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Authors
Falick, Arnold M.
Myers, Rollie J.

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Arnold M. Falick and Rollie J. Myers

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LAWRENCE RADIATION LABORATORY
UNIVERSITY of CALIFORNIA BERKELEY

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Photon Coupling for the Low Frequency Modulation of High Voltage Oscillators

Arnold M. Falick* and Rollie J. Myers*

Department of Chemistry of the
University of California and
the Inorganic Materials Research Division
of the Lawrence Radiation Laboratory,
Berkeley, California 94720

The recent note by Remeikes et al.[1] points up the problem of the low frequency modulation of klystrons and other high voltage oscillators. Their scheme is to modulate an rf oscillator, transformer couple to the high voltage level and then demodulate. A number of years ago in these laboratories one of us used a similar scheme, but we had great difficulty avoiding spurious modulation of the klystrons by the rf oscillator. There are several advantages to an all dc scheme, and photon coupling can be used to provide both high voltage isolation and dc frequency response. Solid state laser diodes can be combined with a number of light sensitive devices to form a practical and linear photon coupled isolator system.

Our circuit was designed to frequency lock a commercial klystron oscillator (HP 8616A) to a microwave cavity. For this purpose it is necessary to apply the dc output of a phase detector to the reflector of the klystron. Many commercial oscillators provide an external connection, for frequency stabilization, which is in series with the reflector. As shown in Fig. 1, the output of our photon coupled isolator is placed in the reflector circuit using the external frequency stabilization connections. With this design, it is not necessary to modify the commercial oscillator in any way.

An inexpensive photon coupled isolator was constructed from a gallium arsenide light emitting diode (Motorola - MV10B) and an NPN phototransistor (Fairchild - FPT 100). They were mounted, facing each other, in a one-hole black rubber stopper. The 130 Ω series resistor is necessary to protect the diode from current overload, and it also serves to make the diode current, and light output, nearly linear in voltage. A protective diode is also in series since the emitter diode has a maximum reverse voltage rating of only 3 v. The operational amplifier was necessary with our phase detector to provide 100 ma at 15 v (max.) to drive the diode circuit. In the HP 8616A oscillator the 1MΩ load resistor is internally mounted in the reflector circuit. Other oscillators may not provide this resistor.

Figure 2 shows the frequency variation of the HP 8616A at 3.1 GHz with the output voltage of the operational amplifier. This frequency range is quite ample for stabilization purposes, but it may be too small for sweep purposes. It could be increased by using a higher battery voltage, a stage of amplification or by using a more efficient photon coupled isolator unit. The reflector sensitivity in the HP 8616A is, however, lower than most klystrons.

We have also used a more efficient, but also more expensive, commercial photon coupled isolator (HP 5082-4303). With this same circuit, except for a series 220 Ω resistor, the commercial isolator increased the sweep range by over a factor of five. The isolation of the HP 5082-4303 is rated at 20 kv and its basic time response extends into the manosecond range.

We would like to thank Mr. Steven Smiriga for help in selecting our devices. This work was supported by the U. S. Atomic Energy Commission.

