GPS Disciplined Quartz Frequency Standard

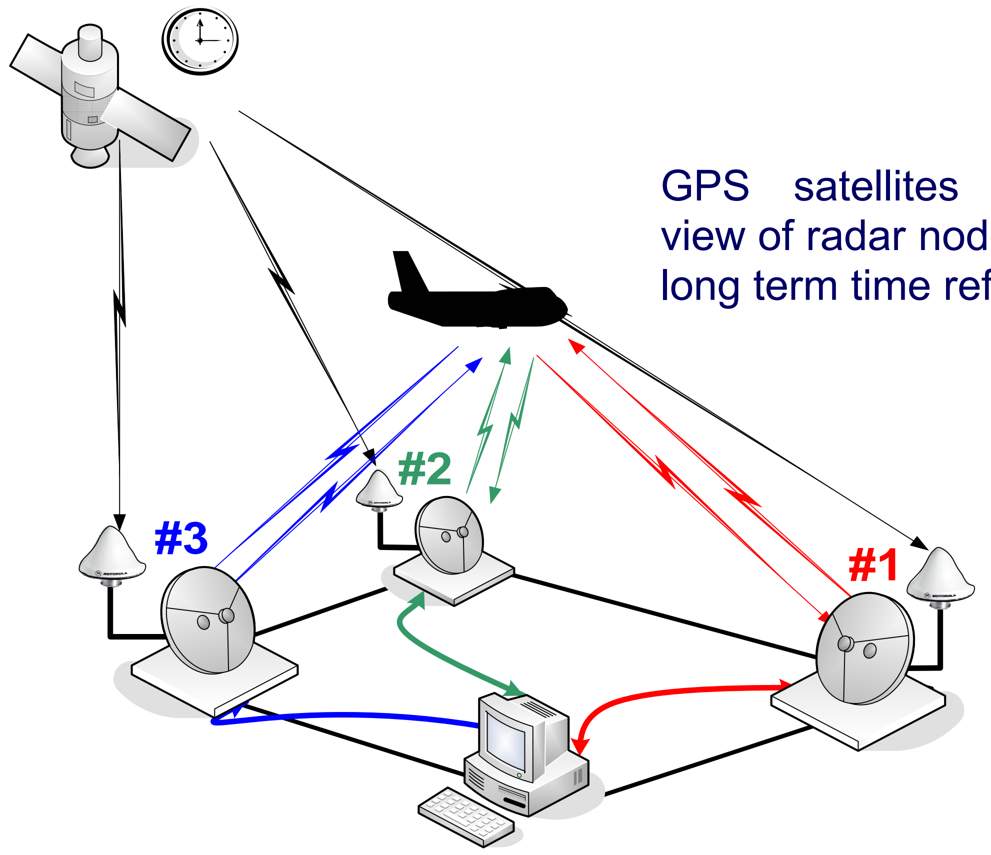
Student: J.S. Sandenbergh **Supervisor: M.R. Inggs**

Abstract

In this research the viability of synchronizing a coherent netted radar system, using GPS time transfer techniques (GPSTT), will be tested. The study is done using in-house designed common-view GPS disciplined quartz oscillators (GPSDO). More specifically, the relationship between time synchronization and coherence in a netted radar system will be determined experimentally. Some initial experiments were already conducted in collaboration with the University College London (UCL). These and other experimental results will later be verified using the FERS (see www.brooker.co.za/fers) simulator that is under development at UCT.

