AN Creation of ISO 16750-2 waveforms with Siglent AWG and Tekbox TBDCA1

1 Introduction

ISO 16750-2 and ISO 7637-2 specify supply waveforms for stress testing of automotive electronics. Certain waveforms require rise times that are challenging to produce using arbitrary programmable power supplies.

This application note describes how to create a cranking waveform with a setup that consists of a SDG6000X Siglent arbitrary waveform generator and a Tekbox TBDCA1 DC-coupled amplifier.
The TBDCA1 has a 3dB power bandwidth of 3 MHz and an output power of 150 W continuous and 300 W peak. With an output voltage range of ± 28 V and an output current capability of 10 A_{RMS} it can supply a wide range of loads.
A Phyton script is used to create the required waveform CSV file for the AWG.

2 Cranking waveforms

ISO 16750-2 specifies following starting profiles:

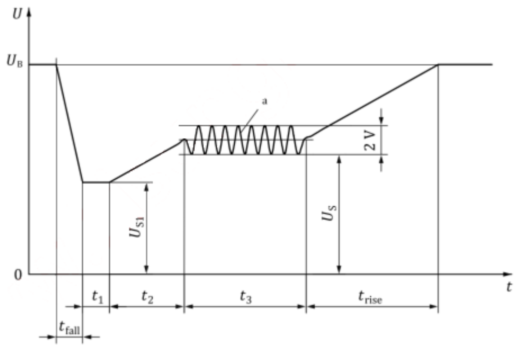

Figure 1: Starting profile waveform; from ISO 16750-2:2023

t	time [s]	U	test voltage
t_{fall}	falling slope	U_B	supply voltage for alternator not in operation
t_{rise}	rising slope	U_S	supply voltage
t_1, t_2, t_3	duration parameters, see table 1, 2	U_{S1}	supply voltage at t_1
a	f = 2 Hz		

Parameter		**Level**			
		I Warm crank	**II** cold crank with good battery at cold temperature	**III** cold crank with aged battery at cold temperature	**II** cold crank with good battery at cold temperature
Voltage [V]	U_{S1}	8 (+0 / -0.2)	4.5 (+0 / -0.2)	3 (+0 / -0.2)	6 (+0 / -0.2)
	U_S	9.5 (+0 / -0.2)	6.5 (+0 / -0.2)	5 (+0 / -0.2)	6.5 (+0 / -0.2)
Duration [ms]	t_{fall}	5 (± 0.5)	5 (± 0.5)	5 (± 0.5)	5 (± 0.5)
	t_1	15 (± 1.5)	15 (± 1.5)	15 (± 1.5)	15 (± 1.5)
	t_2	50 (± 5)	50 (± 5)	50 (± 5)	50 (± 5)
	t_3	1000 (± 100)	1000 (± 100)	1000 (± 100)	1000 (± 100)
	t_{rise}	40 (± 4)	40 (± 4)	40 (± 4)	40 (± 4)

Table 1: Starting profile values for systems with 12 V nominal voltage (U_N)

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Parameter		Level		
		I	II	III
Voltage [V]	U_{S1}	10 (+0 / -0.2)	8 (+0 / -0.2)	6 (+0 / -0.2)
	U_S	20 (+0 / -0.2)	15 (+0 / -0.2)	10 (+0 / -0.2)
Duration [ms]	t_{fall}	10 (± 1)	10 (± 1)	10 (± 1)
	t_1	50 (± 5)	50 (± 5)	50 (± 5)
	t_2	50 (± 5)	50 (± 5)	50 (± 5)
	t_3	1000 (± 100)	1000 (± 100)	1000 (± 100)
	t_{rise}	40 (± 4)	40 (± 4)	40 (± 4)

Table 2: Starting profile values for systems with 24 V nominal voltage (U_N)

