LOW COST EQUIPMENT FOR USE IN A TELECOMMUNICATIONS LABORATORY: 1. AM/DSBSC MODULATOR – DEMODULATOR.

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Summary

An amplitude modulator – demodulator unit which is to be used for laboratory experiments in AM/DSBSC is described. This is the first of a series of units, to be used in experiments in Telecommunications, designed and fabricated in the Electrical Engineering Laboratories of the University of the West Indies – St. Augustine. All units are designed using standard off-the-shelf components, thus making them cheaper and easy to repair and maintain.

INTRODUCTION

In any field of engineering education laboratory exercises, demonstrating the underlying principles and focussing the attention on the important parameters of a system are of paramount importance. In fields like telecommunications, this tends to require rather expensive and sophisticated equipment. When one considers the ever increasing number of students and the diminishing resources made available to Universities the cost of providing a comprehensive schedule of laboratory exercises could be prohibitive. A solution to this problem, which is sometimes adopted, is to conduct a 'demonstration' type of experiment for the whole class. This may give the student an insight into the exercise but it does not allow the student to experiment. It also means that the student may not learn to connect up a set of equipments and perform an experiment himself. Furthermore having performed an experiment one tends to remember the procedure and results far better than if it were done for him as a demonstration.

There is also a point to be made about conducting laboratory exercises long before the student is exposed to the relevant theoretical background One solution, is to let the whole class perform and complete one particular exercise before going on to the next. This, of course, pre-supposes the ability to allow several groups of students to perform the same experiment at the same time using several sets of the same equipment. There are at present commercial units available which could be used to perform experiments in (say) Amplitude and Frequency modulation, TDM/PCM etc. Authors' experience with these units are that;

(i) They are rather expensive if we need to duplicate experiments,
(ii) their design in most cases leaves much to be desired, and
(iii) due to the use of specialised components repair and maintenance of these units are expensive and time-consuming.

These factors work against the use of such units in developing and third world countries.

The requirements that must be satisfied by the equipment to be used in an environment where more than one group of students undertake the same experiment and other external constraints like availability of funds exist are,

(i) ease of duplication
(ii) ease of repair and maintenance, which in turn lead to the use of standard components.
(iii) ease of setting up and manipulation by students, by minimising the number of external adjustments and controls.
(iv) cost saving in the design stage, by the use of standard components and by reducing the frequency of operation (as a general rule the cost will increase as the frequency is increased).

With these objectives in mind a program to develop low-cost laboratory equipment in the field of Telecommunications has been initiated at the Electrical Engineering Laboratories of the University of the West Indies, St. Augustine Campus.

This paper is the first of a series describing units that have been designed and fabricated at the U.W.I., and are being used at Part II level of the Electrical Engineering curriculum.

2. AMPLITUDE MODULATOR/DEMODULATOR UNIT

2.1 Introduction

An amplitude modulator/demodulator unit was designed to be used in a comprehensive series of experiments illustrating the basic principles involved in amplitude modulation as well as more advanced techniques of detection (demodulation). The unit enables the students (at Part II and III levels) to gain an insight into,

(a) the basic modulation (AM) process and the waveforms involved.
(b) Double Side Band Suppressed Carrier (DSBSC) modulation and corresponding waveforms.
(c) Envelope detection and its limitations
and (d) Synchronous (Coherent) detection.

A schematic diagram of the unit is shown in fig. 1. It consists of an internal oscillator which is used as the carrier supply and a 'switching type' balanced modulator. The modulated signal is filtered, amplified and buffered and appears at the output terminals.

The modulating signal itself is buffered and applied to the modulator together with an adjustable d.c. voltage. With the d.c. voltage set to zero, the unit functions as a balanced modulator providing a 'double side band — suppressed carrier' waveform. Adjusting the d.c. level varies the modulation index of the AM waveform.

The demodulator could be either a diode detector or a coherent detector, whose local carrier supply is derived from the same oscillator used for modulation via a phase shifter. This arrangement serves to illustrate the importance of correct phase relationship between the local carrier and the incoming carrier, in DSBSC operation.

The following sections give a brief description of each of the sub-units.

2.2 Carrier Oscillator and the Modulator

A FET-input amplifier incorporating a Wein-bridge circuit is used as an oscillator to produce a carrier waveform at about 50 KHz. An operational amplifier, in the differential configuration is used as a switching modulator, with a shunt switch in the signal path applied to the non-inverting input as shown in fig. 2. Modulating signal is buffered and applied to the modulator.

Provision has been made for balancing out the residual carrier and the addition of a d.c. voltage at the input buffer. This d.c. voltage is used to control the carrier level when normal AM is generated.

2.3 Filter and output buffer

A schematic of the low-pass filter and the output buffer is shown in fig. 3. The filter used is a 3^{rd} order Elliptic type with passband ripple <0. 5dB. The cutoff frequency is around 70 KHz and a minimum stop-band attenuation of 40dB is achieved for frequencies greater than 150 KHz.

