# Quickstart guide to using Signal & Systems Expt 13 on netTIMS

Author: EMONA TIMS cmanfredini@emona.com.au 18-8-14

The Signals & Systems lab manual experiment "S13: Poles and zeros in z-plane IIR-V2-1" is the implementation of a 2nd order IIR Direct Form structure, and delivered remotely using the EMONA net*TIMS system.

Figure 3 of the experiment is the block diagram for this structure and is shown below.
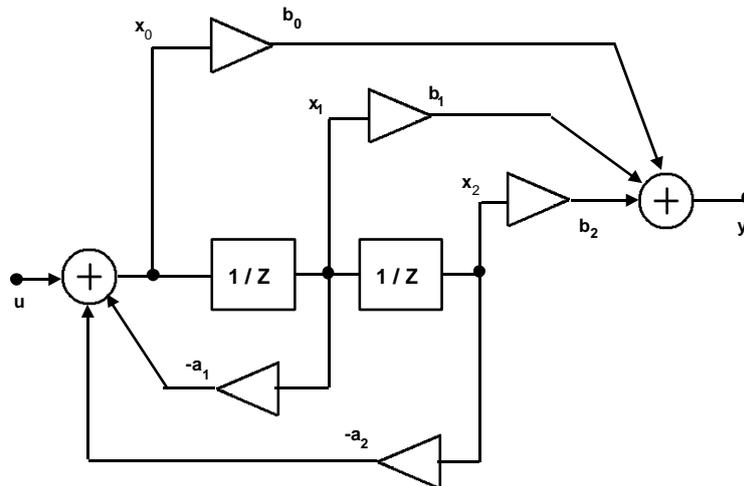
Block diagram of the 2nd order Direct Form 2 structure

As we have implemented this experiment in the manual, it can be seen that the system has 2 parts. The input signal generation, and the IIR structure.
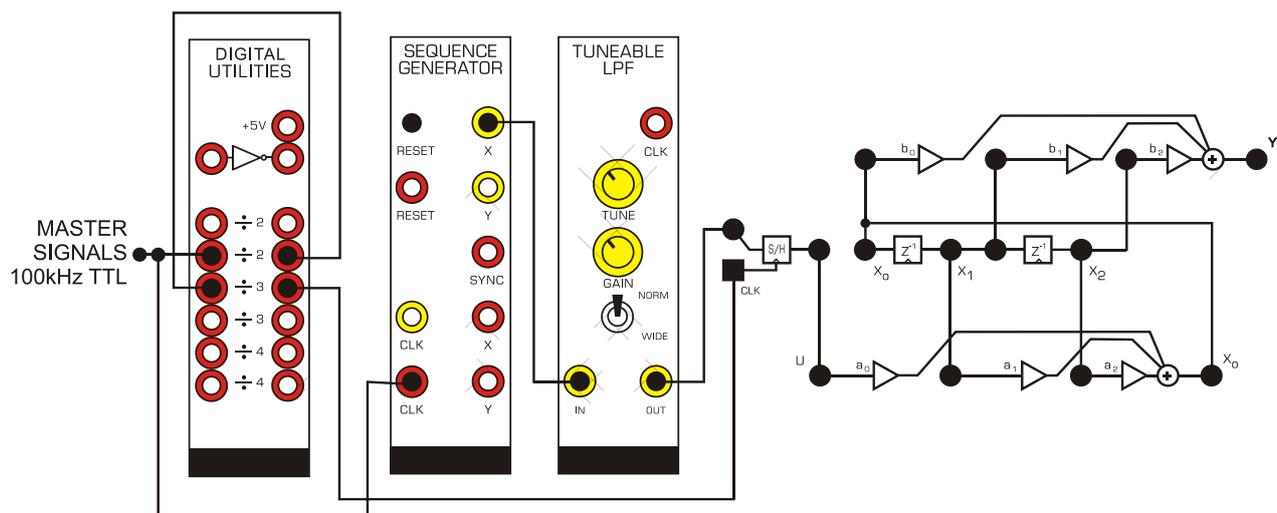
Experiment patching diagram for IIR experiment with noise input

In order to view the complete frequency response of the IIR structure at once, a multifrequency input is use,(rather than sweeping a single frequency signal across the input which is also done earlier in the experiment). This input is gaussian noise, with a

bandwidth of approx. 7 kHz, which covers the entire frequency range of interest and remains below the nyquist frequency.
In order to make the setup simpler for a quick demonstration, set up the controls as shown below.

You will need to:

-Set SG sequence knob to 4 (longest sequence)
-TLPF's TUNE to fully clockwise: max cutoff frequency
-TLPF's mode to NORM
-TLPF's GAIN to around 11 o'clock (medium)
-the SCOPE settings as shown below.

