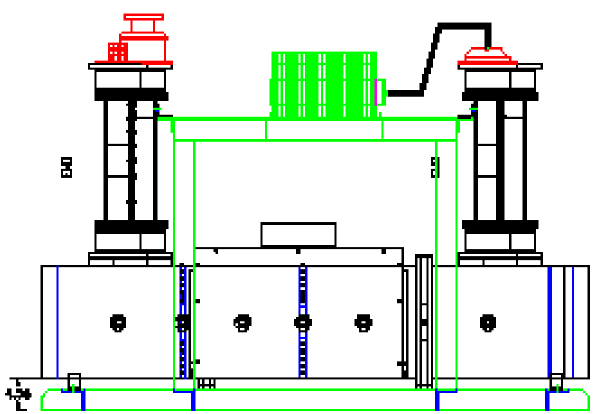
→ Poland Combiner, NB= ch27&44 at 60KW

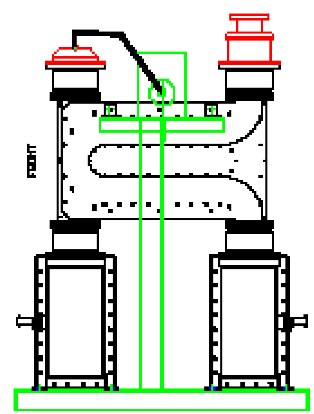
WB = ch33,41,48,51,55 &58 at 15KW

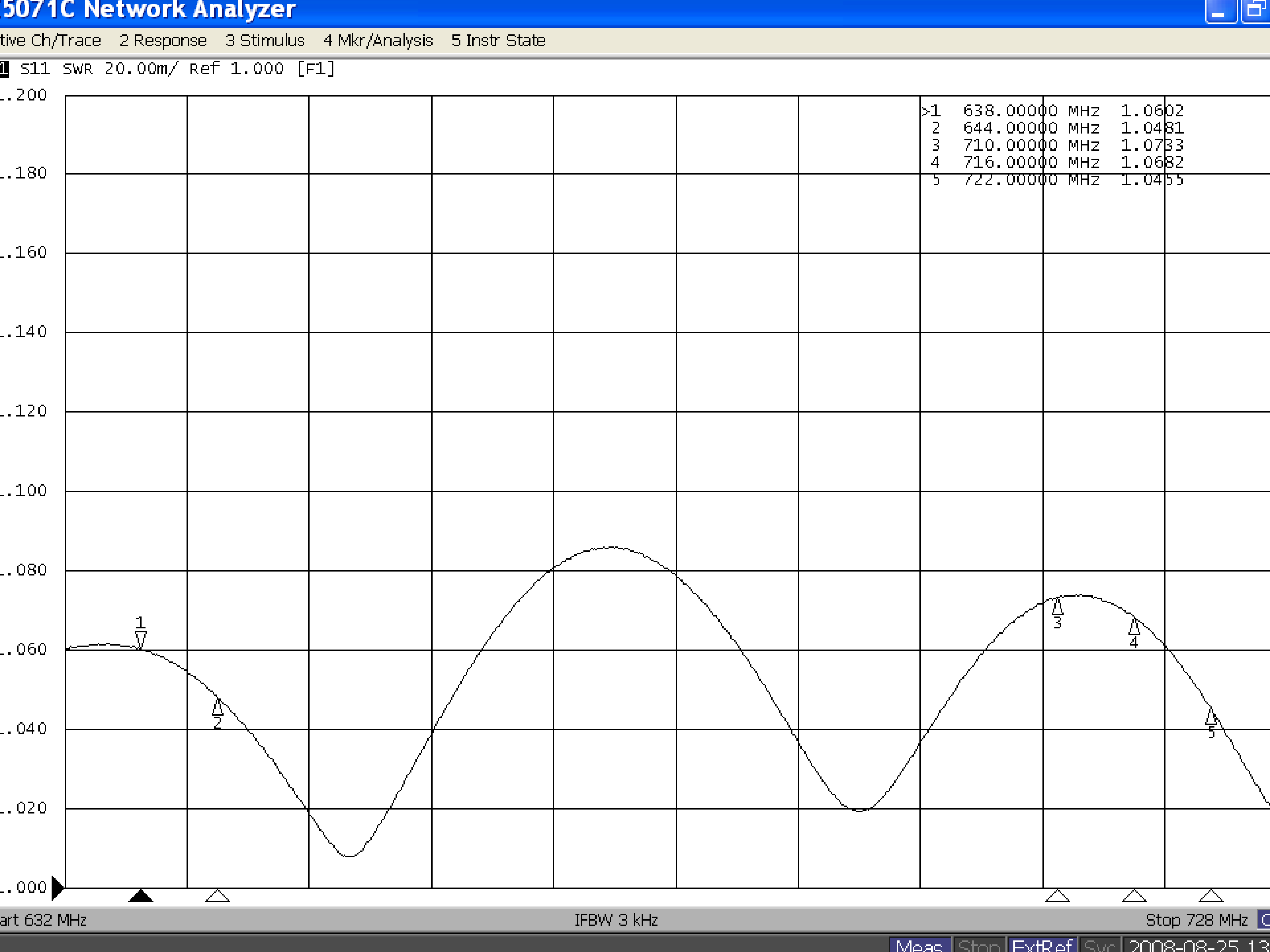
Ion Media CICC with Superhybrids










5071C Network Analyzer
tive Ch/Trace 2 Response 3 Stimulus 4 Mkr/Analysis 5 Instr State
S11 SWR 20.00m/ Ref 1.000 [F1]
>1 638.00000 MHz 1.0602
2 644.00000 MHz 1.0481
3 710.00000 MHz 1.0733
