Detection of Amplitude Shift Keying Signals Using Current Mode Scheme

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Abstract

This paper reports a new system for detection of amplitude shift keying signals. The scheme employs a precision rectifier, low-pass filter and comparator for the purpose and falls under asynchronous demodulation category. The work is in extension to the recently reported method for amplitude shift keying (ASK) generation, wherein a new precision rectifier was also suggested. The proposed detector uses basic building blocks designed using extra-X current conveyor (EX-CCII), and presents a modular approach for the ASK detection, wherein the generation as well as detection is carried out using similar blocks. Thus, this method is expected to enable usage of identical blocks for both transmission as well as reception. Simulation studies are presented which justify the usefulness of proposed approach. Two sets of results using for a digital baseband signal are included, wherein the ASK signal is generated using different carrier frequencies, and in each case the detected signal is successfully obtained.

Keywords: Amplitude Shift Keying; Extra-X Current Conveyor; On-Off Keying

1 Introduction

The transmission of digital baseband signal over radio links or satellites require modulating a high frequency carrier by the baseband signal. It is necessary since the baseband signal possess enough power at lower frequencies, which would otherwise mandate large antenna requirements. Modulating a high frequency carrier allows the baseband signal spectrum to shift to higher frequency. Thus in digital communication, a sinusoidal high frequency carrier is modulated by the digital baseband signal. One of the simplest digital modulation involves changing the amplitude of the carrier in accordance with digital baseband signal, which in case of two valued digital signal takes the form of amplitude shift keying (ASK). A special case of ASK simply suppresses the carrier for 'zero' bit of digital signal, whereas, allows carrier to pass on for 'one' bit of the digital signal. This is referred to as on-off keying (OOK). Detection of ASK/OOK at the receiver end is carried out in either synchronous or asynchronous fashion. The latter is simpler, effective and preferred for ASK/OOK, especially if the signal to noise ratio is not poor [8, 19]. It is worth noting that ASK find useful applications such as radio frequency identification tags, biomedical equipment, portable wearables and health monitoring implants.

Recently, current-mode techniques have become well founded, due to the favorable features offered to the designed circuits, using this approach. The technical literature has recently covered to utility of extra-X current conveyor (EX-CCII) for various applications of communication and instrumentation systems [3-6]. One recent work provides ASK/BPSK and precision rectifier design using a single EX-CCII [13]. This study is motivated as an extension of the reported work, and aims to propose an ASK detector using asynchronous method [8, 19]. The proposed approach employs EX-CCII for the purpose. Simulation studies are presented for verification of the detector circuit. The following sections are respectively devoted to the proposed circuit for ASK detection, simulation results and conclusion.

2 Proposed Circuit

The basic block diagram for non-coherent detection (asynchronous demodulation) of ASK signal comprises of a rectifier, low pass filter (LPF) and a comparator, and is shown in Figure 1. The basic scheme is implemented using EX-CCII, wherein, the rectifier circuit of ref. [13] is employed. The LPF is realized using a simple RC network, whereas, another current conveyor is employed for realizing the comparator block. In the scheme of Figure 1, the rectifier converts the ASK signal into unidirectional. It may be noted that a full-wave rectifier is essential for ASK signal, although a half wave rectifier can be employed for OOK signal.

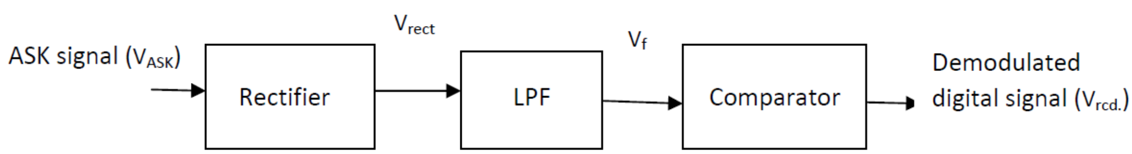

Figure 1: Basic block diagram for ASK asynchronous detector

The detection of envelope is completed by passing the signal through a RC low-pass filter, to retain only the low-frequency content. The comparator decisively provides two levels, by comparing the rectified and filtered signal (V_f) with a reference threshold voltage. The precision rectifier and comparator blocks employed for the purpose are respectively shown in Figure 2(a) and (b), whereas, the low-pass filter used is simple one pole RC circuit, not shown for its obvious popularity.

