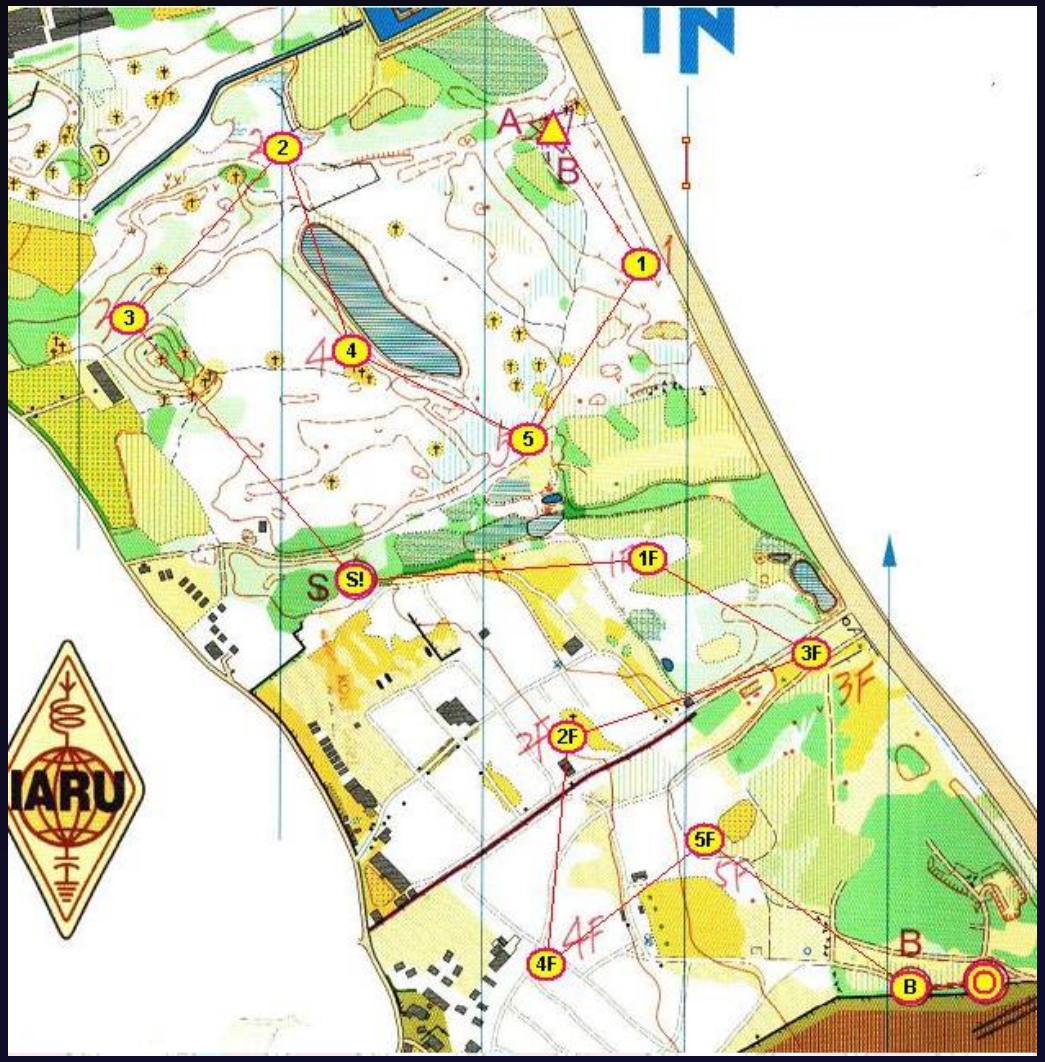
Automatic 80m ARDF Receiver based on Phase Measurement

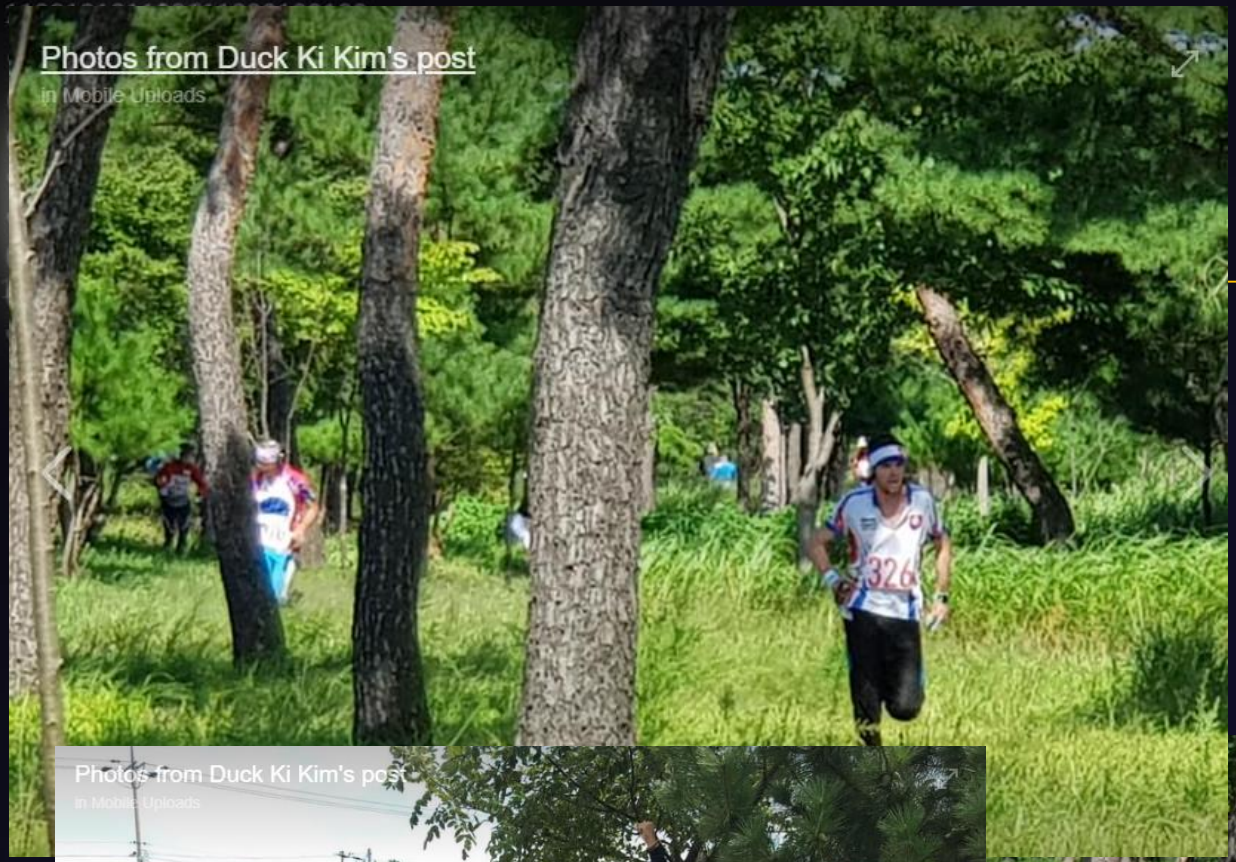
ON4CHE
UBA SNW
16/11/2018

World Championships Korea 2018

World Championships Korea 2018
Sprint competition

World Championships Korea 2018
Sprint competition




Photos from Duck Ki Kim's post
in Mobile Uploads
326


229


Photos from Duck Ki Kim's post
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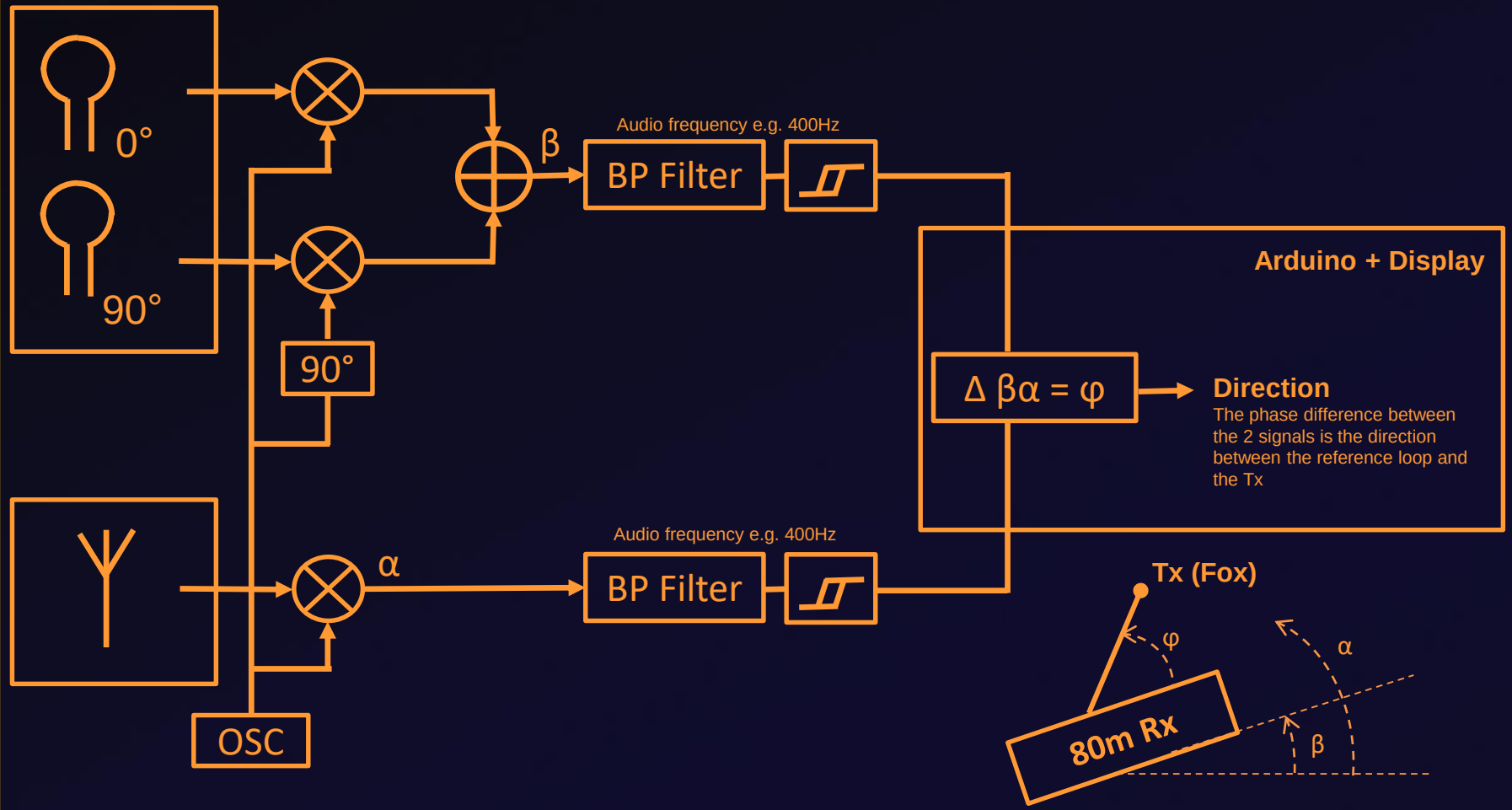
12 seconds window during 80m sprint competition to find the Fox direction.

THE IDEA

ARDF Rx based on Phase Difference

ON4CHE



Prototyping based on 80m Blind-O receiver.

