

Implementation of frequency domain multiplexing in imaging arrays of microcalorimeters

Jan van der Kuur, P.A.J. de Korte, P. de Groene, N.H.R. Baars, M.P. Lubbers

SRON National Institute for Space Research

The Netherlands

M. Kiviranta

VTT Microsensing, Espoo, Finland





Overview

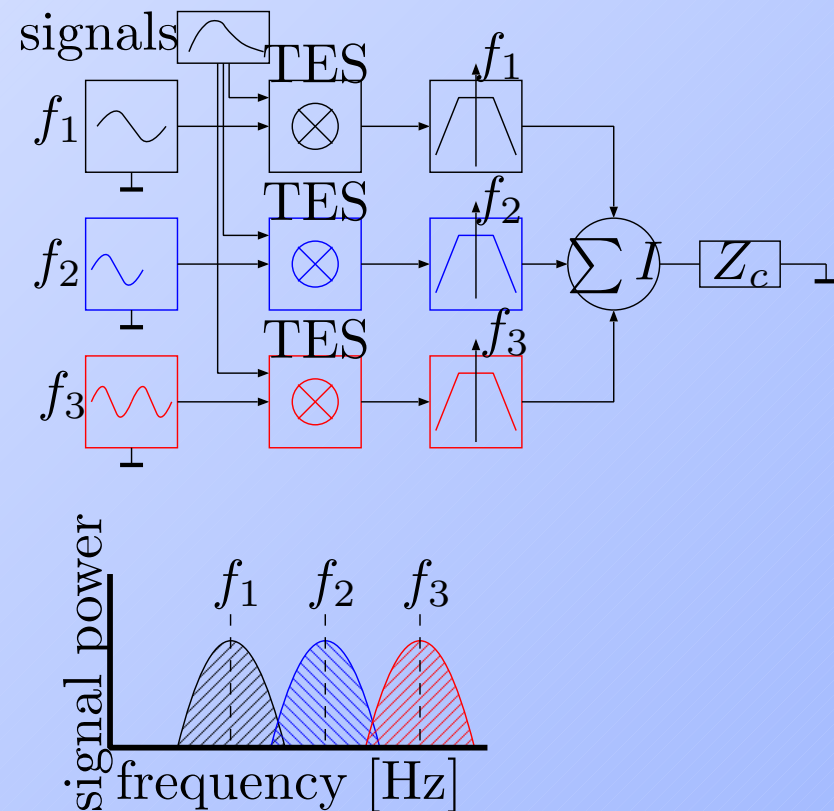
- Frequency domain multiplexing
- Non-ideal behaviour
 1. summing point impedance
 2. magnetic coupling between filters
- Bias source multiplexing topologies
- Conclusions

Frequency domain multiplexing

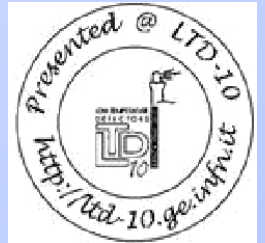


Operating principle

- TES voltage biased with AC source
- Amplitude modulation by TES
- Signals separated in frequency space
- SQUID in summing point
- Noise blocking filters required
- High count rate \Rightarrow low bias source impedance

