ES9023 DAC : Coax SPDIF

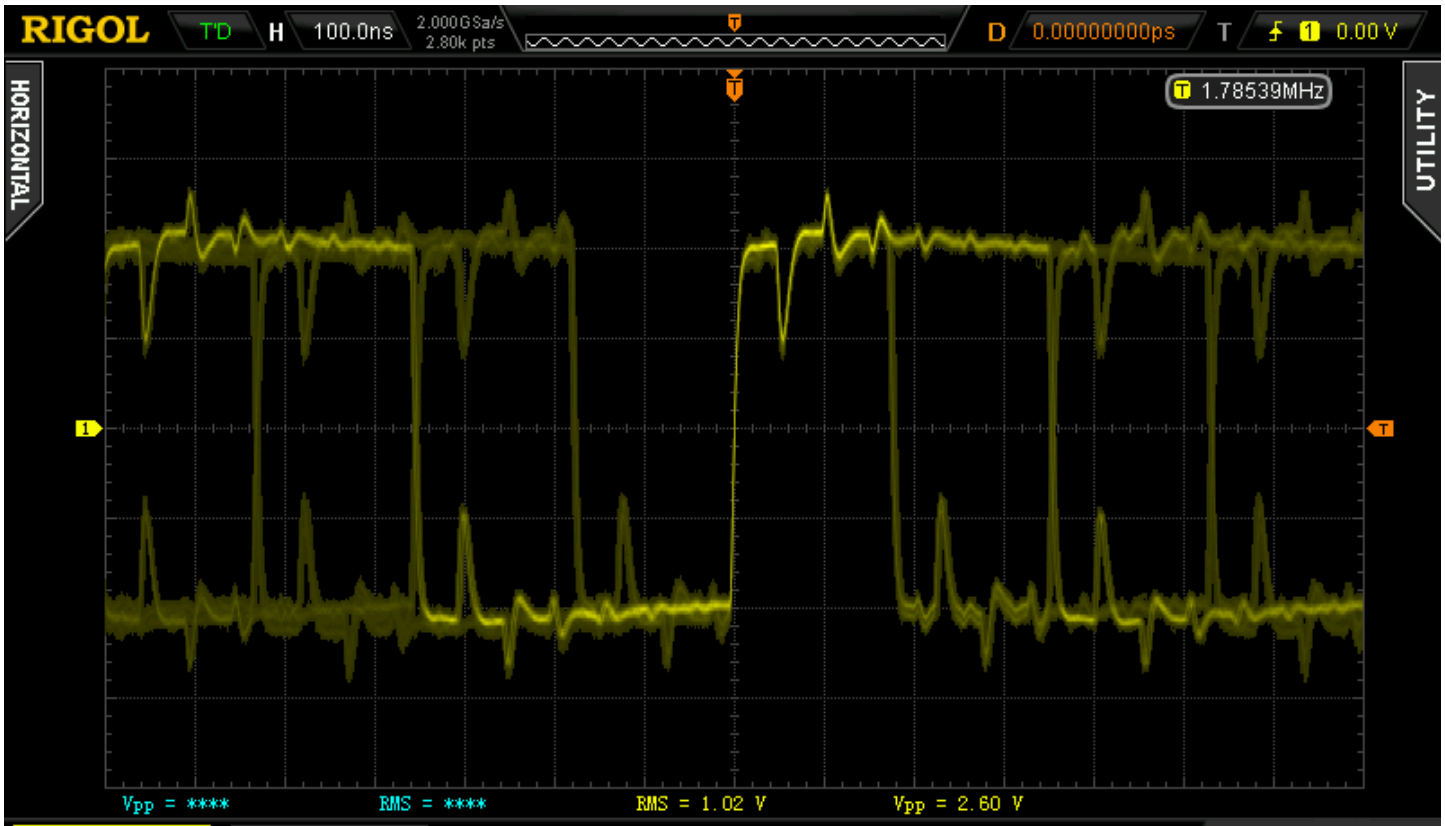
Build, test & validation

Cable termination

Source : PC (RCA connector)

Cable : 5m RG-59 75R coax with RCA connectors.