PROTOTYPING

BLIND - O

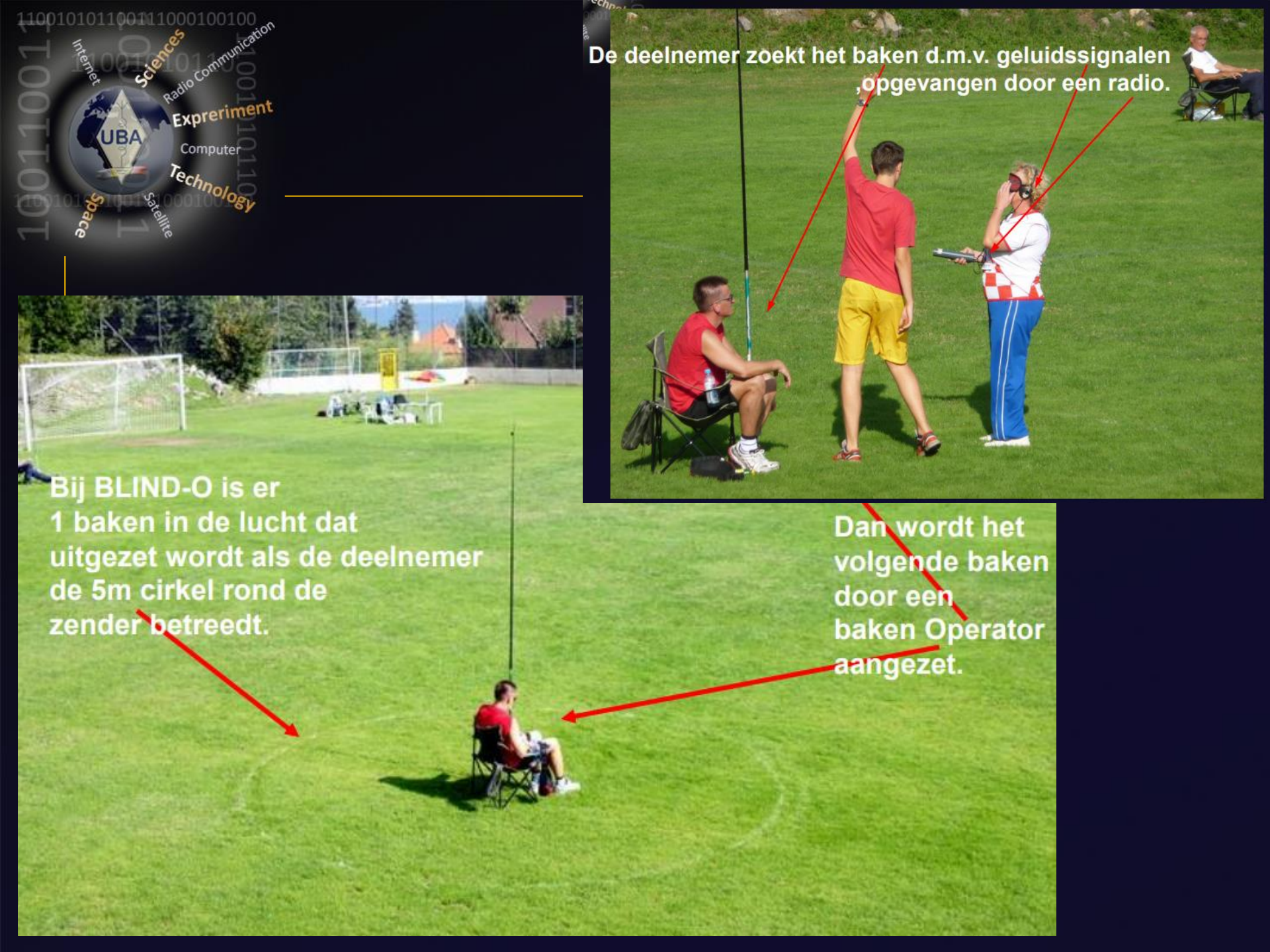
De speciale Blind-O ontvanger is ontworpen met volgende kriteria in gedachte:

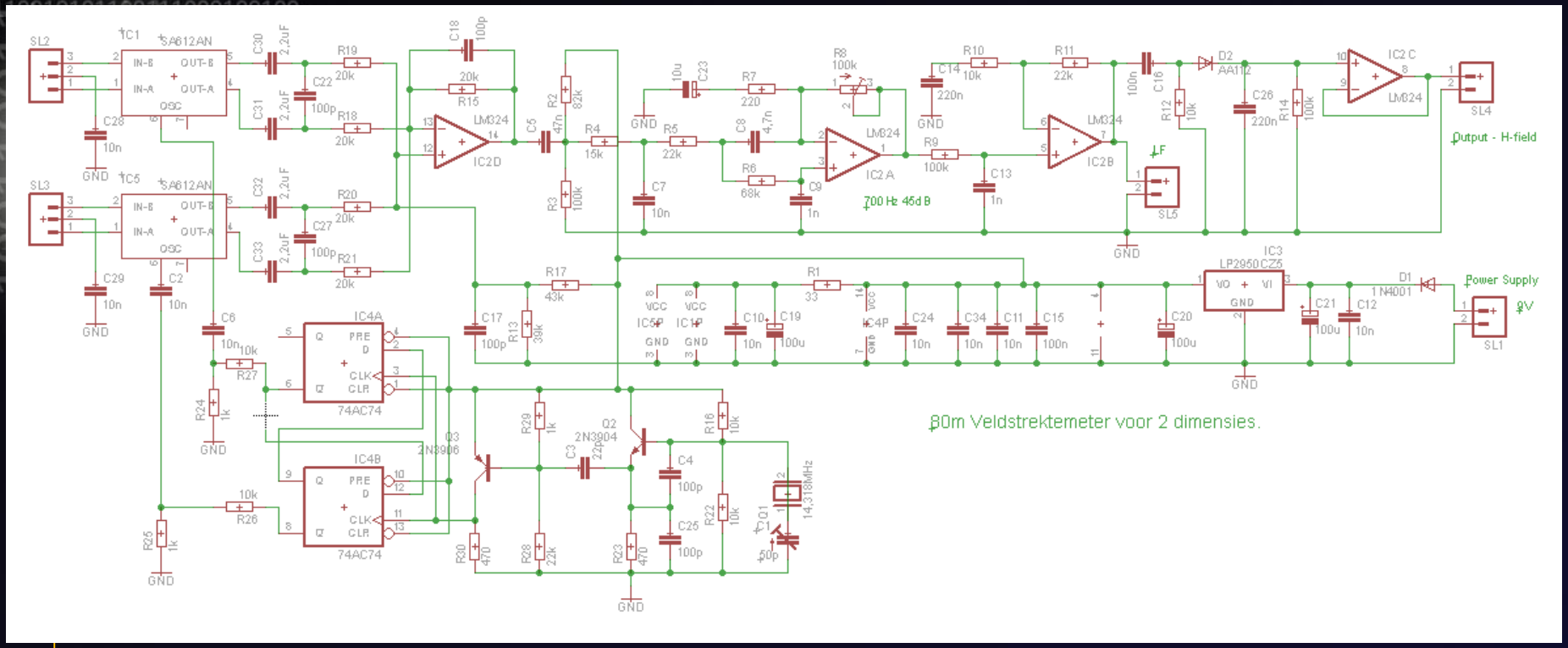
- Ergonomisch in gebruik.
- Eenvoudig bedienbaar.
- Veilig. Dit betekent, als de gebruiker struikelt, mag hij hem niet kunnen kwetsen.
- Perfecte peileigenschappen hebben in het nabije veld van een 80m zender.
- Goedkoop.
- Robuust.
- Eenvoudig nabouwbaar en afregelbaar.
- Professioneel printje.
- Componenten die gemakkelijk te verkrijgen zijn en nog nieuw geproduceerd worden.
- Standard 3,5 mm stereo hoofdtelefoon.

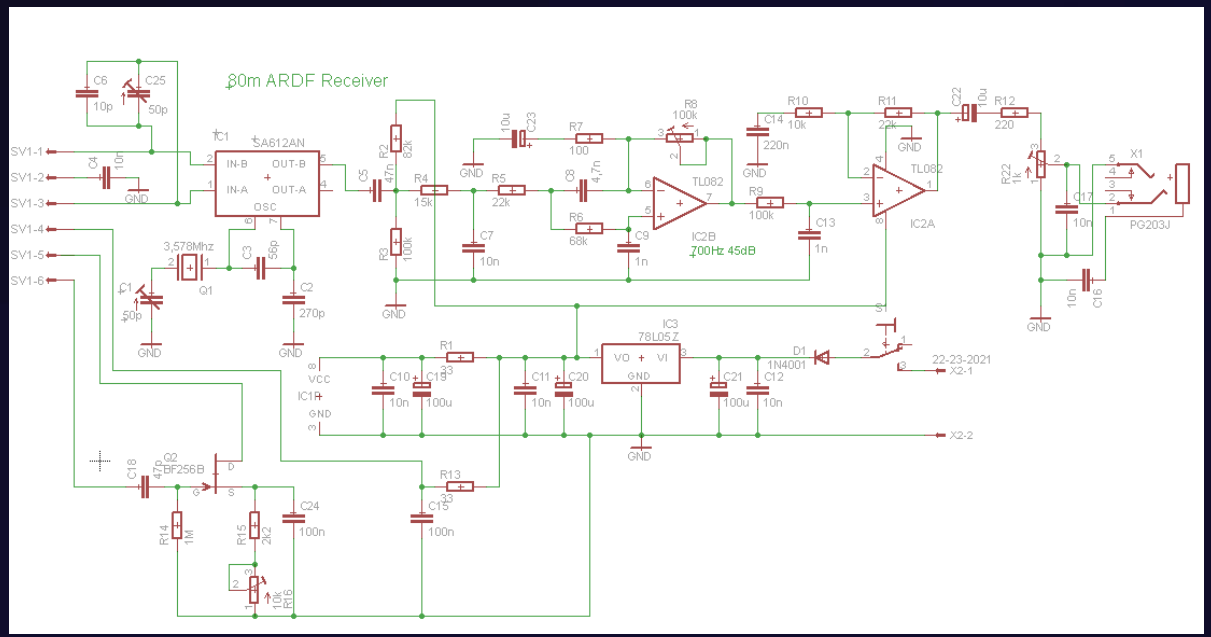
Deze ontvanger is gebouwd om gebruikt te worden met de 80m ARDF zenders ontworpen door ON7YD (http://www.qsl.net/on7yd/atx80.htm gevoed op 12V). Daardoor konden we de ontvanger vereenvoudigen (goedkoper) en hadden we minder last van storingen uit de omgeving.

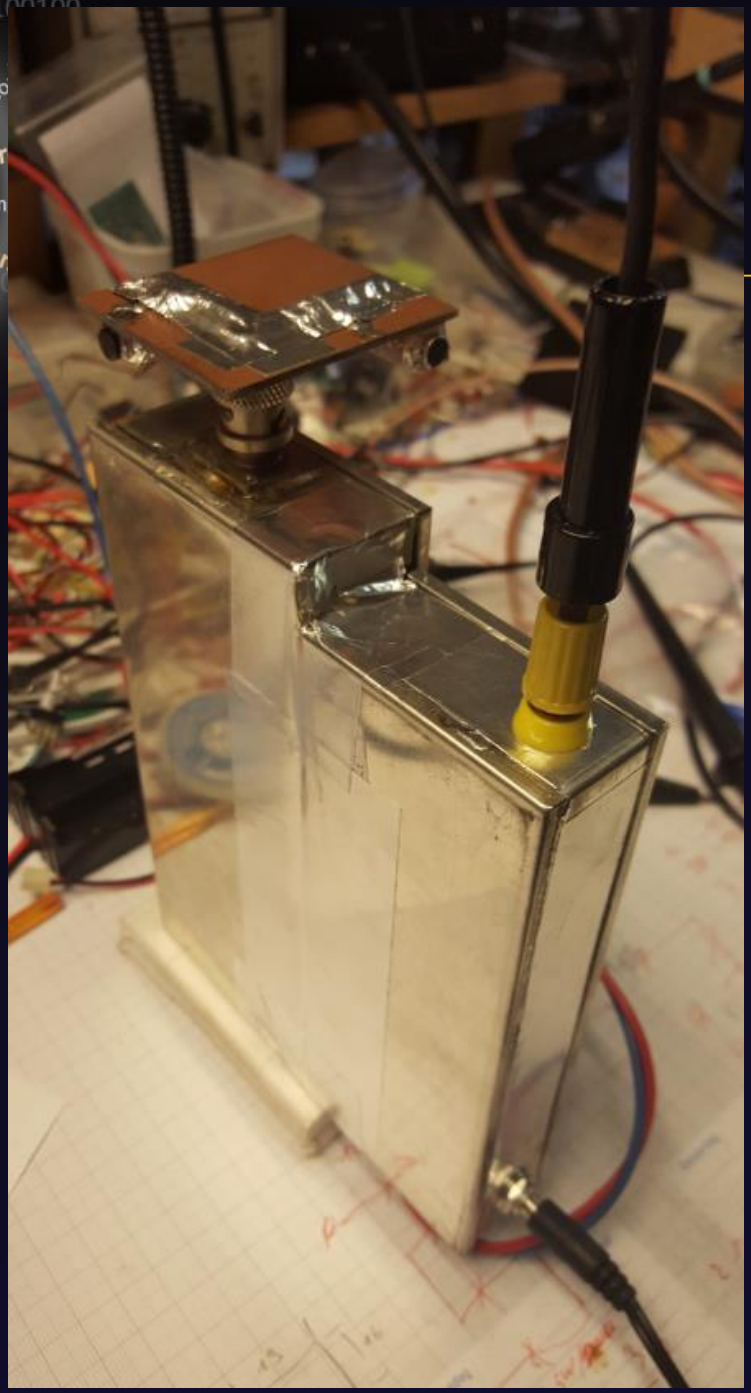
Schema:

