<u>DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS</u>

The wireless video and audio system that transmits and receives analog video signal, analog and digital audio signals simultaneously over a single high-frequency channel. An analog video signal source and an audio signal source may be connected to a single transmitter. The plurality of source audio signals may be configured for transmission in digital or analog forms. A receiver is used to receive the video source and the plurality of source audio signals. In the presently preferred embodiment, five separate source audio signals and one source video signal is transmitted to a receiver.

Each of the less than all of the plurality of source audio signals is digitized by CVSD encoding, which is then used to frequency-modulate a high frequency sub-carrier preferably between 4.5 and 40 MHz. Each of the remaining source audio signals is used to frequency-modulate a high frequency sub-carrier preferably between 4.5 and 40 MHz. The modulated sub-carriers are combined together with the analog video signal to frequency-modulate a single radio frequency carrier, preferably over 900 MHz . This single radio frequency carrier is then amplified and transmitted wirelessly to the receiver.

The receiver is configured to down-convert the radio frequency signal to an intermediate frequency signal, which is then frequency-demodulated to recover the combined analog video and modulated sub-carriers. The analog video signal is recovered by low-pass filtering the combined signal. The sub-carriers are recovered by band-pass filtering the combined signal at each sub-carrier frequency. They are then frequency-demodulated to recover the analog or digital audio signals. If it is analog, then it is directly amplified and fed to external outputs. If it is digital, then it is CVSD decoded and then amplified and fed to external outputs.

Referring to the drawings in detail, Figs. 1 and 2 are block diagrams of a transmitter and receiver, respectively, configured according to the present invention generally designated 100 and 200. The general operation of the transmitter 100 and receiver 200 will be discussed first, followed by a detailed description of the preferred embodiment including the specific circuits and operation thereof.

The transmitter 100 receives an analog video input signal 132. As used herein, an analog video signal source may be, by way of non-limiting example, CCD camera, compact disc player, television (TV) set, video cassette recorders (VCR), and other similar analog video signal producing device. This source video signal passes through a video buffer 134 which amplifies 132 to the right amplitude and then low-pass filters the resulting waveform to reduce the frequency contents approximately above 4 MH. The amplifier can be a simple balance or unbalance video amplifier with 0 db gain, input impedance at 75 Ohms and output impedance approximately below 1000 Ohms. This is used as a buffer only so that the input can be matched to any standard video source. The filter can be composed of RLC components and a 12-db roll-off per octave will suffice. Both circuits are very common place and can be implemented with ordinary state of the art.

In the presently preferred embodiment, the audio encoder 120 is configured to input 5 source audio signal in which two are chosen as digital and the other three are chosen as analog. This corresponds to the front left and right, front middle and the back left and right. This is a very common practice in surround sound system in which the two front left and right are required to be high fidelity sound. This can be satisfied only with digital audio because of its high signal to noise

ratio and low distortion characteristics in wireless communication. The same digitization technique, namely CVSD encoding as in the Wireless Speaker System, is used here and the bit rate is preferably below 256 KHz. The two digitized audio signals are each used to frequency-modulate two separate sub-carriers at different frequencies. The other three source audio inputs are each used to frequency-modulate three separate sub-carriers at different frequencies. The five sub-carriers are then band-pass filtered and combined together to form the output signal 122. It is then combined together again with video signal 136, and is input to the RF Modulator 140 to frequency-modulate the RF carrier 142. The RF modulator 140 contains a PLL synthesizer which can be programmed to different frequencies by external means, for example, a mechanical switch or a keyboard. Signal 142 is amplified by RF amplifier 170 and then low-pass filtered and transmitted via antenna 104.

