Application
The NTGB digital protection relay integrates a number of functions required for the protection of generators. It is used in power stations from gas, steam, hydraulic turbine, or diesel driven generators, operating in parallel with the public network and/or in island and with any neutral state and network layout.

Protection elements
- Three phase current and one residual current inputs with nominal currents independently selectable at 1 A or 5 A using jumpers
- Three voltage inputs software programmable within 50...130 V or 200...520 V ranges and one residual voltage software programmable within 50...130 V range
- Software selectable nominal frequency at 50 or 60 Hz.

Construction
Standard rack 19" 3U high case.
Plug-in terminals.

Measuring inputs
- Currents and voltages are sampled 16 times per period and measured in the effective value (RMS) of the fundamental component using the DFT (Discrete Fourier Transform) algorithm and digital filters.

Metering
The relay measures all the generators electrical quantities (currents, voltages, frequency, impedance, power, energies, flux, etc.) and the relay input/output logic states, making them available for reading on a display or to communication interfaces. Currents and voltages are sampled 16 times per period and measured in the effective value (RMS) of the fundamental component using the DFT (Discrete Fourier Transform) algorithm and digital filters.

Firmware updating
The use of flash memory units allows on-site firmware updating.
**Binary inputs**
Eight binary inputs are available which may be used for preset functions.

**Output relays and LEDs**
There are eight change-over contacts output relays and 16 indicator LEDs. Each output relay may be individually programmed in relation to resting state (normally energized- de-energized) and reset mode (manual or automatic). Each LED is programmable in relation to reset mode (manual or automatic). The user may program the function of each output relay and LED in accordance with a matrix (tripping matrix) structure.

**MMI (Man Machine Interface)**
The user interface comprises a membrane keyboard, a backlight LCD alphanumeric display and 16 LEDs. Regarding the LEDs, one are set aside to indicate auxiliary and self diagnostics power supply (green ON LED), whilst the remaining red LEDs are user assigned.

**Frequency tracking**
Within the generator frequency range 20...70 Hz, a frequency tracking algorithm alters the currents and voltages sampling frequency, so as to keep the number of samples in any given period constant. The precision and availability of all relay functions are hence even guaranteed during generator start-up and shut-down.

**Control and monitoring**
Several predefined functions are implemented:
- Activation of two set point profiles
- Logic selectivity
- Sequential logic
- Trip circuit supervision (74TCS)
- Circuit Breaker diagnostic

**Multiple setpoint profiles**
The relay protection functions have two setting parameters configurations (BANK A or BANK B). Activation of the two data sets is controlled binary input or communications interfaces.

**Circuit Breaker monitoring and diagnostics**
The relay comprises the following functions for monitoring and controlling circuit breaker:
- Status monitoring (open, closed, anomalous)
- Monitoring the trip circuit (74TCS) for any indication of trip circuit anomalies prior to the tripping of the protective devices
- Diagnostics: the relay provides a series of cumulative data (number of operations, cumulative value of the currents broken by each pole, cumulative I^2t broken by each pole, duration of operations), to assist the user in the task of circuit breaker managing maintenance programmes.

**Logic selectivity**
With the aim of providing a selective protection system, some of the relay protective functions may be blocked by logic selectivity binary input (pilot wire accelerated logic).

**Sequential trip logic**
To avoid any over-speeding of the turbine-generator unit during shut-down of the unit or due to the delayed tripping of the protective devices, a binary input may be configured in order to open the machine circuit breaker as a result of tripping of the Low forward power (37P) or Reverse power (32R) functions, only after closure of the turbine intake valve.

**Self diagnostics**
Anomalies may refer to:
- Hw faults (auxiliary power supply, output relay coil interruptions, MMI board,...)
- Sw faults (boot and run time tests for data base, EEPROM memory checksum failure, data BUS,...)
- Activation of trip circuit monitoring function
- Activation of CT and VT monitoring functions
- Circuit breaker faults.