3 Creating a waveform file for the Siglent AWG

A convenient method to load a waveform file into an arbitrary waveform generator is using a CSV-file containing waveform samples. The CSV-file can be imported into the EasyWaveX software of Siglent and exported in a format suitable for the AWG. A suitable CSV-file can be easily generated with a Python script:

```
import numpy as np

# 1. Global Configuration
SAMPLE_RATE = 10000  # 10 kHz Sampling rate for good resolution
FILENAME = "ISO16750-2_cranking_waveform.csv"

# 2. Definition of voltages (V/10) and waveform segments (duration in seconds)
U_B = 1.2   # supply voltage for alternator not in operation
U_S1 = 0.45   # supply voltage at t1
U_S = 0.75   # mean supply voltage at t3
U_sine = 0.1   # amplitude of sinusodial signal
t_start = 0.050   # 50 ms Holding at voltage U_B
t_fall = 0.005   # 5 ms Ramp-down to voltage U_S1
t1 = 0.015   # 15 ms Holding at voltage U_S1
t2 = 0.050   # 50 ms Ramp-up to 0.65V
t3 = 10.000  # 10 s Sinus (2 Hz, Amp 0.2V, Offset 0.65V, 180° Phase)
t_rise = 0.100   # 100 ms Ramp-up to voltage U_B
t_stop = 10.000  # 10 s Holding at voltage U_B

# Calculates the number of samples per segment
n1 = int(t_start * SAMPLE_RATE)
n2 = int(t_fall * SAMPLE_RATE)
n3 = int(t1 * SAMPLE_RATE)
n4 = int(t2 * SAMPLE_RATE)
n5 = int(t3 * SAMPLE_RATE)
n6 = int(t_rise * SAMPLE_RATE)
n7 = int(t_stop * SAMPLE_RATE)
```

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```
# 3. create voltage curve (absolute voltage values)
v1 = np.full(n1, U_B)
v2 = np.linspace(U_B, U_S1, n2, endpoint=False)
v3 = np.full(n3, U_S1)
v4 = np.linspace(U_S1, U_S, n4, endpoint=False)

# Segment 5: Sinus with 180° Phase (starts negative)
t_sine = np.arange(n5) / SAMPLE_RATE
v5 = U_S - U_sine * np.sin(2 * np.pi * 2.0 * t_sine)

v6 = np.linspace(U_S, U_B, n6, endpoint=False)
v7 = np.full(n7, U_B)

# concatenate the voltage curves in Volt
v_total = np.concatenate([v1, v2, v3, v4, v5, v6, v7])
total_points = len(v_total)
t_total = np.arange(total_points) / SAMPLE_RATE

# 4. Calculation of the CSV Header Values
v_max = np.max(v_total)
v_min = np.min(v_total)
amp = v_max - v_min      # Ergibt exakt 0.750000
offset = (v_max + v_min) / 2.0  # Ergibt exakt 0.825000

# Base repetition-frequency of the complete period (1 / 40.22s)
base_frequency = 1.0 / (total_points / SAMPLE_RATE)

# 5. write CSV-file (Strict formatting without space after semicolons in header)
with open(FILENAME, "w", newline="\n", encoding="utf-8") as f:
    # Metadata-Header
    f.write(f"data length,{total_points}\n")
    f.write(f"frequency,{base_frequency:.6f}\n")
    f.write(f"amp,{amp:.6f}\n")
    f.write(f"offset,{offset:.6f}\n")

