TAMSAT

Amatör Uydu Teknolojileri Derneği

Turkish Amateur Satellite Technologies Organization (AMSAT-TR)

GnuRADIO ile Yazılım Tabanlı Radyo İletişimi (Software Defined Radio)

Barış DİNÇ
Teknik Başkan Yardımcısı

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Burcu AYBAK
Genel Sekreter

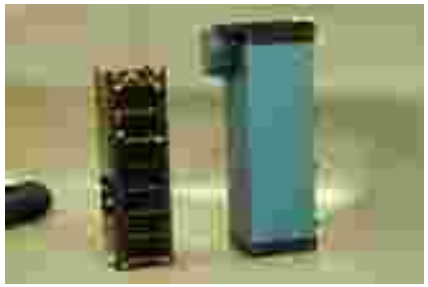
ta2nba@tamsat.org.tr

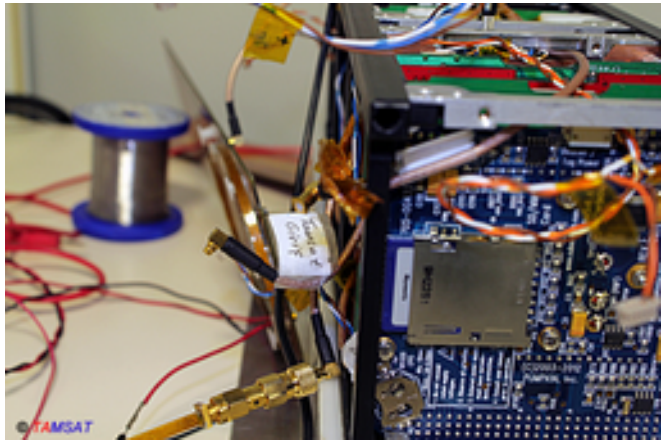
Sunum İçeriği

- TAMSAT Tanıtım
- Radyo Nedir ?
- DSP Nedir ?
- Komplex Sayıların Dünyası
- Yazılım Tabanlı Radyo (Software Defined Radio) Nedir ?
- Örnek SDR Donanımları
- Örnek SDR Yazılımları
- GNURadio Genel Tanıtım ve Yükleme Adımları
- GnuRadio Uygulamaları
- SDR Proje Örnekleri

TAMSAT

- 25 Mart 2010 tarihinde Ankara'da 17 Radyo Amatörü tarafından kuruldu
- Bugün üye sayısı 100'e yaklaşmaktadır
- Pekçok küçük/büyük projede yer aldı
- TAMSAT IHU 2011 yılında tamamlandı
- TAMSAT V/U Transponder 2013 yılında tamamlandı
- İlk Uydu Fırlatması (TURKSAT 3USAT) 2013 yılında gerçekleşti
- TAMSAT OBC 2015 yılında tamamlandı
- TAMSAT MikroSAT 2016 yılında tamamlandı
- TAMSAT OBC çalışmaları devam ediyor
- TAMSAT SDR Transponder çalışmaları devam ediyor
- UBAKUSAT 2017 yılı içinde Uluslar Arası Uzay İstasyonundan fırlatılacak
- TAMSAT web sayfası hergün yeni bir içerikle hizmetlerine devam ediyor

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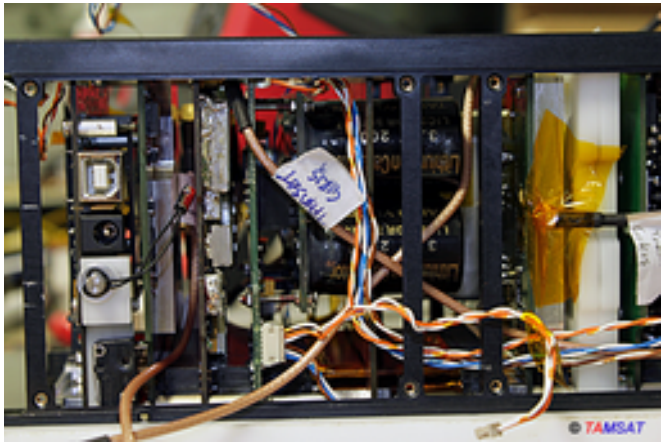
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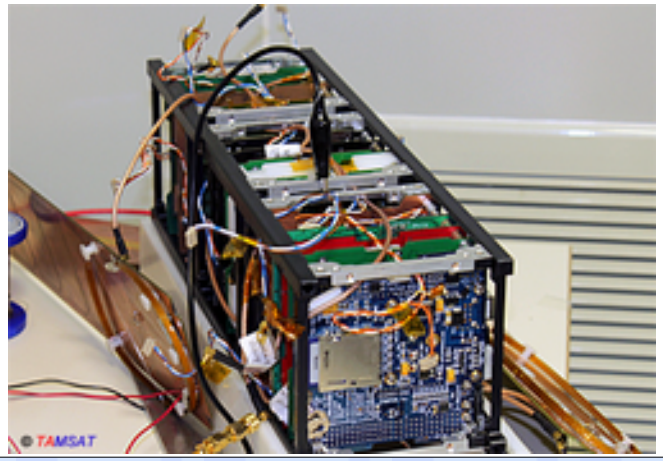
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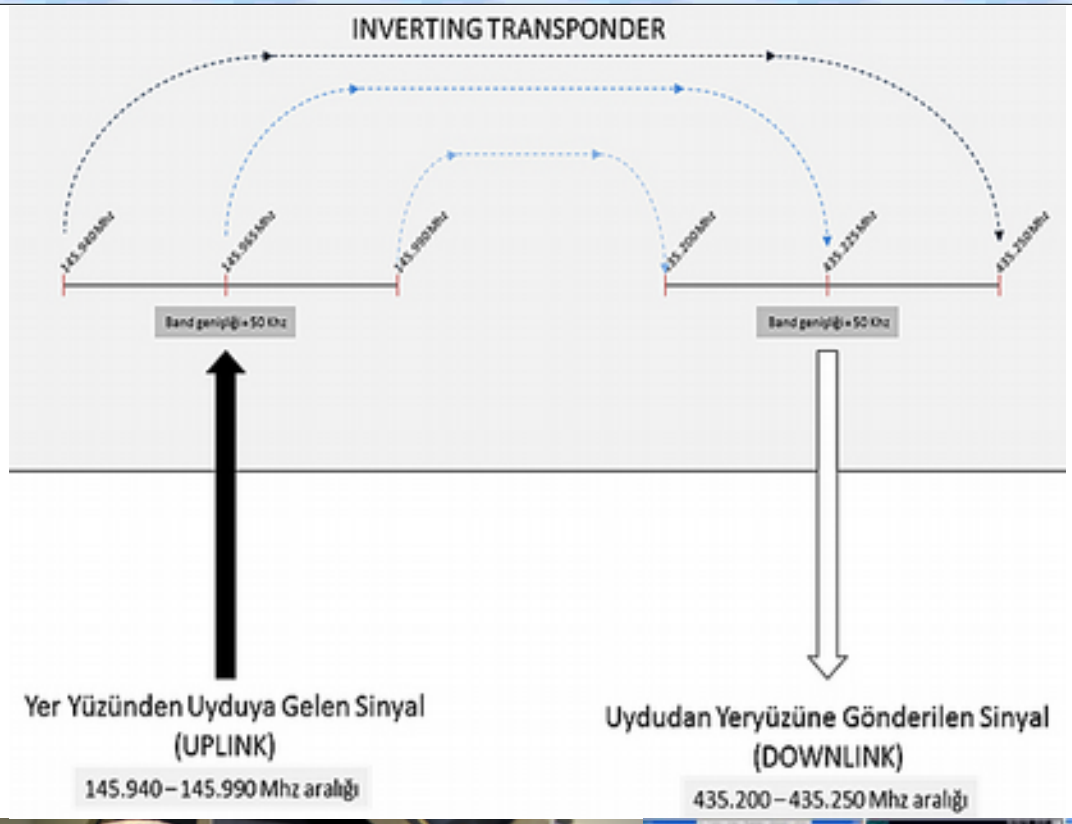
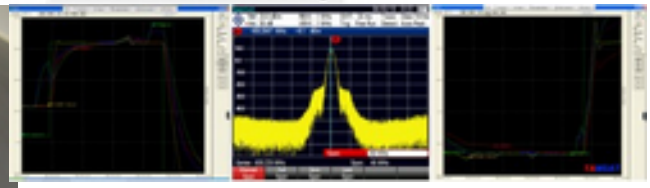
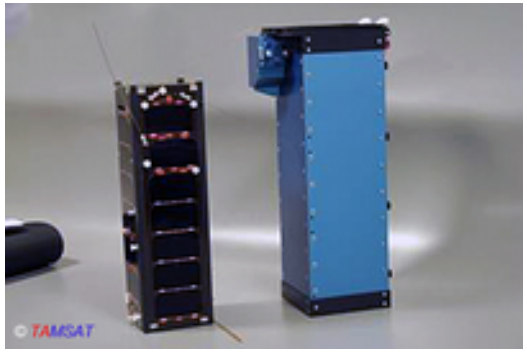
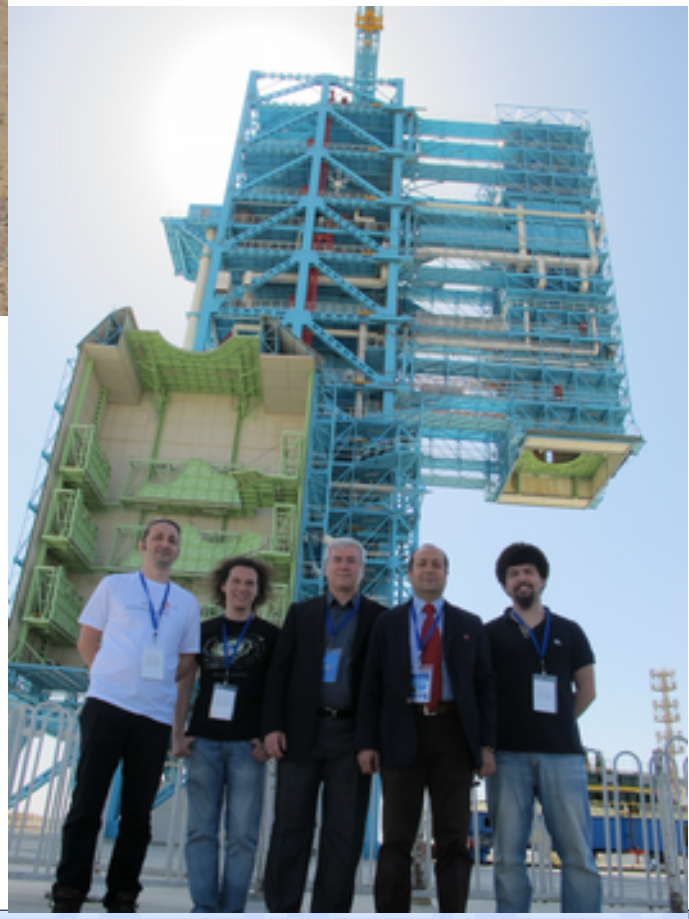

INVERTING TRANSPONDER
145.940Mhz
145.990Mhz
145.995Mhz
435.200Mhz
435.225Mhz
435.250Mhz
Band genişliği = 50 Khz
Band genişliği = 50 Khz
Yer Yüzünden Uyduya Gelen Sinyal
(UPLINK)
145.940 – 145.990 Mhz aralığı
Uydudan Yeryüzüne Gönderilen Sinyal
(DOWNLINK)
435.200 – 435.250 Mhz aralığı


TAMSAT




TAMSAT


JiGuan Space Center - China May 2013
TAMSAT 3U-SAT TRANSPONDER LAUNCH



TAMSAT


AMATÖR UYDU TEKNOLOJİLERİ DERNEĞİ
TAMSAT


TURKSAT-3USAT


TURKSAT-3USAT
Okulu: 24 Kasım Aşağıkuşlu
Şehir: Giresun / Merkez
İsim: Efe Kağan ÖZDEMİR
Seri No: 27 EFL
Mesaj: Ülkemi seviyorum T.C.

TAMSAT

TAMSAT Amatör Uydu İzleme Ağı
(TAMSAT Amateur Satellite Tracking Network)

- (T4-06-1B) Ankara
  - (YUS-DC-1) Washington
  - (T4-07-1B) Antalya
  - (YUS-NJ-1) New Jersey
  - Diğer (Other)

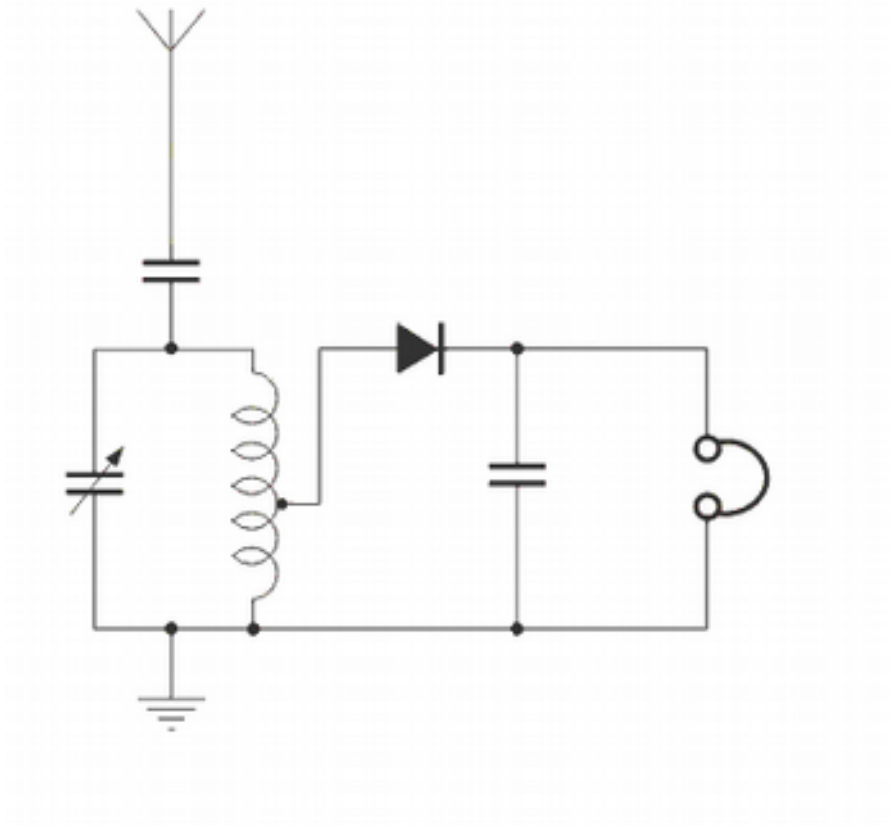
MİSYONUMUZ :

- Yurdumuzda amatör, bilimsel ve benzer amaçlı uyduların projelendirme, **üretim ve işletme çalışmaları** ile ilgili araştırma, geliştirme, **uygulama ve eğitim** hizmetleri vermek;
- Gerçekleştirdiği projeleri amatör ve bilimsel kullanım için telsiz ve radyo amatörlerinin ve ilgili kullanıcıların hizmetine sunmak ve **bu bilgi ve beceriye sahip gençlerin sayılarının artması** için eğitimler ve seminerler düzenlemek;
- Gelişen ve yaygınlaşan bilişim teknolojileriyle, amatör uydu sistemlerinin ortak konularında ülkemiz gençleri için **araştırma ve geliştirme alanları oluşturmak**, gerektiğinde ulusal ve **uluslar arası düzenleyici kuruluşlarla koordinasyonu sağlamak ve işbirliği yapmaktır**.

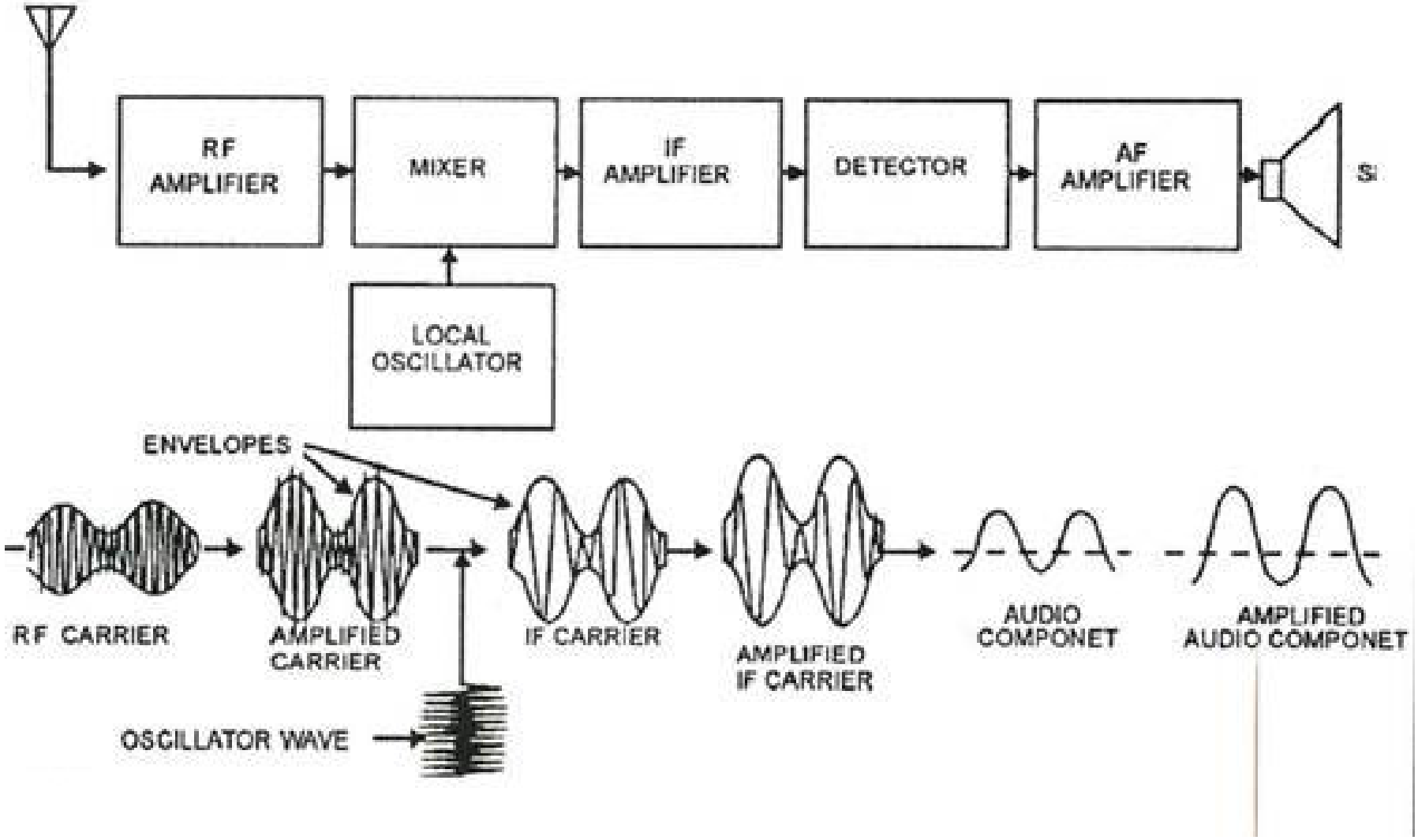
VİZYONUMUZ:

- Türk Gençlerinin ve radyo amatörlerinin **kendi uydu sistemlerini yapmalarına** yardımcı olmak, yurt içinde bulunmayan yedek parça ve cihazları yasal girişimlerle temin etmek, gerekirse ithalatını yapmak,
- **Doğal afetler ve olağanüstü hallerde uydu sistemlerinin azami şekilde kamu yararına kullanılmasına öncülük etmek**,
- Amatör Telsizcilik ile ilgili yönetmeliklerde belirtilen eğitim, araştırma, arama kurtarma ve izcilik kuruluşlarında yasa ve yönetmelikler uyarınca kurulacak olan amatör telsiz istasyonlarına gerektiğinde geçici cihaz, anten, uydu takip sistemi temin ederek, eğitim ve uydu haberleşme desteği vermek gelecek vizyonumuzu belirtmektedir.