4 716.00000 MHz 1.0682
5 722.00000 MHz 1.0455
..200
..180
..160
..140
..120
..100
..080
..060
..040
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1
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art 632 MHz
IFBW 3 kHz
Stop 728 MHz
Meas
Stop
ExtRef
Svc
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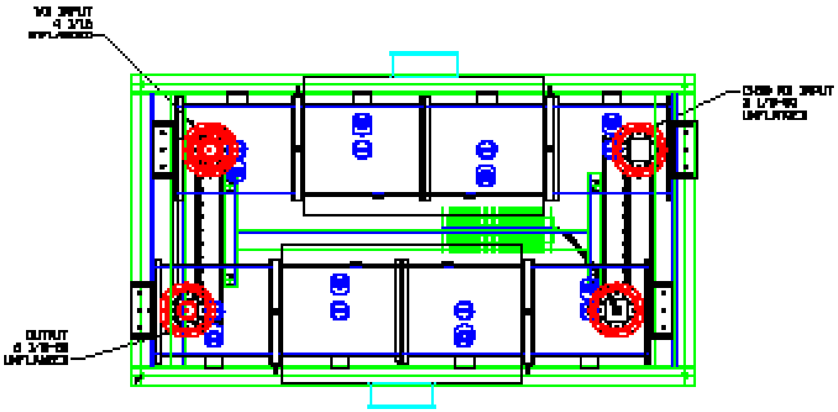
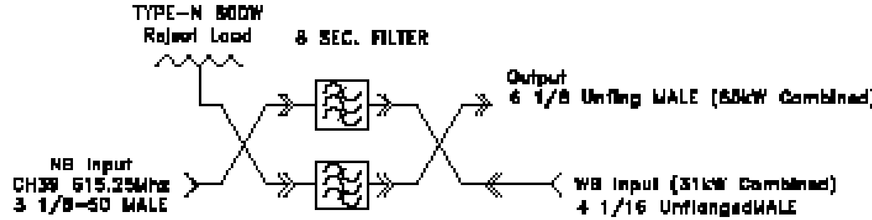
Can Tho Combiner 41276-8DMF-FB

