

# データ集

## 付 録 A 衝撃力センサの検定時の出力波形

第 I 部にて説明した 3 種の衝撃力センサの、検定時の出力波形である。検定に関する詳細は第 4 章にて説明している。

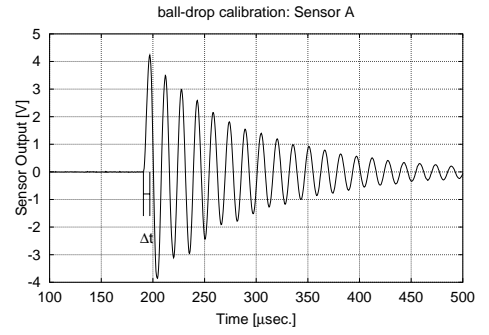
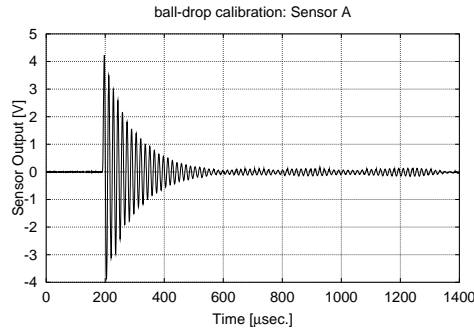
それぞれの波形は、計測された過渡電圧そのものである。最大電圧  $E_{\max}$  は、第 4 章で説明している手順で雑音除去した後の値を示しているので、グラフの最大値とは微妙に異なる。

鋼球の質量	落下高さ	センサ A	センサ B	センサ C
0.130 g	30 mm	Fig. A.1	Fig. A.5	Fig. A.7
	80 mm	—	—	Fig. A.8
0.440 g	30 mm	Fig. A.2	Fig. A.6	Fig. A.9
	80 mm	Fig. A.3	—	Fig. A.10
	150 mm	Fig. A.4	—	—
2.030 g	30 mm	—	—	Fig. A.11
	80 mm	—	—	Fig. A.12

$$E_{\max} = 4.2352 \text{ V}$$

$$\Delta t = 6.20 \text{ } \mu\text{sec.}$$

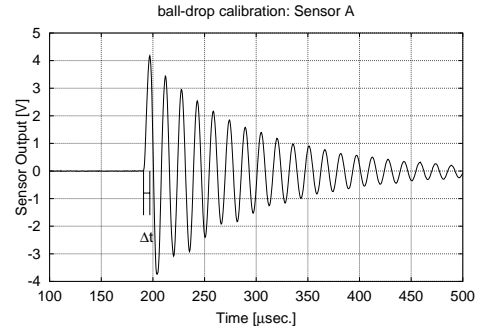
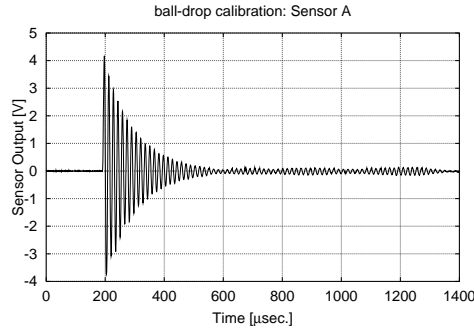
$$F = 29.0683 \text{ N}$$



$$E_{\max} = 4.1710 \text{ V}$$

$$\Delta t = 6.05 \text{ } \mu\text{sec.}$$

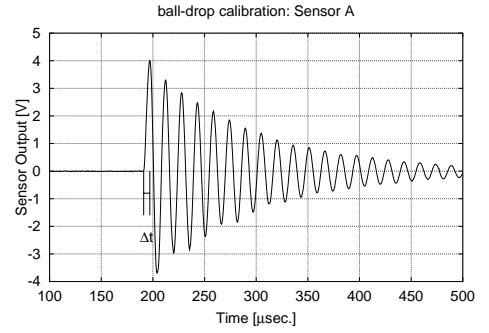
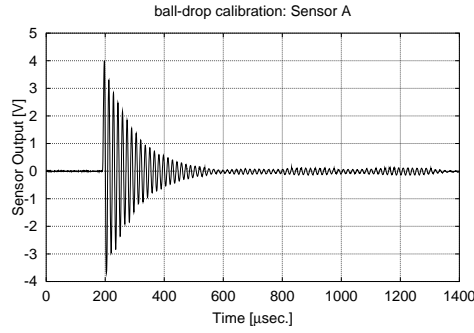
$$F = 29.7890 \text{ N}$$



$$E_{\max} = 4.0059 \text{ V}$$

$$\Delta t = 5.95 \text{ } \mu\text{sec.}$$

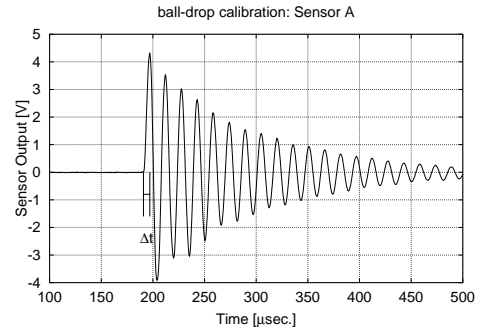
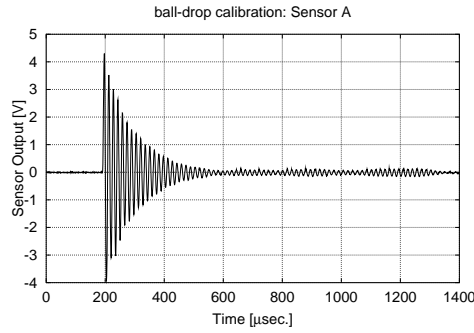
$$F = 30.2897 \text{ N}$$



$$E_{\max} = 4.3113 \text{ V}$$

$$\Delta t = 6.10 \text{ } \mu\text{sec.}$$

$$F = 29.5449 \text{ N}$$



$$E_{\max} = 4.1401 \text{ V}$$

$$\Delta t = 6.50 \text{ } \mu\text{sec.}$$

$$F = 27.7267 \text{ N}$$

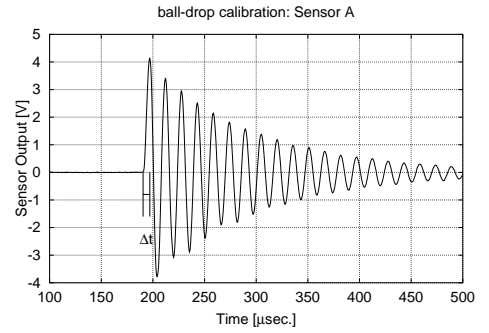
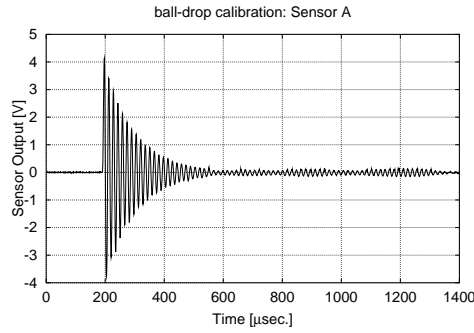
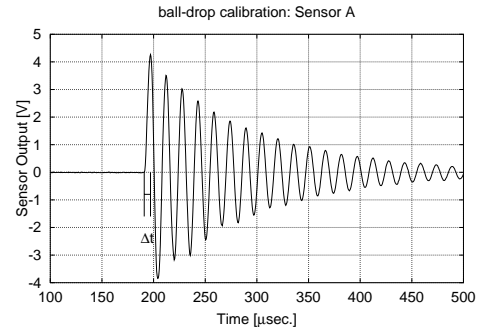
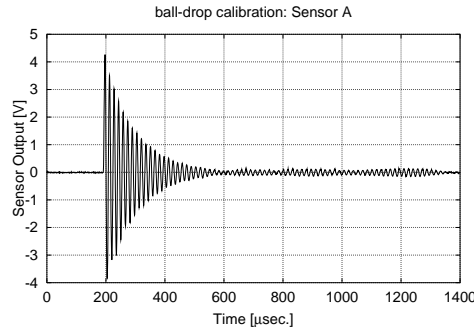


Fig. A.1: Output of Sensor A at ball-drop calibration.  $m = 0.130 \text{ g}$ ,  $h = 30 \text{ mm}$

$$E_{\max} = 4.2776 \text{ V}$$

$$\Delta t = 6.05 \mu\text{sec.}$$

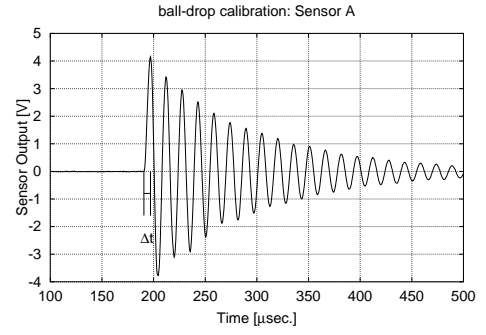
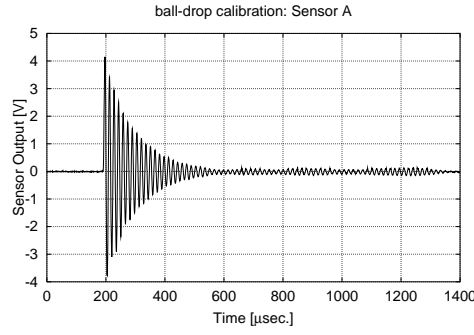
$$F = 29.7890 \text{ N}$$



$$E_{\max} = 4.1587 \text{ V}$$

$$\Delta t = 6.35 \mu\text{sec.}$$

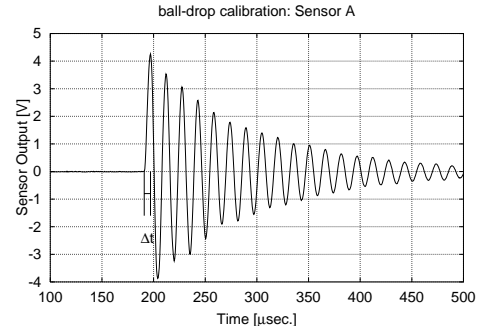
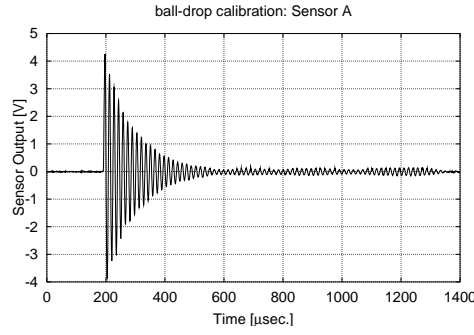
$$F = 28.3817 \text{ N}$$



$$E_{\max} = 4.2730 \text{ V}$$

$$\Delta t = 6.05 \mu\text{sec.}$$

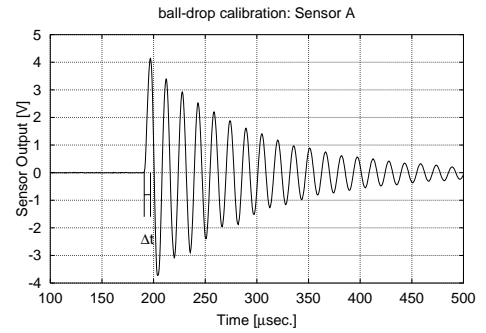
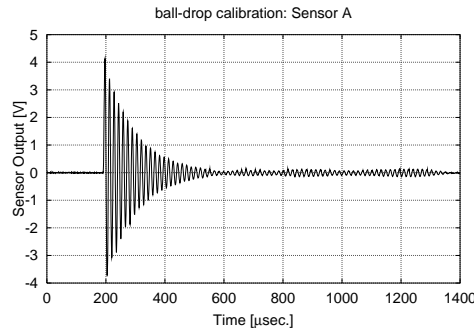
$$F = 29.7890 \text{ N}$$



$$E_{\max} = 4.1483 \text{ V}$$

$$\Delta t = 6.05 \mu\text{sec.}$$

$$F = 29.7890 \text{ N}$$



$$E_{\max} = 4.2433 \text{ V}$$

$$\Delta t = 5.95 \mu\text{sec.}$$

$$F = 30.2897 \text{ N}$$

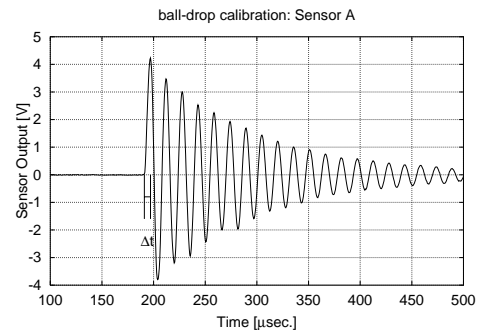
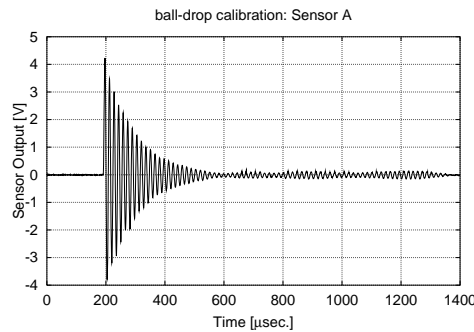
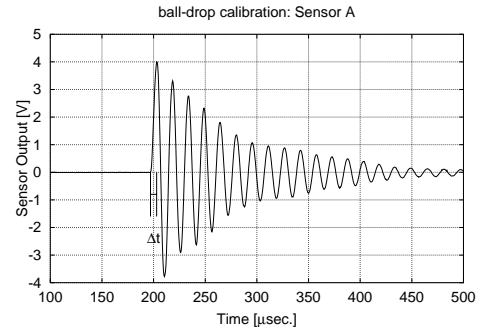
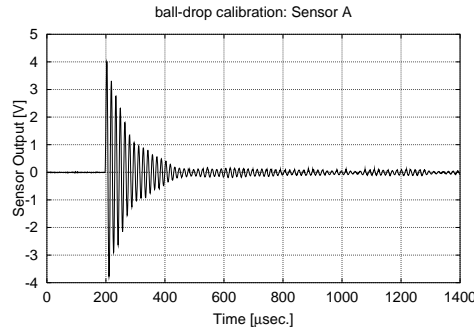


Fig. A.1: (continued)

$$E_{\max} = 4.0167 \text{ V}$$

$$\Delta t = 6.00 \mu\text{sec.}$$

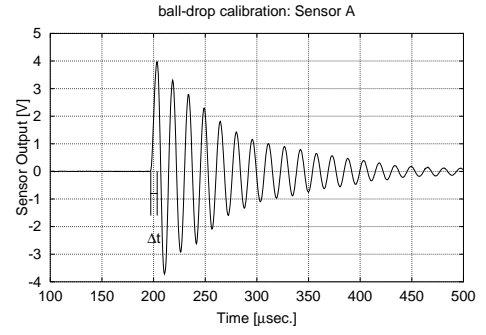
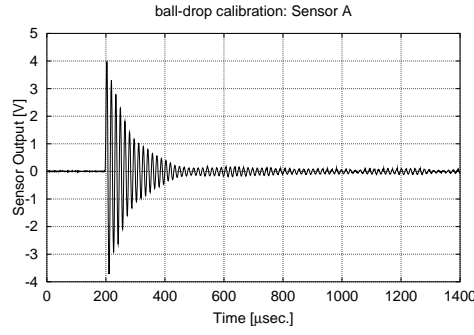
$$F = 30.0373 \text{ N}$$



$$E_{\max} = 3.9813 \text{ V}$$

$$\Delta t = 6.20 \mu\text{sec.}$$

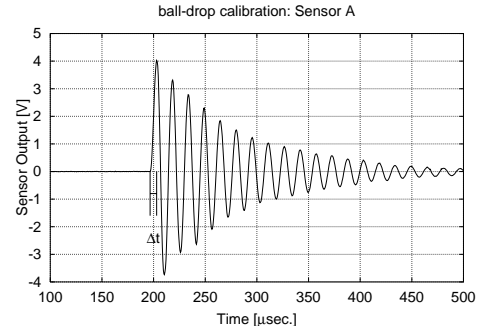
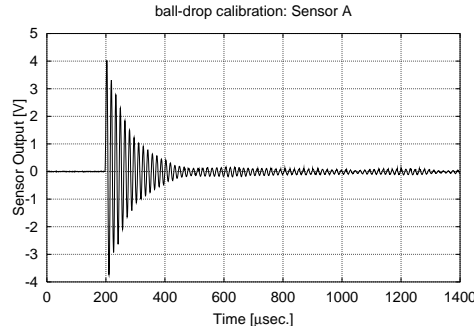
$$F = 29.0683 \text{ N}$$



$$E_{\max} = 4.0334 \text{ V}$$

$$\Delta t = 6.35 \mu\text{sec.}$$

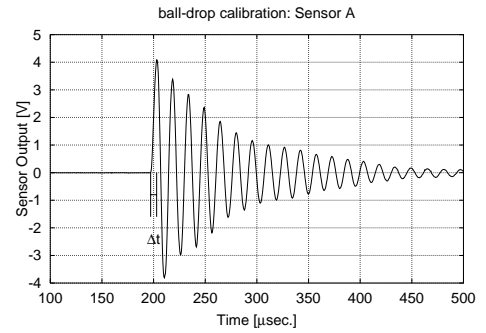
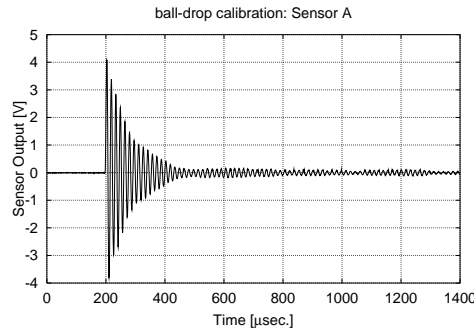
$$F = 28.3817 \text{ N}$$



$$E_{\max} = 4.1089 \text{ V}$$

$$\Delta t = 5.85 \mu\text{sec.}$$

$$F = 30.8075 \text{ N}$$



$$E_{\max} = 3.8148 \text{ V}$$

$$\Delta t = 6.30 \mu\text{sec.}$$

$$F = 28.6069 \text{ N}$$

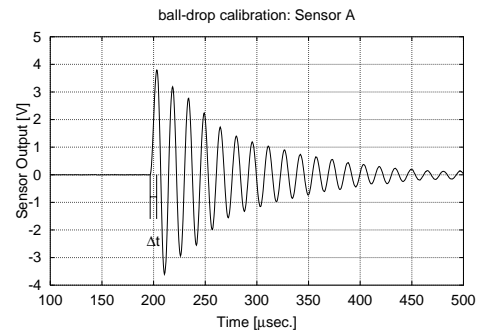
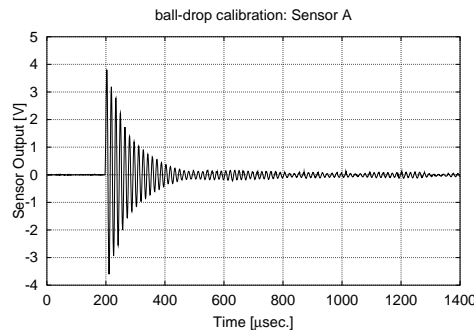
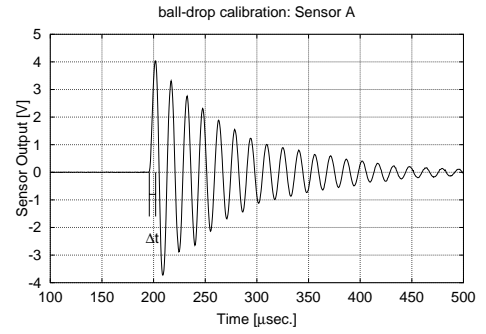
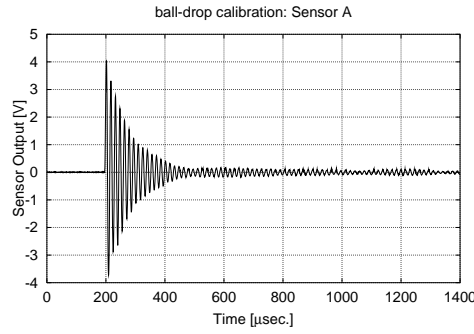


Fig. A.1: (continued)

$$E_{\max} = 4.0592 \text{ V}$$

$$\Delta t = 6.15 \mu\text{sec.}$$

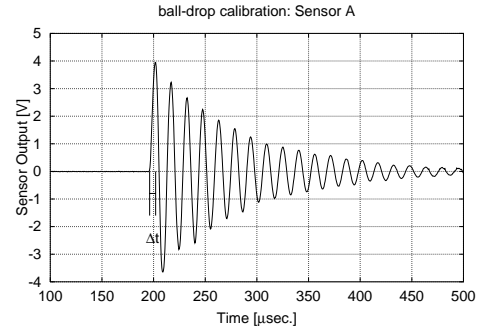
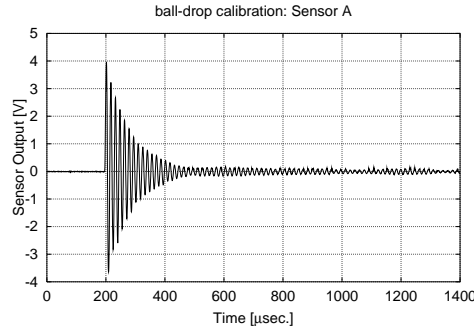
$$F = 29.3046 \text{ N}$$



$$E_{\max} = 3.9790 \text{ V}$$

$$\Delta t = 5.80 \mu\text{sec.}$$

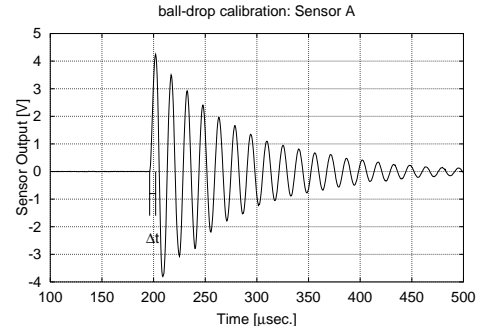
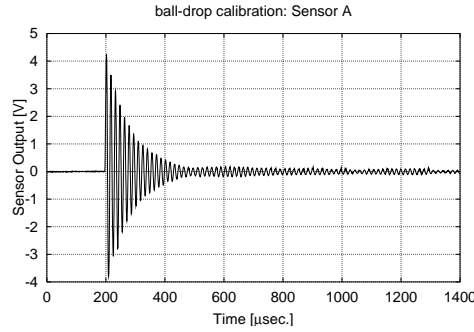
$$F = 31.0730 \text{ N}$$



$$E_{\max} = 4.2536 \text{ V}$$

$$\Delta t = 5.80 \mu\text{sec.}$$

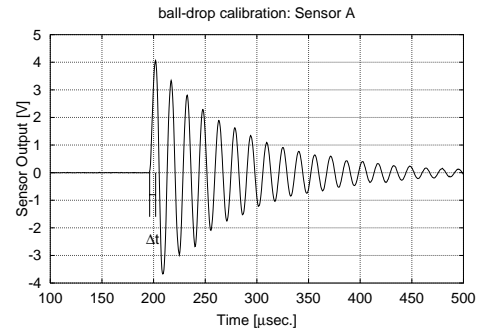
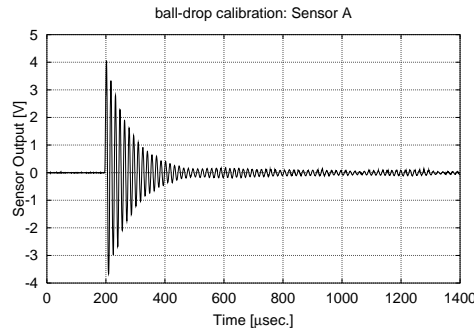
$$F = 31.0730 \text{ N}$$



$$E_{\max} = 4.0610 \text{ V}$$

$$\Delta t = 5.80 \mu\text{sec.}$$

$$F = 31.0730 \text{ N}$$



$$E_{\max} = 3.8368 \text{ V}$$

$$\Delta t = 6.00 \mu\text{sec.}$$

$$F = 30.0373 \text{ N}$$

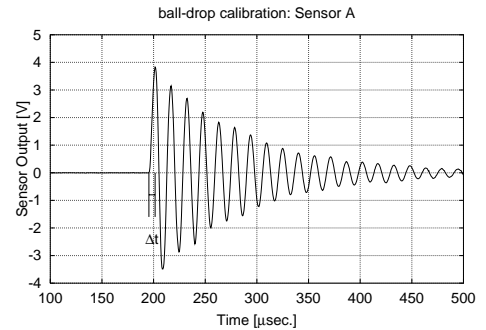
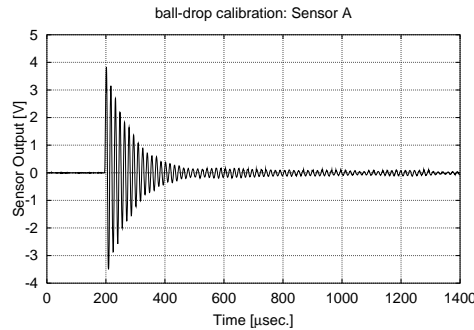
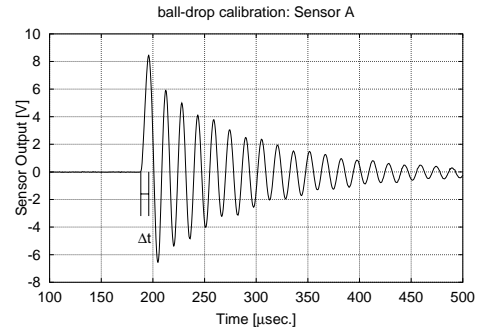
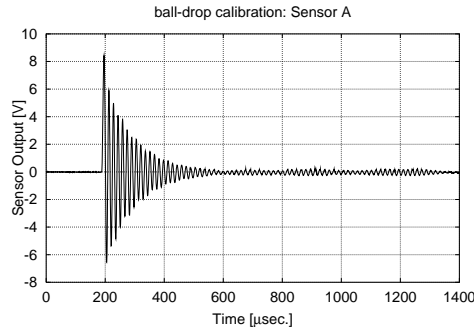


