Group	Parameter	Used By libfg	Used By libreg	Used By cctest	Default Value(s)	Max # of Values	Type or Values	Description	Change since V4
GLOBAL – Global Parameters									
GLOBAL	PRE_FUNC_DELAY			✓	0.1	1	Float	Delay in seconds between consecutive functions (ignored if only one function is specified).	
GLOBAL	RUN_DELAY	✓			1	1	Float	Delay in seconds before the start of each function	
GLOBAL	STOP_DELAY			✓	1	1	Float	Delay in seconds after end of last function before the simulation ends	
GLOBAL	ITER_PERIOD_US	✓	✓	✓	1000	1	Unsigned	Base iteration period in microseconds: The is the measurement period. Current or field regulation runs at an integer multiple of this period.	Replaces floating point ITER_PERIOD.
GLOBAL	ABORT_TIME			✓	0	1	Float	Time in seconds at which the Current or Field reference function should be aborted. The abort sequence switches to a RAMP function that smoothly takes over from the running reference function and ramps down to LIMITS.B_MIN or LIMITS.I_MIN. Set to zero to disable testing the abort behaviour. If ABORT_TIME > 0, REG_MODE must be CURRENT or FIELD and FG_LIMITS must be ENABLED.	
GLOBAL	ACTUATION		✓		VOLTAGE	1	VOLTAGE CURRENT	Specify VOLTAGE to simulate control of a voltage source. In this case, cctest can use libreg to regulate the current or field or it can drive a voltage reference in open-loop. Specify CURRENT to simulate control of a current source. In this case, cctest can use libfg to generate a current reference and the regulation of the current is assumed to be the responsibility of the current source.	
GLOBAL	REVERSE_TIME			✓	DISABLED	1	DISABLED ENABLED	If ENABLED, the function is sampled with decreasing times to test if it can handle time going backwards. To enable this option, REG_MODE must be VOLTAGE, SIM_LOAD must be DISABLED, only one function can be specified and the RAMP function many not be selected.	
GLOBAL	REG_MODE		✓	✓	VOLTAGE	10	VOLTAGE CURRENT FIELD	Select regulation mode. If VOLTAGE, regulation is disabled and the function is directly used as the voltage reference. If CURRENT or FIELD is selected, the function will be used to define the current or field reference and the voltage reference will be calculated using the RST regulation algorithm. In this case, SIM_LOAD must be ENABLED. If ACTUATION is CURRENT, then REG_MODE must also be CURRENT. A different REG_MODE can be defined for every FUNCTION. If fewer REG_MODE parameters are defined than FUNCTION parameters, then the last REG_MODE will continue for all subsequent functions.	
GLOBAL	FUNCTION			✓	SINE	10	PLEP RAMP PPPL TABLE STEPS SQUARE SINE COSINE LTRIM CTRIM	Selects which function to generate. Multiple functions can be specified, separated by white space or commas. The functions will run consecutively, with a delay of PRE_FUNC_DELAY between them. See the parameter section for each function below for more details. The units of the function are defined by REG_MODE.	
GLOBAL	REG_ERR_RATE		✓		REGULATION	1	REGULATION MEASUREMENT	If REGULATION, calculate the field regulation error at regulation rate. If MEASUREMENT, calculate regulation error at measurement rate.	Replaces ERR_RATE and BREG and IREG.
GLOBAL	FG_LIMITS			✓	DISABLED	1	DISABLED ENABLED	Controls whether limits are checked by libfg when initialising each reference function. As the same limits are used during the simulation of the voltage source and load, FG_LIMITS must be DISABLED to test the limits with a function that exceeds them.	
GLOBAL	SIM_LOAD			✓	DISABLED	1	DISABLED ENABLED	If DISABLED, only function generation is tested. If ENABLED, the voltage source (or current source if ACTUATION is CURRENT) and the load are simulated as well.	
