EEGer4™

Neurofeedback Software

Technical Manual
Version 4.4.0

This manual contains information intended for licensees of EEGer software.

Initial release 31 July 2012
TM43001 16 August 2012 for standardized revision control
TM43002 09 December 2012 to add data acquisition methodology
TM43003 30 January 2013 for added explanation of amplifier test/data
TM44001 1 November 2017
TM44002 01 June 2021

Table of Contents

Computer Requirements

EEGer software requires one or two computers to operate (depending upon user configuration selections). EEGer executes on the following operating system configurations:

- Windows 7 32-bit
- Windows 7 64-bit
- Windows 8
- Windows 8.1
- Windows 10

The most sensitive element in a computer system (for EEGer) is the graphics interface. Some graphics chipsets/drivers exhibit poor performance, causing apparent display lagging although acquisition and processing continue normally.

Recommended minimum computer requirements:

	Single computer system	Therapist computer	Client/Game computer
Processor speed	2 GHz	1.8 GHz	1.8 GHz
Memory	8GB	8GB	8GB
Storage	500 GB	500 GB	250 GB
Video card/chipset At least DirectX 9.0c supported. Minimum resolution 1024x768.	Extended desktop support for an external monitor (and external monitor connector). High-level gaming performance. Note: ATI/AMD or nVidia recommended since not all Intel graphics have required performance.	1 GB memory with mid-level gaming performance	1 GB memory with mid-level gaming performance
Communication ports	USB for EEGer dongle+ USB/serial for acquisition device	USB for EEGer dongle+ USB/serial for acquisition device+ ethernet/serial for game connection link	ethernet/serial for therapist connection link

Timing

EEGer processes EEG samples at 256 Hz. Each “frame” (1/256 of a second) data is stored, filtered, and decision-tested. There are some inherent delays in the filtering process since multiple samples are needed to provide a filter “output”. The default timing/delays used in EEGer are as follows:

Sample acquisition timing

> Although the nominal sample time is nominal 4 milliseconds per sample, USB interfaces transmit data in blocks so there is a variable time based on block size. Range is 0 to about 32 milliseconds 'lateness' in each sample. This time disregards any acquisition component internal delays (settling times).

Filtering timing

> This timing depends on the number of filter stages. EEGer default is 2 stages so the delay is 8 milliseconds for a signal to “exit” a filter. Actual computation time is less than a microsecond.

Decision logic

> This is the time it takes for the software to smooth the raw cyclic data. It depends on user-selection of a smoothing value which ranges from 0.1 to 0.9 seconds. EEGer default is 0.5 seconds but actual delay depends on significance of new sample (larger signals have more impact on the smoothed value).

Clinician display

> The clinician display process runs at a rate between 25 and 40 Hz so the data is displayed within 25 to 40 milliseconds of computation.

Transmission to client

> For a single-computer system, data is transmitted using an internal TCP/IP transmission with a delay time of about 100 microseconds (until ready for receipt).
>
> For a two-computer system with serial connections, data is sent at a 115,200 baud rate to the client computer. Each message ranges from 8 bytes to about 80 bytes so the maximum delay is about 10 milliseconds.
>
> For a two-computer system with ethernet connections, the maximum delay is about a millisecond.

Client data processing

> The client feedback/game software runs at a 40 millisecond interval. Aural cues are processed immediately. Visual data is smoothed a rates dependent on the display so that “strobe” effects are not generated. The maximum processing delay is thus 25 milliseconds.

Overall latency is thus the sum of delays ranging from each stage:

Best case: 0+8+1+25+smoothing = 34 milliseconds plus any smoothing delays

Worst case: 32+8+10+25+smoothing = 75 milliseconds plus any smoothing delays

Filters

Filters are characterized by many values. These typically include:

a) Filter type (moving average, FIR, IIR, JTFA, wavelet, etc.)
b) Number of stages (filter order)
c) Rolloff (frequency) characteristics
d) Measurement points (edge, corner, 50%, etc.)
e) Ripple
f) Impulse/step (transient) response
g) Phase accuracy
h) Delay

EEGer4 uses IIR digital filtering to separate out frequency bands of interest.

IIR (Infinite Impulse Response) filters are characterized by good amplitude fidelity but poor phase fidelity. FIR (Finite Impulse Response) filters are characterized by relatively poor amplitude fidelity but good phase fidelity. FIR filters typically require many more computations than IIR filters and consequently have a longer filter delay.

Also, there are many kinds of digital filter computations (Butterworth, ...)., each with their own characteristics. The actual filter computation logic in EEGer4 is performed using biquad computations to model the required polynomials. Each “quad” contains the coefficients needed. Each quad corresponds to one filter order. This computation looks like this:

$$y_n = a0 * x_n + a1 * x_{n-1} + a2 * x_{n-2} - b1 * y_{n-1} - b2 * y_{n-2}$$

Equation 1

where x_n is the input sample and y_n is the output sample.

Filters Provided With EEGer4

There are three sets of filters provided with EEGer4, all sampled and computed at 256 Hz.

The first set consists of precomputed IIR elliptical filter coefficient sets in the range 0 to 65 Hz in 1/8 Hz steps. This set is the same set used in earlier versions of EEGer. The set was generated with specifications of:

ripple= 0.5db
rolloff= -60db (lowpass) or -30db (bandpass)
order= 1 (lowpass) or 2 (bandpass)

The second set of filters is similar (IIR elliptical filter coefficients) but with dynamically-computed values and a choice of order ranging from 2 to 5. Also, this filter set has a step size of 0.1 Hz if the high frequency is more than 1 Hz and 0.001 Hz if high frequency is less than 1 Hz.

ripple= 0.5db
rolloff= -30db
order= 2 to 8

The third set of filters is mechanized using an open-source filter module (FIDlib) which is also used by some other neurofeedback manufacturers. The specific filter types EEGer4 uses with FIDlib are BsBu (Bandstop Butterworth), BpBu (Bandpass Butterworth), and LpBu (LowpassButterworth). These filters all use the following specifications:

order= 2 to 8
width specified at -3db points (.707 of peak)

A comparison of the three methods is shown in Figures 1,2,3,4.

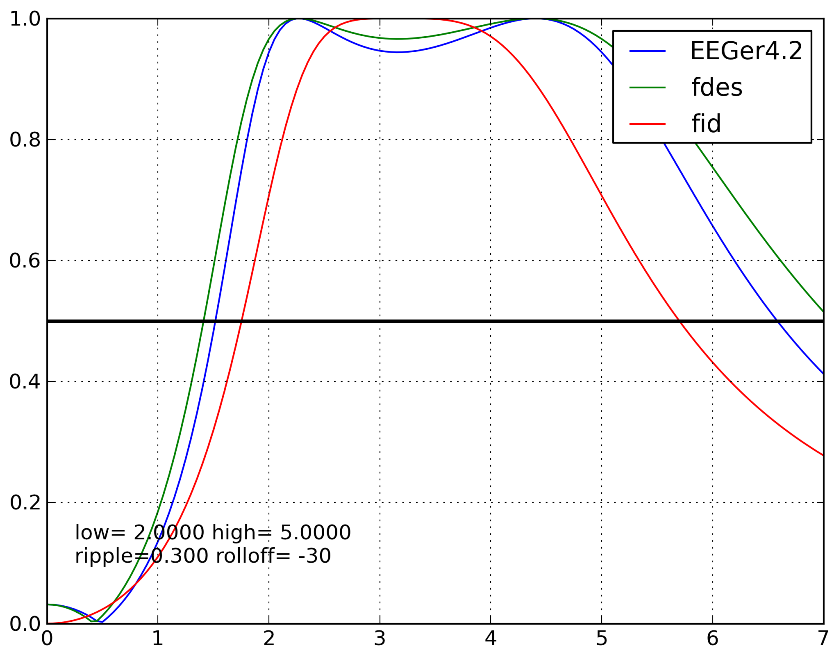


Figure 1

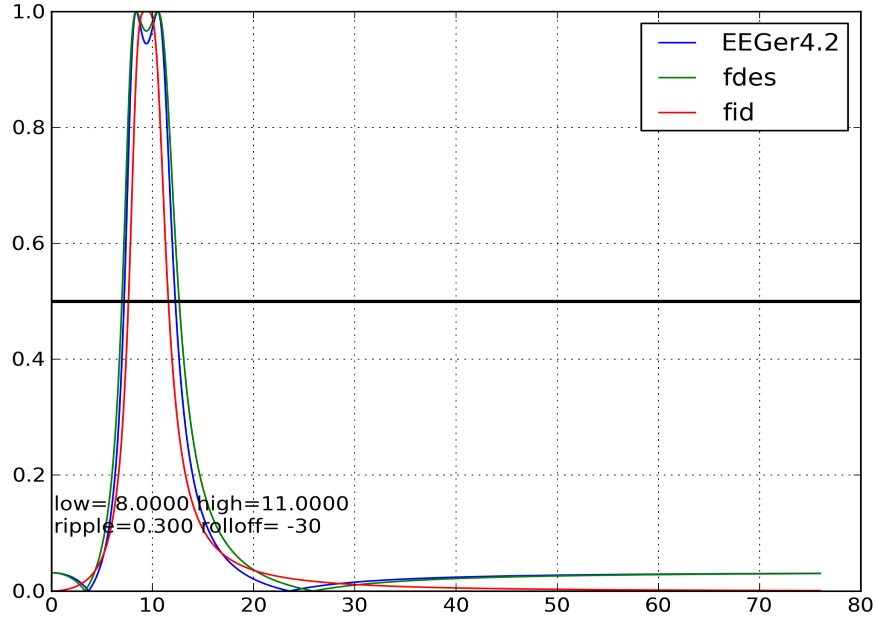


Figure 2

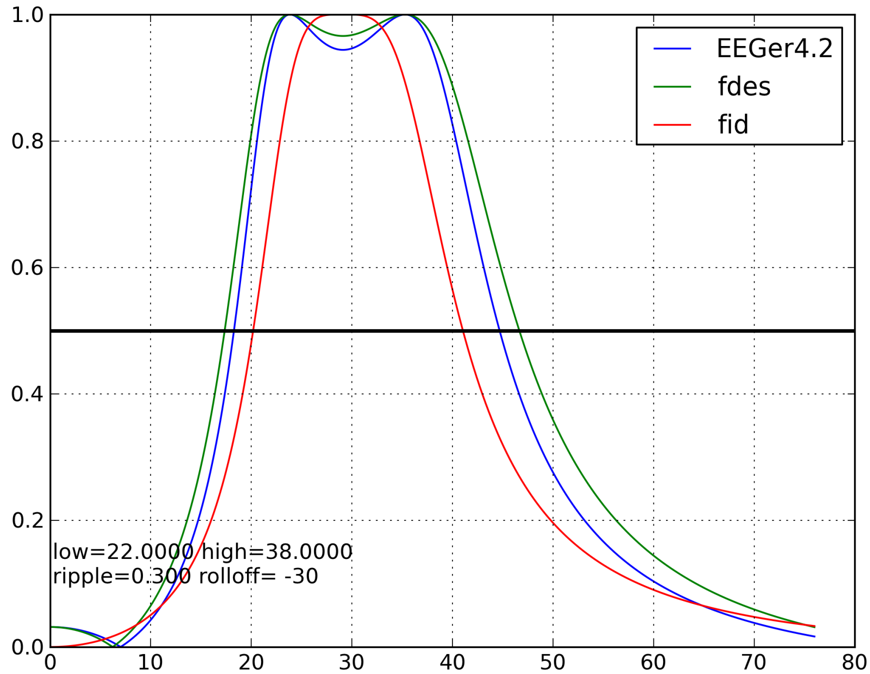


Figure 3

Here is a comparison of the filter sets for various orders:

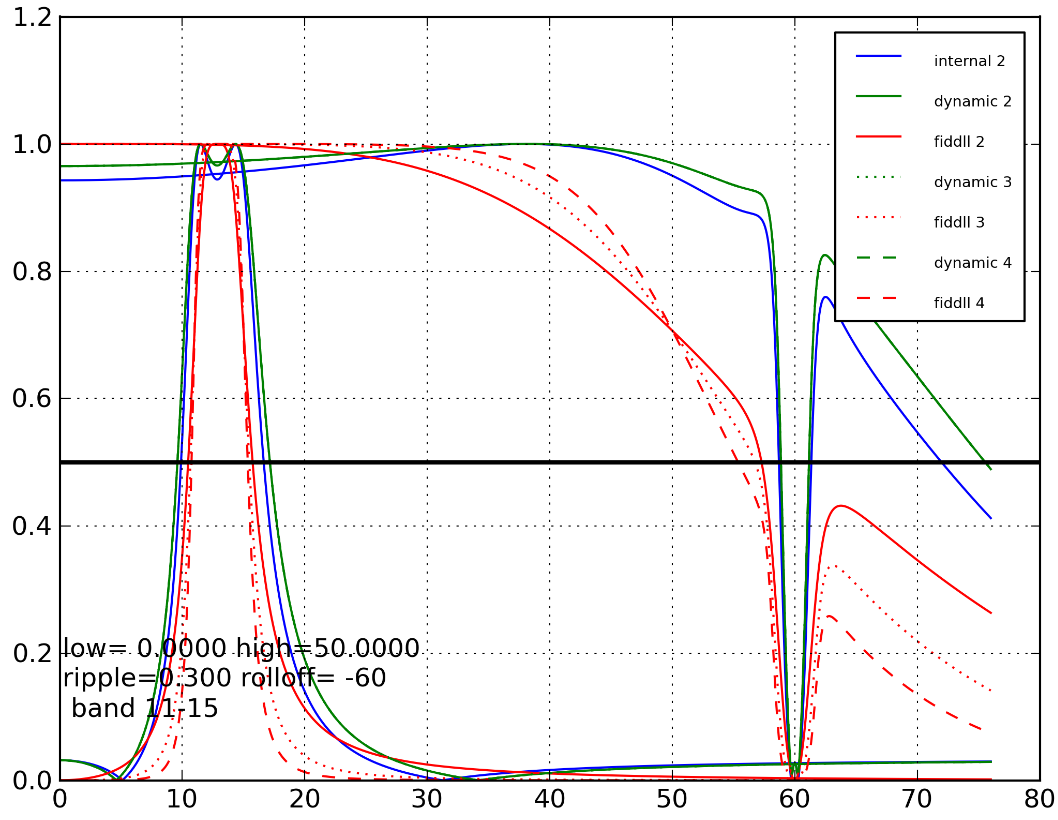


Figure 4

Note that the EEGer4 frequency specifications are to the edges of the flat response while the FIDlib specifications are to the -3db points. Full bandpass characteristics are shown for each filter method are shown in Appendix A. Appendix E describes the methodology used to acquire this data.

Acquisition Components

EEGer4 supports amplifier/encoder components from many manufacturers. Each component has (or may have) different frequency response characteristics. The following encoder/amplifiers are supported by EEGer4 (Pass/Fail/Untested noted in the last column):

Device Name	Manufacturer	Hardware Interface	Interface method	Support status	EEG Channels Supported	P/F
BrainLynx	J&J Engineering	USB	Mfr DLL	Currently supported	2	P
C2mini	J&J Engineering	USB	Mfr DLL	Obsolete/ supported	2	U
C2	J&J Engineering	USB	Mfr DLL	Obsolete/ supported	2	U
C2+mini	J&J Engineering	USB	Mfr DLL	Currently supported	2	P
C2+	J&J Engineering	USB	Mfr DLL	Currently supported	2	P
Spectrum 2	J&J Engineering	USB	Mfr DLL	Currently supported	2	P
Spectrum 4	J&J Engineering	USB	Mfr DLL	Currently supported	2/4	P
GP8e	Physiocom	USB	MFR DLL	Currently supported	2A202	P
GP12e	Physiocom	USB	MFR DLL	Currently supported	2/4	P
esiPro 2.2	TeleDiagnostic Systems	USB	Mfr DLL	Currently supported	2	P
esiPro 4.3	TeleDiagnostic Systems	USB	Mfr DLL	Currently supported	2/4	P
A200	Phoenix Neuro Systems	USB	Mfr DLL	Currently supported	2	P
A400	Phoenix Neuro Systems	USB	Mfr DLL	Currently supported	2/4	P

Device Name	**Manufacturer**	**Hardware Interface**	**Interface method**	**Support status**	**EEG Channels Supported**	**P/ F**
A202	Southeast Signal	USB	Mfr DLL	Currently supported	2	P
A404	Southeast Signal	USB	Mfr DLL	Currently supported	2/4	P
ProComp2	Thought Technology	Serial port	Internal code (serial interface)	Currently supported	2	P
ProComp+	Thought Technology	Serial port	Internal code (serial interface)	Currently supported	2	P
Infiniti	Thought Technology	Serial port	Internal code (serial interface)	Currently supported	2	P
ProComp5	Thought Technology	Serial port	Internal code (serial interface)	Currently supported	2	U
ProComp2	Thought Technology	USB	Mfr DLL	Currently supported	2	P
ProComp+	Thought Technology	USB	Mfr DLL	Currently supported	2/4	P
Infiniti	Thought Technology	USB	Mfr DLL	Currently supported	2/4	P
ProComp5	Thought Technology	USB	Mfr DLL	Currently supported	2/4	U
Brainmaster 2E	Brainmaster	Serial port	Mfr DLL	Currently supported	2	P
Atlantis 2	Brainmaster	USB with serial port	Mfr DLL	Currently supported	2	P
Atlantis 4	Brainmaster	USB with serial port	Mfr DLL	Untested/ no device but same DLL as all Brainmaster devices	2/4	U
Discovery	Brainmaster	USB with serial port	Mfr DLL	Under test/ no device	2/4 (24)	U

Device Name	**Manufacturer**	**Hardware Interface**	**Interface method**	**Support status**	**EEG Channels Supported**	**P/ F**
Pet2.0	Brainquiry	Bluetooth serial	Internal code (serial interface)	Obsolete/ no device but previously supported	2	U
QPET	Brainquiry	Bluetooth serial	Mfr DLL	Obsolete/ no device but previously supported	2	U
Pendant-EEG	Pocket-Neurobics	Bluetooth serial	Internal code (serial interface)	Under test/ no device but previously supported	2	U
UWiz	Pocket-Neurobics	Bluetooth/ USB	Generic driver	Currently supported	2	P
QWiz	Pocket-Neurobics	Bluetooth/ USB	Generic driver	Currently supported	2/4	P
Q20/Q21	Neurofield	CAN	Mfr DLL	Currently supported	2/4 (24)	P
CQuick			Mfr DLL	Under test/ no device	2/4	U
Optima	Neurobit	Bluetooth/ USB	Mfr DLL	Currently supported	2/4	P
(external amplifier)	------------------	USB	A/D device supported by Measurement Computing Corporation InstaCal software	Currently supported (used for system testing)	2/4	P

The acquisition devices use a variety of interface methods, usually serial, Bluetooth, or USB connections. Each device manufacturer has a custom interface method. EEGer has interface modules written to support all the above devices using either direct programming or the device manufacturer's provided interface methodology (i.e. DLL or other interface program). All the devices from J&J Engineering use a common interface DLL, differing only by a command code, and a common EEGer interface module.. All the C2+ based devices (including BrainLynx and Spectrum 2/4) use a single command code (and a common printed circuit board). All the devices from Brainmaster use a common DLL and s single EEGer interface module. All the Thought Technology devices using serial interfaces use generic Windows serial interfaces and a single EEGer interface module. All the Thought Technology devices using the USB (TTUSB) interface use a common DLL and a single EEGer interface module. Since the interfaces are common between device models, extensive testing was only necessary for devices using each interface. A simpler test was used to confirm that the other models supported could also communicate across the interface.

Appendix B contains the bandpass characteristics of these components. These bandpass characteristics are in addition to the filter characteristics of whatever filter method and frequency band selected.

Appendix E contains the methodology used to acquire the test data for Appendix A and B.

Layout and Feedback Modes

EEGer4 provides a number of screen configurations (called "layouts") of EEG data.
Each layout has a number of "feedback modes" with predefined usage of each element of the screen.
All layouts have two or four lowpass EEG traces at the top of the screen and some number of additonally filtered traces below.

The current list of layouts (and the short titles) is:

5= 5-trace
6i= 6-trace,inhibit
6r= 6-trace,reward
8= 8-trace
14= 14-trace
14x4= 14-trace,monitor
14a= ChanA,screen
14ab= 2-chan,screen
14b= ChanB,screen
5r= Reward-only
6m= 6-trace,monitor
7m= 7-trace,monitor
7im=7 trace,monitpr 3 inhibit, 1 reward
8z= 8-trace-4zcomp
8p= 8-trace-2-rewards
8q=8-trace,1reward
10c=10-trace,coherences
10r=10-trace,ratios
12=4 chan,4 monitor, 1 reward, 3 inhibit
12x=4 chan,4 reward, 4 inhibit

Each feedback mode (internally) consists of a sequence of filter operations and decisions tied to particular elements (traces both visible and invisible) of the layout. Appendix C has the block diagrams of each of these feedback modes. The operation blocks on those diagrams use the following operations/decisions (names shown in **bold**). Certain generic operations are used. Most importantly, smoothing is performed using an Exponentially-Weighted-Moving-Average (EWMA) filter characterized by

$$G_n = G_{n-1} * \frac{k_t - 1}{k_t} + g_n * \frac{1}{k_t}$$

Equation 2

Also, a threshold decision is made using a comparison between a short-term (EWMA) average and a user-specified threshold value.

lowpass
Lowpass filter and DC correct a raw input from an acquisition component.

The input value is compared to the current "artifact threshold" to determine if the data is a spike (short term amplitude value) or artifact (longer term amplitude value). If the signal is determined to be an "artifact" (probably due to eyeblinks, muscle motion, etc.), a zero value is the output of the operation. Once in an artifact condition, that condition will be held for a short time after the condition disappears (allowing the data to stabilize). If the input is NOT an artifact, the input value is lowpass filtered. The output of the filter is DC-corrected (to center the data display) and is the output of this operation. It is also integrated using an EWMA filter with a short-term, user-specified time constant (typically 0.5 seconds, with a range of 0.1 to 0.9 seconds).

bandpass
Bandpass filter a lowpass data sample and check for target threshold.

The input value is bandpass filtered. The signal is integrated using an EWMA for comparison with the target threshold. This block has several outputs: the signal, the 'average' value (actually the effective Peak-Peak voltage), and an integral-value-over-threshold flag. There are actually four submodes of this (fundamental) operation depending on the elements/traces configured:

OneChannelReward – if element is a reward element and only one input was specified
SumReward --if element is a reward element and two inputs were specified
(the two input values are arithmetically added together before filtering, etc.)
OneChannelInhibit -- if element is an inhibit element and only one input was specified
TwoChannelInhibit ----if element is an inhibit element and two inputs were specified
(the two input values are arithmetically added together before filtering, etc.)

differ
Subtract the second specified element from the first specified element, then proceed as in OneChannelReward bandpass.

psync
Coherence measure between peak values.

The two (specified) input streams are each narrow-band filtered (using the reward frequency band limits) yielding two values (x and y). A cross correlation is then performed on a window (w) of the value histories:

$$\frac{\int X(t)Y(t)}{\sqrt{\int X(t)X(t)\int Y(t)Y(t)}}$$

Equation 3

This reduces in practice to

$$\frac{\sum_{1}^{W} X(t)\,Y(t)}{\sqrt{\sum_{1}^{W} X(t)\,X(t) * \sum_{1}^{W} Y(t)\,Y(t)}}$$

Equation 4

The window width is user-specifiable but defaults to 0.5 seconds. The resulting correlation value is smoothed using the standard EWMA filter. This value ranges from 0 to 1. It is multiplied by a constant (user specified but default to 10.0) to place it in an appropriate display range (0-10) for typical EEG displays. The scaled value is the principal output of this operation.

async
Coherence measure between wave slope angles.

The two (specified) input streams are each narrow-band filtered (using the reward frequency band limits) yielding two values (x and y). Each stream history is examined (looking 'backward' for one cycle) to find the min/max of the wave. The difference between the (smoothed) average amplitude of the stream and the current value is computed. A cross correlation is performed of the difference values using Equation 4. The output of this is the async value which ranges from 0 to 2. It is multiplied by a constant (user specified but default to 10.0) to place it in an appropriate display range (0-10) for typical EEG displays. The scaled value is the principal output of this operation.

gasync
Coherence measure exactly like async except using the lowpass (wideband) data instead of the narrow band data.

aminusb
Compute difference between short-term average of two channels.

This operation filters each channel of data separately and computes a short-term moving average value. The two short-term values are subtracted and the result added to the threshold value to give an output (display) value.

pdelta
Compute variation in timing between peaks on two channels.

This routine determines the 'time' of the peak value of the last cycle's samples in each channels. The smoothed time is compared to the smoothed time of the other channels and a normalized delta time value is determined. The delta time is smoothed and compared to the instantaneous delta time and used as the output value. The value is subtracted from 1 so that zero variation in peak times results in a perfect correlation factor. It is multiplied by a constant (user specified but default to 10.0) to place it in an appropriate display range (0-10) for typical EEG displays. The scaled value is the principal output of this operation.

ratio
Compute the ratio of two channels or two streams of data.

Depending in the input specifications, this operation determine the ratio of the inputs. It is a user configuration selection whether the ratio is squared (for power) or not (for voltage).

diffsum
This operation computes the difference of the filtered samples divided by the sum.

$$\frac{A_n - B_n}{A_n + B_n}$$

Equation 5

unity
This operation is very similar to the diffsum operation except the value is subtracted from 1.

$$1 - \frac{A_n - B_n}{A_n + B_n}$$

Equation 6

QPS modes
The QPS modes are 4-channel modes where the coherence of each pair of bands is computed/averaged to improve hypo- or hyper-coherence.

uncouple
This operation monitors (typically) a low frequency band for a spindle exceeding a (user) threshold. When seen, it alters (temporarily) the threshold for (typically) the reward band. The purpose of these modes is to inhibit rewards when spindles are detected in the monitored band.

zcomp
This operation is not a filtering operation but examines various output combinations of data computed by the Applied NeuroScience Inc. (ANI) zscore module. The zcomp logic examines each user-specified element of the ANI data outputs and tracks the percentage of rewardable states. The composite percentage is the output of this operation block. Further details of the comparison logic are described in the Operator Manual.

The following operations are not filtering operations but reward decision operations that receive inhibit and reward inputs and make various decisions about scoring, sounds, etc.

bsmr
This operation block accepts the inhibit and reward threshold comparisons and determines rewardable state for SMR and EXP protocol classes. It also determines if a reward event is to occur based on time-on-task, event rate, time between rewards, and other controlling criteria.

at
This operation block accepts the inhibit and reward threshold comparisons and determines rewardable state for the AT protocol class. Reward sounds are determined in the feedback games/displays. The feedback consists of two environmental tones signaling the general *range* of the client's state-of-relaxation, and tones that signal momentary bursts of EEG in one or the other reward band. The alpha environment is a running stream, and its tone is a high-pitched bell. The theta environment is ocean waves, and the theta tone is a low-pitched bell. As relaxation deepens, the ongoing environmental sound will cross-fade from stream to ocean and low-pitched bell tones will replace the high-pitched tones. In cases where both frequency ranges are over threshold at the same time, the system is biased toward signaling the alpha state. The user has control over the “fade” rate when transitioning between states. If neither signal is over threshold, there will be no change in relative volumes (fading).

