Yazılım Tabanlı Radyo
- GİRİŞ -

Barış DİNÇ
TA7W / OH2UDS
Dünyadaki Mars Projesi / Mars on Earth Project
http://www.marsonearthproject.org

Gündem

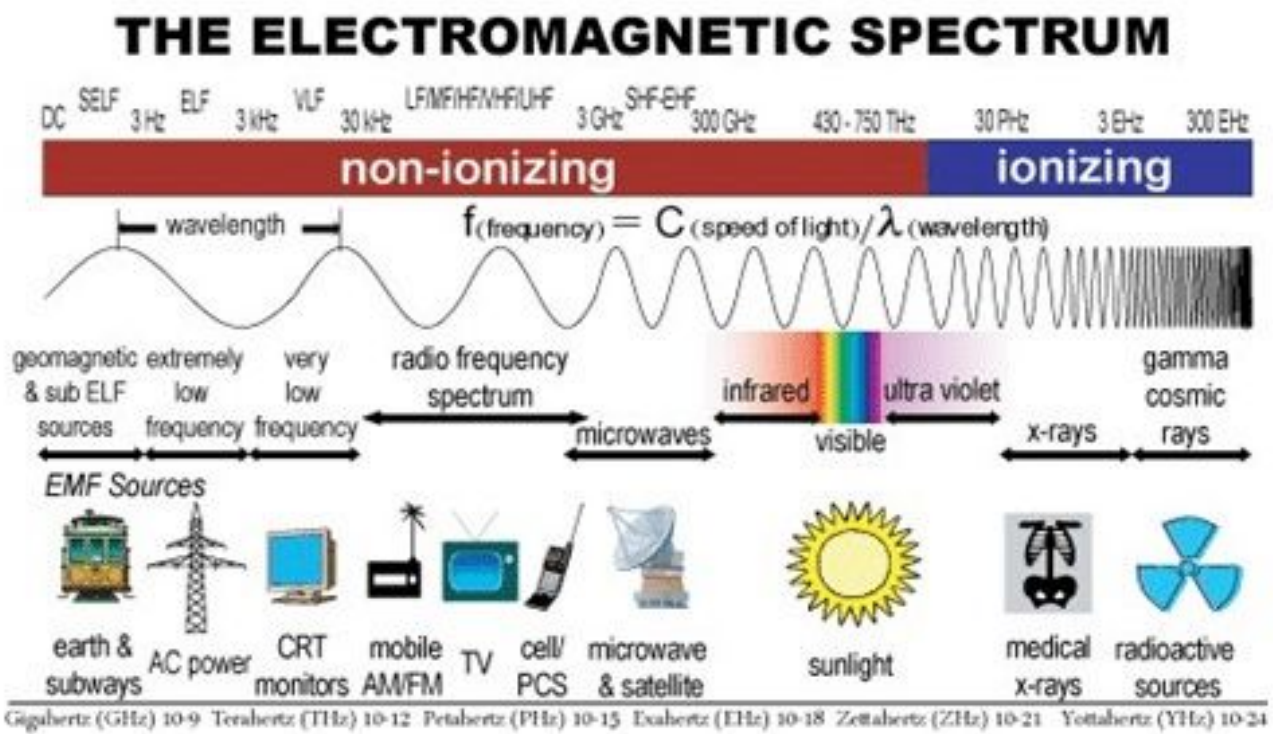
GİRİŞ

- Tanıtım
- Radyo Nedir ?
- Komplex Sayıların Dünyası
- Yazılım Tabanlı Radyo (SDR) Nedir ?
- Örnek SDR Donanımları
- Örnek SDR Yazılımları
- SDR Proje Örnekleri

Devamı

- uSDX'e yakından bakış
  - Donanım
  - Yazılım
- mcHF'e yakından bakış
  - Donanım
  - Yazılım
- GNURADIO ile SDR
  - Giriş
  - Konvansiyonel (AM,FM, SSB, CW)
  - Sayısal Haberleşme (FSK, ASK, GFSK, GMSK)
- Python ile SDR

Elektromanyetik Spektrum



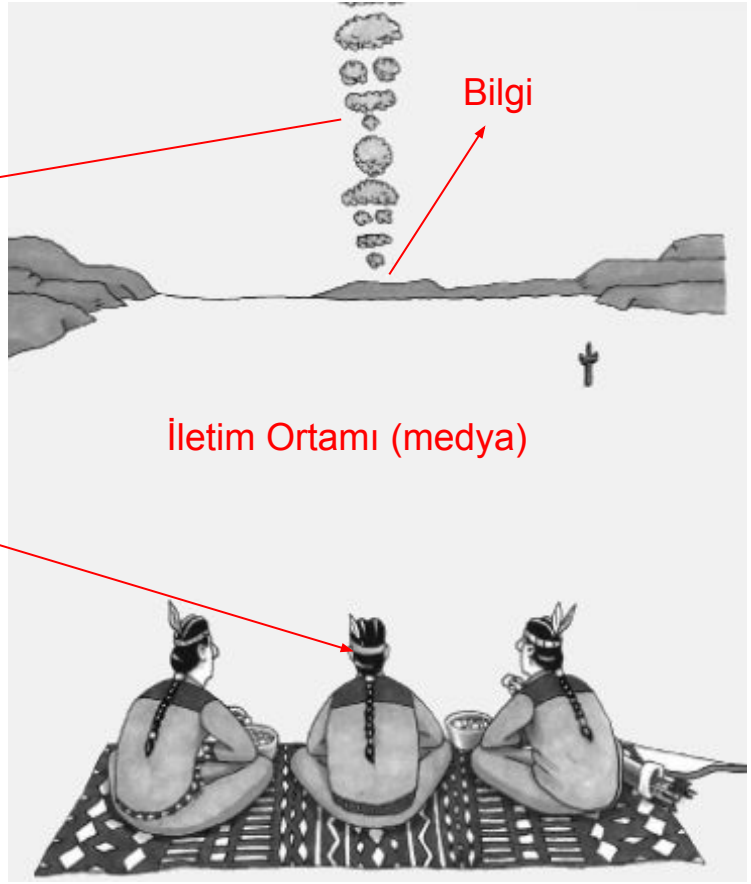
TANITIM

1974/Trabzon
Elektronik Mühendisliği
Astronomi ve Uzay Bilimleri
TA7W / OH2UDS (1990)
Uzay ve Haberleşme

TAMSAT

HABERLEŞME

Haberleşme



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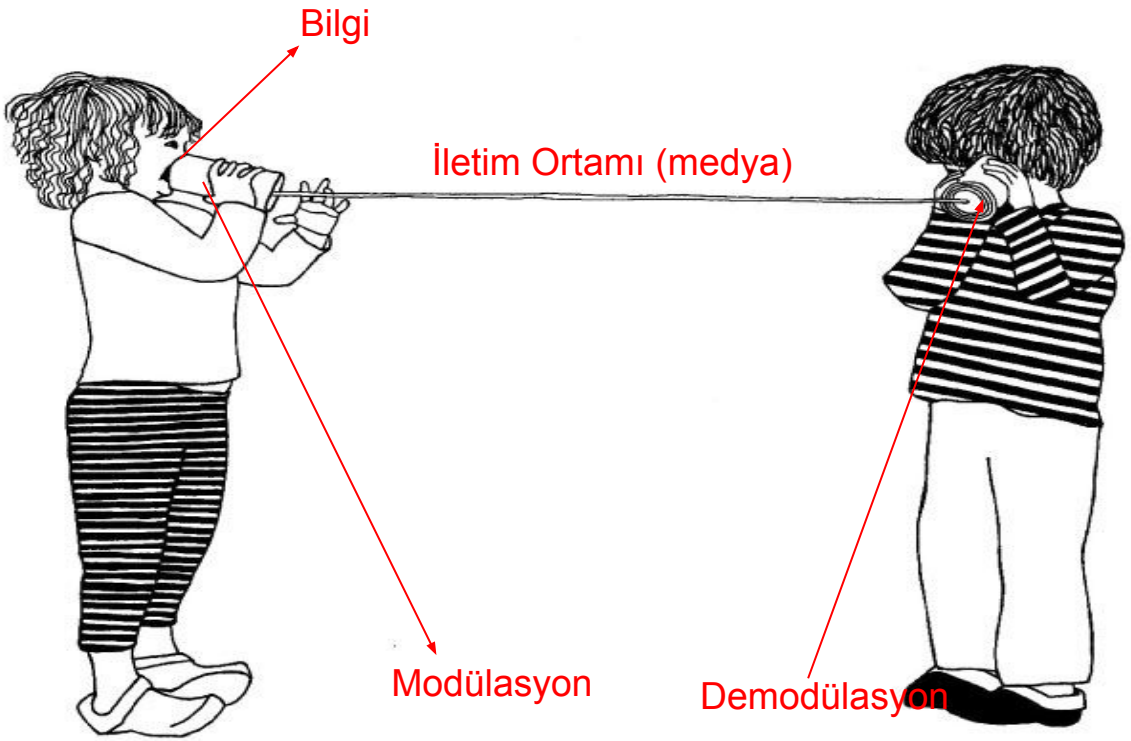
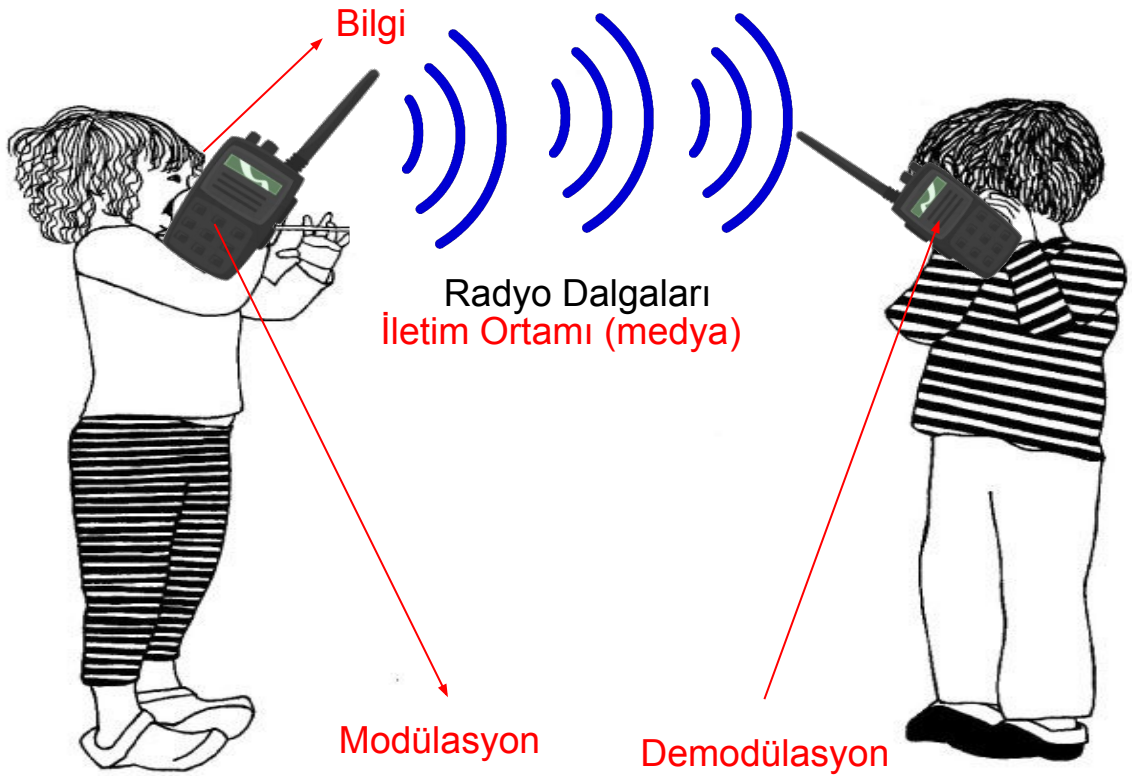
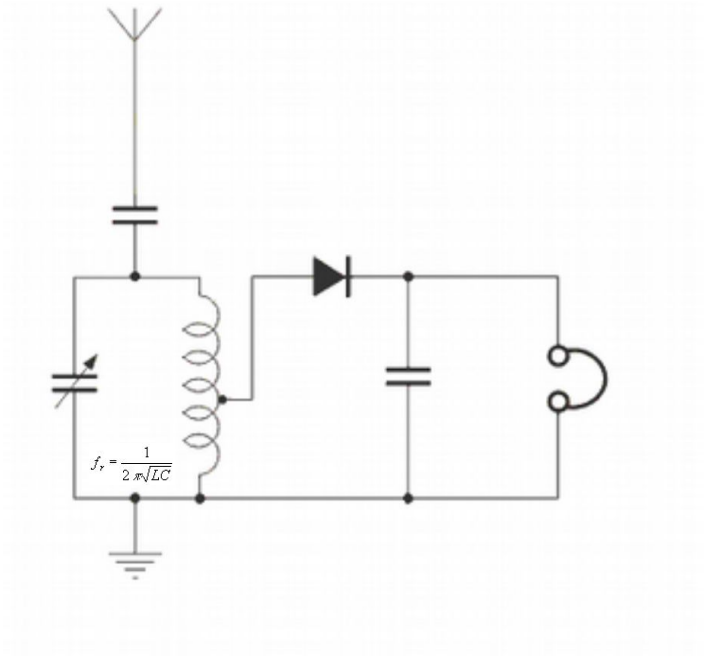


