Fusenet - WP7.A Documentation
Hands-on Experiment: Magnetic Diagnostic

Edition 1.2

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Contents

1 Introduction

To support the lectures in the Master track "Science and Technology of Nuclear Fusion" at the Eindhoven University of Technology, a PlasmaLab is in operation. In the lab the students experiment with the concepts that are introduced in the courses and are able to develop their experimental skills. The laboratory is a joint effort of all plasma groups in the department of Applied Physics. A total of 10 experiments are available:

1. Waves in Plasma
2. Zeeman Splitting
3. **Magnetic Diagnostic**
4. Spectroscopy
5. Paschen Curve
6. Probes
7. Interferometer
8. Laser Spectroscopy
9. Reasonance Spectroscopy
10. Fusor

The first three of these experiments are co-funded by the the Fusenet Association. This report provides technical documentation on the **Magnetic Diagnostic** experiment such that Fusenet Association partners can build a duplicate.

1.1 Topic and teaching aims

Magnetic field measurements provide important machine parameters in tokamaks such as the plasma current and the location of the plasma. Local fluctations in current density, such as MHD instabilities and sawteeth, are extensively probed with magnetic pick-up coils. Magnetic diagnostics have been around for a long time but new challenges also appear. For instance, an accurate measurement of the plasma current becomes more difficult as the pulse length increases due to drift and interference that add up in the integrators. Another difficulty is where to best mount the pick-up coils: inside the vacuum vessel is preferred to avoid losses due to Eddy currents and attenuation in the vessel wall, but inside the vessel the environment is very harsh and access in case of repairs is limited.

In this experiment the fundamentals of magnetic diagnostics can be analysed. In the experiment a plasma current is mimicked using a current carrying conductor. The current in the wire can be gradually ramped up, kept constant, and ramped down again resembling a plasma pulse. The wire runs perpendicular to a plate with an array of magnetic pick-up coils. The wire may also be moved along a slit in the plate. The signals of the probes can be displayed directly on an oscilloscope, can be amplified and integrated with discrete electronics, or can be digitised, and processed with software. In the experiment the studenst are asked to i) calculate the current through the wire given the number of windings in the pick-up coils, ii) give an expression for the location of the wire using two coils on opposite sides of a slit in the plate through which the wire is moved, and iii) give an expression for the location of the wire using all available pick-up coils. Item iii) may be evaluated experimentally too in case the students have sufficient experience programming in LabView©to program this expression. A second excercise, but not yet fully implemented at the time of writing the report, is a measurement with a very fast probe (μs-scale) to assess Eddy currents and attenuation in a stainless steel tube that can optionally be mounted around the wire. A very fast change in the current in the wire is simply generated by switching the power supply on and off. Finally the students are asked to comment on design considerations for the slow measurement system (plasma current) and the fast measurement system (MHD-fluctuations).

1.2 Overview of experiment

The overall experiement is depicted in Fig. **??**. The large item to the left is a frame in which the current conducting wire (1) is suspended. The current from the power supply (2) flows through the centre conductor from the right hand side plate to the left hand side plate, and is returned through the 4 brass bars holding the frame together. This way the contribution of the return current on the measurement is minimised.

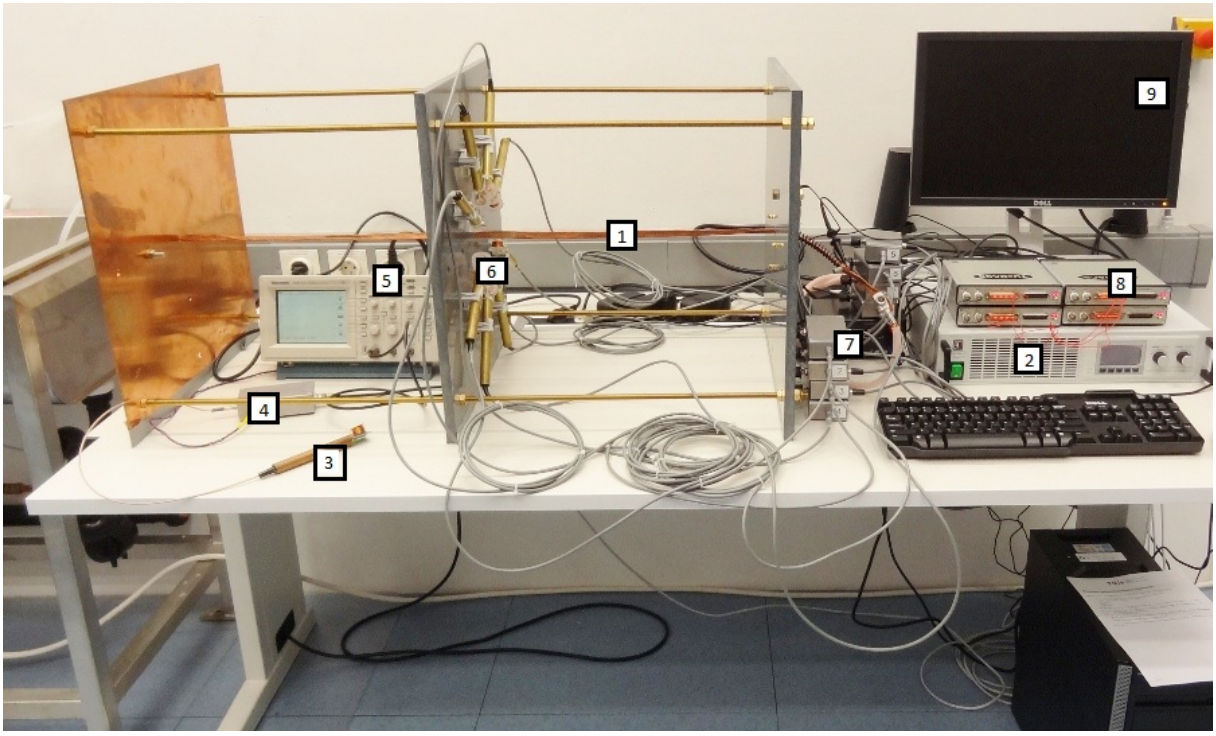


Figure 1: *Overall view of the experiment: 1) Current carrying central conductor ("Plasma current"), 2) Power Supply, 3) Single probe, 4) amplifier and integrator, 5) Oscilloscope, 6) Set of 8 pick-up coils, 7) Amplifiers for pick-up coils, 8) DAQ-system ("TU/e nano-Giants"), 9) PC running LabView©.*

A single pick-up coil (3) is shown and a set of 8 pick-up coils mounted onto the central plate. The single probe is connected to an amplifier and analoge integrator in a single case (4) and displayed on the scope. The probe can be used to assess the field in the vicinity of the experiment and performance of the analog integrator may be assessed. The set of 8 coils are conditioned by amplifiers (7) and fed into a DAQ system (8) which is controlled by LabView©.

2 Detailed description of the experiment

The aim of this document is to enable other members of the FuseNet Association to duplicate the experiment. The focus of the description is therefore on those items that require own manufacture or modification. The description of the experiment is divided into the following sections:

1. Frame
2. Pick-up coils
3. Current source and connections
4. Amplifiers and integrators

2.1 Frame

An overall assembly of the frame is shown in Fig. ??.

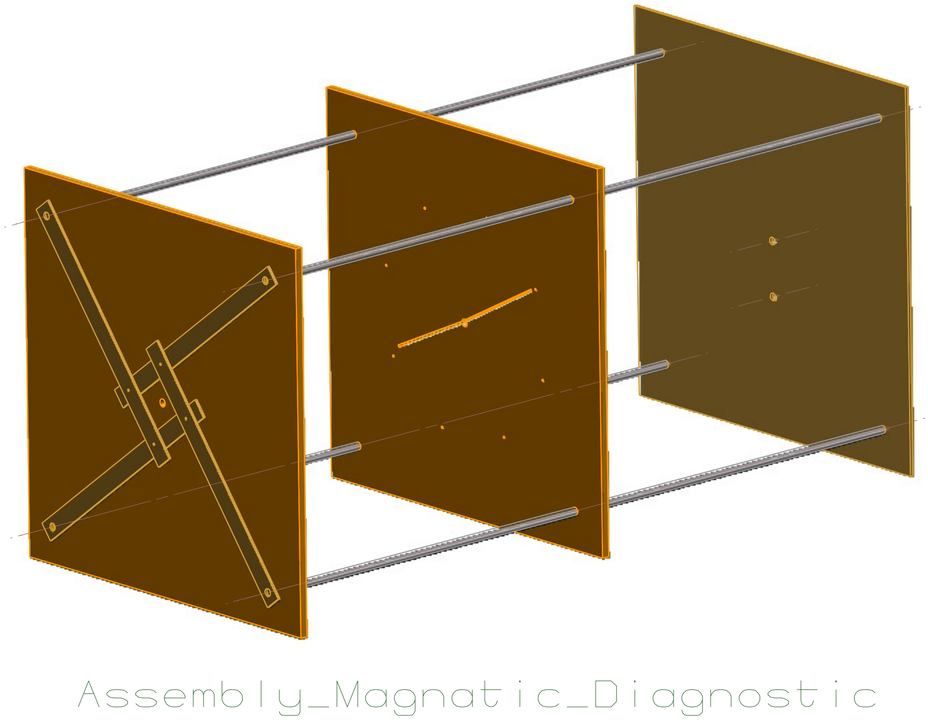
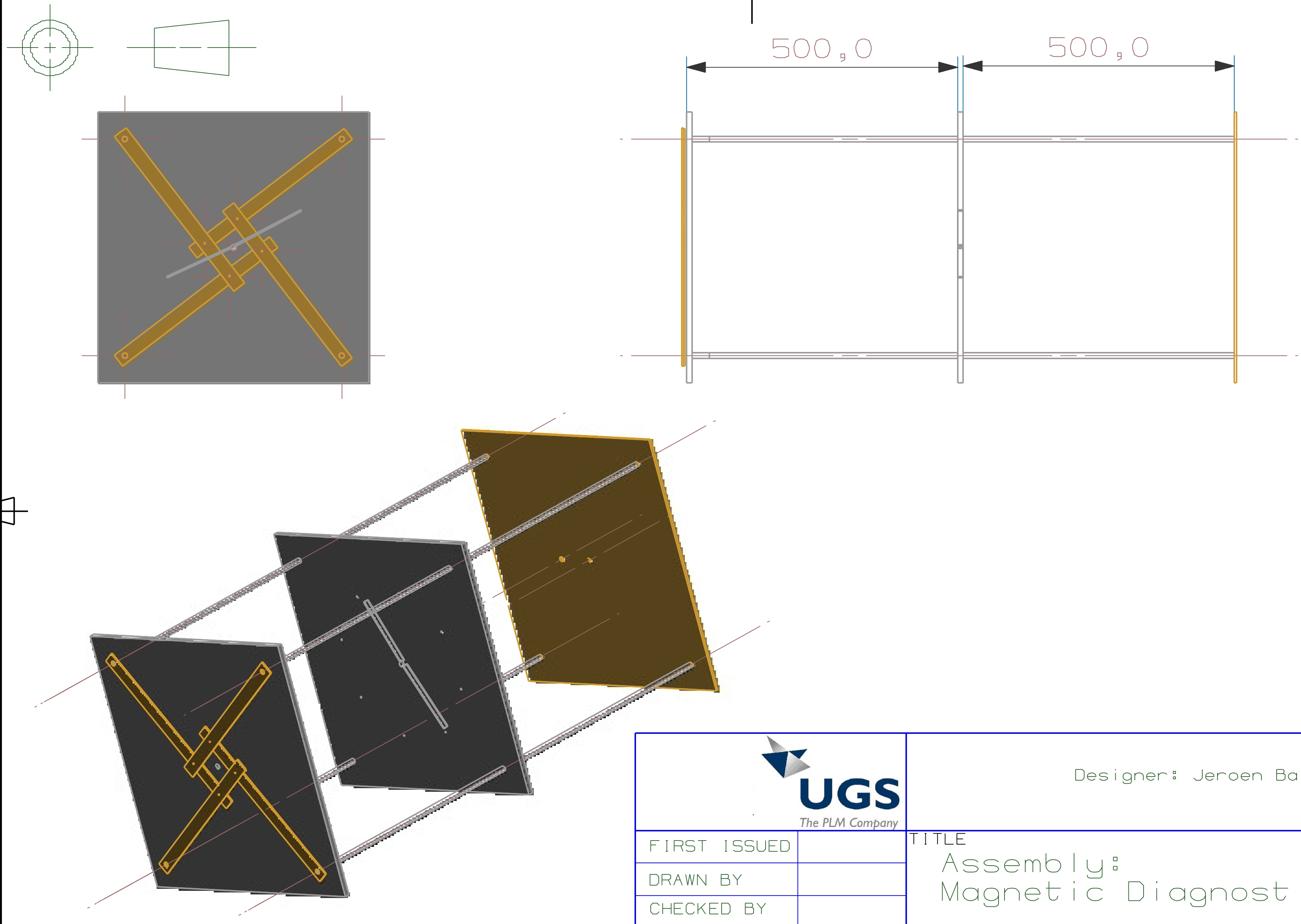


