

The iMEK Vibrotactile Actuator Characterization Database: Dataset Description and Metadata

Technical Note accompanying the data publication in TORE

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Abstract—This technical note describes the structure, content and usage of the iMEK vibrotactile actuator characterization database, published as a citable dataset with a DOI in the TUHH Open Research repository (TORE). The dataset consolidates the standardized characterization of 26 commercial vibrotactile actuators, 22 linear resonant actuators (LRA) and 4 eccentric rotating mass actuators (ERM), obtained on an automated test stand under idle (unloaded) and blocked conditions. For every actuator, the database contains the summary frequency response of acceleration, velocity, displacement, force and mechanical power, the electrical impedance magnitude over frequency, and, for the LRAs, complete stepped frequency sweeps at six drive voltages together with derived drift and bandwidth figures; ERMs carry signal-to-noise sweeps over drive voltage. The note documents the relational schema of all nine tables column by column with units, states known limitations of the current data release, and describes the three access routes: the SQL snapshot published here, a MATLAB interface, and a public web frontend. The dataset is intended as the citable data backbone for a series of publications describing the measurement methodology, the key performance indicators, and the application of the database in haptic research.

Index Terms—Haptics, Vibrotactile Actuators, Dataset, Open Data, Characterization, Database.

I. INTRODUCTION

Vibrotactile actuators are the dominant output elements of today’s haptic user interfaces, but their published specifications are neither complete nor comparable across manufacturers [1], [2]. Datasheets typically report a rated voltage and a resonance frequency measured on an unspecified fixture, leaving load-dependent behavior, frequency response and noise characteristics unaddressed. The lack of standardized actuator data has been identified both by the research community [3], [4] and by industry bodies such as the Haptics Industry Forum [2].

This data publication addresses the gap with primary measurement data. Following the FAIR guiding principles [5] and the Joint Declaration of Data Citation Principles [6], the dataset is published as a first-class, citable research output with a DataCite-registered DOI [7] in TORE, the open research repository of Hamburg University of Technology. The

publication strategy is data-first: this note documents the data themselves. The measurement procedure is described in an accompanying technical note [8], the derivation of the key performance indicators (KPIs) in a second one [9], and the motivation and usage of the database in haptic research in a separate journal publication [10].

To the authors’ knowledge, this is the first openly licensed database of systematically measured performance characteristics of commercial vibrotactile actuators. Existing resources either catalog literature metadata of kinesthetic devices (Haptipedia [4]), organize vibration *signals* rather than hardware (VibViz [11]), or provide measured benchmarking for grounded force-feedback devices (Haptify [12]); none provides measured, load-aware frequency-response data of vibrotactile actuators.

II. DATASET OVERVIEW

The dataset release contains the characterization results of **26 actuators**: 22 LRAs and 4 ERMs from Grewus (12), Vybrionics (6), Gruner, Actronika, Foster Electric, Apple, and four anonymized samples. The measured corpus includes consumer-grade references such as the Apple Taptic Engine and the PS5 DualSense actuator. Fig. 1 shows the summary acceleration responses of the full corpus.

Each actuator carries: (i) a catalog entry with physical properties (volume, mass), rated voltage and headline peak figures including the frequencies at which they occur; (ii) a summary frequency response with one row per frequency point covering acceleration, velocity, displacement, force and mechanical power; (iii) the electrical impedance magnitude over the same frequency grid; and (iv) for 16 of the 26 actuators a photograph. LRAs additionally carry the complete per-voltage stepped sweeps at 1.0, 1.4, 1.8, 2.2, 2.6 and 3.0 V (69 frequency points each, i.e. 414 rows per LRA) plus derived load-dependent drift, control-dependent drift and resonance bandwidth per drive voltage. ERMs, having a DC input, instead carry signal-to-noise ratios of power, acceleration and force against a drive-voltage ramp from 0.49 V to the rated maximum (80–84 points per ERM).

Table I summarizes the tables of the release and their row counts.

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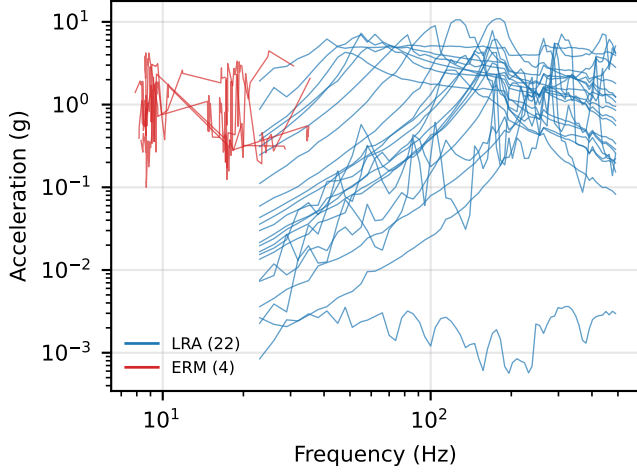


Fig. 1. Summary acceleration frequency responses of all 26 actuators in the database. LRAs (blue) were swept from 23 Hz to 490 Hz at 69 discrete frequency points; ERMs (red) operate between approximately 8 Hz and 35 Hz, controlled by their DC drive voltage.

