Conclusions: The enhancements to the digital complex sampling system presented eliminate the detrimental effects of DC content in the A/D input and drastically reduce the distortion caused by the sampling offset between the I and Q channels. The techniques discussed are simple to implement. The oversampling of the input signal makes it possible to use the simple interpolation circuit to provide a significant improvement.

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CMOS VHF TRANSCONDUCTANCE-C LOWPASS FILTER

Indexing terms: Filters, Circuit theory and design

Experimental results of a VHF CMOS transconductance-C lowpass filter are described. The filter is built with transconductors as published earlier. The cutoff frequency can be tuned from 22 to 98 MHz and the measured filter response is very close to the ideal response.

Introduction: Several continuous-time high frequency integrated filters have been reported in the literature.[1–3] Most filters were built with transconductance elements and capacitors, to take advantage of these structures at high frequencies. The maximal frequencies, however, were limited to the lower megahertz range. Krummenacher and Joehl[1] reported a 4 MHz lowpass filter and Kim and Geiger[2] reported a bandpass filter, programmable up to 16 MHz.

Tsividis[3] has proposed another approach: minimal transistor-only VHF filters. With this technique, filters at very high frequencies (10–100 MHz) can be made, but these filters seem to be restricted to low quality factors and accuracy.

In this paper an accurate transconductance-C lowpass filter is presented with a cutoff frequency up to 98 MHz.

Transconductor: Recently, a transconductance element for VHF filters has been presented.[4] This circuit is given in Fig. 1. The circuit is based on CMOS inverters and has good linearity. The circuit has no internal nodes and an output resistance tunable to infinity. The result of this is that an integrator built with this transconductor has a high DC-gain and parasitic poles located in the gigahertz region. This is a good starting point for VHF filters.

The transconductance can be tuned with the supply voltage V_{dd}:[4]

$$g_m = (V_{dd} - V_{tn} - |V_{tp}|)\sqrt{(\beta_n \cdot \beta_p)} \qquad (1)$$

The output resistance of the transconductor can be tuned with V'_{dd}. The DC-gain of the transconductance-C integrator is only limited by mismatch: It can be shown that the measured 0·5% transconductance mismatch results in a DC-gain of minimally 200, which is high enough for most applications.

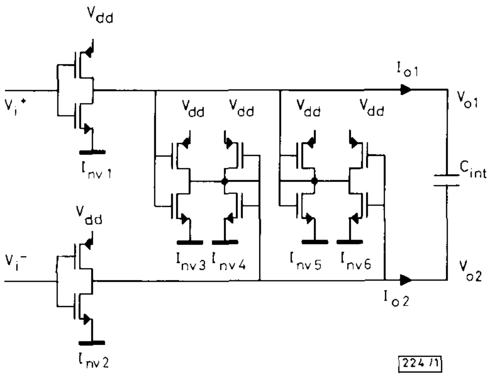

Fig. 1 *VHF linear transconductance element*[4]

Filter: A third order elliptic filter has been built with the transconductor of Fig. 1. The normalised passive prototype filter is given in Fig. 2. The active implementation is shown in Fig. 3. The filter is a direct implementation of the ladder filter using a gyrator (G_3–G_6) to simulate the inductor.

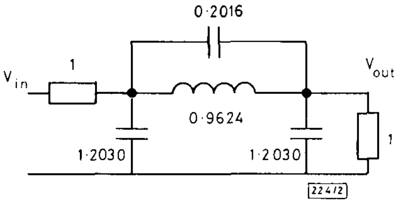

Fig. 2 *Normalised passive prototype of third order elliptic filter*

The filter operates mainly on parasitic capacitances. The parasitic capacitances are all at nodes where a capacitance is desired in the filter. The parasitic capacitances comprise roughly 70% of gate oxide capacitance (C_{ox}) and are consequently quite linear. C_1 is fully determined by parasitic capacitances. The other capacitances C_2 to C_4 are designed by adding small extra capacitors. These extra capacitors are polysilicon *n*-well capacitors; also with gate oxide dielectric. The time constants of the filter can be written as $\tau = C/g_m$, with C a capacitance in Fig. 3 and g_m the transconductance of the transconductor. Both C and g_m are approximately proportional to C_{ox}. The result of this is that the spread in τ due to spread in C_{ox} is small. This results in quite accurate time constants, even if the filter operates mainly on its own parasitics. Another advantage of operation on parasitics is that the series resistance in the capacitances is very small, which is important at very high frequencies.

The balanced input voltage of the filter is generated from a single ended signal by means of an off-chip transformer (T_1). The output voltages of the filter are converted to output currents by means of G_8. These currents are converted to voltages by means of two off-chip 100 Ω resistors. The differential output voltage is converted to a single ended voltage at 50 Ω by means of a transformer (T_2). An on-chip reference path, also buffered with a transconductor (G_9), is used to compensate for all parasitic elements outside the filter during measurements.

The chip was processed in a 3 μm BICMOS process using only the CMOS part of it.

