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PRECISION RECTIFIER

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ABSTRACT

Electric phenomena dependence of non electric one rises a lat of issues in design and running of electric and electronic equipments. So, this is basic problem of one of most dynamic field of measurements technique, represented by electric measurements of non electric phenomena. The paper proposes a precision full-ware rectifier scheme that solves main aspects existing in conventional precision rectifiers based on diode and op-amps.

1. Introduction

By now, modern equipments of measurement without electric or electrinic parts start to become rarefied. Acquiring data systems and processing signals systems are electric systems that are used in all cases of real measurements requests.

Electronic measurement systems field are in a continuu progress, in the same time with increase of precision, sensitivity, work speed and flexibility for real measurement situations.

Electric measurement of non electric phenomena is strongly introduces in almost all activity fields and first of all in industrial processes where represents a necesity of productions costs, quality ensurings, life and environment protection. For high speed processes occures the issue of high precission rectifier using.

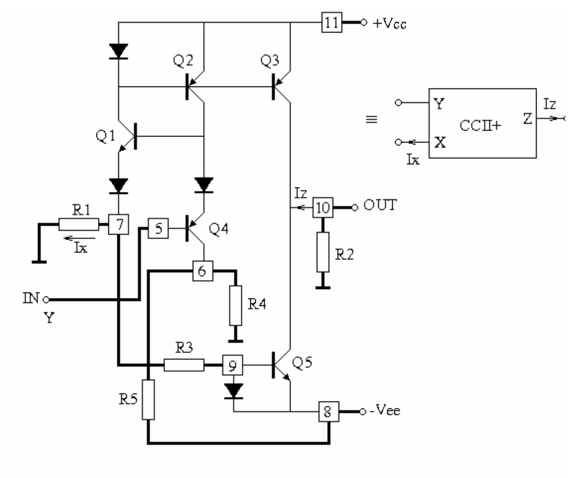


Figure 1 Internal schematic of the CCII01

This paper shows such a rectifier used by translators for kinematics value measurements.

The first commercially available current-conveyor based on the current-feedback op-amp is the CCII01 from LTP Electronics, shown in Figure 1. The circuit is fully symmetrical, with Q_1 to Q_4 comprising the input stage, Y input being high impedance and X input-output being low impedance.

A voltage applied to the Y input is followed by the X input. The collector currents of Q_2 and Q_3 are reflected and recombined through current- mirrors CM_1 and CM_2 to the high output impedance Z node. Hence any input into the X node is conveyed with unity current gain through to the Z output node.

The CCII01 is built on a high speed dielectric isolation fully complementary bipolar process and supplied as dual device in an 8-pin DIL package. The device features an equivalent slew-rate of 2000 V/μs and 100 MHz bandwidth. The equivalent open-loop gain is 80 dB and the CMRR performance is better than 53 dB at 1 MHz. The maximum output current from the device is $\pm$10mA and it operates from $\pm$5V to $\pm$15V supplies.

A particularly useful and elegant application of the current-conveyor is the current-mode instrumentation amplifier (IA) employing the differential V to I converter.

2. CCII01 precision full-wave rectifier

Another equally elegant use of the current-conveyor is for high speed precision rectification. The classical problem with conventional precision rectifiers based on diodes and op-amps is that during the non-conduction/ conduction transition of the diodes the op-amps have to recover with a finite small-signal dV/dt resulting in significant distortion during the zero-crossing of the input signal. Using high slew-rate op-amps does not solve this fundamental drawback since it is a small-signal transient problem. Conventional rectifiers are thus limited to a frequency performance well below the gain-bandwidth product of the amplifier.

Improvements have been made to rectifier high frequency performance by the use of current-mode techniques primarily based upon employing the power supply rails of the op-amp as a current rectification path. However, a problem encountered with such schemes is that signal levels need to be significantly higher than the supply bias to guarantee precision rectification at high frequency and so again loss of precision occurs at signal zero-crossings. Even using high speed current-feedback amplifiers the performance is still limited to some tens of kiloHertz, whitch is significantly below the f_T of the current-feedback amplifiers used.

A full-wave precision rectifier can be configured easily using two CCIIs, as shown in Figure 2. Both the CCIIs form a differential voltage to current converter such that during the positive input cycle, the output currents of value V_{IN}/R flow out of the Z-node of CCII(a) and into the Z-node of CCII(b), thus making only D_4 and D_2 active. Because D_2 is activ, the current from the Z-node of CCII(a) flows into the output resistor R making $V_{OUT} = V_{IN}$.

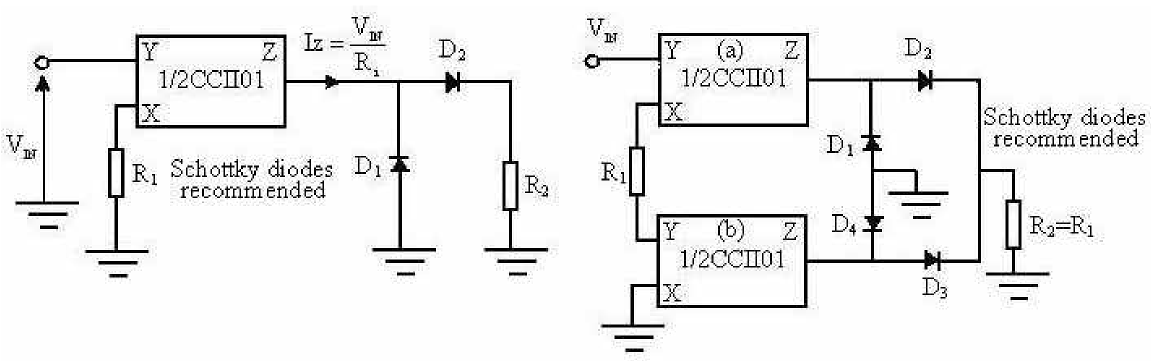
During the negative input cycle, only D_3 and D_1 are active thus the output current of CCII(b) is driven into R making $V_{OUT} = V_{IN}$. Clearly the magnitude of gain is R_2/R_1 and this can be increased from unity by making $R_2 > R_1$.