GLOBAL	STOP_ON_ERROR			✓	ENABLED	1	DISABLED ENABLED	If ENALBED, then execution of a script being read from a file will stop if an error is reported. Specify DISABLED if errors are expected and execution must continue.	
GLOBAL	CSV_FORMAT			✓	NONE	1	NONE STANDARD FGCSPY LVDV	cctest can write a CSV file with all the signals from a simulation. The parameter allows different header formats for the data. STANDARD output can be opened in a spreadsheet. FGCSPY adds the suffix _D to the signal names for signals that need trailing step interpolation. LVDV adds a metadata header line and cursors for the CERN Labview Dataviewer.	
GLOBAL	FLOT_OUTPUT			✓	ENABLED	1	DISABLED ENABLED	If ENABLED, cctest will generate HTML+Flot (jQuery) output files in ../../results/webplots/ for graphical display in a web browser. A compatible version of the Flot library must be installed in ../../results/webplots/flot to use this option.	
GLOBAL	DEBUG_OUTPUT			✓	ENABLED	1	DISABLED ENABLED	If ENABLED, generate debugging output for each run. This can be found in cctest/results/debug/	
GLOBAL	GROUP			✓	sandbox	1	String	Output is written ../../results/{csv,debug,webplots}/ GROUP/PROJECT/FILE.{csv,ccd,html}	
GLOBAL	PROJECT			✓	FG	1	String		
GLOBAL	FILE			✓	cctest	1	String		
LIMITS – Limit Parameters									
Used during the arming of the reference function when GLOBAL.FG_LIMITS = ENABLED and during the simulation when GLOBAL.SIM_LOAD = ENABLED									
LIMITS	B_POS	✓	✓		10	1	Float	Maximum positive field	
LIMITS	B_MIN	✓			0	1	Float	Minimum field that can be regulated by a 1- or 2-quadrant converter. This is usually set to zero for a 4-quadrant converter.	
LIMITS	B_NEG	✓	✓		-10	1	Float	Maximum negative field. Set to zero for a 1- or 2- quadrant converter.	
LIMITS	B_RATE	✓	✓		5	1	Float	Maximum absolute rate of change of field. If set to zero, then the rate check is disabled.	

LIMITS	B_ACCELERATION	✓	✓	1000000	1	Float	Maximum absolute field acceleration. If set to zero, the acceleration checks are disabled.	
LIMITS	B_ERR_WARNING		✓	0	1	Float	Field regulation error warning threshold. If set to zero, the field regulation warning check is disabled. The field regulation error is compared to this threshold and the flag (0 or 1) indicating if the threshold is exceeded is filtered with a first order filter with a time constant of 10 periods. If the filtered flag exceeds 0.3, the warning will be activated and the threshold is halved. This hysteresis of the threshold should reduce the chance that the warning will toggle repeatedly. Once the filtered flag falls below 0.3, the threshold returns to original value defined in B_ERR_WARNING. This check will be done at the regulation rate if BREG ERROR_RATE is set to REGULATION, or the measurement rate if set to MEASUREMENT.	
LIMITS	B_ERR_FAULT		✓	0	1	Float	Field regulation error fault threshold. If set to zero, the fault check is disabled. The treatment of the fault threshold is the same as the warning threshold described above. If the fault is activated, cctest will simulate the tripping of the power converter.	
LIMITS	B_CLOSELOOP		✓	0.5	1	Float	Field regulation closed-loop threshold For a 1- or 2-quadrant converter. This is the level at which the regulation switches from open-loop to closed-loop. For a 4-quadrant converter it isn't used.	New in V5.
LIMITS	I_POS	✓	✓	10	1	Float	Maximum positive current	
LIMITS	I_MIN	✓		0	1	Float	Minimum current that can be regulated by a 1- or 2-quadrant converter. This is usually set to zero for a 4-quadrant converter.	
LIMITS	I_NEG	✓	✓	-10	1	Float	Maximum negative current. Set to zero for a 1- or 2-quadrant converter.	
