asyn Driver Tutorial and Demo

Measurement Computing 1608GX-2A0

Mark Rivers

University of Chicago

Measurement Computing Corporation

- Inexpensive I/O devices
- PCI, USB, Ethernet
- Example USB devices
  - DAQ module with 8 analog inputs, up to 12-bit resolution, 50 kS/s, two D/A outputs, and 16 digital I/O lines $189.00
  - 8-channel quadrature encoder device (differential or single-ended) $599.00
  - 8-channel electromechanical relay interface device $249.00
  - 8-channel thermocouple input module $329.00
  - 16-channel, 500 kS/s device with two analog outputs, eight DIO lines, two 32-bit counter inputs, and one timer output $799.00
  - 10-channel, 16-bit, high-performance 9513-based counter/timer device $349.00
- I’ve purchased the last 2 (USB-1608GX-2A0, and USB-4303) and written EPICS drivers for them

USB-1608GX-2A0 ($799)

- 16-bit analog inputs
  - 16 single-ended channels or 8 differential channels
  - Programmable per-channel range: +-1V, +-2V, +-5V, +-10V
  - 500 kHz total maximum input rate, i.e. 1 channel at 500 kHz, 8 channels at 62.5 kHz, etc.
  - Internal or external trigger. External trigger shared with analog outputs.
  - Internal or external clock, input and output signals.
  - 4 kSample input FIFO, unlimited waveform length
- 16-bit analog outputs
  - 2 channels, fixed +-10V range
  - 500 kHz total maximum input rate, i.e. 1 channel at 500 kHz, 2 channels at 250 kHz
  - Internal or external trigger. External trigger shared with analog inputs.
  - Internal or external clock, input and output signals
  - 2 kSample output FIFO, unlimited waveform length

USB-1608GX-2A0 ($799)

- Digital inputs/outputs
  - 8 signals, individually programmable as inputs or outputs
- Pulse generator
  - 1 output
  - 64MHz clock, 32-bit registers
  - Programmable period, width, number of pulses, polarity
- Counters
  - 2 inputs
  - 20 MHz maximum rate, 32-bit registers

Measurement Computing EPICS Support

- They provide a nice Windows library for all of their devices. Very few calls to get a lot of functionality.
- Some of their older devices have Linux support from Dr. Warren J. Jasper at NCSU:
  - ftp://lx10.tx.ncsu.edu/pub/Linux/drivers
- Measurement Computing have recently released drivers for a few new devices (including USB-1608G) using a new open-source message based driver, with support for Linux, Mac and Windows.
  - However, the driver is written in C#, and so to use it on Linux requires the "mono" compiler for Linux. I don't think one can call it from gcc/g++, but I am not sure.
  - The C# driver is open-source, so it should definitely be possible to rewrite it in C++.
- For now my drivers use the Windows-only library, as will the example drivers to be presented today.

USB-1608GX-2AO EPICS Support

- Based on asynPortDriver
- Standard asyn device support
- 1250 lines of code
- Digital I/O
  - 8 bi records, 8 bo records, longin, longout
- Pulse generator
  - Control of pulse period (frequency), width, count, polarity
- Analog input
  - ai records, periodically scanned. Programmable range per channel.
- Analog output
  - ao records

USB-1608GX-2AO
EPICS Waveform Generator Support

- Global control
  - Internal/external trigger
  - Internal/external clock
  - Retrigger, retrigger count
  - Continuous/one-shot (hardware)
- Predefined waveforms (defined in driver, not by device)
  - Types
    - Sin wave
    - Square wave
    - Sawtooth
    - Pulse (adjustable width)
    - Random (white noise)
  - Control
    - Number of points in waveform
    - Repeat frequency (or time per point)
    - Amplitude
    - Offset

USB-1608GX-2AO
EPICS Waveform Generator Support

- User-defined waveforms (arbitrary waveform generator)
  - Waveforms defined by external application (e.g. Matlab, IDL, Python) and downloaded to waveform record over Channel Access
  - Control
    - Number of points in waveform
    - Repeat frequency (or time per point)
- Waveforms are defined in volts, not device units
- 16-bit output, maximum 500,000 output voltages/s
- Only limit on number of points is available RAM.

USB-1608GX-2AO
EPICS Waveform Digitizer Support

- Control
  - Number of points to digitize
  - Time per point
  - First channel to digitize
  - Number of channels to digitize
  - Burst mode (all channels measured as close together in time as possible)
  - Internal/external trigger
  - Internal/external clock
  - Retrigger, retrigger count
  - Continuous/one-shot (hardware)
  - Auto-restart (software)
  - Read rate to read device into waveform records. Automatically reads when acquisition completes.
- Waveforms are read in volts, not device units
- 16-bit input, maximum 500,000 conversions/s
- Only limit on number of points is available RAM.

USB-1608GX-2A0 Tutorial

- Will present 5 simplified versions of driver, building feature-by-feature
  - V1: 2 simple analog outputs
  - V2: Add 2 simple analog inputs
  - V3: Add digital outputs
  - V4: Add digital inputs; poller thread
  - V5: Add pulse generator output, counter inputs
  - Full version: Add waveform generators, waveform digitizers, and trigger control.

Measurement Computing 1608GX-2A0 Driver

Version 1

- 2 simple analog outputs
- 1 parameter, ANALOG_OUT_VALUE
- Use asynPortDriver C++ base class
- 131 lines of code

```
/* drvUSB1608G_V1.cpp
 *
 * Driver for Measurement Computing USB-1608G
 * multi-function DAQ board using asynPortDriver base class
 *
 * This version implements only simple analog outputs
 *
 * Mark Rivers
 * April 14, 2012
*/

#include <iocsh.h>
#include <epicsExport.h>
#include <asynPortDriver.h>

#include "cbw.h"

static const char *driverName = "USB1608G";

// Analog output parameters
#define analogOutValueString      "ANALOG_OUT_VALUE"

#define NUM_ANALOG_OUT  2   // Number of analog outputs on 1608G
#define MAX_SIGNALS     NUM_ANALOG_OUT
```

```
/** Class definition for the USB1608G class
  */
class USB1608G : public asynPortDriver {
public:
  USB1608G(const char *portName, int boardNum);

  /* These are the methods that we override from asynPortDriver */
  virtual asynStatus writeInt32(asynUser *pasynUser, epicsInt32 value);
  virtual asynStatus getBounds(asynUser *pasynUser, epicsInt32 *low,
                               epicsInt32 *high);

protected:
  // Analog output parameters
  int analogOutValue_;
  #define FIRST_USB1608G_PARAM  analogOutValue_
  #define LAST_USB1608G_PARAM   analogOutValue_

private:
  int boardNum_;
};

#define NUM_PARAMS (&LAST_USB1608G_PARAM - &FIRST_USB1608G_PARAM + 1)
```

```
/** Constructor for the USB1608G class
  */
USB1608G::USB1608G(const char *portName, int boardNum)
  : asynPortDriver(portName, MAX_SIGNALS, NUM_PARAMS,
      asynInt32Mask | asynDrvUserMask,  // Interfaces that we implement
      0,                                // Interfaces that do callbacks
      ASYN_MULTIDEVICE | ASYN_CANBLOCK, 1,
      /* ASYN_CANBLOCK=1, ASYN_MULTIDEVICE=1, autoConnect=1 */
      0, 0),  /* Default priority and stack size */
    boardNum_(boardNum)
{
  // Analog output parameters
  createParam(analogOutValueString, asynParamInt32, &analogOutValue_);
}
```

```
asynStatus USB1608G::getBounds(asynUser *pasynUser, epicsInt32 *low,
                                                    epicsInt32 *high)
{
  int function = pasynUser->reason;

  // Analog outputs are 16-bit devices
  if (function == analogOutValue_) {
    *low = 0;
    *high = 65535;
    return(asynSuccess);
  } else {
    return(asynError);
  }
}
```

```
asynStatus USB1608G::writeInt32(asynUser *pasynUser, epicsInt32 value)
{
  int addr;
  int function = pasynUser->reason;
  int status=0;
  static const char *functionName = "writeInt32";

  this->getAddress(pasynUser, &addr);
  setIntegerParam(addr, function, value);

  // Analog output functions
  if (function == analogOutValue_) {
    status = cbAOut(boardNum_, addr, BIP10VOLTS, value);
  }

  callParamCallbacks(addr);
  if (status == 0) {
    asynPrint(pasynUser, ASYN_TRACEIO_DRIVER,
              "%s:%s, port %s, wrote %d to address %d\n",
              driverName, functionName, this->portName, value, addr);
  } else {
    asynPrint(pasynUser, ASYN_TRACE_ERROR,
              "%s:%s, port %s, ERROR writing %d to address %d, status=%d\n",
              driverName, functionName, this->portName, value, addr, status);
  }
  return (status==0) ? asynSuccess : asynError;
}
```

```
/** Configuration command, called directly or from iocsh */
extern "C" int USB1608GConfig(const char *portName, int boardNum)
{
  USB1608G *pUSB1608G = new USB1608G(portName, boardNum);
  pUSB1608G = NULL;  /* This is just to avoid compiler warnings */
  return(asynSuccess);
}


static const iocshArg configArg0 = { "Port name",      iocshArgString};
static const iocshArg configArg1 = { "Board number",      iocshArgInt};
static const iocshArg * const configArgs[] = {&configArg0,
                                              &configArg1};
static const iocshFuncDef configFuncDef = {"USB1608GConfig", 2, configArgs};
static void configCallFunc(const iocshArgBuf *args)
{
  USB1608GConfig(args[0].sval, args[1].ival);
}

void drvUSB1608GRegister(void)
{
  iocshRegister(&configFuncDef,configCallFunc);
}

extern "C" {
epicsExportRegistrar(drvUSB1608GRegister);
}
```

measCompAnalogOut.template

```
record(ao,"$(P)$(R)") {
    field(PINI, "YES")
    field(DTYP, "asynInt32")
    field(FLNK, "$(P)$(R)Return.PROC  PP MS")
    field(OUT,  "@asyn($(PORT),$(ADDR))ANALOG_OUT_VALUE")
    field(EGUL, "$(EGUL)")
    field(DRVL, "$(DRVL)")
    field(LOPR, "$(LOPR)")
    field(EGUF, "$(EGUF)")
    field(DRVH, "$(DRVH)")
    field(HOPR, "$(HOPR)")
    field(PREC, "$(PREC)")
    field(LINR, "LINEAR")
    field(VAL,  "$(VAL)")
}
```

```
record(ao,"$(P)$(R)Return") {
    field(DTYP, "asynInt32")
    field(DISV, "0")
    field(SDIS, "$(P)$(R)Pulse.VAL  NPP NMS")
    field(OUT,  "@asyn($(PORT),$(ADDR))ANALOG_OUT_VALUE")
    field(OMSL, "closed_loop")
    field(EGUL, "$(EGUL)")
    field(DRVL, "$(DRVL)")
    field(LOPR, "$(LOPR)")
    field(EGUF, "$(EGUF)")
    field(DRVH, "$(DRVH)")
    field(HOPR, "$(HOPR)")
    field(PREC, "$(PREC)")
    field(LINR, "LINEAR")
    field(VAL,  "$(VAL)")
}

record(bo,"$(P)$(R)Pulse") {
    field(ZNAM, "Normal")
    field(ONAM, "Pulse")
}
```