6-1/8 CIBP-8DMF 2CH COMBINER

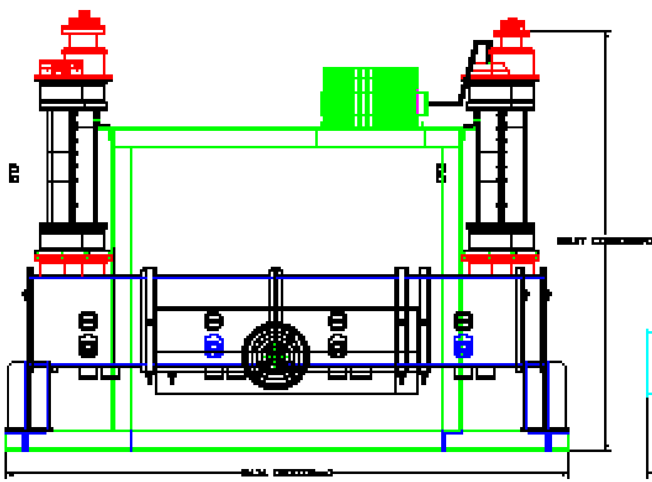
2161330-6325

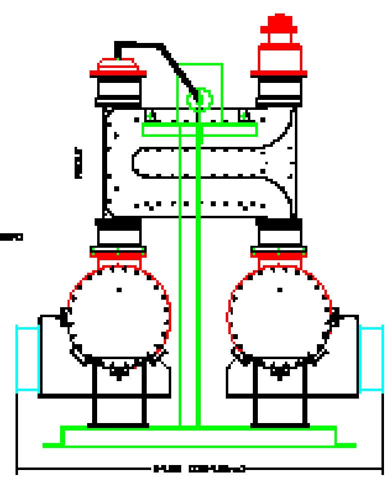




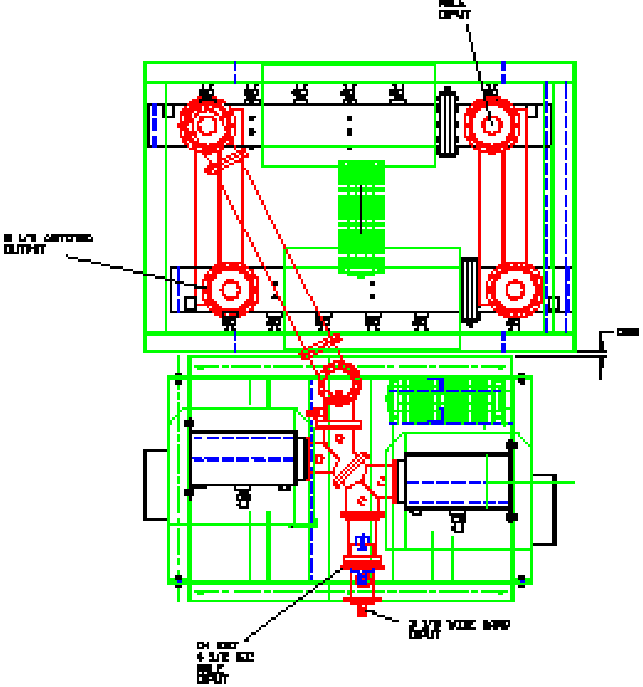
RF SCHEMATIC

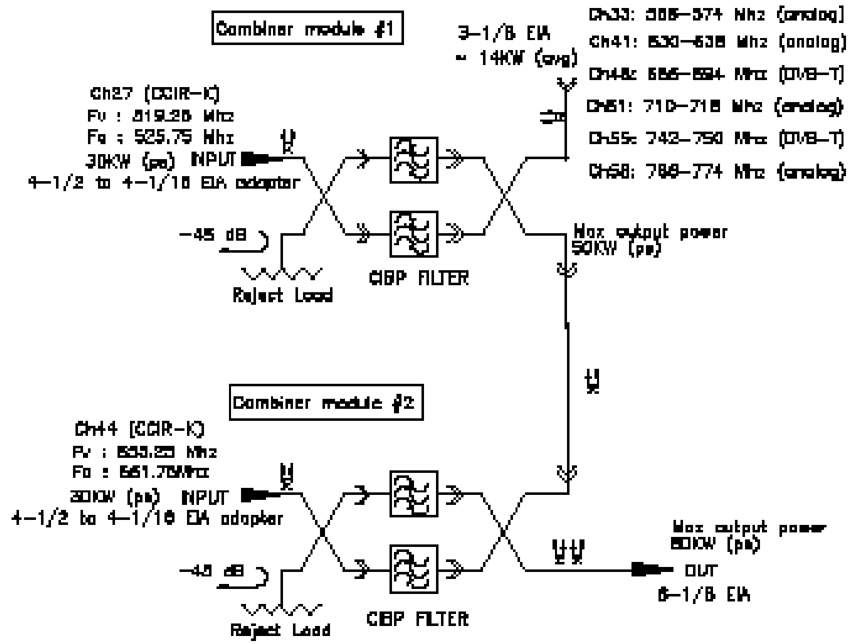
Channel	Fv(Mhz)
33	567.25
34	575.25
38	607.25
54	735.25
60	783.25
61	791.25