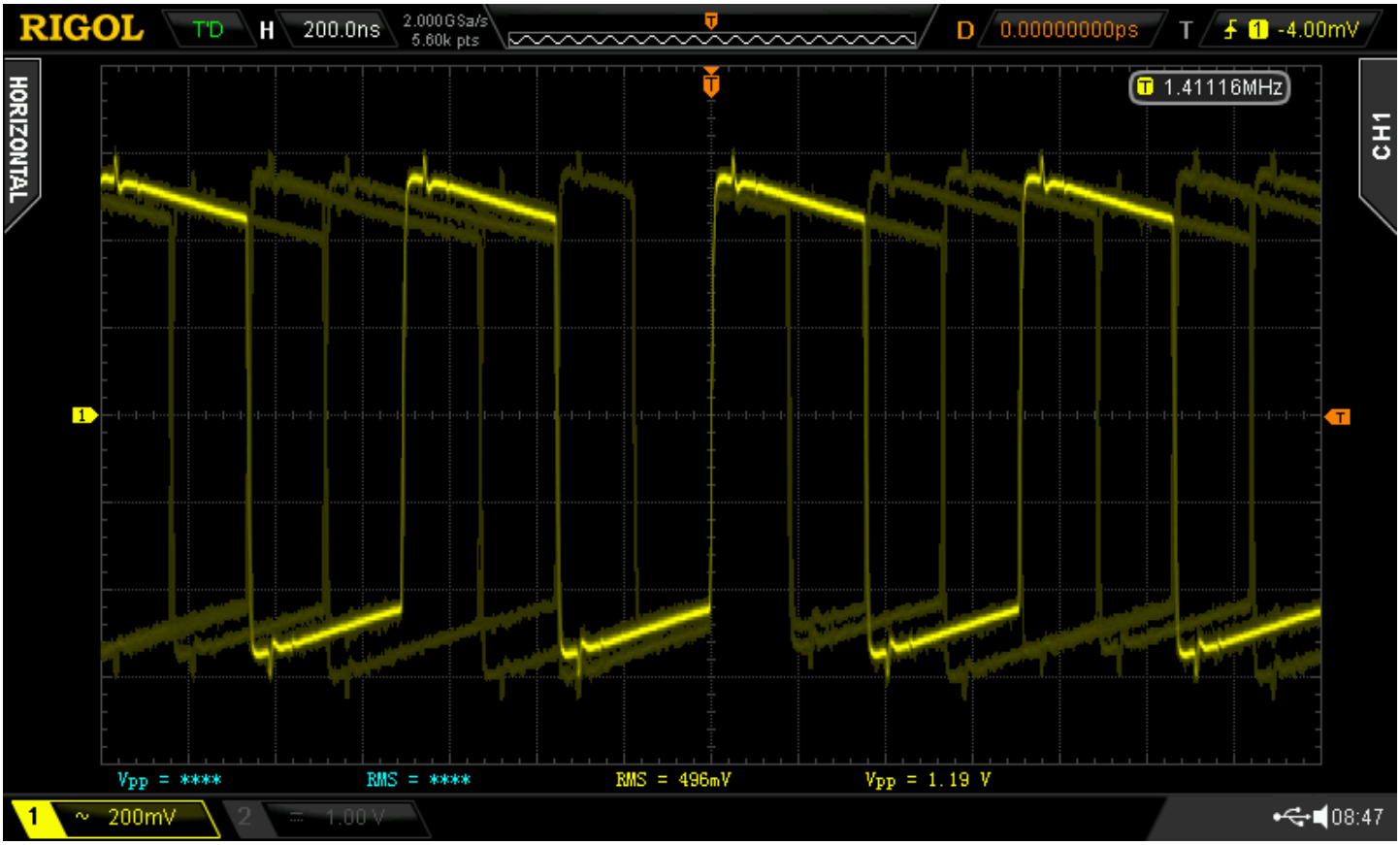
44k & 192k unterminated : UGLY



75R termination directly across cable

Looking good at 192k, although there is a little reflection blip... from RCA connector or PC mobo ?

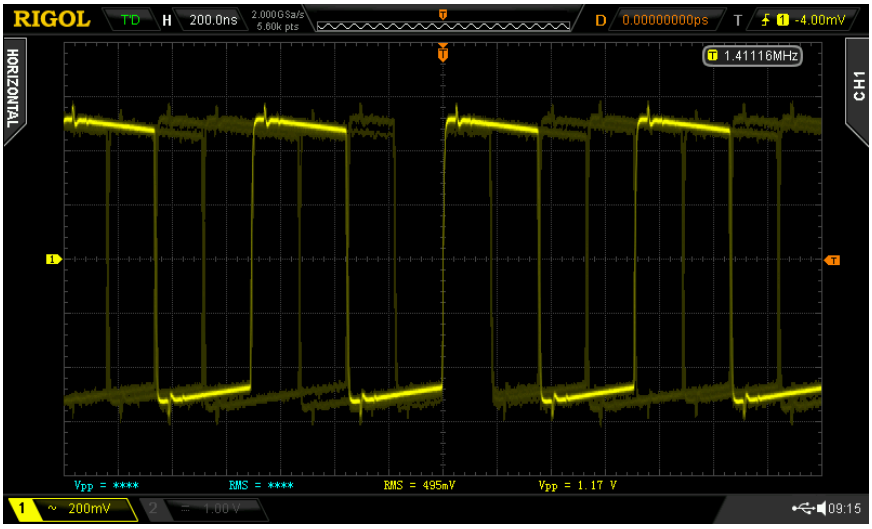
At 44k, it is visible that the coupling capacitor in the SPDIF transmitter creates a highpass with termination resistor on my end of the cable, which adds data-dependent jitter :



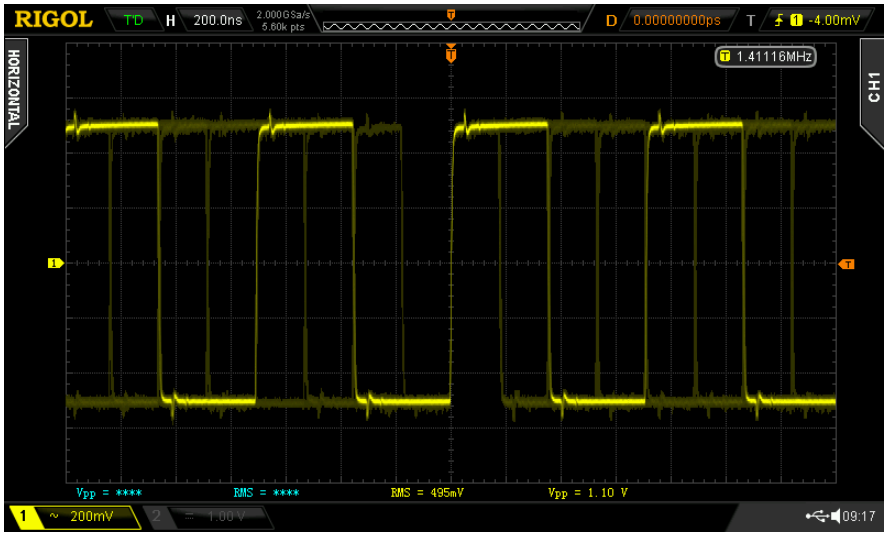
A bit of calculation : the slope looks like the transmitter has a 22nF cap in series.

So, I AC-couple the termination resistor at the end of the cable. Termination is only useful at HF anyway.