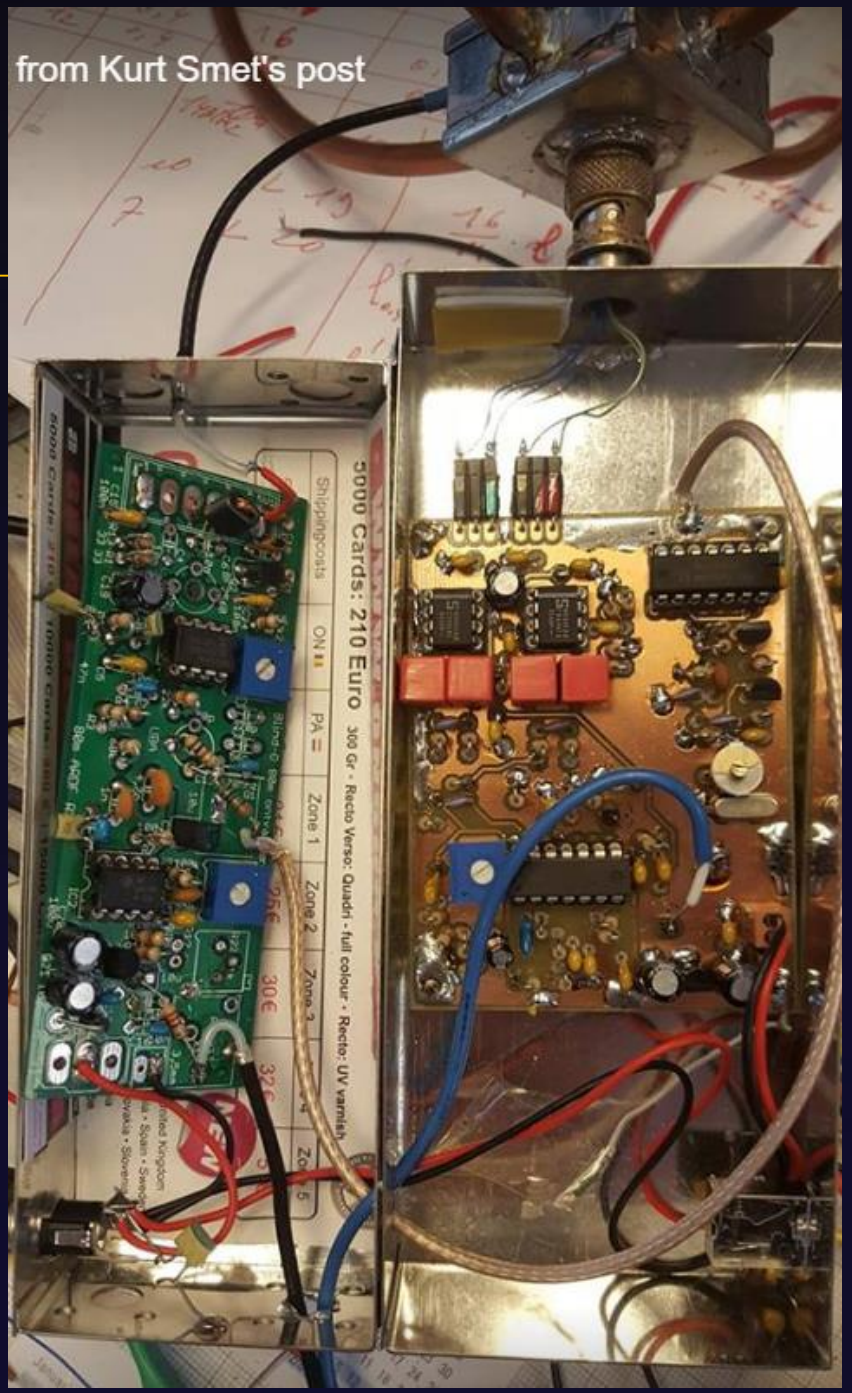
Het schema is een vereenvoudigde DF1FO 80m ontvanger


De deelnemer zoekt het baken d.m.v. geluidssignalen ,opgevangen door een radio.
Bij BLIND-O is er 1 baken in de lucht dat uitgezet wordt als de deelnemer de 5m cirkel rond de zender betreedt.
Dan wordt het volgende baken door een baken Operator aangezet.


80m Veldsterktemeter voor 2 dimensies.
Output - H-field
Power Supply
9V
700 Hz 45dB
74AC74
LM324
SA612AN
LP2950CZ5
14,3118MHz

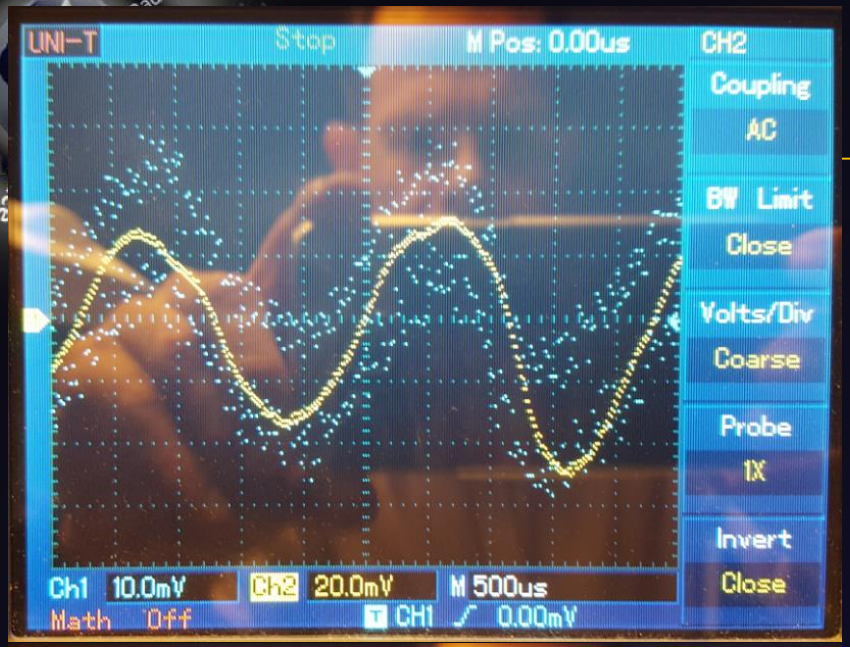

80m ARDF Receiver
SA612AN
TL082
78L05Z
3,578Mhz
700Hz 45dB
1N4001
PG203J

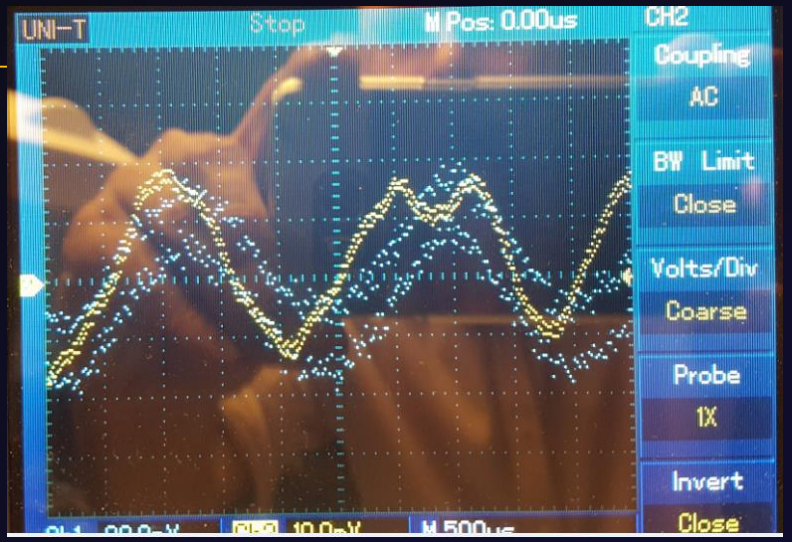


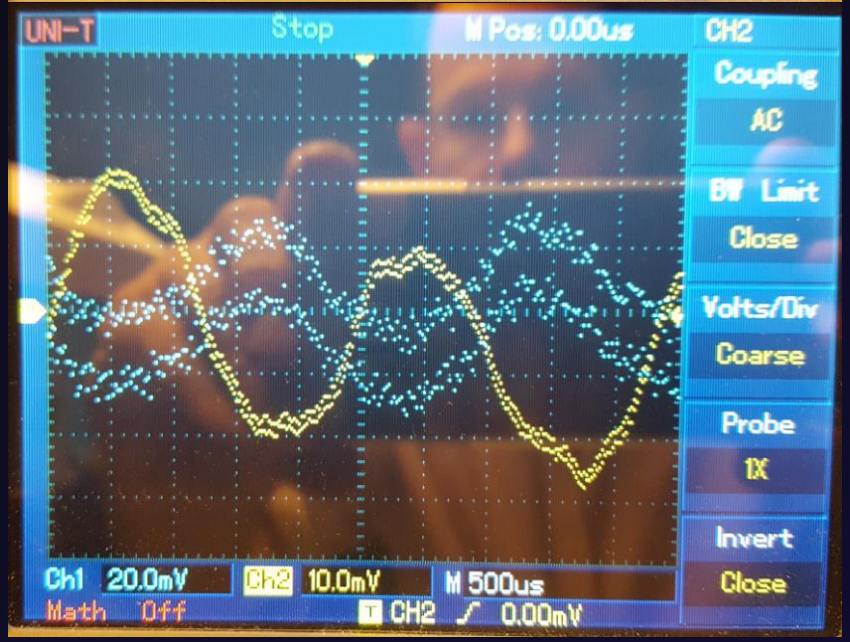

from Kurt Smet's post
5000 Cards: 210 Euro
300 Gr - Recto Verso: Quadri - full colour - Recto: UV varnish
Shippingcosts
ON
PA
Zone 1
Zone 2
30€

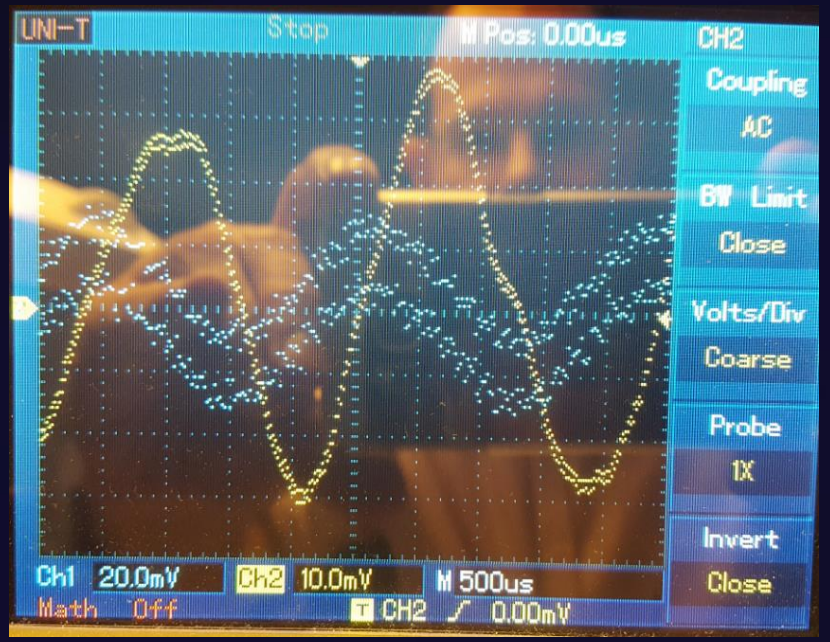
THE FIRST RESULTS

The first tests









THE REACTION ON FACEBOOK AND THE UNEXPECTED

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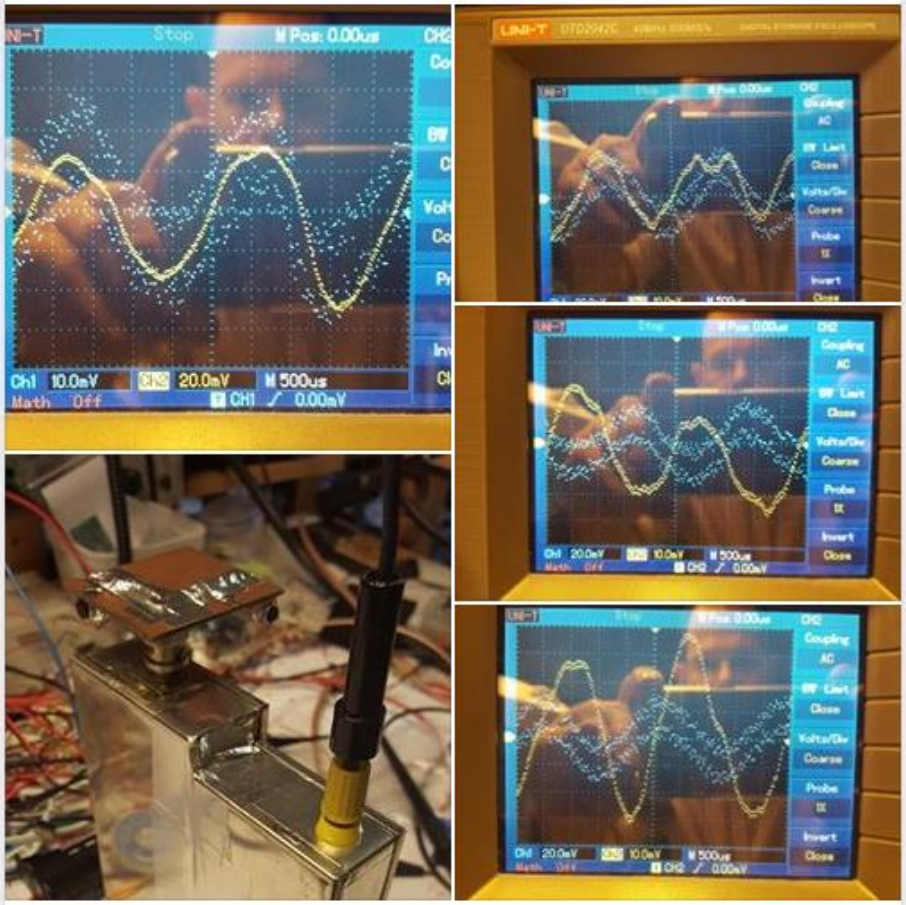
Kurt Smet
24 September

Hi, I'm busy with creating a new ARDF receiver for 80m based on the phase shift of 2 loop antennas and 1 electrical antenna. The prototype showed that it's a workable principle. You see on the screens the phase shift between the reference signal (yellow) of the electrical antenna and the signal in physical line with my receiver during I'm turning my receiver. I will use this forum to put more information of the progress of this new ARDF kind of reciever (principle is old but nobody used it during till now or normal ARDF).