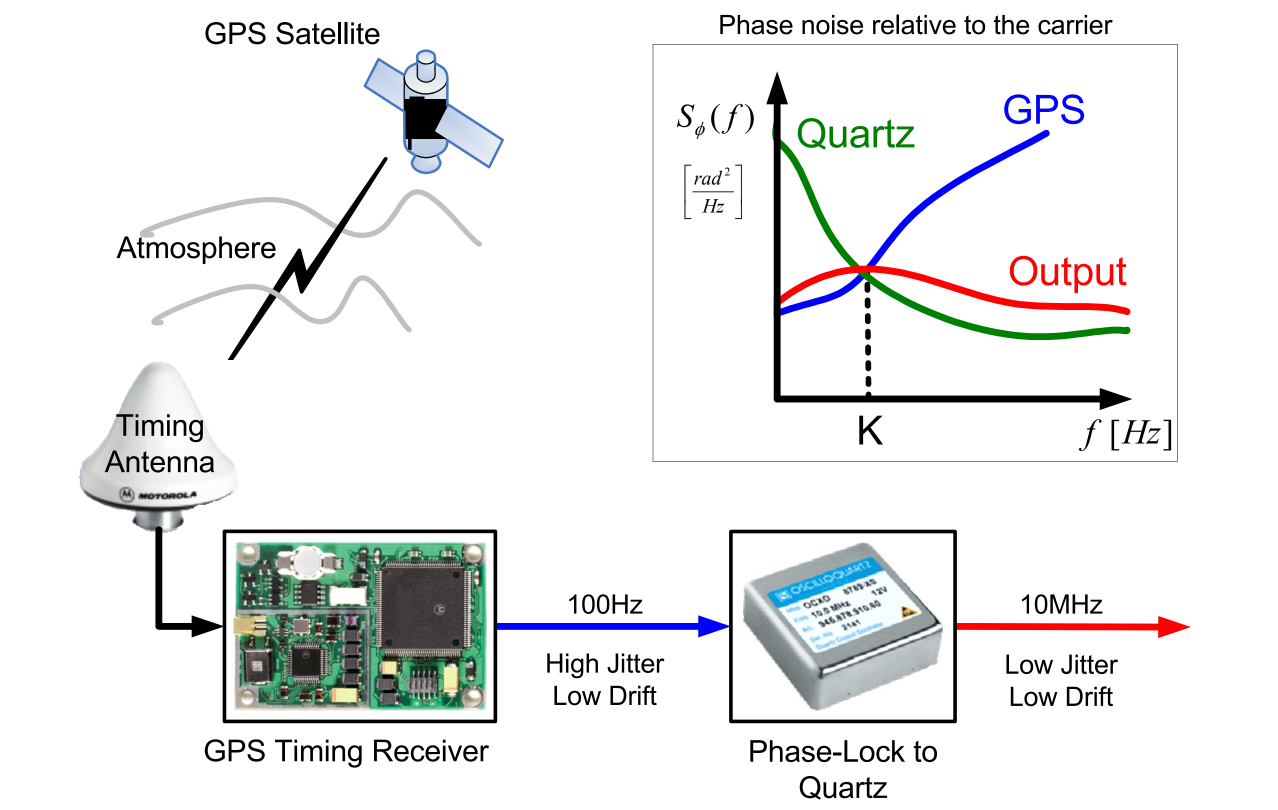
Research on netted radar is driven by the need for improved detection performance, especially for targets with varying radar cross-sections (RCS). Multiple radar sensors that cooperate within a common reference frame of time and space are the underlying principle of netted radar. If each node has an exact knowledge of this common reference frame, it is said that the system operates coherently.

One of the complexities, which have hindered coherent operation in the past, is that of synchronizing the radar nodes. GPS time transfer may pose an elegant solution to this problem. When a GPS timing signal is phase-locked to a quartz oscillator, it results in a low cost frequency standard with stability traceable to the reference atomic standard. Each node gains knowledge of the common reference frame via a common view of the GPS constellation in a completely autonomous fashion.



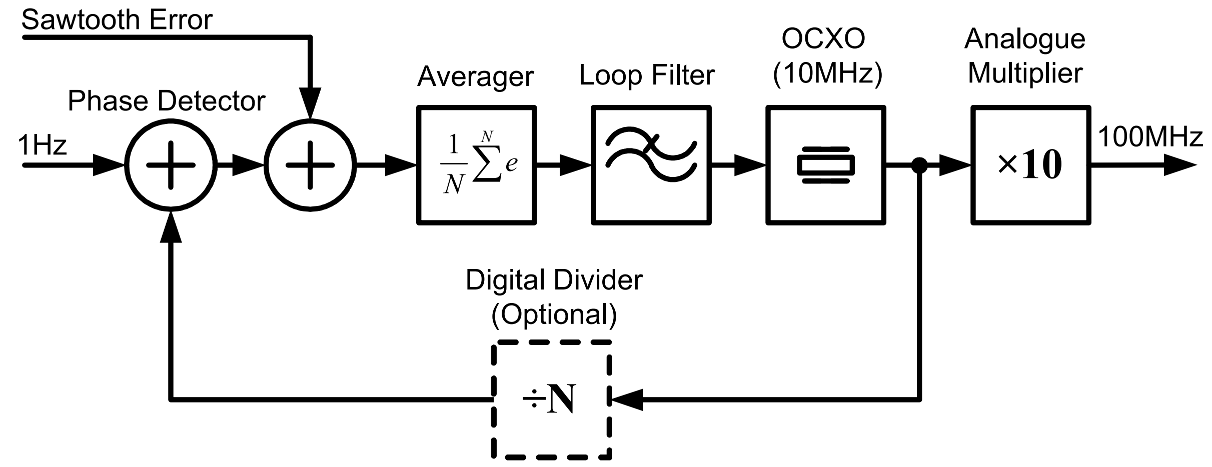
GPS satellites in common view of radar nodes supply the long term time reference

