Master Oscillator Concept for ESS

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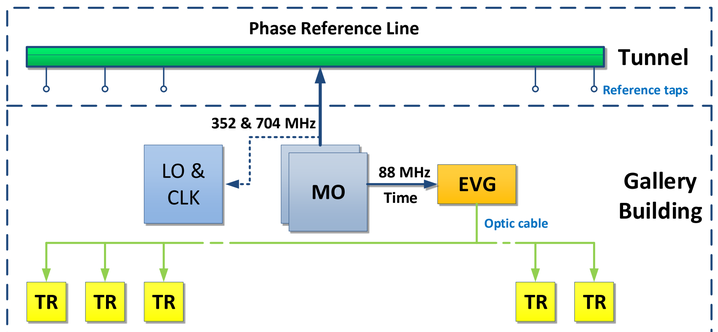
The ESS Master Oscillator (MO) is the primary time and frequency source for LINAC and Target. It provides two reference signals, 352 MHz and 704 MHz, to the Phase Reference Line (PRL) that is being used by LLRF and Beam Instrumentation. It also provides accurate timing for the whole ESS timing infrastructure interfacing the Event Generator (EVG). Timing information is distributed over optic fiber to local timing receivers (TR). LO and Clk generation used by LLRF and BPM is also using reference from the MO.

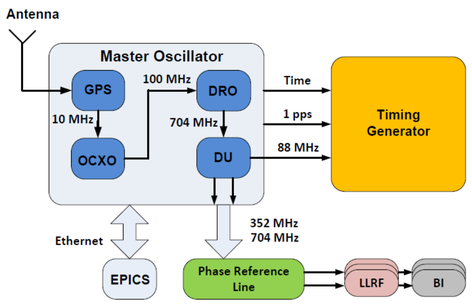
All signals will be generated from one common source and being phase locked to each other. This means the pulse frequency of the accelerator will not be exactly 14 Hz, but instead 88.0525 MHz divided by 6289464 giving 14.000000636 Hz. This way there will always be the same integer number of RF cycles in the accelerator between each pulse start. The target wheel is synchronized to the timing system and MO.



MO architecture and main building blocks

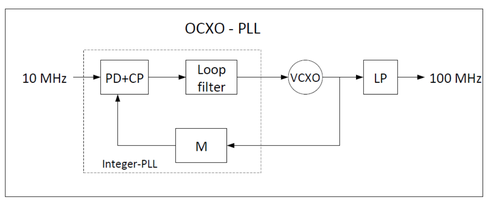
MO main build blocks and functions:

- GPS disciplined Rubidium source provides accurate timing on long scale
- OCXO PLL with low jitter provides accurate timing on short time scale
- DRO PLL comprise low phase noise 704.42 MHz source
- Distribution unit generates 352.21 MHz and 88.0525 MHz
- Ethernet interface to EPICS for monitoring and control



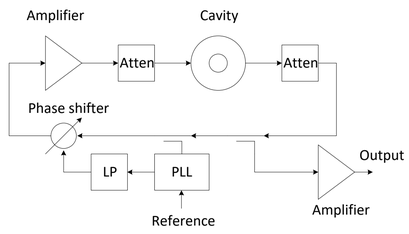
OCXO - PLL

The OCXO is a SC-cut oven controlled VCXO at 100 MHz providing reference to the DRO. An active loop filter is used to utilize the full VCO control range.



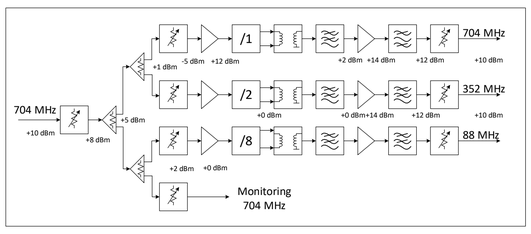
DRO – PLL

A DRO topology is chosen for the high Q and thereby excellent phase noise performance. It is designed for 704.42 MHz since DR dimensions gets to large at lower frequencies. A fractional-N PLL is adjusting the phase shifter to keep it locked to the reference.



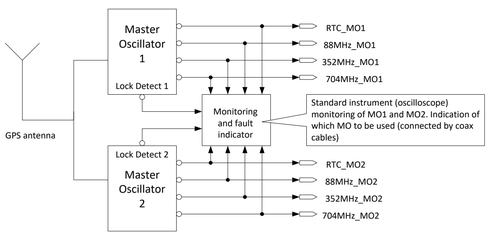
Distribution unit

Low jitter dividers are used to generate the lower frequencies. Also the 704 MHz signal is fed through a divider to minimize the phase drift between the paths. All outputs will be sinusoidal at 10 dBm.



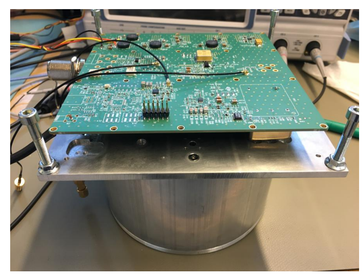
Availability

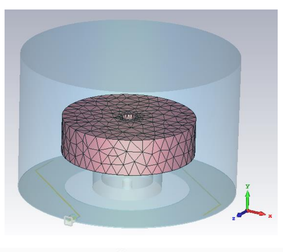
High availability is of great importance as MO failure will cause the whole machine to stop, and therefore redundancy will be utilized. Two Master Oscillators will be running at the same time, one being active and the other as hot spare. Both will be continuously monitored and compared, and the active unit is selected manually from a switch box to avoid extra complexity and failure probability.



