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AN ADAPTATION OF THE MINIMUM HF PROPAGATION
PREDICTION PROGRAM TO THE TI-59 CALCULATOR

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ABSTRACT

An algorithm for predicting the Maximum Usable Frequency between two points on the surface of the earth for High Frequency communications is implemented on a TI-59 hand-held programmable calculator.

1. INTRODUCTION

An algorithm for predicting the Maximum Usable Frequency (MUF) in the High Frequency radio band has been developed at the Naval Ocean Systems Center, San Diego, California, by R.B. Rose and J.N. Martin [1], and has been implemented in both FORTRAN IV and BASIC computer languages under the name MINIMUF-3.5. The algorithm has been incorporated into the CLASSIC PROFHET propagation analysis system, and has been demonstrated to provide a field-deployable capability for computing HF propagation paths with micro-computer resources.

2. OBJECTIVE

The essential portions of MINIMUF-3.5 are contained in approximately 80 BASIC language statements, reproduced in appendix A, which suggests a potential for being encoded in hand-held programmable calculators. H.F. Hite of Hughes Aircraft Company adapted a restricted version of MINIMUF-3.0 for the HF-67 calculator that computes MUFs for 1-hop F-layer propagation and is thus limited to station separations of 4000 kilometers or less. A complete implementation of MINIMUF, capable of 2-hop path prediction, was desired.

3. PROGRAM DEVELOPMENT

A TI-59 calculator program was adapted directly from the Rose and Martin BASIC program listing with some logic changes required to accommodate the memory constraints of the calculator. The program listing, summary of logic changes, operating instructions, and test case are contained in appendices B, C, D, and E, respectively. The program listing is annotated with cross-references to statements in the BASIC listing for assistance in tracing logic flow. The bulk of the development task was to minimize program and data storage requirements. Several iterations finally produced the current version which requires 800 program steps and 20 data registers, the full capacity of the normally-accessible calculator attributes.

4. PERFORMANCE

The TI-59 program was optimized for storage, that being the overriding constraint. Execution time for single-hop predictions is approximately 50 seconds. Were the program optimized for speed, given a larger storage capacity, execution time could conceivably approach 40 seconds. The test case contained in appendix E is the identical test case promulgated with the Rose and Martin report, and yields the same results on the TI-59. Notice, however, that the MUF limit of 32 MHz has been raised to 50 MHz, thereby providing

for HF path prediction during periods of high solar flux when customary band limitations are exceeded. The test case should be executed after initially programming the TI-59 by keystroke to ensure correct program entry. A copy of the program is available on magnetic cards by sending two blank cards to the authors, however, the user is cautioned that magnetic cards are not guaranteed to be transportable among all TI-59 calculators.

5. CONCLUSIONS AND RECOMMENDATIONS

A capability for predicting Maximum Usable Frequencies in the HF radio band can be realized with hand-held calculators, and therefore can be widely deployed in the field. An even larger capability can be realized by utilizing custom made modules for the TI-59. Each module provides for 5000 program steps in addition to the normal 960 maximum step capacity of the calculator, and could provide for additional portions of the CLASSIC PROPHEET System to be included in calculator implementations, such as the D-region absorption model. Appendix F lists several persons to contact in regard to having custom modules manufactured for the TI-59.

APPENDIX A

BASIC MINIMUF-3.5 PROGRAM LISTING

The BASIC language listing of MINIMUF-3.5 is reprinted here with the permission of R.B. Rose, and serves as a guide for the TI-59 keystroke listing.

