

H-MODE MIXER (HMM), some story and some info

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The most update and complete information on the H-Mode Mixer is available on Martein Bakker, PA3AKE, web site, associated to his super transceiver project.

<http://www.xs4all.nl/~martein/pa3ake/hmode/index.html>

I would like to report some story about the H-Mode Mixer and additional information to appreciate it.

The H-Mode Mixer was designed by Colin Horrabin, G3SBI (SK), derived from the N6NWP mixer at the beginning of 90s, which originated from the KB6QJ JFET mixer in the 80s. Colin used an SD5000 IC, containing 4 MOS transistor, and 3 transformers (forming an H on the schematic). The key improvement of this mixer was due to the transistors switching the transformers winding to ground, having the transformers doing the mixing, contrary to the other switching type of mixers where the semiconductor elements provide the mixing; also, this solution avoids the signal being potentially modulated by the oscillator. The SD5000 and HMM was characterized by an IP3 of +50dBm. These MOS transistors were requiring a substrate bias voltage adjustment to be applied, creating some set-up difficulties.

Around middle of 98, I received information from Fairchild about Fast Bus Switches. I was trigger by the possibility of being, potentially, good switches for mixers, particularly, the FST3125/FST3126 for the H-Mode Mixer. I presented information and schematic of a simplified HMM, using these switches, to Pat Hawker, G3VA (SK), managing the RadCom "Technical Topics" column (RSGB). Pat informed Colin, about my idea, and him shared this with Bill Carver, W7AAZ. Bill got samples and tested the FST3125 H-Mode Mixer, driven by a 74AC86 squarer as I suggested. Results were very positive giving an IP3 around +40dBm.

The Fast Bus Switches, FST3253/PI5V331 (multiplexer/demultiplexer), were then used in the QSD Mixer, by Dan Tayloe N7VE, and by Gerald Youngblood AC5OG, in his SDR transceiver project, the start of the Flex Radio production. The FST3253 requires a Local oscillator drive four times the HF plus IF frequencies; the FST3125 configuration can work at HF plus IF LO.

In the first years of this century, I experimented with FST3125 HMM configurations and homebrewed transformers. I had no proper equipments to do testing so I was able to measure only the conversion gain, not the ideal information to compare mixers as we should know IMD and NF too. I "accepted" the information given by G3SBI and W7AAZ. At the same time, the FST3125 H-Mode Mixer was applied into the "CDG2000". Around the same period, Peter Rhods, G3XJP, started his transceiver project "Pic-A-Star". Peter applied the classic 4 diodes mixer to the equipment. I suggested to Peter that his project should have included the H-Mode Mixer, for the best performances. He accepted the idea but he was puzzled by the cost of the 3 transformers. Bill told me I should present to Peter my latest HMM simplification, a mixer with two homebrewed transformers. Peter liked the idea and arranged his project to have the 2 or 3 transformers H-Mode Mixer. This solution used the FST3125 and the 74AC86. Takahiro Kato, JA9TTT, performed IMD test of the 2T H-MM with professional equipment, the spectrum analyzer results were reported in his web site. Also, I reported these pictures in my file "I7SWX IMPROVED TWO-TRANSFORMER H-MODE MIXER", where I also wrote IP3 and conversion losses I was able to measure.

Kits were made available for experimenters. Later, Colin and Martein discovered the FSA3157, an analog switch. This IC permitted to reach the IP3 of around +50dBm with bias adjustment. A better performance than the FST3125. Probably this is due to the fact that this switch has a function of break-before-make. I also tried the FSA3157 switches HMM to avoid squarer bias regulation, going from the XOR 74AC86 to the LVDS receiver FIN1002, this IC is good as no bias adjustment is required; also a low power oscillator can be used. An IP3 of +40dBm +/- is available. A first kit was arranged, as "universal" where a JFET amplifier buffer was present to permit mods to equipment having a high impedance input mixer. Then a 50 ohm only HMM kit was produced. The schematic of this HMM is reported in all mods files. Also, I developed a Passive Squarer 2T H-Mode Mixer with FSA3157 to simplify further the mixer, requiring +7dBm 50 ohm oscillator drive, normally required in quad diode mixers.

