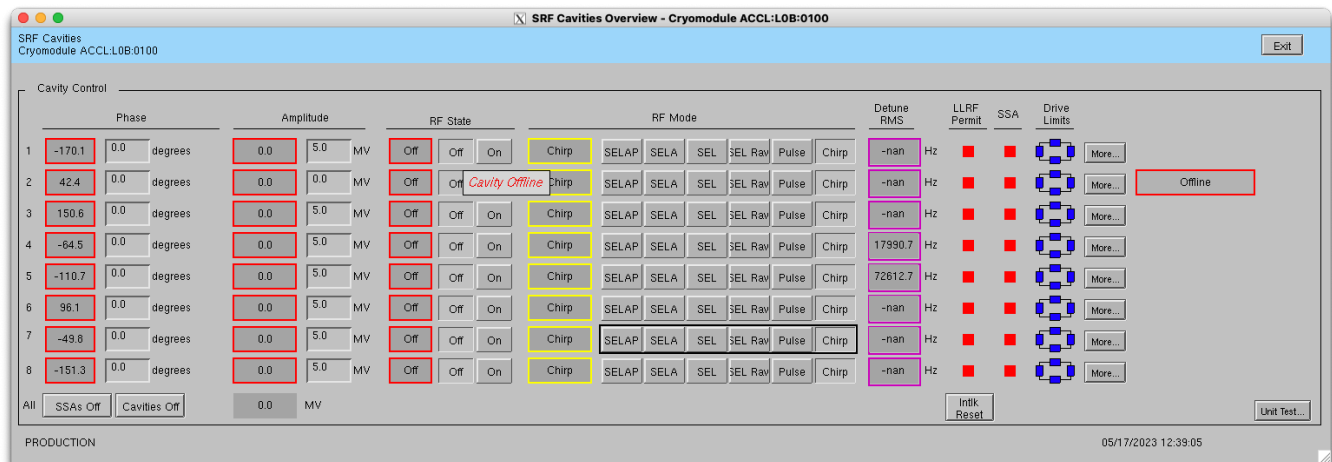# RF Commissioning

- [EPICS Screens](#)
- [GUI Procedure](#)
  - [Piezo Pre-RF Check](#)
  - [SSA Characterization](#)
  - [Cavity Tuning](#)
  - [8/9 and 7/9](#)
  - [Cavity Characterization](#)
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  - [Ramp Up in SELAP](#)
