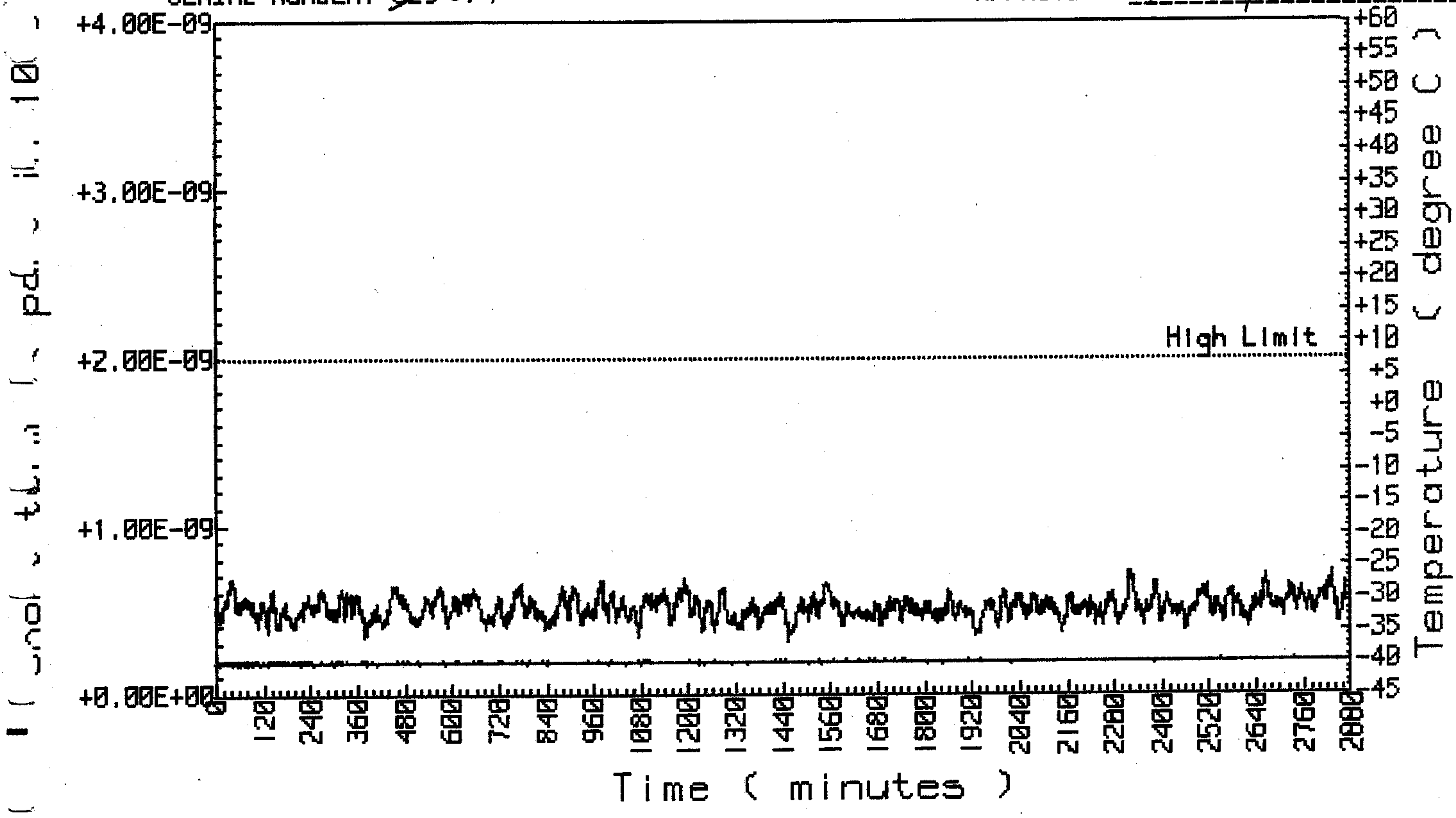
BEACON SHORT TERM STABILITY

SAFT BATTERY

MANUFACTURER: SEIMAC
MODEL NUMBER: PROFIND 406
SERIAL NUMBER: ~~029~~ 017 JCH

DATE: 14 Oct 2000
TESTED BY: [signature]
APPROVED : Rosa Barrineau

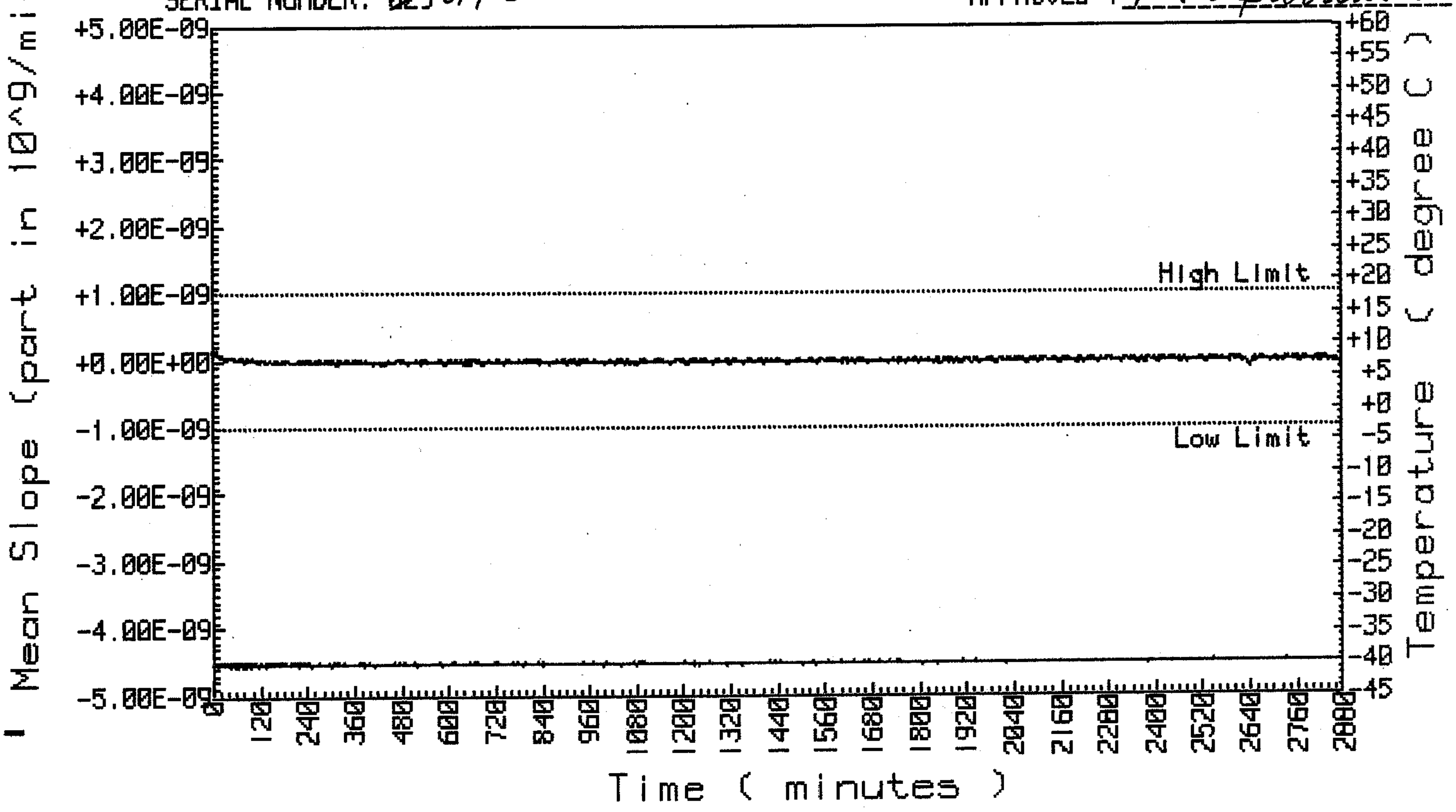


BEACON MEDIUM TERM STABILITY

SAFT BATTERY

MANUFACTURER: SEIMAC
MODEL NUMBER: PROFIND 406
SERIAL NUMBER: 029 017 scH

DATE: 14 Oct 2000
TESTED BY: [signature]
APPROVED : Rosa Barrineau

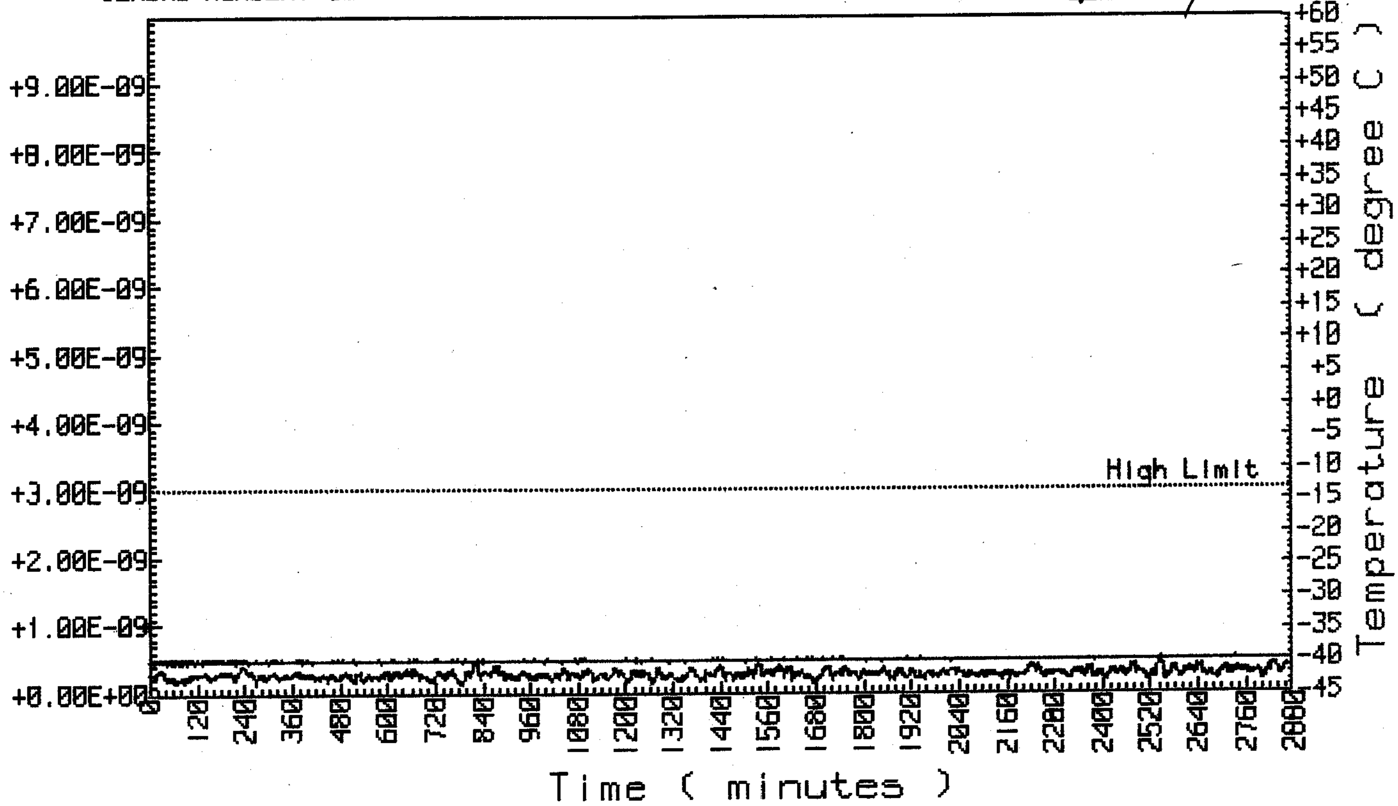