3. The performance and conclusions

The circuit was built with 100 Ω resistors and Schottky diodes and Figure 3 shows typical performance for the half-wave precision rectifier shown in Figure 2a at two operating frequencies, 100 KHz and 1 MHz.

The performance is good but with CCII01 exhibiting an f_T of approximately 100MHz, one would naturally expect the circuit to work close to the f_T of the device. However, this is not the case since at very low signal levels all the diodes are off, and as a result the differential voltage to current converter is transformed into a high gain differential voltage amplifier. Although the CCII01 exhibits a very high slew-rate, in the region of 2000V/μs, it is the small signal dV/dt that limits performance at zero-crossings. The solution to this problem is to modify the circuit by offsetting the output of the conveyors by biassing all the diodes appropriately. The new scheme is shown in Figure 4.

In the circuit, the voltage at the anode of diodes, D_1 and D_4, is biassed by a low impedance voltage source, V_B, at approximately 0,6V, allowing 0,3V forward bias for each Schottky diode. Thus when D_1 and



(a) Half-wave precision rectifier (b) Full-wave precision rectifier

Figure 2 Current-conveyor precision rectifiers

This condition ensures that the load impedance presented to the Z-terminal is kept low at all times, especially as the diode pairs D_1/D_3 and D_2/D_4 swap conduction roles.

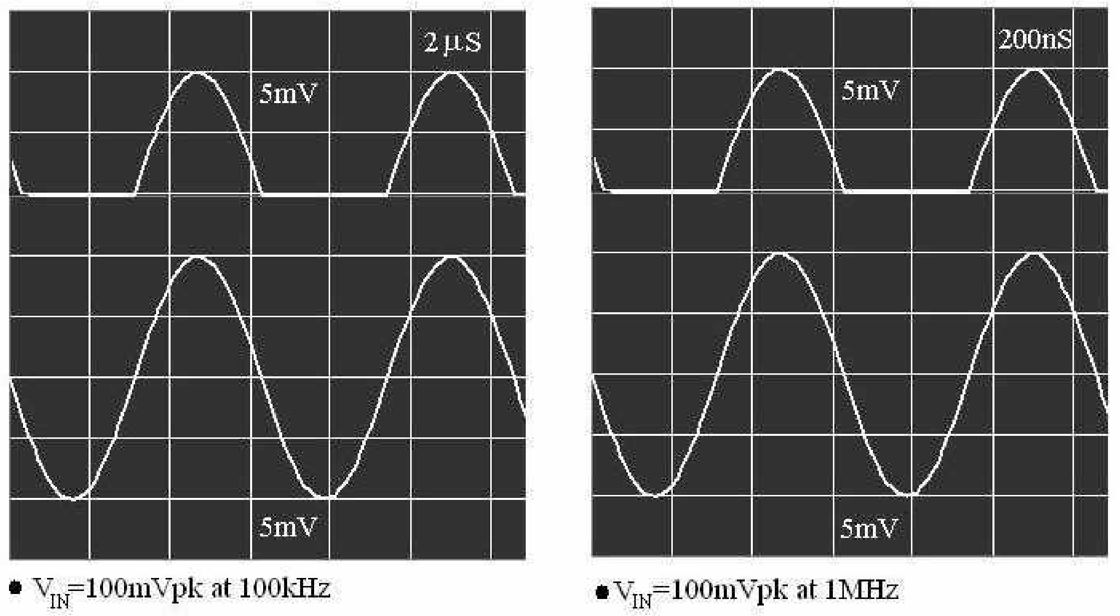


Figure 3 Precision half-wave rectifier

The net effect is that the current-conveyor outputs do not go into slew at each zero-crossing. Effectively the improved scheme provide a class AB voltage bias so that all the diodes are on the edge of conduction during the zero input condition. Note that the battery, V_B, may be replaced by an appropriately biassed

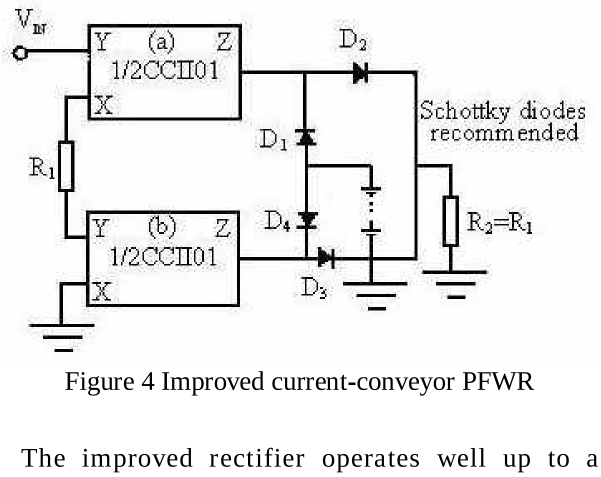


Figure 4 Improved current-conveyor PFWR

The improved rectifier operates well up to a frequency of 30 MHz. Quite an acceptable rectifier performance is achieved and clearly is substantially less distorted than the non-diode biassed circuit which begins to show significantly poor performance at about 4 MHz. Beyond 30 MHz, the rectifier integrity of the final circuit does start to deteriorate. This is due to the roll-off in V_X/V_Y with frequency. However the measured results are encouraging and represent a significant improvement.

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