The following operations are not strictly operations performed by EEGer4. They consist of various selection of outputs from the Applied NeuroScience Inc. (ANI) zscore module for display/reward controls.
zasymm - asymmetry measure
zcohere - coherence measure
zphase - absolute phase measure
zabspa - absolute power
zabspb - absolute power

zrelpa - relative power
zrelpb - relative power
zpratioa – power ratios
zpratiob – power ratios

For an explanation of these computations, please see the applicable ANI documentation.

All the feedback modes are diagrammed in Appendix C.

Examples of modes

Some explanation of (internal) entries in the samples below:

- display means display the output
- game specifies the game strand
- extra enables multiple reward modes
- proc gives text displayed to therapist
- kind is the layout code where C means channel, I means Inhibit, R means reward.

Each stream has its own frequency bandwidth for bandpass filtering.

A simple example of the mode logic (all diagrammed in Appendix C) is Differ.

```
kind=CCIRI
10=lowpass,in=0,out=0,display                        >Lowpass channel A, display
                                                      on trace 0
20=lowpass,in=1,out=1,display                        >Lowpass channel B, display
                                                      on trace 1
30=bandpass,in=0-1,out=2,game=0,display              >Bandpass trace 0 and 1
                                                      added, display on trace 2
40=bandpass,in=0-1,out=4,game=3,display              >Bandpass trace 0 and 1
                                                      added, display on trace 4
50=differ,in=0-1,out=3,game=1,display,extra,proc=Diff >Subtract trace 1 from trace 0,
                                                      bandpass, display on trace 3
60=bsmr,in=3-3,inhibit=2-4                           >Reward if trace 3 rewardable
                                                      and no inhibit on traces 2
                                                      and 4
```

Another example is the 8-trace Dual mode:

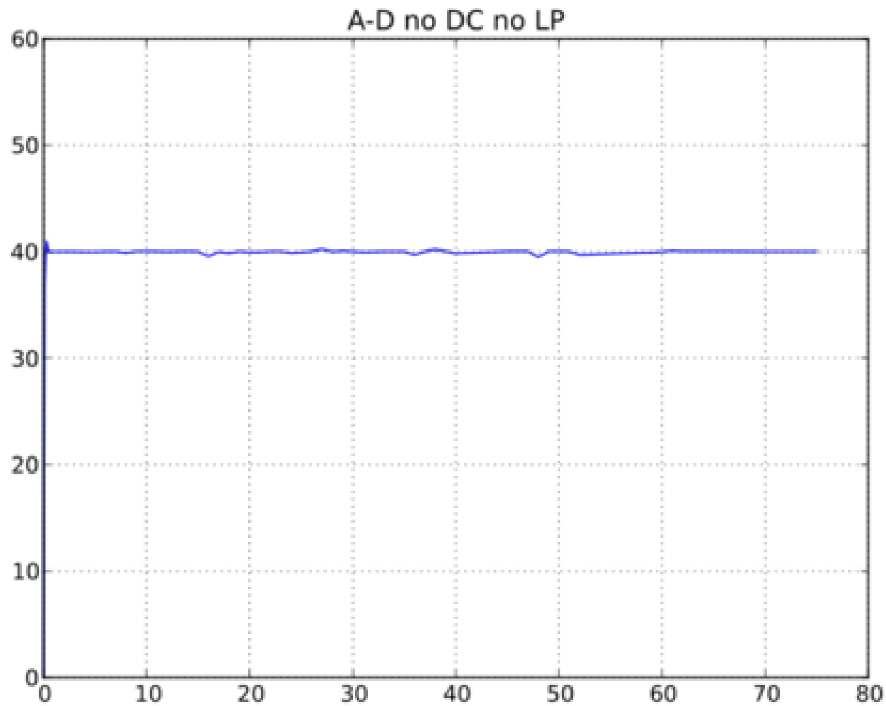
```
kind=CCIRIIRI
10=lowpass,in=0,out=0,display
20=lowpass,in=1,out=1,display
30=bandpass,in=0,out=2,game=0,display
40=bandpass,in=0,out=4,game=3,display
50=bandpass,in=0,out=3,game=1,display,extra,proc=Ampl  > note inputs come from a
                                                         single channel
51=bandpass,in=1,out=5,game=4,display
52=bandpass,in=1,out=7,game=7,display
53=bandpass,in=1,out=6,game=6,display,extra,proc=Ampl > note inputs come from a
                                                         single channel
60=bsmr,in=3-6,inhibit=2-4-5-7                         > both rewards and all 4
                                                         inhibits participate
```

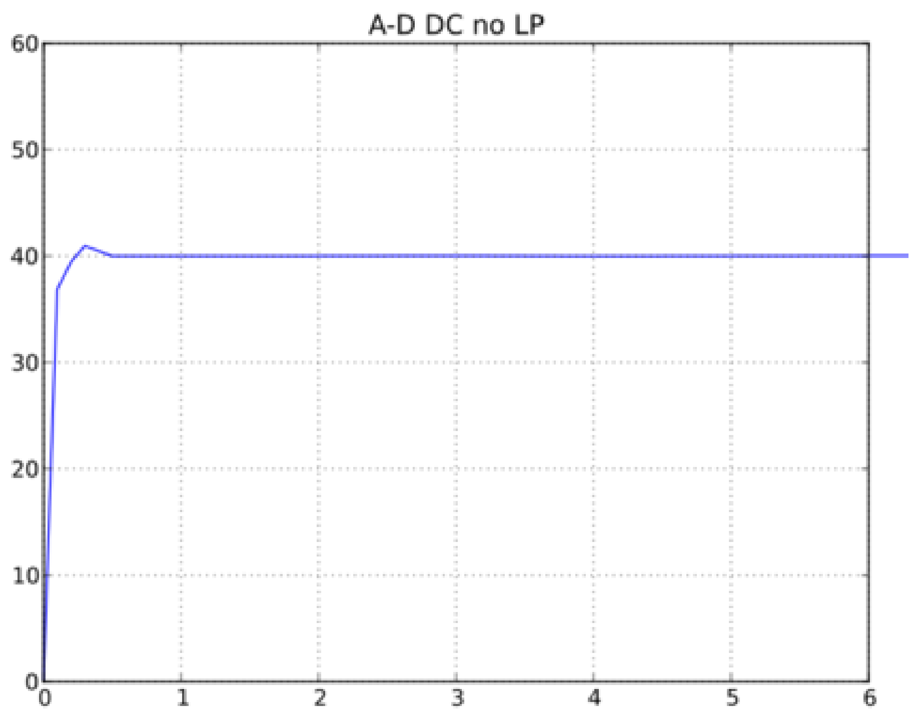

Data Storage Format

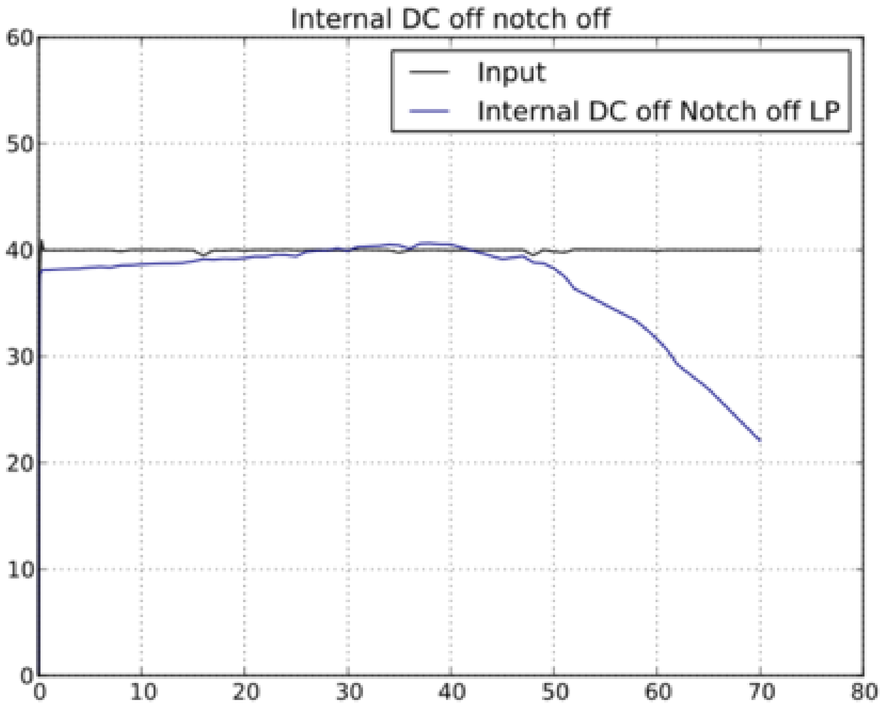
The internal data structures for raw and summary data are described by the header files listed in Appendix D. Further information and guidance can be obtained from EEG Software on request.

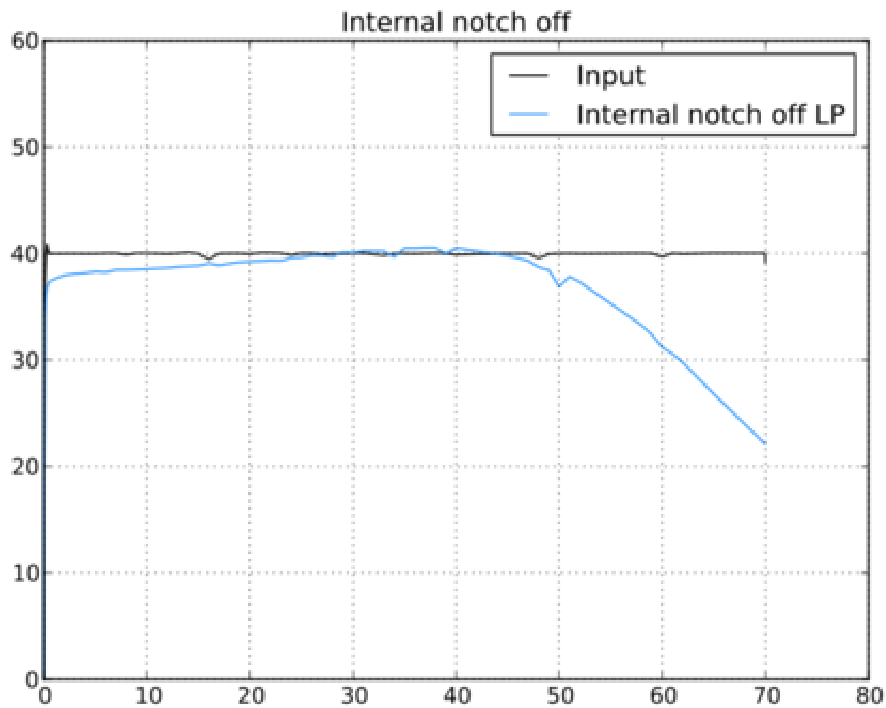
Appendix A: Filter Bandpass Characteristics

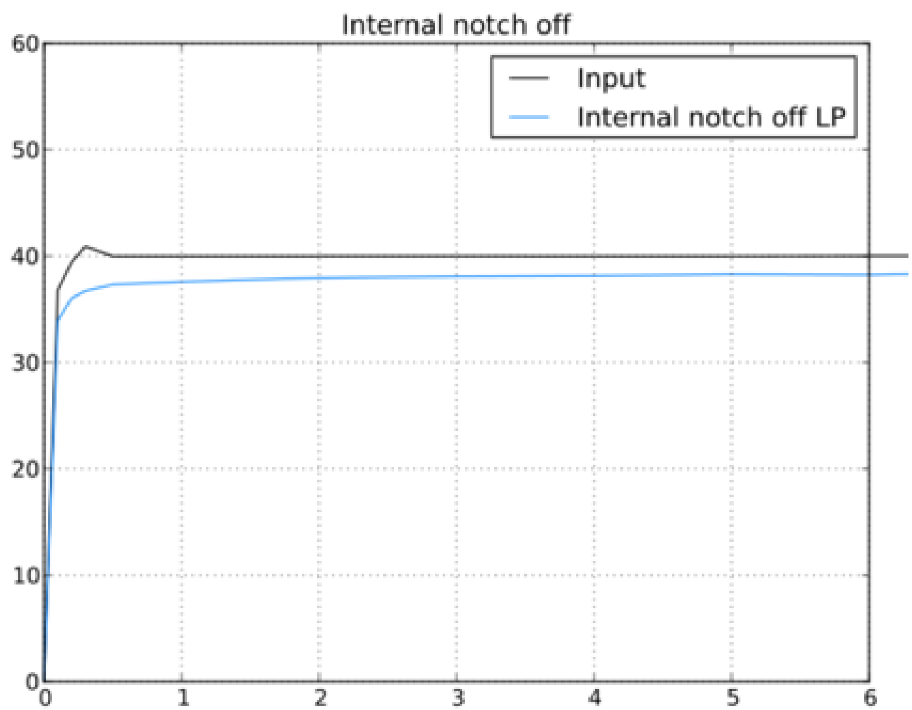
All these data results are based on a 40 microvolt peak-peak input voltage.

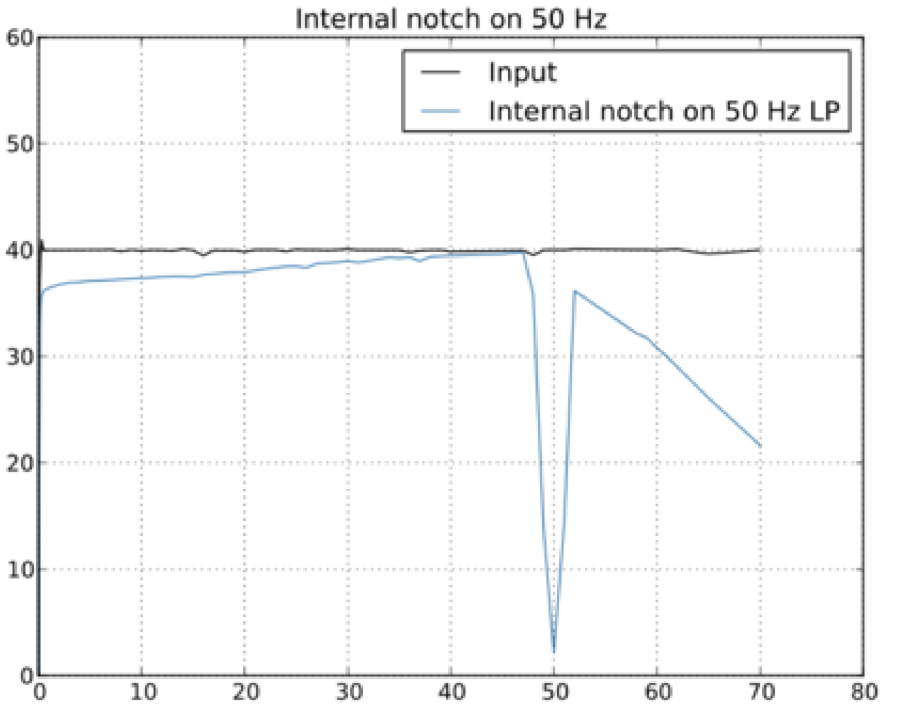


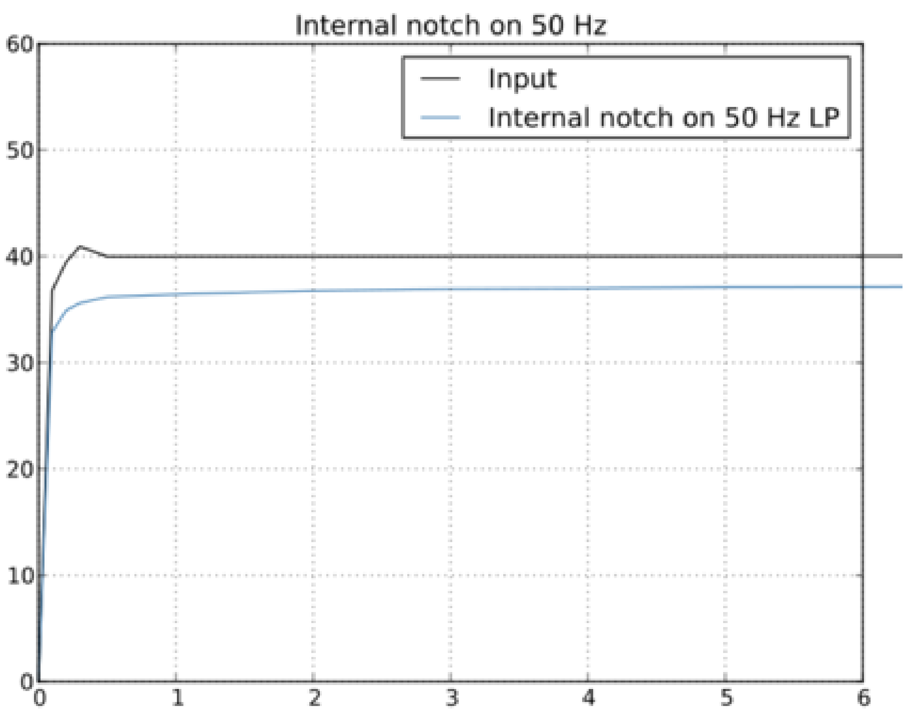


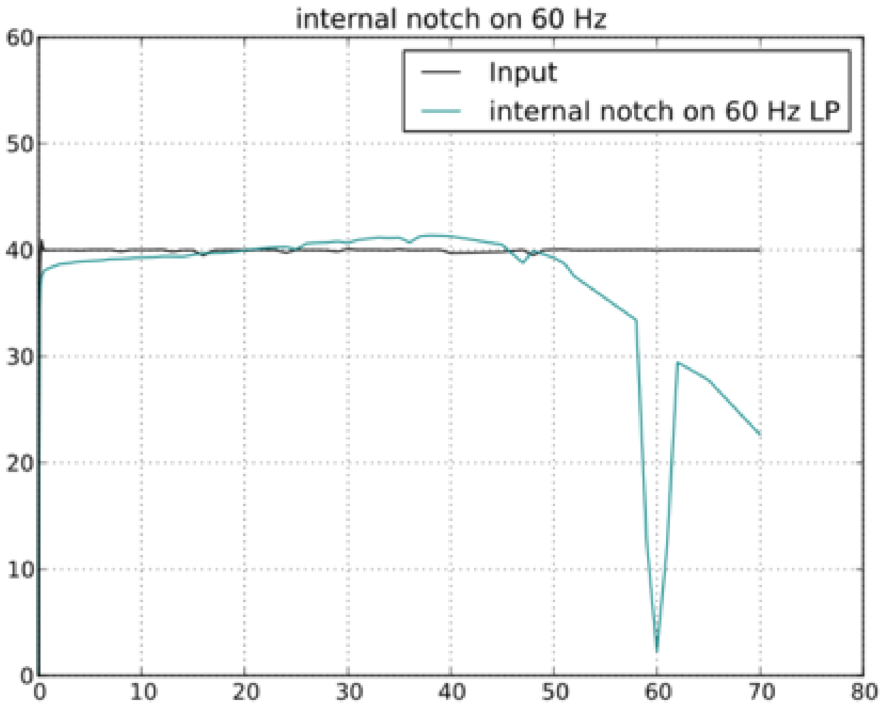

Internal DC off notch off
Input
Internal DC off Notch off LP
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80

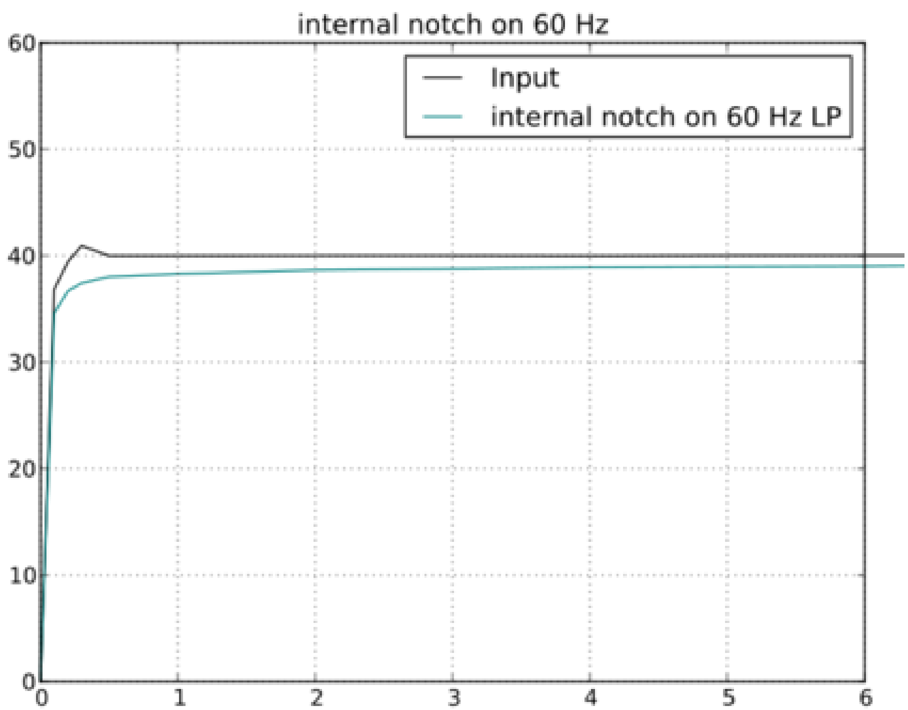

Internal notch off
Input
Internal notch off LP
0
10
20
30
40
50
60
0
10
20
30
40
50
60
70
80

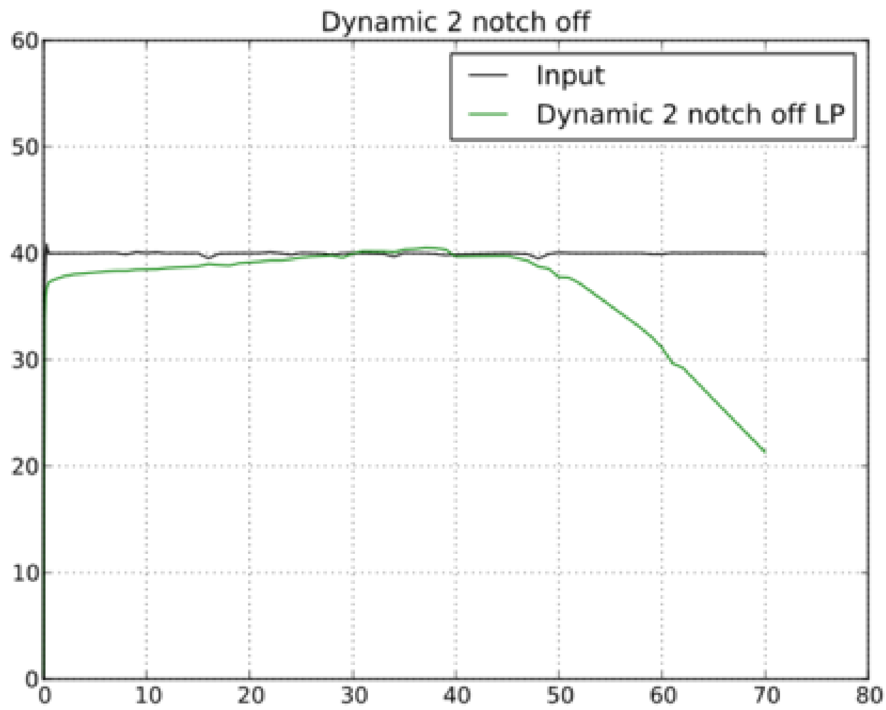

Internal notch off
Input
Internal notch off LP
0
10
20
30
40
50
60
0
1
2
3
4
5
6

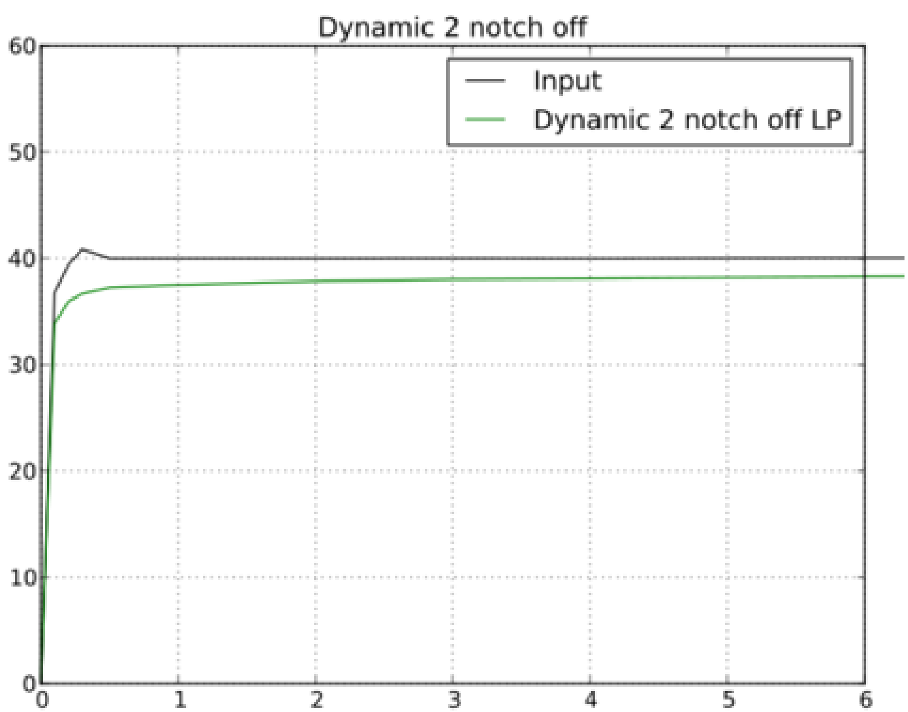

Internal notch on 50 Hz
Input
Internal notch on 50 Hz LP
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80

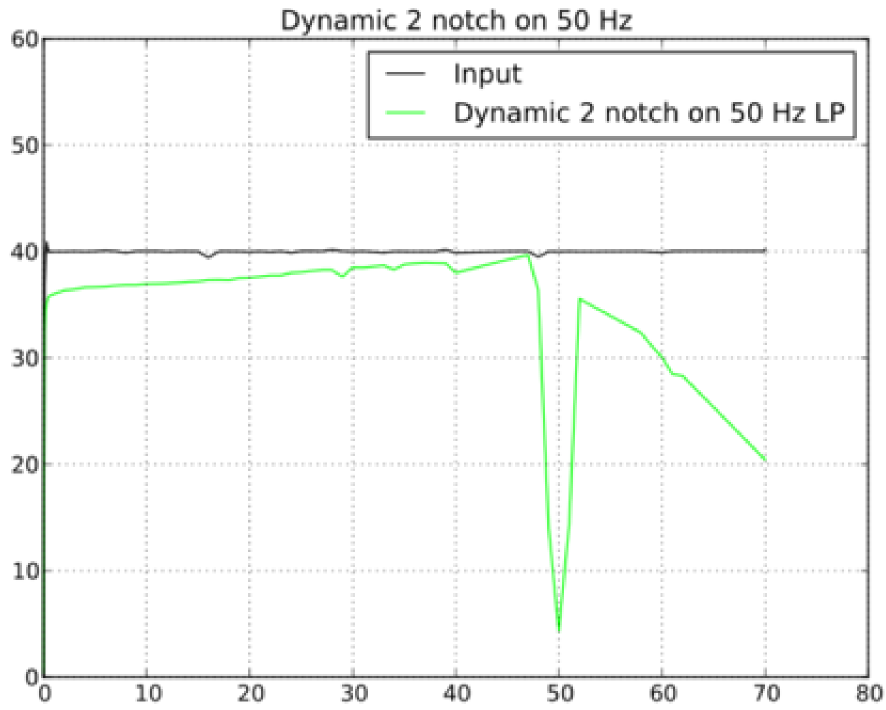

Internal notch on 50 Hz
Input
Internal notch on 50 Hz LP
60
50
40
30
20
10
0
0
1
2
3
4
5
6