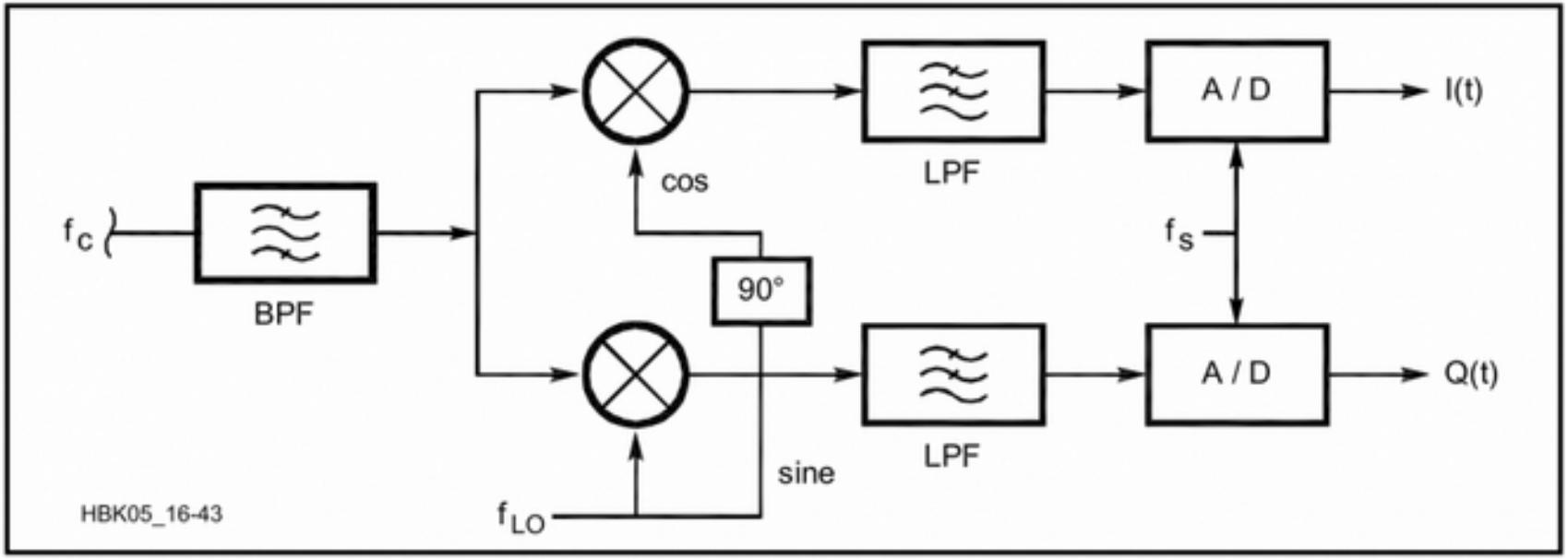
Ne menem şeydir bu SDR



En Basit Radyo Alıcısı



Süperheterodin Radyo Alıcısı


f_c
BPF
cos
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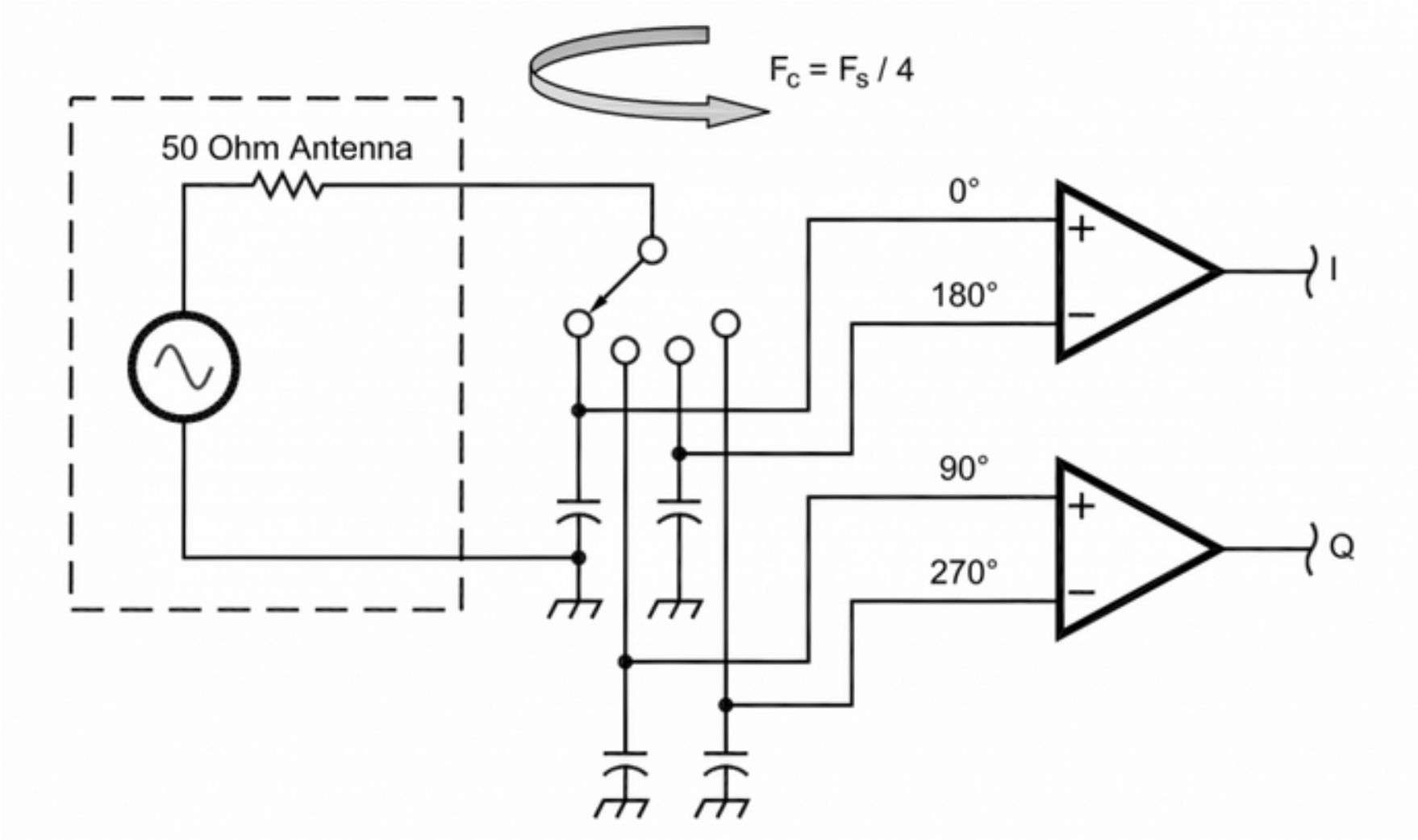
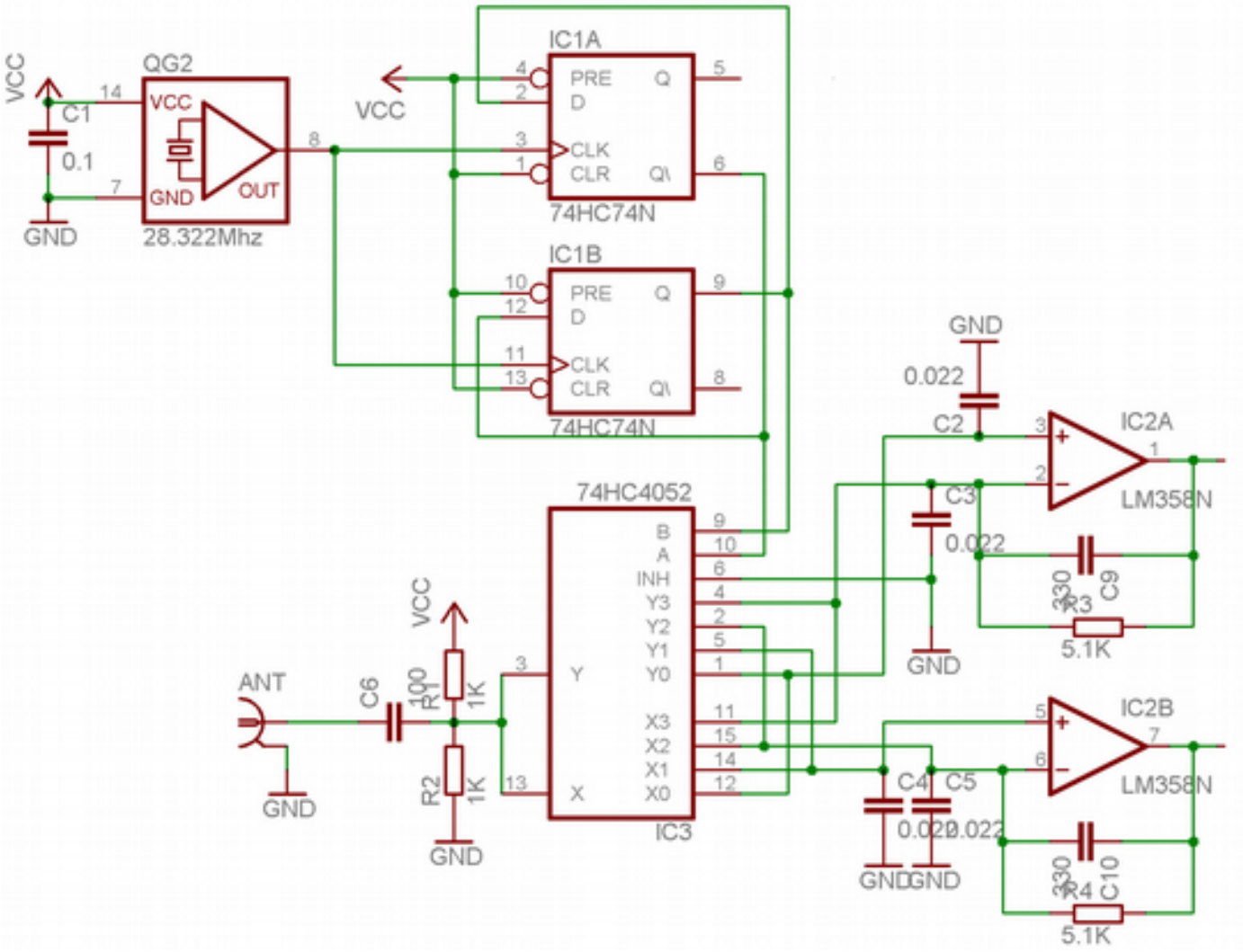
LPF
A / D
A / D
f_s
I(t)
Q(t)
HBK05_16-43



Tyloe Detektörü

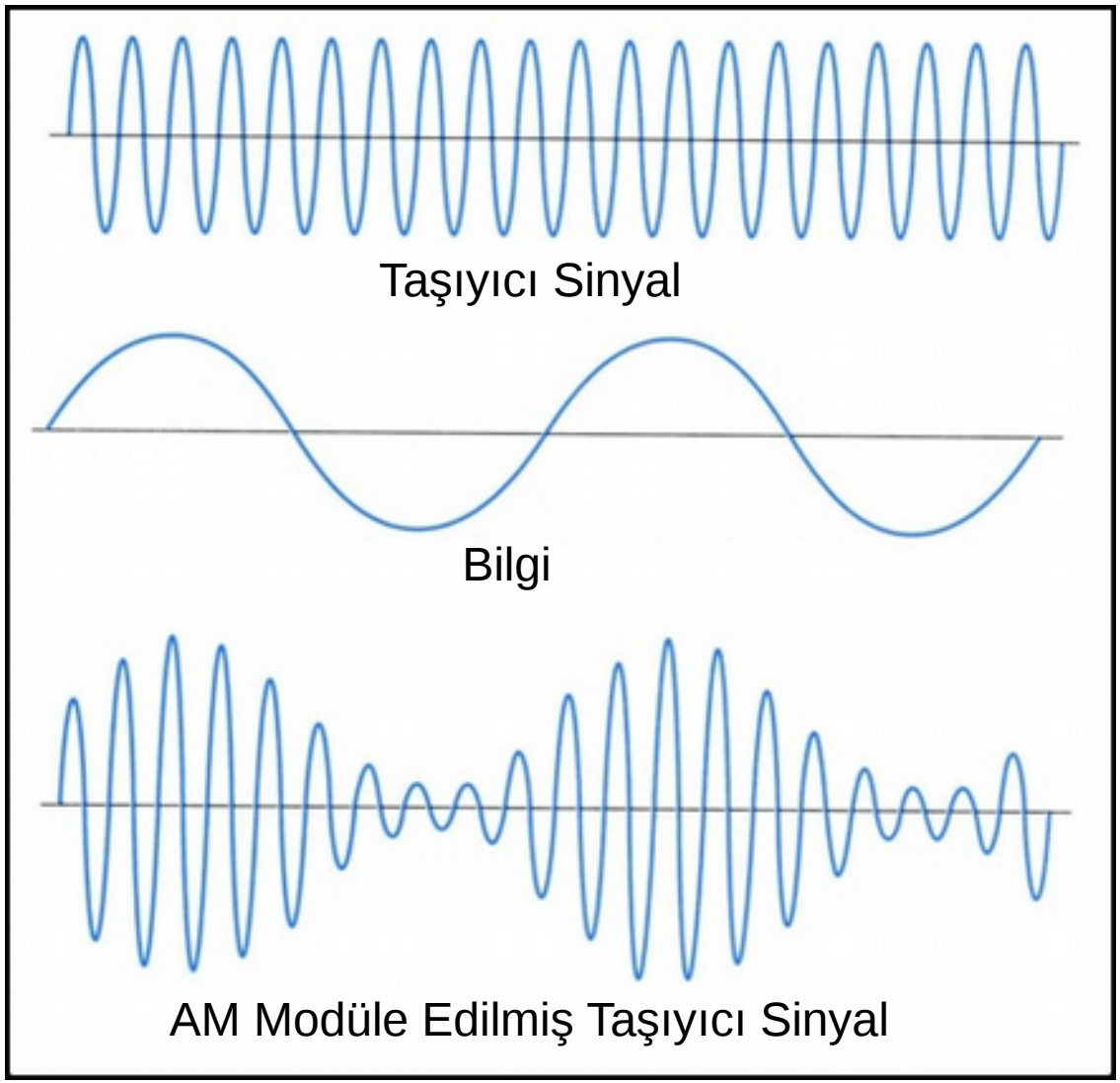
Yazılım Tabanlı Radyo Nedir ?



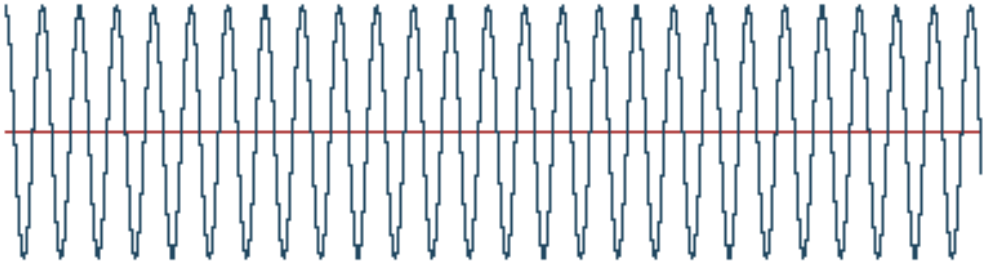
SES KARTI SOL KANAL

SES KARTI SAĞ KANAL

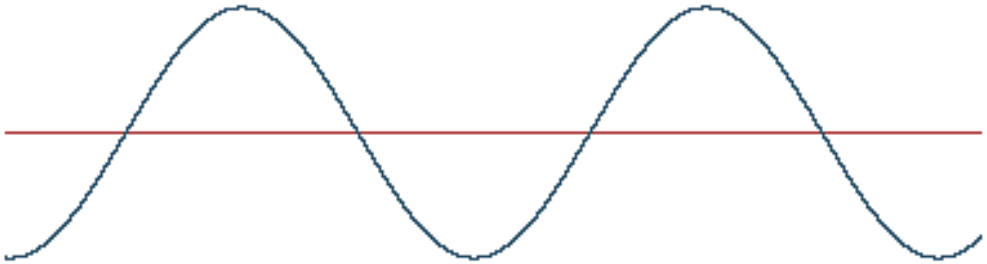
(Yaklaşık Maliyet 10 TL)



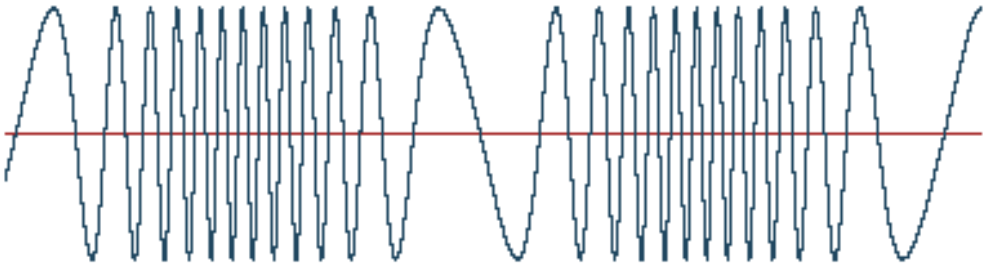
Genlik Modülasyonu (AM)



Taşıyıcı Sinyal



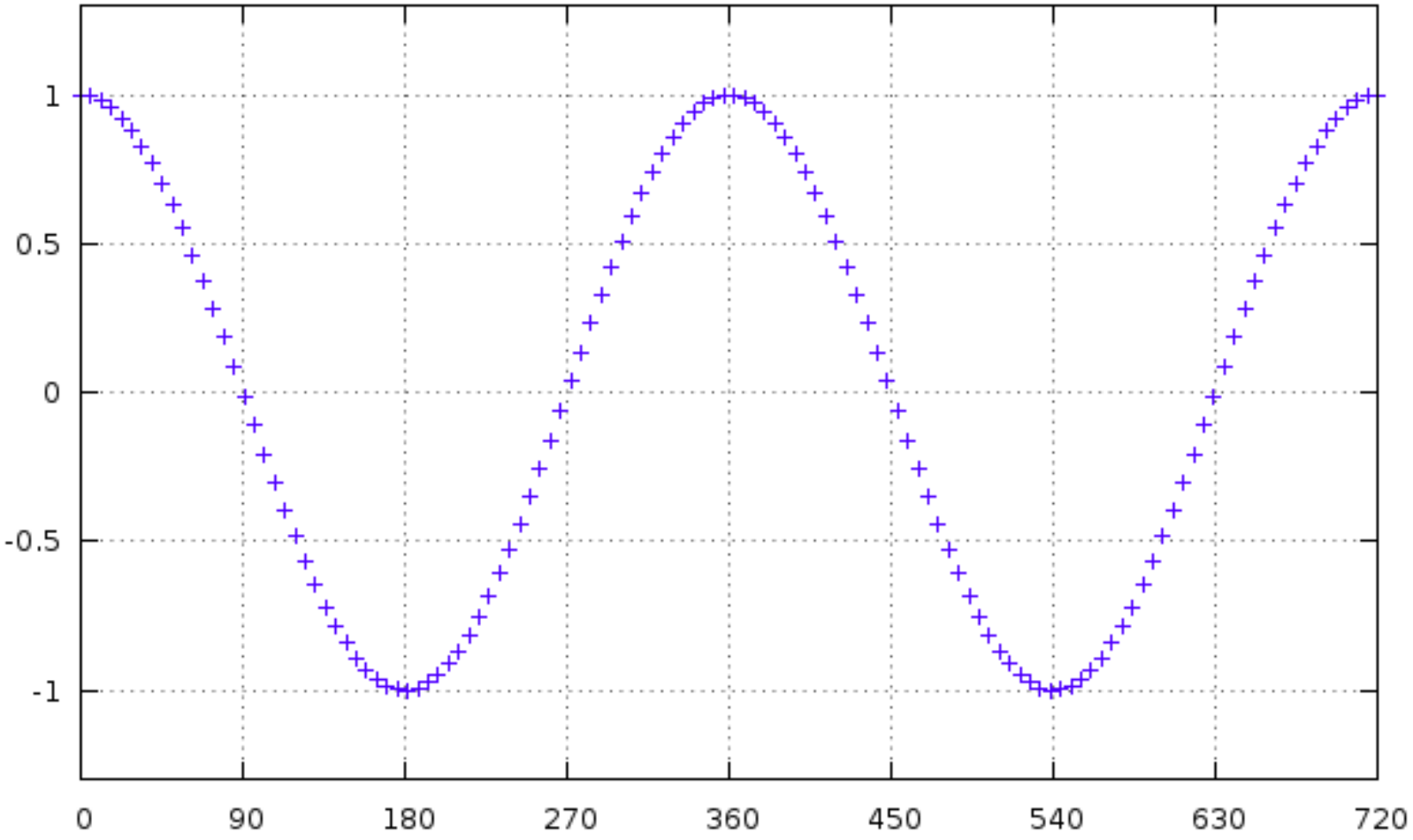
Bilgi



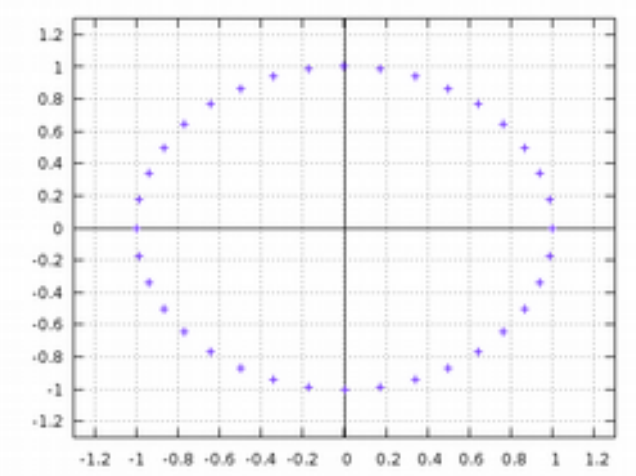
FM Modüle Edilmiş Taşıyıcı Sinyal

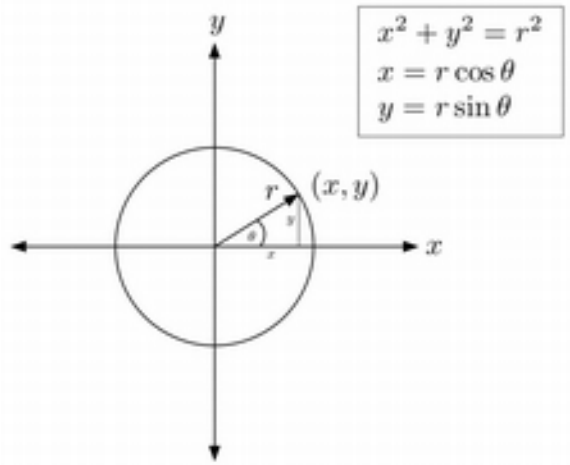
Frekans Modülasyonu (FM)

Direk A/D çevrimi yapsaydık

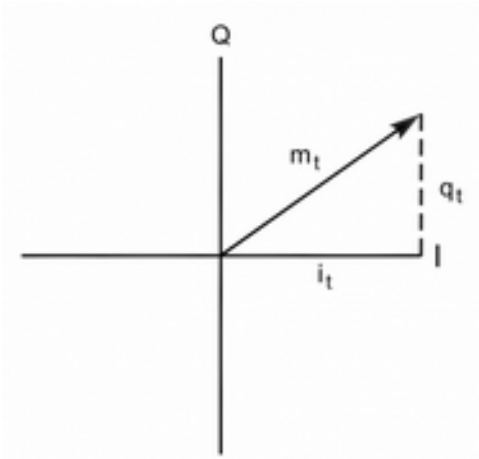


cos(wt) mi, cos(-wt) mi ?
W= ?

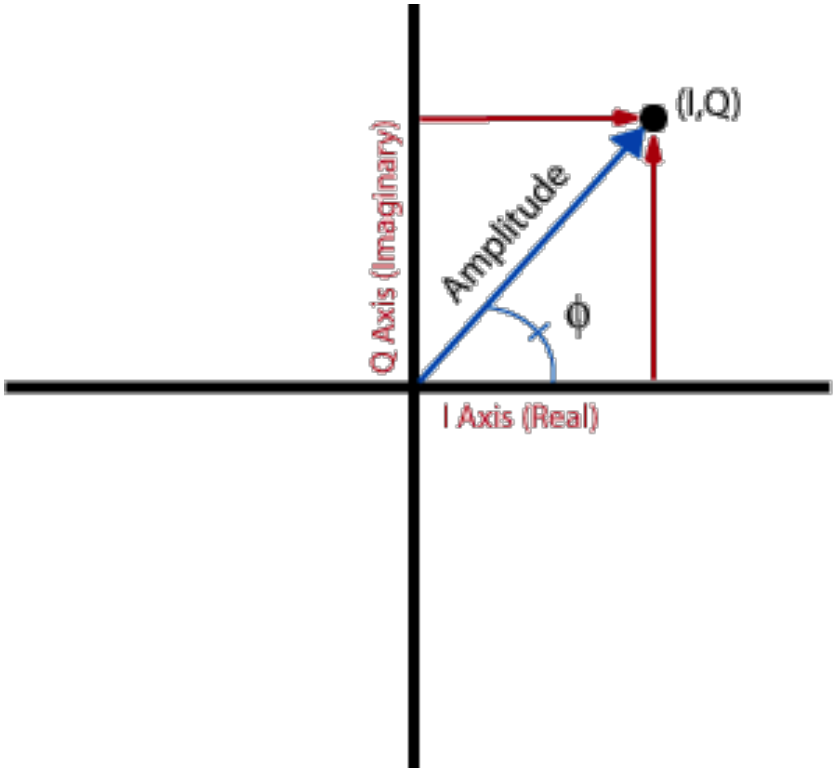




$$m_t = A.\cos\theta$$



$$m_t = \sqrt{I_t^2 + Q_t^2}$$



Koordinat : (I,Q)

Vektör : [I,Q]

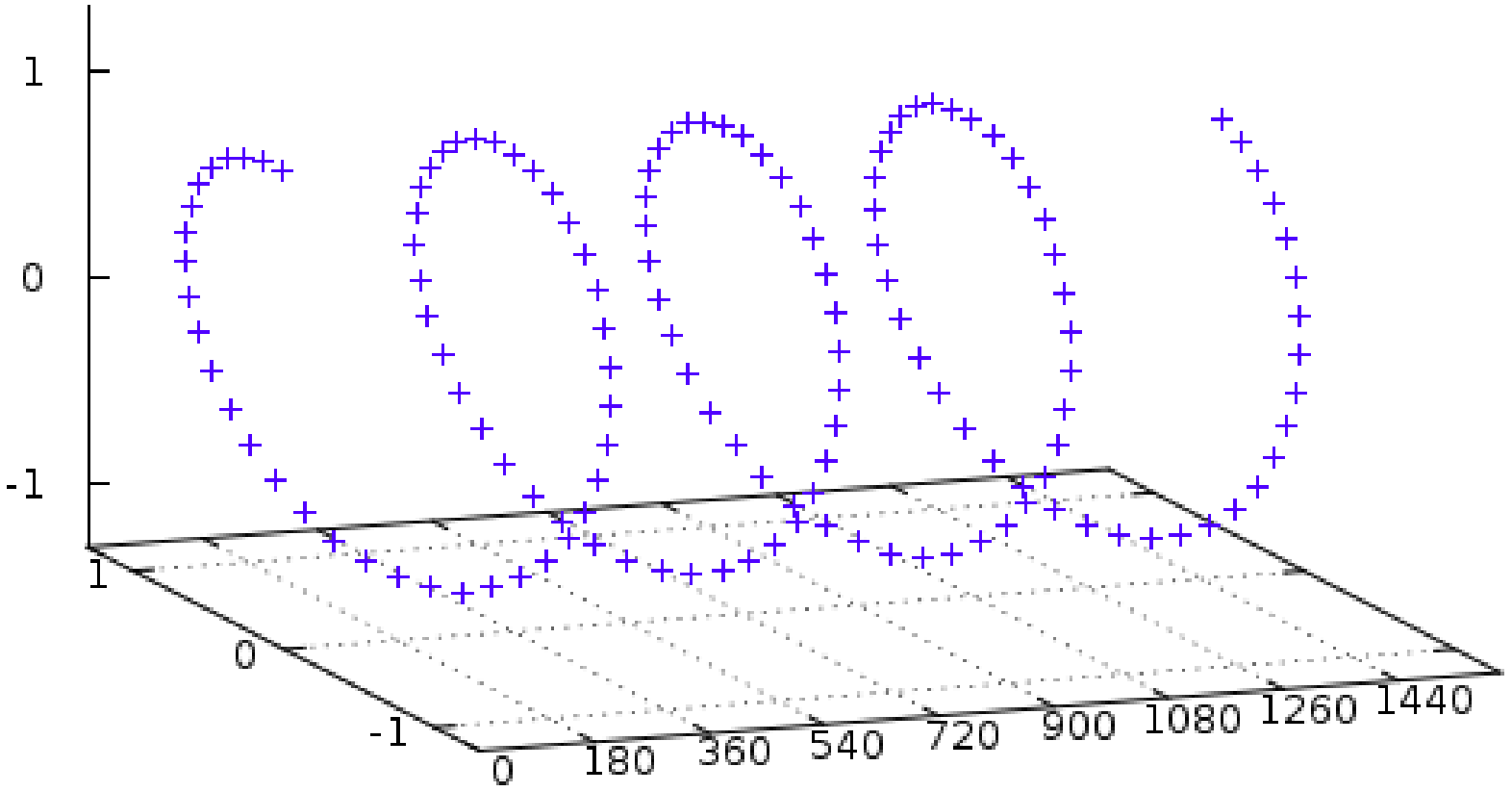
Komplex Sayı : I+Qi

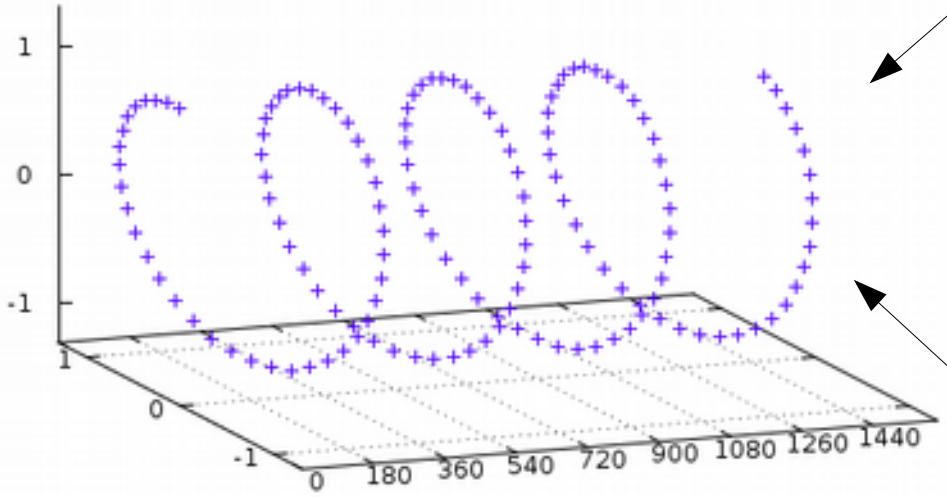
Polar : I=A.cos(wt), Q=A.sin(wt)