MINIMUF-3.5 PROGRAM

```

1000 REM
1010 K7=SIN(L1)*SIN(L2)+COS(L1)*COS(L2)*COS(W2-W1)
1020 G1=ACS(K7 MAX -1+1.0E-5 MIN 1-1.0E-8)
1030 K6=1.59*G1
1040 K6=K6 MAX 1
1050 K5=1/K6
1060 J9=100
1070 FOR K1=1/(2*K6) TO 1-1/(2*K6) STEP 0.9999-1/K6
1080 IF K5=1 THEN 1100
1090 K5=0.5
1100 P=SIN(L2)
1110 Q=COS(L2)
1120 A=(SIN(L1)-P*COS(G1))/(Q*SIN(G1))
1130 B=G1*K1
1140 C=P*COS(B)+Q*SIN(B)*A
1150 D=(COS(B)-C*P)/(Q*SQR(1-C*C))
1160 D=ACS(D MAX -1+1.0E-5 MIN 1-1.0E-8)
1170 W0=W2+SGN(SIN(W1-W2))*D
1180 IF W0=>0 THEN 1200
1190 W0=W0+P1
1200 IF W0<P1 THEN 1220
1210 W0=W0-P1
1220 L0=P0-ACS(C MAX -1+1.0E-5 MIN 1-1.0E-8)
1230 Y1=0.0172*(10+(W0-1)*30.4+D6)
1240 Y2=0.409*COS(Y1)
1250 K8=3.82*W0+12+0.13*(SIN(Y1)+1.2*SIN(2*Y1))
1260 K8=K8-12*(1+SGN(K8-24))*SGN(ABS(K8-24))
1270 IF COS(L0+Y2)>-0.26 THEN 1350
1280 K9=0
1290 G0=0
1300 M9=2.5*G1*K5
1310 M9=M9 MIN P0
1320 M9=SIN(M9)
1330 M9=1+2.5*M9*SQR(M9)
1340 G0 TO 1590
1350 K9=(-0.26+SIN(Y2)*SIN(L0))/(COS(Y2)*COS(L0)+1.0E-3)
1360 K9=12-ATH(K9/SQR(ABS(1-K9*K9)))*7.639437
1370 T=K8-K9/2+12*(1-SGN(K8-K9/2))*SGN(ABS(K8-K9/2))
1380 T4=K8+K9/2-12*(1+SGN(K8+K9/2-24))*SGN(ABS(K8+K9/2-24))

```

```

1390 C0=ABS(COS(L0+Y2))
1400 T9=9.7*C0+9.6
1410 IF T9>0.1 THEN 1430
1420 T9=0.1
1430 M9=2.5*G1*K5
1440 M9=M9 MIN P0
1450 M9=SIN(M9)
1460 M9=1+2.5*M9*SQR(M9)
1470 IF T4<T THEN 1500
1480 IF (T5-T)*(T4-T5)>0 THEN 1510
1490 GO TO 1640
1500 IF (T5-T4)*(T-T5)>0 THEN 1640
1510 T6=T5+12*(1+SGN(T-T5))*SGN(ABS(T-T5))
1520 G9=PI*(T6-T)/K9
1530 G8=PI*T9/K9
1540 U=(T-T6)/T9
1550 G0=C0*(SIN(G9)+G8*(EXP(U)-COS(G9)))/(1+G8*G8)
1560 G7=C0*(G8*(EXP(-K9/T9)+1))*EXP((K9-24)/2)/(1+G8*G8)
1570 IF G0=>G7 THEN 1590
1580 G0=G7
1590 G2=(1+S9/250)*M9*SQR(6+58*SQR(G0))
1600 G2=G2*(1-0.1*EXP((K9-24)/3))
1610 G2=G2*(1+(1-SGN(L1))*SGN(L2))*0.1)
1620 G2=G2*(1-0.1*(1+SGN(ABS(SIN(L0))-COS(L0))))
1630 GO TO 1700
1640 T6=T5+12*(1+SGN(T4-T5))*SGN(ABS(T4-T5))
1650 G8=PI*T9/K9
1660 U=(T4-T6)/2
1670 U1=-K9/T9
1680 G0=C0*(G8*(EXP(U1)+1))*EXP(U)/(1+G8*G8)
1690 GO TO 1590
1700 IF G2>J9 THEN 1720
1710 J9=G2
1720 NEXT K1
1730 J9=J9 MAX 2 MIN 32
1740 RETURN

```

APPENDIX B

TI-59 PROGRAM LISTING

The keystroke listing of the TI-59 program implementation of MINIMUF-3.5 follows. Segments of TI-59 code are cross-referenced to the BASIC program listing.