Figure 2: *Overall assembly*



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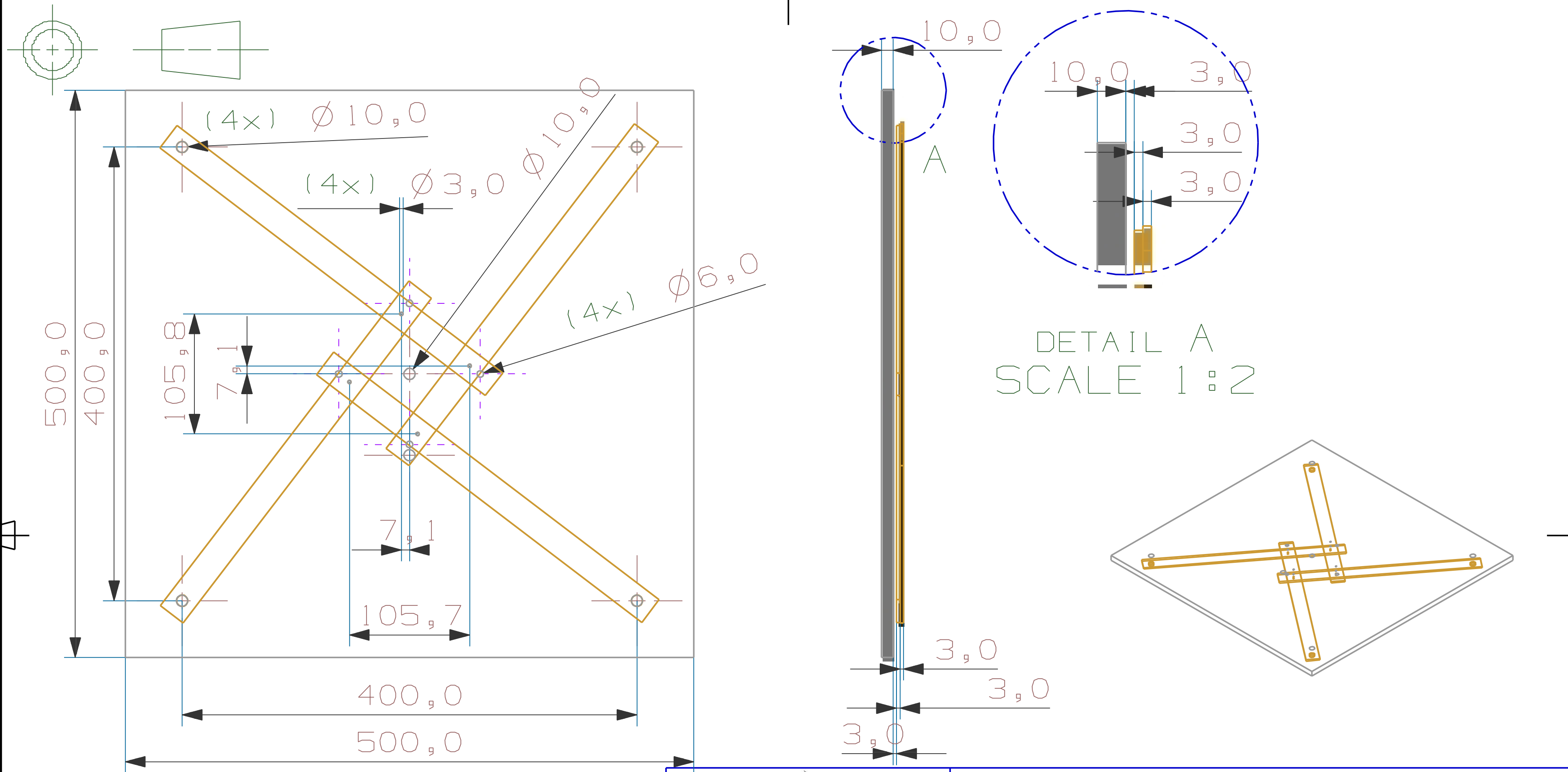

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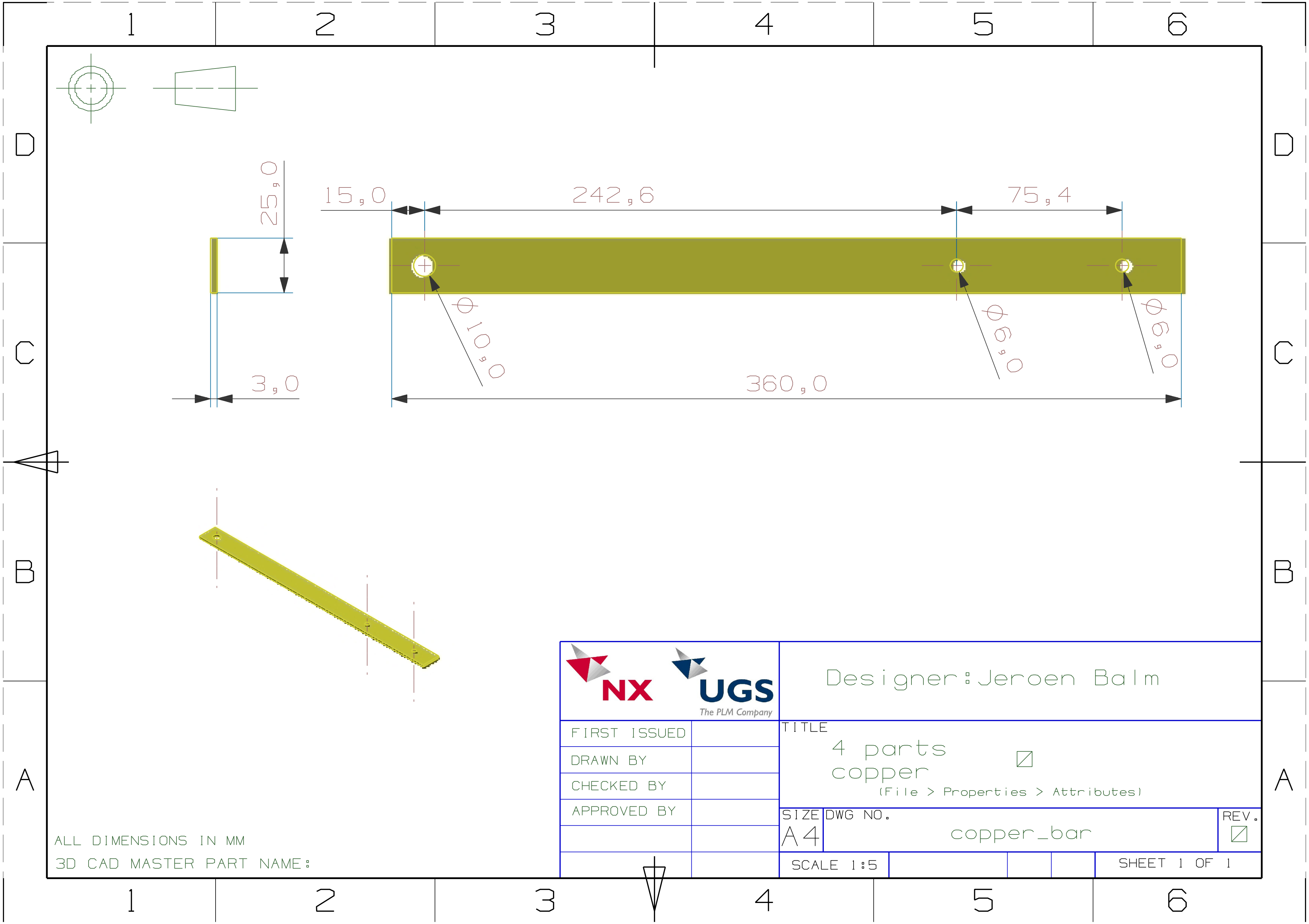

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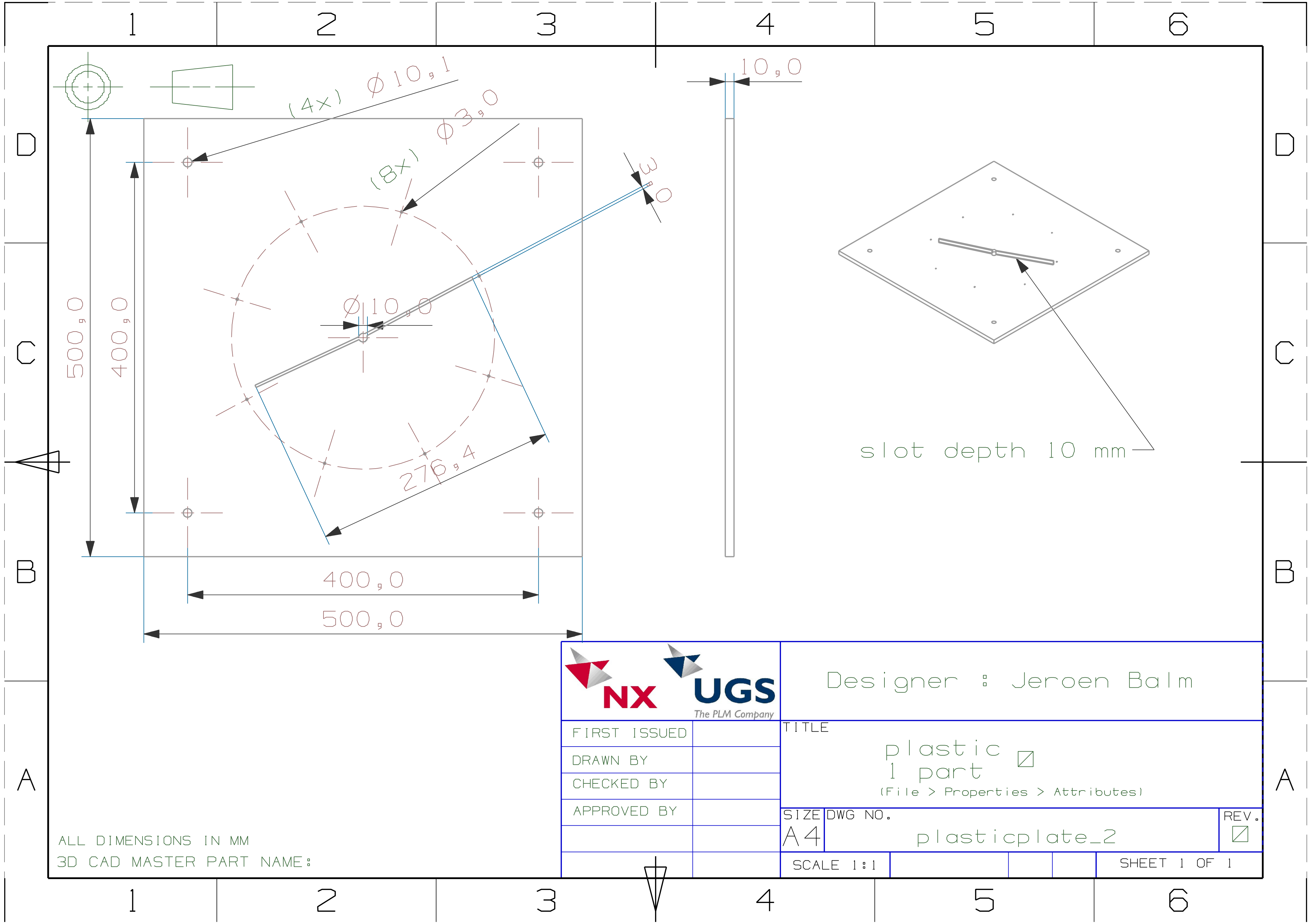