LIMITS	I_RATE	✓	✓	5	1	Float	Maximum absolute rate of change of current. If set to zero, then the rate check is disabled.	
LIMITS	I_ACCELERATION	✓	✓	1000000	1	Float	Maximum absolute current acceleration. If set to zero, the acceleration checks are disabled.	
LIMITS	I_ERR_WARNING		✓	0	1	Float	Current regulation error warning threshold. If set to zero, the current regulation warning check is disabled. The current regulation error is compared to this threshold and the flag (0 or 1) indicating if the threshold is exceeded is filtered with a first order filter with a time constant of 10 periods. If the filtered flag exceeds 0.3, the warning will be activated and the threshold is halved. This hysteresis of the threshold should reduce the chance that the warning will toggle repeatedly. Once the filtered flag falls below 0.3, the threshold returns to original value defined in I_ERR_WARNING. This check will be done at the regulation rate if IREG ERROR_RATE is set to REGULATION, or the measurement rate if set to MEASUREMENT.	
LIMITS	I_ERR_FAULT		✓	0	1	Float	Current regulation error fault threshold. If set to zero, the fault check is disabled. The treatment of the fault threshold is the same as the warning threshold described above. If the fault is activated, cctest will simulate the tripping of the power converter.	
LIMITS	I_CLOSELOOP		✓	0.5	1	Float	Current regulation closed-loop threshold For a 1- or 2-quadrant converter. This is the level at which the regulation switches from open-loop to closed-loop. For a 4-quadrant converter it isn't used.	New in V5.
LIMITS	I_QUADRANTS41		✓	0	2	Float	Used with V_QUADRANT41 to limit voltage as a function of current. This can protect 2- or 4-quadrant converters which cannot send energy back onto the mains and may overheat if forced to extract energy to quickly from a highly inductive load.	
LIMITS	V_POS	✓	✓	100	1	Float	Maximum positive voltage from the voltage source.	
LIMITS	V_NEG	✓	✓	-100	1	Float	Maximum negative voltage from the voltage source.	
LIMITS	V_RATE	✓	✓	1000	1	Float	Maximum absolute rate of change of voltage allowed by the voltage source. If set to zero, the rate of change checks are disabled.	
LIMITS	V_ACCELERATION	✓	✓	1000000	1	Float	Maximum absolute voltage acceleration. If set to zero, the acceleration checks are disabled.	
LIMITS	V_ERR_WARNING		✓	0	1	Float	Voltage regulation error warning threshold. If set to zero, the voltage regulation warning is disabled. Libreg does not support the voltage regulation, however, if the voltage is measured, the error of the external voltage regulation loop can be calculated and monitored. The algorithm is the same as for the current or field regulation warning threshold.	
LIMITS	V_ERR_FAULT		✓	0	1	Float	Voltage regulation error fault threshold. If set to zero, the voltage regulation fault is disabled. Libreg does not support the voltage regulation, however, if the voltage is measured, the error of the external voltage regulation loop can be calculated and monitored. The algorithm is the same as for the current or field regulation fault threshold. If the fault is activated, cctest will simulate the trip of the power converter	
LIMITS	V_QUADRANTS41		✓	0	2	Float	Used with I_QUADRANT41 to limit voltage as a function of current. This can protect 2- or 4-quadrant converters which cannot send energy back onto the mains and may overheat if forced to extract energy to quickly from a highly inductive load.	
LIMITS	I_RMS_TC		✓	0	1	Float	Converter RMS current protection: RMS Current filter Time Constant. If zero, the converter protection RMS current will not be calculated and I_RMS_WARNING and I_RMS_FAULT are ignored.	

LIMITS	I_RMS_WARNING		✓		0	1	Float	Converter RMS current protection: RMS Current warning limit. If set to zero, the warning check is disabled. The square of the current is filtered with a first order filter with time constant I_RMS_TC. If this filtered value exceeds the square of the I_RMS_WARNING, then the RMS warning flag will be activated and the threshold will be reduced by 20% to reduce the risk of toggling.	