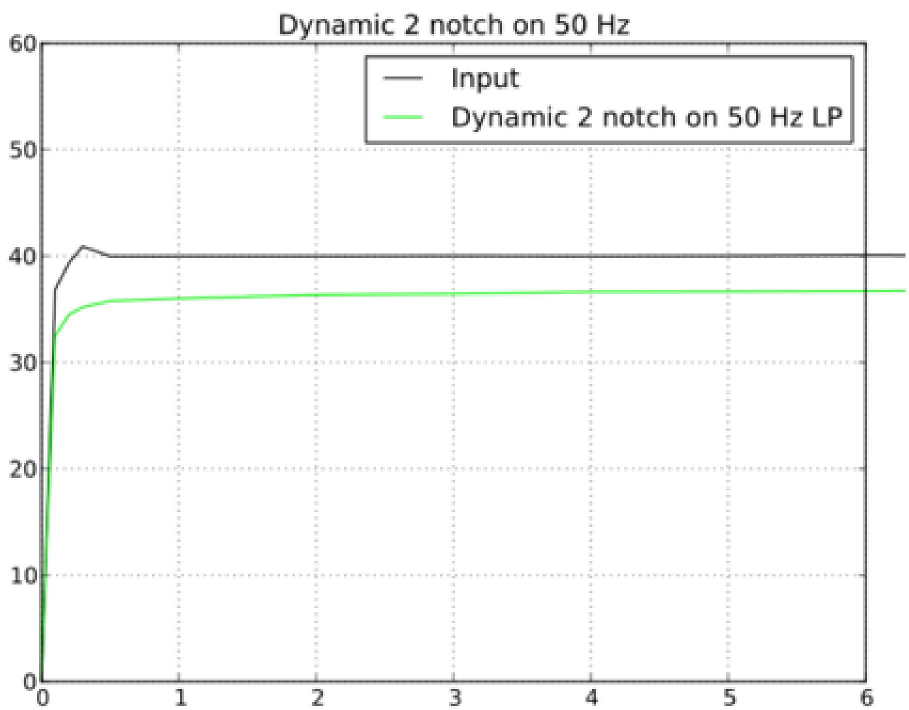

internal notch on 60 Hz
Input
internal notch on 60 Hz LP

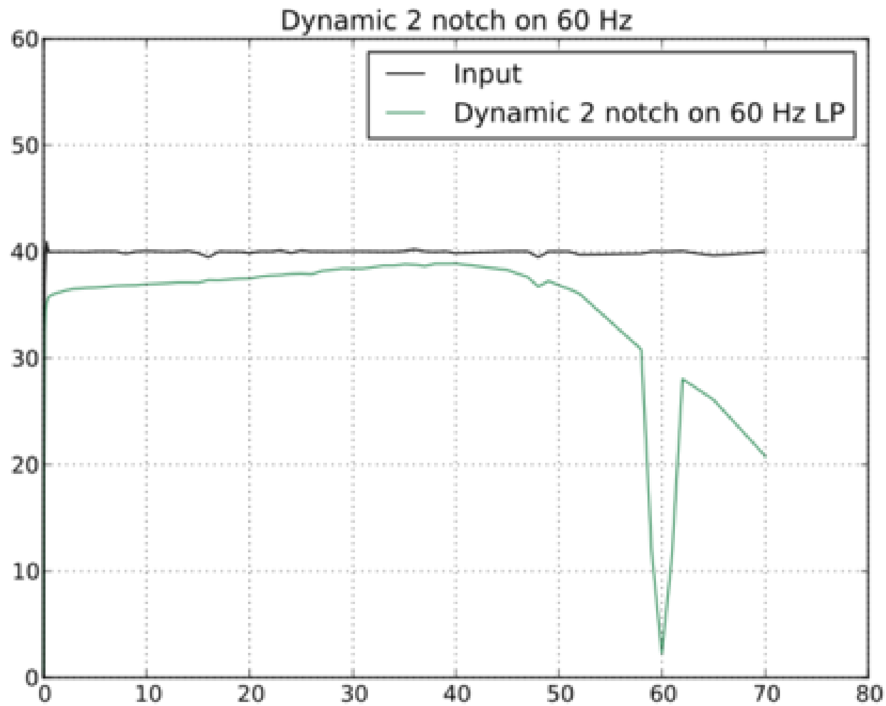

internal notch on 60 Hz
Input
internal notch on 60 Hz LP

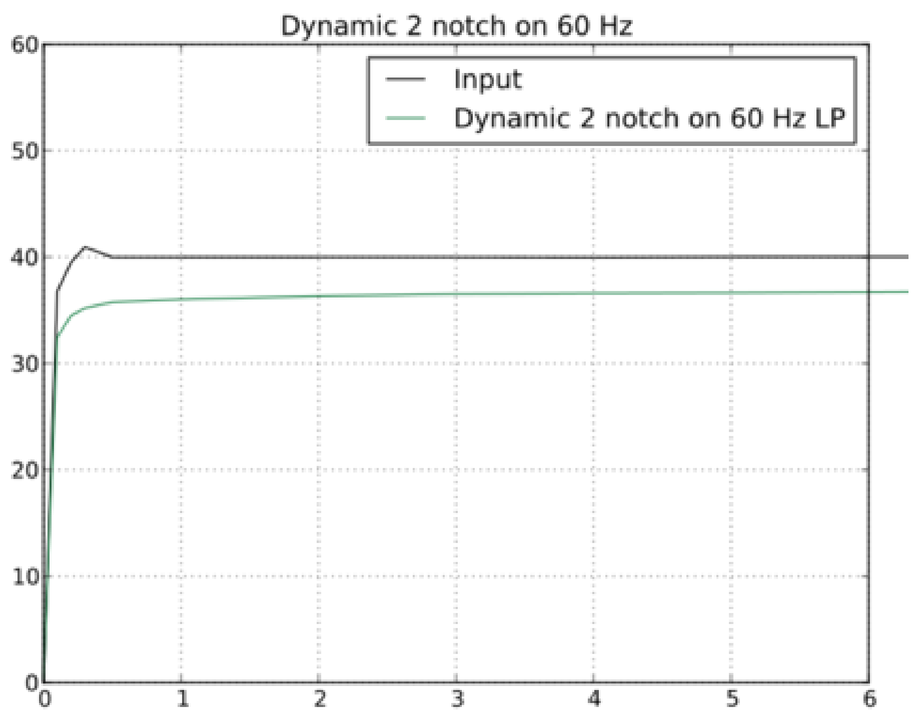

Dynamic 2 notch off
Input
Dynamic 2 notch off LP
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80


Dynamic 2 notch off
Input
Dynamic 2 notch off LP
60
50
40
30
20
10
0
0
1
2
3
4
5
6

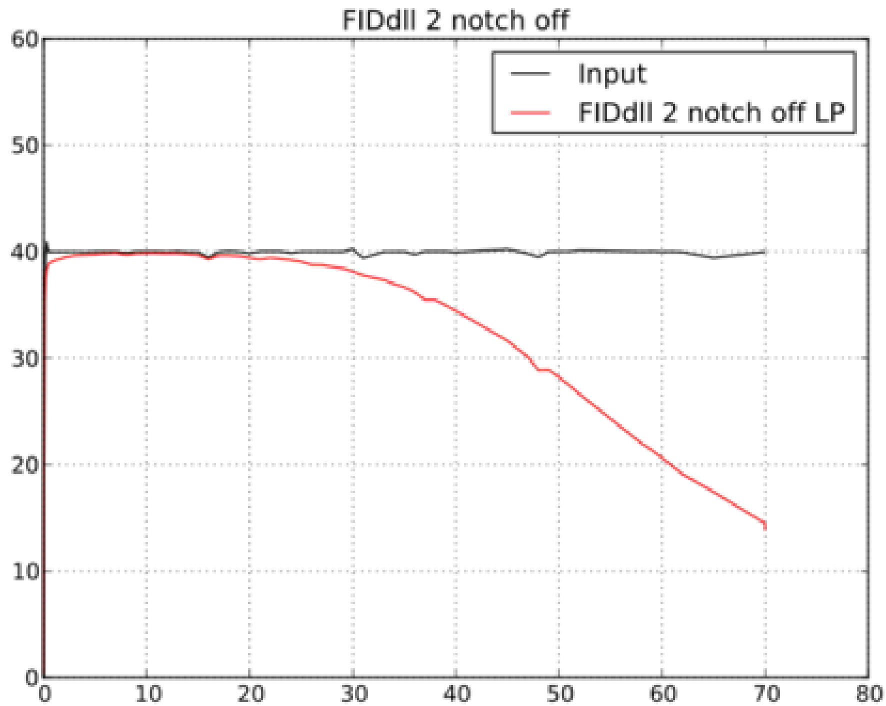

Dynamic 2 notch on 50 Hz
Input
Dynamic 2 notch on 50 Hz LP
0
10
20
30
40
50
60
0
10
20
30
40
50
60
70
80

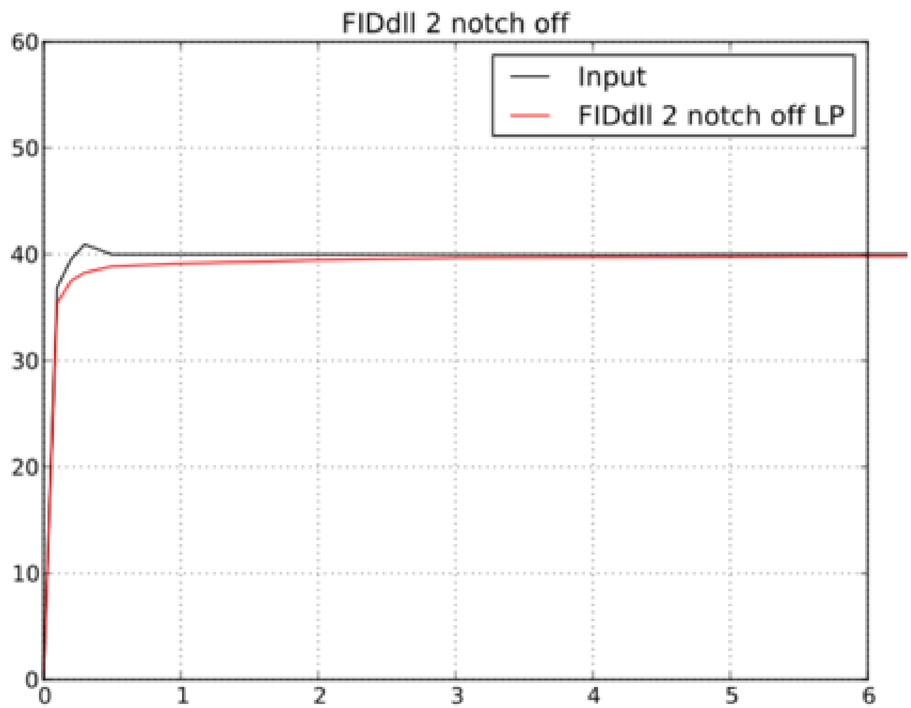

Dynamic 2 notch on 50 Hz
Input
Dynamic 2 notch on 50 Hz LP
0
10
20
30
40
50
60
0
1
2
3
4
5
6

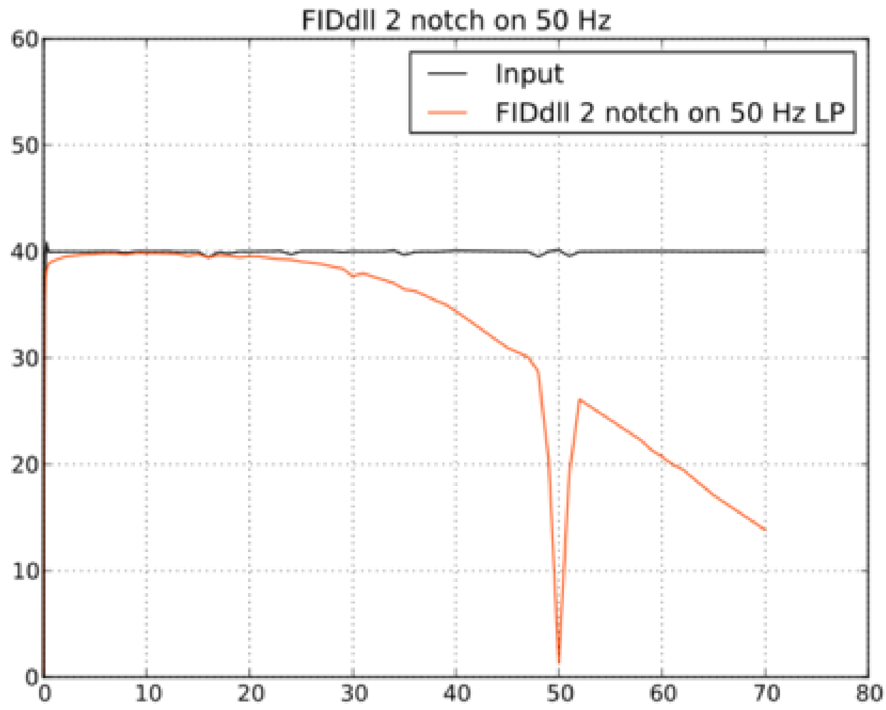


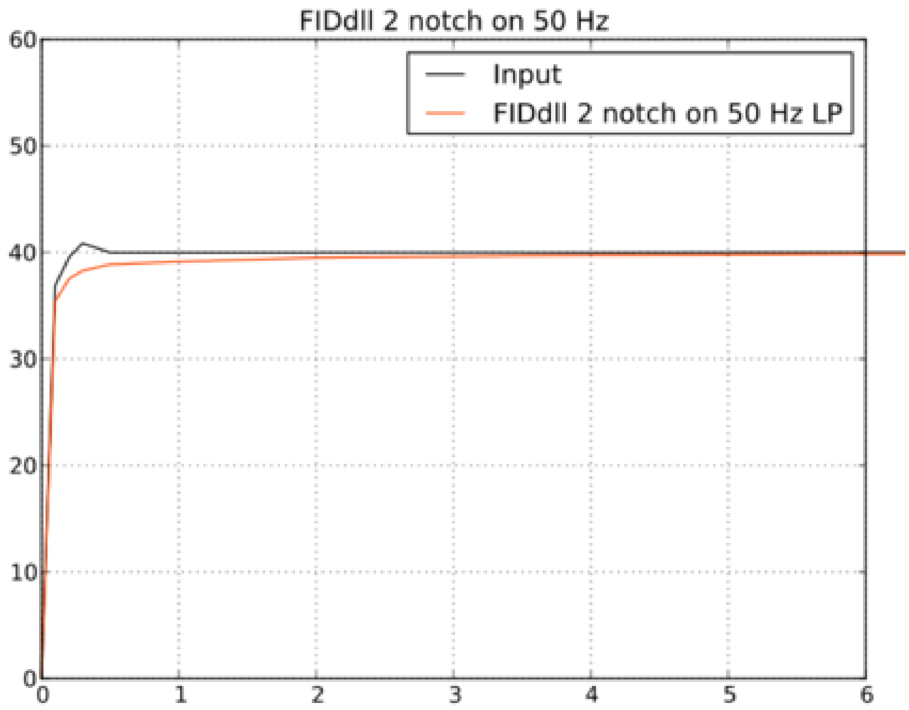


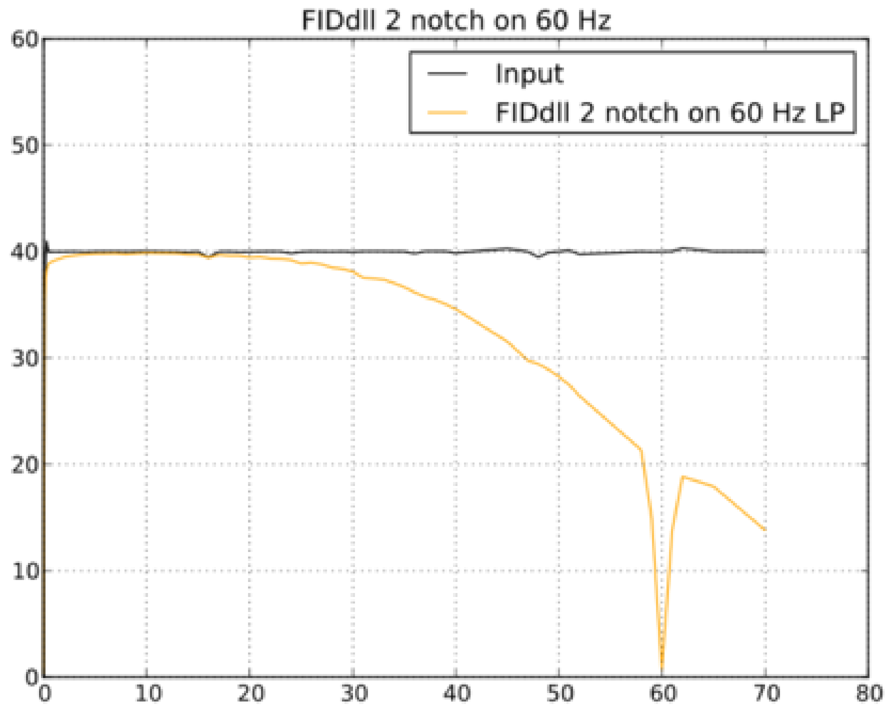
All lowpass filtering (0 to 30,40,50 Hz) use the same filters as Dynamic 2 settings.

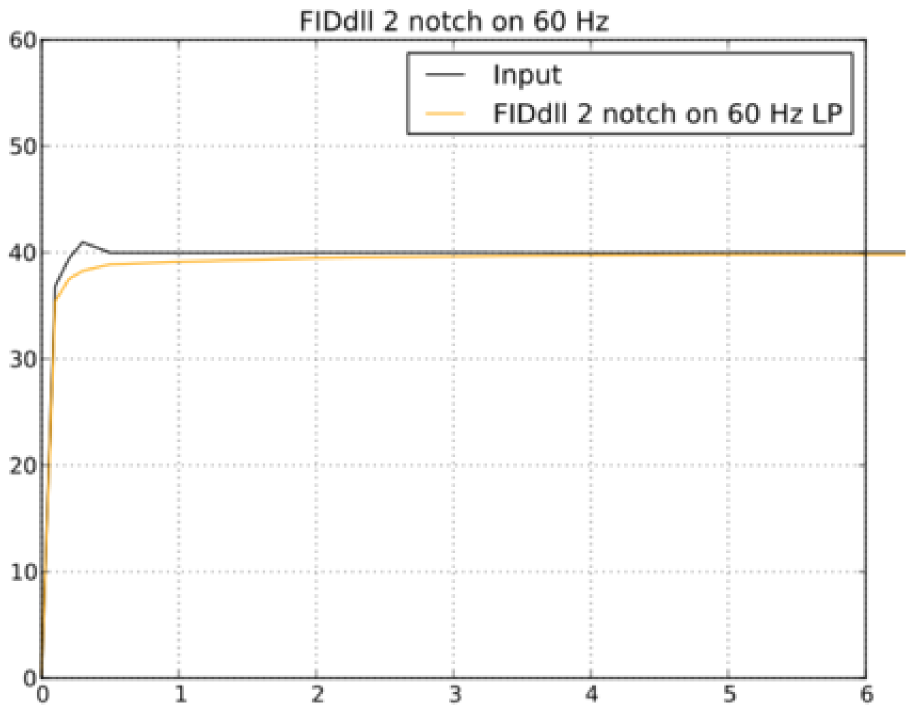

FIDdll 2 notch off
Input
FIDdll 2 notch off LP
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80

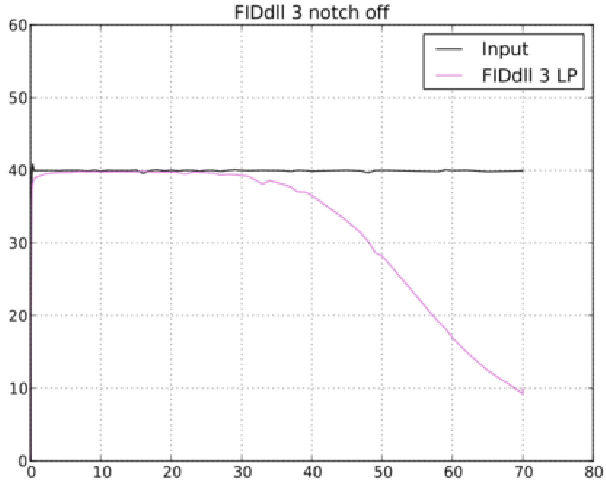

FIDdll 2 notch off
Input
FIDdll 2 notch off LP
60
50
40
30
20
10
0
0
1
2
3
4
5
6

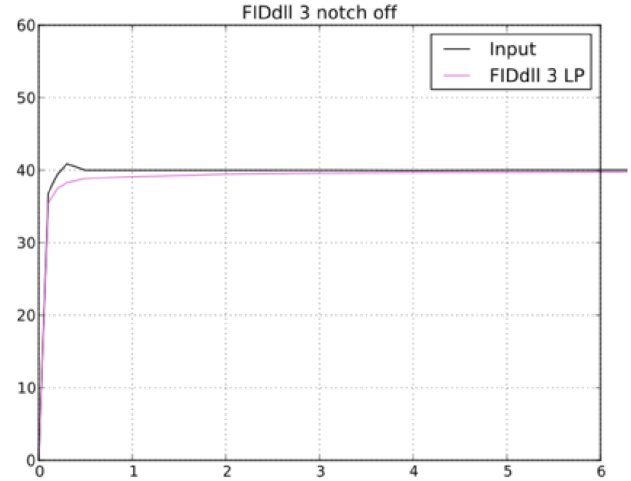

FIDdll 2 notch on 50 Hz
Input
FIDdll 2 notch on 50 Hz LP
0
10
20
30
40
50
60
0
10
20
30
40
50
60
70
80

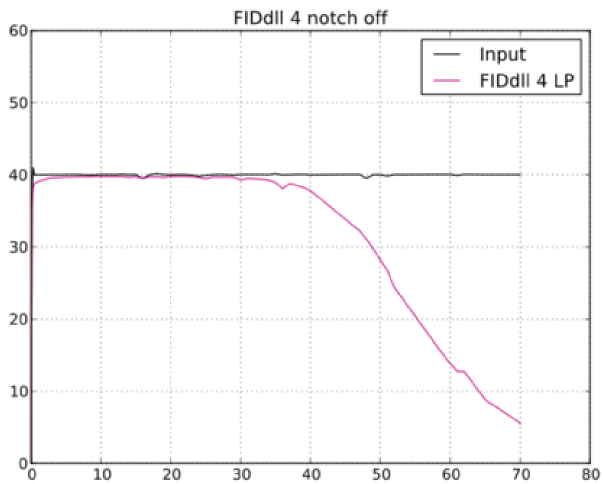

FIDdll 2 notch on 50 Hz
Input
FIDdll 2 notch on 50 Hz LP
0
10
20
30
40
50
60
0
1
2
3
4
5
6

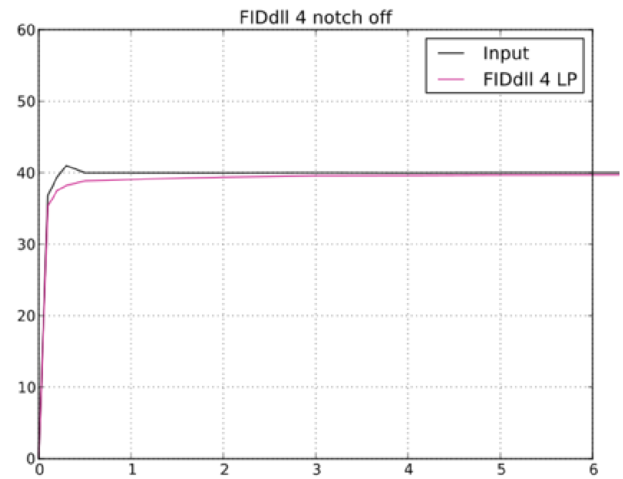

FIDdll 2 notch on 60 Hz
Input
FIDdll 2 notch on 60 Hz LP
0
10
20
30
40
50
60
70
80

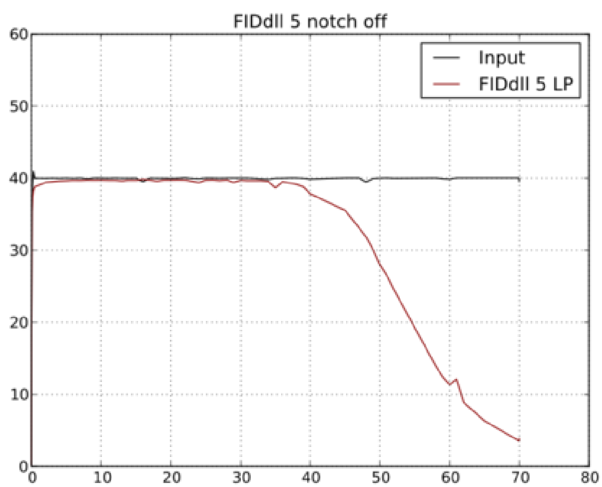

FIDdll 2 notch on 60 Hz
Input
FIDdll 2 notch on 60 Hz LP
0
1
2
3
4
5
6

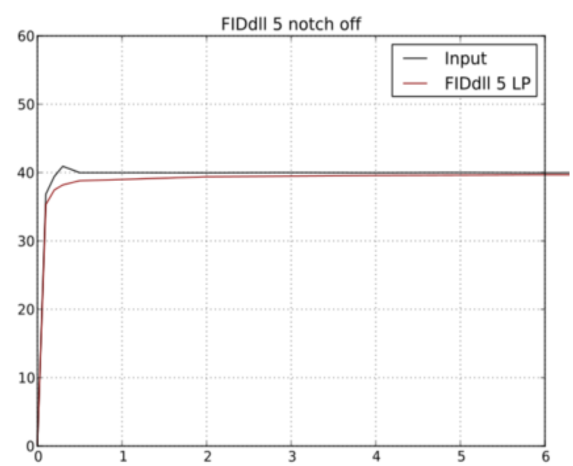

FIDdll 3 notch off
Input
FIDdll 3 LP
0 10 20 30 40 50 60
0 10 20 30 40 50 60 70 80


FIDdll 3 notch off
Input
FIDdll 3 LP
0 10 20 30 40 50 60
0 1 2 3 4 5 6


FIDdll 4 notch off
Input
FIDdll 4 LP
0 10 20 30 40 50 60
0 10 20 30 40 50 60 70 80

