Plans for GEO Pulsar Hardware Injections

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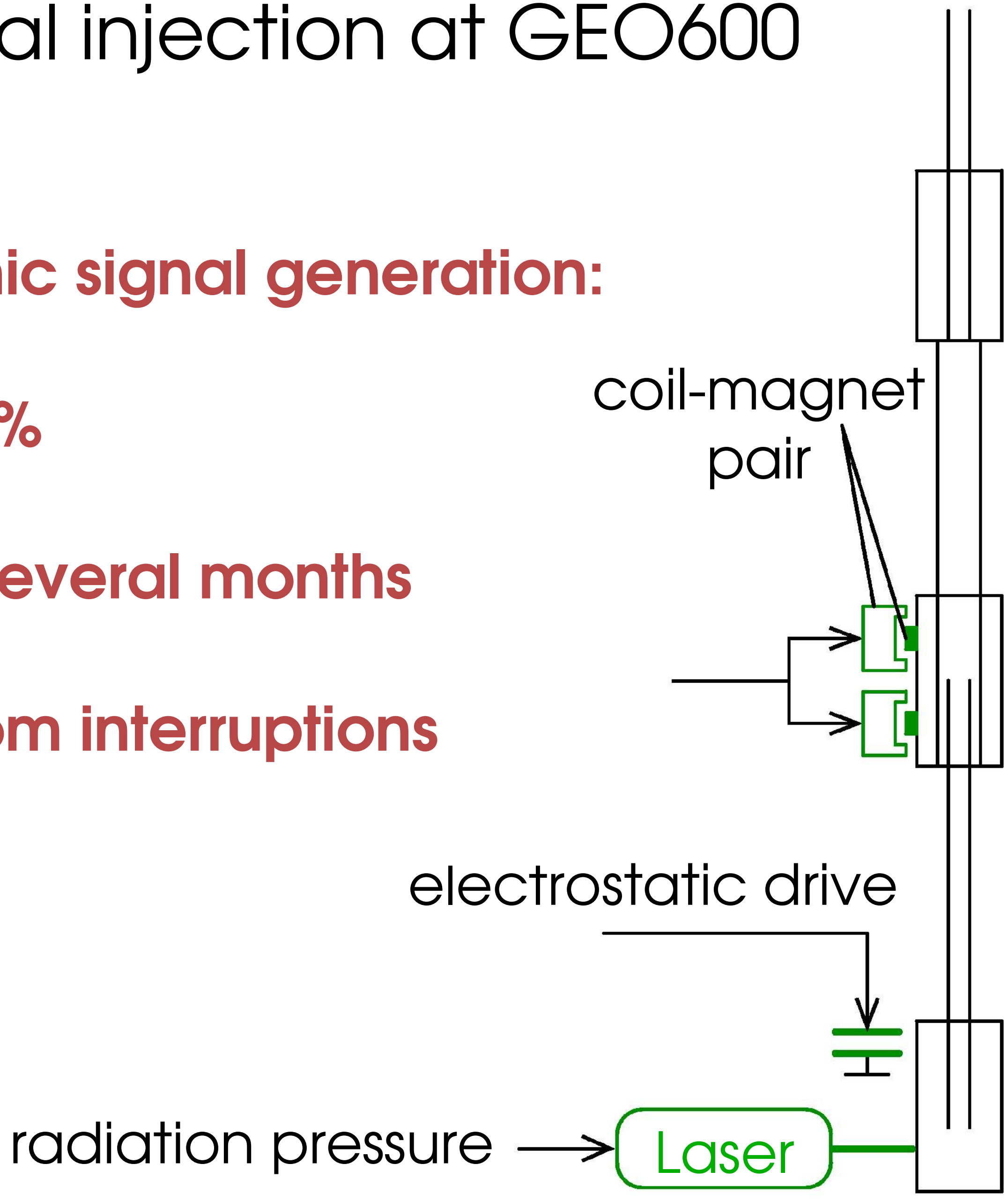
Pulsar signal injection at GEO600