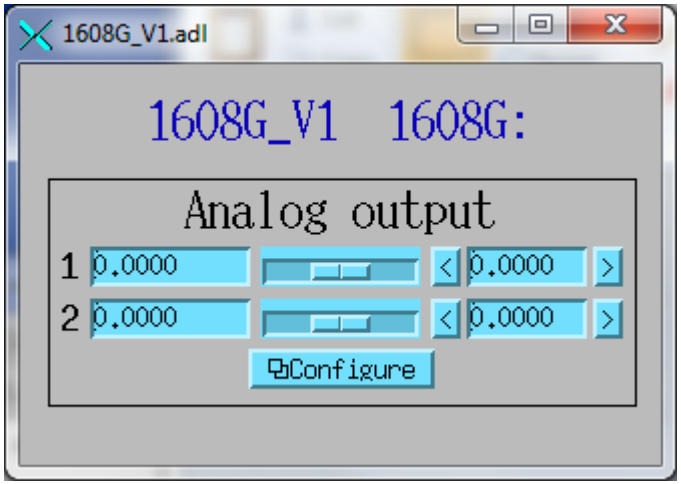
```
record(ao,"$(P)$(R)TweakVal") {
    field(PREC, "$(PREC)")
}

record(calcout,"$(P)$(R)TweakUp") {
    field(CALC, "A+B")
    field(INPA, "$(P)$(R).VAL  NPP MS")
    field(INPB, "$(P)$(R)TweakVal.VAL  NPP MS")
    field(OUT,  "$(P)$(R).VAL  PP MS")
    field(PREC, "$(PREC)")
}

record(calcout,"$(P)$(R)TweakDown") {
    field(CALC, "A-B")
    field(INPA, "$(P)$(R).VAL  NPP MS")
    field(INPB, "$(P)$(R)TweakVal.VAL  NPP MS")
    field(OUT,  "$(P)$(R).VAL  PP MS")
    field(PREC, "$(PREC)")
}
```

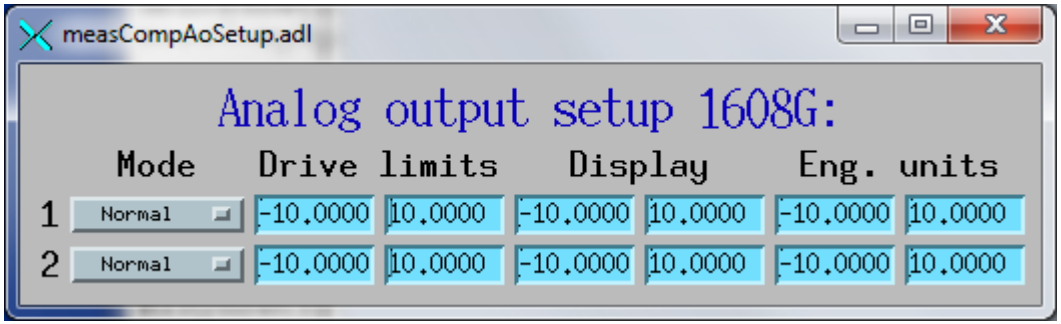
st.cmd_V1

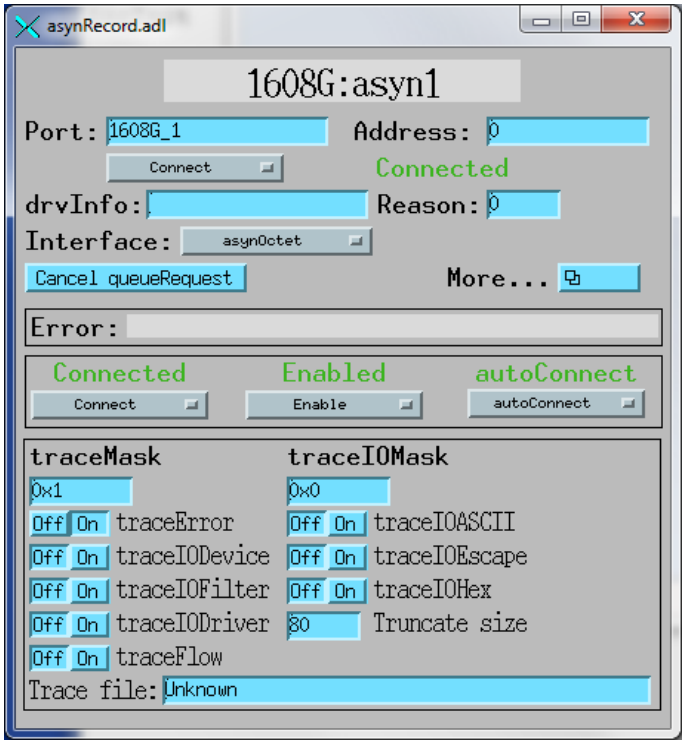
```
< envPaths

## Register all support components
dbLoadDatabase "../../dbd/measCompApp.dbd"
measCompApp_registerRecordDeviceDriver pdbbase

dbLoadTemplate("1608G.substitutions_V1")

## Configure port driver
# USB1608GConfig(
#   portName,  # The name to give to this asyn port driver
#   boardNum)  # The number of this board assigned by the
               #   Measurement Computing Instacal program
USB1608GConfig("1608G_1", 1)

#asynSetTraceMask 1608G_1 -1 255

iocInit
```

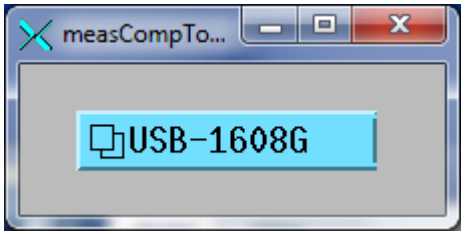
1608G.substitutions_V1

```
# asyn record
file "$(ASYN)/db/asynRecord.db"
{
pattern
{    P,        R,      PORT,    ADDR, IMAX, OMAX}
{   1608G:,  asyn1, 1608G_1,     0,  80,    80}
}

# Analog outputs
file "$(MEASCOMP)/measCompApp/Db/measCompAnalogOut.template"
{
pattern
{    P,        R,    VAL,    PORT,    ADDR, EGUL, DRVL, LOPR, EGUF, DRVH, HOPR, PREC}
{   1608G:,  Ao1,    0,  1608G_1,     0,  -10., -10., -10.,  10.,  10.,  10.,    4}
{   1608G:,  Ao2,    0,  1608G_1,     1,  -10., -10., -10.,  10.,  10.,  10.,    4}
}
```


1608G_V1.adl
1608G_V1 1608G:
Analog output
1
0.0000
0.0000
2
0.0000
0.0000
Configure


measCompAoSetup.adl
Analog output setup 1608G:
Mode
Drive limits
Display
Eng. units
1
Normal
-10.0000
10.0000
-10.0000
10.0000
-10.0000
10.0000
2
Normal
-10.0000
10.0000
-10.0000
10.0000
-10.0000
10.0000


asynRecord.adl
1608G:asyn1
Port:
1608G_1
Address:
0
Connect
Connected
drvInfo:
Reason:
0
Interface:
asynOctet
Cancel queueRequest
More...
Error:
Connected
Enabled
autoConnect
Connect
Enable
autoConnect
traceMask
traceIOMask
0x1
0x0
Off On traceError
Off On traceIOASCII
Off On traceIODevice
Off On traceIOEscape
Off On traceIOFilter
Off On traceIOHex
Off On traceIODriver
80
Truncate size
Off On traceFlow
Trace file:
Unknown


measCompTo...
USB-1608G

Measurement Computing 1608GX-2A0 Driver

Version 2

- Add 8 simple analog inputs
  - 2 new parameters, ANALOG_IN_VALUE, ANALOG_IN_RANGE
- Add report() function
- 197 lines of code (~60 more than V1)

```
/* drvUSB1608G_V2.cpp

 *
 * Driver for Measurement Computing USB-1608G multi-function DAQ board using
asynPortDriver base class
 *
 * This version implements simple analog inputs and simple analog outputs
 *
 * Mark Rivers
 * April 14, 2012
*/

#include <iocsh.h>
#include <epicsExport.h>
#include <asynPortDriver.h>

#include "cbw.h"

static const char *driverName = "USB1608G";

// Analog output parameters
#define analogOutValueString      "ANALOG_OUT_VALUE"

// Analog input parameters
#define analogInValueString       "ANALOG_IN_VALUE"
#define analogInRangeString       "ANALOG_IN_RANGE"

#define NUM_ANALOG_IN   16  // Number analog inputs on 1608G
#define NUM_ANALOG_OUT  2   // Number of analog outputs on 1608G
#define MAX_SIGNALS     NUM_ANALOG_IN
```

```
/** Class definition for the USB1608G class

  */
class USB1608G : public asynPortDriver {
public:
  USB1608G(const char *portName, int boardNum);

  /* These are the methods that we override from asynPortDriver */
  virtual asynStatus writeInt32(asynUser *pasynUser, epicsInt32 value);
  virtual asynStatus readInt32(asynUser *pasynUser, epicsInt32 *value);
  virtual asynStatus getBounds(asynUser *pasynUser, epicsInt32 *low,
                               epicsInt32 *high);
  virtual void report(FILE *fp, int details);

protected:
  // Analog output parameters
  int analogOutValue_;
  #define FIRST_USB1608G_PARAM  analogOutValue_

  // Analog input parameters
  int analogInValue_;
  int analogInRange_;
  #define LAST_USB1608G_PARAM   analogInRange_

private:
  int boardNum_;
};

#define NUM_PARAMS (&LAST_USB1608G_PARAM - &FIRST_USB1608G_PARAM + 1)
```

```
/** Constructor for the USB1608G class

  */
USB1608G::USB1608G(const char *portName, int boardNum)
  : asynPortDriver(portName, MAX_SIGNALS, NUM_PARAMS,
      asynInt32Mask | asynDrvUserMask,  // Interfaces that we implement
      0,                                // Interfaces that do callbacks
      ASYN_MULTIDEVICE | ASYN_CANBLOCK, 1,
     /* ASYN_CANBLOCK=1, ASYN_MULTIDEVICE=1, autoConnect=1 */
      0, 0),  /* Default priority and stack size */
    boardNum_(boardNum)
{
  // Analog output parameters
  createParam(analogOutValueString,           asynParamInt32, &analogOutValue_);

  // Analog input parameters
  createParam(analogInValueString,            asynParamInt32, &analogInValue_);
  createParam(analogInRangeString,            asynParamInt32, &analogInRange_);

}
```

```
asynStatus USB1608G::getBounds(asynUser *pasynUser, epicsInt32 *low,
                                                    epicsInt32 *high)
{
  int function = pasynUser->reason;

  // Both the analog outputs and analog inputs are 16-bit devices
  if ((function == analogOutValue_) ||
      (function == analogInValue_)) {
    *low = 0;
    *high = 65535;
    return(asynSuccess);
  } else {
    return(asynError);
  }
}
```

