# Artificial Network AN-Series

**In accordance with LV123, ISO 21498 and IEC 61851-23.**

**Customer specific solutions according to in-house standards like the MBN 11123, GS 95023, VW 80303 or Impedances taken from vehicular measurements.**

**Liquid cooled for stabile resistance temperature and constant ohmic value.**

**True continues current loading without derating, ideal for in-the-loop testing during the development stage of HV components.**

**2x tighter tolerance than required in ISO 21498. Accredited DAkkS calibration available upon request.**

**Modular and upgradable system that grows with your testing needs.**

**Self-monitoring, safe and reliable system**

AN-Series is an Artificial Network that electrically recreates the vehicular power-net impedance for component tests of voltage class B (high voltage) components in laboratories and test-benches. The AN-Series uses an analog system with a bandwidth covering up to 150 kHz. An artificial network like the AN-Series is crucial for the proper testing of all voltage class B component in both hybrid and electric vehicles. Generated DUT interferences like ripple, dynamics, spikes and other higher frequency noise is correctly absorbed and reflected by the Artificial Network, recreating conditions similar to that in a vehicular high voltage power-net. This allows for better testing of the component's robustness and its immunity to its own generated noise. Testing with AN-Series artificial network would also bring efficiency and life-cycle tests closer to real-world results and in line with standards like the ISO 21498, LV 123, IEC 61851-23 and internal-norm requirements.
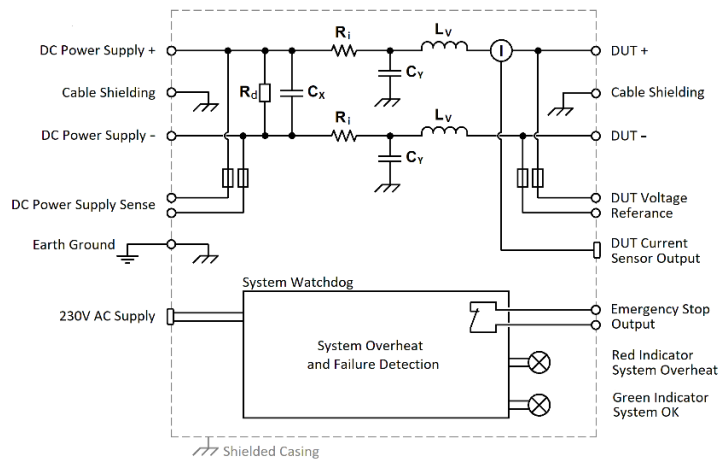




Physical form B for high power DUTs



Physical form A for low power DUTs

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Electric Specifications** | | | | | | | | |
| **MODEL** | **USE CASE** | **2× $R_{i, HV}$ TYPE** | **$L_V$ TYPE** | **$C_Y$ TYPE** | **$C_X$ TYPE** | **MAX CONTINUOUS CURRENT (AC & DC)** | **FREQUENCY BANDWIDTH** | **MAX VOLTAGE** |
| | | **[mΩ]** | **[µH]** | **[µF]** | **[mF]** | **[A RMS]** | **[kHz]** | **[V]** |
| **AN-V-A** | ISO 21498 A | 2× 10 | 1 | 1 | 0, 6, 10, 12 | 120, 400, 550, 700, 1100 | 0 - 150 | 1000 |
| **AN-V-B** | ISO 21498 B | 2× 25 | | | | 120, 300, 450, 570, 850, 900 | | |
| **AN-V-C** | ISO 21498 C | 2× 100 | | | | 120, 200, 350, 450 | | |
| **AN-V-Z1** | ISO 21498 Z1 | 2× 50 | | | | 120, 300, 450, 570, 670 | | |
| **AN-B-A** | LV 123 | Artificial network in accordance to LV 123 | | | | | | |
| **AN-C** | IEC 61851-23 | Artificial network in accordance to IEC 61851-23 A, B and C | | | | | | |
| **AN-U** | | Customer specific artificial network | | | | | | |

*Detailed table of all model numbers and order codes on page 6*

Table of Contents

## 1    SAFETY NOTE

**High voltage system:**
This product is a high voltage and high current system and should <u>only</u> be used and handled by <u>qualified professionals</u> in proper laboratory conditions.

