Linear Amplifier SEND Interfacing

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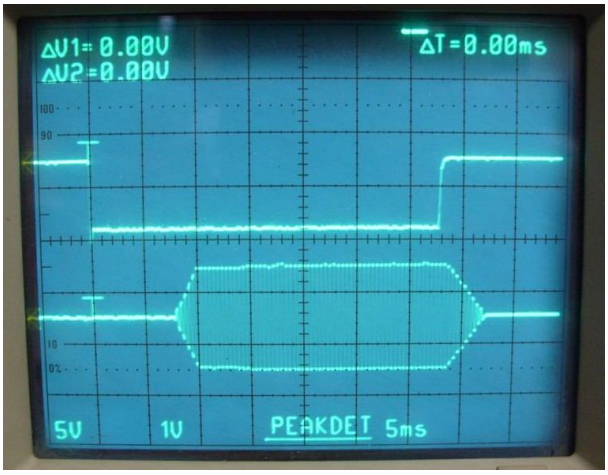
I was asked by another club member to investigate the coupling of his IC-7100 radio to a non-ICOM amplifier and got into experimental mood over the holidays since I also have a 7100 that has not seen an amplifier yet. The findings below are to create an awareness of the factors involved.

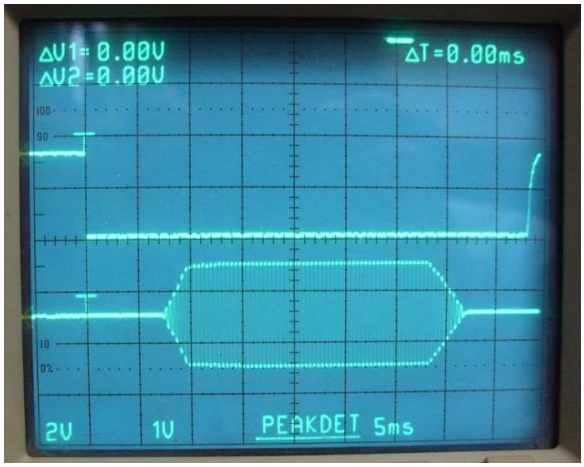
If radio and amplifier parameters are not properly known then “hot switching” can cause damage to both units. The amplifier may receive RF from the radio before its RF relay has properly switched over and finally settled from receive to transmit. Similarly amplifier relay dropout must occur after RF TX has ceased.
Every relay has a pull-in delay and release delay of several milliseconds very dependent on its construction as they are made for all type of service.
A really fast one that can be fitted as an option in amplifiers is a vacuum relay but although they are desirable especially for QSK operation, most standard fitted relays are suitable for general use.

Depending on the radio model driving an amplifier, there can be as many as three relays involved in the PTT chain. First the radio can have a built-in SEND relay (or not). If that SEND relay is inadequate, you need another in between to take the stress of driving the amplifier’s relay coil.
The total delay can exceed the onset of RF as RF and PTT run different paths with their own individual delays. Note that this is not recommended for QSK operation but OK for SSB and semi-break-in CW.

Taking some measurements on my IC-7600 which has an ACC1 HSEND and a relay driven SEND RCA output socket, one can already see a wide difference in timing:



HSEND ACC1 output pin3
Onset delay 8ms. Release -4ms



SEND from radio internal reed relay
Onset delay 8ms. Release +10ms

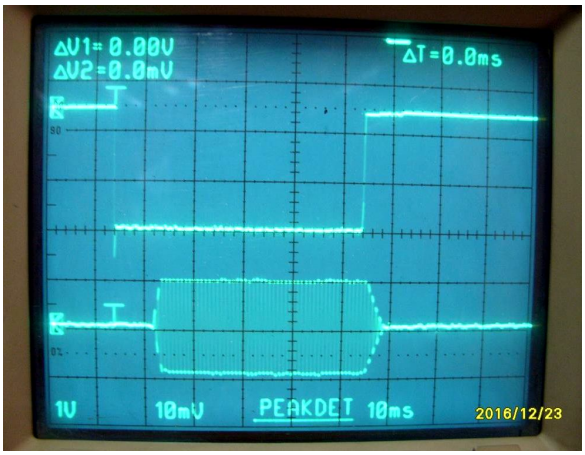
In these pictures, the start of electronic HSEND is where “T” is placed and represents the oscilloscope trigger point initiated by HSEND itself. So what does an extra relay cause?
One would think a hot switch will take place on HSEND release but with an amplifier relay also in the chain the end result could be like in the second picture.
Hopefully relay switching times are published so you know where your safety margins are.
Interestingly, the IC-7600 reed relay has a very fast pull-in (“T” to RF onset about the same) but a slow release of some 10ms.
Of course we do not know what electronic design drives that relay but the end result is text book.

