

Table of Contents

1	SFM1 Sap Flow Meter Manual	10
1.1	Intellectual Property	10
1.2	SFM1 Start Up Check List	10
2	System Requirements.....	11
2.1	Hardware	11
2.2	Software.....	11
2.3	Screen Resolution.....	11
3	Bibliography.....	12
3.1	Essential Reading	12
3.2	Highly recommended reading	14
4	Quick Start Guide.....	15
4.1	Charge the SFM1 Internal Battery	15
4.2	Install the SFM1 Software & USB Driver	15
4.3	Turn the Instrument On	15
4.4	Connect to the Instrument.....	15
4.5	Perform a Verification Test.....	15
4.6	Install the Sap Flow Meter	15
4.7	Set the Logging Interval	16
4.8	Download Data.....	16
4.9	Analyse Data.....	16
5	Sap Flow Meter Description	17
5.1	SFM1 Needle Set	17
5.1.1	Measurement Resolution	18
5.1.2	Needle Design	18
5.1.3	Heater Needle Design	18
5.1.4	Colour coded probes.....	19
5.2	Measurement Reporting Options.....	20
5.2.1	Needle Temperature	20
5.2.2	Heat Pulse Velocity.....	20
5.2.3	Corrected Sap Velocity	20
5.2.4	Corrected Sap Flow	20
5.3	SFM1 Sap Flow Meter	21
5.3.1	Water Proofing.....	22
5.3.2	Power Management.....	22
5.3.3	External power.....	22
5.3.4	Tools	22

5.3.5	Power Fail Safe Mode.....	22
5.3.6	Lightning Protection	23
5.3.7	Data Storage & Memory	23
5.3.8	Communication	23
5.3.9	Software & Firmware.....	23
5.3.10	Operating Temperature Range.....	23
6	Heat Ratio Method Theory	24
6.1	Measurement and calculation of heat pulse velocity	25
6.1.1	CHPM (Compensation Heat Pulse Method)	25
6.1.2	HRM (Heat Ratio Method)	25
6.2	Influence of measurement time	26
6.3	Correction for probe misalignment	27
6.4	Correction for wounding	28
6.5	Determining sap velocity.....	29
6.6	Converting sap velocity to sap flow.....	29
7	Measurement Cycle and Process.....	30
8	Powering - Charging the instrument	31
8.1	Power Requirements.....	31
8.1.1	Idle State Power Consumption	31
8.1.2	Communications Power Consumption	31
8.1.3	Heater Power Consumption	31
8.2	External Power Supply Options	32
8.2.1	External Battery-Only Power Supply.....	32
8.2.2	Solar Power Supply	32
8.3	Extension cables.....	33
9	Connecting a Power Supply to the Instrument.....	34
9.1	Individual Power Supply Connections	36
9.1.1	Connecting Power Directly via Solar Panel.....	36
9.1.2	Connecting Power via External 12V Battery	37
9.1.3	Connecting Power via External 12V Battery and Solar Panel.....	38
9.2	Shared Power Supply for Multiple Instruments.....	39
9.2.1	Sharing an External 12V Battery and Solar Panel via Daisy Chaining.....	40
10	Solar Panels.....	41
10.1	Solar Panel Specifications	41
10.2	Solar Panel Calculator.....	42
10.3	Solar Panel Mounting.....	43
10.3.1	Mounting on a Star Picket	43
10.3.2	Mounting Options	44
10.4	Connection of Solar Panel to the SFM1	45