**Large internal Cx capacitance (greater than 6 mF):**
This product contains large internal Cx capacitance connected between the high voltage lines. Even when DC power supply to the Artificial Network (AN) is turned off, high voltage will linger for longer periods of time. Hence, before handling or starting any work on the high voltage system and connected equipment, always test for absence of voltage. Ensure that the high voltage lines are fully discharged (to below 10 V). Voltages above 10 V can lead to arc flashes when a short-circuit between the high voltage lines occur.

**Fused voltage outputs:**
High voltage measurement points "DUT Voltage Reference" and "DC Power Supply Sense" are fused and may not be electrically connected to the high voltage lines when the fuses are blown. To ensure the test for absence of voltage is valid, proceed first with a positive test or a connectivity test between "DUT Voltage Reference" and "DC Power Supply Sense". After testing for absence of voltage at the voltage measurement points "DUT Voltage Reference" and "DC Power Supply Sense", testing for absence of voltage directly at the high voltage busbar.

**Internal Cy capacitance (equal or greater than 2 µF):**
This product contains internal Cy capacitance between high voltage lines and ground. When connected to other devices the Cy capacitance may exceed safe values. Before begging handling or starting any work on the high voltage system always test for absence of voltage between high voltage lines and ground.

**Emergency-Stop:**
Before the use of this product or system, ensure that the product or system is connected to the laboratory Emergency-Stop. This product or system must be able to shut off or cut off the DC power supply and DUT in a case of overheating or internal error.

**Cooling:**
For Physical form B system or product, the correct temperature and flowrate of the liquid coolant must be present and running as soon as voltage is present on the high voltage lines, otherwise the internal components of the system may be damaged.

## 2    TYPICAL APPLICATION SETUP
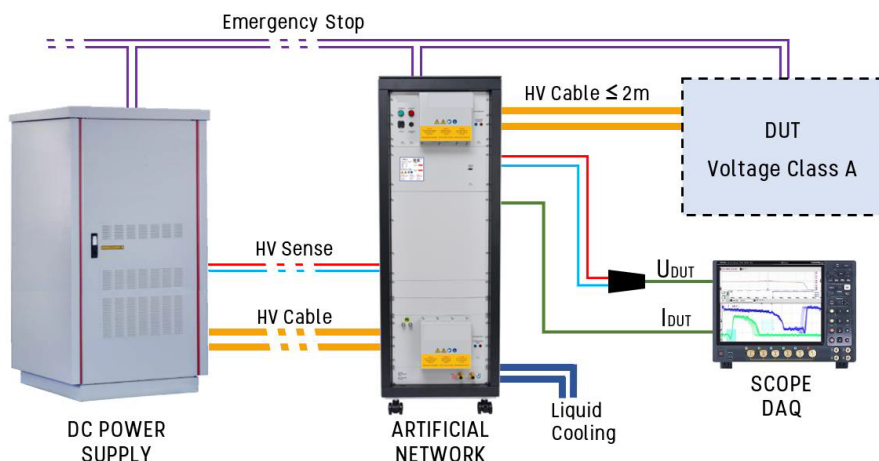
# 3    SPECIFICATION

## 3.1    IMPEDANCE (TOLERANCES & CALIBRATION)

Listed below are the impedance tolerances of AN-Series-V units according to ISO 21498. For other tolerances, please contact BOLAB Systems GmbH for more information and details. Impedances are measured, as specified in ISO 21498 at the DUT busbar terminals while the DC Power Supply busbar terminals are short-circuited. All Artificial Networks come with an in-house impedance calibration certificate. An additional external DAkkS accredited calibration is available upon request.

