Hi Andres and others “Field Miller’s”!

I resume my experimentation around Andres's design.

Here the points of progress.

I tried to investigate around the offset problem and discover that the displayed value was not symmetrical when reversing the polarity of the multimeter... I suppose the input resistance of the DVM is neither negligible nor symmetrical (sink or source). So I decided to mount an OPAMP amplifier with the possibility to switch between 0 and 20 dB gain and with 3 switchable input impedances (100K, 1M, 10M). I also introduced a 1Hz LPF in the amplification chain.
Note that the inverted output (Vout-) is intended to process negative values in the case of the future addition of a measurement acquisition system using an Arduino because this system have analog inputs usable only in the positive domain.

Now, why to kill the very high input impedance of the OPAMP with shunt resistors? Because I want to try different values in order to determine the approx internal resistance of the source (the switched the disk) and also because my feeling is that it's better to work with a defined input impedance to understand how goes the things here... One know not exactly what are the needs of the OPAMP in terms of input bias current etc...

So I built a first version using TL072's but it was not very successful due to their very modest offset (vs temp) stability. Finally I replace them with LMC6482 and it's a lot better. The offset of the chain with unity gain is now +/- 2mV max, stable versus temperature.
Calibration

To try to calibrate the system, I use a small wooden table, high 75cm then I install alu foils on the ground and metallic plates on the table. Then I use a High voltage transformer (cannibalized from a microwave oven) + Graetz rectifier + filter capacitor.

So I get 2800 V DC and connect this source to the plates in both polarity, alternatively. This will produce a field of approx +/- 3700 V/m. (2800V/0.75m)

I do 3 times the 3 measurements (-2800V, 0v, +2800V) with each value of resistance in front of the OPamp (100k, 1M, 10M).

The results are shown on the 3 following graphs:
Basically one can say that in the range of 100K to 10M the voltage is nicely proportional to the disk load resistance ... which means that the disc acts like a current source with an internal resistance >> 10 Megs. So it is necessary to provide this load resistance in front of the Opamp in order to convert the current in a voltage to amplify.

It is clear that this will have to be optimized in order to obtain the desired sensitivity.

For further experiments I make the choice to keep a value of 10 Megs for the moment and to give a gain of 10 to the amplifier chain.

This give the following calibration graph:
Field-Mill output voltage with 10 MOhm load and x10 buffer

The equation of the linear curve is approx.:

\[ E = -0.71 \times V - 158 \]

with:  
\( E \) = Field in [V/m]  
\( V \) = OPAMP output (Vout+) in [mV]

Note that there is always a small negative offset corresponding to what I claim to be a null field ...! I still do not understand this effect which is beyond the order of magnitude of the offset introduced by the OPAMP’s! But is the field really null?
Using this graph I therefore made some test measurements in open air, at 1 meter high from the ground and I obtain the following results:

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Meteo</th>
<th>Temp</th>
<th>Vout+ [mV]</th>
<th>Field [V/m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>02.07.2020</td>
<td>15:00</td>
<td>Clouds 2/8, warm wind</td>
<td>28°C</td>
<td>-550</td>
<td>+232</td>
</tr>
<tr>
<td>02.07.2020</td>
<td>21:45</td>
<td>Clouds 8/8, stormy no lightning, no wind, twillight</td>
<td>20°C</td>
<td>+150</td>
<td>-264</td>
</tr>
<tr>
<td>02.07.2020</td>
<td>23:30</td>
<td>Clouds 8/8, light rain, night</td>
<td>20°C</td>
<td>+70</td>
<td>-208</td>
</tr>
<tr>
<td>03.07.2020</td>
<td>08:00</td>
<td>Clouds 8/8, no rain, no wind</td>
<td>17°C</td>
<td>+140</td>
<td>-257</td>
</tr>
<tr>
<td>03.07.2020</td>
<td>17:15</td>
<td>Clouds 7/8, no rain, no wind, sporadic sunshine</td>
<td>22°C</td>
<td>+100</td>
<td>-229</td>
</tr>
<tr>
<td>03.07.2020</td>
<td>21:45</td>
<td>Clouds 1/8, no wind, twillight</td>
<td>17°C</td>
<td>-110</td>
<td>-78</td>
</tr>
</tbody>
</table>

The next step is now to use an Arduino to make periodic measurements automatically and to analyze the results over a few days and look for a correlation with the weather conditions.

Thank you for any remark, advice or correction about my experimentations!