Haberleşme

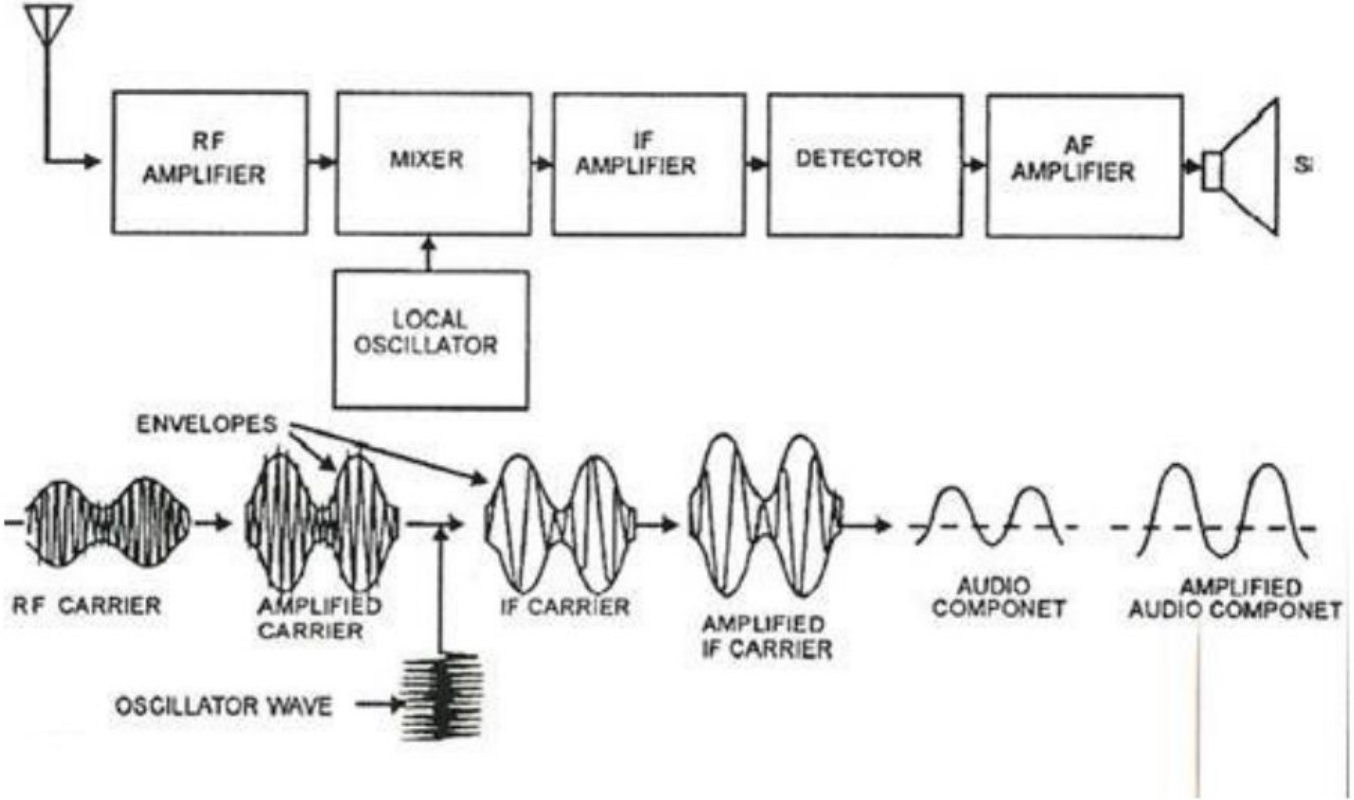

Bilgi
Radyo Dalgaları
İletim Ortamı (medya)
Modülasyon
Demodülasyon

Radyo Nedir ? (1/2)



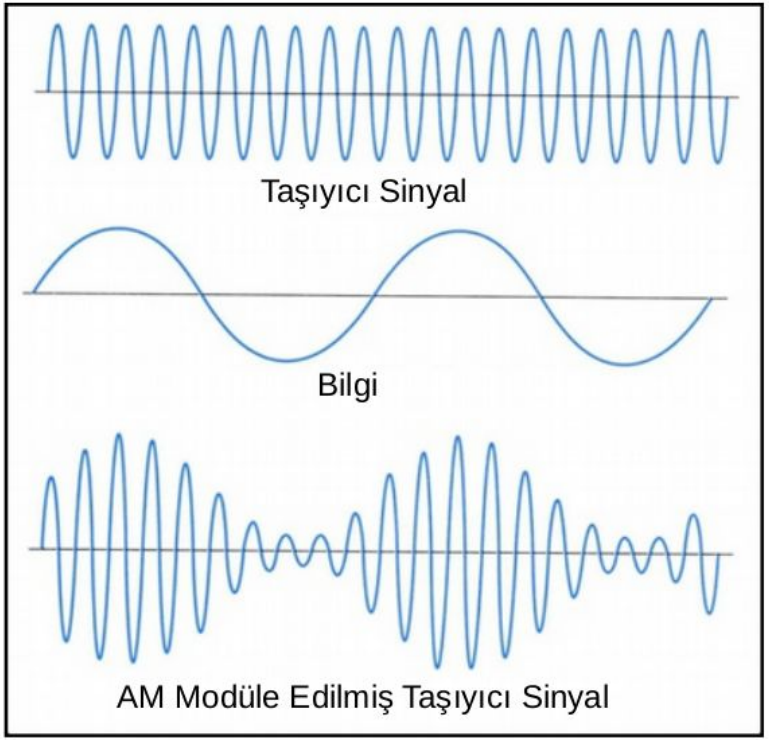
En Basit Radyo Alıcısı

Radyo Nedir ? (2/2)



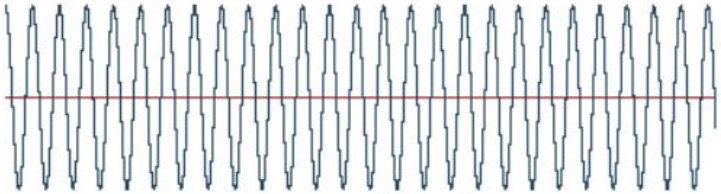
Süperheterodin Radyo Alıcısı

Modülasyon Nedir ? (AM)

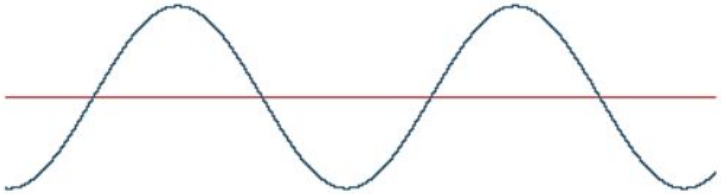


Genlik Modülasyonu (AM)

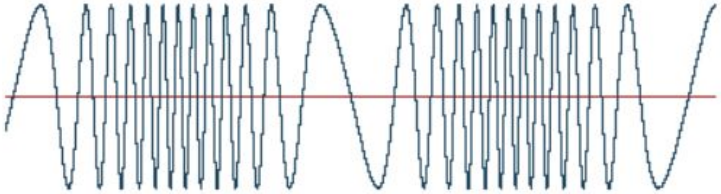
Modülasyon Nedir ? (FM)



Taşıyıcı Sinyal

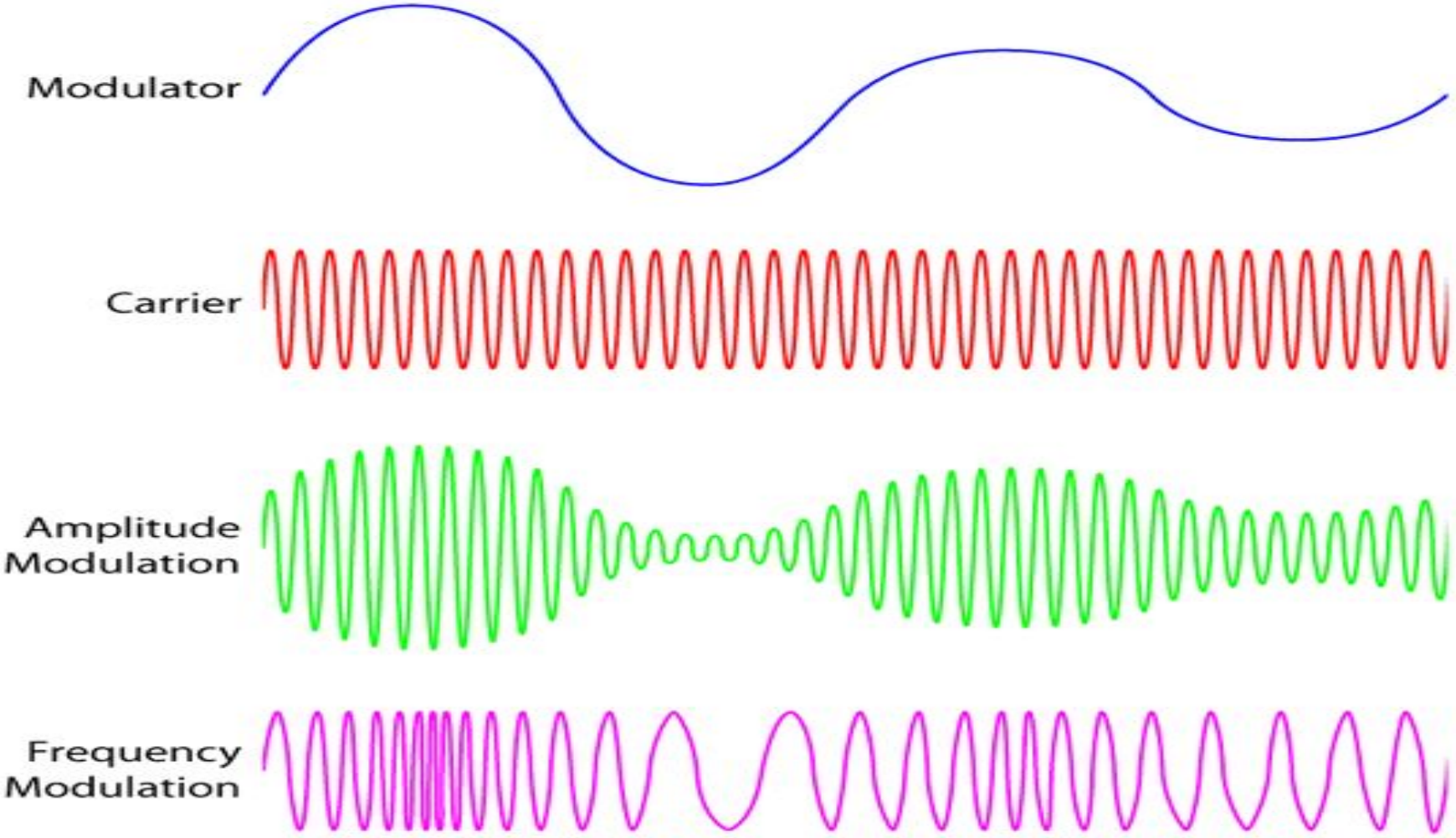


Bilgi

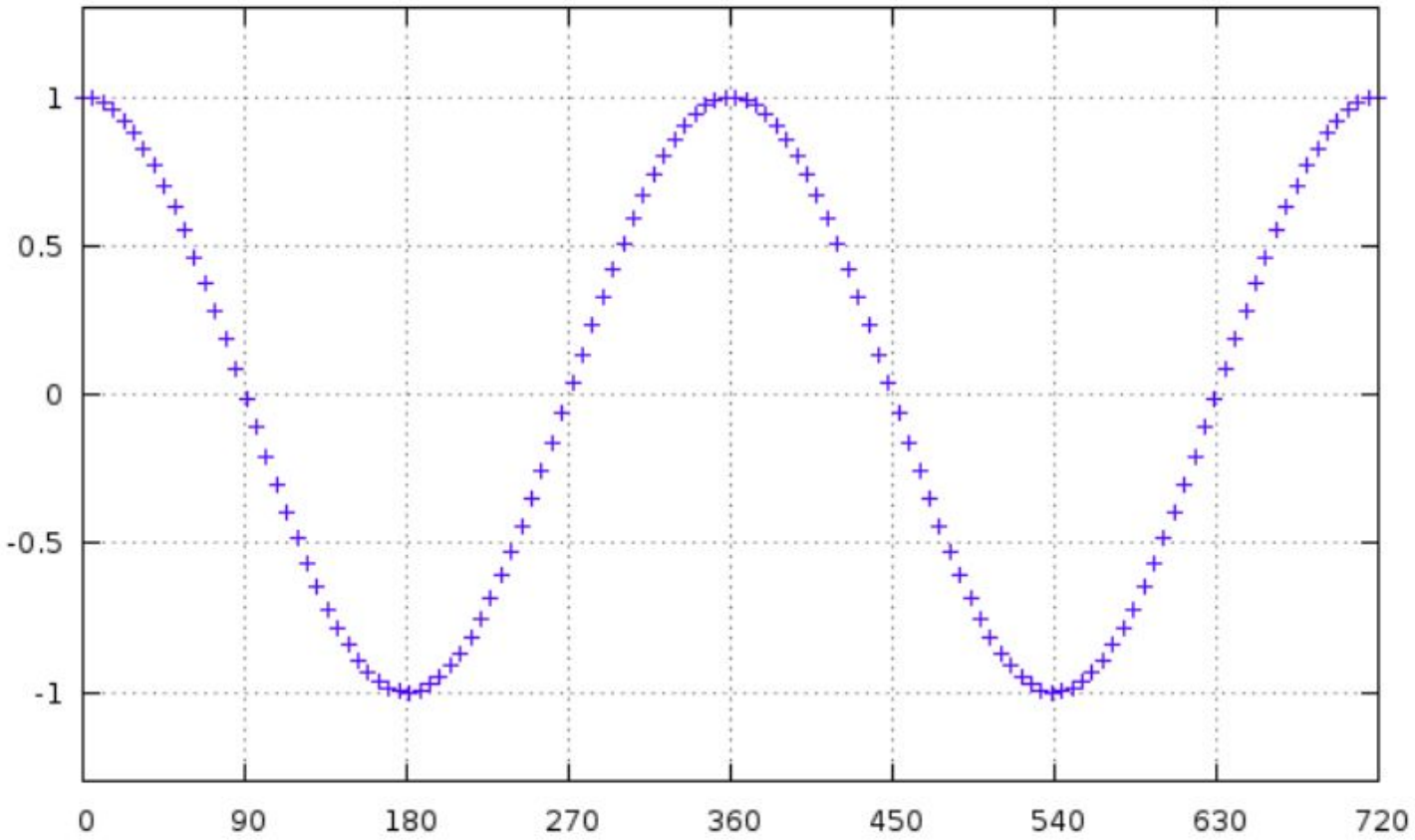


FM Modüle Edilmiş Taşıyıcı Sinyal

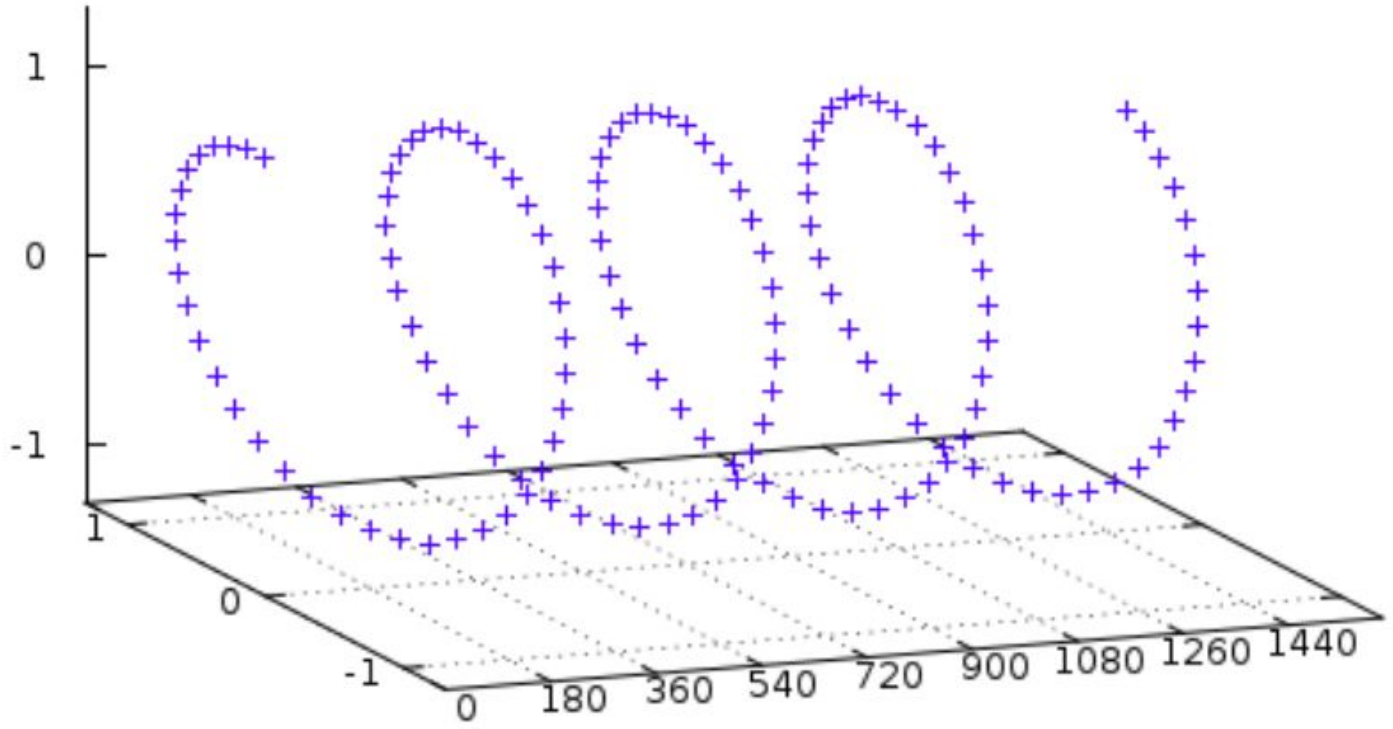
Frekans Modülasyonu (FM)


Modulator
Carrier
Amplitude Modulation
Frequency Modulation

Birazcık MATEMATİK !