Referring next to Fig. 2, the receiver 200, receives the amplified signal 142 via antenna 262 and down-converts the received signal to an intermediate frequency (IF) signal 266 by the RF down-converter section 260. The RF down-converter 260 can be programmed, just like the transmitter, to match the transmitted carrier frequency so that the IF is fixed no matter what the carrier frequency is. The IF demodulator frequency-demodulates the IF to recover the original video signal 136 and the combined sub-carriers 122. The video signal 136 is fed to a video output buffer section 256, which contains a low-pass filter to remove the high-frequency components approximately above 4 MHz and an amplifier to amplify the video signal to approximately 1V peak-to-peak at 75-Ohm loading. The recovered source video signal 132 is output to the video signal destination. On the other hand, the combined sub-carriers 122 is decoded by the audio decoder to recover the original source audio signals 112 and then amplified and output to the audio signal destination.

Referring next to Figs. 1, 3-5, 9, the detailed operation of the transmitter 100 of the present invention will now be described. The video signal 132 passes through the video buffer 134 to form a signal 136 with frequency contents approximately between 50 Hz to 4 MHz. The maximum amplitude of this signal is trimmed by resistor network to frequency-modulate the RF carrier so that it occupies a bandwidth of approximately 4 MHz.

On the other hand, the front right and left source audio signals pass through the two digital modulator sections 160. Each section 160 contains an anti-alias low-pass filter 162 with bandwidth approximately 20 KHz. It is preferred to implement filter 162 with active components, which gives a sharper cut-off characteristic, otherwise the frequency response of the source audio signal will be sacrificed. The low-pass signal then go through the digital encoder 180 which is a CVSD encoder in this preferred embodiment. This produces a bit stream at approximately 256 KHz. Note that the same CVSD encoder as in the WSS is used here. The choice of CVSD encoder is just a preference for its cost and performance . Other encoders like PCM, ADPCM or the like can be used as well. Now at this stage, the bit stream 167 is low-pass filtered by 168 which is a simple RLC filter to attenuate the higher harmonic contents of the bit stream by approximately 12 db at 512 KHz. The resultant signal 192 is then used to frequency-modulate an oscillator 190. The modulated oscillator 194 then passes through a band-pass filter 164 to produce the sub-carrier 166 with limited bandwidth preferably within 300 KHz.

At the same moment, the other three source audio signals, which are chosen to be transmitted in analog form, will each go through a RC low-pass filter 152 to get rid of high frequency spurious. Each is then used to frequency-modulate an oscillator 190. The modulated oscillator signal 194

then passes through a band-pass filter 154 to produce the sub-carrier 156 with limited bandwidth preferably within 200 KHz.

It should be noted that the filtering of sub-carriers is accomplished generally with low-cost ceramic filters or LC filters as in the WSS. The additional requirement for shaping the digital sub-carrier is by a filter with wider bandwidth, more specifically, a filter with minimum 3-db bandwidth of not less than 300 KHz.

Now, the two digitized audio sources and the three analog audio sources are each used to modulate an oscillator, which consequently creates five different modulated sub-carriers. These oscillators can be implemented with numerous techniques and the most common low-cost solution is to use the 74HC4046. The frequency of each oscillator is preferably chosen between 4.5 and 40 MHz The lower choice is to prevent overlapping with the video signal 136 and the higher choice is actually chosen to utilize the total available bandwidth. For instance, if the ISM band 2.4 to 2.483 GHz is chosen as the communication channel and the RF carrier is chosen to be 2.441 GHz, then the choice of sub-carrier frequency can be as high as 40 MHz (with 1 MHz slack on the band edges).

The sub-carriers are combined together with resistor network to produce the signal 122. Signal 122 is then combined with video signal 136 with resistor network to form the modulation signal 906. It is then used to frequency-modulate a programmable synthesizer 900 and passes through a buffer amplifier 144 before output to the RF amplifier 170. The buffer amplifier 144 is used to provide better isolation between the source and the load. This results in a lower phase noise performance.

The art of programmable synthesizer is well-known and a functional block diagram (Fig. 9) is included to superficially express its implementation. The heart of the synthesizer is the phase lock loop integrated circuit. This type of IC working at GHz frequency is very common place. For example, the 1600 series from National Semiconductor, the 15E00 series from Fujitzu, etc., are readily available at big volume. Application details can be found in their literature and the synthesizer 900 is a straight forward standard application.

