FDM readout system for MKID far infrared space telescope cameras

Rosette Nebula

SRON

RF2016 TECHNOLOGY DAYS
STUDIO 21 · MEDIAPARK · HILVERSUM
FHI SEMINAR · 12 APRIL 2016

Netherlands Institute for Space Research
Ed de Vries

Netherlands Organisation for Scientific Research (NWO)

Netherlands Institute for Space Research

SRON is part of the Netherlands Organization for Scientific research NWO

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SRON Groningen

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- **Scientific expertise**
- **Enabling technology**
- **End-to-end instrument development**
  - analogue electronics engineering
  - digital electronics and software
  - mechanical engineering
  - electrical and mechanical assembly
  - quality control

SRON programs :

- **Astrophysics**
- **Earth observation**
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https://www.sron.nl/

SRON instrument hardware heritage

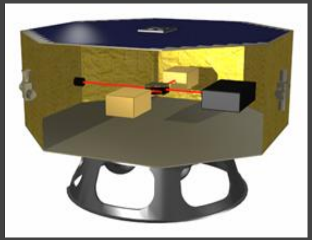
ISO-SWS

Chandra

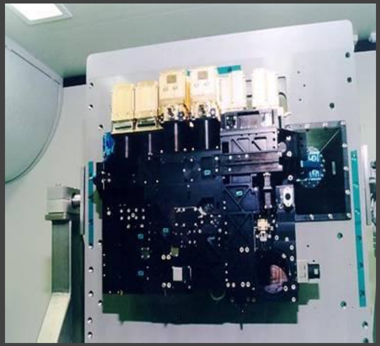
XMM-RGS

Herschel HIFI

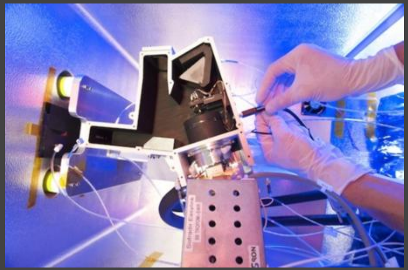
BeppoSAX-WFC



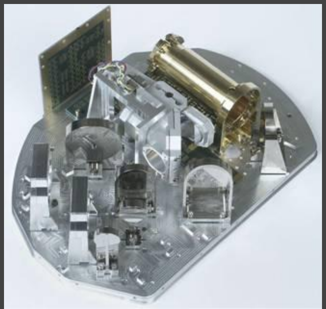
LISA pathfinder



Envisat-SCIAMACHY



TROPOMI



Telis

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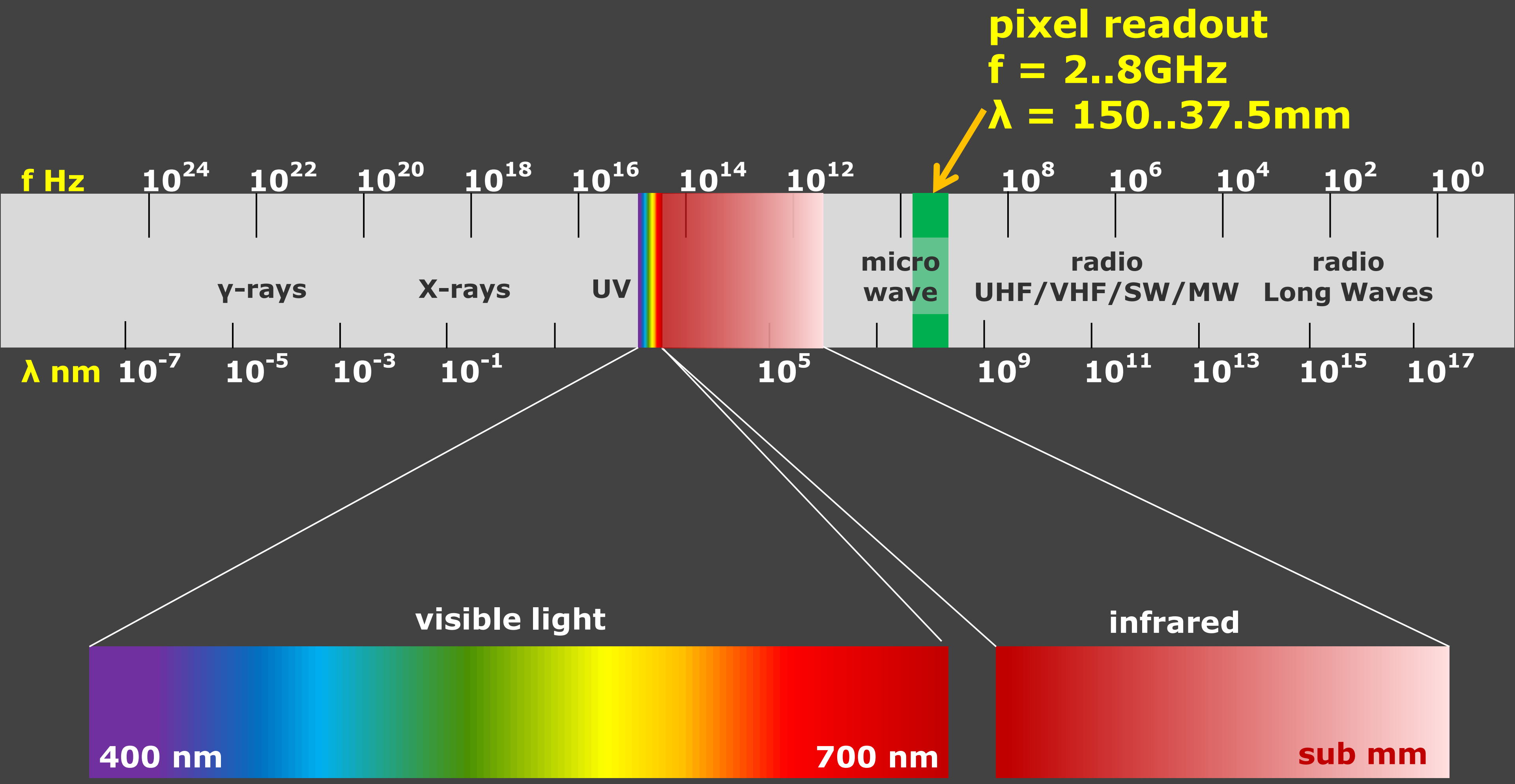
frequency spectrum