Birazcık MATEMATİK !



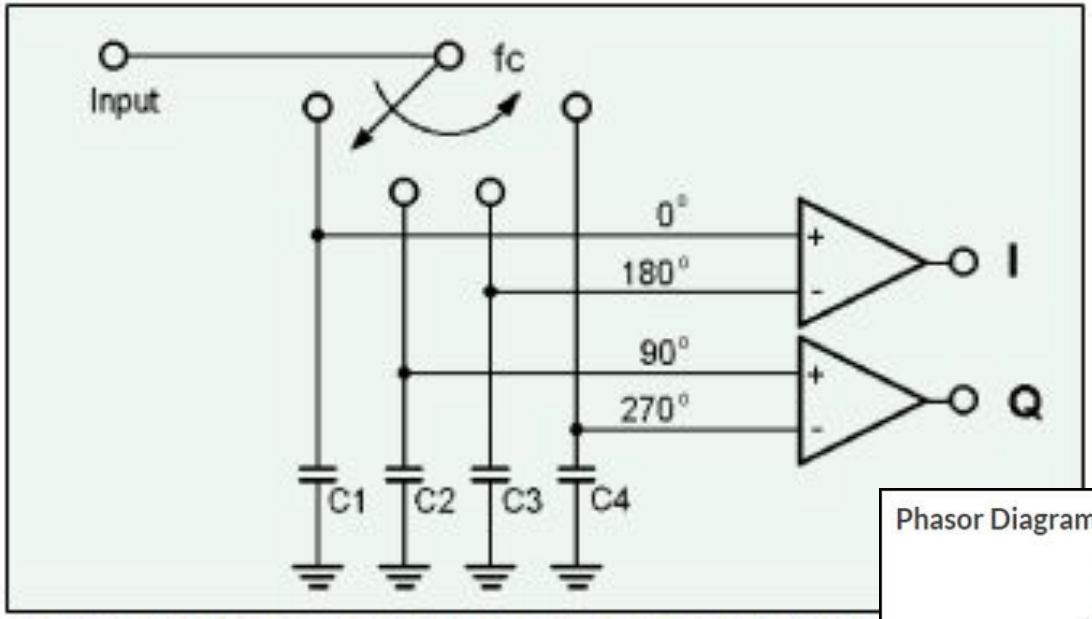
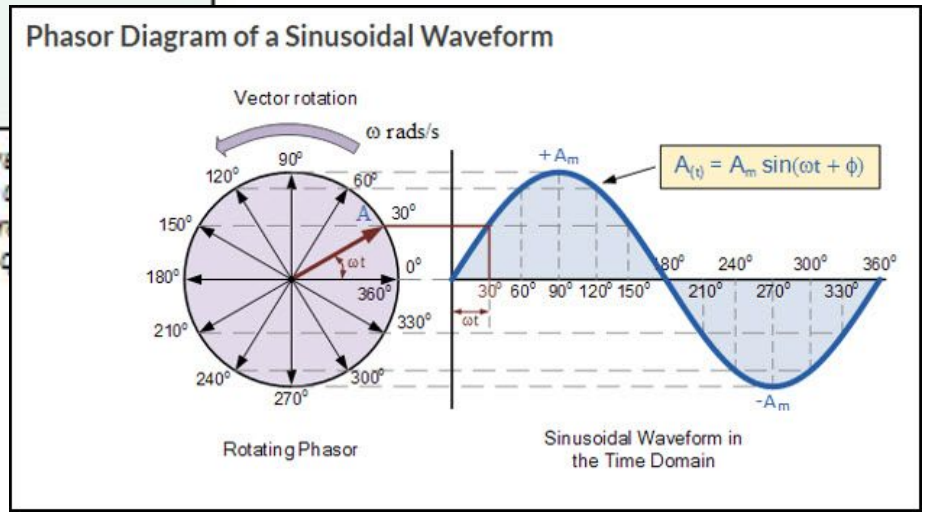
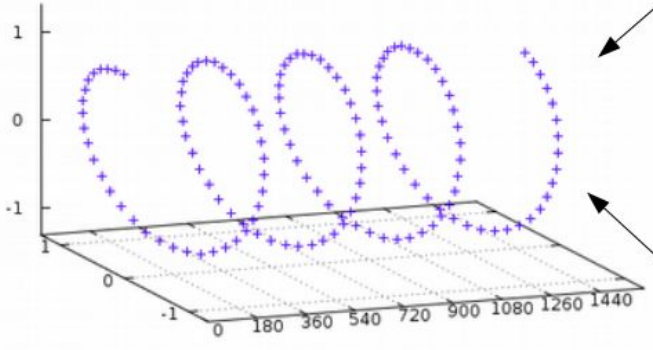


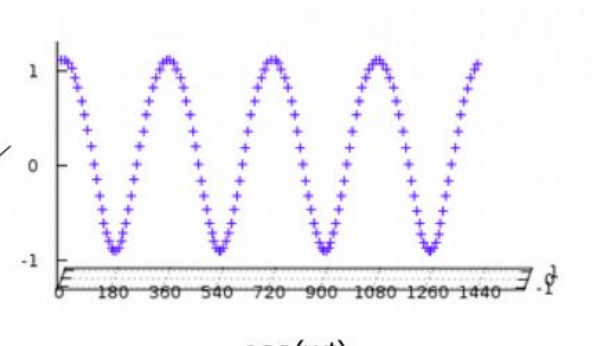
Fig. 2– A quadrature sampling detector is nothing but a four-w switch rotates (moves across all four outputs) at the RF carrier fre capacitors sample the voltage during each quarter waveform, cr phases, which are fed to amplifiers to create the in-phase and q nals, I and Q.



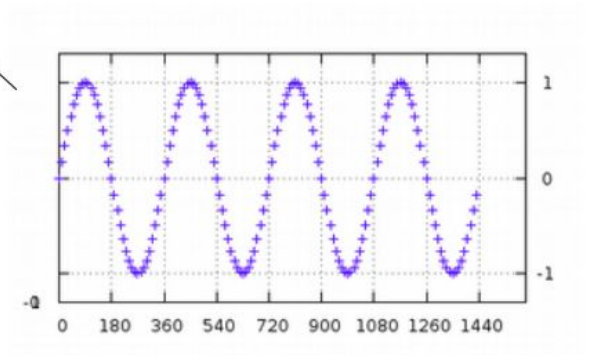
Birazcık MATEMATİK !



cos(wt) + i.sin(wt)

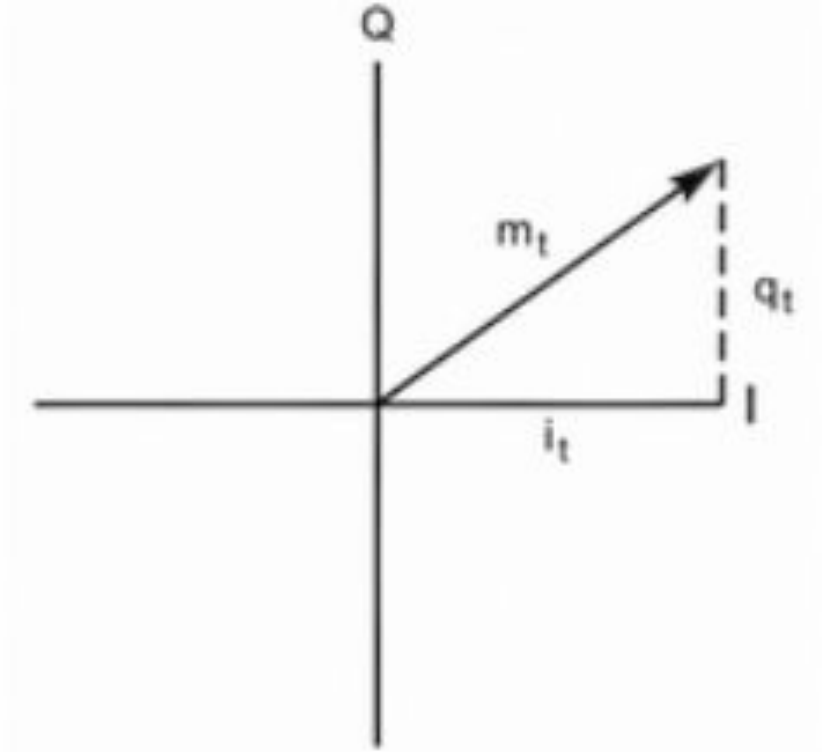


cos(wt)

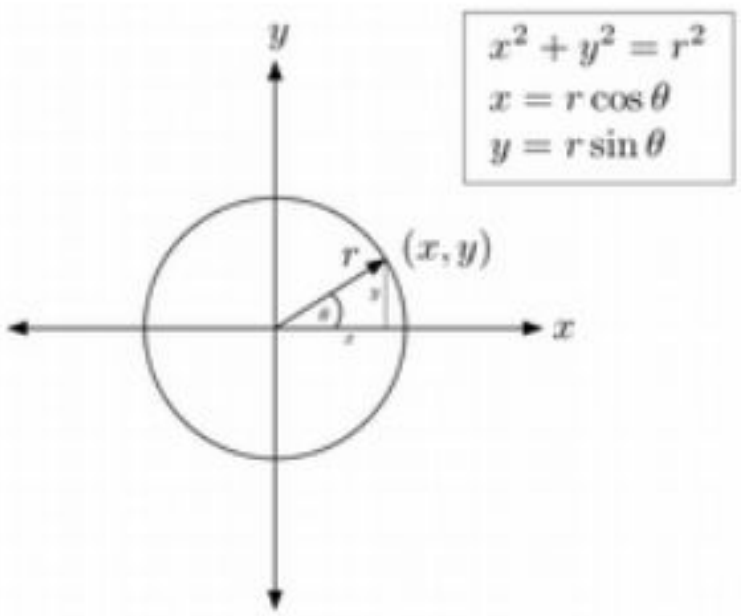


sin(wt)

Birazcık MATEMATİK !

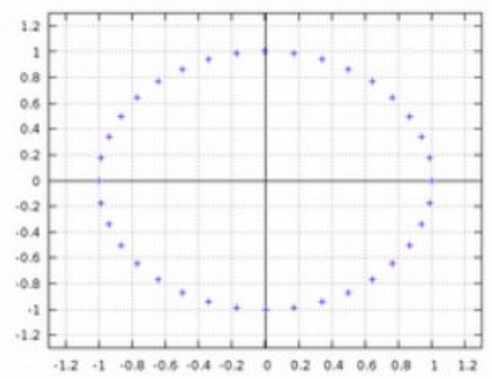


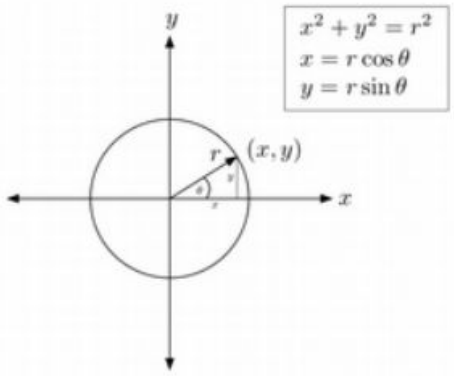
Birazcık MATEMATİK !



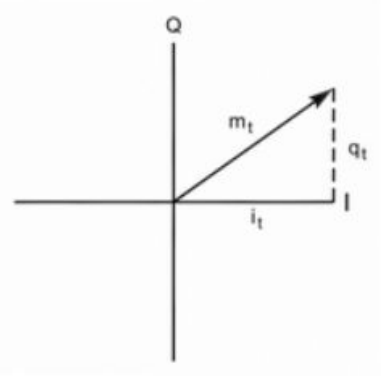
$$m_t = A.\cos\theta$$

Birazcık MATEMATİK !



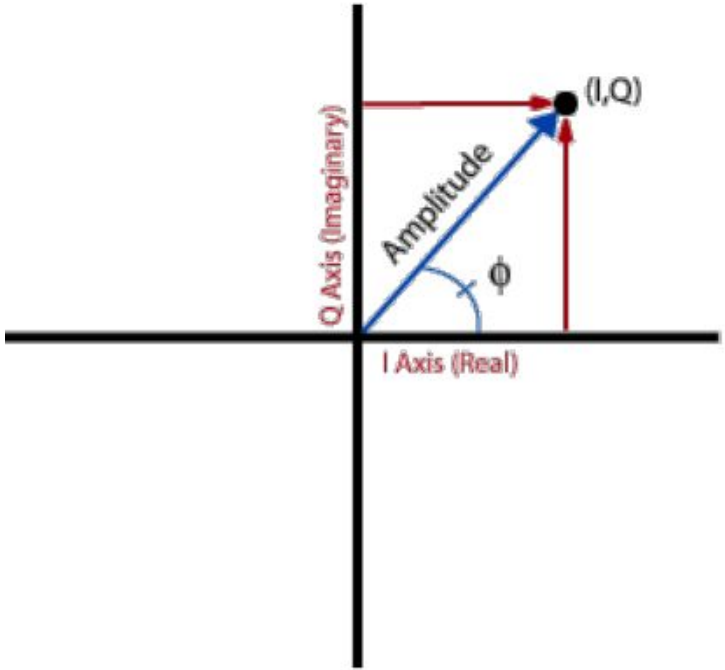


$$m_t = A.\cos\theta$$



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

Birazcık MATEMATİK !



