Digital Computer Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

SUBJECT: **PRELIMINARY REPORT — TEMPERATURE EFFECTS IN MTC-TYPE FERRITE CORES**

To: D. R. Brown

From: James D. Childress

Date: June 26, 1953

Abstract: The curves given in this note show the effect of temperature on ferrite core operation. For a particular driving current amplitude, there is a point (or range) in temperature beyond which core operation degenerates rapidly. For the MTC cores used in this test, the temperature coefficient is about 1 mv/degree C; the Critical Point at 1.00 amp is 40° C; at 0.95 amp 50° C; at 0.90 amp 60°; at 0.80 amp 70° C.

The equipment and experimental method used is much the same as described in E-533, "Effect of the Current Pulse Duration on the Pulse Response of MTC Memory Cores," by P. K. Baltzer.

At first, plans for this study were to take data for current pulse durations of 1.2 μs, 1.5 μs, and 2.0 μs. This variation in pulse duration had little effect, so the pulse duration was standardized at 2.0 μs.

The test mode was six "read-write" cycles followed by (1) thirty "disturbs" for the "delta" measurements or (2) six "disturbs" for the "one" and "disturbed one" measurements. This number was too small to give accurate values of the "disturbed one" beyond the Critical Temperature Point.

Other experimental inaccuracies were caused by unreliable logic and variations in the supply voltages. Therefore, the data given here have only qualitative value. Since these data were taken, the equipment has been improved and plans are to take new data.

Data: Figure 1 shows ${}_uV_1$ (undisturbed one) and $V_1$ (disturbed one) vs. temperature for current-pulse amplitudes of 1.00 amp, 0.95 amp, 0.90 amp, and 0.80 amp. The sampling time was the time of the ${}_uV_1$ peak, roughly 0.6 μs.

There is a positive temperature coefficient of ${}_uV_1$ so that ${}_uV_1$ might be expressed as:

$${}_uV_1 = c_1 (1 + \alpha T) + c_s I$$

Early work by McCusker and Schallerer indicated that $\alpha$ would vary from lot to lot.

Note also that $V_1$ increases (negligibly different from $_uV_1$), reaches a maximum at a point in temperature, then decreases rapidly. Operation beyond this maximum does not seem feasible. Note that the point of the maximum shifts upward in temperature as the current pulse amplitude is decreased.

Figure 2 gives the variation of $\delta_1$ and $\delta_2$ vs Temperature for current pulse amplitudes of 1.00 amp, 0.95 amp, 0.90 amp, and 0.80 amp.

The "deltas" are defined as*

$\delta_1$ = "first half-selected one" - "first half-selected zero"

$\delta_2$ = "second half-selected one" - "second half-selected zero"

These are the "deltas" given in Figure 2, sampling time 0.6 μs.

Note that $\delta_1$ is constant below a point in temperature, then increases rapidly. Also, $\delta_2$ is negligibly different from zero below a temperature point but increases rapidly above that point.

Roughly, the point in temperature at which $V_1$ has its maximum is the same point at which $\delta_1$ and $\delta_2$ begin to increase. This point (or range) may be called the Critical Temperature Point for Core Operation. Note that the Critical Point depends on the current pulse amplitude--lower current pulse amplitude, higher Critical Point.

Since these measurements were made, the "deltas" have been re-defined. New measurements will be made of the proper "delta" vs temperature. Until then, Figure 2 indicates what type of variation might be expected.

From the data in Figures 1 and 2, conclusions are as follows:

1. Temperature has an important effect on core operation.
2. Temperature is one of the variables which should be closely controlled in ferrite-core evaluation. From Figure 1, a ten-degree change in temperature produces about a fifteen-percent change in $_uV_1$ or $V_1$. This is as wide as the limits for acceptability of cores. Therefore, for accuracy in production testing, the temperature of the cores need be accurately controlled.

Further measurements are being made and others are being planned. Plans are to measure the following:

1. Temperature Coefficients for different lots.
2. Critical Points for different lots.
3. Hysteresis Loops vs. Temperature.
4. Physical dimensions vs. Temperature Coefficients vs. Critical Point.

---

* E. A. Guditz, E-448, "$\text{Delta}_{ns}$ in Ceramic Array #1," Digital Computer Laboratory, MIT.

