FLEX LAB INFO
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LOW FREQUENCY CONDUCTED IMMUNITY TEST (30 Hz TO 100 kHz)

1. SCOPE

1.1. This procedure defines a method for exposing electronic modules and systems to electromagnetic energy in the frequency range of 30 Hz to 100 kHz. The electromagnetic energy is coupled onto the vehicle wiring harness from sources such as alternators, motors, solenoids and other loads. Electronic devices intended for the vehicle environment must be designed to tolerate fluctuations on their leads. This test is applicable to both power lines and input / output lines.

2. TEST EQUIPMENT

2.1.

AC Current Probe, 30 Hz to 100 kHz, maximum current greater than or equal to 5 A, accuracy +/- 3%. *Tektronix model 503 or equivalent.*
AC Voltmeter, 30 Hz to 100 kHz, maximum voltage greater than or equal to 10 V, accuracy +/- 1%, rms. *HP 3478A or equivalent.*
Coupling Capacitor (if required), 100 µF, >25 V, with through loss =< 0.5 dB from 400 Hz to 100 kHz in a 50 Ω system only. *Nichicon or equivalent.*
Isolation Transformer, 4:1 impedance ratio 30 Hz to 100 kHz, minimum current >= 20 A. *Solar Electronics Co. type 6220-1A. 100 watt audio maximum or equivalent.*
Oscilloscope, Bandwidth greater than or equal to 1 MHz.
Power Amplifier, 50 W out (minimum), output impedance less than or equal to 2 Ω, 30 Hz to 100 kHz. *Techron model 7570 Power Supply Amplifier or equivalent.*
Power Supply, 13.5 volts +/- 0.5 V, 10 A minimum. *Refer to SAE J1113-1 Section 6.6. HP model 6033 or 6038 or equivalent.*
Sinewave Generator, 30 Hz to 100 kHz, sinewave harmonic distortion less than -40 dB. *HP model 3314A or equivalent.*
Programmable Controller, GPIB/USB, for control of instruments in automated tests.
D/A Converter, if desired for control of test sample equipment.

All equipment that requires calibration shall be within its calibration period and shall be traceable to NIST.

3. TEST METHOD

3.1. This test is carried out using the substitution method.

- A signal is applied to the primary side of an isolation transformer and the line tested in is series with the secondary side.
- The complex input impedance of most module lines results in distortion of the applied sine wave. In order to maintain a consistent reference for these measurements, the voltage that will be applied to the line under test of the DUT shall be measured across a 4 ohm (i.e., a precision high power resistor) load substituted for the line under test of the DUT.
- The signal generator level needed to achieve the voltage(s) across a 4 ohm load shall be mapped out for each test frequency. This signal generator level shall be used to generate the signal voltage coupled to the line under test of the DUT which then replaces the 4 ohm load. In addition, the current into the line under test of the DUT shall be monitored and limited to 1 amp (rms) from 30 Hz to 100 kHz. The voltage applied across the secondary side of the transformer shall be monitored and this value shall be used for relative threshold if effects are encountered.

4. TEST PLAN

4.1.

- Use the categories of the Functional Performance Status Classification defined by SAE J1113-1.
- classification of DUT functions
- performance region requirements
- injection technique (series, common mode, or parallel)
- inputs and outputs to be tested
- system voltage levels to be applied
- functions to be monitored
- the number of samples required
- DUT identifier
- DUT design development level (ED/DV/PV)
- PCB identifier
- DUT potential responses for residual levels of the injected test signal appearing at its outputs that may interfere with proper operation or with other electronic modules to which it is connected.
- If common mode injection is required, provide impedance plots over the frequency range to be tested along with the load resistance between the balanced circuits.

5. DUT CONFIGURATION

5.1.

- The DUT is set up to perform the functions specified in the test plan.
- The lead under test is passed through the isolation transformer secondary.
- There are three different types of injection methods based on the lead configurations:
  - **Series Injection Test Setup** - default setup for Power Lines.
  - **Parallel Injection Test Setup** - used for lines that cause normal system operation to be inhibited when loaded with the series impedance of the transformer secondary.
  - **Common Mode Injection Test Setup** - used for balanced lines, i.e. speaker, sensor, or twisted pair.

