

The Effects of the Command Decoder Cycle Time on Short Exposures  
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The greater the accuracy of determination of the "true" exposure time for very short exposures, the greater the accuracy that could potentially be realized for the new absolute calibrations. For very short exposure time spectra the OBC tic digitization time (409.6 msec) as well as the rise and fall time of the camera voltages (120 msec) become significant. In addition, the 30 msec command decoder cycle time may also be significant. Three of the low-dispersion absolute calibration stars (Zeta Cas, Lambda Lep and Eta Aur) require exposure lengths of 1 OBC "tic" for the large-aperture point-source spectra. For these three stars, in particular, the command decoder cycle time may account for significant flux errors of individual spectra. The purpose of this study is to determine how to correct for the command decoder cycle time and what impact this has on the derivation of the new absolute calibrations.

No corrections for command decoder cycle time were included in the initial derivation of the new LWR absolute calibration because it was not known exactly how to correct the fluxes or if it was even possible to separate the repeatability errors from the command decoder cycle time errors. It was felt that it was better to use an average OBC "tic" length rather than do the correction wrong. After some discussion with D. Bradley and after looking at some of the absolute calibration data, I feel that it is possible to correct for the command decoder cycle time when enough 1 tic spectra are available for comparison.

Worker 2 cycles in units of 409.6 msec, while the command decoder cycles in units of 30 msec. Since these are not integral values of each other, the length of a 1-tic exposure varies between two values. The OBC exposure tic length of 409.6 msec is actually an average value, and 65% of the time a 1 OBC tic exposure will be 10.4 ms too long, while 35% of the time it will be 19.6 msec too short. Thus, after correction for the rise time of the camera (120 msec), the net exposure length will be 300 msec about 65% of the time and 270 msec about 35% of the time.

The 65%/35% distribution is not intuitively obvious, but can be understood with the help of Figure 1. Every 15 ms the command decoder cycles between accepting ground commands and accepting OBC commands. In addition, while accepting ground commands it is executing OBC commands and vice versa. Note that a command to start or stop a camera is an OBC controlled command. An OBC command must be received by the command decoder exactly at the beginning or before the start of a "G" cycle in Figure 1. If it is received in the middle of a "G" or "O" cycle it must wait until the next G cycle to be accepted by the command decoder. In addition, the actual OBC command to start an exposure takes about 10.3 msec to leave the command decoder during the "O" cycle. For example, if a command to start an exposure is received exactly at time  $t=0$ , then it will be executed at  $t=25.3$  msec.

Two general cases can be identified:

Case 1. Suppose the exposure start command is ready at the decoder between  $0 < t \leq 10.4$  msec after the beginning of the G1 cycle. It is not accepted by the decoder until the G2 cycle and the exposure will be started at  $t = 55.3$  msec, during the O2 cycle. Similarly, the exposure end command will be accepted by the decoder during the G15 cycle and executed at  $t = 445.3$  msec, during the O15 cycle. Thus, the 1-tic exposure is 390 msec in length or 19.6 msec shorter than the average of 409.6 msec.

Case 2. If the exposure start command is ready at the decoder between  $10.4 < t < 30$  msec, it will not be accepted by the decoder until G2 and will not be started until  $t = 55.3$  msec, during the O2 cycle. Similarly, the exposure end command will be accepted by the decoder during the G16 cycle and the exposure will be stopped at  $t = 475.3$  msec. Thus, the 1-tic exposure is 420 msec in length or 10.4 msec longer than the average of 409.6 msec.

If the commands arrive at random times at the decoder, case 1 will occur 35% of the time ( $10.4/30$ ) and case 2 will occur 65% of the time ( $30 - 10.4/30$ ).

The 1-tic exposure data acquired for the new LWR absolute calibration appear to show this effect. After the basic reductions were completed (i.e. processing with the new ITF, correction for THDA/sensitivity variations and division by the assumed exposure time of 289.6 msec) the available spectra for each star were averaged together. Next, the individual spectra (in units of FN/sec) were divided by the corresponding averaged spectrum. This was originally done to detect any gross errors. Figures 2-4 show the flux ratio's for the 3 Zeta Cas spectra. From these figures it can be seen that the flux for LWR 17783 is about 3% high compared to the averaged spectrum, while LWR 17784 is about 7% too low and LWR 17785 is about 5% too high.

