IMC length noise requirement

This note gives IMC (Input Mode Cleaner) length noise for advancedVirgo. Simulation is made with Optickle. The parameters of the model (MSRC) used are defined in table 1.
IMC length noise is simulated thanks to a small motion of the output mirror. The motion on the IMC leads then to frequency noise. The IMC cavity length is controlled with the SSFS (Second Stage of Frequency Stabilisation). The IMC length noise requirement could be thus defined after the SSFS and before the servo loop for the seismic isolation.
Therefore requirement on IMC length noise is obtained by considering:

- The transfer function of IMC length noise to the dark frange $TF_{\partial IMC \to h}$,
- the advancedVirgo sensitivity h,
- the transfer function in open loop of SSFS G_T.

Cavity length	2999.9 m	Arm cavity finesse	897
Lprc	11.953 m	OMC finesse	200
Lsrc	11.033 m	fMod1	6270339.2 Hz
Lprbs	5.980 m	fMod 2	81515709.5 Hz
offset Darm	1e-11 m	fMod3	8360585.6 Hz

Table 1:Optickle parameters

I. IMC length noise requirement after SSFS

After the SSFS, signal from IMC motion on dark fringe should not be higher than h.
The IMC length noise requirement is then given by (with a factor 10 safety): $\frac{h}{TF_{\partial IMC \to h}} * \frac{1}{10}$.

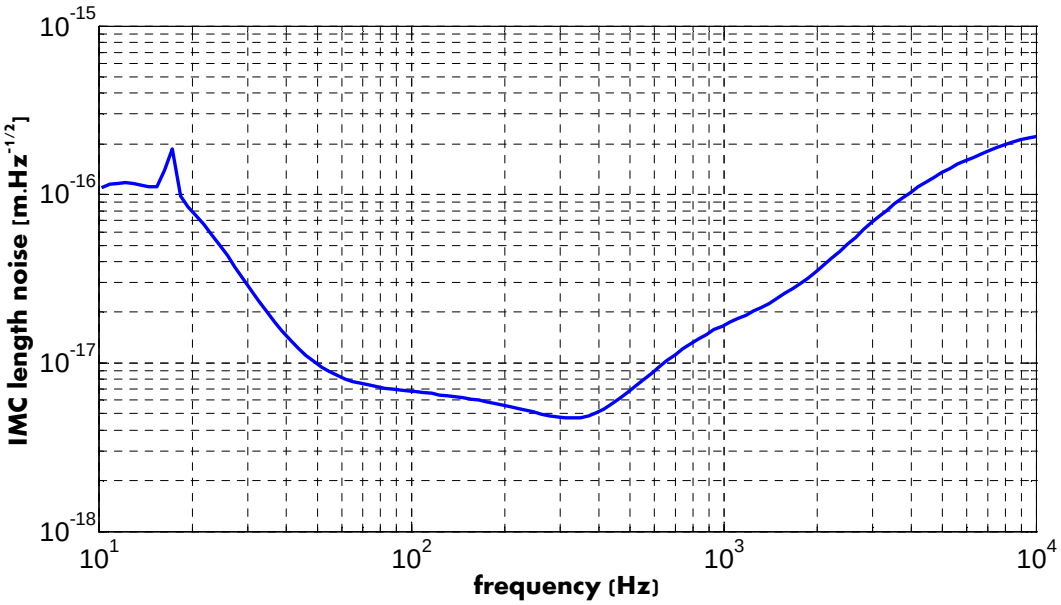

Figure 1: IMC length noise requirement after SSFS.

In this case, the IMC length noise requirement shows a noise floor of 5 10^{-18} $m/\sqrt{Hz}$.

II. IMC length noise requirement before SSFS

The SSFS transfer function in open loop G_T could be defined in a simple way by:

$$G_T = \frac{250 * 3000^2 * 25000\sqrt{1 + (\frac{f}{250})^2} * \left(1 + (\frac{f}{3000})^2\right)}{(1 + f^2)^2}$$

As presented figure 2, the unity gain is obtained at 25 KHz. The IMC length noise before the servo loop corresponds to the first IMC length noise requirement multiplied by GT: $\frac{h}{TF_{\partial IMC \to h}} * \frac{1}{10} * G_T$.
Figure 3 gives the IMC length noise requirement for seismic isolation.