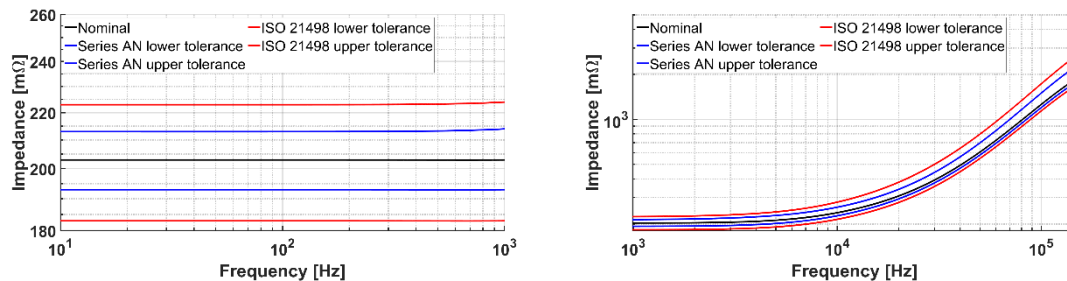**Impedance characteristics of AN-V-A in accordance with ISO 21498 use case A:**
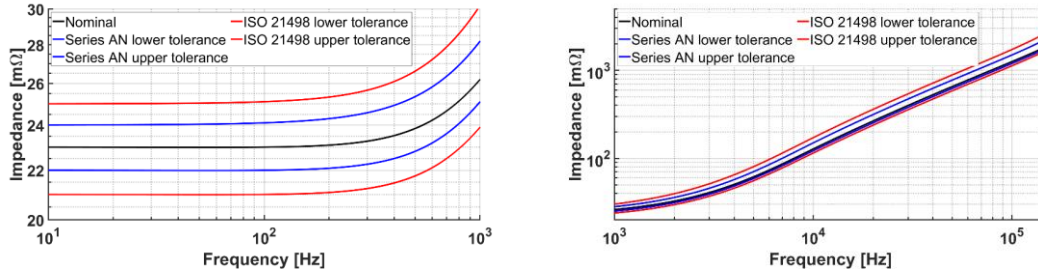


| Frequency [Hz] | ISO 21498 lower tolerance | AN-Series lower tolerance | ISO 21498 Nominal | AN-Series upper tolerance | ISO 21498 upper tolerance |
|---|---|---|---|---|---|
| 1,00E+01 | 2,10E-02 | 2,20E-02 | 2,30E-02 | 2,40E-02 | 2,50E-02 |
| 1,00E+02 | 2,10E-02 | 2,20E-02 | 2,30E-02 | 2,41E-02 | 2,51E-02 |
| 1,00E+03 | 2,39E-02 | 2,51E-02 | 2,62E-02 | 2,82E-02 | 3,02E-02 |
| 1,00E+04 | 1,15E-01 | 1,22E-01 | 1,28E-01 | 1,50E-01 | 1,72E-01 |
| 1,00E+05 | 1,13E+00 | 1,20E+00 | 1,26E+00 | 1,50E+00 | 1,73E+00 |
| 1,50E+05 | 1,70E+00 | 1,79E+00 | 1,88E+00 | 2,29E+00 | 2,70E+00 |

**Impedance characteristics of AN-V-B in accordance with ISO 21498 use case B:**
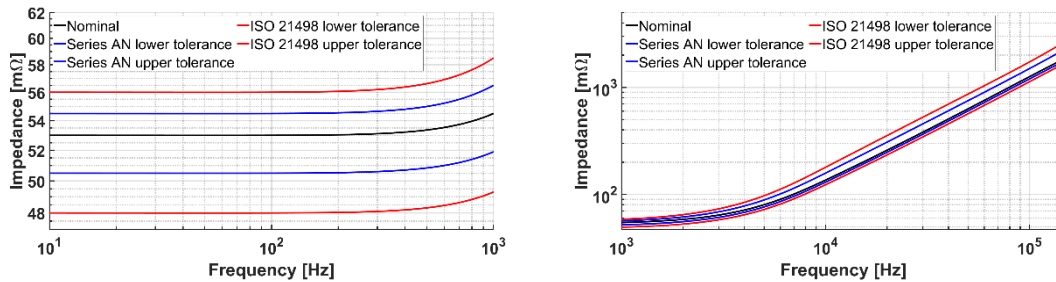


| Frequency [Hz] | ISO 21498 lower tolerance | AN-Series lower tolerance | ISO 21498 Nominal | AN-Series upper tolerance | ISO 21498 upper tolerance |
|---|---|---|---|---|---|
| 1,00E+01 | 4,80E-02 | 5,05E-02 | 5,30E-02 | 5,45E-02 | 5,60E-02 |
| 1,00E+02 | 4,80E-02 | 5,05E-02 | 5,30E-02 | 5,45E-02 | 5,60E-02 |
| 1,00E+03 | 4,93E-02 | 5,19E-02 | 5,45E-02 | 5,65E-02 | 5,85E-02 |
| 1,00E+04 | 1,23E-01 | 1,30E-01 | 1,36E-01 | 1,58E-01 | 1,79E-01 |
| 1,00E+05 | 1,13E+00 | 1,20E+00 | 1,26E+00 | 1,50E+00 | 1,73E+00 |
| 1,50E+05 | 1,70E+00 | 1,79E+00 | 1,88E+00 | 2,29E+00 | 2,70E+00 |