NOTE: No change, we don't handle analogOutRange_ here, just put in parameter library

```
asynStatus USB1608G::writeInt32(asynUser *pasynUser, epicsInt32 value)
{
  int addr;
  int function = pasynUser->reason;
  int status=0;
  static const char *functionName = "writeInt32";

  this->getAddress(pasynUser, &addr);
  setIntegerParam(addr, function, value);

  // Analog output functions
  if (function == analogOutValue_) {
    status = cbAOut(boardNum_, addr, BIP10VOLTS, value);
  }

  callParamCallbacks(addr);
  if (status == 0) {
    asynPrint(pasynUser, ASYN_TRACEIO_DRIVER,
              "%s:%s, port %s, wrote %d to address %d\n",
              driverName, functionName, this->portName, value, addr);
  } else {
    asynPrint(pasynUser, ASYN_TRACE_ERROR,
              "%s:%s, port %s, ERROR writing %d to address %d, status=%d\n",
              driverName, functionName, this->portName, value, addr, status);
  }
  return (status==0) ? asynSuccess : asynError;
}
```

```
asynStatus USB1608G::readInt32(asynUser *pasynUser, epicsInt32 *value)
{
  int addr;
  int function = pasynUser->reason;
  int status=0;
  unsigned short shortVal;
  int range;
  //static const char *functionName = "readInt32";

  this->getAddress(pasynUser, &addr);

  // Analog input function
  if (function == analogInValue_) {
    getIntegerParam(addr, analogInRange_, &range);
    status = cbAIn(boardNum_, addr, range, &shortVal);
    *value = shortVal;
    setIntegerParam(addr, analogInValue_, *value);
  }

  // Other functions we call the base class method
  else {
     status = asynPortDriver::readInt32(pasynUser, value);
  }

  callParamCallbacks(addr);
  return (status==0) ? asynSuccess : asynError;
}
```

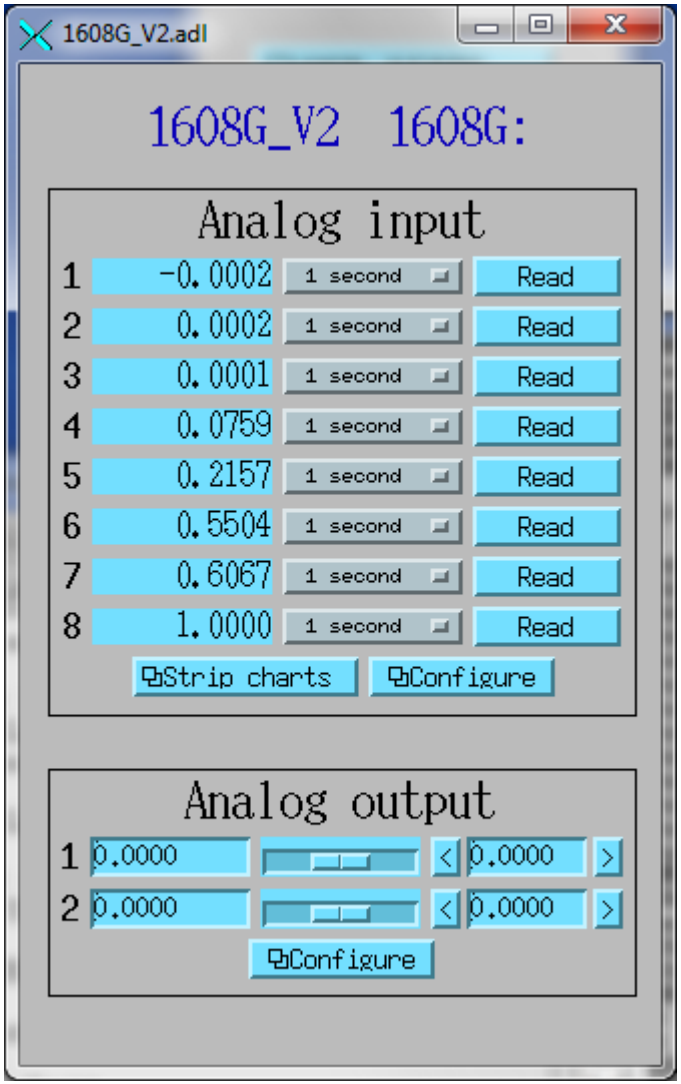
```
/* Report  parameters */
void USB1608G::report(FILE *fp, int details)
{
  int i;
  int range;

  fprintf(fp, "  Port: %s, board number=%d\n",
          this->portName, boardNum_);
  if (details >= 1) {
    for (i=0; i<NUM_ANALOG_IN; i++) {
      getIntegerParam(i, analogInRange_, &range);
      fprintf(fp, "channel %d range=%d", i, range);
    }
    fprintf(fp, "\n");
  }
  asynPortDriver::report(fp, details);
}
```

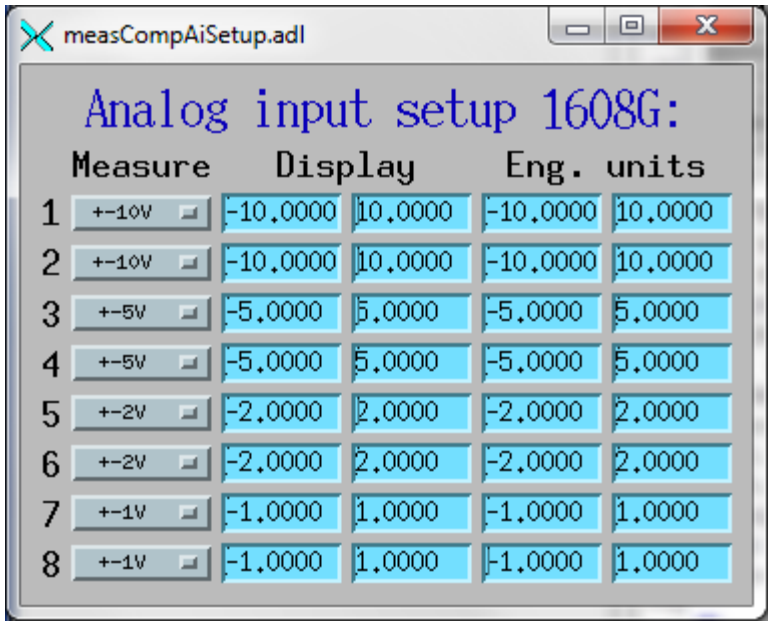
measCompAnalogIn.template

```
record(ai,"$(P)$(R)")
{
    field(SCAN, "$(SCAN)")
    field(DTYP, "asynInt32")
    field(INP,  "@asyn($(PORT),$(ADDR))ANALOG_IN_VALUE")
    field(LINR, "LINEAR")
    field(EGUF, "$(EGUF)")
    field(EGUL, "$(EGUL)")
    field(HOPR, "$(HOPR)")
    field(LOPR, "$(LOPR)")
    field(PREC, "$(PREC)")
}
# Note: the ZRVL, etc. fields correspond to the values of BIP1VOLTS, etc. in cbw.h
record(mbbo,"$(P)$(R)Range")
{
    field(PINI, "YES")
    field(DTYP, "asynInt32")
    field(OUT,  "@asyn($(PORT),$(ADDR))ANALOG_IN_RANGE")
    field(ZRST, "+-1V")
    field(ZRVL, "4")
    field(ONST, "+-2V")
    field(ONVL, "14")
    field(TWST, "+-5V")
    field(TWVL, "0")
    field(THST, "+-10V")
    field(THVL, "1")
    field(VAL,  "$(RANGE)")
}
```

1608G.substitutions_V2

```
# Analog inputs
file "$(MEASCOMP)/measCompApp/Db/measCompAnalogIn.template"
{
pattern
{    P,         R,    PORT,    ADDR,  EGUL, LOPR, EGUF, HOPR,  RANGE,    SCAN,    PREC}
{   1608G:,    Ai1, 1608G_1,     0,  -10., -10.,  10.,  10.,    3,  "1 second",    4}
{   1608G:,    Ai2, 1608G_1,     1,  -10., -10.,  10.,  10.,    3,  "1 second",    4}
{   1608G:,    Ai3, 1608G_1,     2,   -5.,  -5.,   5.,   5.,    2,  "1 second",    4}
{   1608G:,    Ai4, 1608G_1,     3,   -5.,  -5.,   5.,   5.,    2,  "1 second",    4}
{   1608G:,    Ai5, 1608G_1,     4,   -2.,  -2.,   2.,   2.,    1,  "1 second",    4}
{   1608G:,    Ai6, 1608G_1,     5,   -2.,  -2.,   2.,   2.,    1,  "1 second",    4}
{   1608G:,    Ai7, 1608G_1,     6,   -1.,  -1.,   1.,   1.,    0,  "1 second",    4}
{   1608G:,    Ai8, 1608G_1,     7,   -1.,  -1.,   1.,   1.,    0,  "1 second",    4}
}
```


1608G_V2.adl
1608G_V2 1608G:
Analog input
1 -0.0002 1 second Read
2 0.0002 1 second Read
3 0.0001 1 second Read
4 0.0759 1 second Read
5 0.2157 1 second Read
6 0.5504 1 second Read
7 0.6067 1 second Read
8 1.0000 1 second Read
Strip charts
Configure
Analog output
1 0.0000 0.0000
2 0.0000 0.0000
Configure


measCompAiSetup.adl
Analog input setup 1608G:
Measure Display Eng. units
1 +-10V -10.0000 10.0000 -10.0000 10.0000
2 +-10V -10.0000 10.0000 -10.0000 10.0000
3 +-5V -5.0000 5.0000 -5.0000 5.0000
4 +-5V -5.0000 5.0000 -5.0000 5.0000
5 +-2V -2.0000 2.0000 -2.0000 2.0000
6 +-2V -2.0000 2.0000 -2.0000 2.0000
7 +-1V -1.0000 1.0000 -1.0000 1.0000
8 +-1V -1.0000 1.0000 -1.0000 1.0000