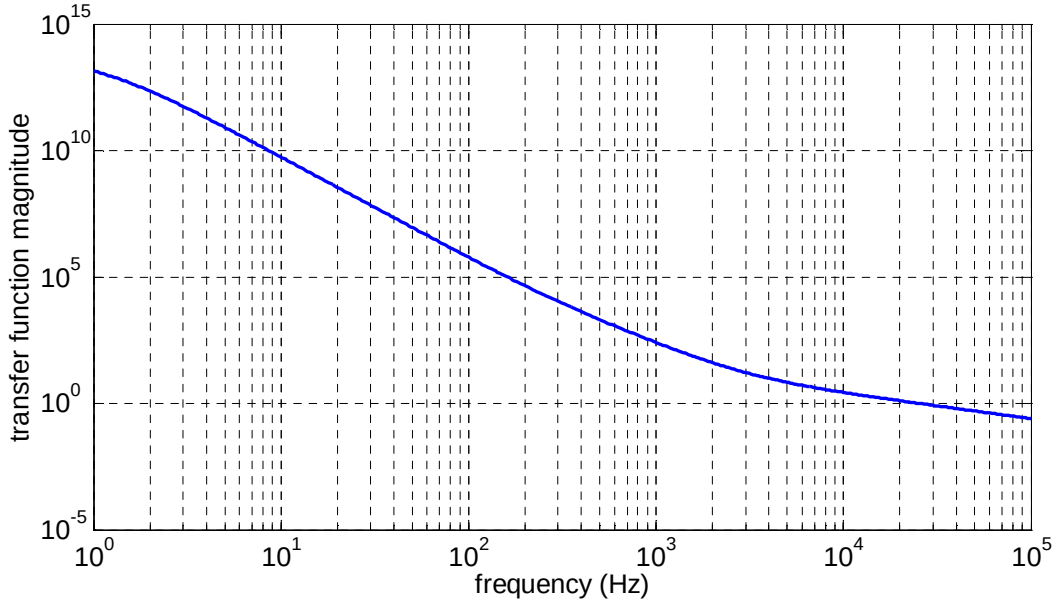

Figure 2: Open loop transfer function G_T magnitude.

It shows a noise floor of 1.5 10^{-15} $m/\sqrt{Hz}$.

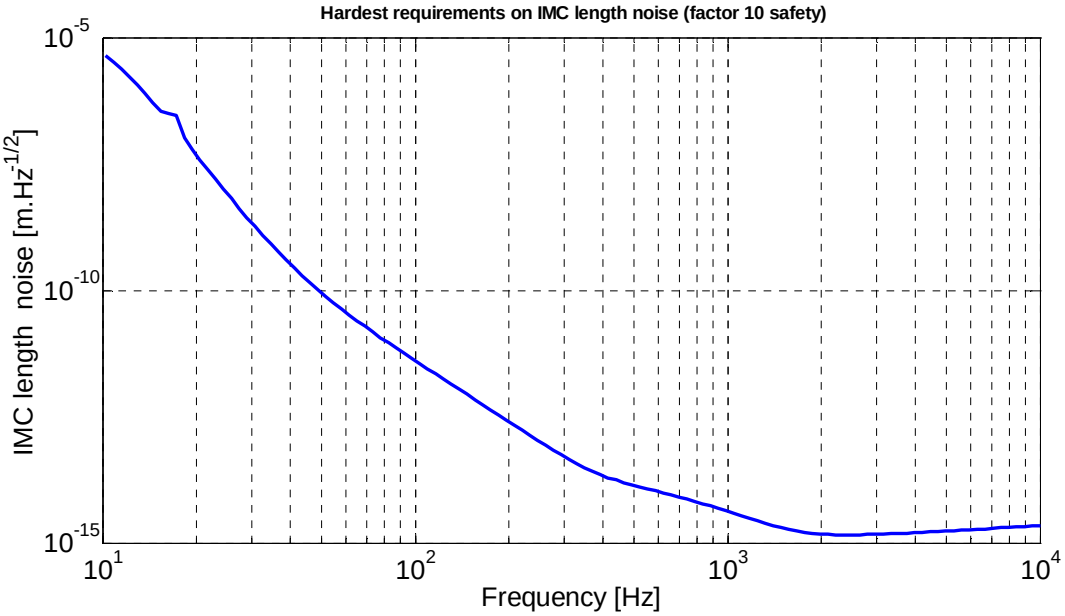

Figure 3: IMC length noise requirement for seismic isolation.