Calibration Certificate

Client Name	Unipulse Corporation
Client Address	1-3, Sengendainishi, Koshigaya, Saitama, 343-0041 JAPAN
Calibration Laboratory	JCSS Calibration Laboratory, Unipulse Corporation
Calibration Site	1-3, Sengendainishi, Koshigaya, Saitama, 343-0041 JAPAN
Calibration Items	Torque Measuring Device
(1) Torque Transducer	
Manufacture	Unipulse Corporation
Type and Capacity	UTS-100Nm 100 N m
Serial Number	XXXXXXX
(2) Indicator	
Manufacture	Unipulse Corporation
Type and Capacity	FS2000-X7
Serial Number	XXXXXXX
Calibration Method	JMIF015 (TTSG-T102)
Calibration Conditions	As in Page 2
Calibration Results	As in Page 3 to 5
Date of Application	XX/XX/20XX
Date of Calibration	XX/XX/20XX

The calibration results we certified are on the following pages.

Date of Issue XX/XX/20XX

The Issuing Authority
Atsushi Shimamoto

The Head of JCSS Calibration Laboratory
Unipulse Corporation

- This certificate is based on Article 144 of the Measurement Act and indicates the result of calibration in accordance with measurement standards traceable to Primary Measurement Standards (National Standards) which realized the physical units of measurement according to the International System of
- The accreditation symbol is an attestation of which the result of calibration is traceable to Primary Measurement Standards (National Standards).
- The certificate shall not be reproduced except in full without the written approval of the issuing laboratory.
- The calibration laboratory who issued this calibration certificate conforms to ISO/IEC 17025:2017.
- This calibration certificate was issued by the calibration laboratory accredited by IAJapan who is a signatory to the Mutual Recognition Arrangement (MRA) of International Laboratory Accreditation Cooperation (ILAC) and Asia Pacific Accreditation Cooperation (APAC).
- This (These) calibration result(s) can be accepted internationally through ILAC/ALAC MRA.

Calibration Conditions

1) The calibration was made with Torque Calibration Machine (TCM) as below.
2) Preload was applied three times on each rotational mounting position of the torque transducer. However, preloading was conducted one time in the next position when it took shorter than 20 minutes for changing the position.
3) Torque loadings were made in three mounting positions of 0°, 120°, and 240° in both clockwise and counterclockwise torque.
4) The time interval between two successive loading cycles was two minutes.
5) The reading corresponding to each torque step was noted after waiting 30 seconds after the torque was applied or removed.
6) One cycle of incremental and decremental torque and one cycle of only incremental torque were made in the mounting position of 0°. One cycle of incremental and decremental torque was made in mounting position of 120° and 240°.
7) The resolution of the indicator itself was 1 000 000 digits for the output of 1.0 mV/V as the rated output of the torque transducer.
8) The Cut-off Frequency of the low-pass filter of the indicator was 2 Hz.
9) The torque transducer was excited with the voltage of DC 10 V.
10) A six-conductor cable of 5 m length was used for connecting the torque transducer and the indicator.
11) The torque transducer and the indicator were energized at least one hour before the calibration, and continuously kept energized throughout the calibration.
12) The ambient conditions of the calibration room were as follows:

Temperature:	22.3 °C	～	23.1 °C
Atmospheric pressure:	1007.3 hPa	～	1008.5 hPa
Relative Humidity:	50.5 %	～	65.0 %

13) The acceleration of gravity at the calibration site was calculated according to the method described in JCG23001 and JCG23002 published by IAJapan was as follows:
Acceleration of gravity: 9.798483 m/s^2

14) Readings at null applied torque:
Before mounting on the TCM: -0.069361 mV/V
After dismounting from the TCM: -0.069415 mV/V

Reference Standard used

Reference Standard

Name:	Torque Calibration Machine
Type and Capacity:	UTC-100Nm 100 N m
Serial Number:	D030000
Torque Directions:	Both clockwise and counterclockwise

Expanded Relative Uncertainty of Torque Calibration Machine

Torque Range	Expanded Relative Uncertainty, U_{tcm} (k = 2)
10 N m～100 N m	0.0095%

The expanded relative uncertainty shown above corresponds to a confidence interval of approximately 95%, and is calculated by multiplying the relative composite uncertainly and the coverage factor, k = 2.

■ Calibration Results

Calibration results (values given by the interpolative formulae) and uncertainties of calibration

	Torque, T /N m	Value, S' /(mV/V)	Expanded Relative Uncertainty U (k = 2)[1)] including decremental torque, %
CCW (Cubic)	-----	-----	-----
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	-100	-1.179204	0.014
	-80	-0.943303	0.014
	-60	-0.707438	0.014
	-50	-0.589516	0.016
	-40	-0.471602	0.018
	-30	-0.353694	0.020
	-20	-0.235791	0.020
	-10	-0.117894	0.021
	0	-----	-----
CW (Cubic)	0	-----	-----
	10	0.117895	0.020
	20	0.235791	0.020
	30	0.353691	0.019
	40	0.471596	0.017
	50	0.589506	0.016
	60	0.707423	0.014
	80	0.943279	0.014
	100	1.179168	0.014
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1) $U^2 = U^2_{tra} + U^2_{tcm}$

Torque ranges and the corresponding Maximum Expanded Relative Uncertainties and Classes.