**Impedance characteristics of AN-V-C in accordance with ISO 21498 use case C:**



| Frequency [Hz] | ISO 21498 lower tolerance | AN-Series lower tolerance | ISO 21498 Nominal | AN-Series upper tolerance | ISO 21498 upper tolerance |
|---|---|---|---|---|---|
| 1,00E+01 | 1,83E-01 | 1,93E-01 | 2,03E-01 | 2,13E-01 | 2,23E-01 |
| 1,00E+02 | 1,83E-01 | 1,93E-01 | 2,03E-01 | 2,13E-01 | 2,23E-01 |
| 1,00E+03 | 1,83E-01 | 1,93E-01 | 2,03E-01 | 2,14E-01 | 2,24E-01 |
| 1,00E+04 | 2,15E-01 | 2,27E-01 | 2,38E-01 | 2,59E-01 | 2,80E-01 |
| 1,00E+05 | 1,14E+00 | 1,20E+00 | 1,26E+00 | 1,50E+00 | 1,73E+00 |
| 1,50E+05 | 1,70E+00 | 1,79E+00 | 1,88E+00 | 2,29E+00 | 2,70E+00 |

## 3.2    ELECTRICAL CHARACTERISTICS

| High Voltage Lines | | | | |
|---|---|---|---|---|
| **PARAMETER** | **MIN.** | **TYP.** | **MAX.** | **UNITS** |
| Voltage | | | 1000 | V |
| Voltage Ripple | | | 80 | V pk |
| Current Continuous | $I_{Total} = \sqrt{I_{DC}{}^2 + I_{AC}{}^2}$ <br> See table on page 6 | | | A RMS |
| Current Ripple | See table on page 6 | | | A RMS |
| Isolation Resistance | 100 | 200 | | M Ω |

| Passive High Voltage Components | | | | |
|---|---|---|---|---|
| **PARAMETER** | **MIN.** | **TYP.** | **MAX.** | **UNITS** |
| $C_X$ capacitance tolerance | -10 | | 10 | % |
| $C_X$ discharge time | | | 5 | min |
| $C_Y$ capacitance tolerance | -10 | | 10 | % |
| $C_Y$ discharge time | | | 1 | min |
| $R_{i,HV}$ resistance tolerance | Tuned to match tolerances on page 3 | | | |
| $L_V$ inductance tolerance | Tuned to match tolerances on page 3 | | | |

*\* AN in standalone, discharge time from 1000V to 60 V*

| System | | | | |
|---|---|---|---|---|
| **PARAMETER** | **MIN.** | **TYP.** | **MAX.** | **UNITS** |
| IEC inlet voltage | 90 | | 250 | V AC |
| IEC inlet consumption | | | 200 | W |
| Emergency-Stop output relay | Max.: 2 A at 250 V AC or Max. 3 A at 30 V DC | | | |

## 3.3    DC POWER SUPPLY REQUIREMENTS

The High voltage DC Power Supply is connected to the AN-Series via the lower busbars labeled "DC Power Supply".

Requirements of the DC Power Supply:
1) DC Power Supply Cx output capacitance connected between the high voltage lines shall not exceed 200 uF.
2) Current limit (CC) of the DC Power Supply shall be set to not more than the max continuous current of the AN-Series as written on page 6.

The following points are recommended for the DC Power Supply:
1) Shielded cables between the DC Power Supply and the AN with shielding connected on both ends.
2) Sense input of the DC Power Supply connected to the AN sense out.
3) Sense Response bandwidth of the DC Power Supply ≥ 1 kHz
4) DC Power Supply with Insulation monitoring.

## 3.4    ENVIRONMENTAL REQUIREMENTS

| Operating conditions for Physical form A | |
|---|---|
| **PARAMETER** | **Condition** |
| Operating temperature | 5°C to 35°C |
| Storage temperature | 5°C to 50°C |
| Operating humidity range | 10% RH to 70% RH, non-condensing |
| Storage humidity range | 10% RH to 70% RH, non-condensing |
| Operating environment | Indoor laboratory condition |
| Ingress protection code | IP20 |

| Operating elevation | Max. 1,500 m |
|---|---|
| Pollution degree | Max. pollution degree of 1 |

*Customer specific solutions possible upon request*

## 3.5    COOLING REQUIREMENT

Physical form A:
Ensure that all air inlets and outlet are not obstructed and filters cleaned regularly. The required clearance from air inlets and outlet for adequate cooling is 100 mm.