    # Data-identification line
    f.write("Second,Volt\n")

    # Write data points as true voltage values
    for t, v in zip(t_total, v_total):
        f.write(f"{t:.6f},{v:.6f}\n")

print(f"Successful generation of '{FILENAME}' for Siglent AWGs; Tekbox Vietnam")
```

The Python script can be downloaded from the Tekbox webpage for the TBDCA1. It uses NumPy, a package for scientific computing.

The section in red at the beginning of the script contains the waveform parameters. It can be edited according to the desired nominal voltage and stress level. The default values are configured for 12V/Level II. Note that all voltage levels are divided by 10. The AWG cannot output voltages as high as 24V. Consequently, we scale the waveform from 12V (24V) to 1.2V and 2.4V respectively. The gain of the DC-coupled amplifier will be set to 20 dB to restore the required amplitude.

Run the Python script and import the created CSV-file into EasyWaveX:

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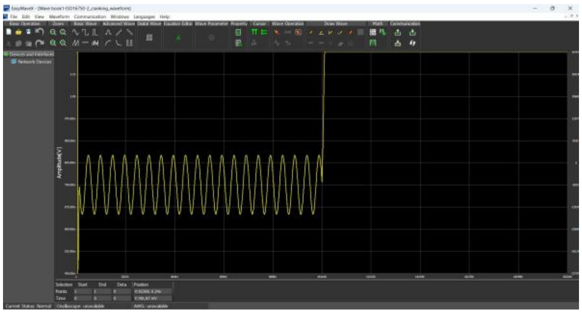

Figure 2: ISO16750-2_cranking_waveform.csv opened with EasyWaveX

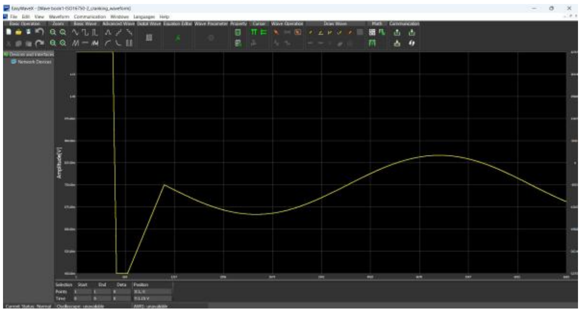

Figure 3: ISO16750-2_cranking_waveform.csv, zoomed section

EasyWaveX can download the waveform staight to the AWG via USB.

Alternatively, save the waveform as binary file and copy it to a USB stick. To load the waveform file from the USB stick into the Siglent SDG6000X, plug the USB drive into the front-panel USB host port, press Store/Recall browse to the USB Device directory, select the file, and press Recall to load it into internal memory.

4 Setup

First scale the waveform amplitude and offset:

Figure 4: setup to adjust the output signal

Connect an oscilloscope to the AWG output and turn the output on. The amplitude of the example waveform is 1.2V – 0.45V = 0.75 V_{PP}

Set the output level of the AWG accordingly and increase the output offset, until the voltage maximum reaches 1.2V.

Disable the AWG output and complete the setup as depicted below:

Figure 5: complete test setup

Connect the oscilloscope to the amplifier´s voltage monitor output and set the input to 1:10 in order to compensate for its voltage division ratio.
Turn the amplifier on and set the input to DC-coupling and High Impedance. Set the amplifier gain to 20 dB. Connect the EUT and turn on the amplifier output. Turn on the AWG output, validate the output voltage with the oscilloscope and check the EUT with respect to its functional status when exposed to the cranking voltage.

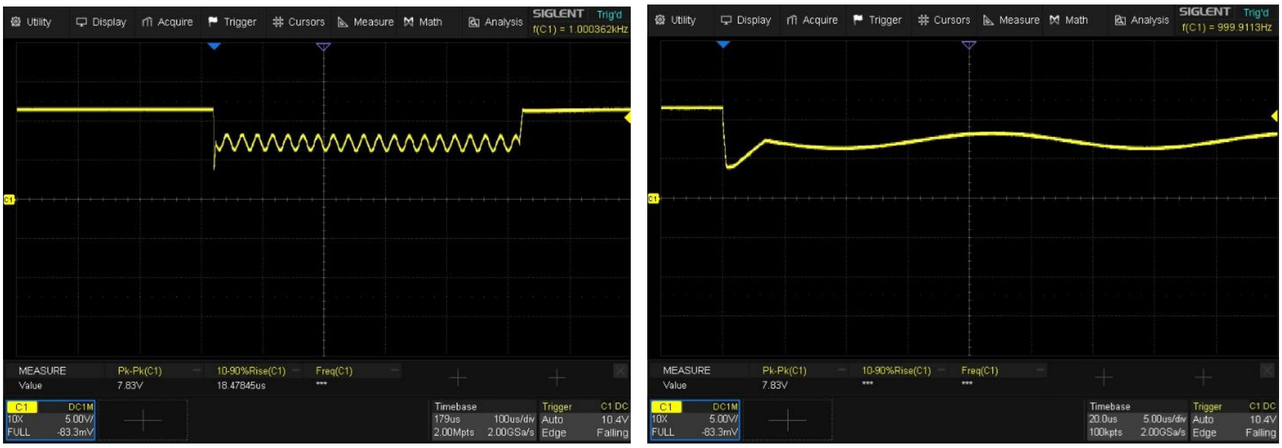

Figure 6: cranking voltage measured across the EUT supply line

5 History

Version	Date	Author	Changes
V1.0	12.9.2026	Mayerhofer	Creation of the document