Fig. A.1: (continued)

$$E_{\max} = 8.4529 \text{ V}$$

$$\Delta t = 7.70 \text{ } \mu\text{sec.}$$

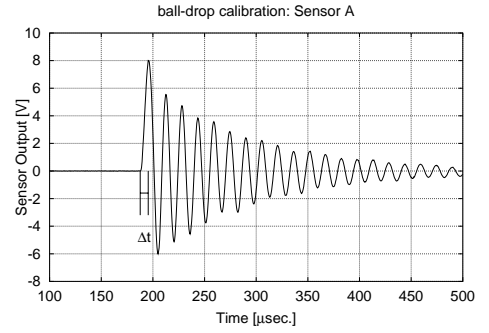
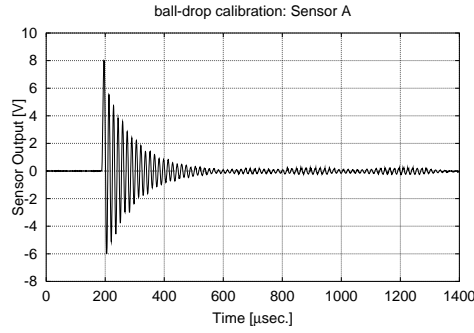
$$F = 77.5971 \text{ N}$$



$$E_{\max} = 8.0635 \text{ V}$$

$$\Delta t = 7.75 \text{ } \mu\text{sec.}$$

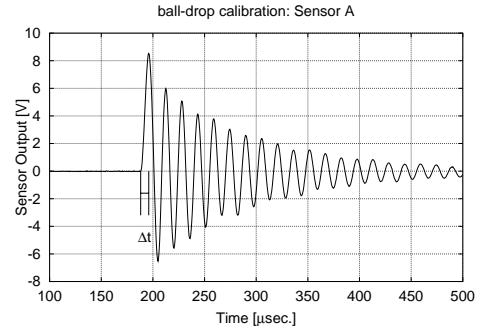
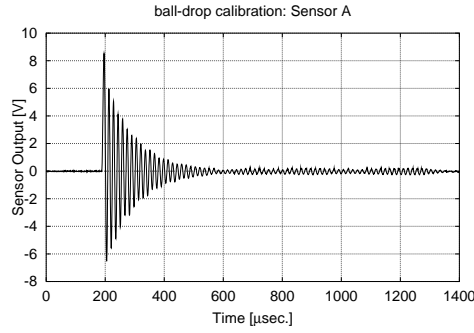
$$F = 77.0964 \text{ N}$$



$$E_{\max} = 8.5576 \text{ V}$$

$$\Delta t = 7.80 \text{ } \mu\text{sec.}$$

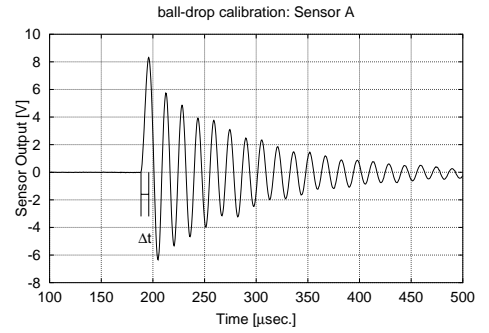
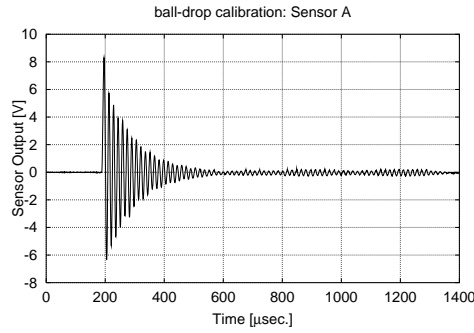
$$F = 76.6022 \text{ N}$$



$$E_{\max} = 8.3319 \text{ V}$$

$$\Delta t = 7.50 \text{ } \mu\text{sec.}$$

$$F = 79.6663 \text{ N}$$



$$E_{\max} = 8.0655 \text{ V}$$

$$\Delta t = 7.80 \text{ } \mu\text{sec.}$$

$$F = 76.6022 \text{ N}$$

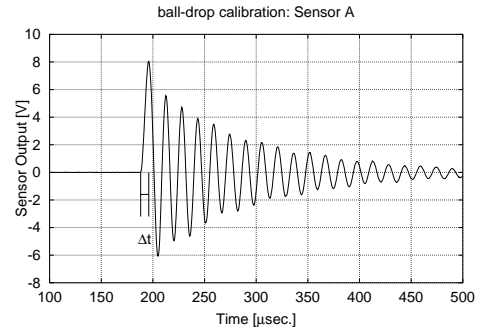
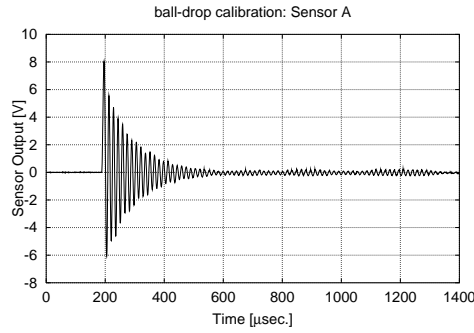
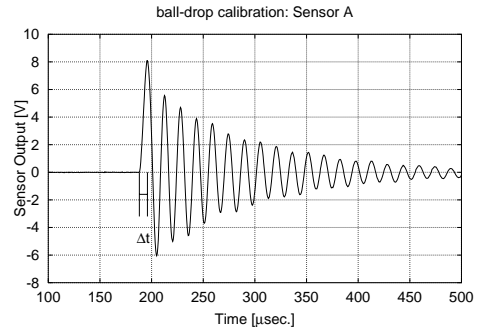
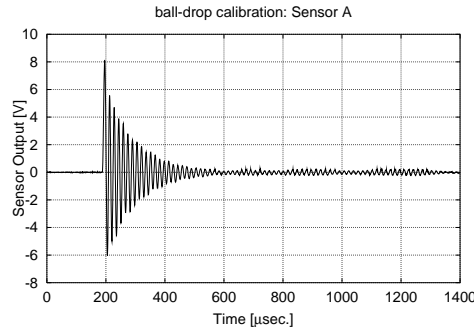


Fig. A.2: Output of Sensor A at ball-drop calibration.  $m = 0.440 \text{ g}$ ,  $h = 30 \text{ mm}$

$$E_{\max} = 8.1199 \text{ V}$$

$$\Delta t = 7.80 \text{ } \mu\text{sec.}$$

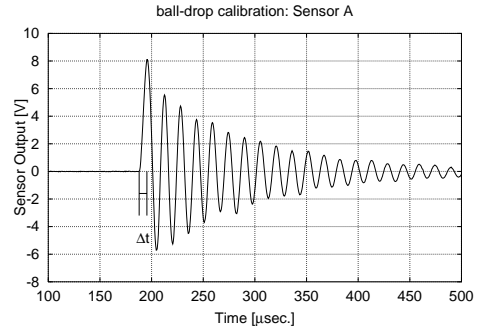
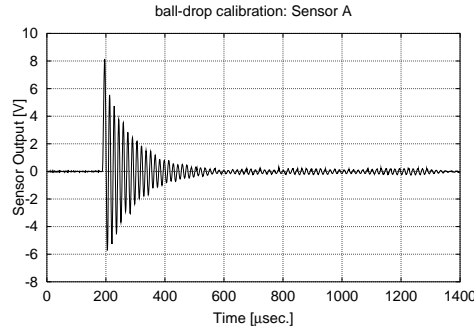
$$F = 76.6022 \text{ N}$$



$$E_{\max} = 8.1637 \text{ V}$$

$$\Delta t = 7.50 \text{ } \mu\text{sec.}$$

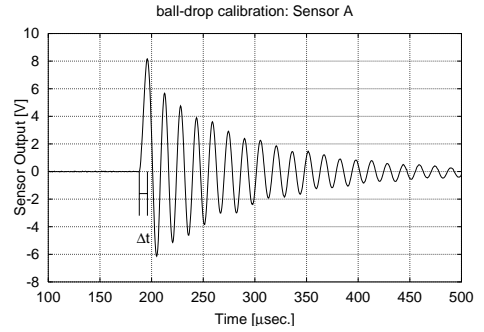
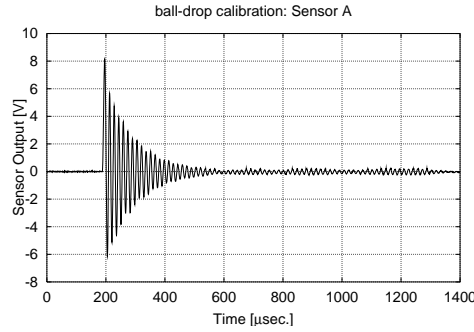
$$F = 79.6663 \text{ N}$$



$$E_{\max} = 8.1738 \text{ V}$$

$$\Delta t = 7.90 \text{ } \mu\text{sec.}$$

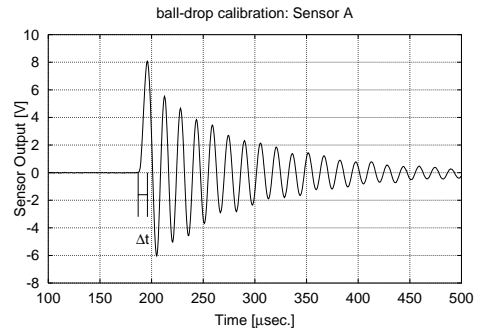
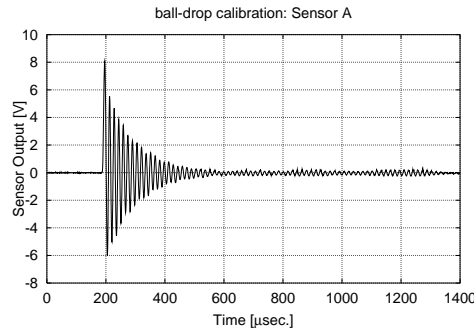
$$F = 75.6326 \text{ N}$$



$$E_{\max} = 8.0938 \text{ V}$$

$$\Delta t = 9.00 \text{ } \mu\text{sec.}$$

$$F = 66.3886 \text{ N}$$



$$E_{\max} = 8.2280 \text{ V}$$

$$\Delta t = 7.75 \text{ } \mu\text{sec.}$$

$$F = 77.0964 \text{ N}$$

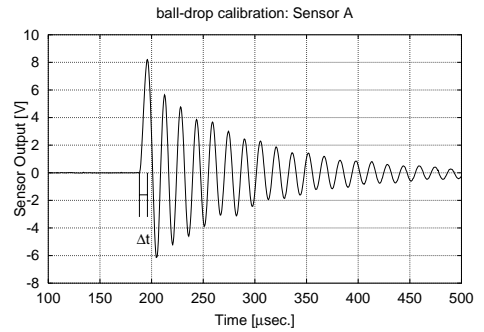
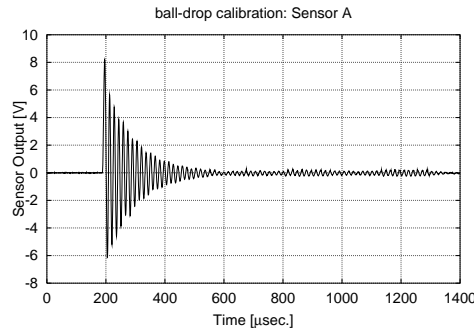


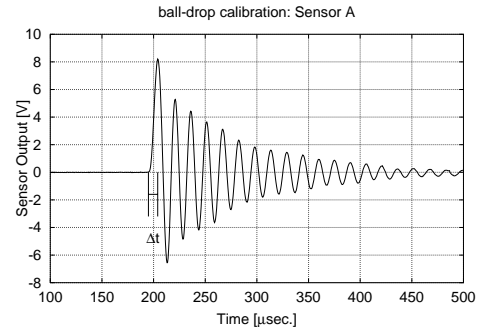
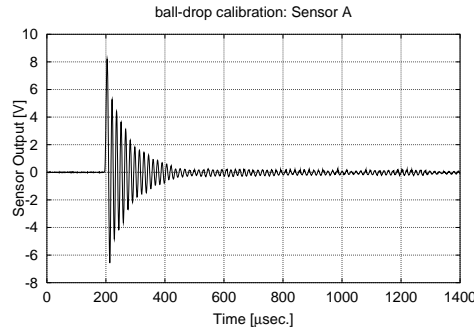
Fig. A.2: (continued)



$$E_{\max} = 8.2258 \text{ V}$$

$$\Delta t = 9.00 \text{ } \mu\text{sec.}$$

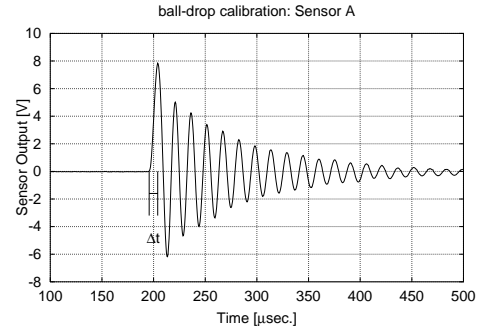
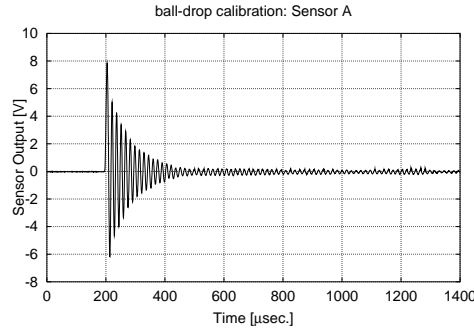
$$F = 66.3886 \text{ N}$$



$$E_{\max} = 7.8642 \text{ V}$$

$$\Delta t = 8.25 \text{ } \mu\text{sec.}$$

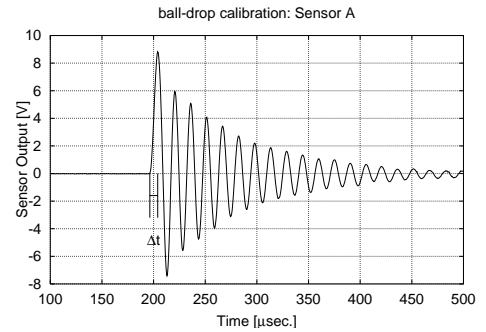
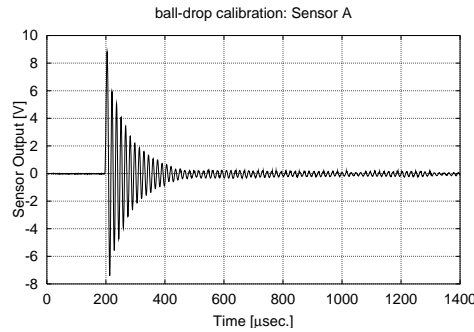
$$F = 72.4239 \text{ N}$$



$$E_{\max} = 8.8401 \text{ V}$$

$$\Delta t = 7.60 \text{ } \mu\text{sec.}$$

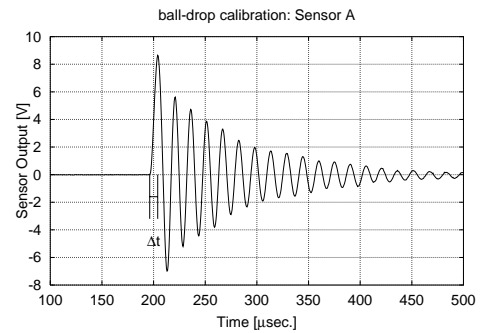
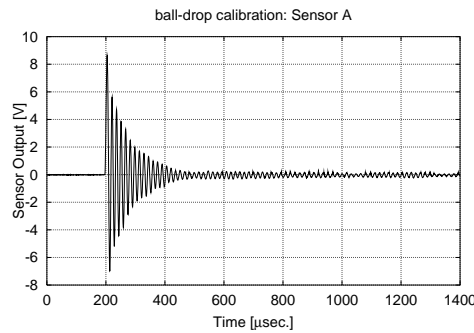
$$F = 78.6181 \text{ N}$$



$$E_{\max} = 8.6729 \text{ V}$$

$$\Delta t = 7.75 \text{ } \mu\text{sec.}$$

$$F = 77.0964 \text{ N}$$



$$E_{\max} = 8.0574 \text{ V}$$

$$\Delta t = 8.40 \text{ } \mu\text{sec.}$$

$$F = 71.1307 \text{ N}$$

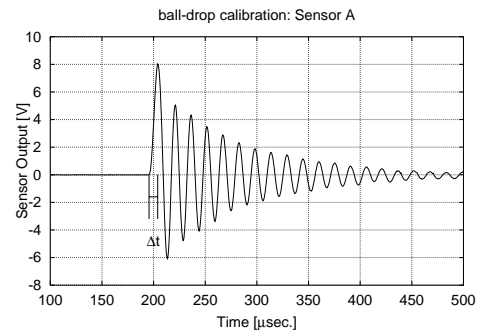
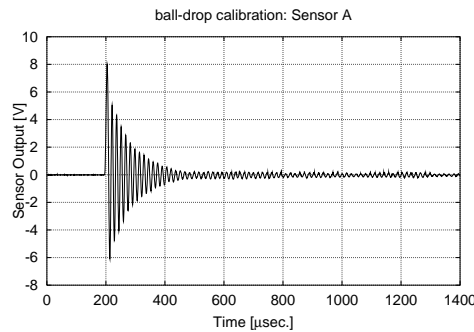
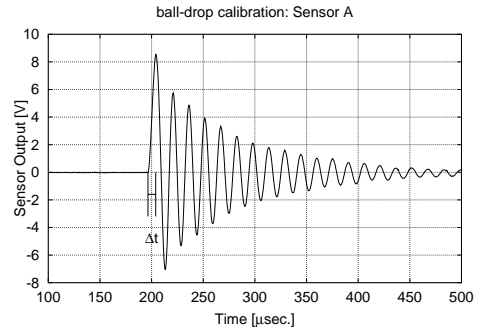
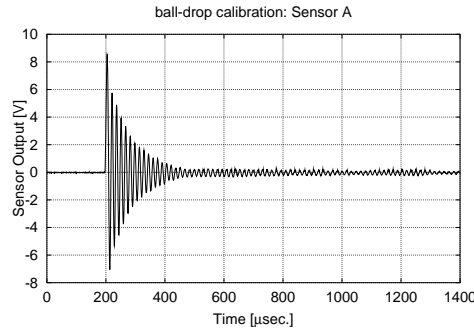


Fig. A.2: (continued)

$$E_{\max} = 8.5781 \text{ V}$$

$$\Delta t = 7.50 \text{ } \mu\text{sec.}$$

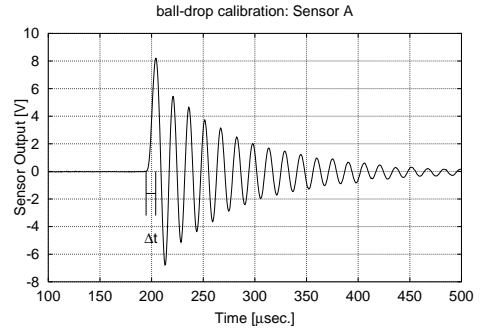
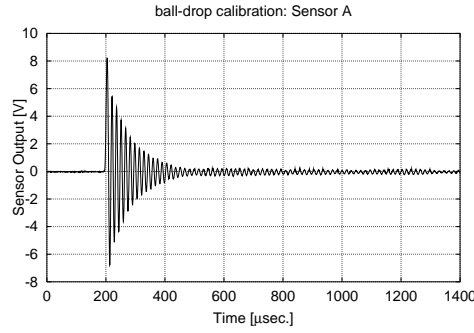
$$F = 79.6663 \text{ N}$$



$$E_{\max} = 8.2497 \text{ V}$$

$$\Delta t = 9.30 \text{ } \mu\text{sec.}$$

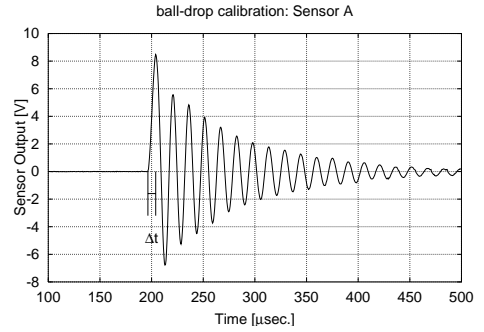
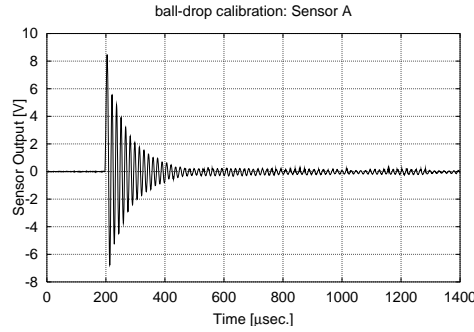
$$F = 64.2470 \text{ N}$$



$$E_{\max} = 8.4777 \text{ V}$$

$$\Delta t = 7.55 \text{ } \mu\text{sec.}$$

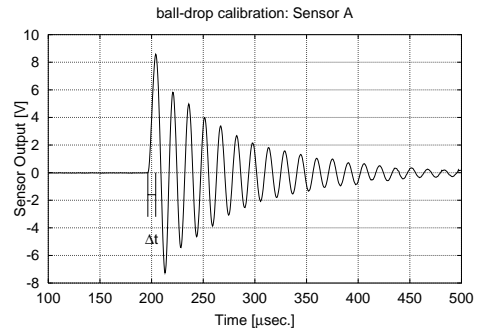
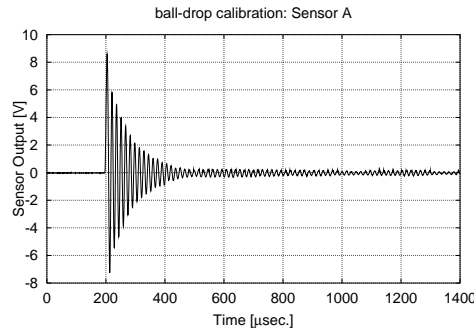
$$F = 79.1387 \text{ N}$$



$$E_{\max} = 8.6210 \text{ V}$$

$$\Delta t = 7.60 \text{ } \mu\text{sec.}$$

$$F = 78.6181 \text{ N}$$



$$E_{\max} = 8.6879 \text{ V}$$

$$\Delta t = 7.60 \text{ } \mu\text{sec.}$$

$$F = 78.6181 \text{ N}$$

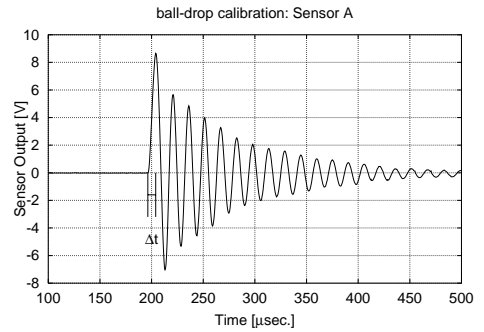
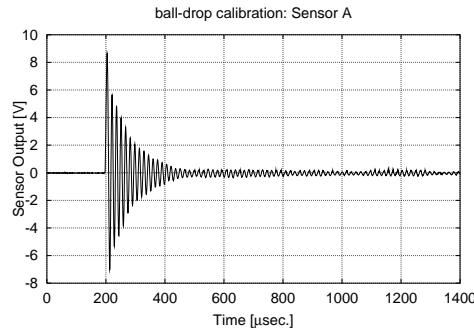
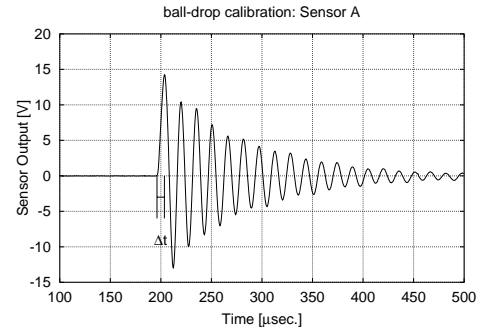
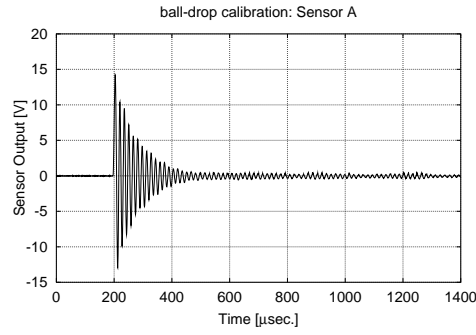