000	76	LBL	
001	11	A	
002	42	STD	
003	18	18	
004	99	PRT	
005	35	CLR	
006	60	DEG	1010,20
007	43	RCL	
008	15	15	
009	75	-	
010	43	RCL	
011	13	13	
012	95	=	
013	39	CDS	
014	65	X	
015	43	RCL	
016	12	12	
017	39	CDS	
018	65	X	
019	43	RCL	
020	14	14	
021	39	CDS	
022	85	+	
023	43	RCL	
024	12	12	
025	38	SIN	
026	65	X	
027	43	RCL	
028	14	14	
029	38	SIN	
030	95	=	
031	70	RAD	
032	22	INV	
033	39	CDS	
034	42	STD	
035	06	06	
036	65	X	1030,40,50
037	01	1	
038	93	.	
039	05	5	
040	09	9	
041	95	=	
042	32	X:T	
043	01	1	
044	71	SBR	
045	07	07	
046	95	95	
047	35	1/X	
048	42	STD	
049	07	07	

050	32	X:T	1080,90
051	01	1	
052	67	EQ	
053	00	00	
054	57	57	
055	93	.	
056	05	5	
057	65	X	1300,10,20,30
058	43	RCL	
059	06	06	
060	65	X	
061	05	5	
062	95	=	
063	32	X:T	
064	89	π	
065	71	SBR	
066	07	07	
067	94	94	
068	55	÷	
069	02	2	
070	95	=	
071	38	SIN	
072	45	YX	
073	01	1	
074	93	.	
075	05	5	
076	65	X	
077	02	2	
078	93	.	
079	05	5	
080	85	+	
081	01	1	
082	95	=	
083	42	STD	
084	08	08	
085	01	1	1060
086	00	0	
087	00	0	
088	42	STD	
089	11	11	
090	02	2	1070
091	75	-	
092	43	RCL	
093	07	07	
094	59	INT	
095	95	=	
096	42	STD	
097	09	09	
098	01	1	1070 - cont'd
099	75	-	

100	43	RCL
101	07	07
102	95	=
103	65	*
104	53	(
105	43	RCL
106	09	09
107	75	-
108	01	1
109	54	)
110	85	+
111	43	RCL
112	07	07
113	55	÷
114	02	2
115	95	=
116	65	*
117	43	RCL
118	06	06
119	95	=
120	42	STD
121	00	00
122	43	RCL
123	14	14
124	60	DEG
125	39	ODS
126	42	STD
127	01	01
128	35	1/X
129	65	*
130	53	(
131	43	RCL
132	12	12
133	38	SIN
134	75	-
135	43	RCL
136	14	14
137	38	SIN
138	42	STD
139	02	02
140	65	*
141	43	RCL
142	06	06
143	70	RAD
144	39	ODS
145	95	=
146	55	÷
147	43	RCL
148	06	06
149	38	SIN

1130

1100,10,20

150	65	*
151	43	RCL
152	00	00
153	38	SIN
154	65	*
155	43	RCL
156	01	01
157	85	+
158	43	RCL
159	02	02
160	65	*
161	43	RCL
162	00	00
163	39	ODS
164	95	=
165	42	STD
166	03	03
167	22	INV
168	39	ODS
169	94	+/-
170	05	+
171	39	ODS
172	55	÷
173	02	2
174	95	=
175	42	STD
176	10	10
177	43	RCL
178	00	00
179	39	ODS
180	75	-
181	43	RCL
182	03	03
183	65	*
184	43	RCL
185	02	02
186	95	=
187	55	÷
188	43	RCL
189	01	01
190	55	÷
191	53	(
192	01	1
193	75	-
194	43	RCL
195	03	03
196	33	X²
197	54	)
198	34	FX
199	95	=