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- When adding in the Series Capacitance used in the Common and Parallel Injection techniques, the test range is limited to a low frequency of 400 Hz.
- DUT inputs and outputs must be terminated in their actual sources and loads whenever possible; otherwise, they may be simulated using carefully chosen substitutes with consideration given to inductive and capacitive reactance.

6. TEST EQUIPMENT CONFIGURATION

6.1. The sine wave generator feeds the power amplifier and serves as the level control for the test. The test level is incremented at the sine wave generator either by the operator or by computer control.

6.2. Test Station Characterization Procedure

Series Injection

- Connect the transformer secondary as indicated in Figure 6.1 - A with a precision non-inductive 4 Ω resistor across the transformer secondary, passing one leg of the resistor through the current probe.
- Connect the test level voltmeter across the resistor.

Parallel Injection

- Connect the transformer secondary as indicated in Figure 6.1 - B with the capacitor (c) in series with the precision non-inductive 4 Ω resistor across the transformer secondary, passing one leg of the resistor through the current probe.
- Connect the test level voltmeter across the resistor.

Common Mode Injection

- Same as Series Injection Setup.

6.3. Characterization Measurement

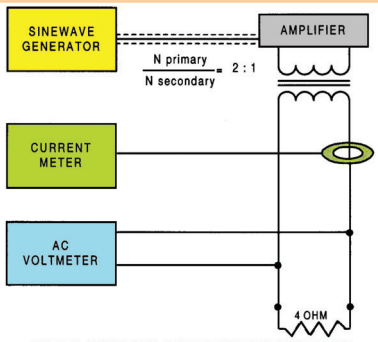
- Before the system characterization, the initialization procedure of the current probe shall be performed and a current reference source shall be used to insure the accuracy of the current probe.
- Set the function generator from 30 Hz to 100 kHz using Table 6.1 - A frequency increments and increase the test level to achieve the test limit (e.g., 0 dBV / 2.8 volts peak to peak / 1.0 V, rms) across the resistor (5.6 volts peak to peak for common mode).
- Record the power outputs from the function generator at each frequency to achieve the required test limit.

6.4. Test Setup

- Series Injection Test Setup per Figure 6.2 - A.
- Parallel Injection Test Setup per Figure 6.2 - B.
- Common Mode Injection Test Setup per Figure 6.2 - C.

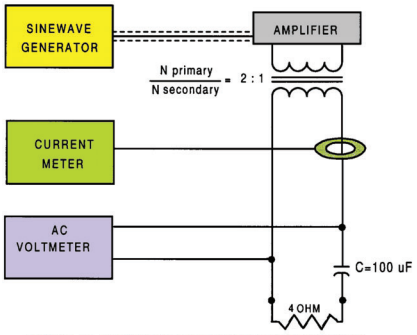
Figure (6.1)

Figure 6.1 - A



SERIES INJECTION CHARACTERIZATION SETUP

Figure 6.1 - B



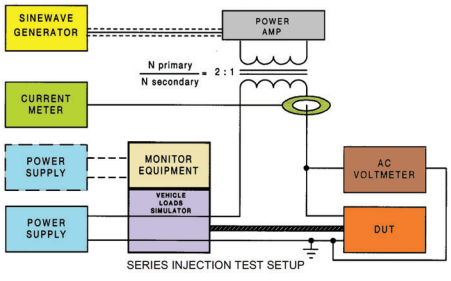
PARALLEL INJECTION CHARACTERIZATION SETUP

Table 6.1 - A

FREQUENCY INCREMENTS TABLE	
FREQUENCY INCREMENT	FREQUENCY RANGE
10 Hz	30 Hz to 100 Hz
100 Hz	100 Hz to 1 kHz
1 kHz	1 kHz to 10 kHz
10 kHz	10 kHz to 100 kHz