Referring again to Fig. 2 and also Figs. 6-8, the operation of the receiver 200 of the present invention will now be discussed in greater detail. In the present preferred embodiment, one video source and five audio sources are required to be output from the receiver. The receiver receives the RF signal 142 from antenna 262 and is fed to the RF down-converter section 260. This signal is amplified by an ordinary RF amplifier 261, preferably with low noise figure and approximately 20 of gain, and then input to the RF mixer 265. The RF mixer 265 is preferably of the high isolation type which prevents local oscillator leakage to the RF amplifier. There are numerous choices for this type of mixer and is well-known to the ordinary state of the art. Manufacturers like Motorola, Mini-circuits, etc. readily offer low cost and high performance mixers at frequencies above 900 MHz. Detail application can be found in their literatures. Now, the local oscillator is generated by a programmable synthesizer 900 which is of the same type as for the transmitter, only that the modulation input 906 is left open. The intermediate frequency signal 264 generated by the mixer 265 is preferably below 500 MHz and is filtered by a band-pass filter 268. Filter 268 can be composed of RLC components or, more preferably, with surface acoustic wave (SAW) filters. SAW filters have higher out-of-band attenuation and sharper roll-off at the band edges and most importantly, they have very stable temperature characteristics and no tuning requirement. Part numbers like B680, B4637, KAF-134NR-MB and KAF-130NR-MB are some of the readily

available SAW filters for this application. The characteristics of filter 268 affects the receiver's sensitivity and selectivity, and RLC filter is found to be sufficient if the communication range is limited to 500 feet. After the filtering, the IF signal 267 is further amplified by amplifier 269 preferably of low noise and high gain type. This amplifier 269 is preferably implemented with low noise transistors cascaded in three stages which gives a total gain of not less than 40 db. This is necessary for the amplified signal 266 to reach the demodulation threshold of an ordinary wide-band FM-demodulation IC so that a reasonable receiver sensitivity can be obtained. Now the IF signal 266 is input to the FM-demodulator section 250. This is composed of a wide-band FM-demodulation IC such as Motorola's MC13155, Sony's CXA165, etc.. The choice of IC only depends on the IF frequency and details of circuits can be found in their corresponding literatures.

Now the demodulated signal contains the video signal 136 and the combined carriers 122. On one hand, signal 136 is input to a video output buffer section which firstly low-pass filters the signal with RC components at a corner frequency of approximately 4 MHz, and then amplifies it to a peak-to-peak amplitude of one volt at 75-ohm loading. The original video signal 132 is recovered in this way and output to the video signal destination.

On the other hand, signal 122 is input to the audio decoder 240. To recover a sub-carrier which is used to carry digital information, the same type of band-pass filter 164 as in the transmitter audio encoder is used. The recovered sub-carrier 166 is input to a demodulator 282 to recover the bit stream 167. Bearing in mind that the 3-db bandwidth of sub-carrier 166 is at a minimum of 300 KHz, therefore the choice of demodulator 282 is chosen to be of the types like MC13055, MC13156, 74HC4046 etc.. The recovered bit stream 167 then goes through the digital decoding section 284 and then low-pass filtered in 286 to recover audio signal 112. This audio signal 112 is input to an audio amplifier 230 and output to the audio signal destination. To recover a sub-carrier which is used to carry analog information, the same type of band-pass filter 154 as in the transmitter audio encoder is used. The recovered sub-carrier 156 is input to a demodulator292. Bearing in mind that the bandwidth of the sub-carrier 156 is much narrower than the digital sub-carrier 166, therefore the choice of demodulator292, in addition to the choices for the demodulator 282, can include TBA120, TDA5710 etc.. The demodulated audio signal 112 is input to an audio amplifier 230 and output to the audio signal destination.

