Physikalisch-Technische Bundesanstalt
Braunschweig and Berlin
National Metrology Institute

EMPIR
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

EURAMET

DC Grids

Superposing DC and AC signals for testing DC meter

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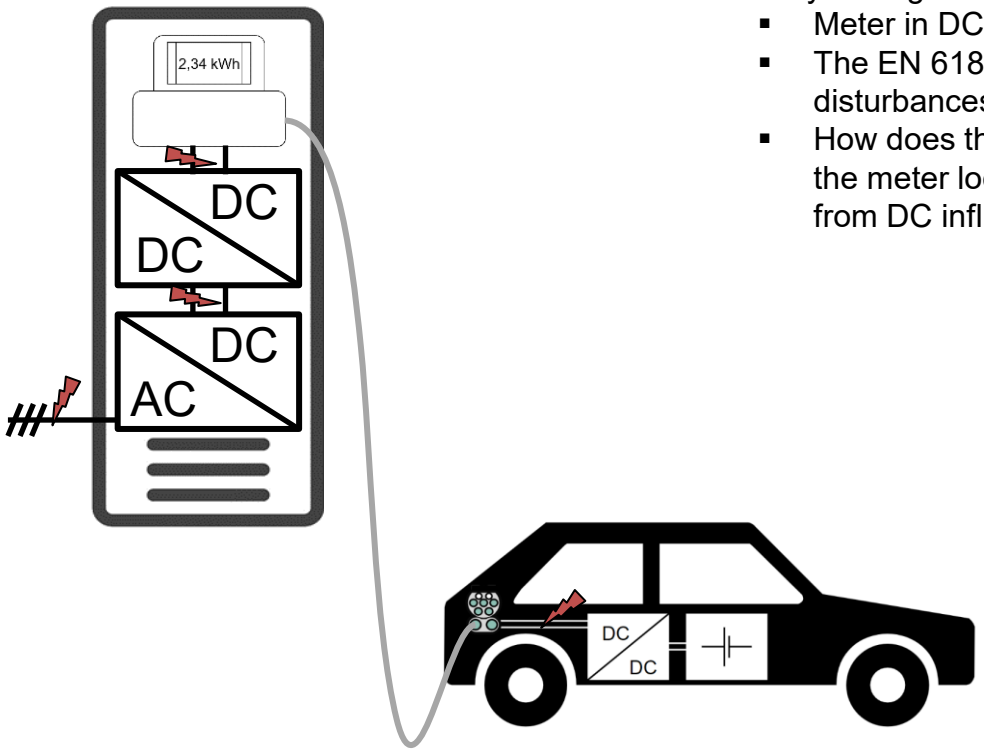
Outline

- Motivation
- Measurements at DC charging stations
- Setup for testing DC meter with disturbed signals
- Conclusion