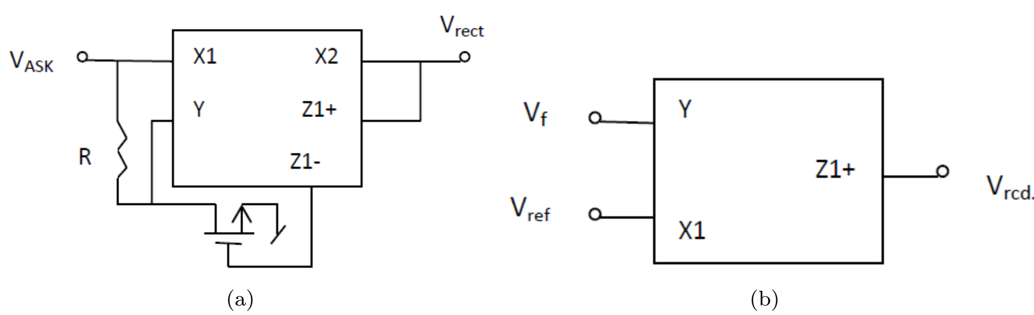

Figure 2: (a) Precision rectifier circuit [6]; (b) Comparator circuit

The active building block used is extra-X current conveyor (EXCCII), which is recently receiving considerable attention in literature, The CMOS circuitry of the conventional EXCCII is given in Figure 3 [13].

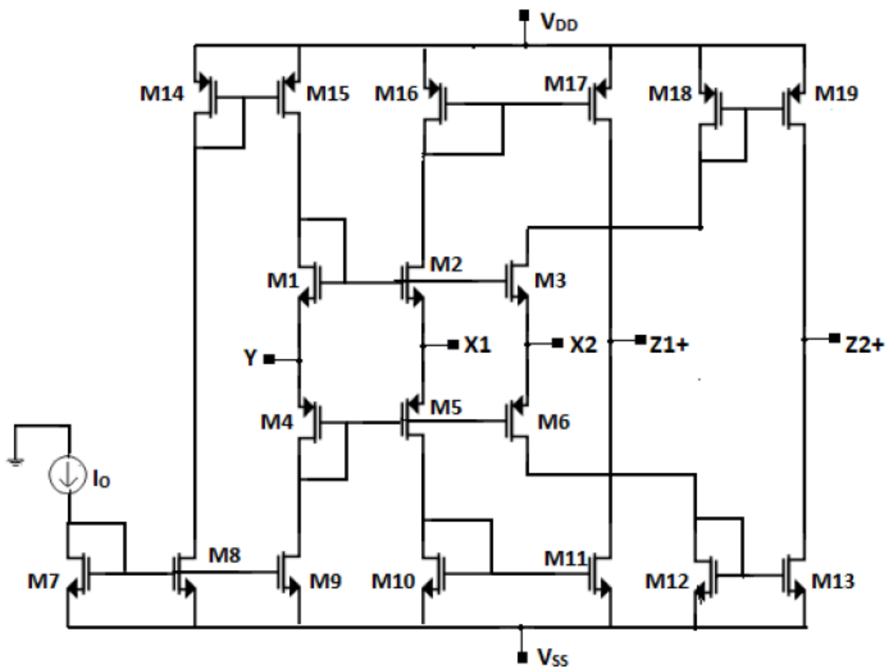

Figure 3: CMOS circuitry for EXCCII with positive current gains

This is modified for additional Z1- stage, while Z2+ stage is suppressed. The operation of rectifier circuit is already described in recent literature [13]. The operation of the comparator of figure 2b is summarized in Equations (1) - (5) as below.

$$i_{x_1} = (V_f - V_{ref})/R_{x_1} \quad (1)$$
$$i_{z_1} = i_{x_1} = (V_f - V_{ref})/R_{x_1} \quad (2)$$
$$V_{rcd} = i_{z_1}R_z == (V_f - V_{ref})(R_z/R_{x_1}) \quad (3)$$
$$\text{For, } V_f < V_{ref}; V_{rcd} = -VS \quad (4)$$
$$\text{For, } V_f > V_{ref}; V_{rcd} = +VS \quad (5)$$

The operation of comparator depends on the parasitics of EX-CCII, where R_z and R_x are considered to be high and low respectively. Thus for small signal at Y node of comparator (V_{ASK}), a comparison made with reference (V_{ref}) at X_1 node yields negative and positive saturation levels of the used current conveyor, as given by Equations (4) and (5). The detection of the ASK signal is thus completed, as the two voltage levels received are easily identifiable as two possible states of the digital baseband signal. As far as the design of RC low-pass filter is concerned, following conditions apply. For, carrier frequency "f_c", baseband signal frequency "f_m", and $\tau = RC$, the design guideline is as below.

$$(1/f_m) > \tau > (1/f_c). \quad (6)$$

Equation (6) suggest removal of high frequency carrier, while allowing the baseband signal. However, the low-pass filter cutoff frequency must be high enough, so as to maintain the purity of recovered baseband signal, which is often a train of rectangular pulses.