Add Location

TAGS Edit
Rádio-orientação · Orienteering · Amateur radio direction finding

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Clifford Heath
24 September

Thanks for making this group.

Kurt: Ewen (VK3OW) built a Watson-Watt receiver for 80m in about 2010, and one for 6m the year after. He'd already had one for 10m for over a decade before that. So it has been done before. He uses them in car-based DF events, not foot.

BTW: why did you turn off commenting?

Kurt Smet — 2 Comments Seen by 38

Like · Comment · Share

Bruce Person Does Ewen's have the 500hz carrier, and is this required?

Like · Reply · 5w

Hide 11 Replies

Clifford Heath It's not a carrier, it's a low IF beat and/or AM audio (it doesn't matter which of these it is, or both, if you think about it). Ewen feeds I and Q into X and Y of an oscilloscope, and the phase of the 3rd signal path says which end of the line (or mor... See more

Like · Reply · 5w

Clifford Heath (and yes, I know it's not I and Q, but it just seemed convenient to call them that)

Like · Reply · 5w

Clifford Heath Hmmm. Second thoughts. He's not really aiming to use signal strength, but absolute phase wrt the reference. It's still a fairly similar principle.

Like · Reply · 5w

Clifford Heath Third thoughts: and that won't work, because the two loops at 90 degrees will receive exactly the same phase, but different strengths. They'd need to be 20m apart to receive 90 degrees phase difference.

Ian Holland Thanks for the photos Kurt Smet. As they say, a picture is worth a 1000 words! The explanation for how you could get all the required signals through a BNC connector is now obvious and it allows fairly easy swapping of ferrite rods to loops, etc - neat trick! Also, the schematic answers most of the rest of my questions as well, eg re filtering & gain prior to mixer etc. It looks like it should work. How are you planning to determine the phase difference in the arduino - eg just looking at the zero crossing of the sense and loop signals or doing something more clever like correlating the waveforms? Look forward to hearing more as you progress with this. Cheers

Like · Reply · 5w — 3

Clifford Heath shared a link.
24 September

This 2012 article entitled "Introduction into Theory of Direction Finding" by Rhode & Schwarz is very good too:

TELEKOMUNIKACIJE.ETF.BG.AC.RS
telekomunikacije.etf.bg.ac.rs
Save

You, Yasunori Iwata and Bo Lenander — 1 Comment Seen by 37

Вадим Афонькин Clifford Heath

This is photo of receiver I built few years ago. It has GPS and compass. Receiver itself is simple enough, no measurements done there with exception of woopie which provides audible tone based on signal level. Woopie would start at about 1k.

PIC processor is used as brains to collect and process data.

Few years ago I implemented algorithm to calculate fox location based on location and compass data.

It worked. In theory 1 degree error at distance 1k will give you an error equals to 17 meters. 2 degrees - 34 meters and so on. To calculate fox location you need 2 bearings. Best compass, I found even after calibrations will have +/- 2 degrees error. My field test results proved theory, I was able to calculate fox locations with errors ranging between 30 - 150 meters.

I ran few training courses and found this working well enough.

However I never ran with this algorithm at competitions.

Later, I came up with better algorithm which provides me with precision I needed, but I do not triangulate and do not calculate fox location.

I do not use GPS for navigation as well.

Prohibiting GPS from receiver will not do any good, as same technology (or better) can be applied to handheld watch.

After all without experience and good physical condition no matter what you do you will not win.

1

Like · Reply · 5w · Edited

1

Like · Reply · 5w · Edited

Kurt Smet First of all, I can confirm, you didn't use it in Korea (I have photos of all receivers:)), but it's allowed. I believe also that good skills and condition is still the winning factor. But nevertheless, we are radio amateurs and want to push the bord... See more

Like · Reply · 5w

Kurt Smet Eddie de Kerf GPS is not forbidden as long as no graphical map is used. But even if they forbid gps, I can calculate the location of the fox on the straight path based on the number of steps I take in combination with the direction of the compass. And then I get the distance to the fox in number of steps or in meter if I run 100m on my map for example.

Like · Reply · 5w

Вадим Афонькин Kurt Smet I used Haversine formula to calculate fox location. You need to use tilt compensated compass. I used one from Honeywell, pretty expensive one ($150), I noticed it was giving errors up to 7 - 9 degrees, and replaced it with cmps11 (I believe this is correct name)