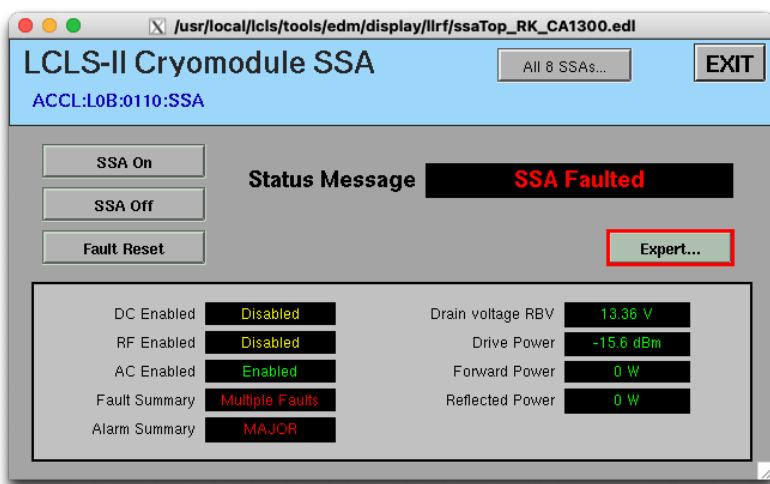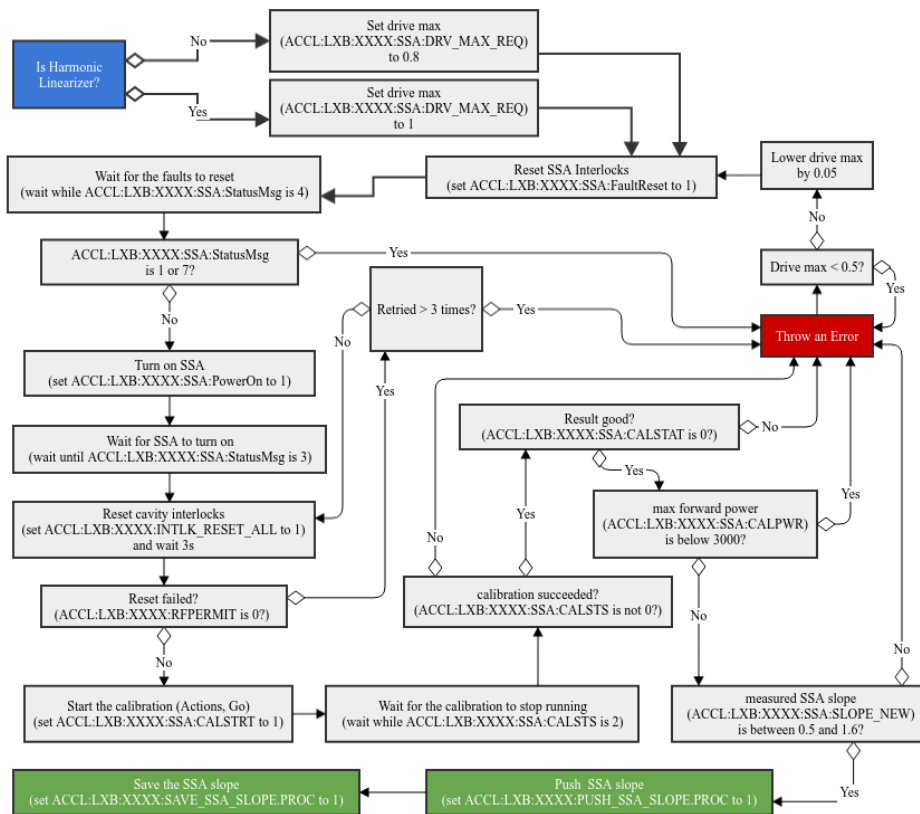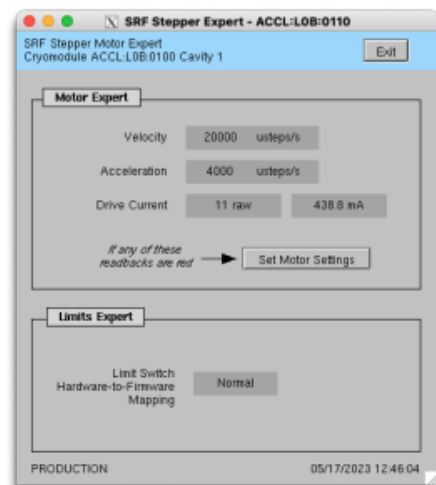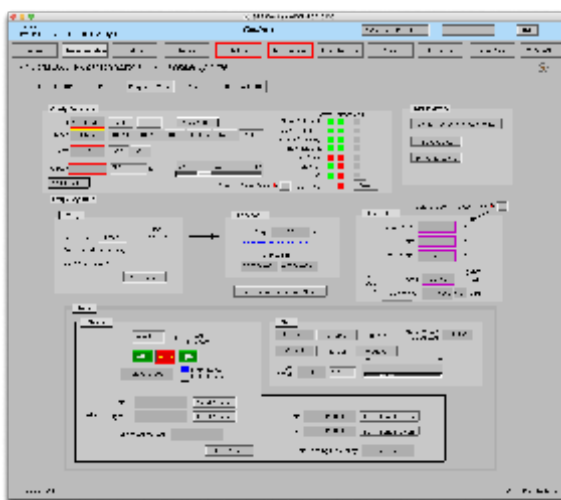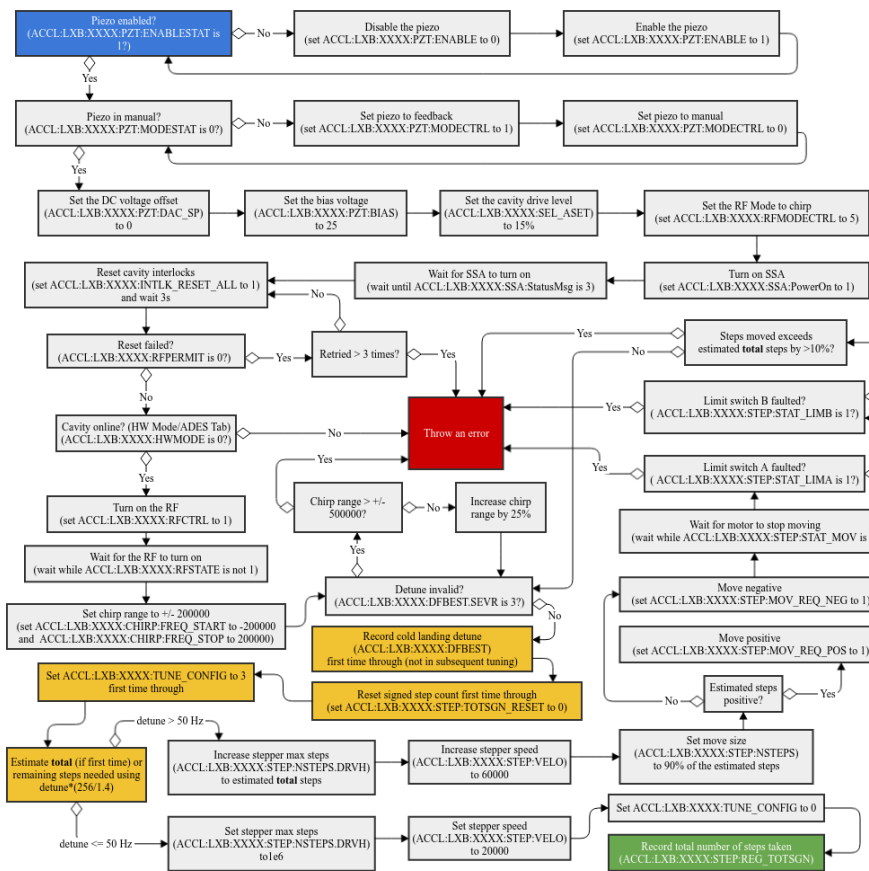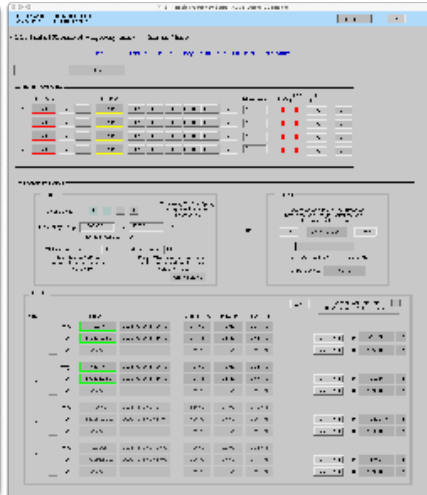