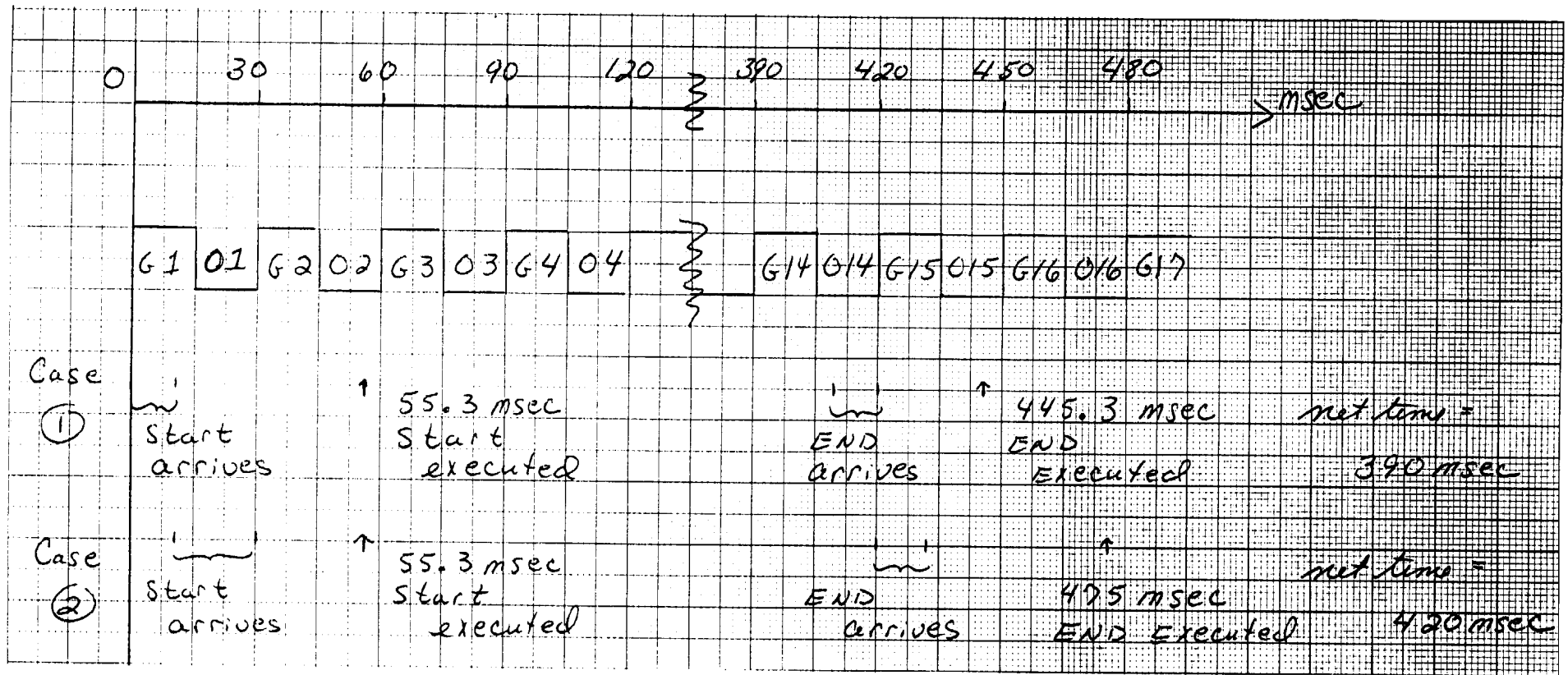
The flux errors expected due to this effect can be estimated by comparison of the "true" exposure time (i.e. corrected for decoder timing uncertainty) with the average exposure time. If the "true" exposure time for a given spectrum were 270 msec (and an average time of 289.6 msec was used) then the net flux should be too low by about 7% or  $[(270 - 289.6)/270]$ . Similarly if the "true" exposure time were 300 msec then the flux ratio should be high by about 3.5%. This is very similar to the errors seen for Zeta Cas (and the other two stars as well). This seems to imply that the best exposure time for LWR 17783 and 17785 should be 300 msec while the best time for LWR 17784 should be 270 msec. Looking over the 11 1 OBC tic exposures, I find 7 whose flux ratio is high and 4 low. This almost exactly agrees with the 65%/35% expected distribution. Of course, given the small number statistics this may just be a coincidence.

An estimate of the net inverse sensitivity curve error expected from using the average exposure time of 289.6 msec can be made. Assuming 7 of the spectra had +3.5% flux errors while 4 had -7.0% flux errors, then the net flux error averaged over the 11 spectra is -0.3%. Note that I've just averaged all the errors in for the 3 stars. This in turn implies an error of +0.3% in the derived average inverse sensitivity curve for the 3 stars and a net error of about 0.15% when all 6 OAO standards are averaged together. Thus the command decoder cycle time error has a negligible effect on the derivation of the LWR inverse sensitivity curve because a

sufficiently large number of spectra were used to average out this error.