Measurement Computing 1608GX-2A0 Driver

Version 3

- Add digital outputs
  - 2 new parameters, DIGITAL_DIRECTION, DIGITAL_OUTPUT
- 253 lines of code (~60 more than Version 2)

```
/* drvUSB1608G_V3.cpp
 *
 * This version implements digital outputs, simple analog inputs and simple analog
outputs
 *
 * Mark Rivers
 * April 14, 2012
*/
#include <iocsh.h>
#include <epicsExport.h>
#include <asynPortDriver.h>
#include "cbw.h"

static const char *driverName = "USB1608G";

// Analog output parameters
#define analogOutValueString      "ANALOG_OUT_VALUE"

// Analog input parameters
#define analogInValueString       "ANALOG_IN_VALUE"
#define analogInRangeString       "ANALOG_IN_RANGE"

// Digital I/O parameters
#define digitalDirectionString    "DIGITAL_DIRECTION"
#define digitalOutputString       "DIGITAL_OUTPUT"

#define NUM_ANALOG_IN   16  // Number analog inputs on 1608G
#define NUM_ANALOG_OUT  2   // Number of analog outputs on 1608G
#define NUM_IO_BITS     8   // Number of digital I/O bits on 1608G
#define MAX_SIGNALS     NUM_ANALOG_IN
```

```
/** Class definition for the USB1608G class
  */
class USB1608G : public asynPortDriver {
public:
  USB1608G(const char *portName, int boardNum);

  /* These are the methods that we override from asynPortDriver */
  virtual asynStatus writeInt32(asynUser *pasynUser, epicsInt32 value);
  virtual asynStatus readInt32(asynUser *pasynUser, epicsInt32 *value);
  virtual asynStatus getBounds(asynUser *pasynUser, epicsInt32 *low,
                                                    epicsInt32 *high);
  virtual asynStatus writeUInt32Digital(asynUser *pasynUser, epicsUInt32 value,
                                        epicsUInt32 mask);
  virtual void report(FILE *fp, int details);

protected:
  // Analog output parameters
  int analogOutValue_;
  #define FIRST_USB1608G_PARAM  analogOutValue_
  // Analog input parameters
  int analogInValue_;
  int analogInRange_;
  // Digital I/O parameters
  int digitalDirection_;
  int digitalOutput_;
  #define LAST_USB1608G_PARAM digitalOutput_

private:
  int boardNum_;
};
```

```
/** Constructor for the USB1608G class
  */
USB1608G::USB1608G(const char *portName, int boardNum)
  : asynPortDriver(portName, MAX_SIGNALS, NUM_PARAMS,
      // Interfaces that we implement
      asynInt32Mask | asynUInt32DigitalMask | asynDrvUserMask,
      // Interfaces that do callbacks
                       asynUInt32DigitalMask,
      ASYN_MULTIDEVICE | ASYN_CANBLOCK, 1,
      /* ASYN_CANBLOCK=1, ASYN_MULTIDEVICE=1, autoConnect=1 */
      0, 0),  /* Default priority and stack size */
    boardNum_(boardNum)
{
  // Analog output parameters
  createParam(analogOutValueString,           asynParamInt32, &analogOutValue_);

  // Analog input parameters
  createParam(analogInValueString,            asynParamInt32, &analogInValue_);
  createParam(analogInRangeString,            asynParamInt32, &analogInRange_);

  // Digital I/O parameters
  createParam(digitalDirectionString,  asynParamUInt32Digital, &digitalDirection_);
  createParam(digitalOutputString,     asynParamUInt32Digital, &digitalOutput_);
}
```

```
asynStatus USB1608G::writeUInt32Digital(asynUser *pasynUser, epicsUInt32 value,
epicsUInt32 mask)
{
  int function = pasynUser->reason;
  int status=0;
  int i;
  epicsUInt32 outValue=0, outMask, direction=0;
  static const char *functionName = "writeUInt32Digital";


  setUIntDigitalParam(function, value, mask);
  if (function == digitalDirection_) {
    outValue = (value == 0) ? DIGITALIN : DIGITALOUT;
    for (i=0; i<NUM_IO_BITS; i++) {
      if ((mask & (1<<i)) != 0) {
        status = cbDConfigBit(boardNum_, AUXPORT, i, outValue);
      }
    }
  }

  else if (function == digitalOutput_) {
    getUIntDigitalParam(digitalDirection_, &direction, 0xFFFFFFFF);
    for (i=0, outMask=1; i<NUM_IO_BITS; i++, outMask = (outMask<<1)) {
      // Only write the value if the mask has this bit set and the direction
      // for that bit is output (1)
      outValue = ((value &outMask) == 0) ? 0 : 1;
      if ((mask & outMask & direction) != 0) {
        status = cbDBitOut(boardNum_, AUXPORT, i, outValue);
      }
    }
```

```
  }

  callParamCallbacks();
  if (status == 0) {
    asynPrint(pasynUser, ASYN_TRACEIO_DRIVER,
      "%s:%s, port %s, wrote outValue=0x%x, value=0x%x, mask=0x%x, direction=0x%x\n",
      driverName, functionName, this->portName, outValue, value, mask, direction);
  } else {
    asynPrint(pasynUser, ASYN_TRACE_ERROR,
      "%s:%s, port %s, ERROR writing outValue=0x%x, value=0x%x, mask=0x%x,
      direction=0x%x, status=%d\n",
      driverName, functionName, this->portName, outValue, value, mask, direction,
      status);
  }
  return (status==0) ? asynSuccess : asynError;
}
```

measCompBinaryDir.template

```
record(bo, "$(P)$(R)")
{
    field(PINI, "YES")
    field(DTYP, "asynUInt32Digital")
    field(OUT,  "@asynMask($(PORT),$(ADDR),$(MASK))DIGITAL_DIRECTION")
    field(ZNAM, "In")
    field(ONAM, "Out")
    field(VAL,  "$(VAL)")
    field(PINI, "YES")
}
```

measCompBinaryOut.template

```
record(bo, "$(P)$(R)")
{
    field(PINI, "YES")
    field(DTYP, "asynUInt32Digital")
    field(OUT,  "@asynMask($(PORT),$(ADDR),$(MASK))DIGITAL_OUTPUT")
    field(ZNAM, "Low")
    field(ONAM, "High")
}
# This is a readback of the output, with SCAN=I/O Intr
record(bi, "$(P)$(R)_RBV")
{
    field(DTYP, "asynUInt32Digital")
    field(INP,  "@asynMask($(PORT),$(ADDR),$(MASK))DIGITAL_OUTPUT")
    field(ZNAM, "Low")
    field(ONAM, "High")
    field(SCAN, "I/O Intr")
```

```
}
```

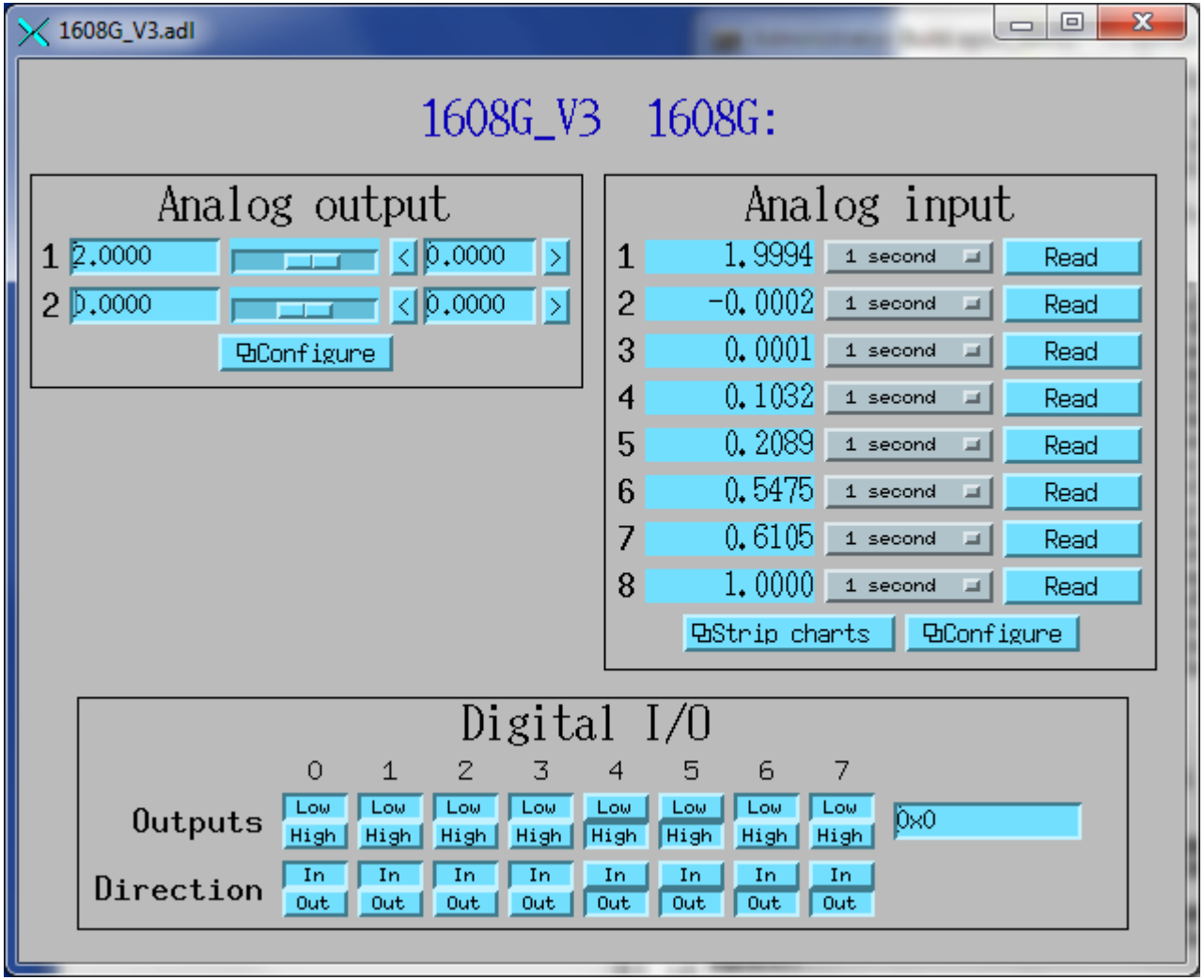
measCompLongOut.template

```
record(longout, "$(P)$(R)")
{
    field(PINI, "YES")
    field(DTYP, "asynUInt32Digital")
    field(OUT,  "@asynMask($(PORT),$(ADDR),$(MASK))DIGITAL_OUTPUT")
}

# This is a readback of the output, with SCAN=I/O Intr
record(longin, "$(P)$(R)_RBV")
{
    field(DTYP, "asynUInt32Digital")
    field(INP,  "@asynMask($(PORT),$(ADDR),$(MASK))DIGITAL_OUTPUT")
    field(SCAN, "I/O Intr")
}
```