My receiver schematic is publicly available

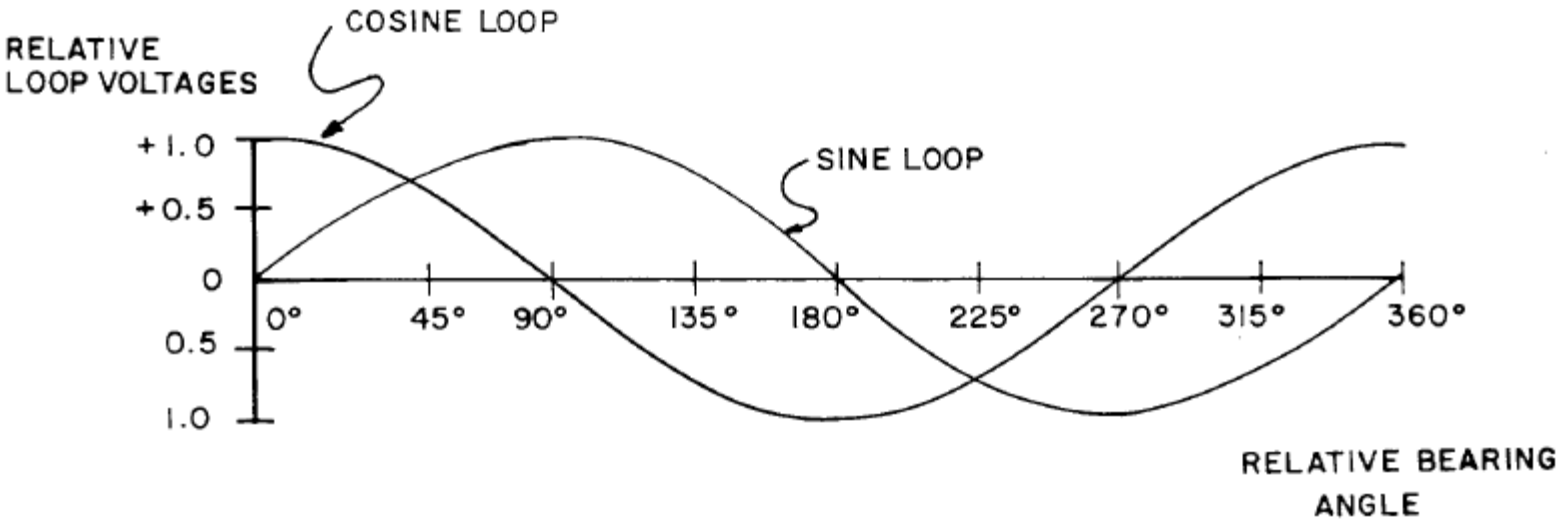
1

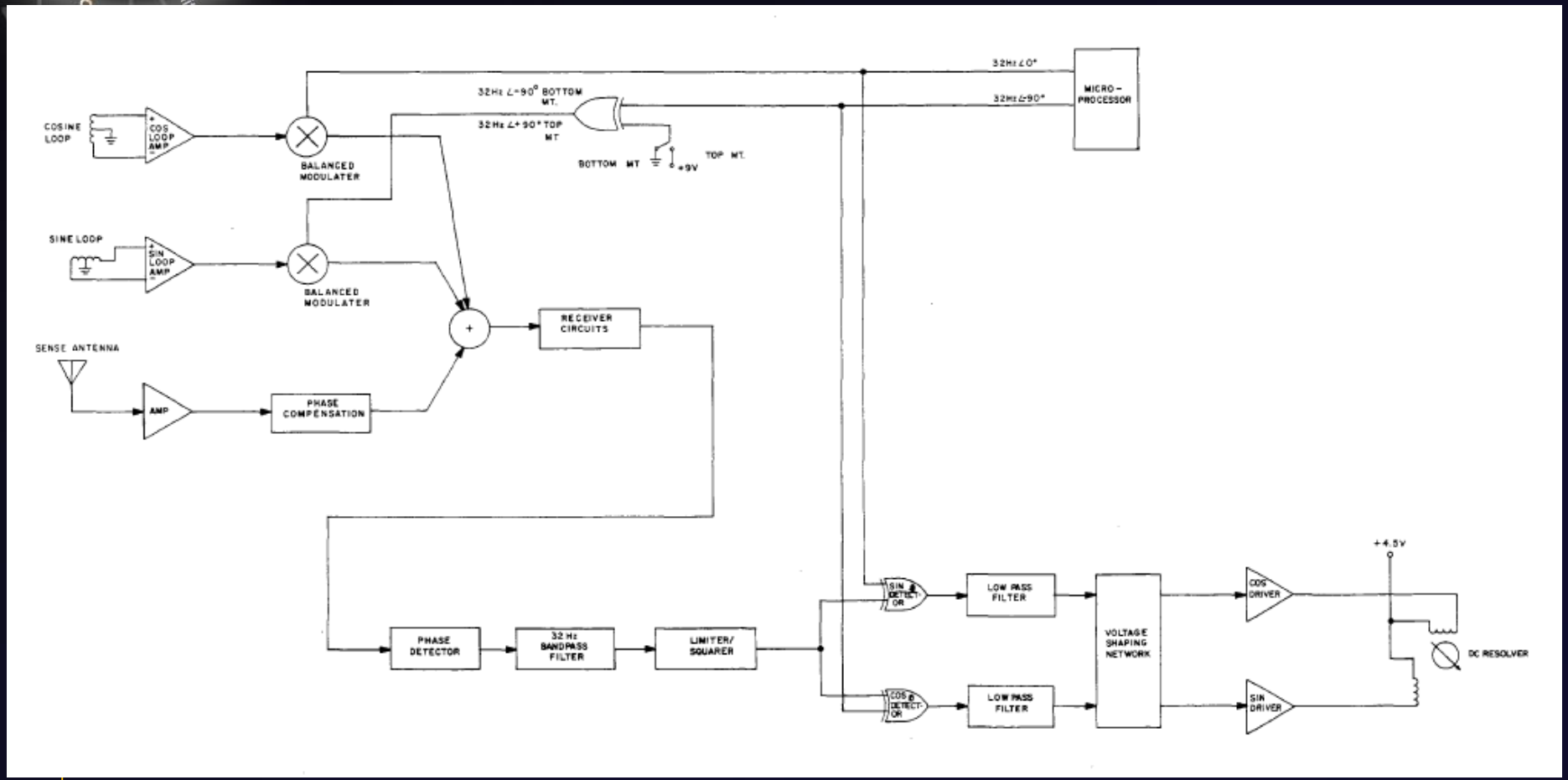
Like · Reply · 5w · Edited

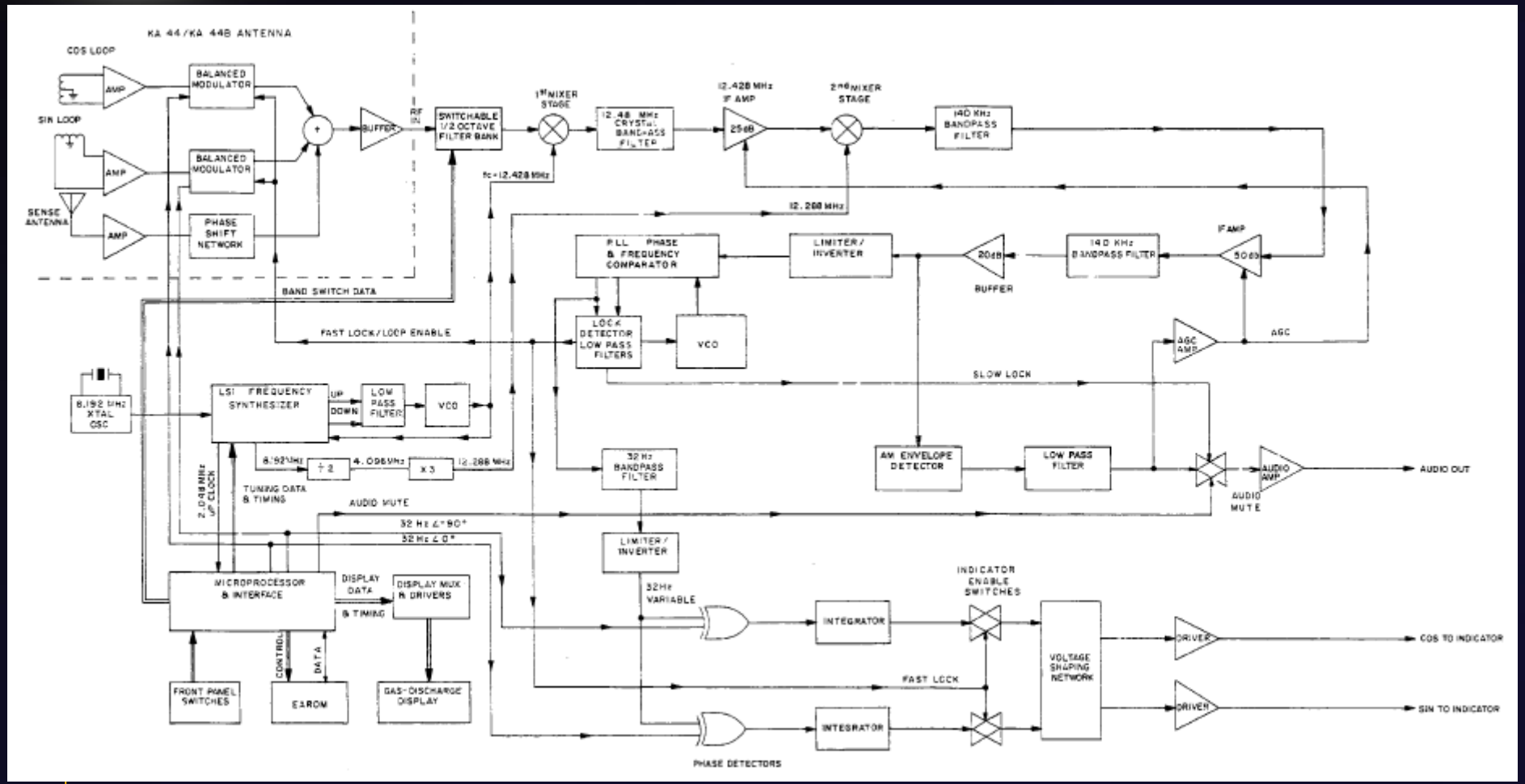
Avionic System

KING

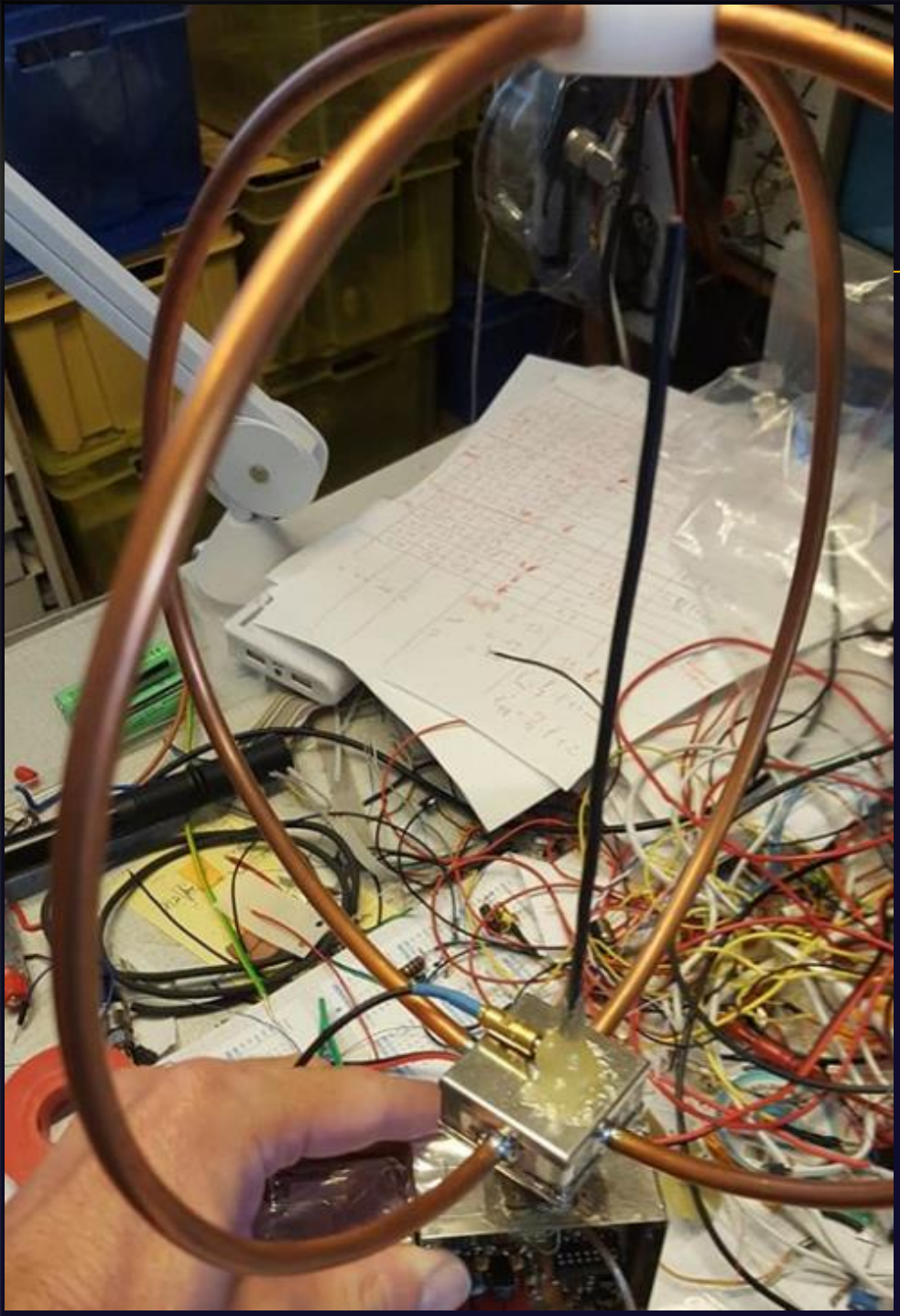
KR 87
AUTOMATIC DIRECTION FINDER

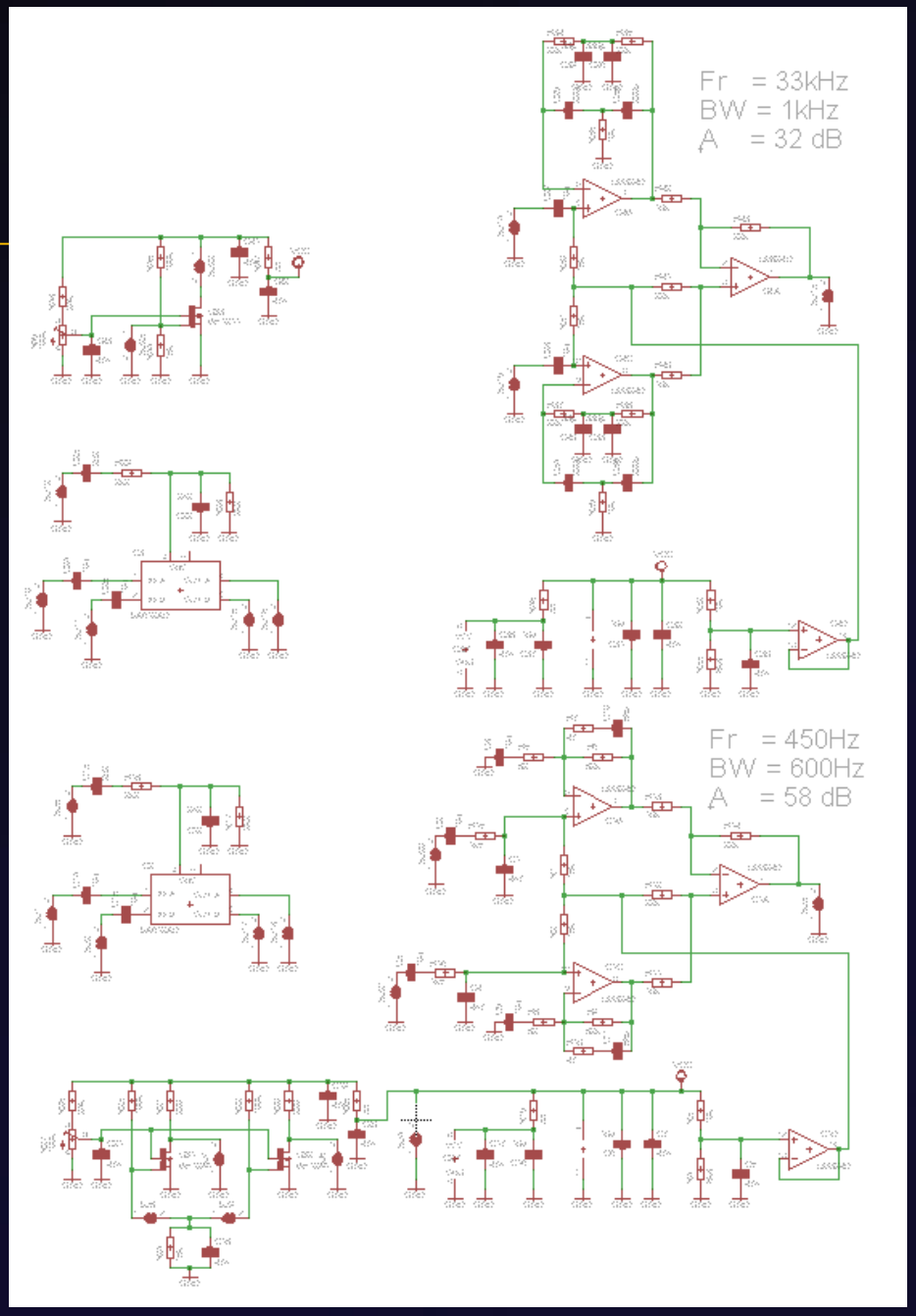


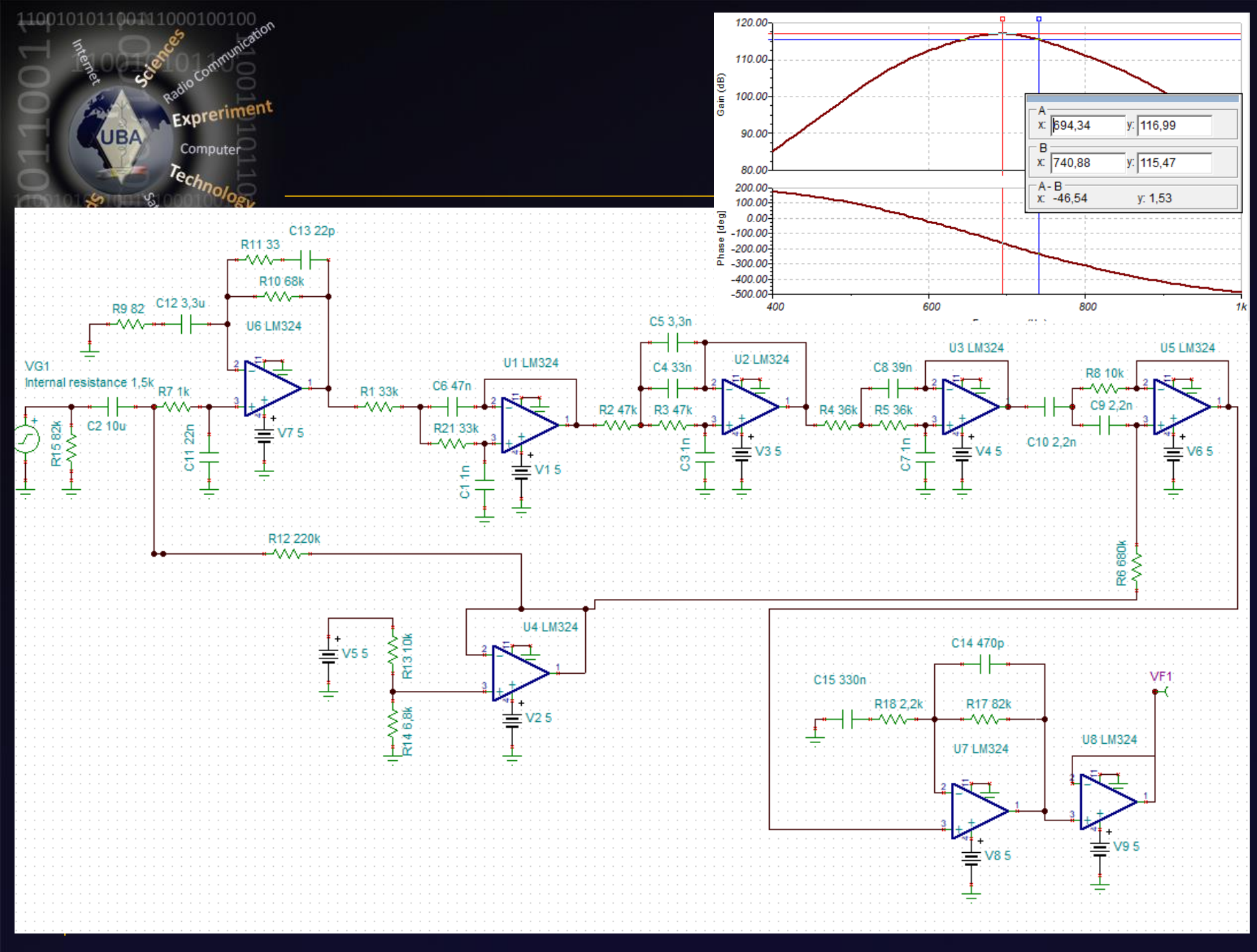

COSINE LOOP
COS LOOP AMP
BALANCED MODULATER
SINE LOOP
SIN LOOP AMP
BALANCED MODULATER
SENSE ANTENNA
AMP
PHASE COMPENSATION
RECEIVER CIRCUITS
32Hz ∠-90° BOTTOM MT.
32Hz ∠+90° TOP MT
BOTTOM MT
+9V
TOP MT.
32Hz ∠0°
32Hz ∠90°
MICRO-PROCESSOR
PHASE DETECTOR
32 Hz BANDPASS FILTER
LIMITER/ SQUARER
SIN DETECTOR
COS DETECTOR
LOW PASS FILTER
LOW PASS FILTER
VOLTAGE SHAPING NETWORK
COS DRIVER
SIN DRIVER
+4.5V
DC RESOLVER


KA 44/KA 44B ANTENNA
COS LOOP
SIN LOOP
SENSE ANTENNA
AMP
BALANCED MODULATOR
PHASE SHIFT NETWORK
BUFFER
RF IN
SWITCHABLE 1/2 OCTAVE FILTER BANK
1ST MIXER STAGE
12.48 MHz CRYSTAL BAND-PASS FILTER
12.428 MHz IF AMP
25dB
2ND MIXER STAGE
140 KHz BANDPASS FILTER
fc=12.428 MHz
12.288 MHz
BAND SWITCH DATA
PLL PHASE & FREQUENCY COMPARATOR
LIMITER/ INVERTER
20dB
BUFFER
140 KHz BANDPASS FILTER
IF AMP
50dB
AGC
AGC AMP
FAST LOCK/LOOP ENABLE
LOCK DETECTOR LOW PASS FILTERS
VCO
SLOW LOCK
8.192 MHz XTAL OSC
LSI FREQUENCY SYNTHESIZER
UP
DOWN
LOW PASS FILTER
VCO
8.192 MHz
÷2
4.096 MHz
X3
12.288 MHz
2.048 MHz µP CLOCK
TUNING DATA & TIMING
32 Hz BANDPASS FILTER
AM ENVELOPE DETECTOR