TABLE I
TABLES OF THE DATASET RELEASE AND THEIR CONTENT

Table	Rows	Content
Actuator	26	catalog, one row per actuator
Measurement_ALL	1 842	summary frequency responses
PW_Bode_Amplitude_ALL	1 842	electrical impedance magnitude
PW_Measurement_LRA	9 108	per-voltage sweeps (LRA only)
PW_Table	132	drift and bandwidth (LRA only)
PW_SNR_ERM	324	SNR vs. voltage (ERM only)
Pictures	16	photographs (PNG/JPEG blobs)
PW_Bode_Phase_LRA	0	impedance phase (reserved, empty)
Voltage_Frequency_ERM	0	voltage-frequency map (reserved)

III. DATA ACQUISITION IN BRIEF

The measurement concept is documented in detail in the accompanying technical note [8]; the following summary establishes the context needed to interpret the columns. Every actuator was characterized as an electromechanical two-terminal source in two complementary configurations [13]: an *idle* (unloaded) measurement, in which the actuator is suspended by strings and pretensioned springs inside a support frame so that the rig resonance stays well below the measurement band, yielding the open-circuit velocity; and a *blocked* measurement, in which the actuator is clamped onto a piezoelectric force sensor on a massive bench, yielding the short-circuit force. Excitation was a discrete, stepped frequency sweep exciting the band from 20 Hz to 1 kHz, for LRAs repeated at six drive voltages; the published summary grid comprises the 69 logarithmically spaced points between 23 Hz and 490 Hz at which all derived quantities are valid across the corpus. ERMs, having a DC input, were ramped in drive voltage instead. Velocity and displacement follow from integration of the accelerometer signal, and mechanical power is computed as $P = F \cdot v/2$ at impedance match. The KPI definitions (SNR, mechanical power class, load-dependent drift, control-dependent drift, power linearity, power density, resonance bandwidth) are derived from these raw signals as documented in [9]. Their stor-

age locations differ: SNR values live in the sweep tables, MPC, power density, the actuator-level drift figure and the resonance bandwidth in the catalog columns of Actuator (note that the legacy column names `load_drift_dependency` and `load_dependent_drift` both refer to the LDD indicator), the per-voltage drift and bandwidth values in `PW_Table`, and the power linearity is computed on demand from the per-voltage sweeps rather than stored.

IV. SCHEMA DOCUMENTATION

The data live in a relational schema in which everything hangs off the Actuator table: every other table carries an `actuator_id` column referencing `Actuator.id`. This relationship is a convention of the release, not an enforced constraint: apart from `Pictures`, no table declares a primary key or foreign key. The `id` values are unique in practice.

A. Actuator — catalog (26 rows)

One row per actuator. Columns: `id` (int, key referenced by all other tables); `model` (text); `manufacturer` (text); `class` (LRA or ERM — decides which tables hold data for the actuator); `volume_in_cc` (cm³); `mass_in_g` (g); `tag` (short marker, often NULL); `mechanical_power_class` (woofer, mid-range or tweeter; NULL for ERMs); `maximum_voltage` (V); `peak_power` (W); `peak_acceleration` (g); `peak_velocity` (m/s); `peak_displacement` (m); `peak_force` (N); each peak paired with the integer frequency (Hz) at which it occurs (`resonance_frequency_peak_*`); `power_density` (mW/cm³); `load_drift_dependency` (Hz); `resonance_power_bandwidth` (Hz); and four provenance columns (`pw_teststand_version`, `pw_software_version`, `pw_actuator_id`, `pw_measurement_id`) tracing every row back to the originating test-stand system.

B. Measurement_ALL — summary responses (1 842 rows)

One row per actuator per frequency point: 69 points per LRA (23–490 Hz), 80–84 per ERM (8–35 Hz). Columns: `id`; `actuator_id`; `input_frequency` (Hz); `acceleration` (g); `velocity` (m/s); `displacement` (m); `force` (N); `mechanical_power` (W); `snr_power` (dB; always 0.0 in this table, see Sec. V); `comment` (always NULL). Note that `force` is a reserved word in MySQL 8 and must be written in backticks in SQL queries.

