FIRST RESULTS FROM THE WISCONSIN NON-CIRCULAR RFP

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Plasma Studies

University of Wisconsin

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Included here are figures covering that portion of the UW contribution to the 1986 US/Japan RFP Workshop (February 18-21) not contained in previous publications (see also PLP 958 and 959). The major new result is the attainment of 200 kA/8 msec, ramped, self-reversed, sustained, RFP discharges in the large, non-circular, Levitated Octupole vacuum vessel with the octupole rings removed.

The following points are worthy of note:

1) The discharges are started up with $\lesssim$ 200 volts on the poloidal gap with no evidence of gap arcing despite the fact that the gap is in contact with the plasma. The present protector consists of a 20 cm wide strip of ceramic over the gap.

2) The plasma enters the reversed-field state at a current of ~100 kA, making this one of the lowest current density RFP's in existence (~100 kA/m^2).

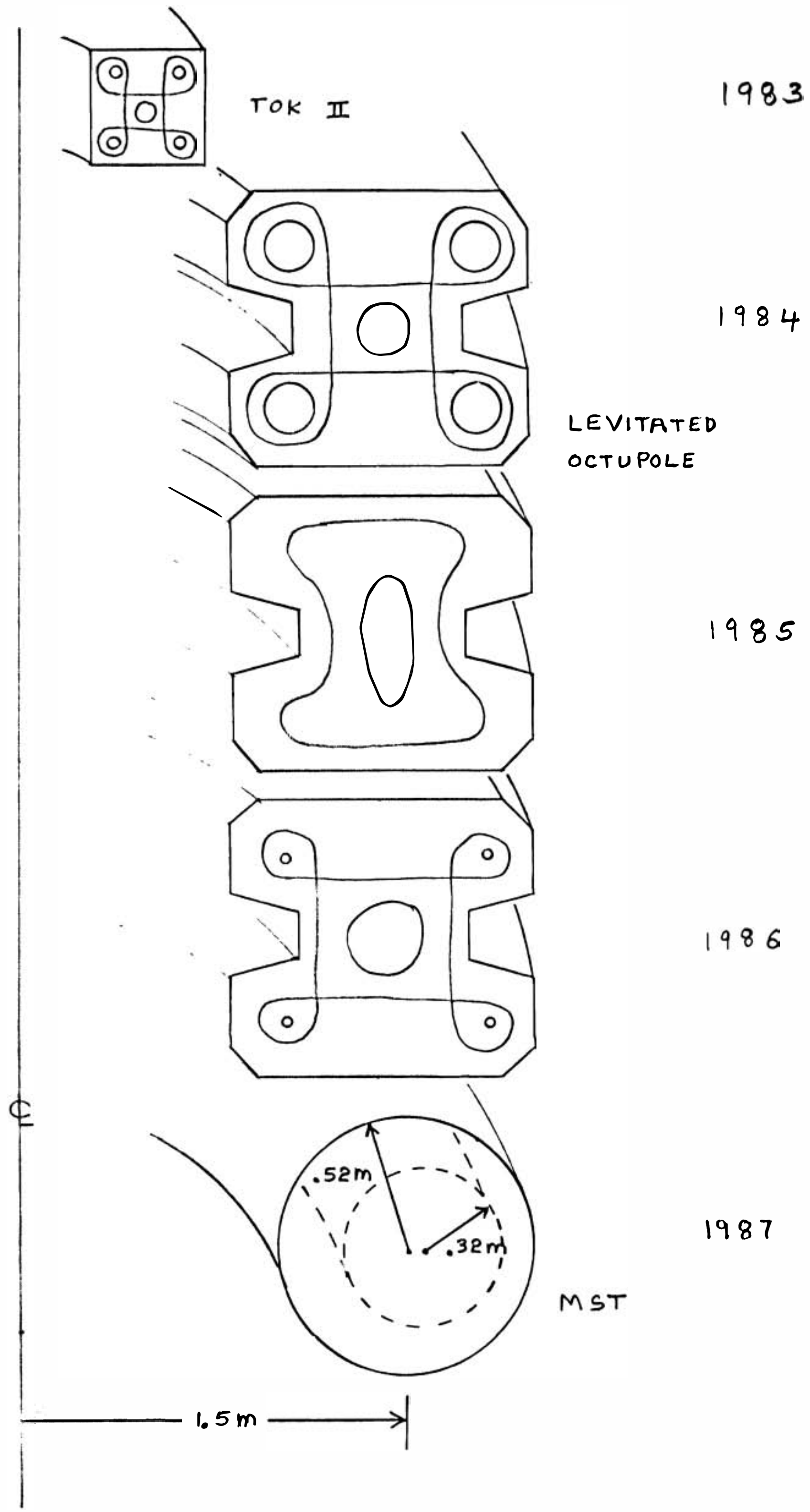
3) The plasmas follow the theoretical F-θ curve for λ = constant reasonably well until reversal occurs, and then they depart from the curve toward the right. Theta values as high as 2.5 and F values as low as -0.8 have been obtained.

4) Long duration (10-20 msec), high current ($\gtrsim$100 kA) discharges can be produced at any theta value spanning the range from q ~ 1 tokamaks to deeply reversed RFP's. The highest current discharges (~300 kA) occur at θ ~ 0.9 (q ~ 0.5). The RFP discharges are sustained for $\gtrsim$10 resistive diffusion times and terminate only because the volt-second limit of the iron core (without reverse biasing) is reached.

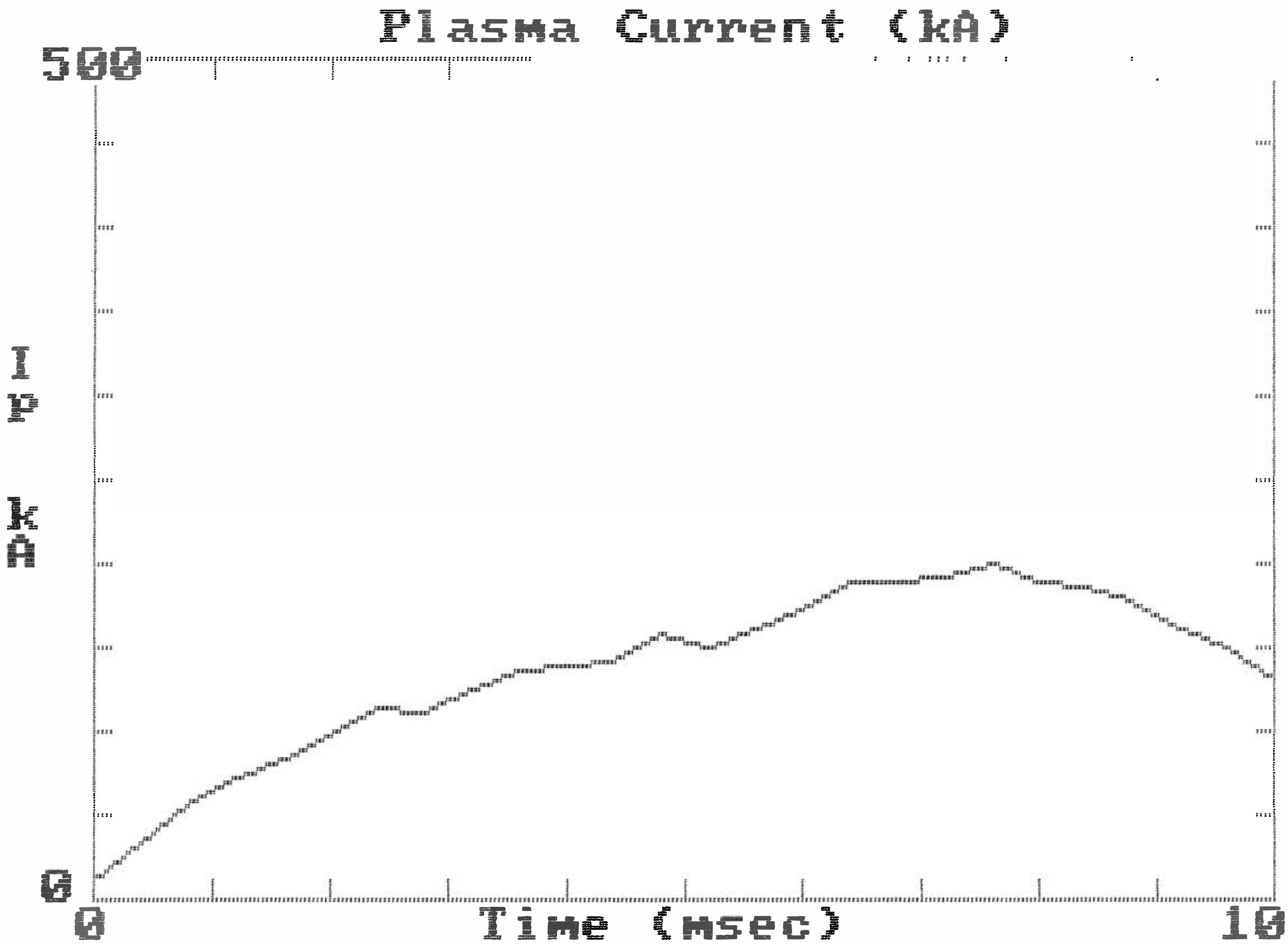
5) The plasma resistance drops, and the conductivity temperature rises when the plasma enters the reversed-field state. However, there is no noticeable quiet period, and the resistivity is still an order of magnitude higher than in ZT-40. The conductivity temperature strongly correlates with vacuum conditions, indicating a need for more aggressive discharge cleaning. Removal pumping rate per unit wall surface area is quite low ($\sim 1000\ell/sec/40m^2$).

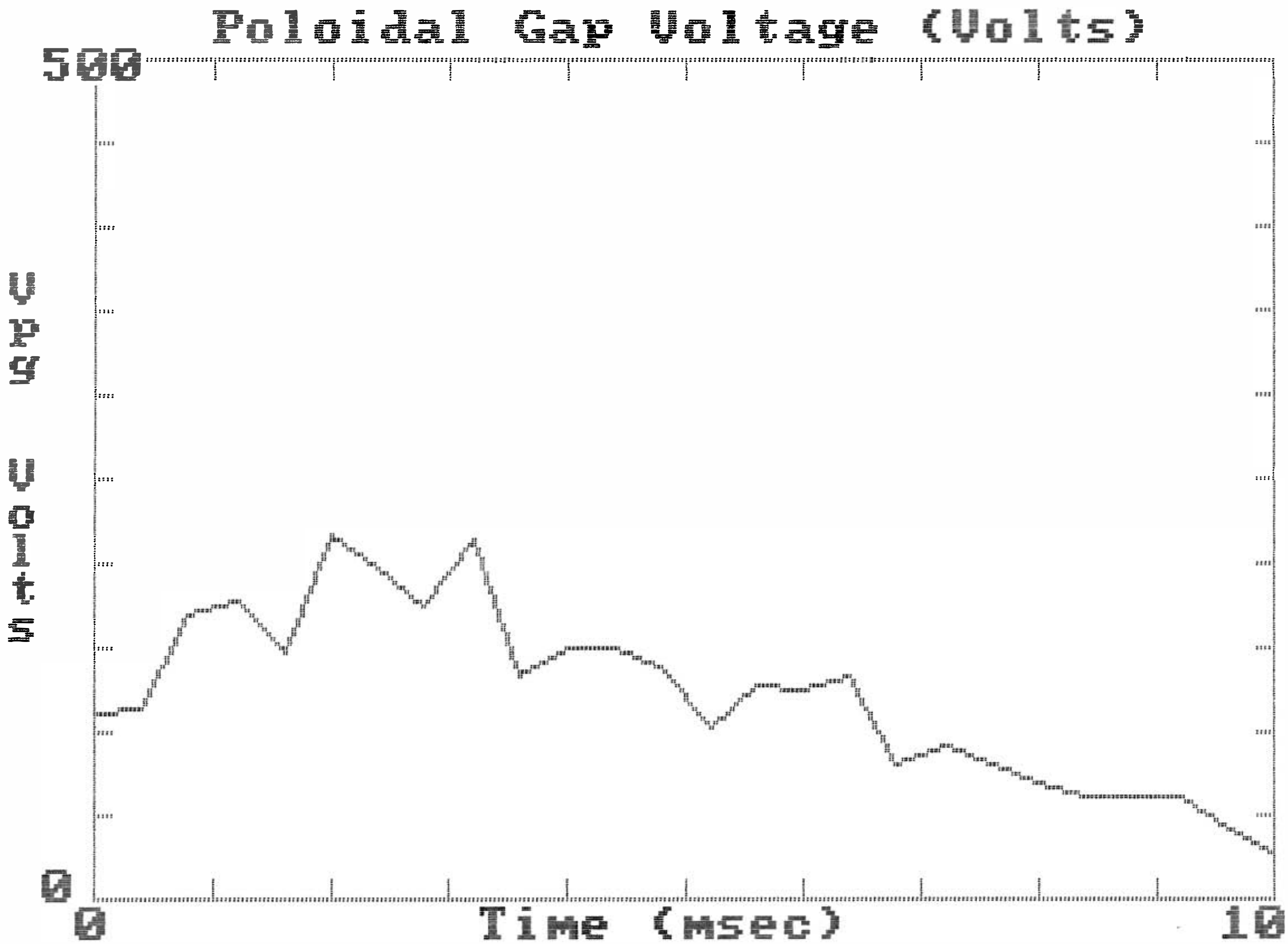
6) Numerical circuit modeling using the experimentally observed F-θ curve and a plasma resistance of $R_p = 65/I_\phi$ at all times produces a remarkably accurate prediction of the plasma electrical waveforms. If the plasma resistivity can be lowered to the ZT-40 value, small improvements in the electrical circuits should allow 500 kA/20 msec RFP discharges.