BEACON MEDIUM TERM STABILITY

SAFT BATTERY

MANUFACTURER: SEIMAC
MODEL NUMBER: PROFIND 406
SERIAL NUMBER: 025017 JCH

DATE: 14 Oct 2000
TESTED BY: [signature]
APPROVED : Rosa Barrineau



406 SIGNAL OUTPUT POWER

SAFT BATTERY

MANUFACTURER: SEIMAC

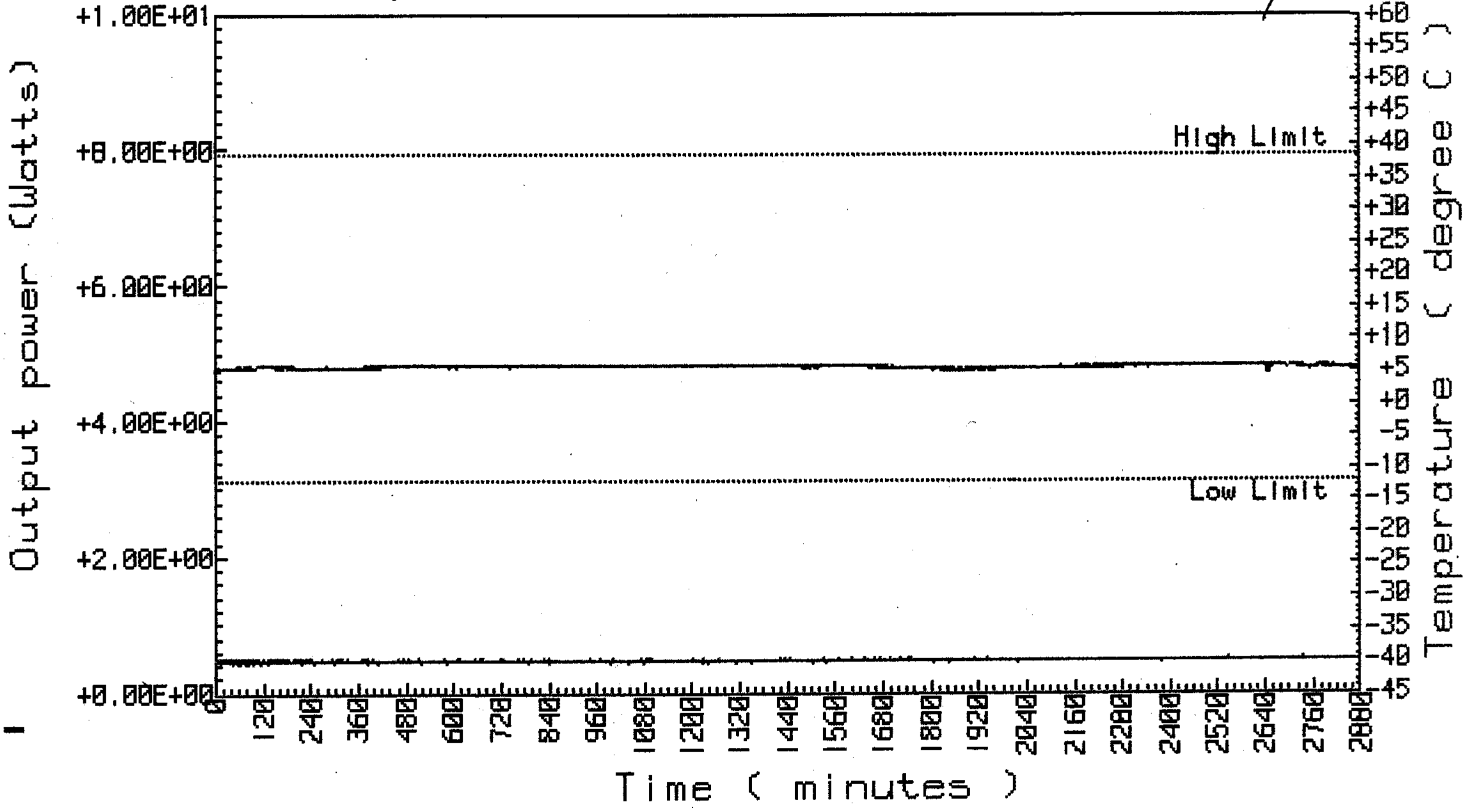
MODEL NUMBER: PROFIND 406

SERIAL NUMBER: ~~029~~ 017 JCH

DATE: 14 Oct 2000

TESTED BY: [illegible]

APPROVED : Rosa Barrineau



ANNEX 5. SELF-TEST MODE

Low Temperature

~~WSMR~~ ELECTRONIC PROVING GROUND, US ARMY, FORT HUACHUCA, ARIZONA
MANU: SEIMAC MODEL NO: PROFIND 406 SERIAL NO: 029
BEACON CERTIFICATION TEST RESULTS - SELF TEST VERIFICATION - Low Temp
MEASUREMENT DATE: 4 Oct 2000 TIME: 14:43:21

TESTED BY: CBel APPROVED BY: Rosa Barrineau

FRAME SYNCHRONIZATION BIT #:	16	17	18	19	20	21	22	23	24
Should be:	0	1	1	0	1	0	0	0	0
Decoded:	0	1	1	0	1	0	0	0	0

NUMBER OF BURST DURING SELF TEST CYCLE: 1

440.3 ms
53 Sec Burst delay.
Flash rate 20 PMin.

