Active guitar electronics

A guitar magnetic pickup is a high-impedance voltage source, with an inductance in the order of henries. Because the cable capacitance and the pickup inductance form a parallel resonant circuit, this can alter the overall frequency response of the pickup.

Hence, when the cable hits any solid surface, clicks and rustles are induced by the cable dielectric polarisation. Such unwanted signals, which also include hum and RF interference, decrease the output signal dynamic range.

An active electronic circuit can be offered as a solution, consisting of a battery-driven low-noise preamplifier, built inside the musical instrument. Obviously, a circuit which has an external power supply, but shares the same cable and connectors would be more convenient. Hence, this is the setup given in the schematic.

The preamplifier uses a field-effect transistor (Q1) in common source mode, which is connected by shielded cable to a current-to-voltage converter built around IC1 (5532). Resistor R4 in the main circuit isolates the summing point of op-amp IC1a from the cable capacitance (shown as C_{cable}), while the multiloop feedback through resistor R5 and capacitor C4 forms a low-pass filter.

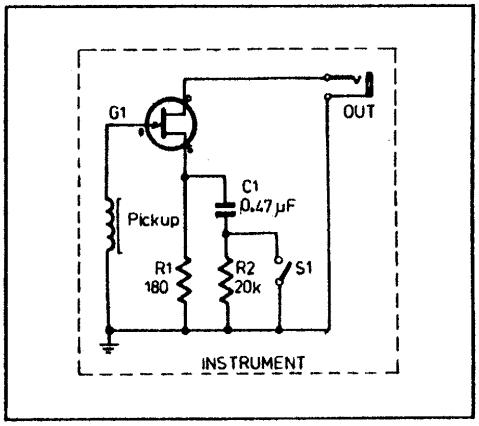
The circuit transfer function is given by: $A = g_{m1}.R5/(s^2/\omega_0^2 + \alpha s/\omega_0 + 1)$

where s is a complex frequency, g_{m1} is the input stage transconductance, while $\omega_0 = (R4.R5.C4.C_{cable})^{-1/2}$ is a resonant frequency, and the damping factor α is given by $w_0.C4.(R4+R5+R4.R5/R3)$.

With the component values shown in the diagram, the low-pass filter cut-off frequency lies above audio range (f_{-3dB} = 45-65kHz) and the circuit is uncritically damped ($\alpha < 1.4$) with cable length up to 60m (and C_{cable} up to 8nF). The low-pass filter effectively attenuates RF and pulse interference from thyristor-operated lighting. The non-inverting integrator IC1b restores DC conditions on the inverting input of IC1a, thus holding the DC output offset near zero. The circuit operates well with both magnetic and piezo-electric pickups.

Transistor Q1 is a 2N4416, 2N5270, 2N5459 or similar, with I_{dss} = 10mA and $-V_{(p)gs}$ = 3V. The pinch-off voltage $-V_{(p)gs}$ must exceed the peak output value of the pickup being used. The quiescent gate-to-source voltage is set by resistor R1 and should lie exactly in the middle of the transistor input operating range of $-V_{(p)gs}$ to +0.5V. Capacitor C1 boosts frequencies over 4kHz and implements the 'presence effect' when switch S1 is closed.

If you don't want to place the FET and its associated components inside the guitar, then Q1, R1 (and an additional 5.1M resistor from the FET gate to ground) may be mounted in the cable jack.



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