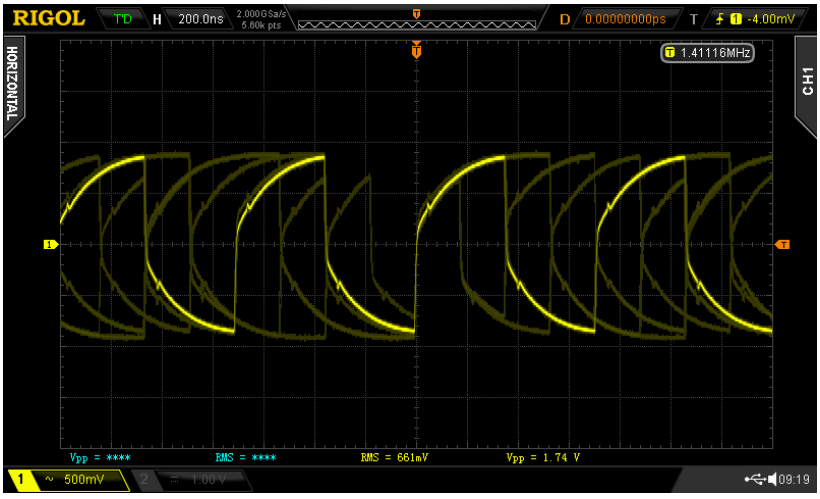
75R + 22nF : still drooping



75R + 10nF : nice and flat



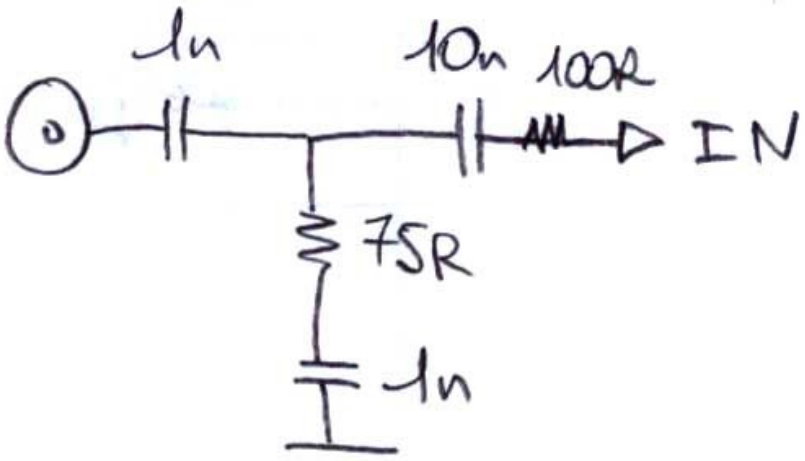
75F + 1nF : slope goes the other way around, as expected.



So, AC-coupling the termination resistor seems to have useful effect, but there is a gotcha, the AC coupling cap should be about the same value as the coupling cap in the transmitter …

Since this can vary (usually 10-100nF), perhaps a useful compromise can be found.

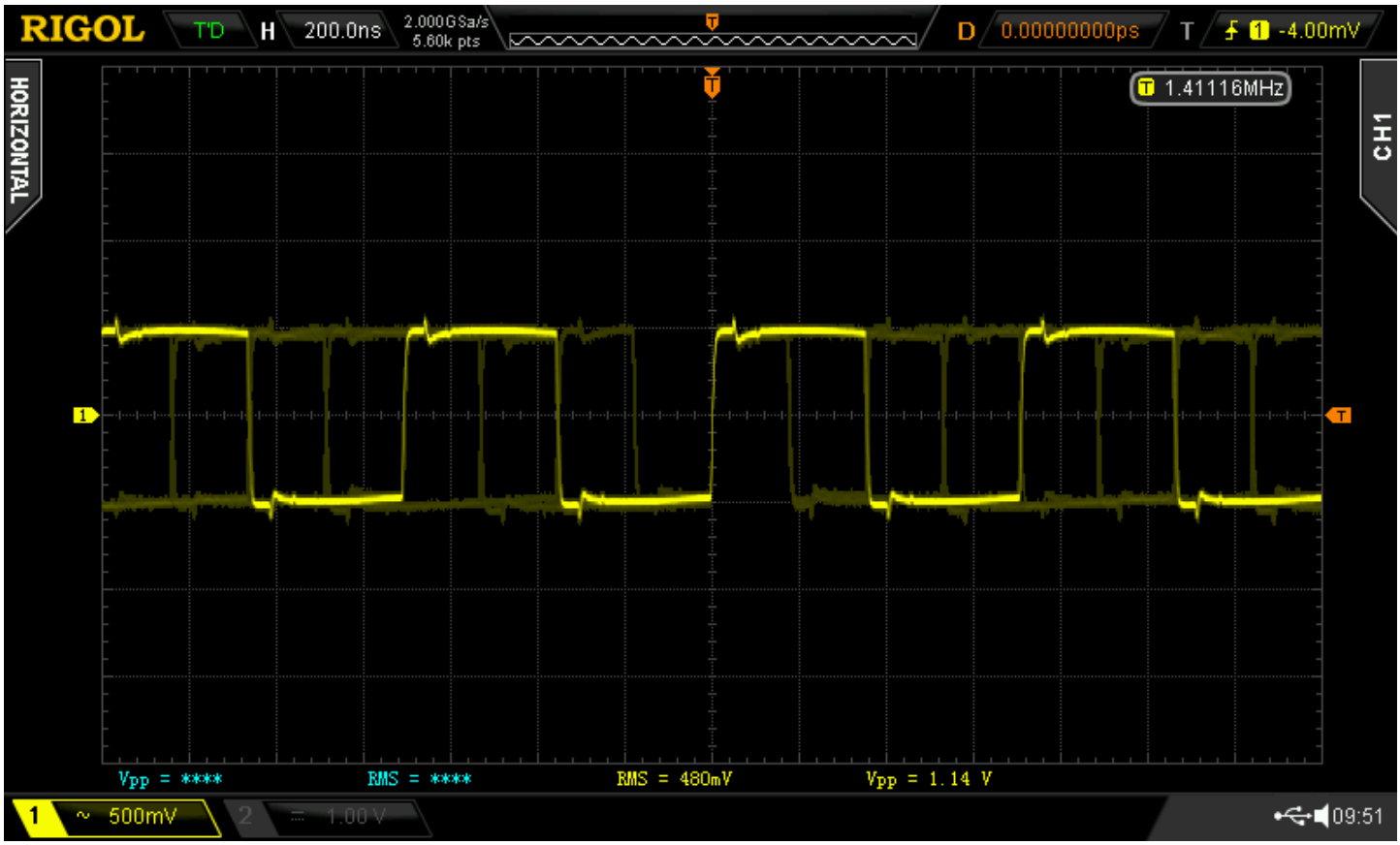
I try this :