Fig. A.2: (continued)

$$E_{\max} = 14.2563 \text{ V}$$

$$\Delta t = 7.30 \mu\text{sec.}$$

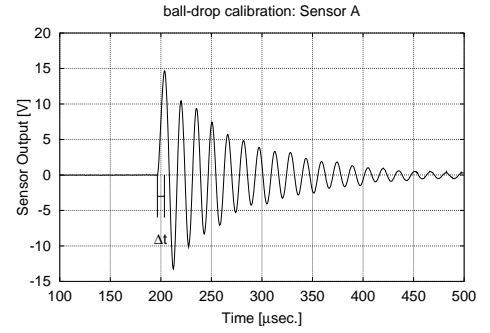
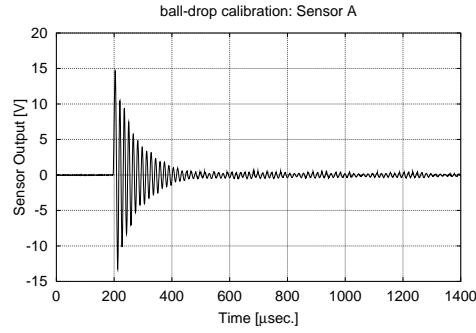
$$F = 129.5834 \text{ N}$$



$$E_{\max} = 14.6965 \text{ V}$$

$$\Delta t = 6.95 \mu\text{sec.}$$

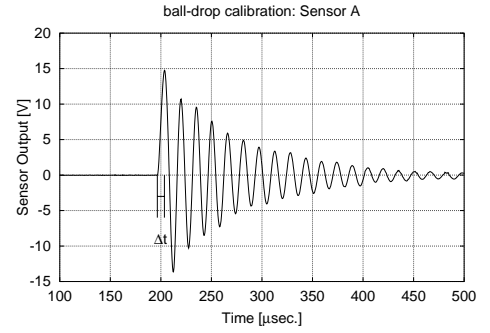
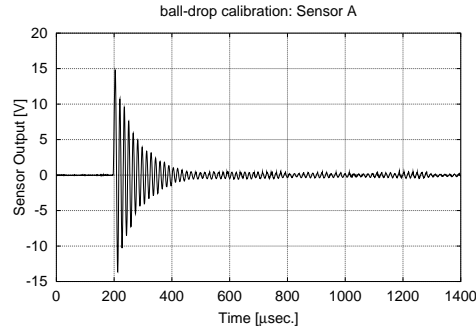
$$F = 138.9385 \text{ N}$$



$$E_{\max} = 14.8411 \text{ V}$$

$$\Delta t = 7.00 \mu\text{sec.}$$

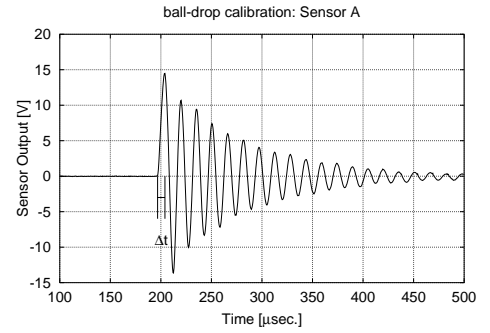
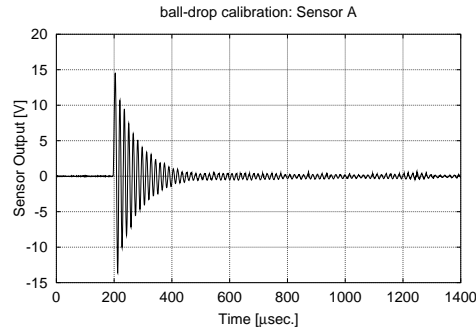
$$F = 136.6562 \text{ N}$$



$$E_{\max} = 14.5498 \text{ V}$$

$$\Delta t = 7.25 \mu\text{sec.}$$

$$F = 131.9324 \text{ N}$$



$$E_{\max} = 14.5708 \text{ V}$$

$$\Delta t = 7.40 \mu\text{sec.}$$

$$F = 130.3599 \text{ N}$$

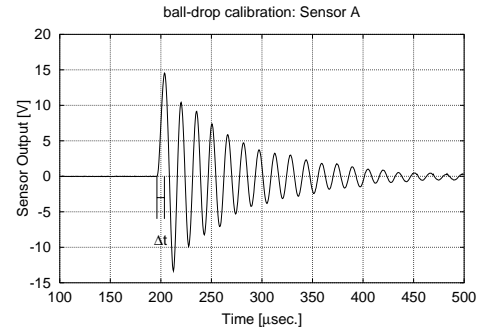
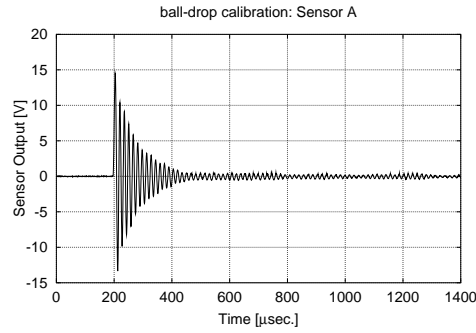
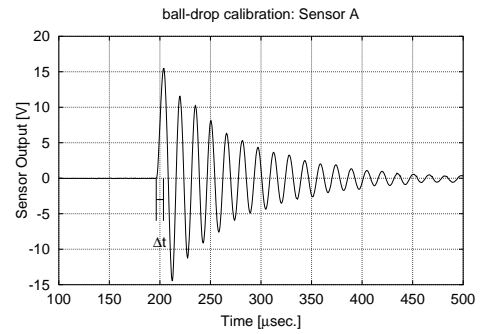
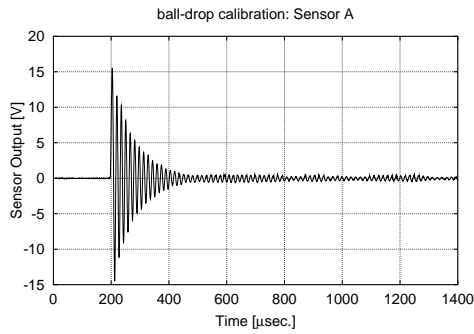


Fig. A.3: Output of Sensor A at ball-drop calibration.  $m = 0.440 \text{ g}$ ,  $h = 80 \text{ mm}$

$$E_{\max} = 15.5820 \text{ V}$$

$$\Delta t = 7.10 \mu\text{sec.}$$

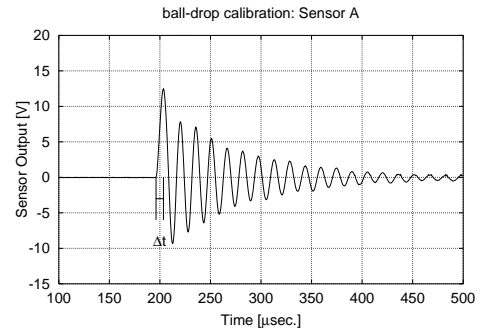
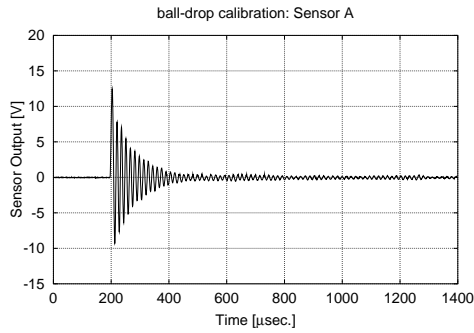
$$F = 136.8674 \text{ N}$$



$$E_{\max} = 12.5147 \text{ V}$$

$$\Delta t = 7.35 \mu\text{sec.}$$

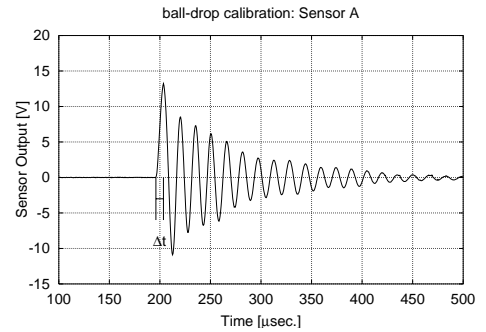
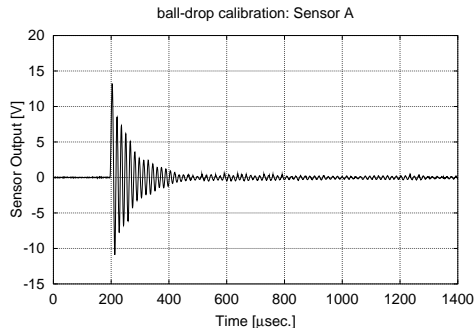
$$F = 128.5061 \text{ N}$$



$$E_{\max} = 13.1290 \text{ V}$$

$$\Delta t = 7.45 \mu\text{sec.}$$

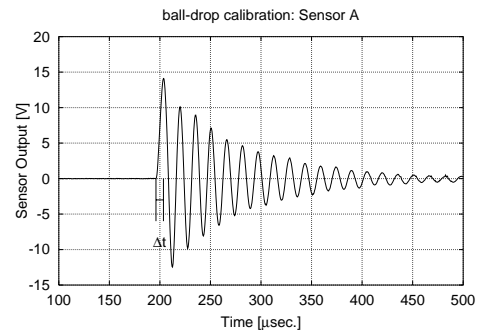
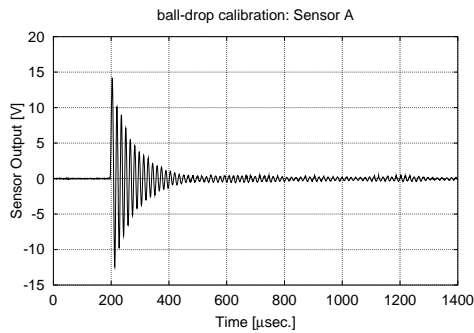
$$F = 126.7169 \text{ N}$$



$$E_{\max} = 14.1639 \text{ V}$$

$$\Delta t = 7.40 \mu\text{sec.}$$

$$F = 129.1933 \text{ N}$$



$$E_{\max} = 14.6306 \text{ V}$$

$$\Delta t = 7.40 \mu\text{sec.}$$

$$F = 129.2581 \text{ N}$$

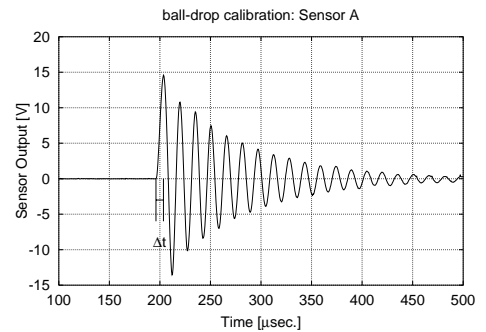
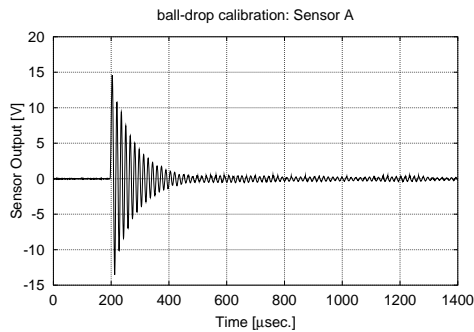
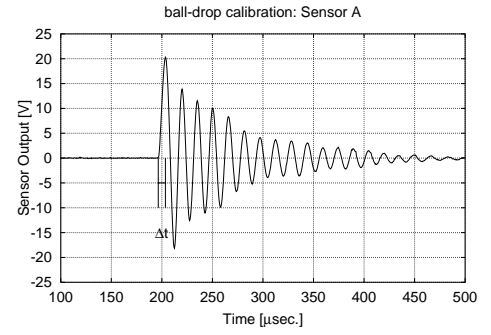
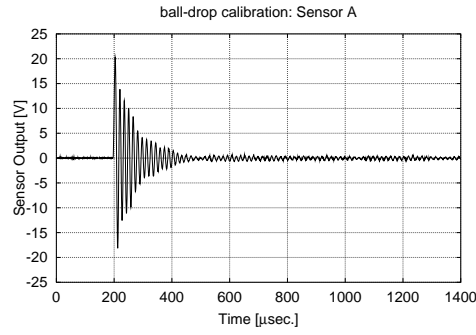


Fig. A.3: (continued)

$$E_{\max} = 20.3467 \text{ V}$$

$$\Delta t = 7.05 \mu\text{sec.}$$

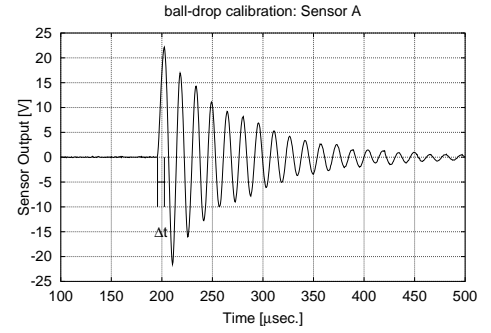
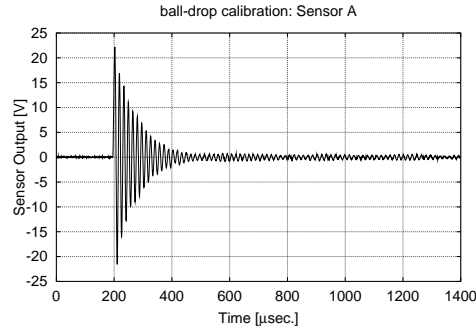
$$F = 180.4704 \text{ N}$$



$$E_{\max} = 22.1590 \text{ V}$$

$$\Delta t = 6.80 \mu\text{sec.}$$

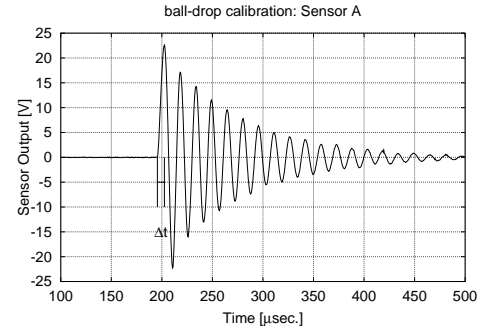
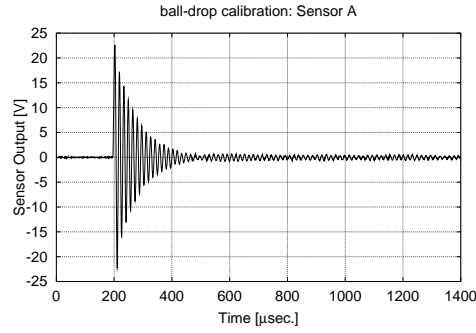
$$F = 187.3169 \text{ N}$$



$$E_{\max} = 22.6149 \text{ V}$$

$$\Delta t = 6.90 \mu\text{sec.}$$

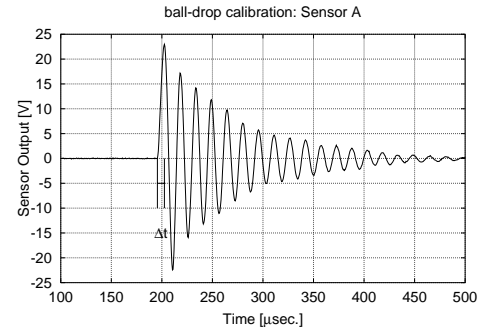
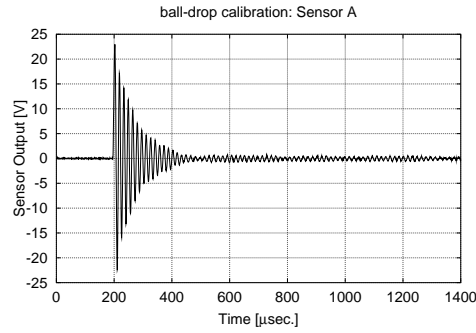
$$F = 185.5753 \text{ N}$$



$$E_{\max} = 23.0262 \text{ V}$$

$$\Delta t = 6.90 \mu\text{sec.}$$

$$F = 186.4093 \text{ N}$$



$$E_{\max} = 23.8841 \text{ V}$$

$$\Delta t = 7.05 \mu\text{sec.}$$

$$F = 183.3956 \text{ N}$$

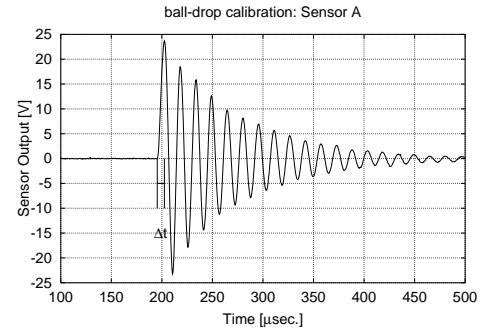
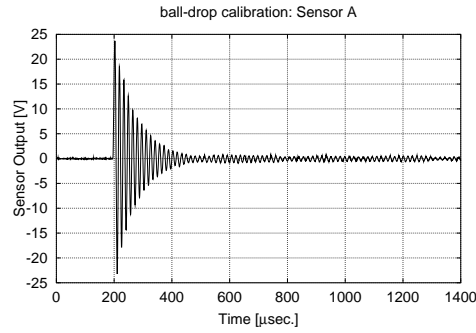
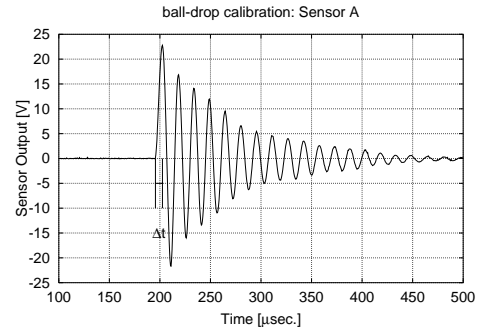
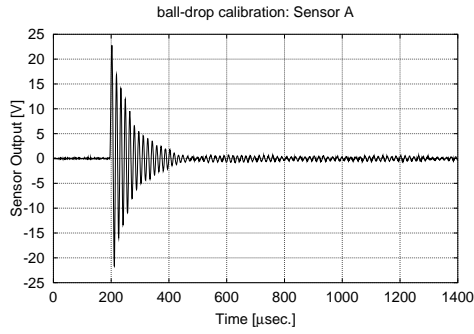


Fig. A.4: Output of Sensor A at ball-drop calibration.  $m = 0.440 \text{ g}$ ,  $h = 150 \text{ mm}$

$$E_{\max} = 22.8021 \text{ V}$$

$$\Delta t = 6.90 \mu\text{sec.}$$

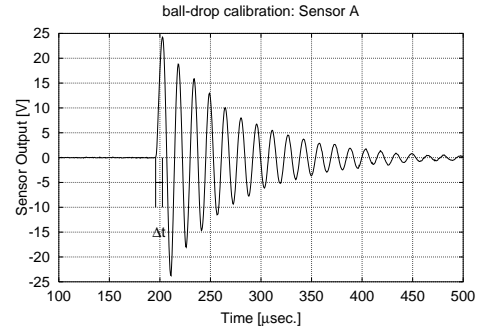
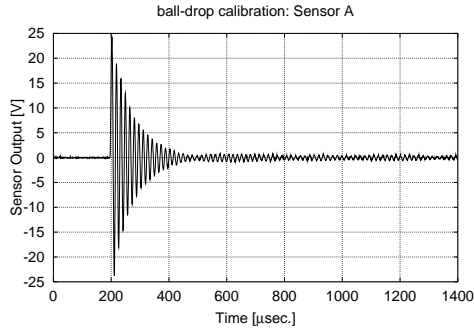
$$F = 187.2434 \text{ N}$$



$$E_{\max} = 24.3600 \text{ V}$$

$$\Delta t = 6.70 \mu\text{sec.}$$

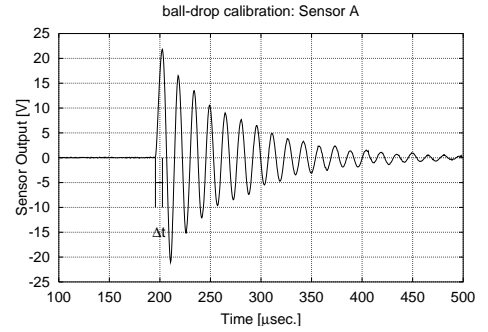
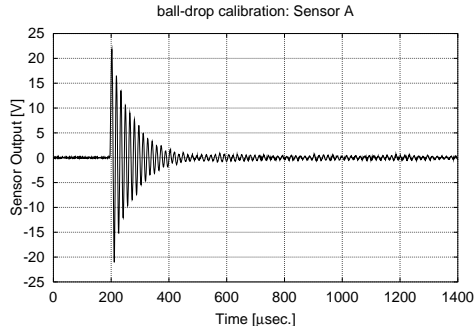
$$F = 193.3339 \text{ N}$$



$$E_{\max} = 21.8515 \text{ V}$$

$$\Delta t = 6.95 \mu\text{sec.}$$

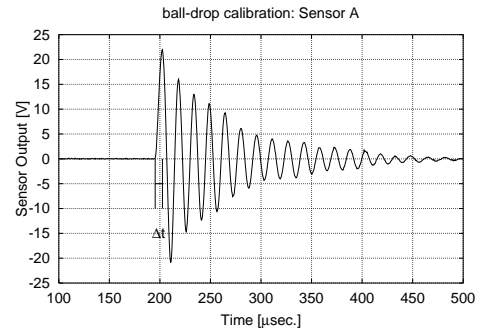
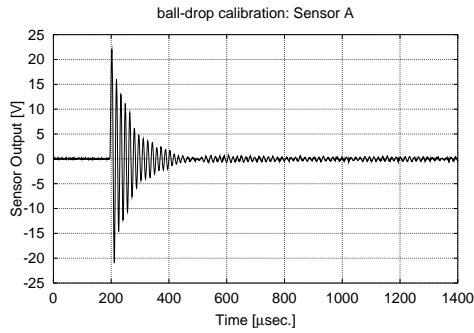
$$F = 183.4811 \text{ N}$$



$$E_{\max} = 21.9451 \text{ V}$$

$$\Delta t = 7.20 \mu\text{sec.}$$

$$F = 177.9762 \text{ N}$$



$$E_{\max} = 22.4618 \text{ V}$$

$$\Delta t = 7.05 \mu\text{sec.}$$

$$F = 181.6949 \text{ N}$$

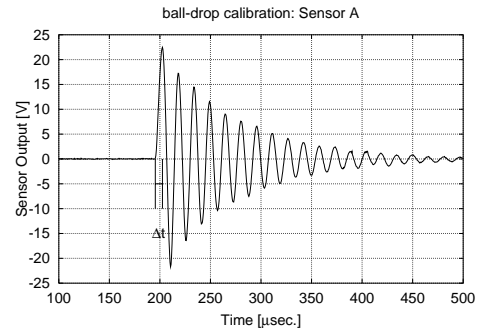
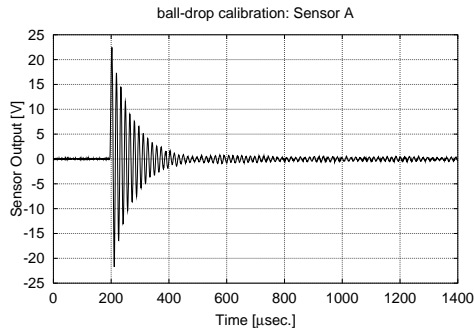
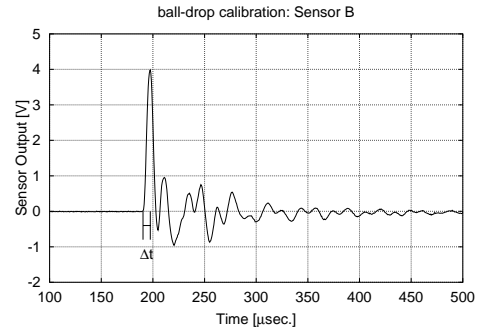
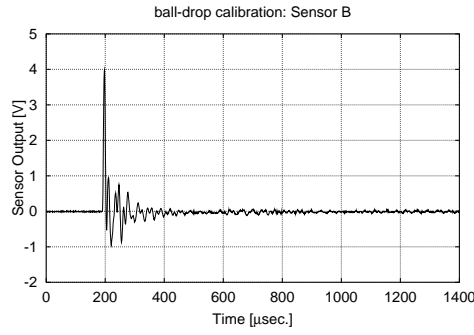