1140

1220

1150

200	22	INV	<u>1160</u> ,70,80,90,1200,10	250	17	17	
201	39	COS		251	85	+	
202	65	*		252	03	3	
203	53	(		253	00	0	
204	43	RCL		254	93	.	
205	13	13		255	04	4	
206	75	-		256	65	*	
207	43	RCL		257	53	(	
208	15	15		258	43	RCL	
209	54	)		259	16	16	
210	60	DEG		260	75	-	
211	38	SIN		261	01	1	
212	69	DP		262	95	=	
213	10	10		263	42	STD	
214	85	+		264	00	00	
215	43	RCL		265	70	RAD	<u>1240</u>
216	15	15		266	39	COS	
217	65	*		267	65	*	
218	89	n		268	93	.	
219	55	+		269	04	4	
220	01	1		270	00	0	
221	08	8		271	09	9	
222	00	0		272	95	=	
223	95	=		273	42	STD	
224	32	X:T		274	01	01	
225	89	n		275	32	X:T	<u>1250</u>
226	65	*		276	65	*	
227	02	2		277	03	3	
228	85	+		278	93	.	
229	32	X:T		279	08	8	
230	95	=		280	02	2	
231	22	INV		281	85	+	
232	77	GE		282	01	1	
233	02	02		283	02	2	
234	38	38		284	85	+	
235	75	-		285	93	.	
236	32	X:T		286	01	1	
237	95	=		287	03	3	
238	32	X:T		288	65	*	
239	93	.	<u>1230</u>	289	53	(	
240	00	0		290	43	RCL	
241	01	1		291	00	00	
242	07	7		292	38	SIN	
243	02	2		293	85	+	
244	65	*		294	01	1	
245	53	(		295	93	.	
246	01	1		296	02	2	
247	00	0		297	65	*	
248	85	+		298	53	(	
249	43	RCL		299	43	RCL	

300	00	00	
301	65	*	
302	02	2	
303	54	)	
304	38	SIN	
305	95	=	
306	75	-	<u>1260</u>
307	32	XIT	
308	02	2	
309	04	4	
310	95	=	
311	32	XIT	
312	75	-	
313	01	1	
314	02	2	
315	65	*	
316	53	(	
317	01	1	
318	85	+	
319	32	XIT	
320	69	DP	
321	10	10	
322	42	STD	
323	00	00	
324	54	)	
325	65	*	
326	43	RCL	
327	00	00	
328	50	IXI	
329	95	=	
330	42	STD	
331	00	00	
332	93	.	<u>1270</u>
333	02	2	
334	06	6	
335	94	+/-	
336	32	XIT	
337	43	RCL	
338	01	01	
339	85	+	
340	43	RCL	
341	10	10	
342	95	=	
343	39	ODS	
344	42	STD	
345	02	02	
346	77	GE	
347	04	04	
348	60	60	
349	00	0	<u>1280,90</u>

350	42	STD	
351	03	03	
352	34	FX	<u>1590</u>
353	65	*	
354	05	5	
355	08	8	
356	85	+	
357	06	6	
358	95	=	
359	34	FX	
360	65	*	
361	43	RCL	
362	08	08	
363	65	*	
364	53	(	
365	01	1	
366	85	+	
367	43	RCL	
368	19	19	
369	55	+	
370	02	2	
371	05	5	
372	00	0	
373	95	=	
374	65	*	<u>1600</u>
375	53	(	
376	01	1	
377	75	-	
378	93	.	
379	01	1	
380	65	*	
381	53	(	
382	43	RCL	
383	03	03	
384	55	+	
385	03	3	
386	75	-	
387	08	8	
388	54	)	
389	22	INV	
390	23	LNK	
391	95	=	
392	65	*	<u>1610</u>
393	53	(	
394	01	1	
395	85	+	
396	93	.	
397	01	1	
398	65	*	
399	53	(	