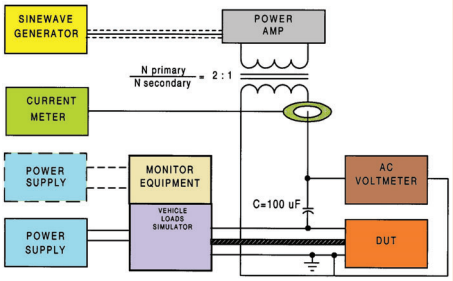
Figure (6.2)

Figure 6.2 - A



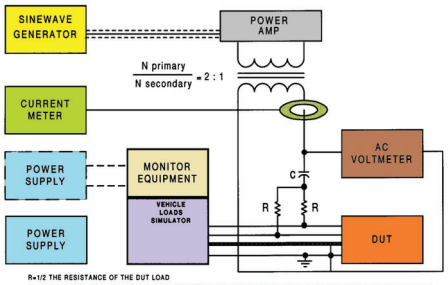
SERIES INJECTION TEST SETUP

Figure 6.2 - B



PARALLEL INJECTION TEST SETUP

Figure 6.2 - C



R=1/2 THE RESISTANCE OF THE DUT LOAD
C=100 uF. REDUCE CAPACITANCE VALUE IF DUT SIGNAL BECOMES TOO DISTORTED. RECORD THIS CAPACITANCE VALUE.
COMMON MODE INJECTION TEST SETUP

7. TESTING PROCESS

7.1. Use the substitution method with the test voltage defined in terms of dBV(rms).

- The test signal applied may become distorted due to DUT loading.
- The AC voltmeter in the setup is used to monitor the DUT AC voltage and to threshold the effects during the test regardless of distortion (mathematically converted to dBV (rms) by (20 log (volts)) while the DUT performs its required function(s).
- The test signal level is gradually increased to the specified amplitude limit at the function generator for the first test frequency while monitoring DUT performance.
- The limit is then maintained throughout the entire frequency range unless a deviation from DUT performance is detected.
- It is required to meet one of these conditions in order to advance to the next test frequency:
  - A. AC Current is greater or equal to 1 A (rms).
  - B. The generator output reaches the values obtained for the test limit during the pre-calibration with the 4 Ω resistor.
- Certain DUT lines with signals present may interfere with the AC Current meter when it is monitoring the current limit. For modules with these conditions, disconnect the AC current meter and use condition B to monitor the test.

8. DUT MONITORING

8.1.

- The test operator monitors the performance of DUT function as the test level is incremented to the specified amplitude limit at each test frequency.
- When an interaction with DUT functional performance is detected, the operator achieves and logs the minimum required test level that consistently reproduces the interaction for each frequency where it occurs, producing a curve of susceptibility with threshold levels for that particular line under test.
- If the current limit is reached before the specified test level is achieved, measurement of residual levels will be non-referenced. In this case, it is assumed that the high AC current implies adequate filtering of the DUT supply lead under test and therefore the DUT has a good voltage isolation.
- When testing a line, there may be performance degradation beyond that allowed as defined in the test plan due to the inductance of the transformer and this shall be recorded in the test report.

8.2. *This test is normally implemented using computer controlled test equipment. The test operator monitors the performance of the DUT, recording any deviation from required performance at the computer keyboard. Initially, the computer will be doing a quick sweep at limit greater or equal to the required level. The operator monitors the DUT function and marks the frequency window if any anomaly is observed. Then the increment mode will be performed at the attained frequency window. As the test level is incremented at each test frequency, the operator logs the minimum required test level where an anomaly is observed. Thus, producing a curve of susceptibility threshold level in the window. The computer automatically records the voltage in dBV and frequency of each deviation marked by the operator.*

9. REPORTING TEST DATA

9.1. The test report must include:

- the diagram of the test set-up and wire harness routing
- the digital picture of the test set-up
- the DUT interaction description, functional performance region, test levels and frequency recorded for each interaction and for each lead tested.
- Units: Frequency in kHz, Voltage in dBV (rms) and Current in A-rms.
- the report summary must show a comparison of the measurements with the performance limits, number of DUT tested, modes, and lines, etc.

REVISION CHANGES

END OF DOCUMENT