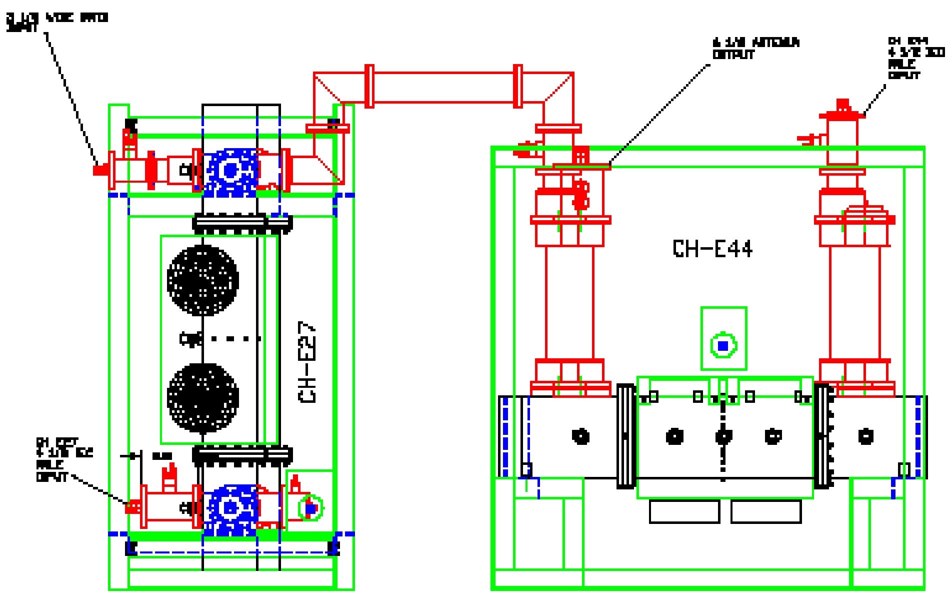




Poland Broadband Combiner







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