11	Software & USB Driver Installation.....	47
11.1	Instrument Set-up and Configuration	47
11.2	SFM1 Utility Software.....	47
11.2.1	Installation	47
11.2.2	Microsoft Operating System Minimum Requirements	47
12	Turning the Instrument On and Off	49
12.1	Turn the SFM1 On	49
12.2	Turn the SFM1 OFF	51
13	Communications.....	52
13.1	Connect to the Instrument.....	52
13.1.1	The opening Splash Screen displays the following.....	52
13.1.2	A status bar along the bottom of the window.....	52
13.2	USB Connection.....	53
13.2.1	USB - Find Devices.....	53
13.2.2	USB Select Device	54
13.2.3	SFM Connection Options.....	56
13.3	MCC1 - RF Modem.....	58
13.3.1	RF Connection Type.....	58
13.3.2	RF Find Devices.....	58
13.3.3	RF Select Device	59
13.3.4	RF Discover.....	59
13.3.5	RF Device Wake Up Routine	60
13.3.6	RF Search for more Devices.....	60
13.3.7	Saving Discovered Devices as a Group.....	61
13.3.8	Adding Devices to a Saved Group	62
13.3.9	Connecting to a Device via RF	62
14	LED Status Indicators	64
14.1	Power Circuit LEDs.....	64
14.1.1	LED Flash Sequence Definitions	64
14.2	USB Communication LEDs	64
14.2.1	Red LED.....	64
14.2.2	Green LED	64
14.3	Device Firmware	65
14.4	Power down	65
15	Instrument Configuration.....	66
15.1	Instrument Information.....	67
15.1.1	Name.....	67
15.1.2	Comment.....	67
15.1.3	Update Instrument Information.....	68

15.1.4	SD Card.....	68
15.1.5	SD Card Initialisation.....	68
15.1.6	SD Card Formatting.....	69
15.1.7	Instructions to reformat a MicroSD Card.....	69
15.1.8	Format Check.....	69
15.1.9	File Name Error.....	69
15.1.10	Serial Number.....	70
15.1.11	I icon.....	70
15.1.12	APP Serial #.....	70
15.1.13	COM Serial #.....	70
15.1.14	O icon.....	71
15.1.15	APP Ver.	71
15.1.16	COM Ver.	71
15.1.17	External Supply.....	71
15.1.18	Battery.....	72
15.1.19	Status.....	72
15.2	Dialogue Box.....	73
15.2.1	Copy to Clipboard Icon.....	73
15.2.2	Clear Icon.....	73
15.2.3	Dialogue Box Clear Icon.....	74
15.3	Status Bar:.....	74
15.3.1	Connection status.....	74
15.3.2	Batt.....	74
15.3.3	Port.....	74
15.3.4	Device Date.....	74
15.3.5	Device Time.....	74
15.4	Help Menu.....	75
15.4.1	About.....	75
15.4.2	Check for Updates.....	75
15.4.3	Display Debug Registers.....	76
15.5	Measurement Control.....	77
15.5.1	Measurement Mode.....	77
15.5.2	Reporting Options.....	79
15.5.3	Delayed Start/Suspend Measurement.....	80
15.6	Commands.....	83
15.6.1	Update Date & Time.....	83
15.7	SD Card Logging Options.....	84
15.7.1	Probe Selection.....	85
15.7.2	Calculated Results.....	85

15.7.3	Power Management.....	85
15.7.4	Raw Temperature Mode.....	86
15.7.5	Interpreting Raw Temperature Data.....	87
15.8	SFM Data Tab.....	89
15.8.1	Pulse Energy.....	91
15.9	Corrections	92
15.9.1	Probe Spacing.....	93
15.10	Needle Symmetry	94
15.10.1	Base-line Asymmetry Multipliers (BLAM)	95
15.10.2	Base-line Asymmetry Offsets (BLAO)	95
15.11	Thermal Diffusivity.....	96
15.11.1	Measuring Fresh Weight.....	97
15.11.2	Measuring Fresh Volume.....	97
15.11.3	Measuring Dry Weight	99
15.12	Wounding Coefficient.....	100
15.13	V _s Factor	101
15.14	Sap Wood Area.....	102
15.14.1	The weighting is calculated by.....	102
15.15	Reports	103
16	Install the Sap Flow Meter.....	104
16.1	Selecting a Measurement Tree.....	104
16.2	Measure the Stem Diameter.....	104
16.2.1	How to convert stem Circumference to stem Diameter.....	105
16.2.2	Stem Diameter Measuring protocol.....	105
16.3	Measure Bark Depth	105
16.3.1	Bark Depth Gauge	106
16.4	Measure Sapwood thickness.....	107
16.4.1	Setup the Coring Tool.....	108
16.4.2	Extracting a Sapwood Core	108
16.4.3	Preparing an Indicator Stain.....	110
16.4.4	Destructive Sampling to Measure Sapwood	111
16.4.5	Microscopic analysis	112
16.5	Attach Installation Guide.....	112
16.6	Begin Drilling	113
16.6.1	Drill bit specifications.....	114
16.6.2	Cordless Power Drill.....	114
16.7	Check the Holes are Parallel.....	116
16.8	Use Spacers	117
16.9	Grease Needles.....	117