Functional Description and Performance



Courtesy to Motorola and Oscilloquartz for the photos taken from their datasheets

The high frequency jitter that is present in the GPS time mark is filtered by locking it to a low phase noise quartz oscillator. This is done by using the hybrid analogue/digital PLL that is shown above and below.



Some technical specifications and performance characteristics of the designed GPSDOs are given below.

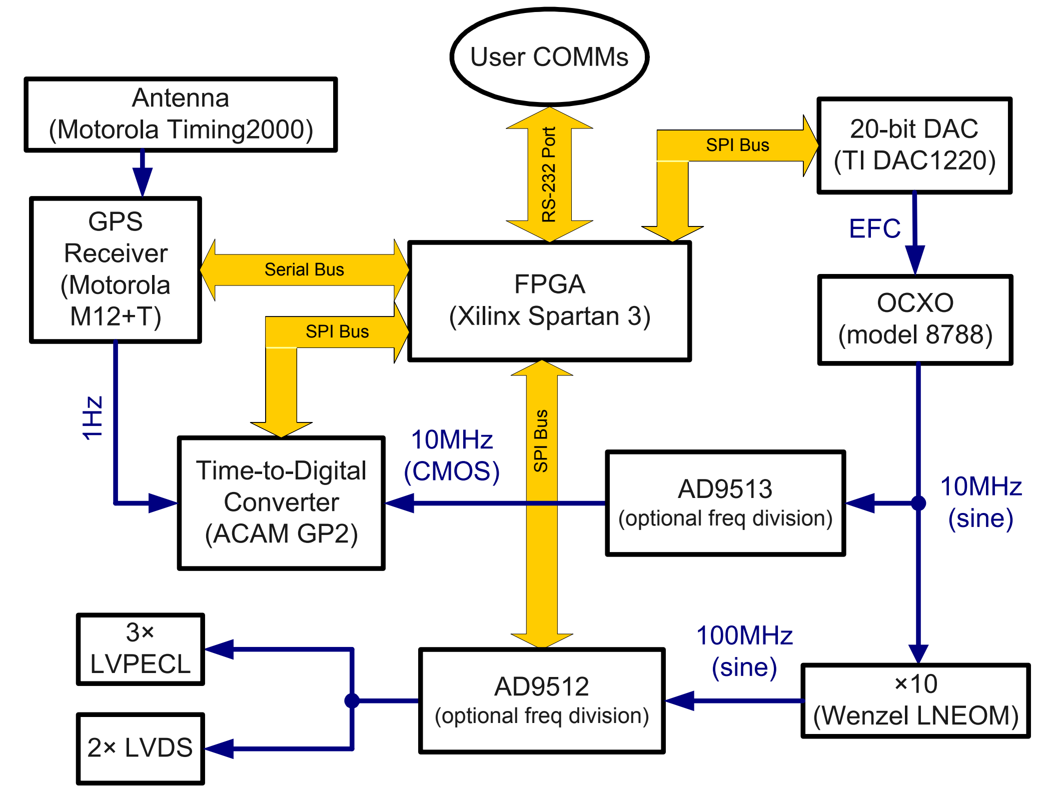
Offset from carrier	Phase Noise (dBc/Hz) OCXO 8788 (10MHz)	Phase Noise (dBc/Hz) Expected after 10x multiplication (100MHz)
1 Hz	-100	--
10 Hz	-130	-78
100 Hz	-152	-108
1 kHz	-160	-130
10 kHz	-165	-138
100 kHz	-165	-143
1 MHz	-165	-143

