Digital Computer Laboratory
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SUBJECT: FIRST NOTE ON PULSE TRANSFORMERS FOR MEMORY DRIVERS

To: N. H. Taylor

From: Frank Durgin and Earle Gates

Date: May 27, 1953

Abstract: It is possible to drive the coordinate lines of a magnetic-core memory plane with small-current-capacity vacuum tubes by using push-pull pulse transformers with large ratios of current transformation. A push-pull transformer is necessary to eliminate pulse-repetition sensitivity and to make possible bi-directional currents on a single-wire driving line.

In order to drive a magnetic-core memory of the M.T.C. type a pulse of 500 ma amplitude is required from both an "x" and "y" driver. As determined in Engineering Note E-533, the mimimum current pulse duration is 1.5 μsecond. From this note a desired read-write pulse can be postulated.

Figure 1 shows the waveforms and timing first suggested by the Magnetic-Core Memory Section.

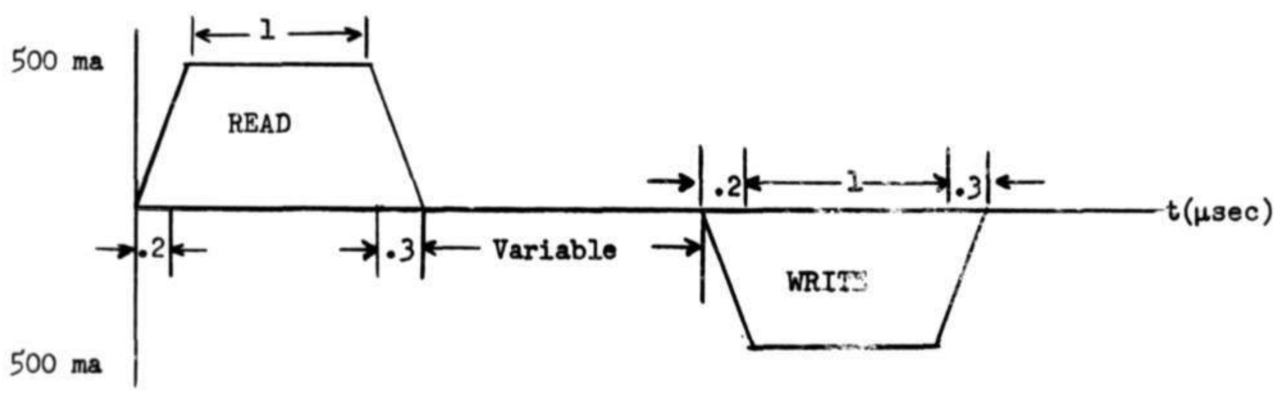


Figure 1 (Time in micro-seconds)

In order to drive the magnetic-core memory directly from vacuum tubes the tubes must supply up to 500 ma plate current. To do this we either need large capacity tubes or several tubes in parallel. Also since a vacuum tube conducts in only one direction two wires are required for each coordinate ("x" and "y") of the array.

If we transformer-couple the vacuum-tube drivers to the memory array and connect the transformer so as to obtain a step-up in current, then we can use smaller and more reliable tubes. However, the transformer has one very undesirable feature which is on overshoot voltage opposite to the desired polarity. In a linear transformer the overshoot cannot be eliminated since the voltage-time integral must go to zero (unless the load is a non-linear resistance).

However, it is possible to utilize this overshoot voltage. Referring to Fig. 1 we see that the "write pulse" is of opposite polarity than the "read pulse". By using a push-pull transformer and making the "write pulse" follow directly after the "read pulse" the overshoot voltage and recovery time are no longer a problem. The voltage-time integral is zero at the end of the "write pulse" so there is no overshoot. Since current flows in both directions in the secondary of the transformer we need only one driving wire instead of the two needed when driving directly with vacuum tubes.

Because the transformer is connected voltage step-up from the load to the tubes, any voltage induced in the load appears as a large back voltage on the plates of the tubes. The allowable back voltage will depend upon supply voltages and the tube types used. If we can reduce the impedance of the memory array then higher current ratios can be used without excessive back voltages.

The tests reported in this note were made with transformers having 5:5:1 turns ratio driving the Z-plane winding of one digit plane. It was assumed that the Z-plane impedance was as large or larger than the impedance which the x or y coordinates of a complete memory would present to the transformer. Under these conditions it was possible to reduce the current from the driving tubes to 150 ma.

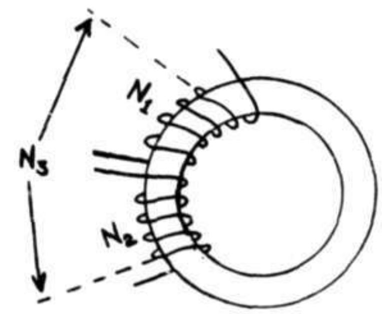
Equipment

In order to test these push-pull pulse transformers the setup in Fig. 2 was used.