Signed James D. Childress
James D. Childress

Approved DRB
David R. Brown

JDC/jk

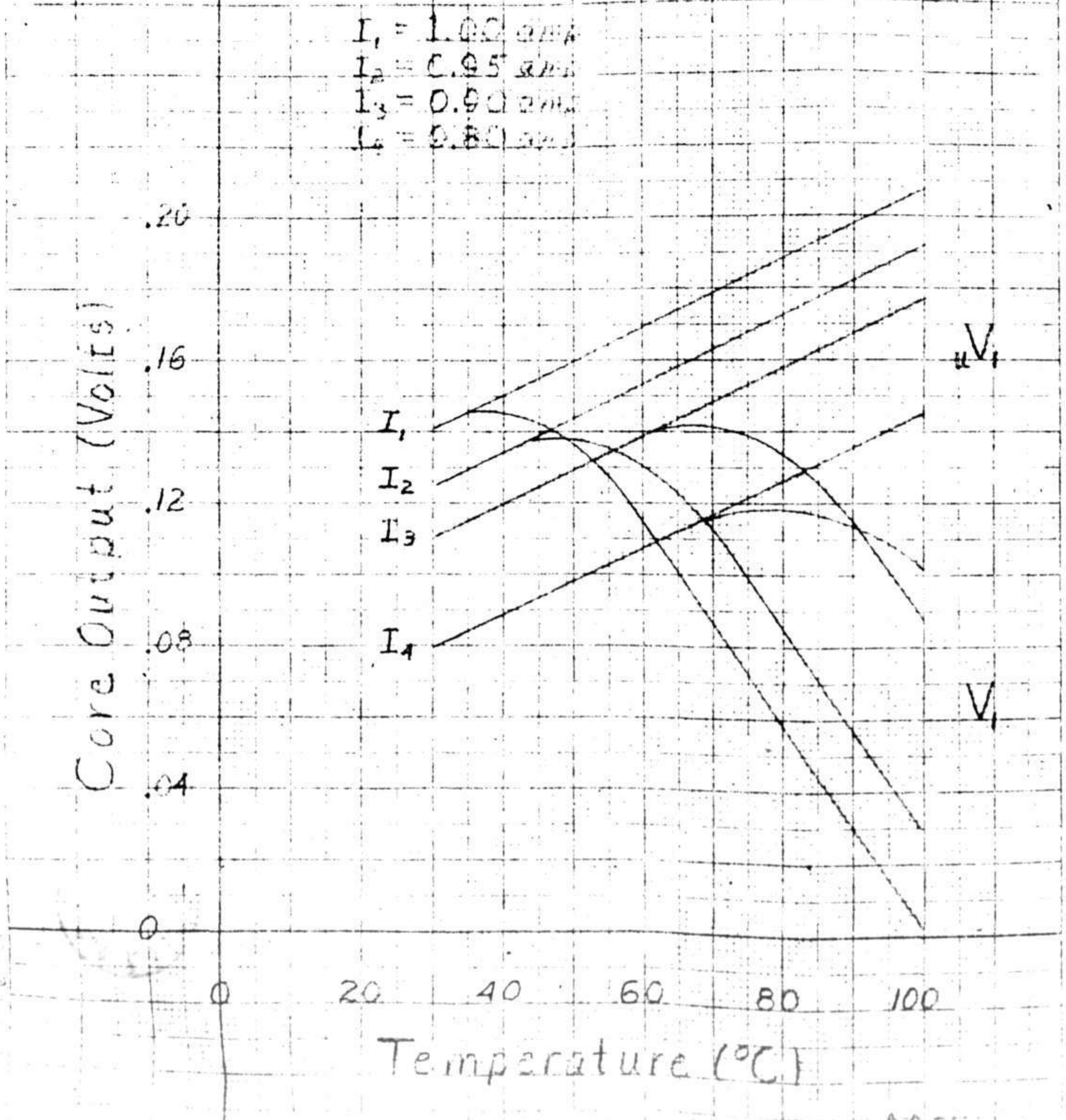
Drawings attached:

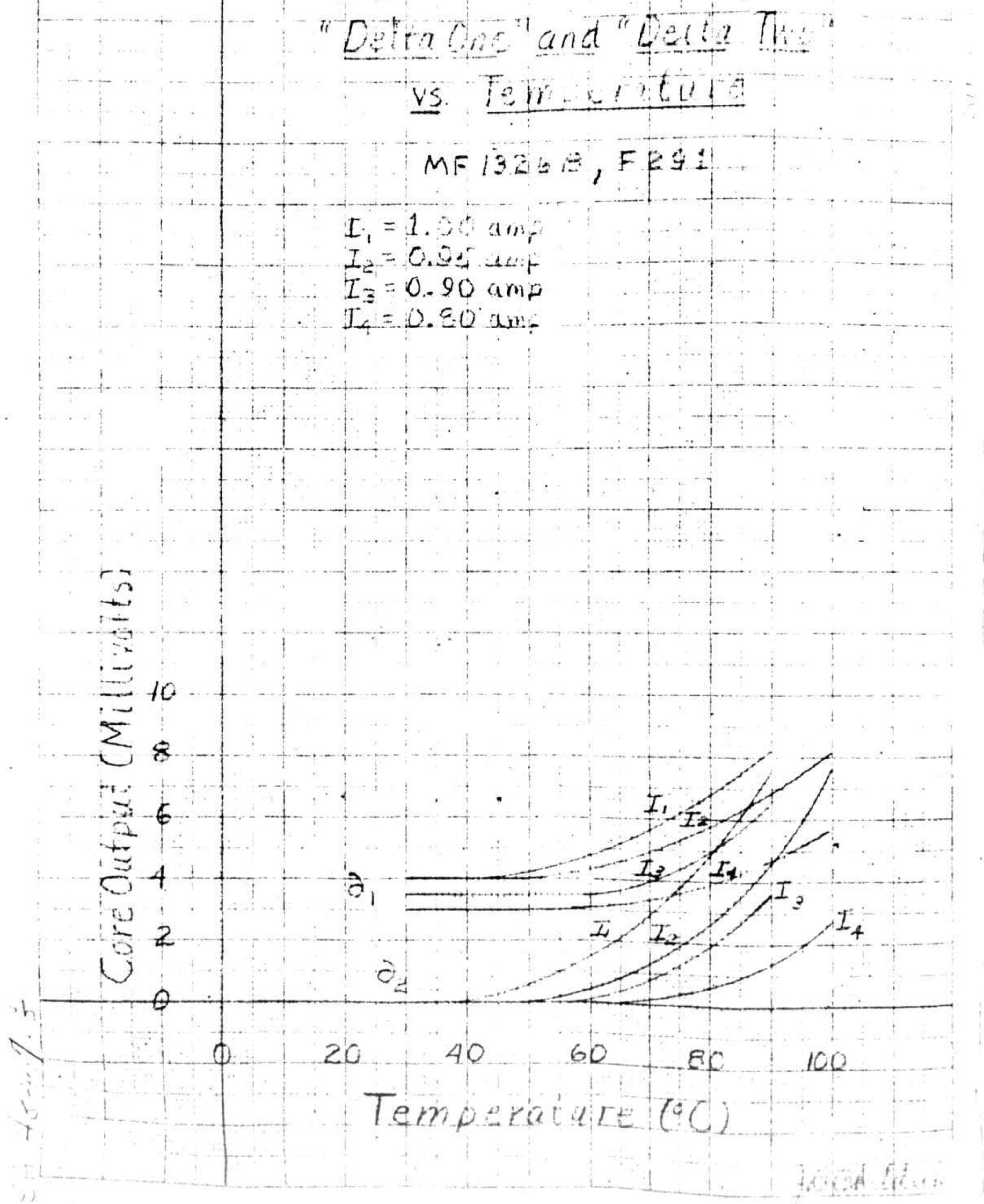
Figure 1 SA-48446-G
Figure 2 SA-48447-G

cc: Group 63 Staff
N. H. Taylor
Group 62 Memory Section
IBM

# "One" and "Disturbed One" vs. Temperature

MF 1326B, F291




"Delta One" and "Delta Two"
vs. Temperature
MF 1326B, F291
$I_1$ = 1.00 amp
$I_2$ = 0.95 amp
$I_3$ = 0.90 amp
$I_4$ = 0.80 amp
Core Output (Millivolts)
10
8
6
4
2
0
$\partial_1$
$\partial_2$
$I_1$
$I_2$
$I_3$
$I_4$
0
20
40
60
80
100
Temperature (°C)