Motivation

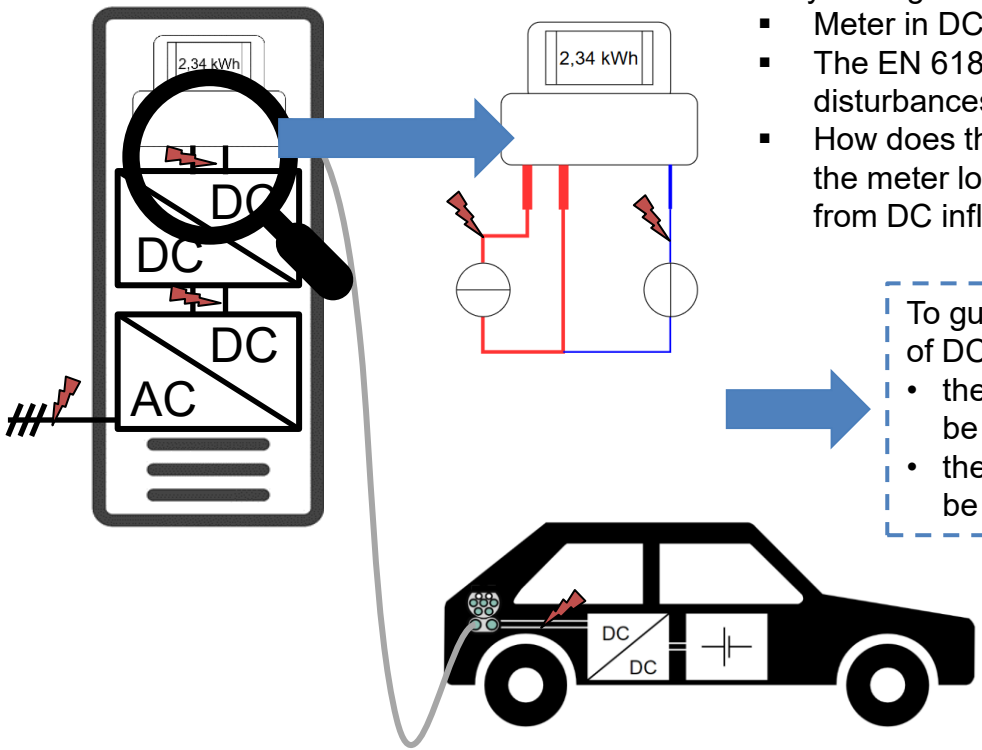


Why testing DC meter with HF disturbances?

- Meter in DC charging stations are between several power electronics
- The EN 61851-23 standard for charging stations defines allowed disturbances up to 150 kHz
- How does the DC measurement signal at the meter looks like and how are deviations from DC influencing the measurement?

Current in A_{pp}	Frequency in kHz
1,5	< 0,01
6	< 5
9	< 150

Motivation



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To guarantee correct measurements of DC energy,

- the occuring disturbances have to be known and
- the immunity of the meter has to be tested

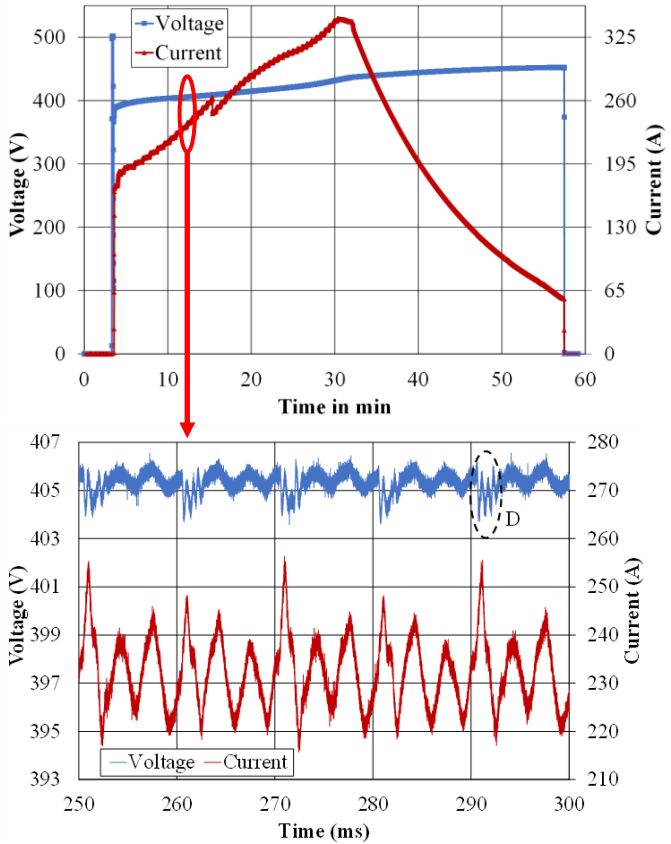
Current in A_{pp}	Frequency in kHz
1,5	< 0,01
6	< 5
9	< 150

Investigation of real DC signal

- Measurements of charging processes at DC charging stations
- Recording of complete charging process with low resolution (500 ms)
- Manual trigger of high resolution measurement every 4 minutes
- Recording of voltage and current with sampling frequency of 1,21 MHz
- Duration of the high resolution record: 3 s

