INFOTAINMENT

CHALLENGE OF AUTOMOTIVE AUDIO

Active Antenna Power Supply Design

By Kieran McDonald

In the age of connectivity, increasingly demanding consumer expectations are driving the evolution of in-vehicle infotainment, resulting in greater demands on the infotainment system power supply. In automotive audio systems in particular, the introduction of active antennae to enhance the power of the received radio signal, thereby improving the audio quality enjoyed by the consumer, demands an alternative approach to its power supply.

In the past, the radio antenna was typically composed of a passive receiving element with the signal being passed directly via cabling to the Audio Head Unit (AHU); in some cases this was located an appreciable distance from the antenna itself. The implication of this was signal loss, of an already possibly weak signal, and susceptibility to noise interference. An active antenna, however, makes use of an installed amplifier along with the passive receiving element, to amplify the received audio power, as well as providing a low noise and low distortion output, and an impedance matching function. The installed amplifier requires power and this is usually provided by the AHU, or infotainment system, as either an individual power supply cable or utilising the antenna High Frequency (HF) cable itself, the latter often being referred to as a 'Phantom Supply'.

The power supply could either be a regulated supply, a protected battery supply, or a 'raw' battery supply, depending upon the requirements of the active antenna amplifier IC. The challenge for the power supply is that there are a number of scenarios, either through faulty vehicle assembly or maintenance, which could result in the load becoming disconnected from the supply, shorted to ground or to battery. As a result the power supply needs some means of being able to detect the state of the load to allow the system to deduce whether it is operating within prescribed parameters or whether there is some fault condition present. Most vehicle manufacturers mandate this as a requirement, with the system distinguishing between fault types and displaying a fault diagnostic code on the audio display or the Multi-Function Display (MFD), as a means of assurance of correct assembly.

Current sense regulators, such as the ON Semiconductor NCV47700 and NCV47701, have been developed with these issues

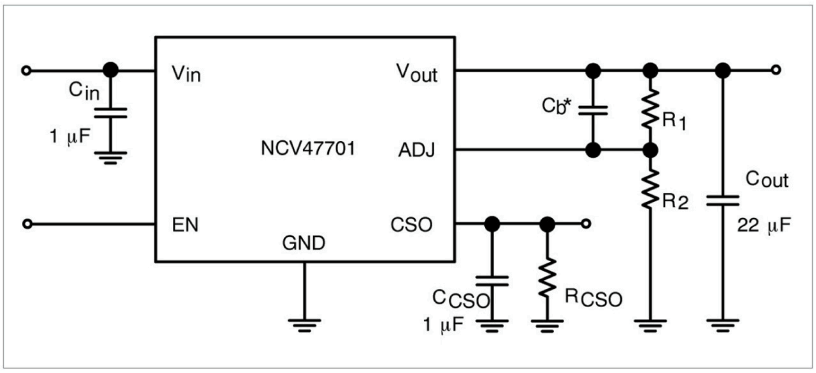

Fig. 1 – The ON Semiconductor NCV47701 Current Sense Regulator Implementation

in mind, measuring the current through the output of the device and providing a mirror current reference output, in addition to providing a linear regulated output voltage, with the input capable of being derived from the car battery.

Introducing the Current Sense Regulator

Current sense regulators make use of an integrated current mirror, providing the ability to diagnose fault conditions in the load. This is of particular importance in vehicle assembly where there is a risk that the AHU, the active antenna or the cabling between them may either be faulty or misassembled. As a result the risk exists that the current sense regulator output, VOUT, could be shorted to ground, left open or, to a lesser extent, shorted to battery. The current mirror provides a mirror current sourced through its output, the current sense output (CSO), which is at a fixed ratio (1:100 ± 10%) to the load current, which can be monitored as a voltage (VCSO) across a fixed resistor to ground, and can be sampled by an ADC for example. The resistor value, RCSO, also programmes the current limit threshold level. By monitoring the CSO voltage the current mirror can be used to distinguish between open circuit, short to ground and normal operating conditions.

In a short to ground condition the load impedance falls to zero, or near to zero, causing the load current to rise and tripping the externally programmed current limit, the output voltage folding back reciprocally. This causes VCSO to rise to its upper limit of 2.55V. Secondary protection is provided for with a second default current limit, set at an internal fixed value of 400 mA, with a faster loop response than the programmed current limit, guaranteeing current limitation at start-up. There is a further level of protection with a thermal limit threshold, detected by a Thermal Sensing Device (TSD), located next to the regulator linear pass element, to ensure that the 150°C maximum junction temperature, TJ (max.), is not exceeded. If the TSD threshold level is exceeded then the regulator disables itself until the threshold is crossed again.