Fig. A.4: (continued)

$$E_{\max} = 3.9956 \text{ V}$$

$$\Delta t = 7.05 \mu\text{sec.}$$

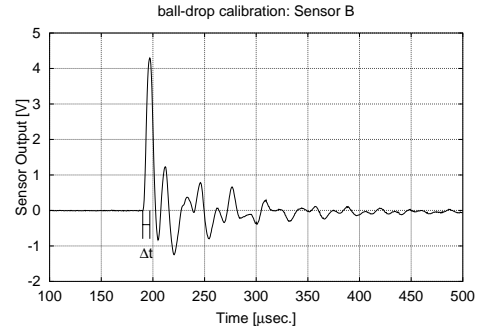
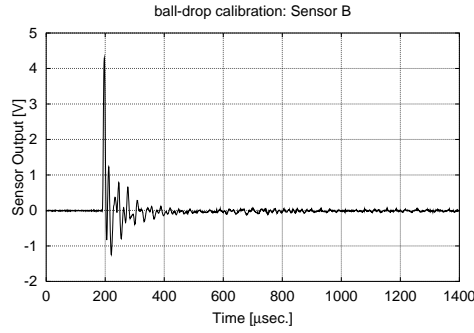
$$F = 24.0923 \text{ N}$$



$$E_{\max} = 4.2998 \text{ V}$$

$$\Delta t = 6.80 \mu\text{sec.}$$

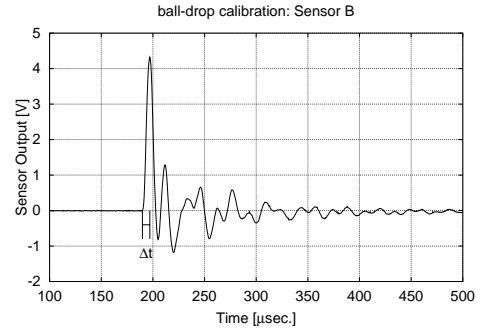
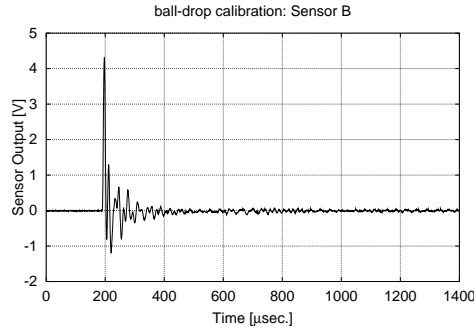
$$F = 24.9781 \text{ N}$$



$$E_{\max} = 4.3272 \text{ V}$$

$$\Delta t = 7.15 \mu\text{sec.}$$

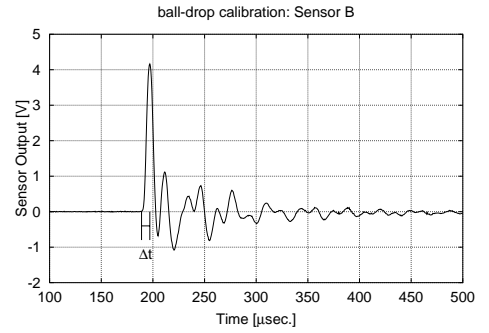
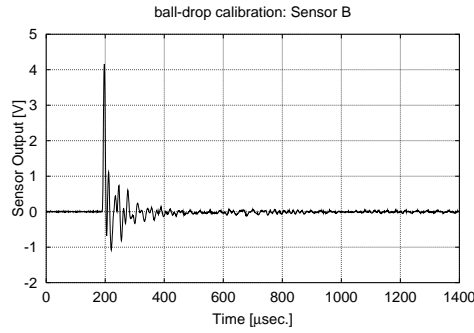
$$F = 23.7554 \text{ N}$$



$$E_{\max} = 4.1665 \text{ V}$$

$$\Delta t = 8.00 \mu\text{sec.}$$

$$F = 21.2314 \text{ N}$$



$$E_{\max} = 4.3034 \text{ V}$$

$$\Delta t = 7.50 \mu\text{sec.}$$

$$F = 22.6468 \text{ N}$$

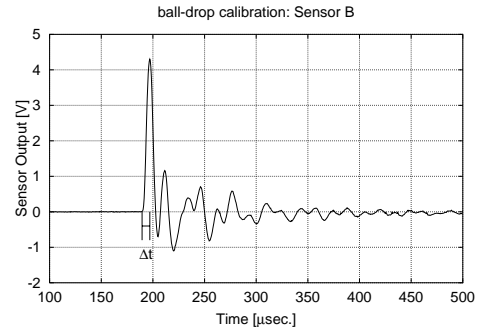
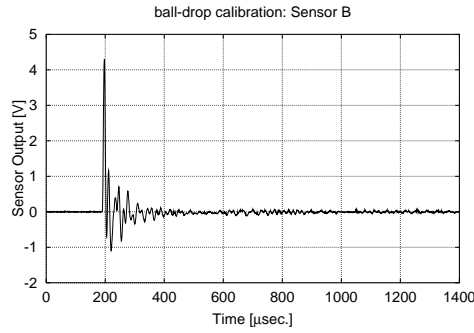
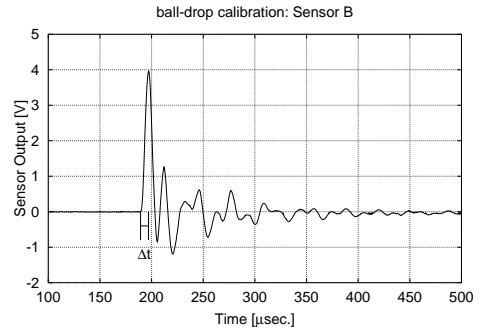
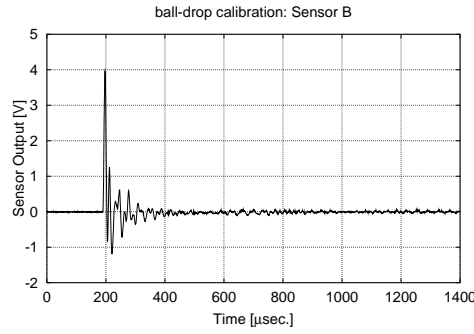


Fig. A.5: Output of Sensor B at ball-drop calibration.  $m = 0.130 \text{ g}$ ,  $h = 30 \text{ mm}$

$$E_{\max} = 3.9732 \text{ V}$$

$$\Delta t = 7.65 \mu\text{sec.}$$

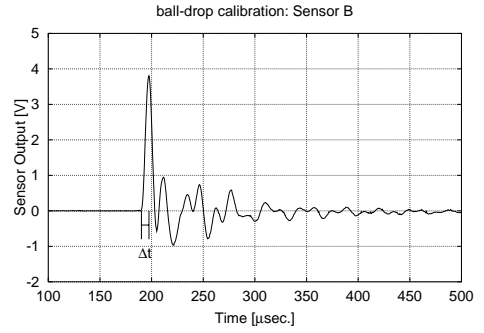
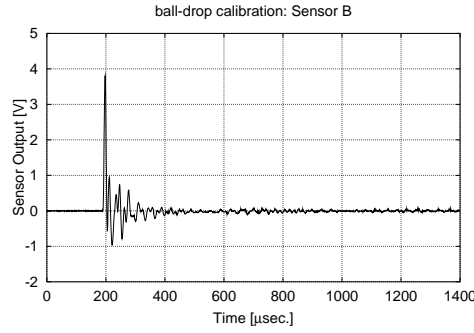
$$F = 22.2027 \text{ N}$$



$$E_{\max} = 3.8110 \text{ V}$$

$$\Delta t = 7.35 \mu\text{sec.}$$

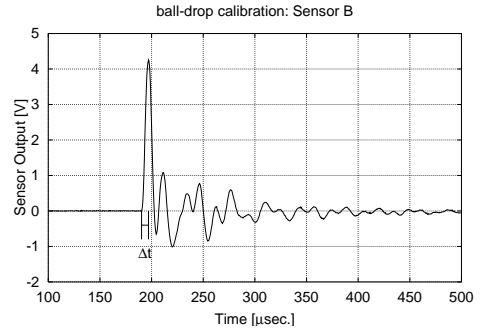
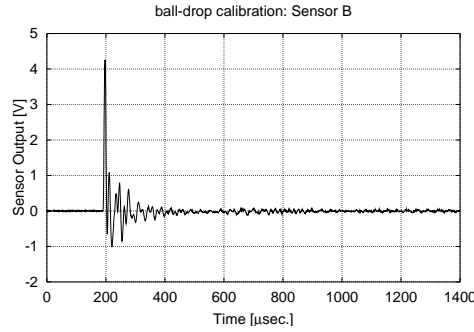
$$F = 23.1090 \text{ N}$$



$$E_{\max} = 4.2565 \text{ V}$$

$$\Delta t = 6.70 \mu\text{sec.}$$

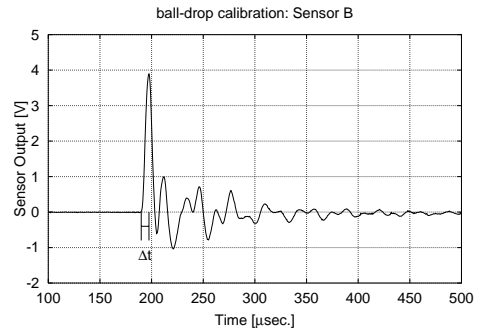
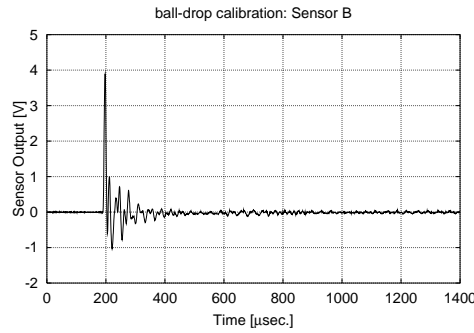
$$F = 25.3509 \text{ N}$$



$$E_{\max} = 3.9055 \text{ V}$$

$$\Delta t = 7.50 \mu\text{sec.}$$

$$F = 22.6468 \text{ N}$$



$$E_{\max} = 4.5302 \text{ V}$$

$$\Delta t = 6.85 \mu\text{sec.}$$

$$F = 24.7958 \text{ N}$$

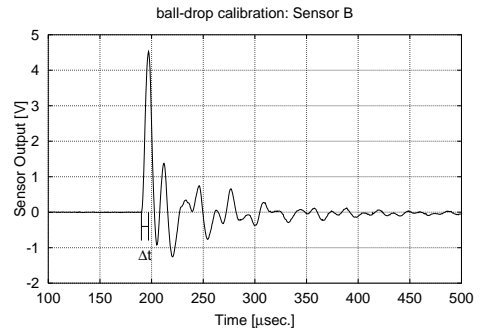
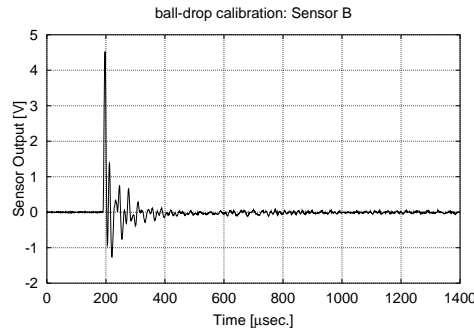


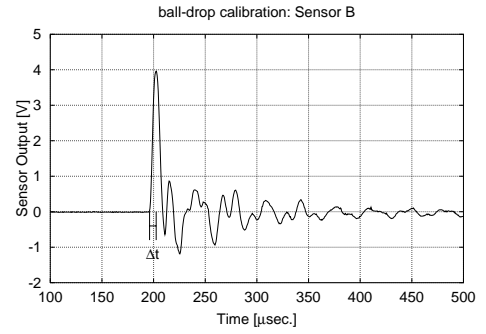
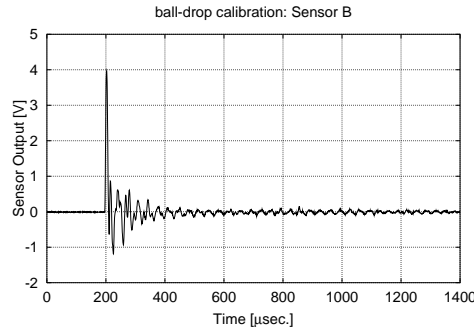
Fig. A.5: (continued)



$$E_{\max} = 3.9786 \text{ V}$$

$$\Delta t = 6.40 \text{ } \mu\text{sec.}$$

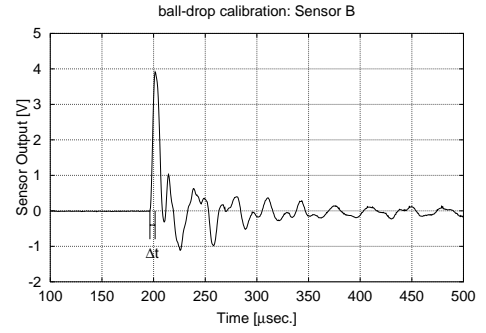
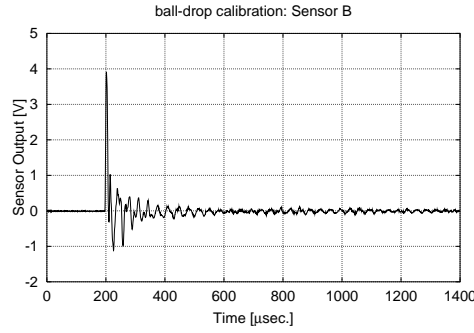
$$F = 26.5392 \text{ N}$$



$$E_{\max} = 3.9223 \text{ V}$$

$$\Delta t = 5.05 \text{ } \mu\text{sec.}$$

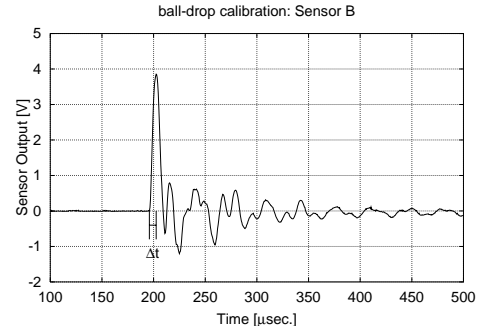
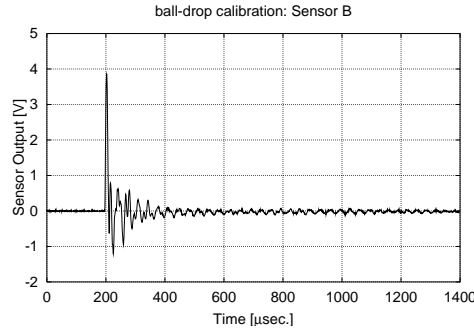
$$F = 33.6339 \text{ N}$$



$$E_{\max} = 3.8564 \text{ V}$$

$$\Delta t = 6.60 \text{ } \mu\text{sec.}$$

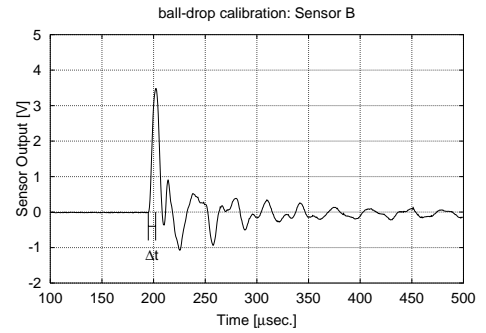
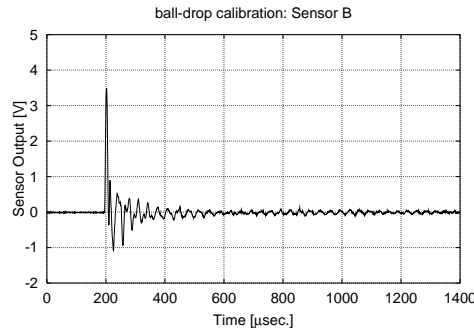
$$F = 25.7350 \text{ N}$$



$$E_{\max} = 3.5057 \text{ V}$$

$$\Delta t = 7.10 \text{ } \mu\text{sec.}$$

$$F = 23.9227 \text{ N}$$



$$E_{\max} = 3.7409 \text{ V}$$

$$\Delta t = 7.05 \text{ } \mu\text{sec.}$$

$$F = 24.0923 \text{ N}$$

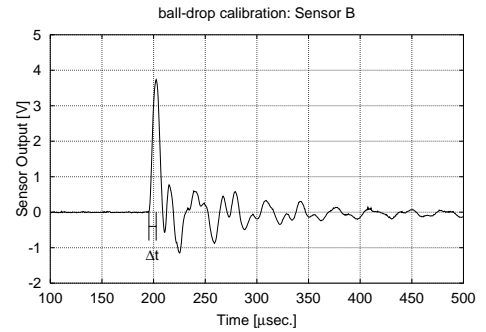
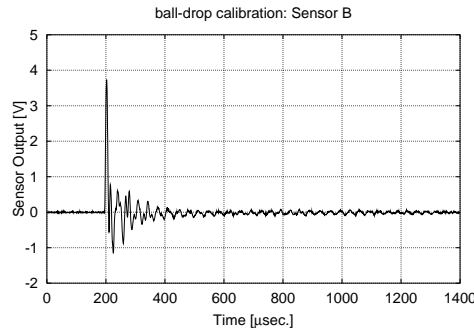
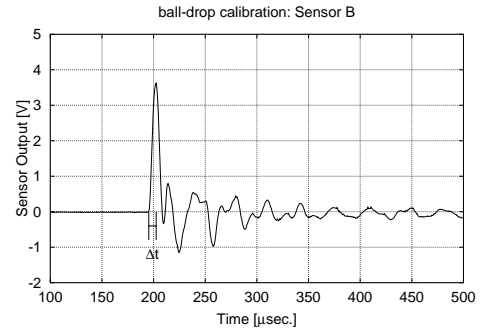
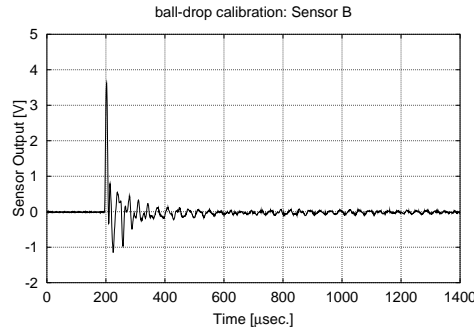


Fig. A.5: (continued)

$$E_{\max} = 3.6446 \text{ V}$$

$$\Delta t = 7.15 \mu\text{sec.}$$

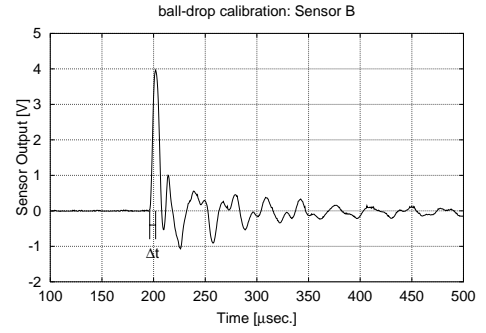
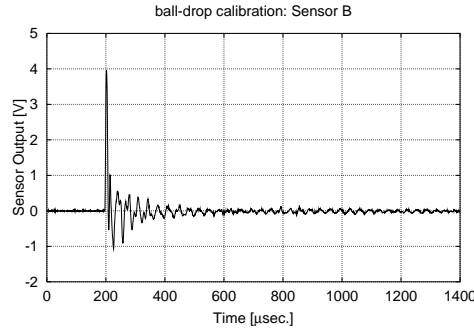
$$F = 23.7554 \text{ N}$$



$$E_{\max} = 3.9487 \text{ V}$$

$$\Delta t = 5.75 \mu\text{sec.}$$

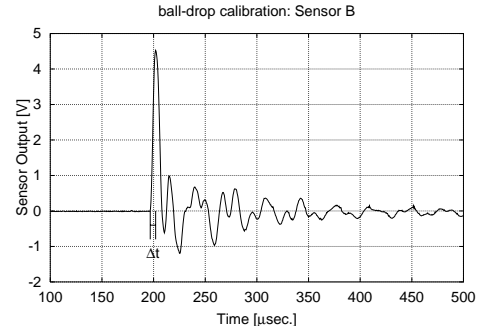
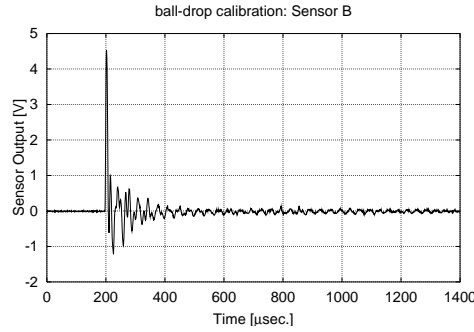
$$F = 29.5393 \text{ N}$$



$$E_{\max} = 4.5324 \text{ V}$$

$$\Delta t = 5.20 \mu\text{sec.}$$

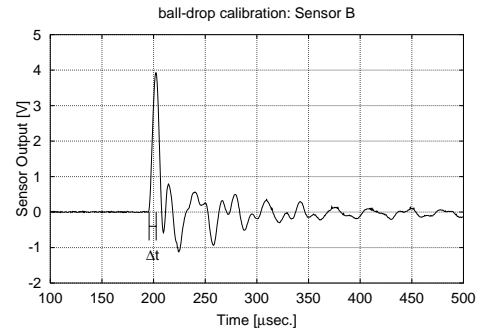
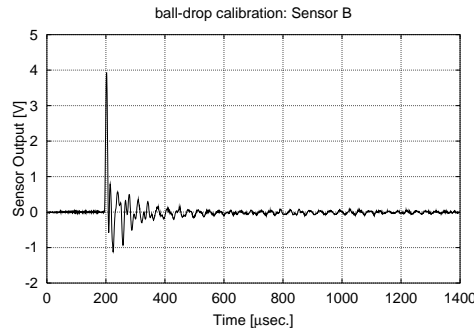
$$F = 32.6637 \text{ N}$$



$$E_{\max} = 3.9371 \text{ V}$$

$$\Delta t = 6.85 \mu\text{sec.}$$

$$F = 24.7958 \text{ N}$$



$$E_{\max} = 4.7527 \text{ V}$$

$$\Delta t = 4.95 \mu\text{sec.}$$

$$F = 34.3133 \text{ N}$$

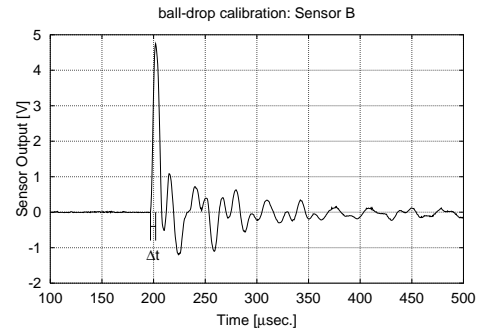
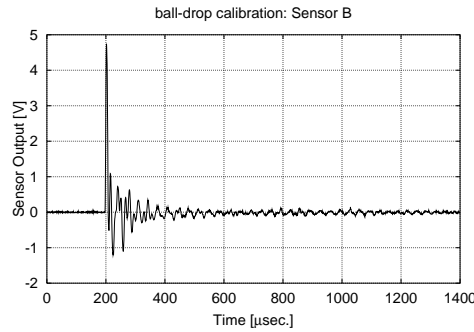
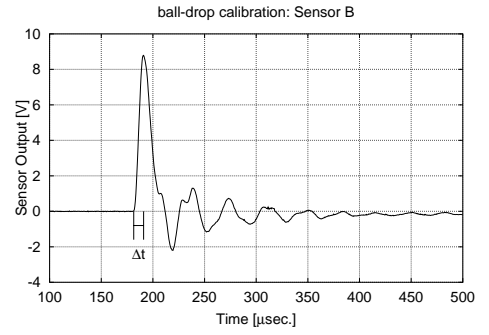
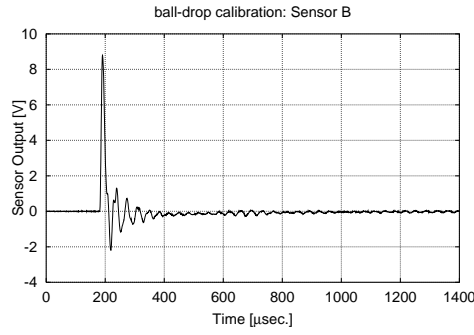


