INSTRUCTIONS AND DESCRIPTION

SINGLE-WIRE TENSION MEASURING UNIT.

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Last Revision: July 12, 1995.

This device measures the resonant frequency of mechanical oscillation of a drift chamber wire. With the resonant frequency, f, in Hertz, one can compute the tension of the wire, T, in grams-equivalent, if its length, L, in meters and mass per unit length, μ, in grams per meter are known. The formula is $T = \frac{4}{g} L^2 f^2 \mu$, where g = 9.8 m/s^2. To make the measurement of f an oscilloscope is needed in addition to this box. Also, a source of magnetic field is needed so that the wire is in a transverse field of ten or more Gauss; any field strength will do if it is above the minimum.

The unit works on the principle that a current-carrying wire in a magnetic field experiences a force. If the force varies in time at the natural fundamental frequency of the wire, then a mechanical oscillation builds up. Once established, the oscillation can be detected using the induced sinusoidal voltage which develops between the ends of the wire; such a voltage occurs whenever a conductor is moving transverse to a magnetic field.

This circuit switches between "driving" the wire and "reading" it after every few cycles. In the driving phase, a current of typically 50 mA (rms) passes through the wire. In the reading phase a voltage of about 1 mV (rms) is detected, and it is amplified by ×1000, so on the oscilloscope the signal is in the range of about one volt. The driving signal (X) and reading signal (Y) may be displayed separately on the oscilloscope. It is usual, however, to display X vs. Y, so that the driving signal is on the horizontal axis and the response is on the vertical axis. When the driving frequency is far from a resonance the display shows a horizontal trace, corresponding to a driving signal but no response. Near resonance the display shows a vertical deflection as well. Exactly on the resonance the display should be an angled line, with no open loops. If the display shows an oval the system is very close to resonance but not on it. If the display shows many loops (examples of so-called Lissajous patterns), then the system is *not* at the "real" resonance but rather at a sub harmonic of the true fundamental resonance. A false resonance will often disappear if the number of read/drive cycles is changed.

Description of Controls

On/Off Switch: Connect line power.
Red Indicator: Illuminates when main power is on and the fuse is OK.
Coarse/Fine/Very Fine: These control the frequency generated by the unit to "drive" the wire. The coarse adjustment selects one of several overlapping ranges. The fine and very fine controls are in series: adjust the fine knob with the very fine knob roughly centered.
Drive: Controls the amount of current going to the wire, from 0 mA to 250 mA (rms). Keep this as low as possible while still getting a good signal.
Cycle: Selects either 1, 2, 4, or 8 driving cycles alternating with an equal number of reading cycles. Set this for the most pleasant-looking signal; often setting 1 is best.
Sym: "Symmetry" adjusts the purity of the sine wave used to drive the circuit. Look at the drive (X) signal as a function of time and adjust for a cleanest looking sine wave. (On version II of this unit this knob has been removed and replaces by a trimpot adjustment labeled S.)

W1, W2: leads to the wire under test. It doesn't matter which one goes where.
X: output to the X input of the oscilloscope. Set scope to 1 Meg-Ohm input resistance.
Y: output to the Y input of the oscilloscope. Set scope to 1 Meg-Ohm input resistance.
Z: output to the trace-blanking input on (some models of) oscilloscope.

LED Digit Display: Shows the *period* of the driving frequency, in microseconds. The driving frequency is the reciprocal of this number. That is, take the display number, P, and compute $f = 10^6 / P$ to get the frequency, f, in Hertz. The flickering of the right-most digits means you can ignore them; the circuit can't measure with perfect precision.

O: output offset adjustment on the model II of the unit. Should not be changed.
C: maximum current adjustment on model II of the unit. Should not be changed.
S: symmetry adjustment on model II of the unit. Should not be changed.

Hints & Troubleshooting Guide

1) The oscilloscope should be set for X-Y display, typically with .1 volts/division vertical and 1 volt/division horizontal. During the drive part of the cycle the display is disabled by the "Z" signal. Most Tektronix scopes have such an input. The inputs on the oscilloscope should be set for **1 Meg-Ohm**, as opposed to 50 Ohms. The wrong setting will give either a poor or no display.

2) The Cycle control can be set as desired for the most pleasant looking display. It does not affect the "true" fundamental resonant frequency. The number of sub harmonics which will make the wire oscillate is reduced for a smaller cycle number. Sub harmonics are identified by the fact that the drive and response signals are not in a one-to-one ratio, *i.e.* one sees a complex Lissajous pattern instead of a simple diagonal line. Some sub harmonics vanish when the cycle number is changed, but the real resonance does not.

3) The Drive setting should be kept constant, especially for the aluminum wires. These wires heat up in proportion to the square of the driving current, and this makes them relax their tension. The tungsten wires are less prone to this effect because of their larger surface-to-volume ratio and their smaller temperature expansion coefficients. Keep this setting as low as practical.

4) It is possible to make the wire response so large that it saturates the amplifier. In this case the display looks "clipped", chopped, or rounded off. Reduce either the magnetic field or the drive current to prevent this.

5) If there is a bright spot at the center of the display, "burning a hole" in the screen, then the "Z" input to the oscilloscope is not connected correctly. The Z signal blanks the trace during the drive part of the cycle.

6) If the magnetic field is produced by a small permanent magnet near the center of the wire there will be a multitude of higher harmonics which can be excited either directly or by sub harmonics of the driving waveform. The resonance for these higher harmonics look identical to the fundamental on the scope. Do not be fooled.