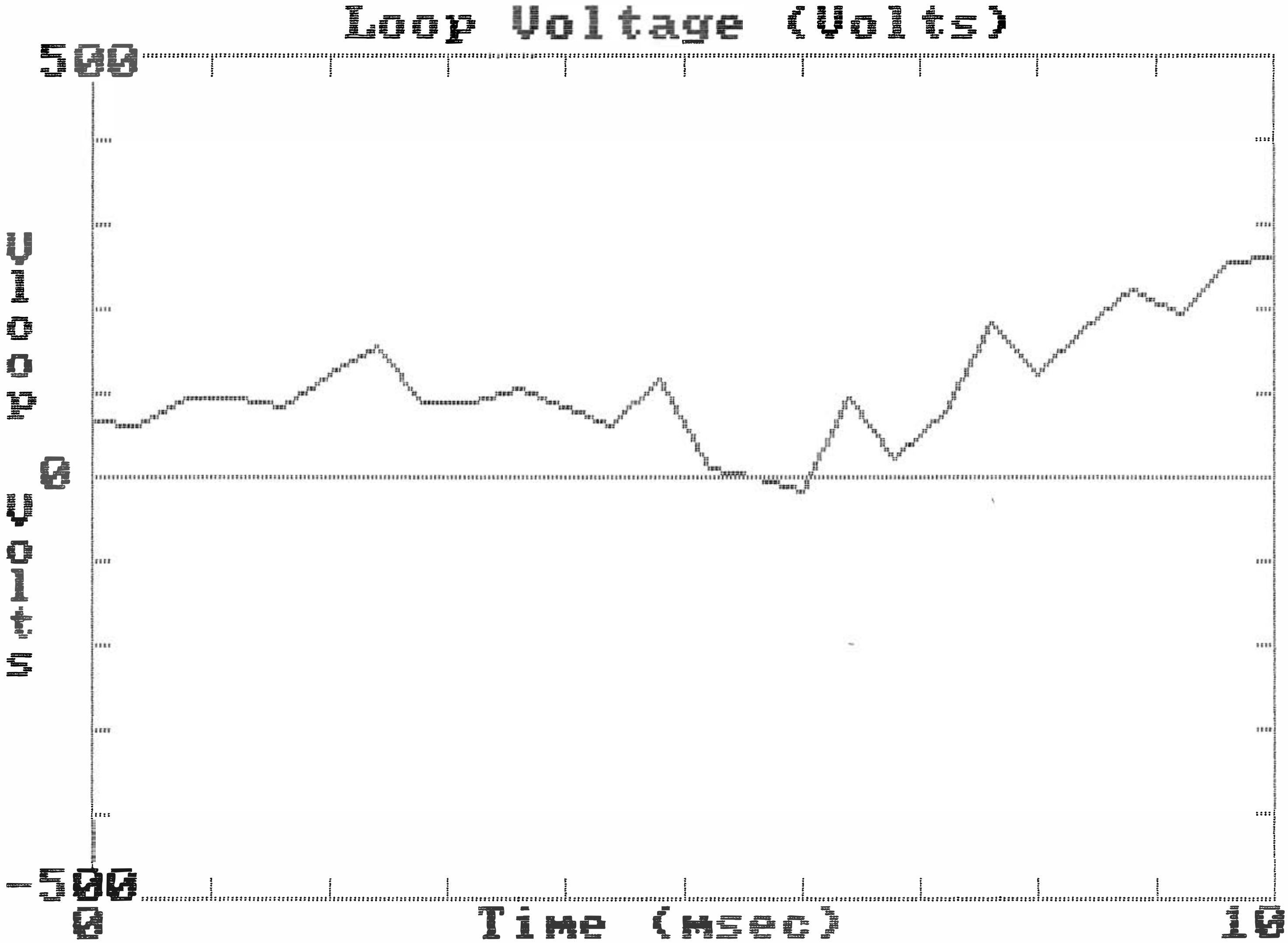
7) Temperature and density (and hence confinement time) have not yet been measured. The conductivity temperature never exceeds 20 eV, but shows improvement with surface cleanliness. Density is apparently low as evidenced by the optimum H_2 fill pressure of ~0.1 millitorr. The ability to start up at low pressure is greatly enhanced by the use of ~50 watts of 2450 MHz ECRH preionization.