LOW PASS FILTER
AUDIO AMP
AUDIO OUT
AUDIO MUTE
32 Hz ∠+90°
32 Hz ∠0°
LIMITER/ INVERTER
MICROPROCESSOR & INTERFACE
DISPLAY DATA & TIMING
DISPLAY MUX & DRIVERS
32Hz VARIABLE
INTEGRATOR
INDICATOR ENABLE SWITCHES
VOLTAGE SHAPING NETWORK
DRIVER
COS TO INDICATOR
FAST LOCK
DRIVER
SIN TO INDICATOR
CONTROL
DATA
FRONT PANEL SWITCHES
EAROM
GAS-DISCHARGE DISPLAY
INTEGRATOR
PHASE DETECTORS

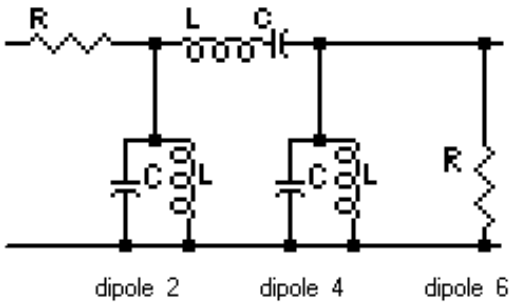
THE NEXT STEPS AND DEMO




Fr = 33kHz
BW = 1kHz
A = 32 dB
Fr = 450Hz
BW = 600Hz
A = 58 dB


Internet
Sciences
Radio Communication
Expreriment
UBA
Computer
Technology
Gain (dB)
Phase [deg]
A
x: 694,34 y: 116,99
B
x: 740,88 y: 115,47
A - B
x: -46,54 y: 1,53
C13 22p
R11 33
R10 68k
R9 82
C12 3,3u
U6 LM324
VG1
Internal resistance 1,5k
R7 1k
C2 10u
R15 82k
C11 22n
V7 5
R1 33k
C6 47n
U1 LM324
R21 33k
C1 1n
V1 5
C5 3,3n
C4 33n
U2 LM324
R2 47k
R3 47k
C3 1n
V3 5
U3 LM324
C8 39n
R4 36k
R5 36k
C7 1n
V4 5
U5 LM324
R8 10k
C9 2,2n
C10 2,2n
V6 5
R6 680k
R12 220k
U4 LM324
V5 5
R13 10k
R14 6,8k
V2 5
C14 470p
C15 330n
R18 2,2k
R17 82k
U7 LM324
V8 5
U8 LM324
V9 5
VF1

Current experiments (11/2018)



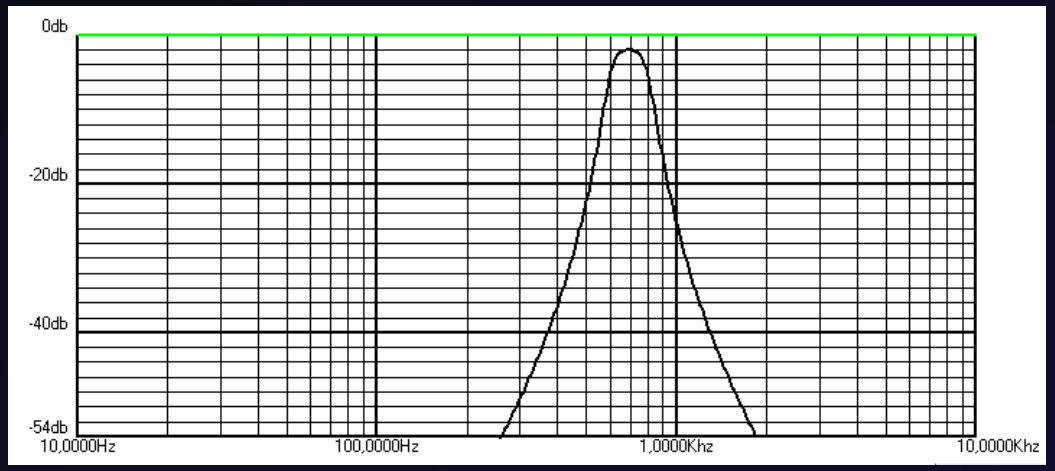
DIPOLE 1
R 1=1,5K

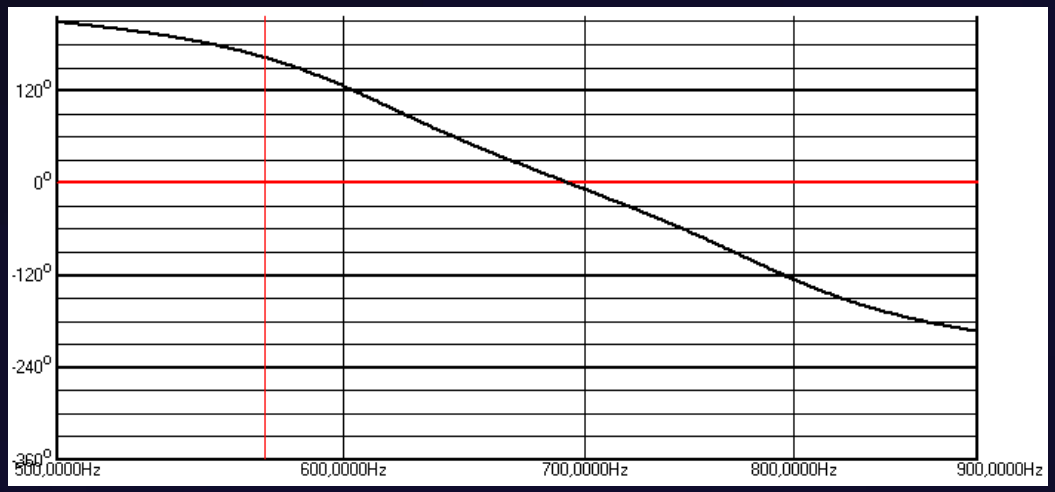
DIPOLE 2
C 2=,530097uF
L 2=99,551mHy
Qu~30,

DIPOLE 3
C 3=,022122uF
L 3=2,385Hy
Qu~30,

DIPOLE 4
C 4=,530097uF
L 4=99,551mHy
Qu~30,

DIPOLE 6
R 6=1,5K



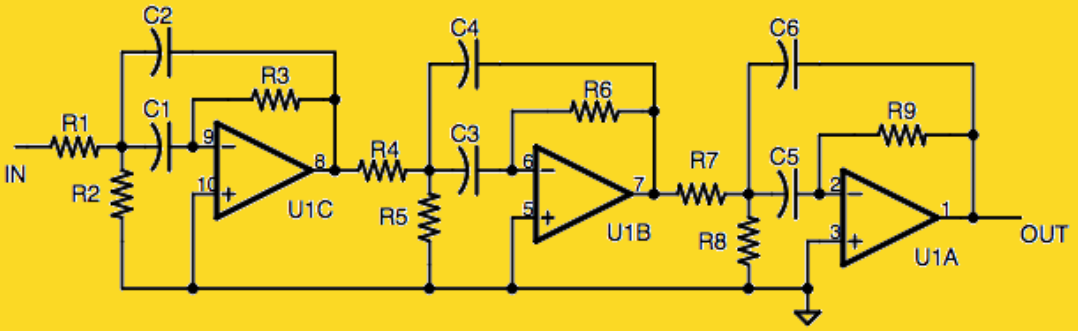


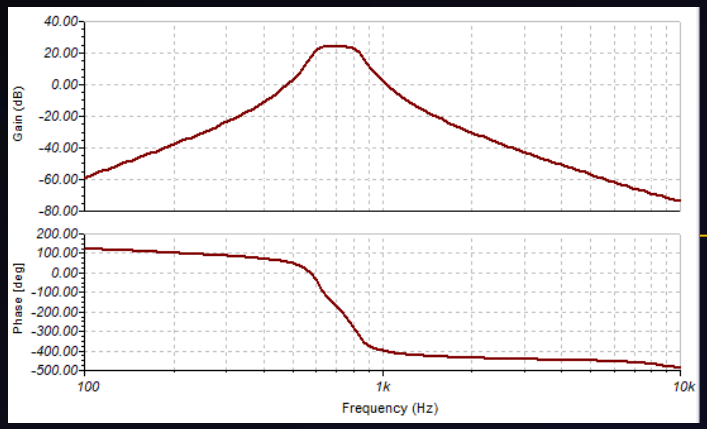
Current experiments (11/2018)