GOAL for electronic signal generation:

- **phase error < 1%**
- **injection over several months**
- **recoverable from interruptions**



Gravitational wave signal of a pulsar

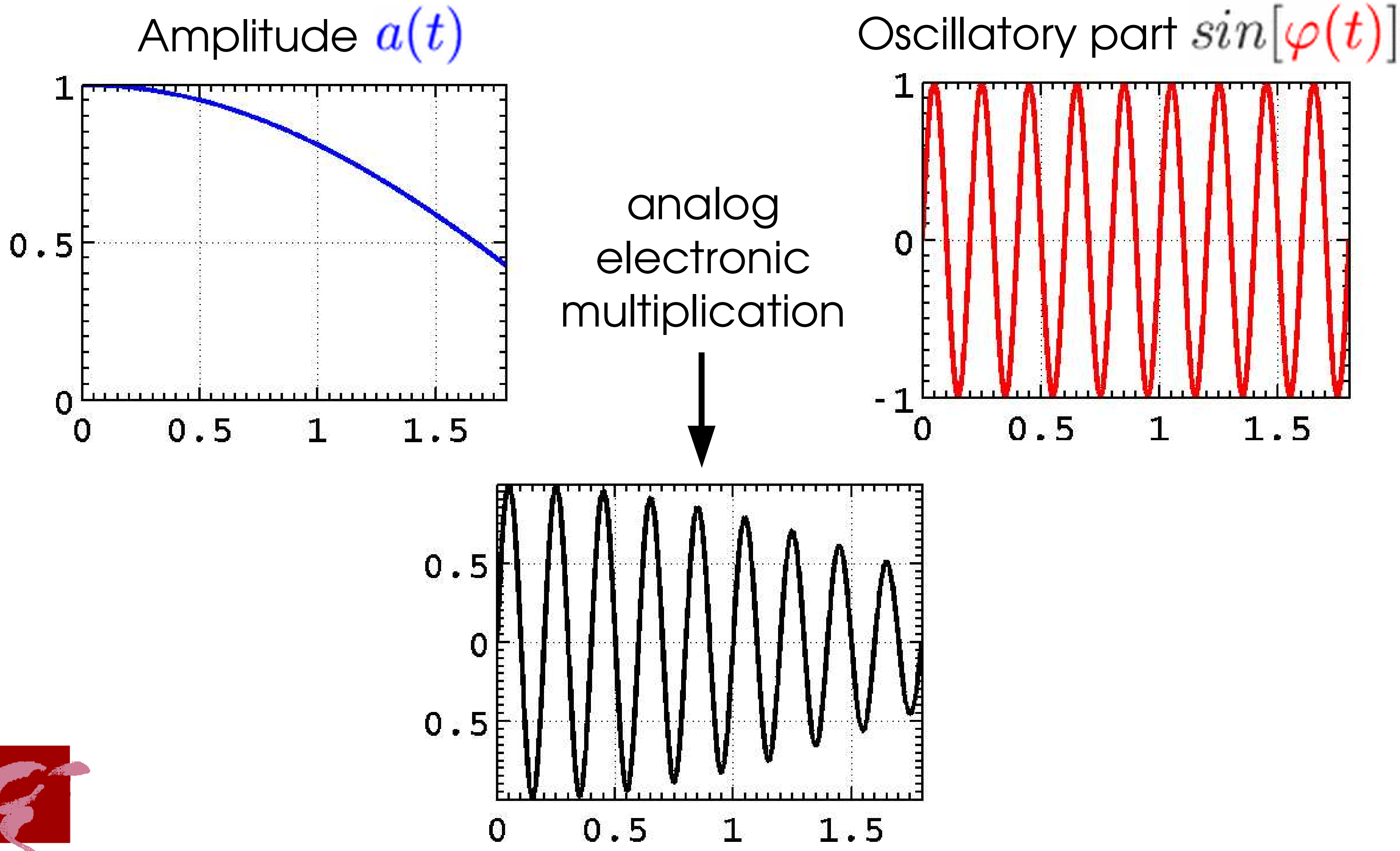
$$h(t) = F_+(t)\frac{1}{2}h_0(1+\cos^2\iota)\cdot\cos 2\psi(t) + F_\times(t)h_0\cos\iota\cdot\sin 2\psi(t)$$

