characterized mechanical device **130**. For example, a haptic device **160** to be programmed can be in communication with the characterization module **120**, allowing the evaluation of the quality of the programmed effect relative to the stored parametric data. The commands to the haptic rotary control can be altered to most closely match the perceptual experience measured directly from the mechanical device **130**.

[**0030**] A file can be output to a design module **150** including a haptic effect design application (e.g., Immersion Studio available from Immersion Corporation, San Jose, Calif.). The haptic effect design application includes data to be used in haptic effect generation. The haptic effect design application can receive data in a specified format. For example, the design application can receive a general force profile with multiple control points (e.g., piece-wise linear); velocity dependent profiles, the ability to create audio feedback by playing back pre-recorded audio files or MIDI files (audio files can be triggered by events such as position in a detent, enter barrier, etc.); and/or real-time audio synthesis to accommodate the need for real time control of the sound of the mechanical device according to speed.

[**0031**] The haptic effect design module can be used, for example, to manually modify the parametric data set. The haptic effect design module employs the parametric data set of the mechanical device **130**, which can be stored or communicated, and experienced by users at other site locations (e.g., remote locations).

[**0032**] In some embodiments, the design module **150** is in communication with the conversion module **140** and the controller **170**. The design module **150** is configured to modify the parametric data set associated with the mechanical device **130** to produce a modified parametric data set as discussed above. The design module **150** compares the haptic effect to the operational characteristics of the mechanical device **130** to produce a comparison signal. The design module **150** can modify the parametric data set based at least partially on the comparison signal.

[**0033**] The design module **150** is configured to produce a user interface associated with the library **185**. The design module **150** can send a signal based on at least one user command to select at least one parametric data set from the library **185** including multiple parametric data sets. The signal causes the haptic device **180** to output haptic feedback associated with the operational characteristics associated with the perceptual experience of the selected mechanical device **130**.

[**0034**] Some embodiments are used in conjunction with programmable haptic devices **160** that allow a single input device to represent a number of different input functions or different operational modes of a mechanical device **130**. For example, the same haptic device **160** can be used to mimic or simulate the feel of a car radio-tuning dial, the car fan dial, or thermostat control dial. The programmable haptic device **160** is configured to receive a control signal from the controller **170** to output the haptic feedback associated with the operational mode of the particular input function being controlled.

[**0035**] **FIG. 3** is an example of a graphical representation of data associated with a plurality of operational characteristics of a mechanical device **130**, such as a rotary knob. The dashed line in **FIG. 3** is representative of the measurements of the operational characteristics of the knob as the knob is turned in the positive or clockwise direction. The solid line in **FIG. 3** is representative of the measurements of the operational characteristics of the knob as the knob is turned in the negative or counter-clockwise direction. An example of a portion of a parametric data set associated with the operational characteristics shown in **FIG. 3** is provided in Table 1 below. The parameters listed in Table 1 are examples of parameters for a particular rotary knob under a predefined set of circumstances.

TABLE 1

Parameter	Value
Base Force profile	Triangular (Initial slope K1 = 26.3 mNm/deg, Trail-off slope K2 = −5.3 mNm/deg)
Number of detents	30 per full revolution (12 degrees per detent)
Maximum force on detent	22 mNm (milliNewton × meters)
Dead band	0.5 degrees
Friction	9 mNm (milliNewton × meters)
Symmetry	Symmetric
Click locations	None
Barriers	None (Continuous)
Velocity dependence	None

[**0036**] In one embodiment, the motor **128** is controlled with a loop rate of at least 1 msec or lower. The minimum resolution of the signals output by the sensor **125** are 12-bit signals. These signals can include, for example, position sensor signals, current command to the motor, a torque sensor signal, and/or a sampling time. The signals provide, for example, 6 bytes of data associated with the mechanical device **130** per clock tick.

[**0037**] If the characterization module is run at 5 degrees/second as the slowest test speed possible, for example, and uses a sampling rate of 1 msec, the number of samples per one cycle of 360 degrees revolution is 72000 samples. With such a configuration, 6 bytes would be transferred every 1 msec from the characterization hardware **124** to the characterization application software **122**.

[**0038**] The characterization hardware **124** that can be used with some embodiments may include, for example, a direct current (DC) motor with at least 100 mNm torque capability, a high performance brake (e.g., a magnetic particle brake) with at least 100 mNm torque capability, a high resolution sensor of at least 16000 counts per revolution (e.g., Agilent HEDS encoder; MicroE Systems encoder; and/or US Digital sensor). Torque sensors for use with the invention include, for example, 28000T(5-1) 0.353 Nm from www.himmelstein.com, plus accessories, torque signal conditional system and/or D-DR2494/M120 0.2 Nm from www.topac.com/LM-DR-2494.htm plus related accessories.

[**0039**] The characterization hardware **124**, which can be in the form of a test bed, can contain both a high quality haptic device and a near-to-production haptic device. In this fashion the approximation of the perceptual experience of the haptic device can be assessed and the likely impact on production examined immediately. The reference test bed can also include loudspeakers to reproduce an audio response.

[**0040**] The characterization hardware **124** can be controlled by a variety of applications, which can be imple-