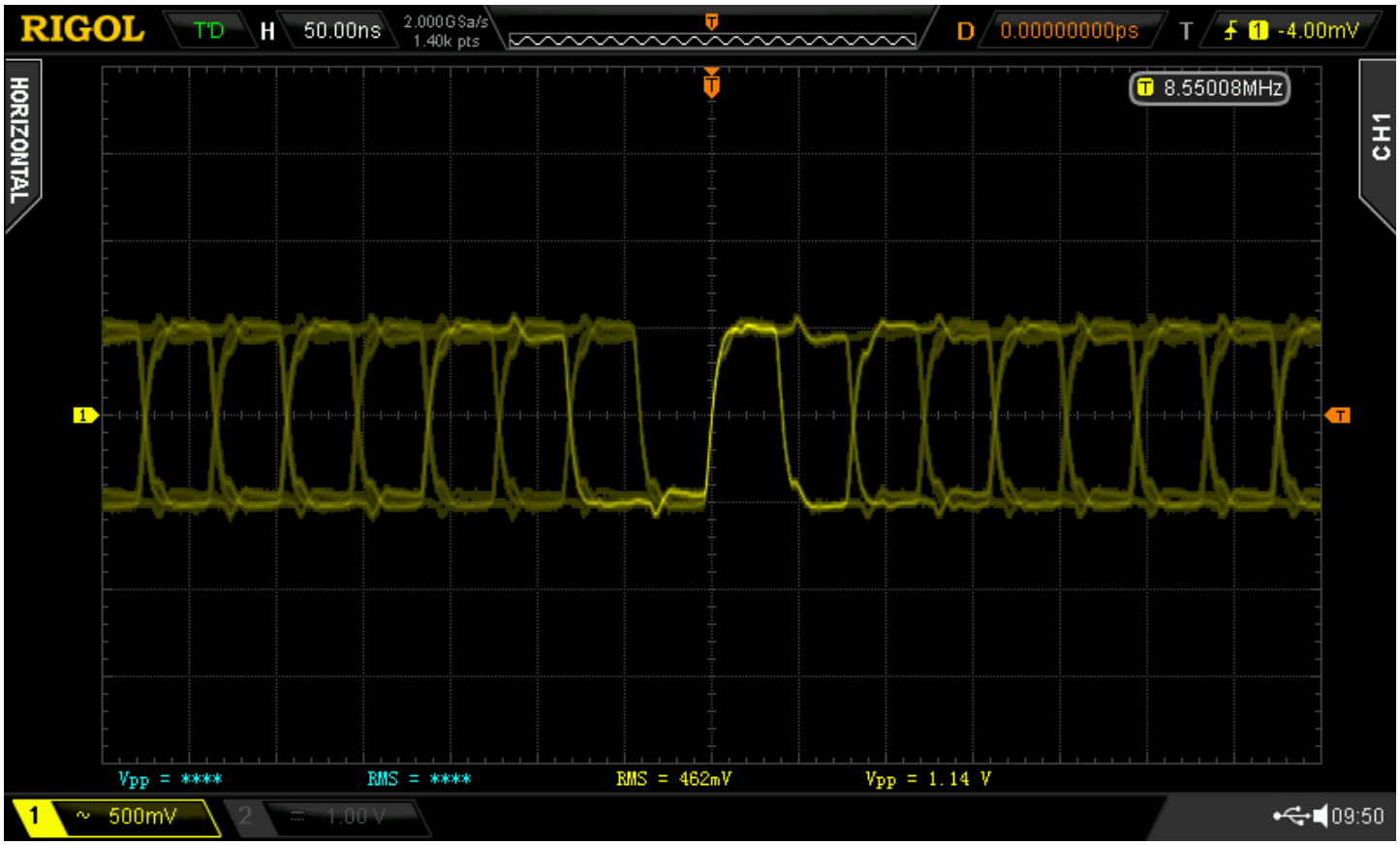
The 1nF cap is in series with the cap inside the transmitter, since it is smaller, it dominates it. The termination network (75R+1n) forms a divider. This is a bit like a 10x scope probe.

Then, I AC-couple it into WM8805. The 100R resistor prevents the input capacitance of WM8805 from resonating.

At 44k, all the lowpass/droop is gone, it is very nice :



At 192k it looks good too :



Still this little bump which looks like a reflection... I should try with different cable lengths (later).

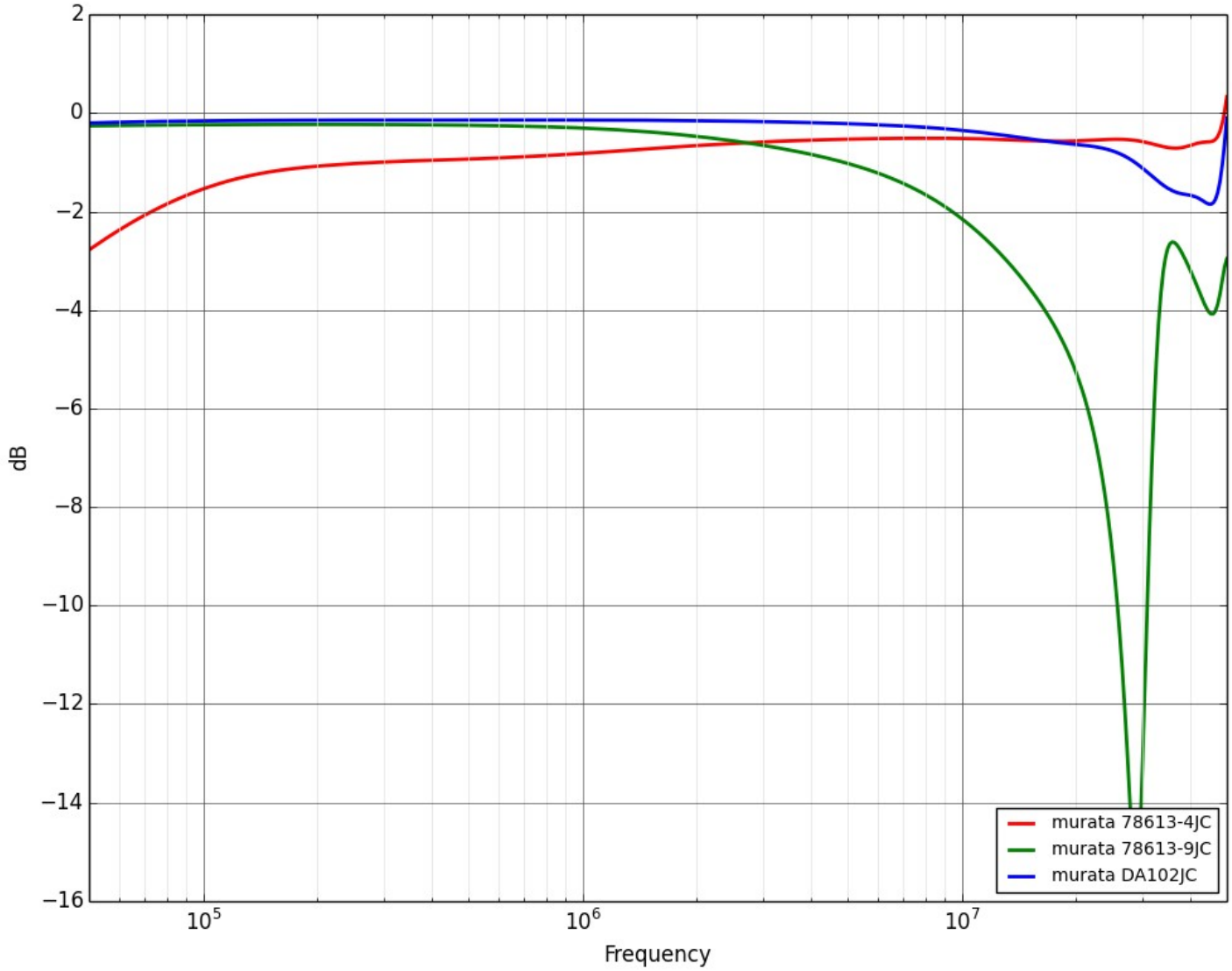
As long as it does not happen on top of a transition, it's fine.

