Low Level RF of ALBA

(A preliminary study)

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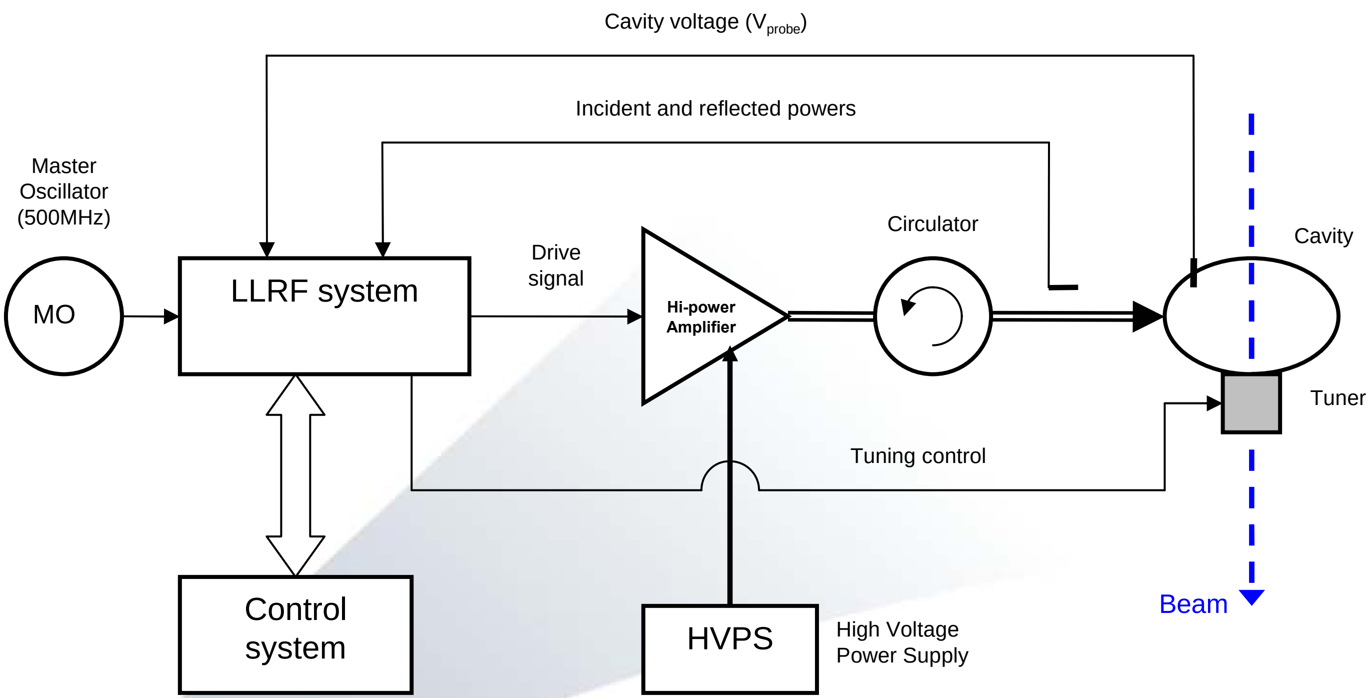
General view of the RF system