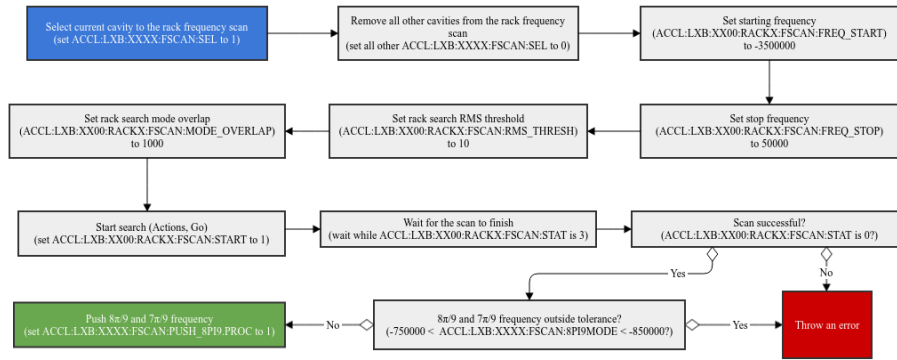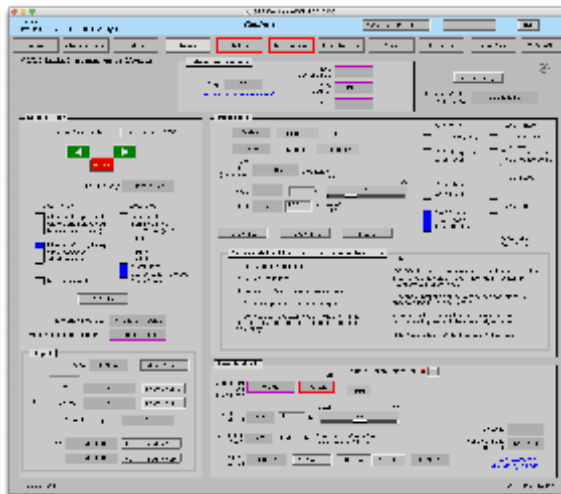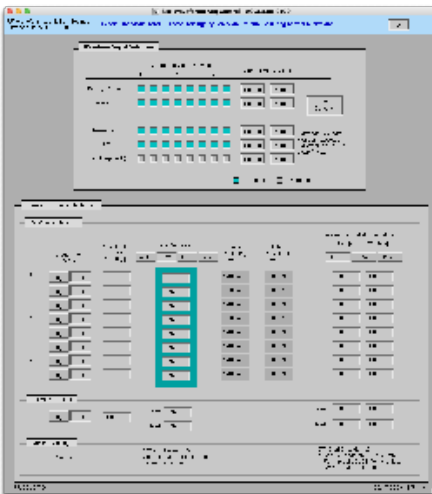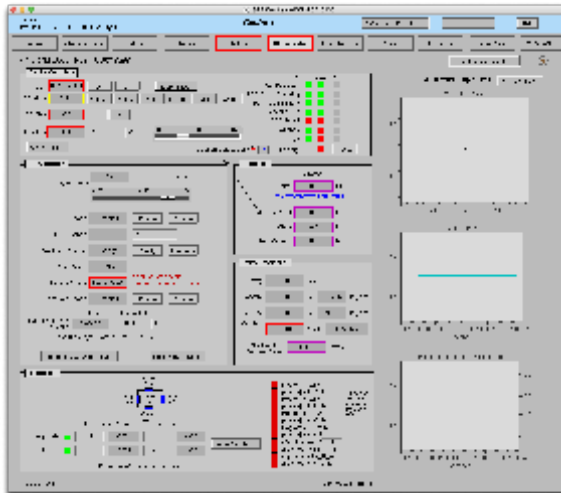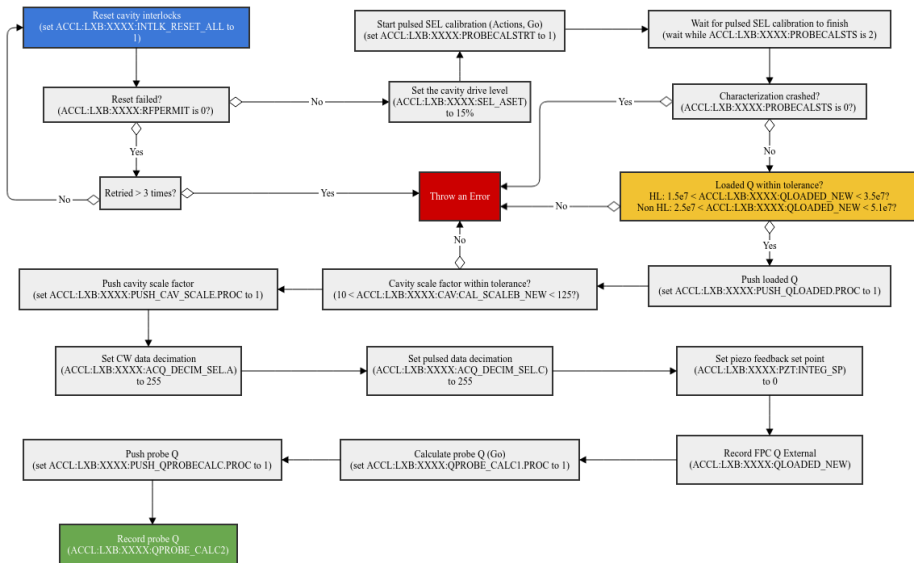
ⓘ Source code can be found [here](#) and can be run locally using [Local PyDM/Simulacrum Setup](#)