Physical form B:
In addition to liquid cooling, the AN-Series also cools its self through its overall surface area, the required clearance from all surfaces is 100 mm.

| Liquid cooling requirement for physical form B | |
|---|---|
| **PARAMETER** | **Condition** |
| Coolant temperature | 10°C to 25°C |
| Overpressure (gauge pressure) | Max 6 bar |
| Coolant Flowrate | See table on page 6 |
| Ethylene Glycol Solution | Max 40 % by volume |

## 3.6    CURRENT SENSOR SELECTION

| Current sensor selection | | |
|---|---|---|
| **CODE** | **SENSOR** | **DATA** |
| A | Shunt | Ri, HV |
| B | LEM LF1010-S | DC - 100kHz, ±0.4%, 1000A |
| C | LEM IN1000-S | DC - 440kHz, ±0.018%, 1000A |
| D | Hioki CT6876 | DC - 1.5MHz, ±0.04%, 1000A |
| Z | Customer specific current sensor | |

## 3.7    MECHANICAL DATA

Physical form A:



Dimensions (WxHxD):      700 mm x 250 mm x 850 mm
Weight:                          42 kg

Physical form B:
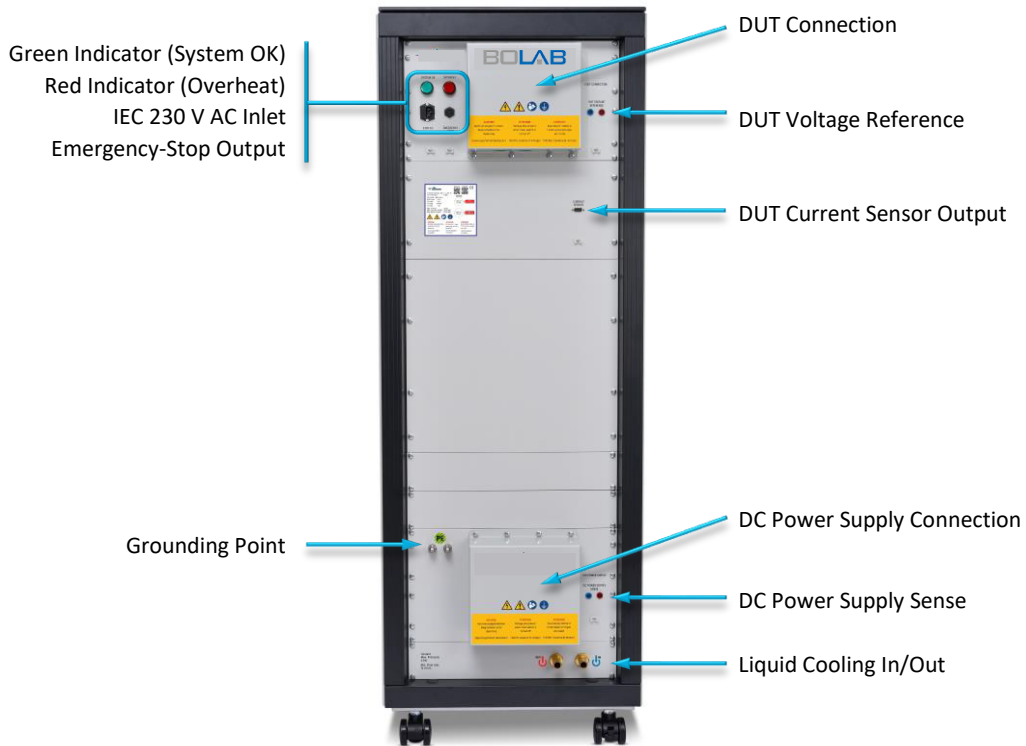


Dimensions (WxHxD):      600 mm x 1670 mm x 650 mm
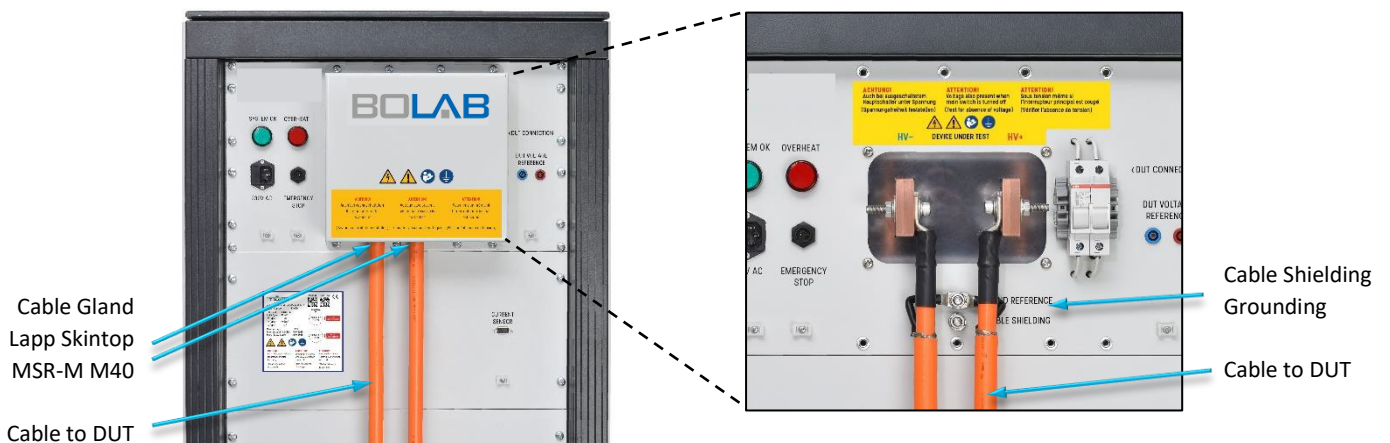Weight:                          140-190 kg

# 4    ARTIFICIAL NETWORK LAYOUT AND CONNECTIONS
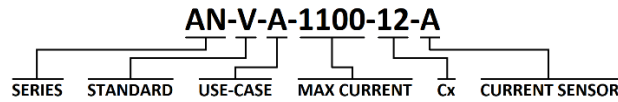
## 4.1    FRONT VIEW OF ARTIFICAIL NETWORK



## 4.2    DUT HV CABLE CONNECTIONS

This product is high voltage and high current system and should only be used and handled by qualified professionals in proper laboratory conditions. Before operations, please read the operating manual and understand fully how to operate the system and perform the electrical wiring connections.