Euler : $A(\cos(\phi) + i \cdot \sin(\phi))$

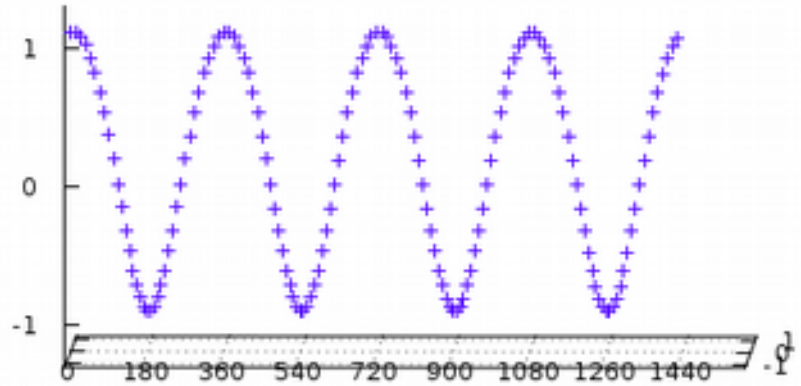
$Ae^{i\phi}$

Komplex Sinyal Görünümü

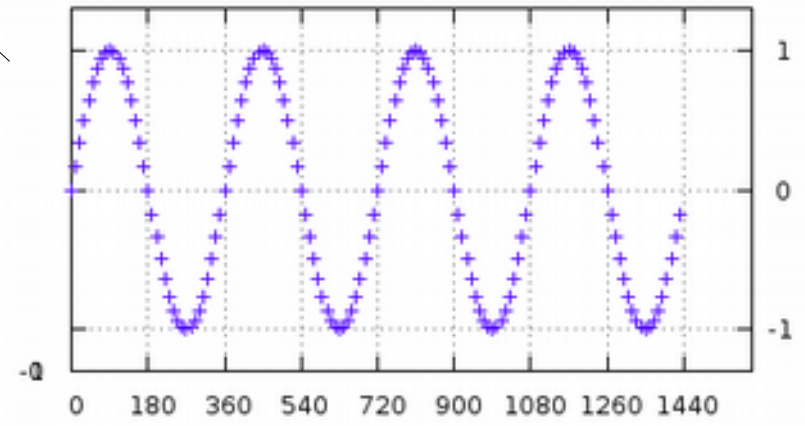




cos(wt) + i.sin(wt)



cos(wt)



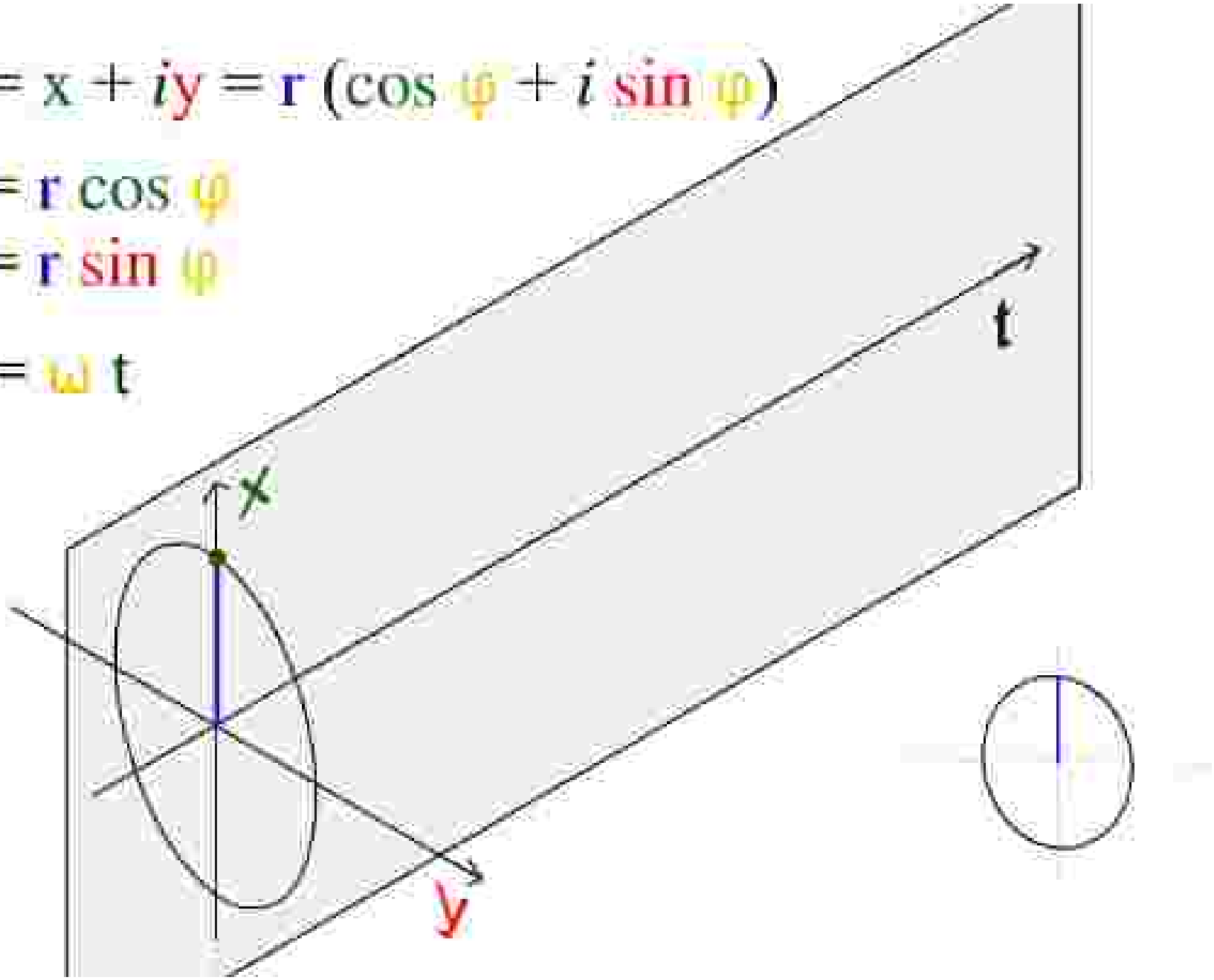
sin(wt)

$$z = x + iy = r\,(\cos\varphi + i\sin\varphi)$$

$$x = r\cos\varphi$$

$$y = r\sin\varphi$$

$$\varphi = \omega\, t$$



Pozitif Frekans – Negatif Frekans

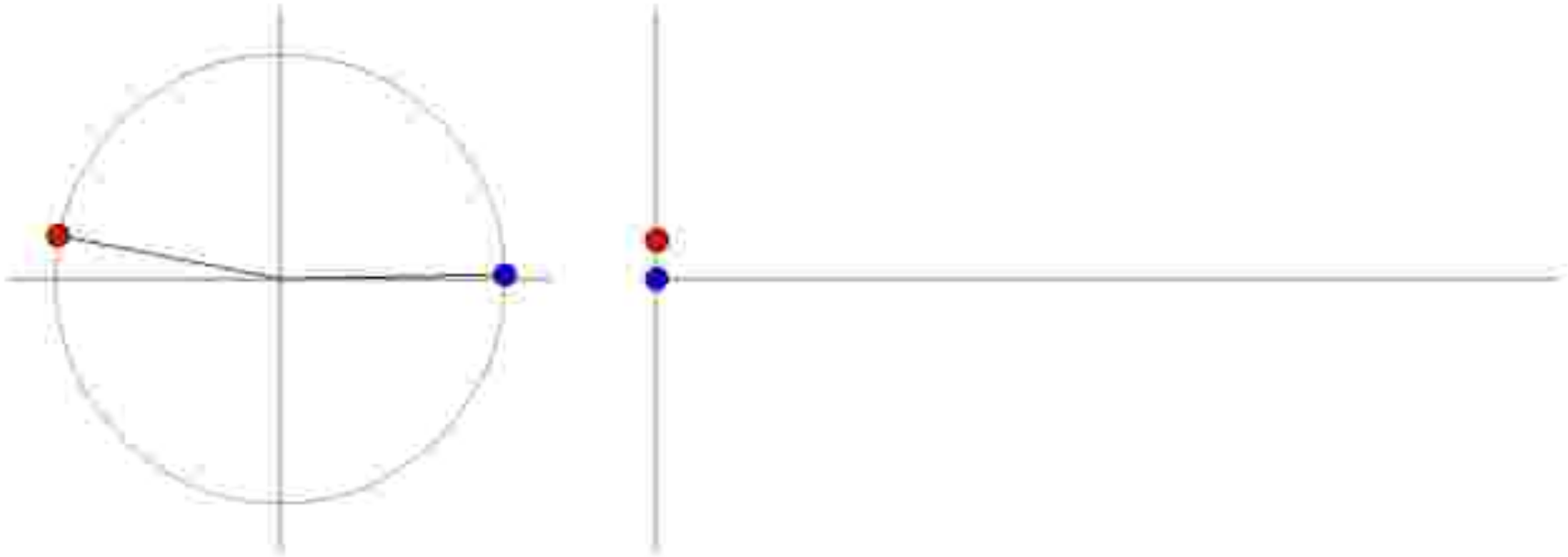
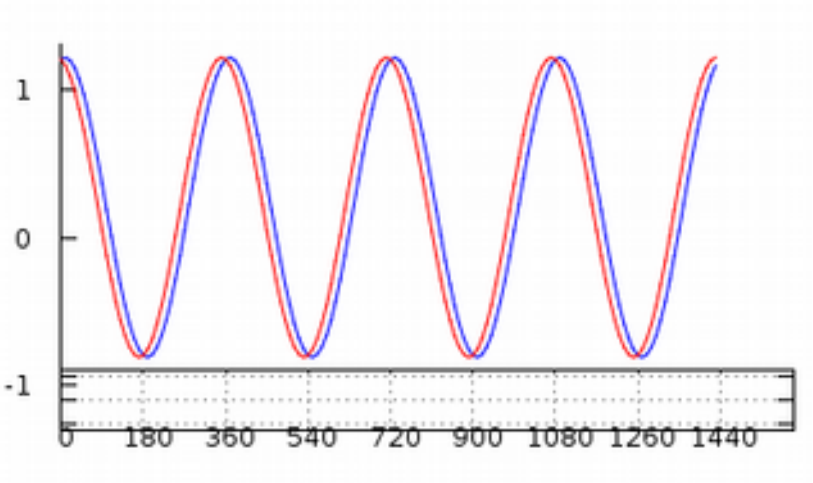


Image courtesy of whiteboard.ping.se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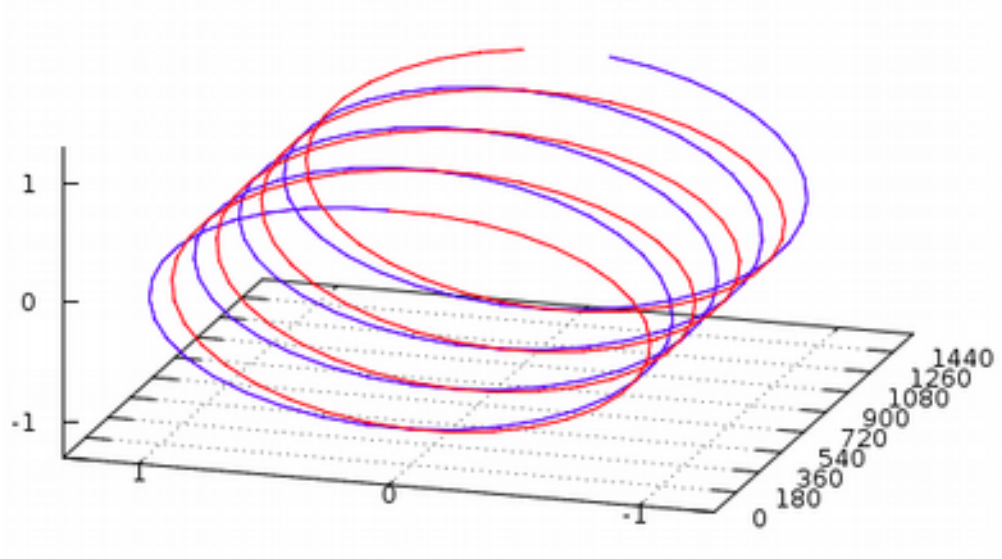
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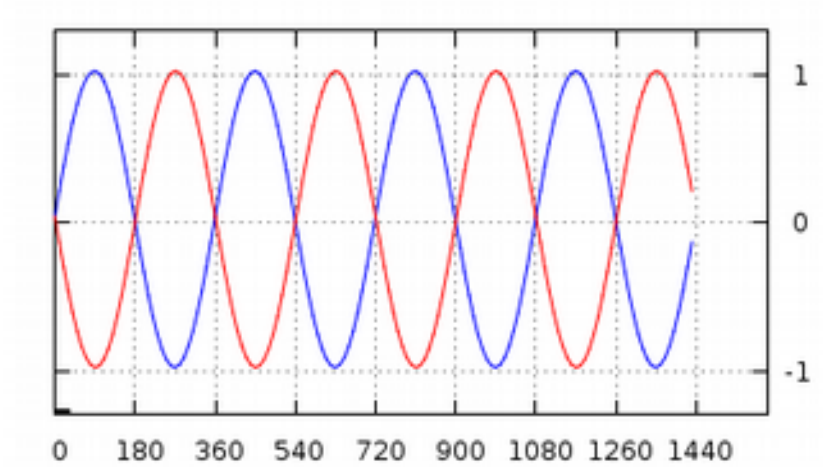
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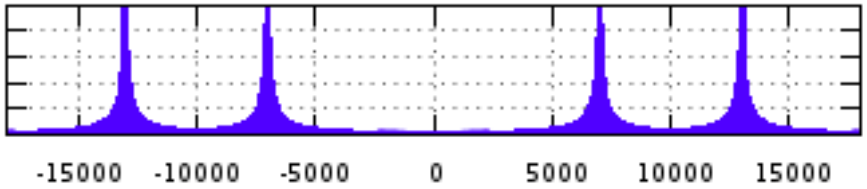
Q

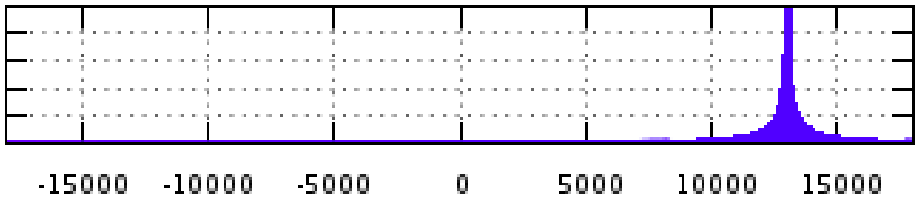
Sinyalleri Toplamak ve Çarpmak

$$\pm f1 \otimes \pm f2 = (\pm)f1 \pm f2$$



Komplex formu kullnırken işaretlerimiz belli olacağı için problem basitleşecektir ;

$$f1 \otimes f2 = f1 + f2$$



Euler ifadesi : $A_1 \cdot e^{i\phi_1} \cdot A_2\, e^{i\phi_2} = A_1 A_2\, e^{i(\phi_1+\phi_2)}$

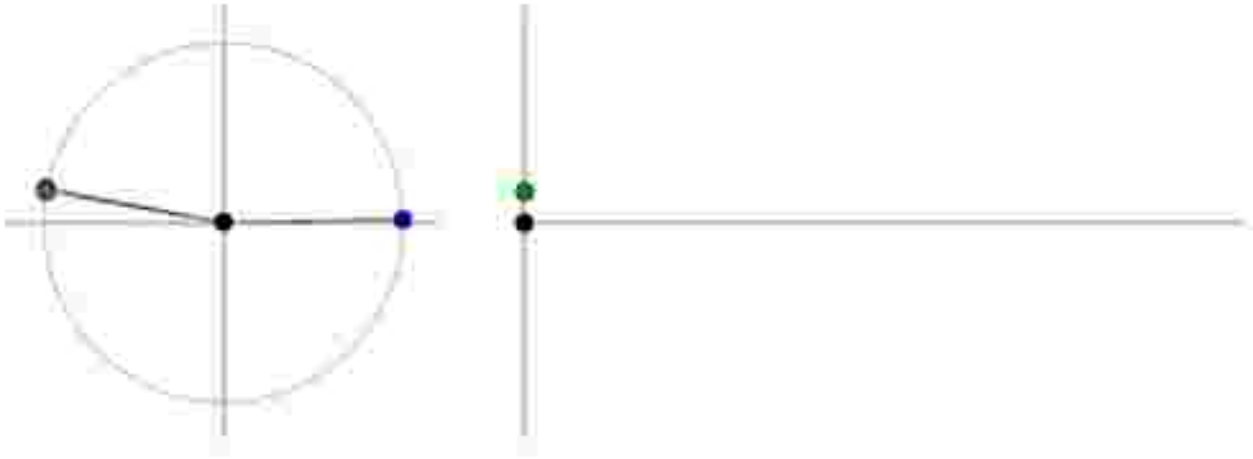


Image courtesy of whiteboard.ping.se

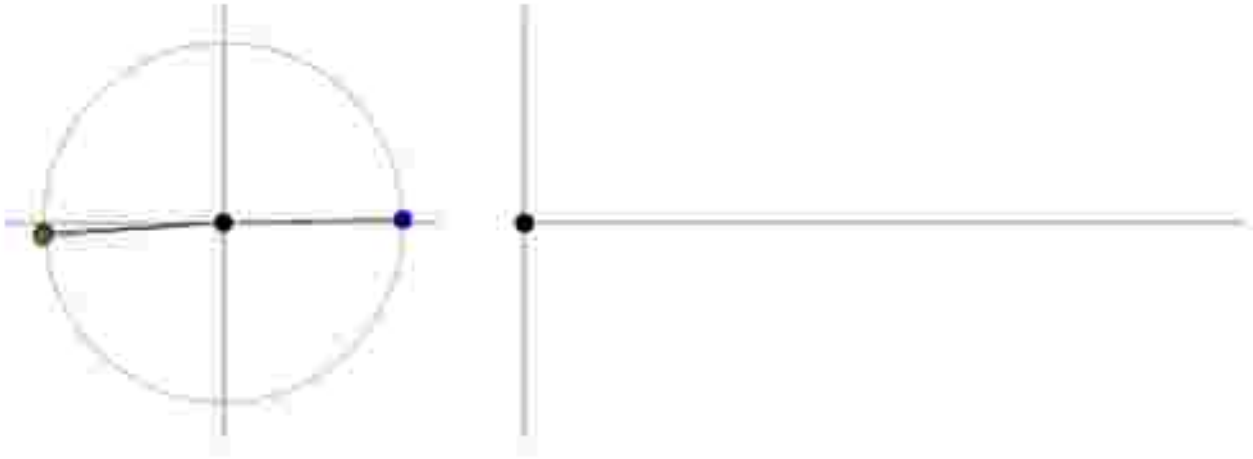
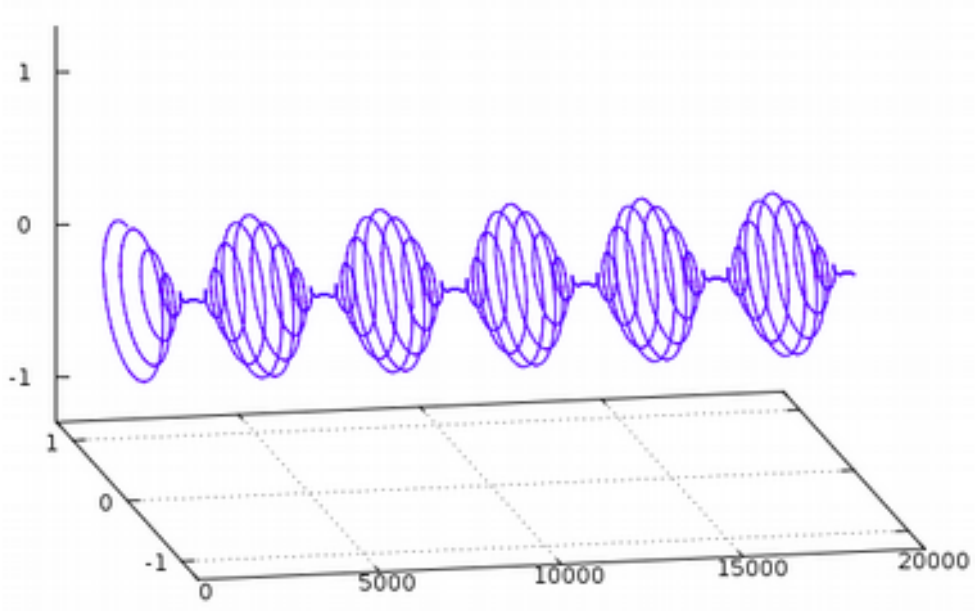
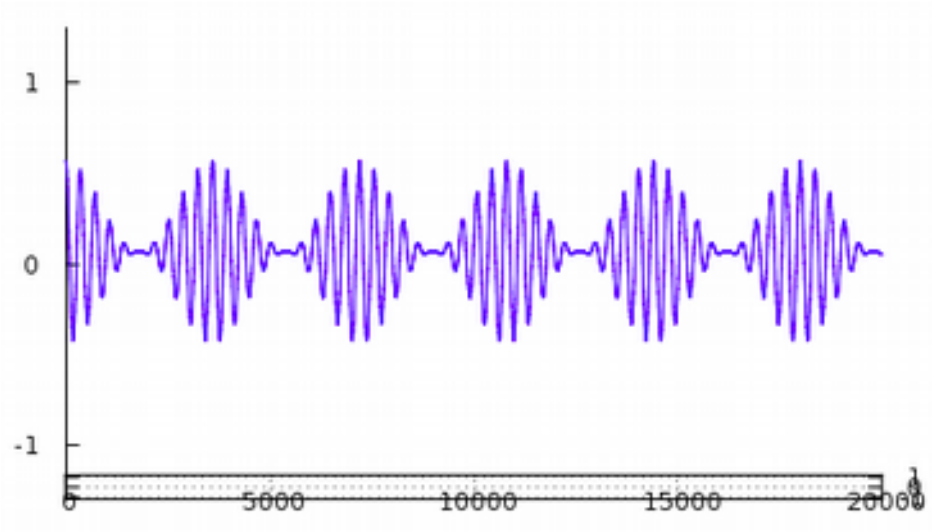