The EXCCII non-ideal model, like a typical current conveyor is characterized by voltage and current transfer gains, which have been shown in published literature [16]. The parasitic model of EXCCII has also been presented in literature [13,15]. The circuit of Figure 2(a), which is used as one of the blocks for ASK detection was analyzed for its parasitic performance in [13]. For the comparator of Figure 2 (b), the parasitic resistance at Z terminal is exploited for the comparator action, which by offering a large resistance facilitates the input at Y terminal to be compared with the reference voltage at X-terminal.

3 Verification Results

The ASK detector scheme is next verified using the EXCCII model as reported in literature [13]. The circuit schematic of Figure 2 is simulated with a real ASK signal generated using the modulator circuit of ref. [13] itself, so as to also show the compatibility of the modulator and demodulator. Thus, the same network, as presented in [13] is adaptable at both transmitting and receiving end of the communication system. This feature makes the new demodulator a viable choice, in addition to some excellent works reported in literature [9,21]. The results are obtained, where the digital baseband signal at the transmitting end, the ASK signal, and the detected baseband signal at receiving end are shown in the results. These results are shown as Figure 4, for a baseband signal of 10 KHz, and carrier frequency used is 0.5 MHz, for obtaining the ASK signal, while the baseband signal is considered as square wave for testing purpose.

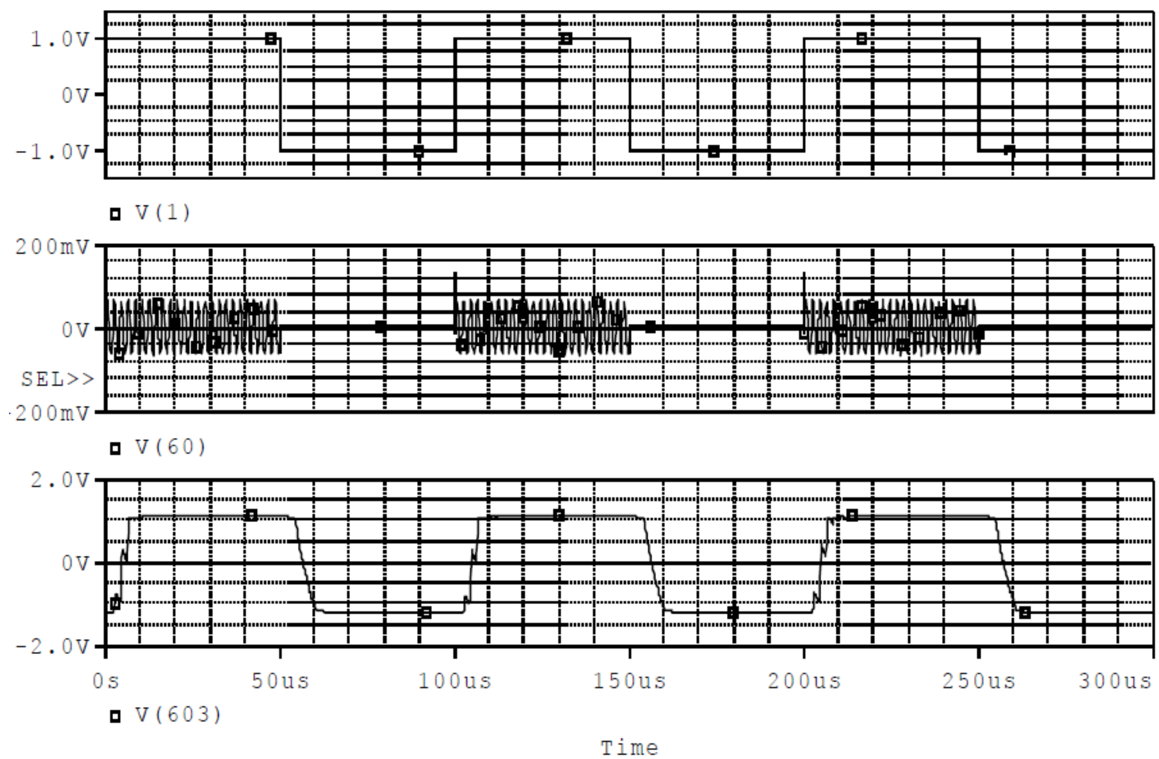

Figure 4: Baseband signal of 10 KHz "V(1)", ASK signal using 0.5 MHz carrier "V(60)" and detected signal of 10 KHz "V(603)"