1 2 3 4 5 6
D C B A
(4x) Ø10,1
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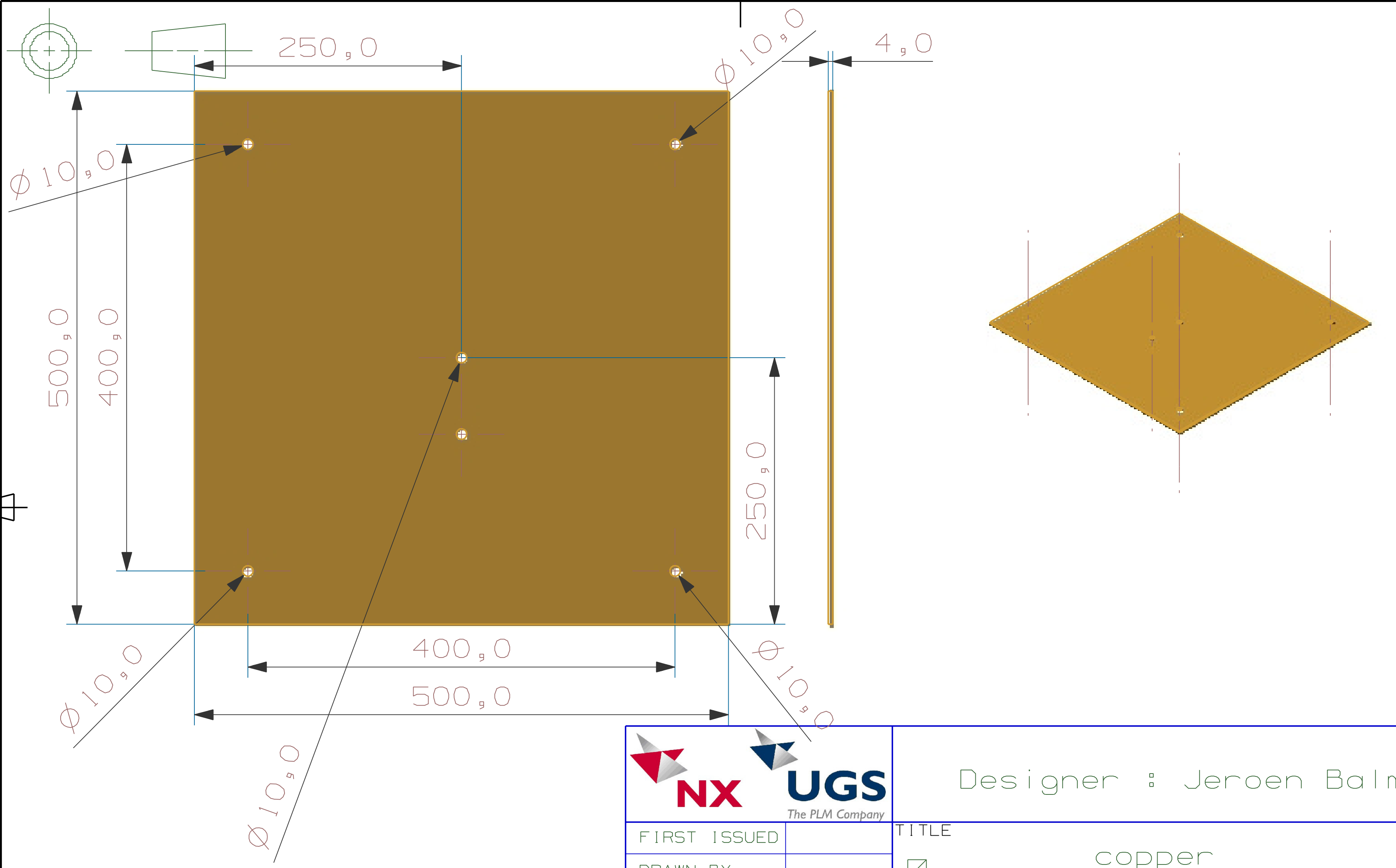

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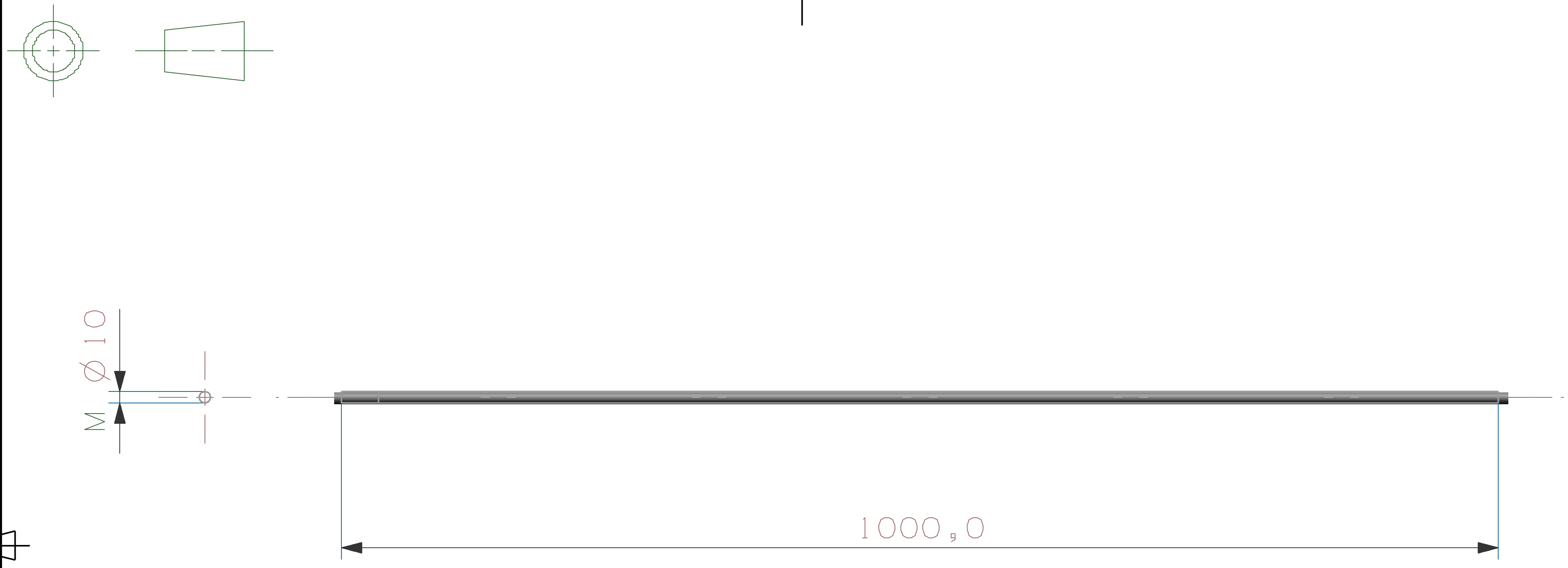

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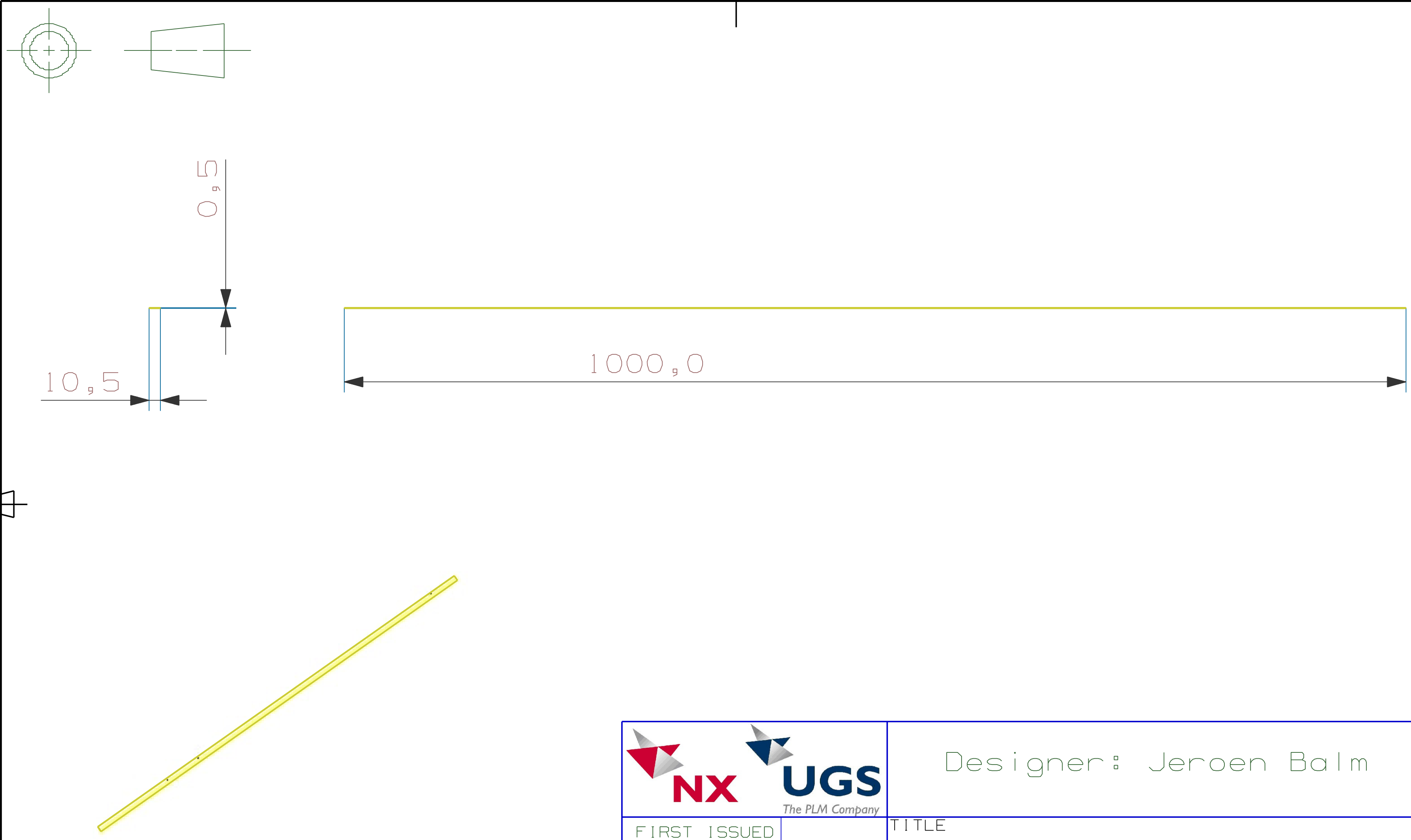

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2.2 Pick-up coils

One separate pick-up coil is available to freely assess the fields in the vicinity of the experiment while a set of 8 pick-up coils is mounted on the central plate in the frame. Fig. **??** shows the single probe, but mounted on a sliding table, and Fig. **??** shows the set of 8 coils. The engineering drawings are shown on the next pages, excluding the sliding table as this is an undocumented accessory.

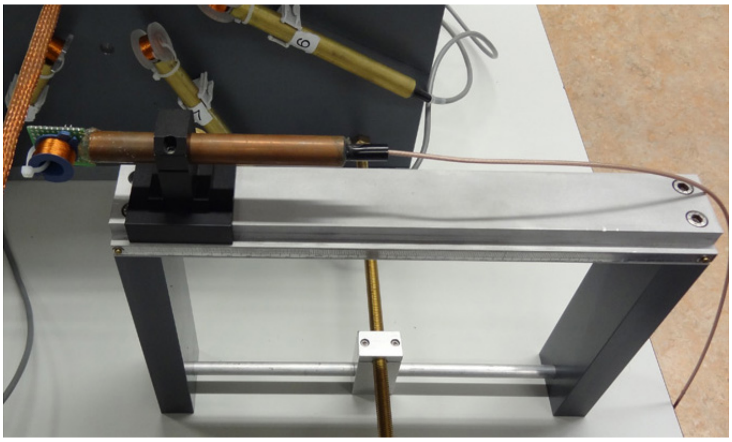


Figure 3: *Separate pick-up coil mounted on sliding table.*

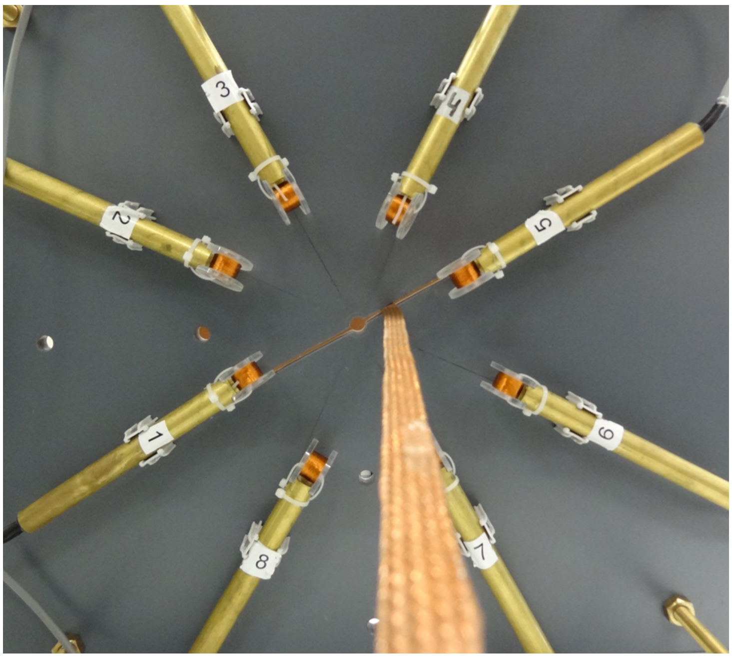
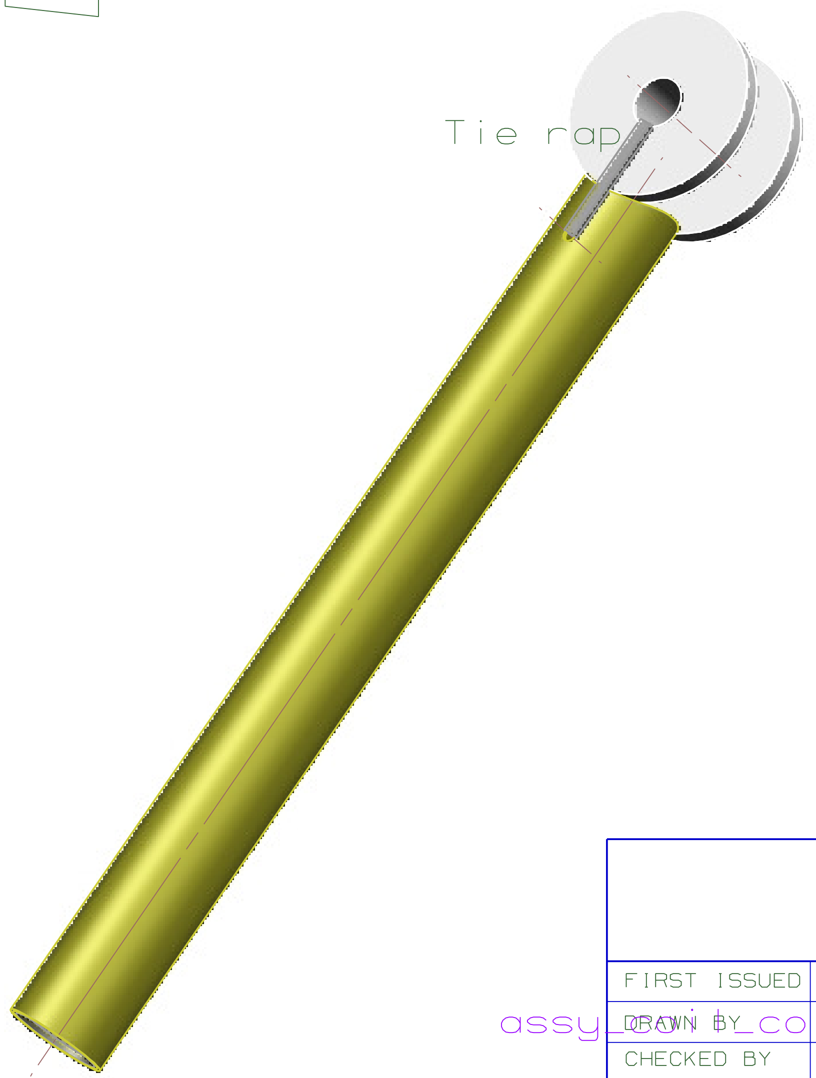


