RC attenuator distortion

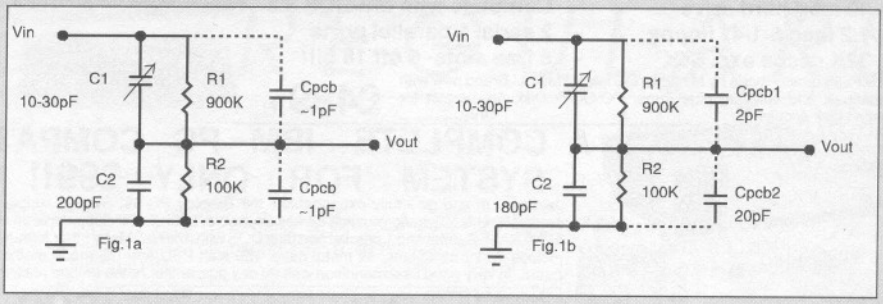

Fig.1. At (a), a typical 1MΩ, 10:1 RC attenuator, showing PCB strays, which are not constant with frequency and introduce a "hook" in a step function. Circuit at (b) is a complete cure; artificial "strays" in proportion to attenuation introduce impedance changes in each branch that compensate each other. Trim the two additional Cs and then adjust C_1 for an ideal response.

Figure 1(a) is a typical 10:1, 1MΩ wide-band attenuator, often used in signal generators, millivoltmeters and oscilloscopes. It is compensated by C_1 and C_2, so that $R_1/R_2 = C_1/C_2$ (neglecting C_{pcb}), and attenuation ought to be constant for all input frequencies, depending on source impedance and input capacitance. Unfortunately, one cannot neglect C_{pcb}, particularly since it is not constant with frequency and cannot therefore be cancelled by adjustment of C_1. Special PCB materials can be used which do have constant electrical properties, but they are expensive.

A step function passed through the attenuator exhibits the effect seen in **Fig.2**, which shows what happens with adjustment of C_1; the "hook" is ever-present, regardless of C_1 setting and makes its presence felt mainly in the 10-200kHz band with the values shown in Fig.1. Its amplitude is roughly $C_{pcb}/(C_{pcb} + C_1)$.

Using a ground plane around the output is not totally effective, since C_2 now has a great deal more capacitance to contend with. Instead, my solution is to make a pair of "deliberate strays", C_{pcb1} and C_{pcb2} in **Fig.1(b)**, using pads on both sides of the board with areas in proportion to the desired attenuation. Trimming the pads to exact size by drilling small holes allows complete cancellation of the hook. **Figure 3** gives a suggested layout.

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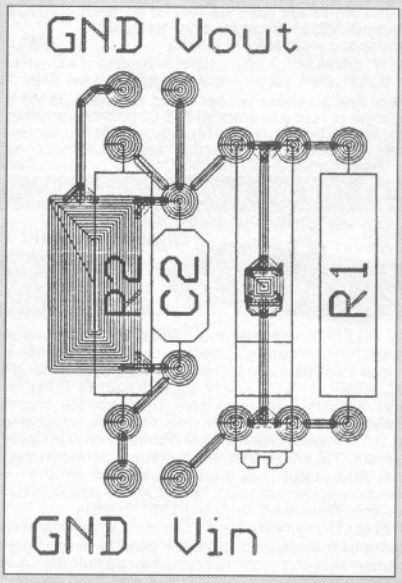

Fig.3. Suggested board layout of Fig.1(b) circuit. The track area is in the ratio of C_1 to C_2.

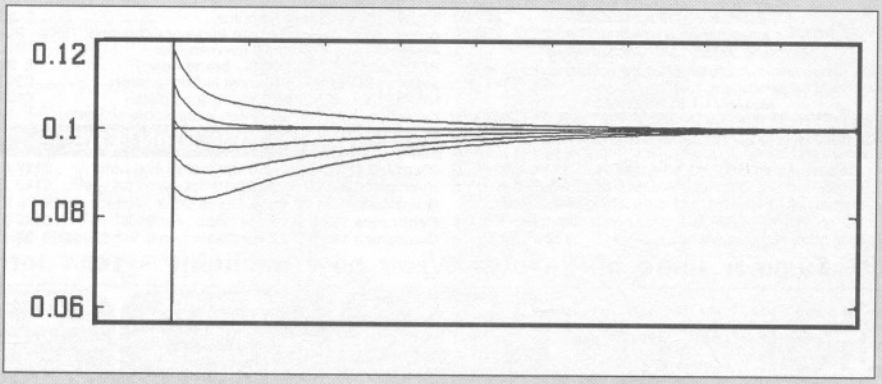

Fig.2. Without the two additional pads, this is the attenuator response to a step function. Whatever the setting of C_1, the hook in the response stays due to dielectric adsorption.