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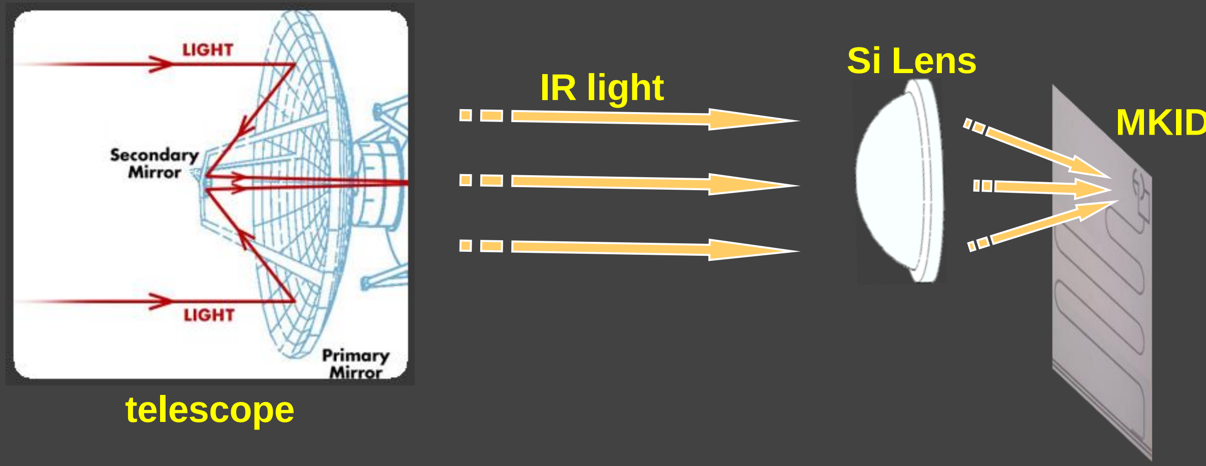
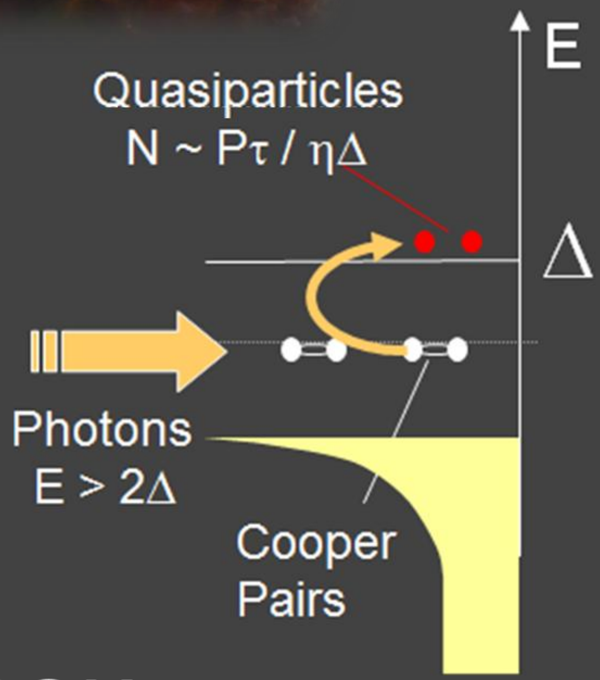
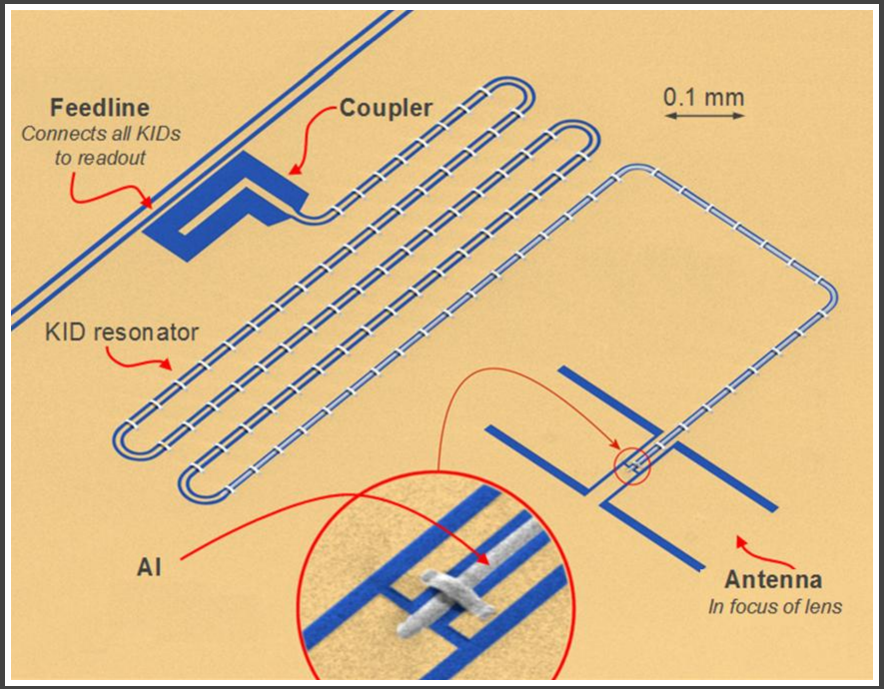
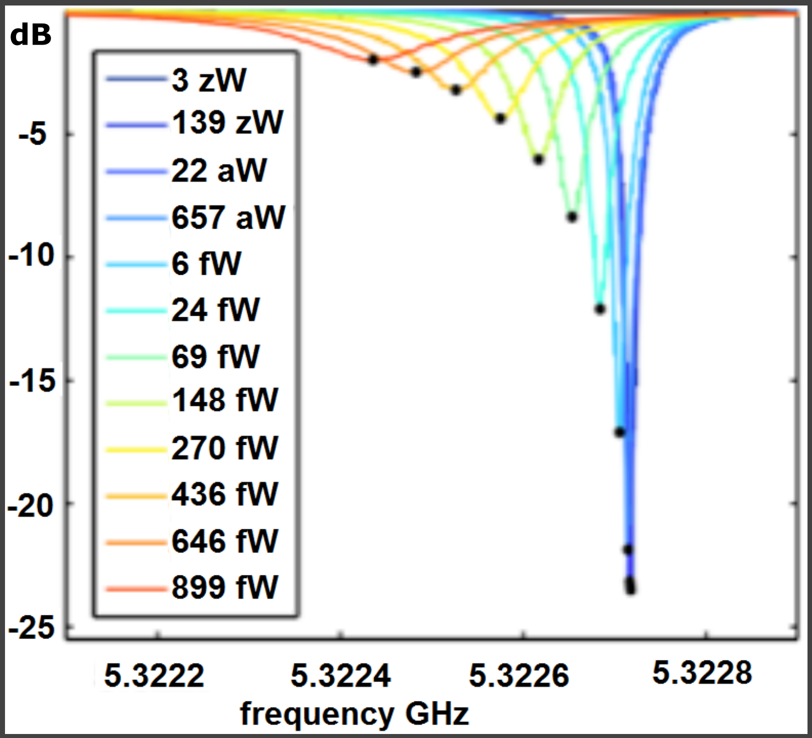
Microwave Kinetic Inductance Detectors (MKID)