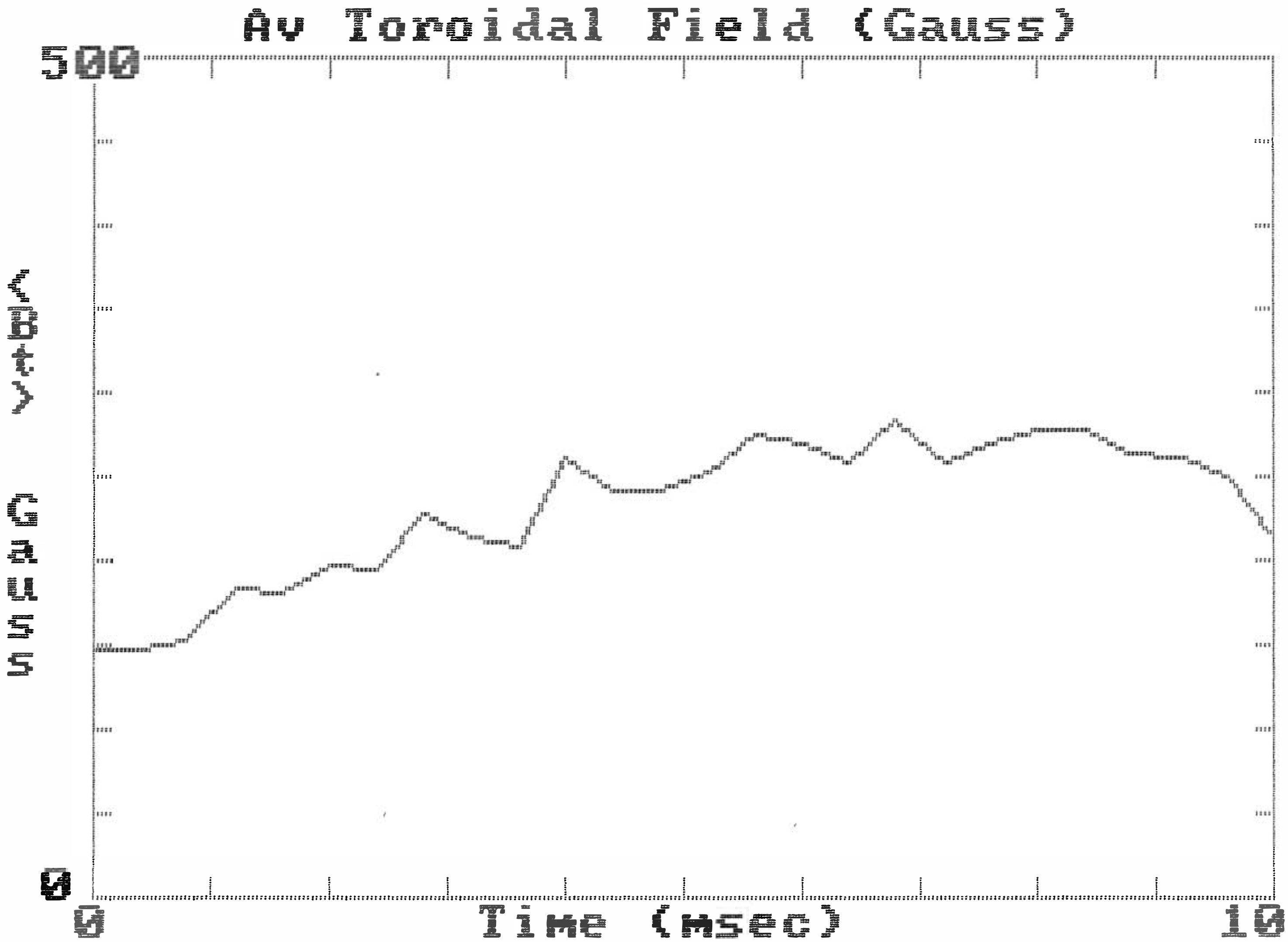


TOK II
1983
1984
LEVITATED OCTUPOLE
1985
1986
.52m
.32m
1987
MST
1.5m

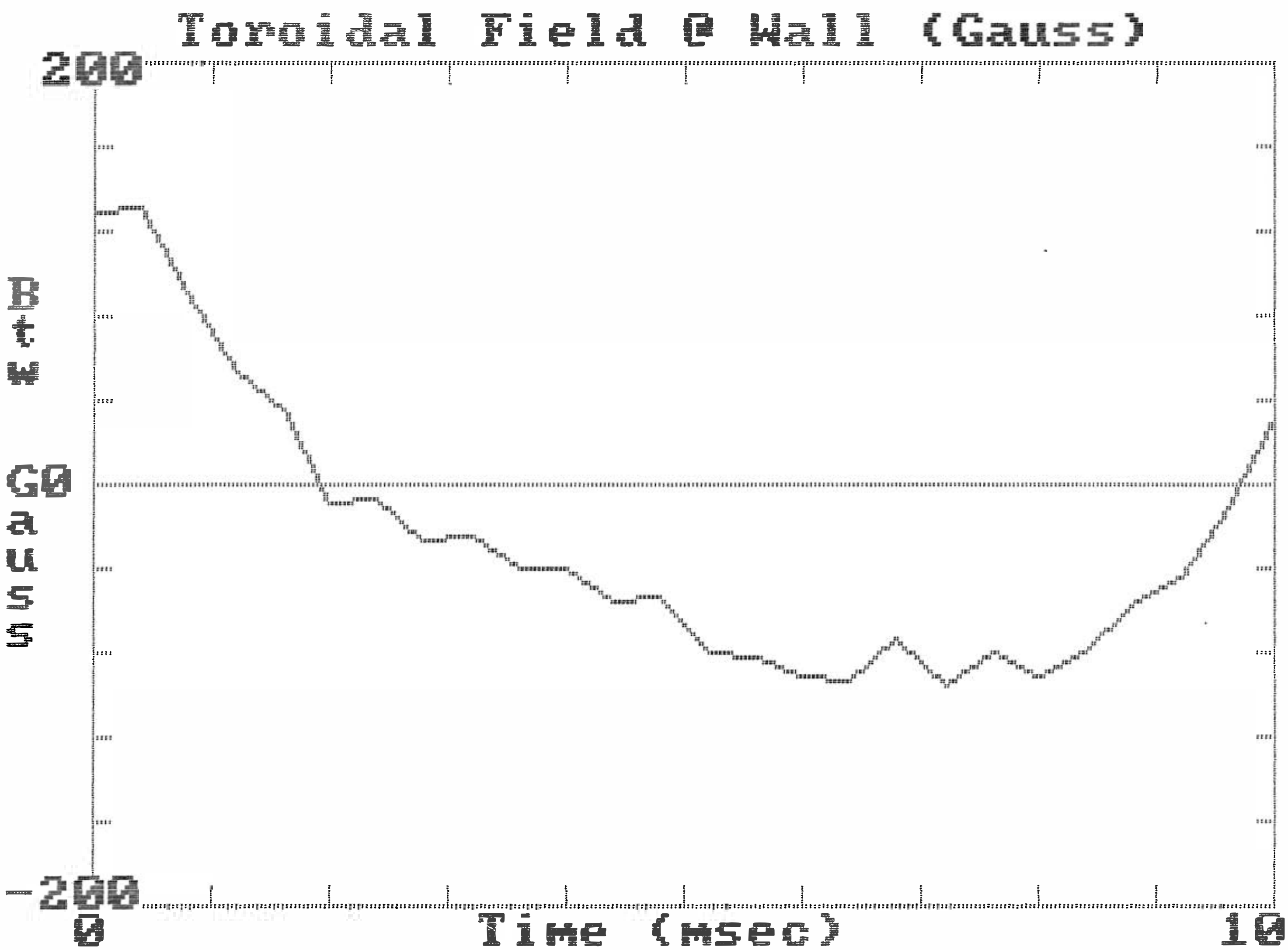

Plasma Current (kA)
500
Ip kA
0
0
Time (msec)
10


Poloidal Gap Voltage (Volts)
500
Vpg Volts
0
0
Time (msec)
10


Loop Voltage (Volts)
500
0
-500
Vloop
Volts
0
Time (msec)
10



Av Toroidal Field (Gauss)
500
0
<Bt> Gauss
0
Time (msec)
10


Toroidal Field @ Wall (Gauss)
200
Btw
G0
auss
-200
0
Time (msec)
10

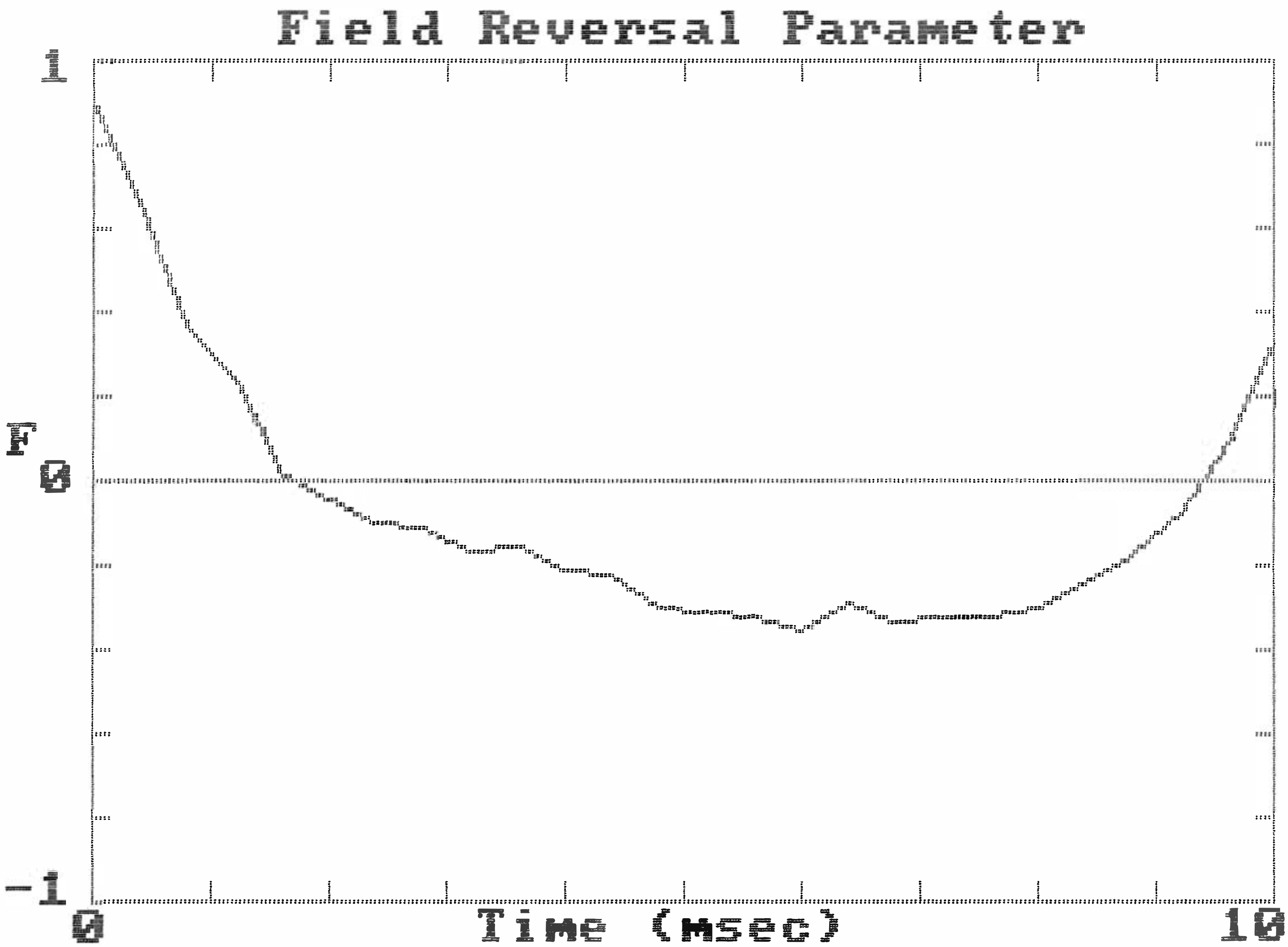
$$F = \frac{B_{TW}}{\langle B_T \rangle}$$

where $\langle B_T \rangle = \frac{\Phi_T}{A}$

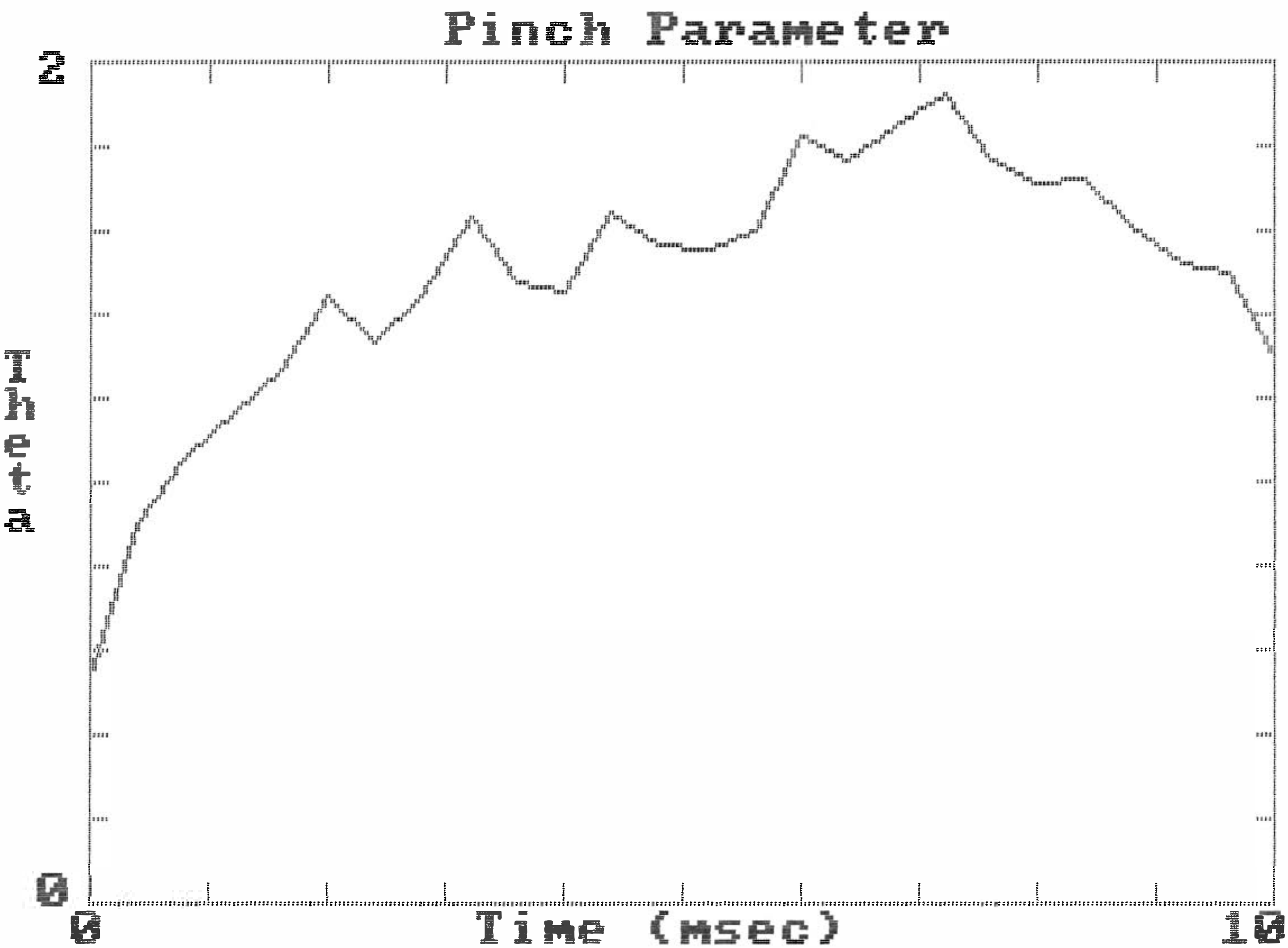
$$\Theta = \frac{\mu_0 I_p}{\ell \langle B_T \rangle}$$