	Torque Range, N m				Maximum Expanded Relative Uncertainty U_{tcm} (k = 2)	Class (informative)
CCW:	-100	N m ～	-10	N m	0.021	0.05
CW:	10	N m ～	100	N m	0.020	0.05

- The expanded relative uncertainties shown above correspond to a confidence interval of approximately 95% and are calculated by multiplying the relative composite uncertainly and the coverage factor, k = 2.
- The interpolative formulae described on page 4 calculated from the measured data can be applied for any values in the ranges from - 100 N m to -10 N m, and from +10 N m to + 100 N m.
- The equivalent values of the indicator calibration data were calculated from the interpolation of the incremental data.
- The expanded relative uncertainty includes the uncertainty of the generating torque of Torque Calibration Machine, the uncertainty due to the mounting positions, repeatability at the same mounting position, the difference between the measured value and the interpolation, the zero-deflection between the start and the end, the hysteresis, and the fluctuations of the indication at the respective load steps.
- The class judgment was made according to JMIF015 (TTSG-103), including the zero error and the hysteresis calculated using the decremental data.

■ Interpolative formulae

To calculate the measurement value, S', in mV/V from a given applied torque, T, in N m

$$S' = A_0 + A_1 \cdot T + A_2 \cdot T^2 + A_3 \cdot T^3$$

CCW		A_0	A_1	A_2	A_3
Cubic	Inc.	-8.0183239E-07	1.1789113E-02	-1.8688055E-08	1.0507102E-10
	Dec.	-----	-----	-----	-----

CW		A_0	A_1	A_2	A_3
Cubic	Inc.	3.1058719E-06	1.1789017E-02	1.5612347E-08	1.0702864E-10
	Dec.	-----	-----	-----	-----

To calculate the torque, T, in N m from a given measured value, S', in mV/V

$$T = B_0 + B_1 \cdot S' + B_2 \cdot S'^2 + B_3 \cdot S'^3$$

CCW		B_0	B_1	B_2	B_3
Cubic	Inc.	6.8414696E-05	8.4824027E+01	1.1418883E-02	-5.4223353E-03
	Dec.	-----	-----	-----	-----

CW		B_0	B_1	B_2	B_3
Cubic	Inc.	-2.6384503E-04	8.4824718E+01	-9.5411611E-03	-5.5258932E-03
	Dec.	-----	-----	-----	-----

■ Characteristics (informative)

	Torque, *T* /N m	*b* /%	*b'* /%	f_a(3rd) /%	f_0 /%	*h* /%	*bl* /%	*r* /N m	u_{c_tra} /%	Class
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CCW	-100.0	0.0015	0.0005	0.0000	-----	0.0000	-----	0.00030	0.002	0.05
	-80.0	0.0015	0.0001	0.0001	-----	0.0047	-----	0.00030	0.003	0.05
	-60.0	0.0016	0.0001	-0.0001	-----	0.0086	-----	0.00030	0.005	0.05
	-50.0	0.0015	0.0003	0.0001	-----	0.0112	-----	0.00030	0.007	0.05
	-40.0	0.0014	0.0006	-0.0003	-----	0.0127	-----	0.00030	0.008	0.05
	-30.0	0.0019	0.0003	0.0004	-----	0.0153	-----	0.00030	0.009	0.05
	-20.0	0.0019	0.0004	0.0000	-----	0.0150	-----	0.00030	0.009	0.05
	-10.0	0.0013	0.0017	-0.0002	-----	0.0153	-----	0.00030	0.009	0.05
	0.0	-----	-----	-----	0.0003	-----	-----	-----	-----	-----
	0.0	-----	-----	-----	0.0005	-----	-----	-----	-----	-----
	10.0	0.0005	0.0017	-0.0002	-----	0.0144	-----	0.00025	0.009	0.05
	20.0	0.0017	0.0013	0.0002	-----	0.0146	-----	0.00025	0.009	0.05
	30.0	0.0009	0.0017	-0.0001	-----	0.0140	-----	0.00025	0.008	0.05
	40.0	0.0008	0.0011	0.0001	-----	0.0122	-----	0.00025	0.007	0.05
	50.0	0.0009	0.0010	-0.0001	-----	0.0107	-----	0.00025	0.006	0.05
	60.0	0.0011	0.0017	-0.0001	-----	0.0086	-----	0.00025	0.005	0.05
	80.0	0.0012	0.0014	0.0001	-----	0.0044	-----	0.00025	0.003	0.05
CW	100.0	0.0011	0.0012	0.0000	-----	0.0000	-----	0.00025	0.001	0.05
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1) *b* shows reproducibility with changed mounting position.
2) *b'* shows reproducibility with unchanged mounting position.
3) f_a shows interpolation error.
4) f_0 shows zero error.
5) *h* shows hysteresis (reversibility error).
6) *r* shows resolution of the torque measuring device.
7) *bl* shows reproducibility with changed length of the lever.
8) The calibration results were classified based on the criteria which is consistent with the those in the JMIF015 (TTSG-T103). Classification involves the hysteresis and zero error.
9) u_{c_tra} shows a relative uncertainty caused by the torque measuring device itself, for the case of using cubic interpolative formulae.

End of the certificate