Giga-bit Class Ultra High Speed Signal Wireless Distribution by Using NRD Guide Technology at 60GHz

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Abstract **— A giga-bit class ultra high speed data distribution has been successfully demonstrated at 60GHz by using the nonradiative dielectric waveguide (NRD guide) technologies. An emphasis is placed on a high speed performance of an ASK modulator and a stability of a Gunn oscillator. By assembling these circuit components, ultra high speed NRD guide transmitter and receiver have been fabricated, and it was confirmed that these NRD guide front ends have great advantage of high speed operation capacity beyond 1Gb/s. Moreover, an SDI (Serial/Digital Interface) signal with a bit rate of 1.48 Gb/s was distributed successfully to drive a high resolution HDTV displays at 60GHz.**

I. INTRODUCTION

With the opening of a broad band communication era, ATM(Asynchronous Transfer Mode)-based communication systems with bit rates ranging from 156Mbps to 2.5Gbps are being built in optical fiber networks[1]. Wireless communication systems with such bit rates have also attracted much attention in the fields of millimeter wave applications, therefore, various millimeter wave front ends for LAN(Local Area Network) use have been developed by using printed transmission lines such as microstrip line and coplanar waveguide[2][3]. Those printed transmission lines are preferable for applications at centimeter frequencies, however, they suffer from a lot of transmission losses at millimeter wave frequencies [4]. The NRD guide which consists of rectangular dielectric strips inserted in a below cutoff parallel metal plate waveguide and features no radiation at curved sections and discontinuities as well as small transmission loss is another candidate as a transmission medium for constructing millimeter wave integrated circuits [5]. Actually NRD guide ASK modulator, fabricated for wireless LAN use at 60GHz, has great advantages such as high speed operation beyond 400Mb/s as well as a small size less than that of the name card [6].

In this paper, the ASK modulator was investigated for giga bit class high speed performance, and it was clear that the ASK modulator has sufficient capability of more than 1Gb/s operation. Moreover, a technique to easily stabilize a Gunn oscillator was devised by using a high Q ceramic resonator since the phase noise reduction was needed to handle such ultra high speed data train.

By assembling these circuit components, NRD guide transmitter and receiver were fabricated and an SDI (Serial/Digital Interface) signal with a bit rate of 1.48 Gb/s was distributed successfully at 60GHz to drive large sized and high resolution HDTV(High Definition Television) displays, which are hanging on wall.

II. IMPROVEMENT OF NRD GUIDE DEVICES

A. ASK Modulator

The structure of the NRD guide ASK modulator is shown in Fig.1. The beam-lead type Schottky barrier diode (SBD) is bonded across a slot between two electrodes etched on a single dielectric substrate together with λ/4 RF choke circuits as shown in Fig.2 and the diode mount is placed in front of one port of the circulator constructed by locating a ferrite disk resonator in the center of the Y junction. A high permittivity sheet is used so as to match between the NRD guide and the forward-biased SBD, and an air gap is installed in front of the SBD to achieve the perfect matching. Incident millimeter waves are therefore absorbed by the forward-biased SBD due to the detection condition, whereas those are reflected from the zero or reverse-biased SBD due to the unmatched condition. Based on this principle of operation, pulse modulated waves appear at another port of the circulator. This ASK modulator can be expected to operate with higher speed than that constructed by PIN diode because the minority carrier lifetime of the SBD is pico-second order while the one of the PIN diode is nano-second order. And it is another advantage of the ASK modulator that a matched load used to make an OFF state in this kind of modulator is dispensable, so the size reduction can be achieved.

In order to investigate the high speed operation, millimeter-wave with the frequency of 62.9GHz was modulated by a 1Gbps clock in the NRD guide ASK modulator. The comparison between the modulating and demodulated waveforms, observed by oscilloscope, is shown in Fig.3. The two patterns are identical in shape, thus, it is confirmed that the millimeter wave can be clearly modulated by the 1Gb/s clock in the NRD guide transmitter.