EPICS Screens

All screens for any given cavity can be gotten from either lcls-home (using SC gun) or SRF Home > RF > Cavities > More

GUI Procedure

> ℹ️ Blue is start, red is error, green is end, yellow is special case.
>
> Arrow with a diamond means conditional.

Piezo Pre-RF Check

Flowchart:

- Turn cavity (RF state) off
  (set ACCL:LXB:XXXX:RFCTRL to 0)

- Enable piezo
  (set ACCL:LXB:XXXX:PZT:ENABLE to 1)

- Set piezo to manual
  (set ACCL:LXB:XXXX:PZT:MODECTRL to 0)

- Set piezo DC offset
  (ACCL:LXB:XXXX:PZT:DAC_SP) to 0

- Start the piezo pre rf test (Actions, Go)
  (set ACCL:LXB:XXXX:PZT:TESTSTRT to 1)

- Wait while the piezo pre rf test is running
  (wait while ACCL:LXB:XXXX:PZT:TESTSTS is 2)

Test failed
(ACCL:LXB:XXXX:PZT:TESTSTS is not 1)

Test complete
(ACCL:LXB:XXXX:PZT:TESTSTS is 1)

- Check Channel A

Channel A failed
(ACCL:LXB:XXXX:PZT:CHA_TESTSTAT is not 0)

Channel A passed
(ACCL:LXB:XXXX:PZT:CHA_TESTSTAT is 0)

- Check Channel B

Channel B failed
(ACCL:LXB:XXXX:PZT:CHB_TESTSTAT is not 0)

Channel B passed
(ACCL:LXB:XXXX:PZT:CHB_TESTSTAT is 0)

- Record piezo capacitance A
  (ACCL:LXB:XXXX:PZT:CHA_C)

- Record piezo capacitance B
  (ACCL:LXB:XXXX:PZT:CHB_C)

- Throw an error

SSA Characterization

LCLS-II Cryomodule SSA

/usr/local/lcls/tools/edm/display/llrf/ssaTop_RK_CA1300.edl

ACCL:L0B:0110:SSA

All 8 SSAs...   EXIT

SSA On
SSA Off
Fault Reset

Status Message   SSA Faulted

Expert...

