Type of test

Sinusoidal only

Tri/Tra only

Sinusoidal

Tri/Tra

Set single duties

setDn and setDp, get setDo

If set duties = 0 Multiple duties

else Single duty

Important! should match DSP params

Set single H_{dc} test

setH_{dc}

Core parameters: Turns, A_e, mu_a, Steinmetz

if Steinmets params are not available set Pvmin to 0 and Pv max very high

Test range: H_{dc}, duties, B, f (max, min, step)

Important! should match DSP params

for Triangular only set D_{0max} to 0

Constants: pi, R_{shunt}, R_{dc}, scope scales, k_i

Protections/limits: V, I_{pk}, P_V, L_m, gain, T_{idle}

I_{ac}, V_{signal}, V_{ac} V_{dc}, I_{dc}

Set up communication and params: oscilloscope

Set up: power supplies

Set up: signal generator

Set up: DSP

Set up communication: DC bias circuit

Press enter

H_{dc} loop

Calculate I_{dc} needed, protection

$I_{dc} = H_{dc} \cdot l_e / N_3$

Command DC bias current

Calculate B_{max}, B_{range}

$B_{dc} = H_{dc} \cdot \mu_0 \cdot \mu_{ra\ max}$ $B_{max} = B_{max\ total} - B_{dc}$

Calculate number of runs

for expected time reporting only

D_0 loop D_0=setD$_0$ D_0 not defined

Check with DSP

D_p loop D_p=setD$_p$ D_p not defined

Check with DSP

D_n calculation D_n=setDn D_n not defined

$D_n = 1 - D_p - 2 \cdot D_0$

Prepare .csv files (output) for this run

each run is a wavefomr shape

f loop

Check with DSP

Flags for out of range points

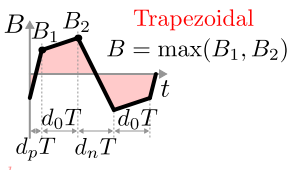
so after the measurement is aborted, the message is hidden

Initial V_{pk} I_{pk}, L_m, gain identification

code similar to the main loop, not described here

gain not defined

log B loop



Calculation of the voltage to be applied

amp=Vpk of the sinewave

$\text{amp} = B \cdot N_1 \cdot A_e \cdot f \cdot 2 \cdot \pi$

amp=Vdc of each supply

$\text{amp} = B \cdot N_1 \cdot A_e \cdot f \frac{1}{D_p} \frac{2}{1-D_p-D_n}$ if $D_p > D_n$

$\text{amp} = B \cdot N_1 \cdot A_e \cdot f \frac{1}{D_n} \frac{2}{1-D_n-D_p}$ if $D_p < D_n$

Calculation of the expected losses

for protection and to speed up the acquisition

Steinmetz equation

$P_V = k \cdot f^{\alpha} \cdot B^{\beta}$

iGSE

$P_V = k_i \frac{(2 \cdot B)^{\beta-\alpha}}{f^{-\alpha}} \left(\frac{(2 \cdot B_1)^{\alpha}}{D_p^{\alpha-1}} + 2 \cdot \frac{|B_1 - B_2|^{\alpha}}{D_0^{\alpha-1}} + \frac{(2 \cdot B_2)^{\alpha}}{D_n^{\alpha-1}} \right)$

if $D_0 = 0$: $B_1 = B$ and $B_2 = B$

if $D_p > D_n$: $B_1 = B$ and $B_2 = B \frac{(1+D_p-D_n)D_n}{(1-D_p+D_n)D_p}$

if $D_p < D_n$: $B_1 = B \frac{(1-D_p+D_n)D_p}{(1+D_p-D_n)D_n}$ and $B_2 = B$

Skip out-of-range points

$P_V > maxP_V$, $P_V < minP_V$

$V_{dc} > maxV_{dc}$, $V_{dc} < minV_{dc}$

$V_{ac} > maxV_{ac}$, $V_{ac} < minV_{ac}$

$V_{signal} > maxV_{signal}$, $V_{signal} < minV_{signal}$

Calculate peak voltage, vertical scale

The vertical scales take predefined values only

$V_{scale} = V_{pk} \frac{N_2}{N_1}$

$V_{scale} = V_{dc} \cdot \max(1 + D_p - D_n, 1 + D_n - D_p) \frac{N_2}{N_1}$

$V_{pk} > maxV_{pk}$ protection

$V_{Vset} = \frac{V_{scale}}{5} \cdot (1 + \text{margin})$

Calculate peak current, vertical scale

$I_{pk} > maxI_{pk}$ protection

$I_{scale} = \left(\frac{V_{pk}}{2 \cdot \pi \cdot f \cdot L_m} + I_{dc} \right) R_{sense}$

$I_{scale} = \left(\frac{V_{pk} \cdot \max(D_p(1-D_p+D_n), D_n(1-D_n+D_p))}{2 \cdot f \cdot L_m} + I_{dc} \right) \cdot R_{sense}$

$I_{Iset} = \frac{I_{scale}}{5} \cdot (1 + \text{margin})$

Calculate trigger level

Half of the positive edge

$V_{trigger} = 0$

$V_{trigger} = V_{dc} \frac{1-2 \cdot D_p-2 \cdot D_n}{2} \frac{N_2}{N_1}$

Run the oscilloscope

Set the trigger and scales

based on expected L_m and gain

Command power supply/signal generator voltage

Soft-start the voltage supply if required

Stop the oscilloscope

Retrieve the scope signals

Save the captured signals

ch2: secondary voltage
ch3: primary current
time and commanded parameters are also saved

Identification: V_{pk}, I_{pk}, Lm, gain

$V_{meas} = \max(|V|)$

$I_{meas} = \frac{\max(I) - \min(I)}{2}$

$V_{real} = V_{meas} \frac{N_1}{N_2}$

$L_m = \frac{V_{real}}{2 \cdot \pi \cdot f} \frac{R_{sense}}{I_{meas}}$

$\text{gain} = \frac{2 \cdot V_{real}}{V_{signal\ (pk-pk)}}$

$L_m = \frac{V_{real}}{2 \cdot f} \frac{\max(D_p(1-D_p+D_n), D_n(1-D_n+D_p))}{\max(1+D_p-D_n, 1+D_n-D_p)} \frac{R_{sense}}{I_{meas}}$

gain not defined

Display last test infomation on screen

Display time in this test

B loop over?

No *B++*

Yes

Display time in this f on screen, and time left in this run

Soft turn off: power supply/signal generator

step the voltage down slowly to avoid premagnetization in the next test

f loop over?

No *f++*

Yes

Display time on this run on screen, and time left

Save the .csv files (output) for this run

.csv outputs

D_p loop over? Skip

No *D_p++*

Yes

D_0 loop over? Skip

No *D_0++*

Yes

Display time in this H_{DC} on screen

H_{DC} loop over?

No *H_{DC}++*

Yes

Close the communitcation with the equipement