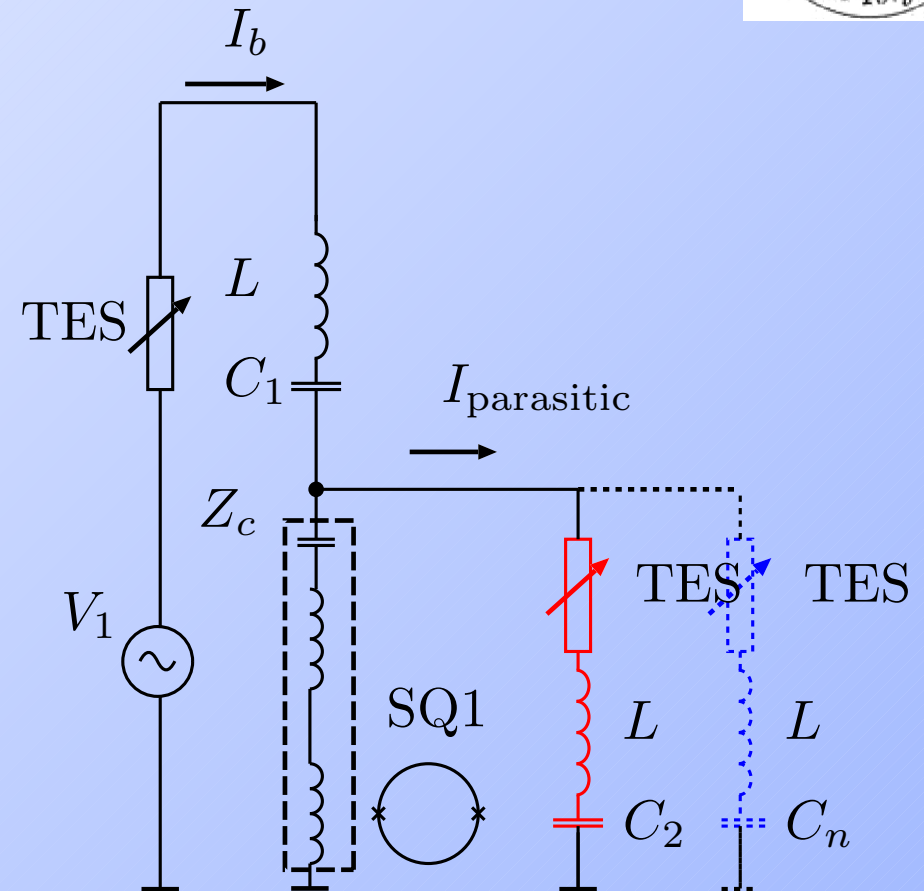


Summing point impedance Z_c



Mechanism (2 channels)

- Voltage across $Z_c \Rightarrow$ current through parallel branches
- $I_{p(\text{parasitic})}/I_{\text{bias}} \propto \frac{Z_c}{L} \frac{f}{\Delta f} = \frac{Z_c}{L} Q$
- Consequences:
 1. increased impedance bias circuit
 2. cross talk by modulation of I_p (power effect)
- tuning $C \Rightarrow Z_c \sim 0 \Rightarrow I_p/I_b \propto Z_c/2L \Rightarrow$ independent f_i and Δf

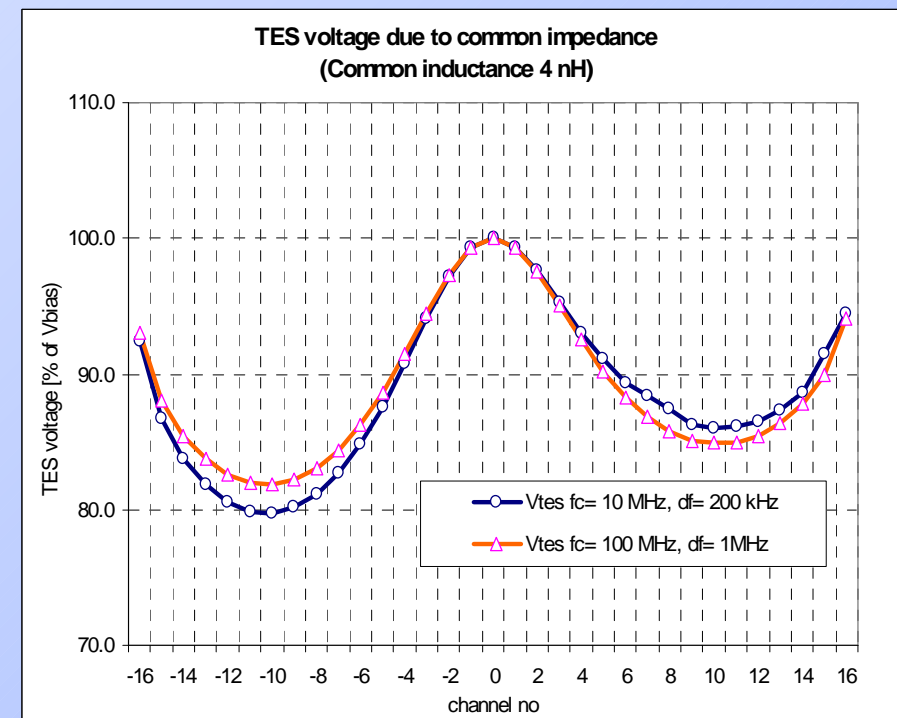


Summing point impedance Z_c

Numerical simulations (32 channels)



- $L_c/L = 5\%$, $\Delta f = 200$ kHz, $f = 10$ MHz, $Z_c = 0$ at \bar{f}_i
- \Rightarrow Extra series impedance: upto 20%
- independent of $Q = f_i/\Delta f$
- Also: shift of resonance frequencies
- Our setup: $L_c < 2$ nH, $L = 90$ nH so $L_c/L = 2.2\%$.
- Low information bandwidth applications: less effects