LIMITS	I_RMS_FAULT		✓		0	1	Float	Converter RMS current protection: RMS Current fault limit. If set to zero, the fault check is disabled. The square of the current is filtered with a first order filter with time constant I_RMS_TC. If this filtered value exceeds the square of the I_RMS_FAULT, then the RMS trip flag will be activated and cctest will simulate a trip of the power converter.	
LIMITS	I_RMS_LOAD_TC		✓		0	1	Float	Load RMS current protection: RMS Current filter Time Constant. If zero, the converter protection RMS current will not be calculated and I_RMS_WARNING and I_RMS_FAULT are ignored.	New in V5.
LIMITS	I_RMS_LOAD_WARNING		✓		0	1	Float	Load RMS current protection: RMS Current warning limit. If set to zero, the warning check is disabled. The square of the current is filtered with a first order filter with time constant I_RMS_TC. If this filtered value exceeds the square of the I_RMS_WARNING, then the RMS warning flag will be activated and the threshold will be reduced by 20% to reduce the risk of toggling.	New in V5.
LIMITS	I_RMS_LOAD_FAULT		✓		0	1	Float	Load RMS current protection: RMS Current fault limit. If set to zero, the fault check is disabled. The square of the current is filtered with a first order filter with time constant I_RMS_TC. If this filtered value exceeds the square of the I_RMS_FAULT, then the RMS trip flag will be activated and cctest will simulate a trip of the power converter.	New in V5.
LIMITS	INVERT	✓	✓		DISABLED	1	DISABLED ENABLED	If ENABLED, libfg and invert the polarity of the limits before checking. This would be used if a 1-quadrant converter is connected to the load via a polarity switch and the switch is in the inverting position.	
LOAD – Load Parameters *Used to simulate a load when GLOBAL.SIM_LOAD = ENABLED*									
LOAD	OHMS_SER		✓		0.5	1	Float	Series resistance (R_s) corresponding to the resistance of the cables from the power converter to the magnet(s).	
LOAD	OHMS_PAR		✓		1000000000	1	Float	Parallel damping resistance (R_p).	
LOAD	OHMS_MAG		✓		1	1	Float	Magnet resistance (R_m).	
LOAD	HENRYS		✓		1	1	Float	Magnet inductance without saturation effects (L).	
LOAD	HENRYS_SAT		✓		1	1	Float	Magnet inductance when fully saturated (L_sat).	
LOAD	I_SAT_START		✓		0	1	Float	Current at start of magnet saturation (I_{sat_start}).	
LOAD	I_SAT_END		✓		0	1	Float	Current at which the magnet is fully saturated (I_{sat_end}). Set to zero if the magnet does not saturate.	
LOAD	GAUSS_PER_AMP		✓		1.2	1	Float	Field to current ratio without saturation effects.	
LOAD	PERTURB_VOLTS		✓		0	1	Float	Voltage perturbation level. This voltage appears as a disturbance on the simulated load at the time given by PERTURB_TIME and remains until the end of the run. This is useful to see the rejection of perturbations by the regulation loop.	
LOAD	PERTURB_TIME			✓	0	1	Float	Voltage perturbation time, the time at which PERTURB_VOLTS appears as a perturbation on the simulated load. Set to zero to disabled the perturbation.	
LOAD	SIM_TC_ERROR		✓		0	1	Float	Simulated load Time Constant error factor. To evaluate the robustness of the regulation, the simulated load parameters can be distorted, resulting in a shift in the simulated load time constant by a factor related to SIM_TC_ERROR. For example, If SIM_TC_ERROR is 0.1, the time constant of the simulated load will be 10% greater than expected by the RST regulation algorithm, whose coefficients are calculated using the undistorted load parameters.	