400	01	1
401	75	-
402	53	(
403	43	RCL
404	12	12
405	65	*
406	43	RCL
407	14	14
408	54	)
409	69	DP
410	10	10
411	95	=
412	65	*
413	53	(
414	01	1
415	75	-
416	93	.
417	01	1
418	65	*
419	53	(
420	01	1
421	85	+
422	53	(
423	43	RCL
424	10	10
425	38	SIN
426	50	I×I
427	75	-
428	43	RCL
429	10	10
430	39	COS
431	54	)
432	69	DP
433	10	10
434	95	=
435	32	X↑T
436	43	RCL
437	11	11
438	71	SBR
439	07	07
440	94	94
441	42	STD
442	11	11
443	97	DSZ
444	09	09
445	00	00
446	98	98
447	32	X↑T
448	02	2
449	71	SBR

1620

1700

1070,1720

1730,40

450	07	07
451	95	95
452	32	X↑T
453	05	5
454	00	0
455	71	SBR
456	07	07
457	94	94
458	99	PRT
459	91	R/S
460	93	.
461	02	2
462	06	6
463	94	+/-
464	85	+
465	43	RCL
466	01	01
467	38	SIN
468	65	*
469	43	RCL
470	10	10
471	38	SIN
472	95	=
473	55	+
474	53	(
475	43	RCL
476	01	01
477	39	COS
478	65	*
479	43	RCL
480	10	10
481	39	COS
482	85	+
483	93	.
484	00	0
485	00	0
486	01	1
487	55	=
488	22	INV
489	38	SIN
490	65	*
491	07	7
492	93	.
493	06	6
494	04	4
495	94	+/-
496	85	+
497	01	1
498	02	2
499	95	=

1350,60

500	42	STD
501	03	03
502	43	RCL <u>1370</u>
503	00	00
504	75	-
505	43	RCL
506	03	03
507	55	+
508	02	2
509	95	=
510	85	+
511	32	X:T
512	01	1
513	02	2
514	65	*
515	53	(
516	32	X:T
517	69	DP
518	10	10
519	94	+/-
520	85	+
521	32	X:T
522	01	1
523	54	)
524	65	*
525	32	X:T
526	50	I×I
527	95	=
528	42	STD
529	04	04
530	43	RCL <u>1380</u>
531	00	00
532	85	+
533	43	RCL
534	03	03
535	55	+
536	02	2
537	75	-
538	32	X:T
539	02	2
540	04	4
541	95	=
542	32	X:T
543	75	-
544	01	1
545	02	2
546	65	*
547	53	(
548	32	X:T
549	69	DP

550	10	10
551	85	+
552	32	X:T
553	01	1
554	54	)
555	65	*
556	32	X:T
557	50	I×I
558	95	=
559	42	STD
560	05	05
561	43	RCL <u>1390,1400,10,20</u>
562	02	02
563	50	I×I
564	42	STD
565	00	00
566	45	Y*
567	09	9
568	93	.
569	06	6
570	65	*
571	09	9
572	93	.
573	07	7
574	95	=
575	32	X:T
576	93	.
577	01	1
578	71	83R
579	07	07
580	95	95
581	42	STD
582	01	01
583	65	*
584	89	7
585	55	+
586	43	RCL
587	03	03
588	95	=
589	42	STD
590	02	02
591	43	RCL <u>1470</u>
592	04	04
593	75	-
594	43	RCL
595	05	05
596	95	=
597	69	DP
598	10	10
599	65	*