Figure 4: *The set of 8 pick-up coils mounted on the central plate in the frame. In the centre the copper litze cable, purposely slighly offset to demonstrate displacement of the current in the plain of the coils.*



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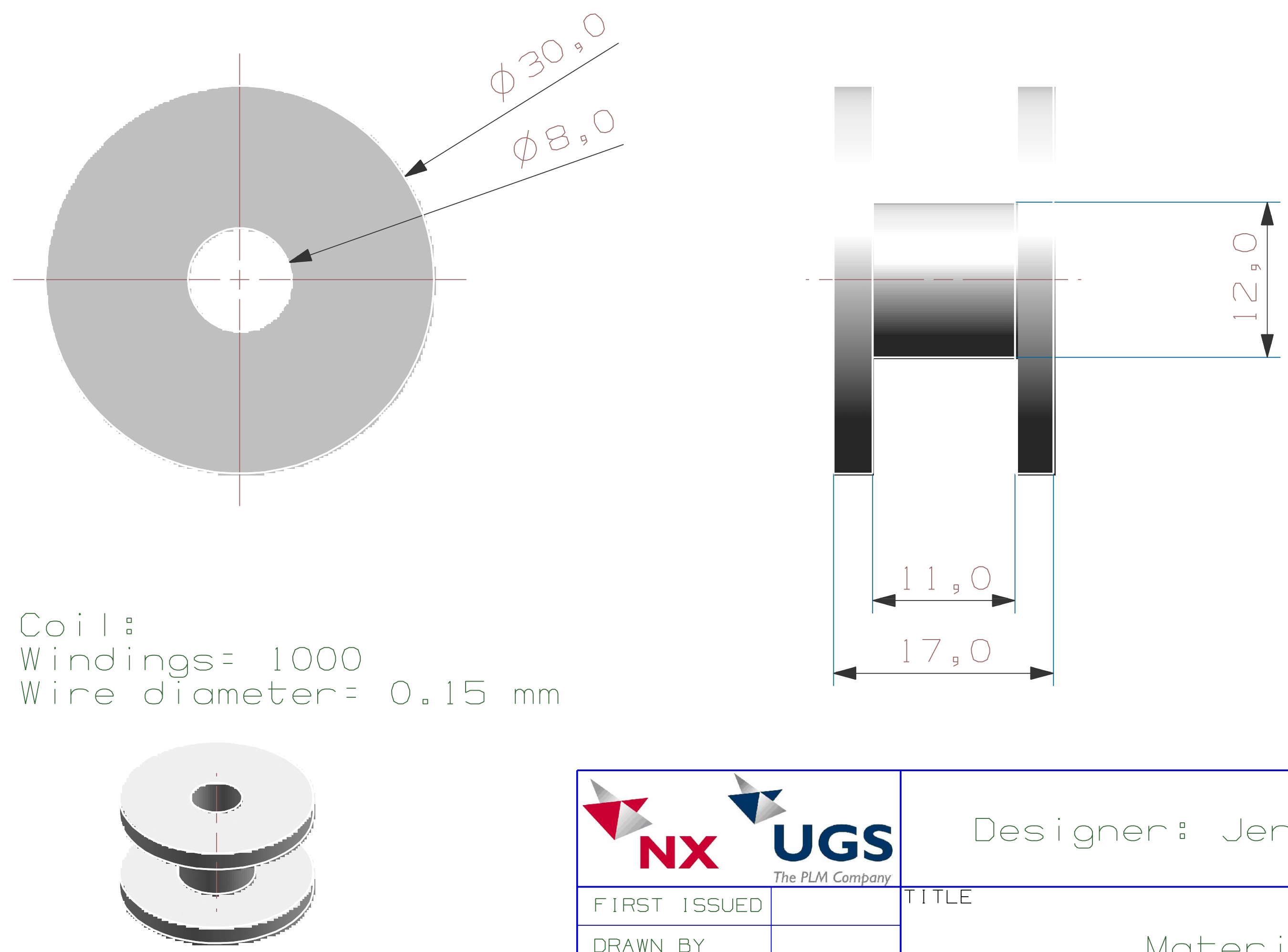

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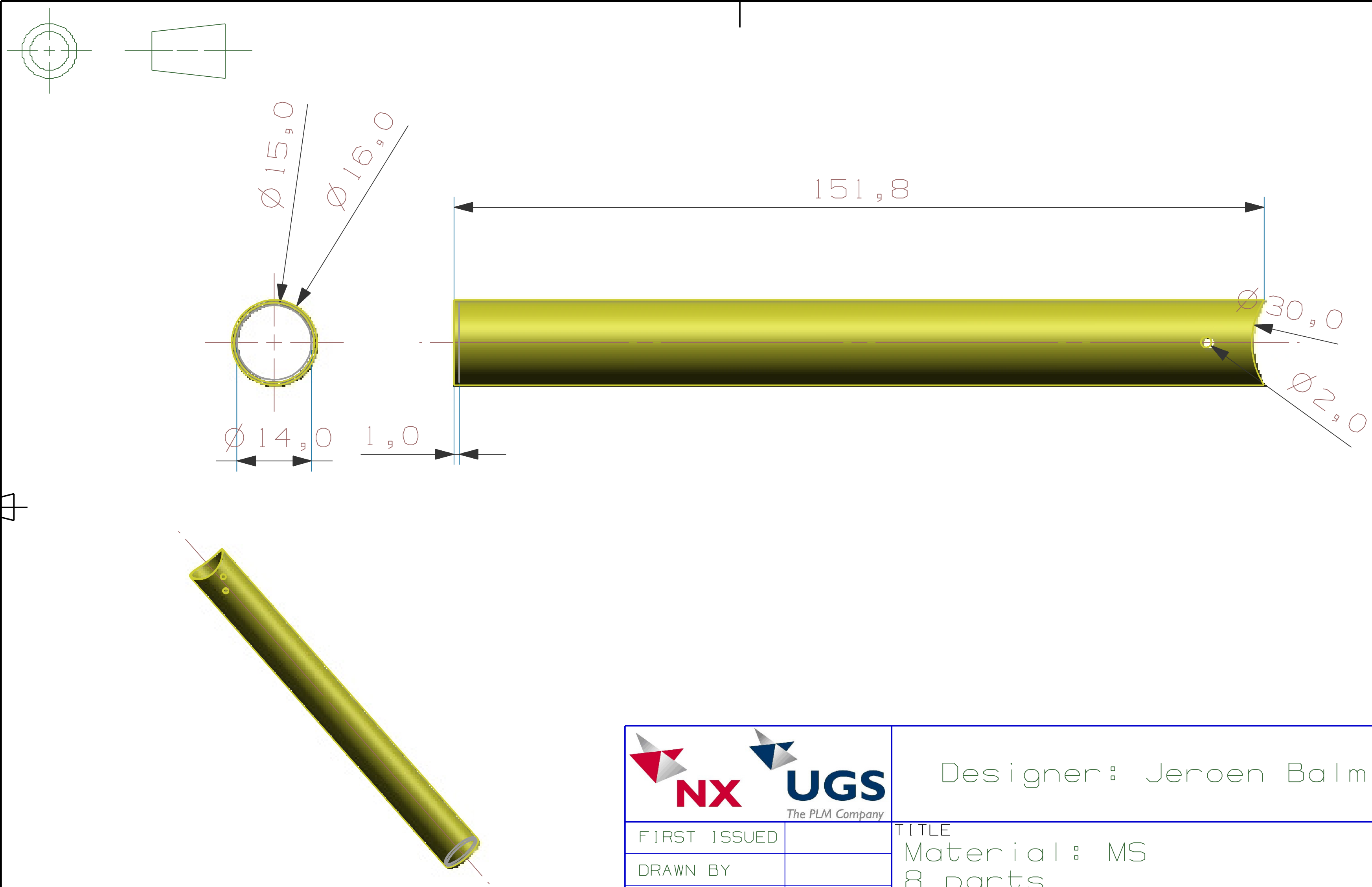

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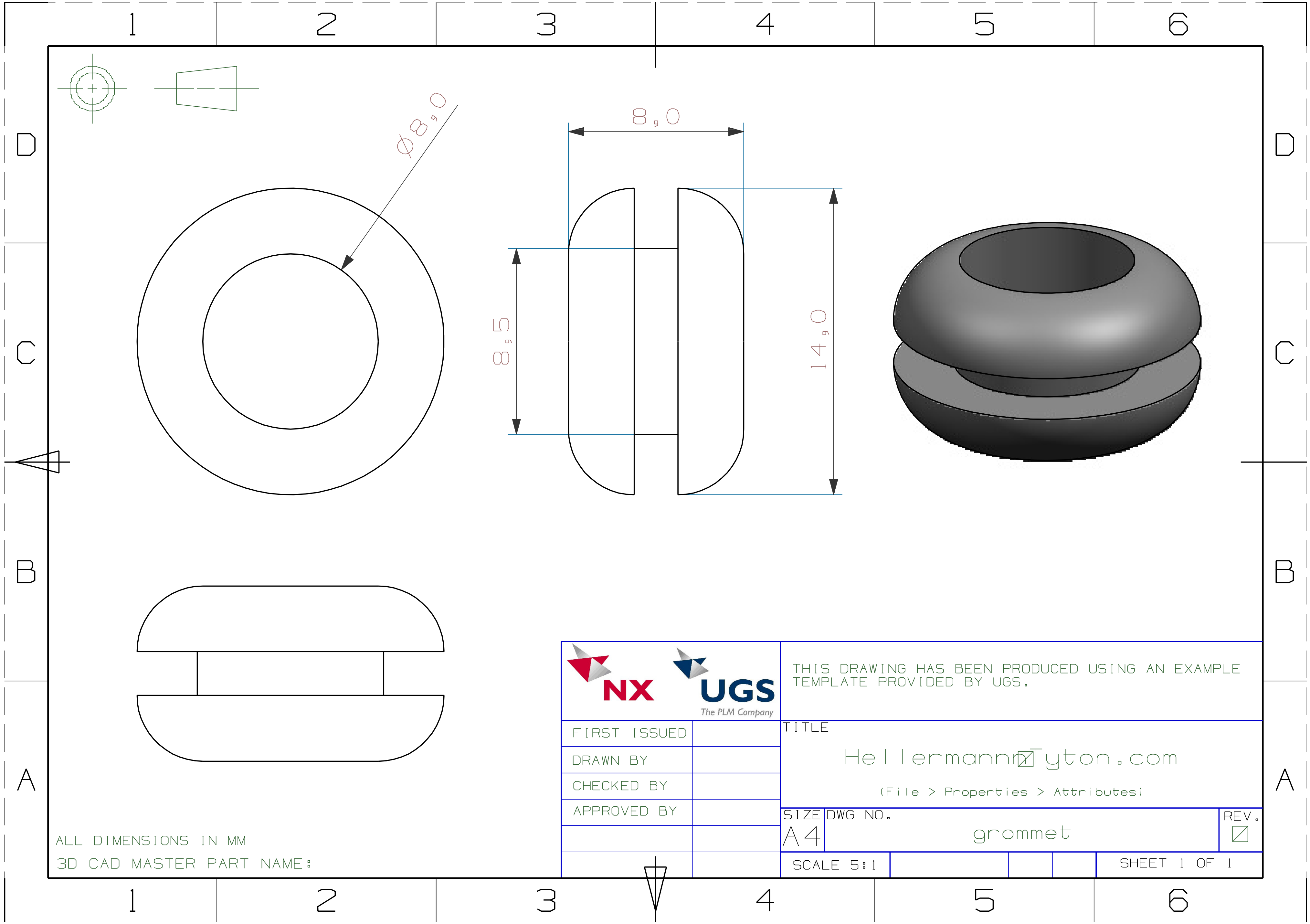