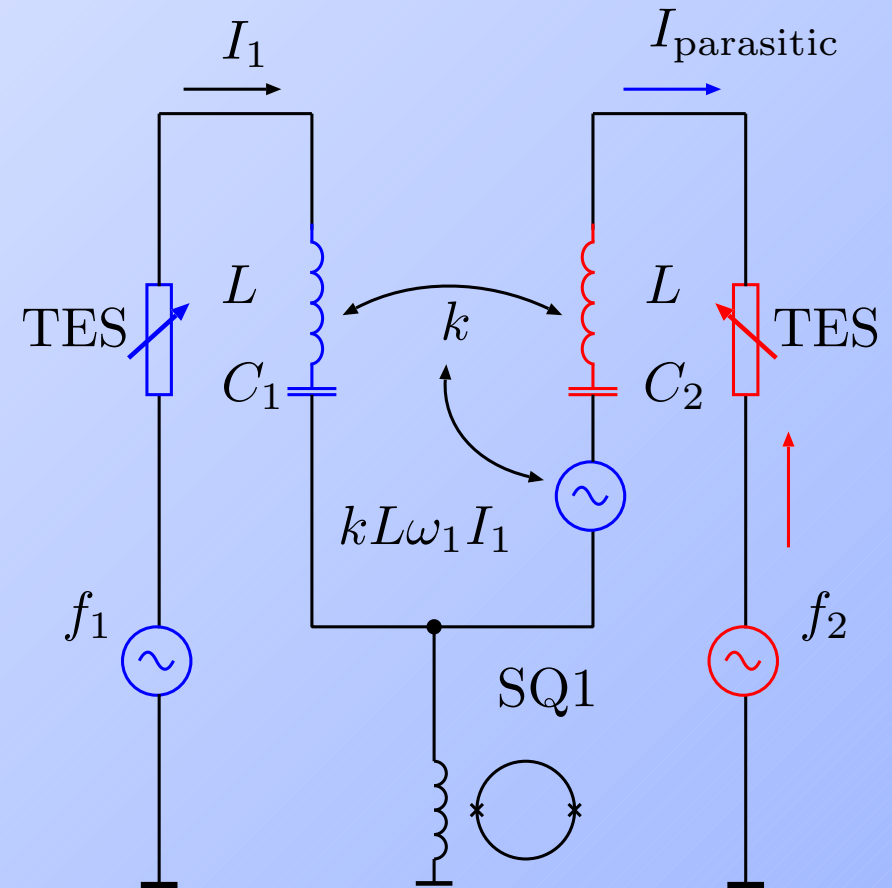




Magnetic coupling between filters

Mechanism (2 channels)

- Coils form transformer
- Effect similar to common impedance (no tuning)
- $I_p/I_c \sim 0.5k f_i/\Delta f = 0.5kQ$
- Too complicated to tune with capacitor
- Minimised by geometric separation of filter coils for nearest frequencies

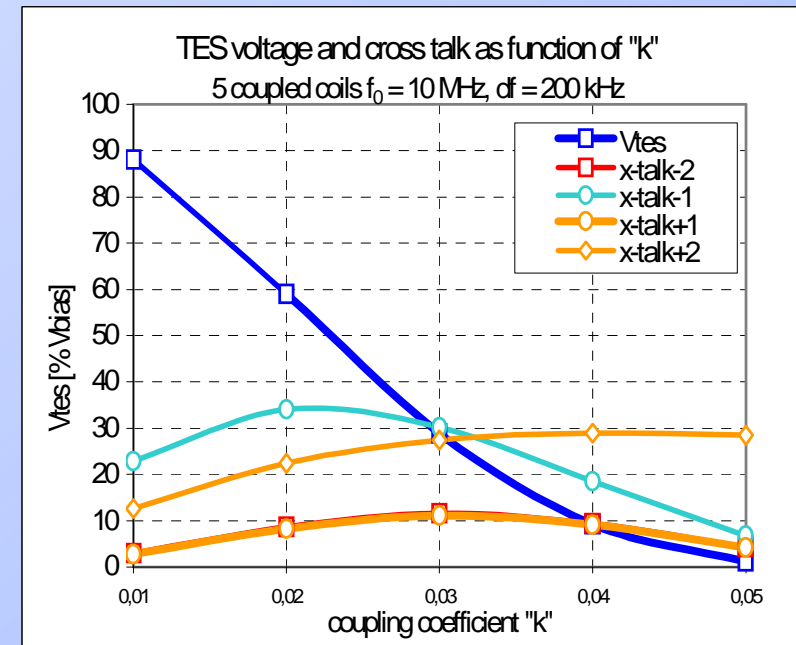




Magnetic coupling between filters

Numerical simulations (5 channels)

- $\Delta f = 200$ kHz, $f = 10$ MHz, $Q = 50$
- Extra Z_{bias} scales strongly with k
- Cross talk less prominent (power effect)
- No scaling with # of channels (nearest pixels dominant)
- Coupling $> 1\%$ problematic (low resistances TESs)