16.10	Insert Needles and Attach SFM1 to Tree	118
16.11	Insulation.....	119
16.11.1	Insulate Needles on Small Diameter Stems	119
16.12	Uninstall.....	120
16.12.1	Needle Removal	120
16.13	Repair	121
16.14	Care & Maintenance	122
16.14.1	Cleaning.....	122
16.14.2	Storage	123
17	Data Storage & Downloading	124
17.1	MicroSD Card Storage Capacity	124
17.2	Data Format	124
17.2.1	Windows FAT-32 Compatible.....	124
17.2.2	Data File Nomenclature.....	124
17.2.3	Data File Format	125
17.2.4	SD Card Logging Options.....	126
17.3	Downloading Data.....	127
17.3.1	Download data Via USB Cable	127
17.3.2	Download Data Icon.....	127
17.3.3	Delete or Rename a data file	128
17.3.4	Appending data to a file.....	128
17.3.5	SD Card Data Management Options.....	129
17.3.6	Download MicroSD Card via USB Adaptor	132
18	PC Logging	134
18.1.1	Log Incoming Reporting Option Data.....	134
18.1.2	Log Temperatures.....	136
19	Data Analysis.....	138
19.1	Analysis of Raw Heat Pulse Velocity.....	138
19.2	Corrected Sap Velocity	139
19.3	Volumetric Sap Flow	140
19.4	Cumulative Sap Flow Analysis.....	140
19.5	Environmental Sap Flow Analysis.....	141
19.6	Measuring Zero Flow	142
19.6.1	Cut Stem Analysis.....	142
20	An ecophysiological framework for interpreting sap flow data	150
20.1	Example Sap Flow data and scenarios.....	150
21	Frequently Asked Questions - FAQ's.....	153
22	Appendices.....	156
22.1	Appendix A.....	156

22.1.1	Heat Ratio Method Correction Coefficients.....	156
22.2	Appendix B	157
22.2.1	Specifications of SFM1 Sap Flow Meter	157
22.3	Appendix C	158
22.3.1	Warranty	158
22.4	Appendix D.....	159
22.4.1	Equipment Checklist	159
22.5	Appendix E.....	160
22.5.1	SFM-SK1 Installation Kit.....	160
22.6	Appendix F.....	161
22.6.1	Example SFM1 Packing List.....	161
22.7	Appendix G	162
22.7.1	Glossary.....	162
22.7.2	Acronyms	163
22.8	Appendix H.....	164
22.8.1	Algebraic Terms.....	164
22.9	Appendix I General structural anatomy of a tree.....	165
22.10	Appendix J.....	166
22.10.1	Show Thermistor Calibration.....	166
22.10.2	Hide Thermistor Calibration	167
22.11	Appendix K	168
22.11.1	Automated Web Updates.....	168
22.11.2	Manual Web Updates	169
22.12	Appendix L.....	171
22.12.1	Extension Cable Specs	171
22.13	Appendix M.....	171
22.13.1	SD Card Re-Initialisation	171
22.14	Appendix N.....	172
22.14.1	SFM1 Test Block	172
22.15	Appendix O	173
22.15.1	SFM1 External Battery Operation Test (without Solar Panel).....	173
22.16	Appendix P	177
22.16.1	Signal Strength Test Procedure	177
22.16.2	Configure HyperTerminal for RSSI Test Utility Interface	179
22.16.3	RSSI Test Utility	179
22.16.4	Option 1 Select Device	180
22.16.5	Locating the instrument Serial Number	180
22.17	Appendix Q	182
22.17.1	Methyl Orange MSDS.....	182

23	List of Equations	185
24	Table of Photos	186
25	Table of Figures.....	188
26	Table of Warnings	193
27	Table of Notes.....	195
28	Contact Details	203