Microwave Kinetic Inductance Detectors (MKID)



MKID

- A KID acts as a resonator in the 2…8GHz region with Q>100.000
- The KID is sensitive for sub-mm radiation of which the wavelength is determined by the KID antenna size
- A KID array operates at 100mK (-273.05˚C) to enable super conductance and to obtain extreme high sensitivity (low noise)
- Cooper-pair state of electrons is responsible for super conductance
- Far Infrared radiation excites the MKID because photons break up the Cooper-pairs into quasiparticles, conductivity decreases and Q decreases

1zW = 10^{-21}W = -180dBm
1aW = 10^{-18}W = -150dBm
1fW = 10^{-15}W = -120dBm

normal small band communications receiver
0.2µV…0.5µV for 12dB sinad
-113…-121dBm (50Ω)

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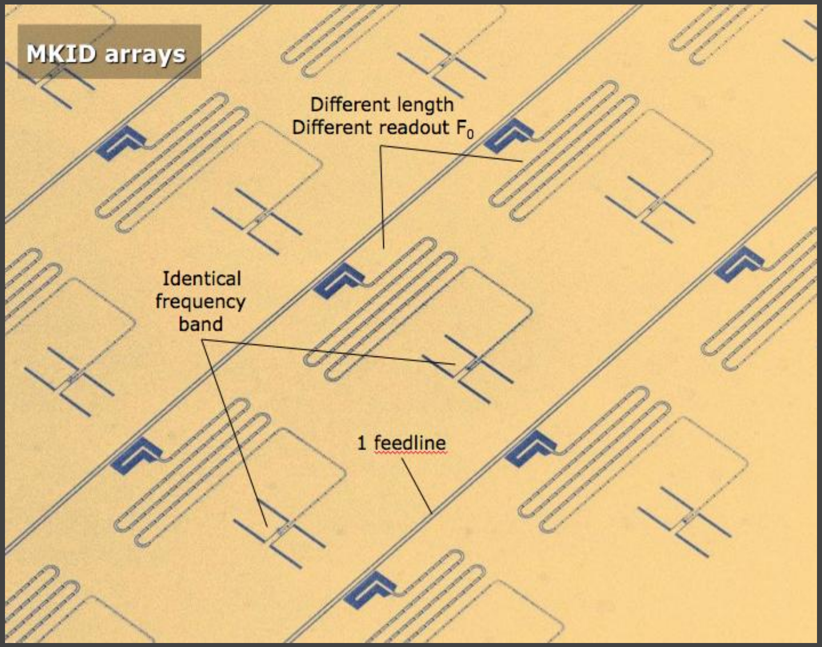
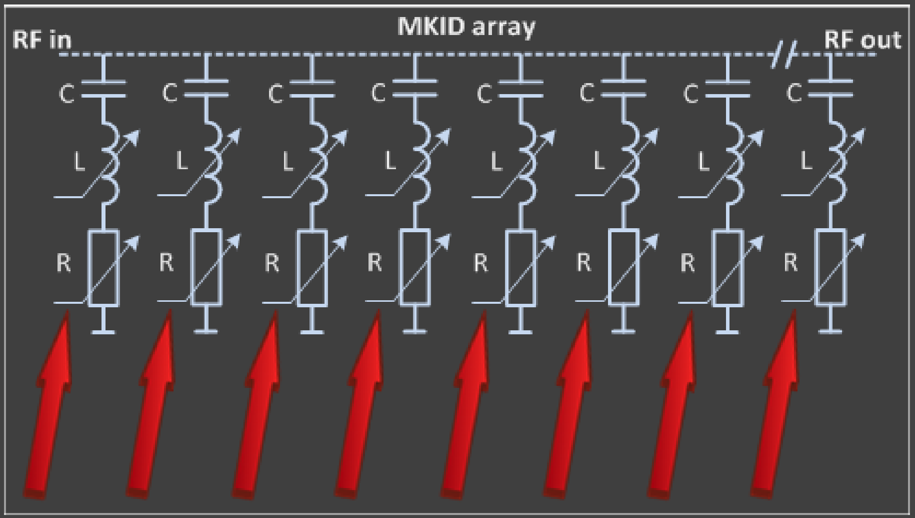
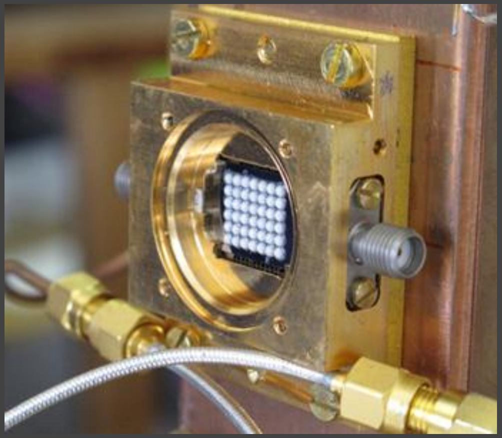
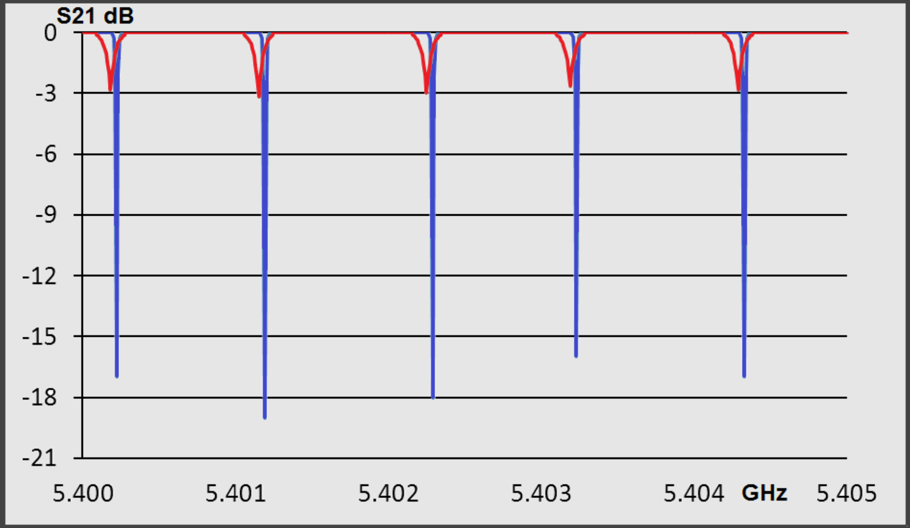
Microwave Kinetic Inductance Detectors (MKID)