600	53	(
601	43	RCL
602	18	18
603	75	-
604	43	RCL
605	04	04
606	54	)
607	65	x
608	53	(
609	43	RCL
610	05	05
611	75	-
612	43	RCL
613	18	18
614	54	)
615	95	=
616	32	X↑T
617	00	0
618	22	INV
619	77	GE
620	07	07
621	35	35
622	43	RCL
623	18	18
624	85	+
625	01	1
626	02	2
627	65	x
628	53	(
629	53	(
630	43	RCL
631	04	04
632	75	-
633	43	RCL
634	18	18
635	54	)
636	69	DP
637	10	10
638	85	+
639	32	X↑T
640	01	1
641	54	)
642	65	x
643	32	X↑T
644	50	IXI
645	75	-
646	43	RCL
647	04	04
648	95	=
649	65	x

1510

1520

650	32	X↑T
651	89	π
652	55	÷
653	43	RCL
654	03	03
655	95	=
656	42	STD
657	05	05
658	32	X↑T
659	94	+/-
660	55	÷
661	43	RCL
662	01	01
663	95	=
664	22	INV
665	23	LNx
666	75	-
667	32	X↑T
668	39	CDS
669	95	=
670	65	x
671	43	RCL
672	02	02
673	85	+
674	43	RCL
675	05	05
676	38	SIN
677	95	=
678	65	x
679	43	RCL
680	00	00
681	55	÷
682	53	(
683	01	1
684	85	+
685	43	RCL
686	02	02
687	33	X²
688	54	)
689	42	STD
690	04	04
691	95	=
692	32	X↑T
693	43	RCL
694	00	00
695	65	x
696	43	RCL
697	02	02
698	65	x
699	53	(

1550

1560

700	53	(
701	43	RCL
702	03	03
703	94	+/-
704	55	+
705	43	RCL
706	01	01
707	54	)
708	22	INV
709	23	LNK
710	85	+
711	01	1
712	54	)
713	65	x
714	53	(
715	43	RCL
716	03	03
717	55	+
718	02	2
719	75	-
720	01	1
721	02	2
722	54	)
723	22	INV
724	23	LNK
725	55	+
726	43	RCL
727	04	04
728	95	=
729	71	88R
730	07	07
731	95	95
732	61	GTO
733	03	03
734	52	52
735	43	RCL
736	05	05
737	75	-
738	43	RCL
739	18	18
740	75	-
741	32	XIT
742	01	1
743	02	2
744	65	x
745	53	(
746	32	XIT
747	89	DP
748	10	10
749	85	+

1570,80

1640,60

750	32	XIT
751	01	1
752	54	)
753	65	x
754	32	XIT
755	50	IxI
756	95	=
757	55	+
758	02	2
759	95	=
760	22	INV
761	23	LNK
762	65	x
763	53	(
764	53	(
765	43	RCL
766	03	03
767	94	+/-
768	55	+
769	43	RCL
770	01	01
771	54	)
772	22	INV
773	23	LNK
774	85	+
775	01	1
776	54	)
777	65	x
778	43	RCL
779	02	02
780	65	x
781	43	RCL
782	00	00
783	55	+
784	53	(
785	01	1
786	05	+
787	43	RCL
788	02	02
789	33	XI
790	95	=
791	61	GTO
792	03	03
793	52	52
794	22	INV
795	77	GE
796	07	07
797	99	99
798	32	XIT
799	92	RTH

1680

MIN/MAX
SUBROUTINE

APPENDIX C

PROGRAM LOGIC MODIFICATIONS

The following program logic changes were made to the BASIC version of MINIMUF-3.5 to minimize program storage requirements:

(1) The computation of M9 at lines 1300-1330 and 1430-1460 is independent of the main loop and was moved to the beginning of the program, immediately following the calculation of G1 and K5.

(2) The loop index computation at line 1070 was separated into a computation of a new variable, KHOP, which is either 1 or 2, and a follow-on computation of K1 from KHOP as the first item within the loop.

(3) The computation of G8 at lines 1530 and 1650 is common to both less of the preceding test for $(T5-T4)(T-T5)$, and has been moved ahead of that test.

