High-Sensitivity and High-Mobility Compact DVB-T Receiver for In-Car Entertainment

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***Abstract*—A compact DVB-T receiver with better than -94 dBm sensitivity for in-car usage is presented. Dual tuners are included in the receiver to reduce multi-path effects as well as realize the diversity technique. A robust audio/video interface (AVIO) is defined to accommodate different kinds of in-car displays with a variety of A/V specs. In addition, a protection circuit is proposed to provide the convenience that either active antennas or passive antennas can be plugged in the same antenna sockets. Field trials proved that the receiver works perfectly when the car is running over 180 Km/hr.**

I. Introduction

A mobile DVB-T digital TV receiver [1], as well as a portable indoor unit, typically receives many multi-path signals. Additionally, the movement of the receiver causes so-called Doppler effects, distorting the DVB-T channel information, based on the speed of the mobile receiver and the DVB-T transmission frequency and the direction of the incoming echo. Each multi-path signal to the receiver will be influenced by the Doppler effects, resulting in a complex, time-varying channel shape, [2], [3], [4]. When receiving DVB-T in a moving car, the receiver must be able to handle fast channel variations and deep fading effects. Diversity techniques significantly improve reception performance by using two antenna/demodulator combinations. A diversity system uses the information of each demodulator and obtains for each data-carrier of the COFDM signal the best possible quality. In case one antenna is experiencing poor reception conditions, for example deep or flat fading, the other antenna will probably receive a better signal. By continuously combining the antenna information at the correct moment with correct weighting, a diversity receiver will deliver an optimal output signal to ensure the A/V quality. The proposed car-use DVB-T receiver has been proved to possess -94 dBm sensitivity and produce perfect A/V even when the care is racing over 180 km/hr.

II. Car-Use DVB-T Receiver Design

An overview of the proposed high-sensitivity and nigh-mobility compact DVB-T receiver, called Hawk Ranger, is shown in Fig. 1.

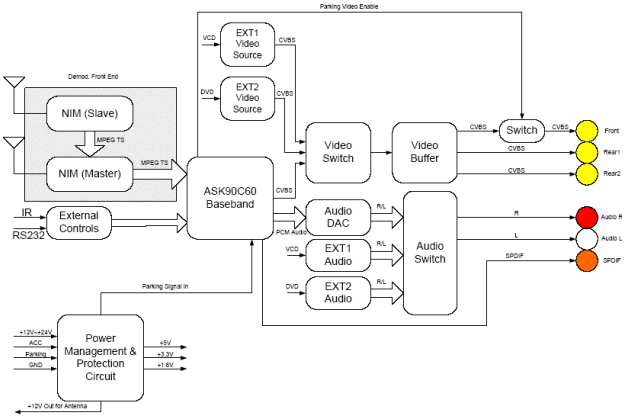

Fig. 1. Overview of the proposed car-use DVB-T receiver

A. Anti-Doppler 2-NIM Demod Front End

Dual antennas as well as dual NIMs (network interface modules) are employed to resolve the multi-path and Doppler effects. Each NIM coupled with a respective antenna contains an RF tuner and a COFDM demodulator to convert the received signal into MPEG2 transport stream (TS). The slave NIM generates its own TS to the master NIM which will decide either one of the two TS's, the TS of the slave NIM or that of the master NIM, is going to the baseband module, ASK90C60, depending on the BER and the signal strength of the two TS's.

B. Diversified Baseband and Peripherals

The baseband IC, ASK90C60, is the core of the entire receiver. It accepts external control commands to carry the following major functions,

- decode the selected TS by an embedded MPEG2 decoder
- convert the selected programs into a CVBS signal by an embedded video encoder
- control all of the peripherals, including, Video Buffer, A/V Switches, etc. by an embedded 8-bit micro-controller
- monitor the power supply variations and the position of the stick shift such that the driver can only enjoy the TV programs on the front in-dash display panel when the car stick shift is placed in the "P" gear.

Notably, two extra external A/V sources are included to accommodate popular VCD and DVD players such that entertainment function in a vehicle can be integrated in a single and compact module.

C. Power Management & Protection

There is a possibility that active antennas which contain a booster to compensate the gain loss resulted from long wires

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will be utilized with car-use DTV receivers. However, if a passive antenna which is either accidentally or deliberately hooked up with a power supply & protection circuit for active antennas will cause oscillations, since the small input impedance of the passive antenna will almost short-circuit the output to the ground. Therefore, we propose an open-loop power protection circuit as shown in Fig. 2. Without any feedback loop, the proposed protection circuit won't introduce any oscillation or short circuit. Besides, a voltage divider generating a stable voltage to the base drive of Q21 ensures the functionality of supplying power to the load. Therefore, either active antenna or passive antenna can be hooked up with Hawk Ranger without any trouble.

Low drop-out circuitry is required for the power management of the entire system, since most of the power supply of automotives is either 12 V or 24 V. By contrast, different supply voltages are needed on the PCB, because there are a variety of chips thereon. For example, 5 V, 3.3 V and 1.8 V are basic voltages required. Last but not least, many countries don't allow drivers to enjoy any visual entertainment when they are driving vehicles. Hence, Hawk Ranger provides an option, "Parking Video Enable", which will turn off the front display if the vehicles are not in a "parking" situation. Drivers can only watch programs when the vehicles are parked.

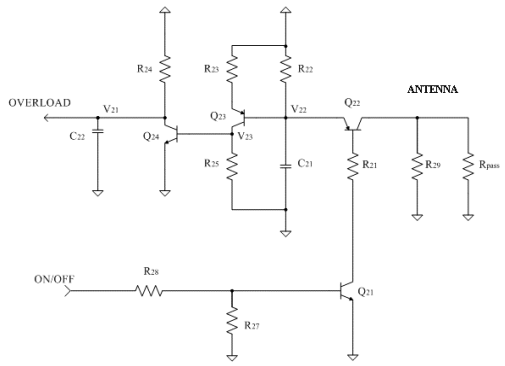

Fig. 2. Proposed antenna protection circuit

D. AVIO interface

Owing to the fact that there are lots of add-on audio (e.g., AM/FM, stereo) and video (DVD, VCD) devices, an interface on the PCB is needed to achieve purposes of easy installation and expansion. We define an AVIO (audio/video I/O) interface thereon to support many A/V signals compliant with a plurality of different specifications by ping sharing and grouping. Therefore, a total of 20 pins in such an interface can support VGA, YCbCr, S-Video, YPbPr，CVBS, audio L/R, GPIO（general-purposed I/O）, I^2C, grounding signals.

III. Implementation And Field Trial

The proposed car-use DVB-T reciever, i.e., Hawk Ranger, has been field trialed in Hannover, Germany during CeBIT 2005 (March 10-16, 2005). Fig. 3 shows the photo that Hawk Ranger was tested in a renatl taxi running with 180 Km/hr in a freeway close to Hannover. The picture of Hawk Ranger is shown in Fig. 4. The overall characteristics of the proposed car-use DVB-T receiver are summarized in Table I.

Fig. 3. Field test of Hawk Ranger

Fig. 4. Outlines of Hawk Ranger

TABLE I
Performance of Hawk Ranger

Outlines	12.9cm x 17.9 cm x 3cm
Frequency range	145.1MHz ~ 862 MHz
RF input impedance	75 Ohm
Channel bandwidth	6/7/8 MHz
Input signal range	-20dBm ~ -80dBm
Demodulation	QPSK, 16-QAM, and 64QAM
Input voltage	9V ~ 25V DC
Sensitivity	-94 dBm
Highest car speed	□ 180 Km/hr

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