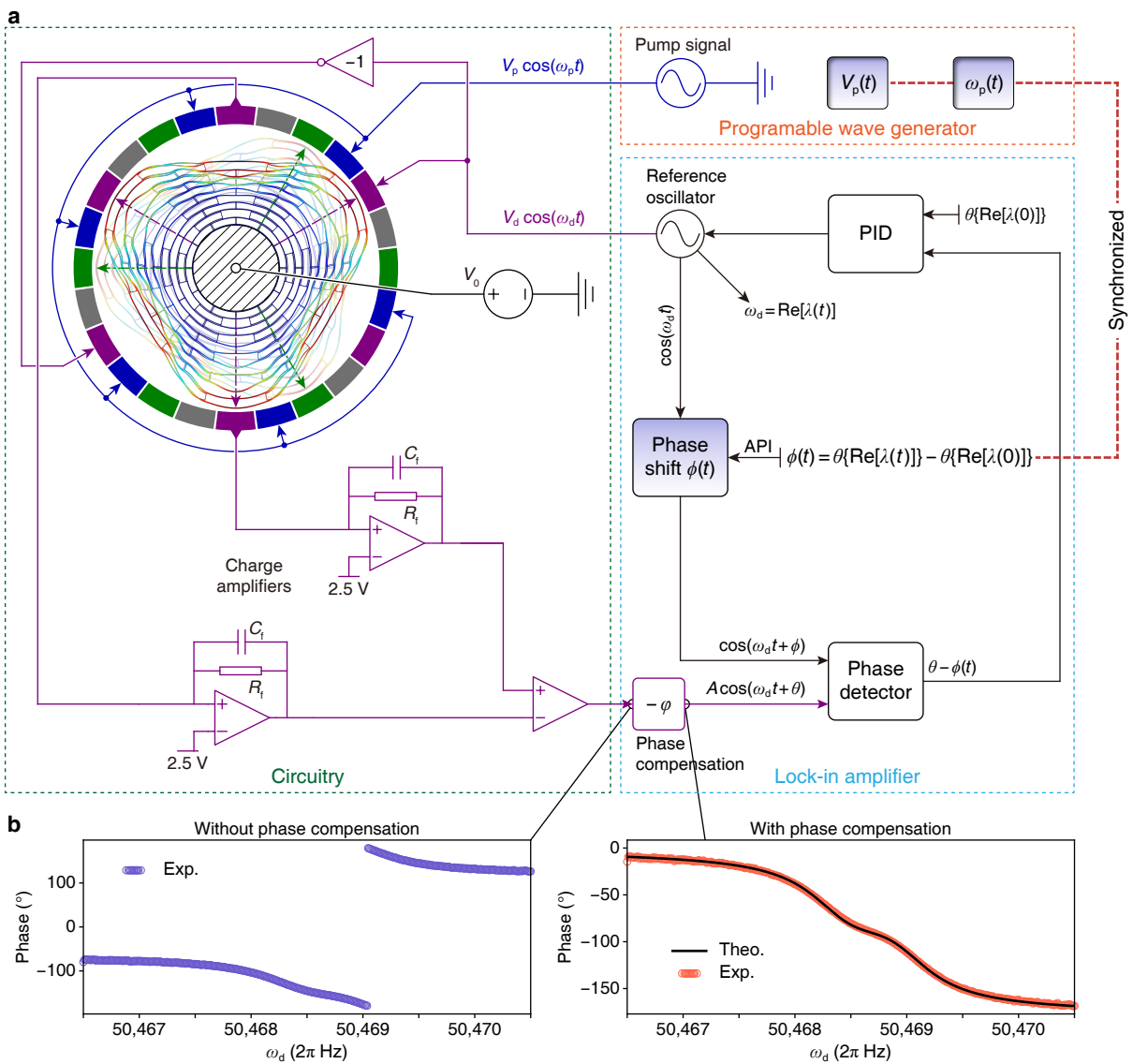
a
−1
$V_p \cos(\omega_p t)$
Pump signal
$V_p(t)$
$\omega_p(t)$
Programable wave generator
Reference oscillator
$V_d \cos(\omega_d t)$
PID
$\theta\{\mathrm{Re}[\lambda(0)]\}$
Synchronized
V_0
$\omega_d = \mathrm{Re}[\lambda(t)]$
$\cos(\omega_d t)$
Phase shift $\phi(t)$
API
$\phi(t) = \theta\{\mathrm{Re}[\lambda(t)]\} - \theta\{\mathrm{Re}[\lambda(0)]\}$
C_f
R_f
Charge amplifiers
2.5 V
C_f
R_f
2.5 V
Circuitry
$\cos(\omega_d t + \phi)$
Phase detector
$\theta - \phi(t)$
$-\varphi$
$A\cos(\omega_d t + \theta)$
Phase compensation
Lock-in amplifier
b
Without phase compensation
Exp.
Phase (°)
100
0
−100
50,467
50,468
50,469
50,470
ω_d (2π Hz)
With phase compensation
Theo.
Exp.
Phase (°)
0
−50
−100
−150
50,467
50,468
50,469
50,470
ω_d (2π Hz)