Experimental results: The measured filter responses are given in Fig. 4 for three values of V_{dd}: $V_{dd} = 2·5$ V, $V_{dd} = 5$ V and

$V_{dd} = 10$ V. From this figure it can be seen that the measured responses fit very closely the ideal response of the passive

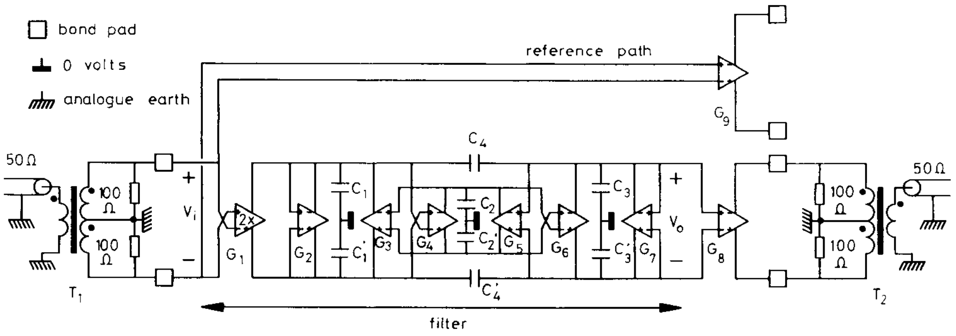

Fig. 3 *Active implementation of filter and test circuit*

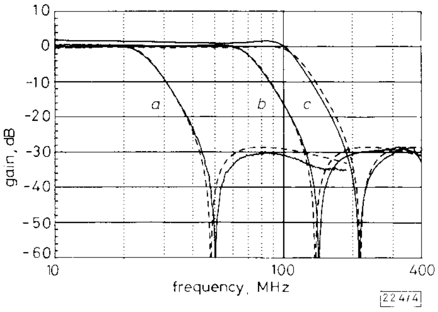

Fig. 4 *Filter responses*

a $V_{dd} = 2{\cdot}5$ V; *b* $V_{dd} = 5$ V; *c* $V_{dd} = 10$ V

——— measured; - - - - ideal

prototype filter of Fig. 2. The cutoff frequency is varied from 22 MHz ($V_{dd} = 2{\cdot}5$ V) to 98 MHz ($V_{dd} = 10$ V). The 98 MHz filter curve is close to the ideal curve up to 350 MHz. This implies that the transconductor has only parasitic poles in the gigahertz region.

The experimental results are summarised in Table 1. The lower limit for the dynamic range was chosen as the total passband noise and the upper limit was the 1% total intermodulation distortion (TIMD) input voltage level. The TIMD was measured with a two-tone input signal with frequencies of around half the cutoff frequency of the filter.

Table 1 EXPERIMENTAL RESULTS

Parameter	$V_{dd} = 2{\cdot}5$ V	$V_{dd} = 5$ V	$V_{dd} = 10$ V
Cutoff frequency	22 MHz	63 MHz	98 MHz
Passband ripple (0·28 dB)	0·3 dB	0·4 dB	0·8 dB
Dynamic range*	?	68 dB	72 dB
CMRR-passband	40 dB	40 dB	40 dB
Transconductance	0·35 mA/V	1·06 mA/V	1·38 mA/V
Power dissipation	4 mW	77 mW	670 mW
V'_{dd}	2·50 V	4·76 V	8·10 V

* See text

The adjustment of V_{dd} (frequency tuning) and V'_{dd} (Q-tuning) was done manually. However, circuitry for automatically tuning V_{dd} and V'_{dd}, which is necessary to compensate for process and temperature variations, is presently being developed.

Conclusions: Experimental results for a VHF CMOS transconductance-C lowpass filter are presented. The filter is built with transconductors as published earlier.[4] The maximal cutoff frequency is 98 MHz and the filter response fits very well with the ideal response, up to 350 MHz. The filter operates mainly on parasitic capacitances, but the accuracy is not affected.

The results obtained with this technique indicate that accurate integrated CMOS filters at very high frequencies are possible. Applications can be found in the field of TV IF filtering and other VHF filters.

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PERFORMANCE CHARACTERISTICS OF HIGH POWER CW, 1 cm WIDE MONOLITHIC AlGaAs LASER DIODE ARRAYS WITH A 2 mm TOTAL APERTURE WIDTH

Indexing terms: Lasers and laser applications, Measurement

1 cm wide monolithic laser diode arrays emitting around 810 nm with a 2 mm total aperture width have been characterised under CW conditions. CW operation up to 16 W has been achieved at a heatsink temperature of 70°C. Several arrays have been lifetested at 10 W CW at a 20°C heatsink temperature for a few thousand hours and have projected lifetimes of between 5000 and 17 000 hours. The temperature dependence of the degradation rate was characterised, from which data an activation energy of 0·2 eV was obtained.

Continuous-wave (CW) AlGaAs monolithic laser diode arrays are reliable, have high power, high efficiency and are narrow bandwidth sources of optical energy.[1,2] CW output power as high as 76 W has been demonstrated using 1 cm wide monolithic arrays with a 3 mm total active aperture width (30% packing density) at 0°C.[1] A projected lifetime in excess of 5000