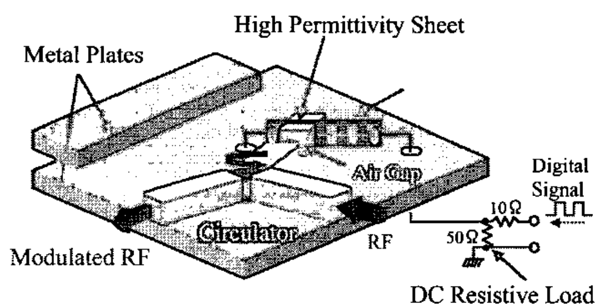


Fig. 1. Structure of NRD guide ASK modulator

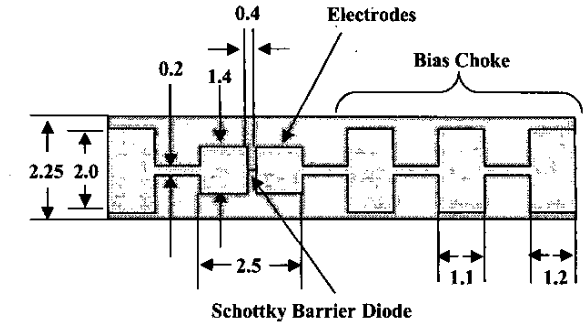


Fig. 2 NRD guide beam lead diode mount

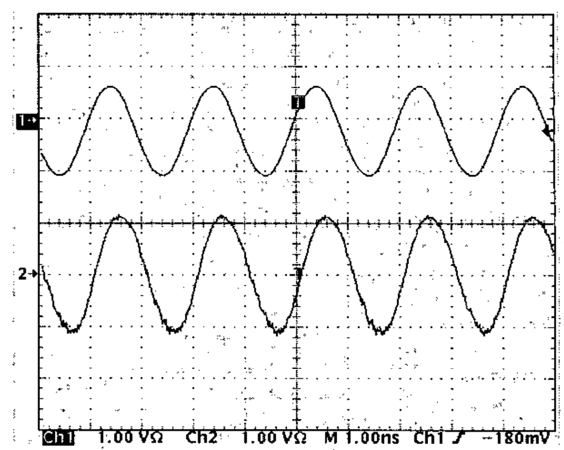


Fig. 3 Comparison between modulating (top) and demodulated (bottom) waveforms with 1Gb/s clock (vertical axis: 1V/div; horizontal axis: 1ns/div)

B. Frequency Stabilized Gunn Oscillator

The structure of the NRD guide Gunn oscillator is shown in Fig. 4. The Gunn diode is transversely inserted in a metal piece with λ/4 chock circuits, and the output power is introduced to the dielectric strip though a metal strip line. In order to stabilize the oscillation frequency, a ceramic resonator, whose unloaded Q factor was measured to be 4000 in 60GHz band, is installed behind the truncated end of the dielectric strip, while the ceramic resonator was side-coupled to the dielectric strip in a previous NRD guide Gunn oscillator [5]. By coupling the ceramic resonator to the dielectric strip longitudinally, an injection range of the oscillation frequency was enlarged, and therefore, the oscillation stability was more improved than the previous one.

Figure 5 shows the observed oscillation spectrum and the measured phase noise versus the coupling spacing between the ceramic resonator and truncated end of the dielectric strip. A small phase noise, found to be -114dBc/Hz (300KHz offset), can be achieved by using the convenient technique.

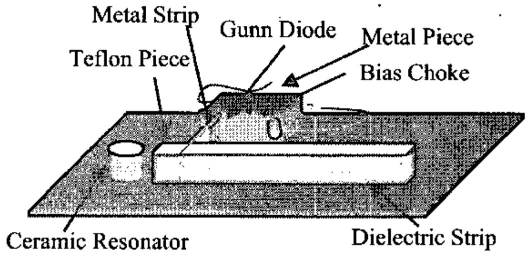
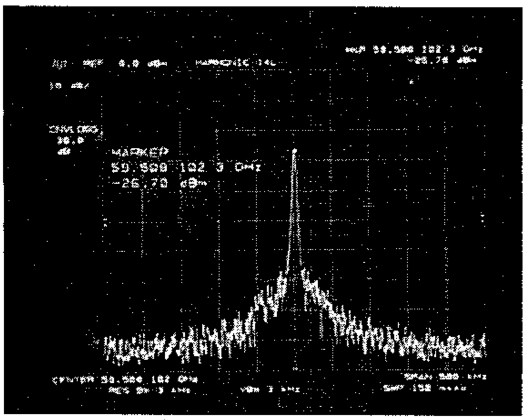
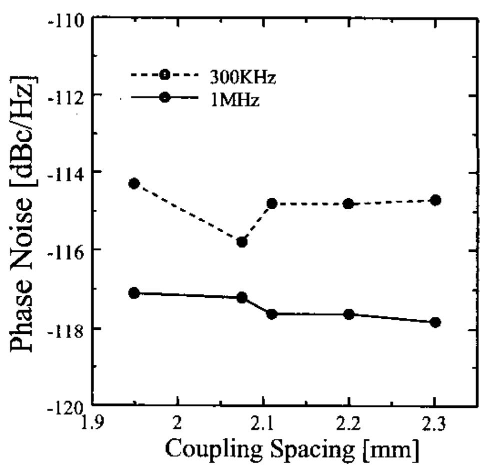


Fig. 4. Structure of frequency stabilized NRD guide Gunn oscillator



(a) Frequency spectrum



(b) Phase noise

Fig. 5. Measured oscillation stability of frequency stabilized NRD guide Gunn oscillator

III. DEMONSTRATION OF SDI SIGNAL DISTRIBUTION

Figure 6 shows a diagram of the fabricated transmitter and receiver. The former consists of Gunn oscillator, ASK modulator, and circulator, while the latter consists of Gunn oscillator, 3dB coupler, and balanced mixer. The performances are summarized in Table 1.

By using the transmitter and receiver, we propose a wireless SDI signal distribution system for wall-hanging high resolution displays as shown in Fig.7.