Fig. A.5: (continued)

$$E_{\max} = 8.8055 \text{ V}$$

$$\Delta t = 9.55 \mu\text{sec.}$$

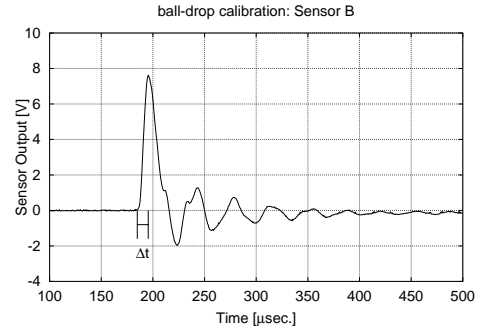
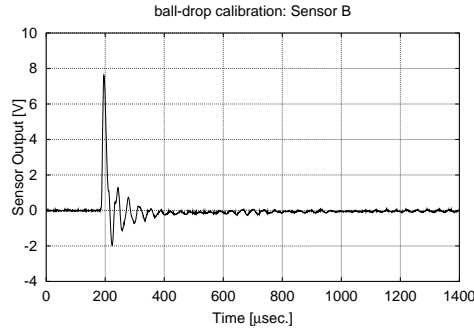
$$F = 60.2322 \text{ N}$$



$$E_{\max} = 7.6213 \text{ V}$$

$$\Delta t = 10.60 \mu\text{sec.}$$

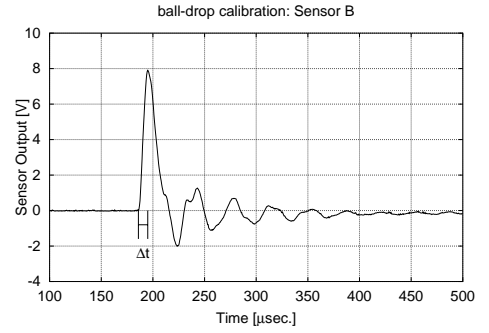
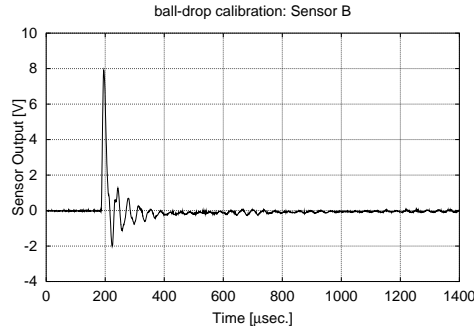
$$F = 54.2658 \text{ N}$$



$$E_{\max} = 7.9057 \text{ V}$$

$$\Delta t = 9.00 \mu\text{sec.}$$

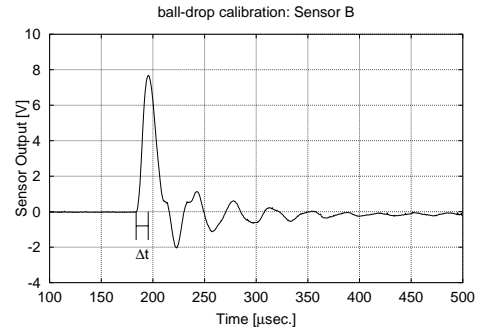
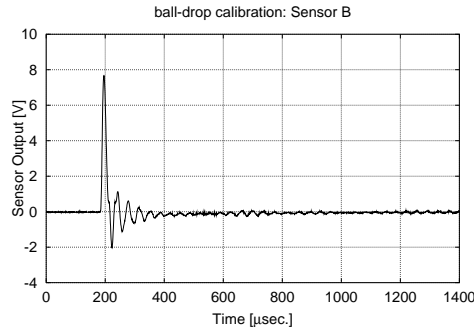
$$F = 63.9131 \text{ N}$$



$$E_{\max} = 7.7057 \text{ V}$$

$$\Delta t = 11.70 \mu\text{sec.}$$

$$F = 49.1639 \text{ N}$$



$$E_{\max} = 7.3368 \text{ V}$$

$$\Delta t = 12.00 \mu\text{sec.}$$

$$F = 47.9348 \text{ N}$$

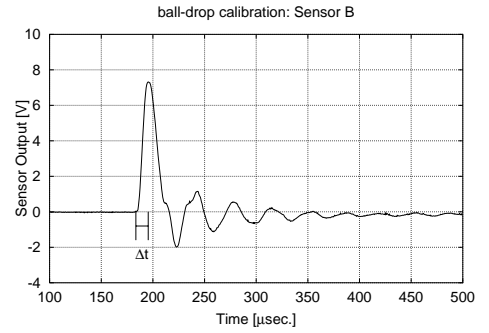
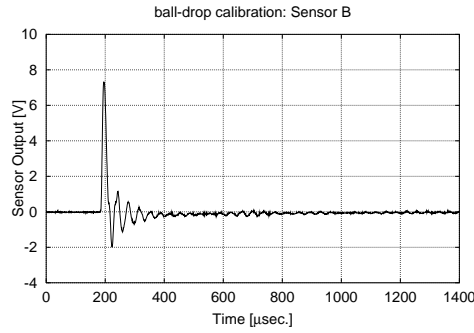
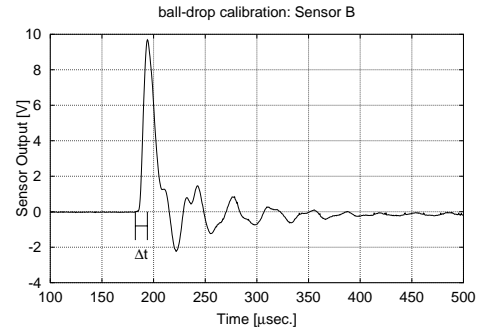
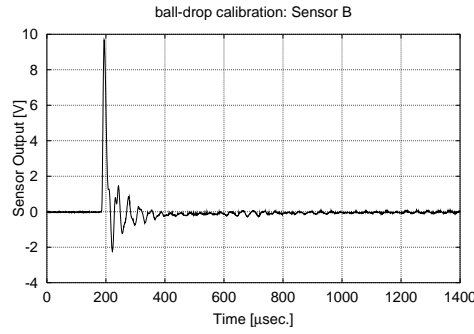


Fig. A.6: Output of Sensor B at ball-drop calibration.  $m = 0.440 \text{ g}$ ,  $h = 30 \text{ mm}$

$$E_{\max} = 9.7160 \text{ V}$$

$$\Delta t = 11.65 \mu\text{sec.}$$

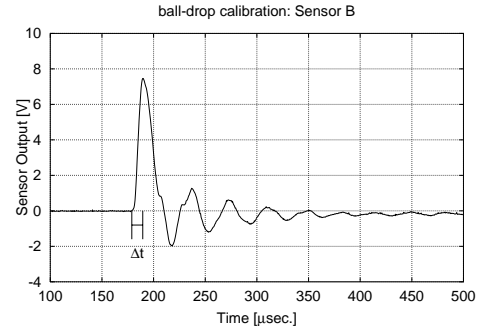
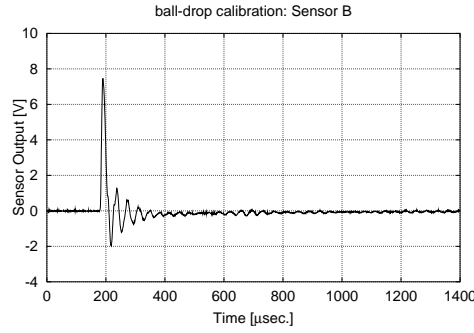
$$F = 49.3749 \text{ N}$$



$$E_{\max} = 7.4816 \text{ V}$$

$$\Delta t = 10.60 \mu\text{sec.}$$

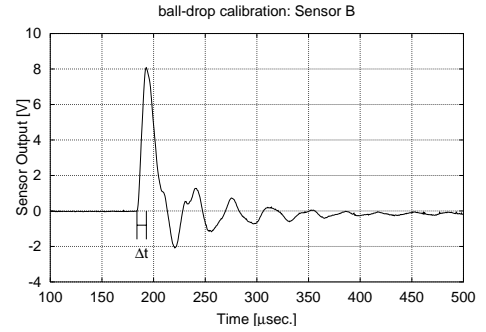
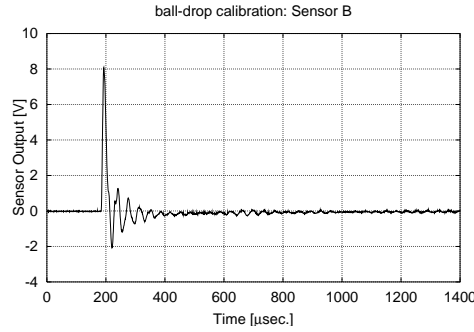
$$F = 54.2658 \text{ N}$$



$$E_{\max} = 8.1175 \text{ V}$$

$$\Delta t = 9.10 \mu\text{sec.}$$

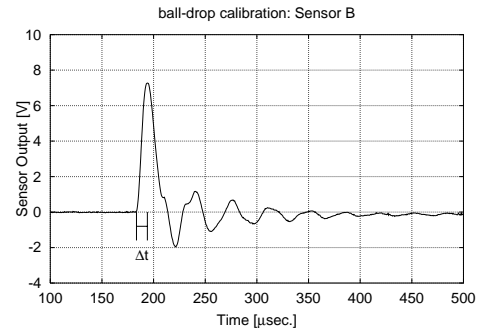
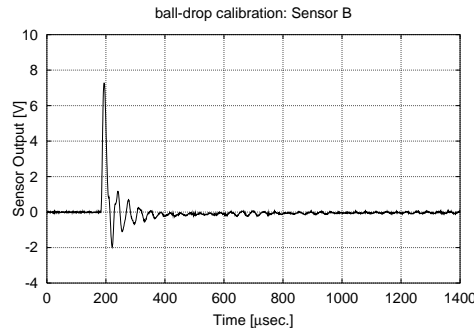
$$F = 63.2108 \text{ N}$$



$$E_{\max} = 7.3075 \text{ V}$$

$$\Delta t = 10.55 \mu\text{sec.}$$

$$F = 54.5230 \text{ N}$$



$$E_{\max} = 7.9279 \text{ V}$$

$$\Delta t = 9.75 \mu\text{sec.}$$

$$F = 58.9967 \text{ N}$$

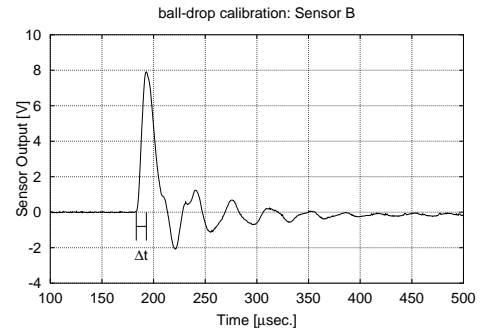
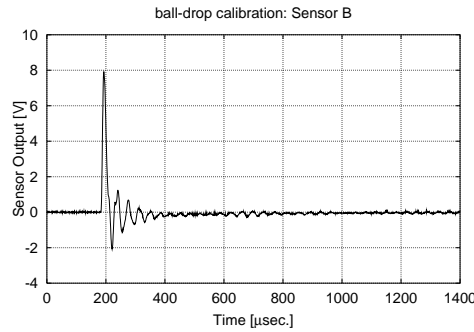
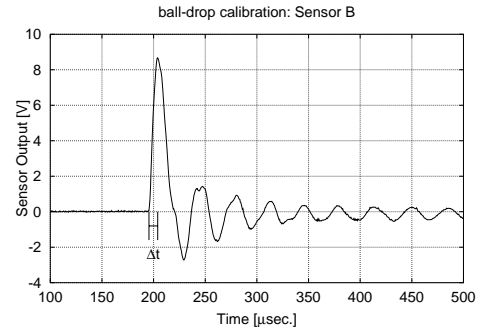
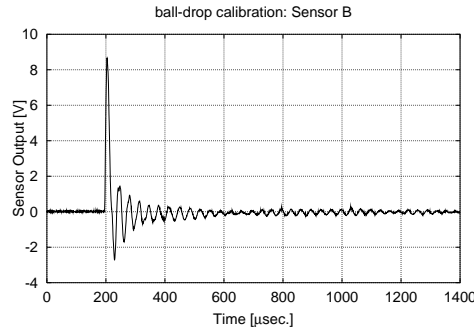


Fig. A.6: (continued)

$$E_{\max} = 8.6622 \text{ V}$$

$$\Delta t = 8.45 \mu\text{sec.}$$

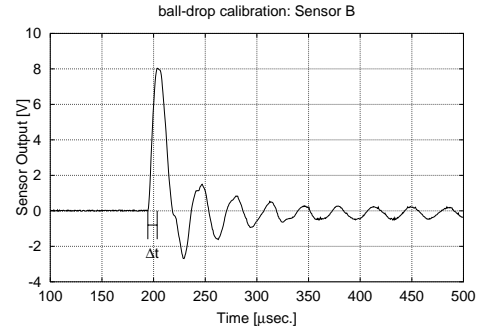
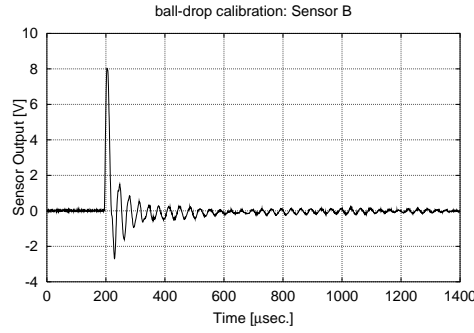
$$F = 68.0731 \text{ N}$$



$$E_{\max} = 8.0267 \text{ V}$$

$$\Delta t = 9.05 \mu\text{sec.}$$

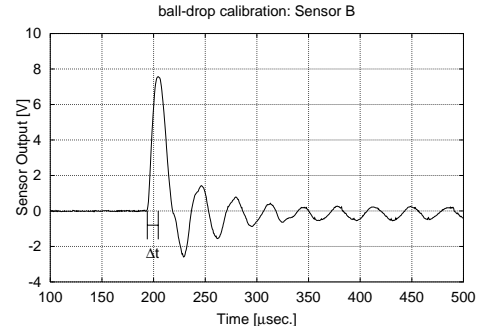
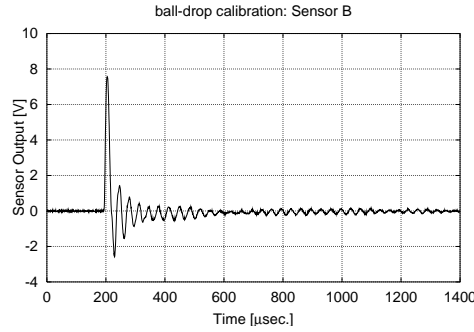
$$F = 63.5600 \text{ N}$$



$$E_{\max} = 7.5768 \text{ V}$$

$$\Delta t = 10.55 \mu\text{sec.}$$

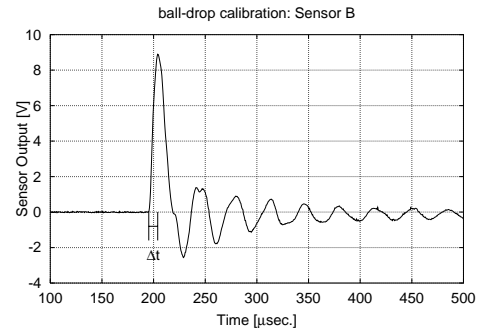
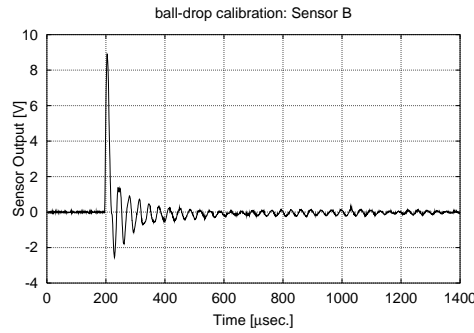
$$F = 54.5230 \text{ N}$$



$$E_{\max} = 8.9120 \text{ V}$$

$$\Delta t = 8.65 \mu\text{sec.}$$

$$F = 66.4992 \text{ N}$$



$$E_{\max} = 6.5977 \text{ V}$$

$$\Delta t = 13.15 \mu\text{sec.}$$

$$F = 43.7428 \text{ N}$$

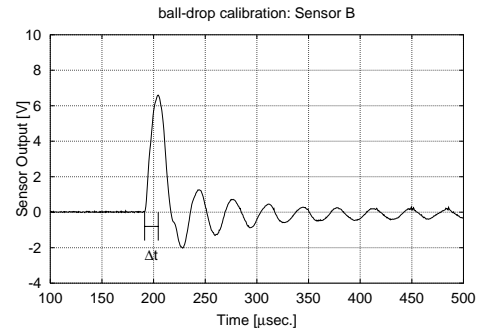
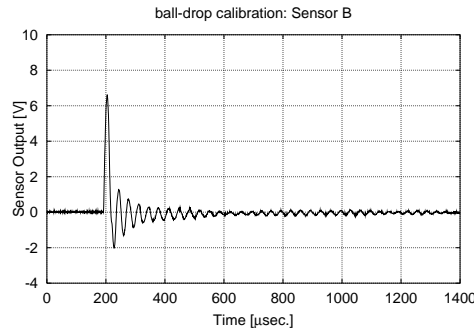
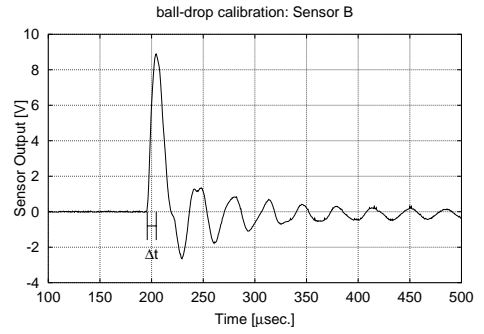
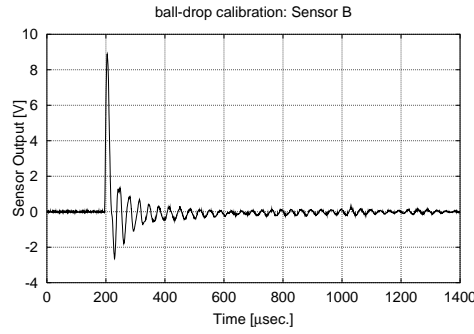


Fig. A.6: (continued)

$$E_{\max} = 8.8935 \text{ V}$$

$$\Delta t = 8.70 \mu\text{sec.}$$

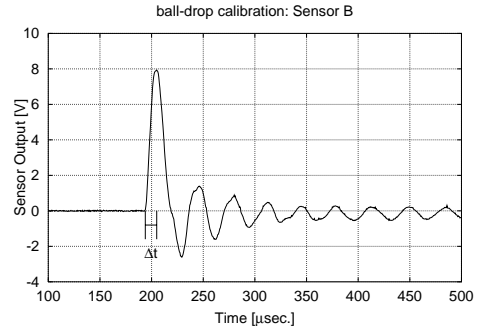
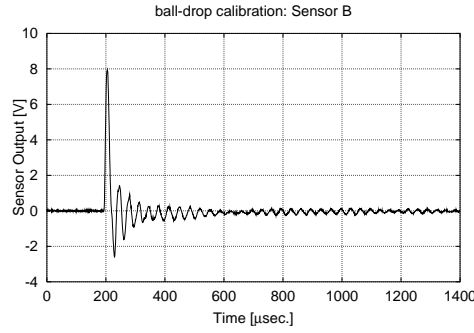
$$F = 66.1170 \text{ N}$$



$$E_{\max} = 7.9296 \text{ V}$$

$$\Delta t = 11.10 \mu\text{sec.}$$

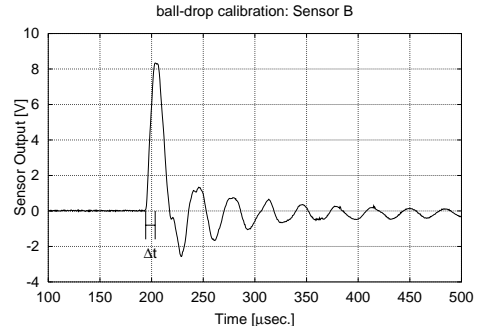
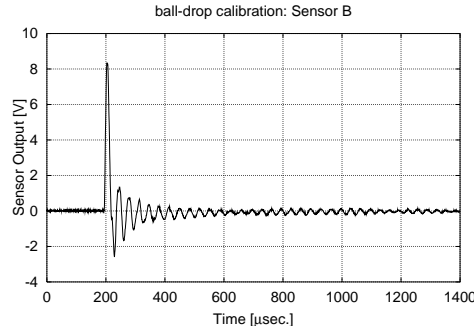
$$F = 51.8214 \text{ N}$$



$$E_{\max} = 8.3363 \text{ V}$$

$$\Delta t = 9.20 \mu\text{sec.}$$

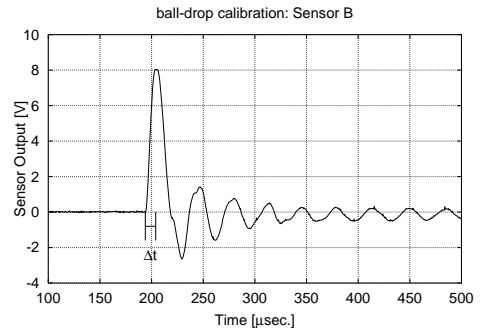
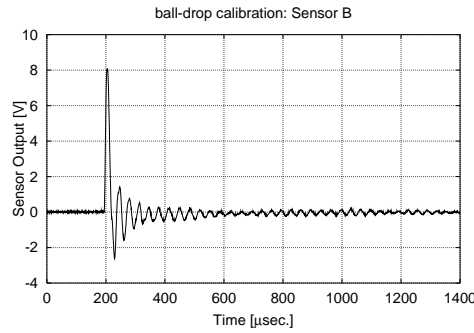
$$F = 62.5237 \text{ N}$$



$$E_{\max} = 8.0449 \text{ V}$$

$$\Delta t = 10.10 \mu\text{sec.}$$

$$F = 56.9523 \text{ N}$$



$$E_{\max} = 7.6240 \text{ V}$$

$$\Delta t = 9.60 \mu\text{sec.}$$

$$F = 59.9185 \text{ N}$$

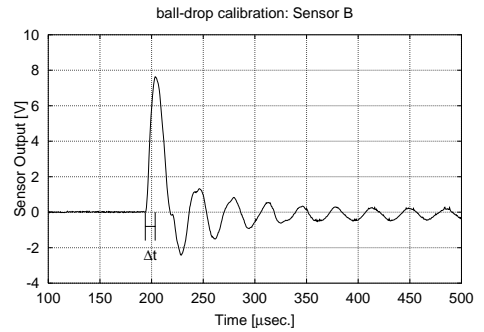
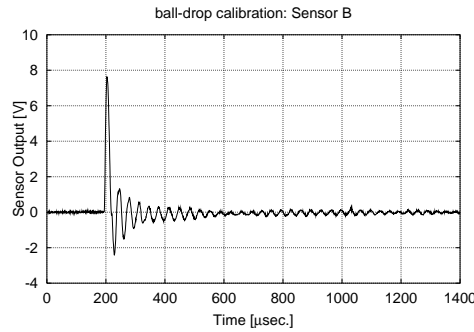
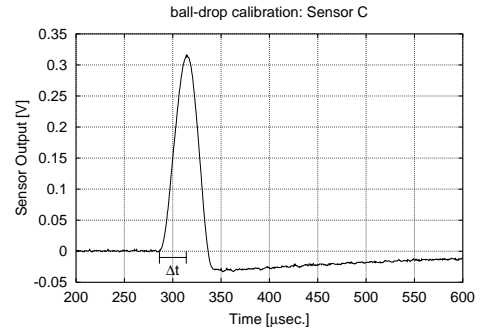
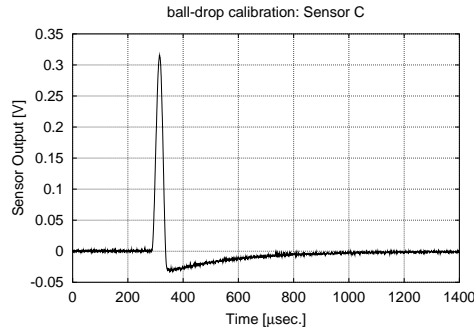