1608G.substitutions_V3

```
file "$(MEASCOMP)/measCompApp/Db/measCompLongOut.template"
{
pattern
{    P,        R,    MASK,    PORT,     ADDR}
{   1608G:,   Lo,    0xFF,   1608G_1,      0}
}

file "$(MEASCOMP)/measCompApp/Db/measCompBinaryOut.template"
{
pattern
{    P,        R,    MASK,    PORT,     ADDR}
{   1608G:,   Bo1,   0x01    1608G_1,      0}
{   1608G:,   Bo2,   0x02    1608G_1,      0}
{   1608G:,   Bo3,   0x04    1608G_1,      0}
{   1608G:,   Bo4,   0x08    1608G_1,      0}
{   1608G:,   Bo5,   0x10    1608G_1,      0}
{   1608G:,   Bo6,   0x20    1608G_1,      0}
{   1608G:,   Bo7,   0x40    1608G_1,      0}
{   1608G:,   Bo8,   0x80    1608G_1,      0}
}
```

```
# Direction bits on binary I/O
#  VAL 0=input, 1=output
file "$(MEASCOMP)/measCompApp/Db/measCompBinaryDir.template"
{
pattern
{    P,        R,    MASK,  VAL,  PORT,     ADDR}
{   1608G:,  Bd1,  0x01    0,  1608G_1,      0}
{   1608G:,  Bd2,  0x02    0,  1608G_1,      0}
{   1608G:,  Bd3,  0x04    0,  1608G_1,      0}
{   1608G:,  Bd4,  0x08    0,  1608G_1,      0}
{   1608G:,  Bd5,  0x10    1,  1608G_1,      0}
{   1608G:,  Bd6,  0x20    1,  1608G_1,      0}
{   1608G:,  Bd7,  0x40    1,  1608G_1,      0}
{   1608G:,  Bd8,  0x80    1,  1608G_1,      0}
}
```


1608G_V3.adl
1608G_V3 1608G:
Analog output
1 2.0000 0.0000
2 0.0000 0.0000
Configure
Analog input
1 1.9994 1 second Read
2 -0.0002 1 second Read
3 0.0001 1 second Read
4 0.1032 1 second Read
5 0.2089 1 second Read
6 0.5475 1 second Read
7 0.6105 1 second Read
8 1.0000 1 second Read
Strip charts
Configure
Digital I/O
0 1 2 3 4 5 6 7
Outputs
Low
High
0x0
Direction
In
Out

Measurement Computing 1608GX-2A0 Driver

Version 4

- Add digital inputs
  - 1 new parameter, DIGITAL_INPUT
- Add a poller thread to read digital inputs; their records are SCAN=I/O Intr
- 314 lines of code (~60 more than Version 3)

```
/* drvUSB1608G_V2.cpp
* This version implements digital inputs and outputs, simple analog inputs and simple
analog outputs, with a poller thread
 *
 * Mark Rivers
 * April 14, 2012
*/

#include <iocsh.h>
#include <epicsExport.h>
#include <epicsThread.h>
#include <asynPortDriver.h>
#include "cbw.h"

static const char *driverName = "USB1608G";

// Analog output parameters
#define analogOutValueString      "ANALOG_OUT_VALUE"
// Analog input parameters
#define analogInValueString       "ANALOG_IN_VALUE"
#define analogInRangeString       "ANALOG_IN_RANGE"
// Digital I/O parameters
#define digitalDirectionString    "DIGITAL_DIRECTION"
#define digitalInputString        "DIGITAL_INPUT"
#define digitalOutputString       "DIGITAL_OUTPUT"

#define NUM_ANALOG_IN   16  // Number analog inputs on 1608G
#define NUM_ANALOG_OUT  2   // Number of analog outputs on 1608G
#define NUM_IO_BITS     8   // Number of digital I/O bits on 1608G
#define MAX_SIGNALS     NUM_ANALOG_IN
```

```
#define DEFAULT_POLL_TIME 0.01
/** Class definition for the USB1608G class
  */
class USB1608G : public asynPortDriver {
public:
  USB1608G(const char *portName, int boardNum);

  /* These are the methods that we override from asynPortDriver */
  virtual asynStatus writeInt32(asynUser *pasynUser, epicsInt32 value);
  virtual asynStatus readInt32(asynUser *pasynUser, epicsInt32 *value);
  virtual asynStatus getBounds(asynUser *pasynUser, epicsInt32 *low,
                                                    epicsInt32 *high);
  virtual asynStatus writeUInt32Digital(asynUser *pasynUser, epicsUInt32 value,
                                        epicsUInt32 mask);
  virtual void report(FILE *fp, int details);
  // These should be private but are called from C
  virtual void pollerThread(void);

protected:
  // Analog output parameters
  int analogOutValue_;
  #define FIRST_USB1608G_PARAM  analogOutValue_

  // Analog input parameters
  int analogInValue_;
  int analogInRange_;

  // Digital I/O parameters
  int digitalDirection_;
  int digitalInput_;
```

```
  int digitalOutput_;
  #define LAST_USB1608G_PARAM digitalOutput_

private:
  int boardNum_;
  double pollTime_;
  int forceCallback_;
};

#define NUM_PARAMS (&LAST_USB1608G_PARAM - &FIRST_USB1608G_PARAM + 1)

static void pollerThreadC(void * pPvt)
{
    USB1608G *pUSB1608G = (USB1608G *)pPvt;
    pUSB1608G->pollerThread();
}
```

```
/** Constructor for the USB1608G class */
USB1608G::USB1608G(const char *portName, int boardNum)
  : asynPortDriver(portName, MAX_SIGNALS, NUM_PARAMS,
      // Interfaces that we implement
      asynInt32Mask | asynUInt32DigitalMask | asynDrvUserMask,
      // Interfaces that do callbacks
      asynUInt32DigitalMask,
      ASYN_MULTIDEVICE | ASYN_CANBLOCK, 1,
      /* ASYN_CANBLOCK=1, ASYN_MULTIDEVICE=1, autoConnect=1 */
      0, 0),  /* Default priority and stack size */
    boardNum_(boardNum),
    pollTime_(DEFAULT_POLL_TIME),
    forceCallback_(1)
{
  // Analog output parameters
  createParam(analogOutValueString,           asynParamInt32, &analogOutValue_);
  // Analog input parameters
  createParam(analogInValueString,            asynParamInt32, &analogInValue_);
  createParam(analogInRangeString,            asynParamInt32, &analogInRange_);
  // Digital I/O parameters
  createParam(digitalDirectionString,  asynParamUInt32Digital, &digitalDirection_);
  createParam(digitalInputString,      asynParamUInt32Digital, &digitalInput_);
  createParam(digitalOutputString,     asynParamUInt32Digital, &digitalOutput_);
  /* Start the thread to poll digital inputs and do callbacks to device support */
  epicsThreadCreate("USB1608GPoller",
                    epicsThreadPriorityLow,
                    epicsThreadGetStackSize(epicsThreadStackMedium),
                    (EPICSTHREADFUNC)pollerThreadC,
                    this);
}
```

```
void USB1608G::pollerThread()
{
  /* This function runs in a separate thread.  It waits for the poll time */
  static const char *functionName = "pollerThread";
  epicsUInt32 newValue, changedBits, prevInput=0;
  unsigned short biVal;;
  int i, status;

  while(1) {
    lock();
    // Read the digital inputs
    status = cbDIn(boardNum_, AUXPORT, &biVal);
    if (status)
      asynPrint(pasynUserSelf, ASYN_TRACE_ERROR,
                "%s:%s: ERROR calling cbDIn, status=%d\n",
                driverName, functionName, status);
    newValue = biVal;
    changedBits = newValue ^ prevInput;
    if (forceCallback_ || (changedBits != 0)) {
      prevInput = newValue;
      forceCallback_ = 0;
      setUIntDigitalParam(digitalInput_, newValue, 0xFFFFFFFF);
    }
    for (i=0; i<MAX_SIGNALS; i++) {
      callParamCallbacks(i);
    }
    unlock();
    epicsThreadSleep(pollTime_);
  }
}
```

measCompBinaryIn.template

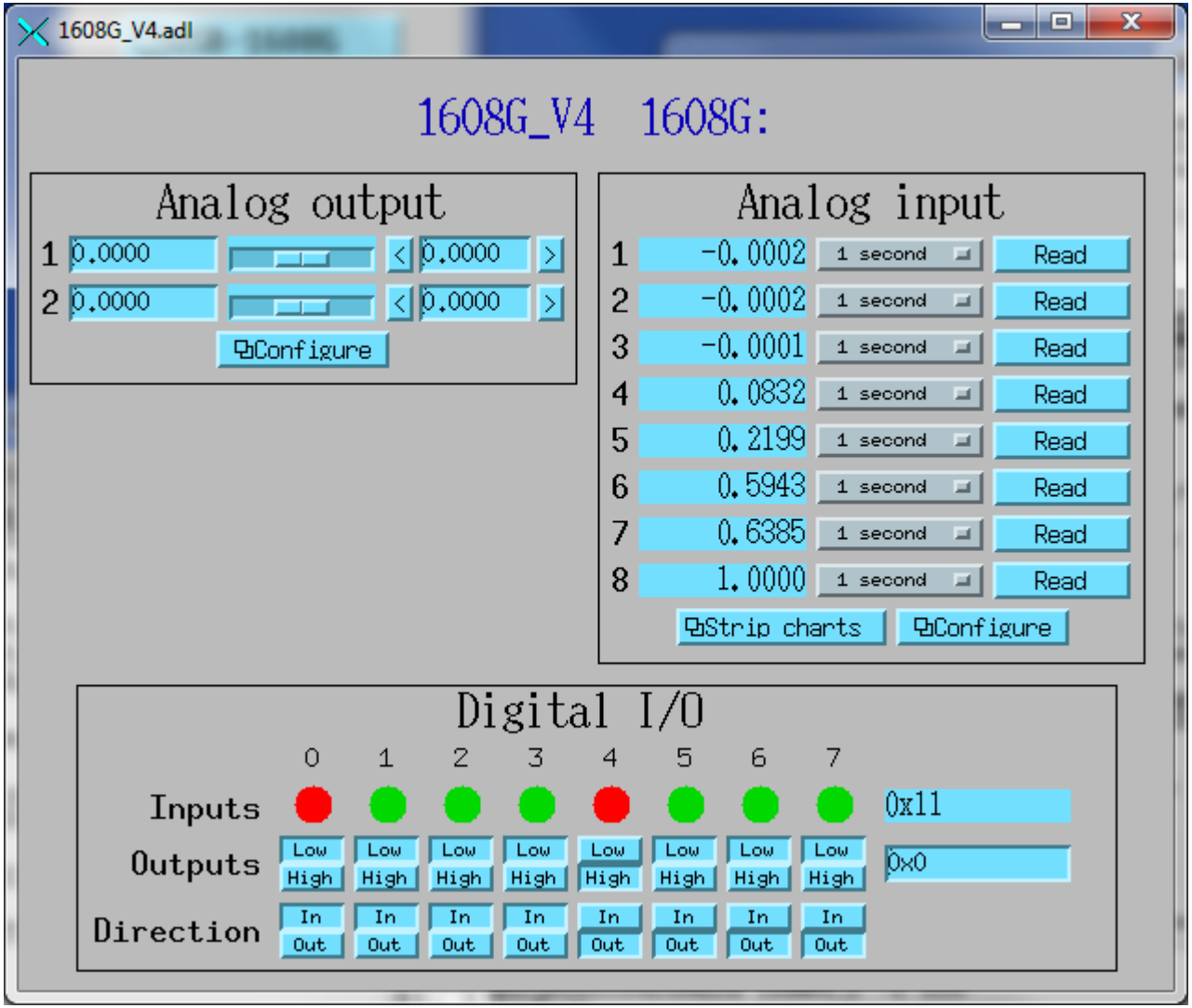
```
record(bi, "$(P)$(R)")
{
    field(DTYP, "asynUInt32Digital")
    field(INP,  "@asynMask($(PORT),$(ADDR),$(MASK))DIGITAL_INPUT")
    field(ZNAM, "Low")
    field(ONAM, "High")
    field(SCAN, "I/O Intr")
}
```