**Communication**
Three communication interfaces are implemented:
- A RS232 local communication front-end interface, used for protection management, viewing and changing the relay programming, obtaining readings of the logic states, the chronological events, measuring, and for relay testing and resetting commands. The local interface is fitted as standard in all relay versions; a dedicated PC Software is provided.
- A RS485 port with Modbus RTU protocol for field bus communication.
- An optional back-end interface for communication with remote monitoring and control systems by 10/100 Ethernet using the Modbus TCP/IP protocol and copper (RJ45) or fiber-optic (FX) connections.

**Event storage**
Several useful data are stored for diagnostic purpose.
- The event recorder runs continuously capturing in circular mode the last twenty events upon trigger of binary input/output and/or element pickup (start-trip). They are graded from the newest to the older after the “Events reading” command (ThySetter) is issued
- Trip counters

**Digital Fault Recorder (Oscillography)**
Upon trigger of tripping/starting of each function or external signals, the relay records in COMTRADE format:
- Oscillography with instantaneous values for transient analysis
- RMS values of the measured signals for long time periods analysis
- Logic states (binary inputs and output relays).
Programming and settings

All relay programming and adjustment operations may be performed through MMI (Keyboard and display) or using a Personal Computer with the aid of the ThySetter software. The same PC setup software is required to set, monitor and configure all Pro_N devices.

Full access to the available data is provided:
- Read status and measures
- Read/edit settings (on-line or off-line edit)

Two session level (User or Administrator) with password for sensible data access are provided.

## SPECIFICATIONS

### GENERAL

- **Mechanical data**
  - Mounting: rack 19”, 3U high, 300 mm depth
  - Mass: 7.0 kg

- **Insulation tests**
  - Reference standards: EN 60255-5
  - High voltage test: 50 Hz, 2 kV, 60 s
  - Impulse voltage withstand: (1.2/50 μs) 5 kV
  - Insulation resistance: >100 MΩ

- **Voltage dip and interruption**
  - Reference standards: EN 61000-4-29

- **EMC tests for interference immunity**
  - 1 MHz damped oscillatory wave: EN 60255-22-1
  - 1 kV, 2.5 kV
  - Electrostatic discharge: EN 60255-22-2
  - 8 kV
  - Fast transient burst (5/50 ns): EN 60255-22-4
  - 4 kV
  - Conducted radio-frequency fields: EN 60255-22-6
  - 10 V
  - Radiated radio-frequency fields: EN 60255-4-3
  - 10 V/m
  - High energy pulse: EN 61000-4-5
  - 2 kV
  - Magnetic field 50 Hz: EN 61000-4-8
  - 1 kA/m
  - Damped oscillatory wave: EN 61000-4-12
  - 2.5 kV
  - Ring wave: EN 61000-4-12
  - 2 kV
  - Conducted common mode (0...150 kHz): EN 61000-4-16
  - 10 V

- **Emission**
  - Reference standards: EN 61000-6-4 (ex EN 50081-2)
  - Conducted emission: 0.15...30 MHz: Class A
  - Radiated emission: 30...1000 MHz: Class A

- **Climatic tests**
  - Reference standards: IEC 60068-x, ENEL R CLI 01, CEI 50

- **Mechanical tests**
  - Reference standards: EN 60255-21-1, 21-2, 21-3

### Safety requirements

- **Reference standards**: EN 61010-1
- **Pollution degree**: 3
- **Reference voltage**: 250 V
- **Overvoltage**: III
- **Pulse voltage**: 5 kV
- **Reference standards**: EN 60529
- **Protection degree**:
  - Front side: IP31
  - Rear side, connection terminals: IP20

### Environmental conditions

- **Ambient temperature**: -25...+55 °C
- **Storage temperature**: -40...+85 °C
- **Relative humidity**: 10...95%
- **Atmospheric pressure**: 70...110 kPa

### Certifications

- **Product standard for measuring relays**: EN 50263
- **CE conformity**: 89/336/EEC
- **EMC Directive**: 73/23/EEC
- **Type tests**: IEC 60255-66