Fig. A.6: (continued)

$$E_{\max} = 0.3152 \text{ V}$$

$$\Delta t = 27.75 \mu\text{sec.}$$

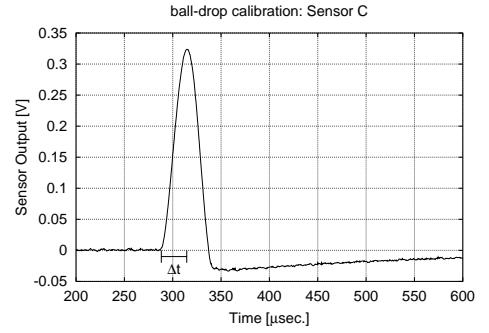
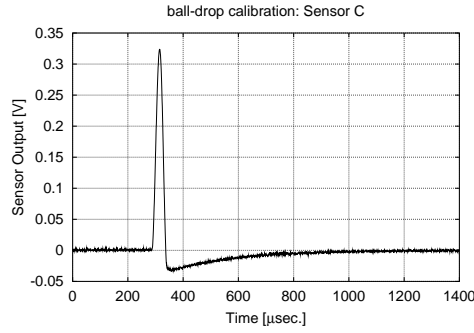
$$F = 5.3921 \text{ N}$$



$$E_{\max} = 0.3239 \text{ V}$$

$$\Delta t = 26.30 \mu\text{sec.}$$

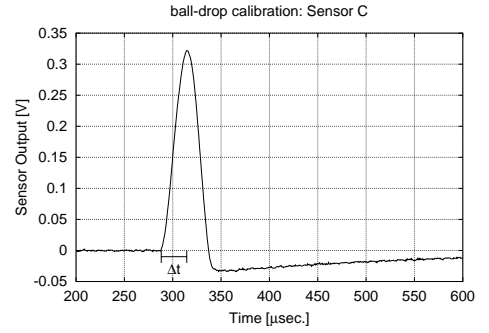
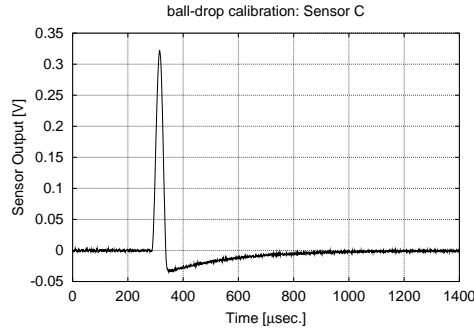
$$F = 5.6624 \text{ N}$$



$$E_{\max} = 0.3223 \text{ V}$$

$$\Delta t = 26.40 \mu\text{sec.}$$

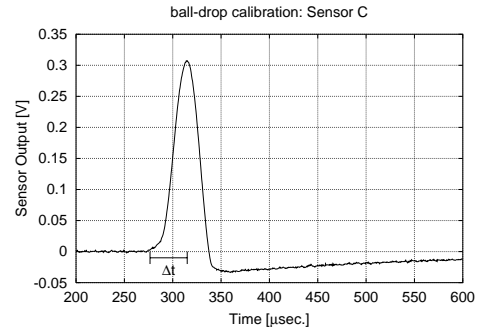
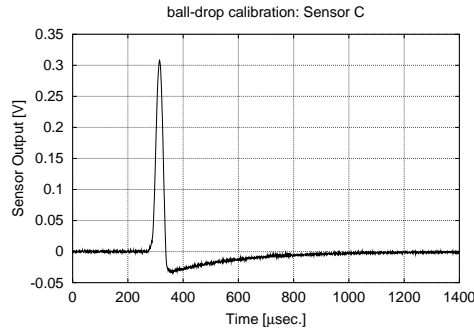
$$F = 5.6941 \text{ N}$$



$$E_{\max} = 0.3074 \text{ V}$$

$$\Delta t = 38.50 \mu\text{sec.}$$

$$F = 3.8751 \text{ N}$$



$$E_{\max} = 0.2970 \text{ V}$$

$$\Delta t = 33.30 \mu\text{sec.}$$

$$F = 4.4929 \text{ N}$$

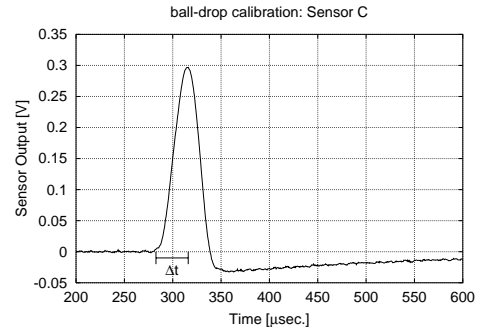
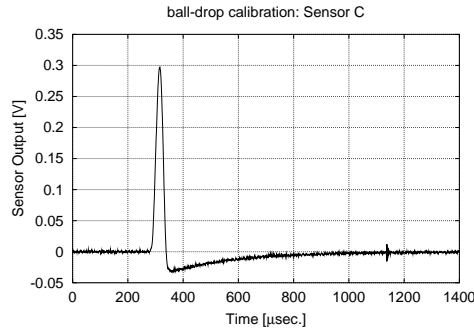
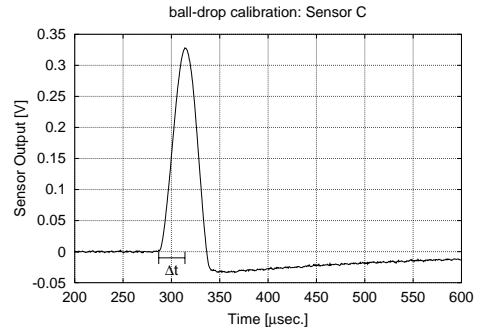
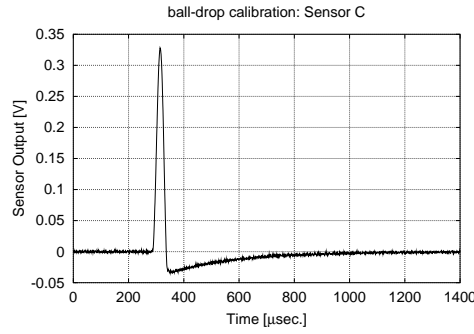


Fig. A.7: Output of Sensor C at ball-drop calibration.  $m = 0.130 \text{ g}$ ,  $h = 30 \text{ mm}$

$$E_{\max} = 0.3284 \text{ V}$$

$$\Delta t = 27.15 \mu\text{sec.}$$

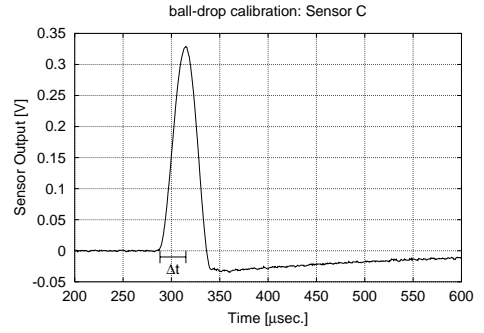
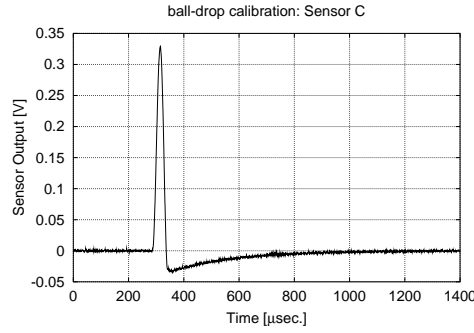
$$F = 5.5162 \text{ N}$$



$$E_{\max} = 0.3292 \text{ V}$$

$$\Delta t = 26.80 \mu\text{sec.}$$

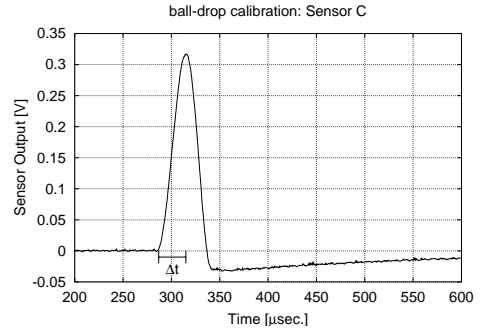
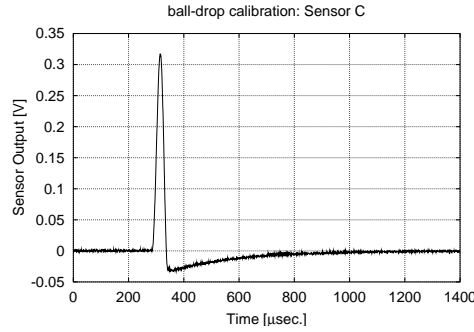
$$F = 5.6041 \text{ N}$$



$$E_{\max} = 0.3171 \text{ V}$$

$$\Delta t = 28.10 \mu\text{sec.}$$

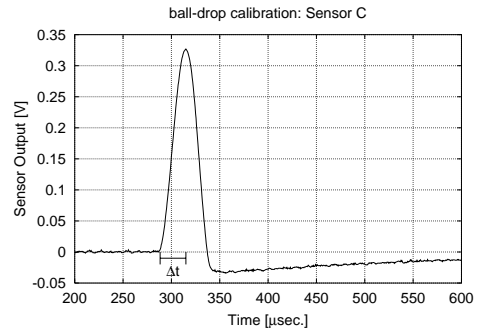
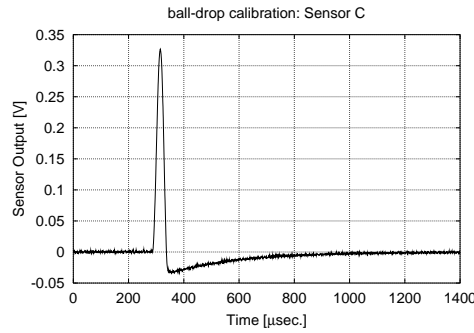
$$F = 5.3445 \text{ N}$$



$$E_{\max} = 0.3274 \text{ V}$$

$$\Delta t = 26.65 \mu\text{sec.}$$

$$F = 5.6353 \text{ N}$$



$$E_{\max} = 0.3406 \text{ V}$$

$$\Delta t = 26.40 \mu\text{sec.}$$

$$F = 5.7209 \text{ N}$$

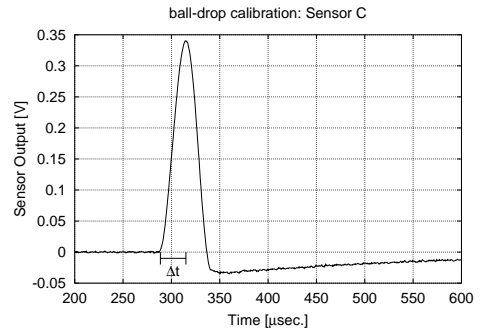
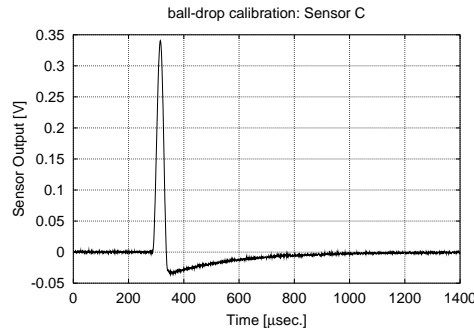


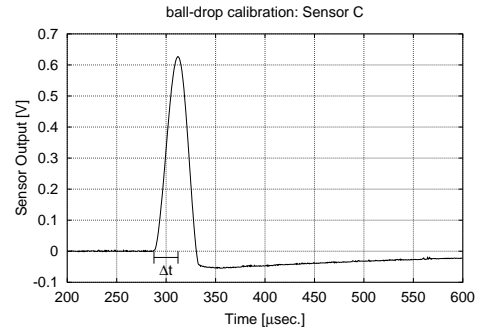
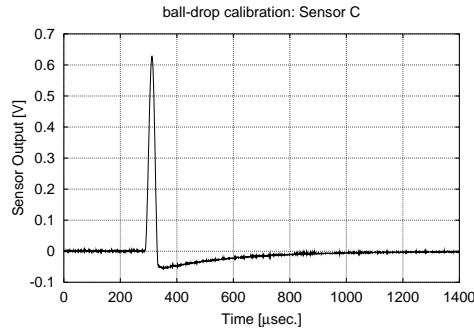
Fig. A.7: (continued)



$$E_{\max} = 0.6268 \text{ V}$$

$$\Delta t = 24.30 \mu\text{sec.}$$

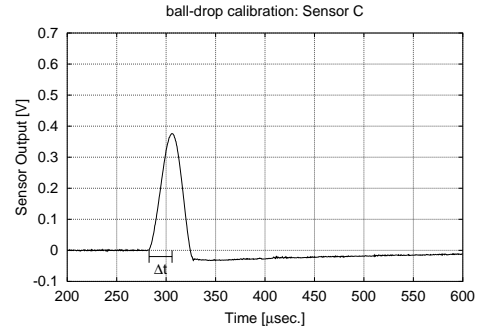
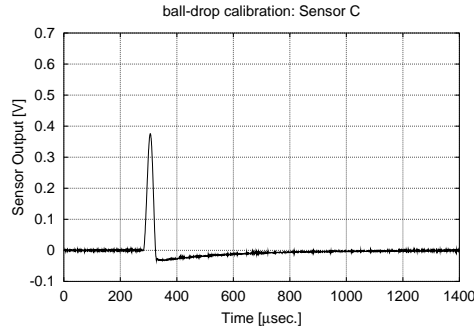
$$F = 10.2595 \text{ N}$$



$$E_{\max} = 0.3761 \text{ V}$$

$$\Delta t = 23.20 \mu\text{sec.}$$

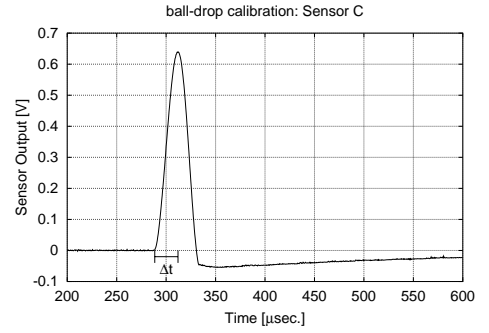
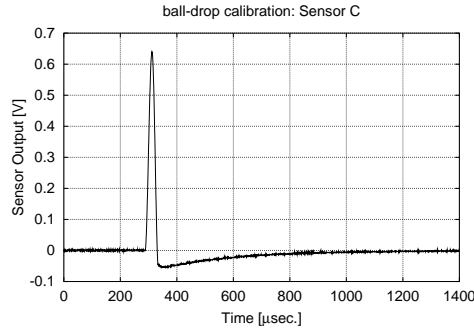
$$F = 10.7520 \text{ N}$$



$$E_{\max} = 0.6407 \text{ V}$$

$$\Delta t = 23.45 \mu\text{sec.}$$

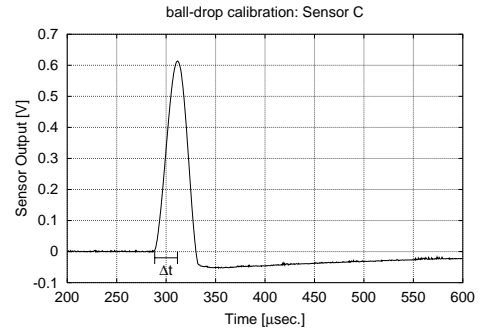
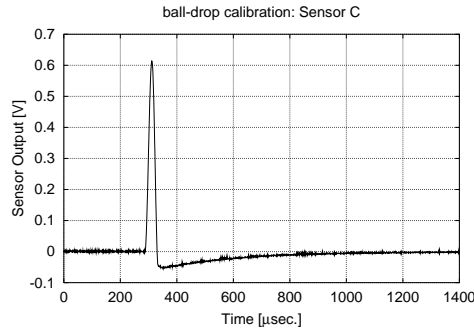
$$F = 10.6858 \text{ N}$$



$$E_{\max} = 0.6135 \text{ V}$$

$$\Delta t = 23.05 \mu\text{sec.}$$

$$F = 10.8589 \text{ N}$$



$$E_{\max} = 0.6477 \text{ V}$$

$$\Delta t = 24.60 \mu\text{sec.}$$

$$F = 10.1401 \text{ N}$$

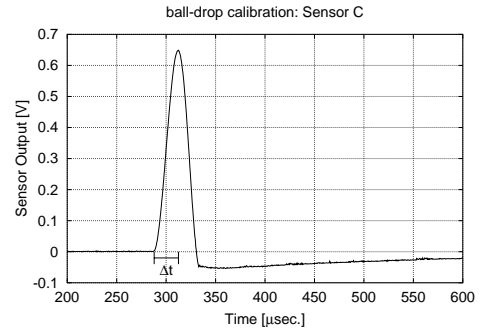
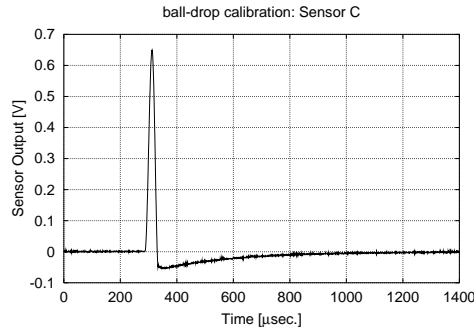
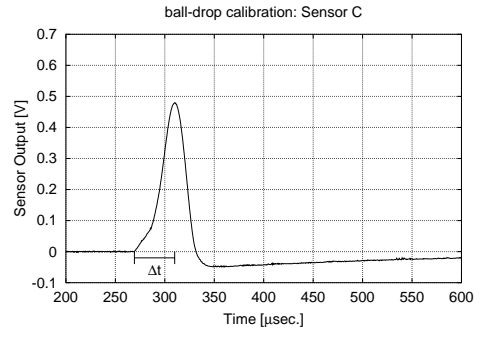
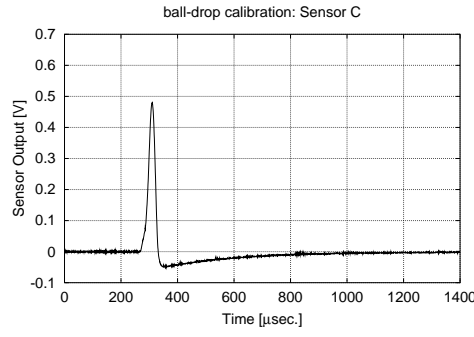


Fig. A.8: Output of Sensor C at ball-drop calibration.  $m = 0.130 \text{ g}$ ,  $h = 80 \text{ mm}$

$$E_{\max} = 0.4801 \text{ V}$$

$$\Delta t = 40.70 \mu\text{sec.}$$

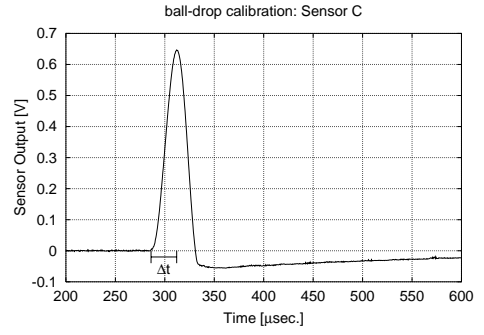
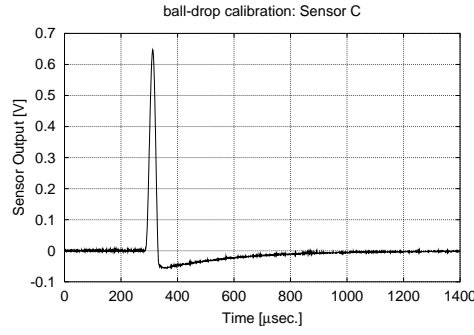
$$F = 5.9931 \text{ N}$$



$$E_{\max} = 0.6466 \text{ V}$$

$$\Delta t = 25.90 \mu\text{sec.}$$

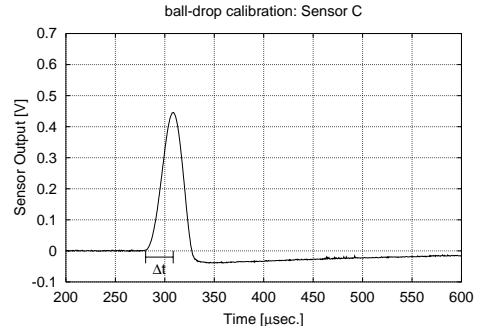
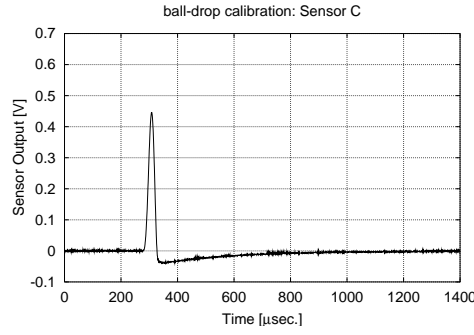
$$F = 9.6202 \text{ N}$$



$$E_{\max} = 0.4458 \text{ V}$$

$$\Delta t = 27.90 \mu\text{sec.}$$

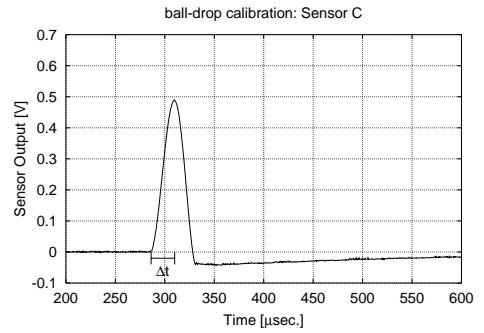
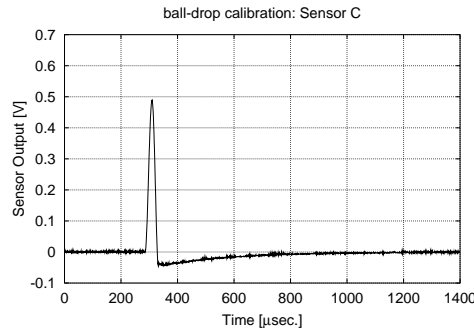
$$F = 8.8595 \text{ N}$$



$$E_{\max} = 0.4888 \text{ V}$$

$$\Delta t = 23.85 \mu\text{sec.}$$

$$F = 10.5006 \text{ N}$$



$$E_{\max} = 0.6371 \text{ V}$$

$$\Delta t = 24.10 \mu\text{sec.}$$

$$F = 10.3564 \text{ N}$$

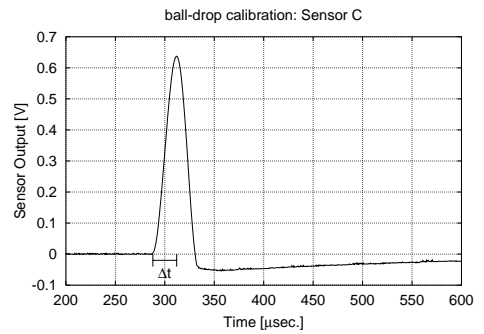
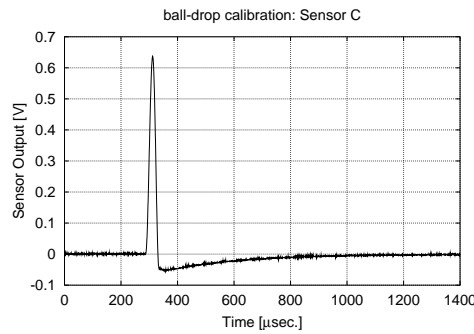
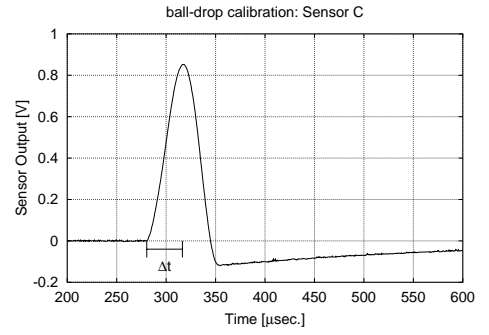
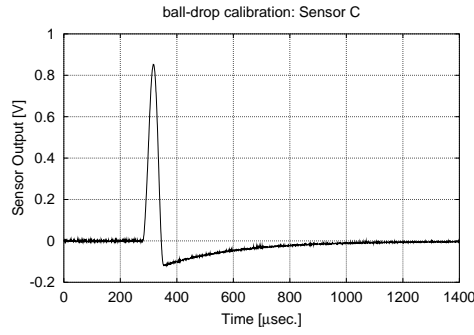