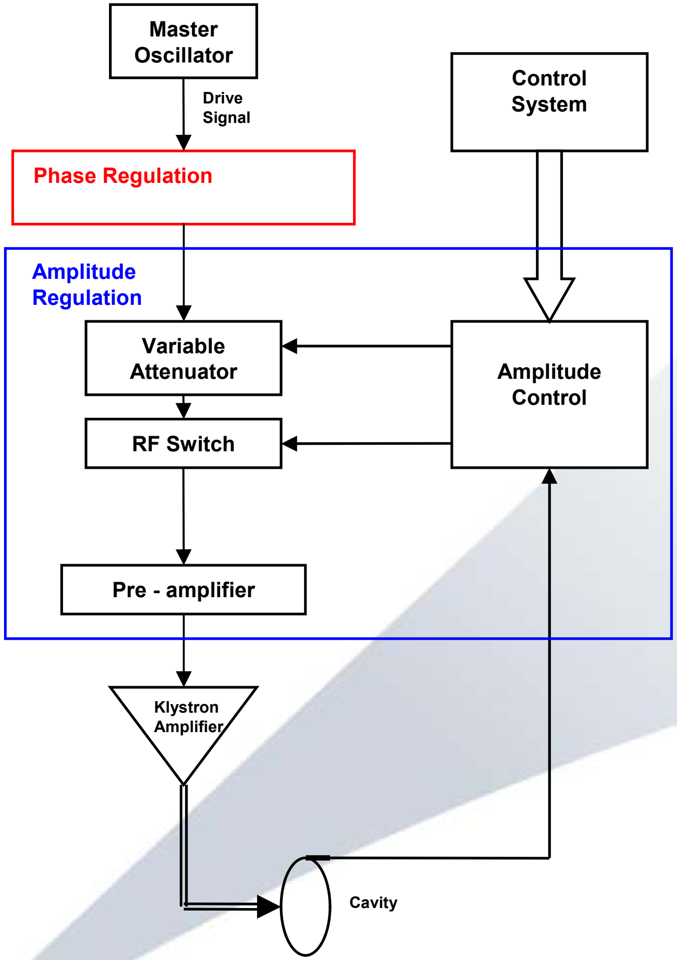


The task of the LLRF is the regulation of the amplitude, frequency and phase of the RF wave.

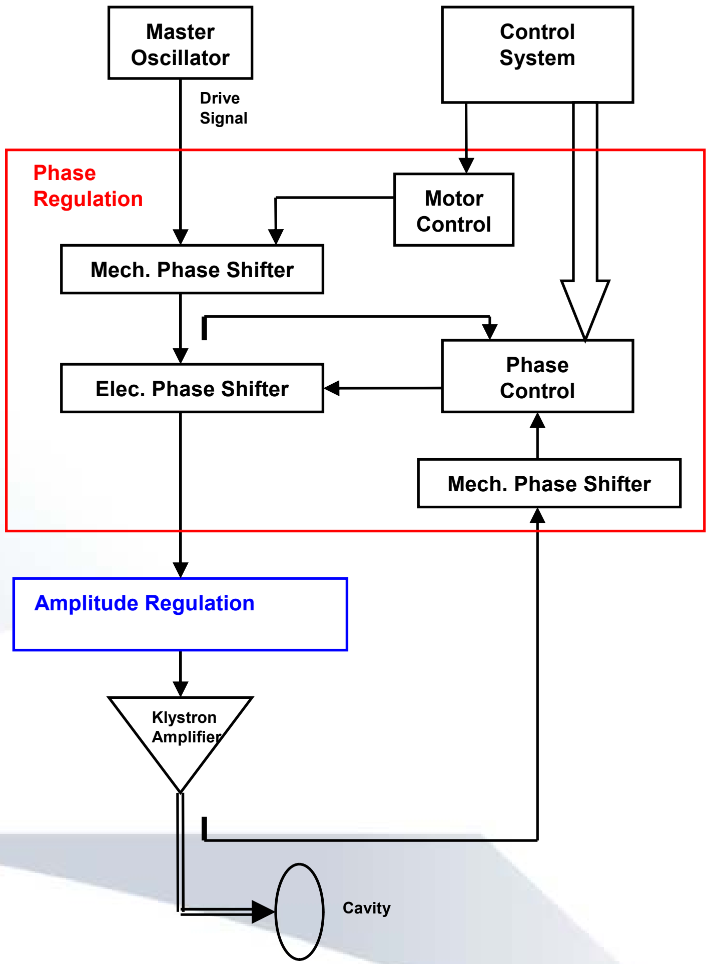
LLRF - hardware

- Sensors for the incident, reflected and cavity power (P_{inc}, P_{refl}, P_{probe})
- The required hardware for the isolation and amplification of the RF signals
- The required Digital / Analog circuits for regulation, interfacing, ADC, DAC, signal processing, etc.
- Drive power amplifier
- PIN diode
- Master oscillator
- Other modules including auxiliary power supplies, PLL, Interlock, etc.