WSMR ELECTRONIC PROVING GROUND, US ARMY, FORT HUACHUCA, ARIZONA
MANU: SEIMAC   MODEL NO: PROFIND 406   SERIAL NO: 029
BEACON CERTIFICATION TEST RESULTS - SELF TEST VERIFICATION - LOW TEMP
MEASUREMENT DATE: 4 Oct 2000   TIME: 14:45:09

TESTED BY: [signature]   APPROVED BY: Rosa Barrineau

BEACON DIGITAL MESSAGE VERIFICATION

SYNCHRONIZATION BIT #:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Should be:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Decoded:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

*** BIT SYNCHRONIZATION OK ***

FRAME SYNCHRONIZATION BIT #:	16	17	18	19	20	21	22	23	24
Should be:	0	0	0	1	0	1	1	1	1
Decoded:	0	1	1	0	1	0	0	0	0

*** ERROR IN FRAME SYNCHRONIZATION *** Self test verification

MESSAGE TYPE: SHORT MESSAGE (bit 25 = 0)

DIGITAL MESSAGE IN HEXADECIMAL: A D C D 0 0 0 0 0 4 4 0 4 0 1 0 0 A A 9 A

BEACON BCH CODE VERIFICATION

BCH CODE BIT #:	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06
Should be:	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1	0	1	0	0	1	1
Decoded:	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1	0	1	0	0	1	1

*** BCH CODE OK ***

Ambient Temperature

WSMR ELECTRONIC PROVING GROUND, US ARMY, FORT HUACHUCA, ARIZONA
MANU: SEIMAC MODEL NO: PROFIND 406 SERIAL NO: 029
BEACON CERTIFICATION TEST RESULTS - SELF TEST VERIFICATION - AMBIENT TEMP
MEASUREMENT DATE: 2 Oct 2000 TIME: 20:08:54

TESTED BY: C Bol APPROVED BY: Rosa Barrineau

FRAME SYNCHRONIZATION BIT #:	16	17	18	19	20	21	22	23	24
Should be:	0	1	1	0	1	0	0	0	0
Decoded:	0	1	1	0	1	0	0	0	0

NUMBER OF BURST DURING SELF TEST CYCLE: 1

Duration 440.3 ms.
First Burst Delay 52 Sec

WSMR ELECTRONIC PROVING GROUND, US ARMY, FORT HUACHUCA, ARIZONA
MANU: SEIMAC MODEL NO: PROFIND 406 SERIAL NO: 029
BEACON CERTIFICATION TEST RESULTS - SELF TEST VERIFICATION - AMBIENT TEMP
MEASUREMENT DATE: 2 Oct 2000 TIME: 20:10:25

TESTED BY: C Bol APPROVED BY: Rosa Barrineau

BEACON DIGITAL MESSAGE VERIFICATION

SYNCHRONIZATION BIT #:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Should be:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Decoded:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

*** BIT SYNCHRONIZATION OK ***

FRAME SYNCHRONIZATION BIT #:	16	17	18	19	20	21	22	23	24
Should be:	0	0	0	1	0	1	1	1	1
Decoded:	0	1	1	0	1	0	0	0	0

*** ERROR IN FRAME SYNCHRONIZATION *** SELF TEST Verification

MESSAGE TYPE: SHORT MESSAGE (bit 25 = 0)

DIGITAL MESSAGE IN HEXADECIMAL: A D C D 0 0 0 0 0 4 4 0 4 0 1 0 0 A A 9 A

BEACON BCH CODE VERIFICATION

BCH CODE BIT #:	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06
Should be:	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1	0	1	0	0	1	1
Decoded:	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1	0	1	0	0	1	1

*** BCH CODE OK ***

Maximum Temperature

WSMR ELECTRONIC PROVING GROUND, US ARMY, FORT HUACHUCA, ARIZONA
MANU: SEIMAC MODEL NO: PROFIND 406 SERIAL NO: 029
BEACON CERTIFICATION TEST RESULTS - SELF TEST VERIFICATION - HIGH TEMP
MEASUREMENT DATE: 3 Oct 2000 TIME: 14:36:23

TESTED BY: CBol APPROVED BY: Rosa Barrineau

FRAME SYNCHRONIZATION BIT #:	16	17	18	19	20	21	22	23	24
Should be:	0	1	1	0	1	0	0	0	0
Decoded:	0	1	1	0	1	0	0	0	0

NUMBER OF BURST DURING SELF TEST CYCLE: 1

4403 ms Pulse.
1ST Burst Delay 53 Sec
STrobe rate 21.