Fig. A.8: (continued)

$$E_{\max} = 0.8532 \text{ V}$$

$$\Delta t = 36.05 \mu\text{sec.}$$

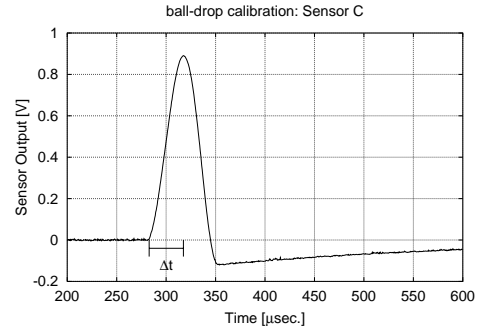
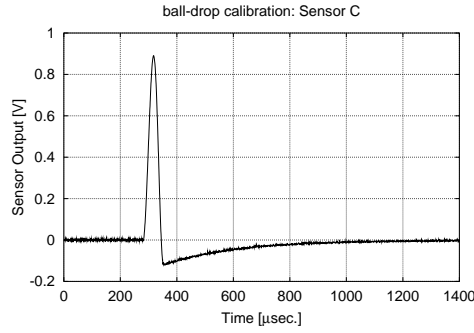
$$F = 14.8051 \text{ N}$$



$$E_{\max} = 0.8919 \text{ V}$$

$$\Delta t = 34.65 \mu\text{sec.}$$

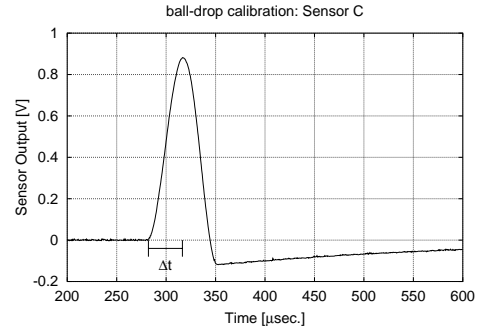
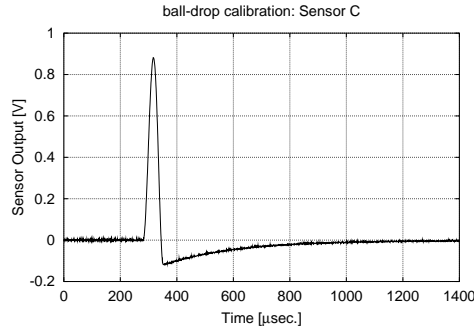
$$F = 15.3633 \text{ N}$$



$$E_{\max} = 0.8834 \text{ V}$$

$$\Delta t = 34.40 \mu\text{sec.}$$

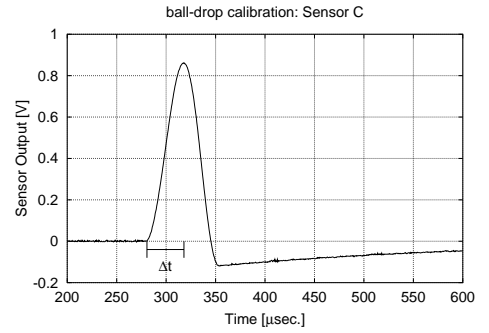
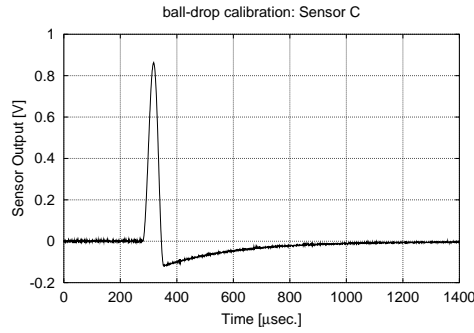
$$F = 15.4610 \text{ N}$$



$$E_{\max} = 0.8629 \text{ V}$$

$$\Delta t = 37.40 \mu\text{sec.}$$

$$F = 14.3220 \text{ N}$$



$$E_{\max} = 0.8718 \text{ V}$$

$$\Delta t = 35.10 \mu\text{sec.}$$

$$F = 15.2742 \text{ N}$$

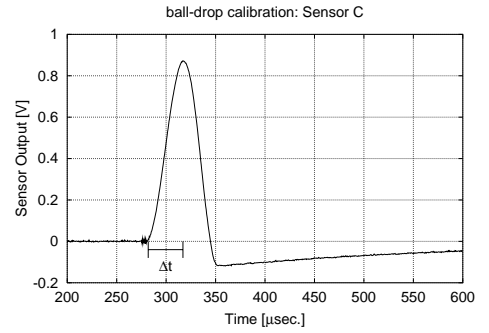
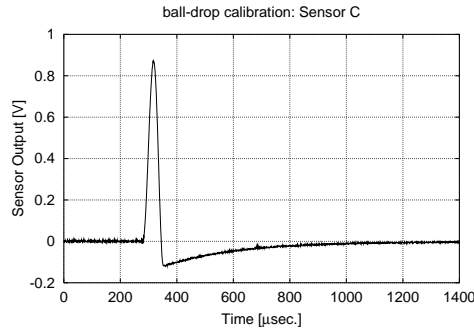
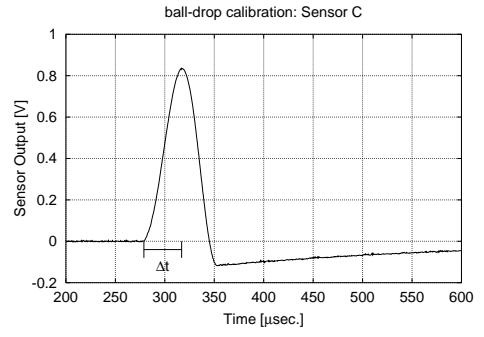
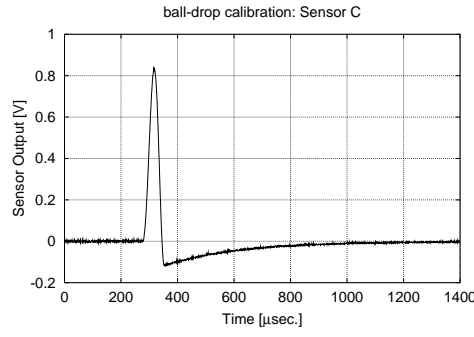


Fig. A.9: Output of Sensor C at ball-drop calibration.  $m = 0.440 \text{ g}$ ,  $h = 30 \text{ mm}$

$$E_{\max} = 0.8362 \text{ V}$$

$$\Delta t = 38.15 \mu\text{sec.}$$

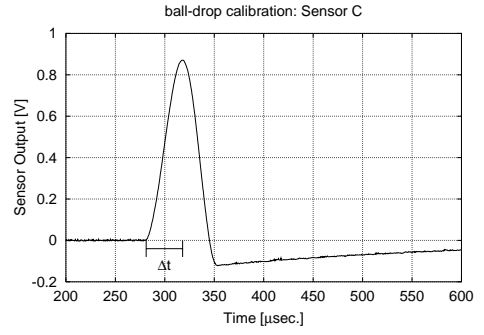
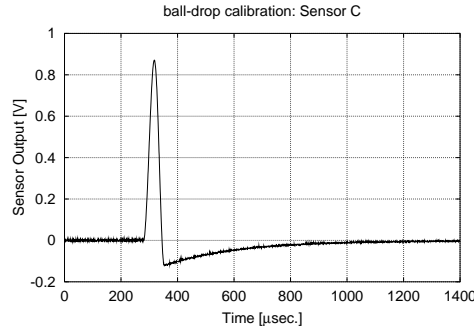
$$F = 13.8533 \text{ N}$$



$$E_{\max} = 0.8717 \text{ V}$$

$$\Delta t = 36.85 \mu\text{sec.}$$

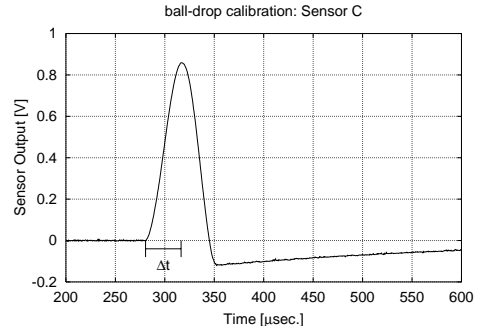
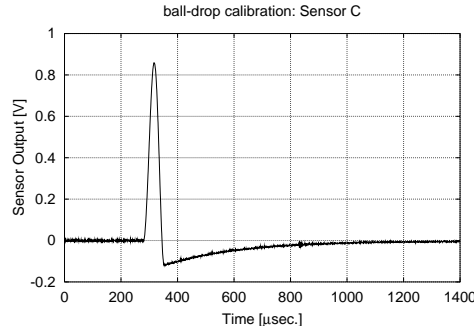
$$F = 14.6509 \text{ N}$$



$$E_{\max} = 0.8598 \text{ V}$$

$$\Delta t = 35.95 \mu\text{sec.}$$

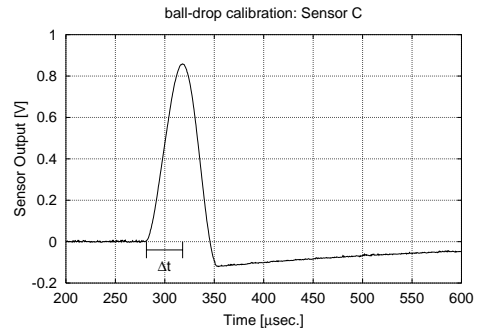
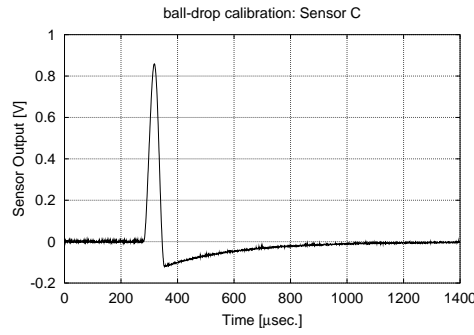
$$F = 14.8463 \text{ N}$$



$$E_{\max} = 0.8592 \text{ V}$$

$$\Delta t = 36.60 \mu\text{sec.}$$

$$F = 14.5827 \text{ N}$$



$$E_{\max} = 0.8639 \text{ V}$$

$$\Delta t = 36.35 \mu\text{sec.}$$

$$F = 14.7093 \text{ N}$$

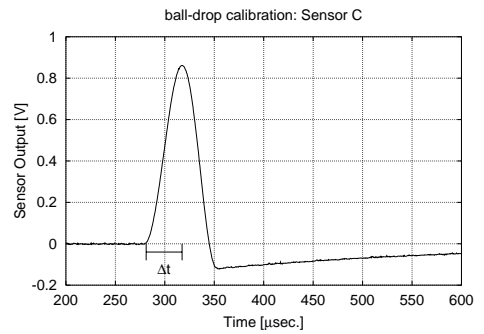
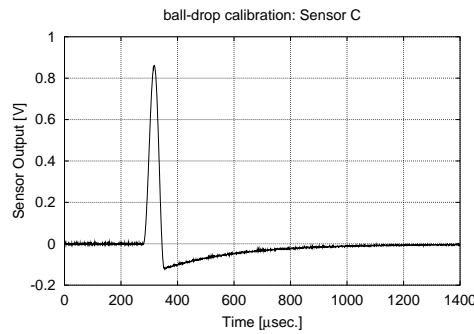


Fig. A.9: (continued)

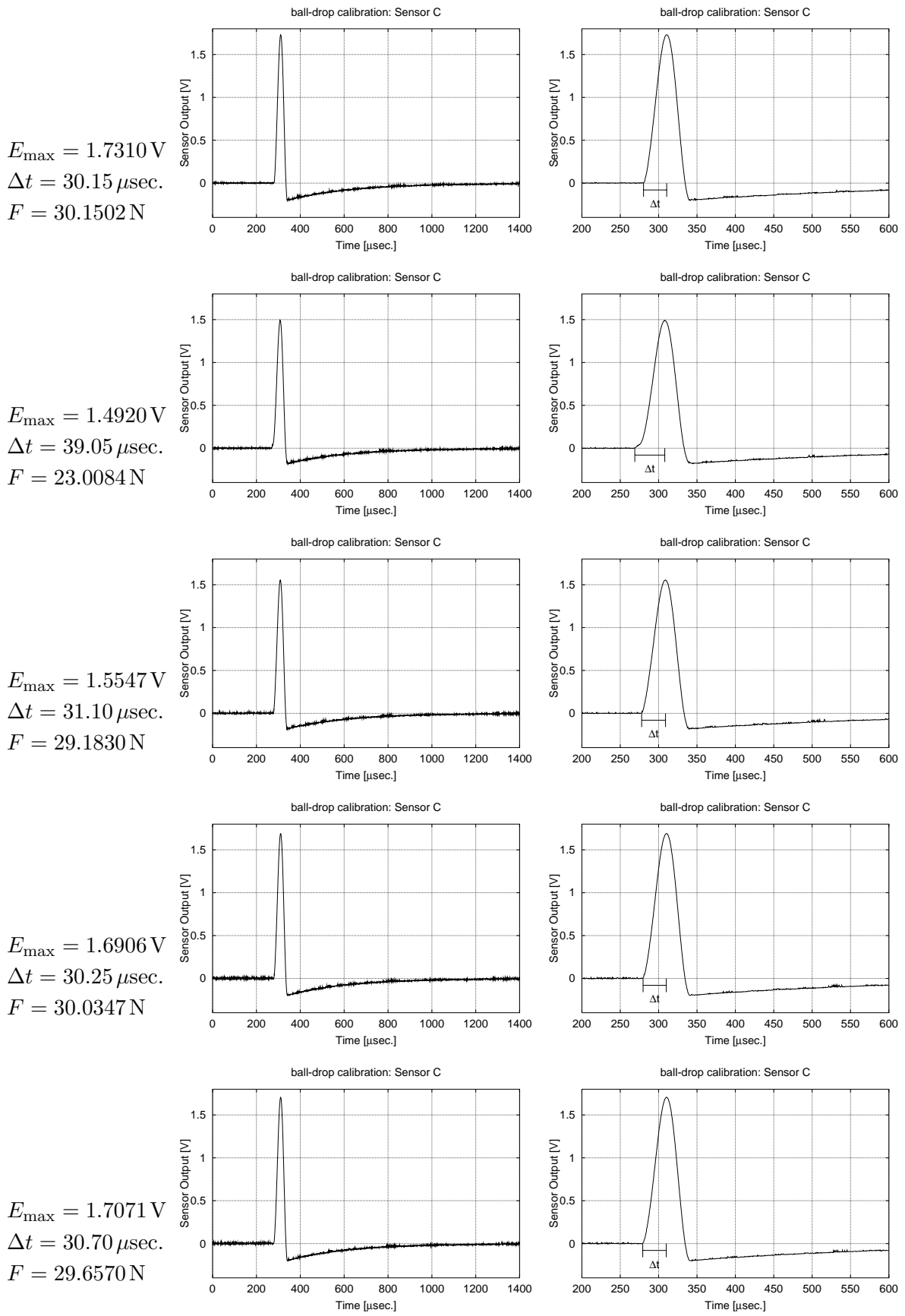
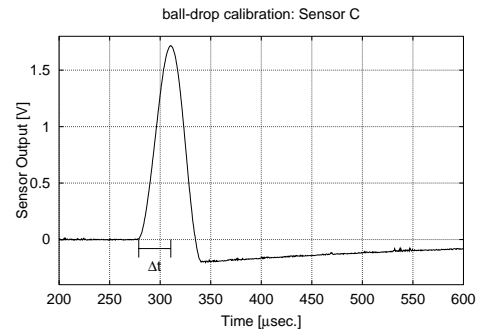
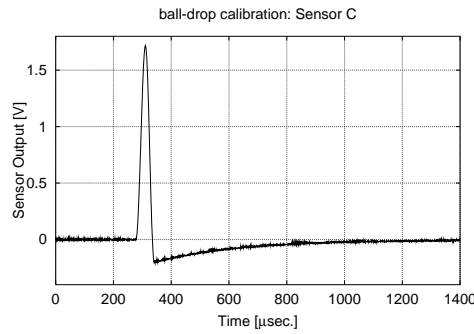


Fig. A.10: Output of Sensor C at ball-drop calibration.  $m = 0.440 \text{ g}$ ,  $h = 80 \text{ mm}$

$$E_{\max} = 1.7174 \text{ V}$$

$$\Delta t = 31.70 \mu\text{sec.}$$

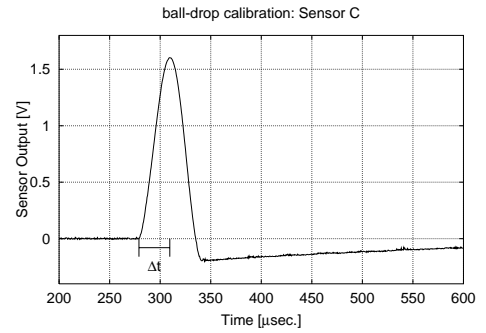
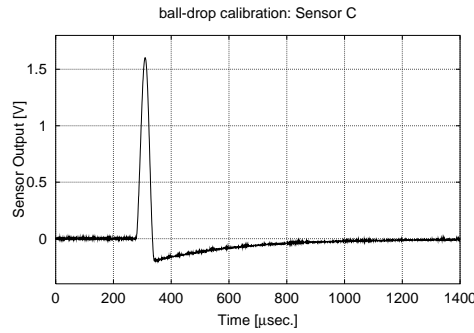
$$F = 28.6911 \text{ N}$$



$$E_{\max} = 1.6048 \text{ V}$$

$$\Delta t = 30.50 \mu\text{sec.}$$

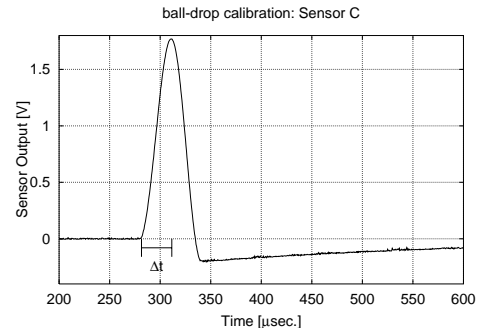
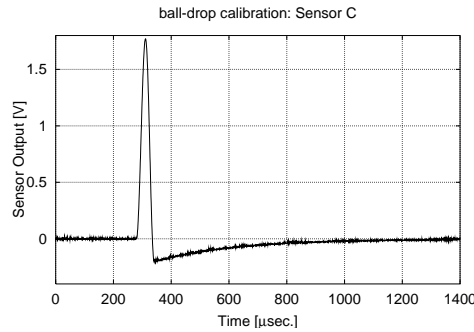
$$F = 30.2131 \text{ N}$$



$$E_{\max} = 1.7719 \text{ V}$$

$$\Delta t = 30.00 \mu\text{sec.}$$

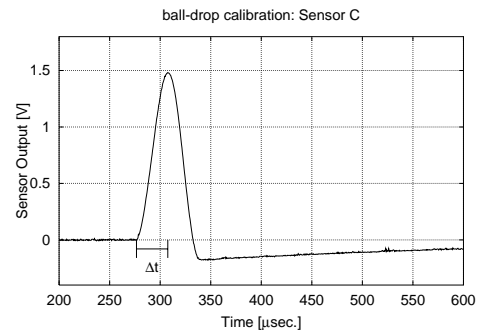
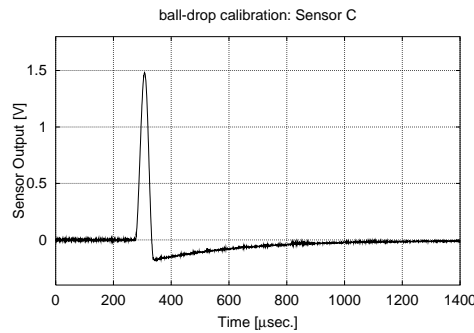
$$F = 30.3649 \text{ N}$$



$$E_{\max} = 1.4823 \text{ V}$$

$$\Delta t = 30.95 \mu\text{sec.}$$

$$F = 29.3864 \text{ N}$$



$$E_{\max} = 1.6488 \text{ V}$$

$$\Delta t = 30.95 \mu\text{sec.}$$

$$F = 29.2779 \text{ N}$$

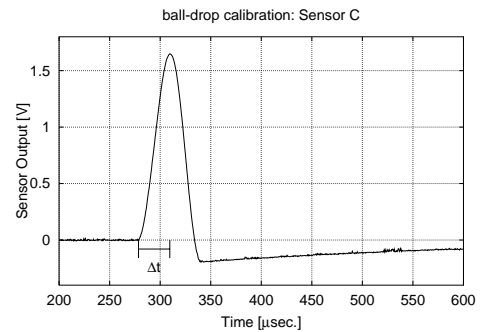
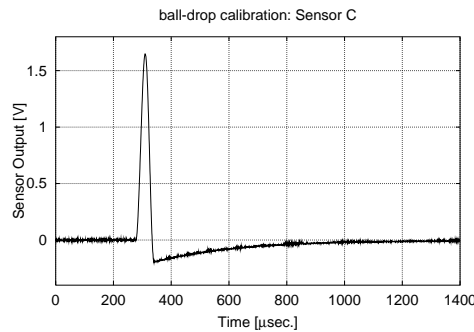
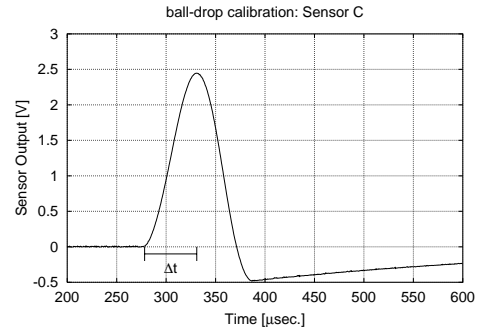
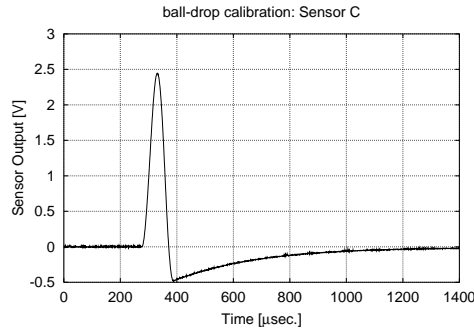