LOAD	POL_SWI_AUTO		✓		DISABLED	1	DISABLED ENABLED	If ENABLED and GLOBAL FG_LIMITS is ENABLED, then the limits used when checking the reference will be based on the range of the function. This assumes that the range of the function will be used when it is about to be played, to set the polarity switch on a 1-quadrant converter automatically. In this way, the anticipated polarity switch position can be used when arming a reference function, at a time when the polarity switch may not be in the anticipated position.	
MEAS – Measurement Parameters									
MEAS	B_REG_SELECT		✓		EXTRAPOLATED	1	UNFILTERED FILTERED EXTRAPOLATED	Selector for the field measurement to use for field regulation. If UNFILTERED, then the raw measurement acquired at the measurement rate will be decimated at the regulation period and used for field regulation. The measurement delay will be B_DELAY_ITERS in measurement periods. This minimises the delay but noise will be aliased into the regulation pass band. If FILTERED, then the filtered field measurement will be decimated at the regulation period and used for field regulation. The filter is implemented in libreg and is configured by B_FIR_LENGTHS. This will reduce the noise aliased in the regulation pass band but will increase the latency. If EXTRAPOLATED, then the filtered measurement will be extrapolated using the measured rate of change to compensate for the delay of the measurement and the FIR filter. This will reduce the latency to zero, but will increase the noise.	
MEAS	I_REG_SELECT		✓		EXTRAPOLATED	1	UNFILTERED FILTERED EXTRAPOLATED	Selector for the current measurement to use for current regulation. This has the same behaviour as the selector for the field measurement (above).	

MEAS	B_DELAY_ITERS	✓		1.3	1	Float	Field measurement delay specified as number of iterations (GLOBAL ITER_PERIOD)	
MEAS	I_DELAY_ITERS	✓		1.3	1	Float	Current measurement delay specified as number of iterations.	
MEAS	V_DELAY_ITERS	✓		1.3	1	Float	Voltage measurement delay specified as number of iterations.	
MEAS	B_FIR_LENGTHS	✓		1, 1	2	Unsigned	Field measurement Finite Impulse Response (FIR) filter lengths specified as number of iterations. Must be non-zero. Two sliding average filters are cascaded. Setting the length to 1 effectively disables that stage. The filter delay in iterations will be (B_FIR_LENGTHS[0] + B_FIR_LENGTHS[1])/2.	
MEAS	I_FIR_LENGTHS	✓		1, 1	2	Unsigned	Current measurement FIR filter lengths. This has the same behaviour as the field measurement filter described above.	
MEAS	B_SIM_NOISE_PP	✓		0	1	Float	Simulated field measurement peak-peak noise level.	
MEAS	I_SIM_NOISE_PP	✓		0	1	Float	Simulated current measurement peak-peak noise level.	
MEAS	V_SIM_NOISE_PP	✓		0	1	Float	Simulated voltage measurement peak-peak noise level.	
MEAS	TONE_HALF_PERIOD_ITERS	✓		10	1	Unsigned	Simulated measurement tone half-period specified as a number of measurement iterations. This can be used to simulate 50Hz noise and test that the FIR filter is adjusted to cancel this frequency.	
MEAS	B_SIM_TONE_AMP	✓		0	1	Float	Simulated field measurement tone amplitude.	
MEAS	I_SIM_TONE_AMP	✓		0	1	Float	Simulated current measurement tone amplitude.	
MEAS	INVALID_MEAS_PERIOD_ITERS		✓	0	1	Unsigned	Period between bursts of invalid measurements specified as number of iterations. Libreg can replace invalid measurements with an estimate of what the measurement will be, based on the model the regulation error or the rate of change. These cctest parameters allow this feature of libreg to be tested.	
MEAS	INVALID_MEAS_REPEAT_ITERS		✓	1	1	Unsigned	Number of iterations to repeat the invalid measurements. In general, one bad measurement will be fairly transparent. The more bad measurements, the bigger the perturbation is likely to be.	