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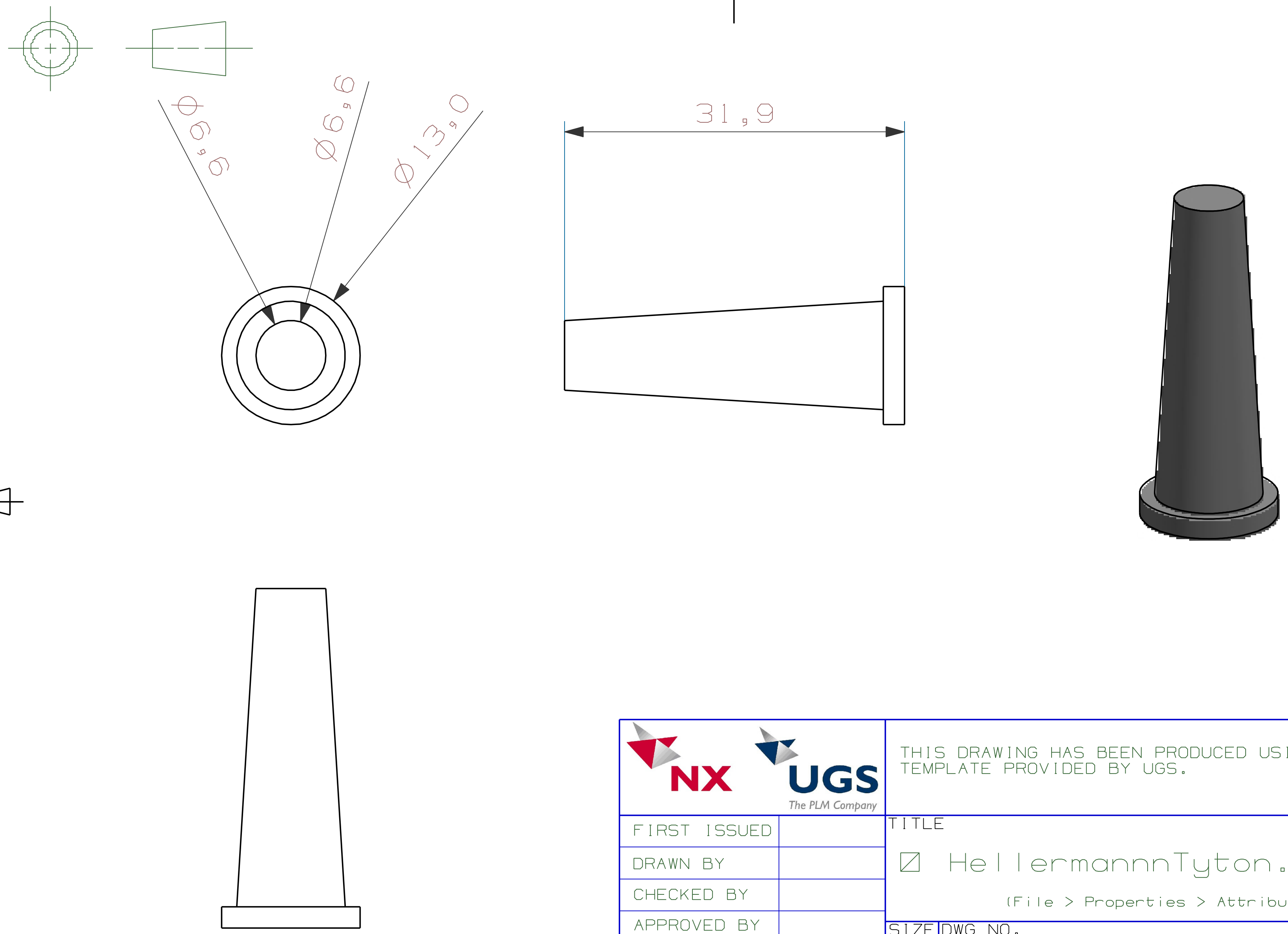

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2.3 Current source and connections

The power supply has been commerically bought, EA-PSI 9080-100. The unit may be programmed to provide e.g. the shape of a typical plasma pulse. Details of the power supply are attached. The unit was bought by Farnell (www.farnell.com). The connections between the power supply and the frame have been made with flexible copper cable 25 mm^2. See datasheet attached.

Programmierbare Netzgeräte

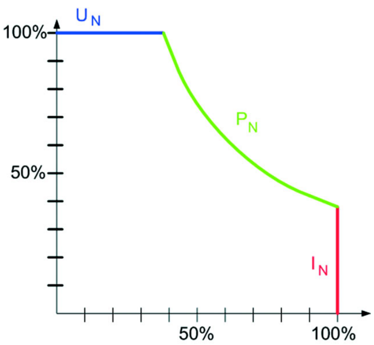
Die Geräteserie EA-PSI 9000 beruht auf der Geräteserie EA-PS 9000. Das neuartige Konzept der Leistungsstufe bietet dem Anwender sowohl eine hohe Ausgangsspannung als auch einen hohen Ausgangsstrom. Die Ausgangswerte werden durch die maximale Ausgangsleistung begrenzt.
Von der Funktionalität eines Labornetzteils bis hin zu komplexen Anwendungen reicht das Spektrum der High- End Geräteserie EA-PSI 9000.
Die benutzerfreundliche und interaktive Menüführung erleichtert die Konfiguration von Benutzerprofilen und Funktionsabläufen. Komplexe Anwendungen können so schneller und einfacher realisiert werden.
Die Funktionsabläufe oder Benutzerprofile können archiviert werden, wodurch die Reproduzierbarkeit einer Prüfung erhöht wird.
Die integrierten Überwachungsfunktionen mit einstellbareren Verzögerungen vereinfachen den Prüfaufbau, da externe Überwachungskreise entfallen können.

Optionen

- ►► Zwei Quadranten Module
- ►► Innenwiderstandsregelung
- ►► Kommunikationsinterface
- ►► CAN BUS mit Gateway-Funktionalität und einstellbarem Adressbereich
- ►► USB
- ►► RS232
- ►► GPIB (auf Anfrage)
- ►► Analoges Interface, galvanisch getrennt, mit programmierbaren Ein- und Ausgängen
- ►► Galvanische Trennung der Interface-Eingänge zum Ausgang von 2kV
- ►► Unterstützung der Kommunikations - schnittstellen durch LABview VI's
- ►► **EAsyPower**, mit der System-, Steuer- und Überwachungssoftware **EAsyPower** können bis zu 30 PSI-Netzteile gleichzeitig gesteuert und überwacht werden.

- ►► **Ausgangsnennleistungen: 1,5kW, 3kW, 6kW und 9kW**
- ►► **PFC Leistungsfaktor >0,99**
- ►► **Ausgangsspannungen: 0...80V; 0...300V; 0...600V; 0...750V**
- ►► **Fernfühlung**
- ►► **Überspannungsschutz OVP**
- ►► **Überwachung von $U_{>(t)}$, $U_{<(t)}$, $I_{>(t)}$ und $I_{<(t)}$**
- ►► **Alarmmanagement**
- ►► **Integrierter Funktionsgenerator**
- ►► **Benutzerprofile mit Passwortschutz**
- ►► **Sperrfunktionen des Bedienfeldes**

- ►► **Output Power: 1,5kW, 3kW, 6kW and 9kW**
- ►► **PFC power factor >0,99**
- ►► **Output Voltages: 0...80V; 0...300V; 0...600V; 0...750V**
- ►► **Remote Sense**
- ►► **Overvoltage Protection OVP**
- ►► **Supervision of $U_{>(t)}$, $U_{<(t)}$, $I_{>(t)}$ und $I_{<(t)}$**
- ►► **Alarm Management**
- ►► **Integrated Funktion Generator**
- ►► **User Profile w. Password protection**
- ►► **Block function of the control panel**



Programmable Power Supplies

The Lab-power series EA-PSI 9000 is based on the series EA-PS 9000. The new conception of the power stage provides to the user either a high output voltage and a high output current. The output values are limited by the output power.
These power supplies are designed for engineering laboratory and complex industrial applications.
The user-friendly and interactive menu guidance simplifies the configuration of user profiles and function sequences. Complex applications can be put into practice very fast and simple.
Function sequences or user profiles can be filed and documented for a better reproducibility of tests.
The integrated monitoring functions with adjustable delays simplify the test assembling because no external monitoring circuits are required.

Options

- ►► Two Quadrant Module
- ►► Internal resistance regulation
- ►► Communication interface
- ►► CAN BUS interface with gateway-function and adjustable adress range
- ►► USB
- ►► RS232
- ►► GPIB (on request)
- ►► Analogue interface, galvanic isolation, with programmable in- and outputs
- ►► Galvanic isolation of the interface inputs and the output for 2kV
- ►► Support of the communication interfaces through LABview VI's
- ►► **EAsyPower**, with the system-, control- and monitoring software **EAsyPower** up to 30 PSI-power supplies can be controlled and monitored at the same time.

Anzeige und Bedienfeld EA-PSI 9000

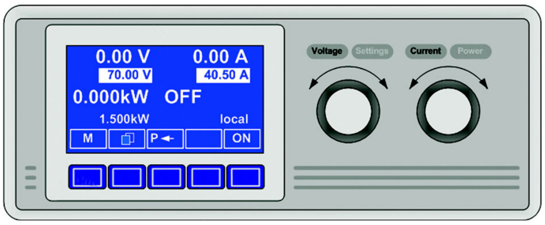
Das Display des Netzteils zeigt an:

- Sollwert von U, I und P
- Istwert von U, I und P
- Betriebsart CV, CC oder CP
- Sollwert des Innenwiderstands (optional)
- Status des Ausgangs **ON OFF**
- Zugriff auf das Netzteil
  -local = Frontbedienung
  -external = anloges Interface
  -remote = Zugriff über Bussystem
- Jeweilige Funktion der Bedientasten
- Alarme, Warnungen und einfache Meldungen

Display and Control Panel EA-PSI 9000

The display of the power supply shows the:

- Set value of V, A and P
- Actual values of V, A and P
- Operating mode CV, CC or CP
- Set value of internal resistance (optional)
- Output status **ON OFF**
- Access to the power supply
  -local = Front panel operation
  -external = Analogue interface
  -remote = Access via BUS system
- Current Function of the push-buttons
- Alerts, warnings and simple alerts

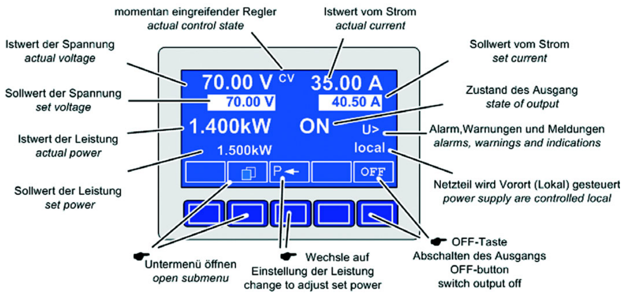


Über die interaktiven Bedientasten werden die im Display angezeigten Funktionen nach einer Betätigung ausgeführt.

The functions indicated on the display can be activated by actuation of the related push button below the display.

Betriebsanzeige

Operating Mode Indication



Benutzerprofile

Über Benutzerprofile können anwendungsspezifische Parameter eingestellt und gespeichert werden. Im Gerät können vier unterschiedliche Profile hinterlegt werden.
Mit der System-, Steuer- und Überwachungssoftware **EAsyPower** können Benutzerprofile ausgelesen, bearbeitet und überschrieben werden.

User Profiles

Profiles designed to user specifications can be used to set and store user specified parameters. Up to four different profiles can be deposited in the units.
Using the system, controll and monitoring software **EAsyPower,** the user profiles can be readout, processed and overwritten.

Alarm Management

Bis zu drei Alarme, Warnungen oder einfache Meldungen werden auf dem Display angezeigt. Alarme und Warnungen können akustisch signalisiert werden.
Alarme schalten unmittelbar den Ausgang ab. Warnungen hingegen müssen quittiert werden, schalten den Ausgang aber nicht ab. Einfache Meldungen werden nur angezeigt.

Alle Meldungen können über das optionale galvanisch getrennte analoge Interface ausgegeben werden.

Alarm Management

Up to three alarms, warnings or simple alerts can be indicated on the display. Alarms and Warnings can be audibly signalized.
Alarms will shut down the output instantly. Warnings must be acknowledged but will not shut down the output. Simple alerts are displayed only.