Operation of the invention is preferably at carrier frequencies above 900 MHz. It is therefore possible to use known circuitry in the transmitter 100 to modulate the video signal and the sub-carriers. In this way, the operating frequency is not limited by the present invention but, rather, is somewhat flexible, such that operation at 2.4 GHz or 5.7 GHz is also possible. All that is required will be modification of the programmable synthesizer to adapt to different frequencies.

Thus, while there have shown and described and pointed out fundamental novel features of the invention as applied to preferred embodiments thereof, it will be understood that various omissions and substitutions and changes in the form and details of the devices illustrated, and in their operation, may be made by those skilled in the art without departing from the spirit of the invention. For example, it is expressly intended that all combinations of those elements and/or method steps which perform substantially the same function in substantially the same way to achieve the same results are within the scope of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the claims appended hereto.

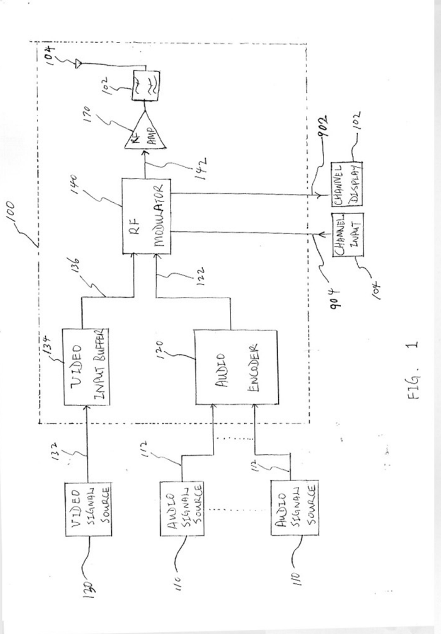

FIG. 1

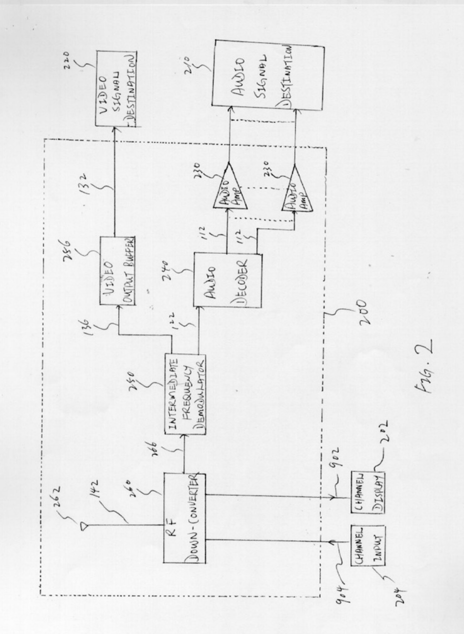

FIG. 2

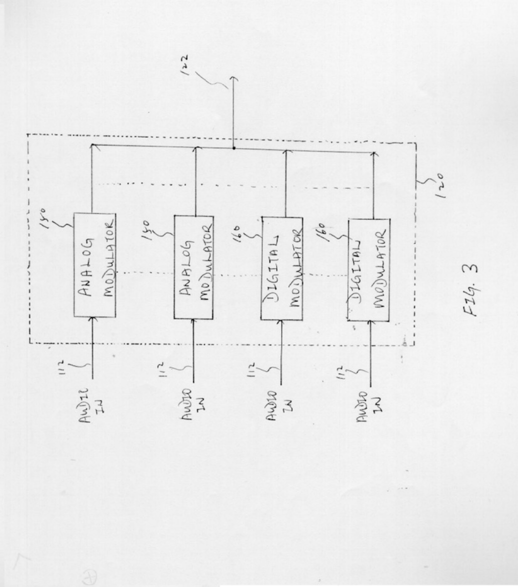

FIG. 3

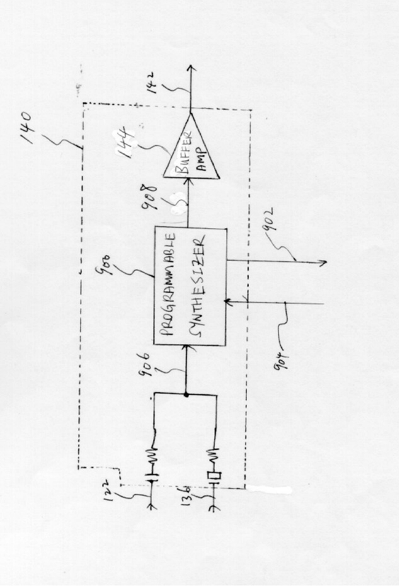

FIG. 4

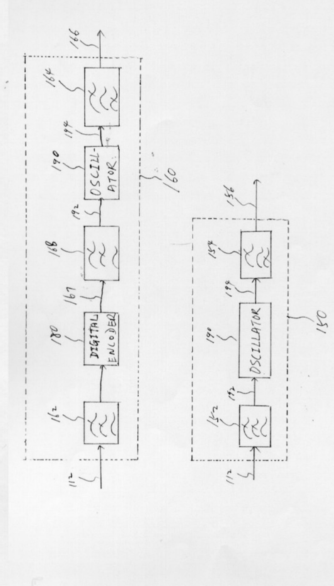

FIG. 5

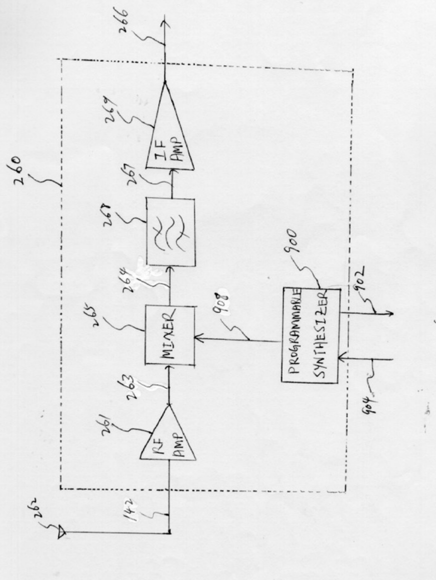

FIG. 6

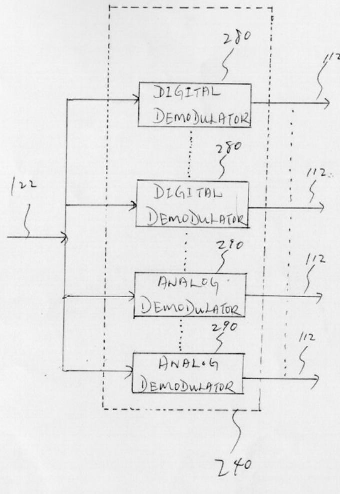

FIG. 7

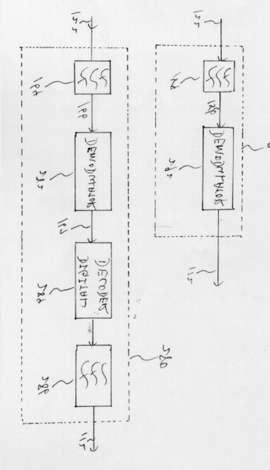

FIG. 8

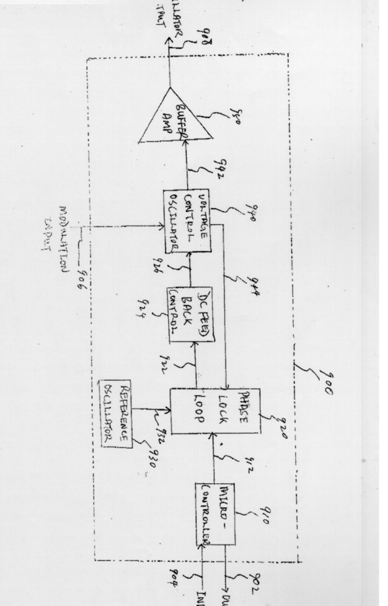

FIG. 9