# 5    MODEL NUMBERS AND ORDER CODES

### AN-V-A-1100-12-A

| | | | | | | |
|---|---|---|---|---|---|---|
| SERIES | STANDARD | USE-CASE | MAX CURRENT | Cx | CURRENT SENSOR |

| MODEL | USE CASE | RESISTANCE TYPE 2× Ri,HV [mΩ] | Lv TYPE [µH] | Cy TYPE [µF] | Cx [mF] | MAX CONTINUOUS CURRENT $I_{Total}$ [A RMS] | MAX RIPPEL CURRENT [A RMS] | FREQUENCY BANDWIDTH [kHz] | MAXIMUM VOLTAGE [V] | PHYSICAL FORM | MIN COOLENT FLOW [l/min] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AN-V-A-120-0-□ | ISO 21498 A | 2x 10 | 1 | 1 | 0 | 120 | 120 | 0 - 150 | 1000 | A | |
| AN-V-A-120-6-□ | | | | | 6 | 120 | 120 | | | | |
| AN-V-A-120-10,5-□ | | | | | 10,5 | 120 | 120 | | | | |
| AN-V-A-120-12-□ | | | | | 12 | 120 | 120 | | | | |
| AN-V-A-400-0-□ | | | | | 0 | 400 | 400 | | | B | 6 |
| AN-V-A-400-6-□ | | | | | 6 | 400 | 200 | | | | |
| AN-V-A-400-10,5-□ | | | | | 10,5 | 400 | 350 | | | | |
| AN-V-A-400-12-□ | | | | | 12 | 400 | 400 | | | | |
| AN-V-A-550-0-□ | | | | | 0 | 550 | 550 | | | | 10 |
| AN-V-A-550-6-□ | | | | | 6 | 550 | 200 | | | | |
| AN-V-A-550-10,5-□ | | | | | 10,5 | 550 | 350 | | | | |
| AN-V-A-550-12-□ | | | | | 12 | 550 | 400 | | | | |
| AN-V-A-700-0-□ | | | | | 0 | 700 | 700 | | | | 16 |
| AN-V-A-700-6-□ | | | | | 6 | 700 | 200 | | | | |
| AN-V-A-700-10,5-□ | | | | | 10,5 | 700 | 350 | | | | |
| AN-V-A-700-12-□ | | | | | 12 | 700 | 400 | | | | |
| AN-V-A-1100-0-□ | | | | | 0 | 1100 | 1100 | | | | 39 |
| AN-V-A-1100-6-□ | | | | | 6 | 1100 | 200 | | | | |
| AN-V-A-1100-10,5-□ | | | | | 10,5 | 1100 | 350 | | | | |
| AN-V-A-1100-12-□ | | | | | 12 | 1100 | 1100 | | | | |
| AN-V-B-120-0-□ | ISO 21498 B | 2x 25 | 1 | 1 | 0 | 120 | 120 | 0 - 150 | 1000 | A | |
| AN-V-B-120-6-□ | | | | | 6 | 120 | 120 | | | | |
| AN-V-B-120-10,5-□ | | | | | 10,5 | 120 | 120 | | | | |
| AN-V-B-120-12-□ | | | | | 12 | 120 | 120 | | | | |
| AN-V-B-300-0-□ | | | | | 0 | 300 | 300 | | | B | 8 |