Parameter	Specification	Value/Comment
1Hz GPS Time Reference (Motorola M12+)	Timing Accuracy	<2ns (1sigma)
		<6ns (6sigma)
OCXO (Oscilloquartz 8788)	Frequency	10MHz
	Long term stability	5×10^{-10} /day
	Short term stability	$<1\times10^{-12}$ (1s Adev)
	EFC (full-scale)	1.6×10^{-6}
	Phase Noise	See Table
Phase Detector (Acam GP2)	Resolution	50ps
	Accuracy	50ps
	Max. PD range	1.8us
	Max. input frequency	10MHz
DAC (TI DAC1220)	Resolution	20 bit
Clock Outputs	1Hz (LVDS)	GPS output
	1Hz (LVDS)	10MHz derived
	10MHz (sine)	Differential
	10MHz (LVDS)	1-32 integer division
	100MHz (3x LVPECL)	1-32 integer division
	100MHz (2x LVDS)	1-32 integer division
External Reference Input	Up to 10MHz	Alternative to 1Hz GPS Reference

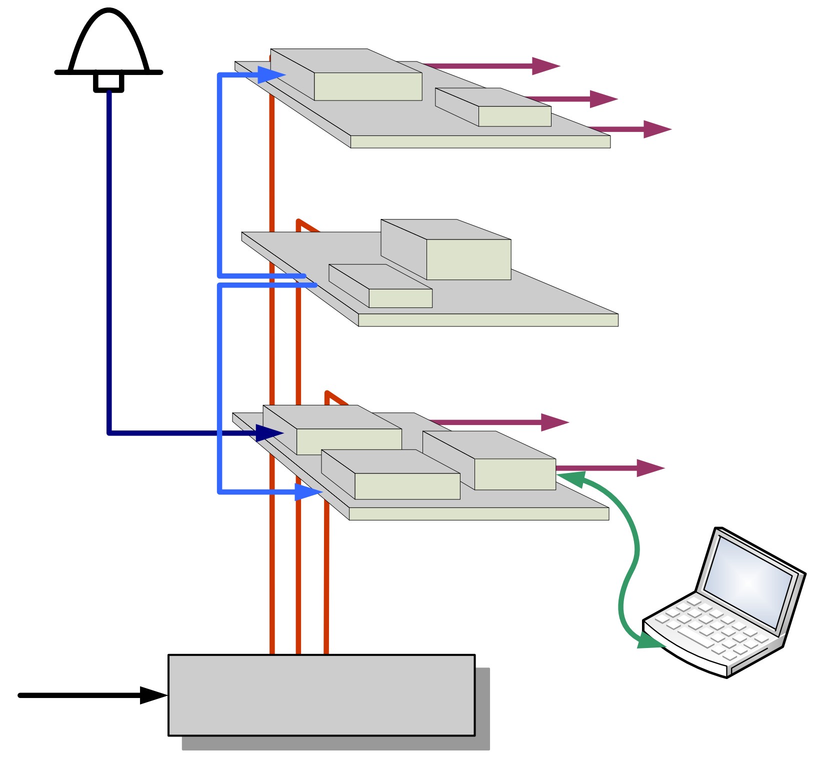
This work is kindly sponsored by the South African National Defense Force.

Hardware Architecture

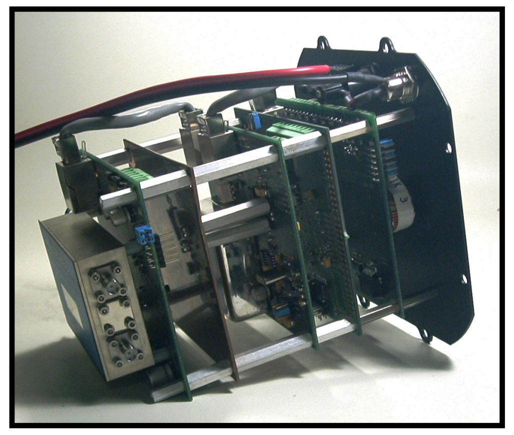
A simplified block diagram of the hardware blocks.



The system is spread across multiple PCBs. This eases system upgrades and hardware re-configuration



Some photos showing the built board-stack and front panel.



Radar Remote Sensing Group, Department of Electrical Engineering, University of Cape Town, Rondebosch, 7701, South Africa
http://www.rrsg.uct.ac.za