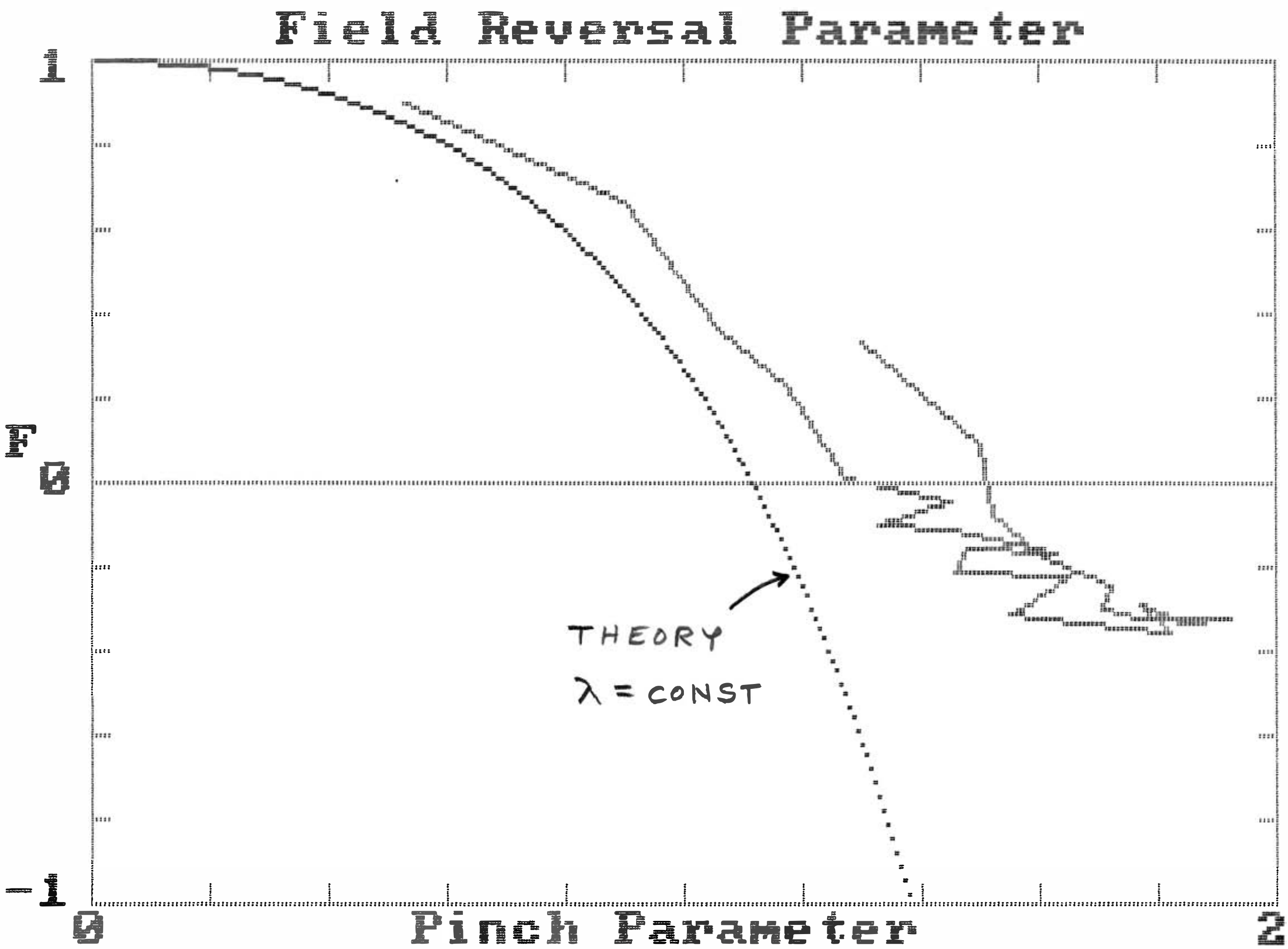
where $\ell = \oint d\ell$ at edge

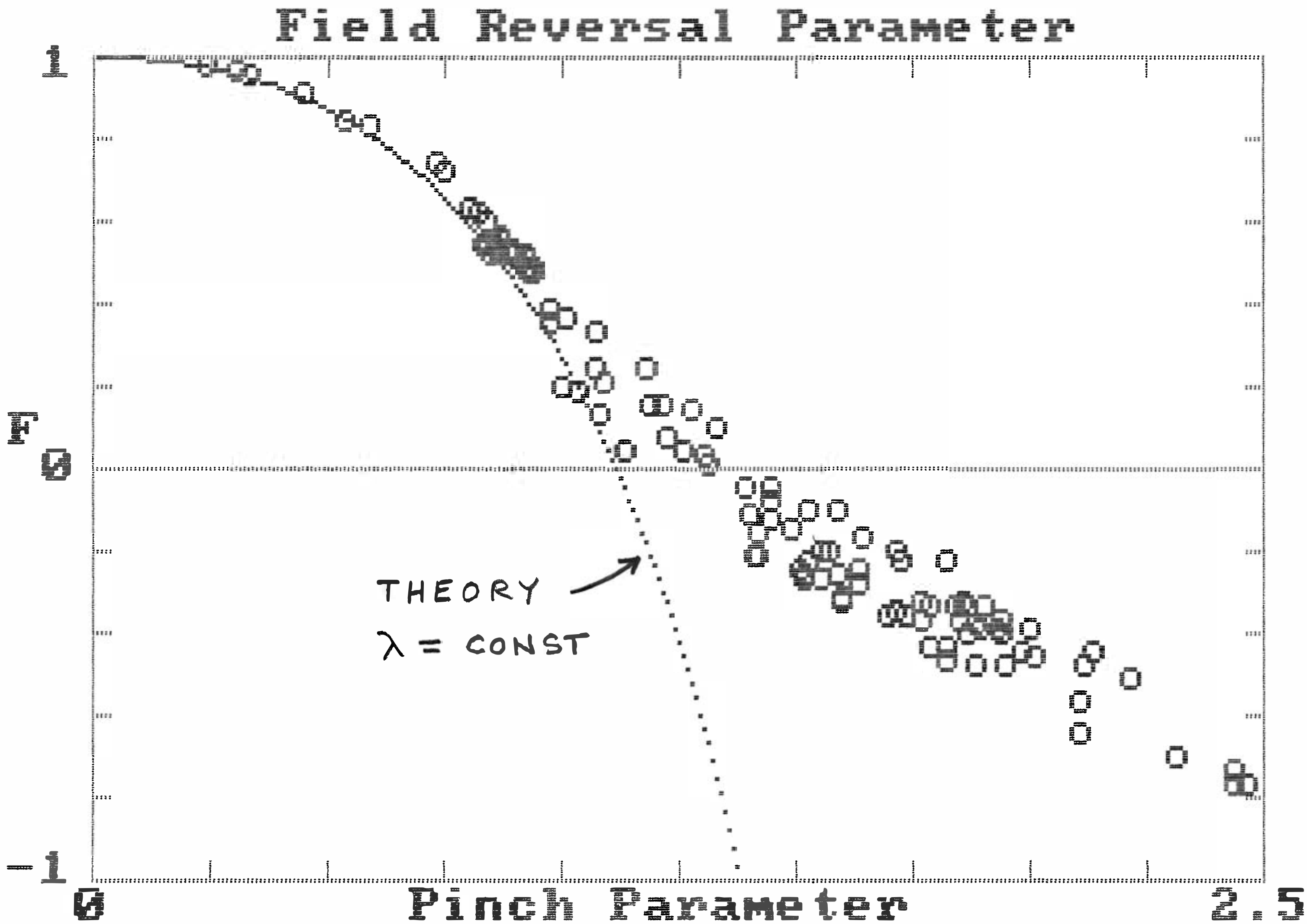
$$q\Theta \cong \frac{a}{R_0}$$

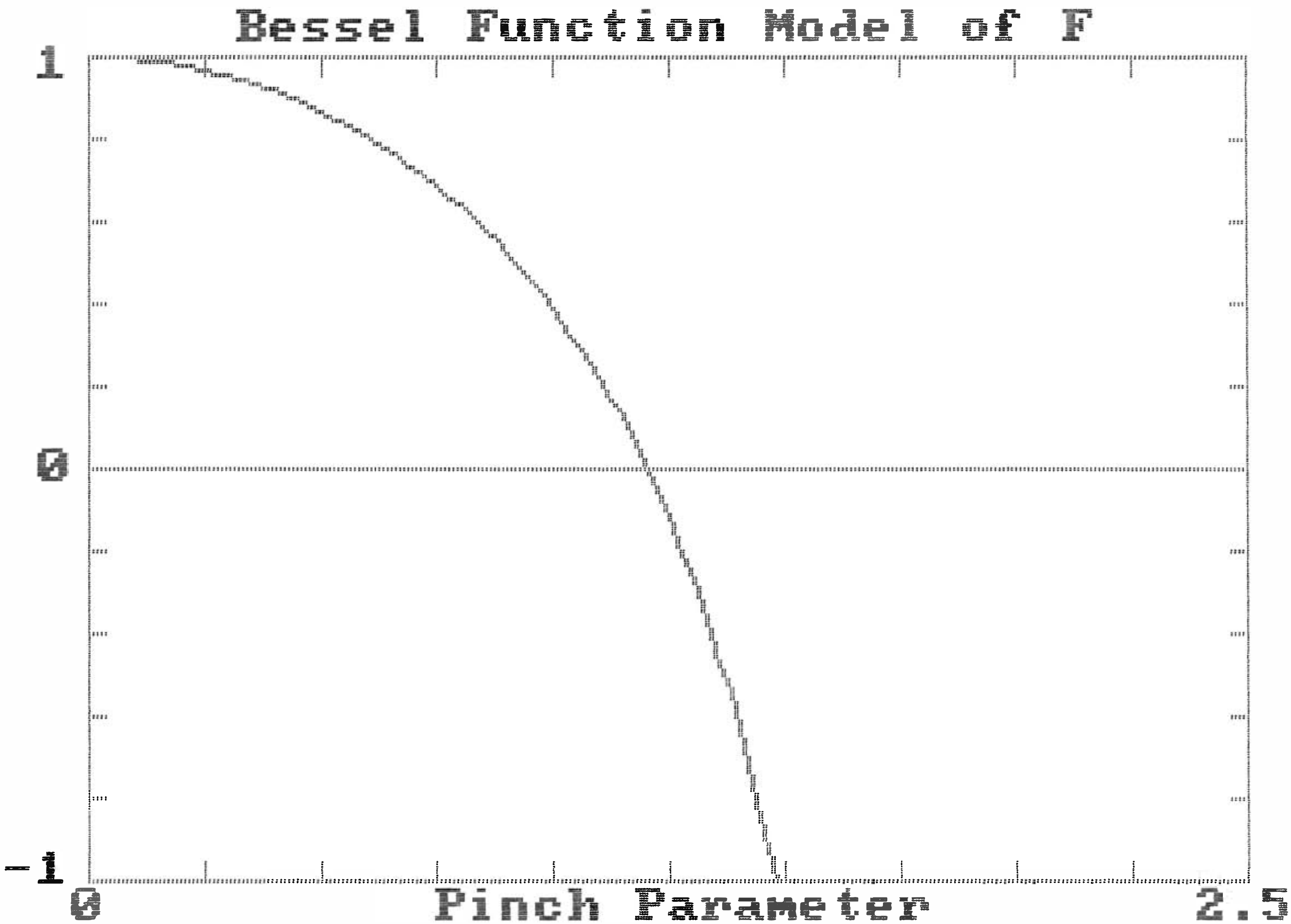


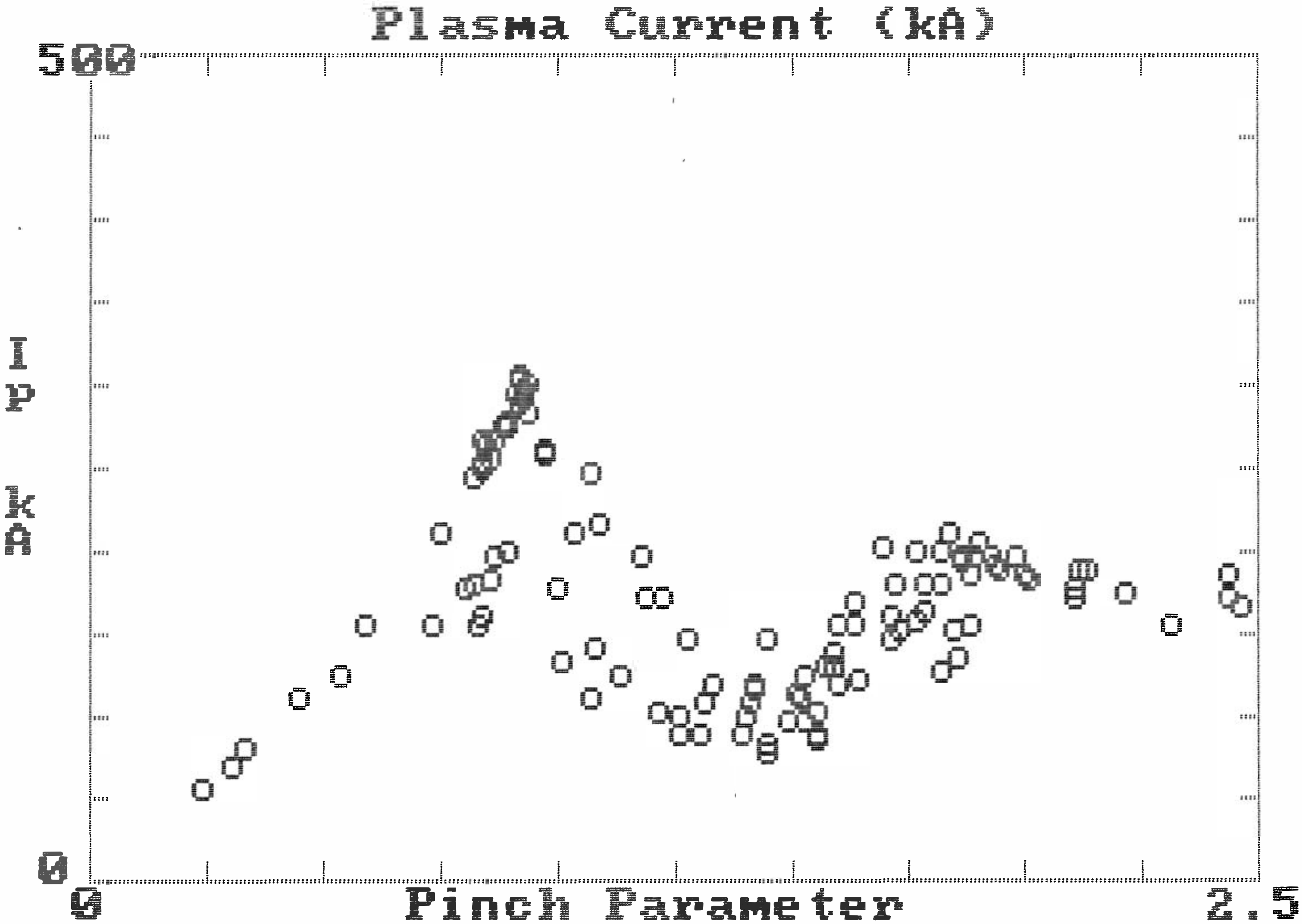
Field Reversal Parameter
1
F
0
-1
0
Time (msec)
10