BREG – Field Regulation Parameters								
BREG	PERIOD_ITERS	✓		10	1	Unsigned	Field regulation period specified as number of iterations.	
BREG	PURE_DELAY_PERIODS	✓		0	1	Float	Pure delay in the field regulation loop, specified as number of regulation periods. If set to zero, cctest will estimate it based on the other known parameters. This delay is a primitive way to model the otherwise unmodelled delays and dynamics around the loop (i.e. everything except the load). This includes the delay before the voltage reference is received by the voltage source (VS V_REF_DELAY_ITERS) + the measurement delay + the voltage source response time. The RST coefficients will be calculated using one of five algorithms selected according to the pure delay. It must be in the range from 0 to 2.4 regulation periods.	
BREG	TRACK_DELAY_PERIODS	✓		0	1	Float	Anticipated delay between the setting of the field reference and the moment when the measurement should equal the reference, specified as number of regulation periods. If this is set to zero, it will be calculated by the algorithm. This is used to calculate the error in the response of the field regulation loop.	
BREG	AUXPOLE1_HZ	✓		10	1	Float	Frequency of the first (real) auxiliary pole. The AUXPOLE* parameters are used to calculate coefficients for the RST regulation algorithm. For fast loads, set AUXPOLE1_HZ to 1.0E+5 and AUXPOLES2_Z to 0.8. Normally AUXPOLE1_HZ = AUXPOLES2_HZ and AUXPOLES2_Z = 0.5. Set to zero to use the R, S and T polynomials	
BREG	AUXPOLES2_HZ	✓		10	1	Float	Frequency of (conjugate) auxiliary poles 2 & 3	
BREG	AUXPOLES2_Z	✓		0.5	1	Float	Damping of (conjugate) auxiliary poles 2 & 3	
BREG	AUXPOLE4_HZ	✓		10	1	Float	Frequency of (real) auxiliary pole 4	
BREG	AUXPOLE5_HZ	✓		10	1	Float	Frequency of (real) auxiliary pole 5	
BREG	R	✓		0,0,0,0,0,0,0,0,0,0	10	Double	RST R coefficient – used when AUXPOLE1_HZ = 0	Was present but not documented.
BREG	S	✓		0,0,0,0,0,0,0,0,0,0	10	Double	RST S coefficient – used when AUXPOLE1_HZ = 0	Was present but not documented.
BREG	T	✓		0,0,0,0,0,0,0,0,0,0	10	Double	RST T coefficient – used when AUXPOLE1_HZ = 0	Was present but not documented.
IREG – Current Regulation Parameters								
IREG	PERIOD_ITERS	✓		10	1	Unsigned	Current regulation period specified as number of iterations.	
IREG	PURE_DELAY_PERIODS	✓		0	1	Float	Pure delay in the current regulation loop, specified as number of regulation periods. If set to zero, cctest will estimate it based on the other known parameters. This delay is a primitive way to model the otherwise unmodelled delays and dynamics around the loop (i.e. everything except the load). This includes the delay before the voltage reference is received by the voltage source (VS V_REF_DELAY_ITERS) + the measurement delay + the voltage source response time. The RST coefficients will be calculated using one of five algorithms selected according to the pure delay. It must be in the range from 0 to 2.4 regulation periods.	
IREG	TRACK_DELAY_PERIODS	✓		0	1	Float	Anticipated delay between the setting of the current reference and the moment when the measurement should equal the reference, specified as number of regulation periods. If this is set to zero, it will be calculated by the algorithm. This is used to calculate the error in the response of the current regulation loop.	

IREG	AUXPOLE1_HZ		✓		10	1	Float	Frequency of the first (real) auxiliary pole. The AUXPOLE* parameters are used to calculate coefficients for the RST regulation algorithm. For fast loads, set AUXPOLE1_HZ to 1.0E+5 and AUXPOLES2_Z to 0.8. Normally AUXPOLE1_HZ = AUXPOLES2_HZ and AUXPOLES2_Z = 0.5.	