SMB ELECTRONIC PROVING GROUND, US ARMY, FORT HUACHUCA, ARIZONA
ANU: SEIMAC MODEL NO: PROFIND 406 SERIAL NO: 029
EACON CERTIFICATION TEST RESULTS - SELF TEST VERIFICATION - HIGH TEMP
EASUREMENT DATE: 3 Oct 2000 TIME: 14:38:17

ESTED BY: C. Bal APPROVED BY: Rosa Barrineau

EACON DIGITAL MESSAGE VERIFICATION

YNCHRONIZATION BIT #:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Should be:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Decoded:	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

*** BIT SYNCHRONIZATION OK ***

FRAME SYNCHRONIZATION BIT #:	16	17	18	19	20	21	22	23	24
Should be:	0	0	0	1	0	1	1	1	1
Decoded:	0	1	1	0	1	0	0	0	0

*** ERROR IN FRAME SYNCHRONIZATION *** SELF TEST Verification

MESSAGE TYPE: SHORT MESSAGE (bit 25 = 0)

DIGITAL MESSAGE IN HEXADECIMAL: A D C D 0 0 0 0 0 4 4 0 4 0 1 0 0 A A 9 A

BEACON BCH CODE VERIFICATION

BCH CODE BIT #:	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06
Should be:	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1	0	1	0	0	1	1
Decoded:	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1	0	1	0	0	1	1

*** BCH CODE OK ***

APPENDIX B. SEIMAC ANTENNA CHARACTERISTICS @ 406.028 MHz

TABLE B-1. VERTICAL POLARIZATION RECEIVED SIGNAL LEVELS (PV, in dBm)

AZIMUTH ANGLE (degrees)	ELEVATION ANGLE (degrees)				
	10	20	30	40	50
0	-16.17	-15.00	-15.17	-15.50	-18.83
30	-17.17	-15.00	-15.17	-15.50	-20.33
60	-17.17	-15.50	-14.83	-15.33	-19.17
90	-17.50	-15.83	-14.17	-16.17	-20.50
120	-17.33	-15.50	-15.50	-16.00	-20.33
150	-17.50	-15.83	-14.50	-16.00	-20.67
180	-17.83	-16.50	-14.83	-17.17	-21.17
210	-18.17	-15.67	-15.50	-15.33	-20.50
240	-17.83	-16.00	-16.17	-16.00	-18.67
270	-17.67	-15.50	-15.50	-15.67	-18.33
300	-16.83	-15.83	-15.50	-15.83	-20.33
330	-17.67	-16.33	-14.83	-15.50	-19.00

TABLE B-2. HORIZONTAL POLARIZATION RECEIVED SIGNAL LEVELS
(PH, in dBm)

AZIMUTH ANGLE (degrees)	ELEVATION ANGLE (degrees)				
	10	20	30	40	50
0	-40.17	-39.00	-41.83	-43.33	-38.33
30	-47.67	-45.67	-33.83	-44.33	-33.50
60	-38.00	-38.67	-39.83	-36.83	-40.50
90	-44.33	-43.33	-39.67	-37.00	-32.67
120	-46.50	-43.00	-47.17	-40.00	-36.83
150	-50.17	-44.33	-49.67	-41.50	-42.17
180	-43.00	-48.83	-40.83	-40.50	-43.17
210	-45.67	-55.83	-39.50	-50.67	-35.00
240	-39.67	-52.67	-40.67	-41.17	-50.83
270	-59.33	-46.83	-55.50	-45.33	-47.33
300	-46.00	-44.67	-36.50	-53.83	-34.00
330	-52.00	-40.83	-43.83	-39.50	-43.50

TABLE B-3. TOTAL ERP (IN dBm) / ANTENNA GAIN (in dBi)

AZIMUTH ANGLE (degrees)	ELEVATION ANGLE (degrees)				
	10	20	30	40	50
0	37.45/+0.91	38.62/+2.08	38.44/+1.90	38.11/+1.57	34.82/-1.72
30	36.43/-0.11	38.60/+2.06	38.49/+1.95	38.11/+1.57	33.47/-3.07
60	36.47/-0.07	38.12/+1.58	38.78/+2.24	38.30/+1.76	34.46/-2.08
90	36.11/-0.43	37.78/+1.24	39.44/+2.90	37.47/+0.93	33.36/-3.18
120	36.28/-0.26	38.11/+1.57	38.10/+1.56	37.62/+1.08	33.37/-3.37
150	36.10/-0.44	37.78/+1.24	39/10/+2.56	37.61/+1.07	32.96/-3.58
180	35.78/-0.76	37.10/+0.56	38.78/+2.24	36.45/-0.09	32.46/-4.08
210	35.44/-1.10	37.93/+1.39	38.12/+1.58	38.27/+1.73	33.25/-3.29
240	35.80/-0.74	37.60/+1.06	37.45/+0.91	37.61/+1.07	34.93/-1.61
270	35.93/-0.61	38.10/+1.56	38.10/+1.56	37.93/+1.39	35.28/-1.26
300	36.78/+0.24	37.78/+1.24	38.18/+1.59	37.77/+1.23	33.45/-3.09
330	35.93/-0.61	37.29/+0.75	38.78/+2.24	38.12/+1.58	34.62/-1.92
VARIATION (dB)	2.01	1.52	1.99	1.82	2.82

Antenna Gain is based on measured power output of 4.51 watts (36.54 dBm)

For the ETERN battery, there was a 0.1dBm loss due to battery discharge.

$ERP_{maxEOL} = ERP_{max} - ERP_{LOSS} = 36.54 - (-0.1) = 36.64$ dBm = 4.57 watts
$ERP_{minEOL} = ERP_{min} - ERP_{LOSS} = 32.46 - (-0.1) = 32.56$ dBm = 1.82 watts

For the SAFT battery, there was no loss (0.0 dBm) due to battery discharge.

$ERP_{maxEOL} = ERP_{max} - ERP_{LOSS} = 36.54 - (0) = 36.54$ dBm = 4.51 watts
$ERP_{minEOL} = ERP_{min} - ERP_{LOSS} = 32.46 - (0) = 32.46$ dBm = 1.78 watts

NOTE: These values do NOT include the range instrumentation accuracy of ±2.45 dB.