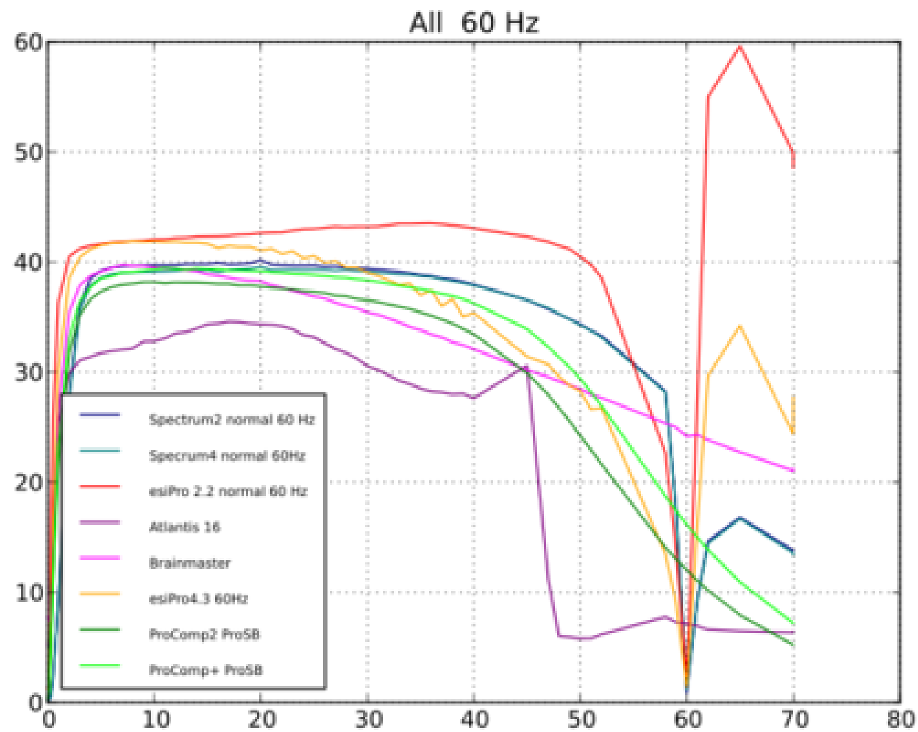

FIDdll 4 notch off
Input
FIDdll 4 LP
0 10 20 30 40 50 60
0 1 2 3 4 5 6

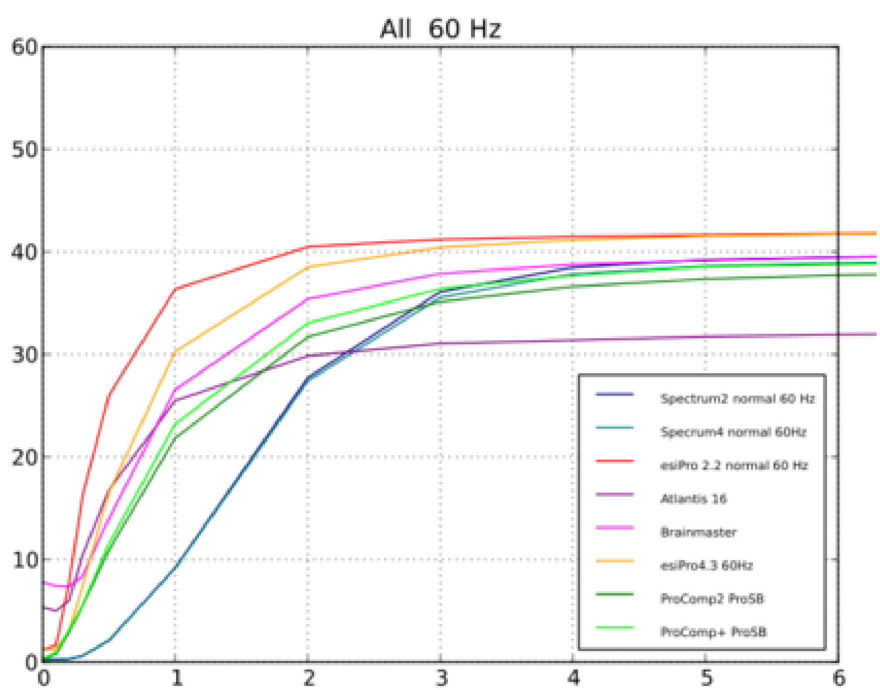

FIDdll 5 notch off
Input
FIDdll 5 LP
0 10 20 30 40 50 60
0 10 20 30 40 50 60 70 80

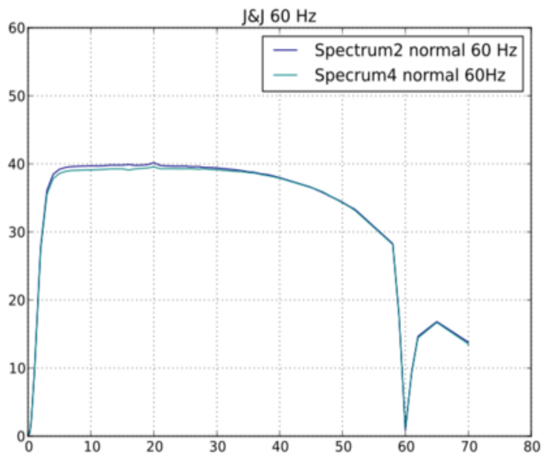

FIDdll 5 notch off
Input
FIDdll 5 LP
0 10 20 30 40 50 60
0 1 2 3 4 5 6

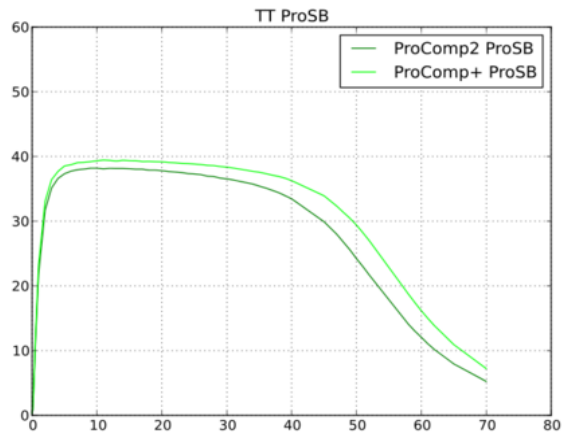
Appendix B: Device Bandpass Characteristics

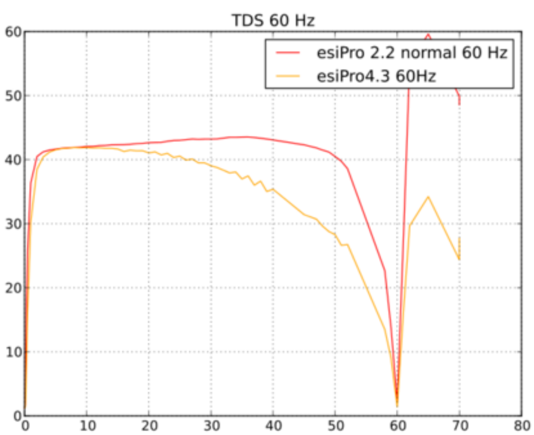
Bandpass characteristics plots based on 40 microvolt peak-peak inputs:

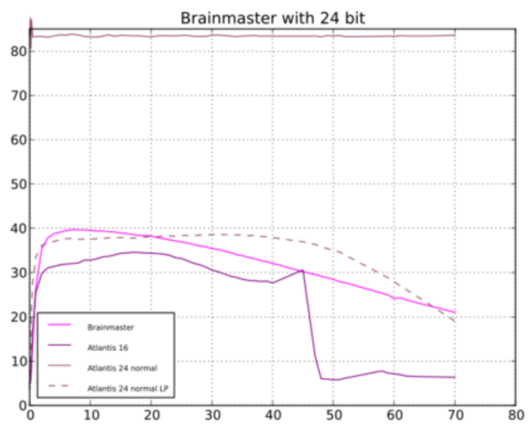


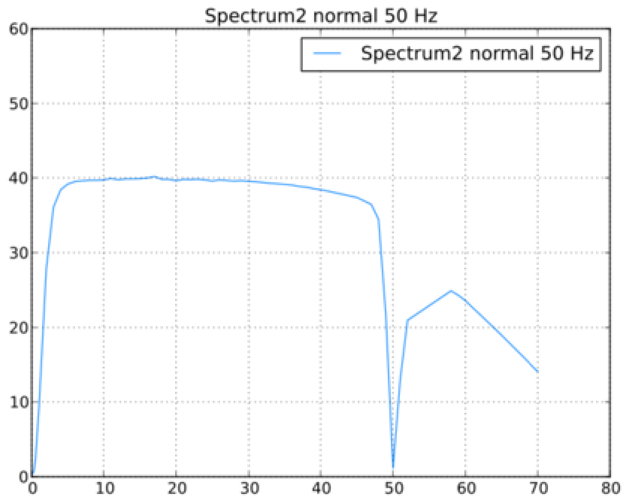


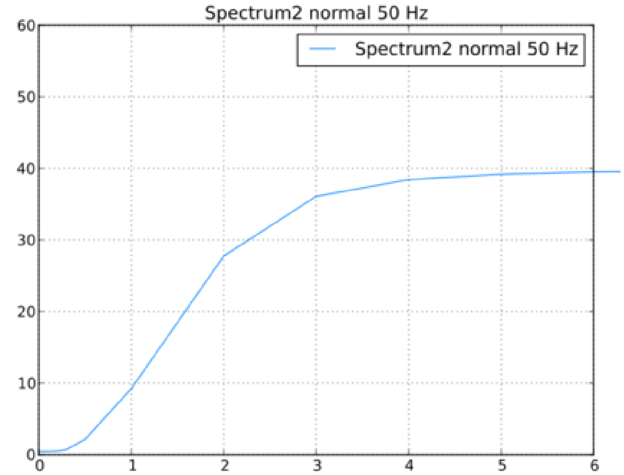

J&J 60 Hz
Spectrum2 normal 60 Hz
Specrum4 normal 60Hz

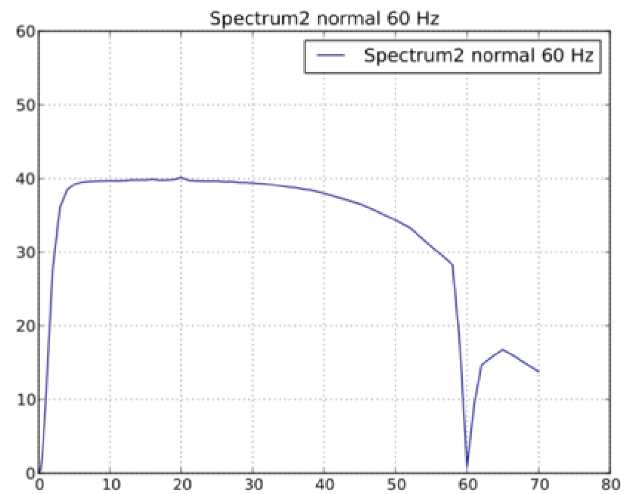

TT ProSB
ProComp2 ProSB
ProComp+ ProSB

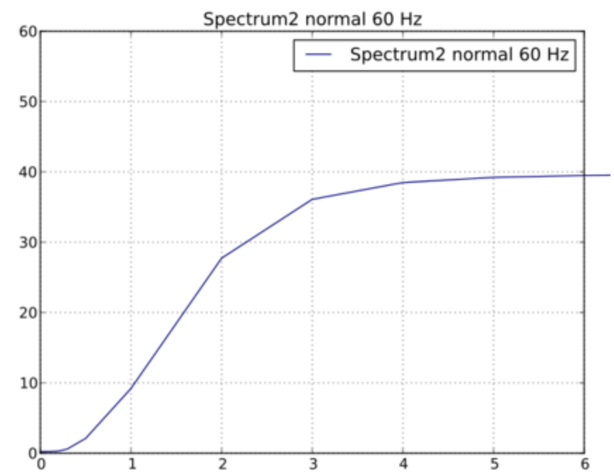

TDS 60 Hz
esiPro 2.2 normal 60 Hz
esiPro4.3 60Hz

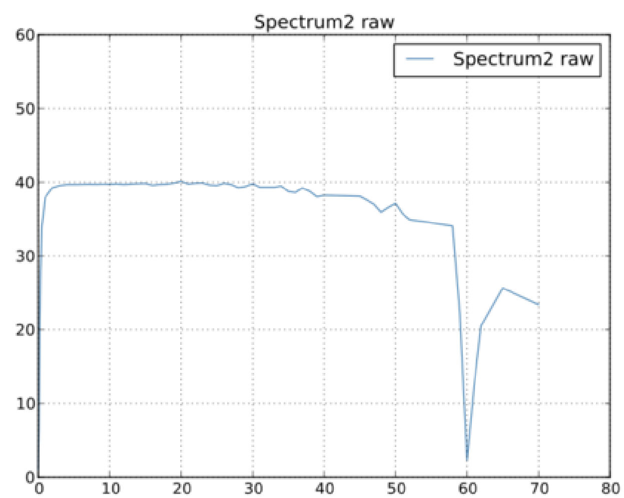

Brainmaster with 24 bit
Brainmaster
Atlantis 16
Atlantis 24 normal
Atlantis 24 normal LP

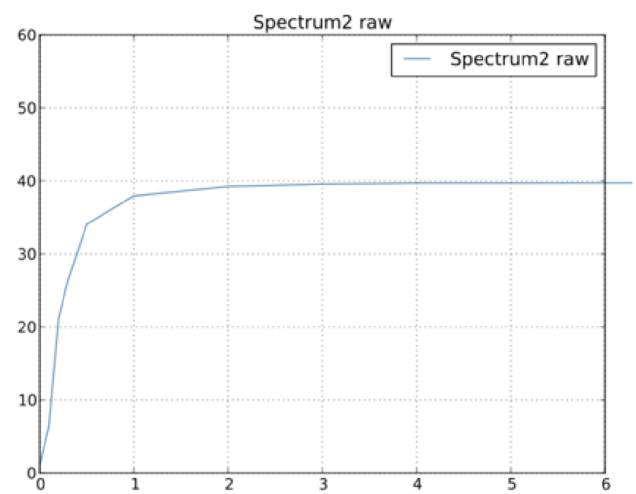

Spectrum2 normal 50 Hz
Spectrum2 normal 50 Hz

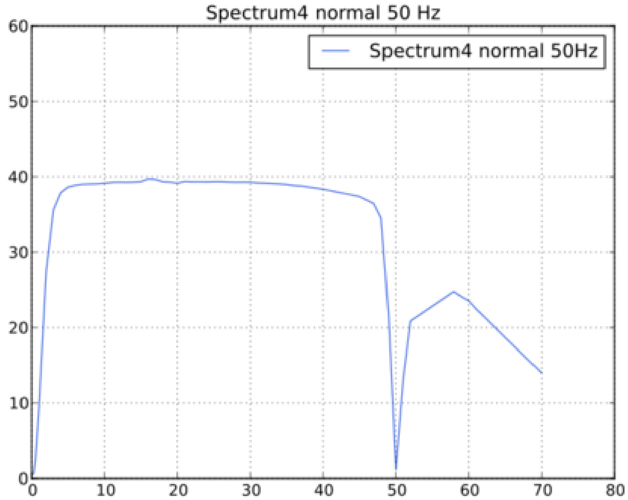

Spectrum2 normal 50 Hz
Spectrum2 normal 50 Hz

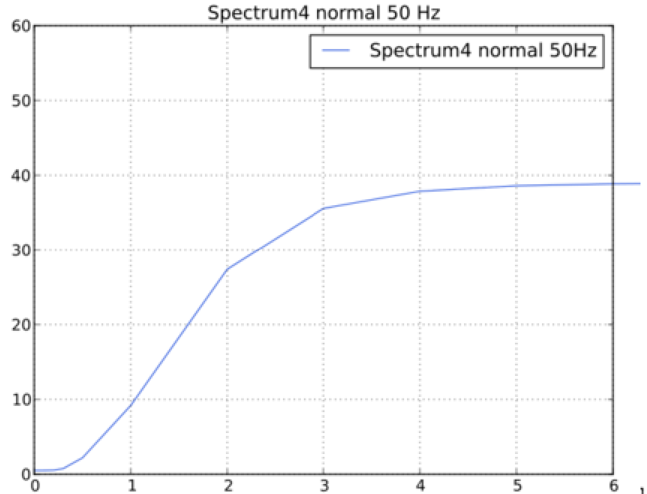

Spectrum2 normal 60 Hz
Spectrum2 normal 60 Hz

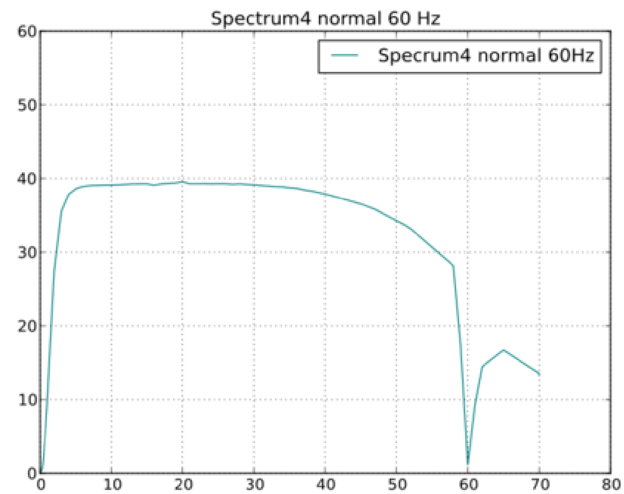

Spectrum2 normal 60 Hz
Spectrum2 normal 60 Hz

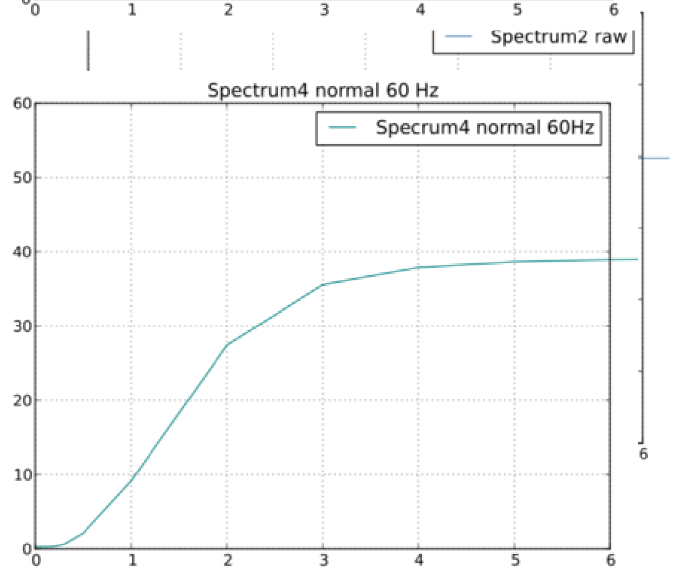

Spectrum2 raw
Spectrum2 raw

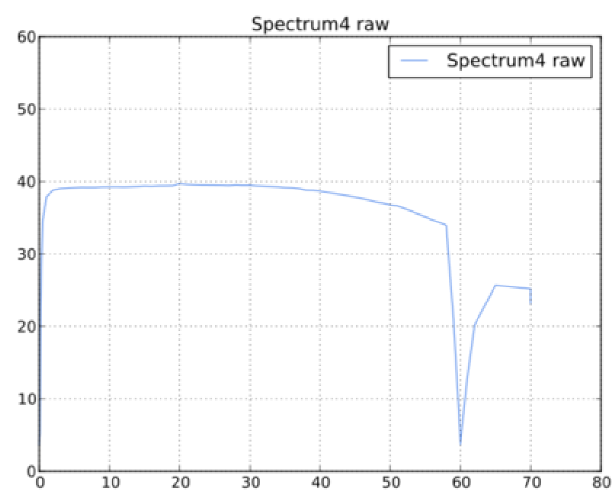

Spectrum2 raw
Spectrum2 raw

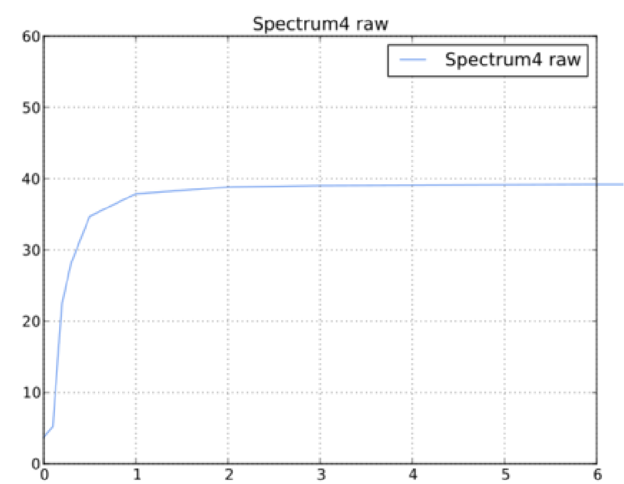

Spectrum4 normal 50 Hz
Spectrum4 normal 50Hz

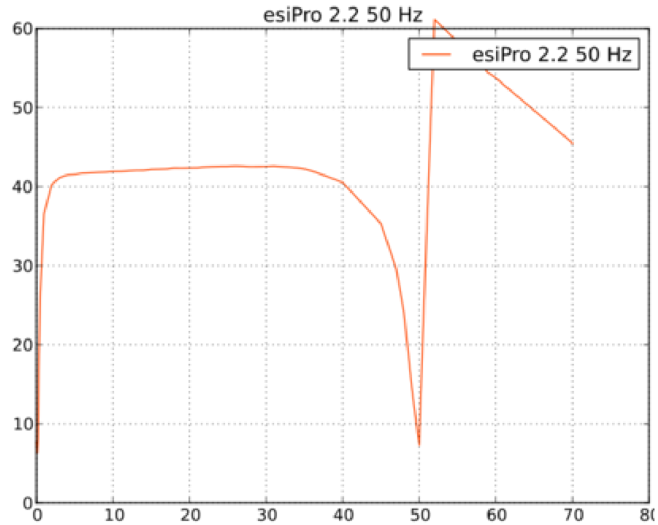

Spectrum4 normal 50 Hz
Spectrum4 normal 50Hz

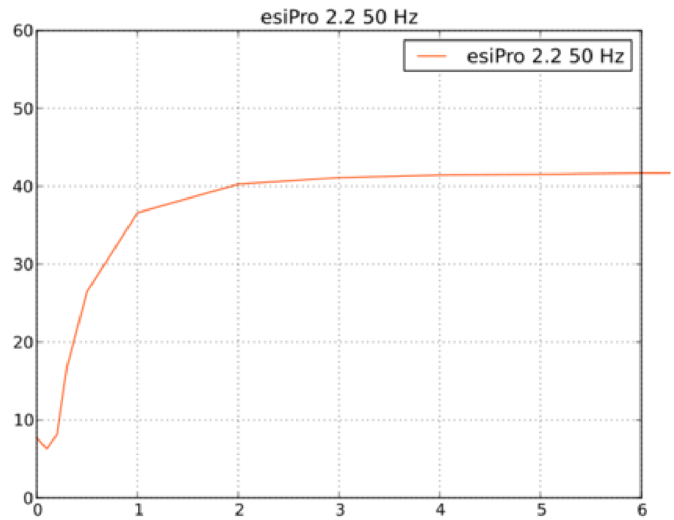

Spectrum4 normal 60 Hz
Specrum4 normal 60Hz

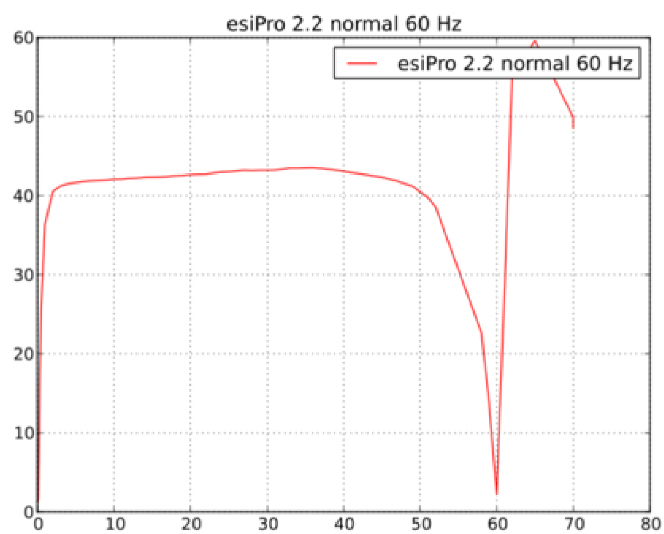

Spectrum2 raw
Spectrum4 normal 60 Hz
Specrum4 normal 60Hz

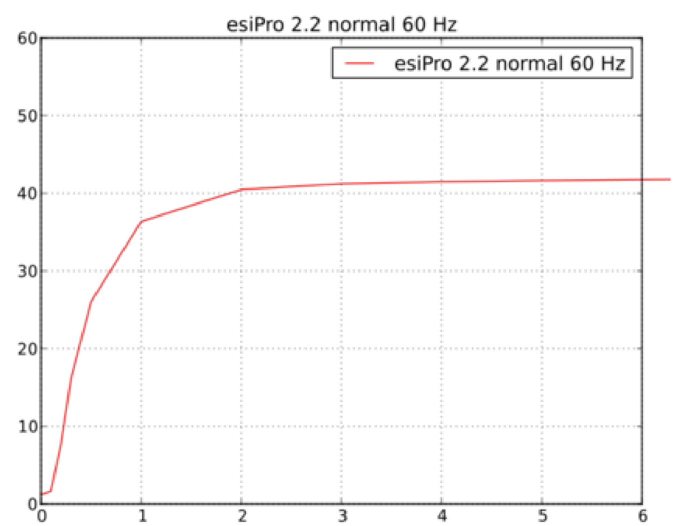

Spectrum4 raw
Spectrum4 raw

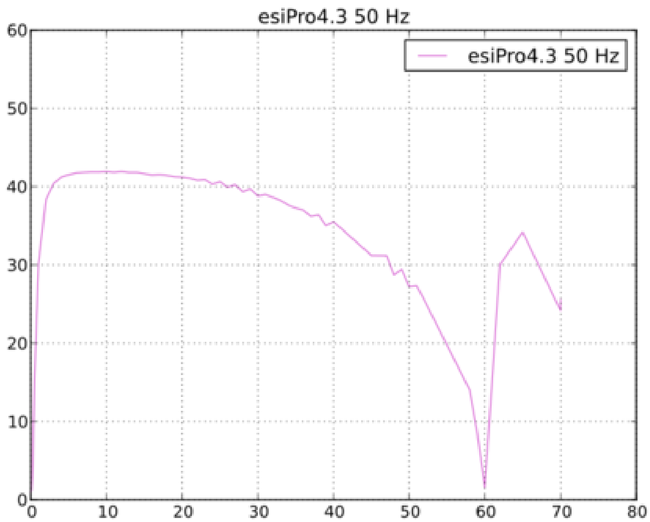

Spectrum4 raw
Spectrum4 raw

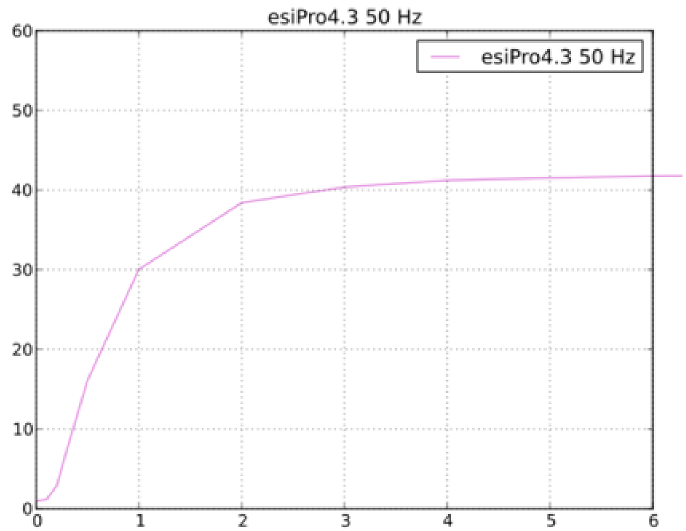

esiPro 2.2 50 Hz
esiPro 2.2 50 Hz
0 10 20 30 40 50 60
0 10 20 30 40 50 60 70

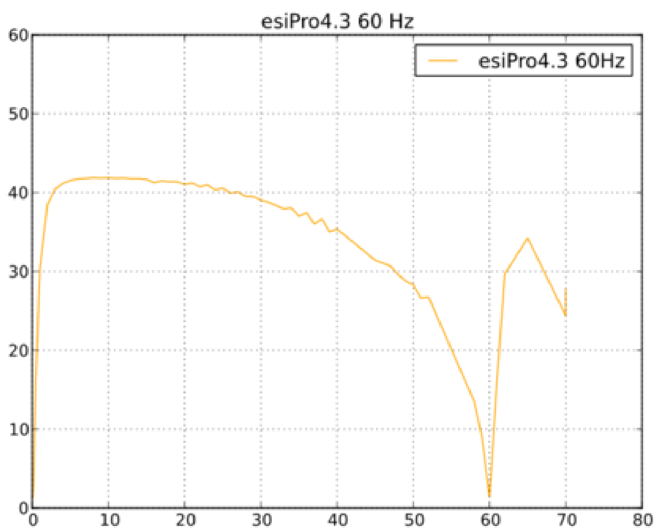

esiPro 2.2 50 Hz
esiPro 2.2 50 Hz
0 10 20 30 40 50 60
0 1 2 3 4 5 6

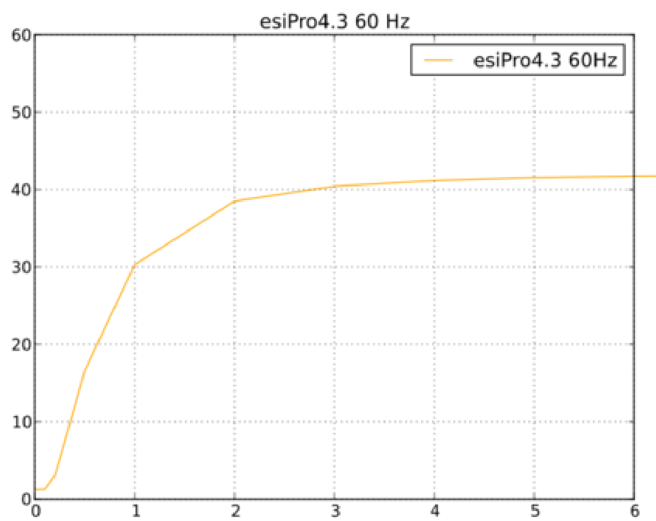

esiPro 2.2 normal 60 Hz
esiPro 2.2 normal 60 Hz
0 10 20 30 40 50 60
0 10 20 30 40 50 60 70 80