| AN-V-B-300-6-□ | | | | | 6 | 300 | 200 | | | | |
| AN-V-B-300-10,5-□ | | | | | 10,5 | 300 | 300 | | | | |
| AN-V-B-300-12-□ | | | | | 12 | 300 | 300 | | | | |
| AN-V-B-450-0-□ | | | | | 0 | 450 | 450 | | | | 17 |
| AN-V-B-450-6-□ | | | | | 6 | 450 | 200 | | | | |
| AN-V-B-450-10,5-□ | | | | | 10,5 | 450 | 350 | | | | |
| AN-V-B-450-12-□ | | | | | 12 | 450 | 400 | | | | |
| AN-V-B-570-0-□ | | | | | 0 | 570 | 570 | | | | 26 |
| AN-V-B-570-6-□ | | | | | 6 | 570 | 200 | | | | |
| AN-V-B-570-10,5-□ | | | | | 10,5 | 570 | 350 | | | | |
| AN-V-B-570-12-□ | | | | | 12 | 570 | 400 | | | | |
| AN-V-B-850-0-□ | | | | | 0 | 850 | 850 | | | | 58 |
| AN-V-B-850-6-□ | | | | | 6 | 850 | 200 | | | | |
| AN-V-B-850-10,5-□ | | | | | 10,5 | 850 | 350 | | | | |
| AN-V-B-850-12-□ | | | | | 12 | 850 | 400 | | | | |
| AN-V-B-900-0-□ | | | | | 0 | 900 | 900 | | | | 65 |
| AN-V-B-900-6-□ | | | | | 6 | 900 | 200 | | | | |
| AN-V-B-900-10,5-□ | | | | | 10,5 | 900 | 350 | | | | |
| AN-V-B-900-12-□ | | | | | 12 | 900 | 400 | | | | |
| AN-V-C-120-0-□ | ISO 21498 C | 2x 100 | 1 | 1 | 0 | 120 | 120 | 0 - 150 | 1000 | A | |
| AN-V-C-120-6-□ | | | | | 6 | 120 | 120 | | | | |
| AN-V-C-120-10,5-□ | | | | | 10,5 | 120 | 120 | | | | |
| AN-V-C-120-12-□ | | | | | 12 | 120 | 120 | | | | |
| AN-V-C-200-0-□ | | | | | 0 | 200 | 200 | | | B | 13 |
| AN-V-C-200-6-□ | | | | | 6 | 200 | 200 | | | | |
| AN-V-C-200-10,5-□ | | | | | 10,5 | 200 | 200 | | | | |
| AN-V-C-200-12-□ | | | | | 12 | 200 | 200 | | | | |
| AN-V-C-350-0-□ | | | | | 0 | 350 | 350 | | | | 40 |
| AN-V-C-350-6-□ | | | | | 6 | 350 | 200 | | | | |
| AN-V-C-350-10,5-□ | | | | | 10,5 | 350 | 350 | | | | |
| AN-V-C-350-12-□ | | | | | 12 | 350 | 350 | | | | |
| AN-V-C-450-0-□ | | | | | 0 | 450 | 450 | | | | 65 |
| AN-V-C-450-6-□ | | | | | 6 | 450 | 200 | | | | |
| AN-V-C-450-10,5-□ | | | | | 10,5 | 450 | 350 | | | | |
| AN-V-C-450-12-□ | | | | | 12 | 450 | 400 | | | | |