References

1. A. Remeikes, R. A. Baudet, R. L. Poynter and G. Steffensen, Rev. Sci. Instrum. 39, 1223 (1968).

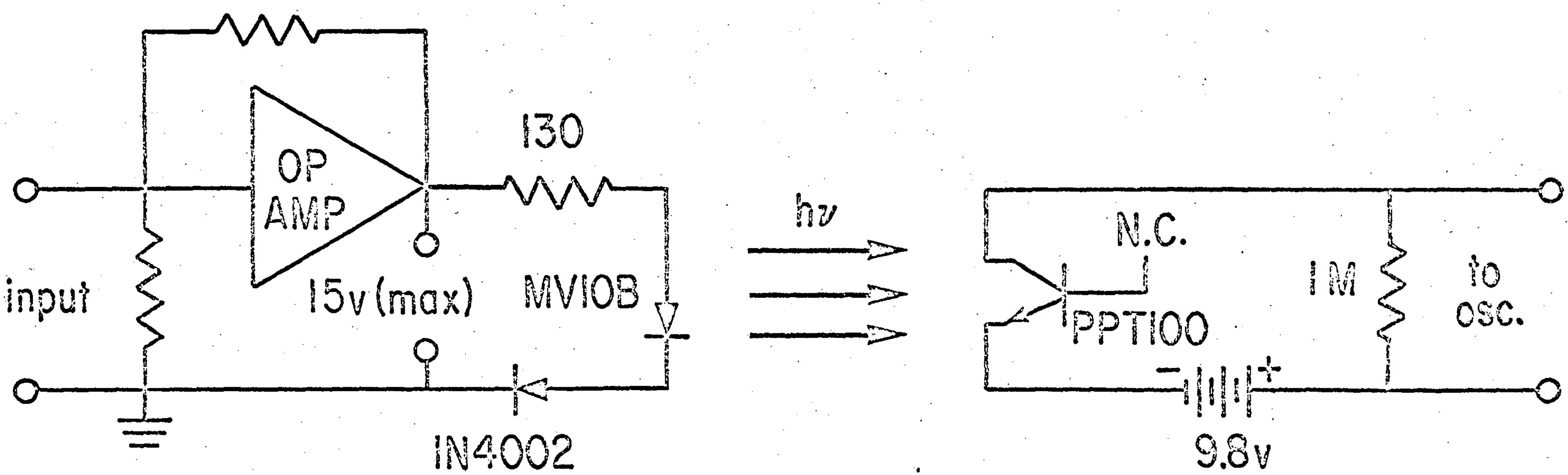

Figure 1. The photon coupled circuit.

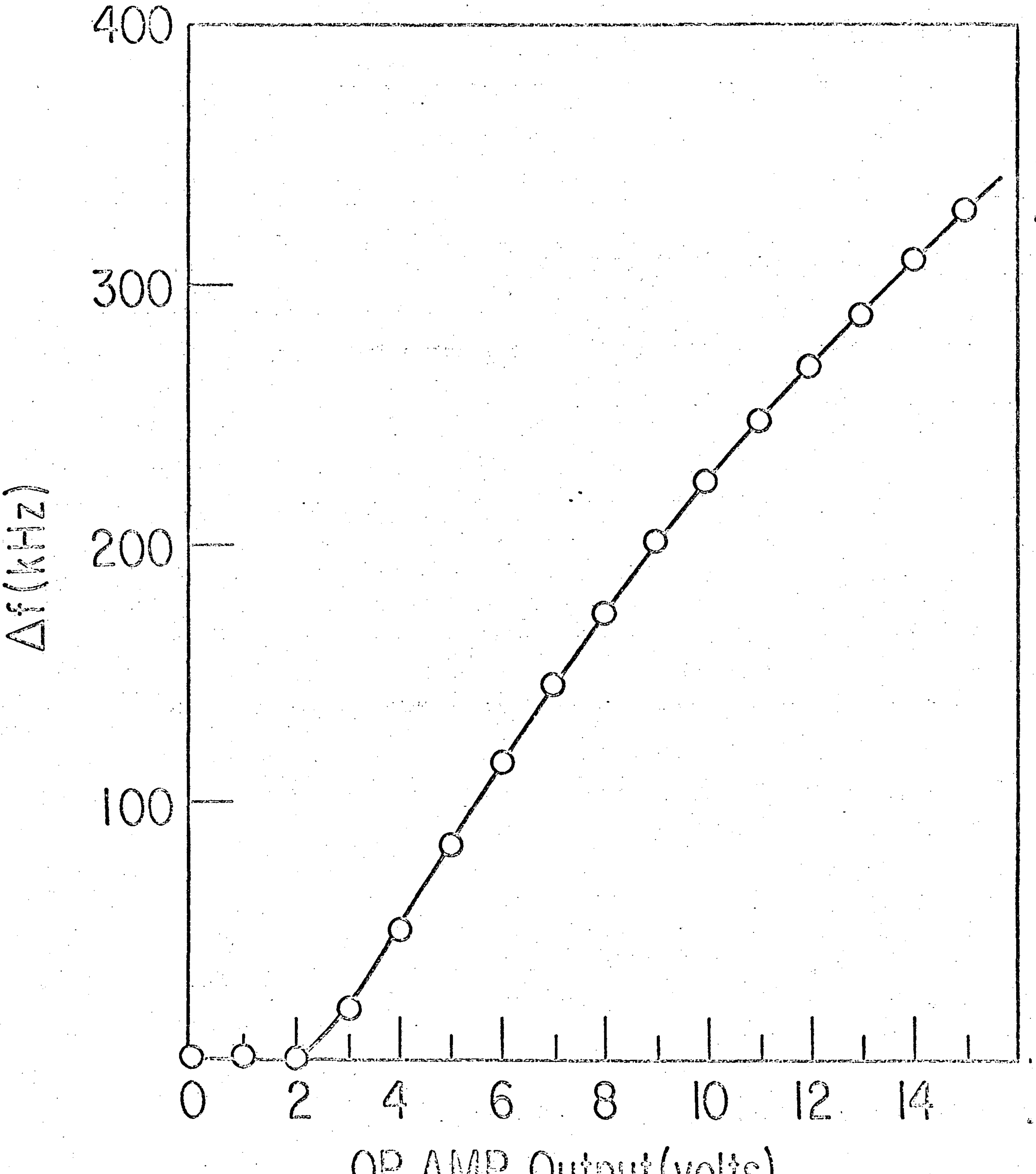

Figure 2. Klystron frequency as a function of operational amplifier output voltage. The reflector sensitivity is about 200 KHz/v for the HP 8616A at 3.1 GHz.