All my fiddlings with the H-Mode Mixer were associate to mixer mods in commercial equipments, particularly the second mixer, the most critical stage. I produced kits with FSA3157 and FIN1002 to modify commercial amateur radio. Easy modification was for Icom mixers as have classic quad diodes mixers, while on the Kenwood and Yaesu the replacement was on active mixer, requiring the addition of a low gain IF amplifier to compensate gain. The mods reported very interesting performances for the commercial equipments. The kits, over 50, were distributed mainly within Europe. Also a K3 HMM was produced, as a plug in replacement. K3 has very good performances and only one mixer, so improvements were more limited than the one with the Japanese products, but in some critical receptions the difference was detected. Following I will report a comment from a contest station manager. Near 40 K3 2T H-Mode Mixer were distributed world wide.

The H-Mode Mixer has removed the mixer from the most critical stage of a receiver (OK for TX too). The critical stages are now the band pass filters, LC and Xtals, and the IF amplifiers plus the oscillators phase noise. In a few words, using a 2 transformers HMM versus a 3 one will not present criticality, only money saving, as, perhaps, having the two secondary windings on the same core gives a natural simmetry as it eliminates any core differences. With the two transformer version the RX input should be at the 5 winding transformer and the IF output to the 3 windings one, the reverse of the 3 transformer HMM. The HMM is bi-directional so it can simplify a transceiver application.

The FST3125 H-Mode Mixer and following configurations were reported in RadCom, Technical Topics Column, by Pat Hawker, G3VA (SK), from middle of 1998 till middle of 2008.

There are commercial amateur transceivers having implemented the H-Mode Mixer in their new Hybrid SDR radio architecture, for stronger performances; an analog front end and a SDR post conversion, receiving the best performances of the two, with a latter one having lower ADC prerequisites. First was Kenwood to apply a 3 Transformer HMM, with FST3125 and 74AC86 configuration, for their hybrid TS990 and TS590. Recently, also Yaesu selected the 3T H-Mode Mixer for their FTdx10, using a single quad IC FST3257 (mux-demux) with an additional transformer as a splitter. The FTdx101 presents a complex DGM mixer, it would be interesting to know why, on the FTdx10, the HMM was implemented.

A big work on experimenting and measuring performances of the H-Mode Mixer has been done and detailed by Martein Bakker, PA3AKE:

<http://www.xs4all.nl/~martein/pa3ake/hmode/index.html>).

Additional information may be collected from the document links in the web page.

The modification files are mainly in italian, there one FT1000mkV in english (limited) that should explain about mods valid for all the other ones. The K3 mod is also in english:

- 1) I7SWX IMPROVED TWO TRANSFORMER H-MODE MIXER ,
- 2) I7SWX 2T H-MODE MIXER FSA3157 – FIN1002 ,
- 3) I7SWX TWO-TRANSFORMER H-MODE MIXER WITH TRANSFORMER PASSIVE SQUARER ,
- 4) I7SWX 2T H-Mode Mixer with blanking for NB application ,
- 5a) FT1000MP and 5b) FT1000MK_V & Field ,
- 6) FTDX9000
- 7) IC775 mods by I7SWX & IZ7ANL (iz1anl since 2020):
One of these mods is the band monitoring using an hybrid receiver, attached to the 1st mixer output, formed with a 2T H-Mode Mixer and a Softrock SDR receiver.
Also it is working as a 3rd IC775 receiver.
- 8) Elecraft **K2** I7SWX 2T H-MODE MIXER *PROPOSED* mods
- 9) Elecraft **K3** I7SWX 2T H-MODE MIXER *MODIFICATION*
- 10) automatic SSB\FM\AM [Inrad roofing switch over](#) for Yaesu FT1000MP mar 2005

Also see “Experimental Methods in RF Design” (Newington, Connecticut: ARRL, 2003

<https://www.ab9il.net/software-defined-radio/h-mode-mixer-ik4auy.pdf>

http://www.radiomanual.info/schemi/RX/AOR_HF-7070_review.pdf

Comment from a K3 user of the I7SWX 2T H-Mode Mixer:

Sabato 23 Febbraio 2013 23:02

A Modified K3 in the 2013 ARRL DX Contest

Giancarlo,

I did a test in the 2013 ARRL DX contest. At xxxx we had 2 x K3 on the same antenna, locked out with the Acom 2S1 box. One of the K3 had the I7SWX K3 2T H-Mode Mixer installed, the other K3 was in original state.

I did not tell about the difference to anybody but after the contest one of the operators told me I should check the K3 because there were weak stations that he could hear with one K3 (the modified one) and could not hear them with the other K (the original K3). xxxx has large/high antennas, see www.xxxx.com. So yes your mixer gives a slight and sometimes decisive advantage, congrats.