The output of the M. V. Pulse Generator was fed to the monostable input of one Mod. V Core Driver directly and thru the Delay Line Panel to the other Mod. V Core Driver. This arrangement was used to simulate push-pull input to the transformer. The delay was adjusted to give the best waveform with a given pulse width adjustment of the first Core Driver.

The plates of the Core Drivers were returned to +150 volts thru the center-top of the transformer so that the back voltage from the array would have less effect on the results.

Three transformers were tested: 2 ferrite transformers and one hypersil transformer.



Transformer 1 (Fig. 5 and 6)

Core material: F-109-3, Ferramic H
Toroidal Core
2 cores stacked together
$N_1 = N_2 = 50$ turns

$N_3 = 10$ turns

Transformer 2 (Fig. 7 and 8)

Core material: F-109-3, Ferramic H
Toroidal Core
$N_1 = N_2 = 100$ turns

$N_3 = 20$ turns

Transformer 3 (Fig. 9 and 10)

This transformer is similar to the Standard WWI 5:1 pulse transformer 6-193-10. An extra winding was added and the center tap was brought out to a 5th terminal.

In the waveforms of Fig. 5 thru Fig. 10 the output pulse is adjusted to 500 ma amplitude with a flat top 1 μsecond in length.

The pictures indicate that the desired waveshapes can be approximated with varying degrees of success. Rise times from .3 μsecond to .5 μsecond were obtained with current ratios from 2.5:1 to 3.5:1. By decreasing leakage inductance we can obtain faster rise times. However present indications are that by using slower rise times the noise in the output of the sensing winding can be reduced, and all of the times shown in Fig. 1 may be increased by 50 percent or more.

In order to obtain higher current ratios leakage inductance must be reduced and a core material which has lower losses at the frequencies we are operating must be used. The turns ratio can be increased, but, increased back voltage and leakage inductance will limit the maximum turns ratio which can be used. If we can also eliminate the damping resistors a much higher current ratio will result.

More tests incorporating the above ideas are being made and the results will be reported as soon as they are ready.

Signed Frank Durgin
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Approved
W. N. Papian

FD/EG:jrt

Drawings attached: A-55018
A-55019
A-55020

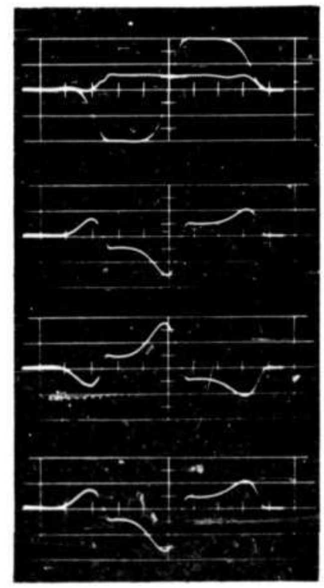
WAVEFORMS
(0.5 μ SEC CM)

OUTPUT CURRENT
IMPUT CURRENT
(250 MA/CM)

SECONDARY VOLT.
(10V/CM)

PRIM. VOLT.
TO CENTER TAP
(50V/CM)

PRIM. VOLT.
TO CENTER TAP
(50V/CM)



$R_p = 47$ $R_l = 8200$
FIG. 9

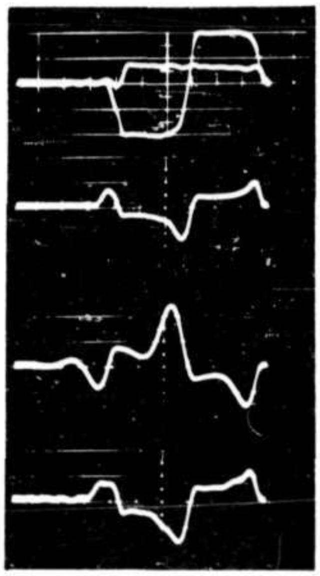
TRANSFORMER 3
SEE FIG. 4

$R_p = 47$ $R_l = 6800$
FIG. 10

WAVEFORMS FOR DRIVING MEMORY-ARRAY

A-55018

WAVEFORMS
(0.5 μSEC/CM)



$R_P = \infty$ $R_1 = \infty$ $R_2 = 1$ K
FIG. 5

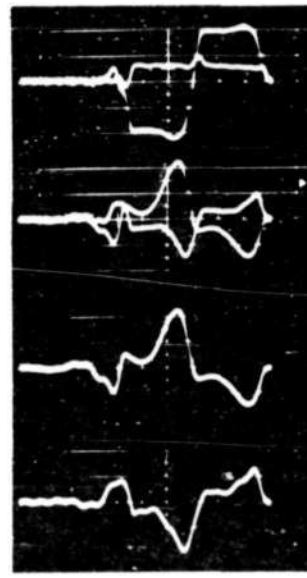
OUTPUT CURRENT
IMPUT CURRENT
(250 MA/CM)

SECONDARY VOLT
(25V/CM)

PRIM. VOLT.
TO CENTER TAP
(75V/CM)