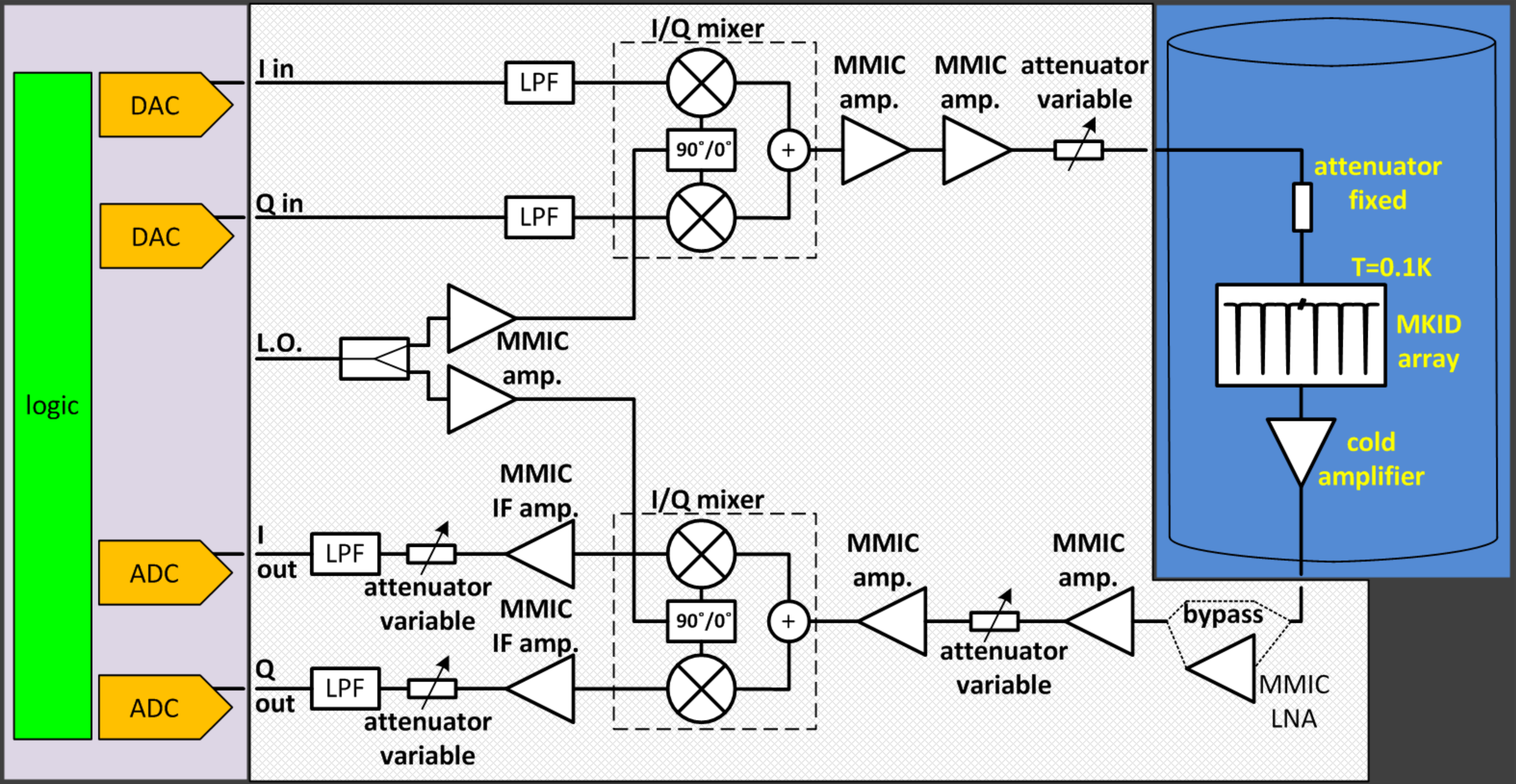




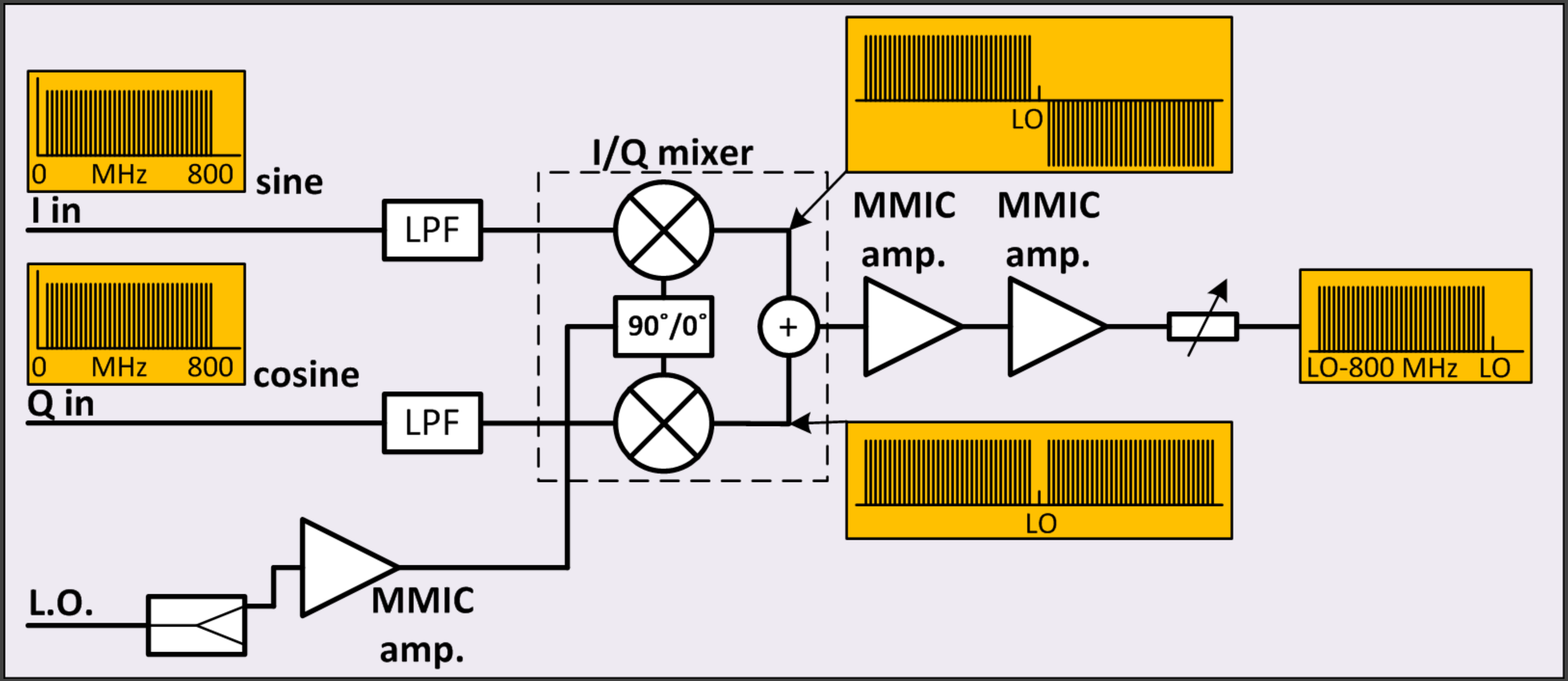




MKID readout system



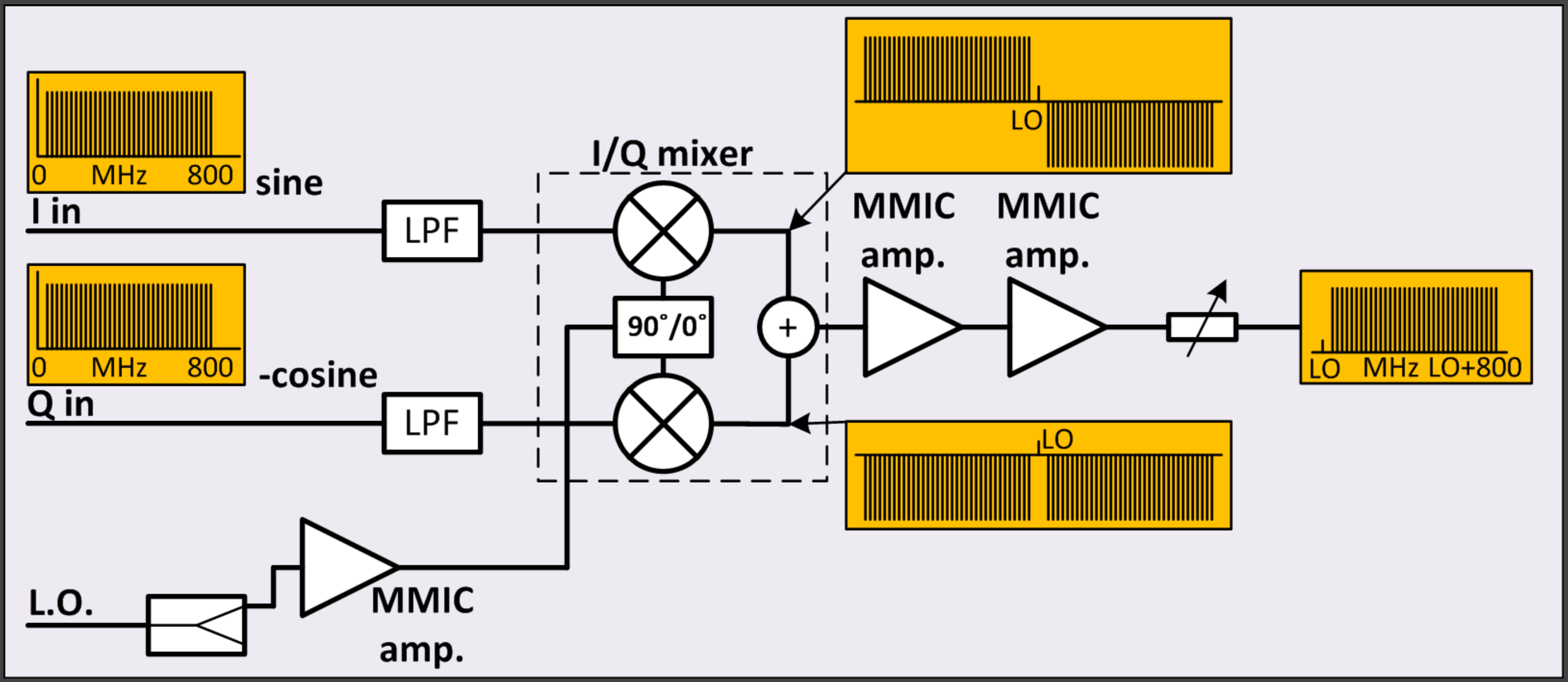
up-converter, lower side band



$$\frac{X.sin(\omega_x t)}{\sqrt{2}} * A.sin(\omega_a t) = +\frac{X.A.cos\big((\omega_x - \omega_a)t\big)}{2\sqrt{2}} - \frac{X.A.cos\big((\omega_x + \omega_a)t\big)}{2\sqrt{2}}$$