So, non-transformer coupled SPDIF connection : done. (and with much less data-dependent jitter than usual since we got rid of the lowpass).

Now, let's check transformers.

Transformer choice

VNA check for 3 transformers of various bandwidths :



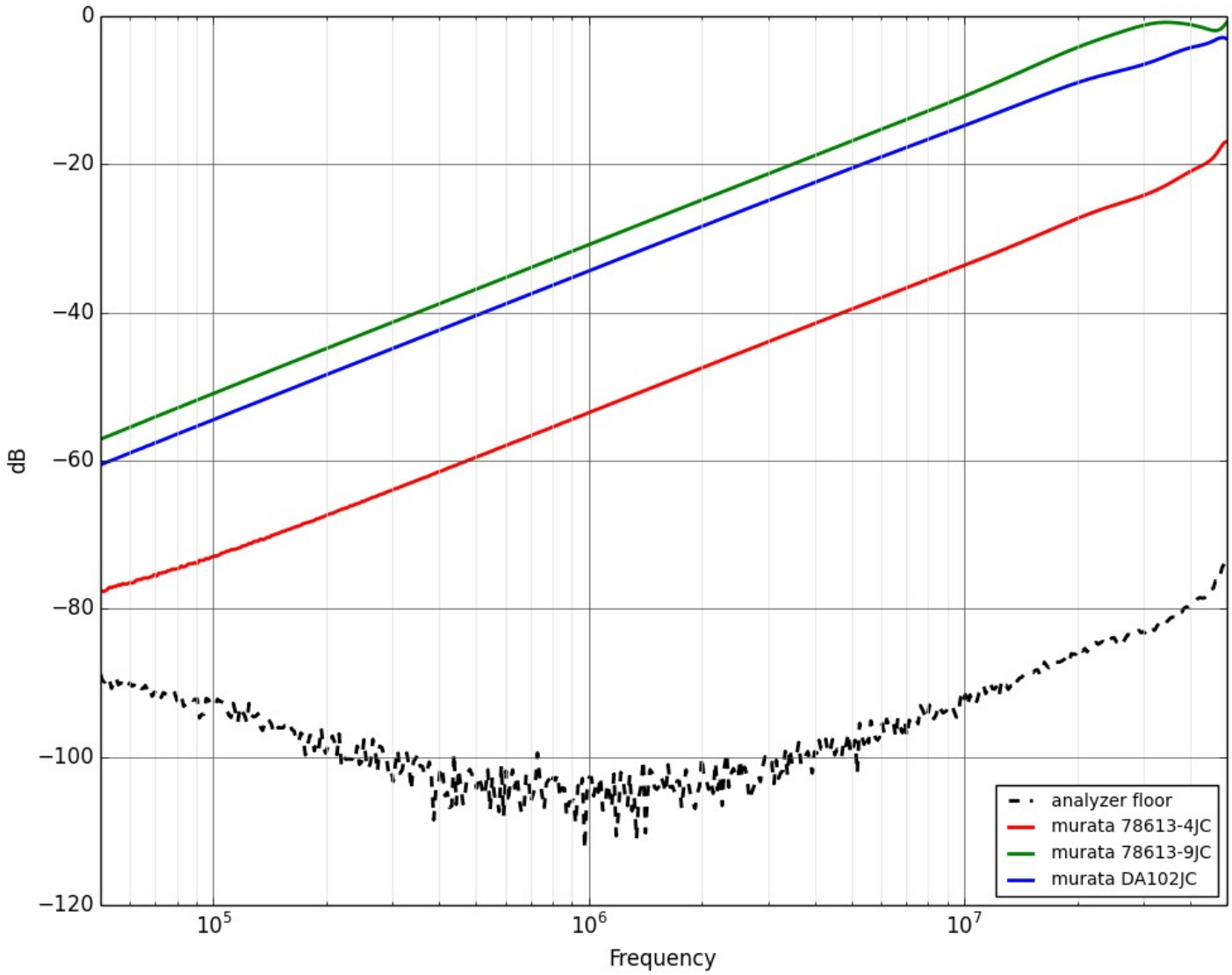
DA102 (blue) is specifically for digital audio. It has wide bandwidth with good extension up and down.

78613-9 : Bandwidth too low.

78613-4 : Good at HF, a bit lacking at LF.

Of course the 78613-4 has less windings than DA102 so it has much lower interwinding capacitance.

Common mode test (50R again). This measures the interwinding capacitance.



78613-4 capacitance is specified around 7pF.

DA102 has about 10x more capacitance.

The point of the transformer being isolation, lower capacitance is better...