Amplitude and phase regulation loops



a) Amplitude Regulation



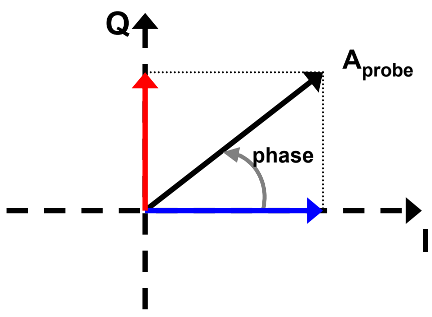
b) Phase Regulation

I-Q demodulator and rotation matrix

Demodulation:

$$V(t) = I.Cos(\omega t) + Q.Sin(\omega t)$$

$$\begin{cases} I = A_{probe} \times Cos(\varphi_{probe} - \varphi_{MO}) \\ Q = A_{probe} \times Sin(\varphi_{probe} - \varphi_{MO}) \end{cases}$$



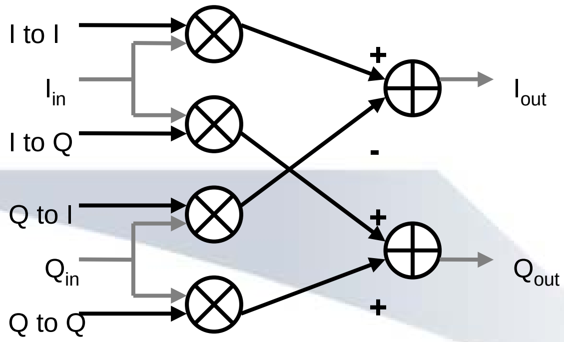
Modulation:

$$A_{probe} = \sqrt{I^2 + Q^2}$$

$$\varphi_{probe} - \varphi_{MO} = \arctan 2(Q/I)$$

Rotation matrix:

$$\begin{bmatrix} I_{out} \\ Q_{out} \end{bmatrix} = A \begin{bmatrix} Cos\theta & -Sin\theta \\ Sin\theta & Cos\theta \end{bmatrix} \times \begin{bmatrix} I_{in} \\ Q_{in} \end{bmatrix}$$