| MODEL | USE CASE | RESISTANCE TYPE 2× Ri,HV [mΩ] | $L_V$ TYPE [µH] | $C_Y$ TYPE [µF] | Cx [mF] | MAX CONTINUOUS CURRENT $I_{Total}$ [A RMS] | MAX RIPPEL CURRENT [A RMS] | FREQUENCY BANDWIDTH [kHz] | MAXIMUM VOLTAGE [V] | PHYSICAL FORM | MIN COOLENT FLOW [l/min] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AN-V-C-120-0-□ | | | | | 0 | 120 | 120 | | | A | |
| AN-V-Z1-120-6-□ | | | | | 6 | 120 | 120 | | | | |
| AN-V-Z1-120-10,5-□ | | | | | 10,5 | 120 | 120 | | | | |
| AN-V-Z1-120-12-□ | | | | | 12 | 120 | 120 | | | | |
| AN-V-Z1-300-0-□ | | | | | 0 | 300 | 300 | | | | 15 |
| AN-V-Z1-300-6-□ | | | | | 6 | 300 | 200 | | | | |
| AN-V-Z1-300-10,5-□ | ISO 21498 Z1 | 2x 50 | 1 | 1 | 10,5 | 300 | 300 | 0 - 150 | 1000 | | |
| AN-V-Z1-300-12-□ | | | | | 12 | 300 | 300 | | | | |
| AN-V-Z1-450-0-□ | MBN 11123 | | | | 0 | 450 | 450 | | | | 33 |
| AN-V-Z1-450-6-□ | | | | | 6 | 450 | 200 | | | B | |
| AN-V-Z1-450-10,5-□ | | | | | 10,5 | 450 | 350 | | | | |
| AN-V-Z1-450-12-□ | | | | | 12 | 450 | 400 | | | | |
| AN-V-Z1-570-0-□ | | | | | 0 | 570 | 570 | | | | 52 |
| AN-V-Z1-570-6-□ | | | | | 6 | 570 | 200 | | | | |
| AN-V-Z1-570-10,5-□ | | | | | 10,5 | 570 | 350 | | | | |
| AN-V-Z1-570-12-□ | | | | | 12 | 570 | 400 | | | | |
| AN-V-Z1-670-0-□ | | | | | 0 | 670 | 670 | | | | 72 |
| AN-V-Z1-670-6-□ | | | | | 6 | 670 | 200 | | | | |
| AN-V-Z1-670-10,5-□ | | | | | 10,5 | 670 | 350 | | | | |
| AN-V-Z1-670-12-□ | | | | | 12 | 670 | 400 | | | | |

| | | |
|---|---|---|
| AN-AN-B-A-…-□ | LV 123 | Please contact us for inquiries to artificial network in accordance to LV 123 |
| AN-AN-C-Zx-…-□ | IEC 61851-23 | Please contact us for inquiries to artificial network in accordance to IEC 61851-23 A, B and C |
| AN-AN-x-Zx-…-□ | Customization | Please contact us for inquiries to your customer specific artificial network |

## 6    SUMMARY AND NOTES

**Research, Global Partners and Sales**
BOLAB Systems GmbH, with a strong commitment to develop quality and reliable products, collaborates with overseas industries, research centres, educational universities and institutions, to research, innovate, build and customise quality and environmentally products and systems.
This provides reliable connections to our partners globally and sales delivery and distribution.

All products and systems from BOLAB Systems GmbH meets European Union (EU)
safety, health and environment standards and requirements

In pursuit for sustainability, starting from the concept design to the final manufacture of our products, all raw materials, electrical & electronic parts, and mechanisms are carefully selected to ensure protection and preservation of nature and our precious environment.
Our products and systems are ecological friendly and fully recyclable, meeting 2011/65/EU, restriction of the use of Hazardous Substances (RoHS).
Our sustainable philosophy includes:
- Environmental considerations and energy efficacy
- Ecological trajectory and low carbon emissions
- Long-lasting and optimised total production cost

**European Union Directives and Standards**
The Artificial Network AN-Series, are compliant with the following European Union directives and standards:
- EN61010/ IEC61010, Safety
- EN61000-6-4, Emissions for Industrial Environment
- EN61000-6-2:2005, Immunity for Industrial Environment
- 2011/65/EU, Restriction of the use of Hazardous Substances (RoHS)

This product is subject to the following operating requirements and the Life and Safety Critical Application Sales Policy

Notes:
_____
_____
_____
_____
_____
_____

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**BOLAB**
S Y S T E M S   G M B H