Seperate amplitude and phase of the signal:

$$h(t) = \underbrace{h_0\sqrt{F_+^2(t)\frac{1}{4}(1+\cos^2\iota)^2 + F_\times^2(t)\cos^2\iota}}_{a(t)}$$

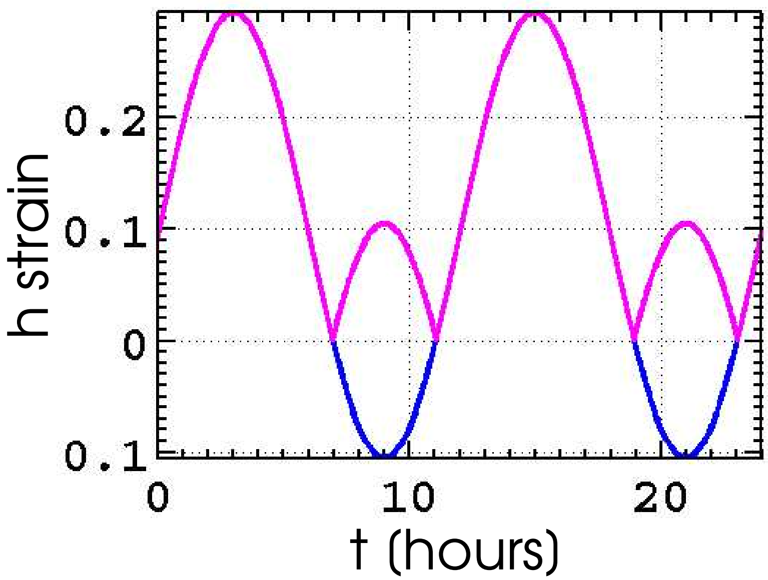
$$\cdot\sin[\underbrace{2\cdot\psi(t) + \arctan\frac{F_+(t)(1+\cos^2\iota)}{2\cdot F_\times(t)h_0\cos\iota}}_{\varphi(t)}]$$

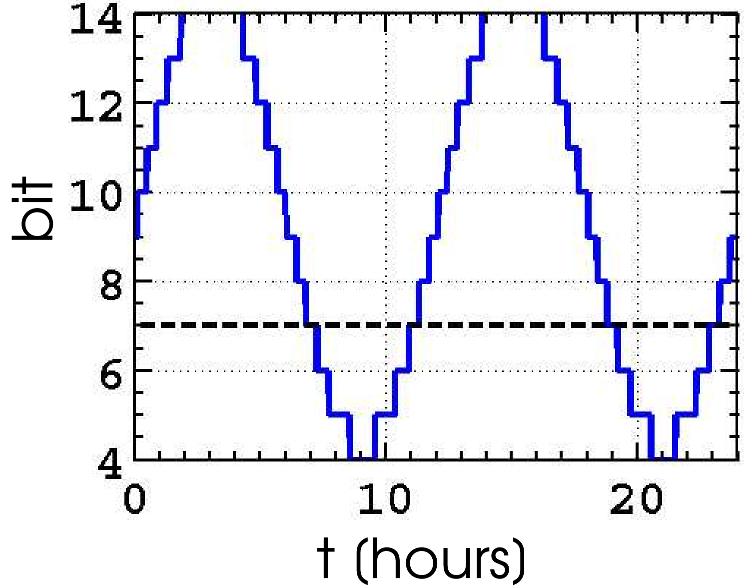
Microcontroller as direct digital synthesiser