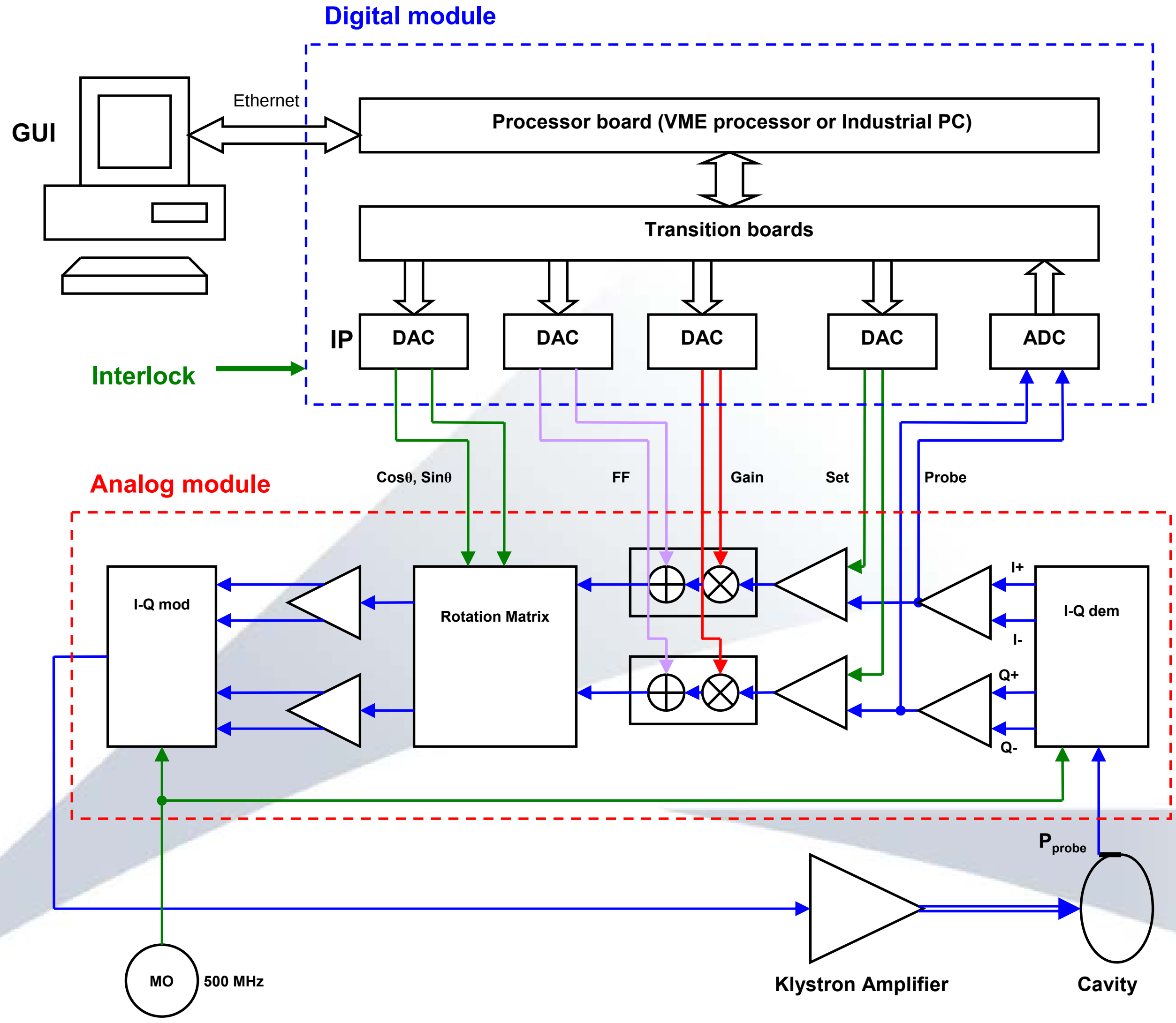


General suggestions for ALBA LLRF

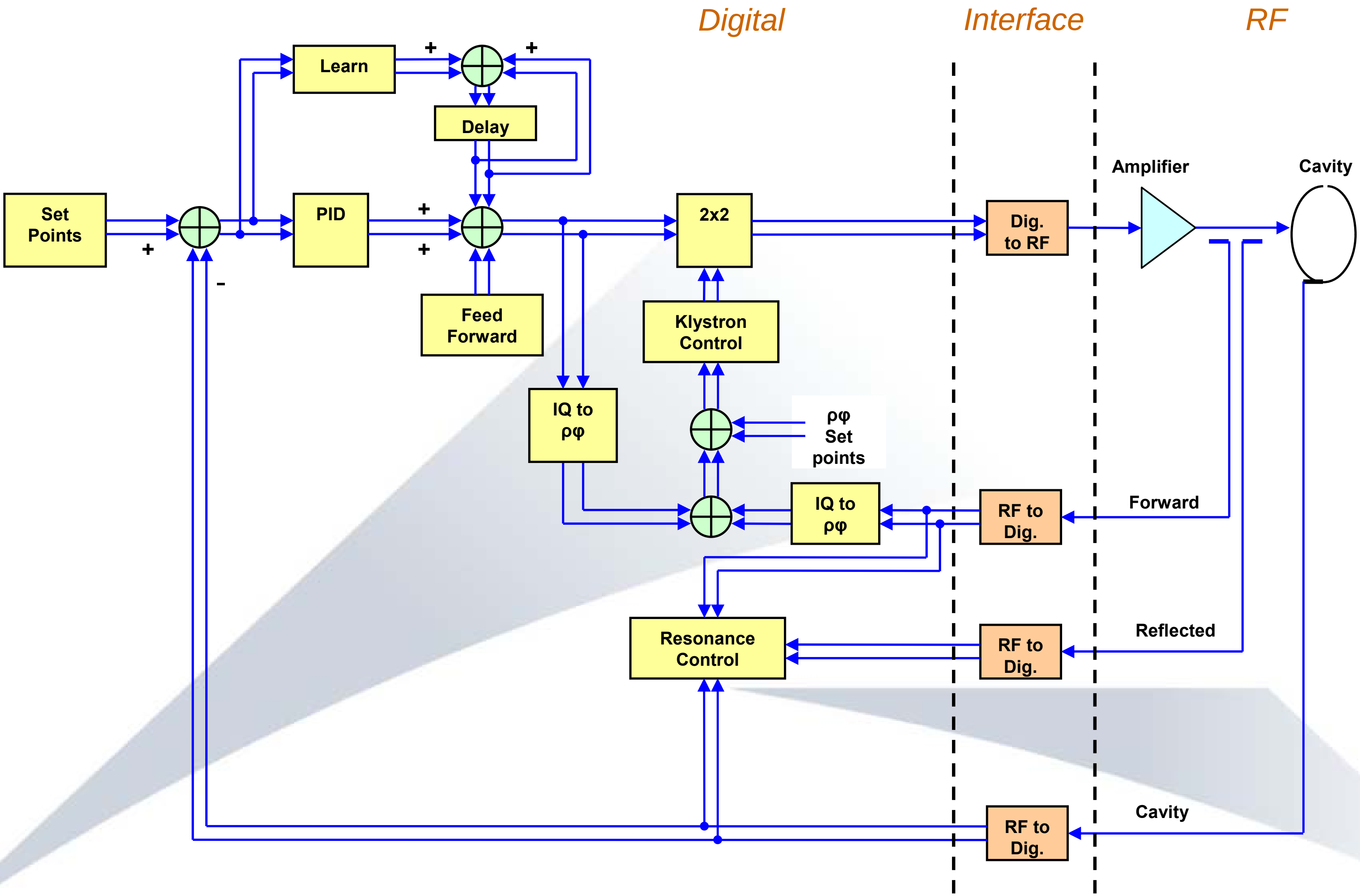
- **I-Q demodulation is more favourable, because two identical regulators will be used acting on baseband signals with wider phase control range compared to the traditional amplitude-phase loops.**