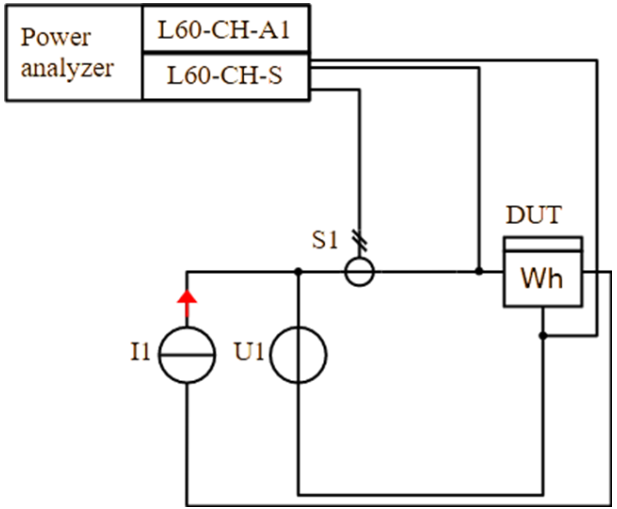
- Measurements of charging processes at DC charging stations
- Example:
  - Current ripple around 20 A_{pp} / 300 Hz
  - Maximum ripple every 6th wave around 35 A_{pp}
  - Corresponding voltage ripple < 2 V_{pp} / 1,5 kHz („D“)

How to create defined disturbed DC signals?



Setup for synthetic signal

- Phantom power setup for testing DC meter
  - 400 A DC current (I1)
  - 1 kV DC voltage source (U1)
  - Power analyzer Zimmer LMG 641 as reference measurement



Setup for synthetic disturbance signal

- Phantom power setup for testing DC meter
  - 400 A DC current (I1)
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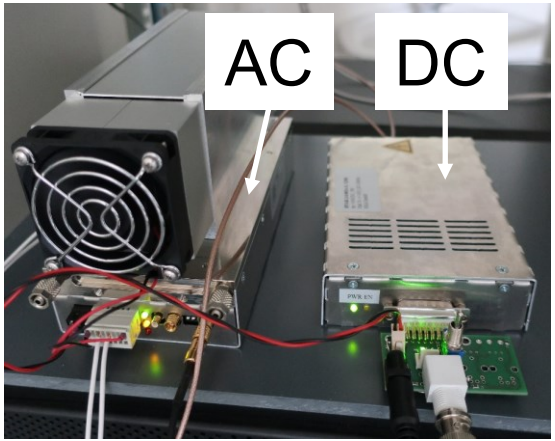
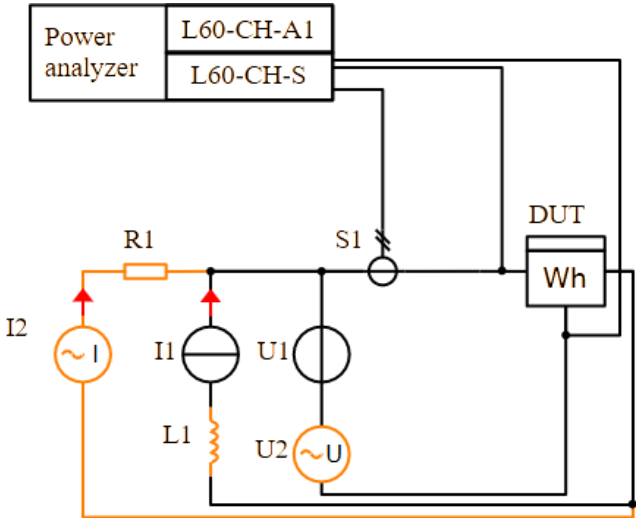
- Setup for adding disturbances with bandwith up to 150 kHz
  - AC voltage signal is created with second source (U2) in series
    - Amplitude: ± 70 V
    - U1 and U2 is an amplifier combination