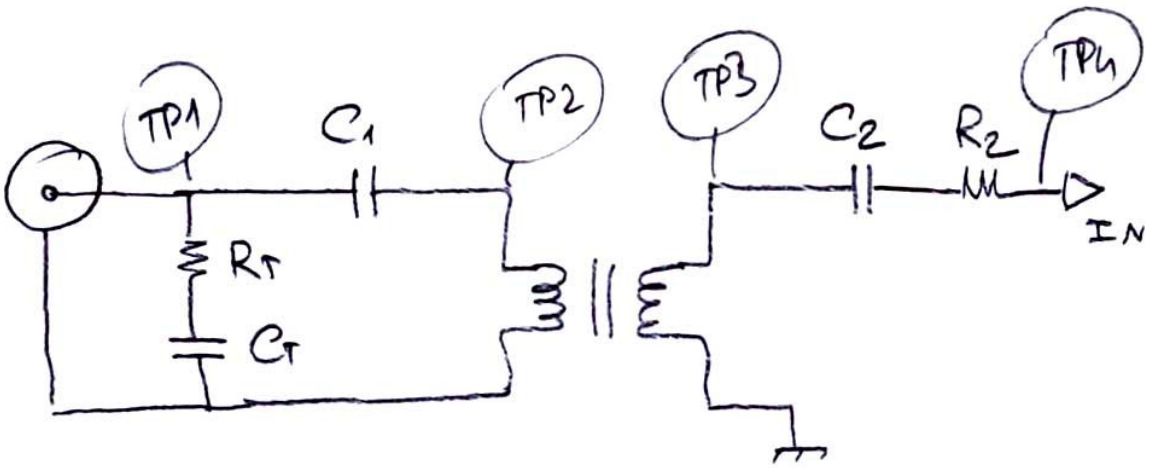
I will try the 78613-4 for now. They have the same footprint.

The previous non-transformer coupled schematic will not work with a transformer.

The 1nF caps are OK when the load is a CMOS input (WM8805) which draws very little DC current, but this is not the case with a transformer.

- It has limited bandwidth at the low end
- The current available to drive it is also limited at the low end due to the transmitter AC coupling cap.

I try this schematic :



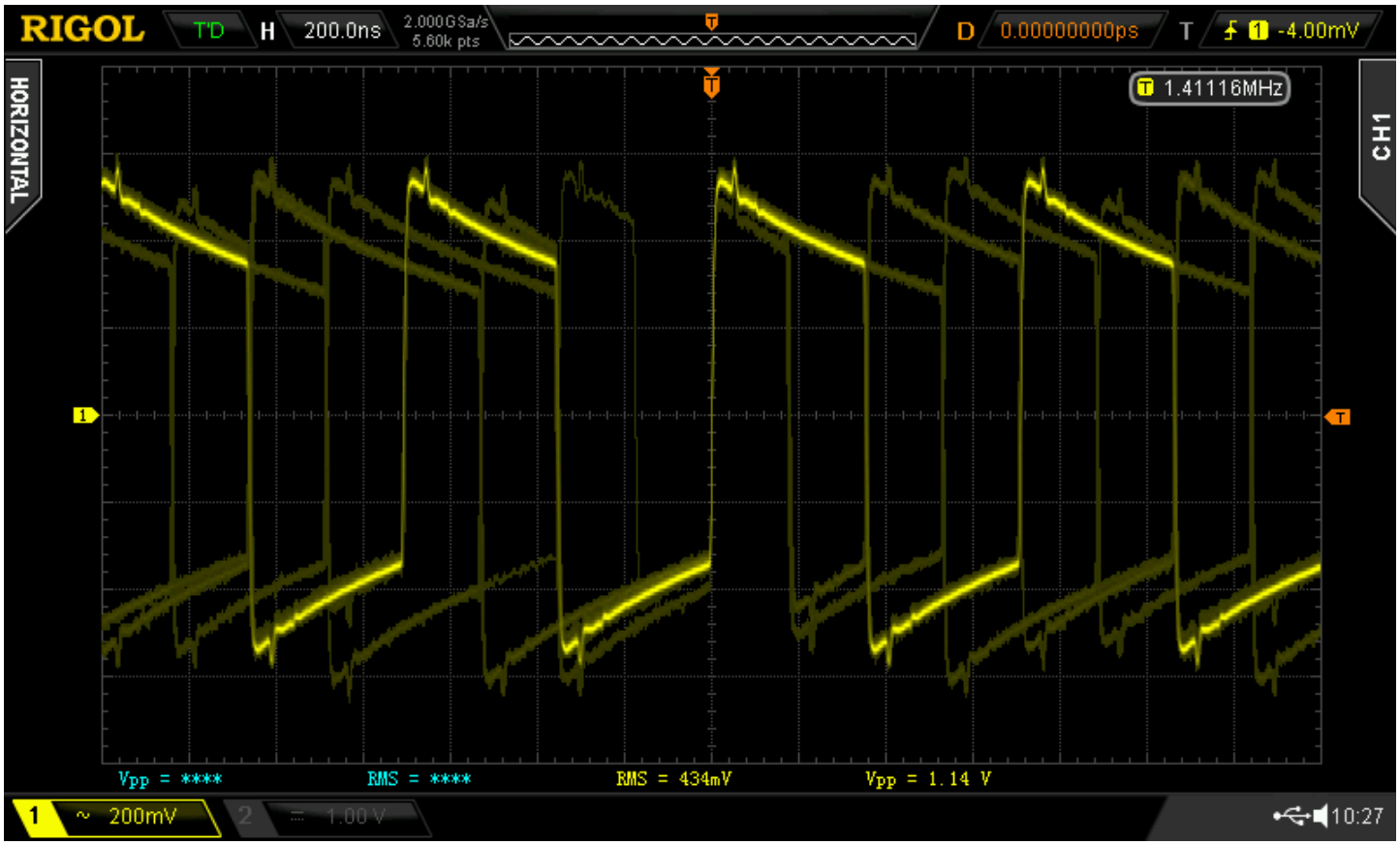
RT = 75R

C1 = 100nF (it should be as large as possible)