In this system, analogue HDTV video signals, consisting of a luminance signal (Y) and color difference signals (Pb, Pr), are converted to the SDI signals with the bit rate of 1.48Gb/s. Millimeter-wave with the frequency of 62.9 GHz is modulated by the SDI signal in the NRD guide transmitter, and the modulated wave which is received by the NRD guide receiver is down-converted to the intermediate frequency (IF) of 3.2GHz. And then, the IF wave is amplified and detected.

In order to exhibit the demonstration, a system configuration as shown in Fig. 8 was constructed. By using an A/D converter, parallel outputted video signals from a personal computer are changed to a serial digital signal with the bit rate of 1.48G/s, namely the SDI signal, and then the SDI signal is distributed by the NRD guide transmitter. Figure 9 shows a demodulated video signal. The picture is quite clear, and it is therefore verified that the NRD transmitter and receiver have good advantage in the application of ultra high speed signal wireless distribution.

IV. CONCLUSION

For the purpose of development of ultra high speed data wireless distribution systems, NRD guide devices such as ASK modulator and frequency stabilized Gunn oscillator were improved at 60GHz.

Moreover, NRD guide transmitter and receiver were fabricated for the application to the SDI signal distribution system for wall-hanging, large sized and high resolution displays by assembling them. From the result of demonstration of this system, it is confirmed that the NRD transmitter and receiver have good advantage in the application of ultra high speed signal wireless distribution beyond 1.48Gb/s.

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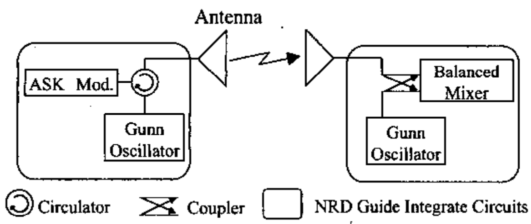

Fig. 6. Structure of NRD guide transmitter

Table 1 Performance of NRD guide transmitter and receiver

Transmitter	
RF Oscillation Frequency	62.9GHz
Transmitting Power (Average)	9dBm
Modulation	ASK
Bit Rate	1.5 Gbps
Antenna Gain	19dBi
Receiver	
LO Frequency	59.7GHz
LO Power	10dBm
Intermediate Frequency	3.2 GHz
Conversion Loss (Average)	12dB
Antenna Gain	19dBi

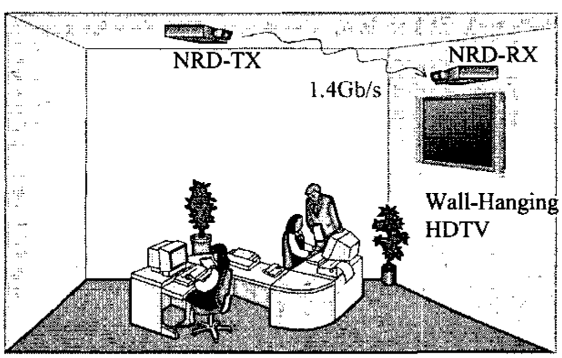

Fig.7 Schematic view of wireless SDI signal distribution system for wall-hanging displays

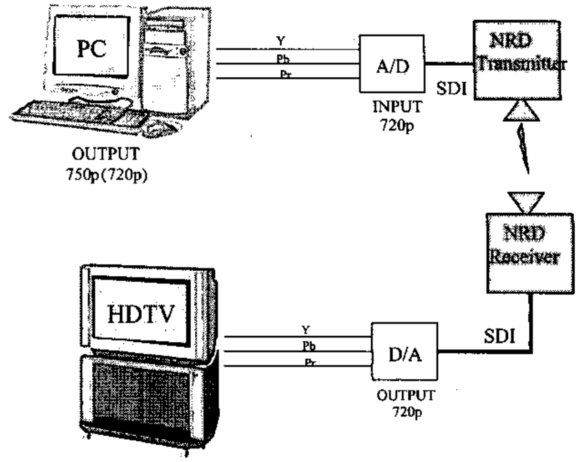

Fig.8 System configuration of HDTV video data distribution test

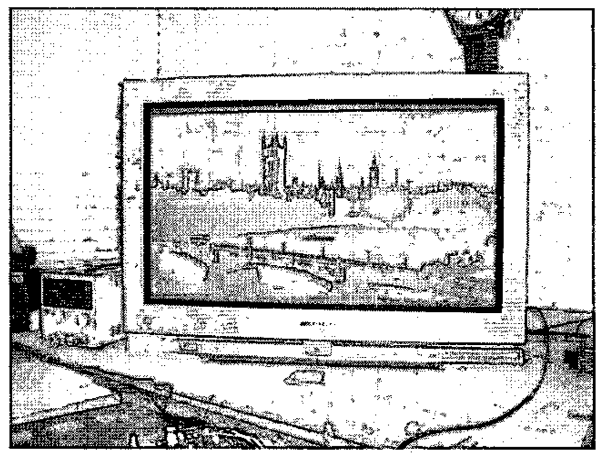

Fig.9 Demodulated HDTV video signal