COMPACT MICROWAVE REMOTE RECOGNITION SYSTEM WITH NEWLY DEVELOPED SSB MODULATION

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ABSTRACT

A Compact Microwave Remote Recognition System (2.45GHz) with newly developed SSB modulation has been built. The system is composed of an interrogator and a responder. The interrogator is able to read and write the data which are stored in the responder by remote control. The SSB modulation makes microwave circuits simpler. By using of a microwave PLO, radio interferences to neighboring systems are eliminated.

This system is widely applicable to factory automation, personnel management, security management, etc.

Key technologies to construct this system are described in this paper.

INTRODUCTION

The Microwave Remote Recognition System has been studied for some years[1][2]. Recently, this kind of system is extremely required in the fields of factory automation, personnel management and security management. Some manufacturing companies have researched and developed. However effective technologies are not yet fully developed and only few papers are available.

A configuration of a basic Microwave Remote Recognition System is shown in Fig.1.

The system is composed of an interrogator and a responder. The interrogator is able to read and write the data which are stored in the responder by remote control.

Generally, two microwave frequencies f_1, f_2 are used to read and write, respectively. To read the data in the responder, a homodyne detection is used for a demodulation of a received signal in the interrogator. However,it is known that the use of one homodyne detector causes a dead point of reception with the relative distance between the interrogator and the responder.

To prevent this phenomenon, the received signal is divided into two parts with 90 degrees phase difference each other, then those signals are independently inputted to two homodyne detectors. Thus the demodulated output signal is obtained without fail from either of the homodyne detectors.

Moreover, when systems are closely set each other, radio interferences occur because the same transmitting frequency is used for each system.

Following new technologies have been introduced to realize a compact and radio interference free system.

(a) By developing the new SSB(Single Side Band) modulation, it is able to demodulate a received signal with one homodyne detector in the interrogator.

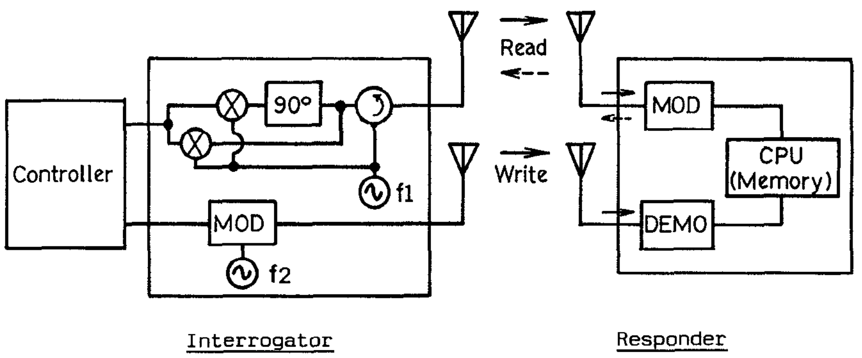

Fig.1 Configuration of a Basic Microwave Remote Recognition System

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(b) TDM(Time Division Multiplex) operation with one frequency is applied to read and write the data.

(c) Improvements of both reading/writing signal recognition and freedom of responder attachment are realized by adopting circularly polarized waves.

(d) By developing a microwave PLO(Phase Locked Oscillator), the radio interferences are removed.

NEWLY DEVELOPED MICROWAVE REMOTE RECOGNITION SYSTEM

The system configuration is shown in Fig.2.

Reading operation

A 2.45GHz carrier is transmitted from the interrogator to the responder with a right hand circularly polarized wave. This carrier is received by the responder and inputted to the SSB modulator. After the SSB modulation of the inputted carrier by the data in the memory, the modulated signal is retransmitted to the interrogator.Then this signal is received and demodulated by one homodyne detector at the interrogator.

Writing operation

The carrier is directly modulated into an ASK (Amplitude Shift Keying) by transmitting data. Then the signal is transmitted to the responder with a left hand circularly polarized wave. This signal is received by the responder and inputted to the demodulator. The demodulated data are stored in the memory.

MICROWAVE KEY TECHNOLOGIES(COMPONENTS)

SSB modulator

The SSB modulator is a reflective type which is developed for the responder. The SSB operation is performed by controlling amplitude and phase of a reflective wave from the responder. A variable capacitance diode is used for the modulator. When the differential waveform voltage(from 3.6 volts to 0 volts) is applied to the diode, the locus of the input impedance of diode(**Za**) moves on a constant resistance circle as shown in Fig.3(a)(b). By connecting a well-designed impedance transformer, the locus of **Za** is transformed into that of **Zb**. Then a reflective coefficient of the SSB modulator(**Γ**) is separated into a rotating vector **S** and a fixed vector **C**. The vector **C** is a constant component which is proportional to a reflected carrier level. The vector **S** is a component which corresponds to the SSB.