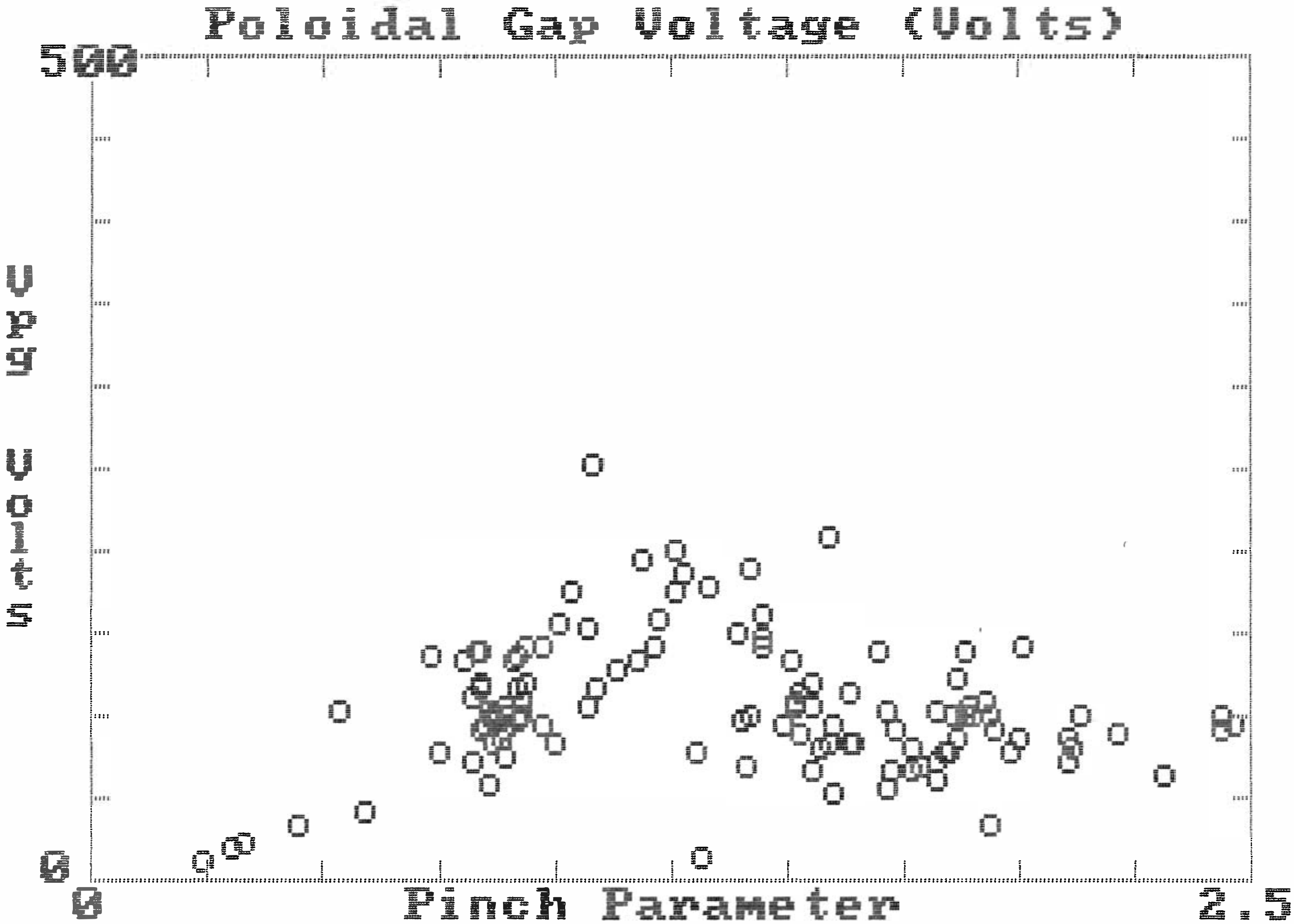

Pinch Parameter
2
Theta
0
0
Time (msec)
10

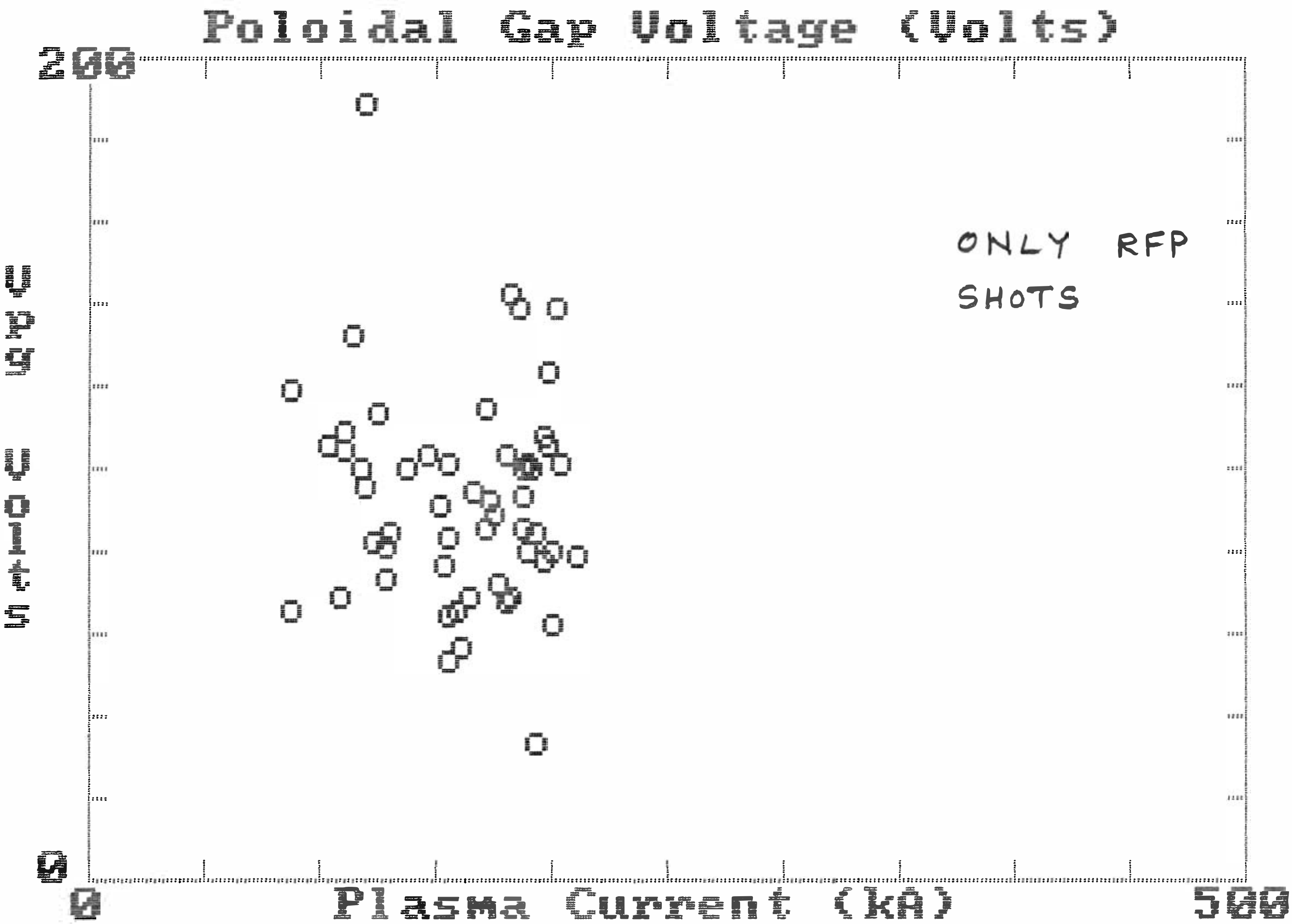

Field Reversal Parameter
1
F
0
-1
0
Pinch Parameter
2
THEORY
λ = CONST

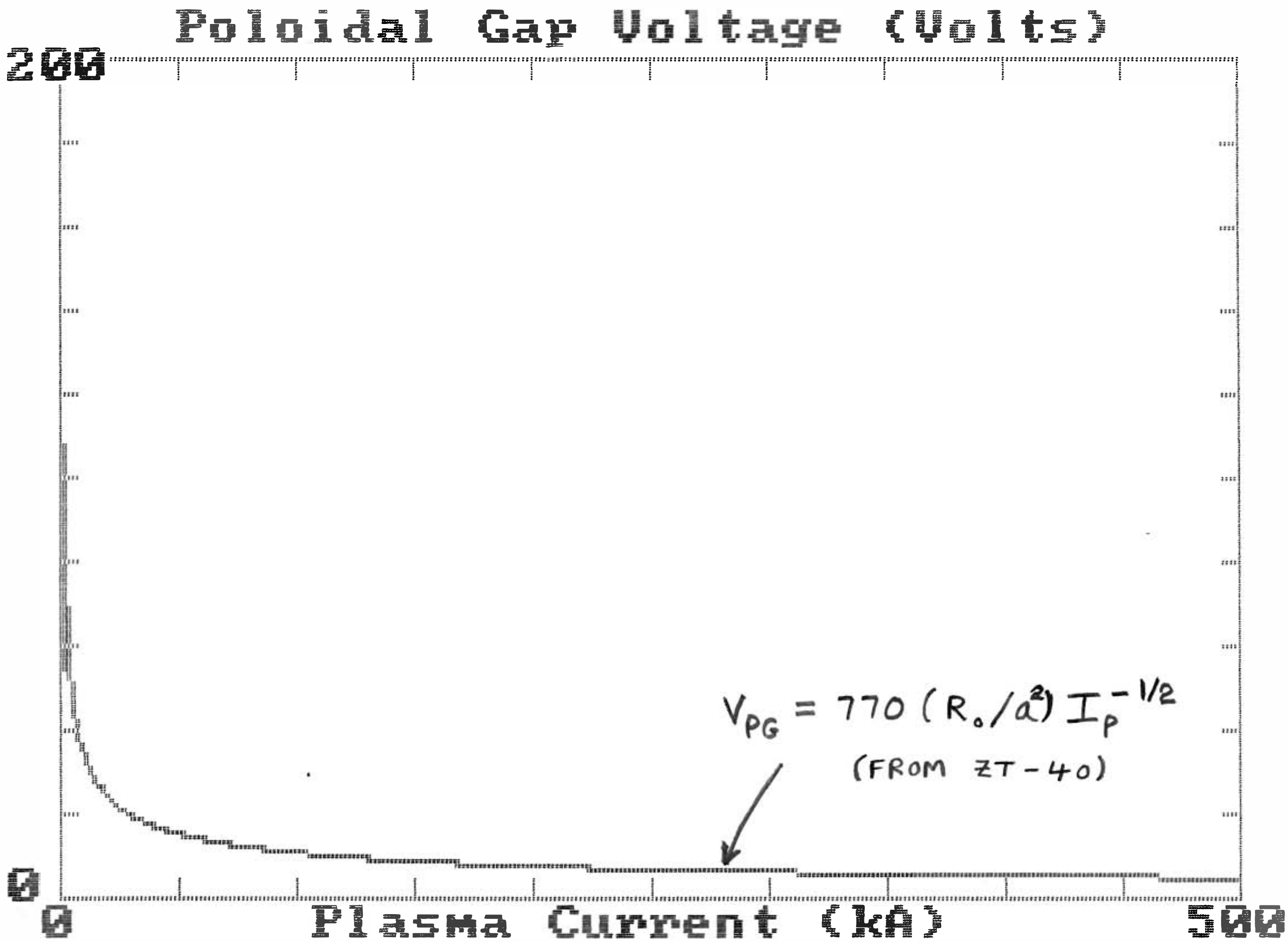

Field Reversal Parameter
1
F
Ø
-1
Ø
Pinch Parameter
2.5
THEORY
λ = CONST

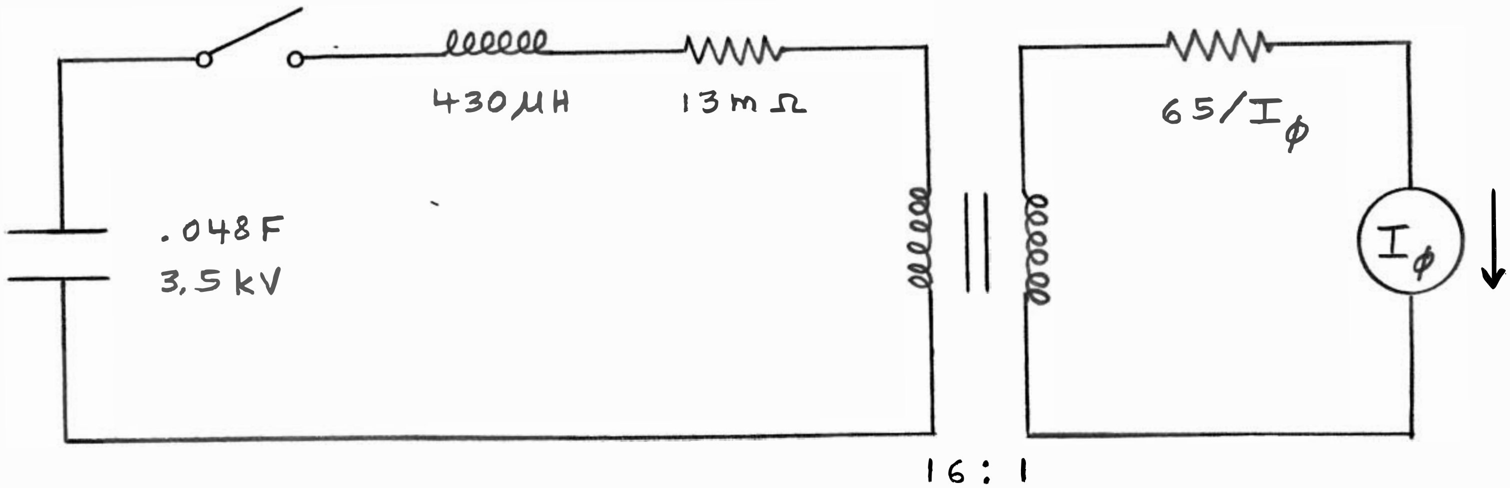

Bessel Function Model of F
1
0
-1
0
Pinch Parameter