measCompLongIn.template

```
record(longin, "$(P)$(R)")
{
    field(DTYP, "asynUInt32Digital")
    field(INP,  "@asynMask($(PORT),$(ADDR),$(MASK))DIGITAL_INPUT")
    field(SCAN, "I/O Intr")
}
```

1608G.substitutions_V4

```
file "$(MEASCOMP)/measCompApp/Db/measCompLongIn.template"
{
pattern
{    P,        R,    MASK,    PORT,     ADDR}
{   1608G:,   Li,    0xFF,   1608G_1,      0}
}

file "$(MEASCOMP)/measCompApp/Db/measCompBinaryIn.template"
{
pattern
{    P,        R,    MASK,    PORT,     ADDR}
{   1608G:,   Bi1,   0x01    1608G_1,      0}
{   1608G:,   Bi2,   0x02    1608G_1,      0}
{   1608G:,   Bi3,   0x04    1608G_1,      0}
{   1608G:,   Bi4,   0x08    1608G_1,      0}
{   1608G:,   Bi5,   0x10    1608G_1,      0}
{   1608G:,   Bi6,   0x20    1608G_1,      0}
{   1608G:,   Bi7,   0x40    1608G_1,      0}
{   1608G:,   Bi8,   0x80    1608G_1,      0}
}
```


1608G_V4.adl
1608G_V4 1608G:
Analog output
1 0.0000 0.0000
2 0.0000 0.0000
Configure
Analog input
1 -0.0002 1 second Read
2 -0.0002 1 second Read
3 -0.0001 1 second Read
4 0.0832 1 second Read
5 0.2199 1 second Read
6 0.5943 1 second Read
7 0.6385 1 second Read
8 1.0000 1 second Read
Strip charts
Configure
Digital I/O
0 1 2 3 4 5 6 7
Inputs
0x11
Outputs
Low High
0x0
Direction
In Out

Measurement Computing 1608GX-2A0 Driver

Version 5

- Add pulse generator output and counter inputs
  - 8 new parameters, PULSE_RUN, PULSE_PERIOD, PULSE_WIDTH, PULSE_DELAY, PULSE_COUNT, PULSE_IDLE_STATE, COUNTER_VALUE, COUNTER_RESET
- Counter inputs are polled in poller thread, SCAN=I/O Intr
- 484 lines of code (~170 more than Version 4)

```
/* drvUSB1608G_V5.cpp
 *
 * Driver for Measurement Computing USB-1608G multi-function DAQ board using
asynPortDriver base class
 *
 * This version implements digital inputs and outputs, simple analog inputs and
simple analog outputs, will a poller thread
 *
 * Mark Rivers
 * April 14, 2012
*/

#include <iocsh.h>
#include <epicsExport.h>
#include <epicsThread.h>
#include <asynPortDriver.h>

#include "cbw.h"

static const char *driverName = "USB1608G";

// Analog output parameters
#define analogOutValueString      "ANALOG_OUT_VALUE"

// Analog input parameters
#define analogInValueString       "ANALOG_IN_VALUE"
#define analogInRangeString       "ANALOG_IN_RANGE"

// Digital I/O parameters
#define digitalDirectionString    "DIGITAL_DIRECTION"
```

```
#define digitalInputString         "DIGITAL_INPUT"
#define digitalOutputString        "DIGITAL_OUTPUT"

// Pulse output parameters
#define pulseGenRunString          "PULSE_RUN"
#define pulseGenPeriodString       "PULSE_PERIOD"
#define pulseGenWidthString        "PULSE_WIDTH"
#define pulseGenDelayString        "PULSE_DELAY"
#define pulseGenCountString        "PULSE_COUNT"
#define pulseGenIdleStateString    "PULSE_IDLE_STATE"

// Counter parameters
#define counterCountsString        "COUNTER_VALUE"
#define counterResetString         "COUNTER_RESET"

#define MIN_FREQUENCY   0.0149
#define MAX_FREQUENCY   32e6
#define MIN_DELAY       0.
#define MAX_DELAY       67.11
#define NUM_ANALOG_IN   16  // Number analog inputs on 1608G
#define NUM_ANALOG_OUT  2   // Number of analog outputs on 1608G
#define NUM_COUNTERS    2   // Number of counters on 1608G
#define NUM_TIMERS      1   // Number of timers on 1608G
#define NUM_IO_BITS     8   // Number of digital I/O bits on 1608G
#define MAX_SIGNALS     NUM_ANALOG_IN
#define DEFAULT_POLL_TIME 0.01
```

```
/** Class definition for the USB1608G class
  */
class USB1608G : public asynPortDriver {
public:
  USB1608G(const char *portName, int boardNum);

  /* These are the methods that we override from asynPortDriver */
  virtual asynStatus writeInt32(asynUser *pasynUser, epicsInt32 value);
  virtual asynStatus readInt32(asynUser *pasynUser, epicsInt32 *value);
  virtual asynStatus writeFloat64(asynUser *pasynUser, epicsFloat64 value);
  virtual asynStatus getBounds(asynUser *pasynUser, epicsInt32 *low,
                                                    epicsInt32 *high);
  virtual asynStatus writeUInt32Digital(asynUser *pasynUser, epicsUInt32 value,
                                        epicsUInt32 mask);
  virtual void report(FILE *fp, int details);
  // These should be private but are called from C
  virtual void pollerThread(void);

protected:
  // Pulse generator parameters
  int pulseGenRun_;
  #define FIRST_USB1608G_PARAM pulseGenRun_
  int pulseGenPeriod_;
  int pulseGenWidth_;
  int pulseGenDelay_;
  int pulseGenCount_;
  int pulseGenIdleState_;

  // Counter parameters
  int counterCounts_;
```

```
  int counterReset_;

  // Analog output parameters
  int analogOutValue_;

  // Analog input parameters
  int analogInValue_;
  int analogInRange_;

  // Digital I/O parameters
  int digitalDirection_;
  int digitalInput_;
  int digitalOutput_;
  #define LAST_USB1608G_PARAM digitalOutput_

private:
  int boardNum_;
  double pollTime_;
  int forceCallback_;
  int startPulseGenerator();
  int stopPulseGenerator();
  int pulseGenRunning_;
};

#define NUM_PARAMS (&LAST_USB1608G_PARAM - &FIRST_USB1608G_PARAM + 1)
```

```
/** Constructor for the USB1608G class
  */
USB1608G::USB1608G(const char *portName, int boardNum)
  : asynPortDriver(portName, MAX_SIGNALS, NUM_PARAMS,
    // Interfaces that we implement
    asynInt32Mask | asynFloat64Mask | asynUInt32DigitalMask | asynDrvUserMask,
    // Interfaces that do callbacks
    asynInt32Mask | asynFloat64Mask | asynUInt32DigitalMask,
    /* ASYN_CANBLOCK=1, ASYN_MULTIDEVICE=1, autoConnect=1 */
    ASYN_MULTIDEVICE | ASYN_CANBLOCK, 1, 0, 0), /* Default priority and stack size */
    boardNum_(boardNum),
    pollTime_(DEFAULT_POLL_TIME),
    forceCallback_(1)
{
  // Pulse generator parameters
  createParam(pulseGenRunString,              asynParamInt32, &pulseGenRun_);
  createParam(pulseGenPeriodString,         asynParamFloat64, &pulseGenPeriod_);
  createParam(pulseGenWidthString,          asynParamFloat64, &pulseGenWidth_);
  createParam(pulseGenDelayString,          asynParamFloat64, &pulseGenDelay_);
  createParam(pulseGenCountString,            asynParamInt32, &pulseGenCount_);
  createParam(pulseGenIdleStateString,        asynParamInt32, &pulseGenIdleState_);

  // Counter parameters
  createParam(counterCountsString,            asynParamInt32, &counterCounts_);
  createParam(counterResetString,             asynParamInt32, &counterReset_);

  // Analog output parameters
  createParam(analogOutValueString,           asynParamInt32, &analogOutValue_);

  // Analog input parameters
```

```
  createParam(analogInValueString,             asynParamInt32, &analogInValue_);
  createParam(analogInRangeString,             asynParamInt32, &analogInRange_);

  // Digital I/O parameters
  createParam(digitalDirectionString,  asynParamUInt32Digital, &digitalDirection_);
  createParam(digitalInputString,      asynParamUInt32Digital, &digitalInput_);
  createParam(digitalOutputString,     asynParamUInt32Digital, &digitalOutput_);

  /* Start the thread to poll digital inputs and do callbacks to
   * device support */
  epicsThreadCreate("USB1608GPoller",
                    epicsThreadPriorityLow,
                    epicsThreadGetStackSize(epicsThreadStackMedium),
                    (EPICSTHREADFUNC)pollerThreadC,
                    this);
}
```

```
int USB1608G::startPulseGenerator()
{
  int status=0;
  double frequency, period, width, delay;
  int timerNum=0;
  double dutyCycle;
  int count, idleState;
  static const char *functionName = "startPulseGenerator";

  getDoubleParam (timerNum, pulseGenPeriod_,    &period);
  getDoubleParam (timerNum, pulseGenWidth_,     &width);
  getDoubleParam (timerNum, pulseGenDelay_,     &delay);
  getIntegerParam(timerNum, pulseGenCount_,     &count);
  getIntegerParam(timerNum, pulseGenIdleState_, &idleState);

  frequency = 1./period;
  if (frequency < MIN_FREQUENCY) frequency = MIN_FREQUENCY;
  if (frequency > MAX_FREQUENCY) frequency = MAX_FREQUENCY;
  dutyCycle = width * frequency;
  period = 1. / frequency;
  if (dutyCycle <= 0.) dutyCycle = .0001;
  if (dutyCycle >= 1.) dutyCycle = .9999;
  if (delay < MIN_DELAY) delay = MIN_DELAY;
  if (delay > MAX_DELAY) delay = MAX_DELAY;

  status = cbPulseOutStart(boardNum_, timerNum, &frequency, &dutyCycle, count,
                           &delay, idleState, 0);
  if (status != 0) {
    asynPrint(pasynUserSelf, ASYN_TRACE_ERROR,
      "%s:%s: started pulse generator %d period=%f, width=%f, count=%d,
```

```
      delay=%f, idleState=%d, status=%d\n",
      driverName, functionName, timerNum, period, width, count, delay,
      idleState, status);
    return status;
  }
  // We may not have gotten the frequency, dutyCycle, and delay we asked for,
  // set the actual values in the parameter library
  pulseGenRunning_ = 1;
  period = 1. / frequency;
  width = period * dutyCycle;
  asynPrint(pasynUserSelf, ASYN_TRACE_FLOW,
    "%s:%s: started pulse generator %d actual frequency=%f, actual period=%f,
    actual width=%f, actual delay=%f\n",
    driverName, functionName, timerNum, frequency, period, width, delay);
  setDoubleParam(timerNum, pulseGenPeriod_, period);
  setDoubleParam(timerNum, pulseGenWidth_, width);
  setDoubleParam(timerNum, pulseGenDelay_, delay);
  return 0;
}

int USB1608G::stopPulseGenerator()
{
  pulseGenRunning_ = 0;
  return cbPulseOutStop(boardNum_, 0);
}
```

```
asynStatus USB1608G::writeInt32(asynUser *pasynUser, epicsInt32 value)
{
  int addr;
  int function = pasynUser->reason;
  int status=0;
  static const char *functionName = "writeInt32";

  this->getAddress(pasynUser, &addr);
  setIntegerParam(addr, function, value);

  // Pulse generator functions
  if (function == pulseGenRun_) {
    // Allow starting a run even if it thinks its running,
    // since there is no way to know when it got done if Count!=0
    if (value) {
      status = startPulseGenerator();
    }
    else if (!value && pulseGenRunning_) {
      status = stopPulseGenerator();
    }
  }
  if ((function == pulseGenCount_) ||
      (function == pulseGenIdleState_)) {
    if (pulseGenRunning_) {
      status = stopPulseGenerator();
      status |= startPulseGenerator();
    }
  }

  // Counter functions
```

```
  if (function == counterReset_) {
    // LOADREG0=0, LOADREG1=1, so we use addr
    status = cbCLoad32(boardNum_, addr, 0);
  }

  // Analog output functions
  if (function == analogOutValue_) {
    status = cbAOut(boardNum_, addr, BIP10VOLTS, value);
  }

  callParamCallbacks(addr);
  if (status == 0) {
    asynPrint(pasynUser, ASYN_TRACEIO_DRIVER,
              "%s:%s, port %s, wrote %d to address %d\n",
              driverName, functionName, this->portName, value, addr);
  } else {
    asynPrint(pasynUser, ASYN_TRACE_ERROR,
              "%s:%s, port %s, ERROR writing %d to address %d, status=%d\n",
              driverName, functionName, this->portName, value, addr, status);
  }
  return (status==0) ? asynSuccess : asynError;
}
```

```
asynStatus USB1608G::writeFloat64(asynUser *pasynUser, epicsFloat64 value)
{
  int addr;
  int function = pasynUser->reason;
  int status=0;
  static const char *functionName = "writeFloat64";

  this->getAddress(pasynUser, &addr);
  setDoubleParam(addr, function, value);
  // Pulse generator functions
  if ((function == pulseGenPeriod_)    ||
      (function == pulseGenWidth_)     ||
      (function == pulseGenDelay_)) {
    if (pulseGenRunning_) {
      status = stopPulseGenerator();
      status |= startPulseGenerator();
    }
  }
  callParamCallbacks(addr);
  if (status == 0) {
    asynPrint(pasynUser, ASYN_TRACEIO_DRIVER,
              "%s:%s, port %s, wrote %d to address %d\n",
              driverName, functionName, this->portName, value, addr);
  } else {
    asynPrint(pasynUser, ASYN_TRACE_ERROR,
              "%s:%s, port %s, ERROR writing %f to address %d, status=%d\n",
              driverName, functionName, this->portName, value, addr, status);
  }
  return (status==0) ? asynSuccess : asynError;
}
```

```
void USB1608G::pollerThread()
{
  /* This function runs in a separate thread.  It waits for the poll time */
  static const char *functionName = "pollerThread";
  epicsUInt32 newValue, changedBits, prevInput=0;
  unsigned short biVal;;
  unsigned long countVal;
  int i;
  int status;

  while(1) {
    lock();

    // Read the counter inputs
    for (i=0; i<NUM_COUNTERS; i++) {
      status = cbCIn32(boardNum_, i, &countVal);
      if (status)
        asynPrint(pasynUserSelf, ASYN_TRACE_ERROR,
                  "%s:%s: ERROR calling cbCIn32, status=%d\n",
                  driverName, functionName, status);
      setIntegerParam(i, counterCounts_, countVal);
    }

    // Read the digital inputs
    status = cbDIn(boardNum_, AUXPORT, &biVal);
    if (status)
      asynPrint(pasynUserSelf, ASYN_TRACE_ERROR,
                "%s:%s: ERROR calling cbDIn, status=%d\n",
                driverName, functionName, status);
    newValue = biVal;
```

```
    changedBits = newValue ^ prevInput;
    if (forceCallback_ || (changedBits != 0)) {
      prevInput = newValue;
      forceCallback_ = 0;
      setUIntDigitalParam(digitalInput_, newValue, 0xFFFFFFFF);
    }

    for (i=0; i<MAX_SIGNALS; i++) {
      callParamCallbacks(i);
    }
    unlock();
    epicsThreadSleep(pollTime_);
  }
}
```