Koordinat : (I,Q)

Vektör : [I,Q]

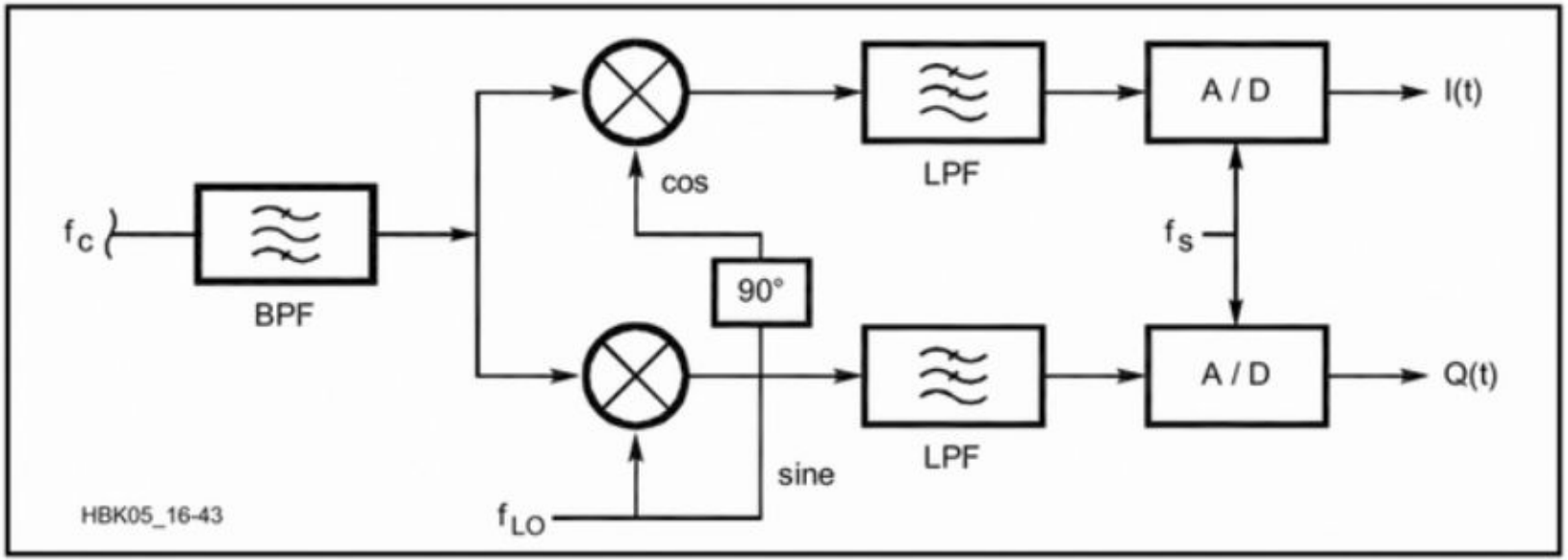
Komplex Sayı : I+Qi

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

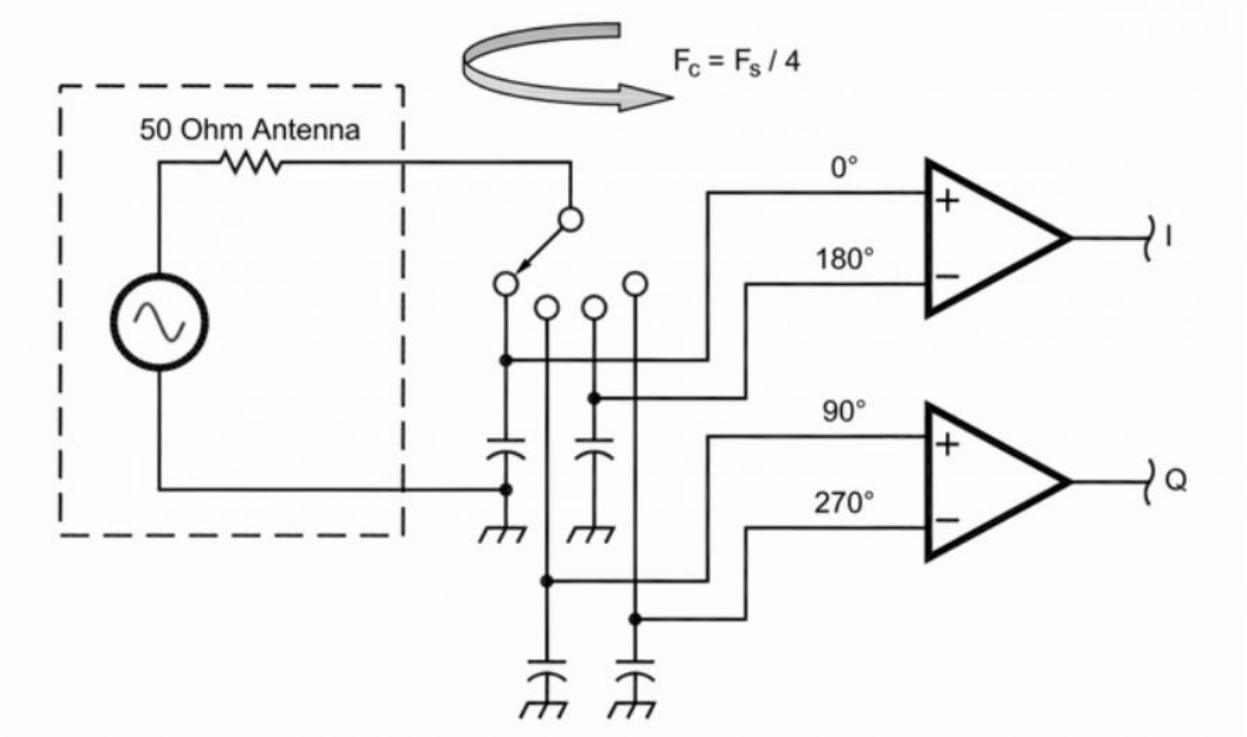
Euler : $A(\cos(\phi) + i \cdot \sin(\phi))$

$Ae^{i\phi}$

Yazılım Tabanlı Radyo Nedir ? (1/3)

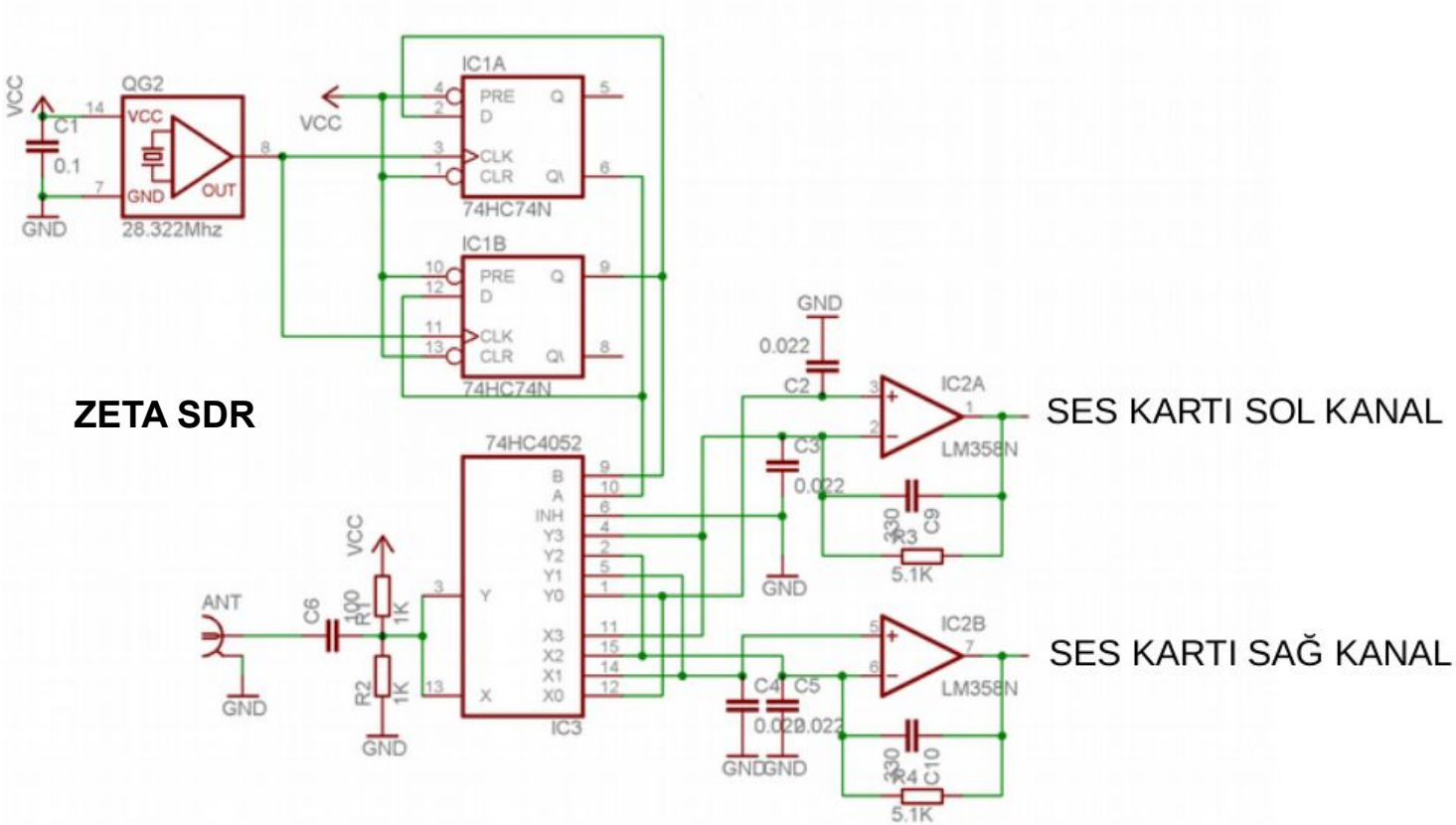


Yazılım Tabanlı Radyo Nedir ? (2/3)



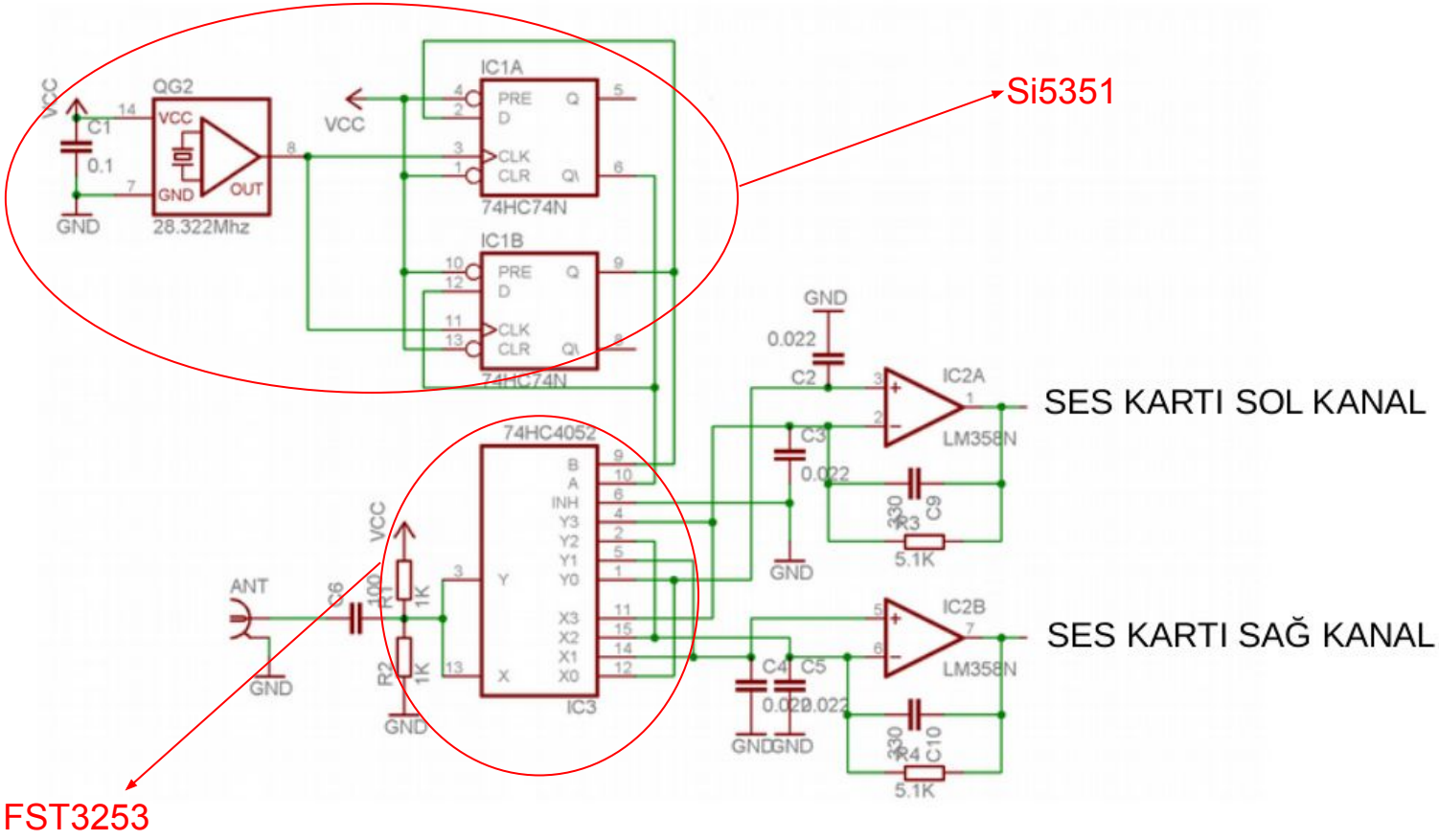
Tyloe Detektörü

Yazılım Tabanlı Radyo Nedir ? (3/3)



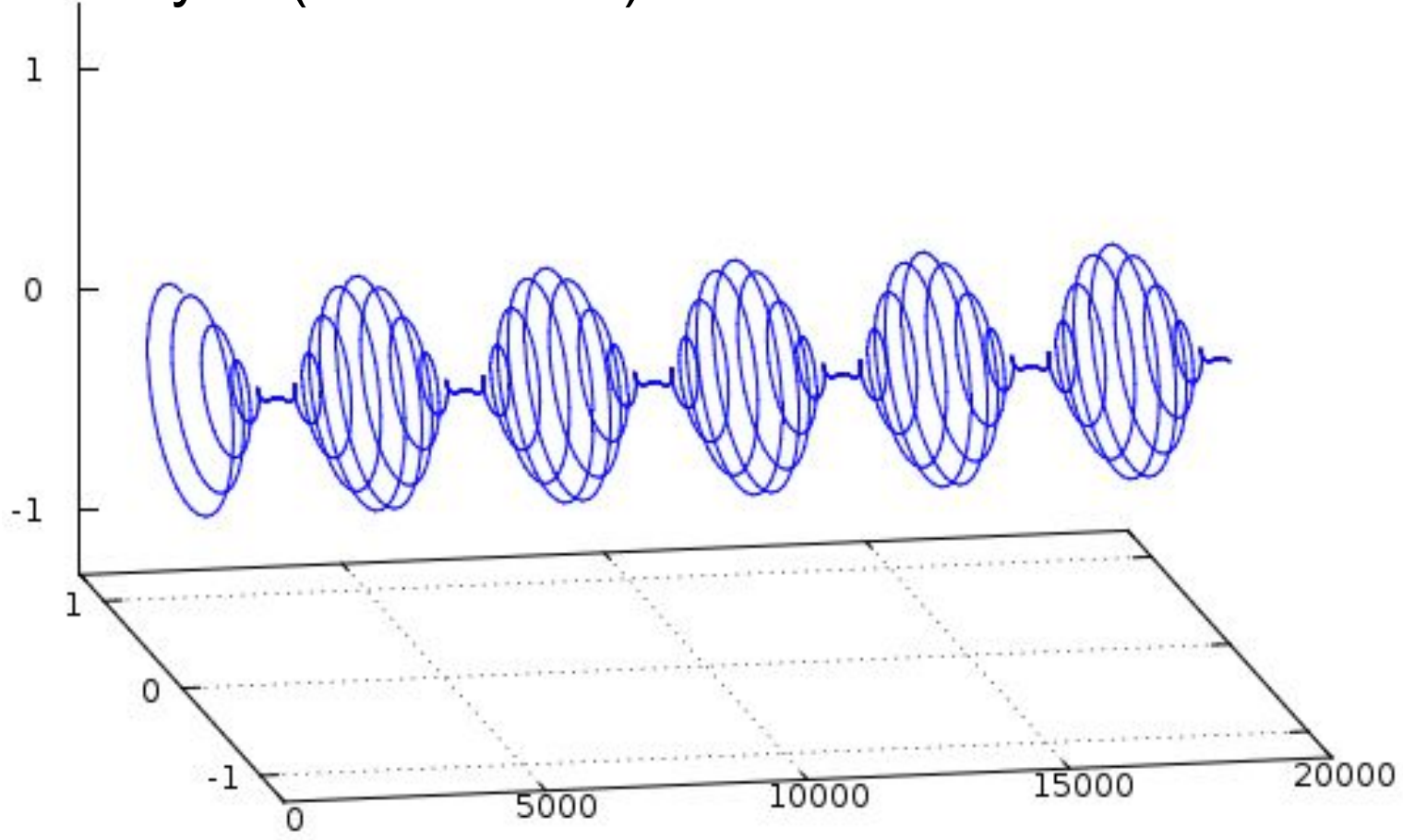
(Yaklaşık Maliyet 10 TL)