Set up the ADDER gains as 1.0, 0, -1.0 for b0,b1,b2 and 1.0, 1.6, -0.9 for a0,a1,a2.
The vary the gains, drag the knob to the approx. position, then use the keyboard left and right arrows for accurate and rapid adjustment.
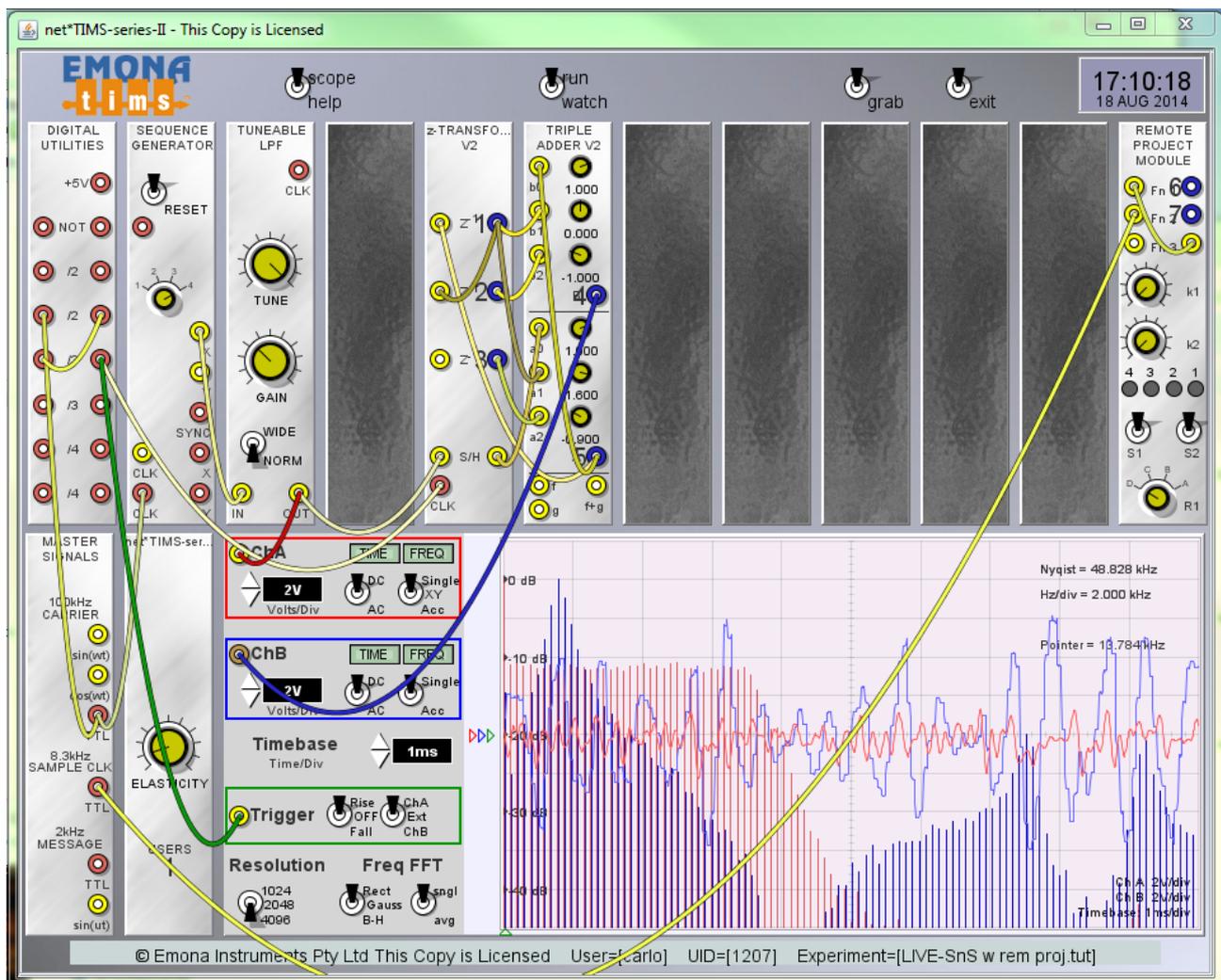
netTIMS client interface to the IIR experiment on the LIVE server

The DIGITAL UTILITIES module creates a 16.6kHz sampling clock.

The SEQUENCE GENERATOR module is clocked at 100kHz and creates a wideband pseudo-noise signal, which when filtered by the TUNEABLE LPF at 7kHz, gives a flat

noise signal from DC to 7kHz. The GAIN is set lower than unity to avoid saturating the IIR structure.

On the scope display the red signal, ChA, is the input, in both time and frequency domains. You can see that the IIR structure has gain greater than one, and hence the output signal is greater than the input.

The output signal is shown as the blue signal, ChB.
The frequency range displayed is also extended so that the images around 16.6kHz can also be seen.

The gains b0,b1,b2,a0,a1,a2 determine the behaviour of the IIR polynomial/structure.
By varying the coefficient gains, the user can see the effect of "changes in the math" as "changes in the actual performance" of the real electrical implementation of the math.

To see these changes in real time:

Vary the gain a1: As theory predicts, this will vary the frequency of the peak, due to rotation of the poles in the z-plane.

Vary the gain a2: As theory predicts, this will vary the Q of the filter by moving the poles closer or further from the unit circle.

Try varying a2 to be -1.10. This will cause the filter to break into oscillation, and this can be seen as the blue signal oscillates, in accordance with theory.

Refer to the experiment itself more detailed step by step theory about these issues.

You can also enter your own calculated coefficient gains into the system and see how well it accords with theory.

Try the following combinations, in this order: [b0,b1,b2,a0,a1,a2]

Allpass: 0.8, 0, 1, 1, 0, -0.8 (note that a1 and a2 are the negative of the actual polynomial coefficient. This is discussed in the experiment.

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