### INPUT CIRCUITS

- **Auxiliary power supply $U_{aux}$**
  - Nominal value (range): 24 Vac/dc 48...110 Vac/dc 230 Vac [1]
  - Operative range: 24 Vac/dc ±15%
  - (each one of the above nominal values): 38...150 Vdc, 38...110 Vca 165...275 Vca [1]
  - Max power consumption: 25 VA

**Note 1** By means DAC200 adapter

- **Phase current input circuits**
  - Nominal current: $I_n$ 1 A or 5 A selectable by jumpers
  - Permanent overload: 20 A
  - Thermal overload (1 s): 500 A
  - Rated consumption (for any phase): ≤ 0.1 VA with $I_n$ = 1 A
  - ≤ 0.3 VA with $I_n$ = 5 A
Residual current input circuit
Nominal current $I_{fn}$ 1 A or 5 A selectable by jumpers
Permanent overload 20 A
Thermal overload (1 s) 500 A
Rated consumption $\leq 0.1$ VA with $I_{fn} = 1$ A
$\leq 0.3$ VA with $I_{fn} = 5$ A

Phase voltage input circuits
Reference voltage $U_R$ 100 V or 400 V
Nominal voltage $U_n$ 50...130 V or 200...520 V selectable by sw
Overload (1 s) 2 $U_R$
Rated consumption $\leq 0.5$ VA

Residual voltage input circuit
Reference voltage $U_{ER}$ 100 V
Nominal voltage $U_{En}$ 50...130 V or 200...520 V selectable by sw
Overload (1 s) 2 $U_{ER}$
Rated consumption $\leq 0.5$ VA

Binary input circuits
Quantity 8
Max permissible voltage $U_{aux}$
Max consumption, energized 3 mA

Output relays
Quantity 8
Type of contacts change-over (SPDT, type C)
Nominal current 8 A
Nominal voltage/max switching voltage 250 Vac/400 Vac
Breaking capacity:
- Direct current 30 W ($U/R = 40$ ms)
- Alternating current 40 W ($U = 0.4$)
Make 1000 W/VA
Short duration current 15 A (0.5 s)

COMMUNICATION INTERFACES
Local PC RS232 ModBus® RTU
Network:
- RS485 ModBus® RTU
- Ethernet 100BaseT 100 Mbps - ModBus®-TCP/IP

GENERAL SETTINGS
Rated values
- Relay nominal frequency $f_n$ 50, 60 Hz
- Relay phase nominal current $I_{fn}$ 1 A, 5 A
- Primary phase CTs nominal current $I_{fnp}$ 1 A...10 kA
- Relay residual nominal current $I_{f}^n$ 1 A...5 A
- Primary residual CT nominal current $I_{Efp}$ 1 A...10 kA
- Generator nominal current $I_{fn}$ 1 A...10 kA
- Relay phase to phase nominal voltage $U_n$ 50...130 V ($U_n = 100V$)
- 200...520 V ($U_n = 400V$)
- Relay phase nominal voltage $E_n$ $E_n = U_n/\sqrt{3}$
- Primary phase to phase VTs nominal voltage $U_{Ep}$ 50 V...500 kV
- Residual primary nominal voltage $U_{En}$ 50...130 V
- Residual primary nominal voltage (phase to phase) $\sqrt{3}$ $U_{Ep}$
- $50 V...500 kV$
- Generator nominal voltage $U_{Eng}$ 50 V...500 kV

Correlated values
- Relay active nominal power $P_n = 3 \cdot U_n \cdot I_n = 3 \cdot E_n \cdot I_n$
- Relay reactive nominal power $Q_n = \sqrt{3} \cdot U_n \cdot I_n = 3 \cdot E_n \cdot I_n$
- Relay apparent nominal power $S_n = \sqrt{3} \cdot U_n \cdot I_n = 3 \cdot E_n \cdot I_n$
- Relay nominal impedance (21 element) $Z_{nf} = U_{nf}/I_{nf}$
- Relay phase nominal impedance (40 element) $Z_{nf} = U_{nf}/I_{nf}$