Amplitude mapping

$$a(t) = h_0 \sqrt{F_+^2(t)\frac{1}{4}(1+\cos^2\iota)^2 + F_\times^2(t)\cos^2\iota}$$

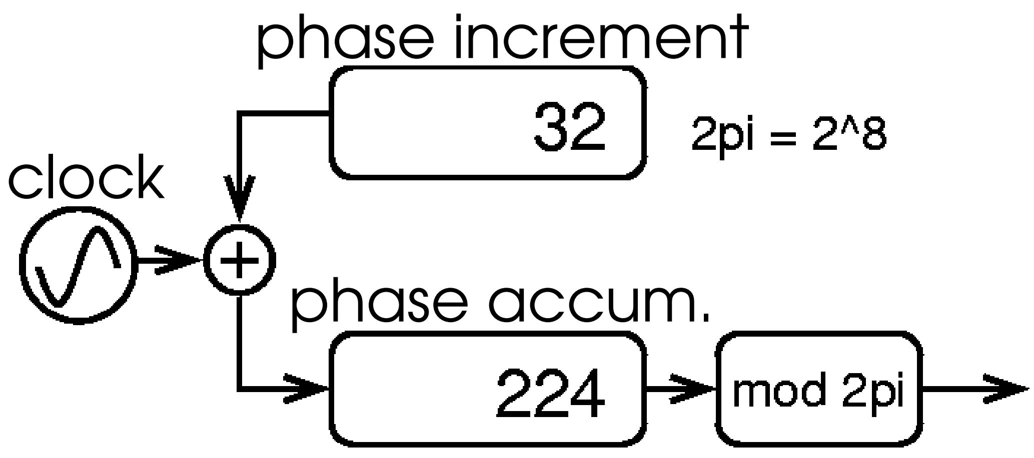


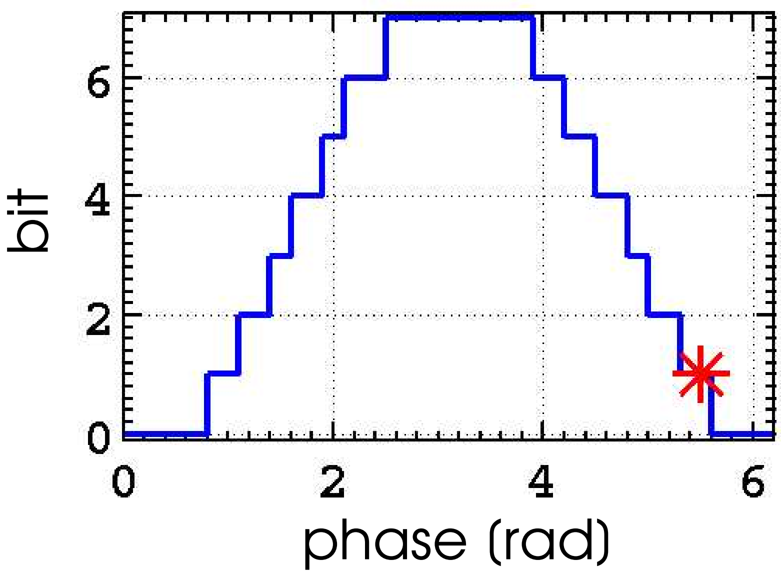


Microprocessor:

DA converter with 8-bit resolution symmetric about zero

Frequency synthesiser





phase accum.	DA bit
$[0, 0.255 \cdot \pi)$	0
$[0.255 \cdot \pi, 0.35 \cdot \pi)$	1
$[0.35 \cdot \pi, 0.446 \cdot \pi)$	2
$[0.446 \cdot \pi, 0.509 \cdot \pi)$	3
$[0.509 \cdot \pi, 0.605 \cdot \pi)$	4
$[0.605 \cdot \pi, 0.668 \cdot \pi)$	5
$[0.668 \cdot \pi, 0.796 \cdot \pi)$	6
$[0.796 \cdot \pi, 1.241 \cdot \pi)$	7
$[1.241 \cdot \pi, 1.337 \cdot \pi)$	6
$[1.337 \cdot \pi, 1.432 \cdot \pi)$	5
...	...