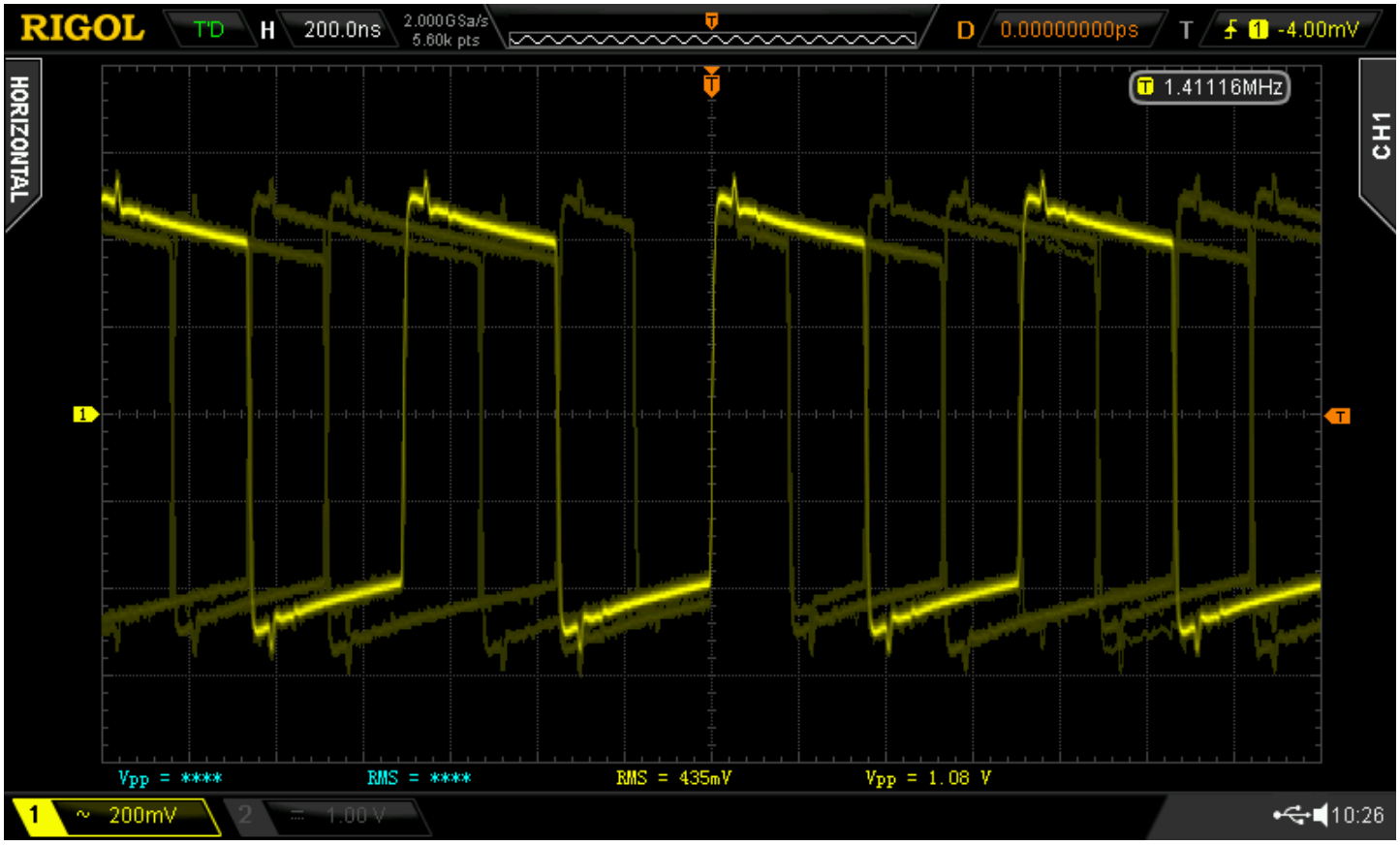
C2 = 1nf (its value has almost no influence due to the high input impedance of WM8805)

R2 = 100R (this damps the transformer resonance by using the input capacitance of WM8805, no need to add a cap for double termination !...)

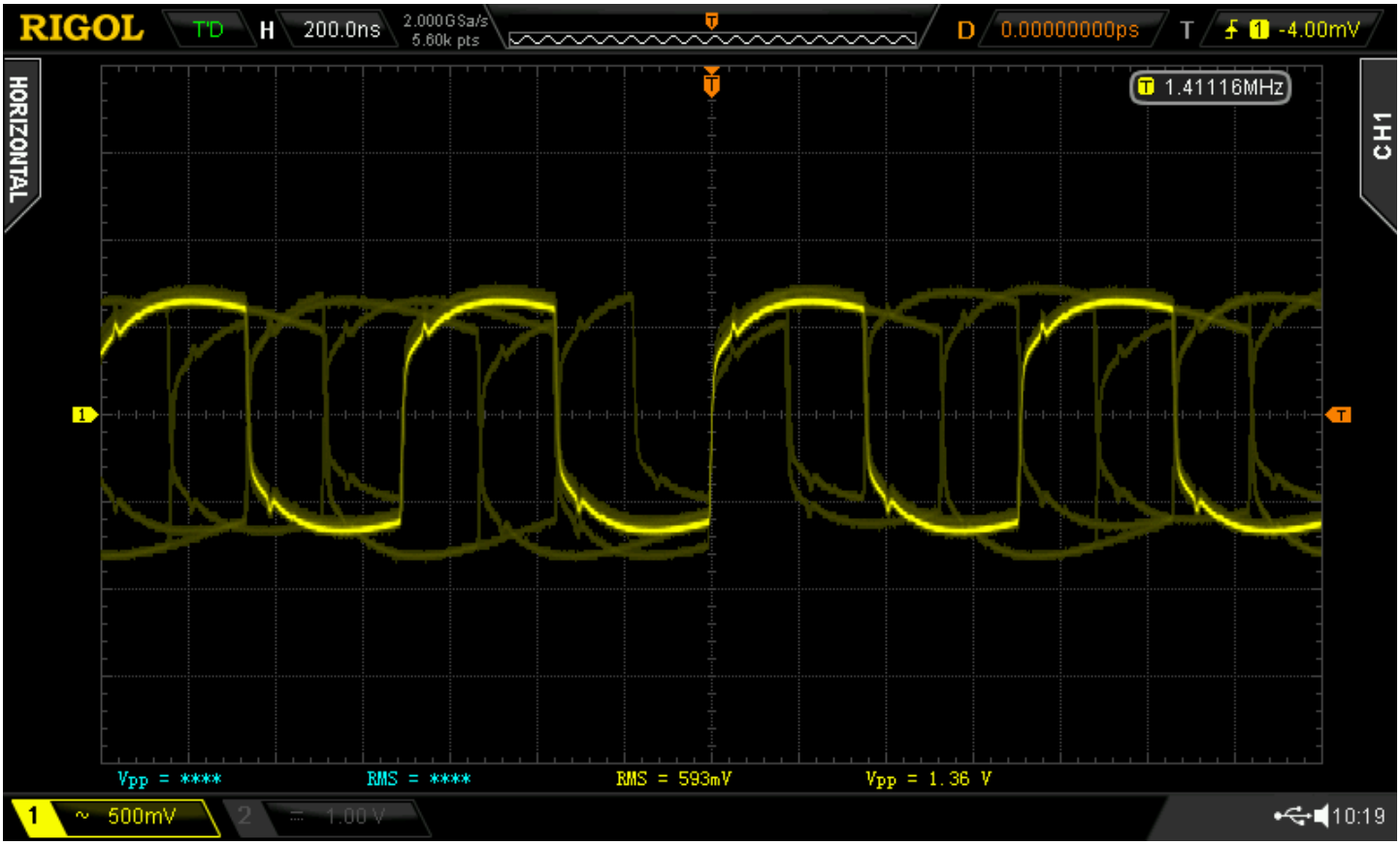
CT = short. Lots of droop.