Image courtesy of whitebook.ping.se

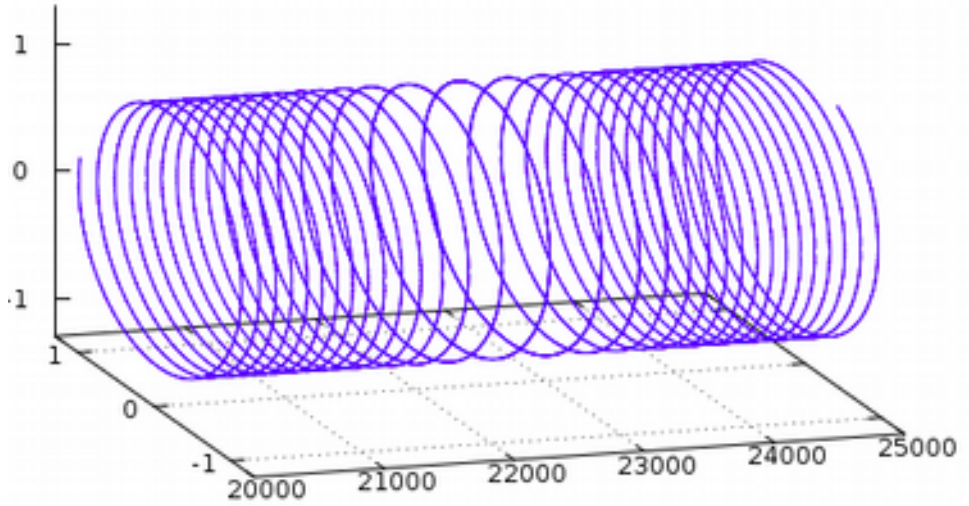


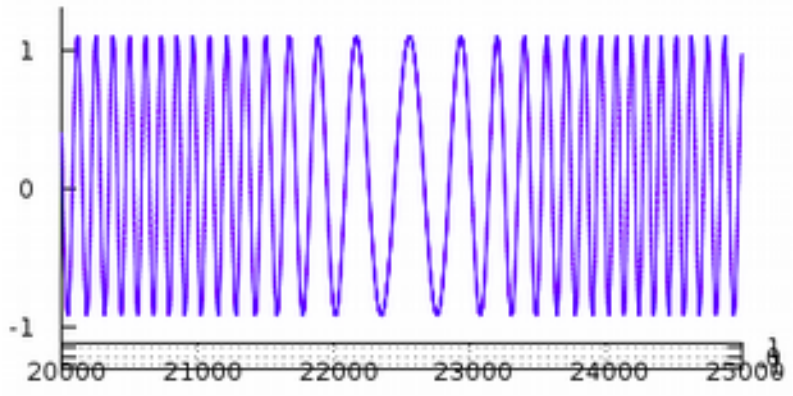


I Görünümü

Genlik = $(I^2+Q^2)^{1/2}$

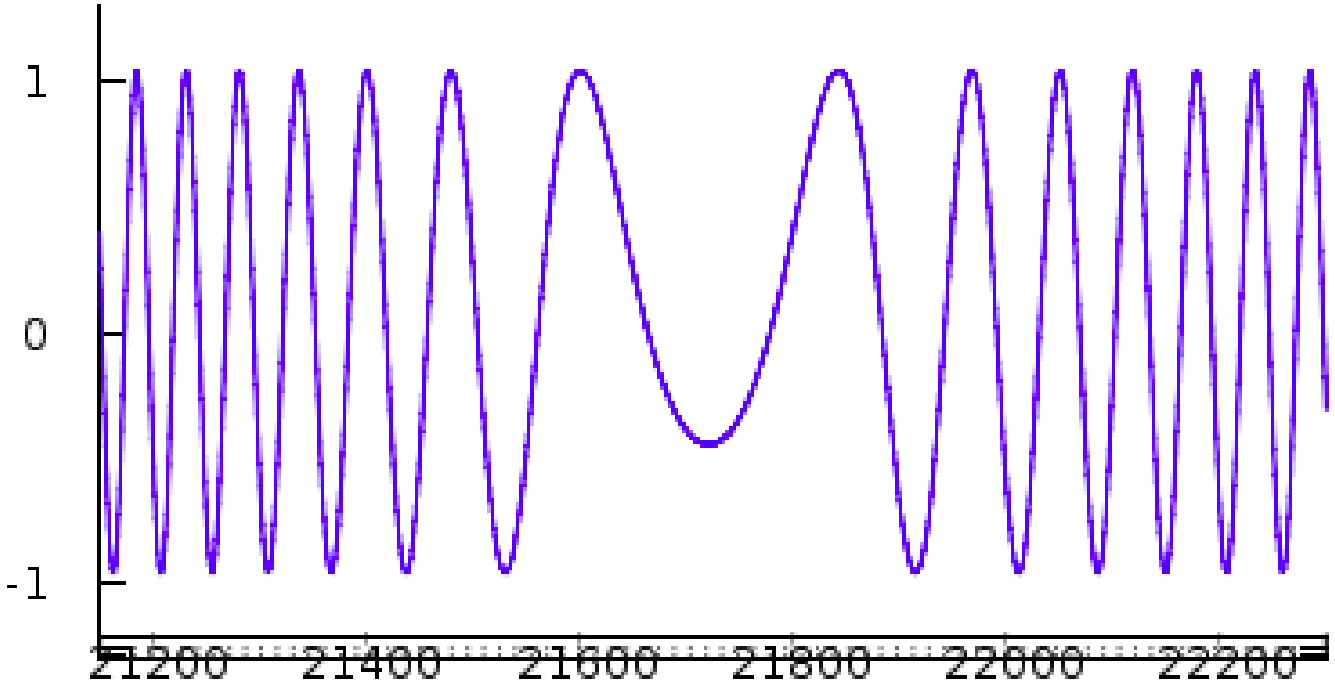
FM Modülasyonu Görünümü





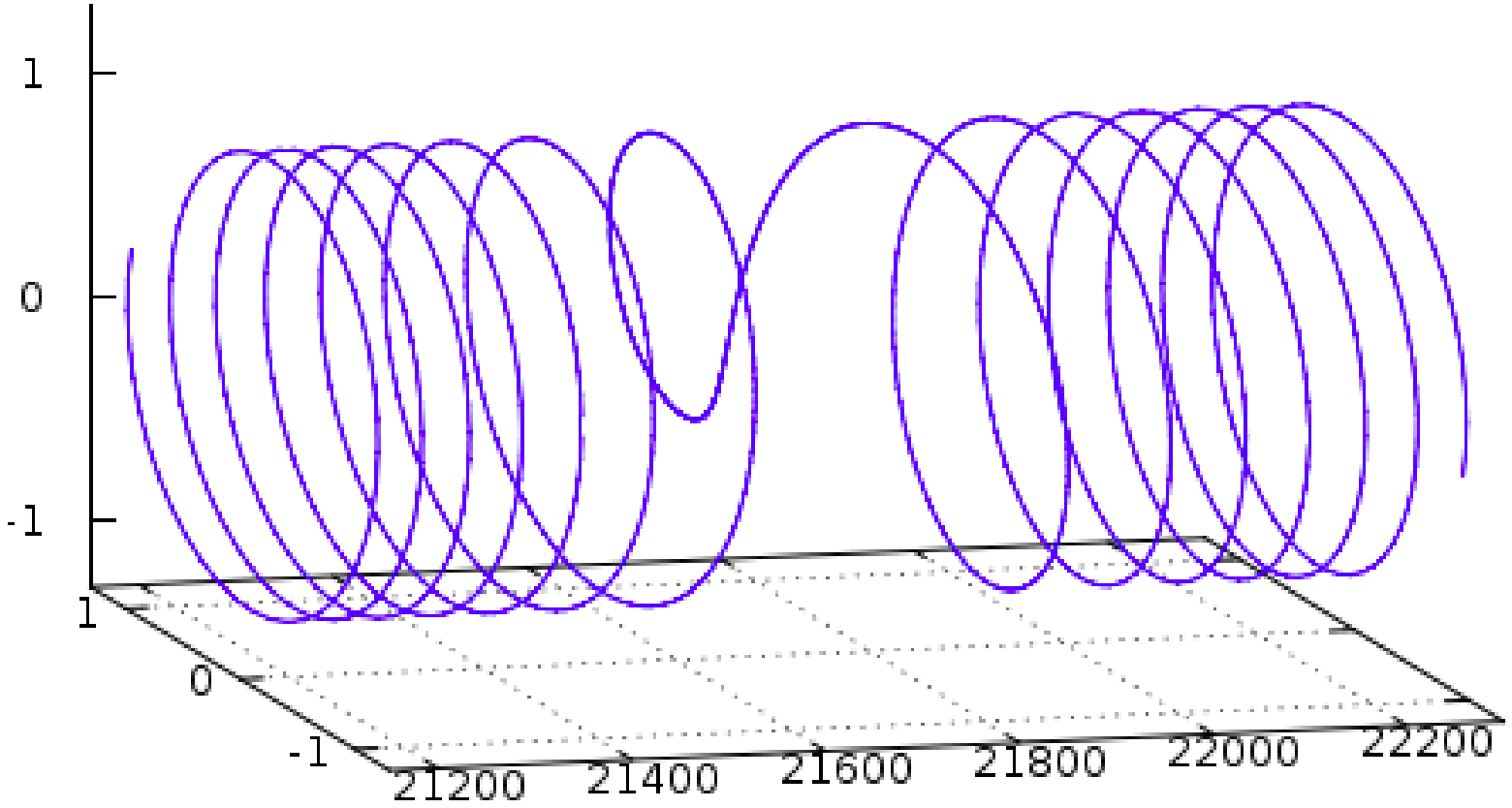
Sadece I Görünümü

FM Modülasyonu Görünümü



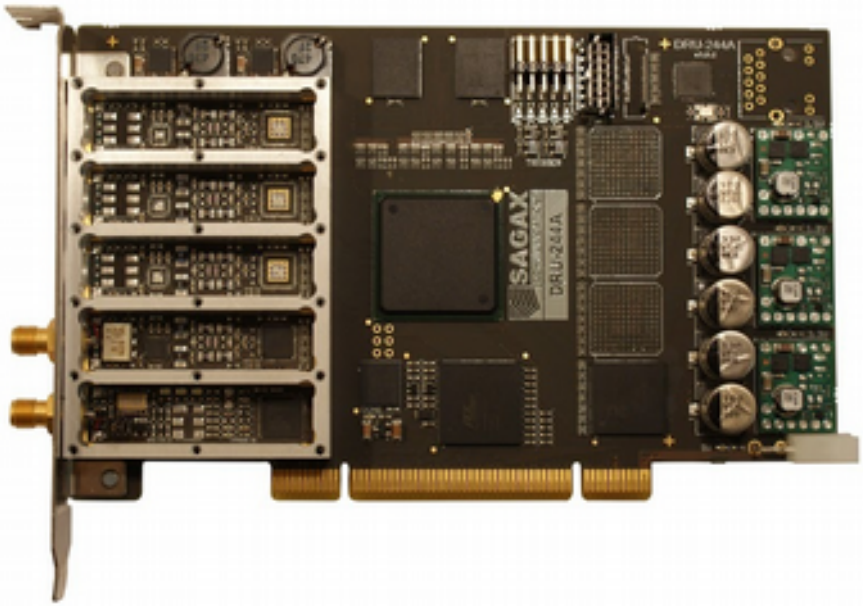
Bu sinyalde ne oluyor olabilir ?