All alerts can read out via the optional galvanically isolated analogue interface.

Funktionsablauf

Sowohl über das Bedienfeld als auch über die Kommunikationsschnittstellen kann der Funktionsablauf gesteuert werden.
Die Istwerte können während des Funktionsablaufs ausgelesen werden. Sie können gespeichert werden und später mit Hilfe der System-, Steuer- und Überwachungssoftware EAsyPower analysiert werden.

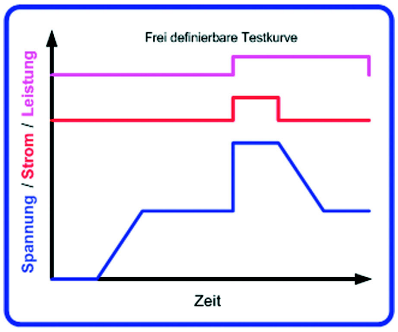
Function Sequence

The function sequence can be controlled via the control panel as well as via the communication interfaces.

The actual values can be read out during a function sequence. They can be stored and later analysed with the system control and monitoring software EAsyPower.

Funktionskurven

Über den integrierten Funktionsgenerator können Sollkurven nach einer Funktion f(U, I, Δt) erzeugt werden. Ein Funktionsablauf kann beliebig oft hintereinander durchlaufen werden.



Function characteristic

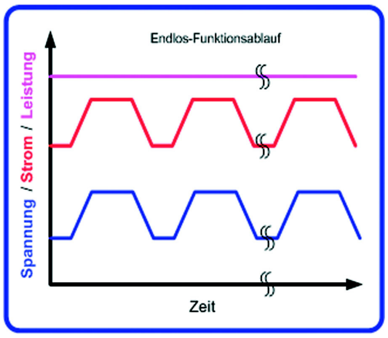
With the integrated function generator user specified characteristics can be defined according the function f(V, A, Δt).
Such function sequence can be repeated as often as wanted.

Der Funktionsablauf kann aus maximal fünf Sequenzen zusammengesetzt sein.

Jeder Sequenz kann separat

- ▶▶ eine Leistungsbegrenzung
- ▶▶ ein Innenwiderstand (optional)
- ▶▶ eine Wiederholrate

zugewiesen werden.



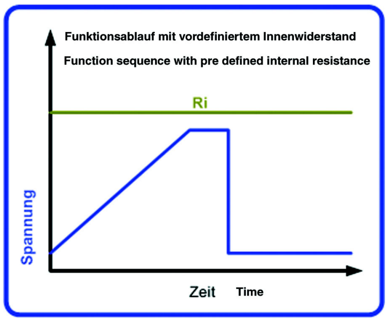
A function sequence can be combined of max. five sequences.

To each sequence can be separately

- ▶▶ a power limit
- ▶▶ an internal resistance (optional)
- ▶▶ a repeat rate

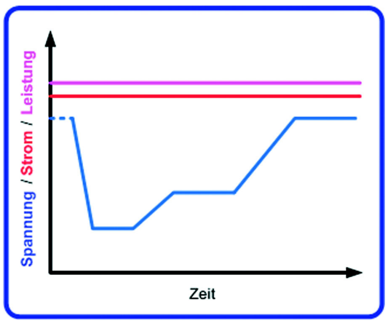
assignated.

Eine Sequenz wird über 10 Sequenzpunkte definiert. Ein Sequenzpunkt wiederum setzt sich aus dem zu erreichenden Endwert U und I nach Ablauf der Zeit Δt zusammen.



A sequence is defined via 10 sequence points.
A sequence point is combined of the targeted final value of V and A after the time Δt.

Funktionskurven können mit der System-, Steuer- und Überwachungssoftware EAsyPower ausgelesen, geschrieben oder archiviert werden.



Function characteristics can be read out and stored with the System, control and monitoring software EAsyPower.

Elektro-Automatik

PROGAMMIERBARE LABORNETZGERÄTE / PROGRAMMABLE LABORATORY POWER SUPPLIES

Technische Daten	Technical Data	EA-PSI 9080-50	EA-PSI 9080-100	EA-PSI 9080-200	EA-PSI 9080-300
Ausgangsspannung	Output voltage	0...80V	0...80V	0...80V	0...80V
Ausgangsstrom	Output current	0...50A	0...100A	0...200A	0...300A
Ausgangsleistung	Output power	1500W max.	3000W max.	6000W max.	9000W max.
Abmessungen BxHxT	Dimensions WxHxD	19“ 2HE 380mm	19“ 2HE 460mm	19“ 4HE 460mm	19“ 6HE 460mm
Gewicht	Weight	10,5kg	13,5kg	25,5kg	36,5kg
Artikelnummer	Item No.	15200768	15200770	15200771	15200772

Technische Daten	Technical Data	EA-PSI 9300-15	EA-PSI 9300-25	EA-PSI 9300-50	EA-PSI 9300-75
Ausgangsspannung	Output voltage	0...300V	0...300V	0...300V	0...300V
Ausgangsstrom	Output current	0...15A	0...25A	0...50A	0...75A
Ausgangsleistung	Output power	1500W max.	3000W max.	6000W max.	9000W max.
Abmessungen BxHxT	Dimensions WxHxD	19“ 2HE 380mm	19“ 2HE 460mm	19“ 4HE 460mm	19“ 6HE 460mm
Gewicht	Weight	10,5kg	13,5kg	25,5kg	36,5kg
Artikelnummer	Item No.	15200769	15200773	15200774	15200775

Eingangsdaten	Input Data	Eingansdaten / Input Data
Eingangsspannung	Input voltage	
1,5kW Geräte	1,5kW units	**180V...264V** / 88V...180V Derating auf / to 1,2kW
3,0kW Geräte	3,0kW units	**207V...264V** / 180V...207V Derating auf / to 2,5kW
6,0kW Geräte	6,0kW units	**360V...460V 2 Phasen / 2 phases** / 310V...360V Derating auf / to 5,0kW
9,0kW Geräte	9,0kW units	**360V...460V 3 Phasen / 3 phases** / 310V...360V Derating auf / to 7,5kW
Eingangsfrequenz	Input frequency	45...65Hz
Netzsicherung	Mains fuse	16A T Rückseite / Rear side
Leistungsfaktor	Power factor	>0,99

Ausgangsdaten	Output Data	Ausgangsdaten / Output Data
Ausgangsleistungen	Output power	1,5kW 3,0kW 6,0kW 9,0kW
Ausgangsspannungen	Output voltages	0...80V, 0...300V
-Lastausregelung	-Load regulation	<0,05% bei/at 0...100% Last/Load
-Netzausregelung	-Mains regulation	<0,05%
-Restwelligkeit	-Ripple	<70mV p-p
Ausgangsströme	Output currents	15A, 25A, 50A, 75A, 100A, 200A, 300A siehe Variantenliste/see list of variants
-Lastausregelung	-Load regulation	<0,15% bei/at 0...100% Last/Load
-Netzausregelung	-Mains regulation	<0,05%
-Restwelligkeit	-Ripple	<100mA p-p
Ausgangssicherung	Output fuse	Nein, Ausgang ist dauerkurzschlußfest / No, continious short circuit proof
Systembus	System bus	Fernfühlung/Sense; Share bus; Klemmen auf der Rückseite/Yes, connectors on the rear side

Überwachung	Monitoring	Überwachung / Monitoring
OVP	OVP	Einstellbarer Überspannungsschutz, Programmable **O**ver **V**oltage **P**rotection
OTP	OTP	Übertemperaturschutz, **O**ver **T**emperature **P**rotection
$U_{>(t)}$, $U_{<(t)}$,	$U_{>(t)}$, $U_{<(t)}$,	Programmierbare zeitverzögerte Überwachungskreise, Programmable delayed monitoring
$I_{>(t)}$ und $I_{<(t)}$	$I_{>(t)}$ und $I_{<(t)}$	Programmierbare zeitverzögerte Überwachungskreise, Programmable delayed monitoring

Funktionsgenerator	Function generator	Funktionsgenerator / Function generator
Funktionsdurchläufe	Funktion cycles	1...254 oder unendlich, 1...254 or endless
Sequenzen	Sequences	Max. 5 Sequenzen in beliebiger Reihenfolge, Max. 5 sequences in arbitary order
Sequenzdurchläufe	Sequences cycles	1...254 oder unendlich, 1...254 or endless
Sequenzpunkte	Sequences points	1 Sequenz besteht aus 10 Sequenzpunkten, 1 sequence consist of 10 sequence points
-Zeitangabe	-Time value	0,001ms...99:59h

Allgemeine Daten	General Data	Allgemeine Daten / General Data
Kühlung	Cooling	Temperatur gesteuerte Lüfter, Lufteintritt vorn/Temperature controlled fans, air intake
Sicherheit	Safety	frontpanel
EMV	EMI	EN 60950, CE Mark
Umgebungstemperatur	Operation temperature	EN 61000-6-2, EN 55022 Klasse B/Class B
Feuchtigkeit	Humidity	0...40°C
Lagertemperatur	Storage temperature	0...95% relative Luftfeuchte, nicht kondensierend/relative humitity, none condensing
Betriebshöhe	Operating altitude	-25...85°C

Silicon-isolierte Litzenleitungen

Silicone Insulated Multistrand Wires

Câbles multi-brins à isolation en silicone

Silistrom®

Hoch flexible Litzenleitungen mit verstärkter Isolierung.

Highly flexible stranded wire with reinforced insulation.

Câble très souple, à isolation renforcée.

Typische Anwendung

Stromzuführungen und Erderleitungen im Maschinen-, Anlagen- und Akkumulatorenbau. Sicherheits-Messleitungen mit hoher Strombelastung.

Typical Application

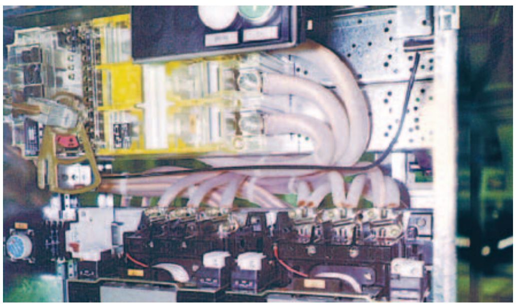
Current feeds and earth/ground wires in machine, plant and accumulator construction. Safety test leads carrying high currents.

Applications

Alimentation et mise à la terre de machines et d'installations diverses. Cordons de mesure pour des intensités élevées.

Typ Type Type	Bestellnummer Order number Numéro de commande	Nennquerschnitt Nominal cross section Section nominale	Litzenaufbau Strand design Composition de l'âme	Leitungsgewicht Weight of cable Masse du câble	Leiterdurchmesser Conductor diameter Diamètre sur âme	Isolierwandstärke Thickness insulation wall Epaisseur d'isolation	Aussendurchmesser Outer diameter Diamètre sur isolant	Bemessungsspannung Rated voltage Tension assignée	Prüfspannung Test voltage Tension d'essai	Bemessungsstrom Rated current Intensité assignée	Prüfzeichen Certification marks Certification	*Standard-Farben *Standard colours *Couleurs standard
SIL		mm^2	n x Ø mm	kg/km	mm	mm	mm	V	V_{AC}	A		
SILI-S ...												
SILI-S 4,0	**61.7611-□***	4,0	1036 x 0,07	55	3,0	1,2	5,4	1500	8000	42	UR 1)	21 22 23 33
SILI-S 6,0	**61.7612-□***	6,0	1548 x 0,07	80	3,8	1,2	6,2	1500	8000	54	UR 1)	21 22 23 33
SILI-S 10	**61.7613-□***	10	2556 x 0,07	145	4,8	2,1	9,0	1500	8000	75	UR 1)	21 22 23 33
SILI-S 16	**61.7614-□***	16	4116 x 0,07	230	6,1	2,2	10,5	1500	8000	100	UR 1)	21 22 23 33
SILI-S 25	**61.7615-□***	25	6384 x 0,07	310	7,0	2,4	11,8	1500	8000	130	UR 1)	21 22 23 33
SILI-S 35	**61.7616-□***	35	9324 x 0,07	440	8,5	2,4	13,3	1500	8000	160	UR 1)	33
SILI-S 50	**61.7617-□***	50	13024 x 0,07	570	10,5	2,2	14,9	1500	8000	200		33
SILI-S 70	**61.7618-□***	70	8967 x 0,10	760	12	2,2	16,4	1500	8000	245		33
SILI-S 95	**61.7619-□***	95	12103 x 0,10	1080	15	2,0	19	1500	8000	290		33