DC Enabled	Disabled	Drain voltage RBV	13.36 V
RF Enabled	Disabled	Drive Power	-15.6 dBm
AC Enabled	Enabled	Forward Power	0 W
Fault Summary	Multiple Faults	Reflected Power	0 W
Alarm Summary	MAJOR		

Cavity Tuning

SRF Chirp - ACCL:L0B:0110

SRF Chirp Deluxe Measurement
Cryomodule ACCL:L0B:0100 Cavity 1   Exit

Configuration and Status

RF Mode   Chirp SELAP SELA SEL SEL Raw Pulse Chirp
RF State   Off   Off On
Drive Level
(used in Chirp,   15.0   15.0   %   15.00   70
Pulse, SEL Raw)

Set Cavity Chirp
Frequency Range   +/- 80 kHz +/- 100 kHz +/- 200 kHz +/- 400 kHz
                  Typical

Max absolute offset   -132819   to   132875   Hz
from zero ~ 400 kHz

Expert Override

			Limit Decimation	Recommended Chirp Decimation
Chirp Waveform Data Decimation	2	2	2	2
Amplitude Maximum	95512	95512		
Amplitude Slope	29	29		
Frequency Initial (dphase)	-24163576	-24163576		
Frequency Slope (dphase)	489303	489303		
Acquisitions Per WF Cycle	1	1		
Chirp Duration	26357	26357		

Chirp State   Not enabled   Chirp Count   0

PRODUCTION   05/17/2023 12:43:45

SRF Stepper Expert - ACCL:L0B:0110

SRF Stepper Motor Expert
Cryomodule ACCL:L0B:0100 Cavity 1   Exit

Motor Expert

Velocity   20000   usteps/s
Acceleration   4000   usteps/s
Drive Current   11 raw   438.8 mA

If any of these
readbacks are red →   Set Motor Settings

Limits Expert

Limit Switch
Hardware-to-Firmware   Normal
Mapping

PRODUCTION   05/17/2023 12:46:04

Flowchart

Piezo enabled? (ACCL:LXB:XXXX:PZT:ENABLESTAT is 1?) — No → **Disable the piezo** (set ACCL:LXB:XXXX:PZT:ENABLE to 0) → **Enable the piezo** (set ACCL:LXB:XXXX:PZT:ENABLE to 1)

Yes ↓

Piezo in manual? (ACCL:LXB:XXXX:PZT:MODESTAT is 0?) — No → **Set piezo to feedback** (set ACCL:LXB:XXXX:PZT:MODECTRL to 1) → **Set piezo to manual** (set ACCL:LXB:XXXX:PZT:MODECTRL to 0)

Yes ↓

Set the DC voltage offset (ACCL:LXB:XXXX:PZT:DAC_SP to 0) → **Set the bias voltage** (ACCL:LXB:XXXX:PZT:BIAS to 25) → **Set the cavity drive level** (ACCL:LXB:XXXX:SEL_ASET to 15%) → **Set the RF Mode to chirp** (set ACCL:LXB:XXXX:RFMODECTRL to 5)

↓

Turn on SSA (set ACCL:LXB:XXXX:SSA:PowerOn to 1) → **Wait for SSA to turn on** (wait until ACCL:LXB:XXXX:SSA:StatusMsg is 3) → **Reset cavity interlocks** (set ACCL:LXB:XXXX:INTLK_RESET_ALL to 1) and wait 3s

↓

Reset failed? (ACCL:LXB:XXXX:RFPERMIT is 0?) — Yes → **Retried > 3 times?** — Yes → **Throw an error**

No ↓

Cavity online? (HW Mode/ADES Tab) (ACCL:LXB:XXXX:HWMODE is 0?) — No → **Throw an error**

Yes ↓

Turn on the RF (set ACCL:LXB:XXXX:RFCTRL to 1)

↓

Wait for the RF to turn on (wait while ACCL:LXB:XXXX:RFSTATE is not 1)

↓

Set chirp range to +/- 200000 (set ACCL:LXB:XXXX:CHIRP:FREQ_START to -200000 and ACCL:LXB:XXXX:CHIRP:FREQ_STOP to 200000)

↓

Set ACCL:LXB:XXXX:TUNE_CONFIG to 3 first time through

↓

Estimate total (if first time) or remaining steps needed using detune*(256/1.4)

— detune > 50 Hz → **Increase stepper max steps** (ACCL:LXB:XXXX:STEP:NSTEPS.DRVH to estimated total steps) → **Increase stepper speed** (ACCL:LXB:XXXX:STEP:VELO to 60000) → **Set move size** (ACCL:LXB:XXXX:STEP:NSTEPS) to 90% of the estimated steps

— detune <= 50 Hz → **Set stepper max steps** (ACCL:LXB:XXXX:STEP:NSTEPS.DRVH to 1e6) → **Set stepper speed** (ACCL:LXB:XXXX:STEP:VELO to 20000) → **Set ACCL:LXB:XXXX:TUNE_CONFIG to 0** → **Record total number of steps taken** (ACCL:LXB:XXXX:STEP:REG_TOTSGN)