measCompPulseGen.template

```
########################################################################
#  Pulse start/stop                                                    #
########################################################################
record(bo, "$(P)$(R)Run")
{
    field(DTYP, "asynInt32")
    field(OUT,  "@asyn($(PORT),$(ADDR))PULSE_RUN")
    field(ZNAM, "Stop")
    field(ZSV,  "NO_ALARM")
    field(ONAM, "Run")
    field(OSV,  "MINOR")
}

# NOTE: The records for the period and the frequency are a bit
# complex because we want to be able to change either ao record
# and have the other one update

########################################################################
#  Pulse period                                                        #
########################################################################
record(ao, "$(P)$(R)Period")
{
    field(PINI, "YES")
    field(DTYP, "asynFloat64")
    field(OUT,  "@asyn($(PORT),$(ADDR))PULSE_PERIOD")
    field(VAL,  "0.001")
    field(PREC, "$(PREC)")
    field(FLNK, "$(P)$(R)CalcFrequency")
}
```

```
#########################################################################
#  Calculate frequency based on new period                              #
#########################################################################
record(calcout, "$(P)$(R)CalcFrequency")
{
    field(INPA, "$(P)$(R)Period")
    field(CALC, "1/A")
    field(SDIS, "$(P)$(R)Frequency.PROC")
    field(DISV, "1")
    field(OUT, "$(P)$(R)Frequency PP MS")
}

#########################################################################
#  Pulse frequency                                                      #
#########################################################################
record(ao, "$(P)$(R)Frequency")
{
    field(PREC, "$(PREC)")
    field(FLNK, "$(P)$(R)CalcPeriod PP MS")
}

#########################################################################
#  Calculate period based on new frequency                              #
#########################################################################
record(calcout, "$(P)$(R)CalcPeriod")
{
    field(INPA, "$(P)$(R)Frequency")
    field(CALC, "1/A")
    field(SDIS, "$(P)$(R)Period.PROC")
```

```
    field(DISV, "1")
    field(OUT, "$(P)$(R)Period PP MS")
}

#########################################################################
#  Pulse width                                                          #
#########################################################################
record(ao, "$(P)$(R)Width")
{
    field(PINI, "YES")
    field(DTYP, "asynFloat64")
    field(OUT,  "@asyn($(PORT),$(ADDR))PULSE_WIDTH")
    field(VAL,  "0.0001")
    field(PREC, "$(PREC)")
}

#########################################################################
#  Pulse delay                                                          #
#########################################################################
record(ao, "$(P)$(R)Delay")
{
    field(PINI, "YES")
    field(DTYP, "asynFloat64")
    field(OUT,  "@asyn($(PORT),$(ADDR))PULSE_DELAY")
    field(VAL,  "0.")
    field(PREC, "$(PREC)")
}
```