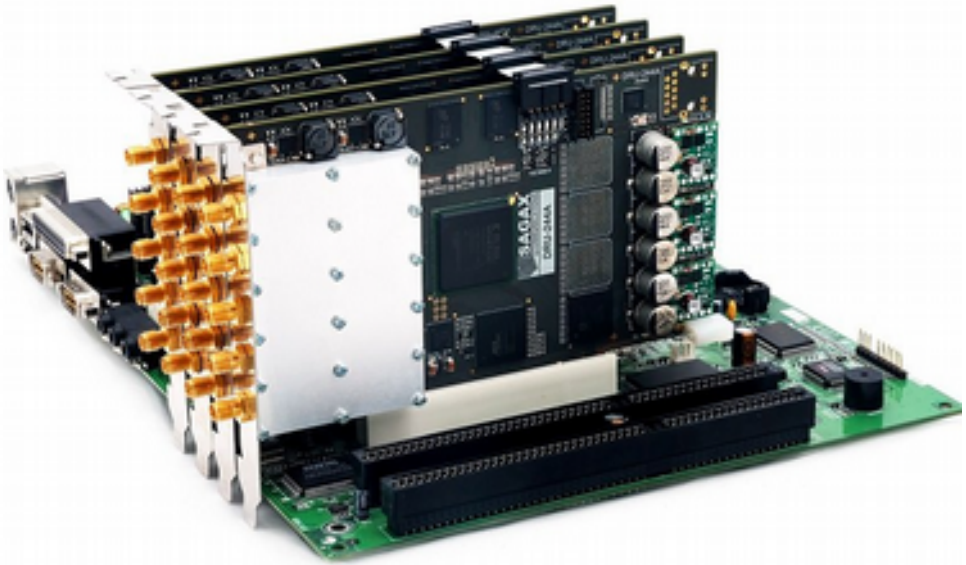
İpucu : Faz modülasyonu



Faz Modülasyonu Görünümü

Örnek SDR Donanımlar





BW > 500 Mhz
>> $40.000

SAGAX QUADRUS

Örnek SDR Donanımlar

B Serisi : < 20Mhz BW, ~$1500

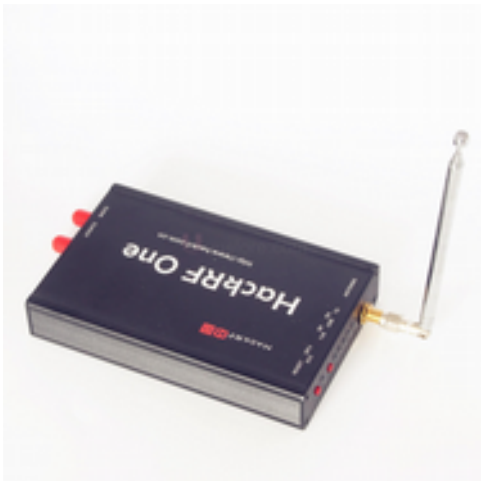
N Serisi : 25Mhz BW, ~$2500

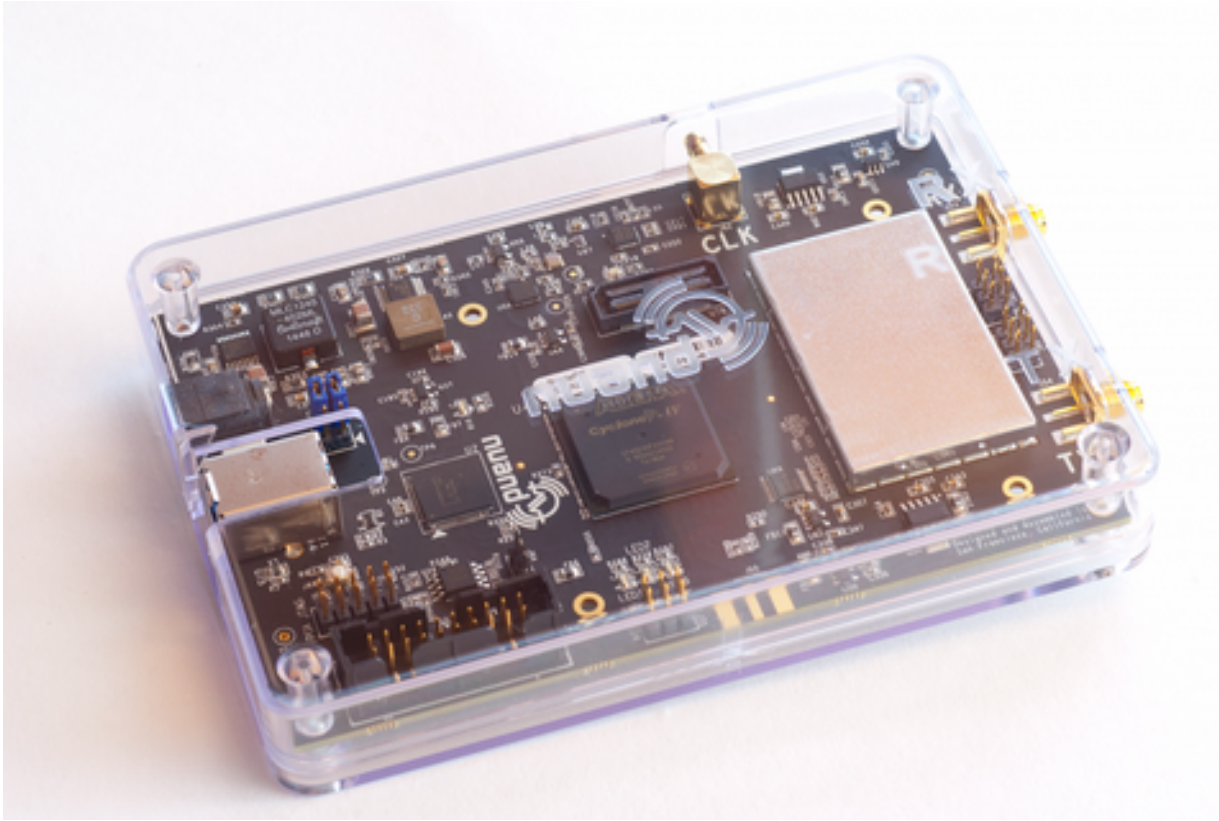
E Serisi : 50Mhz BW, ~$4500

X Serisi : 150 Mhz BW, ~$7500

Ettus Research

Örnek SDR Donanımlar



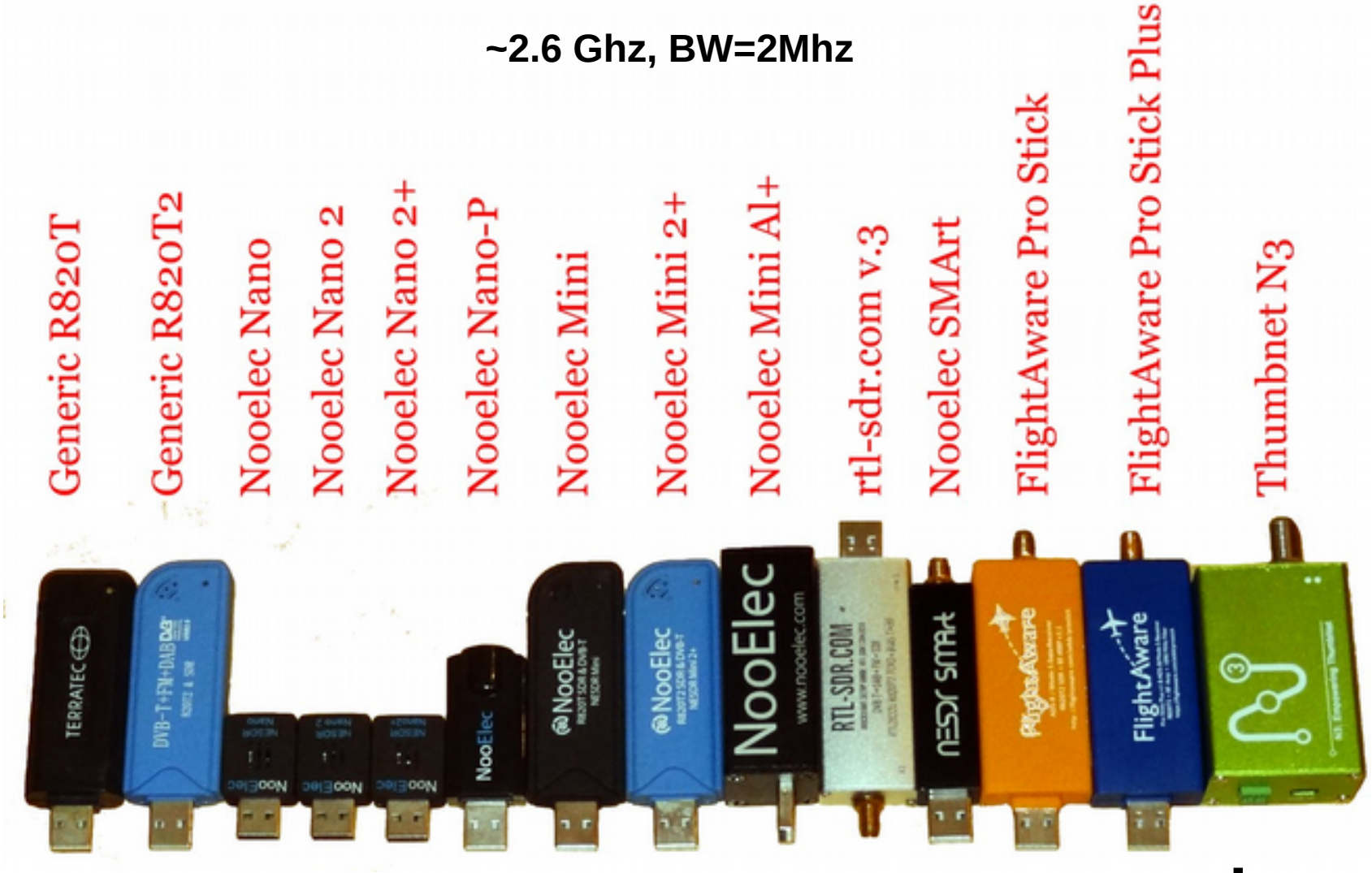


BW ~20Mhz
~$300

HackRF ve BladeRF

Örnek SDR Donanımlar

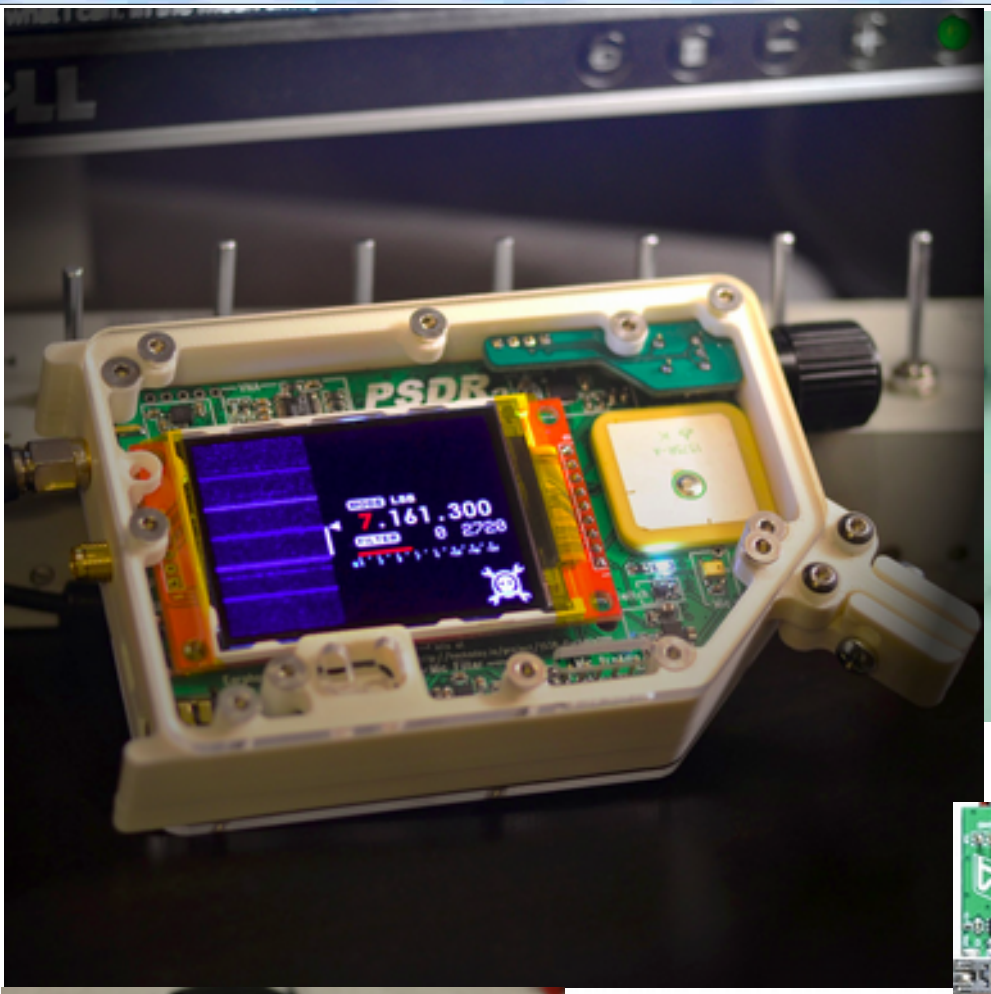
~2.6 Ghz, BW=2Mhz



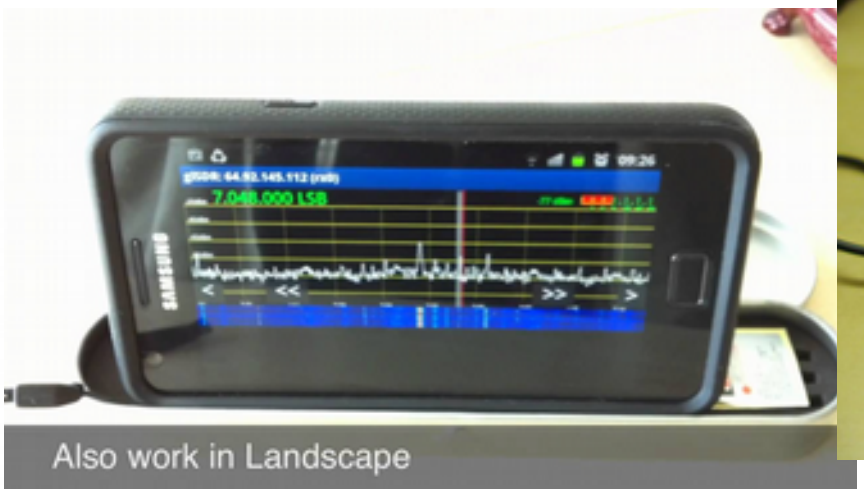
RTL SDR

<$10

Örnek SDR Donanımlar



Örnek SDR Donanımlar

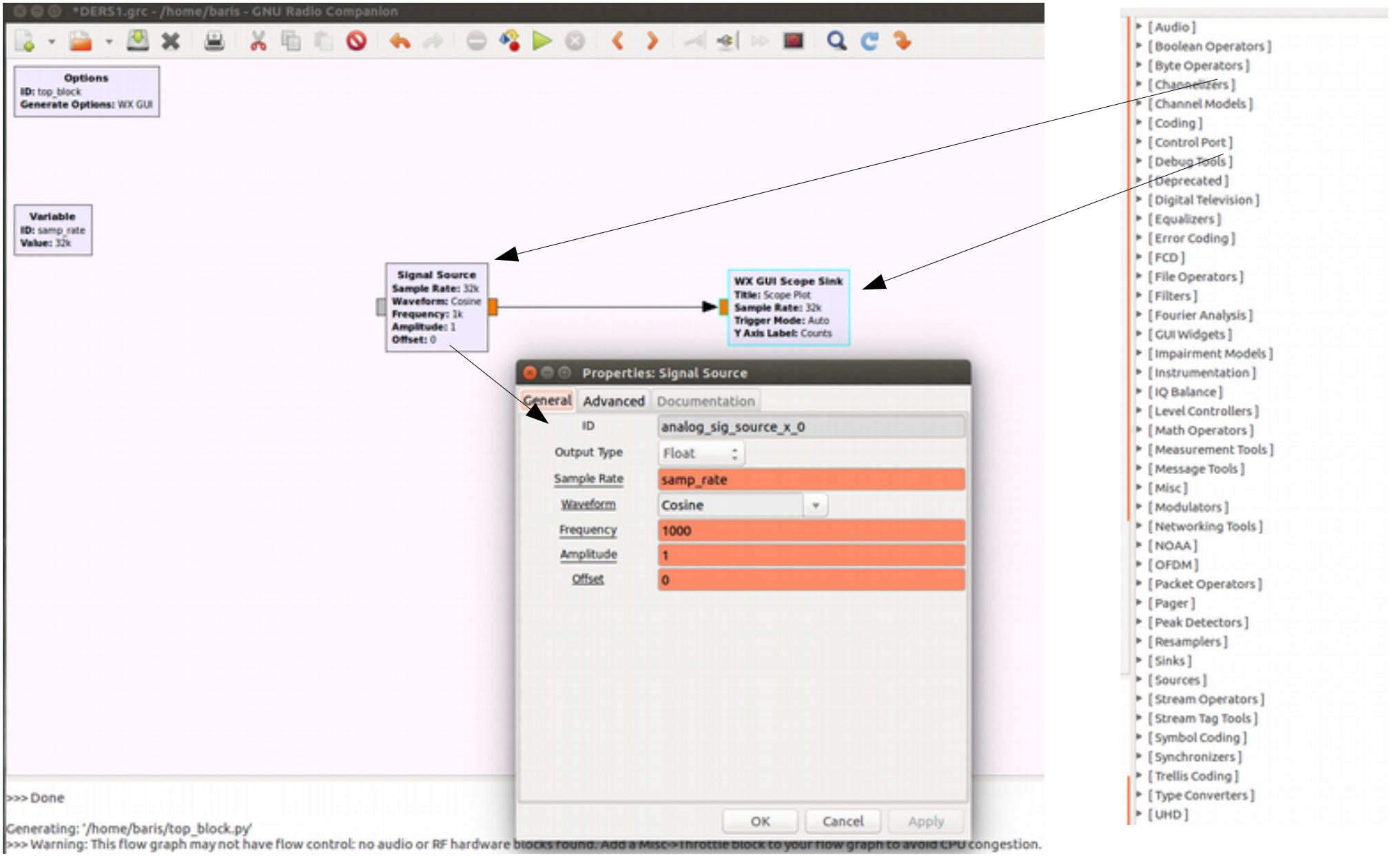


Örnek SDR Donanımlar

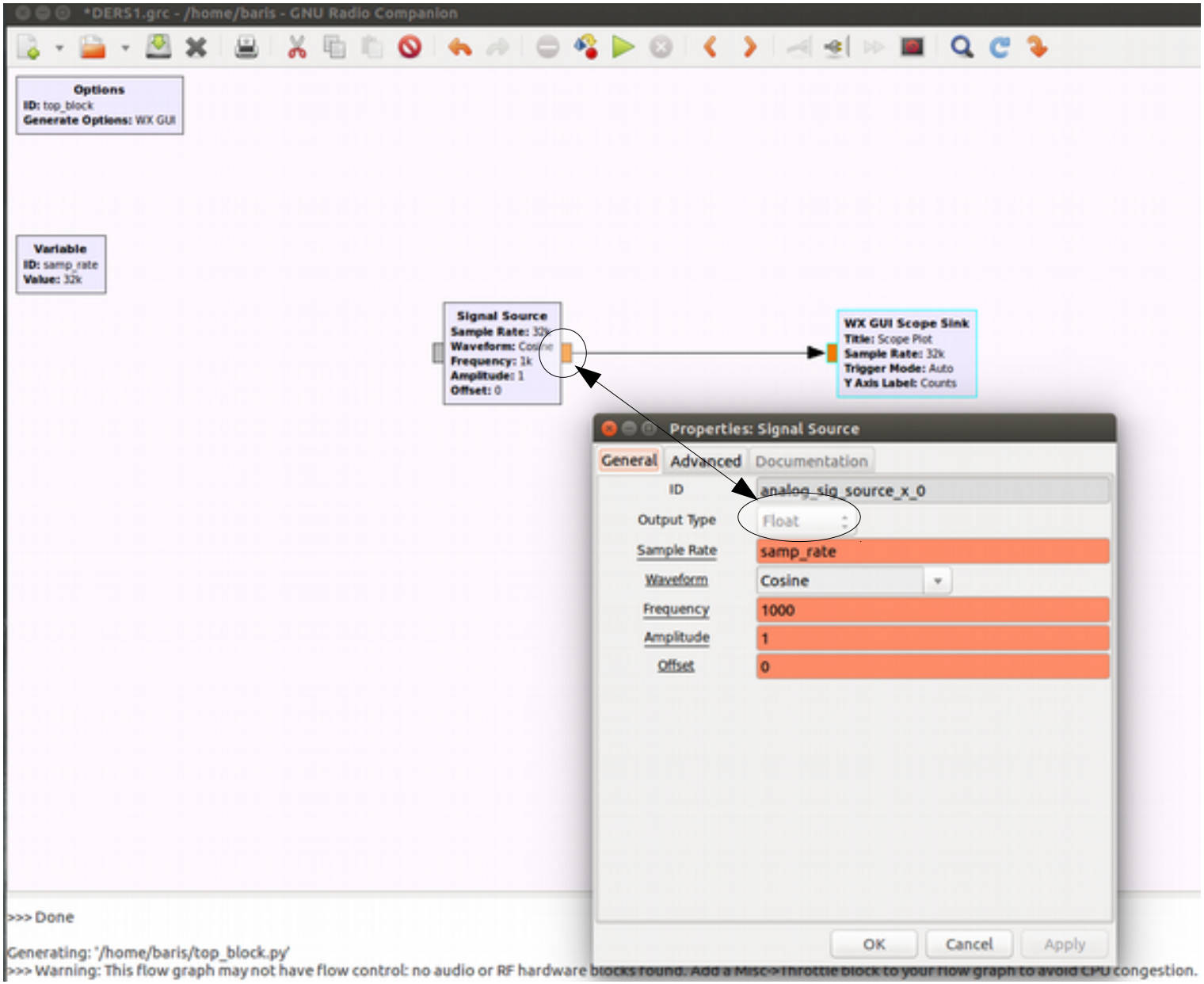
```
onur@onur-Lenovo-G50-70:~$ sudo apt-get install gnuradio
[sudo] password for onur:
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  blt fonts-lyx freeglut3 gnuradio-dev libboost-atomic1.58-dev
  libboost-atomic1.58.0 libboost-chrono1.58-dev libboost-chrono1.58.0
  libboost-date-time-dev libboost-date-time1.58-dev libboost-filesystem-dev
  libboost-filesystem1.58-dev libboost-program-options-dev
  libboost-program-options1.58-dev libboost-program-options1.58.0
  libboost-regex1.58.0 libboost-serialization1.58-dev
  libboost-serialization1.58.0 libboost-system-dev libboost-system1.58-dev
  libboost-test-dev libboost-test1.58-dev libboost-test1.58.0
  libboost-thread-dev libboost-thread1.58-dev libboost-thread1.58.0
  libboost1.58-dev libcodec2-0.4 libcomedi0 libcppunit-1.13-0v5 libcppunit-dev
  libdrm-amdgpu1 libdrm-dev libdrm-intel1 libdrm-nouveau2 libdrm-radeon1
  libdrm2 libexpat1-dev libfftw3-bin libfftw3-dev libfftw3-long3
  libfftw3-quad3 libgl1-mesa-dev libgl1-mesa-glx libglade2-0 libglapi-mesa
```

```
Setting up python-ndg-httpsclient (0.4.0-3) ...
Setting up python-networkx (1.11-1ubuntu1) ...
Setting up python-qwt5-qt4 (5.2.1~cvs20091107+dfsg-7build1) ...
Setting up python-urllib3 (1.13.1-2ubuntu0.16.04.1) ...
Setting up python-requests (2.9.1-3) ...
Setting up python-tk (2.7.11-2) ...
Setting up python-yaml (3.11-3build1) ...
Setting up uhd-host (3.9.2-1) ...
Adding group `usrp' (GID 131) ...
Done.
Setting up librtlsdr0:amd64 (0.5.3-5) ...
Setting up python-scipy (0.17.0-1) ...
Setting up rtl-sdr (0.5.3-5) ...
Processing triggers for libc-bin (2.23-0ubuntu3) ...
```

```
onur@onur-Lenovo-G50-70:~$ gnuradio-companion
```