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APPENDIX C. SUMMARY OF 406-MHz BEACON TEST RESULTS

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Table C2. SUMMARY OF 406MHz BEACON TEST RESULTS

PARAMETERS TO BE MEASURED DURING TESTS		RANGE OF SPECIFICATION	UNITS	TEST RESULTS			COMMENTS
				T_{min} (-40° C)	T_{amb} (+20° C)	T_{max} (+55° C)	
1. POWER OUTPUT							
• Transmitter power output		35 - 39	dBm	36.2	36.6	36.4	
• Power output rise time		<5	ms	0.46	0.52	0.55	
• Power output 1 ms before burst		must be <-10 dBm	✓*	✓	✓	✓	
2. DIGITAL MESSAGE	Bits number						
• bit sync	1-15	15 bits "1"	✓	✓	✓	✓	
• frame sync	16-24	9 bits (000101111)	✓	✓	✓	✓	
• format flag	25	1 bit	data bit	0	0	0	
• protocol flag	26	1 bit	data bit	1	1	1	
• identification/position data	27-85	59 bits	✓	✓	✓	✓	
• BCH code	86-106	21 bits	✓	✓	✓	✓	
• Emerg. code/nat. use/supplem. data	107-112	6 bits	data bits	010000	010000	010000	
• Additional data/BCH (if applicable)	113-144	32 bits	✓	N/A	N/A	N/A	
• Position error (if applicable)		< 5	km	N/A	N/A	N/A	

PARAMETERS TO BE MEASURED DURING TESTS	RANGE OF SPECIFICATION	UNITS	TEST RESULTS			COMMENTS
			T_{min} (-40° C)	T_{amb} (+20° C)	T_{max} (+55° C)	
3. DIGITAL MESSAGE GENERATOR						
• repetition rate**: minimum T_R	47.5	seconds	48.0	48.3	47.6	
maximum T_R	52.5	seconds	51.7	52.2	51.7	
• bit rate: minimum f_b	396	bits/sec.	399.9	399.9	399.9	
maximum f_b	404	bits/sec.	400.1	400.1	400.1	
• total transmission time: short message =	435.6 – 444.4	ms	439.2	439.4	439.4	
long message (optional) =	514.8 – 525.2	ms	N/A	N/A	N/A	
• unmodulated carrier minimum T_1	158.4	ms	159.2	159.1	159.2	
maximum T_1	161.6	ms	159.2	159.3	159.3	
• first burst delay	>47.5	seconds	53	52	53	

PARAMETERS TO BE MEASURED DURING TESTS	RANGE OF SPECIFICATION	UNITS	TEST RESULTS			COMMENTS
			T_{min} (-40° C)	T_{amb} (+20° C)	T_{max} (+55° C)	
4. MODULATION						
• Biphase-L		✓	✓	✓	✓	
• rise time	50 – 250	µs	142.2	134.2	119.5	
• fall time	50 – 250	µs	135.8	129.8	108.5	
• phase deviation: positive	+(1.0 to 1.2)	radians	1.18	1.04	1.01	
• phase deviation: negative	-(1.0 to 1.2)	radians	-1.20	-1.05	-1.02	
• symmetry measurement	≤0.05	✓	✓	✓	✓	
5. 406 MHz TRANSMITTED FREQUENCY						
• nominal value	406.023 – 406.027 or 406.027 – 406.029***)	MHz	406.028	406.028	406.0279	
• short-term stability	$\leq 2 \times 10^{-9}$	/100ms	$5.9E^{-10}$	$4.32E^{-10}$	$1.8E^{-10}$	
• medium-term stability - slope	$(-1 \text{ to } +1) \times 10^{-9}$	/minute	$3.32E^{-11}$	$-3.0E^{-11}$	$2.53E^{-11}$	
- residual frequency variation	$\leq 3 \times 10^{-9}$		$2.80E^{-10}$	$6.03E^{-10}$	$1.97E^{-10}$	
6. SPURIOUS EMISSIONS** (into 50 ohms)**						
• in-band (406.0 – 406.1 MHz)	see spurious emission mask in C/S T.001	✓	✓	✓	✓	

PARAMETERS TO BE MEASURED DURING TESTS	RANGE OF SPECIFICATION	UNITS	TEST RESULTS			COMMENTS
			T_{min} (-40° C)	T_{amb} (+20° C)	T_{max} (+55° C)	
7. 406 MHz VSWR CHECK after open circuit, short circuit, then while VSWR is 3:1, measure:						
• nominal transmitted frequency	406.023 – 406.027 or 406.027 – 406.029***)	MHz	406.028	406.028	406.0279	
Modulation:						
• rise time	50 – 250	µs	142.2	117.5	119.5	
• fall time	50 – 250	µs	135.8	122.5	108.5	
• phase deviation: positive	+(1.0 to 1.2)	radians	1.18	1.04	1.01	
• phase deviation: negative	-(1.0 to 1.2)	radians	-1.20	-1.05	-1.02	
• symmetry measurement	≤0.05	✓	✓	✓	✓	
• digital message	must be correct	✓	✓	✓	✓	

PARAMETERS TO BE MEASURED DURING TESTS	RANGE OF SPECIFICATION	UNITS	TEST RESULTS			COMMENTS
			MIN	AMBIENT	MAX	
8. SELF-TEST MODE (if applicable)						
• frame sync	9 bits (011010000)	✓	✓	✓	✓	
• format flag	1/0	bit	0	0	0	
• single radiated burst	≤440/520 (+1%)	ms	440.3	440.3	440.3	
• default position data (if applicable)	must be correct	✓	✓	N/A	N/A	
• description provided		✓	✓	✓	✓	
9. THERMAL SHOCK **** (30° C change)						
• Soak temperature			T_{soak} = -40 ° C			
• Measurement temperature			T_{meas} = 10 ° C			
The following parameters are to be met within 15 minutes of beacon turn on and maintained for 2 hours:						
• transmitted frequency:						
• nominal value	406.023 – 406.027 or 406.027 – 406.029***)	MHz		406.028		
• short-term stability:	$\leq 2 \times 10^{-9}$	/100ms		$4.0E^{-10}$		
• medium-term stability: - slope - residual frequency variation	$(-1 \text{ to } +1) \times 10^{-9}$ $\leq 3 \times 10^{-9}$	/minute		0 $2.0E^{-10}$		
• transmitter power output	35 - 39	dBm		36.6		
• digital message	must be correct	✓		✓		