Yazılım Tabanlı Radyo Nedir ? (3/3)

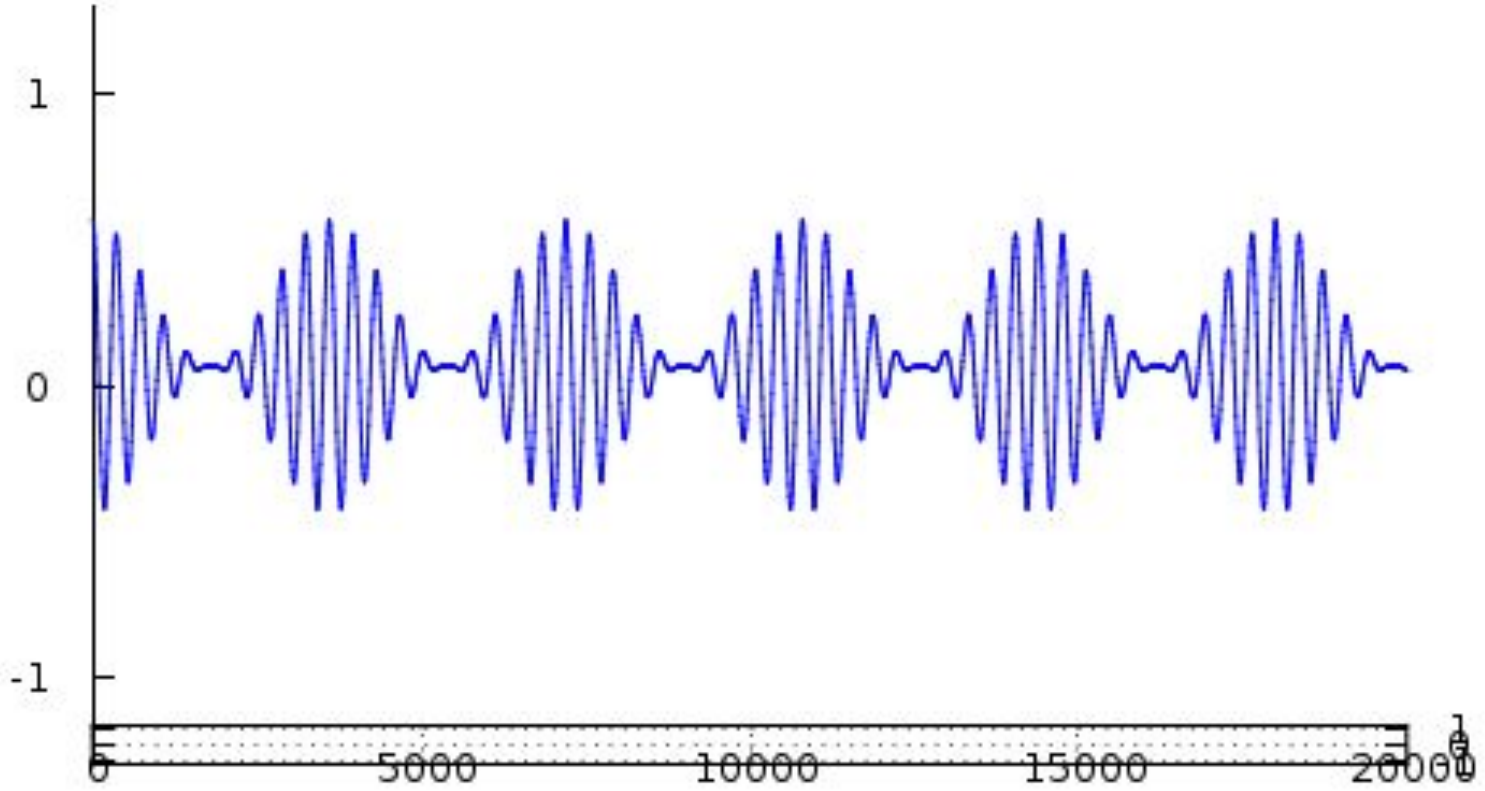


(Yaklaşık Maliyet 10 TL)

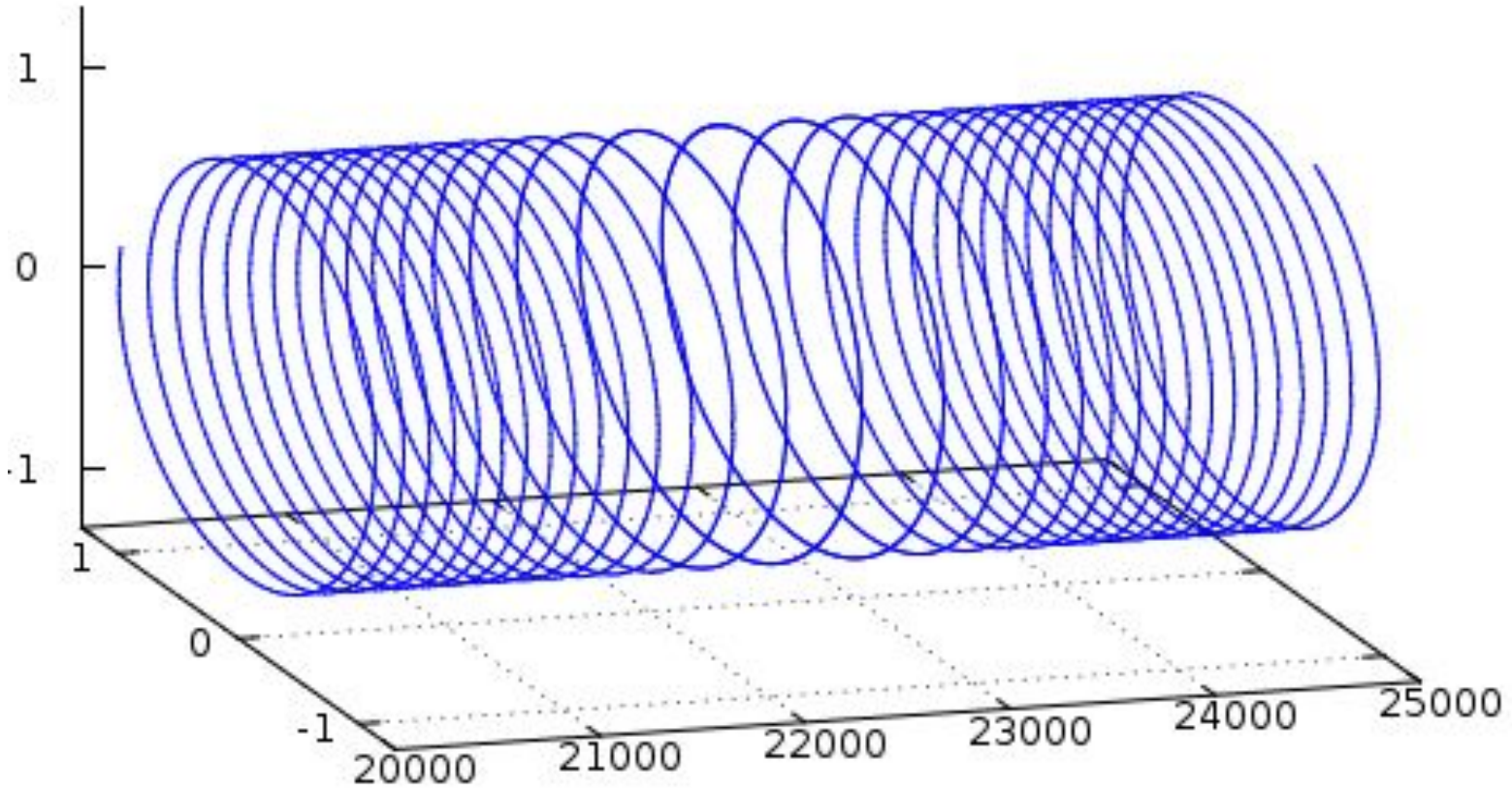
AM Modülasyon (Quadrature)



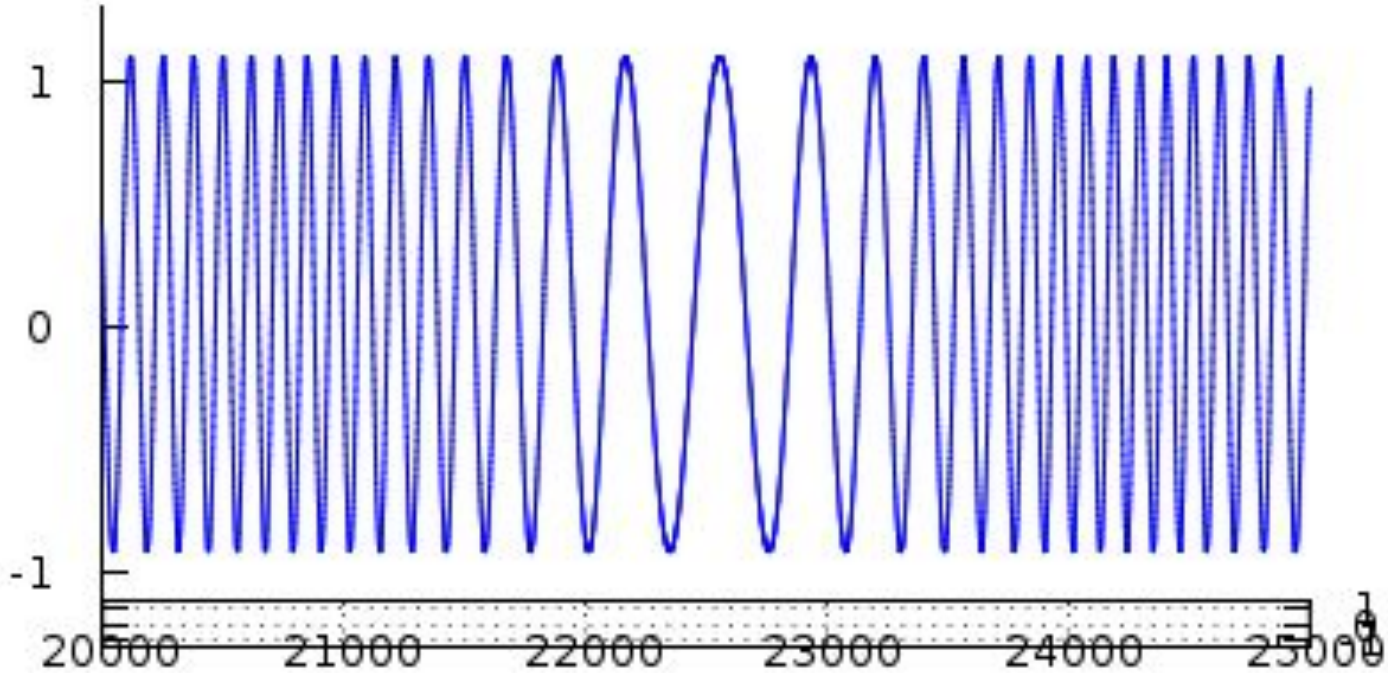
AM Modülasyon (Quadrature - Sadece I veya Q)



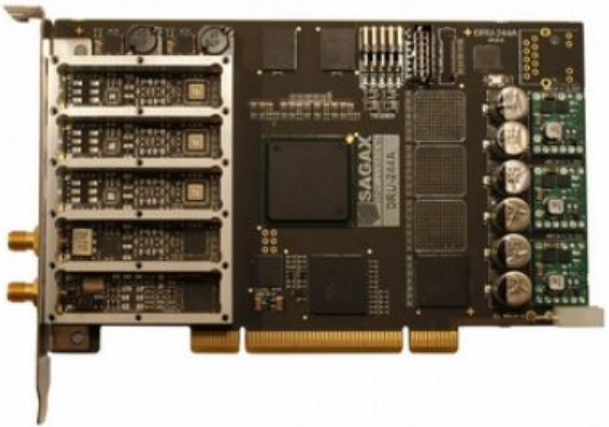
FM Modülasyon (Quadrature)



FM Modülasyon (Quadrature - Sadece I veya Q)