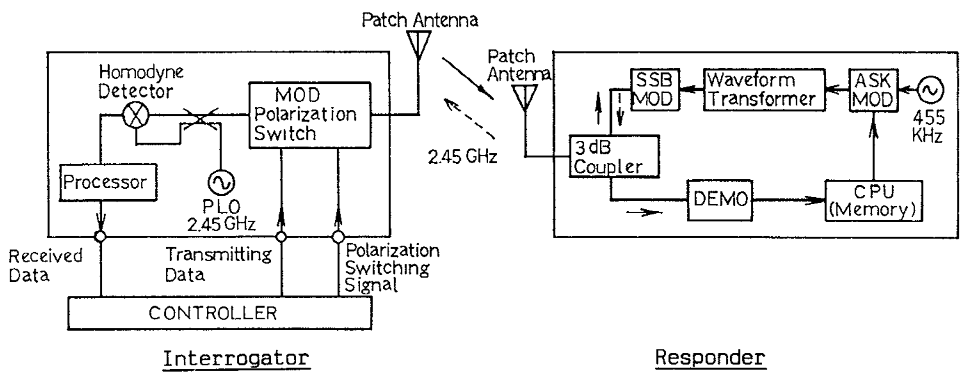
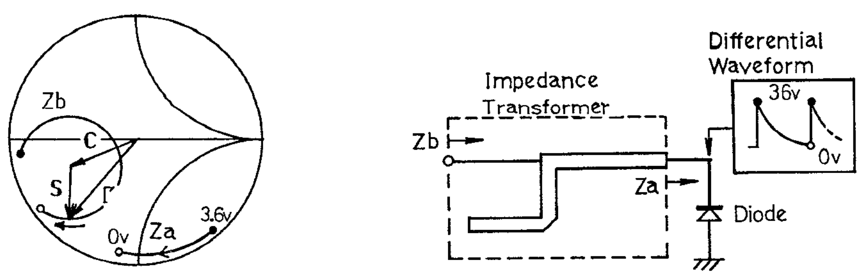


Fig.2 Newly Developed Microwave Remote Recognition System



(a) Impedance Locus (b) Circuit

Fig.3 SSB Modulation

When the applied voltage to the SSB modulator decreases as differential waveform (as shown in Fig.3(b)), the vector **S** rotates clockwise. The phase of the vector **S** delays to that of the vector **C**. Therefore the vector **S** corresponds to LSB(Lower Side Band). If the applied voltage increases and the vector **S** rotates counterclockwise, the vector **S** corresponds to USB(Upper Side Band).

The spectrum of the modulated signal from the responder is shown in Fig.4. The level of the first LSB is about 10.6dB larger than that of the first USB.

The subcarrier(455KHz) is modulated into the ASK by the data in the memory. Then the differential waveform voltage modified from the ASK signal is applied to the diode as shown in Fig.2.

Demodulation of received SSB signal

The mechanism of demodulation for the received SSB signal is shown in Fig.5(a)(b). The received SSB signal(**Vs**) at the interrogator is inputted to the homodyne detector.The divided local signal(**Vl**) from PLO is also inputted to the homodyne detector. This homodyne detector is composed of the 3dB coupler and two mixer diodes. Although the locus of **Zb**(as shown in Fig.3(a)) is not complete circle, subcarrier component of 455KHz exists fundamentally in the output(Vout). The larger amplitude |S| and the more complete circle of the locus of **Zb** are obtained, the larger amplitude of the output(Vout) can be attained (as shown in Fig.3). The subcarrier component is obtained by filtering. This consideration about demodulation is in good agreement with the result of computer simulation.

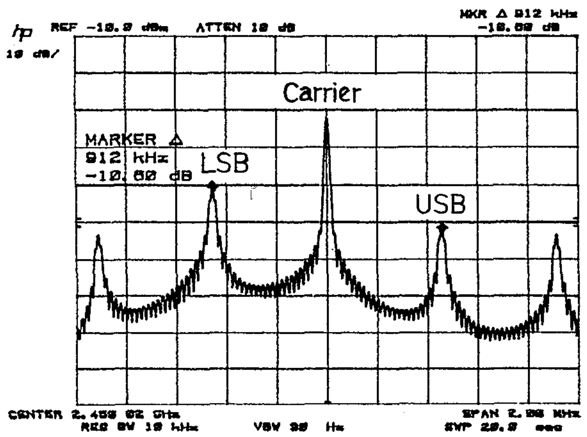


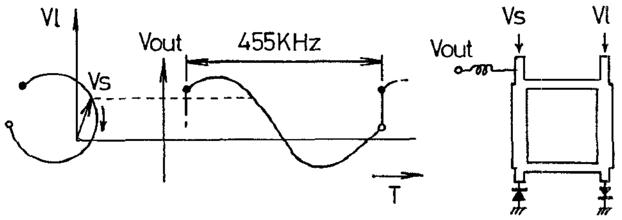
Fig.4 Spectrum of the Modulated Signal
(center : 2450.02MHz)
(H : 200KHz/div.)
(V : 10dB/div.)

Improvement of radio interferences

When interrogators are closely operated each other and the carrier frequency differences among interrogators are almost same as subcarrier frequency (455KHz), radio interferences occur. In order to solve this problem, a microwave PLO is developed and used into the interrogator as the oscillator. The above frequency differece is then adjusted lower than subcarrier frequency.