Bileşenler ve Özellikleri



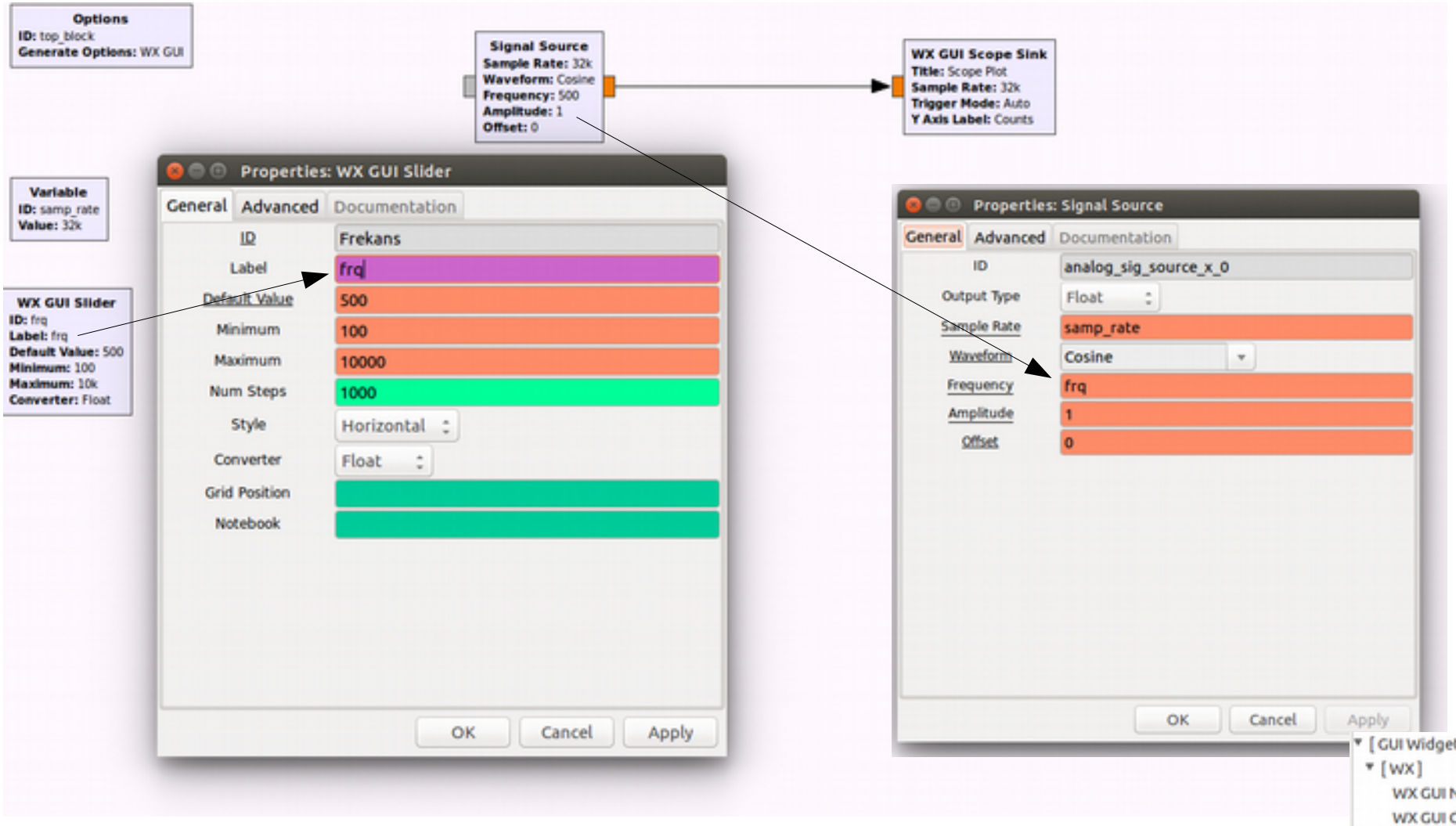
Float

Complex

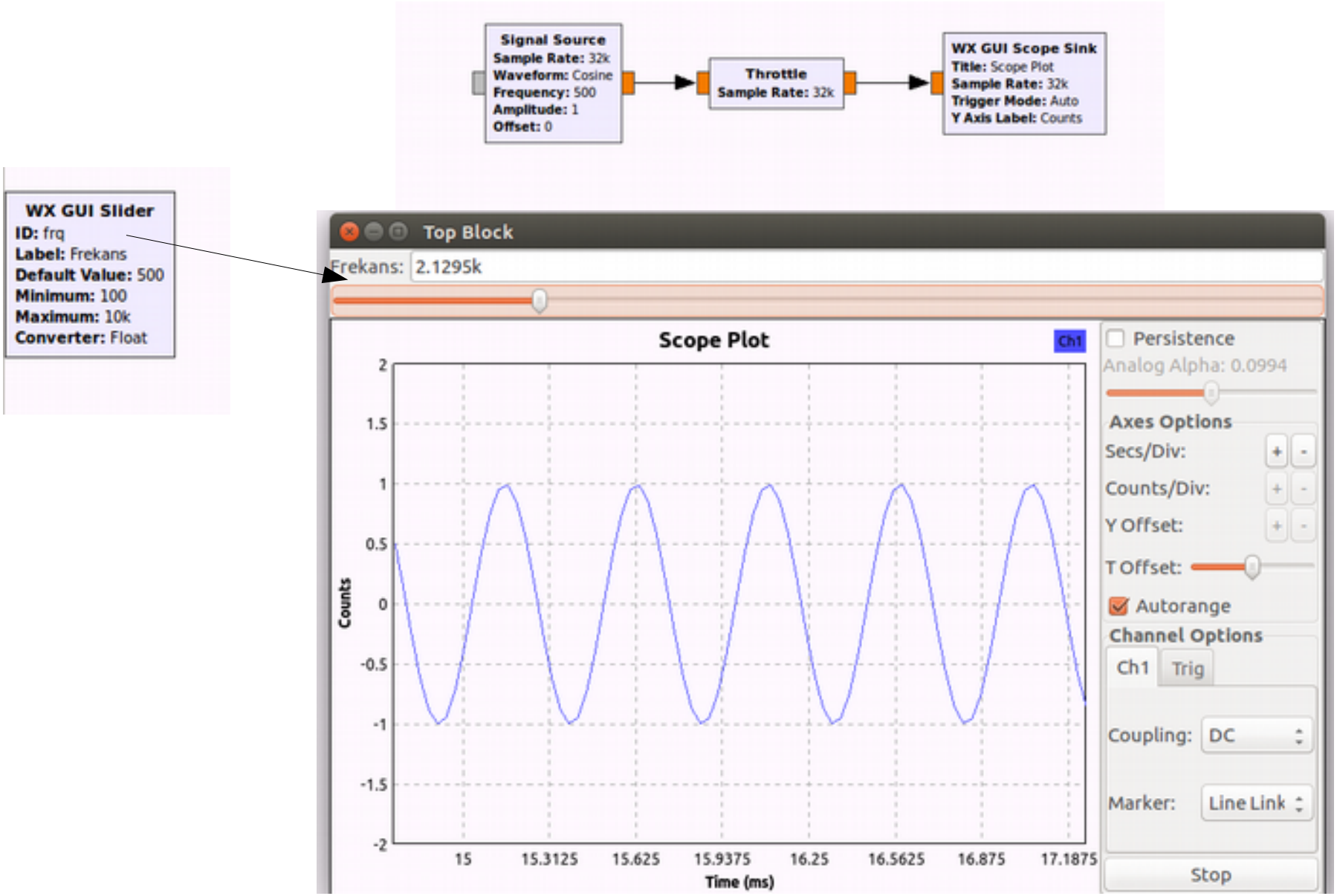
Int

Short

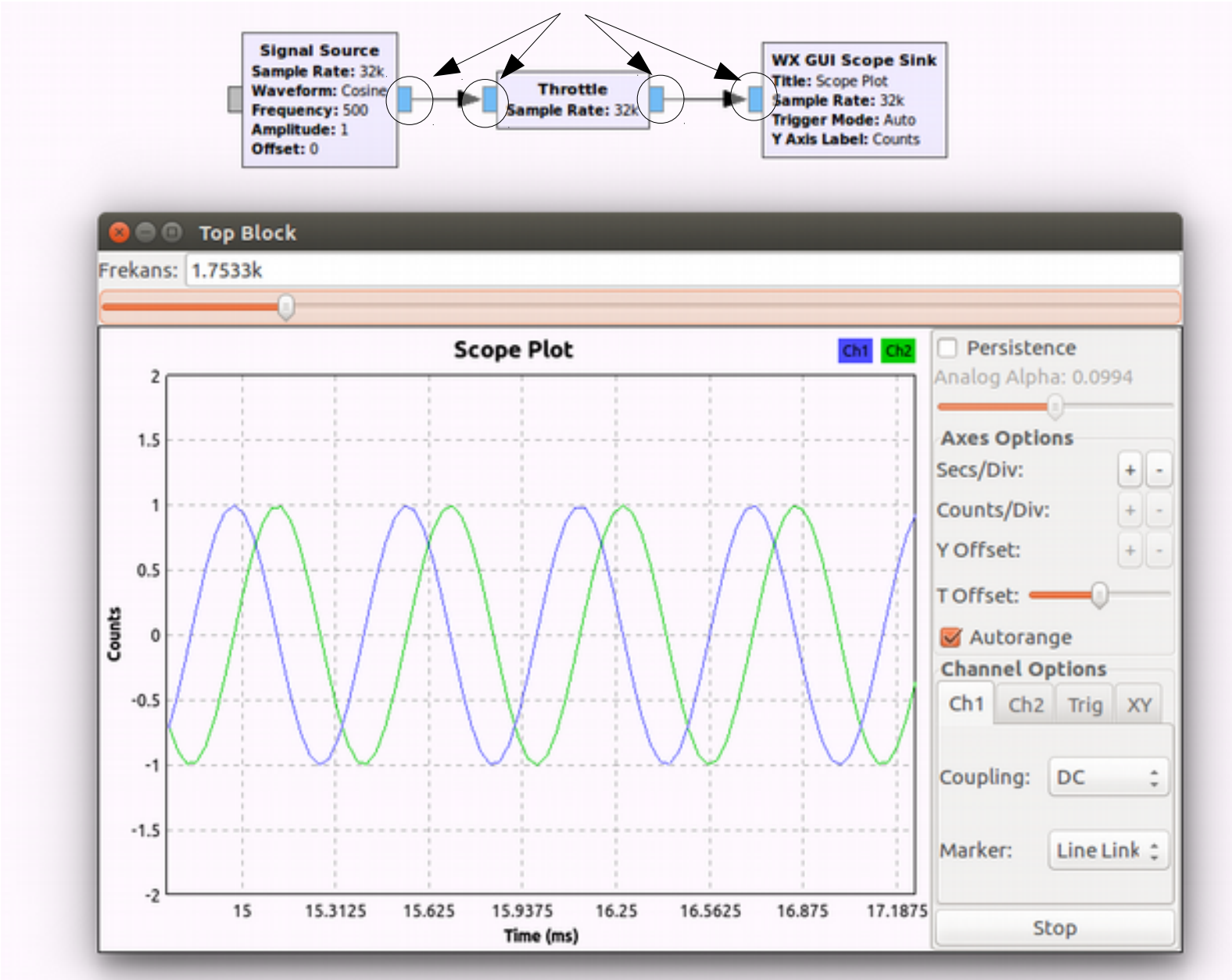
Veri Tipleri



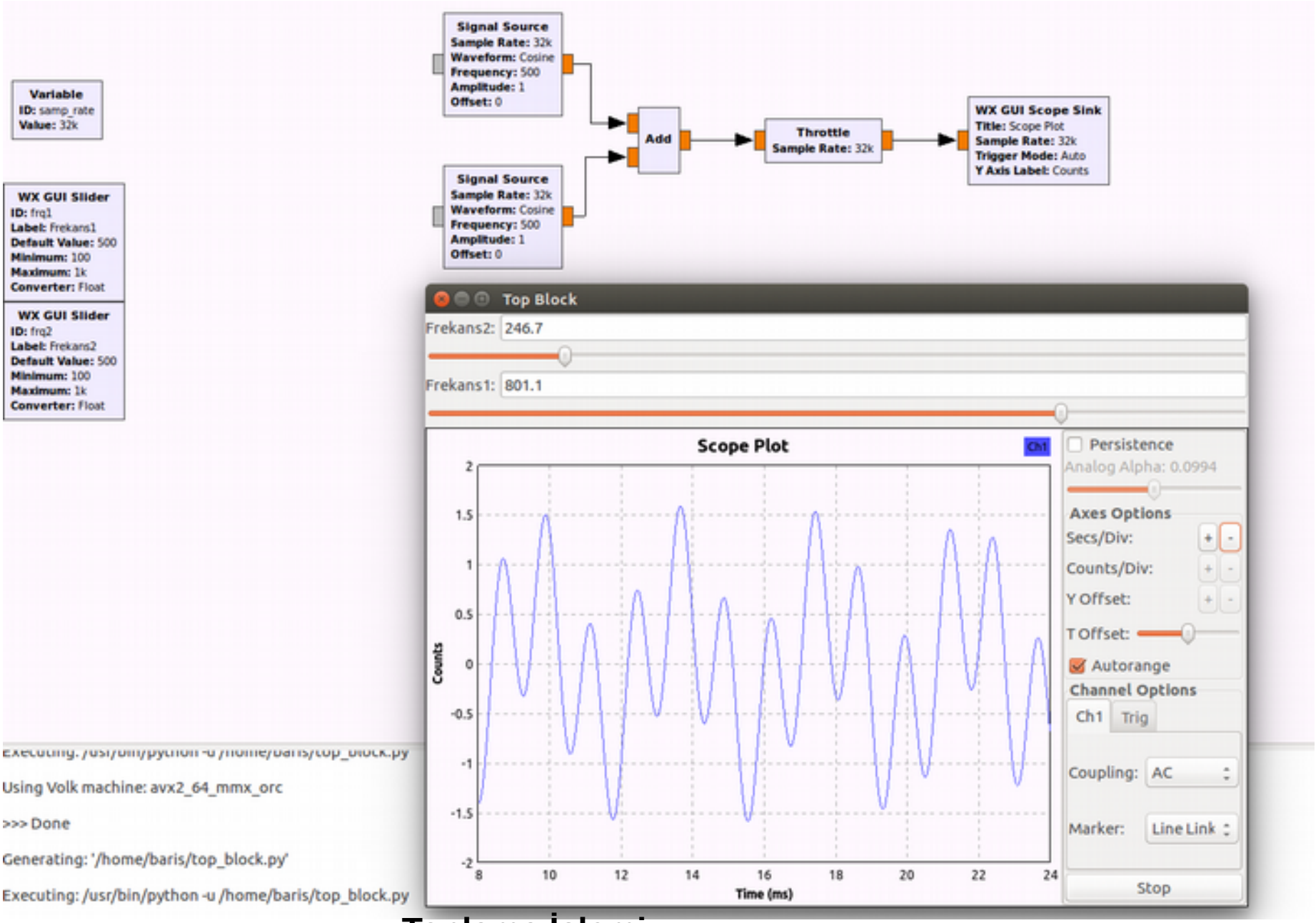
Değişkenler ve Ayar Araçları



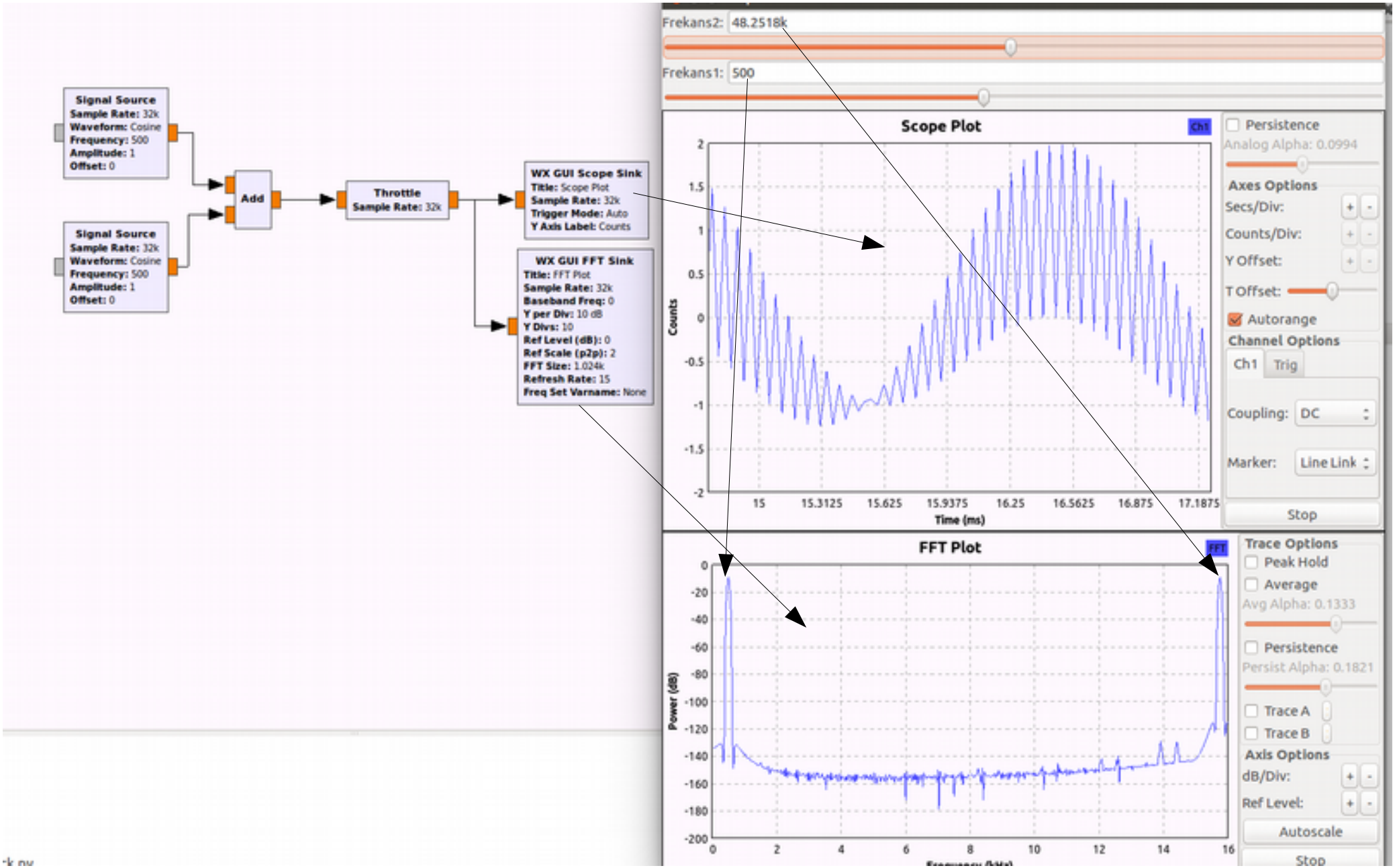
Throttle Elemanı ve Çıktı Görünümü



Komplex Çıktı Görünümü

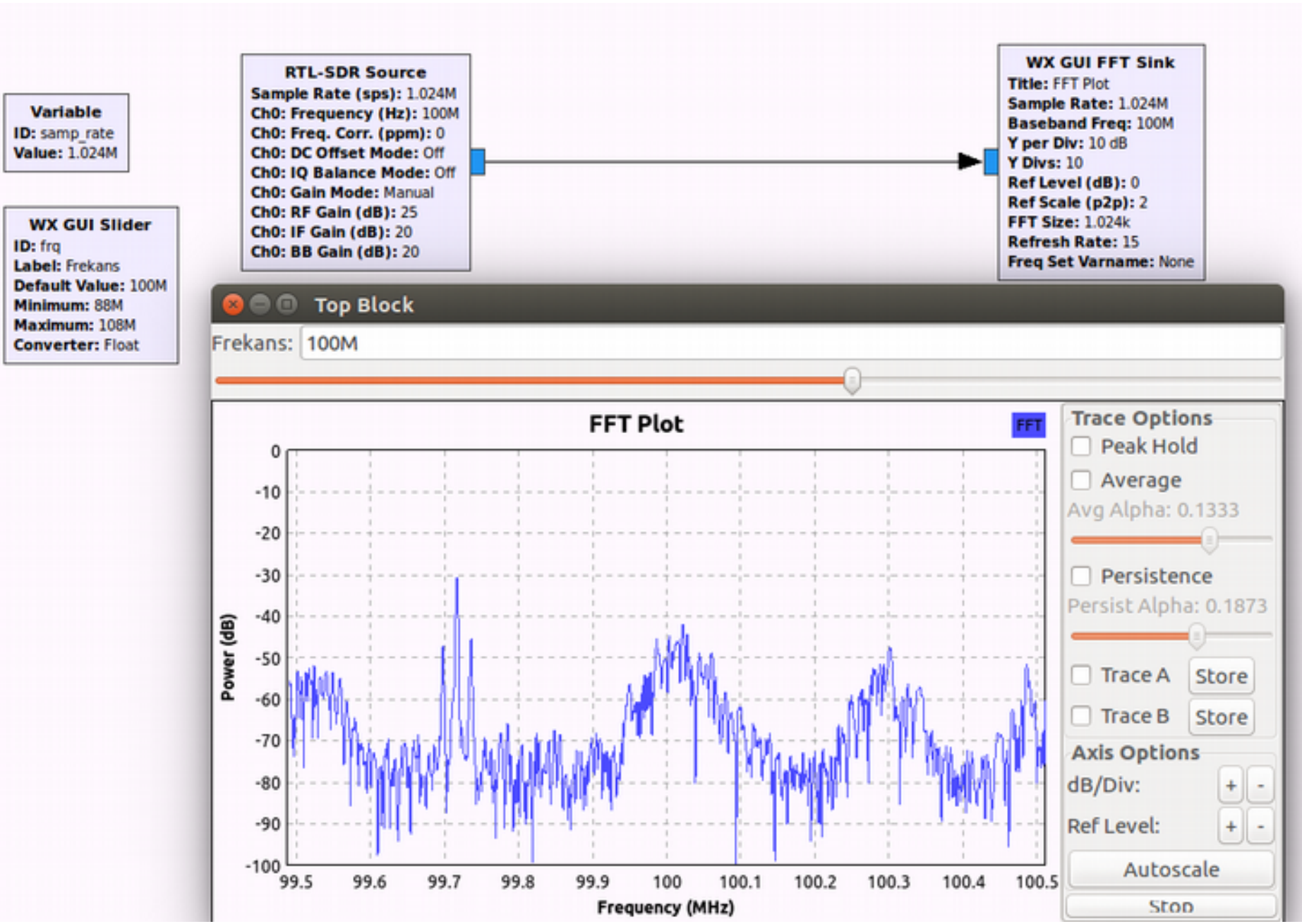


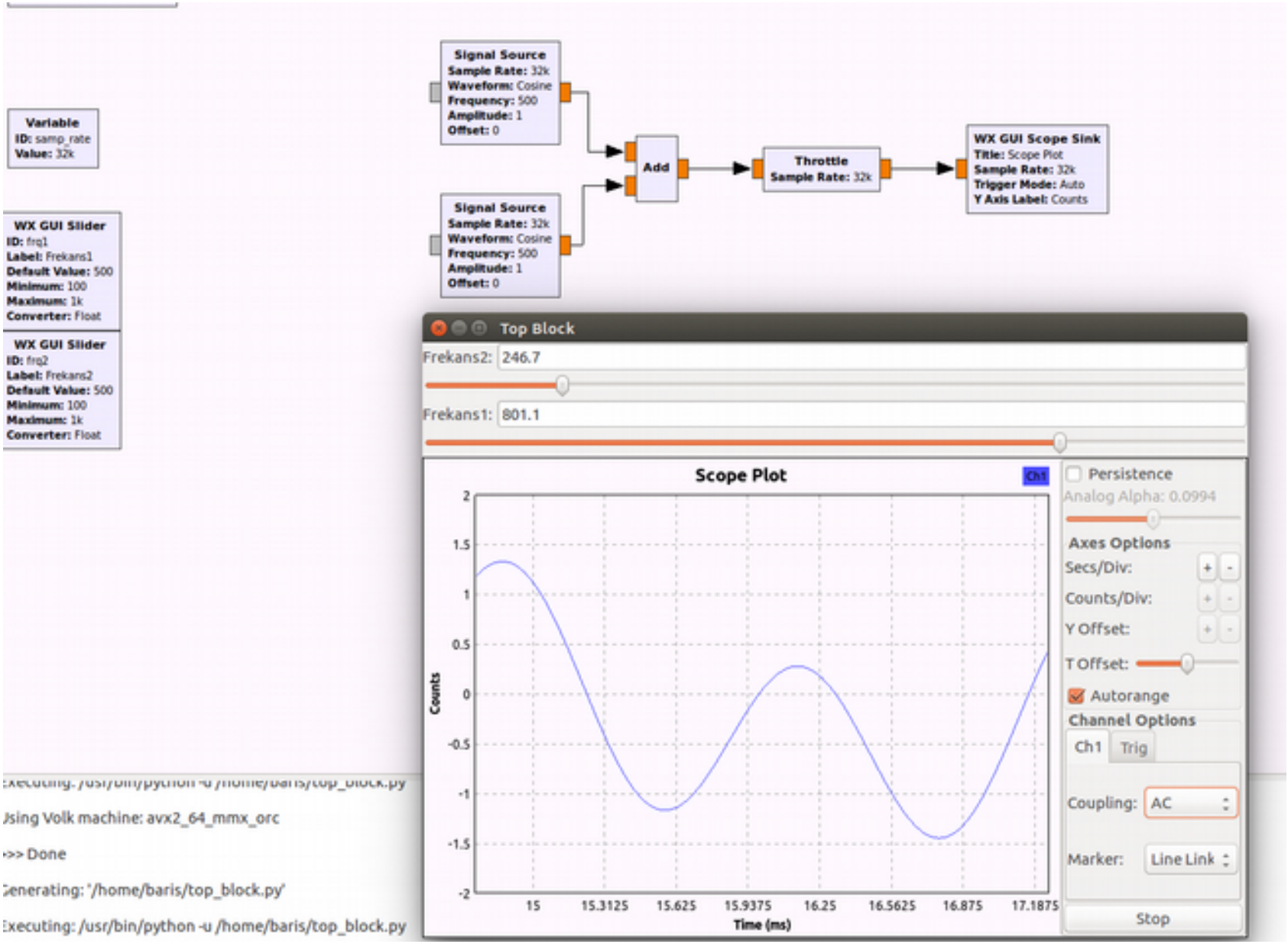
Toplama İşlemi



FFT ve Frekans Spektrumu

GNU-Radio


Variable
ID: samp_rate
Value: 1.024M
WX GUI Slider
ID: frq
Label: Frekans
Default Value: 100M
Minimum: 88M
Maximum: 108M
Converter: Float
RTL-SDR Source
Sample Rate (sps): 1.024M
Ch0: Frequency (Hz): 100M
Ch0: Freq. Corr. (ppm): 0
Ch0: DC Offset Mode: Off
Ch0: IQ Balance Mode: Off
Ch0: Gain Mode: Manual
Ch0: RF Gain (dB): 25
Ch0: IF Gain (dB): 20
Ch0: BB Gain (dB): 20
WX GUI FFT Sink
Title: FFT Plot
Sample Rate: 1.024M
Baseband Freq: 100M
Y per Div: 10 dB
Y Divs: 10
Ref Level (dB): 0
Ref Scale (p2p): 2
FFT Size: 1.024k
Refresh Rate: 15
Freq Set Varname: None
Top Block
Frekans: 100M
FFT Plot
FFT
Power (dB)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
99.5
99.6
99.7
99.8
99.9
100
100.1
100.2
100.3
100.4
100.5
Frequency (MHz)
Trace Options
Peak Hold
Average
Avg Alpha: 0.1333
Persistence
Persist Alpha: 0.1873
Trace A
Store
Trace B
Store
Axis Options
dB/Div:
Ref Level:
Autoscale
Stop



Komplex Çıktı Görünümü

RTLSDR'ye bağlantı

```
use Radio::RTLSDR;

my $freq = shift || 104.5;
$freq *= 1_000_000;

my $rf_sample_rate = 2_000_000;

my $radio = Radio::RTLSDR->new(freq => $freq,
                               sample_rate => $rf_sample_rate);
```

Ses Kartına Bağlantı

```
open(my $audio_sink,
     '|-:raw',
     "play -t raw -r $audio_sample_rate -e float -b 32 -c 1 -");
```

Sinyal Gelince

```
$radio->rx(sub {
  # process raw radio samples in $_[0]
  # this callback will be called several times per second...
});

$radio->run; # enter event loop
```

Veri İşleme

```
use PDL;

my $data = pdl()->convert(byte)->reshape(length($_[0]));

${ $data->get_dataref } = $_[0];
$data->upd_data();

$data = $data->convert(float);

$data -= 128;
$data *= 1000000;

my $I = $data->slice([0,-1,2]);
my $Q = $data->slice([1,-1,2]);
```

RF Filtreler

```
## Decimate 4:1, 2000k -> 500k

$I = PDL::DSP::Fir::Simple::filter($I, { fc => 0.12, N => 81, });
$Q = PDL::DSP::Fir::Simple::filter($Q, { fc => 0.12, N => 81, });

$I = $I->slice([0,-1,4]);
$Q = $Q->slice([0,-1,4]);
```

FM Demodüle İşlemi

```
use PDL::Complex;

my $prev = $I->slice([0, -2]) + (i * $Q->slice([0, -2]));
my $curr = $I->slice([1, -1]) + (i * $Q->slice([1, -1]));

my $deriv = ($prev->Cconj() * $curr)->Carg();

## FIXME: retain previous values:
$deriv = $deriv->append($deriv->at(-1));
```

Sese de filtre uygulayalım

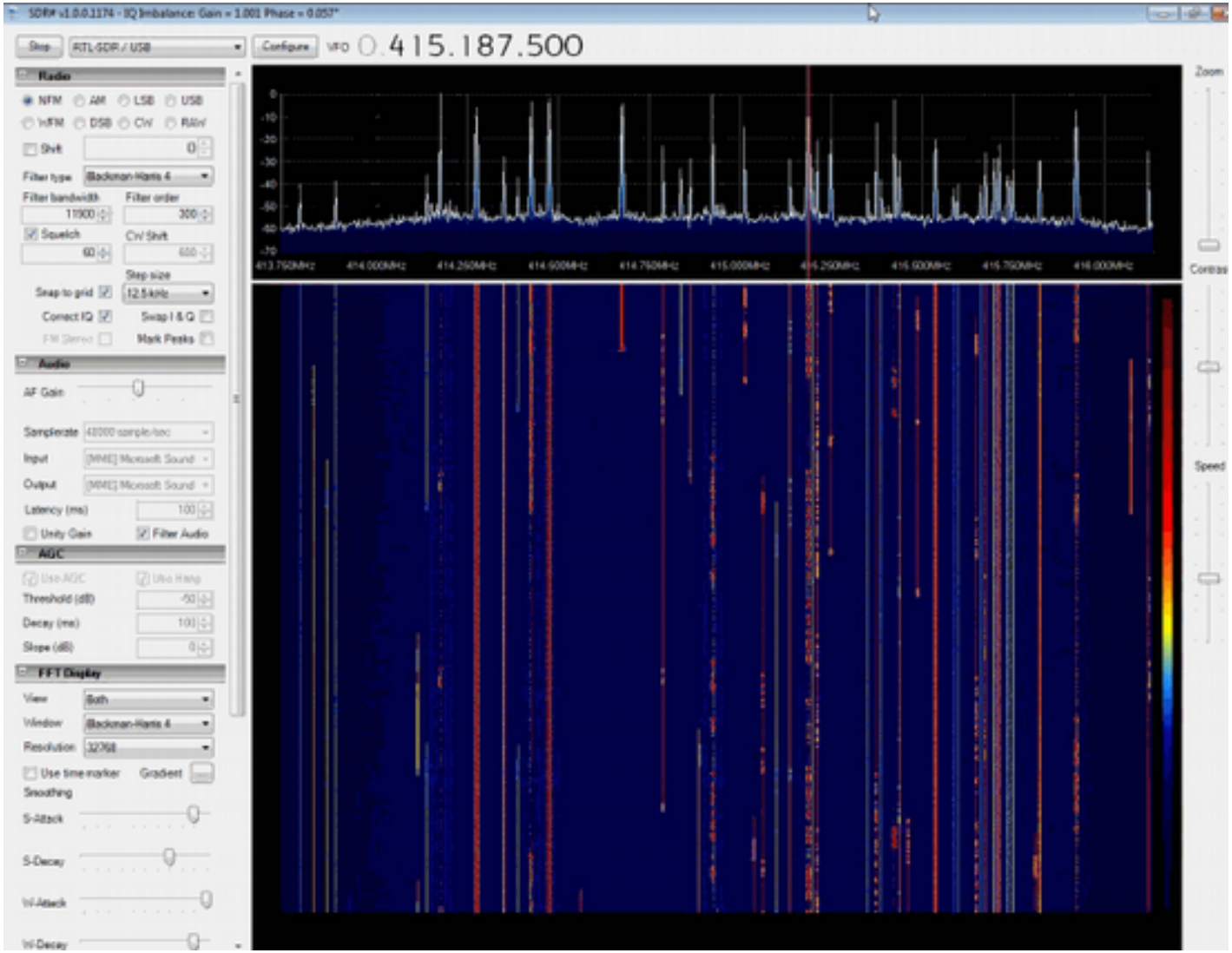
```
my $audio =
  PDL::DSP::Fir::Simple::filter($deriv, { fc => 0.4, N => 32 });

$audio = $audio->slice([0,-1,10]);
```

DİNLEYELİM…….

```
print $audio_sink ${ $audio->convert(float)->get_dataref };
```

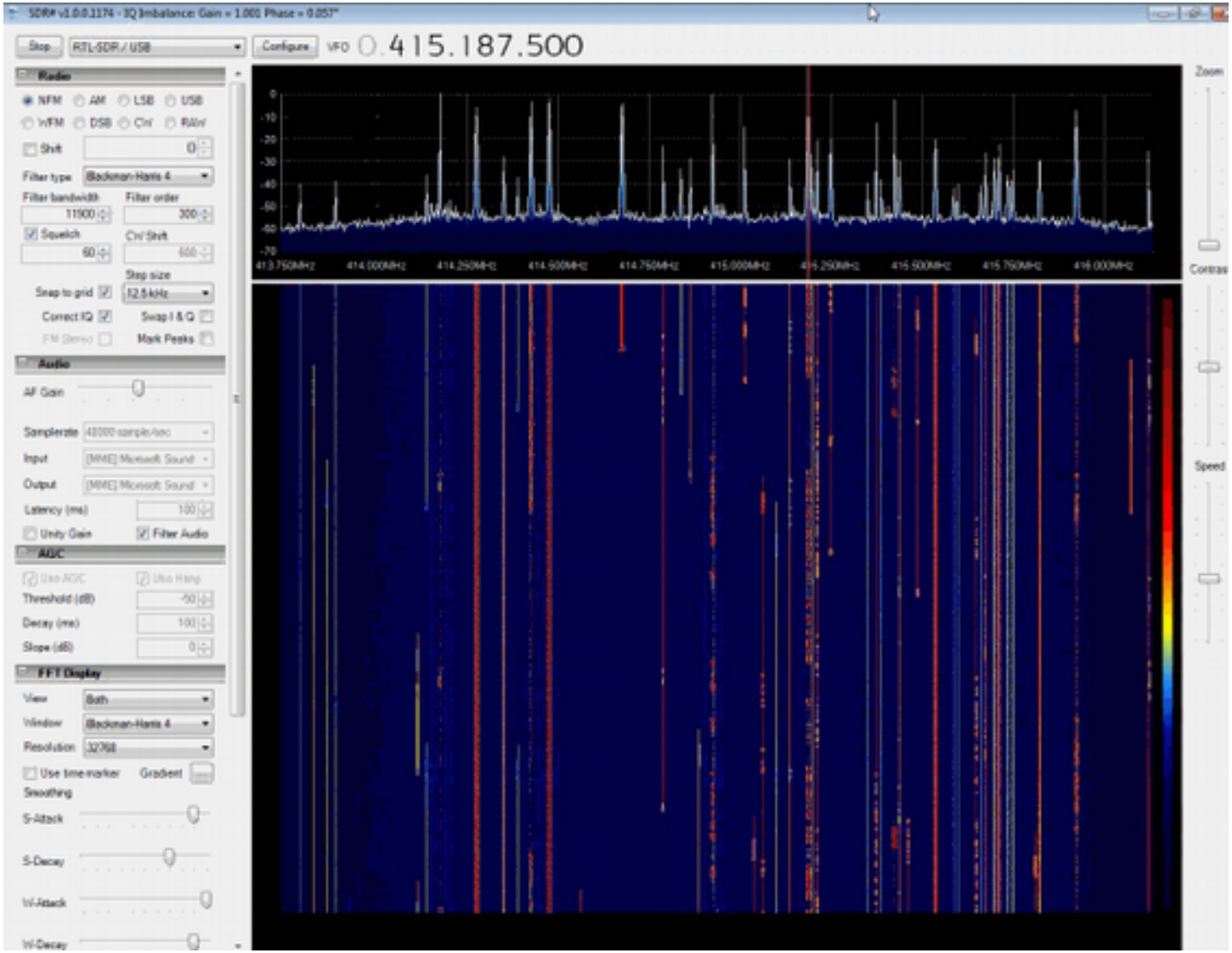
Örnek SDR Yazılımlar

SDR# (Windows) (Free)

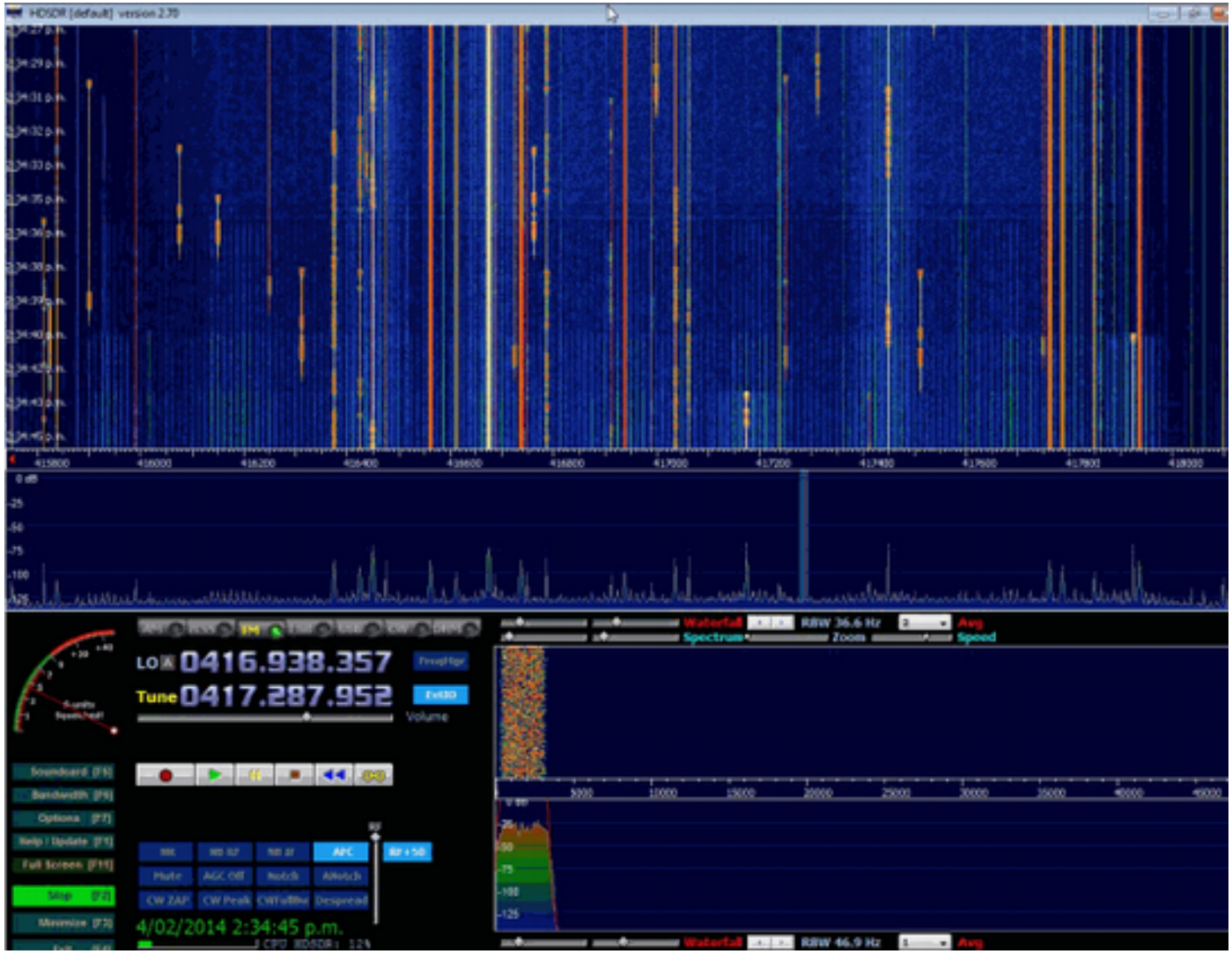


Örnek SDR Yazılımlar

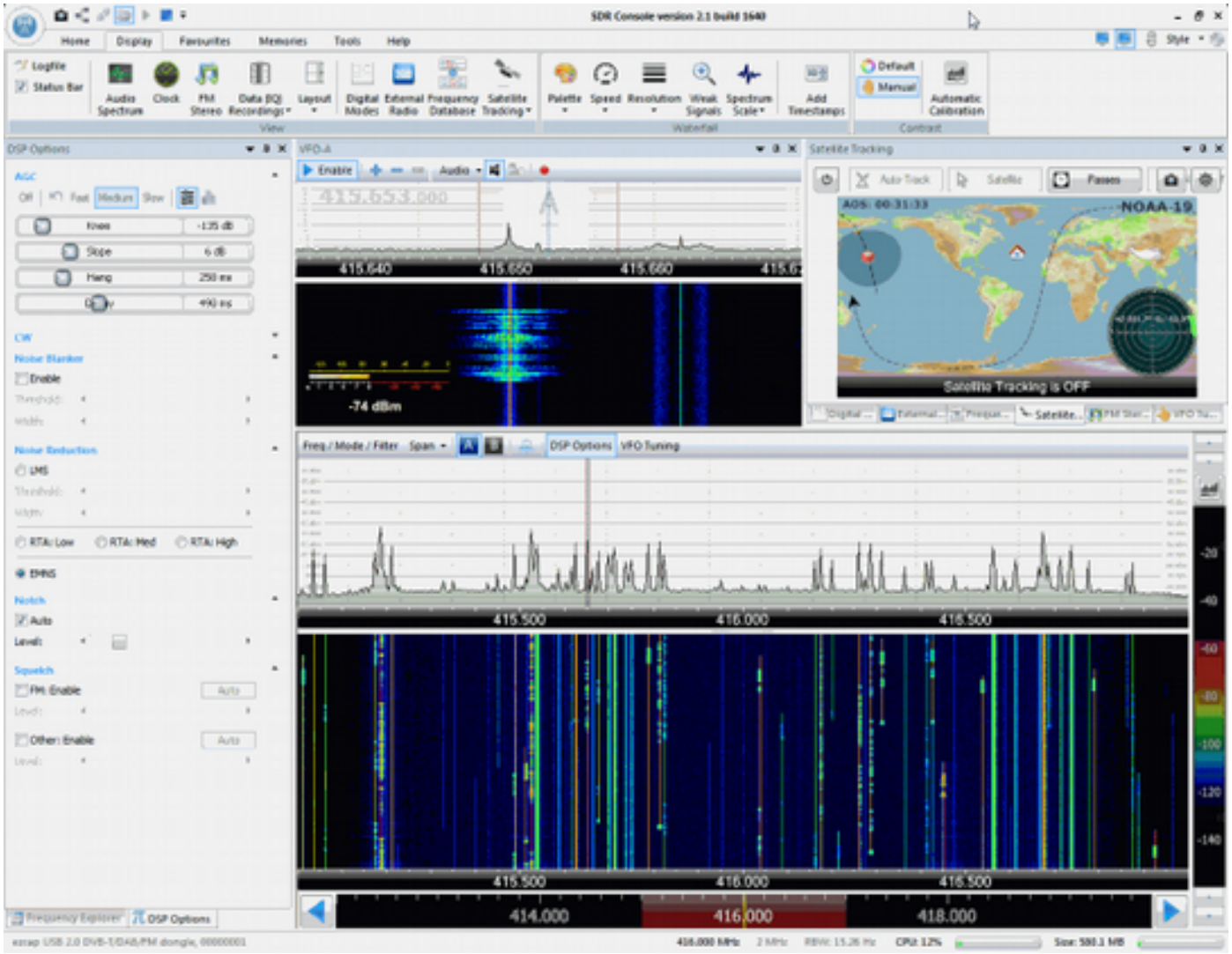
SDR# (Windows) (Free)



