

General Inputs

$anchorSamplePeriod := 64 \cdot min$ $sleepEnergy := 2 \cdot J$ $sleepVolts := 28.0 \cdot V$ $wakeFromSleepEnergy := 2 \cdot J$

$numAnchorSamples := 4$ $anchorPeriod := numAnchorSamples \cdot anchorSamplePeriod = 4.267 \text{ hr}$

$sleepAmps := \frac{sleepEnergy}{anchorSamplePeriod \cdot sleepVolts} = (1.86 \cdot 10^{-5}) \text{ A}$

Science instrument parameters (from Dana for all samples in a 2000 meter profile)

$isusSampleEnergy := 3620 \cdot J$ $sbe41SampleEnergy := 3040 \cdot J$ $pHSampleEnergy := 1280 \cdot J$

$FLBBSampleEnergy := 160 \cdot J$ $optodeSampleEnergy := 100 \cdot J$ $OCRSampleEnergy := 100 \cdot J$

$totalSampleEnergy2000 := isusSampleEnergy + sbe41SampleEnergy + pHSampleEnergy \downarrow$
 $\qquad \qquad \qquad + FLBBSampleEnergy + optodeSampleEnergy + OCRSampleEnergy$

$totalSampleEnergy2000 = (8.3 \cdot 10^3) \text{ J}$

$totalSampleEnergy200 := 0.5 \cdot totalSampleEnergy2000 = (4.15 \cdot 10^3) \text{ J}$

Mission Profile parameters

$profileDepth := 200 \cdot m$ $numProfiles := 200$ $samplesPerProfile := 40$ $descendSpeed := 0.2 \cdot \frac{m}{sec}$

$ascendSpeed := 0.1 \cdot \frac{m}{sec}$

$initCoreEnergy := 158 \cdot J$ $initPlatformEnergy := 1376 \cdot J$ $setBellowsEnergy := 6600 \cdot J$ $initialRecoveryEnergy := 165 \text{ J}$

$preMissionDelayEnergy := 66 \cdot J$ $initProfileEnergy := 119 \cdot J$ $decreaseBuoyancyEnergy := 10461 \cdot J$

$initialDescendEnergy := 1022 \cdot J$ $maintainDescendEnergy := 10 \cdot \frac{J}{m}$ $anchorEnergy := 100 \cdot J$ $deanchorEnergy := 7837 \cdot J$

$startCPModeEnergy := 207 \cdot J$ $initialAscendEnergy := 554 \cdot J$ $maintainAscendEnergy := 10 \cdot \frac{J}{m}$

$dumpCPModeEnergy := 100 \cdot J$ $surfaceOpsEnergy := 562 \cdot J$ $surfaceOpsTime := 15 \cdot min$

$missionSetupEnergy := initCoreEnergy + initPlatformEnergy + initialRecoveryEnergy \downarrow$
 $\qquad \qquad \qquad + preMissionDelayEnergy$

$missionSetupEnergy = (1.765 \cdot 10^3) \text{ J}$

System	Energy Required (KJ)/profile	Per Cent of Total
Buoyancy pump	6.42	32.4
ISUS/NO ₃	3.62	18.3
SeaBird 41CP	3.04	15.3
Iridium-GPS	2.50	12.6
APF9i	1.99	10.0
Durafet pH	1.28	6.5
FLBB	0.16	1.3
Optode/O ₂	0.10	0.5
Self-discharge	0.70	3.5
TOTAL	19.82	100

The energy budget for a UW BGC-Argo float (0-2000 m profile)

[4 DD packs x 4 cells each x 325 KJ/cell = 5200 KJ total energy contained in the float]

[5200 KJ/(19.82 KJ/profile) ≈ 262 profiles]

Note: requires 25% of energy

$$\begin{aligned} totalProfileEnergy &:= initProfileEnergy + decreaseBuoyancyEnergy + initialDescendEnergy \downarrow \\ &\quad + (maintainDescendEnergy \cdot profileDepth) + anchorEnergy + dumpCPModeEnergy + deanchorEnergy \downarrow \\ &\quad + initialAscendEnergy + (maintainAscendEnergy \cdot profileDepth) + surfaceOpsEnergy + totalSampleEnergy200 \\ totalProfileEnergy &= (2.891 \cdot 10^4) \text{ J} \qquad TPEminusAncDeAnc := totalProfileEnergy - anchorEnergy - deanchorEnergy = (2.097 \cdot 10^4) \text{ J} \end{aligned}$$

Anchor parameters

$$\begin{aligned} totalAnchorEnergy &:= anchorEnergy + ((numAnchorSamples - 1) \cdot wakeFromSleepEnergy) \downarrow \\ &\quad + (numAnchorSamples \cdot totalSampleEnergy200) \downarrow \\ &\quad + (numAnchorSamples - 1) \cdot (anchorSamplePeriod \cdot sleepVolts \cdot sleepAmps) \\ totalAnchorEnergy &= (1.671 \cdot 10^4) \text{ J} \end{aligned}$$

