HW #3 SOLUTION & NOTES

0) IN ITEM 0 OF HW#3 DEFINITION I STATED THAT "E_{FSR} IS EFFECTIVE FULL SCALE RANGE, ALSO CALLED THE VOLTAGE INPUT SPAN" WHICH IS CONSISTENT WITH TEXTBOOK NOTATION. THUS A 10V E_{FSR} COULD MEAN A 0 TO 10 VOLT INPUT A/D OR A $\pm$ 5V INPUT A/D.

MOST OF YOU FIGURED THAT OUT, BUT I'M JUST CONFIRMING.

1) $\text{RESOLUTION} = \frac{5V}{2^{11}} = \underline{2.441\ mV}$

$U_0 = \frac{1}{2}\,\text{RESOLUTION} = \frac{2.441}{2} = 1.22\ mV$

$U_{ACCURACY} = .0003 \times 5V = 1.5 mV$

WORST CASE IF BOTH ERRORS OCCUR SIMULTANEOUSLY WITH THE SAME POLARITY, i.e. JUST ADD

$$U_{WORST} = U_0 + U_{ACC} = 1.22 + 1.5 = \underline{\pm 2.72\ mV}$$

NOMINAL HERE MEANS COMBINE USING RMS

$$U_{NOM} = \sqrt{U_0^2 + U_{ACC}^2} = \sqrt{(1.22)^2 + (1.5)^2} = \underline{\pm 1.93\ mV}$$

$$= \frac{1.933\ mV}{5V} = \underline{.0387\%}$$

2) SEE TABLE 7.3 IN BOOK FOR EXAMPLES

RESULTS: REGISTER = $\underline{10100001} = 161_{10}$

$\text{RESOLUTION} = \frac{5V}{2^8} = 19.53\ mV$

$161 \times 19.531 = \underline{3.144\ V}$

DIFFERENCE = $3.150 - 3.144 = 6\ mV$

NOTE THAT THE QUANTIZATION UNCERTAINTY IS $\frac{19.53}{2} = 9.76\ mV$

THE DIFFERENCE BETWEEN INPUT VOLTAGE AND QUANTIZED VALUE IS LESS THAN THE QUANTIZATION UNCERTAINTY AS IT SHOULD BE.

3) COMMERCIAL 10 BIT A/D

a) RESOLUTION $= \frac{20V}{2^{10}} = \underline{19.53\ mV}$

b) FIGURING OUT HOW TO INTERPRET UNCERTAINTY DATA PROVIDED BY EQUIPMENT MAKERS CAN BE A CHALLENGE.

QUANTIZATION UNCERTAINTY $U_0 = \frac{19.53}{2} = \pm 9.77\ mV$

$U_{ACCURACY} = \pm .0025 \times FSR = \pm .0025 \times 10V = 25mV$

NO LINEARITY OR SIMILAR SPECS ARE GIVEN BUT SOMETHING CALLED "OVERALL INACCURACY" IS STATED AS $\pm 64\ mV$ AT 25°C. BECAUSE THIS IS SIGNIFICANTLY GREATER THAN $U_0 + U_{ACCURACY}$ I INTERPRET IT TO INCLUDE $U_0 + U_{ACCURACY}$ PLUS LINEARITY AND ANY OTHER ERRORS.

COMMUNICATION WITH THE DATAQ COMPANY WILL BE REQUIRED TO CONFIRM HOW TO INTERPRET THEIR SPECS.

c) FREQ'S <u>LESS</u> THAN 120 HZ WILL WORK

4) a) RESOLUTION $= \frac{20V}{2^{12}} = \underline{4.883\ mV}$

b) QUANTIZATION $U_0 = \frac{4.883}{2} = \pm 2.441\ mV$

$U_{ACCURACY}$ w/ 5V INPUT $= (.0001 \times 5_V) + 4.883mV = 5.383\ mV$

$U_{LINEARITY} = \pm 4.883\ mV$

$$U_{TOTAL} = \sqrt{\underbrace{(2.441)^2}_{[U_0]} + \underbrace{(5.383)^2}_{[U_{ACC}]} + \underbrace{(4.883)^2}_{[U_{LIN}]}} = \pm \underline{7.63\ mV}$$

c) FREQENCIES <u>LESS</u> THAN $\frac{100 \times 10^3}{2} = 55\ Ks/sec$

NOTE: IT'S POSSIBLE THAT THE ACCURACY SPEC GIVEN, i.e. 0.01% OF READING ± 1 bit INCLUDES THE U_0 UNCERTAINTY. AGAIN, A CALL TO THE COMPANY MIGHT CLEAR THIS UP.

IF SO, $U_{TOTAL} = \sqrt{(5.383)^2 + (4.883)^2} = \pm \underline{7.27\ mV}$