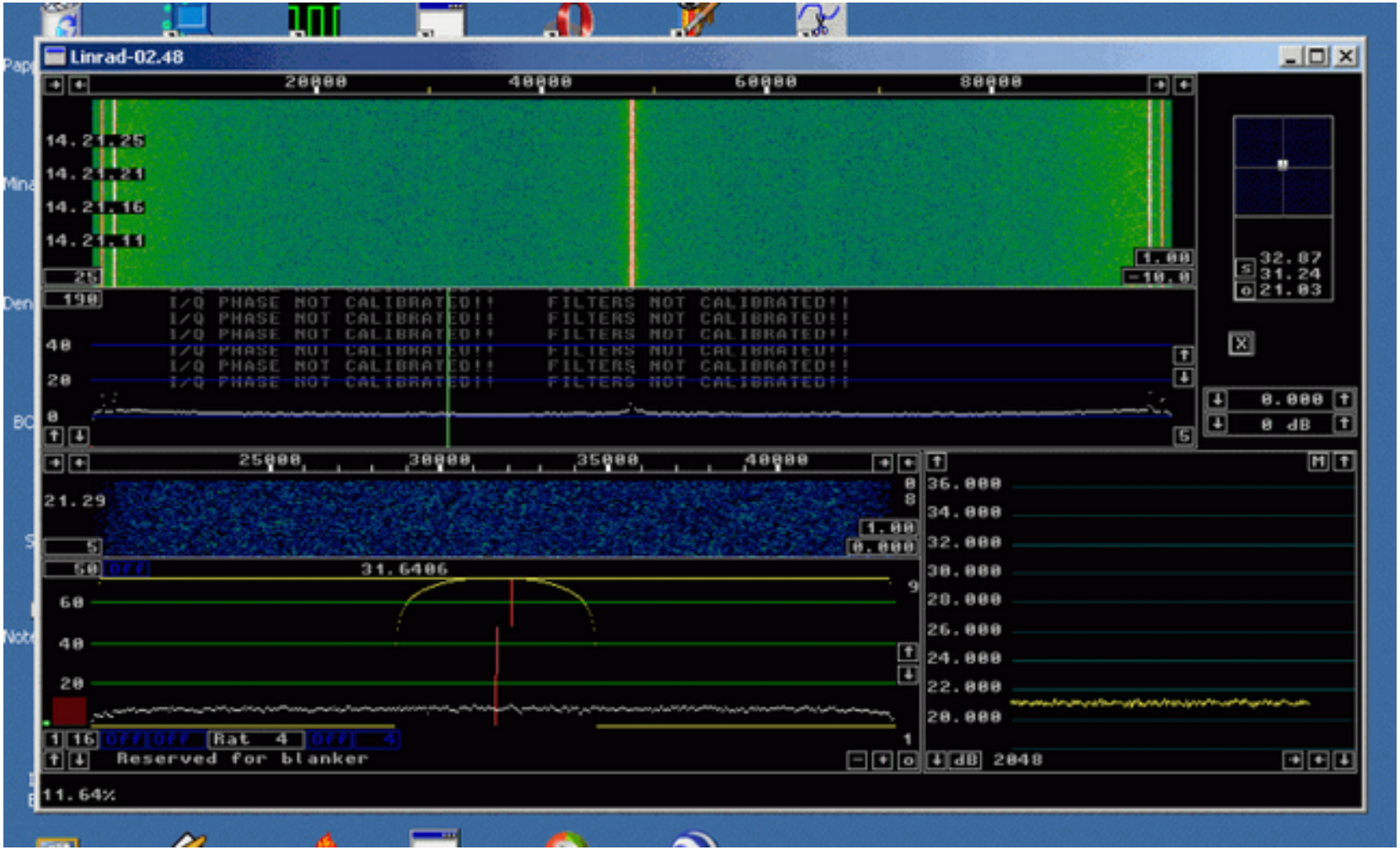
HDSDR (Windows) (Free)



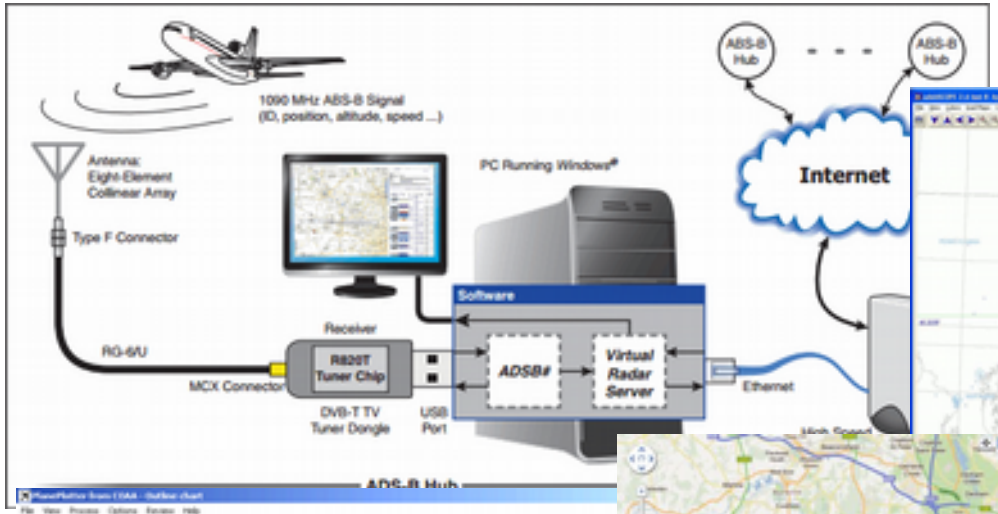
SDR-RADIO.COM V2 (Windows) (Free)

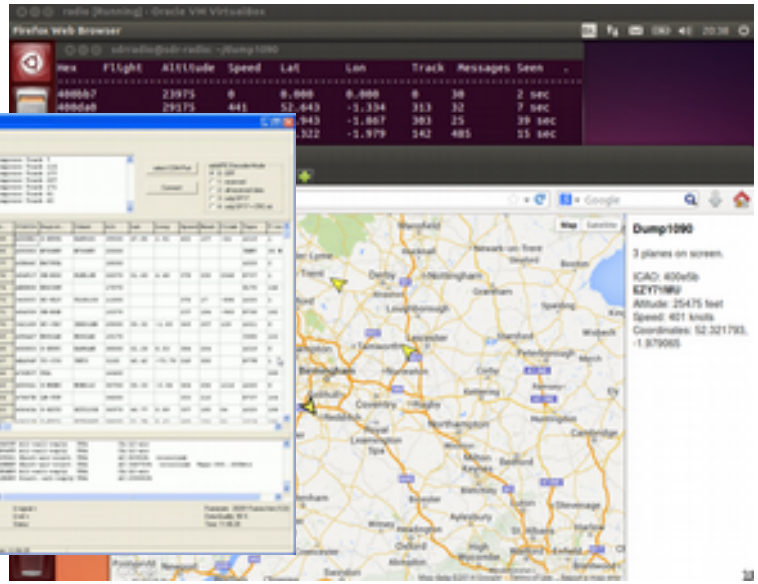


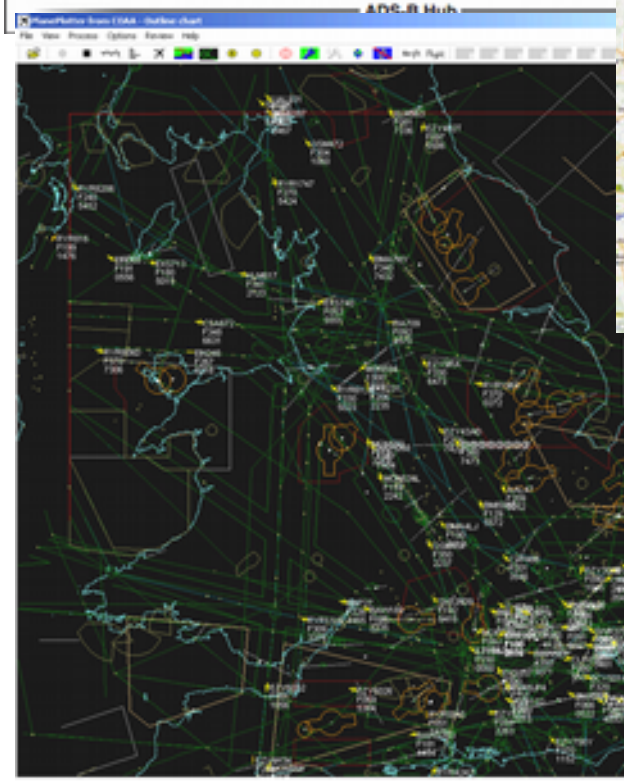
Linrad (Windows/Linux/Mac) (Free) (Related Post)

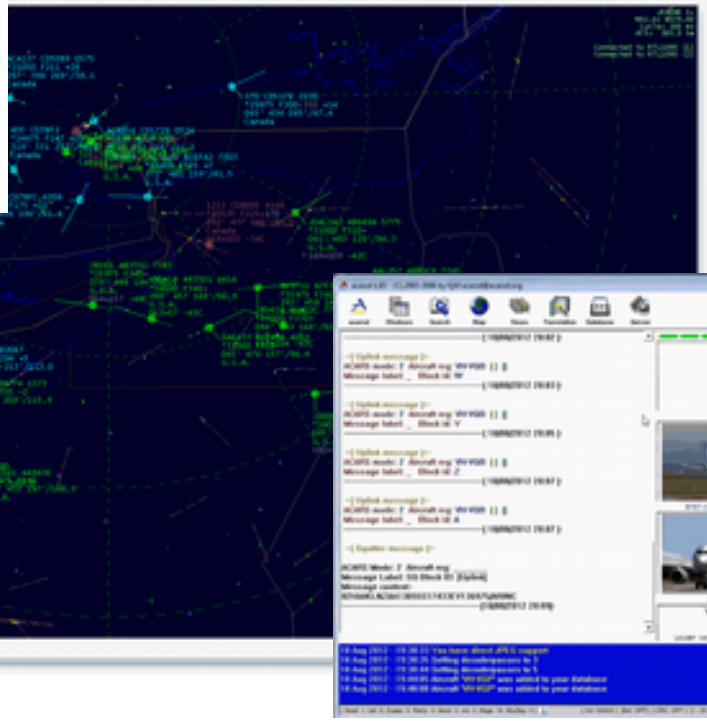


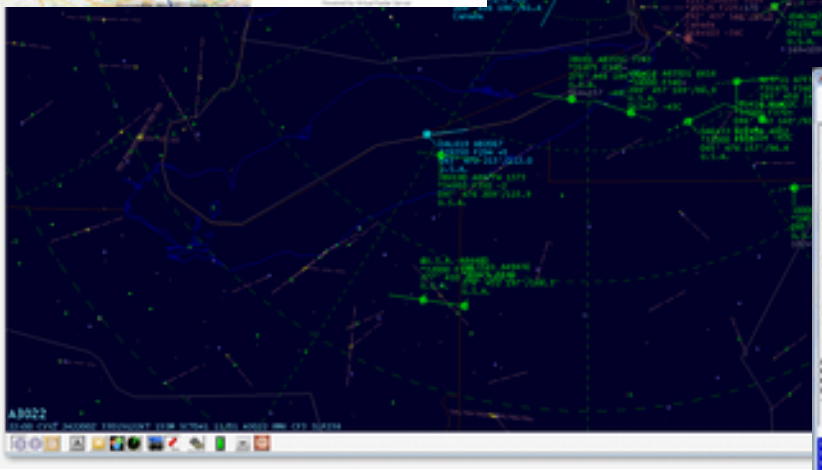
Uygulamalar

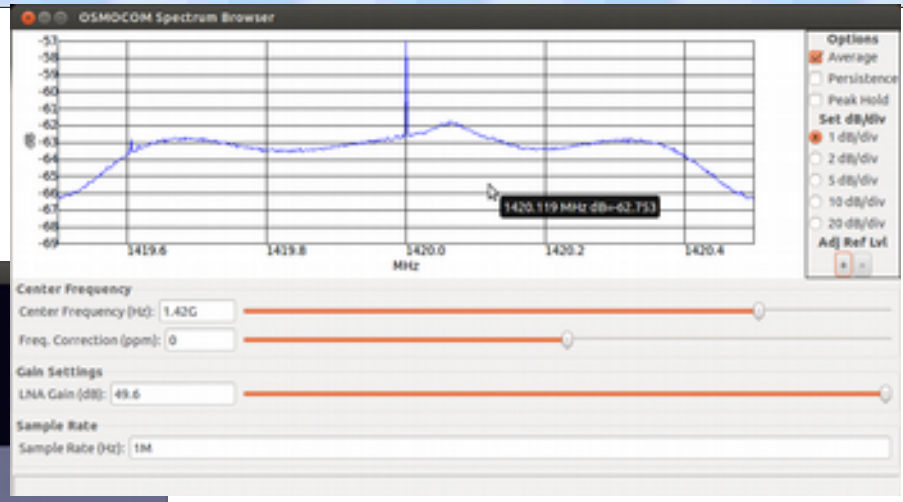


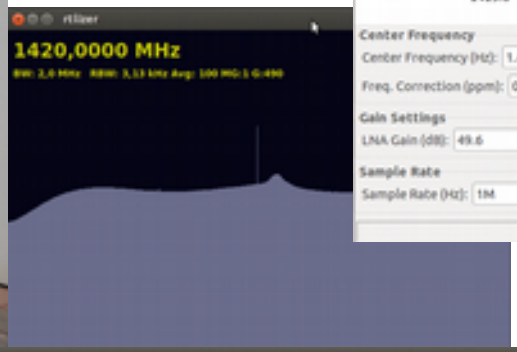


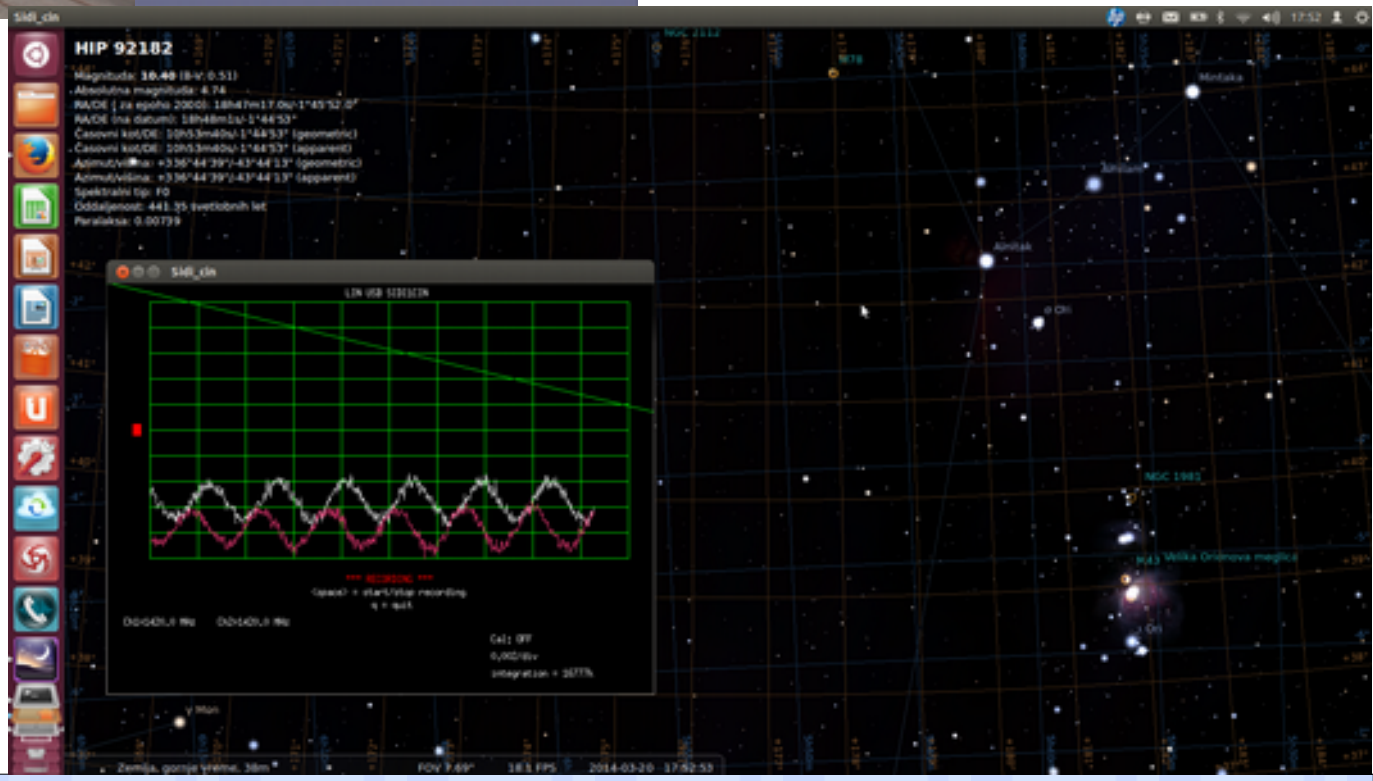






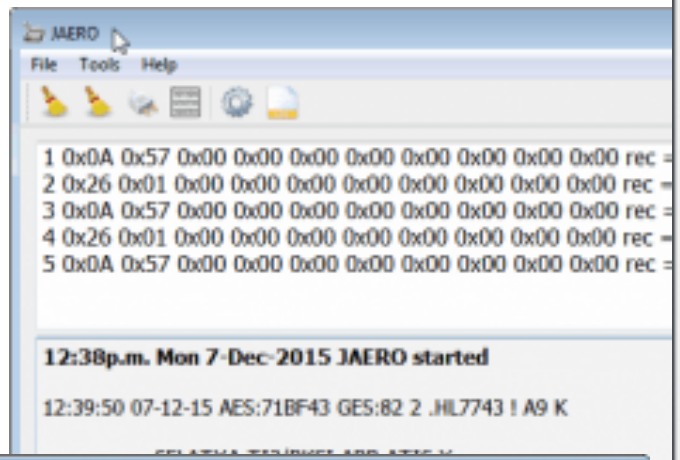


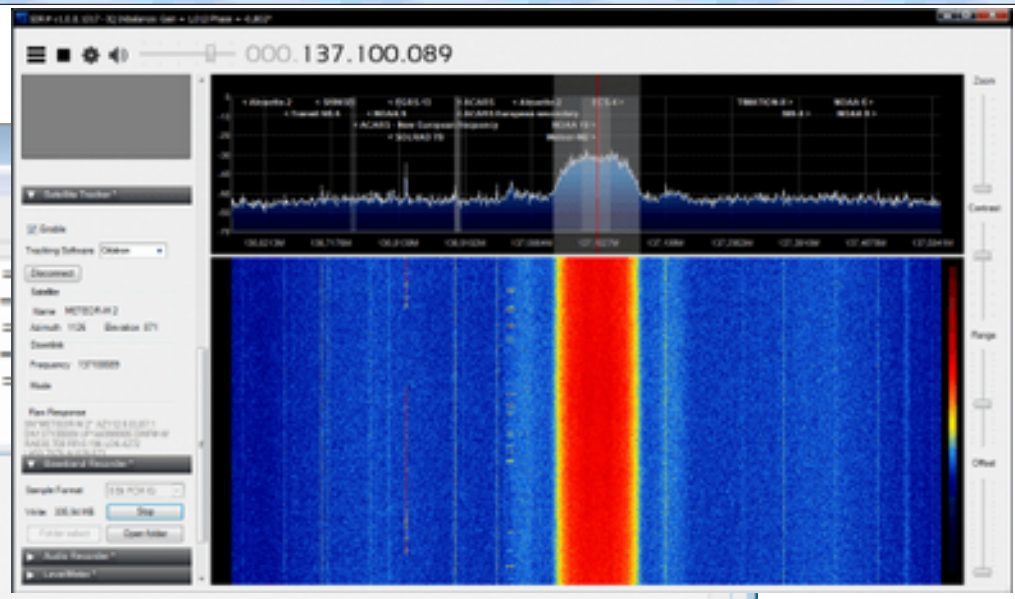


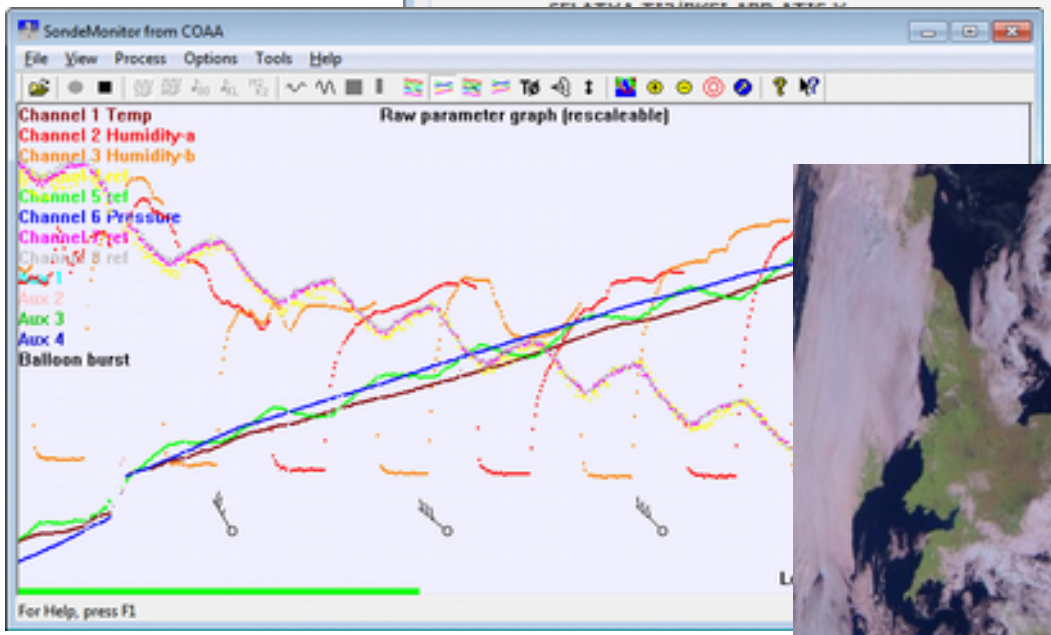


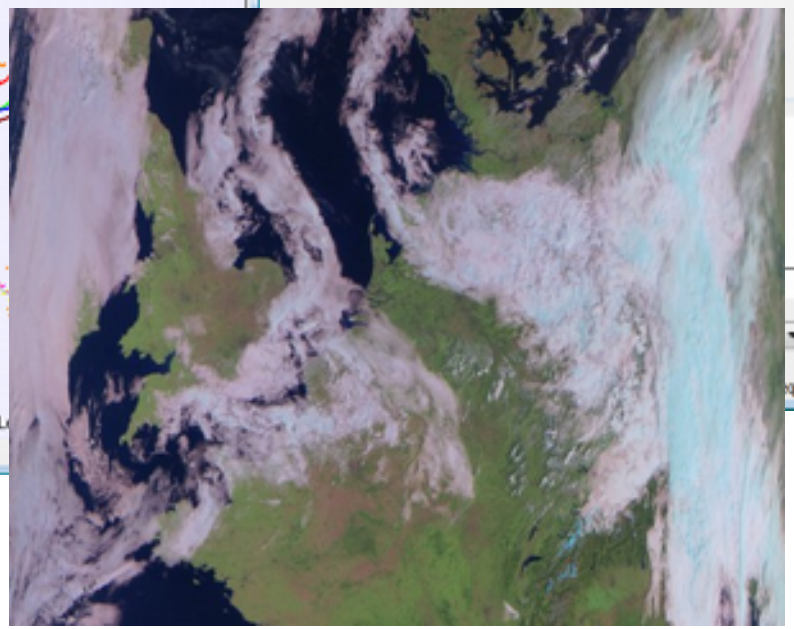
1420Mhz Hydrogen Line

JAERO (Windows) (Free)