2.5


Plasma Current (kA)
500
Ip
kA
0
0
Pinch Parameter
2.5

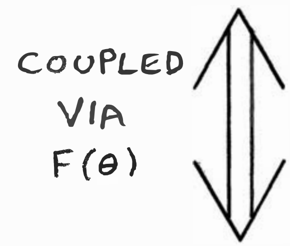

Poloidal Gap Voltage (Volts)
500
Vpg
Volts
0
0
Pinch Parameter
2.5

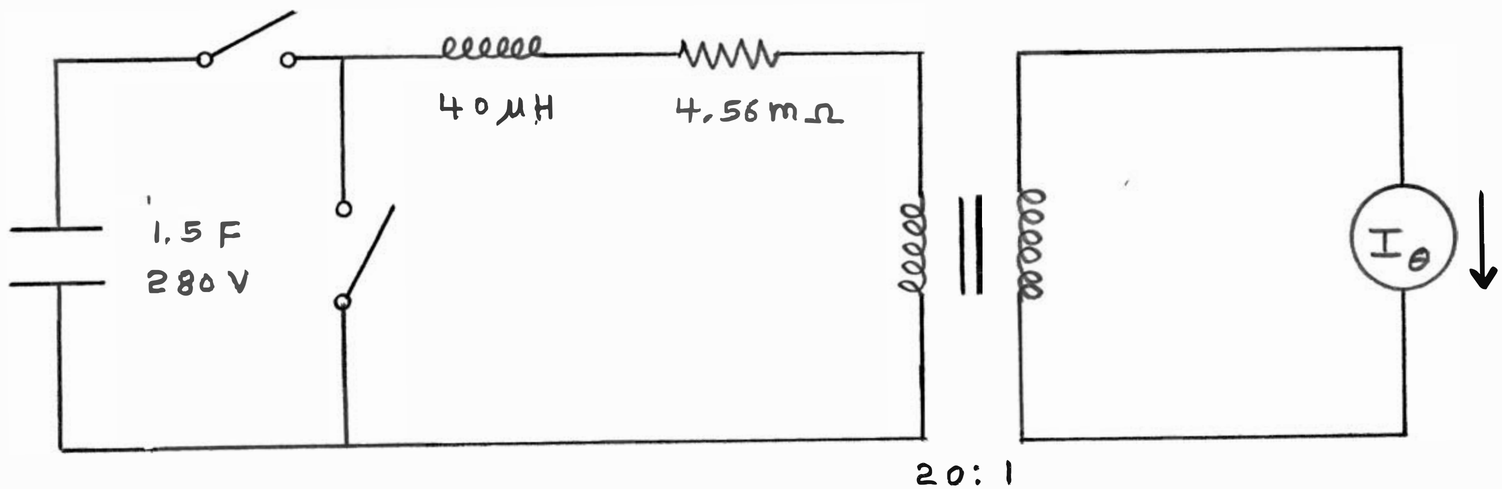

Poloidal Gap Voltage (Volts)
200
0
Gap Volts
ONLY RFP SHOTS
0
Plasma Current (kA)
500


Poloidal Gap Voltage (Volts)
200
0
0
Plasma Current (kA)
500
$V_{PG} = 770\,(R_o/a^2)\,I_p^{-1/2}$
(FROM ZT-40)