PARAMETERS TO BE MEASURED DURING TESTS	RANGE OF SPECIFICATION	UNITS	TEST RESULTS		COMMENTS
			Battery 1 ETERN	Battery 2 SAFT	
10. OPERATING LIFETIME AT MINIMUM TEMPERATURE****					
• duration	>24	hours	48 hours at T_{min} = -40 °C		Conducted battery life tests with two manufacturer batteries: ETERN and SAFT.
• transmitted frequency:					
• nominal value	406.023 – 406.027 or 406.027 – 406.029***)	MHz	406.028	406.0278	
• short-term stability:	≤2 x 10^{-9}	/100ms	1.1E^{-9}	7.0E^{-10}	
• medium-term stability: - slope - residual frequency variation	(-1 to +1) x 10^{-9} ≤3 x 10^{-9}	/minute	0 4.0E^{-10}	1.0E^{-10} 4.0E^{-10}	
• transmitter power output	35 - 39	dBm	35.8	36.4	
• digital message	must be correct	✓	✓	✓	
11. TEMPERATURE GRADIENT**** (5° C/hr)					
• transmitted frequency:					
• nominal value	406.023 – 406.027 or 406.027 – 406.029***)	MHz	406.028		
• short-term stability:	≤2 x 10^{-9}	/100ms	1.0E^{-9}		
• medium-term stability: - slope - residual frequency variation	(-1 to +1) x 10^{-9} ≤3 x 10^{-9}	/minute	5.0E^{-10} 2.0E^{-9}		
• transmitter power output	35 - 39	dBm	36.2		
• digital message	must be correct	✓	✓		

PARAMETERS TO BE MEASURED DURING TESTS	RANGE OF SPECIFICATION	UNITS	TEST RESULTS	COMMENTS
12. LONG-TERM FREQUENCY STABILITY	406.20 – 406.030 or 406.23 – 406.30***)	MHz	✓	See TAB E of packet
• data provided		✓		
13. PROTECTION AGAINST CONTINUOUS TRANSMISSION	≤45	seconds	✓	See TAB E of packet
• description provided		✓		
14. SATELLITE QUALITATIVE TESTS****				
• results provided	successfully located by satellites/LUT	✓	N/A	
15. ANTENNA CHARACTERISTICS				
• polarization	linear or RHCP	✓ ✓	✓	
• VSWR	≤1.5	-	N/A	Non-removable antenna
• $ERP_{max\ EOL}$	≤20	watts	4.57 ETERN 4.51 SAFT	
• $ERP_{min\ EOL}$	≥1.6	watts	1.82 ETERN 1.78 SAFT	
• azimuth gain variation at 40° elevation angle	≤3	dB	1.82	
16. BEACON CODING SOFTWARE				
• sample message provided for each coding option of the applicable coding protocol types	must be correct (attach to report)	✓	✓	
• sample message provided, if applicable, with encoded positions at least 5 km apart	must be correct (attach to report)	✓	N/A	

PARAMETERS TO BE MEASURED DURING TESTS	RANGE OF SPECIFICATION	UNITS	TEST RESULTS	COMMENTS
17. NAVIGATION SYSTEM**** (as applicable)				
• position data default values	must be correct	✓		
• position acquisition time	<30	minutes		
• position data update interval	>20	minutes		
• delta offset				
- position direction	must be correct	✓	N/A	
- negative direction	must be correct	✓		
- overrange to 2 times coarse res.	must be correct	✓		
• last valid position:				
- retained after navigation input lost	must be correct	✓		
- cleared when beacon reactivated	must be correct	✓		
• design data provided on protection against beacon degradation due to navigation device, interface or signal failure or malfunction	no degradation	✓		

* The tick mark ✓ can be used where indicated to record that the requirement is met (no value needs to be shown).

** If ($T_{R\,max}$ - $T_{R\,min}$) #1 second, the manufacturer must provide a technical explanation, as described in section A3.1.1.

*** From 1 January 2000, new 406 MHz beacon models submitted for type approval can be set to transmit at 406.028 MHz ±1 kHz. The transmitted frequency shall not vary more than +2 kHz/-5 kHz from 406.0028 MHz in 5 years. It shall not vary more than 2 parts in 10^9 in 100 ms. After 1 January 2002, all new beacon models submitted for type approval must be set at the frequency 406.028 MHz ±1 kHz and satisfy the above stability requirements.

**** Attach graphs of test results for test numbers 6, 9, 10, and 11 and a summary table of results for test number 14, and if applicable, test number 17.

APPENDIX D. PHASE MODULATION FAILURE

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Technical Report – TR-419-99-013 V1.1
Oct 30, 2000
Phase Modulation Failure

Revision History	Date	Change
Initial Release V1.0	Sept 22, 2000	
Release V1.1	Oct 30, 2000	Added Addendum section

During certification testing the ProFind 406 EPIRB failed the phase modulation test at low temperatures. An investigation was carried out to determine the cause of this failure.