Another set of results is next presented as Figure 5, where the carrier frequency used for obtaining ASK signal is 20 MHz, and the detector output is shown as 'V(603)' in Figure 5. For the set of results shown in Figure 5, it is to be mentioned that the reference voltage (V_{ref}) used in comparator is 20 mV, whereas, the LPF elements as chosen as 4 $K\Omega$ and 60 pF, thus yielding the filter cutoff frequency of 0.66MHz.

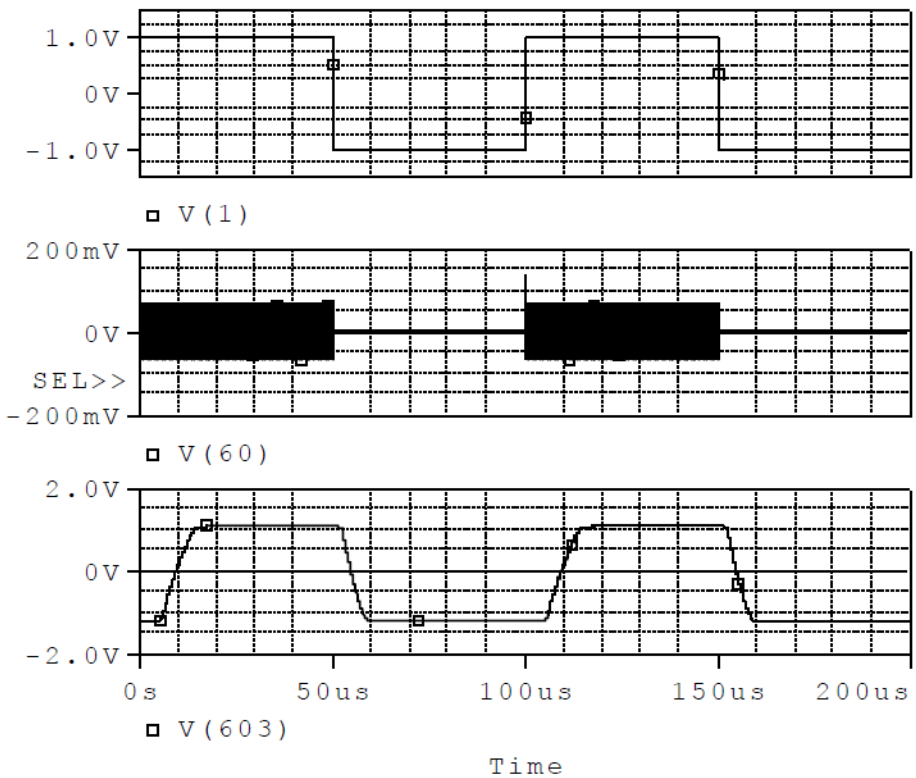

Figure 5: Baseband signal, ASK signal using 20 MHz carrier and detected signal (10 KHz)

The baseband signal frequency is 10 KHz, while the carrier frequency used for obtaining ASK signal is 20 MHz. Thus, the design guideline (Equation (6)) is well followed, which suggests, the filter cutoff frequency to be higher than the baseband signal, but lower than the carrier. Next, the spectrum of the used digital baseband signal, the carrier signal and the detected signal are shown in Figure 6, which shows the spectrum of original digital signal and the detected signal are same. This suggests the validity of the ASK detector circuit. Thus, the new proposed application of current conveyor enrich the literature on the subject.