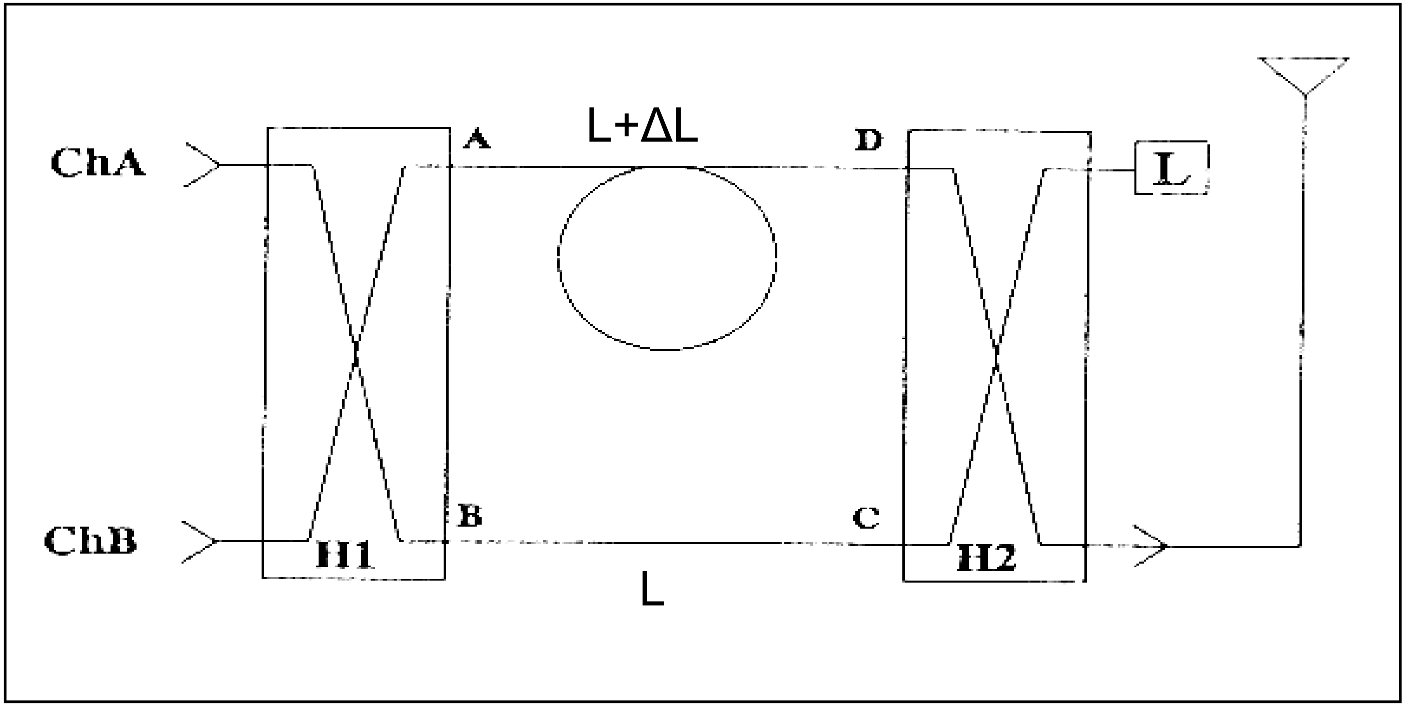
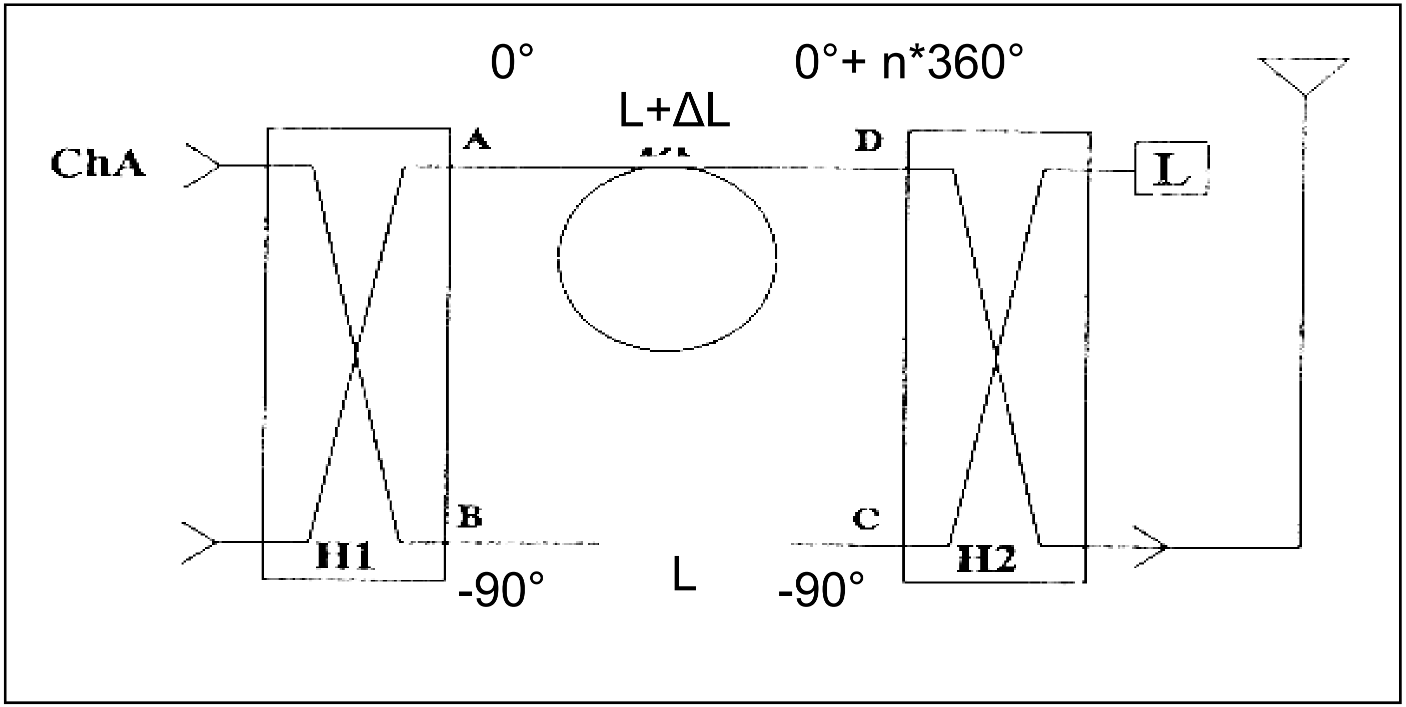
Loop Combiners (Commensurate Line)