Detune invalid? (ACCL:LXB:XXXX:DFBEST.SEVR is 3?) — Yes → **Chirp range > +/- 500000?** — No → **Increase chirp range by 25%** ; Yes → **Throw an error**

No ↓

Record cold landing detune (ACCL:LXB:XXXX:DFBEST) first time through (not in subsequent tuning)

↓

Reset signed step count first time through (set ACCL:LXB:XXXX:STEP:TOTSGN_RESET to 0)

↓

Estimated steps positive? — No → **Move negative** (set ACCL:LXB:XXXX:STEP:MOV_REQ_NEG to 1) ; Yes → **Move positive** (set ACCL:LXB:XXXX:STEP:MOV_REQ_POS to 1)

↓

Wait for motor to stop moving (wait while ACCL:LXB:XXXX:STEP:STAT_MOV is 1)

↓

Limit switch A faulted? (ACCL:LXB:XXXX:STEP:STAT_LIMA is 1?) — Yes → **Throw an error** ; No →

Limit switch B faulted? (ACCL:LXB:XXXX:STEP:STAT_LIMB is 1?) — Yes → **Throw an error** ; No →

Steps moved exceeds estimated total steps by >10%? — Yes → **Throw an error** ; No →

8/9 and 7/9

```
┌─────────────────────────────┐      ┌──────────────────────────────────┐      ┌──────────────────────────────────┐
│ Select current cavity to the│      │ Remove all other cavities from the│      │ Set starting frequency           │
│ rack frequency scan          │─────▶│ rack frequency scan               │─────▶│ (ACCL:LXB:XX00:RACKX:FSCAN:FREQ_START)│
│ (set ACCL:LXB:XXXX:FSCAN:SEL │      │ (set all other ACCL:LXB:XXXX:     │      │ to -3500000                      │
│ to 1)                        │      │ FSCAN:SEL to 0)                   │      │                                  │
└─────────────────────────────┘      └──────────────────────────────────┘      └──────────────────────────────────┘
                                                                                                 │
                                                                                                 ▼
┌──────────────────────────────────────┐   ┌────────────────────────────────────┐   ┌──────────────────────────────────┐
│ Set rack search mode overlap         │   │ Set rack search RMS threshold      │   │ Set stop frequency               │
│ (ACCL:LXB:XX00:RACKX:FSCAN:MODE_OVERLAP)│◀─│ (ACCL:LXB:XX00:RACKX:FSCAN:RMS_THRESH)│◀─│ (ACCL:LXB:XX00:RACKX:FSCAN:FREQ_STOP)│
│ to 1000                              │   │ to 10                              │   │ to 50000                         │
└──────────────────────────────────────┘   └────────────────────────────────────┘   └──────────────────────────────────┘
      │
      ▼
┌─────────────────────────────┐      ┌──────────────────────────────────┐      ┌──────────────────────────────────┐
│ Start search (Actions, Go)  │      │ Wait for the scan to finish      │      │ Scan successful?                 │
│ (set ACCL:LXB:XX00:RACKX:    │─────▶│ (wait while ACCL:LXB:XX00:RACKX:  │─────▶│ (ACCL:LXB:XX00:RACKX:FSCAN:STAT  │
│ FSCAN:START to 1)           │      │ FSCAN:STAT is 3)                  │      │ is 0?)                           │
└─────────────────────────────┘      └──────────────────────────────────┘      └──────────────────────────────────┘
                                                                                       ◇ Yes        ◇ No
                                                                                       │            │
                                                                                       ▼            ▼
┌─────────────────────────────┐   No   ┌──────────────────────────────────────┐  Yes  ┌──────────────┐
│ Push 8π/9 and 7π/9 frequency│◀───────│ 8π/9 and 7π/9 frequency outside      │──────▶│ Throw an error│
│ (set ACCL:LXB:XXXX:FSCAN:    │        │ tolerance?                           │       │              │
│ PUSH_8PI9.PROC to 1)        │        │ (-750000 < ACCL:LXB:XXXX:FSCAN:      │       │              │
│                             │        │ 8PI9MODE < -850000?)                 │       │              │
└─────────────────────────────┘        └──────────────────────────────────────┘       └──────────────┘
```

Cavity Characterization

SRF Probe Q Calculator - ACCL:L0B:0110

Probe Q Calculator

Calculate Probe Q from RevCal scale factor, ADC-full scale, and system losses — [Go] 1.20305e+12