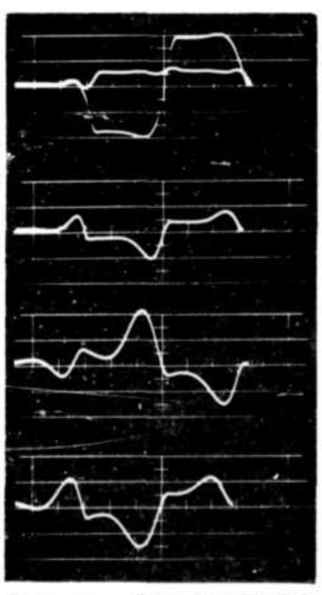
PRIM. VOLT.
TO CENTER TAP
(75V/CM)

TRANSFORMER 1
SEE FIG. 3



$R_P = 100$ $R_1 = R_2 = \infty$
FIG. 6

WAVEFORMS
(0.5 μSEC/CM)



$R_P = \infty$ $R_1 = R_2 = 3900$
FIG. 7

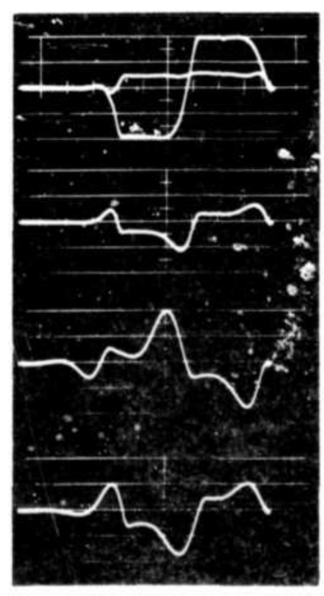
OUTPUT CURRENT
IMPUT CURRENT
(500 MA/CM)

SECONDARY VOLT
(25 V/CM)

PRIM. VOLT.
TO CENTER TAP
(75V/CM)

PRIM. VOLT.
TO CENTER TAP
(75V/CM)

TRANSFORMER 2
SEE FIG. 3



$R_P = 220$ $R_1 = R_2 = 3900$
FIG. 8

WAVEFORMS FOR DRIVING MEMORY-ARRAY

A-55019

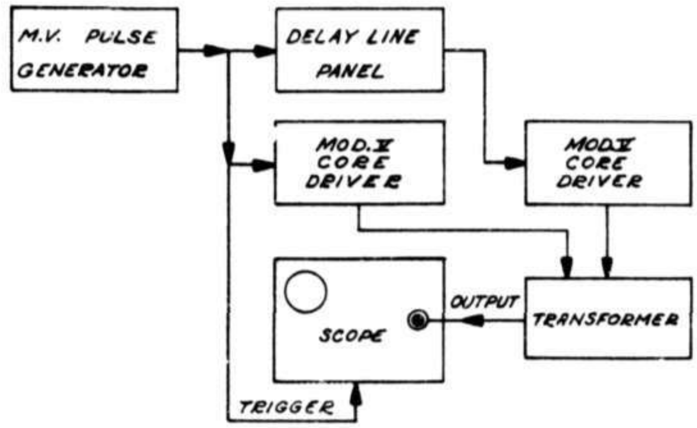
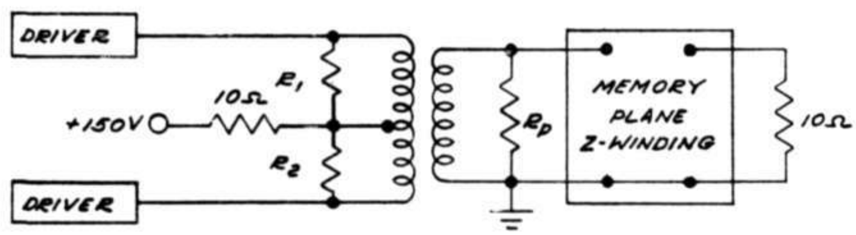
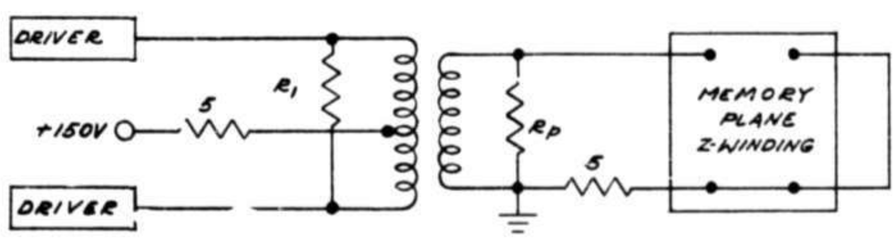


FIG. 2
TEST SET-UP



THE 2-10Ω RESISTORS ARE FOR MEASURING CURRENT

FIG. 3
ELECTRICAL CIRCUIT FOR FIG. 5-8



THE 2-5Ω RESISTORS ARE FOR MEASURING CURRENT

FIG. 4
ELECTRICAL CIRCUIT FOR FIG. 9-10

A-55020

PULSE TRANSFORMERS FOR DRIVING MEMORY-ARRAY