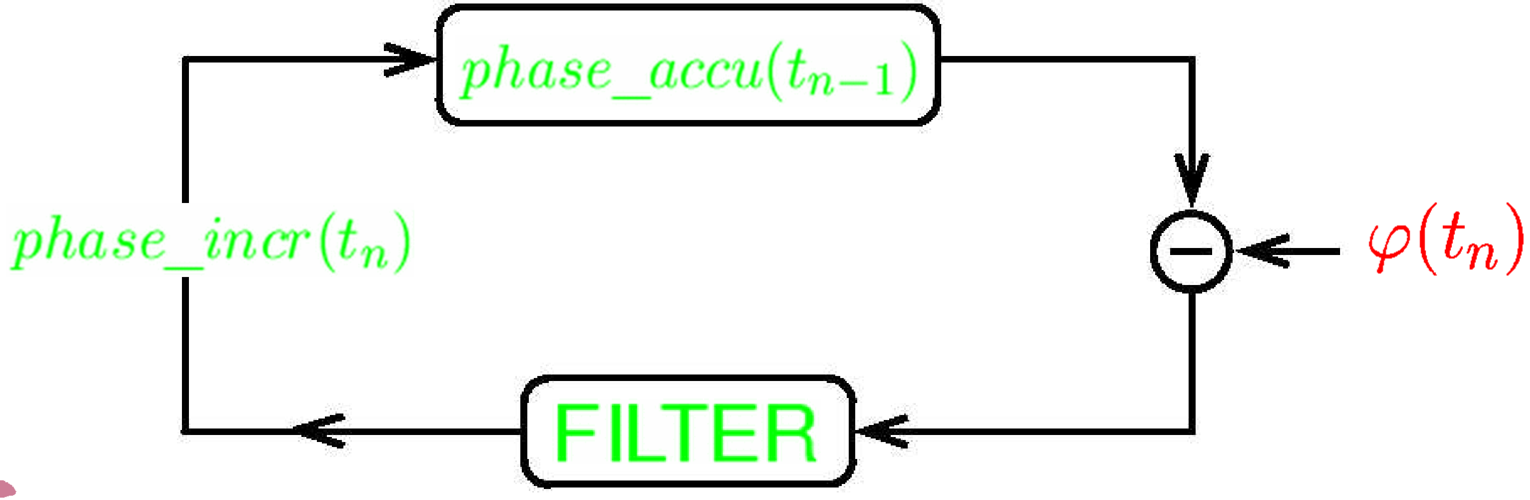
$$f = \frac{phase\ incr}{2^n} \cdot f_{clock}$$