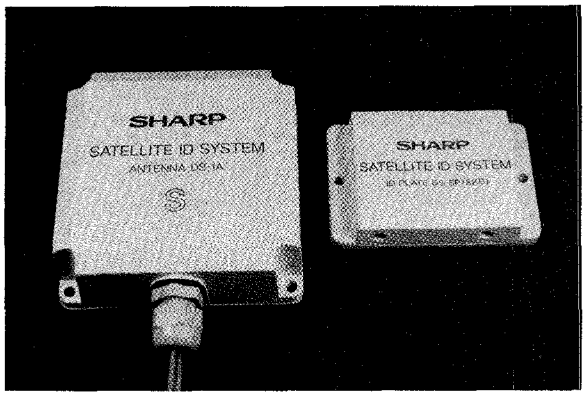
DEVELOPED SYSTEM AND BER(BIT ERROR RATE) CHARACTERISTICS

The overview of the developed system is shown in Fig.6. A very compact interrogator(100x100x35mm) is realized with new technologies. The microwave circuits of the interrogator and the responder are shown in Fig.7 and Fig.8, respectively. One element patch antenna is used in both the interrogator and the responder. The circularly polarized waves are made by a combination of the patch antenna and the 3dB coupler. A modulator (also used as polarization switch) of the interrogator is composed of PIN diodes. The transmitted and received signals are separated by the directional coupler instead of a circulator.



(a) Mechanism (b) Circuit

Fig.5 Homodyne Detection



Interrogator Responder

Fig.6 Overview of the Developed System

The total BER is less than 10^{-5} with transmitted power of 0.1mW (distance between the interrogator and the responder : 80cm for reading, 30cm for writing shown in Fig.9).

Basic specifications are shown in Table.1.

CONCLUSIONS

The new SSB modulation has been developed for the Compact Microwave Remote Recognition System. This SSB modulation makes microwave circuits simpler in the interrogator. By applying a microwave PLO to the interrogator, radio interferences among interrogators can be removed.

ACKNOWLEDGMENT

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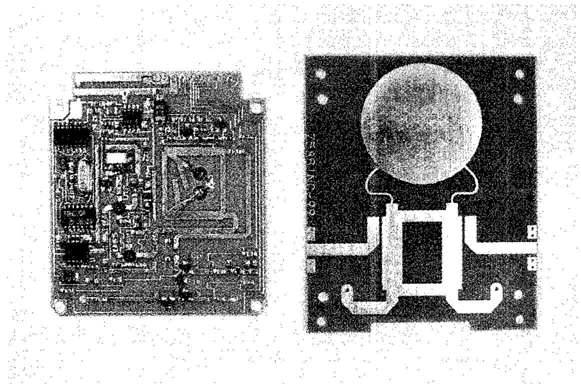
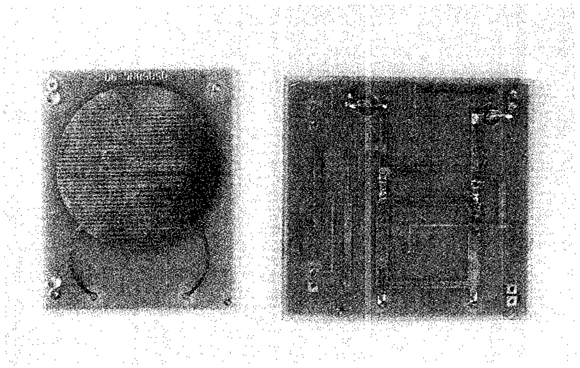


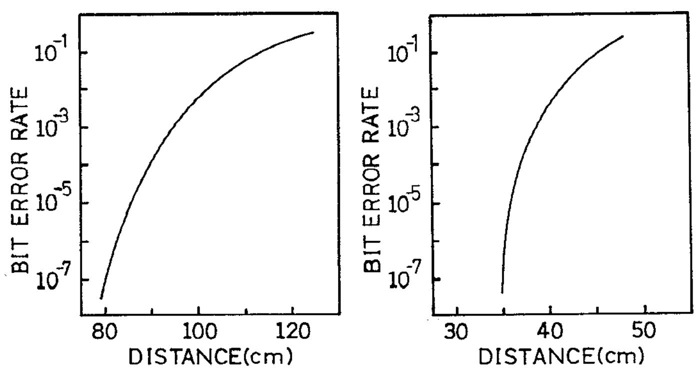
Homodyne Demo,Mod,PLO   Patch Antenna

Fig.7 Microwave Circuits(Interrogator)



Patch Antenna   SSB Mod,Demo

Fig.8 Microwave Circuits(Responder)



Reading   Writing

Fig.9 Bit Error Rate Characteristics

•	Frequency	: 2.450GHz
•	Transmitting Power	: 0.1mW
•	Communication Distance	: 30cm
•	Data Speed	: 19.2kb/s
•	Bit Error Rate	: < 10^{-5}
•	Size -- Interrogator	: 100×100×35mm
	-- Responder	: 90×60×20mm

Table.1 Basic Specifications