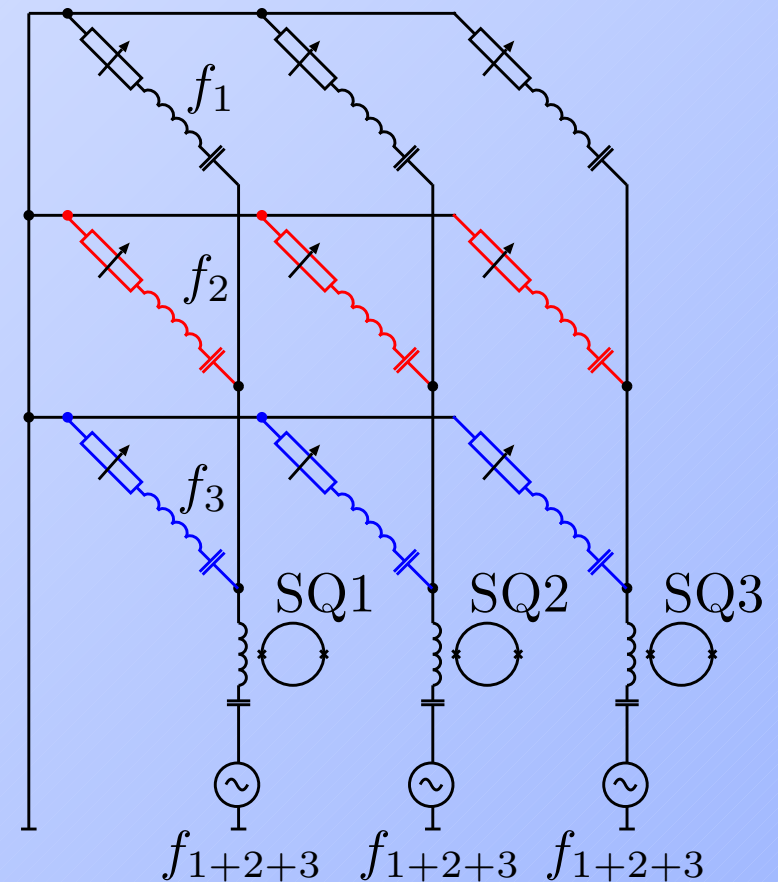




Bias source multiplexing topologies

Bias per column

- One bias source per column
- Multiple frequencies per source
- Cross talk equivalent to highly coupled filters
- filter accuracies moderate
- applicability depends on carrier separation (Q-factor)

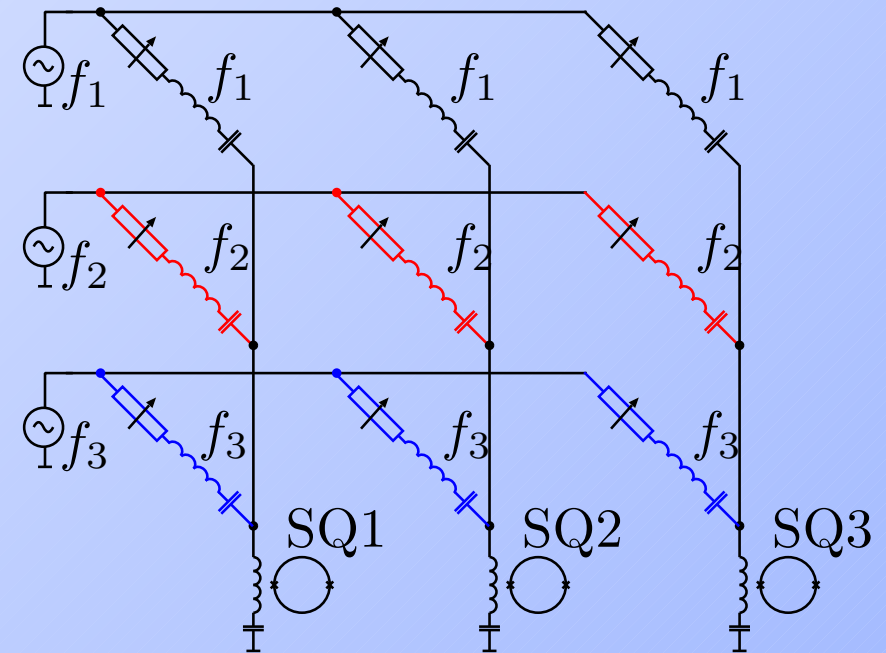


Bias source multiplexing topologies



Bias per row

- One bias source per row
- Filter center frequencies highly uniform
- Frequency errors can lead to instability
- No additional cross talk effects
- applicability dependent on filter reproducibility



Conclusions



- Summing point impedance \Rightarrow lower count rate and cross talk
- Minimised by tuning capacitor
- Effects largest for high countrate applications

- Magnetic coupling between filters similar to summing point impedance
- Effects scale with operating frequency and band separation
- Effects largest for low countrate applications

- Bias source multiplexing feasible, preferred topology is application dependent
- Simulations required for optimal solutions