So far this all looks very reasonable, however a couple of questions still remain. (1) The uncertainty due to the decoder cycle time is about equal to the uncertainty in the measurement of the 120 msec rise and fall time of the camera voltages. How do you separate the two errors? (2) The repeatability error of an individual spectrum is about 3% and is about equal to the expected flux error of +3.5% 35% of the time. Again, how do you separate the two errors? (3) Potential errors due to the command decoder cycle time were not included in the determination of the camera response time or of the determination of the repeatability error. This effect may be important for the camera response time test, which involved the use of multiple l-tic exposures. However, the effects of the decoder error was probably minimized in this study because a fairly large number of l-tic exposures (8-10) were used. The repeatability of 3% presumably was derived from stars with long exposure times for which the command decoder error is negligible.

Finally, since the decoder cycle time uncertainty is statistical in nature, there is no way to know how to correct an individual l-tic exposure. Thus, several l-tic exposures need to be obtained and compared before the correction can be determined. This uncertainty, of course, is important for the calibration standards as well as for the occasional l-tic guest observer spectrum.

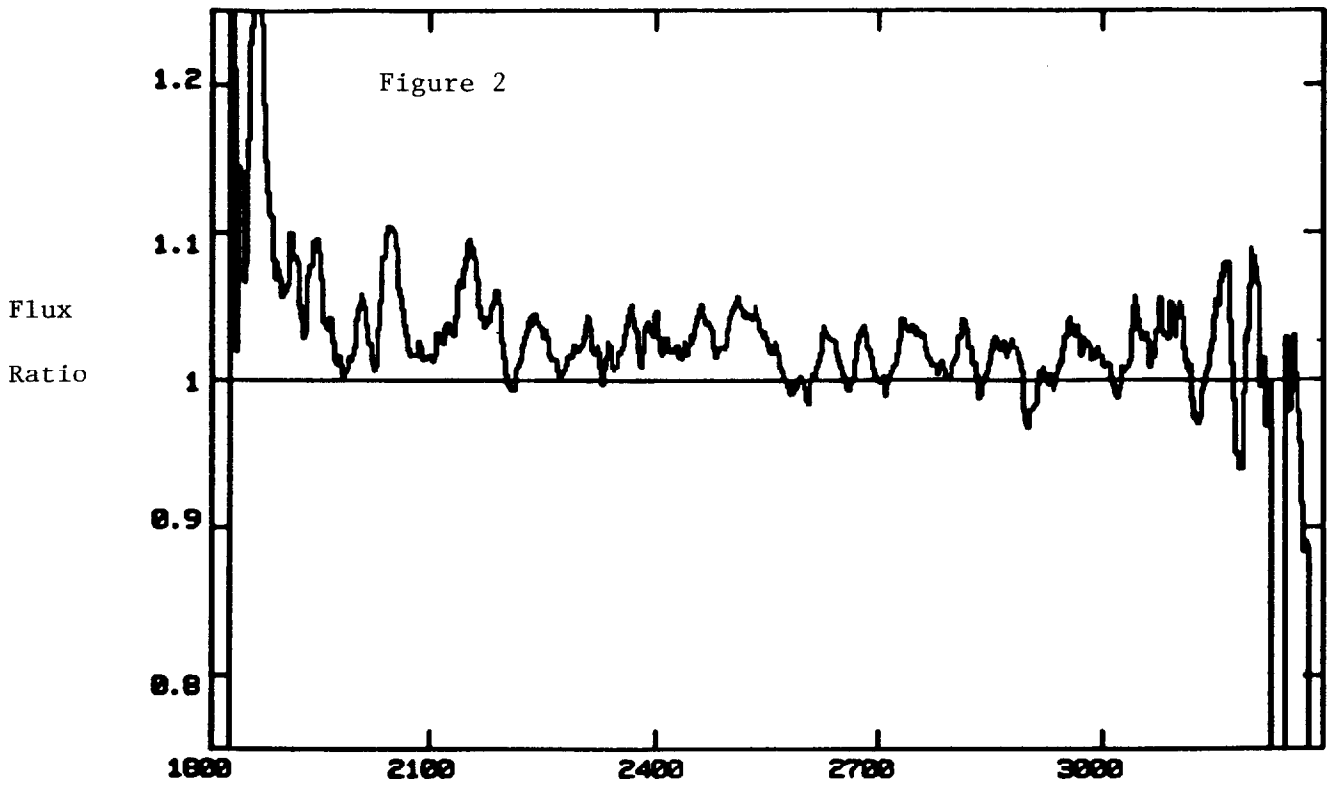


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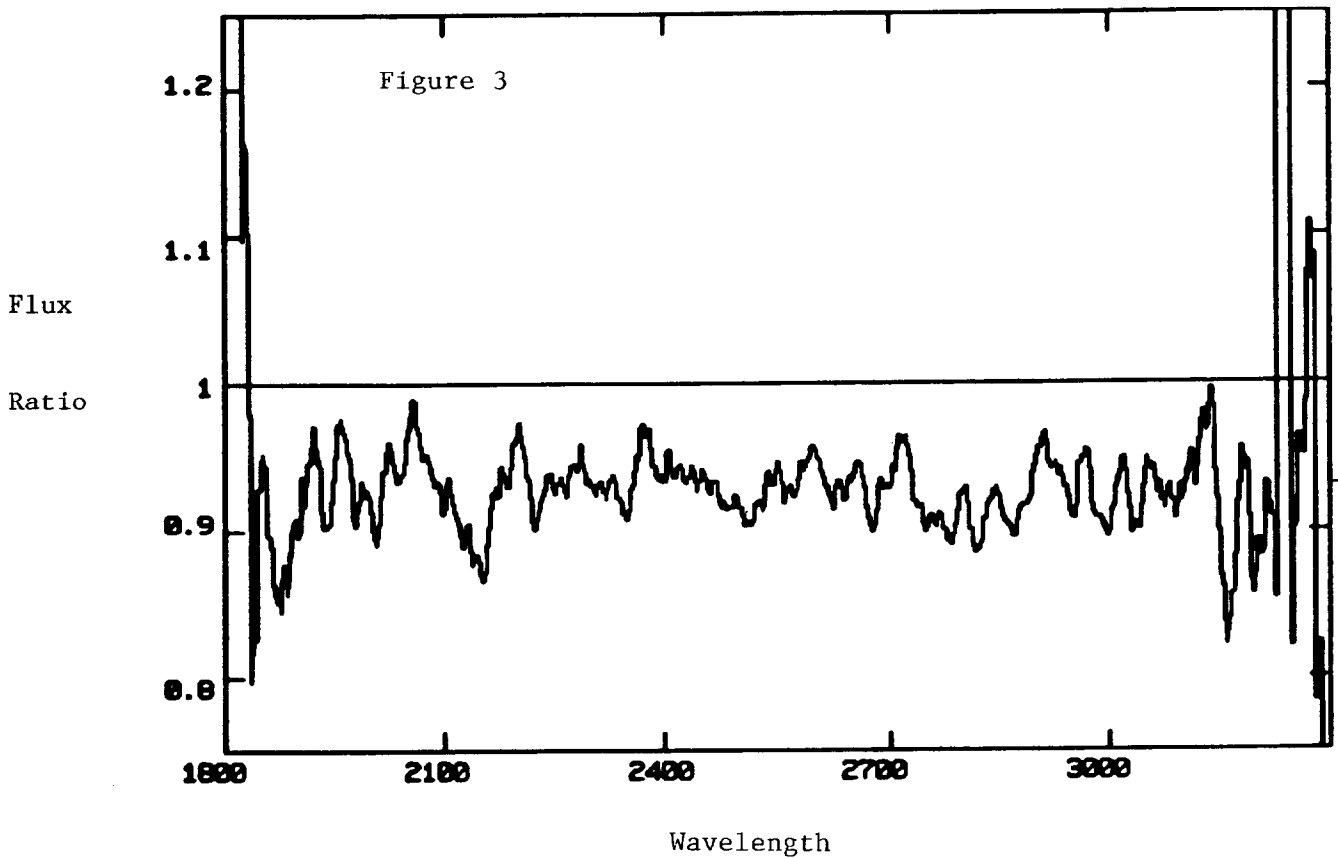
G = Execute ground commands + Receive OBC commands  
 O = Execute OBC commands + Receive ground commands

Figure 1 - Command Decoder Timing

ZETA CAS LWR 17783 / AVERAGE LGAP - POINT 10 PT SMOOTHED



ZETA CAS LWR 17784 / AVERAGE LGAP-POINT 10 PT SMOOTHED



ZETA ORS LWR 17785 / AVERAGE LGAP-POINT 10 PT SMOOTHED