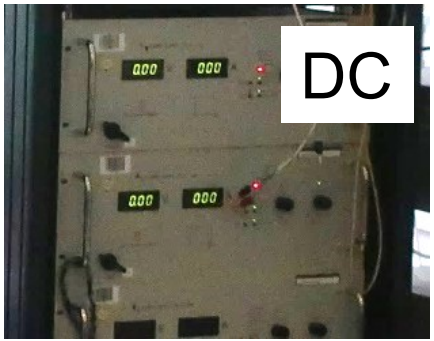


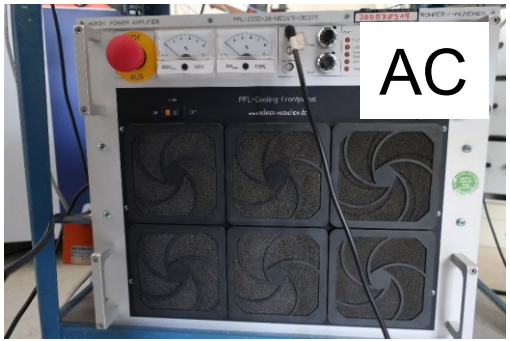


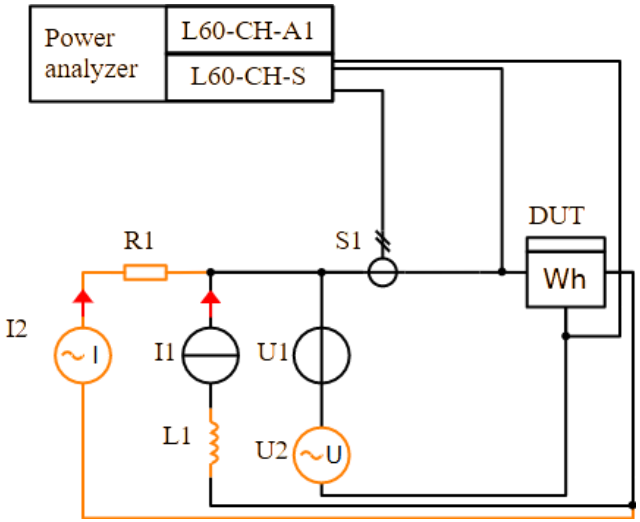
Setup for synthetic disturbance signal

- Phantom power setup for testing DC meter
  - 400 A DC current (I1)
  - 1 kV DC voltage source (U1)
  - Power analyzer Zimmer LMG 641 as reference measurement

- Setup for adding disturbances with bandwith up to 150 kHz
  - AC current signal is created with parallel source (I2)
    - Amplitude: ± 20 A
    - Inductance (L1) to avoid AC signal in DC source
    - Resistance (R1) to avoid DC signal in AC source and as base load for AC amplifier



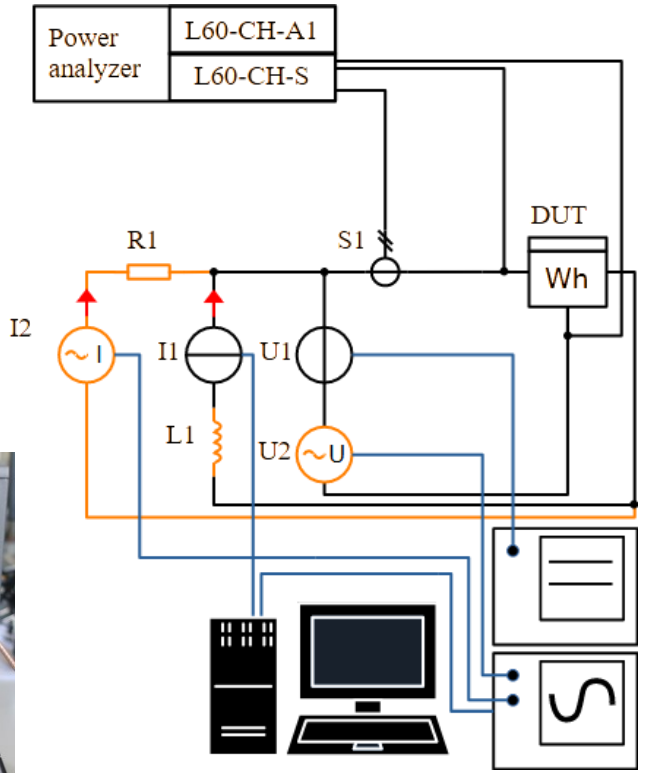




Setup for synthetic disturbance signal

- Phantom power setup for testing DC meter
  - 400 A DC current (I1)
  - 1 kV DC voltage source (U1)
  - Power analyzer Zimmer LMG 641 as reference measurement
- Signal generation
  - Two channel arbitrary function generator for I2 and U2
  - Constant voltage source for U1
- Measurement of combined AC / DC signal
  - Current: 1200 A zero flux transducer (S1)
  - Voltage: direct measurement up to 1 kV