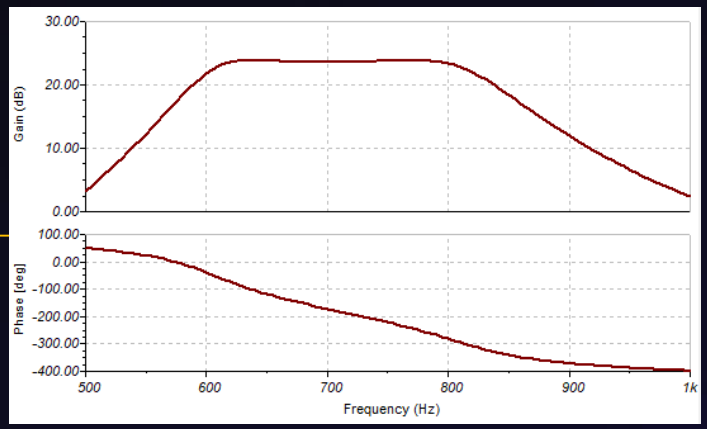
6 Pole Bandpass Active Filter

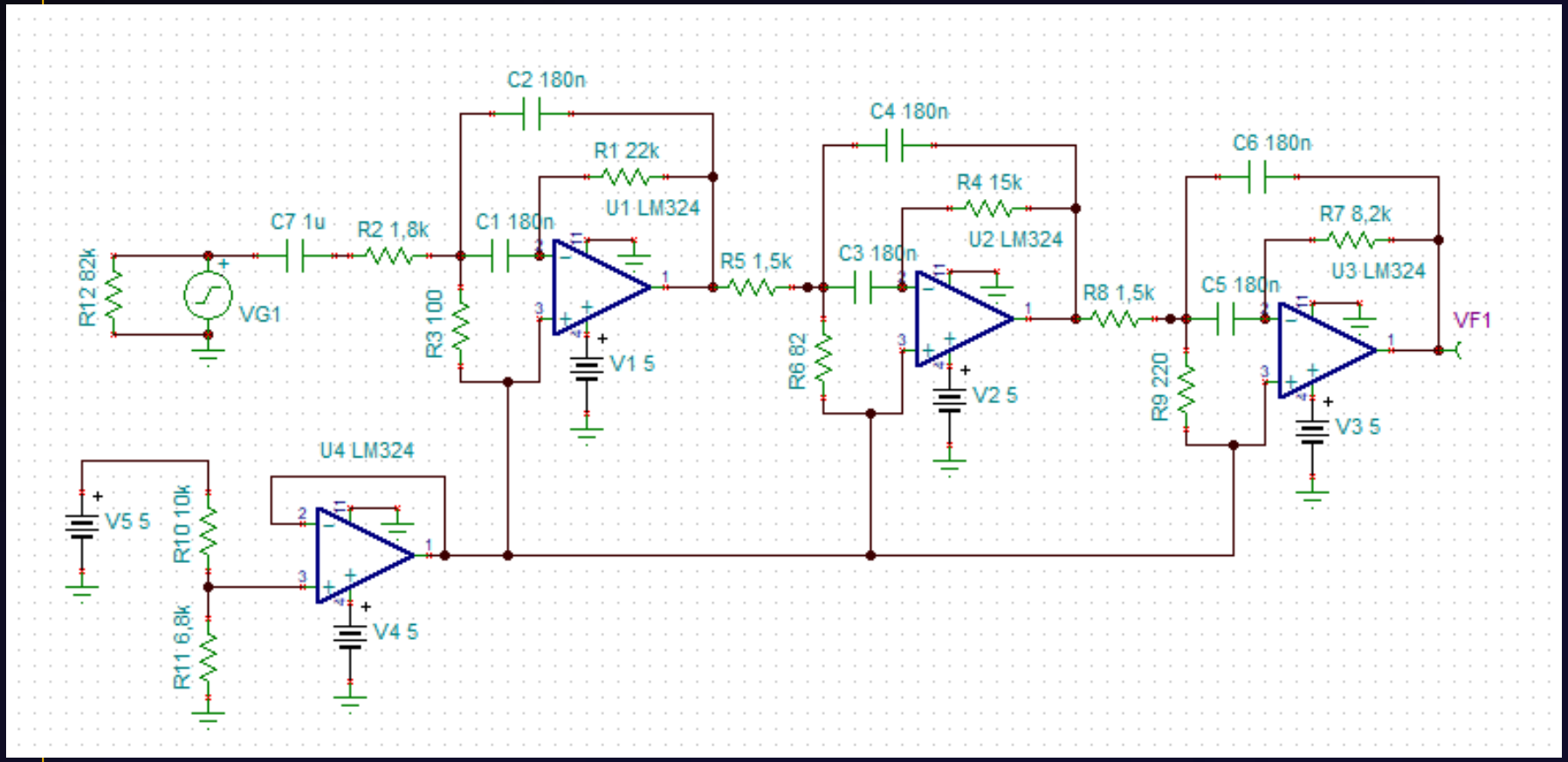
Input		Computed Values	
Filter Type	Butterworth	C1,C2,C3,C4,C5,C6 (uF)	0.18
Capacitors (uF)	0.18	R1 (K Ohms)	1.8432205433
Center Freq (Hz)	700	R2 (K Ohms)	0.1072234230
3dB Bandwidth (Hz)	200	R3 (K Ohms)	20.165975947
Voltage Gain	20	R4 (K Ohms)	1.4392085770
COMPUTE		R5 (K Ohms)	0.0837213271
		R6 (K Ohms)	15.745834459
		R7 (K Ohms)	1.6286995097
		R8 (K Ohms)	0.2029310285
		R9 (K Ohms)	8.8419412828

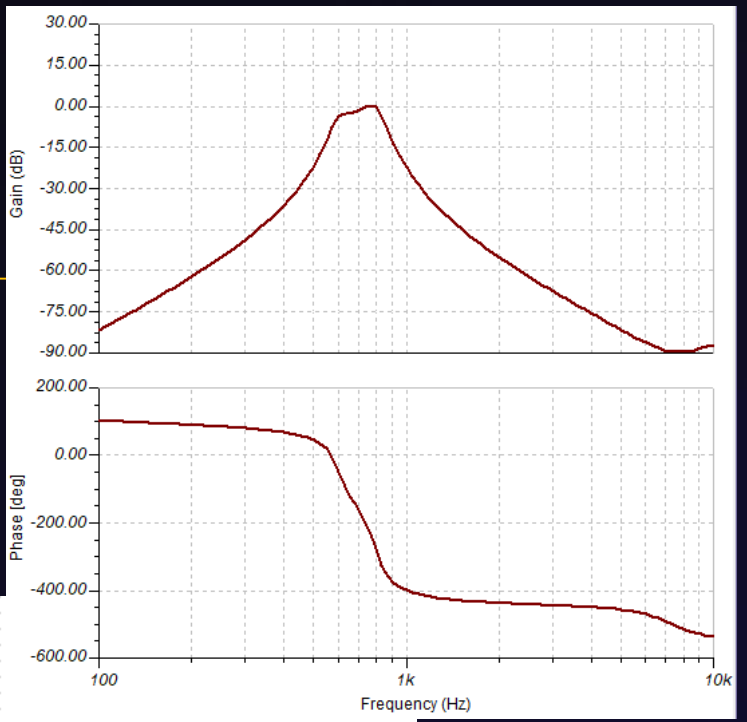
Section	1	2	3
Q	7.053633345	7.053633345	3.5
Freq	618.5449395	792.1817294	700