$$\frac{X.cos(\omega_x t)}{\sqrt{2}} * A.cos(\omega_a t) = +\frac{X.A.cos\big((\omega_x - \omega_a)t\big)}{2\sqrt{2}} + \frac{X.A.cos\big((\omega_x + \omega_a)t\big)}{2\sqrt{2}}$$

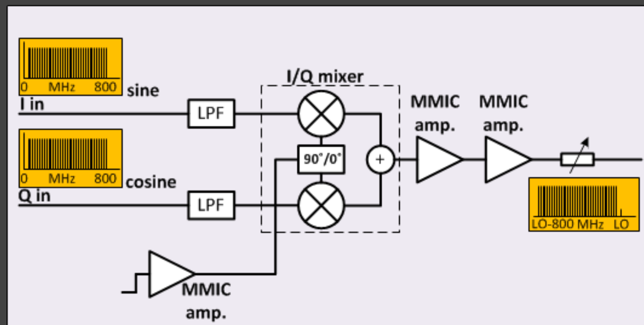
up-converter, upper side band

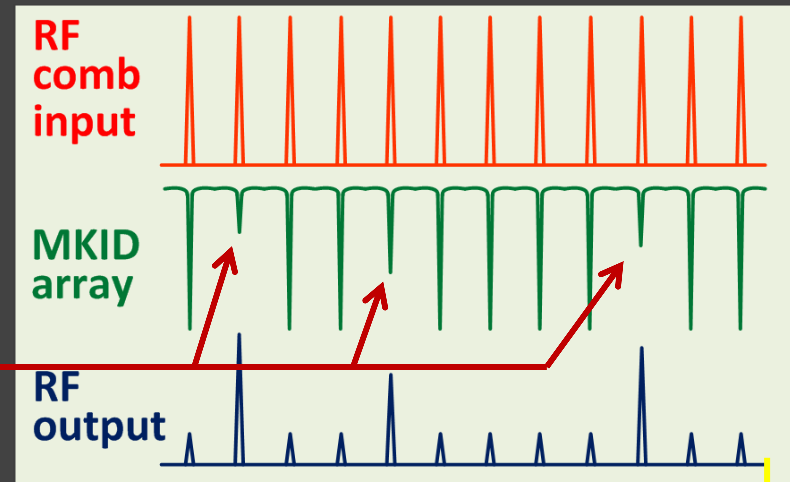


$$\frac{X.sin(\omega_x t)}{\sqrt{2}} * A.sin(\omega_a t) = +\frac{X.A.cos\big((\omega_x - \omega_a)t\big)}{2\sqrt{2}} - \frac{X.A.cos\big((\omega_x + \omega_a)t\big)}{2\sqrt{2}}$$