Calibration for AC signals



Setup for synthetic disturbance signal

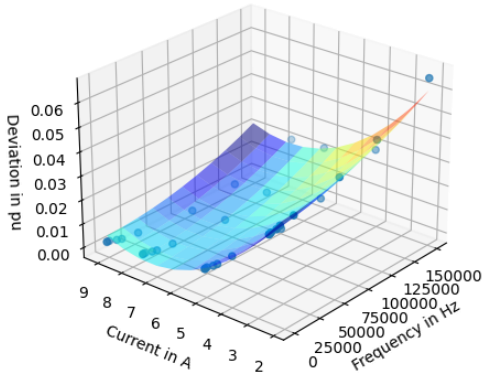
- AC Calibration of power analyzer
  - Frequency: 55 Hz – 150 kHz
  - Voltage: 2 – 50 V / 1000 V measuring range
  - Current: 2 – 9 A / 450 A measuring range
    - Including zero flux transducer

Measurement uncertainty components:

- AC measurement: uncertainty of calibration
- Correction of deviation: maximum deviation between deviation measurement and approximation
- DC offset: Influence of AC measuring point shift due to DC signal
- Resolution: Resolution of measuring instrument

Main influence

- Conservative uncertainty estimation of approximation

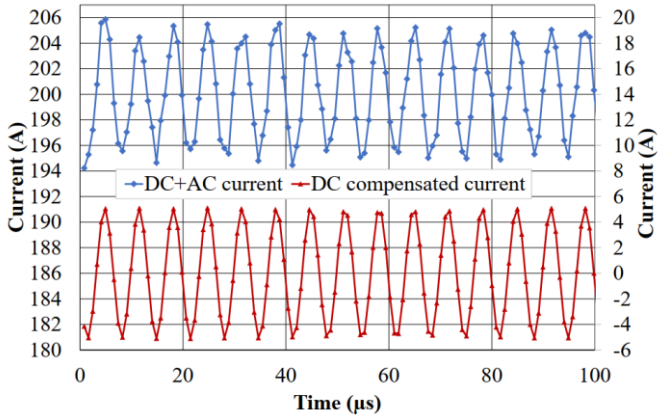


Uncertainty component	Relative uncertainty (k=1)	Relevance
AC measurement	7,15E-04	2,4%
Correction of deviation	7,077444E-03	78,3%
DC Offset	2,03E-03	19,3%
Resolution	5,56E-08	0,0%
u I_{AC}	0,92 % (k=2)	

Uncertainty components	Relative uncertainty (k=1)	Relevance
AC measurement	9,6322E-04	25,8%
Correction of deviation	1,2525E-03	43,7%
DC Offset	1,0455E-03	30,4%
Resolution	1,6981E-08	0,0%
u U_{AC}	0,38 % (k=2)	