IREG	AUXPOLES2_HZ		✓		10	1	Float	Frequency of (conjugate) auxiliary poles 2 & 3	
IREG	AUXPOLES2_Z		✓		0.5	1	Float	Damping of (conjugate) auxiliary poles 2 & 3	
IREG	AUXPOLE4_HZ		✓		10	1	Float	Frequency of (real) auxiliary pole 4	
IREG	AUXPOLE5_HZ		✓		10	1	Float	Frequency of (real) auxiliary pole 5	
IREG	R		✓		0,0,0,0,0,0,0,0,0,0	10	Double	RST R coefficient – used when AUXPOLE1_HZ = 0	Was present but not documented.
IREG	S		✓		0,0,0,0,0,0,0,0,0,0	10	Double	RST S coefficient – used when AUXPOLE1_HZ = 0	Was present but not documented.
IREG	T		✓		0,0,0,0,0,0,0,0,0,0	10	Double	RST T coefficient – used when AUXPOLE1_HZ = 0	Was present but not documented.
VS – Voltage Source model parameters *These parameters define the voltage source model if GLOBAL ACTUATION is VOLTAGE. However, if GLOBAL ACTUATION is CURRENT, then the model will be used to simulate the external current source response.*									
VS	V_REF_DELAY_ITERS			✓	1	1	Float	Delay between the start of an iteration in which V_REF is calculated and the time that it enters the simulation of the voltage source, in iterations. This models the delay that might be due to a DAC settling, or a digital link between a current controller and the voltage source electronics.	
VS	BANDWIDTH		✓		200	1	Float	Voltage source bandwidth. Set to zero if SIM_NUM and SIM_DEN are used to explicitly define the model. If positive it is used to calculate Z Transform using Tustin.	
VS	Z		✓		0.9	1	Float	Damping factor. Used to calculate Z Transform if BANDWIDTH > 0.	
VS	TAU_ZERO		✓		0	1	Float	Time Constant for real zero. Set to zero to turn off the zero. Used to calculate Z Transform if BANDWIDTH > 0.	
VS	SIM_NUM		✓		1,0,0,0	4	Float	Voltage source transfer function numerator.	
VS	SIM_DEN		✓		1,0,0,0	4	Float	Voltage source transfer function denominator.	
START – Parameters for START function *Used when GLOBAL.FUNCTION is START. The START function is special because .*									
START	ACCELERATION	✓			5	1	Float	Acceleration of first parabolic segment. Must be non-zero. Absolute value is used.	Reintroduced after being removed from V4.
START	LINEAR_RATE	✓			3	1	Float	Maximum linear rate of change. Absolute value is used.	Reintroduced after being removed from V4.
START	DECELERATION	✓			10	1	Float	Deceleration of second parabolic segment. Must be non-zero. Absolute value is used.	Reintroduced after being removed from V4.
PLEP – Parameters for Parabola-Linear-Exponential-Parabola (PLEP) function *Used when GLOBAL.FUNCTION is PLEP. The PLEP function is special because it can be initialised with a non-zero initial rate of change. The final reference can also have a non-zero rate of change. If the final rate of change is not zero, then this adds a fifth parabolic segment. This can be an extension of the fourth parabola, or it can have the opposite acceleration.*									
PLEP	INITIAL_REF			✓	0	1	Float	Initial reference at beginning of function	
PLEP	FINAL_REF	✓			1	1	Float	Final reference at end of function	
PLEP	ACCELERATION	✓			1	1	Float	Acceleration/deceleration of the parabolic segments. Absolute value is used.	
PLEP	LINEAR_RATE	✓			1	1	Float	Maximum linear rate of change. Absolute value is used.	
PLEP	FINAL_RATE	✓			0	1	Float	Normalised final linear rate of change.	