- **Each channel is split by an input hybrid, phased by interconnecting cables and combined by an output hybrid.**
- **Proper phasing results in full transmission of both channels to the single output port.**

Loop Combiners
Channel A Solutions

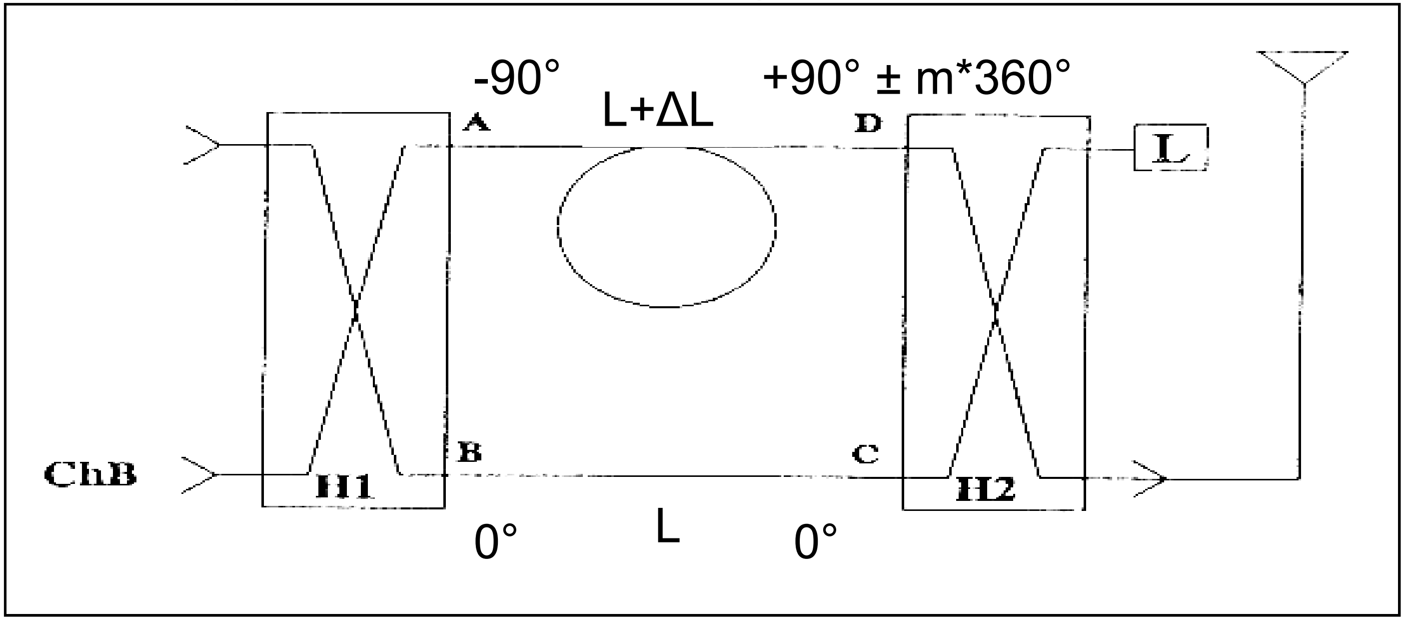


- **The required differential line length for Channel A is any integer multiple of wavelength λ_{A},**