- **It's more desirable to use digital electronics which provides more flexibility, possibility of future changes by the software, better diagnostics and higher functionality compared to analog electronics.**

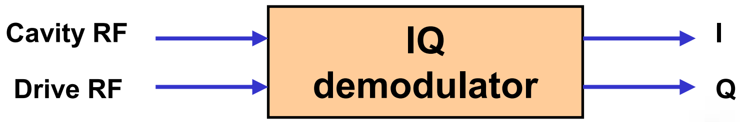
Amplitude / phase control (analog and digital)

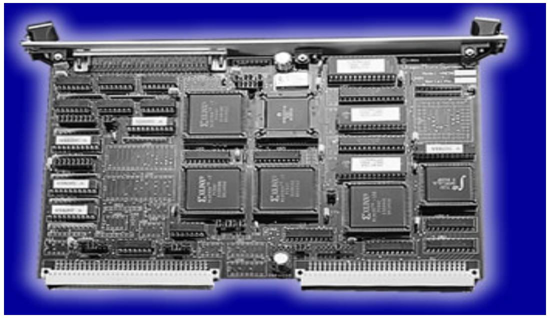


Amplitude / phase control (all digital)



Tuner control





Cavity tuner control:

- An IQ demodulator detects the phase difference between the drive RF and the actual cavity voltage
- The LLRF system drives the phase using the relation Arctan(Q/I)
- The LLRF drives the cavity to maintain the desired phase difference

Inputs / Outputs for LLRF controls

Cavity voltage control inputs:

1. Reference RF
2. Cavity Voltage
3. Cavity In-phase setpoint (FB)
4. Cavity Quadrature setpoint (FB)
5. IQ regulator gains
6. Cavity In-phase setpoint (FF)
7. Cavity Quadrature setpoint (FF)
8. Rotation matrix parameters

Cavity voltage control outputs:

1. Power amplifier drive
2. Cavity voltage In-phase monitor
3. Cavity voltage Quadrature monitor

Cavity tuner control inputs:

1. Cavity voltage
2. Derive RF

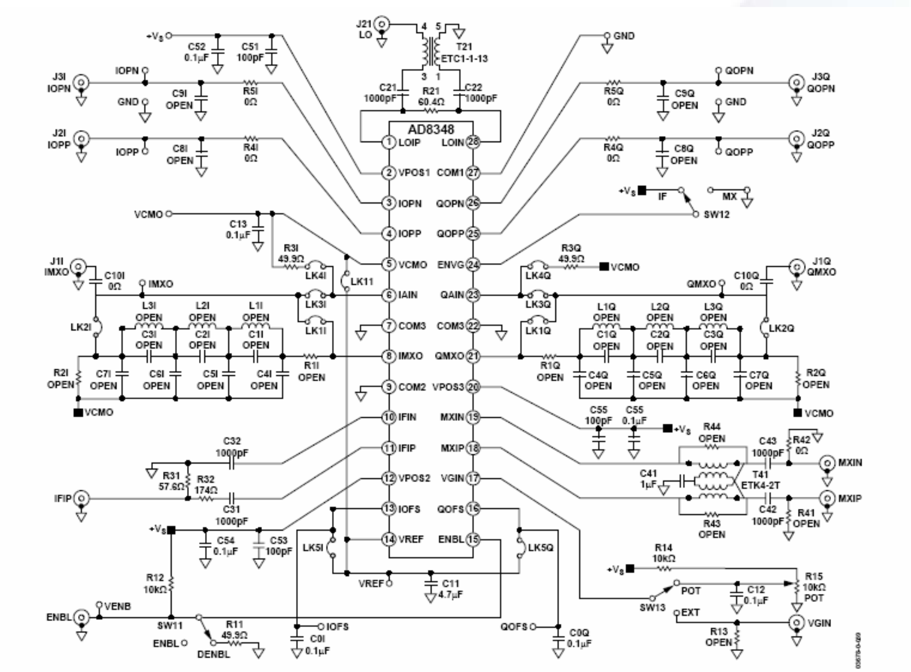
Cavity tuner control outputs:

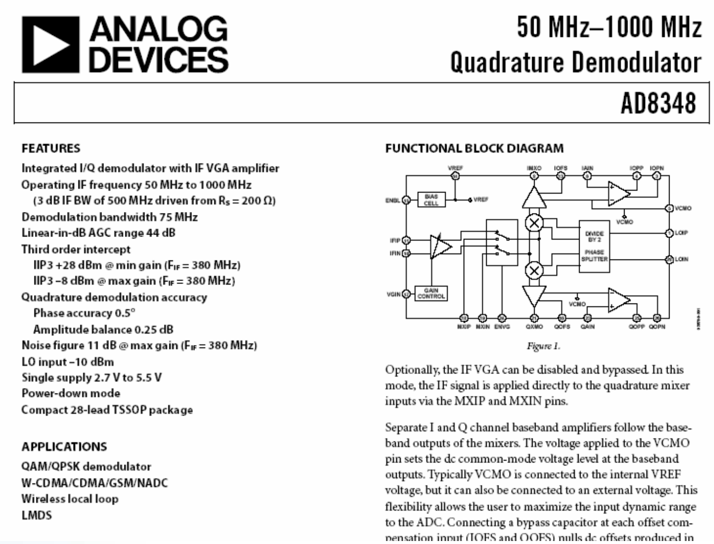
1. Cavity tuning In-phase (I)
2. Cavity tuning Quadrature (Q)

Electrical and performance specifications of the Input / Output signals still have to be defined.

The first step – IQ demodulator

- We'll need it with both Digital and Analog Reg.
- Detailed design is available
- Comparably easy to build
- Can be tested with a function generator





ANALOG DEVICES

50 MHz–1000 MHz Quadrature Demodulator

AD8348

FEATURES

Integrated I/Q demodulator with IF VGA amplifier
Operating IF frequency 50 MHz to 1000 MHz
(3 dB IF BW of 500 MHz driven from R_S = 200 Ω)
Demodulation bandwidth 75 MHz
Linear-in-dB AGC range 44 dB
Third order intercept
IIP3 +28 dBm @ min gain (F_{IF} = 380 MHz)
IIP3 −8 dBm @ max gain (F_{IF} = 380 MHz)
Quadrature demodulation accuracy
Phase accuracy 0.5°
Amplitude balance 0.25 dB
Noise figure 11 dB @ max gain (F_{IF} = 380 MHz)
LO input −10 dBm
Single supply 2.7 V to 5.5 V
Power-down mode
Compact 28-lead TSSOP package

APPLICATIONS

QAM/QPSK demodulator
W-CDMA/CDMA/GSM/NADC
Wireless local loop
LMDS

FUNCTIONAL BLOCK DIAGRAM

Figure 1.

Optionally, the IF VGA can be disabled and bypassed. In this mode, the IF signal is applied directly to the quadrature mixer inputs via the MXIP and MXIN pins.

Separate I and Q channel baseband amplifiers follow the baseband outputs of the mixers. The voltage applied to the VCMO pin sets the dc common-mode voltage level at the baseband outputs. Typically VCMO is connected to the internal VREF voltage, but it can also be connected to an external voltage. This flexibility allows the user to maximize the input dynamic range to the ADC. Connecting a bypass capacitor at each offset compensation input (IOFS and QOFS) nulls dc offsets produced in

The next steps

1. I-Q demodulator (AD8348 from Analog Devices)

   - Can be designed and made at CELLS

   - Test with a function generator

2. Other parts of the "Analog module"

3. ADC, DAC and processor boards ("Digital Module")

   - Off the shelf, but still need programming

   - will be done in collaboration with the Control Group

4. Test with simulated system

5. Interfacing with the control system and GUI

   - Will be done mainly by the Control Group

6. Commissioning and trouble-shooting