PLEP	EXP_TC	✓			0	1	Float	Exponential time constant.	
PLEP	EXP_FINAL	✓			0	1	Float	Final reference for exponential segment (at $t = \infty$)	
RAMP – Parameters for fast ramp based on Parabola-Parabola function *Used when GLOBAL.FUNCTION is RAMP. Parabolic-Parabolic function with time shift when rate limited. The RAMP function is special because it uses the reference from the previous iteration to adjust the function time. This allows a smooth parabolic end to the function, even if the function was rate-limited by the calling application.*									
RAMP	INITIAL_REF			✓	0	1	Float	Initial reference at beginning of function	
RAMP	INITIAL_RATE	✓			0	1	Float	Initial (linear) rate of change	
RAMP	FINAL_REF	✓			1	1	Float	Final reference at end of function	
RAMP	ACCELERATION	✓			4	1	Float	Acceleration of first parabolic segment. Must be non-zero. Absolute value is used.	
RAMP	LINEAR_RATE	✓			1	1	Float	Maximum linear rate of change. Absolute value is used.	
RAMP	DECELERATION	✓			6	1	Float	Deceleration of second parabolic segment. Must be non-zero. Absolute value is used.	
PPPL – Parameters for Parabola-Parabola-Parabola-Linear (PPPL) function *Used when GLOBAL.FUNCTION is PPPL. The parameters define the 4 segments of each PPPL section. Up to 8 PPPLs can be chained together.*									
PPPL	INITIAL_REF			✓	0	1	Float	Initial reference at beginning of function	
PPPL	ACCELERATION1	✓			5	8	Float	Acceleration of first (parabolic) segment. Must be non-zero.	
PPPL	ACCELERATION2	✓			-0.1	8	Float	Acceleration of second (parabolic) segment. If zero, the function becomes PLPL.	
PPPL	ACCELERATION3	✓			-2	8	Float	Acceleration of third (parabolic) segment. Must be non-zero.	
PPPL	RATE2	✓			1	8	Float	Rate of change at start of second (parabolic) segment. Must be non-zero.	
PPPL	RATE4	✓			0	8	Float	Rate of change of fourth (linear) segment.	
PPPL	REF4	✓			1	8	Float	Reference at start of fourth (linear) segment	
PPPL	DURATION4	✓			0.1	8	Float	Duration of fourth (linear) segment	
TABLE – Parameters for linearly interpolated table function *Used when GLOBAL.FUNCTION is TABLE*									
TABLE	REF	✓			0, 1, 1, 0	10000	Float	List of reference values.	
TABLE	TIME	✓			0, 1, 2, 3	10000	Float	List of times corresponding to the reference values.	
TRIM – Parameters for linear and cubic trim functions *Used when GLOBAL.FUNCTION is LTRIM or CTRIM*									
TRIM	INITIAL_REF			✓	0	1	Float	Initial reference at beginning of function	
TRIM	FINAL_REF	✓			1	1	Float	Final reference at end of function	

TRIM	DURATION	✓		1	1	Float	Duration for transition from initial to final reference. Set to zero to go as fast as possible while respecting the rate of change limits.	
TEST – Parameters for test functions *Used when GLOBAL.FUNCTION is STEPS, SQUARE, SINE or COSINE*								
TEST	INITIAL_REF		✓	0	1	Float	Initial reference at beginning of function	
TEST	AMPLITUDE_PP	✓		2	1	Float	Reference peak-to-peak amplitude	
TEST	NUM_CYCLES	✓		3	1	Float	Number of cycles/steps. Although specified as a float, the value is rounded to the nearest integer.	
TEST	PERIOD	✓		2	1	Float	Period of the function (=1/frequency). The duration of the function is equal to NUM_CYCLES*PERIOD	
TEST	WINDOW	✓		ENABLED	1	DISABLED ENABLED	Window Control start and end of SINE and COSINE functions	