C. PW_Bode_Amplitude_ALL — impedance (1 842 rows)

Electrical impedance magnitude against frequency for every actuator. Columns: `id` (shares its numbering with `Measurement_ALL.id`; row n is the same actuator and frequency in both tables, verified across all 1 842 rows — **join on id, not on frequency**); `actuator_id`; `frequency` (Hz; note the different column name); `impedance_amplitude` (Ω); `comment`.

D. PW_Measurement_LRA — per-voltage sweeps (9108 rows)

LRA only; 6 voltages $\times$ 69 frequency points = 414 rows per LRA. Columns: `id`; `actuator_id`; `input_frequency` (Hz); `input_voltage` (V; floating point — compare with a tolerance, e.g. `ABS(input_voltage - 3.0) < 1e-6`); `raw_acceleration` (g); `raw_force` (N); `mechanical_power` (W); `snr_power`, `snr_acceleration`, `snr_force` (dB); `comment`.

E. PW_Table — drift and bandwidth (132 rows)

LRA only; 6 rows per LRA, one per drive voltage. Columns: `id`; `actuator_id`; `input_voltage` (V); `load_dependent_drift` (Hz); `control_dependent_drift` (Hz); `mechanical_power_resonance_bandwidth` (Hz).

F. PW_SNR_ERM — SNR sweeps (324 rows)

ERM only; 80–84 voltage points per ERM from 0.49 V to the rated maximum. Columns: `id`; `actuator_id`; `input_voltage` (V); `snr_power` (dB; always 0.0, see Sec. V); `snr_acceleration`, `snr_force` (dB); `comment`.

G. Pictures — photographs (16 rows)

The only table with a declared primary key and auto-increment. Columns: `id`; `actuator_id`; `picture` (mediumblob holding the complete original PNG or JPEG file, 122 kB–1.2 MB); `mime_type`; `comment`.

H. Reserved empty tables

`PW_Bode_Phase_LRA` (`id`, `actuator_id`, `frequency`, `impedance_phase`, `comment`) was intended to hold the impedance phase and is empty in this release; downstream tools keep the column so code does not break once it is filled. `Voltage_Frequency_ERM` (`id`, `actuator_id`, `input_voltage`, `equivalent_frequency`, `comment`) was intended to relate ERM drive voltage to rotation frequency and is likewise empty.

V. KNOWN LIMITATIONS OF THIS RELEASE

The following properties of the current snapshot are known limitations of this release: (i) `snr_power` is 0.0 throughout `Measurement_ALL` and `PW_SNR_ERM`; meaningful SNR values live in the per-voltage LRA sweep table and in the acceleration/force SNR columns of the ERM table. (ii) `impedance_phase` data were not recorded; the corresponding table is empty. (iii) All `comment` columns are NULL. (iv) One actuator (VL32158H-L25) has `mass_in_g` = 0, a known metadata gap of this release. (v) The relational integrity is by convention; consumers should treat `actuator_id` joins defensively. (vi) LRA and ERM actuators were measured with different procedures appropriate to their drive principle; querying LRA-style voltage sweeps for an ERM returns an empty result by design.

VI. ACCESS ROUTES

Three complementary access routes exist. First, the **SQL snapshot** published with this note in TORE: a complete, self-contained MySQL dump (schema plus data) that can be restored locally or converted to SQLite; this snapshot is the DOI-carrying, citable object. Alongside the dump, per-table CSV exports are included in the deposit for tool-independent reuse, following the interoperability principle of FAIR [5]. Second, the **MATLAB interface**: a set of functions (`connect`, `listActuators`, `getFrequencyResponse`, `getActuator`, `getSNR`, `getPictures`, plotting helpers and six example scripts) that reads the live database or a restored snapshot into MATLAB tables (requires R2020b or newer with the Database Toolbox). Third, the **web frontend**, which offers an overview ranking with normalized peak amplitudes, per-actuator analysis views with all measured quantities, drive-voltage selection, multi-actuator comparison plots, and CSV/XLSX export without requiring any SQL or MATLAB knowledge [10].

VII. LICENSING, CITATION AND VERSIONING

The dataset (database structure and measured content, including the photographs taken by the authors) is licensed under CC BY 4.0, which covers both the content and the European sui generis database right [14]. The recommended citation is the DataCite citation string on the TORE landing page; related resources (the methodology notes [8], [9], the journal publication [10], and the frontend) are linked through DataCite `relatedIdentifier` relations [7]. Future data additions (new actuators, filled phase table) will be published as new versions with their own DOIs; this note describes the snapshot of 2026-08-24.

VIII. CONCLUSION

This note documented the structure and content of the iMEK vibrotactile actuator characterization database: 26 commercial actuators measured under a standardized idle/blocked protocol, published as a citable, openly licensed dataset with complete schema documentation and stated limitations. Together with the accompanying methodology notes and the journal publication, the dataset provides the data backbone on which comparable, load-aware actuator selection and haptic system design can build.

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