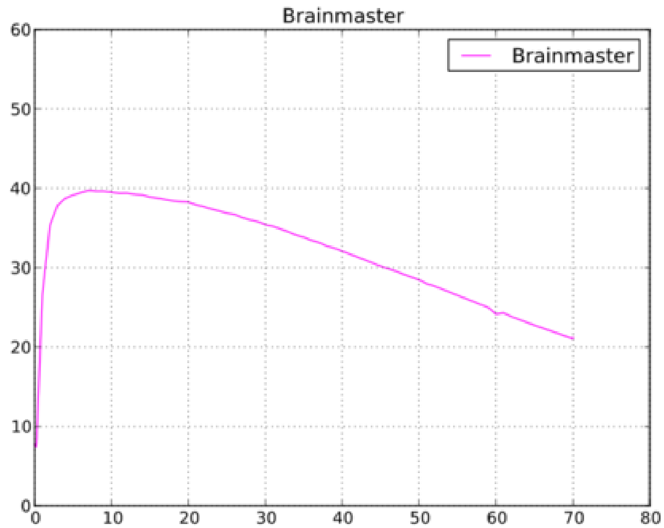

esiPro 2.2 normal 60 Hz
esiPro 2.2 normal 60 Hz
0 10 20 30 40 50 60
0 1 2 3 4 5 6

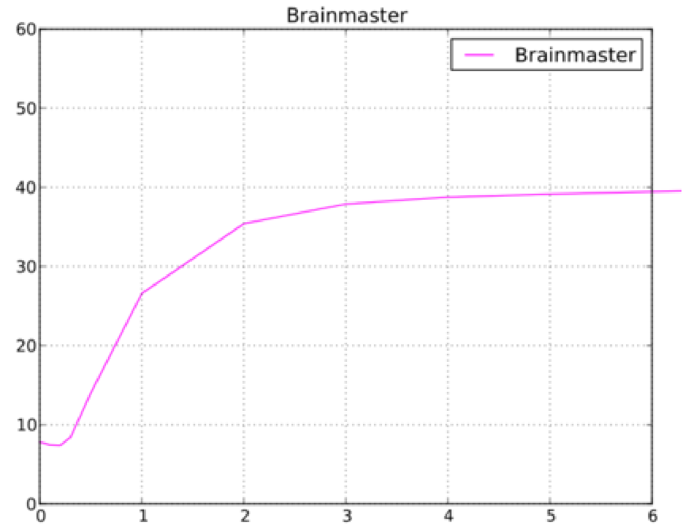

esiPro4.3 50 Hz
esiPro4.3 50 Hz
0
10
20
30
40
50
60
0
10
20
30
40
50
60
70
80

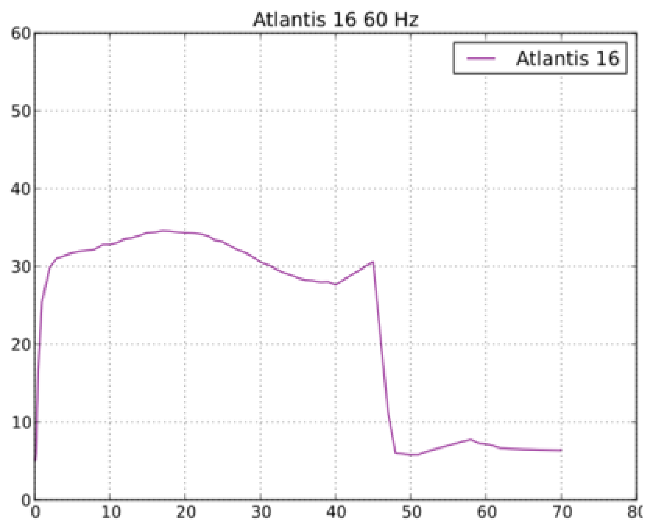

esiPro4.3 50 Hz
esiPro4.3 50 Hz
0
10
20
30
40
50
60
0
1
2
3
4
5
6

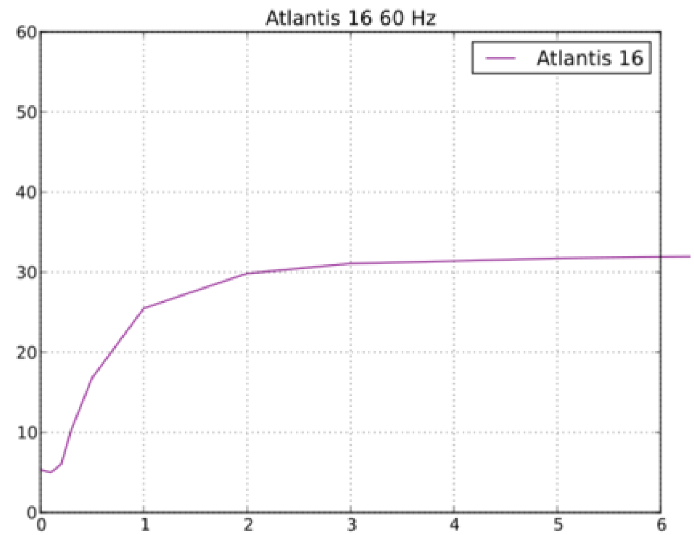

esiPro4.3 60 Hz
esiPro4.3 60Hz
0
10
20
30
40
50
60
0
10
20
30
40
50
60
70
80

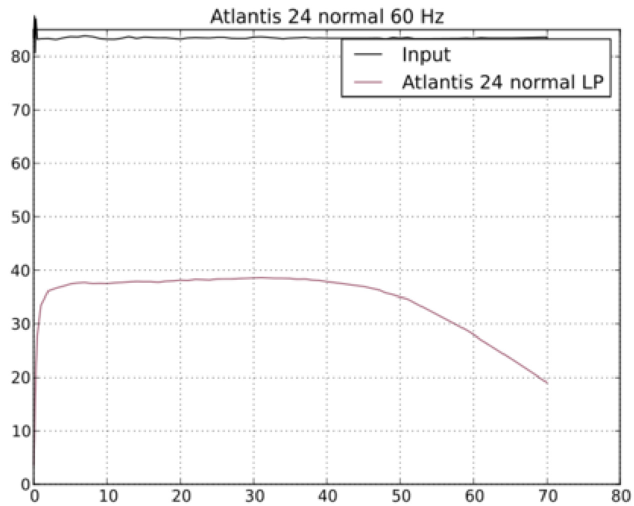

esiPro4.3 60 Hz
esiPro4.3 60Hz
0
10
20
30
40
50
60
0
1
2
3
4
5
6

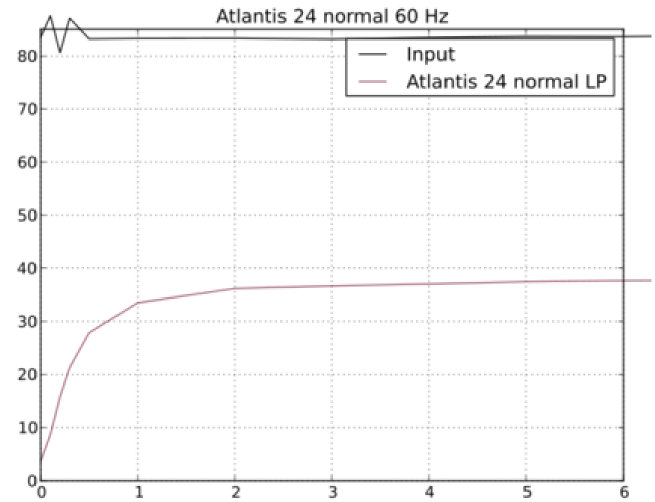

Brainmaster
Brainmaster


Brainmaster
Brainmaster


Atlantis 16 60 Hz
Atlantis 16


Atlantis 16 60 Hz
Atlantis 16


Atlantis 24 normal 60 Hz
Input
Atlantis 24 normal LP


Atlantis 24 normal 60 Hz
Input
Atlantis 24 normal LP

Other graphs and plots available from EEG Software as requested.

Device	Serial number	Notes
Spectrum 2	12399	
Spectrum 4	-------	Prototype without serial number
Brainmaster 2E	4290	
Atlantis II	40403	
esiPro 2.2	2C099132	
esiPro 4.3	B117014	
ProComp2	BC1063	
ProComp+	AD3526	Flexpro=G3936
Infiniti		
Pendant 9v		
Pet2.0		
QPET		
BrainLynx		
Optima		
Neuroamp II		

Appendix C: Feedback Modes

8q (CCCCIIRI)

AvgAQPS	4 channel PSync Averaged + 3 Inhibits	250
QSingleA	4 channel BP-A	251
QSingleB	4 channel BP-B	252
QSingleC	4 channel BP-C	253
QSingleD	4 channel BP-D	254

10r (CCCCIRIIRI)

DAsync	4 channel AsyncAB+AsyncCD	66
DAsyncBPAB	4 channel AsyncAB+BP C	64
DDiffSum	4 channel Diff-SumAB+Diff-SumCD	86
DDiffSumBPAB	4 channel Diff-SumAB+BP C	84
DDiffSumBPCD	4 channel Diff-SumCD+BP A	85
DGAsync	4 channel GAsyncAB+GAsyncCD	69

DGAsyncBPAB	4 channel GAsyncAB+BP C	67
DGAsyncBPCD	4 channel GAsyncCD+BP A	68
DMinus	4 channel MinusAB+MinusCD	75
DMinusBPAB	4 channel MinusAB+BP C	73
DMinusBPCD	4 channel MinusCD+BP A	74
DPdelta	4 channel PsyncAB+PsyncCD	72
DPdeltaBPAB	4 channel PsyncAB+BP C	70
DPdeltaBPCD	4 channel PsyncCD+BP A	71
DPsync	4 channel PsyncAB+PsyncC+D	63
DPsyncBPAB	4 channel PsyncAB+BP C	61
DPsyncBPCD	4 channel PsyncCD+BP A	62
DRatio	4 channel RatioAB+RatioCD	83
DRatioBPAB	4 channel RatioAB+BP C	81
DRatioBPCD	4 channel RatioCD+BP A	82
DSingleAB	4 channel single A B	59
DSingleCD	4 channel single C D	60
DSsyncBPCD	4 channel AsyncCD+BP A	65
DUnity	4 channel UnityAB+UnityCD	89
DUnityBPAB	4 channel UnityAB+BP C	87
DUnityBPCD	4 channel UnityCD+BP A	88
DZcomp	4 channel ZcompAB+ZcompCD	78
DZcompBPAB	4 channel ZcompAB+BP C	76
DZcompBPCD	4 channel ZcompCD+BP A	77

8p (CCCCIRRI)

DDiffABDiffCD	4 channel DiffAB DiffCD	247
DDiffABSumCD	4 channel DiffAB SumCD	246
DDualAC	4 channel Just A,C	248
DDualBD	4 channel Just B,D	249
DPsyncABCD	4 channel two psync	241
DPsyncAvg2	4 channel 2 averaged psyncs	243
DPsyncAvgBP	4 channel averaged psync + A	242
DSingleA	4 channel single A	237
DSingleB	4 channel single B	238
DSingleC	4 channel single C	239
DSingleD	4 channel single D	240
DSumABDiffCD	4 channel SumAB DiffCD	245
DSumABSumCD	4 channel SumAB SumCD	244
DZcomp	4 channel zcomposite	78

DZcompBPAB	4 channel zcompositeAB + single A	76
DZcompBPCD	4 channel zcompositeCD + single A	77

12 (CCCCMMMMIIRI)

QPSAvg	4 channel PSync Averaged Reward + 3 Inhibits	93
QPSdev	4 channel PSync Deviation Reward + 3 Inhibits	95
QPSmod	4 channel PSync Smoothed Reward + 3 Inhibits	94
QQSingleA	4 channel Monitor + Reward+Inhibits	96
QQSingleB	4 channel Monitor + Reward+Inhibits	97
QQSingleC	4 channel Monitor + Reward+Inhibits	98
QQSingleD	4 channel Monitor + Reward+Inhibits	99

14x4 (CCCCMMMMMMMMMM)

4-chan,monitors	4-ch + 10 monitors	111

12x (CCCCRIRIRIRI)

XABCD	4 channel Reward+Inhibits	100
XSingleA	4 channel A Reward+Inhibit	101
XSingleB	4 channel B Reward+Inhibit	102
XSingleC	4 channel C Reward+Inhibit	103
XSingleD	4 channel D Reward+Inhibit	104

8z (CCCCRRRR)

Avg4QPS	4 channel Average Psyncs	257
QABCD	4 channel amplitude	256
QZcomp	4 channel zcomposite	255

7im (CCIIRIM)

AminusB	A channel relationship to B channel	119
Async	comodulation measure between channel A and B	117
BminusA	B channel relationship to A channel	120
Differ	channel A minus channel B	50
GAsync	global comodulation measure between channel A and B	118
Psync	synchrony measure between channel A and B	116
RatioA	Ratio of inhibit3 to reward	122
RatioB	Ratio of inhibit3 to reward	123
SingleA	one channel of data input	47
SingleB	one channel of data input	48
Sum	sum of two channels of data input	49

6i (CCIIRI)

AminusB	A channel relationship to B channel	119
Async	comodulation measure between channel A and B	117
BminusA	B channel relationship to A channel	120
D/S-Ratio	Ratio of A-B to A+B	126
Differ	channel A minus channel B	50
GAsync	global comodulation measure between channel A and B	118
PDelta	B channel relationship to A channel	121
Psync	synchrony measure between channel A and B	116
RatioA	Ratio of 2 streams from 1 channel	122
RatioAB	Ratio of A to B in reward band	124
RatioB	Ratio of 2 streams from 1 channel	123
RatioBA	Ratio of B to A in reward band	125
SingleA	one channel of data input	47
SingleB	one channel of data input	48
Sum	sum of two channels of data input	49
UncAiHiB	Uncouple HiB A	181
UncAiRew	Uncouple Rew A	179
UncBiHiB	Uncouple HiB B	182
UncBiRew	Uncouple Rew B	180
Unity	1-Ratio of A-B to A+B	127
ZAbsPwrA	Zscore Abs Amp A	136
ZAbsPwrB	Zscore Abs Amp B	137
ZAsymm	Zscore amplitude asymmetry	133
ZCohere	Zscore coherence	134
ZCompAB	ZComposite	128
ZPRatioA	Zscore Power ratio A	140
ZPRatioB	Zscore Power ratio B	141
ZPhase	Zscore phase	135
ZRelPwrA	Zscore Rel Pwr A	138
ZRelPwrB	Zscore Rel Pwr B	139

8 (CCIRIIRI)

2-Rew	two channels of data input	233
ABDIFFABDIFF	DIFFAB + DIFFAB	230
ABSUMABDIFF	SUMAB + DIFFAB	231
ABSUMABSUM	SUMAB + SUMAB	229
AsyncDual	comodulation measure between channel A and B	232

Dual	two channels of data input	223
PsyncDual	synchrony measure between channel A and B	228
SingleA	SingleA	47
SingleB	SingleB	48
ZCompAB	Zcomposite + Zcomposite	128
ZCompBPAB	Zcomposite + bandpass	226

7m (CCIRIMM)

AminusB	A channel relationship to B channel	119
Async	comodulation measure between channel A and B	117
BminusA	B channel relationship to A channel	120
Differ	channel A minus channel B	50
GAsync	global comodulation measure between channel A and B	118
Psync	synchrony measure between channel A and B	116
SingleA	one channel of data input	47
SingleA-RM	One channel+ratio between monitors	219
SingleB	one channel of data input	48
SingleB-RM	One channel+ratio between monitors	220
SnglA-RM-NF	One channel+ratio no feedback	221
SnglB-RM-NF	One channel+ratio no feedback	222
Sum	sum of two channels of data input	49

5 (CCIRI)

AminusB	A channel relationship to B channel	119
Async	comodulation measure between channel A and B	117
BminusA	B channel relationship to A channel	120
D/S-Ratio	Ratio of AB diff/AB sum	126
Differ	channel A minus channel B	50
GAsync	global comodulation measure between channel A and B	118
PDelta	Peak Time Coherence	121
Psync	synchrony measure between channel A and B	116
RatioA	Ratio of rwd/inhib	122
RatioAB	Ratio of A to B in reward band	124
RatioB	Ratio of rwd/inhib	123
RatioBA	Ratio of B to A in reward band	125
SingleA	one channel of data input	47
SingleB	one channel of data input	48
Sum	sum of two channels of data input	49
UncAHiB	Uncouple HiB A	131

Psync	synchrony measure between channel A and B	116
SingleA	one channel of data input	47
SingleB	one channel of data input	48
Sum	sum of two channels of data input	49
ZAbsPwrA	Zscore Abs Amp A	136
ZAbsPwrB	Zscore Abs Amp B	137
ZAsymm	Zscore amplitude asymmetry	133
ZCohere	Zscore coherence	134
ZCompAB	ZComposite	128
ZPRatioA	Zscore Power ratio A	140
ZPRatioB	Zscore Power ratio B	141
ZPhase	Zscore phase	135
ZRelPwrA	Zscore Rel Pwr A	138
ZRelPwrB	Zscore Rel Pwr B	139

6i (CCRRII)

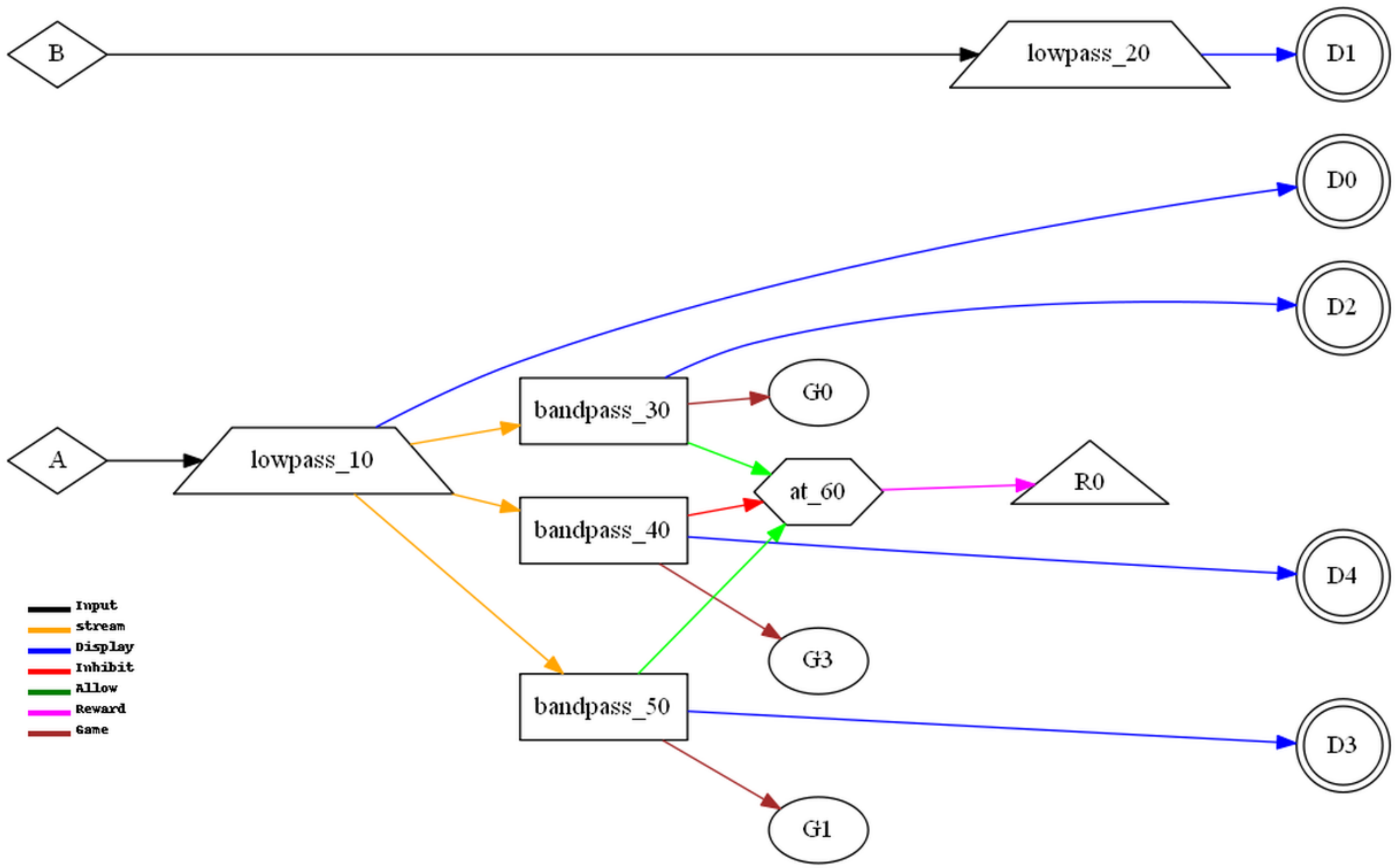
Differ	channel A minus channel B	50
SingleA	one channel of data input	47
SingleB	one channel of data input	48
Sum	sum of two channels of data input	49

8 (CCRRIMMM)

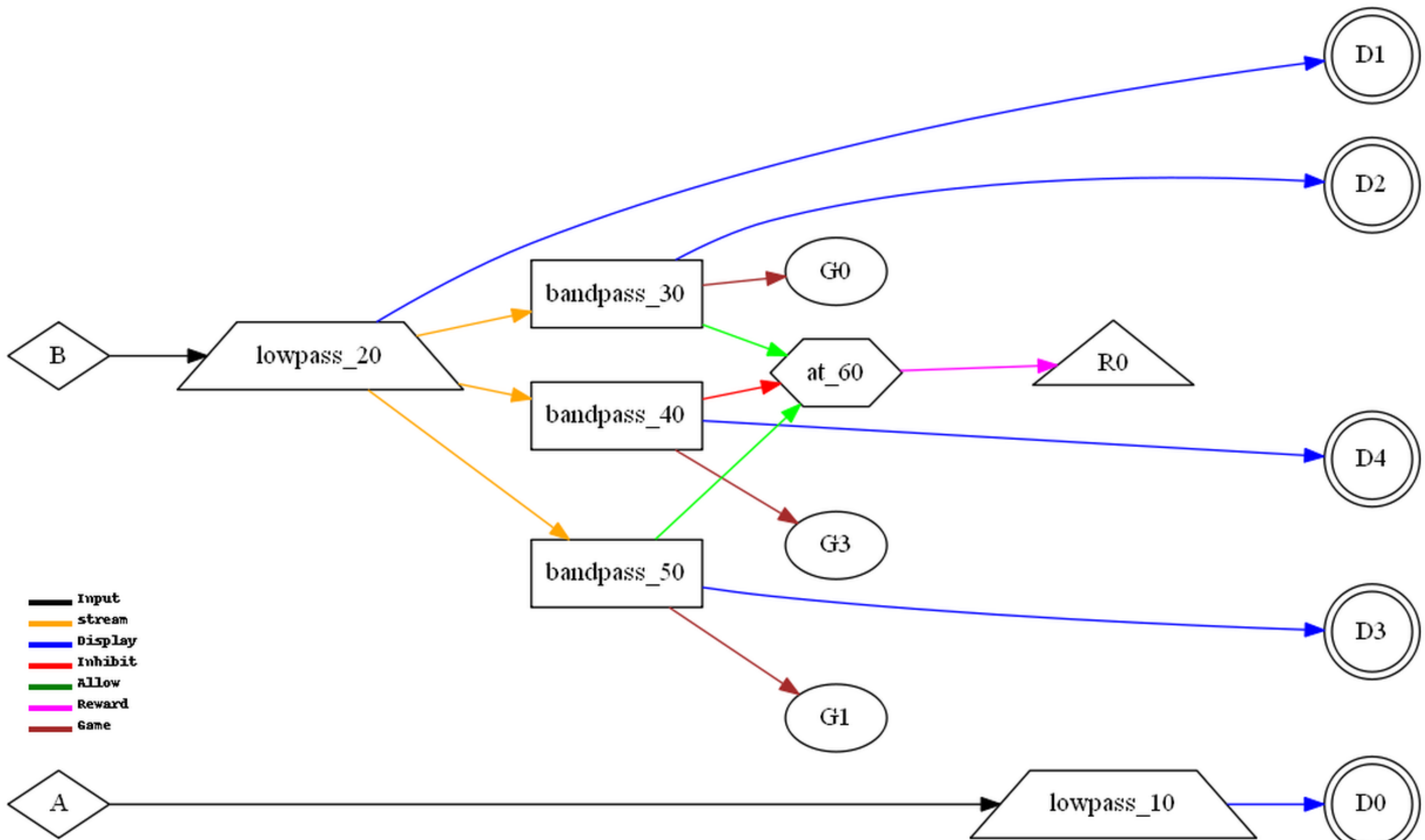
Differ	channel A minus channel B	50
SingleA	one channel of data input	47
SingleB	one channel of data input	48
Sum	sum of two channels of data input	49