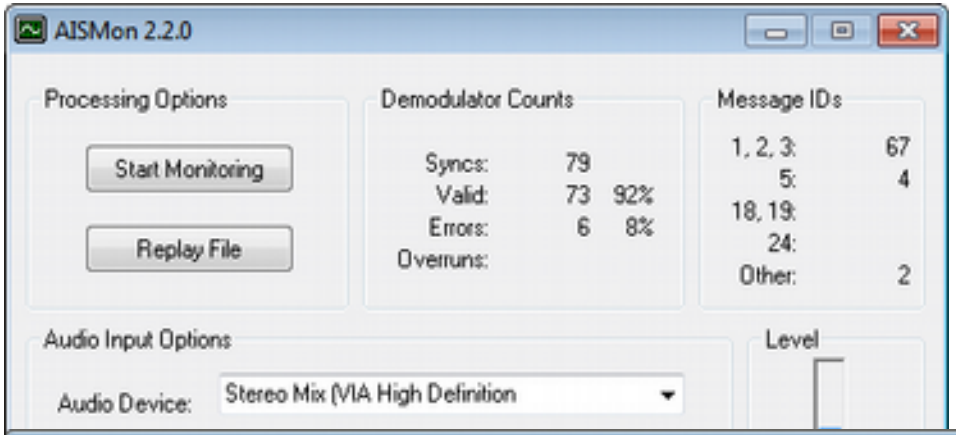




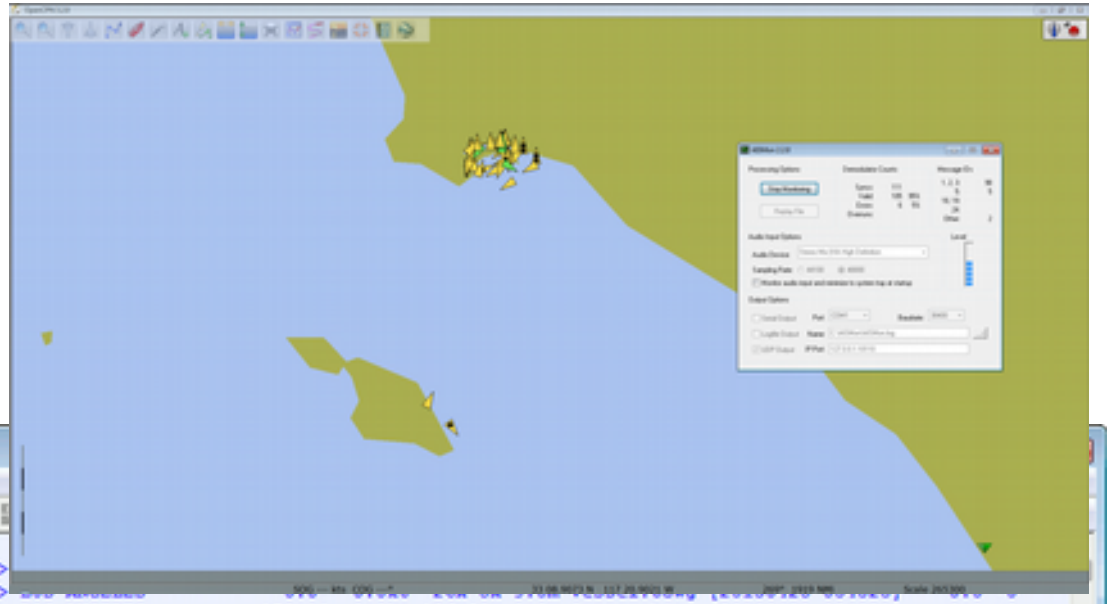


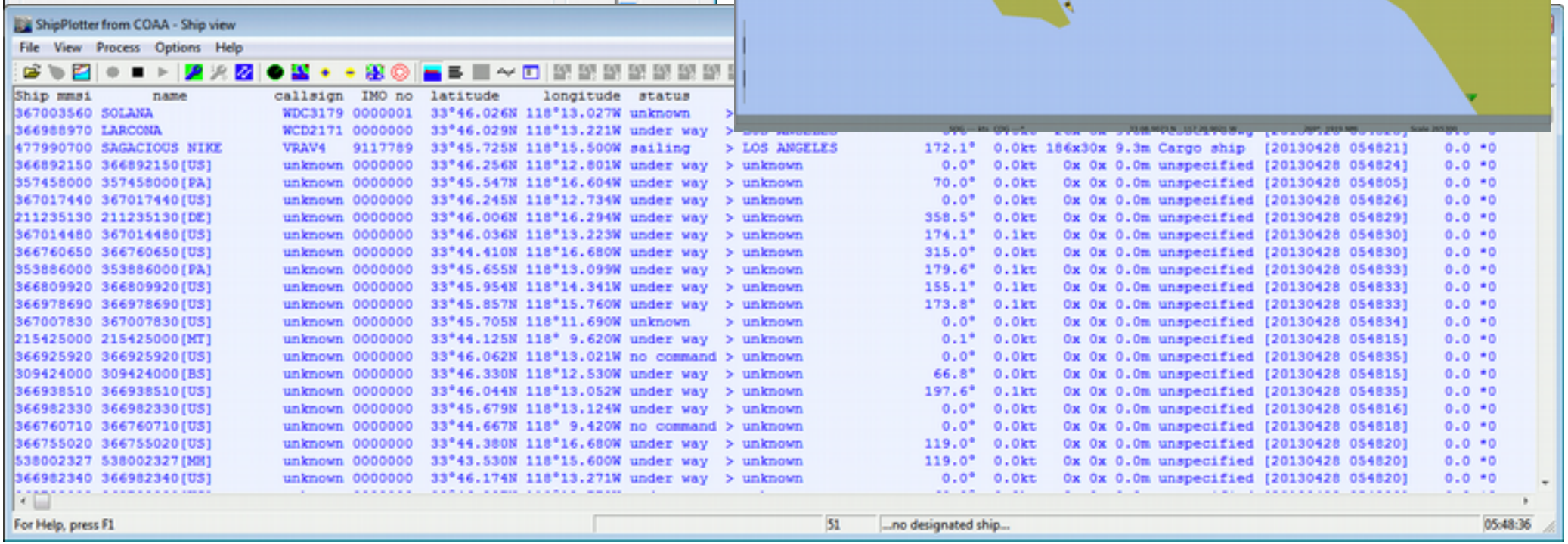
INMARSAT

AISMon (Windows) (Free) (**Related Post**) – AIS

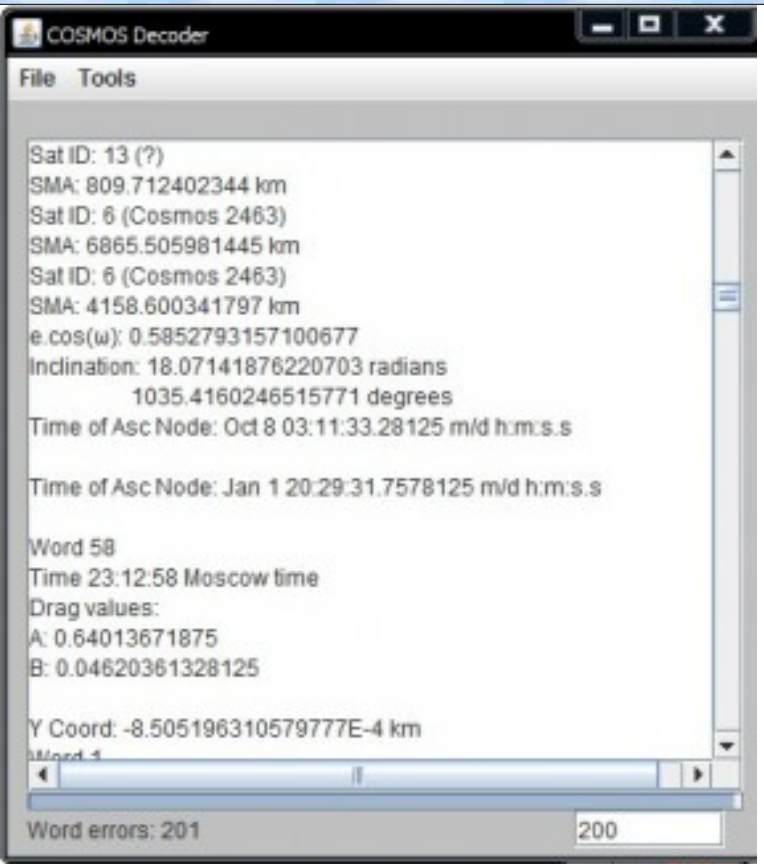


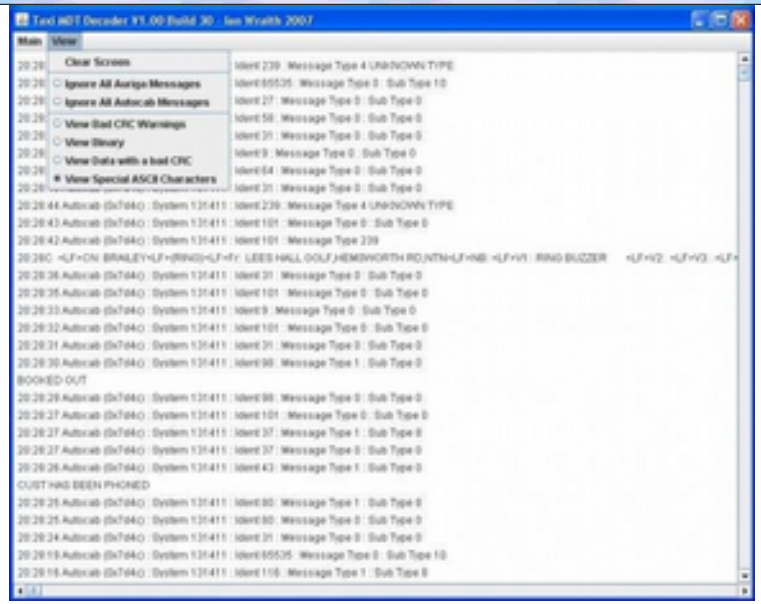
OpenCPN (Windows) (Free) (**Related Post**) – AIS

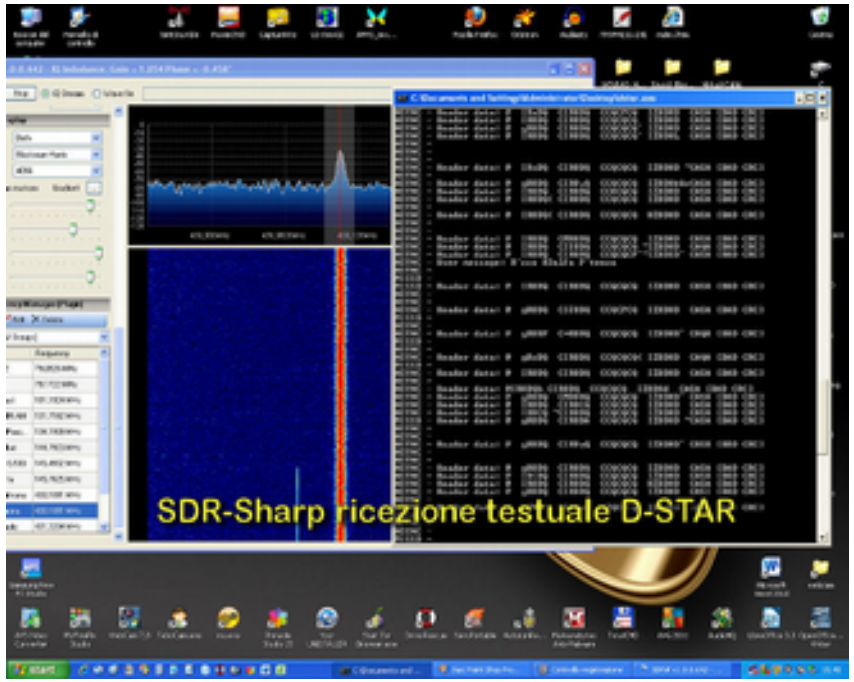


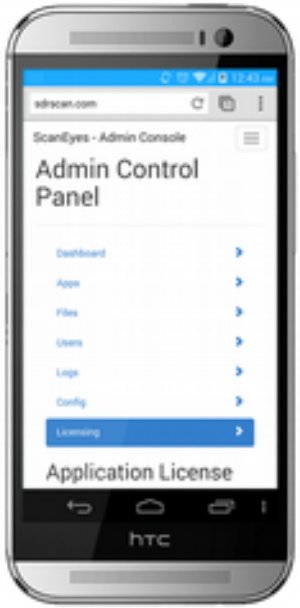


ShipPlotter (Windows) (Trial/Paid) (**Related Post**) AIS



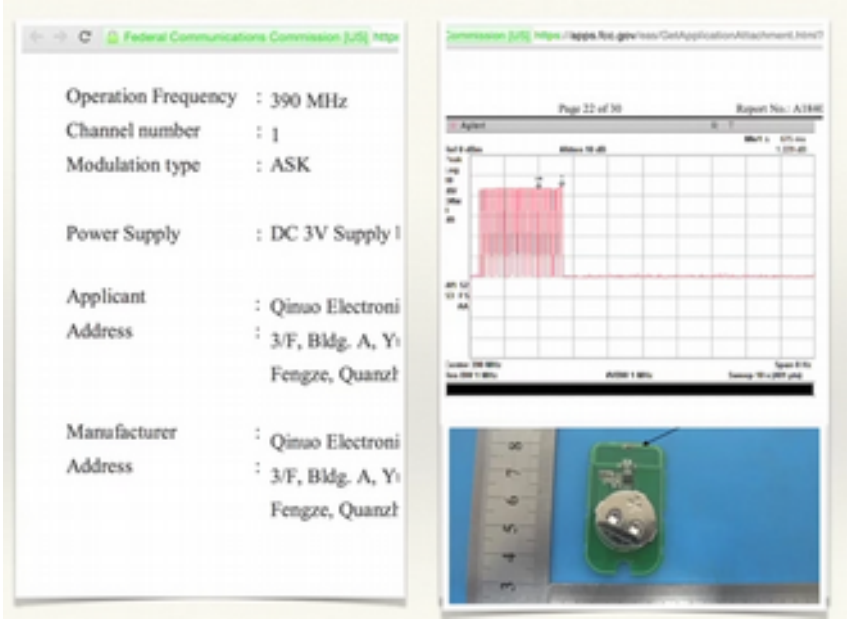


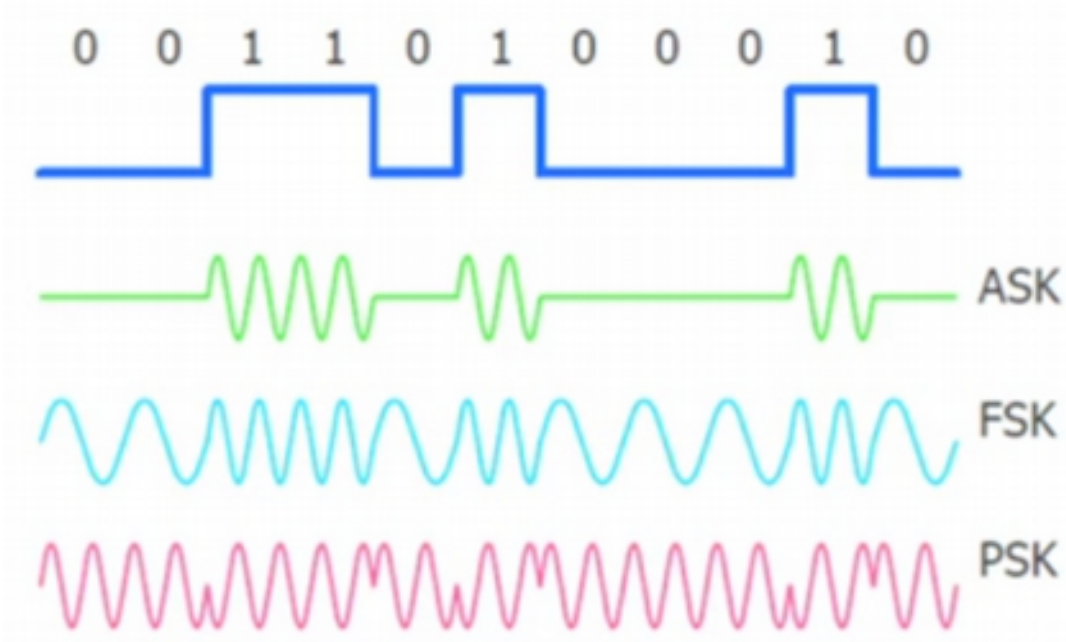


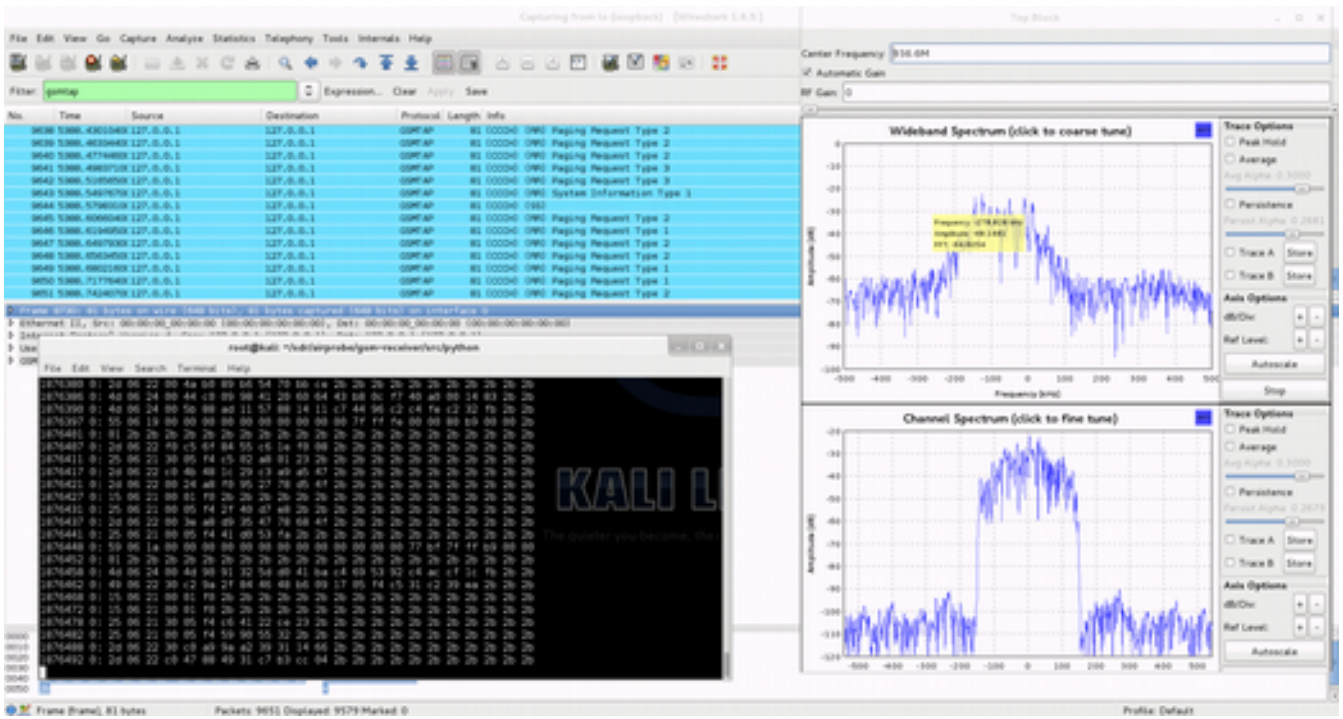


Digital Radio


Part: NSCD-390GIV4
FCC ID: QVQ-QNRS283
Complies with FCC
Rules Part 15
Frequency: 315/390

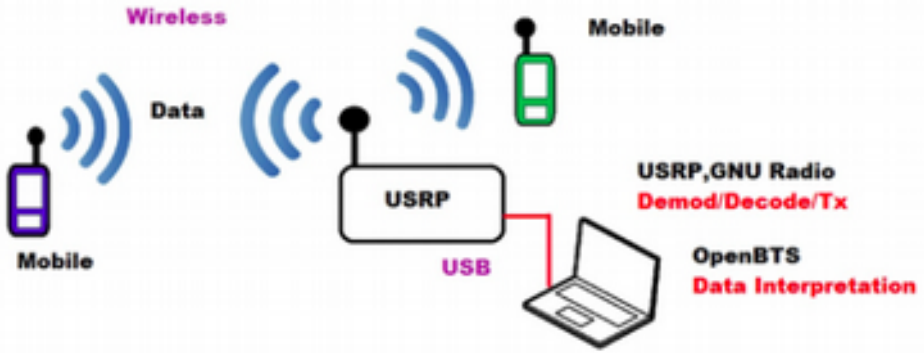

Operation Frequency : 390 MHz
Channel number : 1
Modulation type : ASK
Power Supply : DC 3V Supply
Applicant : Qinuo Electroni
Address : 3/F, Bldg. A, Y
Fengze, Quanz
Manufacturer : Qinuo Electroni
Address : 3/F, Bldg. A, Y
Fengze, Quanz


0 0 1 1 0 1 0 0 0 1 0
ASK
FSK
PSK

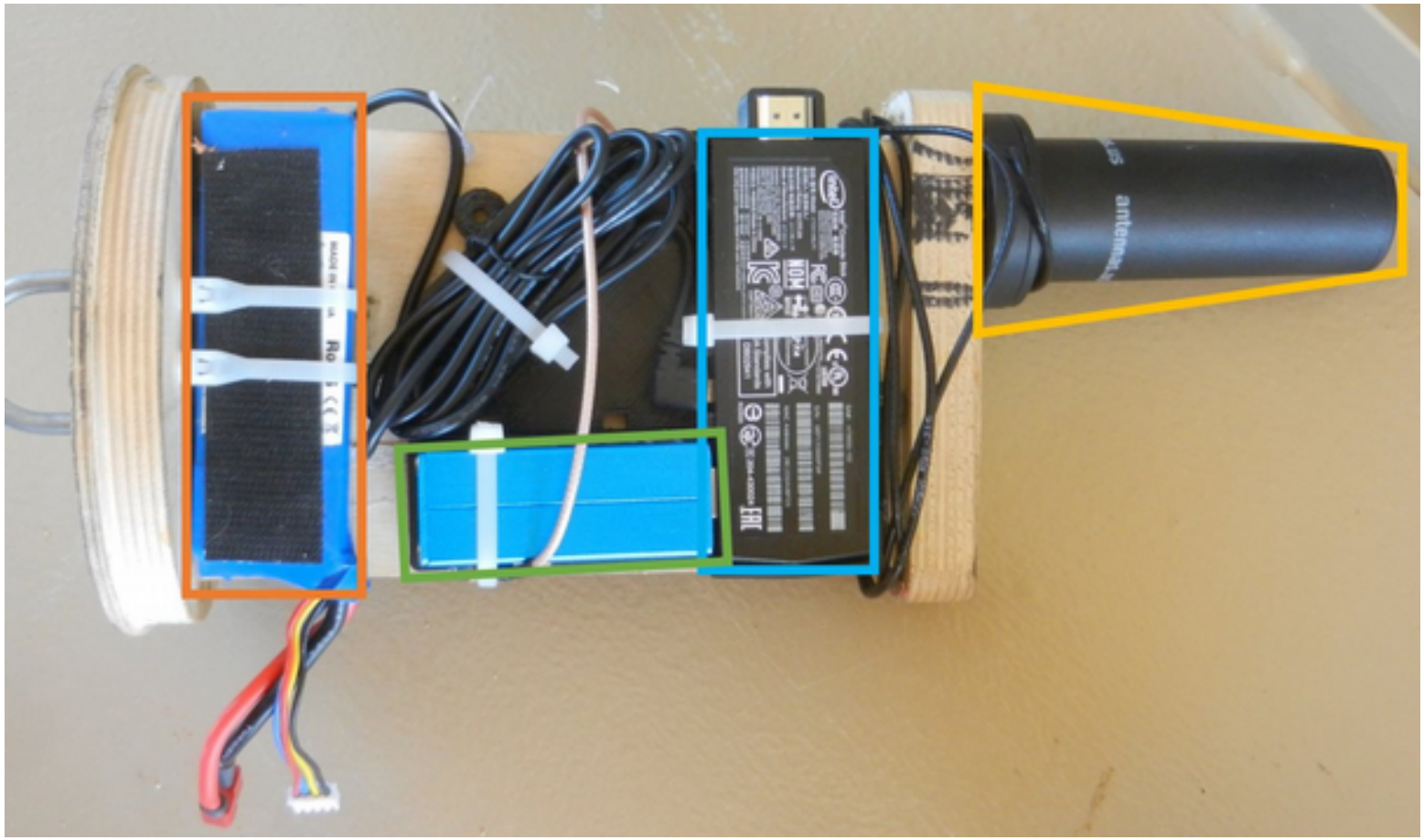

Wideband Spectrum (click to coarse tune)
Channel Spectrum (click to fine tune)
KALI L


DVB-T+DAB+FM


oPEN


Wireless
Data
Mobile
Mobile
USRP
USB
USRP,GNU Radio
Demod/Decode/Tx
OpenBTS
Data Interpretation

GSM



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