Örnek SDR Donanımları



BW > 500 Mhz
>> $40.000

SAGAX QUADRUS

Örnek SDR Donanımları

B Serisi : < 20Mhz BW, ~$1500

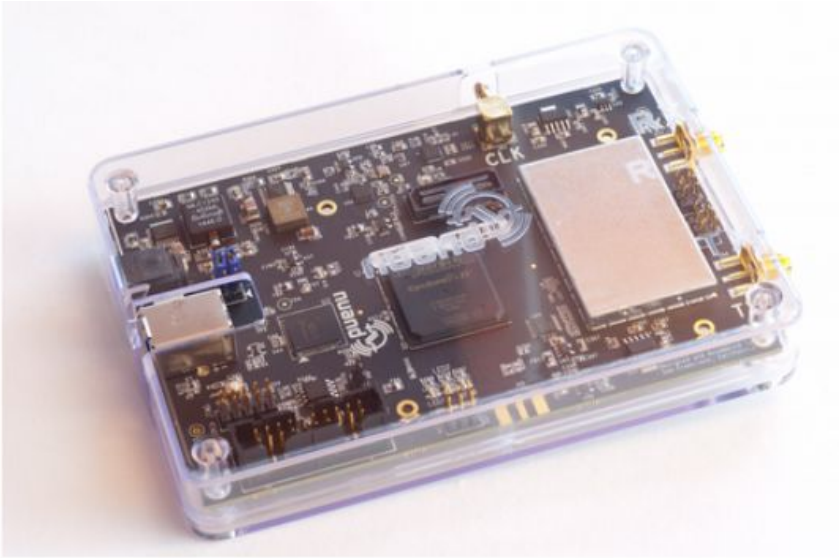
N Serisi : 25Mhz BW, ~$2500

E Serisi : 50Mhz BW, ~$4500

X Serisi : 150 Mhz BW, ~$7500

Ettus Research

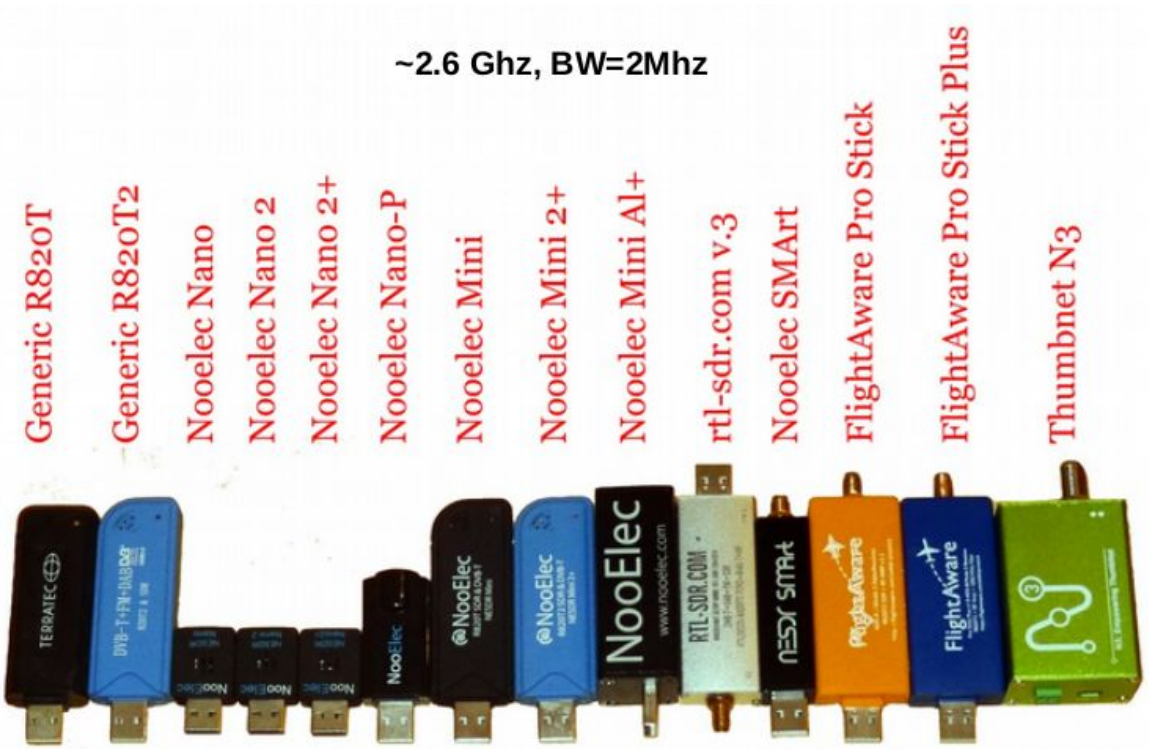
Örnek SDR Donanımları



BW ~20Mhz
~$300

HackRF ve BladeRF

Örnek SDR Donanımları



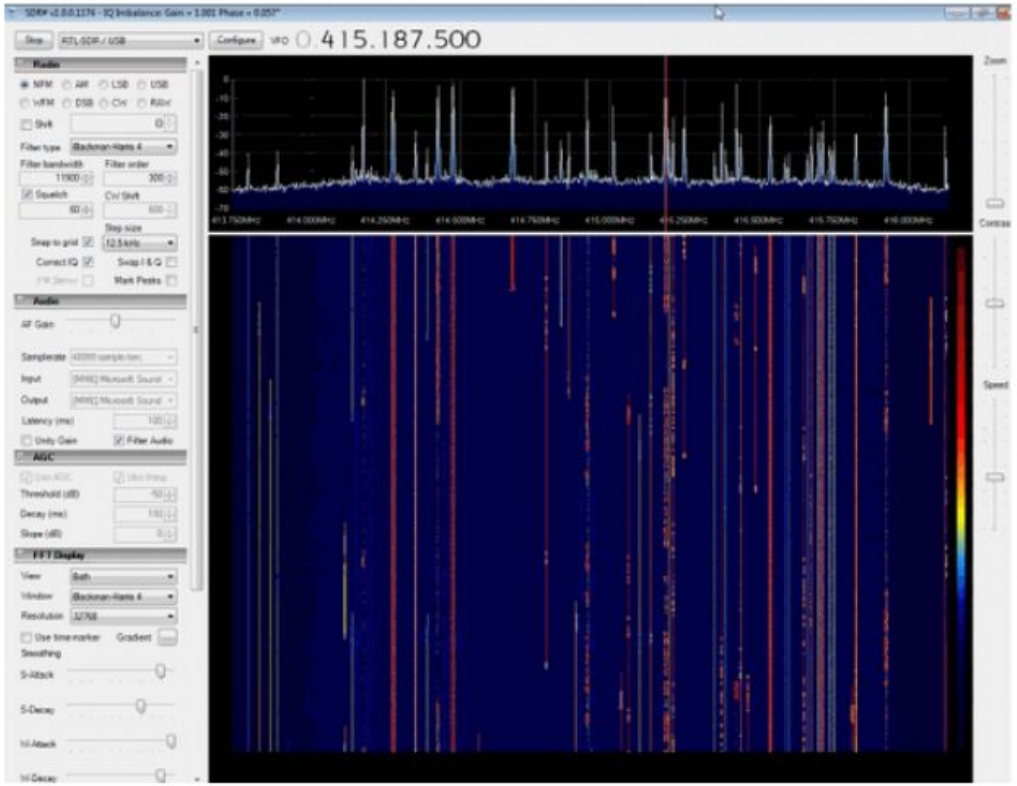
<$10

Örnek SDR Telsizler

Örnek SDR Telsizler

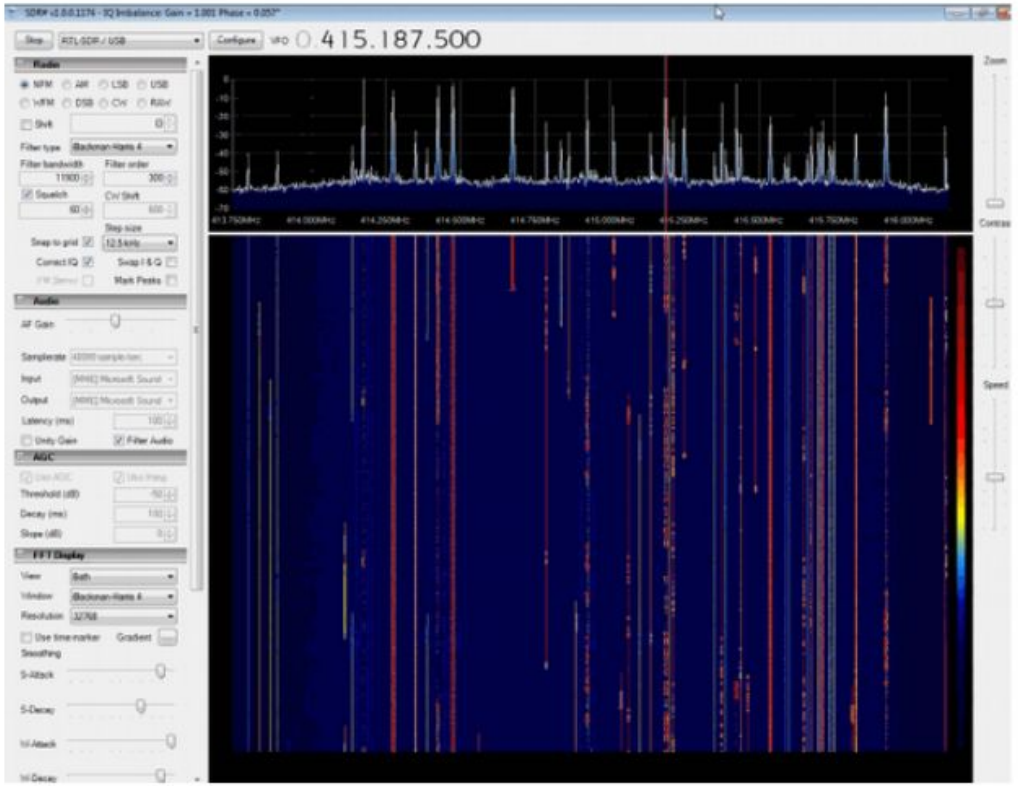
Hazır Yazılımlar

SDR# (Windows) (Free)



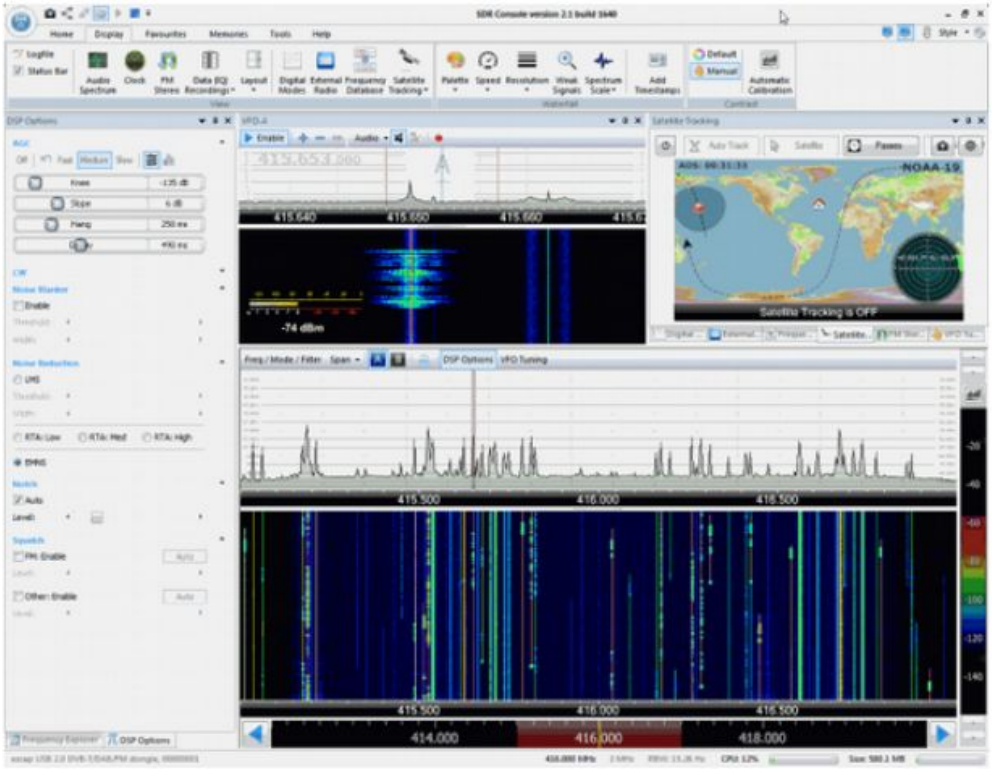
Hazır Yazılımlar

SDR# (Windows) (Free)