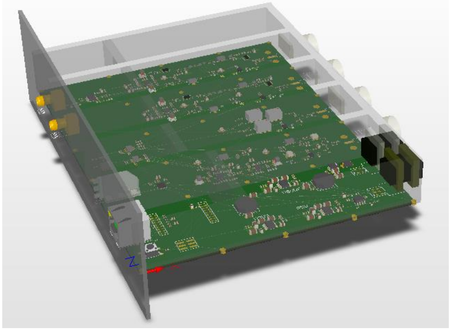
Implementation

OCXO and DRO are implemented on the same PCB where electronics are place on one side and the cavity with the DR on the other side. The distance between DR and microstrip traces on the cavity side decides the amount of coupling through the cavity, and thus changing the loaded Q.





The Distribution Unit is made on a separate PCB and mechanics. The frequency divider outputs are balanced LVPECL and baluns are used to convert to single ended before fed to low pass filters and low noise gain blocks. The unit is supplied with DC and have several LDO's to keep the output signals clean.



The monitoring and comparison of the two MO units have yet not been implemented but will likely be a simple system with phase detectors and standard oscilloscope.

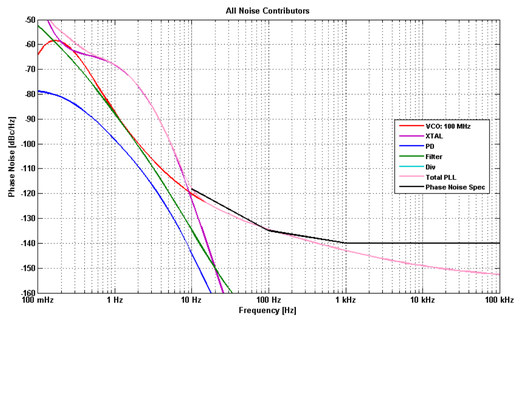
Status and test results

A first prototype made with individual modules interconnected with coax cables to commercial evaluation boards have been evaluated as a proof of concept. A second prototype integrated on two PCBs has been designed and manufactured. The evaluation has just started and first results are looking promising. Unfortunately there is yet no available results for the Distribution Unit.

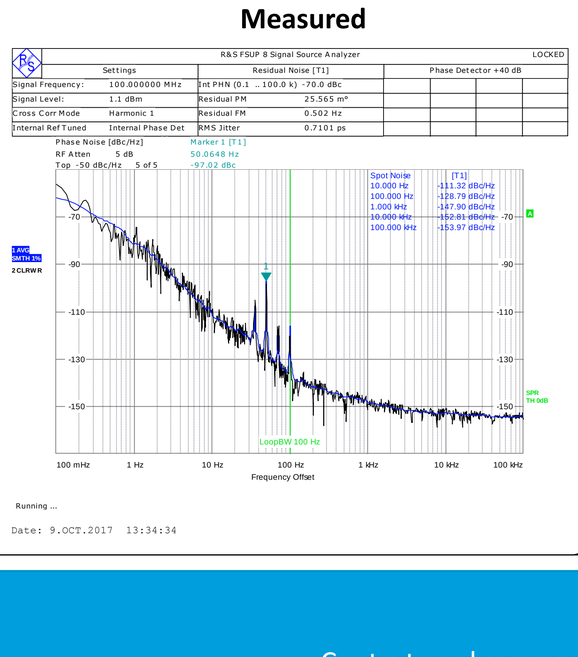
OCXO

Simulated and measured phase noise of the integrated OCXO

Simulated



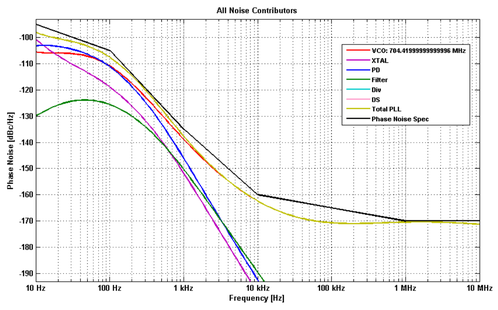
Measured



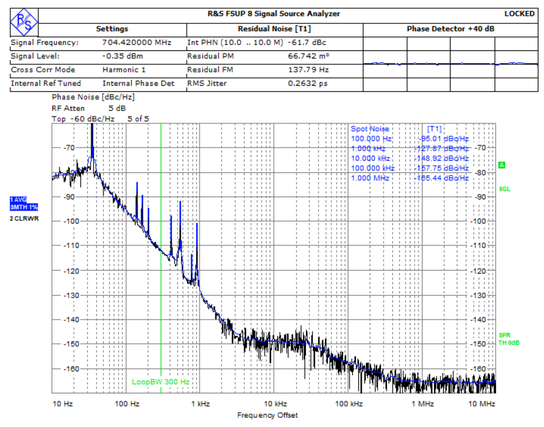
DRO

Simulated and measured results of the DRO. The measured results are obtained from the first prototype since results of the integrated version is not available

Simulated



Measurement of first prototype



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