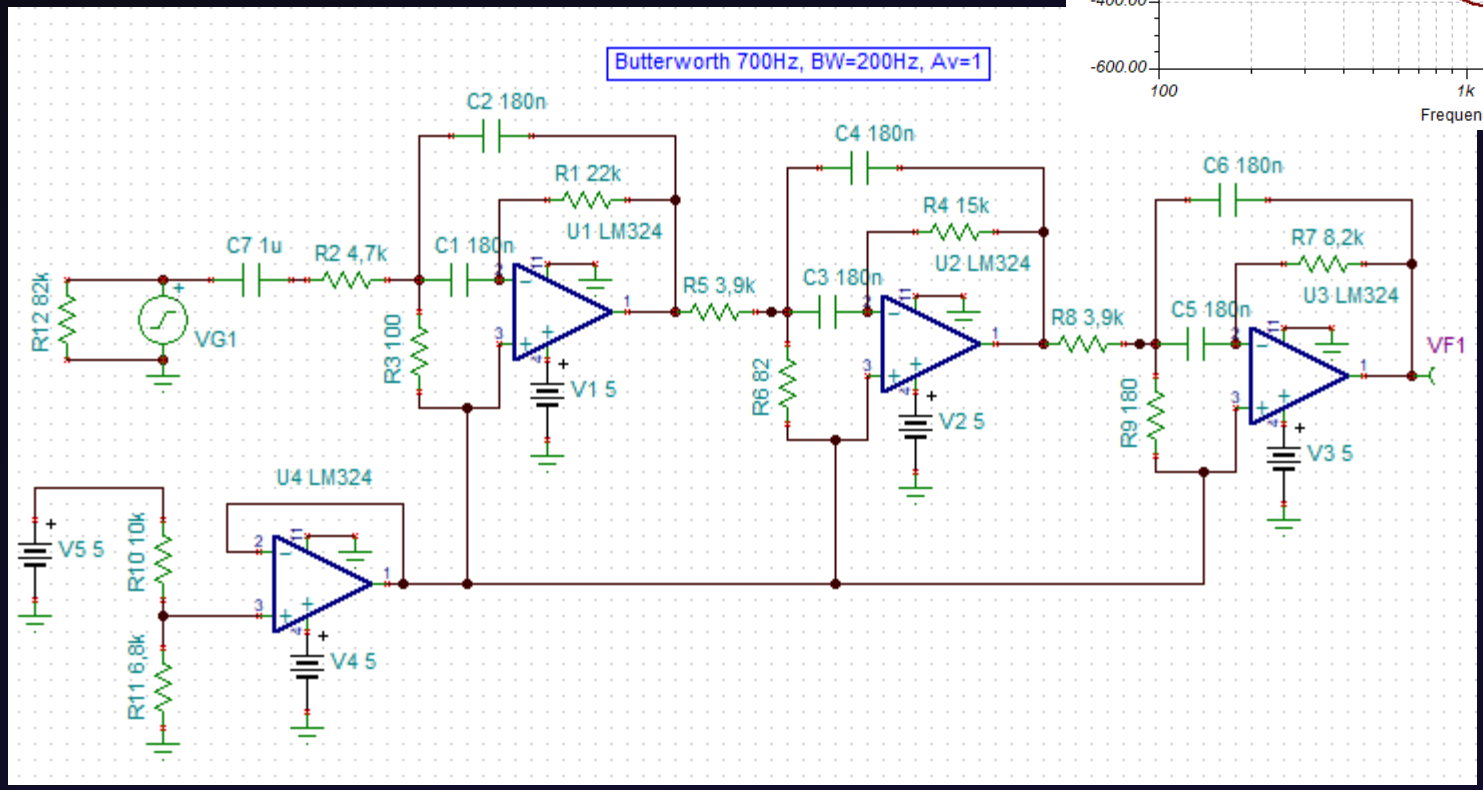


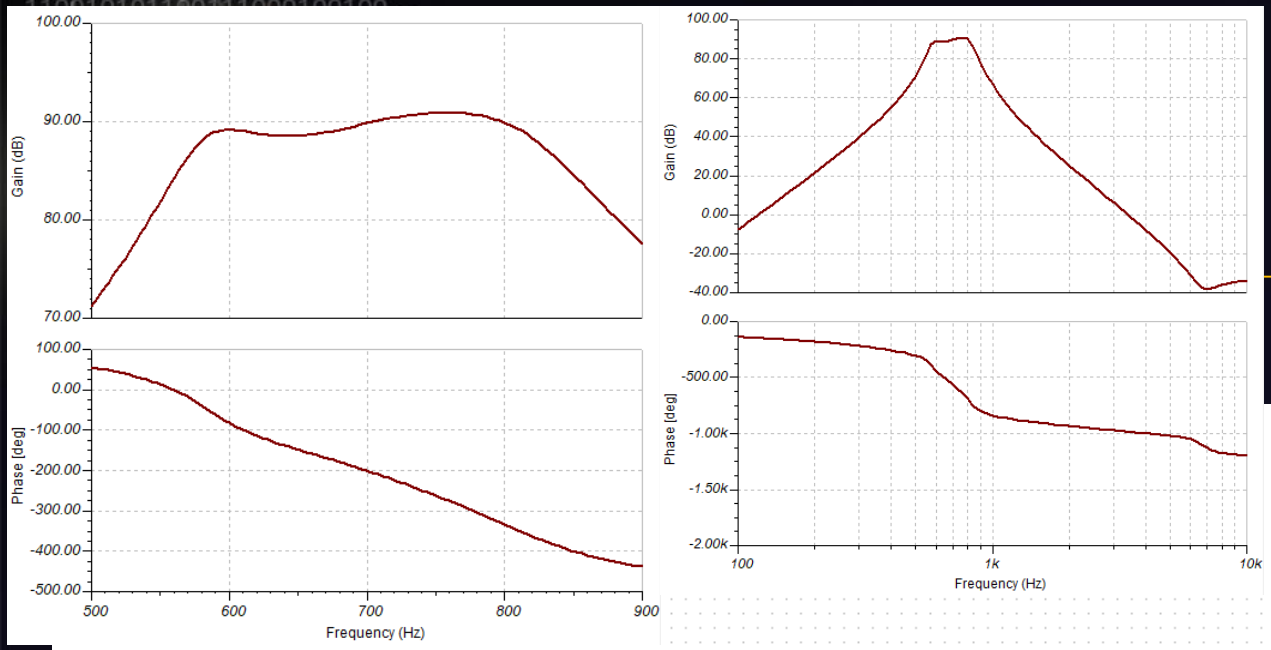

Gain (dB)
Phase (deg)
Frequency (Hz)
100
1k
10k


Gain (dB)
Phase (deg)
Frequency (Hz)
500
600
700
800
900
1k

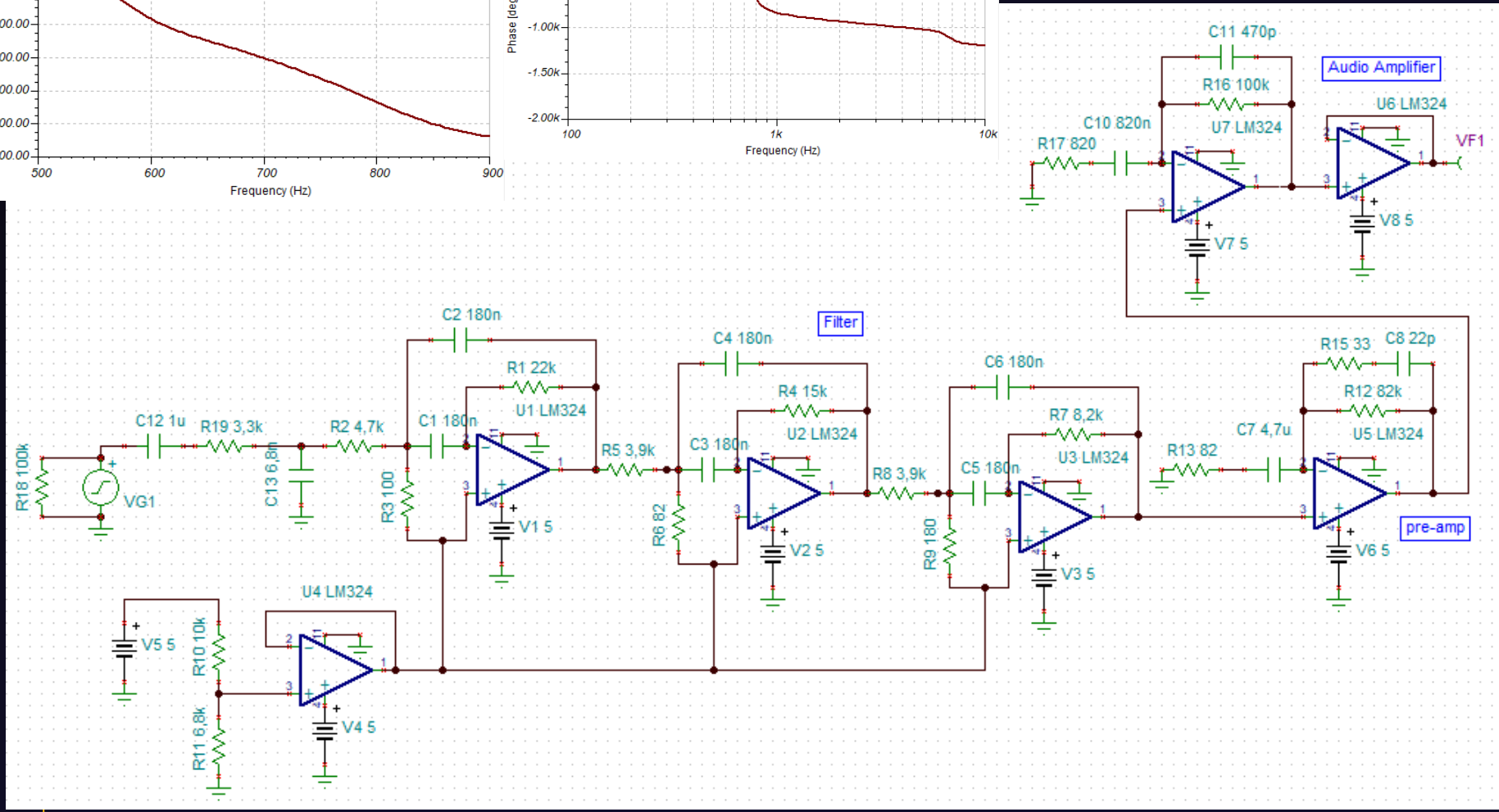

C2 180n
R1 22k
U1 LM324
C7 1u
R2 1,8k
C1 180n
R12 82k
VG1
R3 100
V1 5
R5 1,5k
C4 180n
R4 15k
U2 LM324
C3 180n
R6 82
V2 5
R8 1,5k
C6 180n
R7 8,2k
U3 LM324
C5 180n
VF1
R9 220
V3 5
U4 LM324
V5 5
R10 10k
R11 6,8k
V4 5


30.00
15.00
0.00
-15.00
-30.00
-45.00
-60.00
-75.00
-90.00
Gain (dB)
200.00
0.00
-200.00
-400.00
-600.00
Phase [deg]
100
1k
10k
Frequency (Hz)


Butterworth 700Hz, BW=200Hz, Av=1
C2 180n
R1 22k
U1 LM324
C7 1u
R2 4,7k
C1 180n
R12 82k
VG1
R3 100
V1 5
R5 3,9k
C4 180n
R4 15k
U2 LM324
C3 180n
R6 82
V2 5
R8 3,9k
C6 180n
R7 8,2k
U3 LM324
C5 180n
R9 180
V3 5
VF1
U4 LM324
V5 5
R10 10k
R11 6,8k
V4 5


Gain (dB)
100.00
90.00
80.00
70.00
Phase [deg]
100.00
0.00
-100.00
-200.00
-300.00
-400.00
-500.00
500
600
700
800
900
Frequency (Hz)

Gain (dB)
100.00
80.00
60.00
40.00
20.00
0.00
-20.00
-40.00
Phase [deg]
0.00
-500.00
-1.00k
-1.50k
-2.00k
100
1k
10k
Frequency (Hz)


C11 470p
Audio Amplifier
R16 100k
U6 LM324
C10 820n
U7 LM324
R17 820
VF1
V8 5
V7 5
C2 180n
Filter
C4 180n
R15 33
C8 22p
R1 22k
C6 180n
R12 82k
R4 15k
R7 8,2k
U5 LM324
C12 1u
R19 3,3k
R2 4,7k
C1 180n
U1 LM324
C3 180n
U3 LM324
C7 4,7u
R13 82
R18 100k
R5 3,9k
C5 180n
U2 LM324
R8 3,9k
pre-amp
VG1
C13 6,8n
R3 100
V1 5
R6 82
V2 5
R9 180
V3 5
V6 5
U4 LM324
V5 5
R10 10k
R11 6,8k
V4 5

Automatic Direction Finder

Up to 99 Memory Channels for Spot Reception. :

- Synthesized Double Superheterodyne Receiver.
- Frequency Range from 200 KHZ to 10MHZ.
- Reception Modes Selectable (AM, CW).
- Up to 99 Memory Channels for Spot Reception.

Specification :

Frequency Range	200~3200 KHZ
Wave Form	AM / CW

http://www.radiobuoy.com/webls-en-us/product-%E6%96%B9%E5%90%91%E6%8E%A2%E7%9F%A5%E6%A9%9F-KTD-168.html

KTD-168

主要說明(Specifications) ：

1.頻率範圍(Frequency Range)：200KHz - 9.999MHz

2.中間頻率(Intermediate Frequency)：1ST→10.7MHz
2ND→455KHz

3.接收模式(Wave Form)：A1、A3E

4.顯示(Display)：LCD　A.方位角顯示(Azimuth)
B.頻率顯示(Frequency)

5.接收頻道記憶(Spot Memory)：99頻道(Channels)

6.選擇性(Selectivity)：在6db時高於±2KHz
在60db時小於±5KHz

7.電源(Power)：DC24V/3.5A

8.接收天線(Loop Antenna)：805mmΦ

9.天線引線(Antenna Cable)：5 Cored Coaxial Cable

10.尺寸、重量(Size & Weight)：　H：192mm　W：336mm　D：332mm
重量：8.0kg

Underground Cable Installations

Transmitter Specifications

Pitch resolution standard/XR	±0.1/0.2% at level
Roll data standard/XR	24/12-position clock
Maximum temperature	104° C
I5® Transmitter	
Depth range	19.8 m
Roll/pitch data range	19.8 m
XRange/XR Max data range	32.0/36.6 m
I9® Transmitter	
Depth range	30.5 m
Standard roll/pitch data range	30.5 m
XRange/XR Max data range	51.8/61.0 m
Fluid Pressure Feature[2]	
Pressure range	0–1725 kPa
Pressure resolution, 0–517 kPa	7 kPa
517–1725 kPa	34 kPa

DigiTrak® F5® Transmitters

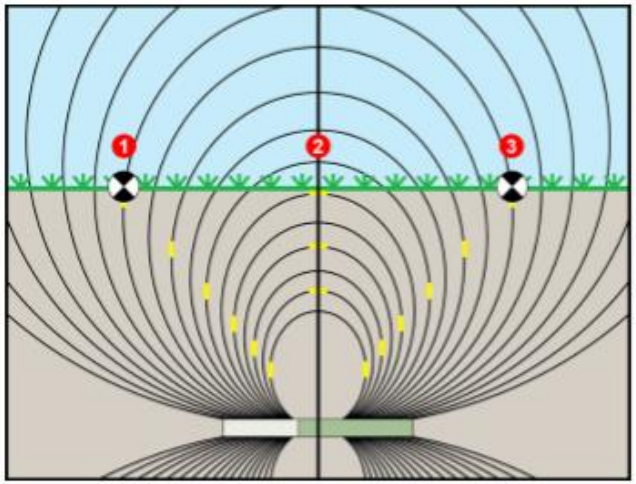
	F5X 18	F5X 8	F5D 12/1.3	F5Dp 12/1.3	F5D 19/12	F5Dpx 19/12	F5DLpx 19/12
Frequency	18.5 kHz	8.4 kHz	12 *and* 1.3 kHz	12 *and* 1.3 kHz	19.2 *or* 12.0 kHz	19.2 *or* 12.0 kHz	19.2 *or* 12.0 kHz
Depth/Data Range (Standard)	19.8 m	19.8 m	19.8 m	19.8 m	19.8 m	19.8 m	30.5 m
Data Range (XR/XR Max)	n/a	n/a	n/a	n/a	n/a	32.0/36.6 m	51.8/61.0 m
Pressure Range	n/a	n/a	n/a	0–1725 kPa	n/a	0–1725 kPa	0–1725 kPa
Length	38.1 cm	38.1 cm	38.1 cm	38.1 cm	38.1 cm	38.1 cm	48.3 cm
Diameter	3.2 cm	3.2 cm	3.2 cm	3.2 cm	3.2 cm	3.2 cm	3.2 cm

XRange® (XR²) mode provides additional roll/pitch range for difficult jobsites. The F5D/F5Dp **12/1.3** dual-frequency transmitters can broadcast simultaneously in 12 and 1.3 kHz or at higher power in 12 kHz alone. The **19/12** transmitters broadcast in 19.2 or 12.0 kHz. XR mode (where applicable) and frequency can be selected mid-bore.

Battery life awake/asleep for a 38.1 cm transmitter is 20/200 hrs for 2 C-cell alkaline, 70/400 hrs for 1 SuperCell™, or 40/400 hrs for 2 SAFT LSH14 batteries. Battery life for the 48.3 cm F5DLpx 19/12 transmitter is 40/400 hrs for SuperCell or 30/400 hrs for SAFT batteries; alkaline batteries are not recommended due to higher power requirements.

What Happens When the Transmitter Is Steep and Deep

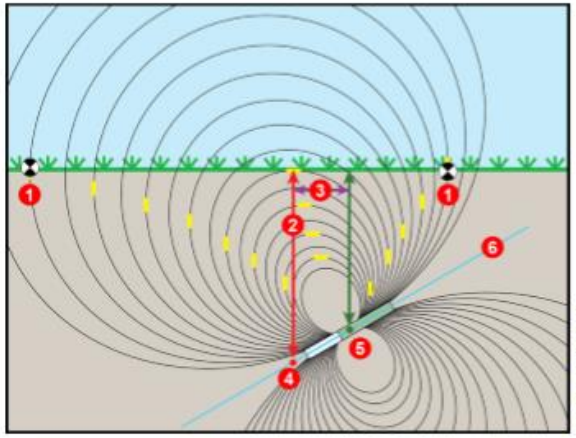
The signal field emitted by the transmitter consists of a set of elliptical signals, or "flux lines". The flux lines indicate the position of the transmitter. When the transmitter is level with respect to the ground, the locate line (LL) is directly over the transmitter, the depth displayed on the receiver is the actual depth, and the locate points (FLP and RLP) are at equal distances from the transmitter. The location of the LL is found at the intersection of the ground and the horizontal component of the flux field; the FLP and RLP are found where the vertical components of the flux field intersect with the ground. Some of the horizontal and vertical components are identified below by short yellow lines.



1. RLP
2. LL
3. FLP

Side View of Flux Field and Geometry of FLP, RLP, and LL

Due to the shape of the transmitter's signal field, when it is at a pitch greater than ±10% (±5.7°) and/or a depth of 15 ft. or more, the position of the locate line will be some distance ahead of or behind the transmitter's actual position. In this case, the depth displayed on the receiver becomes what is called the projected depth. The transmitter's distance ahead of or behind the locate line is called the fore/aft offset.



1. LP
2. LL
3. Fore/aft offset
4. Projected depth
5. Actual depth
6. 30% (17°) pitch

Side View of Actual Depth due to Fore/Aft Offset When Steep and Deep