Binary input timers
- ON delay time $t_{ON1}, t_{ON2}$ 0.00...100.0 s
- OFF delay time $t_{OFF1}, t_{OFF2}$ 0.00...100.0 s

Relay output timers
- Minimum pulse width $t_{TR}$ 0.00...500.0 s

Circuit Breaker supervision
- CB operations 0...10000
- Contact interrupting duty $\Sigma I$ 0...5000 $I_n$
- CB Trip delay ($\Sigma I$ PT computation) 0.05...1.00 s
- Contact interrupting duty $\Sigma I$ PT 0.5000 ($I_n$ PT)
- Break time $t_{break}$ 0.050...1.000 s

FUNCTIONS
Base current $I_b$ 0.40...1.50 $I_n$

Undervoltage (21)
Pickups $Z_1 < Z_2 < (definite time)$
Time delays $t_{Z1}, t_{Z2} < (definite time)$
0.07...100.0 s

Voltage restraint overcurrent - 51V
Characteristic Voltage controlled/Voltage restraint
Reduction factor $K$ 0.10...100
Voltage controlled settings:
- Pickup $U_{SICV}$ 0.10...1.00 $U_n$
- Voltage restraint settings:
  - Pickup $U_{S1CV}$ 0.10...1.00 $U_n$
  - Pickup $I_{S1CV}$ 0.20...10.00 $I_n$
  - Time delay $d_{S1CV}$ (definite time)
    0.07...100.0 s
  - Pickup $I_{S2CV}$ 0.20...20.00 $I_n$
  - Time delay $d_{S2CV}$ (definite time)
    0.07...100.0 s

Undervoltage - 27
Common settings:
- Voltages phase to earth or phase to phase $[1]$
- Logic AND or OR
- $\Delta \theta$
- $U_{aux}$
- $U_{ER}$
- $R=400 V)$
- $R=100 V)$
- $\Sigma$
- $\Sigma$

Active power setter - 32R
Pickups $P_{>}, P_{>>}$ -0.01...+1.00 $P_n$
Time delays $t_{>, t_{>>}}$ (definite time)
0.07...100.0 s

Loss of field - 40
Peak current $I_{P}$ 0.03...0.50 $I_n$
Time delay $t_{P}$ 0.10...100.0 s
Loss of field $I_{P} >$ (definite time)
0.05...0.50 $I_n$

Negative sequence overcurrent - 46
Pickup $I_{SAL}$ 0.03...0.50 $I_n$
Time delay $t_{SAL}$ (definite time)
0.10...100.0 s
Pickup $I_{S2AL}$ (definite time)
0.05...0.50 $I_n$
Heating time constant $K_{heat}$ 0.1...400 s
Cooling time constant $K_{cool}$ 0.1...400 s
Minimum operating time $T_{MIN}$ 0.07...100.0 s
Maximum operating time $T_{MAX}$ 500...2000 s

Thermal image - 49
Thermal time constant $\tau$ 1...200 min
Cooling time constant $\tau$ 1...10 $\tau$
Alarm pickup $\Delta I_{AL}$ 0.3...1.1 $\Delta I_{AL}$
Pickup $\Delta I_{AL}$ 1.2 $\Delta I_{AL}$
Thermal preset $\Delta I_{AN}$ 0...1.0 $\Delta I_{AN}$
Thermal coefficient for negative sequence current $K_\tau 0...10$
Phase overcurrent - 50/51
Pickup f> 0.100...5.00 f₀
Time delay t> (definite time) 0.05...200.0 s
Time delay t> (indefinite time) 0.10...60.0 s
Pickups f>>, f>>> 0.100...20.0
Time delays t>>, t>>> (definite time) 0.04...10.00 s

Residual overcurrent - 50G/51G/Restricted earth fault - 87N
Pickup f> 0.010...2.00 f₀
Time delay t> (definite time) 0.05...200.0 s
Time delay t> (indefinite time) 0.06...60.0 s
Pickups f>>, f>>> 0.010...10.00 f₀
Time delays t>>, t>>> (definite time) 0.05...10.00 s