  $\Delta L = n\lambda_A$, where *n* is any integer

- **This results in no change to the relative phase.**

Loop Combiners
Channel B Solutions

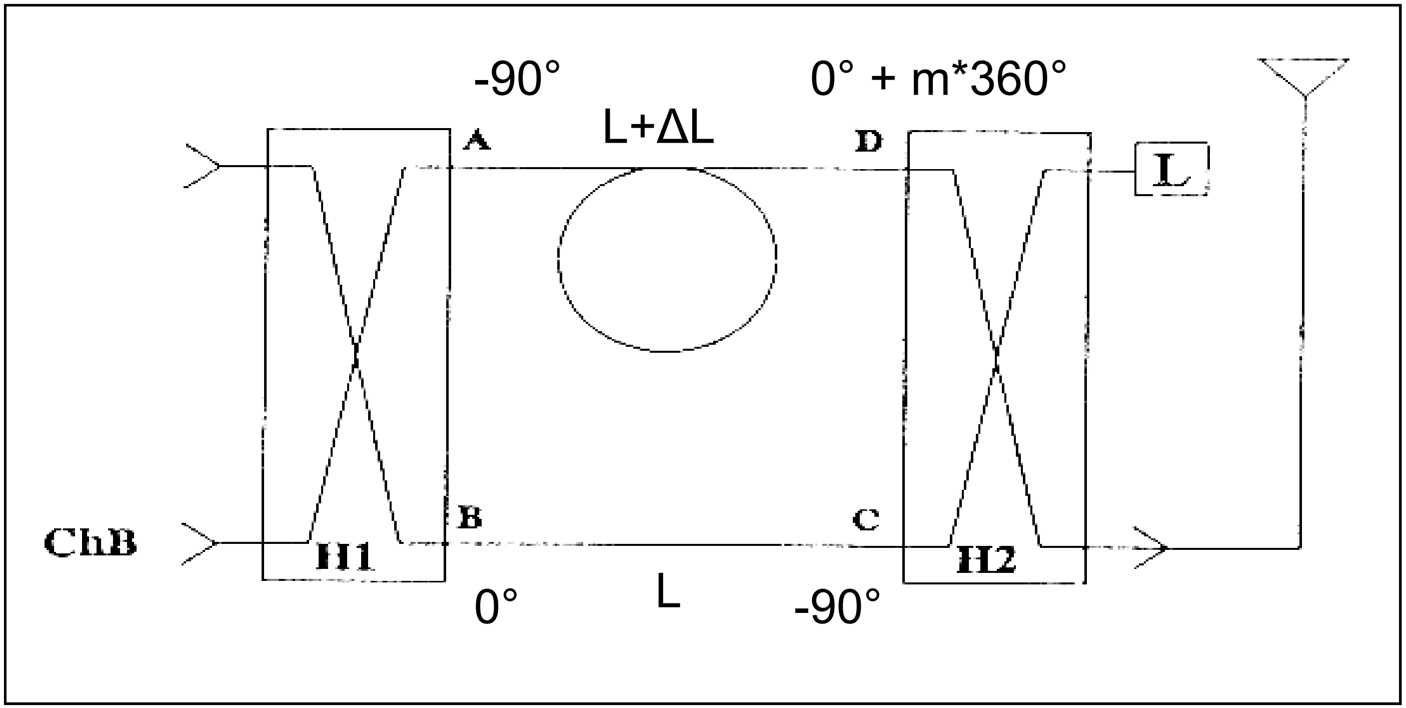


- **The required differential line length for Channel B is any *odd* half-wavelength, e.g. $\lambda_B/2$, $3\lambda_B/2$, $5\lambda_B/2$, …**

$\Delta L = (2m-1)*\lambda_B/2$, where *m* is any integer

- **This inverts the relative phase, changing it by 180°.**
- **We can subtract 90° from the top and bottom values without changing the relative phase, resulting in ….**

Loop Combiners
Channel B Solutions



- **Notice that the phase-lagging leg (upper) becomes the phase-leading leg and vice versa.**
- **This phases the half-signals for recombination to the antenna port**

Loop Combiners
Two-Channel Solution

Two conditions govern the differential line length ΔL
$\Delta L = n\lambda_A$, where n = 1, 2, 3,…
$\Delta L = (2m-1)*\lambda_B/2$, where m = 1, 2, 3…

Combining these two equations we get the required relationship between integers *n* and *m.*
$(2m-1)*\lambda_B/2 = n\lambda_A$

By dividing both sides by we get
$m-1/2 = n (\lambda_A/\lambda_B)$

This problem has no closed-form solution. It is solved graphically, or by computer search.

Loop Combiners

- Require no filters.
  - No group delay variations
  - Low loss, potentially very high power
- Provides no filtering.
- Very rugged and hard to detune.
- Simple to design and build.
- Limited to two, well-separated channels
- Typically more expensive than Starpoint combiners.

Loop Combiner