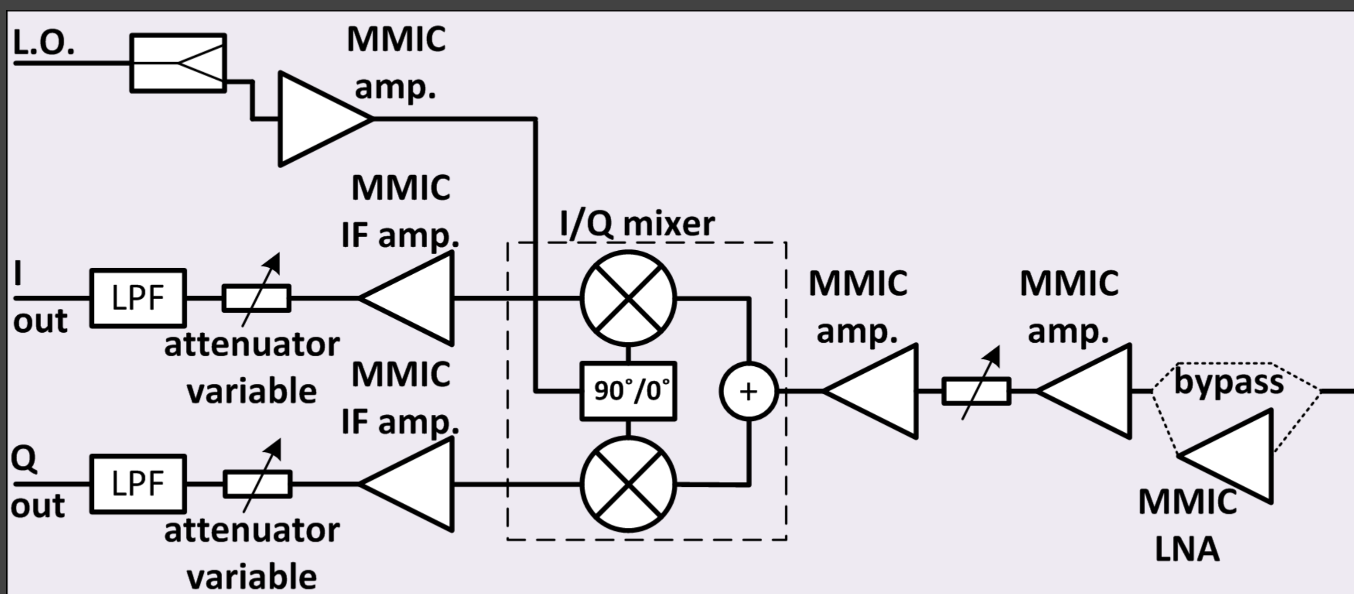
$$\frac{X.cos(\omega_x t)}{\sqrt{2}} * -A.cos(\omega_a t) = -\frac{X.A.cos\big((\omega_x - \omega_a)t\big)}{2\sqrt{2}} - \frac{X.A.cos\big((\omega_x + \omega_a)t\big)}{2\sqrt{2}}$$