5 (CCRRI)

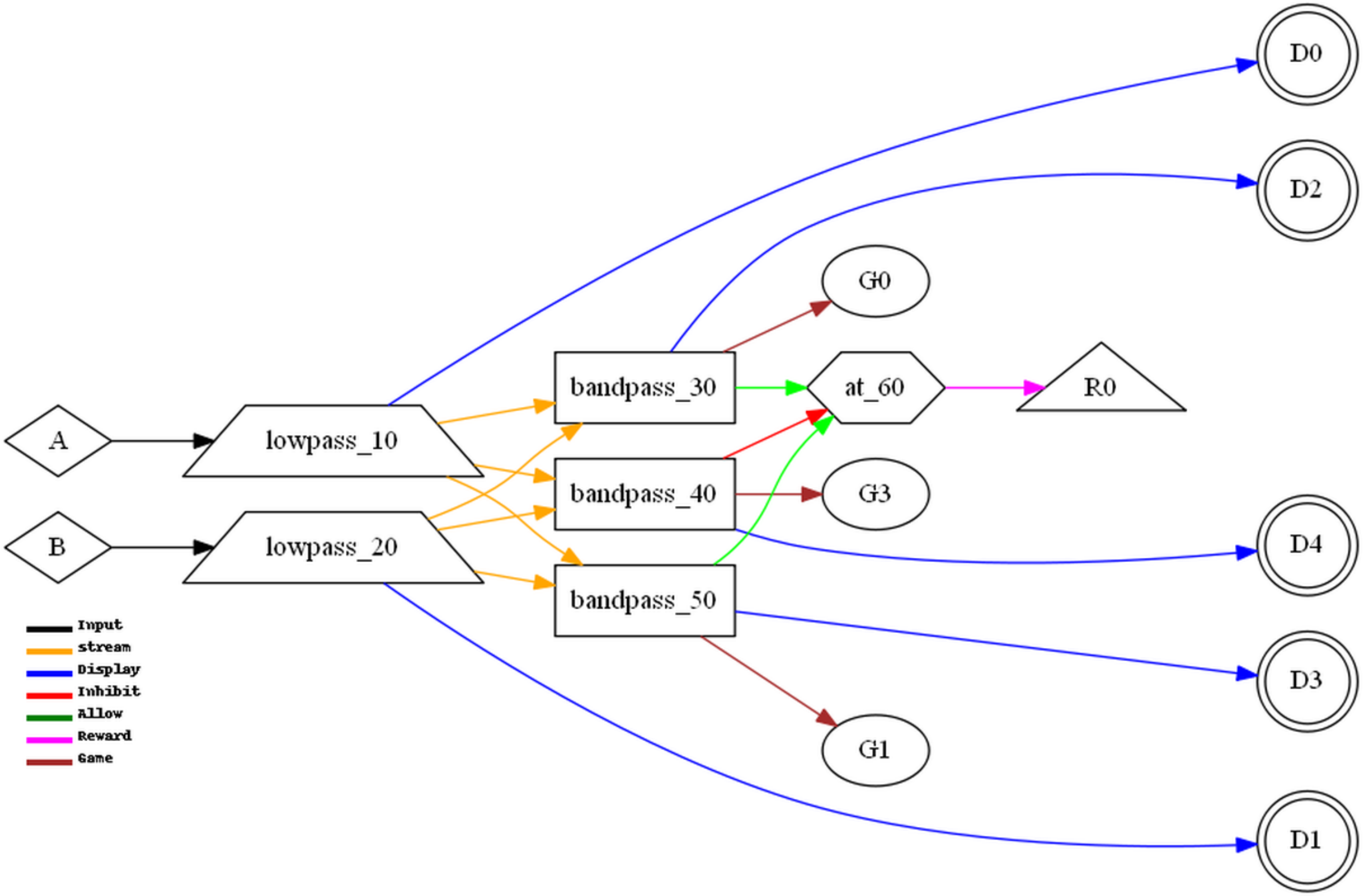
Differ	channel A minus channel B	50
SingleB	one channel of data input	48
Sum	sum of two channels of data input	49



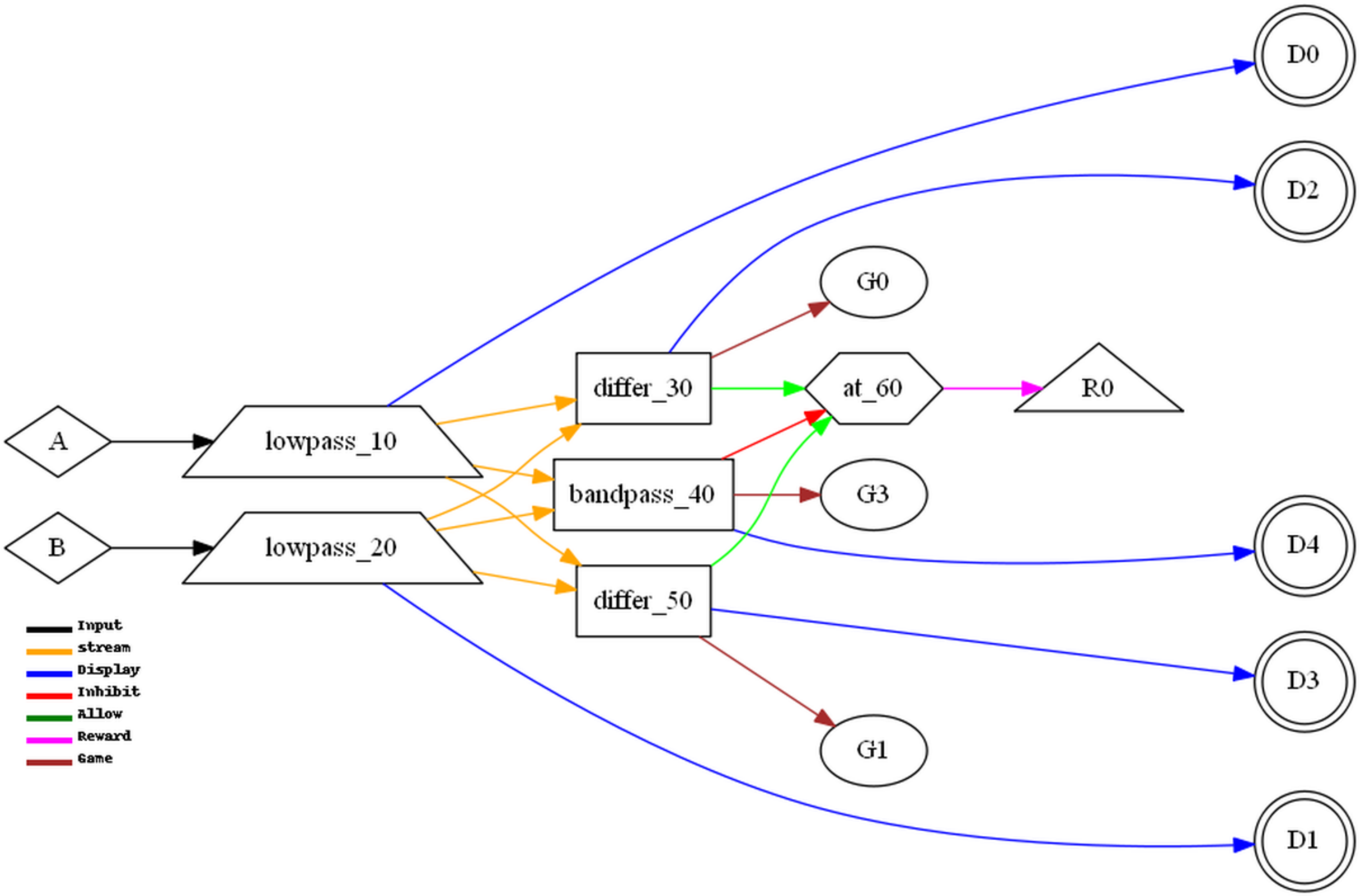
1100 SingleA (one channel of data input) CCRRI



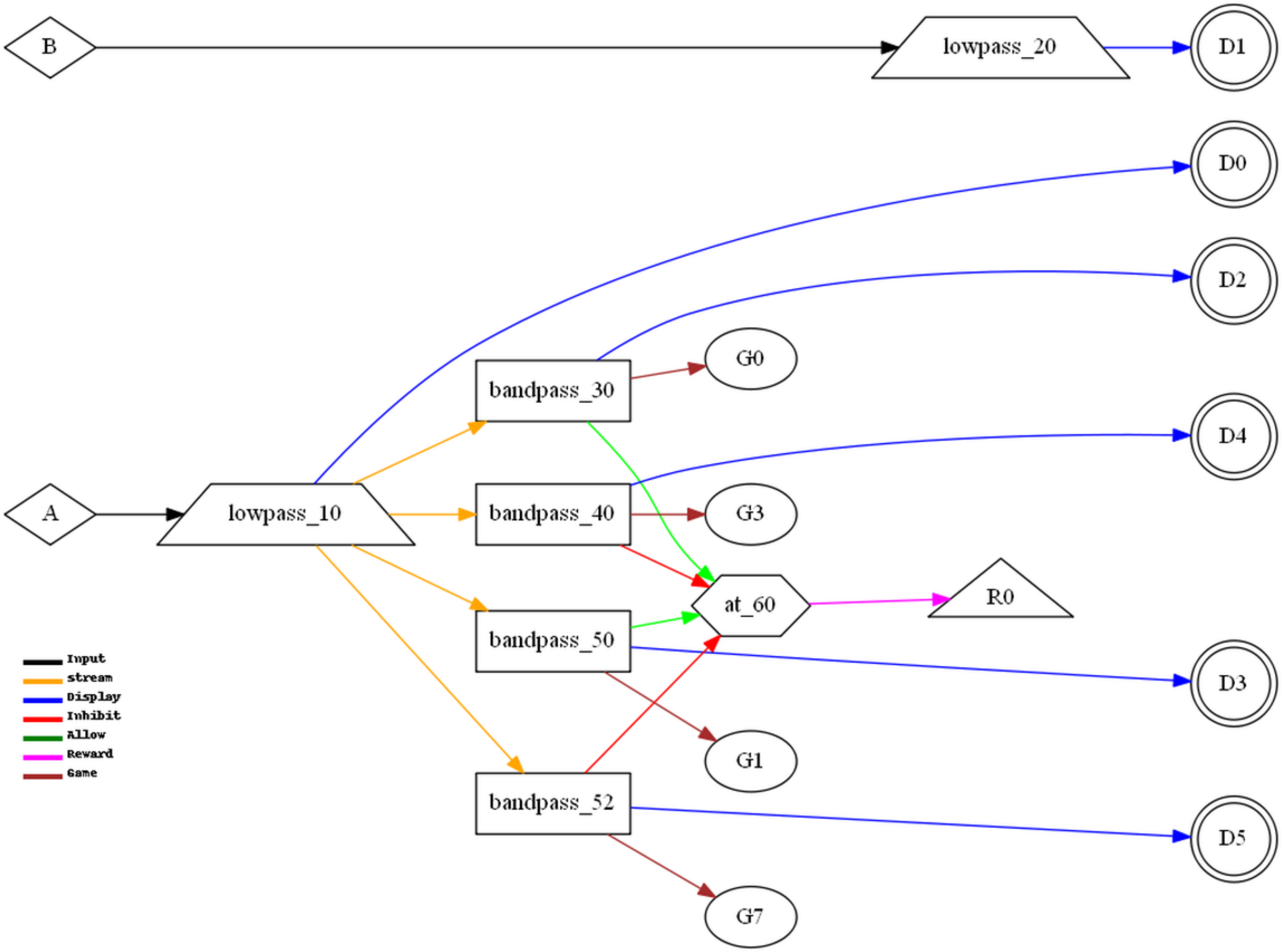
1101 SingleB (one channel of data input) CCRRI



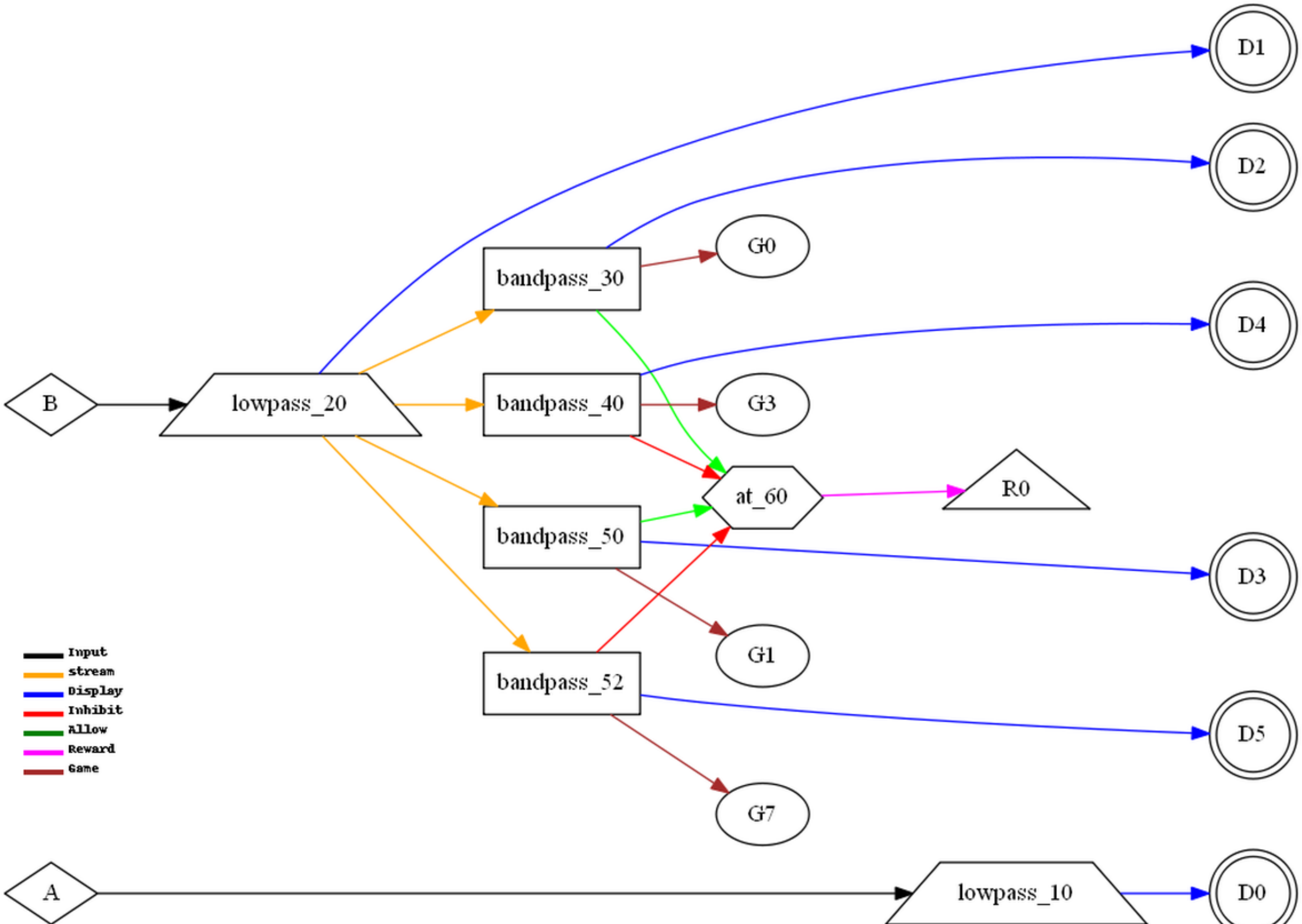
1110 Sum (sum of two channels of data input) CCRRI



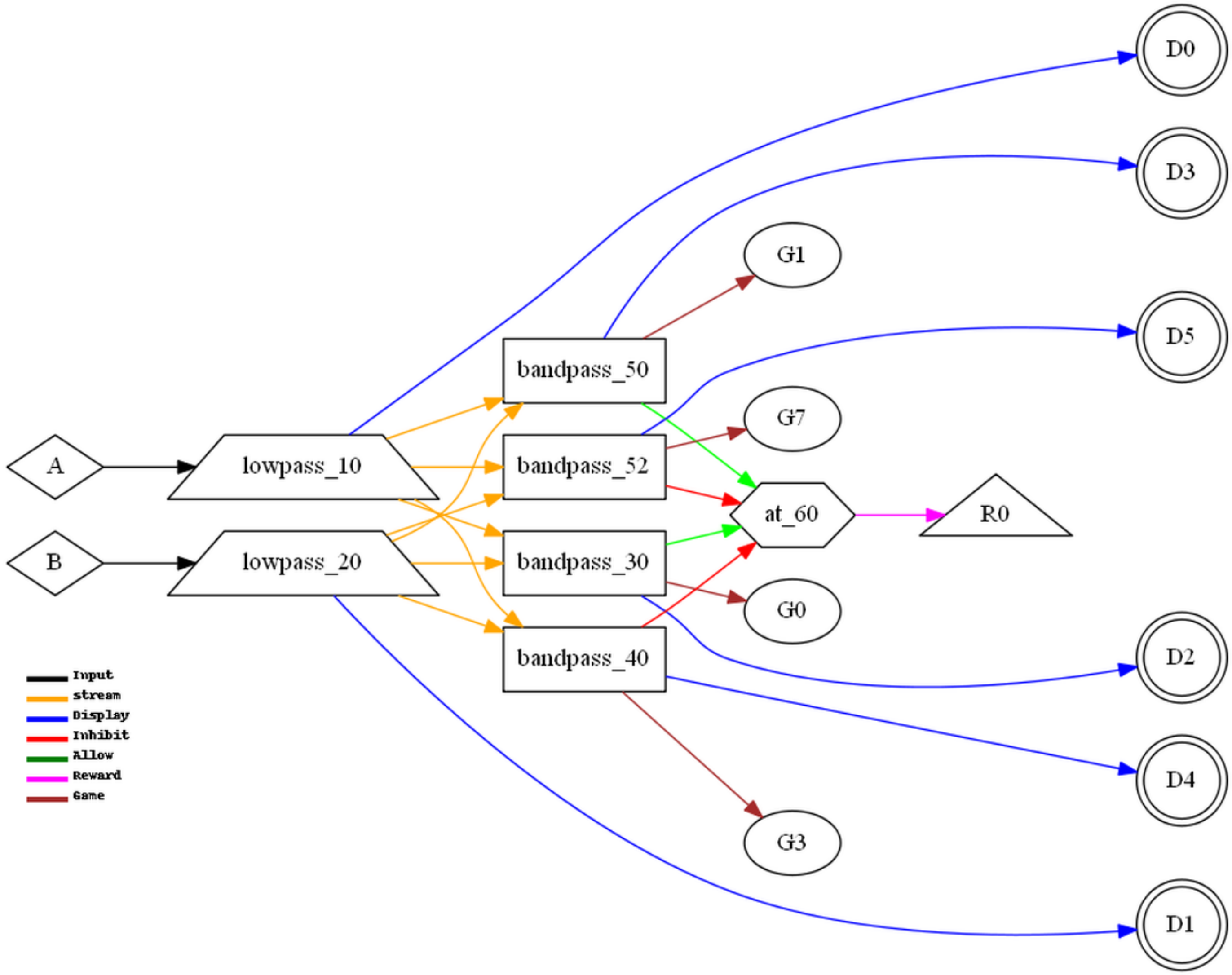
1111 Differ (channel A minus channel B) CCRRI



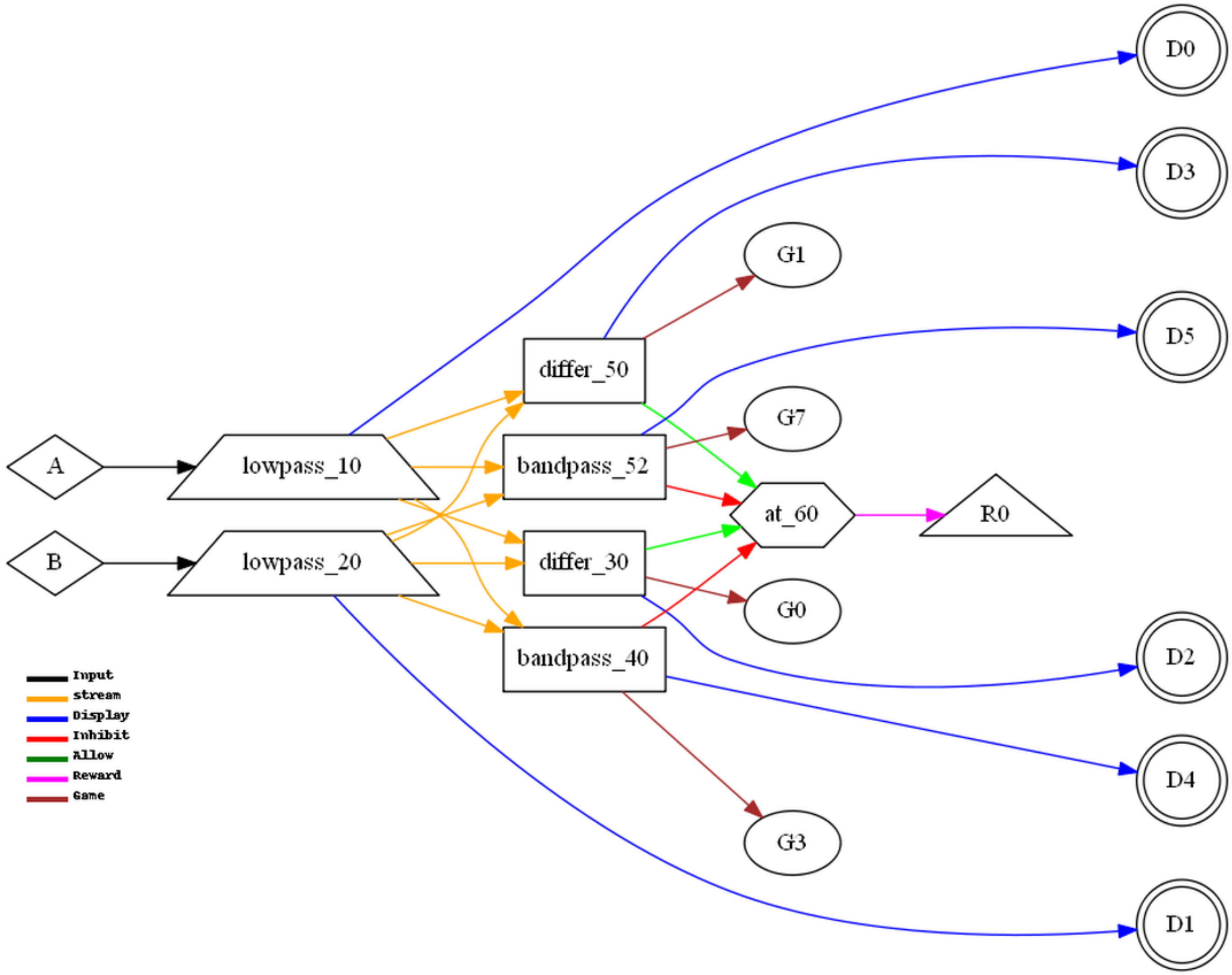
1300 SingleA (one channel of data input) CCRRII



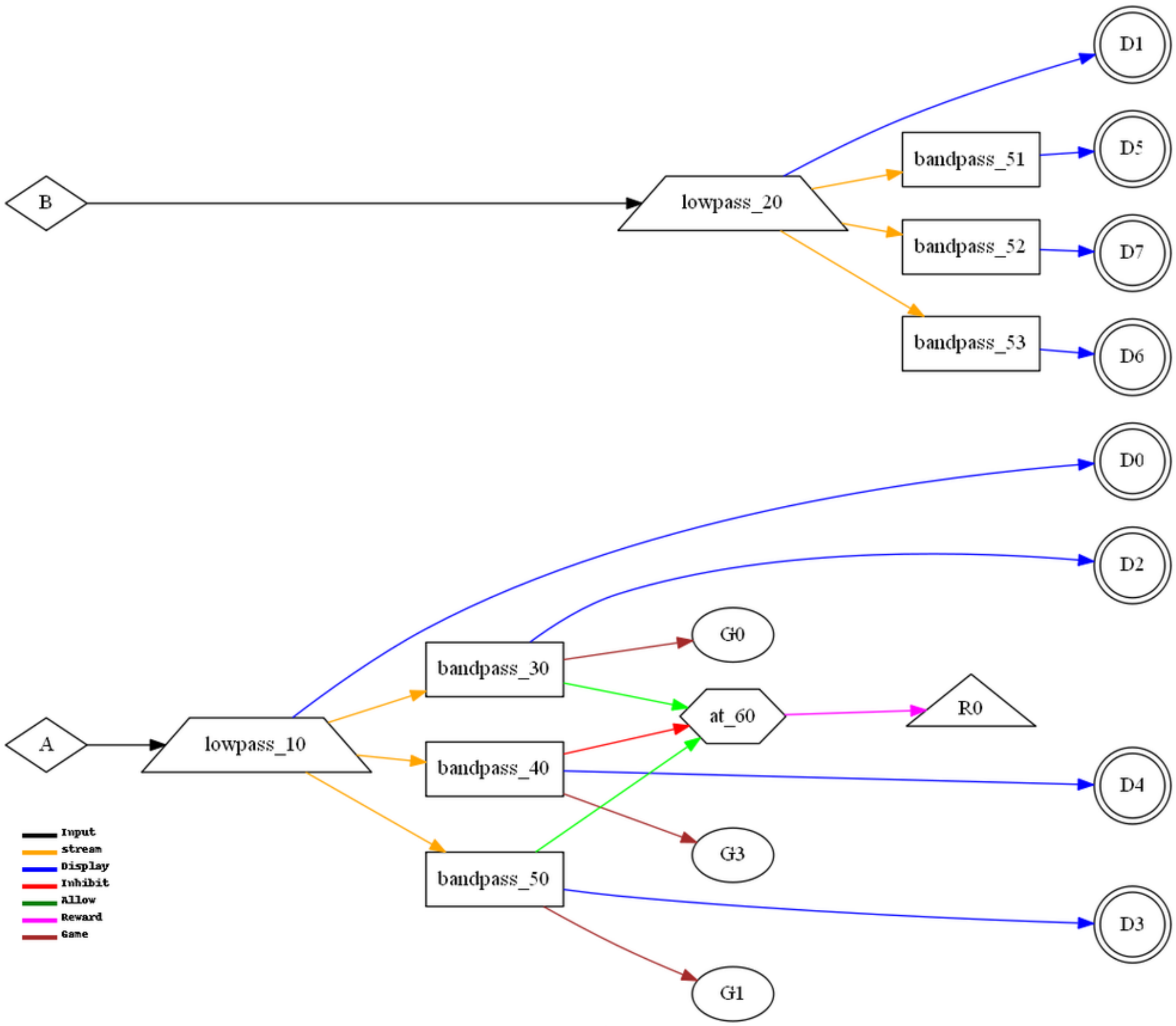
1301 SingleB (one channel of data input) CCRRII