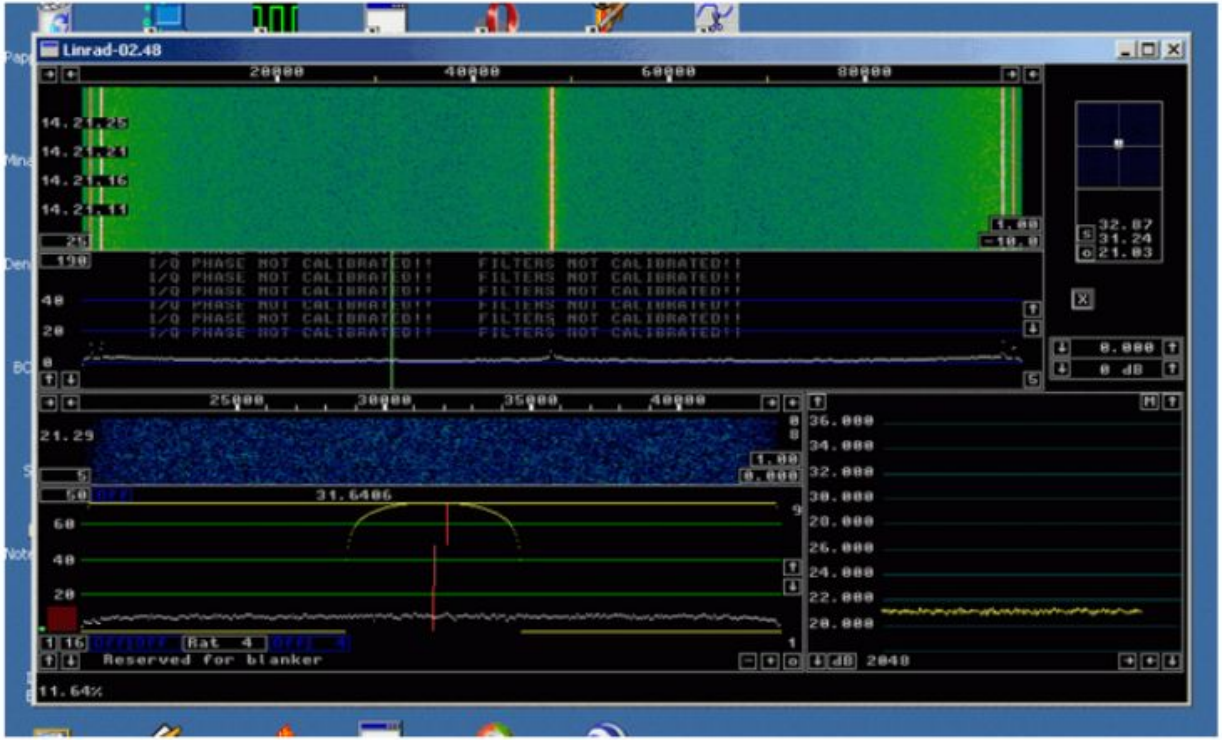
Hazır Yazılımlar

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



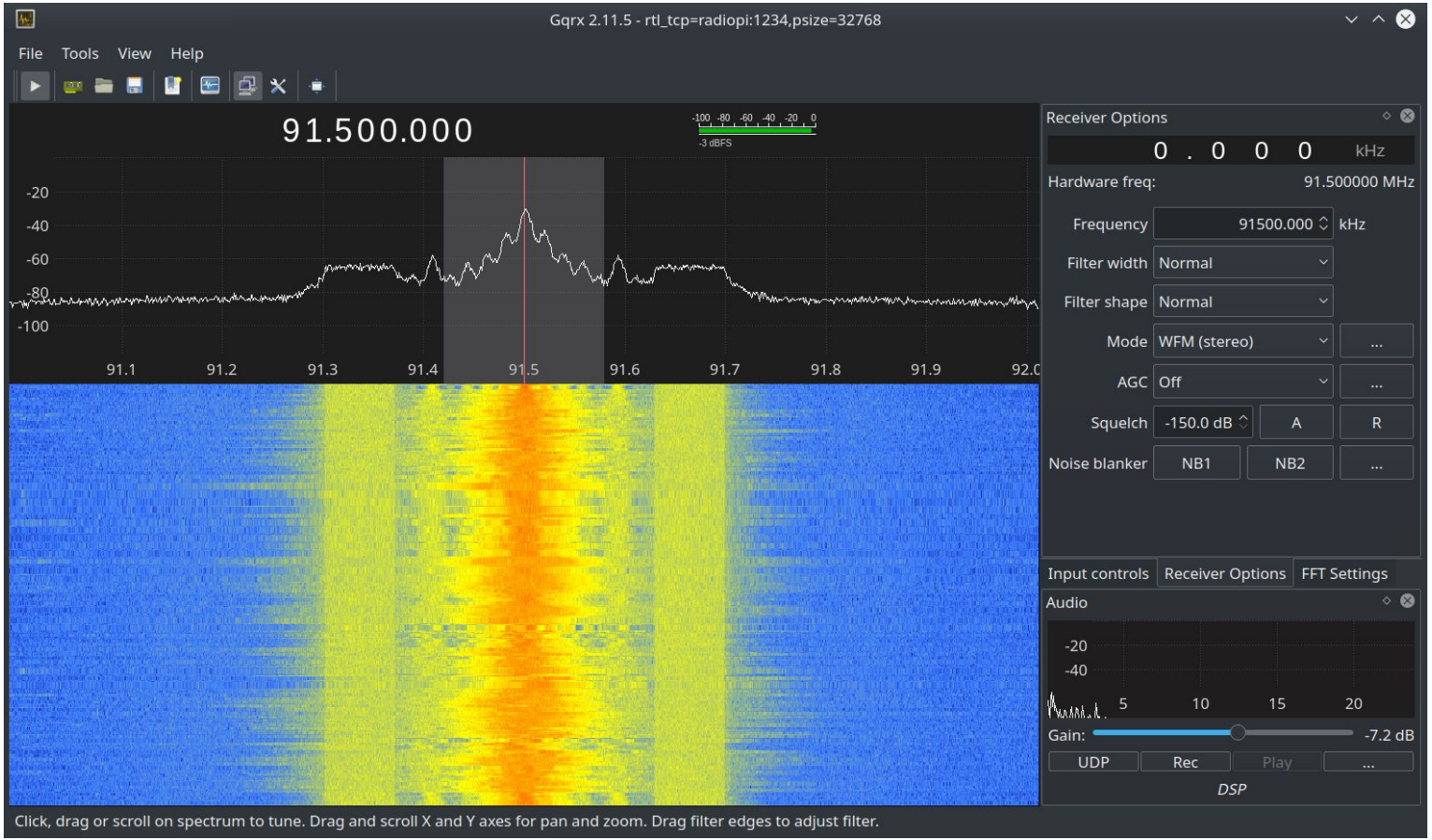
Hazır Yazılımlar

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



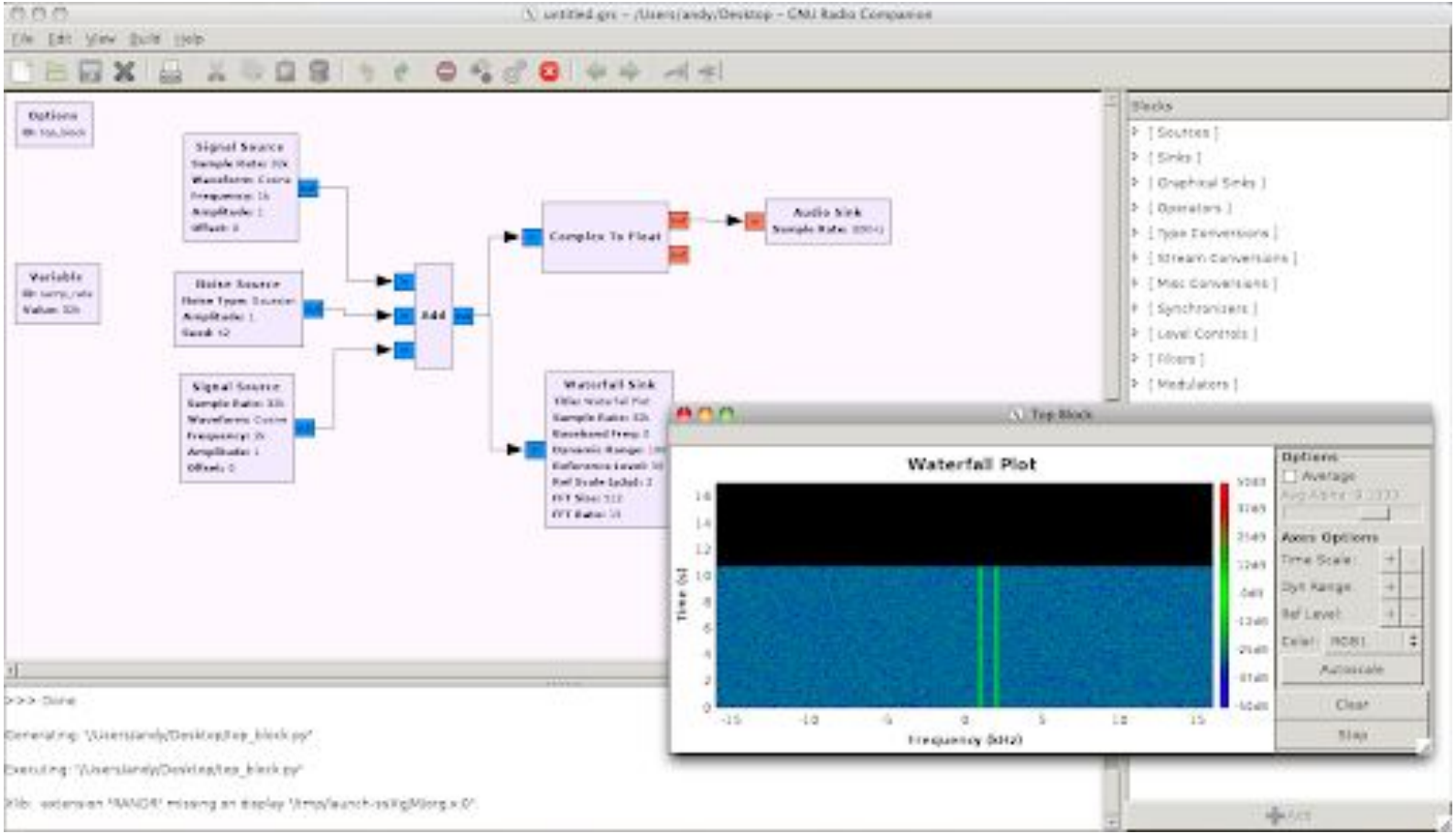
Hazır Yazılımlar

GQRX



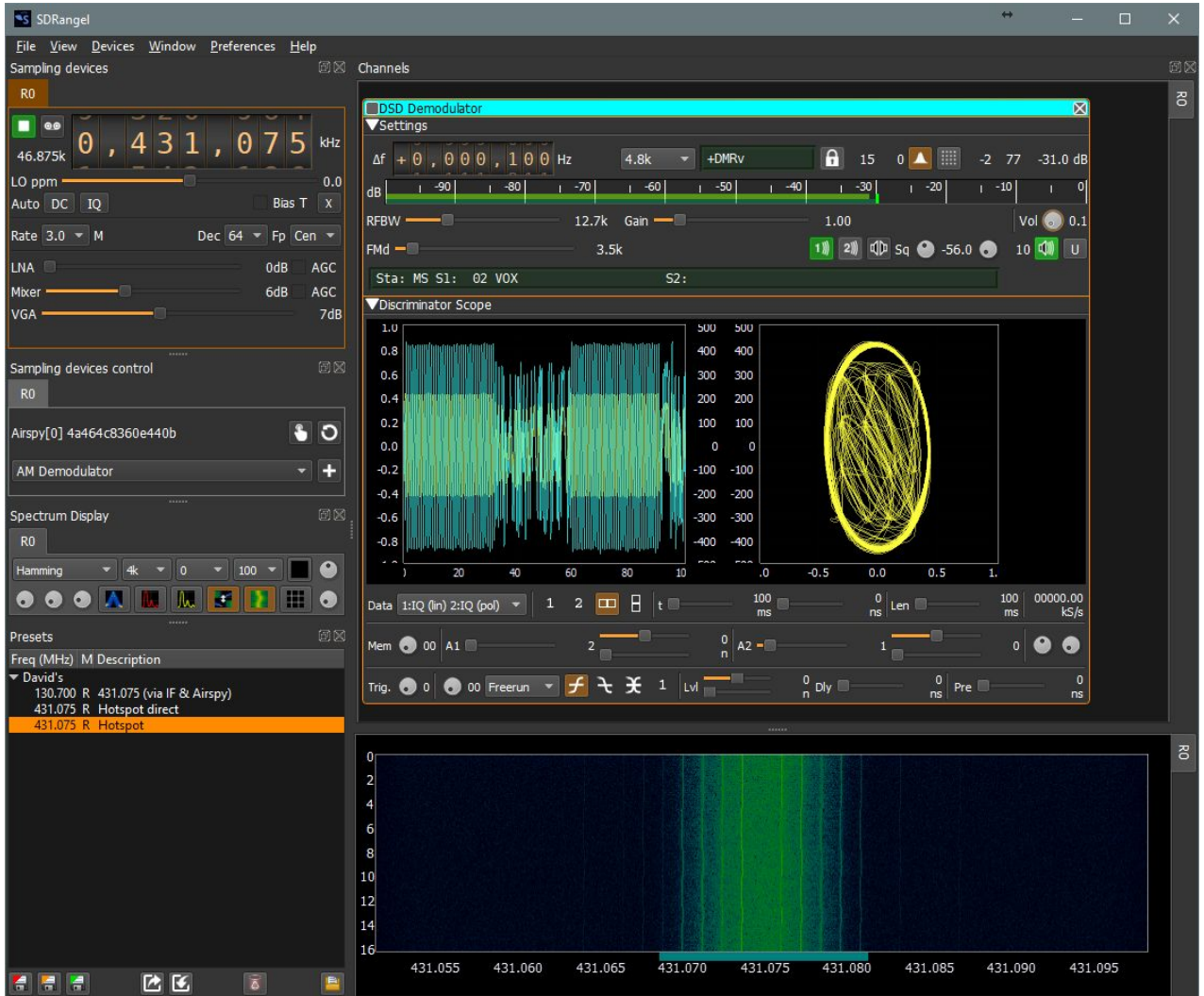
Hazır Yazılımlar

GNURadio



Hazır Yazılımlar

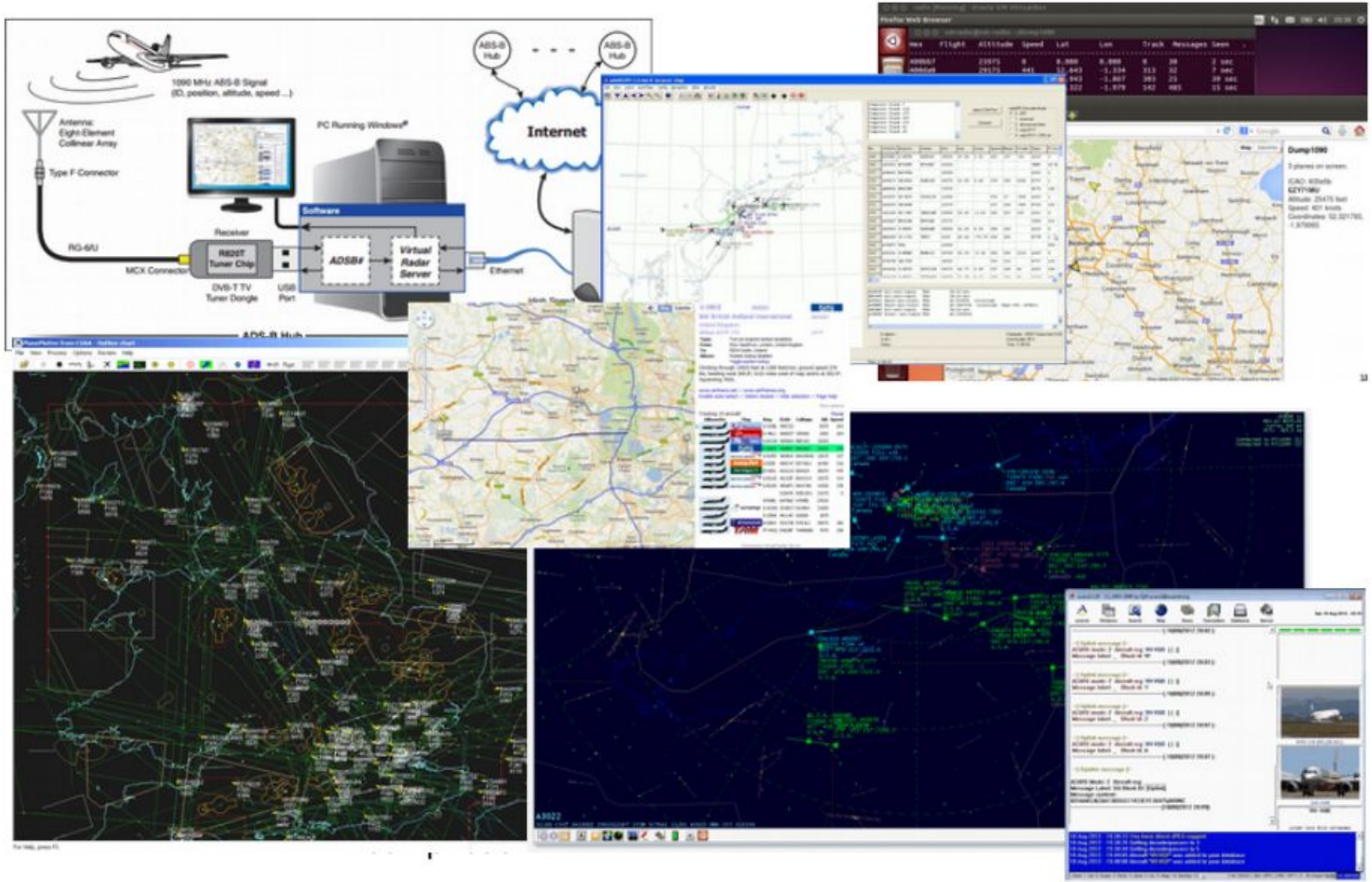
SDRAngel



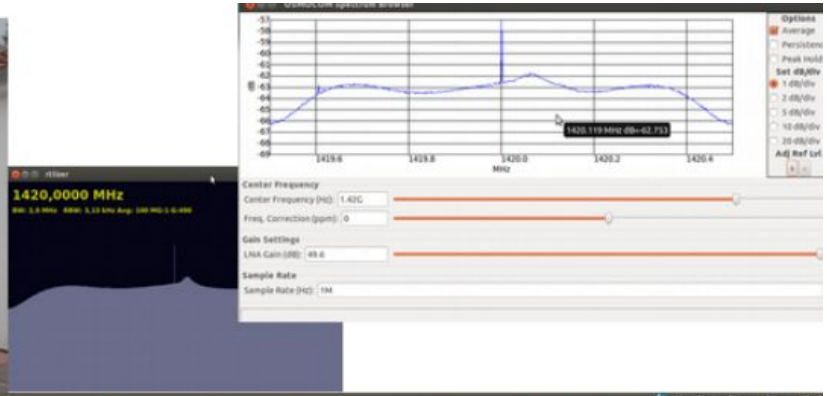
Hazır Yazılımlar

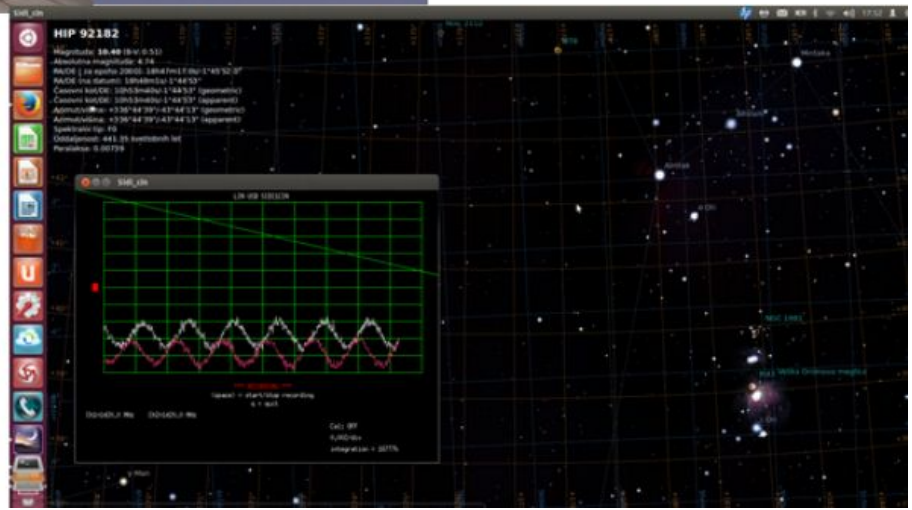
SDRTouch

SDR ile Neler Yapılır ? Projeler



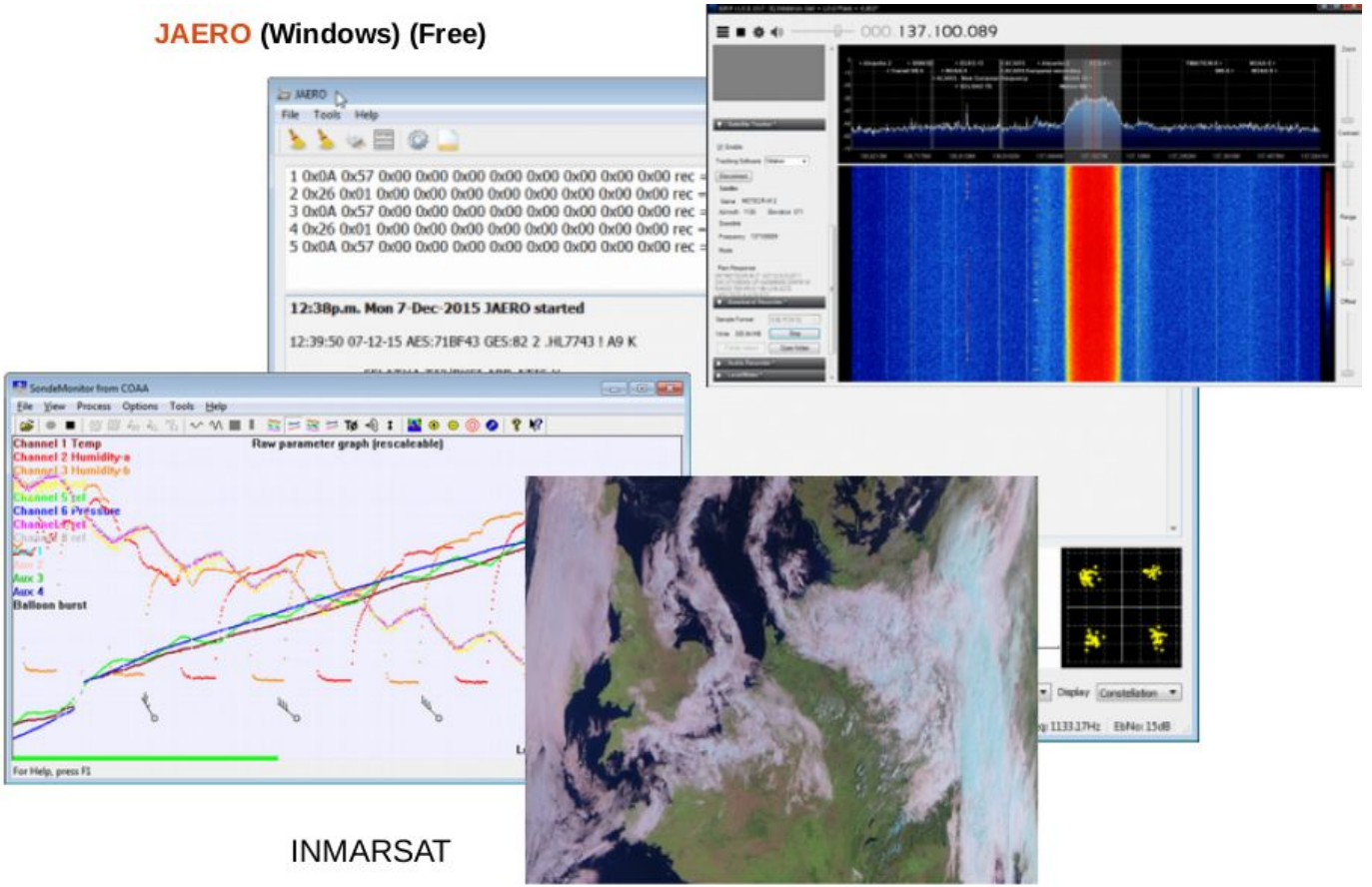
SDR ile Neler Yapılır ? Projeler





1420Mhz Hydrogen Line

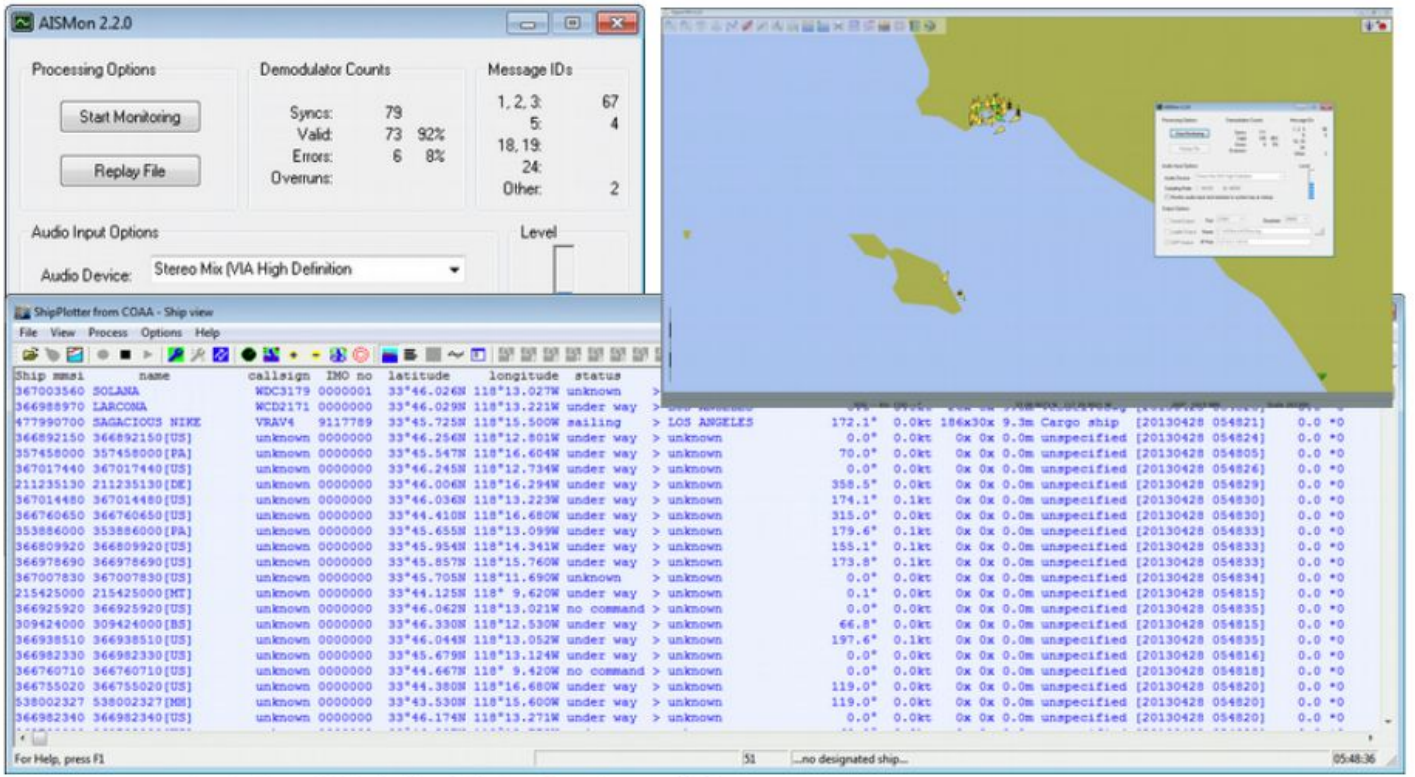
SDR ile Neler Yapılır ? Projeler



SDR ile Neler Yapılır ? Projeler

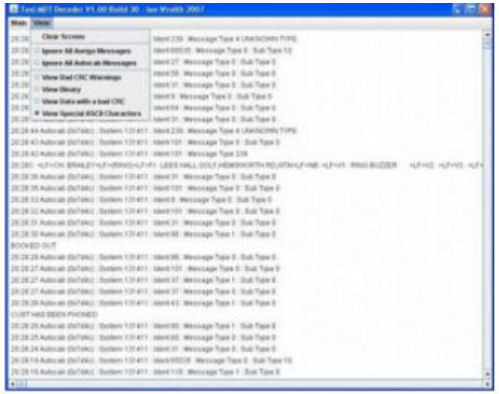
AISMon (Windows) (Free) (Related Post) – AIS

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

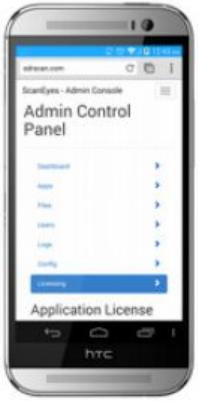


ShipPlotter (Windows) (Trial/Paid) (Related Post) – AIS

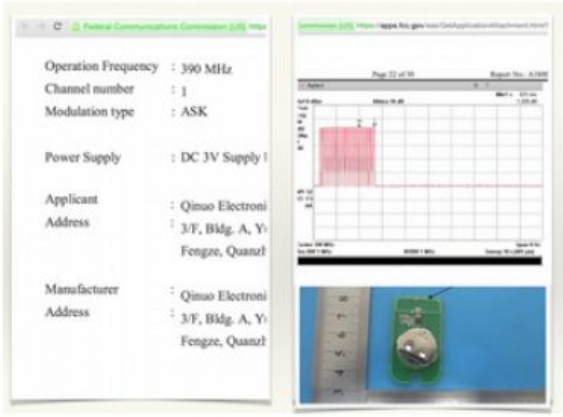