Overvoltage - 59
Common settings:
• Voltages phase to earth or phase to phase
• Logic AND or OR
Pickups U_e, U>> 0.50...15.00 U₀
Time delays t_u, t_u>> (definite time) 0.07...100.0 s
Time delay t_u (inverse time) 0.10...100.0 s

Residual overvoltage - 59N
Pickups U_e, U>> 0.01...0.50 U₀
Time delays t_u, t_u>> (definite time) 0.07...100.0 s
Time delay t_u (inverse time) 0.10...100.0 s

Overfrequency - 810
Pickups f, f>> 1.00...1.200 f₀
Time delays t_f, t_f>> (definite time) 0.07...100.0 s

Underfrequency - 81U
Pickups f<<, f<<<<, f<<<< 0.800...1.000 f₀
Time delays t_f, t_f<<, t_f<<<< (definite time) 0.07...100.0 s

METERING

Frequency
Power frequency 16.000...90.000 Hz

Currents
Phase currents i₁, i₂, i₃ 0.000...30.000 A
Measure residual current i₄ 0.000...15.000 A
Calculated residual current i_ECAL 0.000...15.000 A
Direct sequence current i₁ 0.000...30.000 A
Inverse sequence current i₂ 0.000...10.000 A
Thermal image D_theta 0.00...1.20 °Δθ

Voltages
Phase voltages U₁, U₂, U₃ 0.000...2.000 U₀
Phase to phase voltages U₁₂, U₂₃, U₃₁ 0.000...2.000 U₀
Residual voltage U₄ 0.000...2.000 U₀
Inverse sequence U₄ 0.000...2.000 U₀
3rd harmonic residual voltage U₄-3H 0.000...2.000 U₀
Flux U_MAX/θ

Impedance
Impedance Z₁₂, Z₂₃, Z₃₁ (21 element) 0.000...10.000 Z₀
Impedance Z₄₀ (40 element) 0.000...10.000 Z₀
Resistive component R₄₀ (40 element) -10.000...+10.000 Z₀
Reactive component X₄₀ (40 element) -10.000...+10.000 Z₀
Power factor cosφ Z₄₀ (40 element) -1.000...+1.000

Power
Phase active power P₁, P₂, P₃ -3.000...+3.000 P₀
Total active power P -3.000...+3.000 P₀
Phase reactive power Q₁, Q₂, Q₃ -3.000...+3.000 Q₀
Total reactive power Q -3.000...+3.000 Q₀
Phase apparent power S₁, S₂, S₃ 0.000...3.000 S₀
Total apparent power S 0.000...3.000 S₀
Phase power factor cosφ₁, cosφ₂, cosφ₃ -1.000...+1.000

Digital Fault Recorder (Oscillography)
File format COMTRADE
Records depending on setting
Recording mode linear
Sampling rate 16 samples per period
Trigger setup:
• Source

Events
Number of events 8
Recording mode circular
Trigger: Binary inputs

Data recorded:
• Frequency
• RMS currents i₁, i₂, i₃
• RMS voltages U₁, U₂, U₃
• RMS sequence components l₁, l₂, l₃
• Computed values U_MAX/f, I_ECAL, D_theta, U-3rd
• Active power P₁, P₂, P₃
• Reactive power Q, Q₁, Q₂, Q₃
• Apparent power S₁, S₂, S₃
• Impedance Z₁₂, Z₂₃, Z₃₁, R₄₀, X₄₀, Cosφ₄₀
• Power factor Cosφ₁, Cosφ₂, Cosφ₃

Data recorded on digital channels:
• Output relays K₁...K₈
• Binary inputs IN₁...IN₈

• Communication (ThySetter)
• Binary inputs
• Post-trigger time 0.05...60.00 s
• Pre-trigger time 0.05...1.00 s

Note 1: With phase to phase setting pickups are in p.u. Un
With phase to earth setting pickups are in p.u. En
Connection diagram example

Schematic diagram example (earthing resistor connected from generator star point or earthing TV secondary)