(4) The test at line 1470 serves to reverse the sense of the following tests at lines 1480 and 1500. This logic has been combined into a single test on $(T5-T4)(T-T5)$ with a weighting factor of 1 or -1 to reverse the sense of that test.

(5) The computation at line 1360 was simplified to the arcsine by way of trigonometric identity.

(6) The MUF limit established at line 1730 was changed to 50 vice 32 to accomodate high solar flux densities.

(7) Throughout the program, explicit calculation and storage of variables that are used only once in following statements has been eliminated to conserve on data register requirements.

APPENDIX D

PROGRAM OPERATING INSTRUCTIONS

The following instructions must be followed to operate the TI-59 version of MINIMUF-3.5:

(1) Repartition the calculator for 800 program steps and 20 data registers by pressing 2/OP/17.

(2) Load the 4 memory banks from program cards (2) or by entering program keystrokes with the calculator in the LRN mode.

(3) Enter input data as follows:

(a) Transmitter North Latitude in decimal degrees in R12 (range -90 degrees to 90 degrees)

(b) Transmitter West Longitude in decimal degrees in R13 (range 0 to 360 degrees)

(c) Receiver North latitude in decimal degrees in R14 (range -90 to 90 degrees)

(d) Receiver West Longitude in decimal degrees in R15 (range 0 to 360 degrees)

(e) Month in R16 (range 1 to 12)

(f) Day in R17 (range 1 to 31)

(g) Sunspot Number in R19 (range - positive number)

(4) Enter Time in X-register (range 0 to 24 decimal hours)

(5) Press A

(6) If a printer is attached, the input time is echoed, followed by the answer (MUF) after 50 seconds for single-hop and 100 seconds for two-hop predictions.

(7) The answer is displayed in the X-register when the program halts.

(8) All input quantities remain undisturbed in R12 thru R19 (time is stored by the program in R18). Another MUF for a different time can be computed directly by repeating steps (4) and (5).

APPENDIX E

TEST CASE

The test case that follows was provided in the NOSC report on MINIMUF-3.5. The actual printer listing of input and program output is included.

CONTENTSREG

21.	12	(L1)
156.	13	(W1)
38.	14	(L2)
122.	15	(W2)
10.	16	(M0)
17.	17	(D6)
0.	18	
110.	19	(S9)

0.0 (Time)
36.3 (MUF)

1.0
35.0 (etc)

2.0

32.9

3.0

29.9

4.0

25.0

5.0

22.8

6.0

20.9

7.0

19.3

8.0

18.0

9.0

16.9

10.0

16.0

11.0

15.2

12.0

14.6

13.0

14.1

14.0

13.7

15.0

21.0

16.0

27.6

17.0

31.5

18.0

34.0

19.0

35.6

20.0

36.7

21.0

37.3

22.0

37.5

23.0

37.1

INPUTOUTPUT

APPENDIX F

TI-59 CUSTOM MODULES

The following points of contact are provided for the design and manufacture of TI-59 custom modules. Both Texas Instruments and Horizons Technology (contracting with TI) provide software, emulator, and consulting support for the design and production of custom modules. Costs quoted at this time are approximately \$12,000 for a minimum order of 250 modules. This includes emulator support and manufacture, but does not include software consulting. Cost reduction through quantity is available.

Fred Wilke
TI-59 Custom Module Division
Texas Instruments
Lubbock, TX
(806) 741-3240

Robert Kruser
Horizons Technology, Inc.
7830 Clairemont Mesa Boulevard
San Diego, CA 92111
(714) 292-8331

LIST OF REFERENCES

1. Rose, R.B. and Martin, J.N., "MINIMUF-3.5, Improved Version of MINIMUF-3, A Simplified HF MUF Prediction Algorithm", Technical Document 201, Naval Ocean Systems Center, San Diego, 26 October 1978.

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