4 Comparative Discussion

The new scheme of ASK detection is beneficial in light of the usage of like basic blocks, both for generation and detection purpose, as has been discussed in preceding sections. The literature is full of several detection schemes for ASK signals, using CMOS and related technologies [2, 4, 17, 18]. The

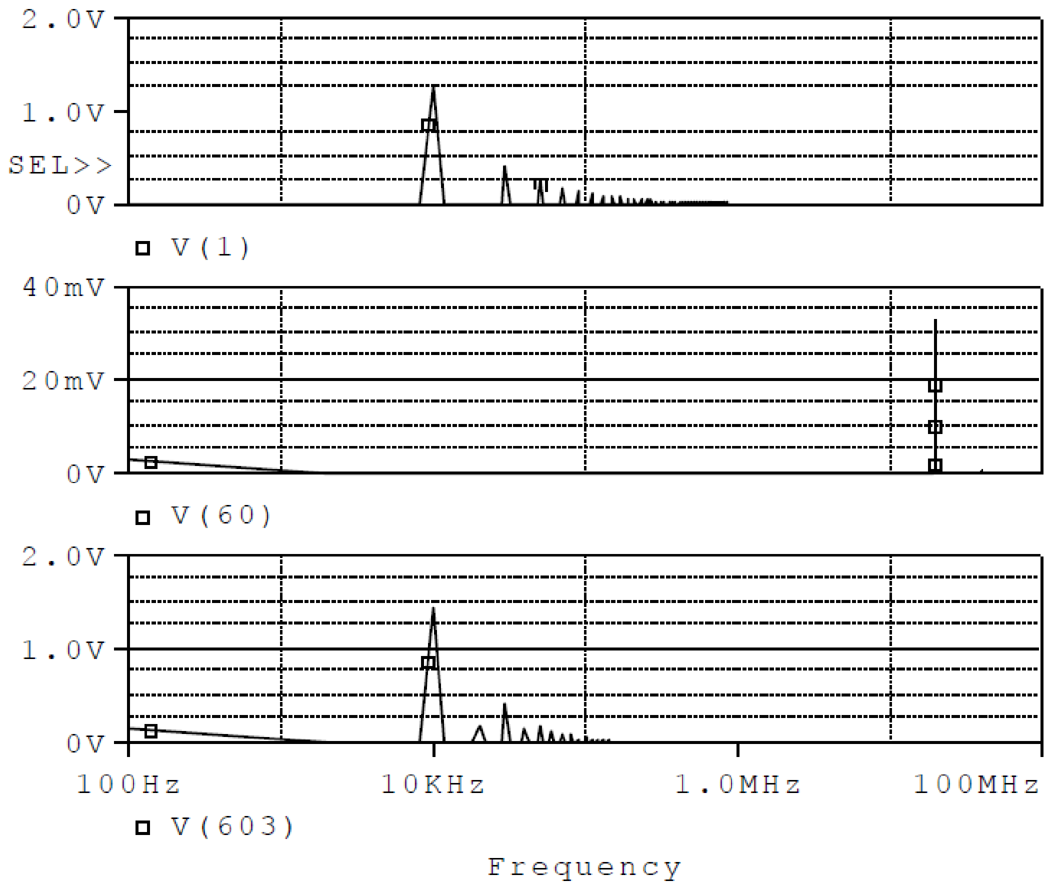

Figure 6: Spectrum of Baseband signal [V(1)], Carrier signal (20 MHz) [V(60)], and recovered baseband signal of 10 KHz [V(603)]

works reported in [2, 17] fall under the current-mode category, while the other works either employ more complex circuit blocks [4], or are based on using switching mode signal shaping and enjoy several performance features [18].

Amongst the current-mode circuits, the circuit in [17] use lower supply voltage as an asset, and employs DTMOS and quasi floating gate transistors along with self-cascode technique. The work in [2] operates at higher supply voltage, and the frequency of baseband signal may not exceed 250 KHz, whereas the proposed work shows higher usable baseband signal frequency. Thus, the new proposed detection scheme for ASK signal is an additional option, with the advantage of employing identical blocks for the design of both modulator and demodulator.

5 Conclusions

This brief paper extends the knowledge on digital modulation and demodulation using current mode active element, in form of EXCCII, by proposing an ASK detector, which is in continuation to the recently reported ASK modulator. The proposed ASK detector is compatible with the recent modulator, and performs the demodulation using the asynchronous method for ASK detection. Several verification results justify the utility of the proposed scheme. Adoption and integration for real life applications is a natural problem open for future investigations. This novel design not only advances the area, but also the reporting of circuits for analog signal processing [10–12, 14] by the current journal.

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Biography

Sudhanshu Maheshwari works as full Professor in AMU, with around 140 publications in the area of Current mode Analog signal processing.