Totals

$$totalMissionEnergy := missionSetupEnergy + numProfiles \cdot (totalProfileEnergy + totalAnchorEnergy) = (9.125 \cdot 10^6) \text{ J}$$

$$profileTime := \frac{profileDepth}{descendSpeed} + \frac{profileDepth}{ascendSpeed} + anchorPeriod + surfaceOpsTime = 5.35 \text{ hr}$$

$$missionTime := numProfiles \cdot profileTime = 44.583 \text{ day}$$

Battery pack parameters (Li primary)

$$\begin{aligned} cellVoltage &:= 3.3 \cdot V \qquad numSCells := 8 \qquad numPCells := 4 \\ numBatteries &:= 32 \qquad batteryVolts := cellVoltage \cdot numSCells = 26.4 \text{ V} \qquad batteryCharge := 30 \cdot amp \cdot hr \qquad selfDischarge := \frac{0.03}{yr} = (9.507 \cdot 10^{-10}) \frac{1}{s} \\ generalDerating &:= 0.8 \\ batteryEnergy &:= batteryVolts \cdot batteryCharge = (2.851 \cdot 10^6) \text{ J} \\ packEnergyTheor &:= numBatteries \cdot batteryEnergy = (9.124 \cdot 10^7) \text{ J} \\ packEnergyLiPrimary &:= generalDerating \cdot (packEnergyTheor \cdot (1 - (selfDischarge \cdot missionTime))) = (7.272 \cdot 10^7) \text{ J} \end{aligned}$$

Battery pack parameters (LiIon)

$numBatteries := 144$

$batteryVolts := 28 \cdot V$

$batteryCharge := 3.4 \cdot amp \cdot hr$

$selfDischarge := \frac{0.03}{yr} = \left(9.507 \cdot 10^{-10}\right) \frac{1}{s}$

$generalDerating := 0.8$

$batteryEnergy := batteryVolts \cdot batteryCharge = \left(3.427 \cdot 10^5\right) J$

$packEnergyTheor := numBatteries \cdot batteryEnergy = \left(4.935 \cdot 10^7\right) J$

$packEnergyLiIon := generalDerating \cdot \left(packEnergyTheor \cdot \left(1 - \left(selfDischarge \cdot missionTime\right)\right)\right) = \left(3.934 \cdot 10^7\right) J$

$\frac{packEnergyLiIon}{packEnergyLiPrimary} = 0.541$

Battery pack parameters (Inspired Energy)

$numBatteries := 48$

$batteryVolts := 28 \cdot V$

$batteryCharge := 3.4 \cdot amp \cdot hr$

$selfDischarge := \frac{0.03}{yr} = \left(9.507 \cdot 10^{-10}\right) \frac{1}{s}$

$generalDerating := 0.8$

$batteryEnergy := batteryVolts \cdot batteryCharge = \left(3.427 \cdot 10^5\right) J$

$packEnergyTheor := numBatteries \cdot batteryEnergy = \left(1.645 \cdot 10^7\right) J$

$packEnergyIE := generalDerating \cdot \left(packEnergyTheor \cdot \left(1 - \left(selfDischarge \cdot missionTime\right)\right)\right) = \left(1.311 \cdot 10^7\right) J$

Energy Summary

$profileDepth = 200 \ m$

$numProfiles = 200$

$samplesPerProfile = 40$

$descendSpeed = 0.2 \frac{m}{s}$

$ascendSpeed = 0.1 \frac{m}{s}$

$numAnchorSamples = 4$

$anchorSamplePeriod = 1.067 \ hr$

Energy for 1 profile:

$totalProfileEnergy = \left(2.891 \cdot 10^4\right) J$

Energy for 1 profile
minus anchor
and deanchor:

$TPEminusAncDeAnc = \left(2.097 \cdot 10^4\right) J$

Missions Per Li
Primary Pack:

$\frac{packEnergyLiPrimary}{totalMissionEnergy} = 7.97$

Missions Per LiIon
Pack:

$\frac{packEnergyLiIon}{totalMissionEnergy} = 4.311$

Missions Per IE Pack:

$\frac{packEnergyIE}{totalMissionEnergy} = 1.437$

“Init Profile”	$initProfileEnergy$
“Decrease Buoyancy”	$decreaseBuoyancyEnergy$
“Initial Descend”	$initialDescendEnergy$
“Maintain Descend”	$(maintainDescendEnergy \cdot profileDepth)$
“Anchor”	$anchorEnergy$
“De–Anchor”	$deanchorEnergy$
“Start CP Mode”	$startCPModeEnergy$
“Initial Ascend”	$initialAscendEnergy$
“Maintain Ascend”	$(maintainAscendEnergy \cdot profileDepth)$

“Set Bellows”	$(6.6 \cdot 10^3) J$
“Initial Recovery”	$165 J$
“Pre–Mission Delay”	$66 J$
“Init Profile”	$119 J$
	$\vdots$

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t3 := WRITECSV (“energyData.txt”, energyData)
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