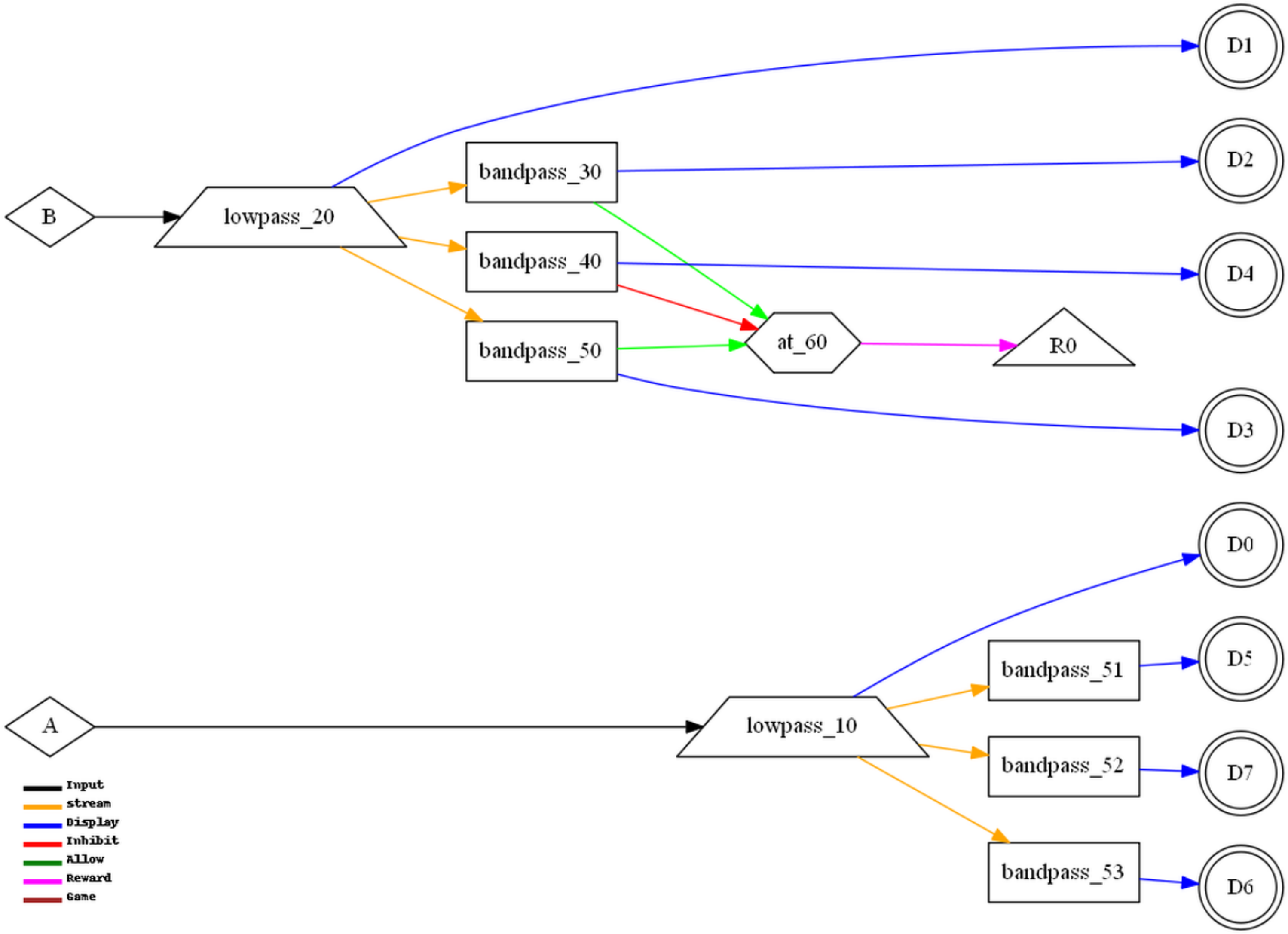
1310 Sum (sum of two channels of data input) CCRRII



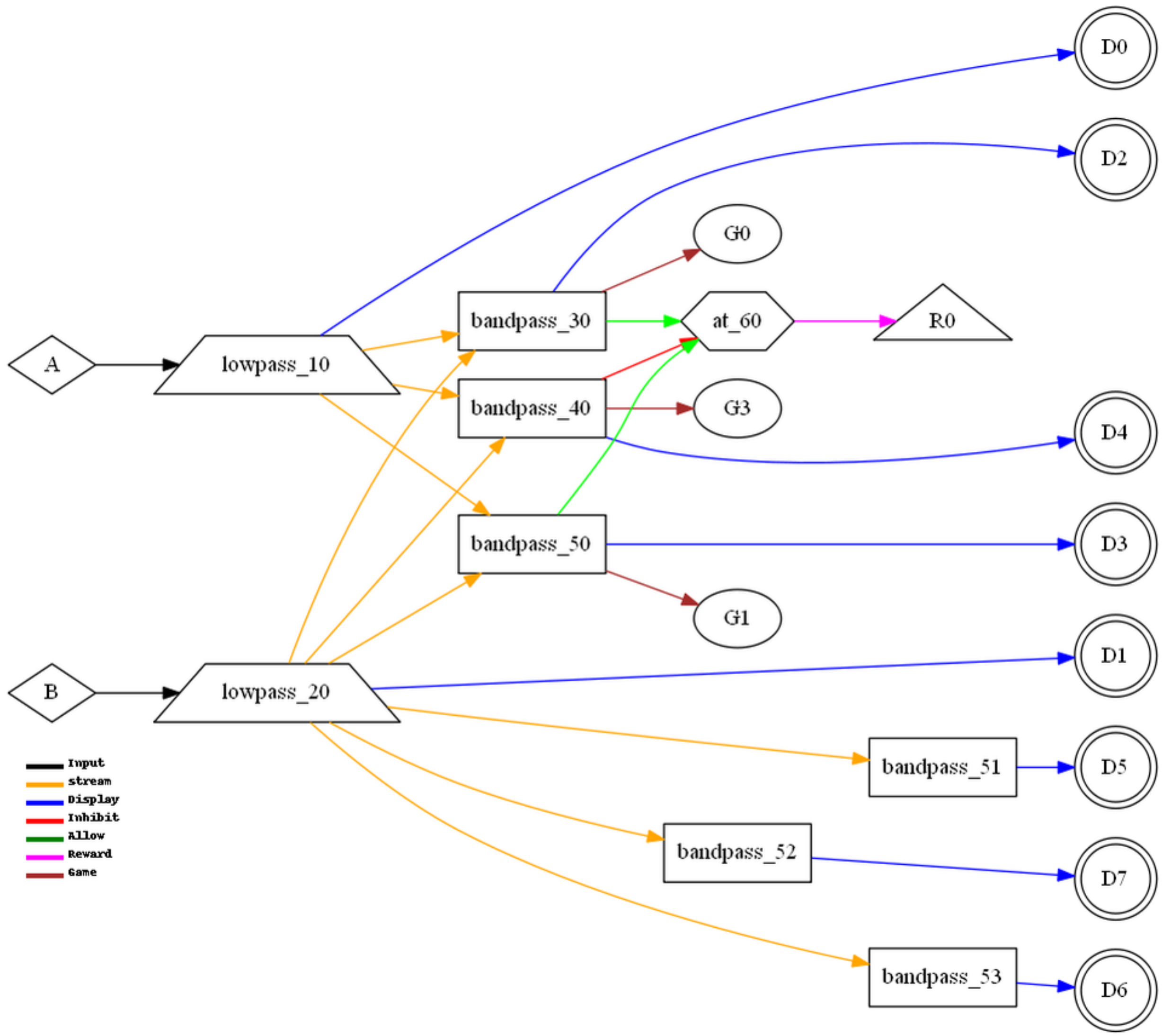
1311 Differ (channel A minus channel B) CCRRII



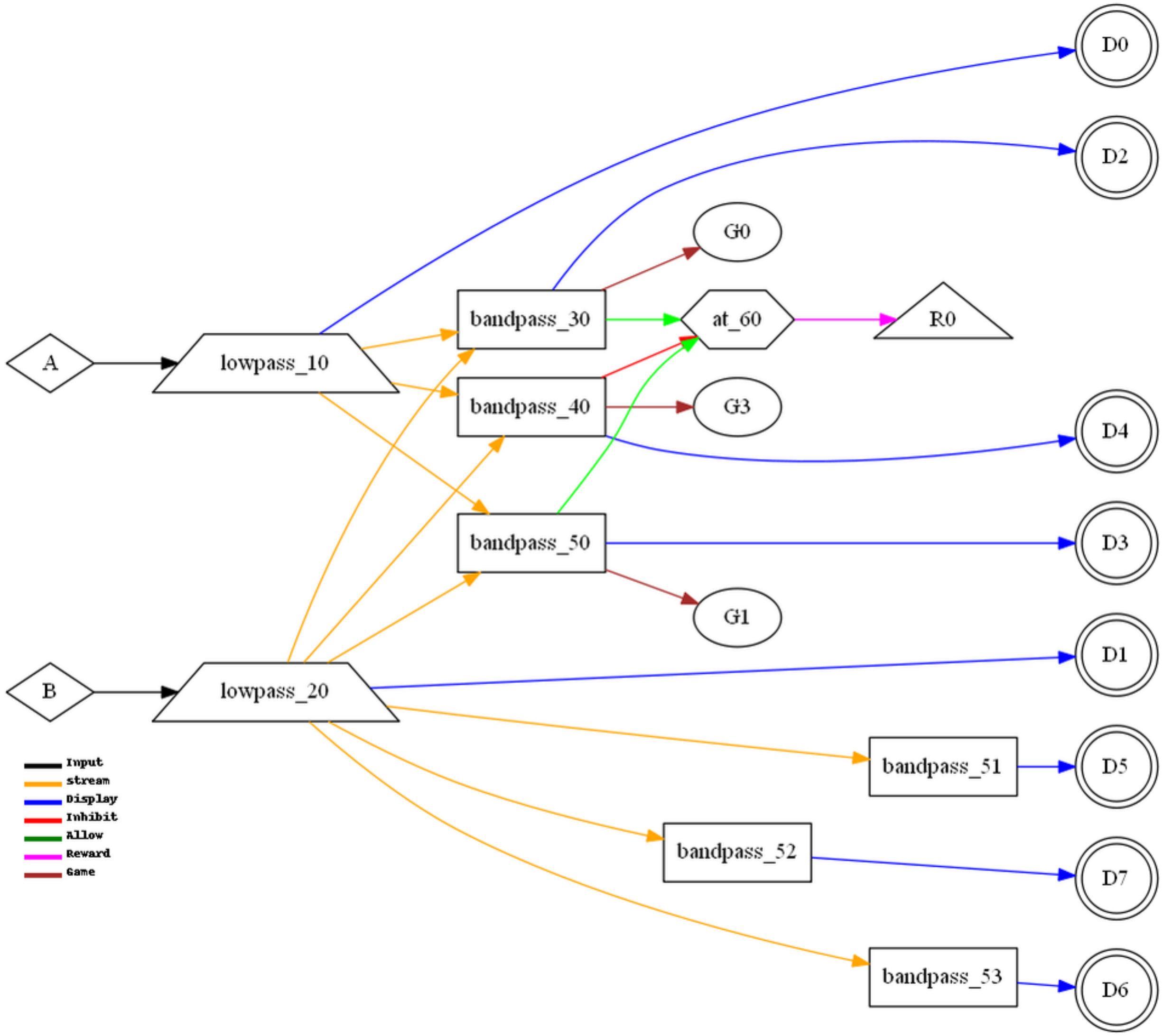
1260 SingleA (one channel of data input) CCRRIMMM



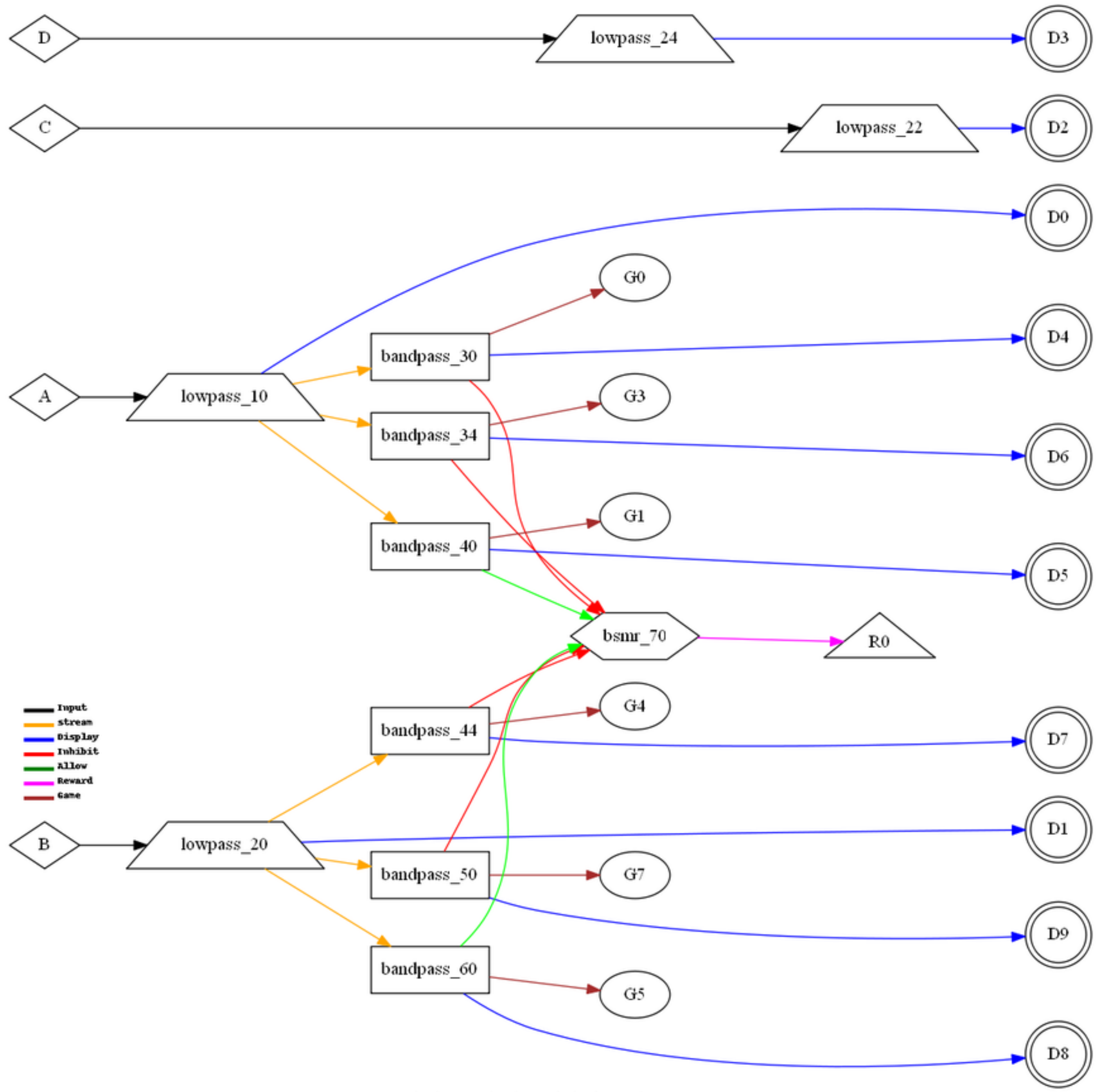
1261 SingleB (one channel of data input) CCRRIMMM



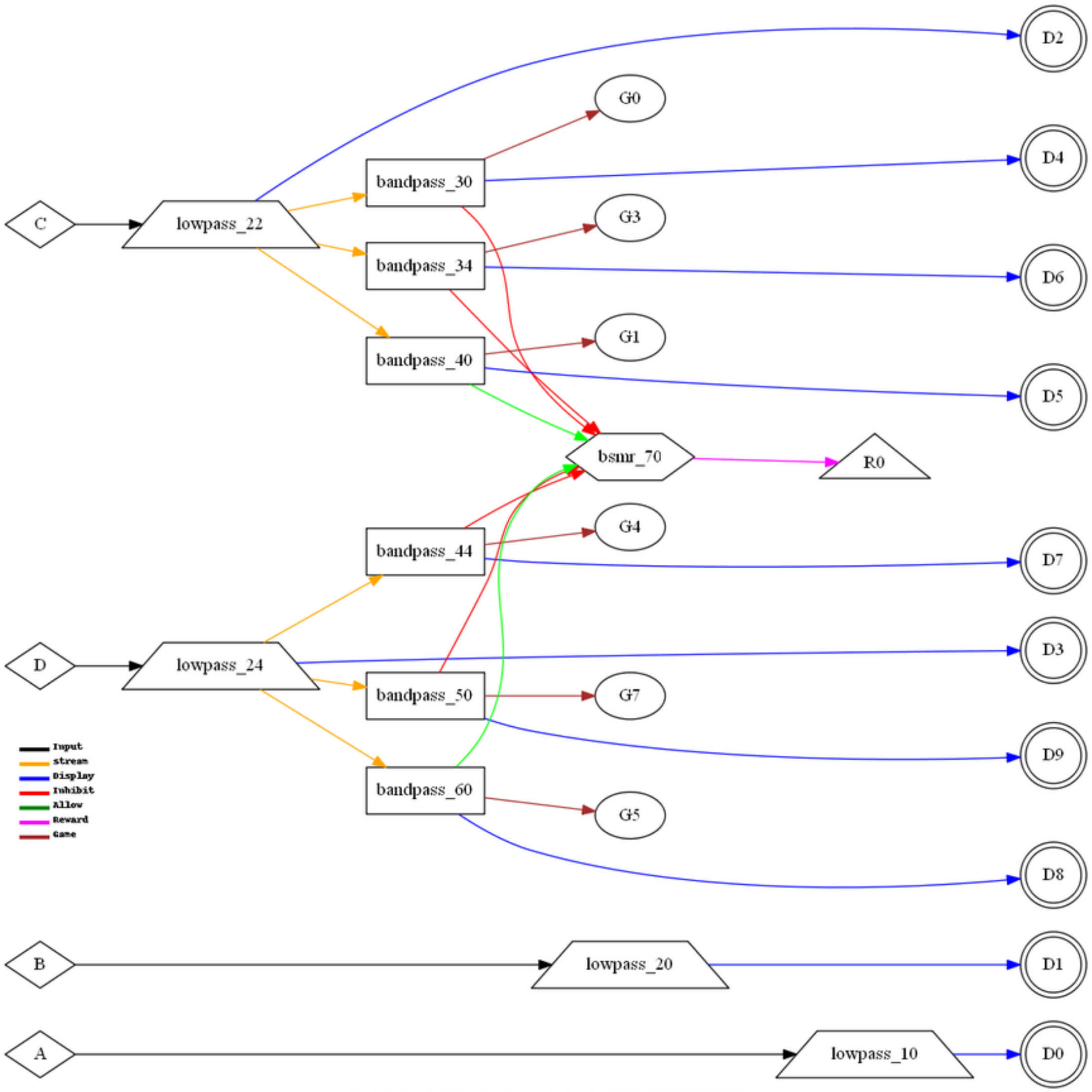
1262 Sum (sum of two channels of data input) CCRRIMMM



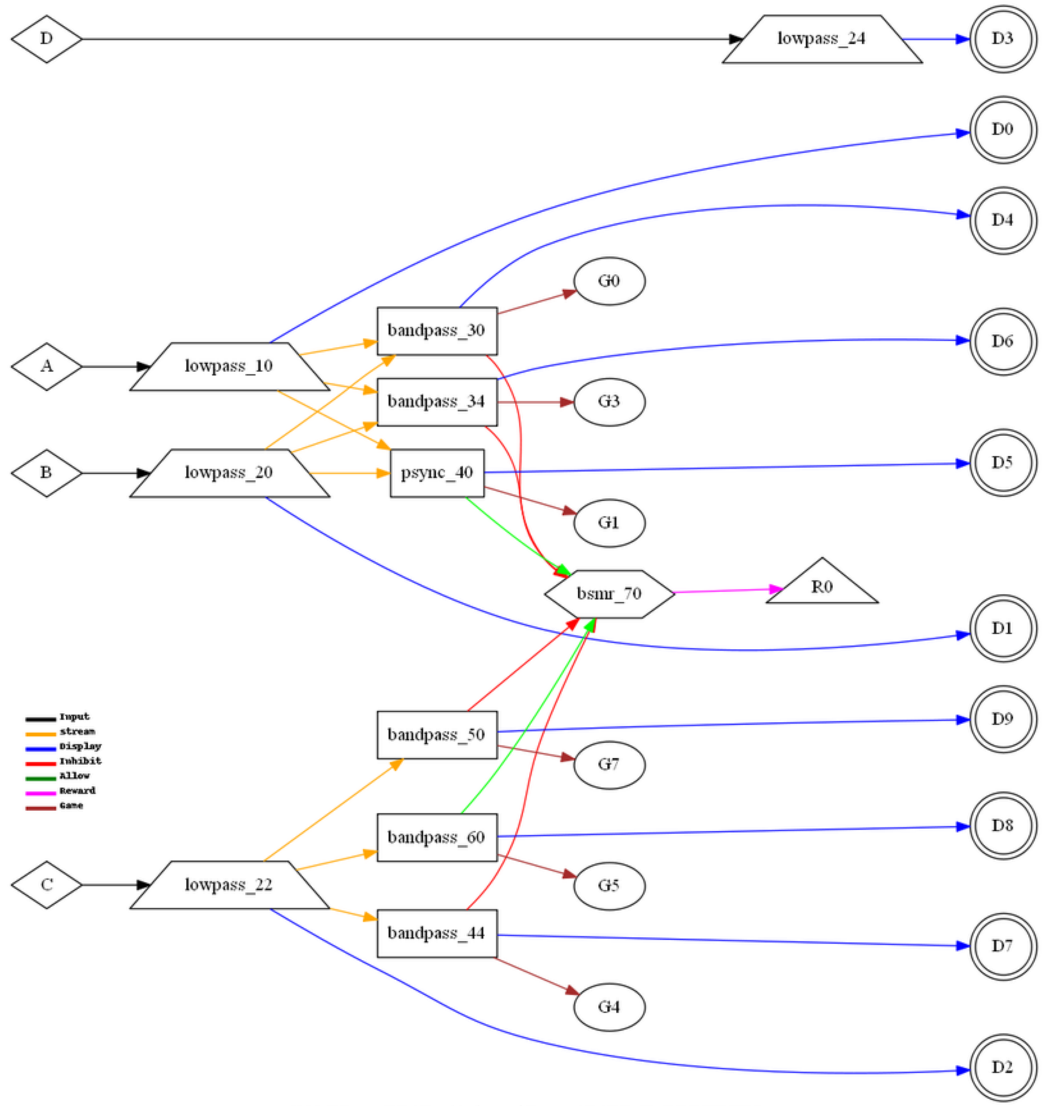
1263 Differ (channel A minus channel B) CCRRIMMM



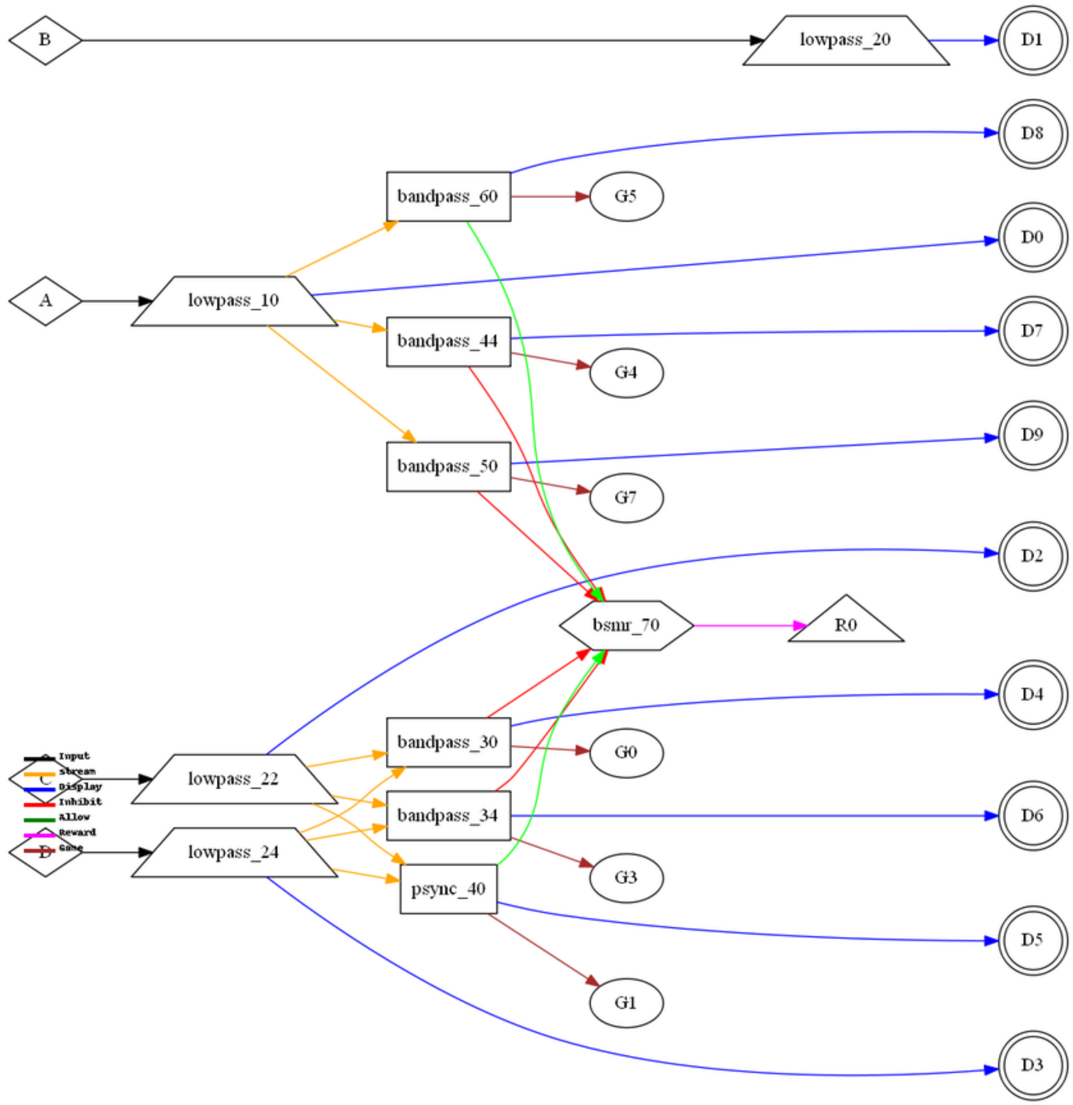
6200 DSingleAB (4 channel single A B) CCCCIRIIRI