Push calculated value to In-Use — [Push] 1.21000e+12   In-Use Probe Q 1.21000e+12

```
┌─────────────────────────┐              ┌─────────────────────────┐              ┌─────────────────────────┐
│   Reset cavity interlocks│              │Start pulsed SEL calibration│              │Wait for pulsed SEL calibration to finish│
│(set ACCL:LXB:XXXX:INTLK_RESET_ALL to│              │(Actions, Go)│              │(wait while ACCL:LXB:XXXX:PROBECALSTS is 2)│
│            1)           │              │(set ACCL:LXB:XXXX:PROBECALSTRT to 1)│              │                         │
└─────────────────────────┘              └─────────────────────────┘              └─────────────────────────┘
```

```
Reset failed?                Set the cavity drive level              Characterization crashed?
(ACCL:LXB:XXXX:RFPERMIT is 0?)  ──No──  (ACCL:LXB:XXXX:SEL_ASET)  ──Yes──  (ACCL:LXB:XXXX:PROBECALSTS is 0?)
                                     to 15%
```

Yes

```
Retried > 3 times?  ──Yes──  Throw an Error  ──No──  Loaded Q within tolerance?
                                                      HL: 1.5e7 < ACCL:LXB:XXXX:QLOADED_NEW < 3.5e7?
──No──                                                Non HL: 2.5e7 < ACCL:LXB:XXXX:QLOADED_NEW < 5.1e7?
```

No

Yes

```
Push cavity scale factor              Cavity scale factor within tolerance?              Push loaded Q
(set ACCL:LXB:XXXX:PUSH_CAV_SCALE.PROC to 1)  ←──  (10 < ACCL:LXB:XXXX:CAV:CAL_SCALEB_NEW < 125?)  ←──  (set ACCL:LXB:XXXX:PUSH_QLOADED.PROC to 1)
```

```
Set CW data decimation              Set pulsed data decimation              Set piezo feedback set point
(ACCL:LXB:XXXX:ACQ_DECIM_SEL.A)  ──  (ACCL:LXB:XXXX:ACQ_DECIM_SEL.C)  ──  (ACCL:LXB:XXXX:PZT:INTEG_SP)
to 255                                  to 255                                  to 0
```

```
Push probe Q              Calculate probe Q (Go)              Record FPC Q External
(set ACCL:LXB:XXXX:PUSH_QPROBECALC.PROC to 1)  ←──  (set ACCL:LXB:XXXX:QPROBE_CALC1.PROC to 1)  ←──  (ACCL:LXB:XXXX:QLOADED_NEW)
```

```
Record probe Q
(ACCL:LXB:XXXX:QPROBE_CALC2)
```

Piezo With RF

Turn cavity RF state off
(set ACCL:LXB:XXXX:RFCTRL to 0)

Wait for RF to turn off
(wait while ACCL:LXB:XXXX:RFSTATE is not 0)

Turn SSA on
(set ACCL:LXB:XXXX:SSA:PowerOn to 1)

Wait for SSA to turn on
(wait while ACCL:LXB:XXXX:SSA:StatusMsg is not 3)

Is HL?

No

Yes

Set amplitude
(ACCL:LXB:XXXX:ADES)
to 6.5 * 1.038

Set amplitude
(ACCL:LXB:XXXX:ADES)
to 6.5 * 0.346

Cavity online?
(ACCL:LXB:XXXX:HWMODE is 0?)

No

Throw Error

Set RF mode to SEL
(set ACCL:LXB:XXXX:RFMODECTRL to 2)

Yes

Yes

Wait for RF to turn on
(wait while ACCL:LXB:XXXX:RFSTATE is not 1)

Turn cavity on (RF State)
(set ACCL:LXB:XXXX:RFCTRL to 1)

Detune invalid?
(ACCL:LXB:XXXX:DFBEST.SEVR is 3?)

No

Piezo enabled?
(ACCL:LXB:XXXX:PZT:ENABLESTAT is 1?)

Yes

Piezo in manual?
(ACCL:LXB:XXXX:PZT:MODESTAT is 0?)

Yes

Detune
(ACCL:LXB:XXXX:DFBEST
> 100?)

Yes

No

No

No

Diable the piezo
(set ACCL:LXB:XXXX:PZT:ENABLE to 0)

Set piezo to feedback
(set ACCL:LXB:XXXX:PZT:MODECTRL to 1)

Run piezo test script (Actions, Go)
(set ACCL:LXB:XXXX:PZT:RFTESTSTRT to 1)

Enable the piezo
(set ACCL:LXB:XXXX:PZT:ENABLE to 1)

Set piezo to manual
(set ACCL:LXB:XXXX:PZT:MODECTRL to 0)

Wait for script to finish running
(wait while ACCL:LXB:XXXX:PZT:RFTESTSTS is 2)

Record amplifier gain B
(ACCL:LXB:XXXX:PZT:CHB_AMPGAIN)

Record amplifier gain A
(ACCL:LXB:XXXX:PZT:CHA_AMPGAIN)

Script completed?
(ACCL:LXB:XXXX:PZT:RFTESTSTS is 1?)

No

Record detune gain
(ACCL:LXB:XXXX:PZT:DFGAIN_NEW)

Test successful?
(ACCL:LXB:XXXX:PZT:RFTESTSTAT is 0?)