down-converter





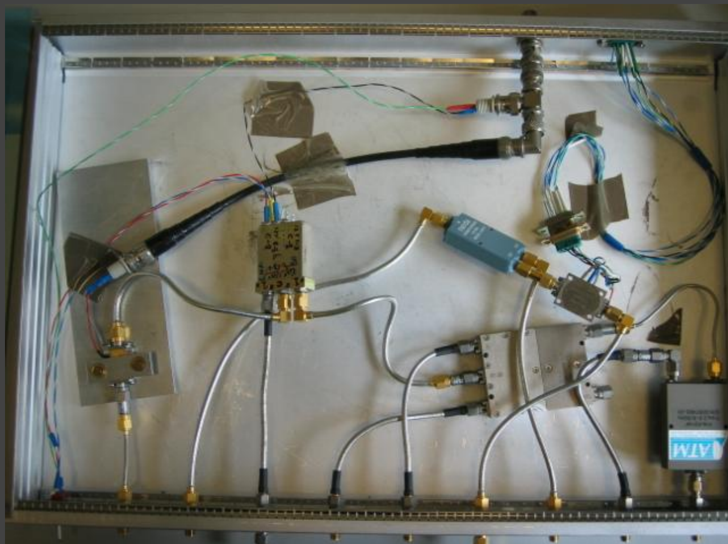
excited pixels

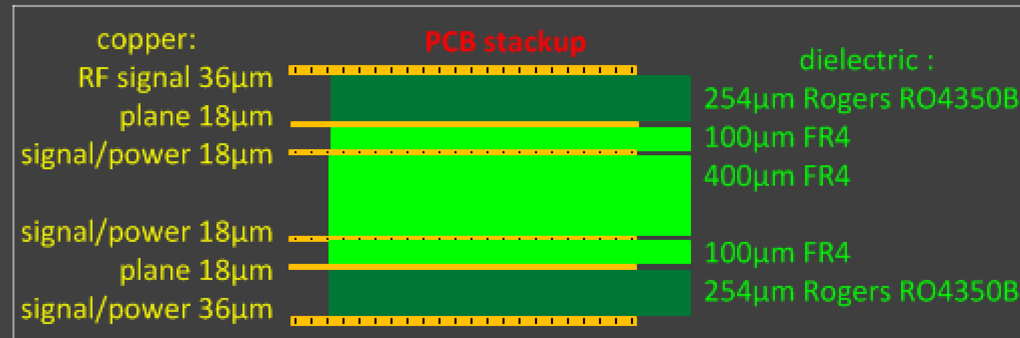


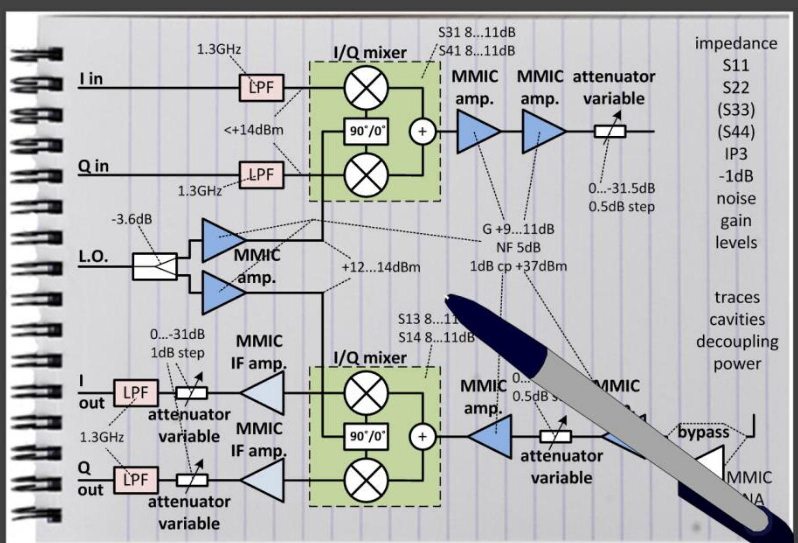
complex fast Fourier transform

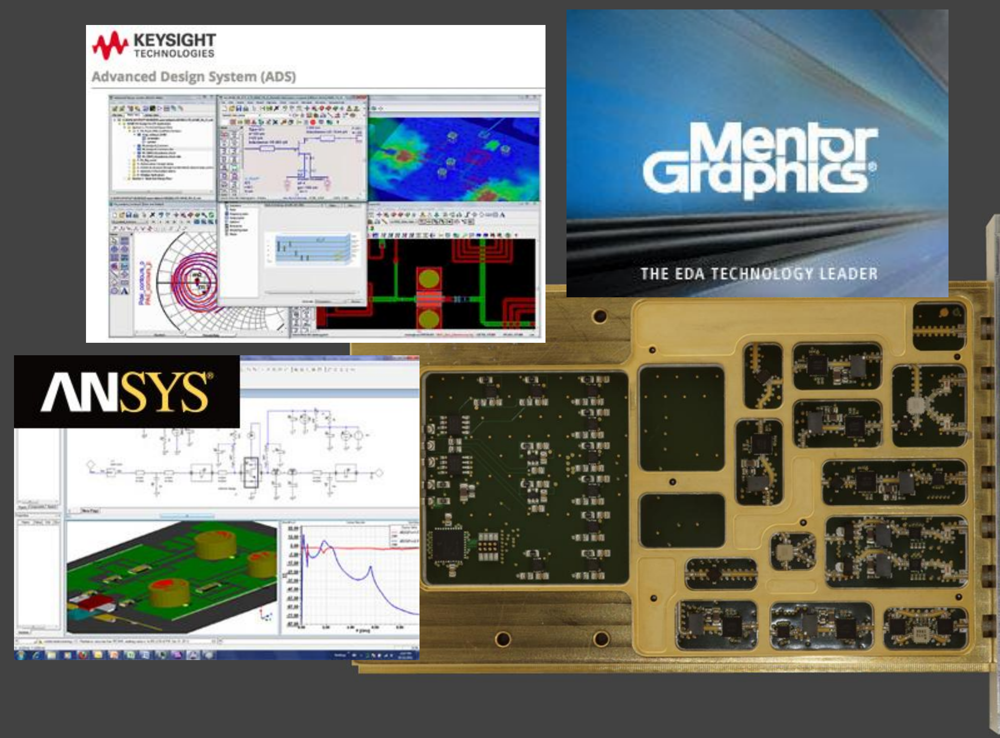
from MKID array

from the first setup to the actual design









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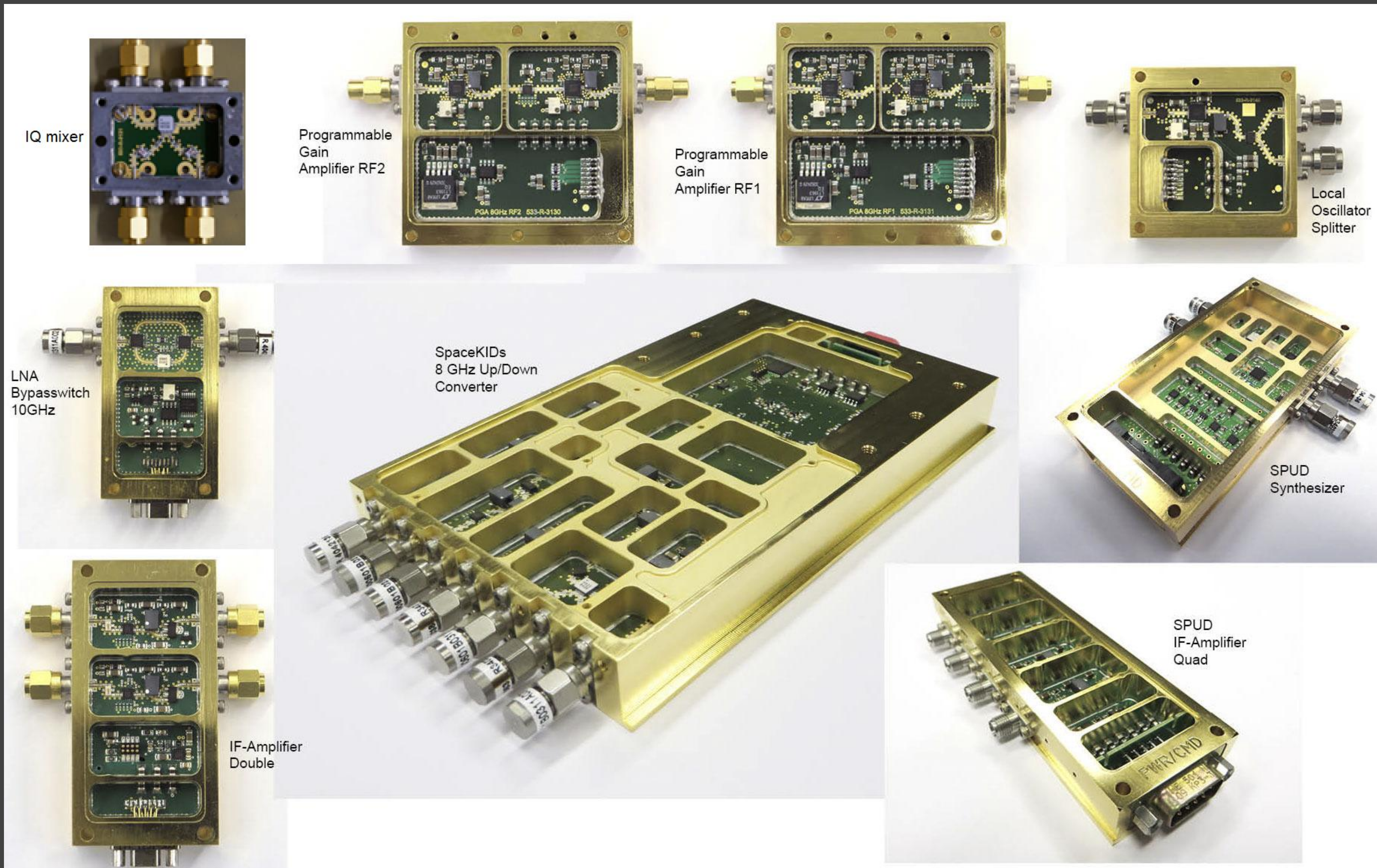
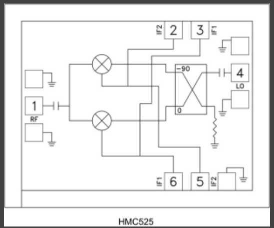
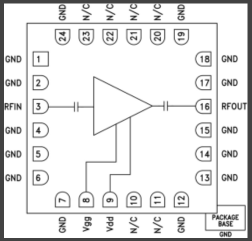
RF modules