CT = 10n : a bit better



CT=1n, droop is still the same, but we get some extra rounding on the transitions...

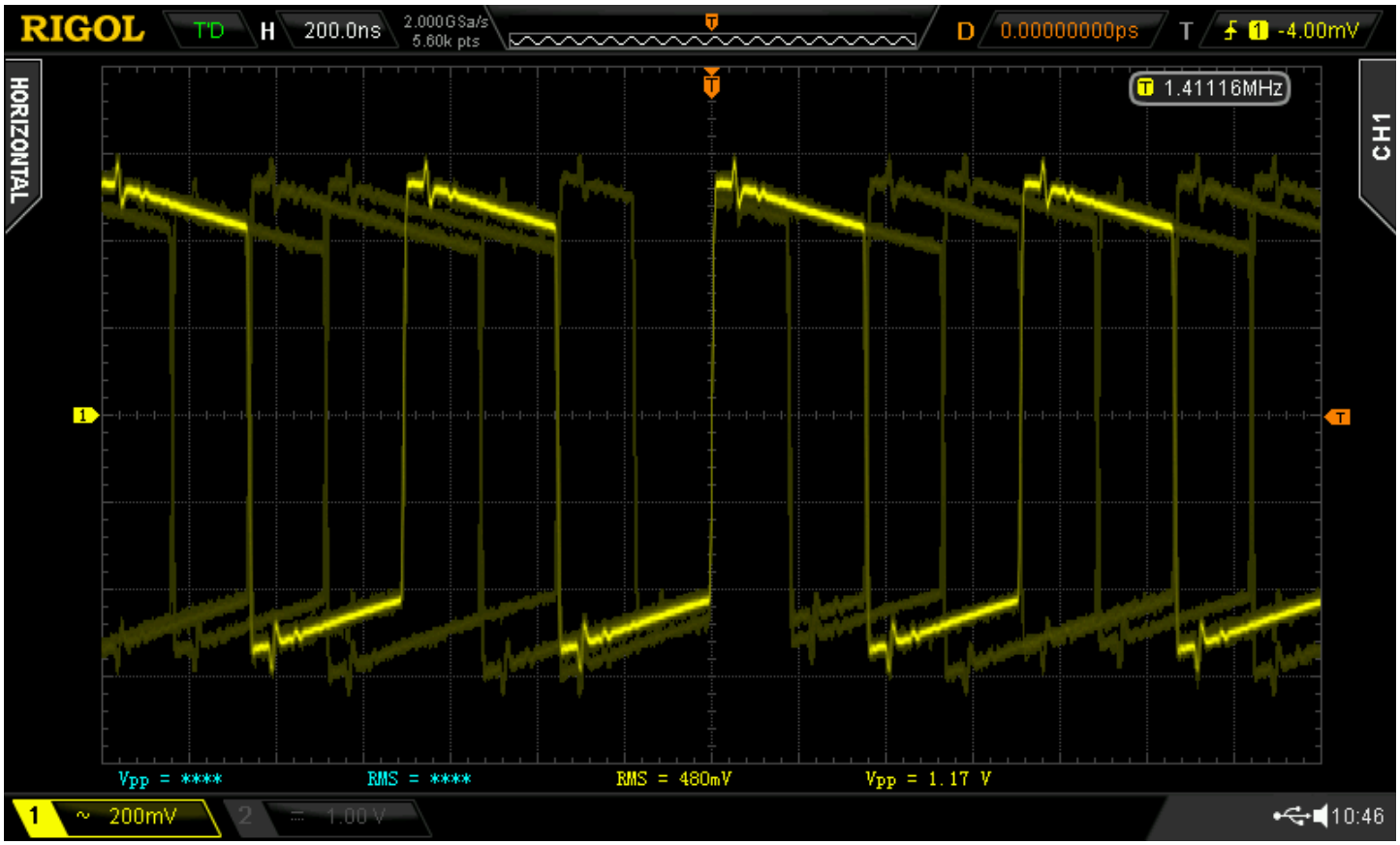


Trying Murata DA102 transformer.

It has much larger bandwidth (and capacitance).

CT=10n, Very good :

CT=Short : transmitter AC-coupling cap distorts waveform.



Conclusion

With a transformer, AC-coupling the termination resistor does extend the LF frequency response, but choices are limited.

- Use a transmitter with a larger coupling cap, to get better LF extension
- Or use a transformer with better LF bandwidth (but worse interwinding capacitance).
- Or oversample everything to 176/192k (this gives much less LF jitter since the SPDIF signal itself moves up in frequency 4x and now fits perfectly inside the transformer bandwidth.)

Jitter measurements

PC (SPDIF output, 44.1k JTEST signal) → 5m coax → DA102 transformer → WM8805

JTEST with LSB toggling at 35 and 350 Hz is used, like previously for toslink. No problem here.