1) UL recognized: File E120880, AWM 3525
Use: Test Probe Lead up to +60°C

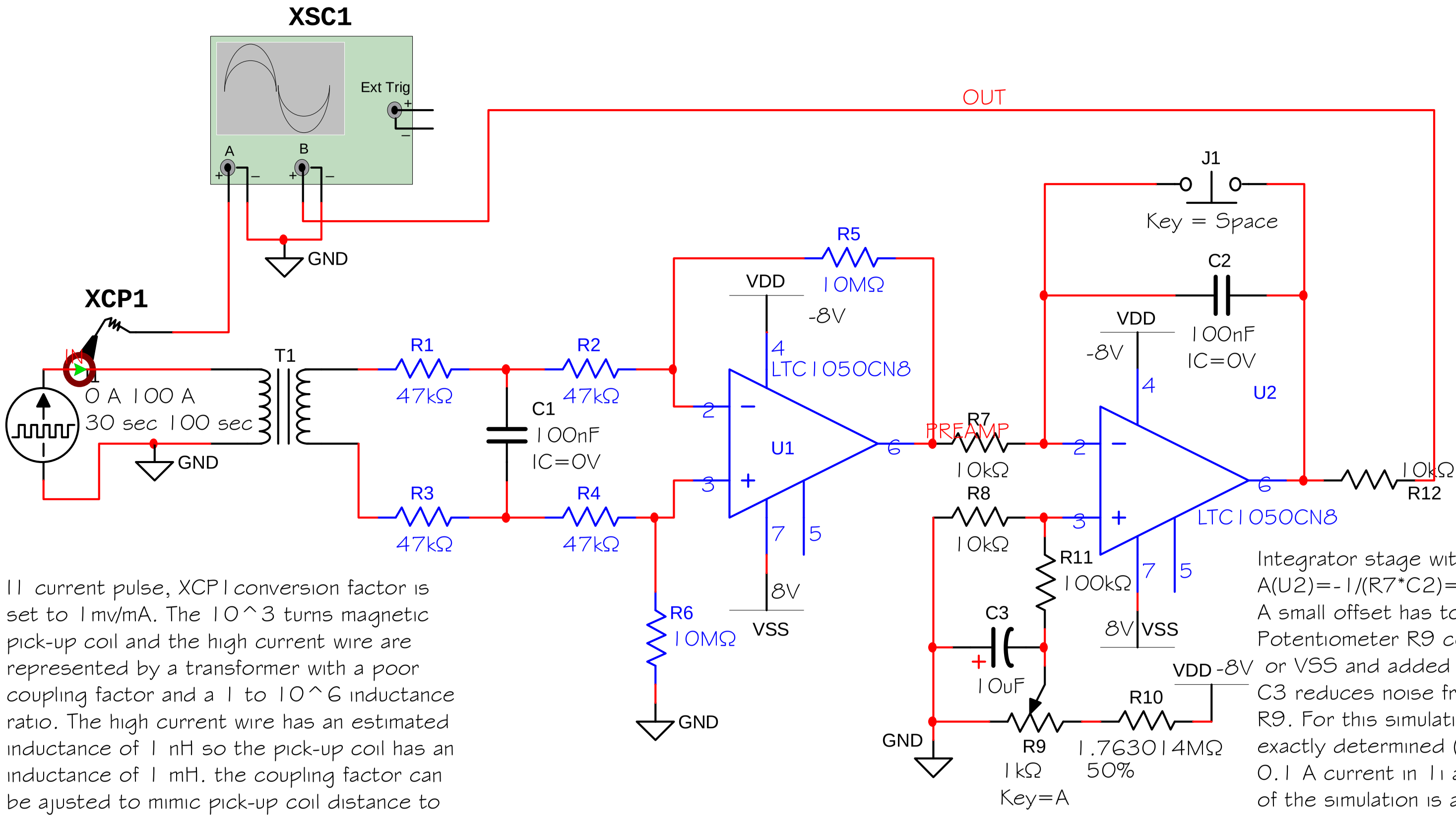


2.4 Amplifiers and Integrators

The next pages show in the following order:

- Amplifier and integrator for separate pickup coil
- Amplifiers for set of 8 pickup coils (feeding into the DAQ system)

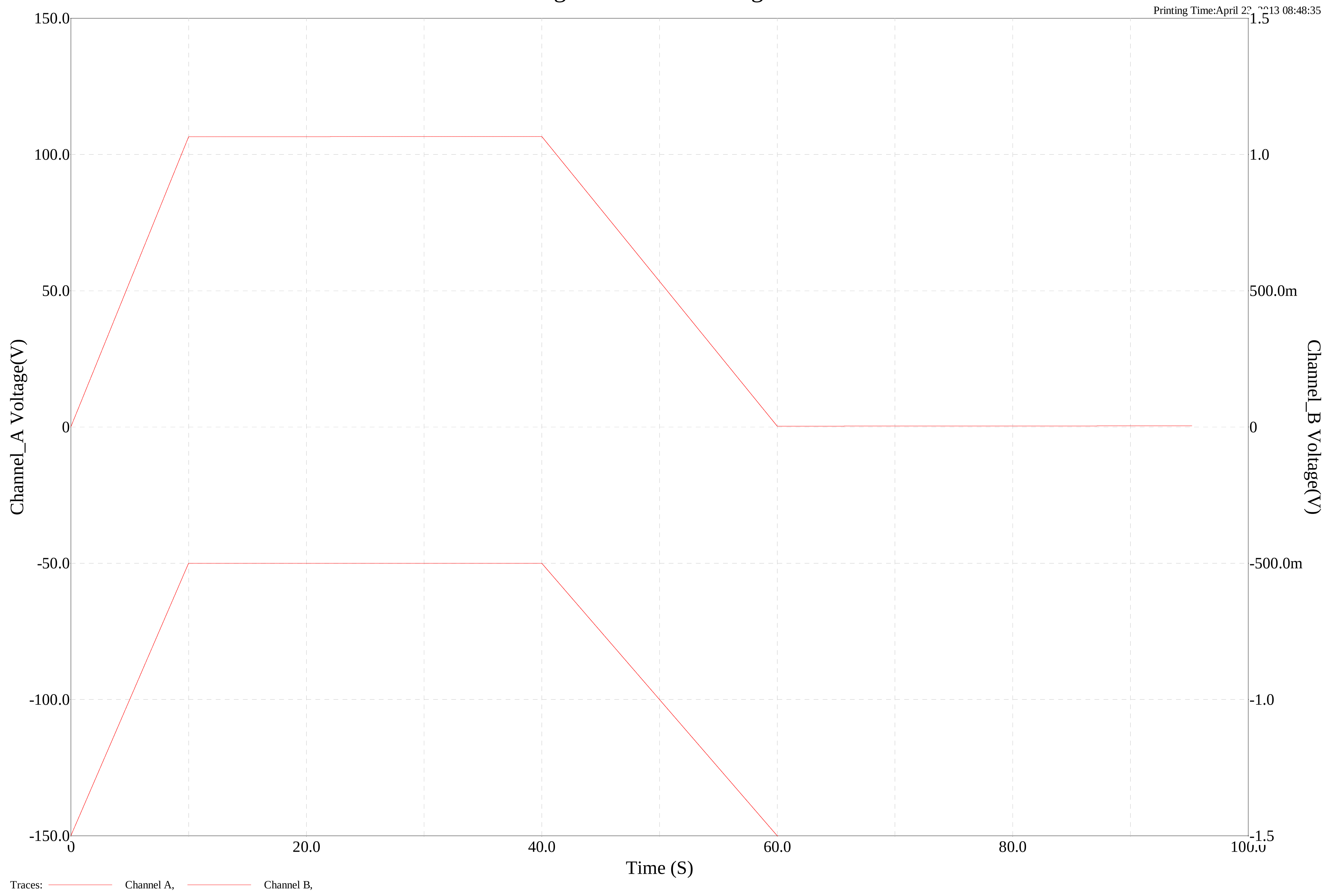
The signals from the amplifiers of the set of 8 coils are input to a DAQ system such that the signals can be manipulated digitally. We used a localy developed DAQ system for Experiment Automation ("nano-Giant": http://www.tuedacs.nl/) but other systems may be used as well.



I1 current pulse, XCP1 conversion factor is set to 1mv/mA. The 10^3 turns magnetic pick-up coil and the high current wire are represented by a transformer with a poor coupling factor and a 1 to 10^6 inductance ratio. The high current wire has an estimated inductance of 1 nH so the pick-up coil has an inductance of 1 mH. the coupling factor can be ajusted to mimic pick-up coil distance to the main conductor.
The passive low pass input filter is designed for 3.4 kHz
Best common mode suppression by U1occurs when the ratio (R1+R2)/R5 match (R3+R4)/R6.
A good match ca be achieved by manually selecting from batch of of 100 pcs of 1% tolerance:
R1/R3-1<+/- 0.1%, R2/R4-1<+/- 0.1% and
R5/R6-1<+/- 0.1%
The amplification of this stage: A(U1)~-R5/(R1+R2)=-100X

Integrator stage with U2
A(U2)=-1/(R7*C2)=-1000X
A small offset has to be nulled with Potentiometer R9 connected to VDD or VSS and added to U2+IN throughR11.
C3 reduces noise from the sliding contact of R9. For this simulation the value of R10 is exactly determined (1.763014 M) so that with 0.1 A current in I1 and R9 is at 50% the drif of the simulation is as low as possible. For the real integrator the value of R10 = 2.2 MOhm

MagneticInductionIntegrator



MagneticInductionIntegrator

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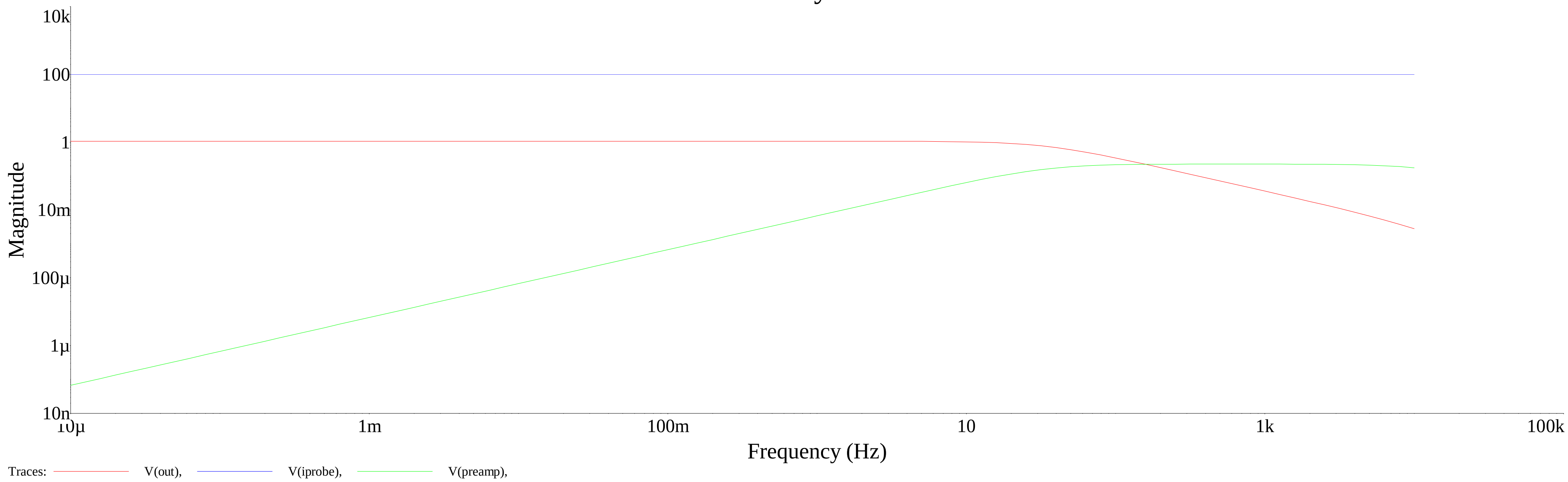
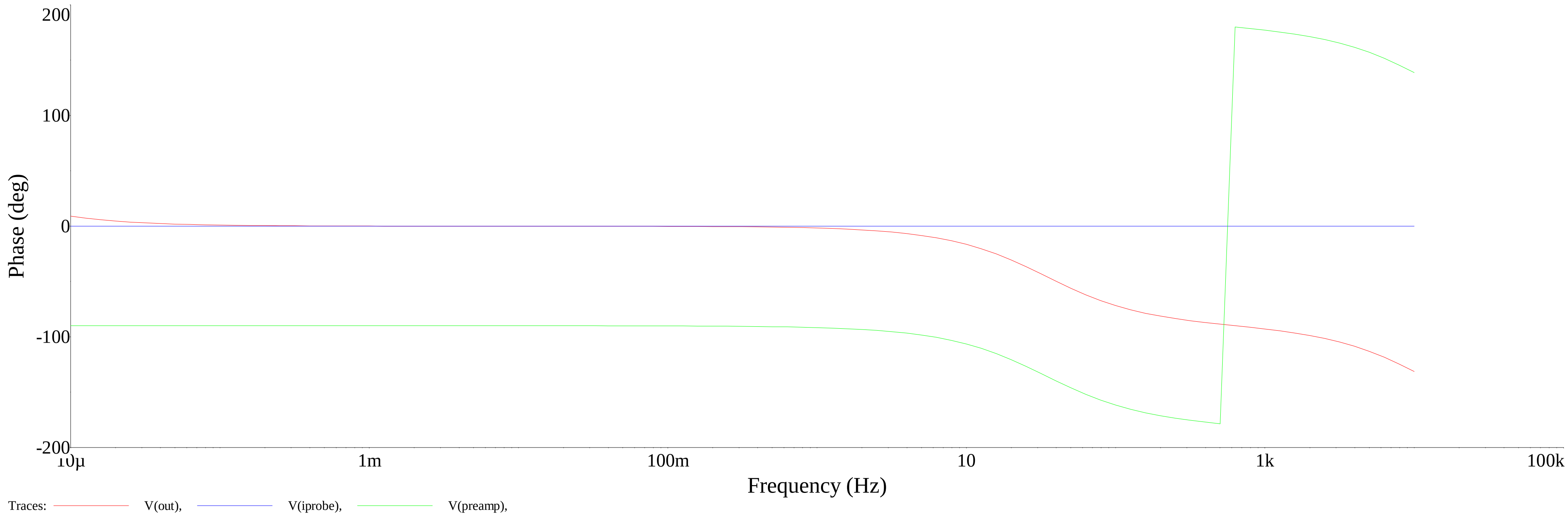
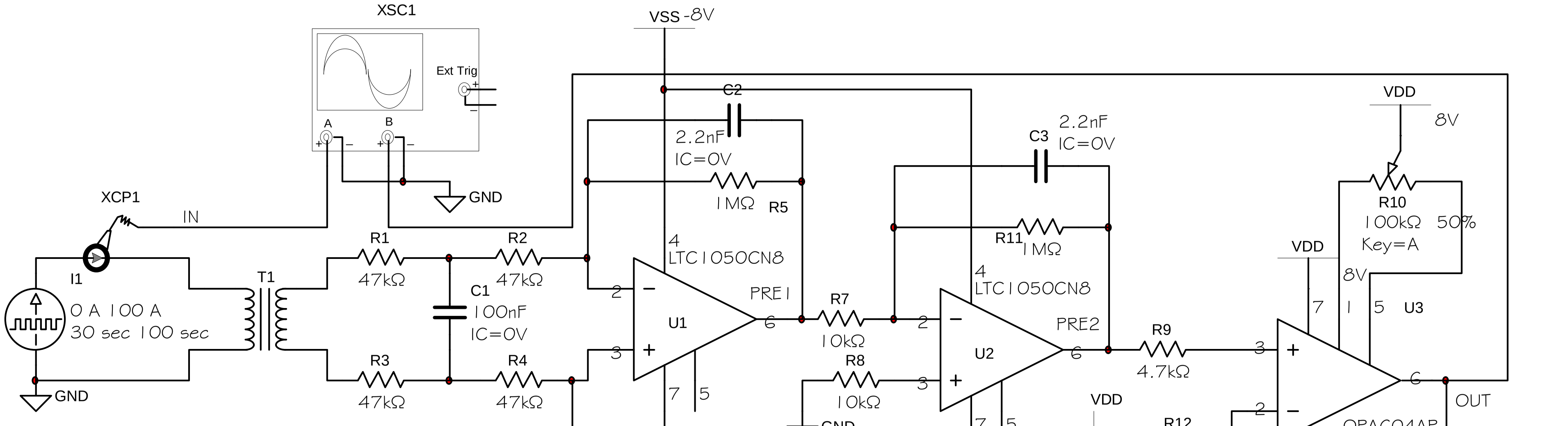
AC Analysis