Output amplifier-buffer is of conventional design and is capable of developing a 6v peak to peak signal into a 1kΩ load.

2.4 Demodulators

Provision has been made for a diode detector as well as a synchronous detector. The diode detector could be used in the 'peak detector mode' or as an average detector (fig. 4). The synchronous detector circuit is identical to the modulator and the local carrier is derived by passing the carrier used for modulation via a phase shifter. A low-pass filter with a cutoff at 3KHz is available for use either with the average detector or the synchronous detector.

2.5 Power Supply

A ±10V power supply is derived form a single supply of 24-30V using two Zener diodes in shunt regulator configuration. All circuits in the unit operate with ±10V.

3. CONCLUSIONS

The unit described enables the students to gain an insight into the processes involved in amplitude modulation and demodulation. Additional equipment required to perform the experiments are dual trace oscilloscope, power supply and a signal generator. A commercial spectrum analyser is used at present but work is underway to replace it with a special purpose unit.

Equipment has been used at the Part II level to perform basic experiments in AM and DSBSC. Units wired up on printed circuit boards have functioned well and work is under-way to extend the range of units to FM and TDM/PCM systems.

Standard off-the-shelf components have been used throughout in the design. All transistors are from the BC/184/212 range, operational amplifiers are general purpose 741's and JFETs are used as switches. Since the circuitry used is of simple design and components are readily available, repair and maintenance have been reduced to a simple level. Front panel control consists of potentiometers to adjust the carier level and phase shift.

In all, authors feel that the objectives of a low-cost unit which is easy to fabricate, maintain and above all easy to use have been achieved.

4. ACKNOWLEDGEMENTS

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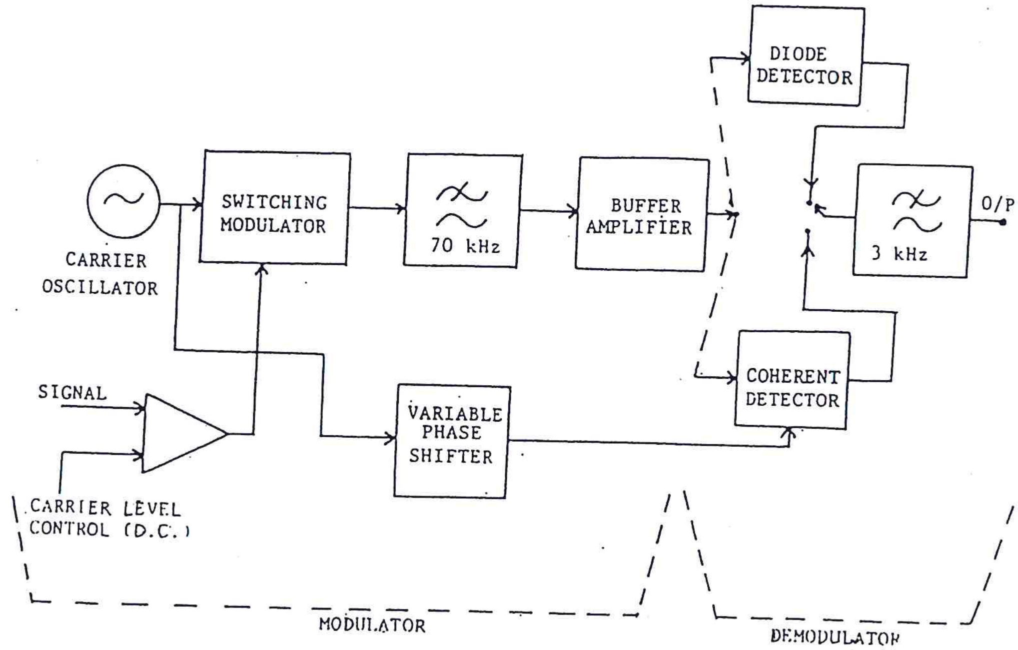