IQ mixer
Programmable Gain Amplifier RF2
Programmable Gain Amplifier RF1
Local Oscillator Splitter
LNA Bypasswitch 10GHz
SpaceKIDs 8 GHz Up/Down Converter
SPUD Synthesizer
SPUD IF-Amplifier Quad
IF-Amplifier Double

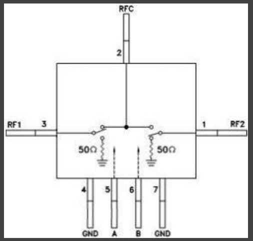
4-8GHz converter board, MMIC RF components



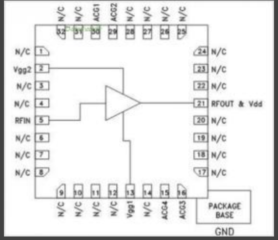
HMC525
IQ mixer



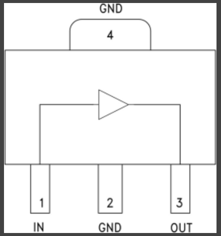
HMC772
LNA



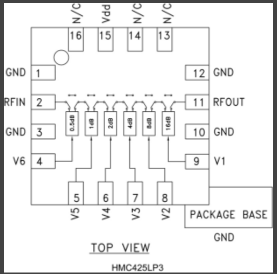
HMC232
Switch (LNA)



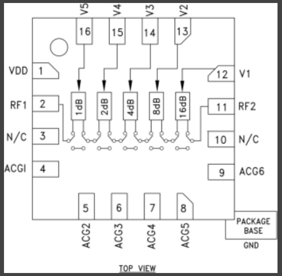
HMC619
RF amp.



HMC741
IF amp.



HMC425
RF attenuator



HMC470
IF attenuator

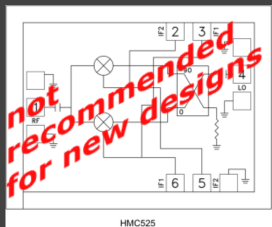
HMC525LC4	**IQ mixer**
HMC619LP5	**RF amplifier**
HMC425LP3	**1/2dB step attenuator**
HMC772LC4	**LNA (RF amplifier)**
HMC232LP4	**RF switch**
HMC741ST89E	**IF amplifier**
HMC470LP3	**1dB step attenuator**

Hittite
MICROWAVE PRODUCTS
FROM ANALOG DEVICES

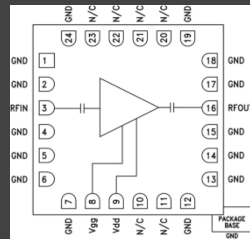
monolithic microwave integrated circuits

SRON

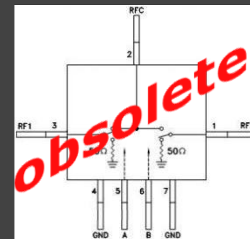
4-8GHz converter board, MMIC RF components



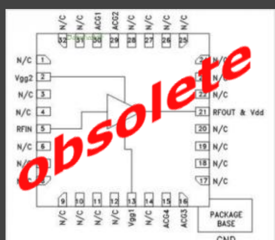
HMC525
IQ mixer



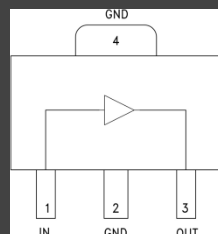
HMC772
LNA



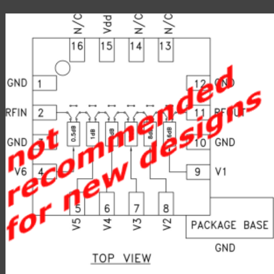
HMC232
Switch (LNA)



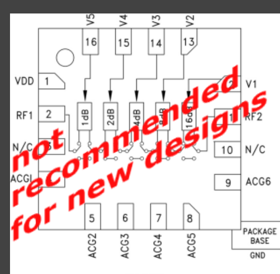
HMC619
RF amp.



HMC741
IF amp.



HMC425
RF attenuator



HMC470
IF attenuator

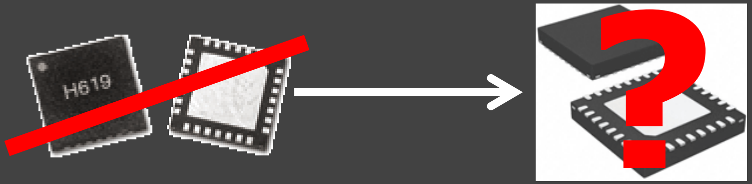
~~HMC525LC4~~	~~IQ mixer~~
~~HMC619LP5~~	~~RF amplifier~~
~~HMC425LP3~~	~~1/2dB step attenuator~~
HMC772LC4	LNA (RF amplifier)
~~HMC232LP4~~	~~RF switch~~
HMC741ST89E	IF amplifier
~~HMC470LP3~~	~~1dB step attenuator~~

Hittite MICROWAVE PRODUCTS FROM ANALOG DEVICES

monolithic microwave integrated circuits

future RF work

- find alternatives for obsolete and not recommended parts
- on board local oscillator
- modify amplifier bias circuits
- small PCB RF improvements
- LNA discrete design
- Upgrade to meet space requirements



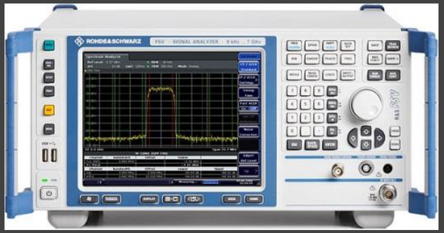
skills and equipment

Rohde & Schwarz

SMF 100A

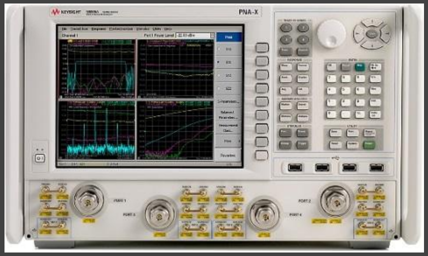
SML 01

ZVL



FSV

Keysight



PNA-X

ASTRON testing-advise

- Erik van der Wal

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- Ed de Vries
- Marcel van Litsenburg
- Mark Leeman
- Rob de la Rie
- Victor van Kooten