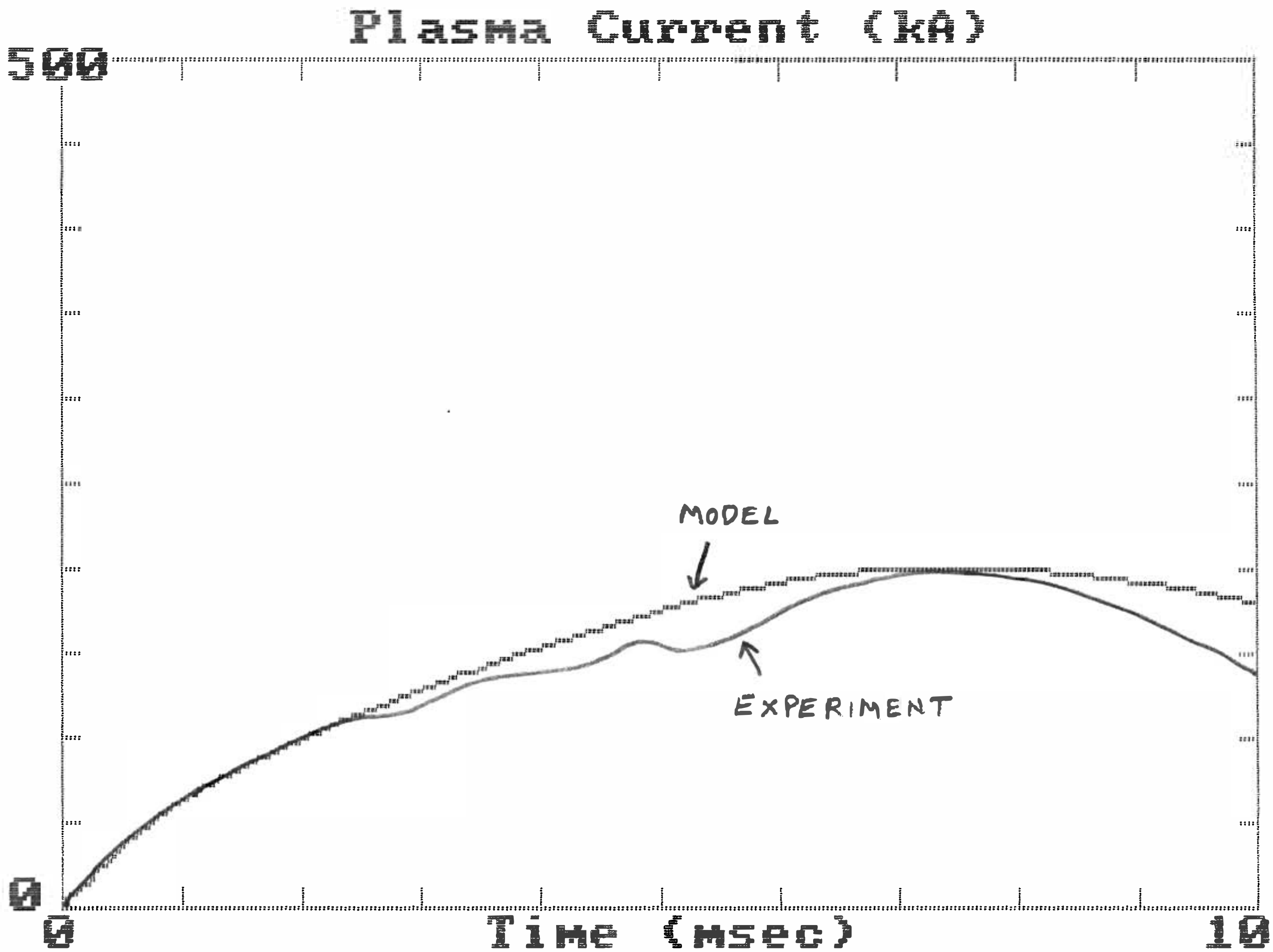


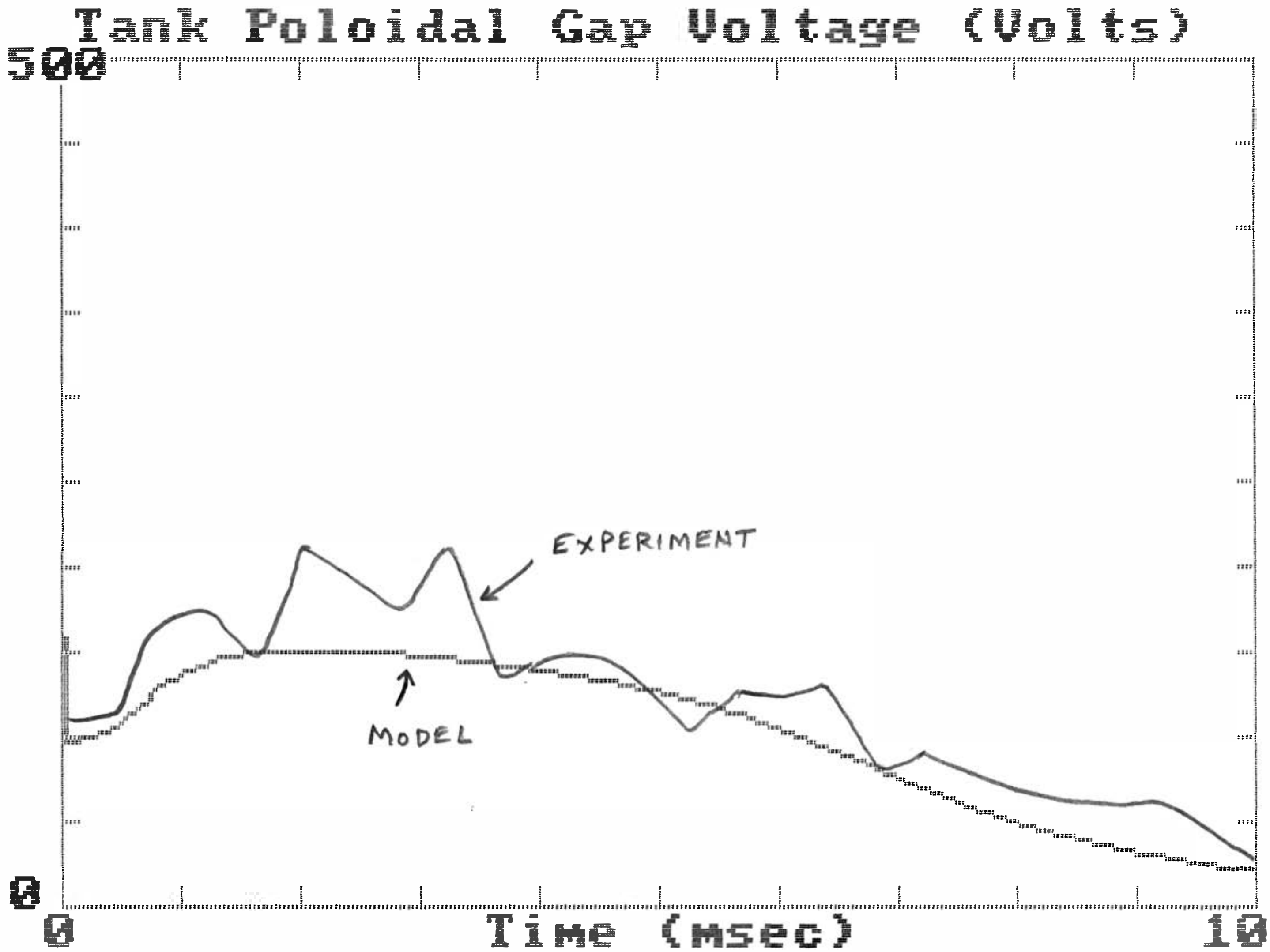
POLOIDAL FIELD CIRCUIT

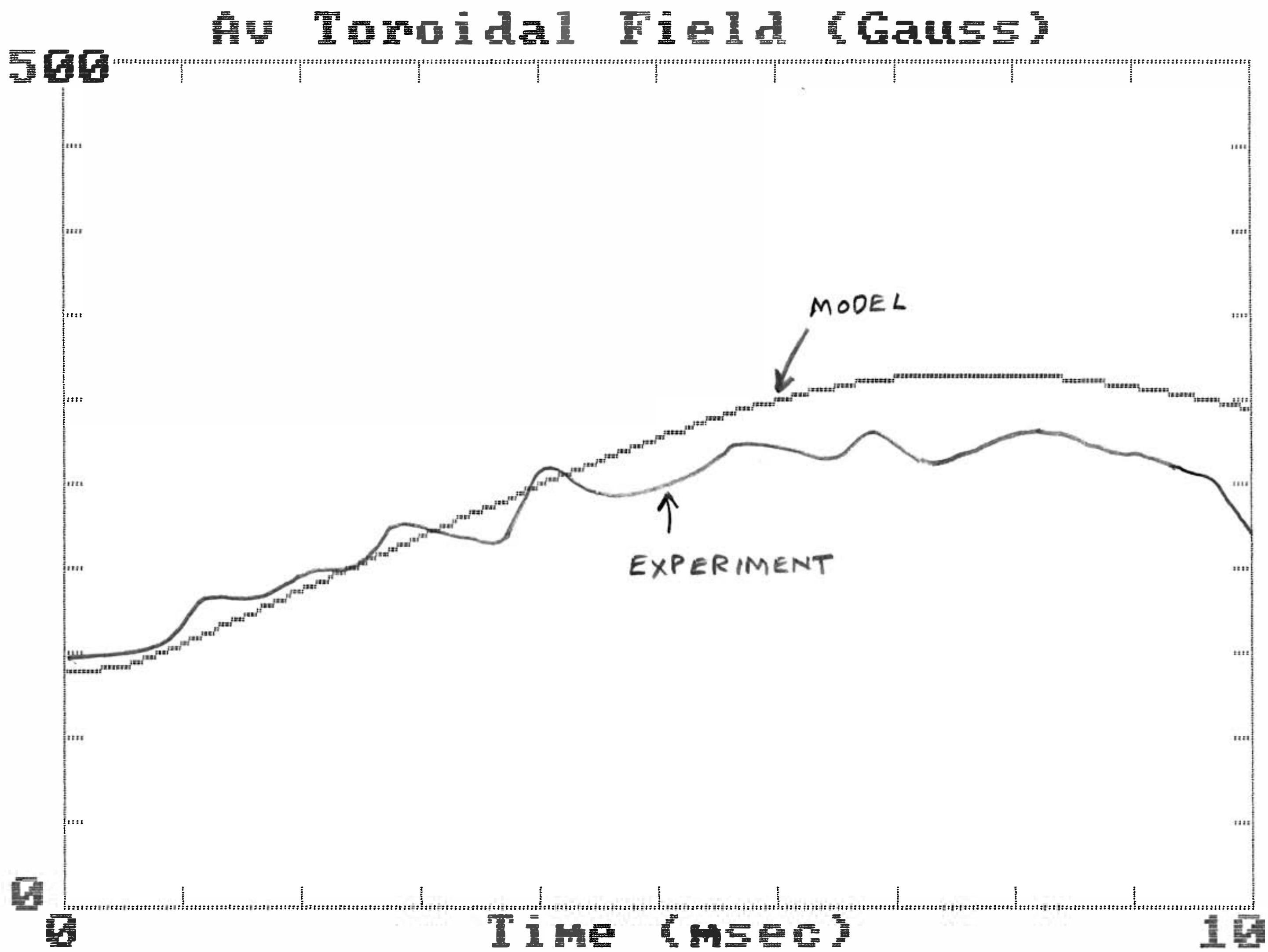




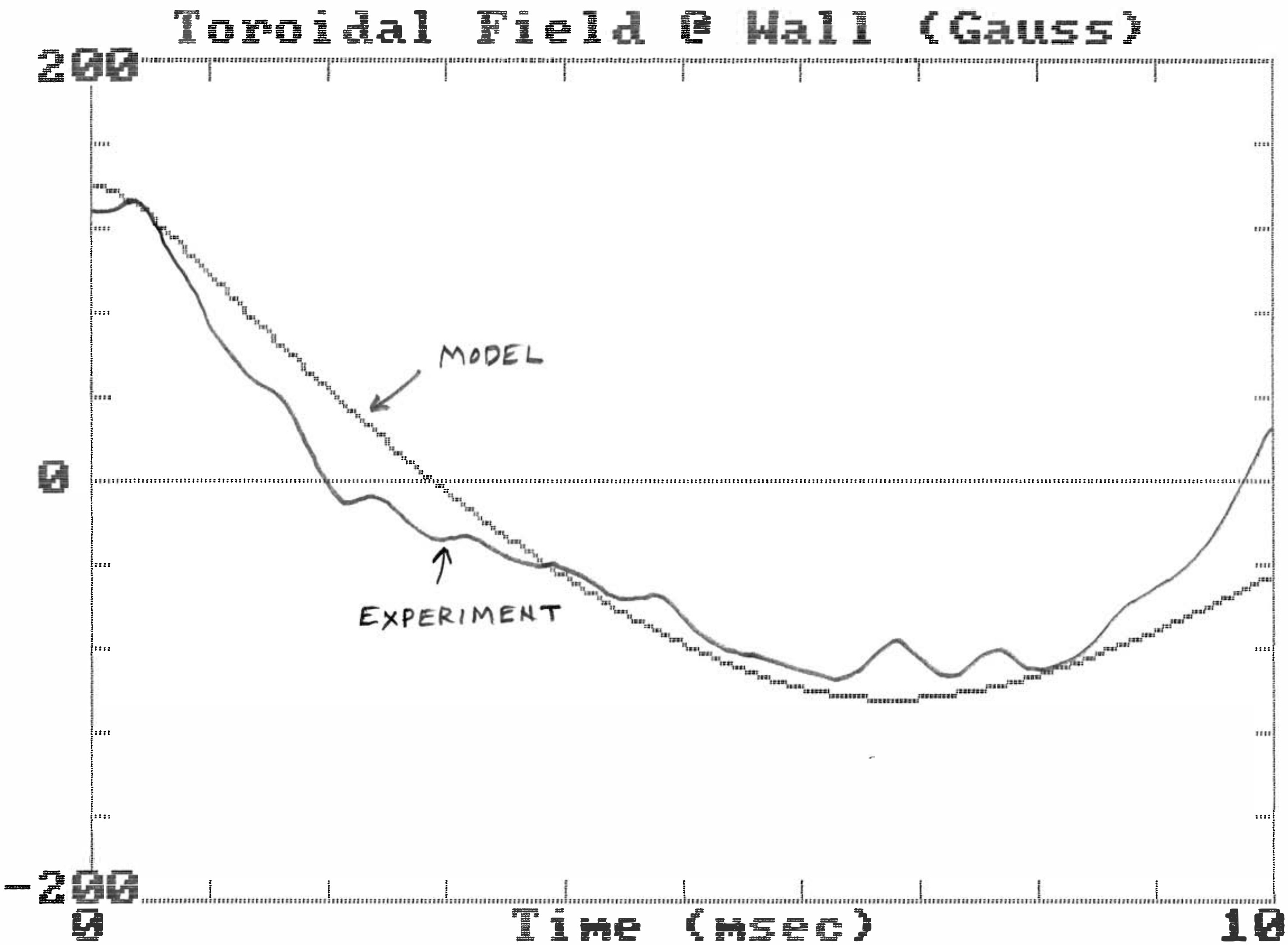
TOROIDAL FIELD CIRCUIT

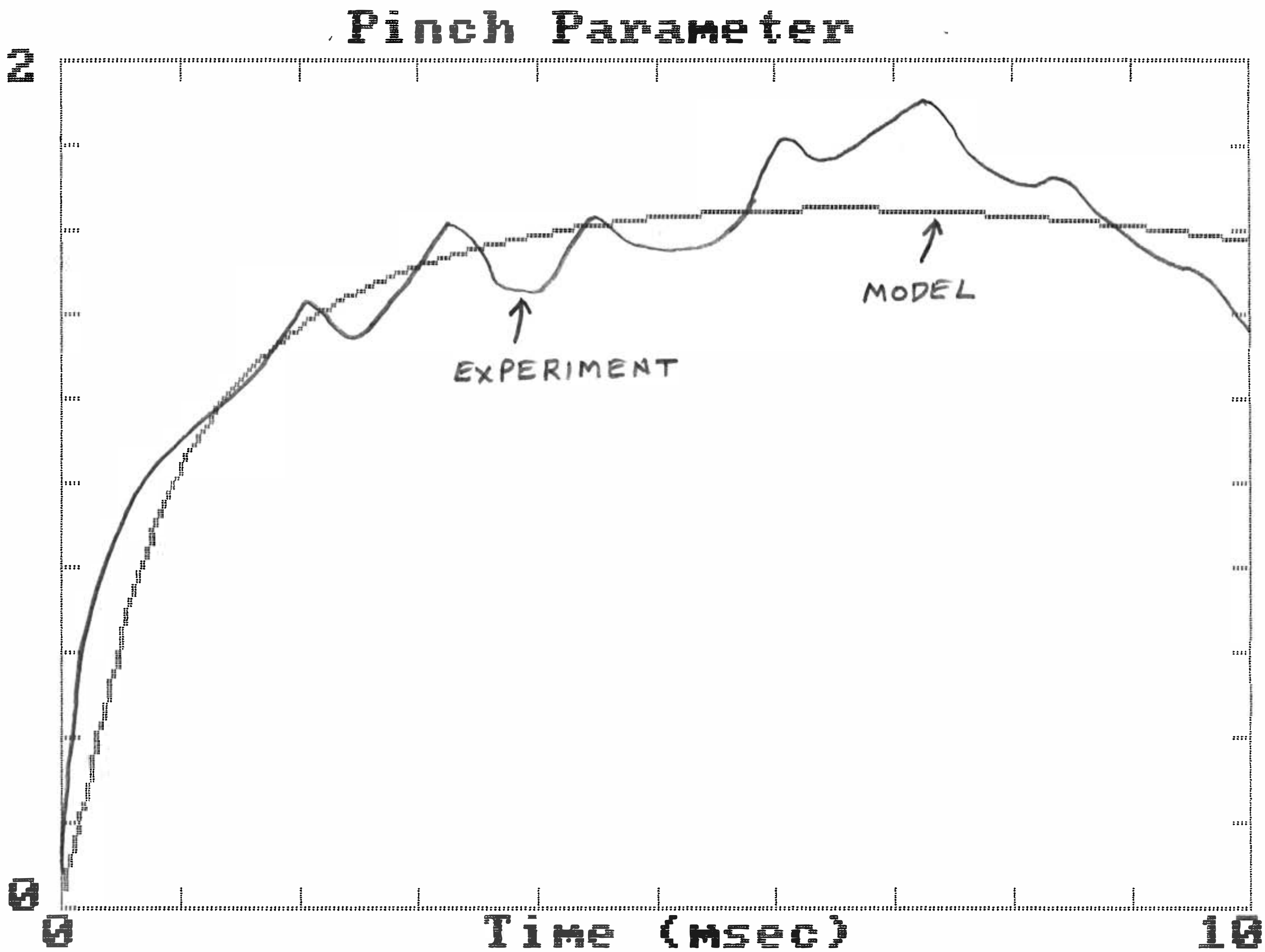

Plasma Current (kA)
500
0
MODEL
EXPERIMENT
0
Time (msec)
10

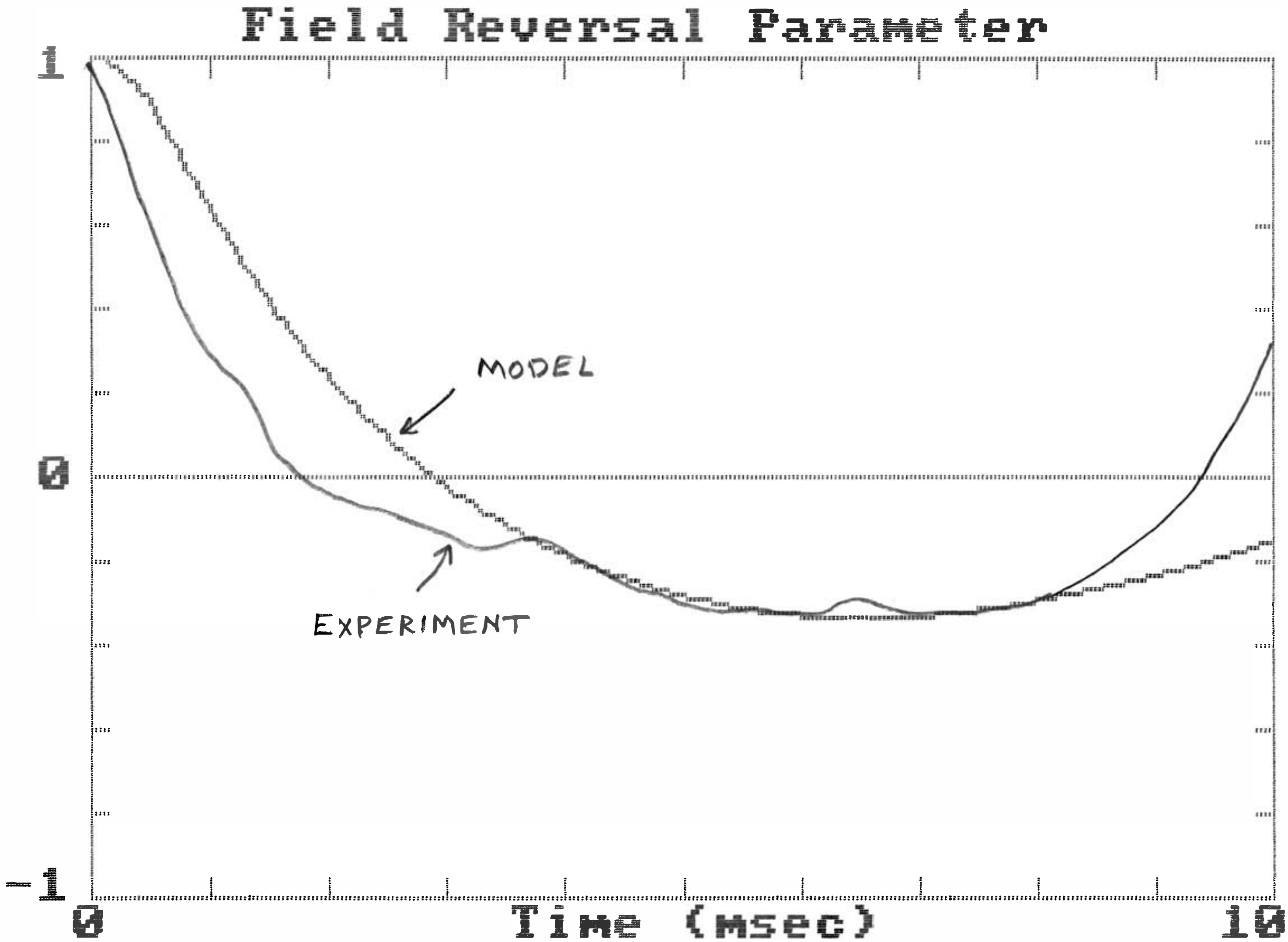

Tank Poloidal Gap Voltage (Volts)
500
0
0
Time (msec)