Fig. 1. Block Schematic of the AM/DSBSC unit

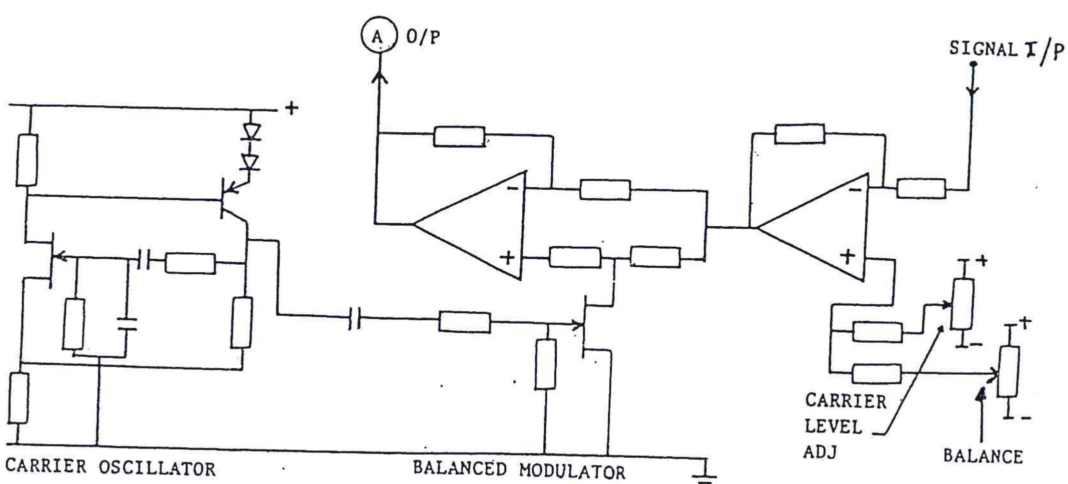

Fig. 2. MODULATOR

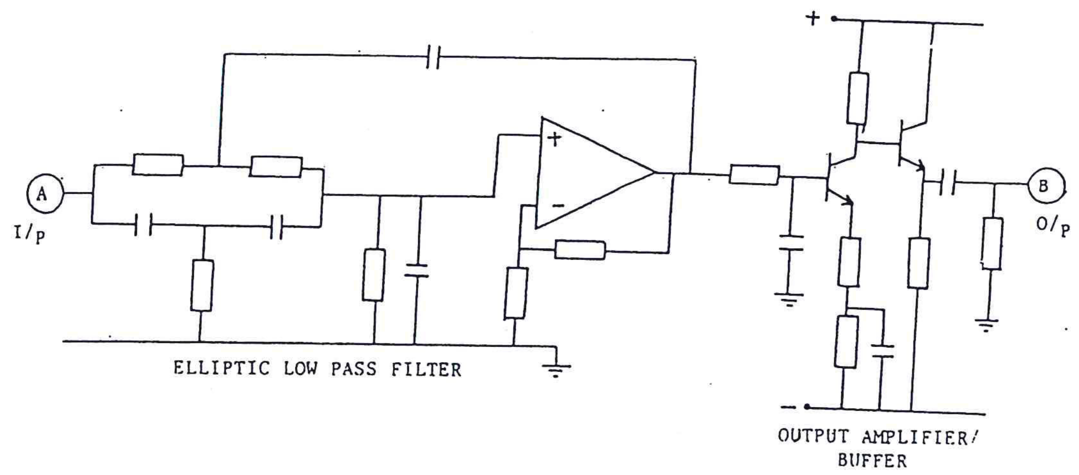

Fig. 3. CARRIER FILTER AND BUFFER

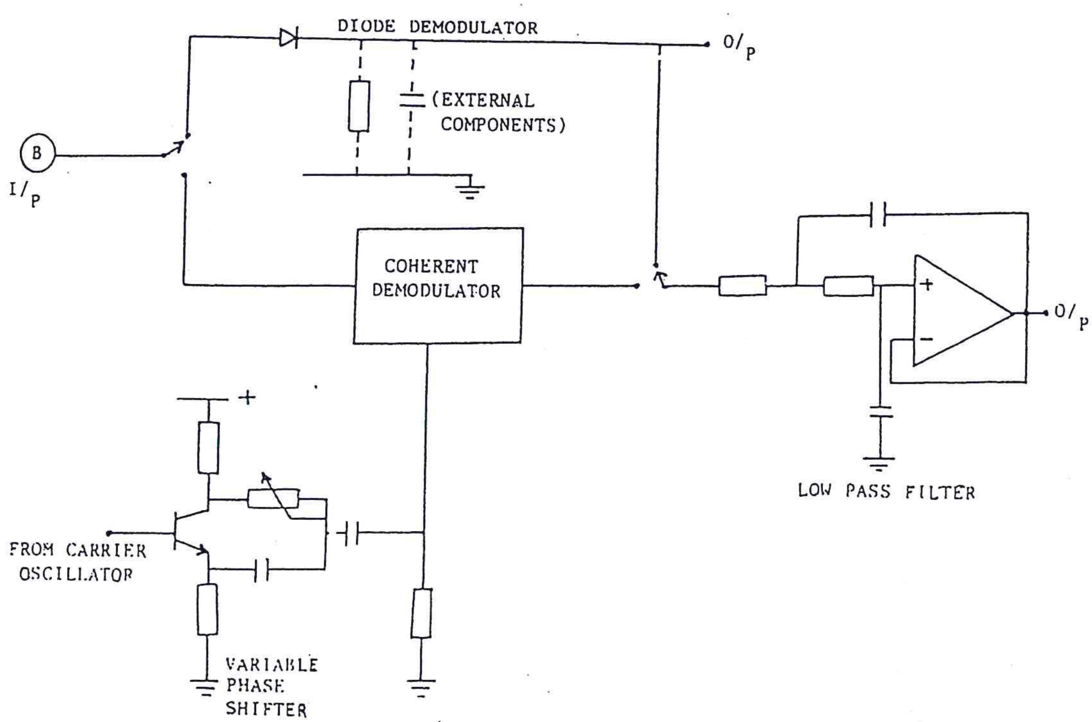

Fig. 4. DEMODULATOR