SDR ile Neler Yapılır ? Projeler

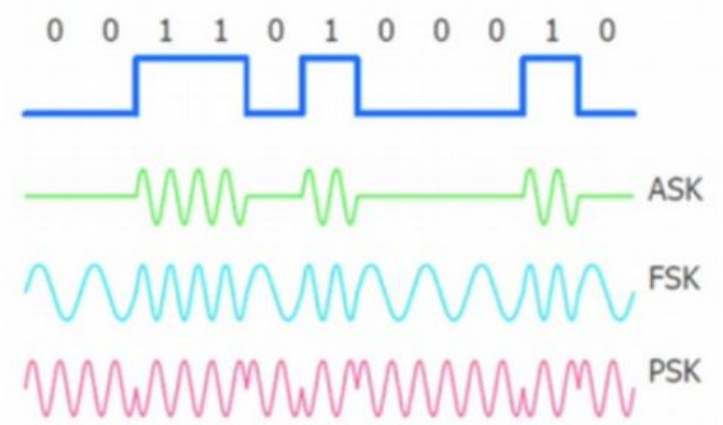


Digital Radio

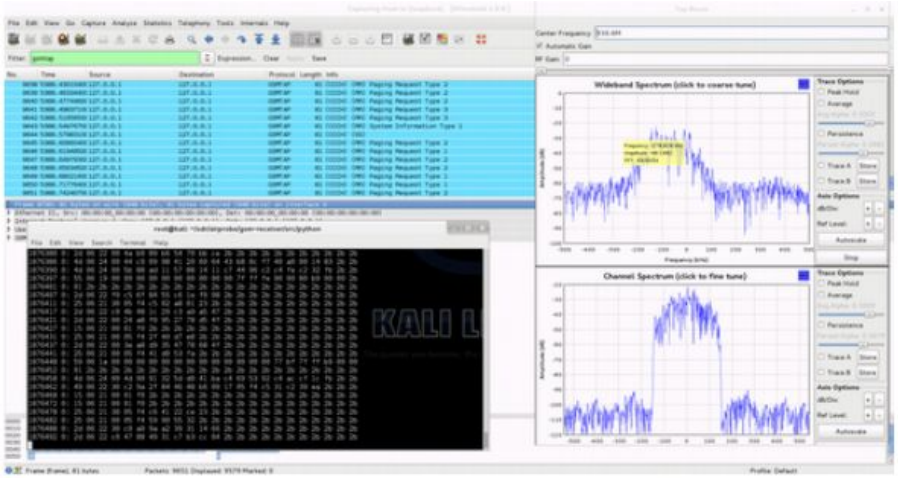


SDR ile Neler Yapılır ? Projeler





SDR ile Neler Yapılır ? Projeler



GSM

Ne kadar kodlama bilmeliyim ?

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
```

Adim adim SDR

USB den okuyup dosyaya yazalim
rtl_sdr -f 101.1M -s 256k -n 2560000 kayit.iq

IQ dosyalari uzerinde SDR demodulasyonu yapalim
cat kayit.iq | fm_cozucu.py > ses.raw

Simdi de kaydi dinleyelim
sox -t raw -r 256000 -b 16 -c 1 -L -e signed-integer ses.raw -d rate 32000

Ne kadar kodlama bilmeliyim ?

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]);
```

Ne kadar kodlama bilmeliyim ?

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 };
```

Daha sonrasında neler öğreneceğiz ?

- RTLSDR’ye yazılım yazalım, dinleyelim
- uSDX donanımına çok detaylı bakış
- McHF donanımına çok detaylı bakış
- GNURadio yazılımı ile oynayalım (Giriş)
- Kendi SDR Cihazımızı Tasarlayalım
- GNURadio yazılımı ile oynayalım (İleri Seviye)