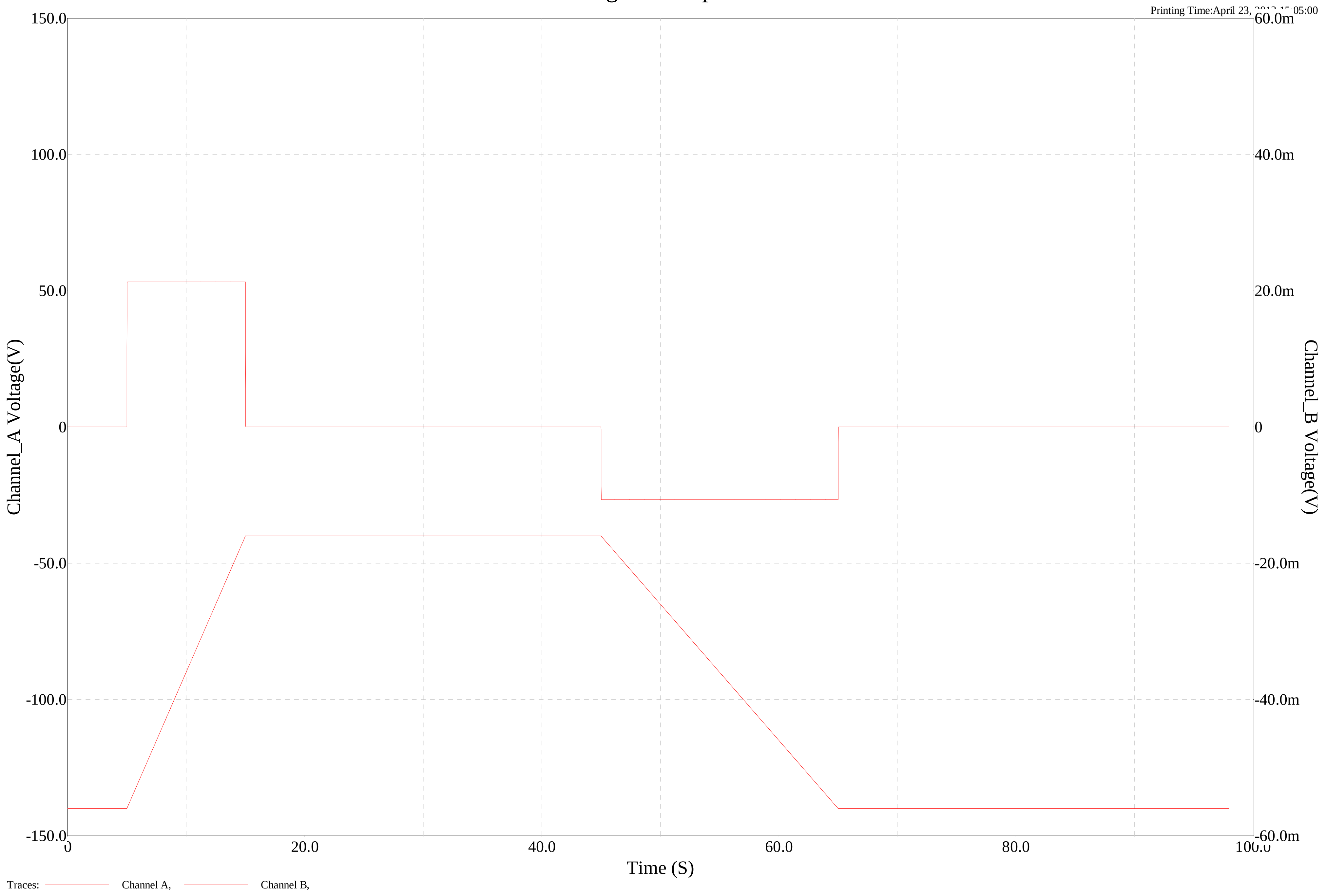


For input side see MagnIndIntSch text.
PreAmp(U1) = -10X low pass 72 Hz
PreAmp(U2) = -100X low pass 72 Hz
Amp(U3) = 2X low pass 400 Hz
The real circuit has +/- 8V stabilisers (78L08 and 79L08). on board, getting power from stabilised +/-12V benchtop PS.
The 72 Hz low pass filters should be ajusted to slichtly under half the sample frequency or the sample frequency should now be set to at least 200 Hz to avoid aliasing.

The setting of potentiometer R10 has no effect in the simulation. The simulation does have an offset from U1 an U2 that I compensated by adding and trimming R12, but R12 is not part of the real circuit.

The choice of OPA604AP for U3 was because it is a Hi-Fi Headphone opamp that can drive up to 600 Ohm Load, unlike the LTC1050, allowing short-curcuiting the output indefinitely. It also has low distortion and low drift for a non chopper type of opamp.

MagnIndAmpSch



MagnIndAmpSch

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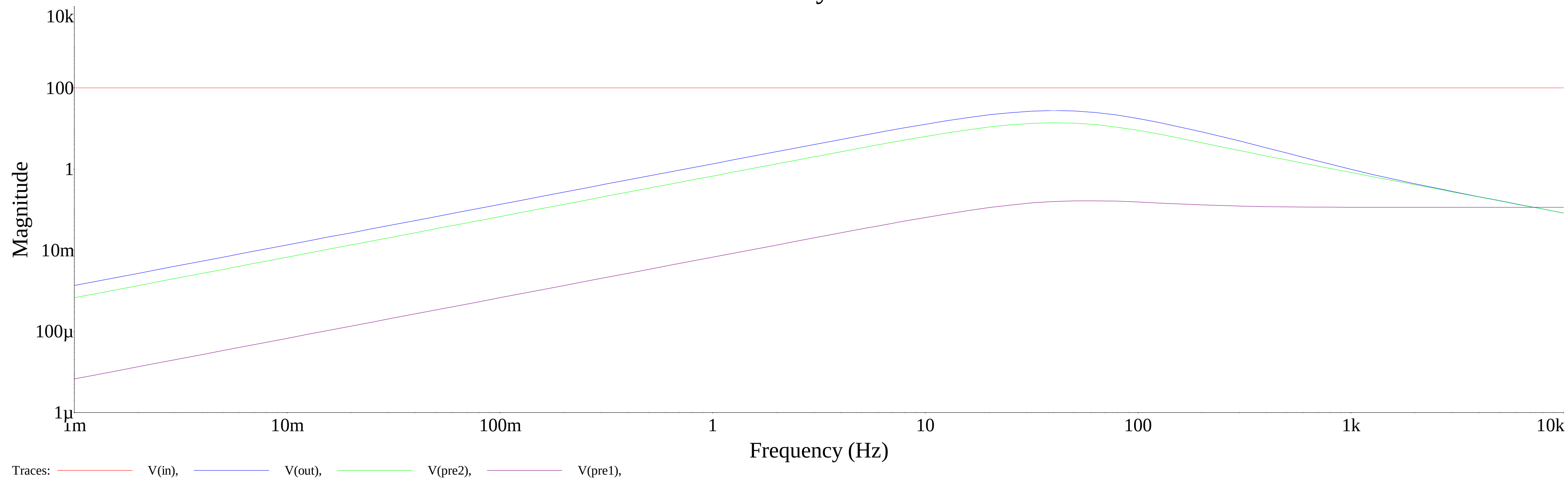
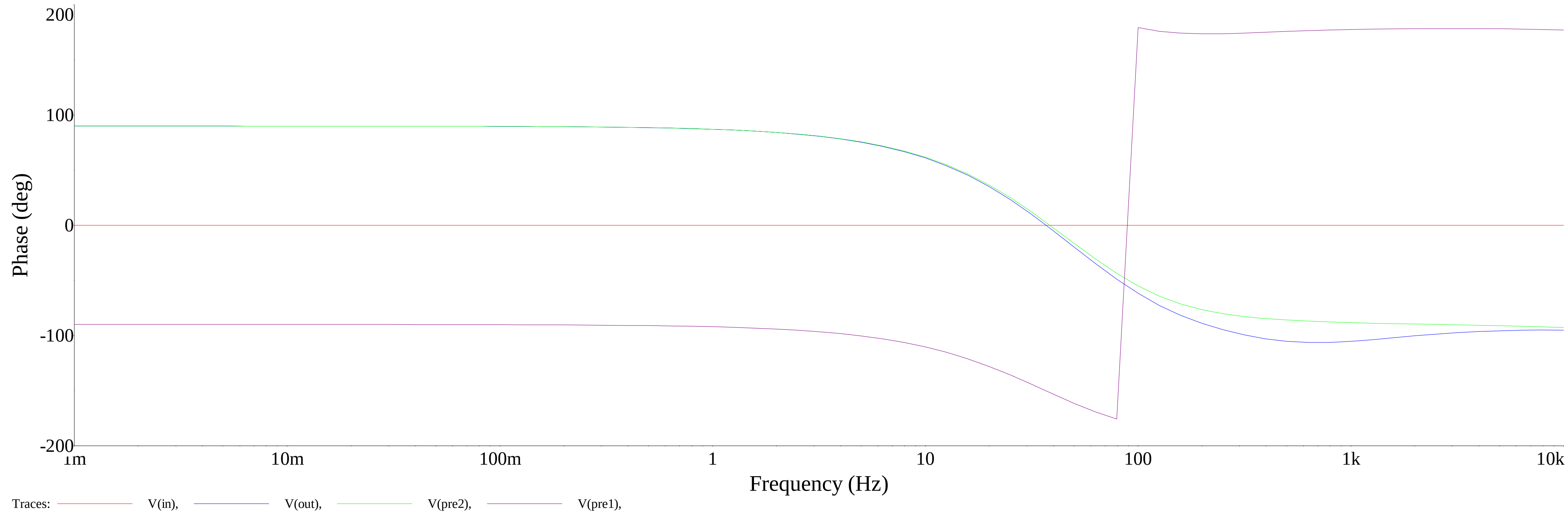
AC Analysis





3 Acknowledgemenst

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