Yes

No

Ramp Up in SELAP

```
┌─────────────────────────┐      ┌─────────────────────────────────┐      ┌─────────────────────────────────┐
│   Turn off the RF       │      │   Wait for the RF to turn off   │      │   Turn on SSA                   │
│ (set ACCL:LXB:XXXX:     │─────▶│ (wait while ACCL:LXB:XXXX:      │─────▶│ (set ACCL:LXB:XXXX:SSA:PowerOn  │
│  RFCTRL to 0)           │      │  RFSTATE is not 0)              │      │  to 1)                          │
└─────────────────────────┘      └─────────────────────────────────┘      └─────────────────────────────────┘
                                                                                          │
                                                                                          ▼
┌─────────────────────────┐      ┌─────────────────────────────────┐      ┌─────────────────────────────────┐
│   Set the RF to SEL     │      │   Set the cavity amplitude      │      │   Wait for SSA to turn on       │
│ (set ACCL:LXB:XXXX:     │◀─────│ (ACCL:LXB:XXXX:ADES)            │◀─────│ (wait until ACCL:LXB:XXXX:SSA:  │
│  RFMODECTRL to 2)       │      │  to 5                           │      │  StatusMsg is 3)                │
└─────────────────────────┘      └─────────────────────────────────┘      └─────────────────────────────────┘
            │
            ▼
┌─────────────────────────┐                        ┌──────────────────────┐
│   Cavity online?        │───── No ──────────────▶│   Throw an error     │◀──────────────────────────────────┐
│ (ACCL:LXB:XXXX:HWMODE   │                        │                      │◀───────────────────────────┐     │
│  is 0?)                 │                        └──────────────────────┘                             │     │
└─────────────────────────┘                                   ▲                                         │     │
            │ Yes                                           Yes │                                        │     │
            ▼                                                   │                                        │     │
┌─────────────────────────┐                        ┌─────────────────────────────────┐                 │     │
│   Turn on the RF        │                        │   Detune invalid?               │                 │     │
│ (set ACCL:LXB:XXXX:     │                    ┌──▶│ (ACCL:LXB:XXXX:DFBEST.SEVR      │                 │     │
│  RFCTRL to 1)           │                    │   │  is 3?)                         │                 │     │
└─────────────────────────┘                    │   └─────────────────────────────────┘                 │     │
            │                                   │                 │ No                                  │     │
            ▼                                   │                 ▼                                     │     │
┌─────────────────────────┐                    │   ┌─────────────────────────────────┐                 │     │
│   Wait for the RF State │                    │   │   Detune                        │                 │     │
│   to turn on            │────────────────────┘   │ (ACCL:LXB:XXXX:DFBEST)          │─── Yes ─────────┘     │
│ (wait while ACCL:LXB:   │                        │  > 100?                         │                       │
│  XXXX:RFSTATE is not 1) │                        └─────────────────────────────────┘                       │
└─────────────────────────┘                                   │ No                                           │
                                                              ▼                                               │
┌─────────────────────────┐      ┌─────────────────────────────────┐                                         │
│   Set piezo to feedback │      │   Piezo with RF test done?      │                                          │
│ (set ACCL:LXB:XXXX:PZT: │◀─────│ (ACCL:LXB:XXXX:PZT:RFSTESTSTAT  │──── No ──────────────────────────────────┘
│  MODECTRL to 1)         │      │  is 0?)                         │
└─────────────────────────┘      └─────────────────────────────────┘
            │
            ▼
┌─────────────────────────┐      ┌─────────────────────────────────┐          ┌─────────────────────────────────┐
│   Set the RF to SELA    │      │ Cavity amplitude <= maximum     │          │   Cavity quenched?              │
│ (set ACCL:LXB:XXXX:     │      │ amplitude - 0.1?                │── Yes ──▶│ (ACCL:LXB:XXXX:QUENCH_LTCH      │
│  RFMODECTRL to 1)       │      │ (ADES <= ACCL:LXB:XXXX:         │          │  is 1?)                         │
└─────────────────────────┘      │  ADES_MAX - 0.1?)               │          └─────────────────────────────────┘
                                 └─────────────────────────────────┘              │ Yes (up to Throw an error)  │ No
                                               │ No                               ▼                             ▼
┌─────────────────────────┐      ┌─────────────────────────────────┐          ┌─────────────────────────────────┐
│   Set the RF to SELAP   │      │   Set the cavity amplitude      │          │   Increase the cavity amplitude │
│ (set ACCL:LXB:XXXX:     │◀─────│   (ADES) to the maximum         │          │   by 0.1                        │
│  RFMODECTRL to 0)       │      │   amplitude (ADES_MAX)          │          │ (set ADES to ADES + 0.1)        │
└─────────────────────────┘      └─────────────────────────────────┘          └─────────────────────────────────┘
```