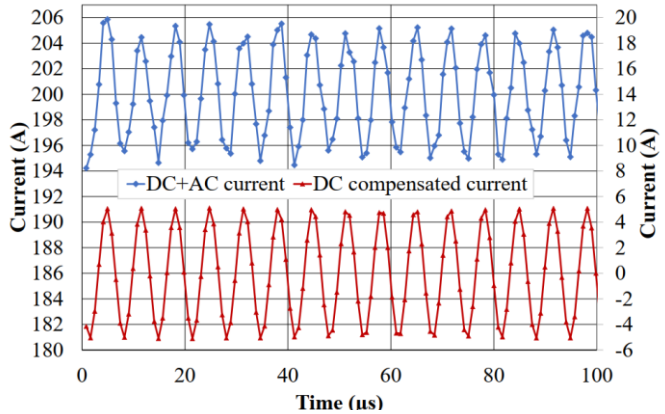
Setup for synthetic disturbance signal

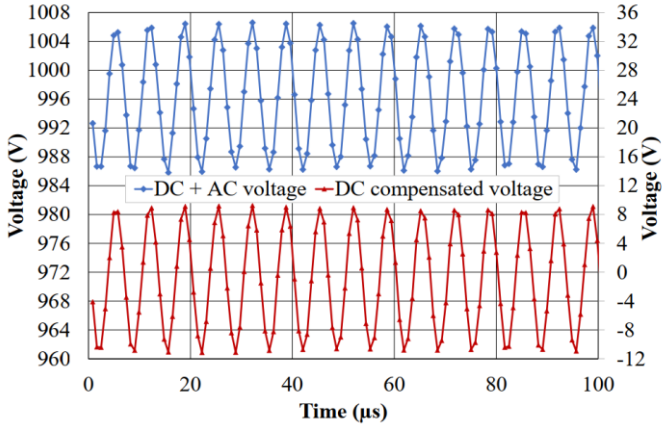
- First functional test
  - DC signal with additional sinusodial AC signal
- Current signal
  - 200 A DC current with additional 3,4 A sinusodial AC current with 150 kHz single tone
    - Higher fluctuation of DC+AC Current signal due to 1200 A zero flux transducer and high measuring range (450 A)



Setup for synthetic disturbance signal

- First functional test
  - DC signal with additional sinusodial AC signal
- Current signal
  - 200 A DC current with additional 3,4 A sinusodial AC current with 150 kHz single tone
    - Higher fluctuation of DC+AC Current signal due to 1200 A zero flux transducer and high measuring range (450 A)
- Voltage signal
  - 1000 V DC voltage with additional 7 V AC voltage, test with 150 kHz single tone
    - DC+AC signal are similar to compensated signal





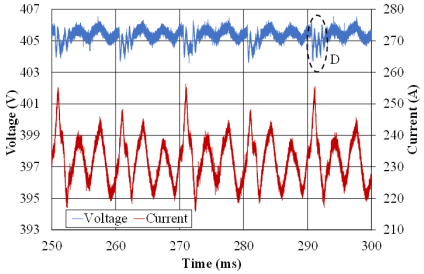
Conclusion & Outlook

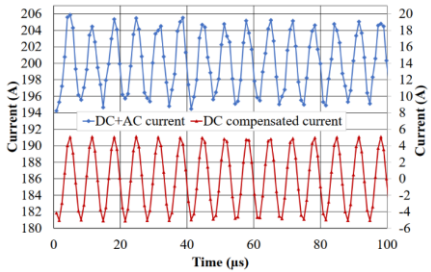
Conclusion

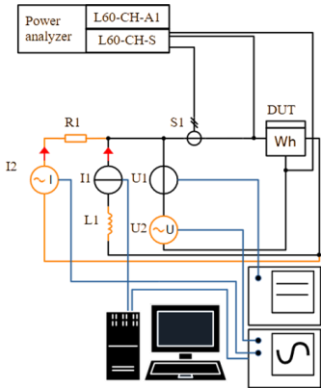
- DC Signals of charging stations have AC components
- Immunity of DC meter regarding the AC disturbances should be tested
- Setup with direct coupling of AC and DC source to create DC signals with AC component up to 150 kHz for current and voltage

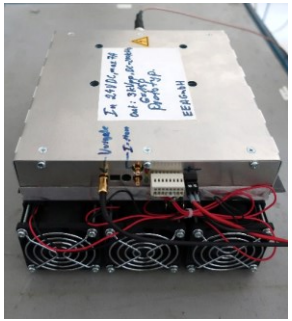
Outlook

- Improved uncertainity due to better consideration of deviation of power analyzer
- New Voltage amplifier to realize mixed signals up ±2 kV









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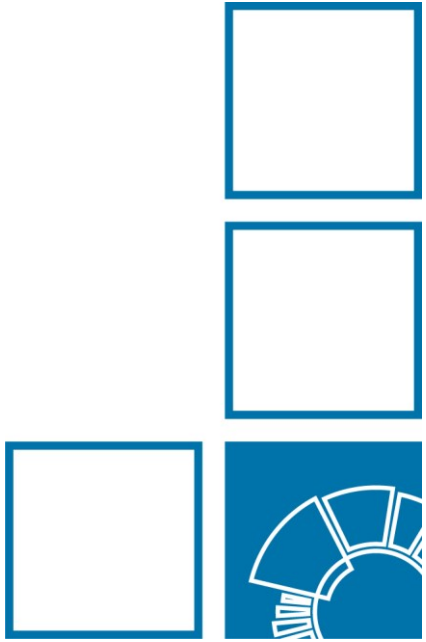
Thank you for your attention!

VSL



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