10
EXPERIMENT
MODEL



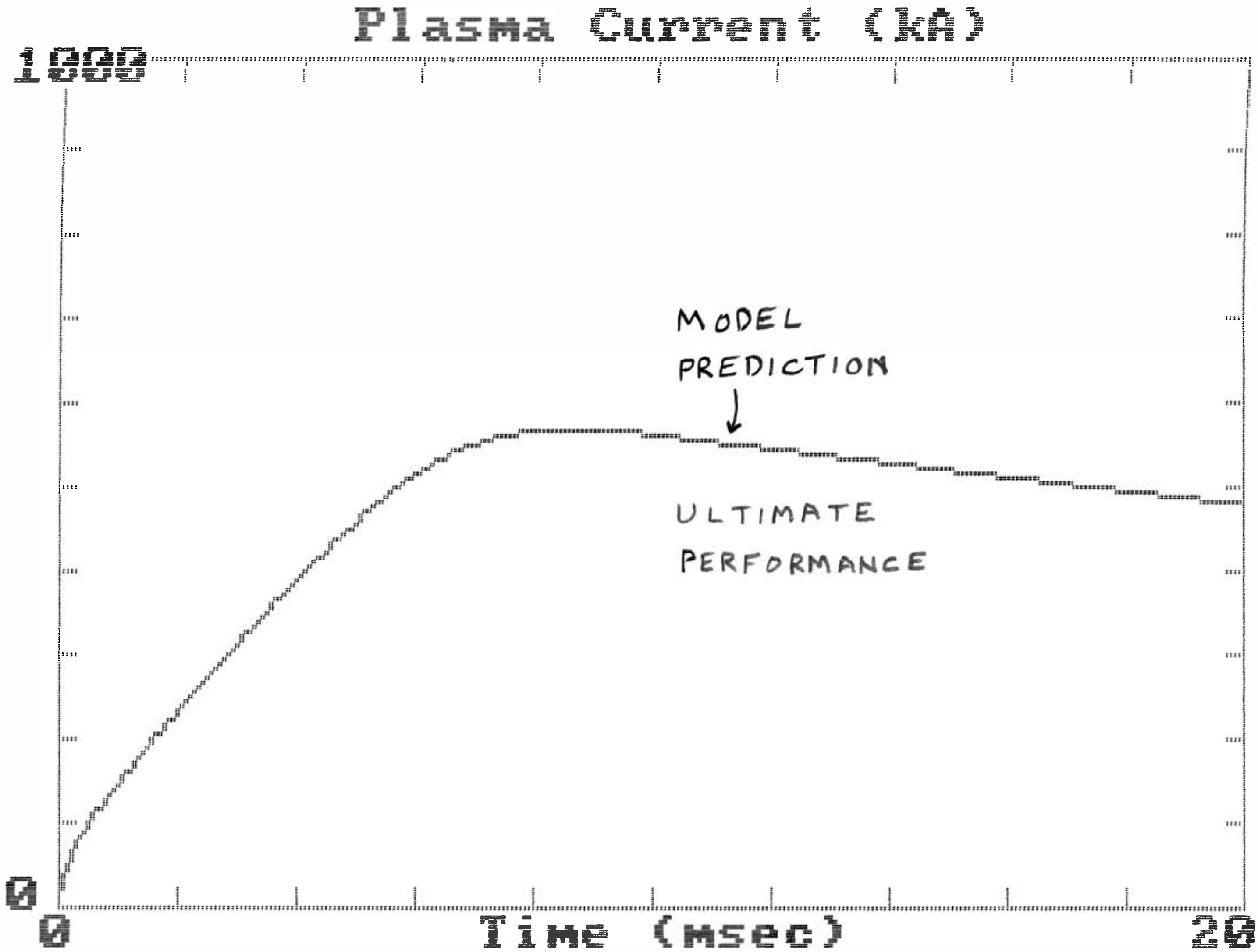
Av Toroidal Field (Gauss)
500
0
MODEL
EXPERIMENT
0
Time (msec)
10


Toroidal Field @ Wall (Gauss)
200
0
-200
0
Time (msec)
10
MODEL
EXPERIMENT


Pinch Parameter
2
0
0
Time (msec)
10
EXPERIMENT
MODEL



Field Reversal Parameter
1
0
-1
0
Time (msec)
10
MODEL
EXPERIMENT


Plasma Current (kA)
1000
0
0
Time (msec)
20
MODEL
PREDICTION
ULTIMATE
PERFORMANCE