Fig. A.10: (continued)

$$E_{\max} = 2.4455 \text{ V}$$

$$\Delta t = 52.75 \mu\text{sec.}$$

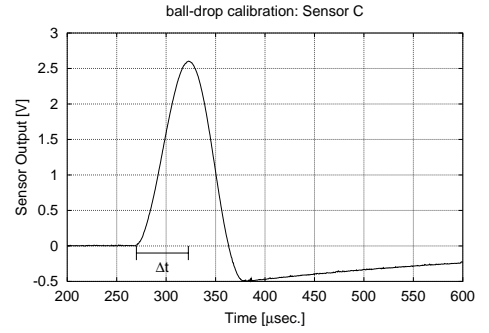
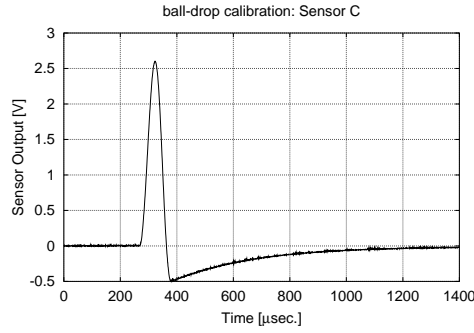
$$F = 49.6662 \text{ N}$$



$$E_{\max} = 2.5984 \text{ V}$$

$$\Delta t = 52.55 \mu\text{sec.}$$

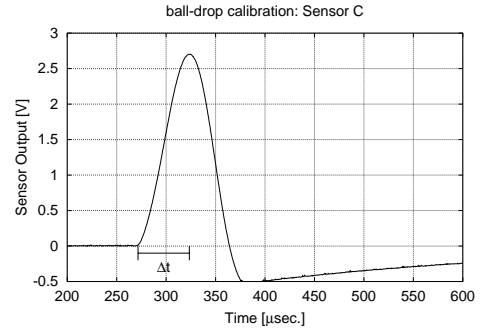
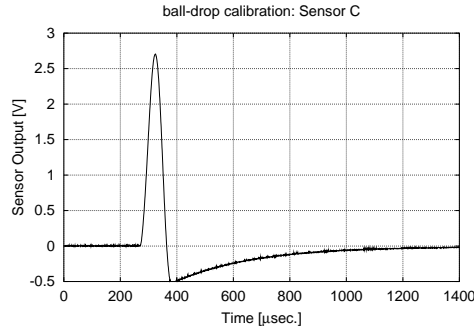
$$F = 50.1849 \text{ N}$$



$$E_{\max} = 2.7001 \text{ V}$$

$$\Delta t = 51.90 \mu\text{sec.}$$

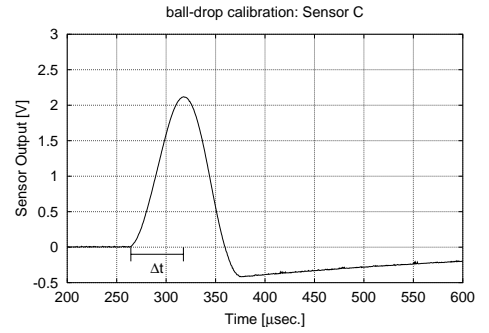
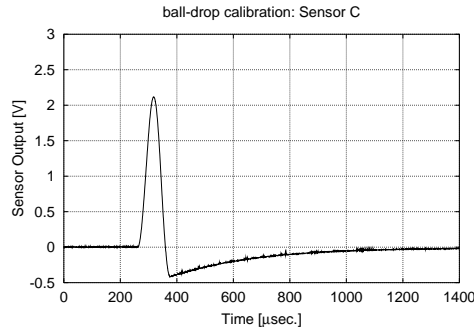
$$F = 51.3251 \text{ N}$$



$$E_{\max} = 2.1160 \text{ V}$$

$$\Delta t = 53.15 \mu\text{sec.}$$

$$F = 49.1651 \text{ N}$$



$$E_{\max} = 2.5234 \text{ V}$$

$$\Delta t = 55.30 \mu\text{sec.}$$

$$F = 46.4961 \text{ N}$$

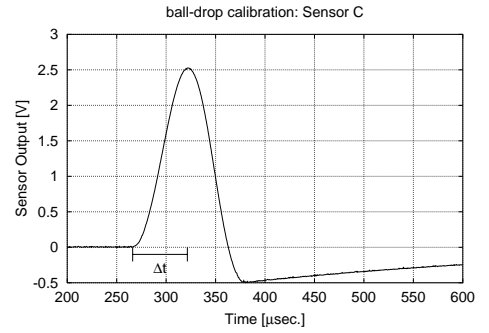
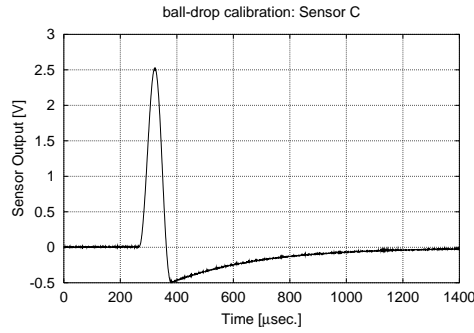
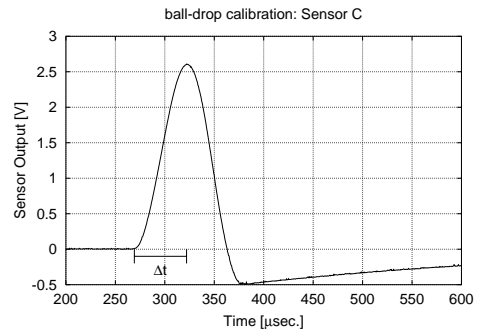
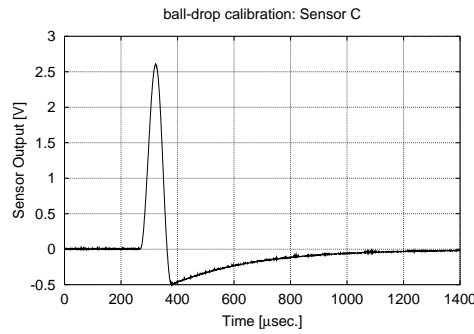


Fig. A.11: Output of Sensor C at ball-drop calibration.  $m = 2.030 \text{ g}$ ,  $h = 30 \text{ mm}$

$$E_{\max} = 2.6043 \text{ V}$$

$$\Delta t = 52.80 \mu\text{sec.}$$

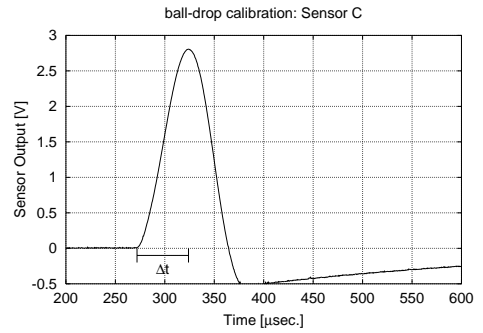
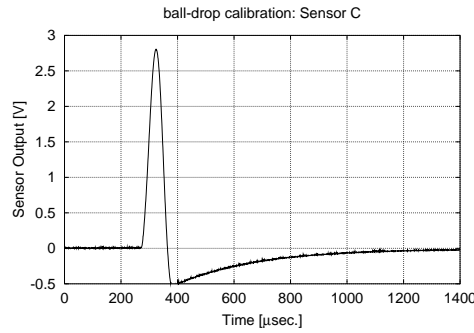
$$F = 50.5759 \text{ N}$$



$$E_{\max} = 2.8031 \text{ V}$$

$$\Delta t = 52.10 \mu\text{sec.}$$

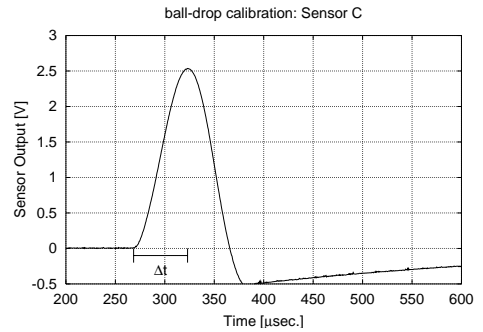
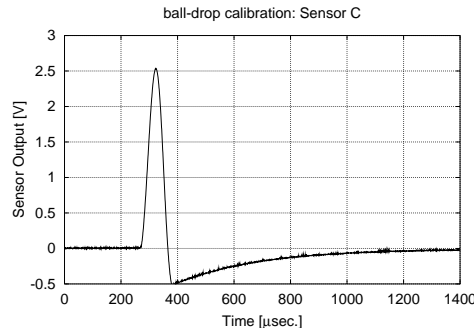
$$F = 51.3829 \text{ N}$$



$$E_{\max} = 2.5325 \text{ V}$$

$$\Delta t = 54.55 \mu\text{sec.}$$

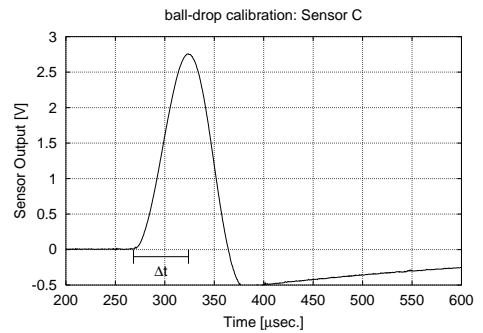
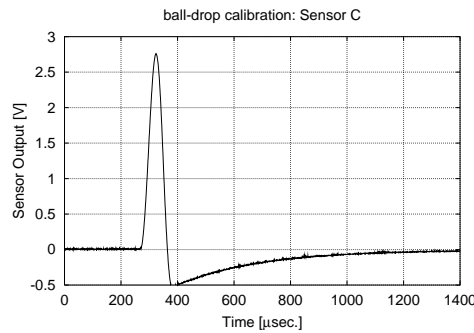
$$F = 49.6430 \text{ N}$$



$$E_{\max} = 2.7520 \text{ V}$$

$$\Delta t = 55.65 \mu\text{sec.}$$

$$F = 47.5484 \text{ N}$$



$$E_{\max} = 2.7082 \text{ V}$$

$$\Delta t = 56.80 \mu\text{sec.}$$

$$F = 46.8974 \text{ N}$$

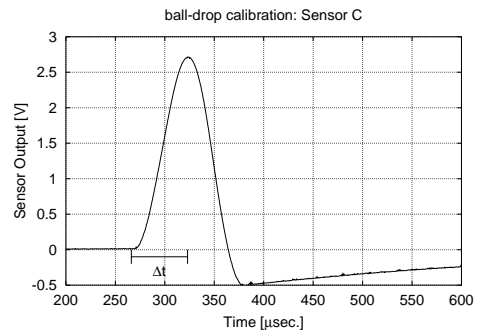
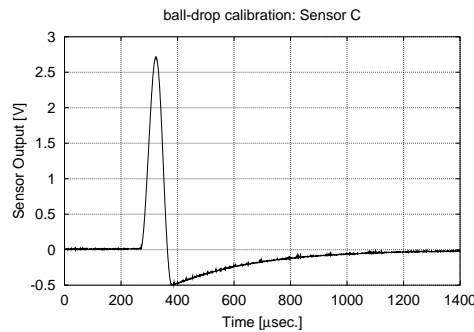


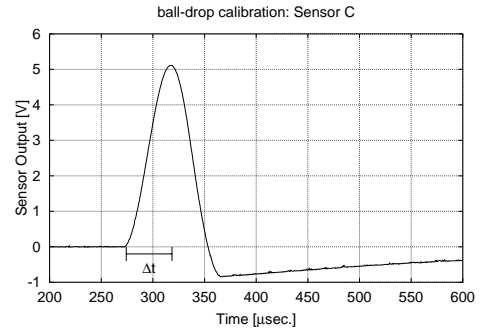
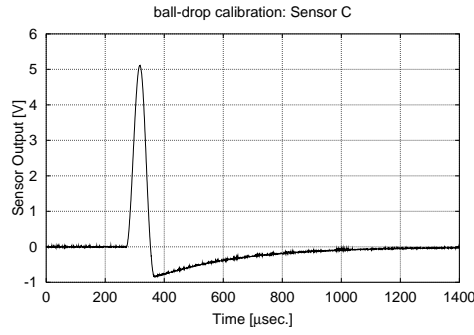
Fig. A.11: (continued)



$$E_{\max} = 5.1152 \text{ V}$$

$$\Delta t = 44.30 \mu\text{sec.}$$

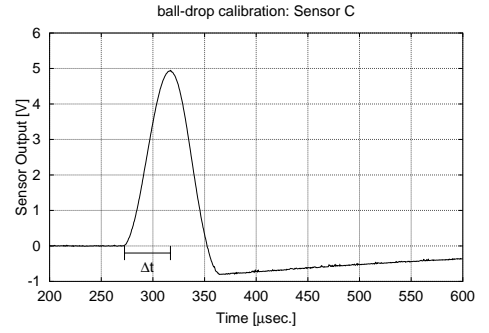
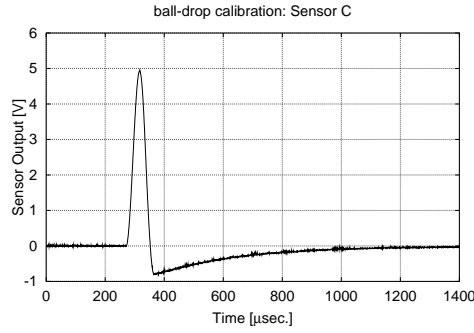
$$F = 101.8637 \text{ N}$$



$$E_{\max} = 4.9360 \text{ V}$$

$$\Delta t = 44.45 \mu\text{sec.}$$

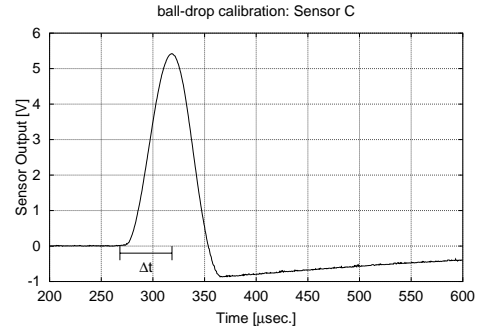
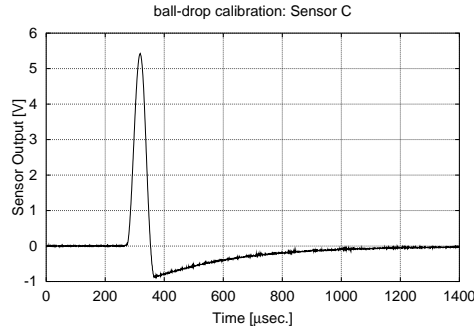
$$F = 101.5199 \text{ N}$$



$$E_{\max} = 5.4179 \text{ V}$$

$$\Delta t = 50.45 \mu\text{sec.}$$

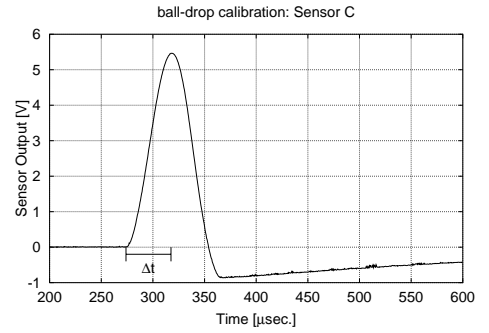
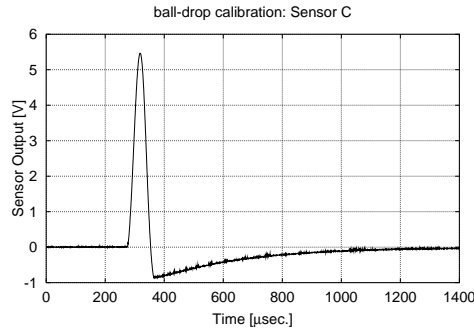
$$F = 89.1831 \text{ N}$$



$$E_{\max} = 5.4656 \text{ V}$$

$$\Delta t = 43.55 \mu\text{sec.}$$

$$F = 103.8212 \text{ N}$$



$$E_{\max} = 5.3578 \text{ V}$$

$$\Delta t = 46.70 \mu\text{sec.}$$

$$F = 96.8183 \text{ N}$$

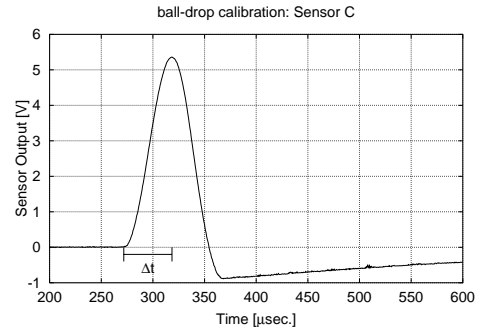
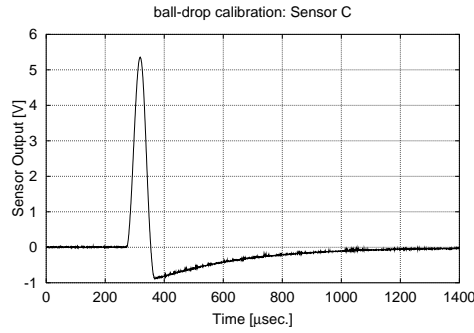
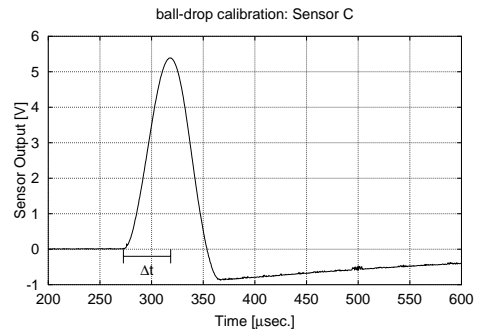
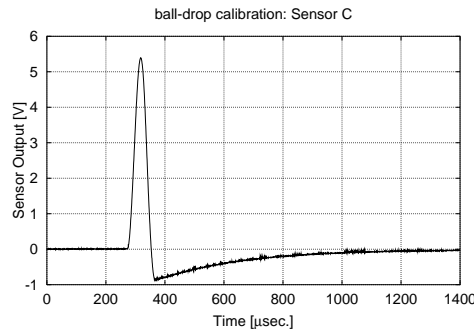


Fig. A.12: Output of Sensor C at ball-drop calibration.  $m = 2.030 \text{ g}$ ,  $h = 80 \text{ mm}$

$$E_{\max} = 5.3871 \text{ V}$$

$$\Delta t = 45.75 \mu\text{sec.}$$

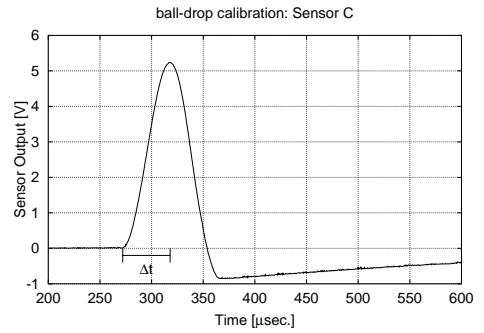
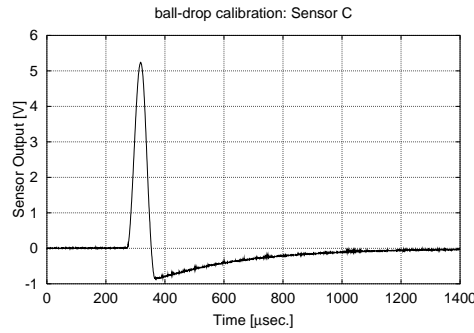
$$F = 98.7320 \text{ N}$$



$$E_{\max} = 5.2290 \text{ V}$$

$$\Delta t = 45.90 \mu\text{sec.}$$

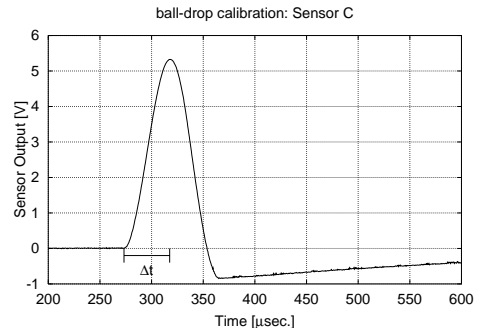
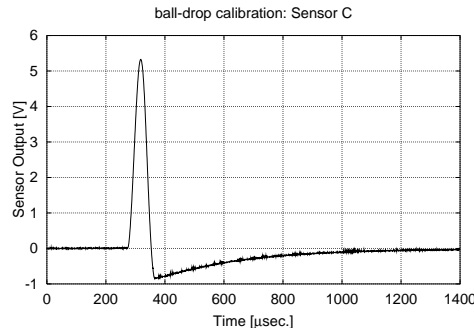
$$F = 98.0236 \text{ N}$$



$$E_{\max} = 5.3286 \text{ V}$$

$$\Delta t = 44.20 \mu\text{sec.}$$

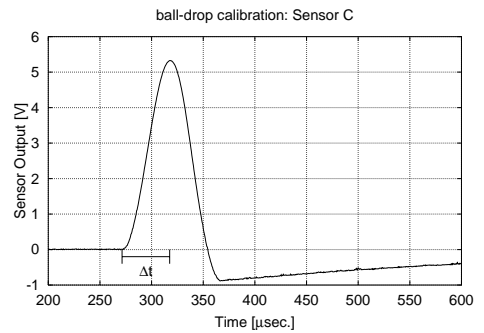
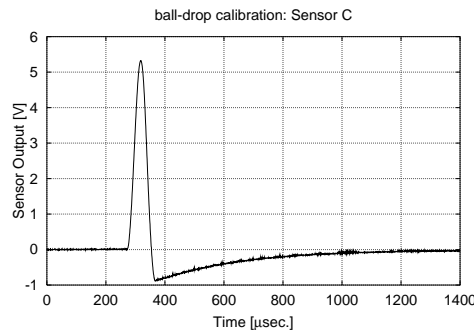
$$F = 102.2944 \text{ N}$$



$$E_{\max} = 5.3266 \text{ V}$$

$$\Delta t = 46.05 \mu\text{sec.}$$

$$F = 98.0888 \text{ N}$$



$$E_{\max} = 5.2458 \text{ V}$$

$$\Delta t = 46.00 \mu\text{sec.}$$

$$F = 97.8106 \text{ N}$$

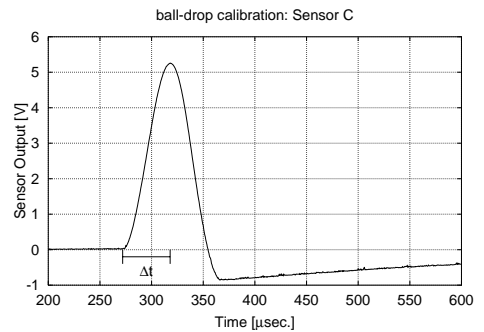
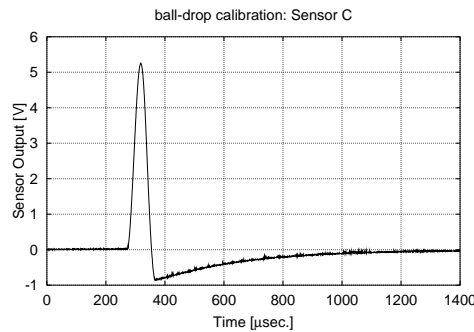


Fig. A.12: (continued)