Published figures (from W0QF) for electronic HSEND release can be different for different radios:
IC-746pro=+8ms, IC-756pro=+5ms, IC-706Mk2G: -4,5ms., IC-7000: -5,5ms.
The last two are thus similar to an IC-7600.

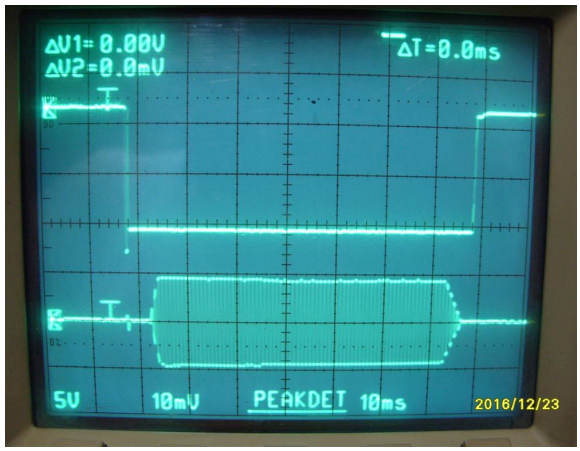
Most radios have a FIXED RF onset delay of generally 7-12ms. Onset delays are often not published.
It is within this space of time that relays must pull in and stabilize (stop bouncing).

The IC-7100 has similar situations and only has an HSEND (ACC1) electronic output available:

The next photos are still triggered by HSEND at “T“ but the traces now show SEND outputs from contacts of randomly chosen relays connected to HSEND.
SEND onset will creep closer to the RF onset if a relay is slow and the contact release will get longer.

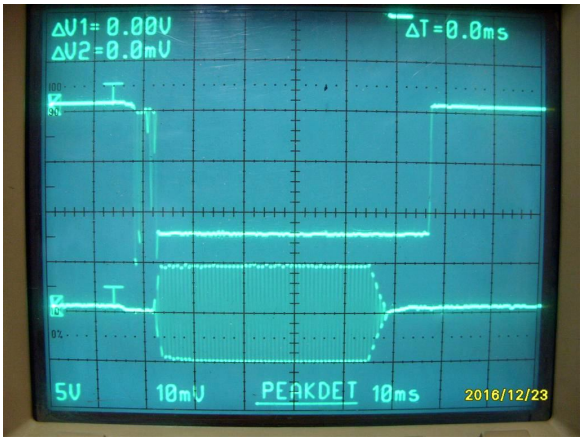


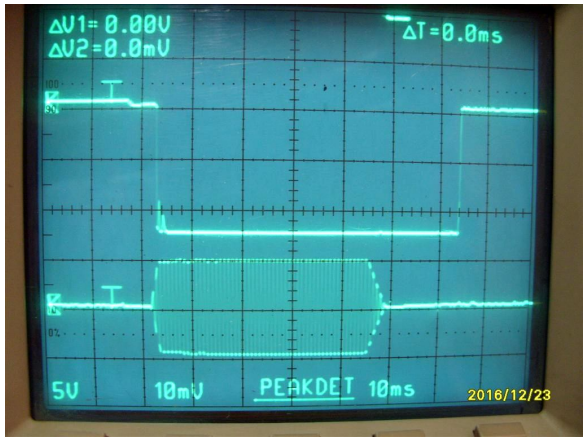
HSEND ACC1 output pin3
Onset delay 9ms. Release -5ms



Same via external relay on breadboard
Onset delay 5ms. Release +4ms.

The above pictures were taken with different WPM CW, so hence the difference in RF lengths. The figures thus tell us that the relay pull-in is 4ms and its release takes 9ms.
Generally the onset time is the one to watch. Below are some really poor relay responses.





The best advice that can be given is to scrutinize relay performance in terms of speed, current handling and even contact plating. Reputable manufacturers will publish these specifications.

Ideally radios can drive a same brand amplifier without trouble when following the user manual. An amplifier’s relay coil is always driven directly from external sources and generally needs to be pulled down to ground. *Always read the specification of this input*. Some are X volts and Y mA which your HSEND or SEND output must handle. Most radios – not all – use an NPN transistor pulling down. If you feel more comfortable with an opto-coupled HSEND connection (safeguards HSEND output and adds no delays) then a 4-pin opto-coupler and a MOSFET driver transistor will do the job nicely.

More modern radios may have a menu option to use “Reed” relay or “MOS-FET” output. The latter option permits driving amplifier relay coils of higher voltage and current.

Mixing brands however forces serious investigation into equipment specifications and the possible need to employ an extra electronic or electromechanical interface. This is especially true for transistorized radios driving valve amplifiers.