an anechoic chamber where the power was measured with receivers. The second guide used a commercial 60-dB sidewall coupler to measure the power. The calorimeter was placed in the third guide. Thus, the measurement made with the calorimeter could be compared against two different diagnostics.

Figure 3 shows the output voltage waveform from the calorimeter for Shot 1217 of the magnetron. The power for this pulse measured by the other diagnostics was 100 MW over a 10-ns pulse. The calibration factor for the calorimeter at 2.75 GHz was 0.23 V/J. The output voltage at peak was 0.23 V giving a 1-J measurement. Since the rise time of the output voltage was approximately 15 s and the calibration pulse was less than 1 s, no extrapolation back to zero time is necessary when interpreting the output voltage on Shot 1217. Both a 10-ns and a 250-ms pulse provide a 15-s rise time. Thus, the peak voltage is used in calibration and in actual high-power operation.

The peak electric field in rectangular waveguide for a given power level has been derived by Moreno[8]:

$$P/E_{\max}^2 = 6.63\times 10^{-4} ab\,[1-(\lambda/\lambda_c)^2]^{1/2},$$

where P is the propagating power in watts, E is the electric field in kV/cm, a is the width of the guide in cm, and b is the height of the guide in cm. The electric field for 100 MW is 97 kV/cm and for 1000 MW is 310 kV/cm. This calorimeter operated very well at power levels up to several hundred MW but above this level possible flashover at the space cloth from the large peak electric field gave discrepancies in the measurement of power. For example, when the receiver and the coupler indicated that 1000 MW was being generated, the calorimeter measured an energy equivalent to only 350 MW. Thus, this calorimeter provides valid results only to about the 500-MW level. However, even at higher levels it still provides a lower bound.

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New high-precision bridge for low-resistance thermometry

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We describe a simple four-terminal ac bridge designed to be used with sensors of low resistance, such as platinum thermometer at low temperature.

This note presents a simplified version of a previously described temperature controller,[1] which was designed to be used with resistance sensors of moderate or high ohmic value (Ge thermometers at cryogenic temperatures or Pt thermometers at room temperatures).

When the sensor resistance is sufficiently small ($R_x < 100\,\Omega$), the precise lead-resistance compensating circuitry previously used in the bridge section (Fig. 2 in Ref. 1) can be dropped and a much simpler design can be adopted, which offers a high intrinsic rejection of the lead-resistance effects.

The new bridge configuration is shown in Fig. 1. A pair of matched transformers (T1 and T2) is placed in the feedback loop of a current booster stage. Thus T1 and T2 are driven by the same constant current i_1, and they feed the separate loops of the sensor (Rx) and of the standard resistance (Rs) with the same constant current i_2.

Because the working frequency f of the temperature controller[1] is 1 kHz or higher, and the typical impedance of the inductive voltage divider (IVD) at this frequency[2] is 500 kΩ, the current flowing in the IVD loop is negligible with respect to the secondary current.

The circuit analysis can, therefore, be simplified by including the resistances Ri of the "current carrying" wires into the secondary winding resistance R_2, and by including the resistances Rv of the "voltage sensing" wires into the IVD resistance R.

Assuming a perfect matching of the transformers, one can express the ratio between the voltages Vx (across Rx) and Vs (across Rs) as

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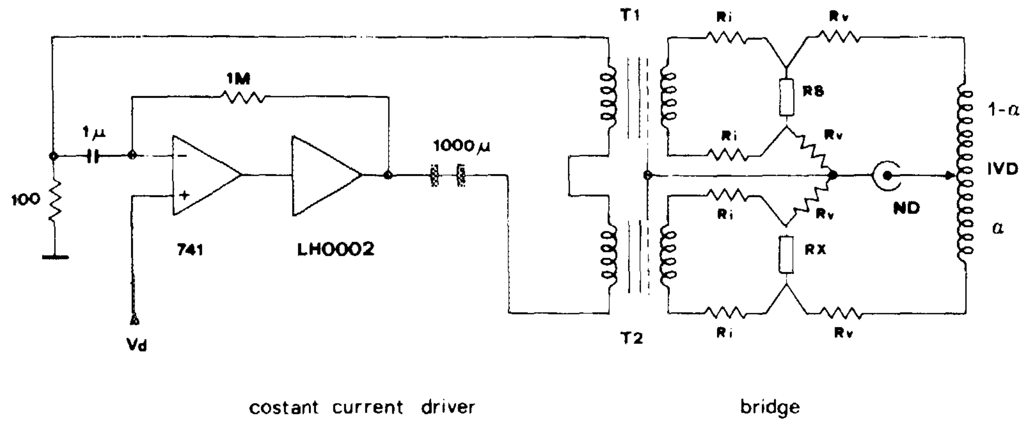

FIG. 1. The circuit of the bridge and of the constant current driver. Vd: 1-, 5-, or 10-kHz driving voltage of constant amplitude; ND: null-detector circuitry.

$$\frac{Vx}{Vs}=\frac{Rx|Rs+R_2+j2\pi fL_2|}{Rs|Rx+R_2+j2\pi fL_2|}=\frac{Rx}{Rs}[1+0(Rx)], \quad (1)$$

where L_2 is the secondary winding inductance and $0(Rx)$ is a function of Rx that can be made negligible with respect to unity, by letting $L_2 \gg |Rs-Rx|/2\pi f$.

On the other hand, by zeroing the bridge output, one gets a measurement of Vx/Vs in terms of the IVD voltage ratio **a**

$$Vx/Vs=\mathbf{a}/(1-\mathbf{a}). \quad (2)$$

Therefore, when $0(Rx)$ can be neglected, one gets

$$Rx=Rs\,\mathbf{a}/(1-\mathbf{a}). \quad (3)$$

In our setup T1 and T2 are obtained from Ferroxcube potcores,[3] with a shield to reduce the capacitive coupling, by winding 20 turns of 0.45-mm-diam wire for the primary ($R_1=0.2\ \Omega$, $L_1=7$ mH) and 2000 turns of 0.1-mm-diam wire for the secondary ($R_2=250\ \Omega$, $L_2=70\ H$).

We have, therefore, with $Rs=100\ \Omega, f=1$ kHz, and a Pt 100 sensor[4]:

$$|Rs-Rx|/2\pi fL_2<2\times10^{-4},$$

for any temperature up to 400 K.

The temperature dependence of the wire resistance Ri^x only affects the correction term $0(Rx)$, which, accounting for Ri^x, becomes

$$0(Rx,Ri)=\frac{[(Rs+Ri^s)-(Rx+Ri^x)]}{[(Rx+Ri^x+R_2)^2+(2\pi fL_2)^2]^{1/2}}. \quad (4)$$

The effect of T1, T2 mismatching is to multiply Rs for a constant factor, so that the effective Rs' value can be easily obtained by calibrating the bridge with a second standard resistance in place of Rx.

The simpler bridge here described does not change the instrument accuracy and long-term stability.

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Small permanent magnet for fields up to 2.6 T

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We describe a small permanent magnet (no dimension exceeds 8 cm) which produces a uniform magnetic field of 2 T in a volume of about 14 mm^3. This magnet has been used to orient macromolecular assemblies for light microscopy, x-ray, and light-scattering studies.

Large diamagnetic molecular assemblies can be oriented in magnetic fields of about 1 T. Almost complete alignment has been achieved in many liquid crystalline materials[1], and in suspensions of biological assemblies such as rod-shaped virus particles[2–4] and retinal rod outer segments.[5,6] When the samples are removed from the field a random orientation of the particles is usually reestablished either by thermal motion or, if the sample exhibits liquid crystalline properties, by

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