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LUMINARY Memo #141

To: Distribution
From: L. Berman
Date: 10 March 1970
Subject: Replacement of LOGSUB in Luminary

The Ascent Guidance Equations in LUMINARY require the generation of a logarithm, specifically $\log(1 - T_{go}/T_{Bup})$. To do this, a 7th order polynomial is used, with POLY doing the actual work. The setup for POLY is done in a section called LOGSUB.

It turns out that LOGSUB is not used anywhere else in LUMINARY. Since the accuracy of a 7th order polynomial is not needed in the guidance, it makes sense to replace it with a simpler procedure.

$$\log(1 - T_{go}/T_{Bup}) = -\frac{T_{go}}{T_{Bup}} - 1/2\left(\frac{T_{go}}{T_{Bup}}\right)^2 - 1/3\left(\frac{T_{go}}{T_{Bup}}\right)^3 \dots$$

For the kind of vehicles we are familiar with, T_{go}/T_{Bup} is normally not larger than about .5 (anything significantly larger means you have very little payload). Thus a short series should work adequately. With a little computation I have found

$$L = -\frac{T_{go}}{T_{Bup}} - .47150942\left(\frac{T_{go}}{T_{Bup}}\right)^2 - .54647754\left(\frac{T_{go}}{T_{Bup}}\right)^3$$

to look reasonable. Its error, $(L - \log)/\log$, is shown on the attached figure. Maximum error for $T_{go}/T_{Bup} \leq .5$ is about 1%, and for a LM-type vehicle, the equivalent error in T_{go} is reduced to .01 sec by the time T_{go} is reduced to 15 sec.

<u>old</u>		<u>new</u>	
DLOAD	DSU	DLOAD	DDV
	TBUP		TGO
	TGO		TBUP

<u>old</u>		<u>new</u>	
DDV	CALL	EXIT	
	TBUP	TC	POLY
	LOGSUB	DEC	2
SL	PUSH	2DEC	0
	5	2DEC	-1.0
	(8 reg)	2DEC	-0.47150942
	+	2DEC	-0.54647754
	LOGSUB (38 reg)	TC	INTPRET
	= 46 reg	PUSH	
			16 reg

A saving of 30 registers is seen (also some time saving), all in BANK 30, so that coding changes would be simple.

Error in the approximation

$$L = -\frac{T_{20}}{T_{sup}} - \kappa_2 \left(\frac{T_{20}}{T_{sup}}\right)^2 - \kappa_3 \left(\frac{T_{20}}{T_{sup}}\right)^3$$

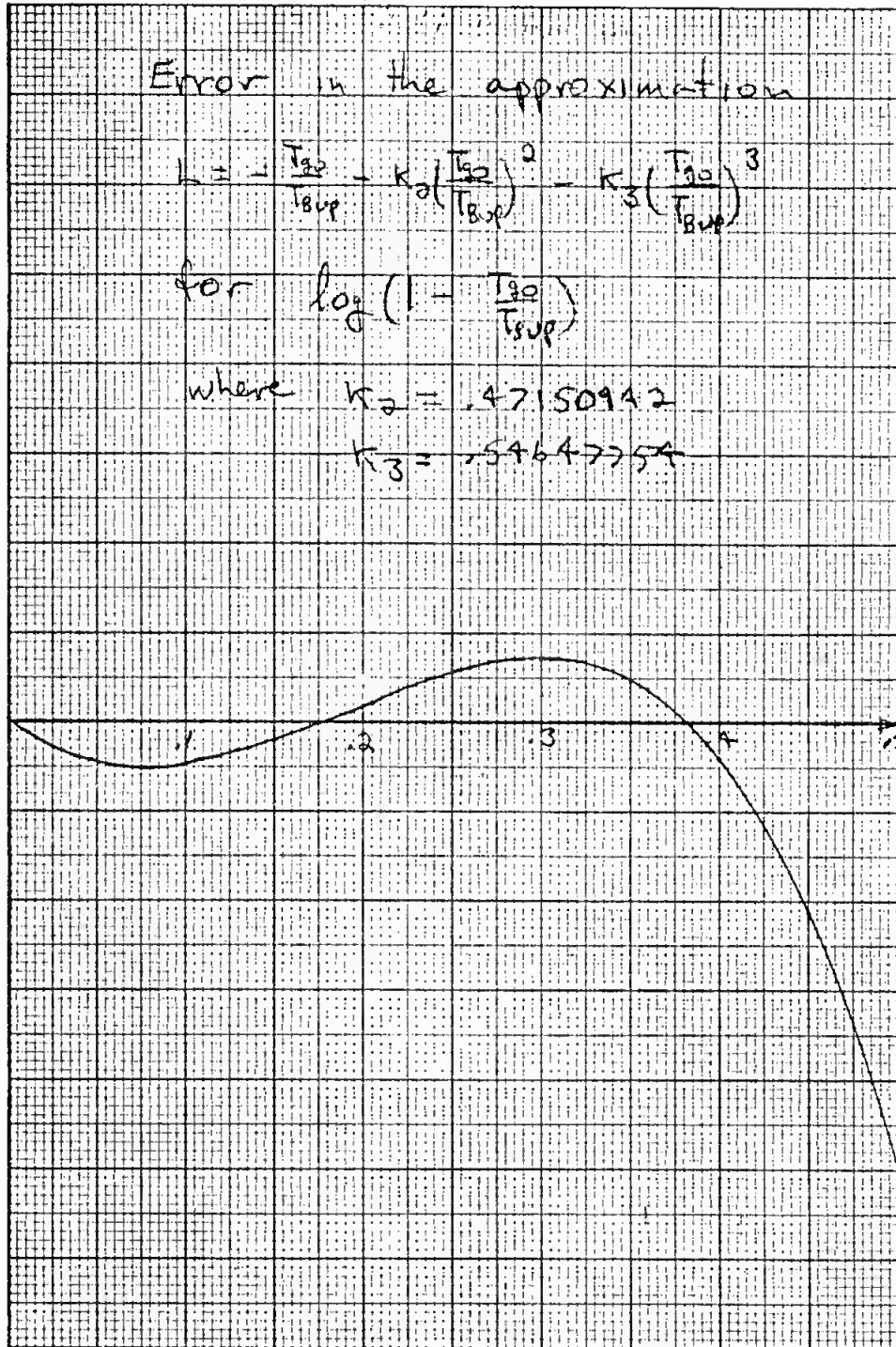
for $\log\left(1 - \frac{T_{20}}{T_{sup}}\right)$

where $\kappa_2 = .47150942$

$\kappa_3 = .54647754$

Error Ratio = $(L - \log) / \log$

.008
.004
0
-.004
-.008
-.012



$\frac{T_{20}}{T_{sup}}$