1. Phase Modulation Circuit

Phase modulation in the ProFind 406 is achieved by injecting an offset current into the feedback loop of the phase-lock-loop (PLL) circuit. A simplified schematic diagram for the circuit is shown in Figure 1.

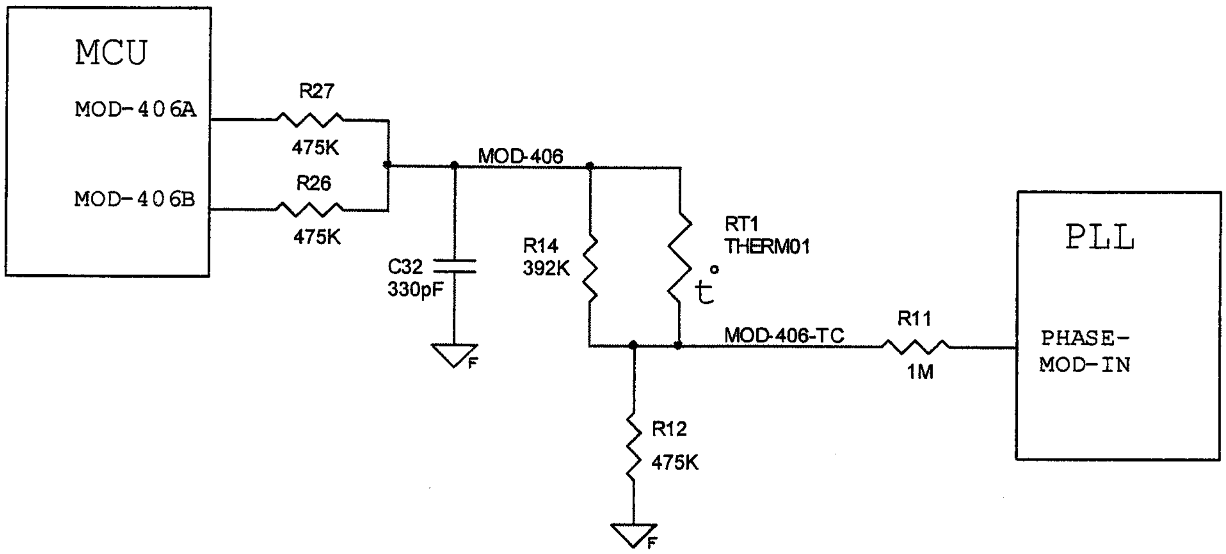

Figure 1. Phase Modulation Circuit

2. Theory of Operation

Digital signals *MOD-406A* and *MOD-406B* from the micro-controller (MCU) are set to one of three different state to achieve the different levels of modulation:

a) During un-modulated carrier (zero phase modulation), *MOD-406A* is set high and *MOD-406B* is set low.
b) For +1.1 radian phase modulation both *MOD-406A* and *MOD-406A* are set high.
c) For -1.1 radian phase modulation both *MOD-406A* and *MOD-406A* are set low.

Signal *MOD-406* is a summing point whose nominal voltage will be one of three levels depending on the modulation state (+1.1, 0, or –1.1 radians). Capacitor C32 controls the rise and fall time of the modulation signal.

Resistor R14 in parallel with thermistor RT1 and series resistor R12 provide a voltage divider network whose output signal *MOD-406-TC*. The current through resistor R11 is proportional to the voltage at *MOD-406-TC* and is used to phase modulate the PLL. The sensitivity of the modulation input signal *PHASE-MOD-IN* is temperature dependent. It is less sensitive at high temperatures. To compensate for this effect, thermistor RT1 is used to increase the modulation current signal into the PLL. The overall effect is to have a relatively constant phase modulation of the PLL over the operating temperature range.

3. Cause of Failure

The circuit described above has been used in several ARGOS transmitter circuits which have a similar phase modulation specifications. Some minor changes were required to adapt the design for the ProFind 406 because of different operating voltages.

During the development and in-house testing, the test engineer found that the phase modulation level measurements were too low (by about 0.1 radians). To increase the modulation he increased the value of R12 from 375K to 475k. This increased the modulation level but he also inadvertently changed the temperature characteristic of the compensating circuit.

The circuit was tested after the resistor value was changed but due to a malfunctioning test chamber, the circuit was only tested over a temperature range of -20°C to +55°C. If the circuit had been tested over the complete temperature range it would have shown that the modulation levels were too high at low temperatures.

As a result of this investigation we found that the in-house test measurements were performed with an uncalibrated instrument which gave readings which were low by about 0.1 radians. The assumption that the modulation level needed to be increased was false. Changing the resistor value increased the modulation level unnecessarily and caused the circuit to exceed the modulation specifications at low temperature. Unfortunately this was not tested sufficiently prior to certification testing.

4. Modulation Symmetry

More detailed in-house testing on separate test units has confirmed the findings at Fort Huachuca. The test results not only indicate that the average modulation levels are too high, but that there is a small offset between the positive modulation level and the negative modulation level. This is caused by the fact that the phase detector response is not quite symmetrical about its operating point. It is slightly more sensitive in the positive direction than the negative direction.

This asymmetry can be corrected by changing the relative values of R26 and R27. The optimum values for R26 and R27 are being evaluated presently.

5. Recommendations

Changing the resistor value R12 should bring the phase modulation with the specified limits. Further testing is recommended to determine the optimum value to minimize the variation with temperature.

It is also recommended that the values of R26 and R27 be changed slightly to make the positive and negative levels more symmetrical which would provide more head room for unit to unit variation.

Addendum

Further investigation found that the following component values should be changed:

Component	Changed from	Changed to
R26	475K	No change
R27	475K	500K
R12	402K	475K

APPENDIX E. DISTRIBUTION

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