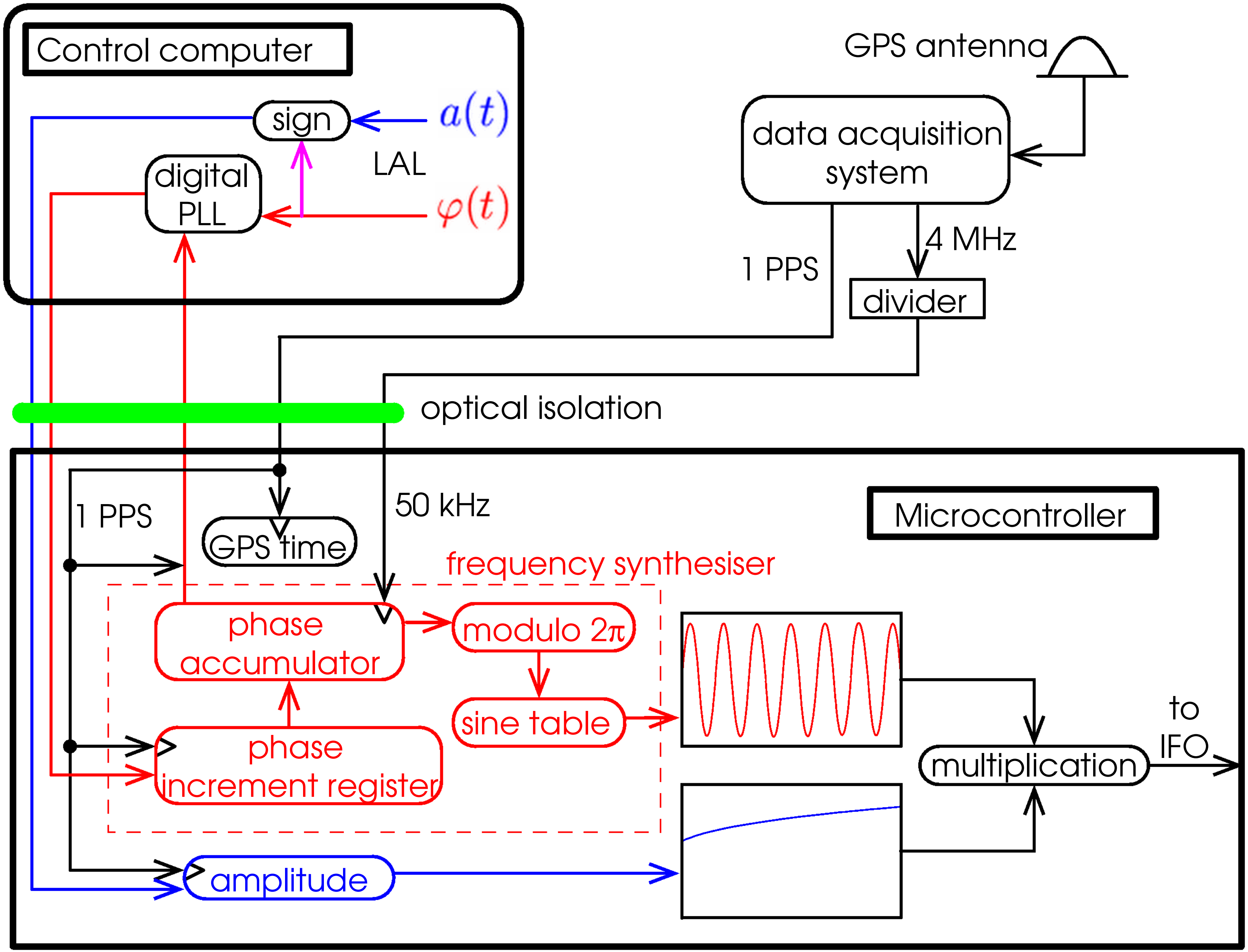
Phase locked loop

Lock the microcontroller phase

$$phase\_accu(t_n) = phase\_accu(t_{n-1}) + \frac{CLOCK}{SRATE} \cdot phase\_incr(t_{n-1})$$

to the signal phase $\varphi(t) = 2 \cdot \psi(t) + \arctan \frac{F_+(t)(1+\cos^2 \iota)}{2 \cdot F_\times(t) h_0 \cos \iota}$





Control computer
sign
$a(t)$
LAL
digital PLL
$\varphi(t)$
GPS antenna
data acquisition system
4 MHz
1 PPS
divider
optical isolation
50 kHz
Microcontroller
1 PPS
GPS time
frequency synthesiser
phase accumulator
modulo 2π
sine table
phase increment register
multiplication
to IFO
amplitude

Summary and outlook

- Hardware is built and first stable PLLs are running
- Implement combined phase and amplitude control into microprocessor setup
- Move setup to the site to record and characterise electronic analog signal
- Test hardware injection into interferometer
- Simulations show that a continuous wave signal with a phase error < 1% over several months is achievable