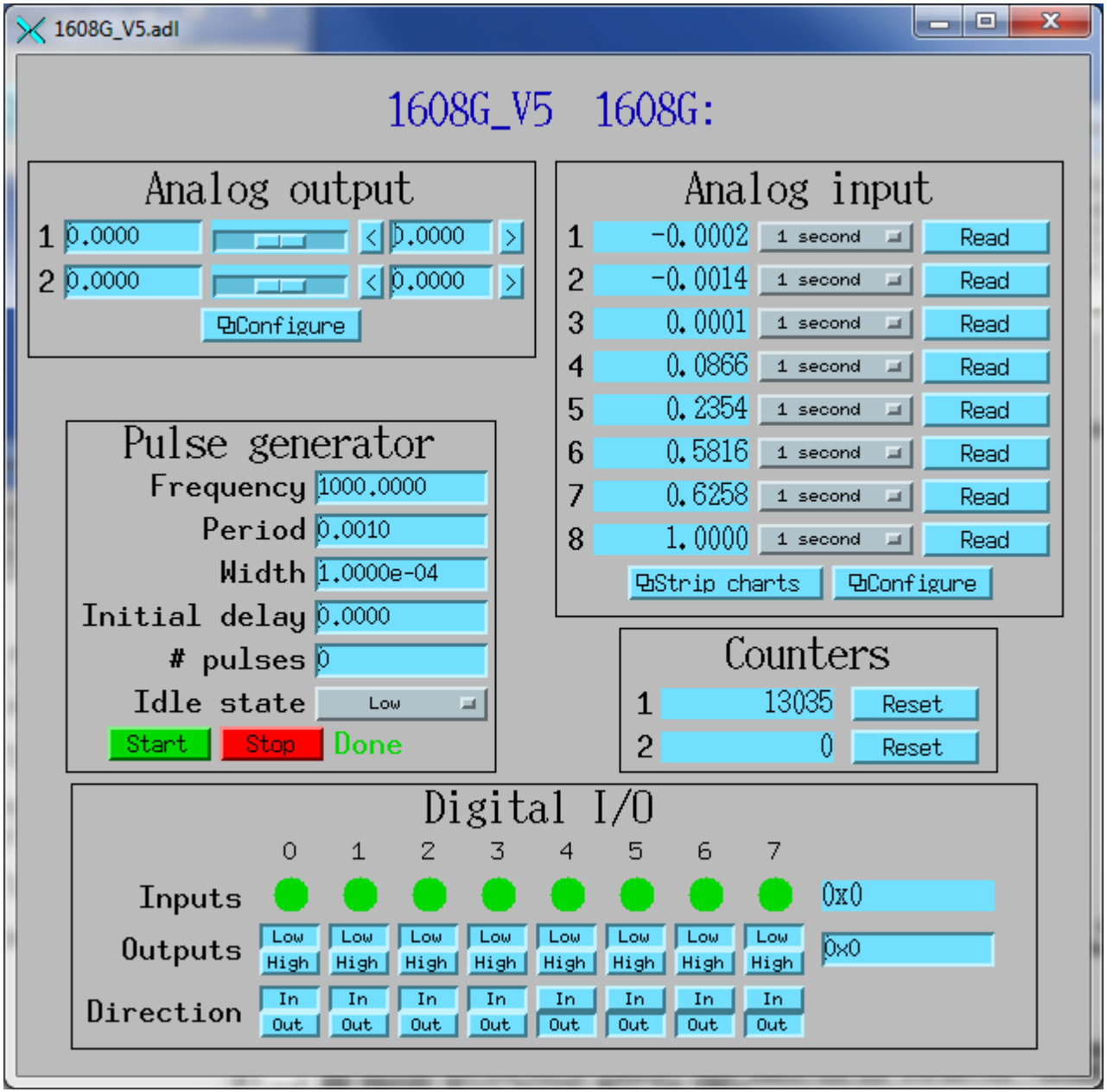
```
#################################################################
#  Pulse count                                                  #
#################################################################
record(longout, "$(P)$(R)Count")
{
    field(PINI, "YES")
    field(DTYP, "asynInt32")
    field(OUT,  "@asyn($(PORT),$(ADDR))PULSE_COUNT")
}

#################################################################
#  Pulse idle state                                             #
#################################################################
record(bo, "$(P)$(R)IdleState")
{
    field(PINI, "YES")
    field(DTYP, "asynInt32")
    field(OUT,  "@asyn($(PORT),$(ADDR))PULSE_IDLE_STATE")
    field(ZNAM, "Low")
    field(ONAM, "High")
    field(VAL,  "0")
}
```

1608GCounter.template

```
record(longin, "$(P)$(R)Counts")
{
    field(DTYP, "asynInt32")
    field(INP,  "@asyn($(PORT),$(ADDR))COUNTER_VALUE")
    field(SCAN, "I/O Intr")
}

record(bo, "$(P)$(R)Reset")
{
    field(PINI, "YES")
    field(DTYP, "asynInt32")
    field(OUT,  "@asyn($(PORT),$(ADDR))COUNTER_RESET")
    field(VAL,  "1")
}
```

1608G.substitutions_V5

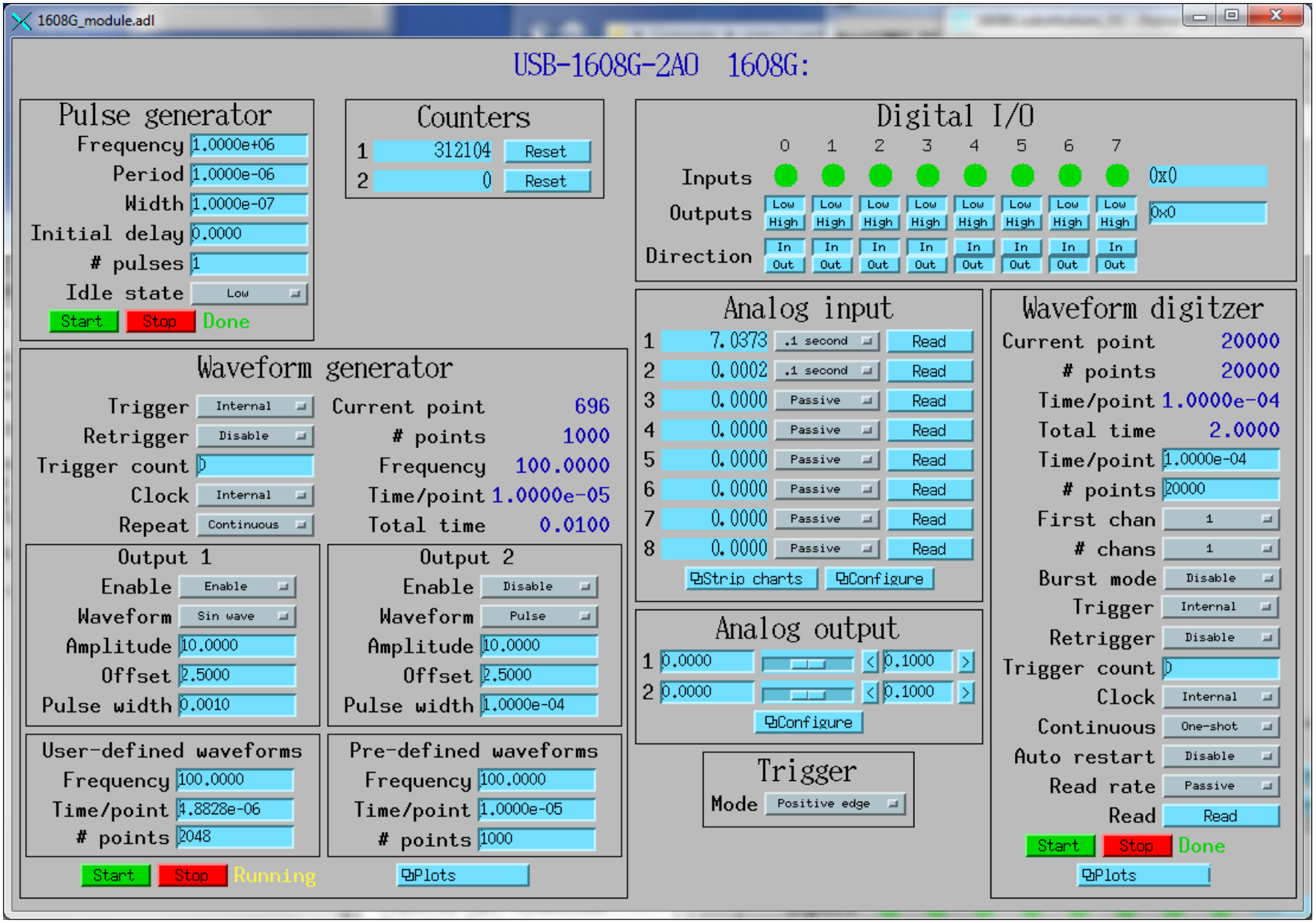
```
file "$(MEASCOMP)/measCompApp/Db/measCompPulseGen.template"
{
pattern
{     P,          R,          PORT,     ADDR,  PREC}
{   1608G:,  PulseGen1,  1608G_1,       0,      4}
}

file "$(MEASCOMP)/measCompApp/Db/1608GCounter.template"
{
pattern
{     P,          R,         PORT,     ADDR}
{   1608G:,  Counter1,  1608G_1,       0}
{   1608G:,  Counter2,  1608G_1,       1}
}
```


1608G_V5.adl
1608G_V5 1608G:
Analog output
1 0.0000 0.0000
2 0.0000 0.0000
Configure
Analog input
1 -0.0002 1 second Read
2 -0.0014 1 second Read
3 0.0001 1 second Read
4 0.0866 1 second Read
5 0.2354 1 second Read
6 0.5816 1 second Read
7 0.6258 1 second Read
8 1.0000 1 second Read
Strip charts
Configure
Pulse generator
Frequency 1000.0000
Period 0.0010
Width 1.0000e-04
Initial delay 0.0000
pulses 0
Idle state Low
Start
Stop
Done
Counters
1 13035 Reset
2 0 Reset
Digital I/O
0 1 2 3 4 5 6 7
Inputs 0x0
Outputs Low High 0x0
Direction In Out

Measurement Computing 1608GX-2A0 Driver

Full Released Version

- Add waveform generator with both predefined and user-defined waveforms
- Add 8-channel waveform digitizer
- Add trigger support
- 42 new parameters
- 1254 lines of code (~770 more than Version 4)
- Supports virtually all features of 1608GX-2A0


1608G_module.adl
USB-1608G-2AO 1608G:
Pulse generator
Frequency 1.0000e+06
Period 1.0000e-06
Width 1.0000e-07
Initial delay 0.0000
pulses 1
Idle state Low
Start Stop Done
Counters
1 312104 Reset
2 0 Reset
Digital I/O
0 1 2 3 4 5 6 7
Inputs 0x0
Outputs Low High
0x0
Direction In Out
Waveform generator
Trigger Internal
Retrigger Disable
Trigger count 0
Clock Internal
Repeat Continuous
Current point 696
points 1000
Frequency 100.0000
Time/point 1.0000e-05
Total time 0.0100
Output 1
Enable Enable
Waveform Sin wave
Amplitude 10.0000
Offset 2.5000
Pulse width 0.0010
Output 2
Enable Disable
Waveform Pulse
Amplitude 10.0000
Offset 2.5000
Pulse width 1.0000e-04
User-defined waveforms
Frequency 100.0000
Time/point 4.8828e-06
points 2048
Pre-defined waveforms
Frequency 100.0000
Time/point 1.0000e-05
points 1000
Start Stop Running
Plots
Analog input
1 7.0373 .1 second Read
2 0.0002 .1 second Read
3 0.0000 Passive Read
4 0.0000 Passive Read
5 0.0000 Passive Read
6 0.0000 Passive Read
7 0.0000 Passive Read
8 0.0000 Passive Read
Strip charts
Configure
Analog output
1 0.0000 0.1000
2 0.0000 0.1000
Configure
Trigger
Mode Positive edge
Waveform digitzer
Current point 20000
points 20000
Time/point 1.0000e-04
Total time 2.0000
Time/point 1.0000e-04
points 20000
First chan 1
chans 1
Burst mode Disable
Trigger Internal
Retrigger Disable
Trigger count 0
Clock Internal
Continuous One-shot
Auto restart Disable
Read rate Passive
Read Read
Start Stop Done
Plots