In an open load condition the load current falls to zero or near to zero. Reciprocally VCSO falls

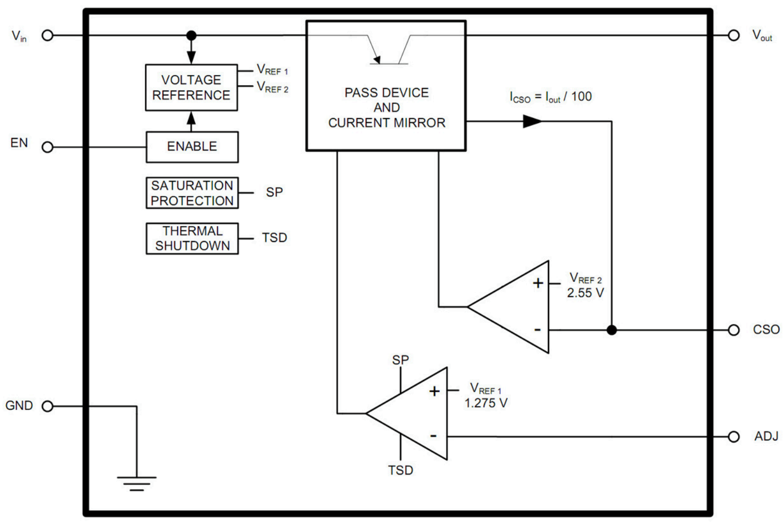

Fig. 2 - The ON Semiconductor NCV47700/1 Current Sense Regulator Block Diagram

close to ground potential with ICSO guaranteed to be no greater than 10 μA.

While a short to battery condition can't be directly diagnosed, using the VCSO output, the device is protected against conditions where VOUT is shorted to battery, either in a powered or an unpowered state.

Current Sense Regulator Benefits
The current sense linear regulator provides an alternative to discrete circuitry or high side switches, with substantial benefits. A typical discrete diagnosis and protection circuit might consist of over twenty discrete components and their ensuing assembly costs, and complex failure modes and effects analysis, as well as consuming valuable microcontroller resources for command and control purposes. The alternative current sense linear regulator is a single integrated circuit (IC), with only seven external small signal components. Additionally being an IC it has carefully controlled process parameters, such as current limit accuracy and current mirror ratio for example, which make the creation of a fault strategy, fault detection thresholds and worst case analysis, using the current sense output, straightforward.

The provision of accurate and adjustable output voltage regulation, including well defined limits of loop stability means that the fully protected output can be set to a target output voltage that correlates to the input requirement of the active antenna amplifier, with a loop that is stable with a low cost and standard equivalent series resistance (ESR) output capacitor. This compared to a high side switch output voltage which will not regulate but rise and fall in proportion to the input source - typically the car battery. The ON Semiconductor NCV47700/1, for example, has an adjustable output voltage, with the output voltage set by an external resistor divider, adjustable between 5.0 V and 20 V (NCV47700 has an output voltage tolerance of ±6% and the NCV477001 ±3%); the output is stable with a 22 μF standard ESR capacitor.

The flexibility, in terms of circuit programmability, inherent in a discrete circuit design can be achieved by the current sense regulator offering a programmable output voltage and current limit levels as well as an IC enable. The ON Semiconductor NCV47700/1 has an externally adjustable current limit, programmable between 10 mA and 350 mA by a resistor (RCSO) to ground, from the CSO pin. The current limit is accurate to ±10%, between 10 mA and 100 mA, and accurate to ±20%, between 100 mA and 350 mA.

Conclusion
Current sense regulators provide a simple integrated solution to power active antenna amplifiers, in automotive audio and infotainment applications. They provide the ability to monitor the status of the load, enabling fault diagnosis, and providing protection from fault conditions.

The ON Semiconductor NCV47700 and NCV47701 ICs are available in both SOIC-8 and SOIC-8 EP (exposed pad) packages. Designed specifically for use in the automotive environment, their input and enable pins can sustain an ISO-7637-2 load dump pulse (5b) of up to a 45 V peak.

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