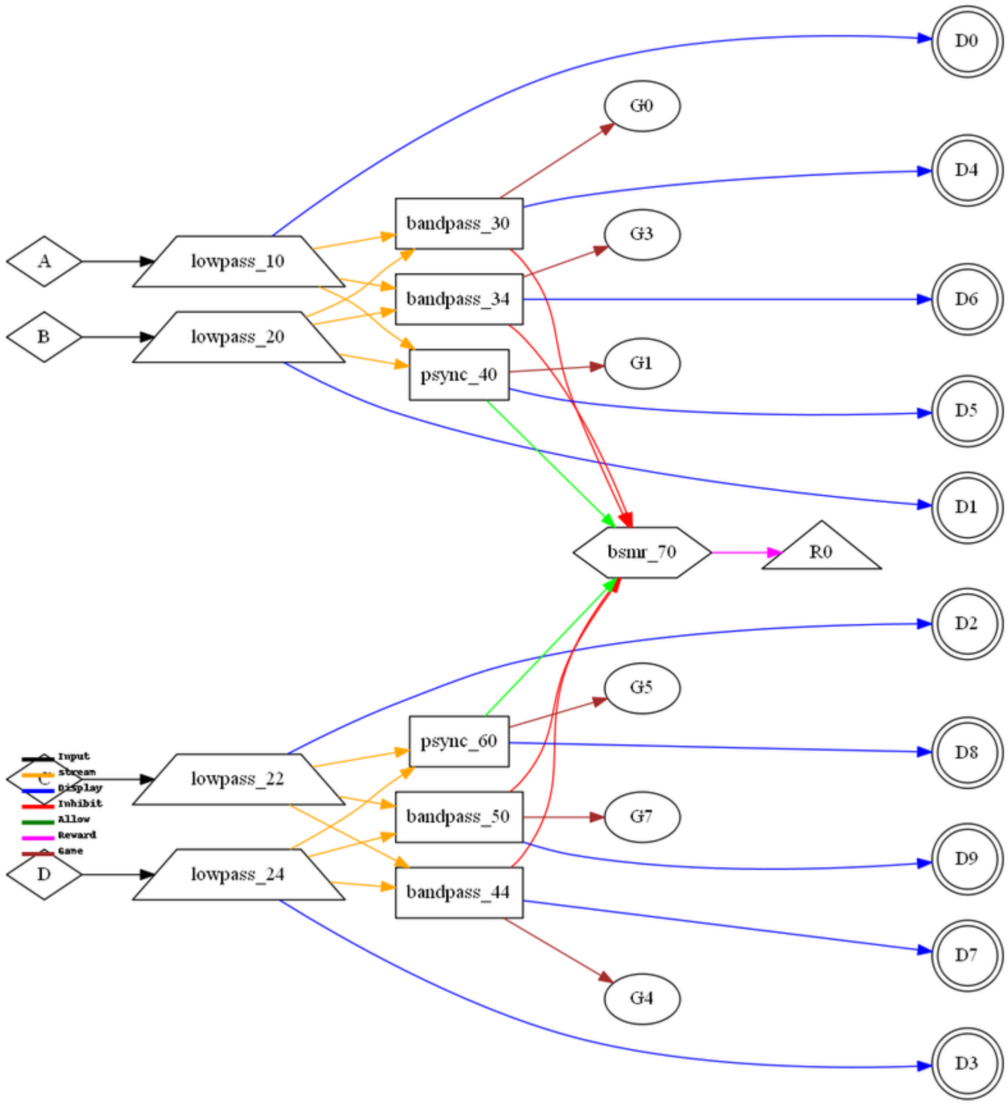
6210 DSingleCD (4 channel single C D) CCCCIRIIRI



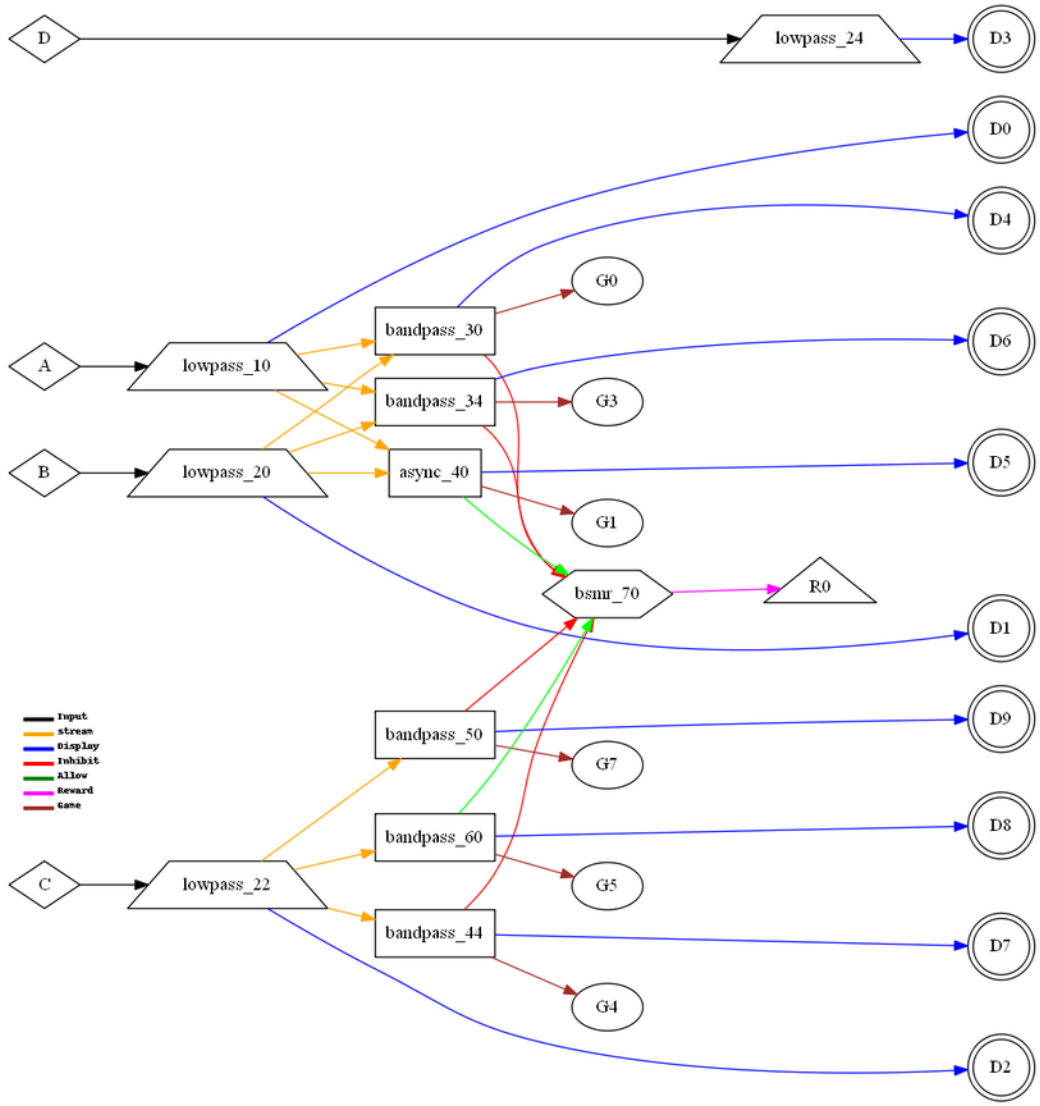
6220 DPsyncBPAB (4 channel PsyncAB+BP C) CCCCIRIIRI



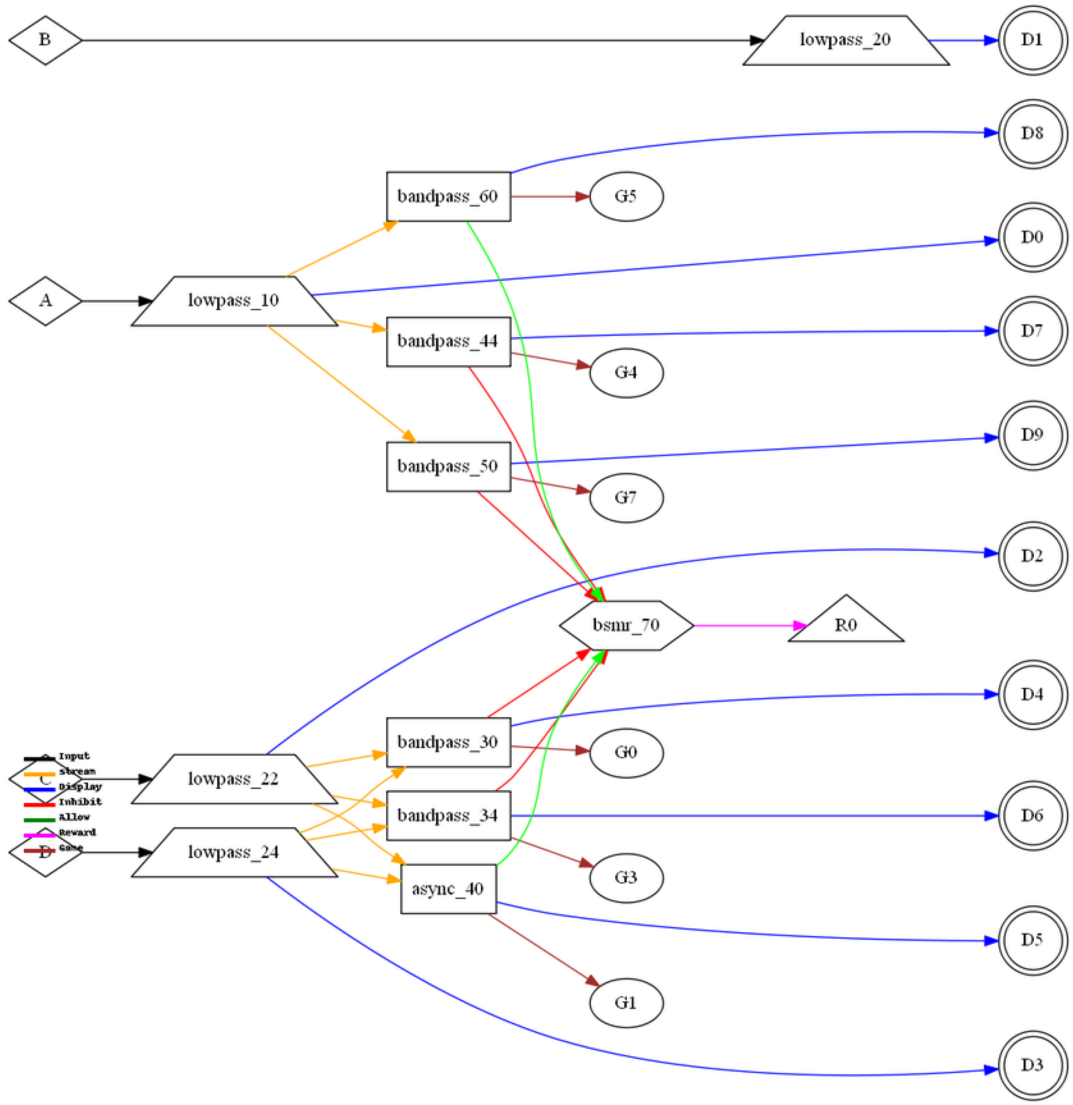
6230 DPsyncBPCD (4 channel PsyncCD+BP A) CCCCIRIIRI



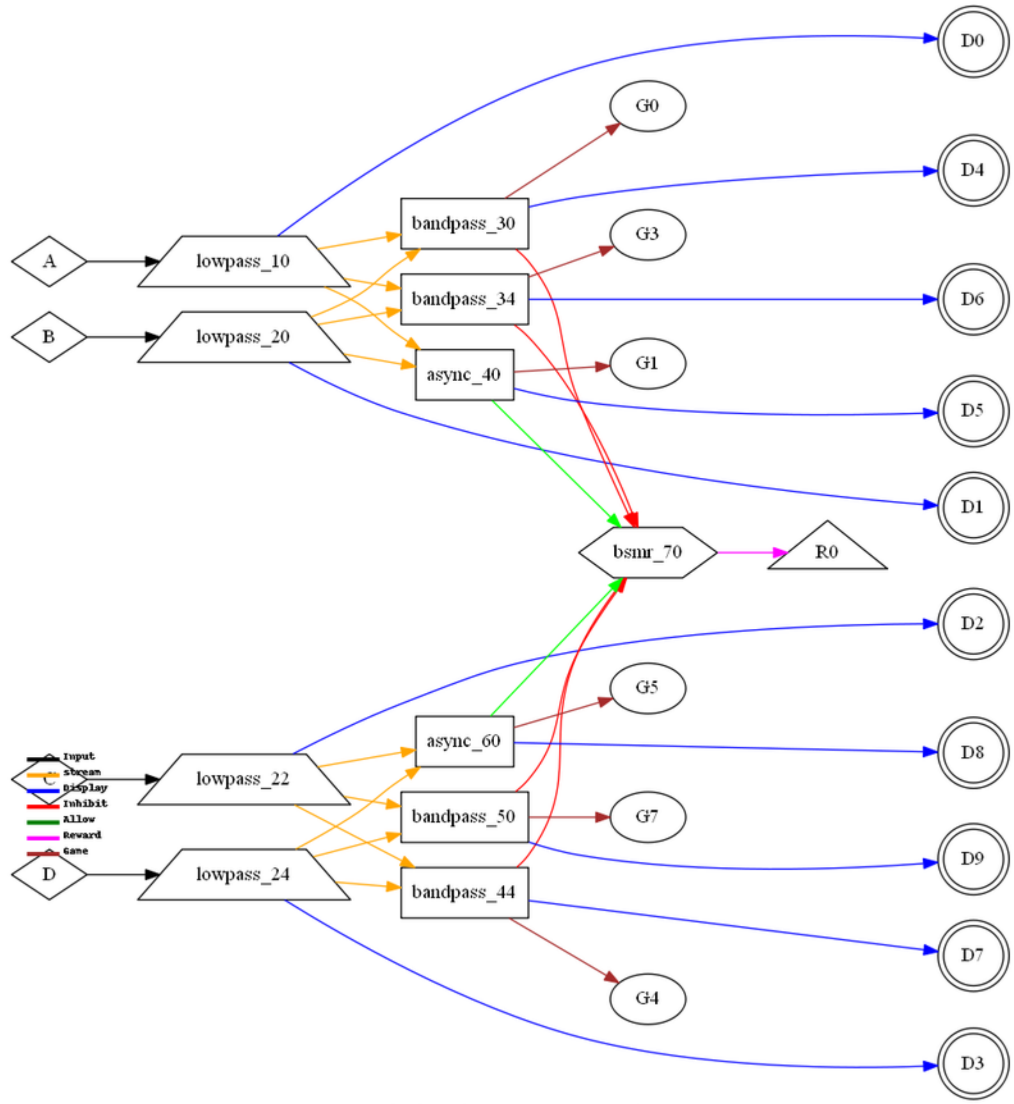
6240 DPsync (4 channel PsyncAB+PsyncC+D) CCCCIRIIRI



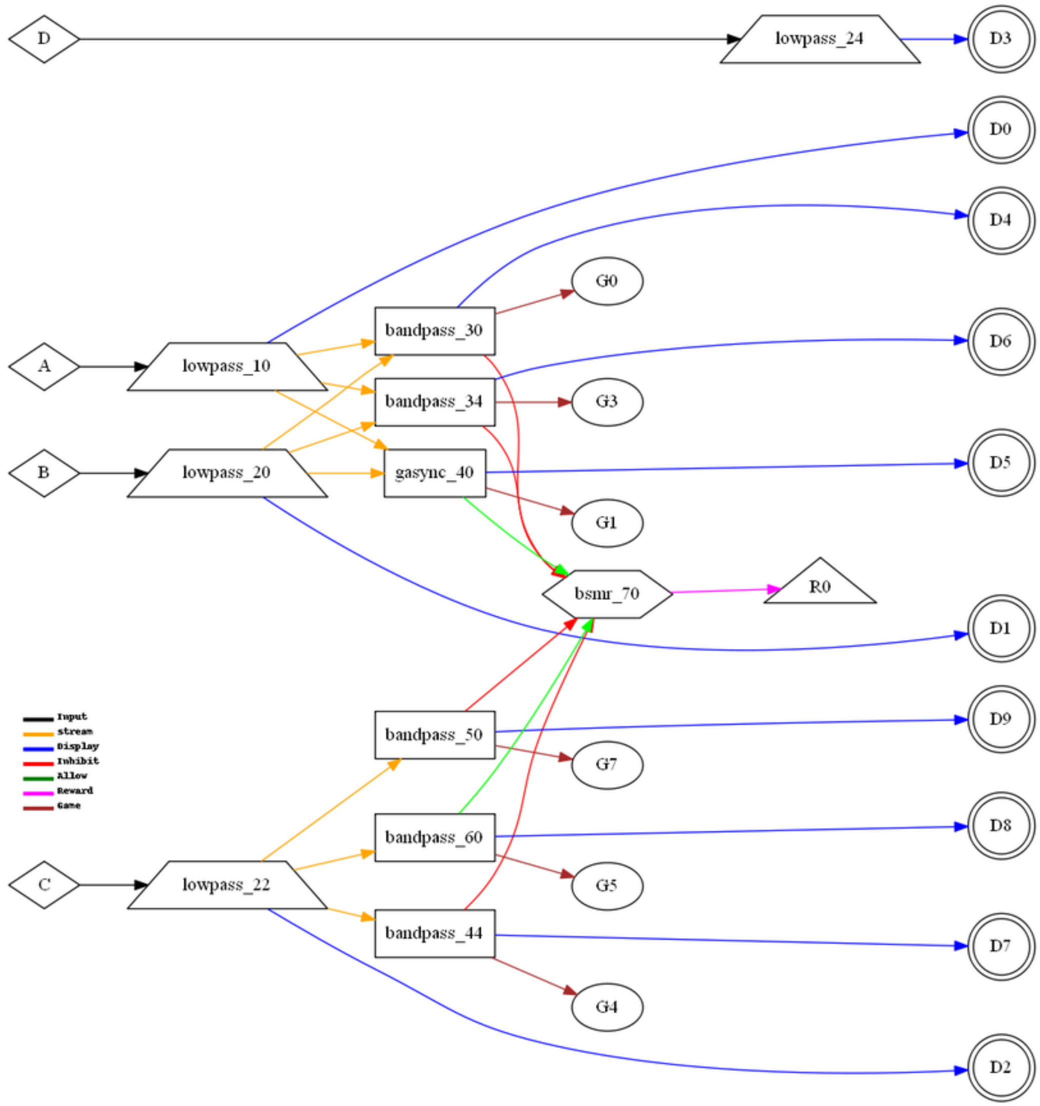
6250 DAsyncBPAB (4 channel AsyncAB+BP C) CCCCIRIIRI



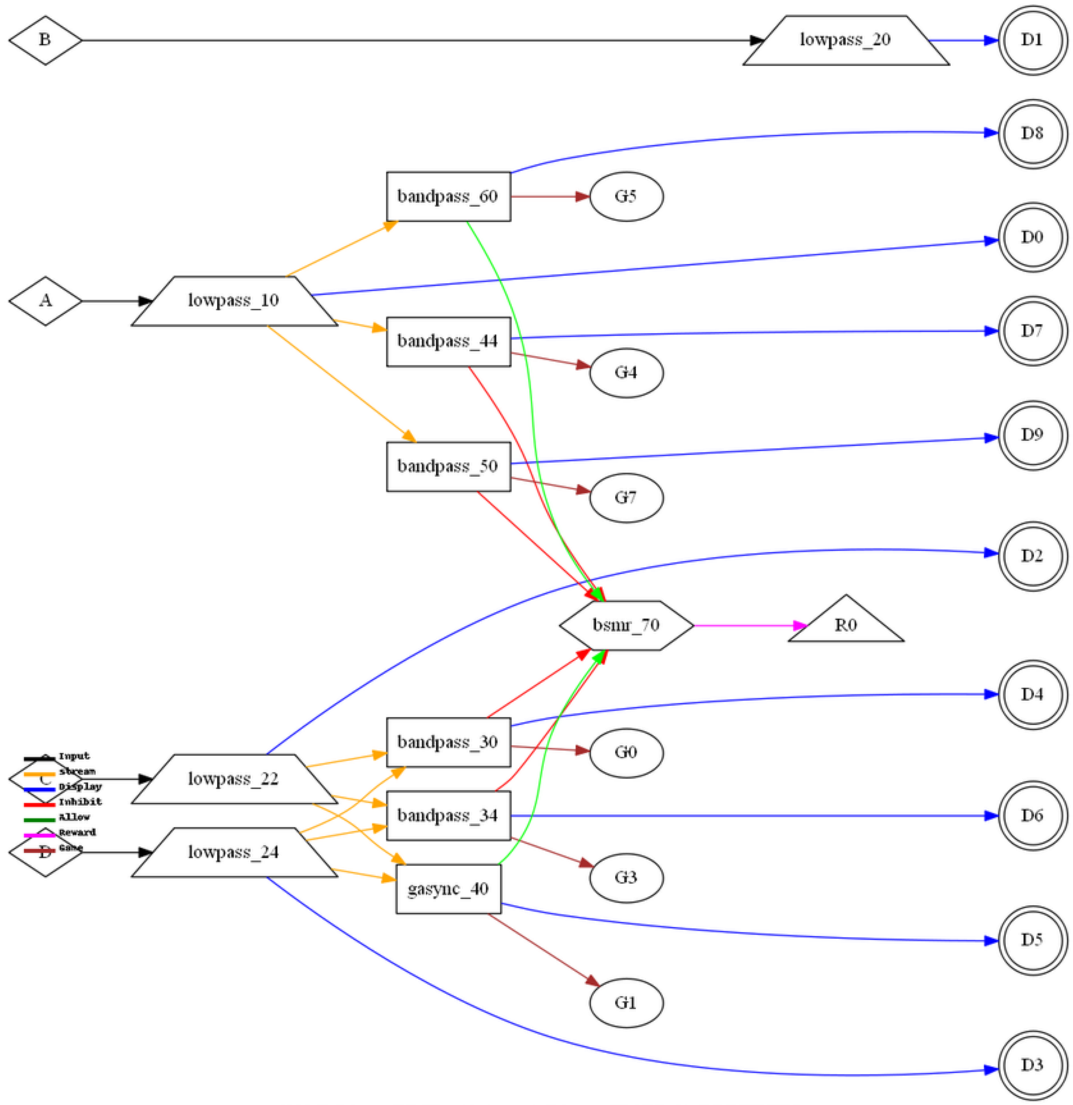
6260 DSsyncBPCD (4 channel AsyncCD+BP A) CCCCIRIIRI



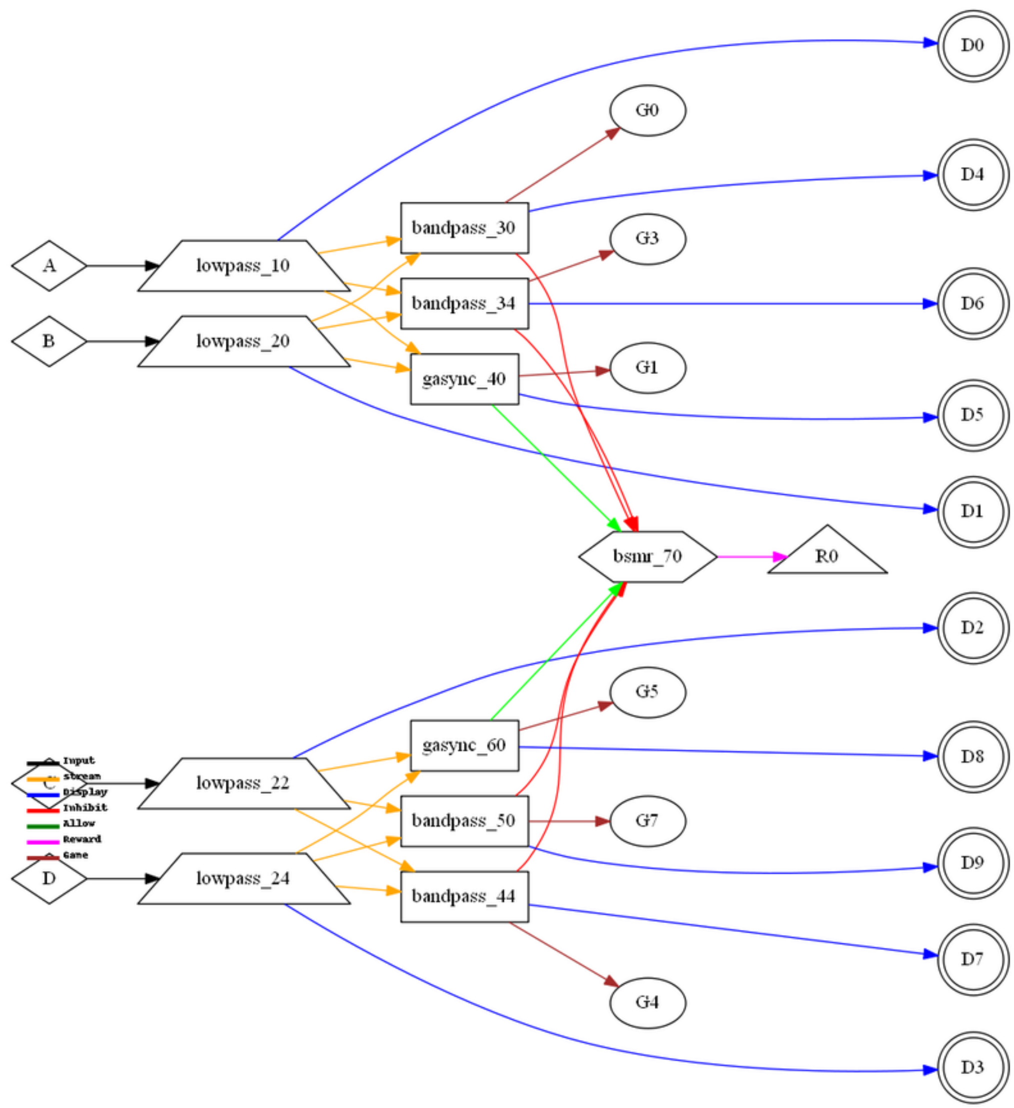
6270 DAsync (4 channel AsyncAB+AsyncCD) CCCCCIRIIRI



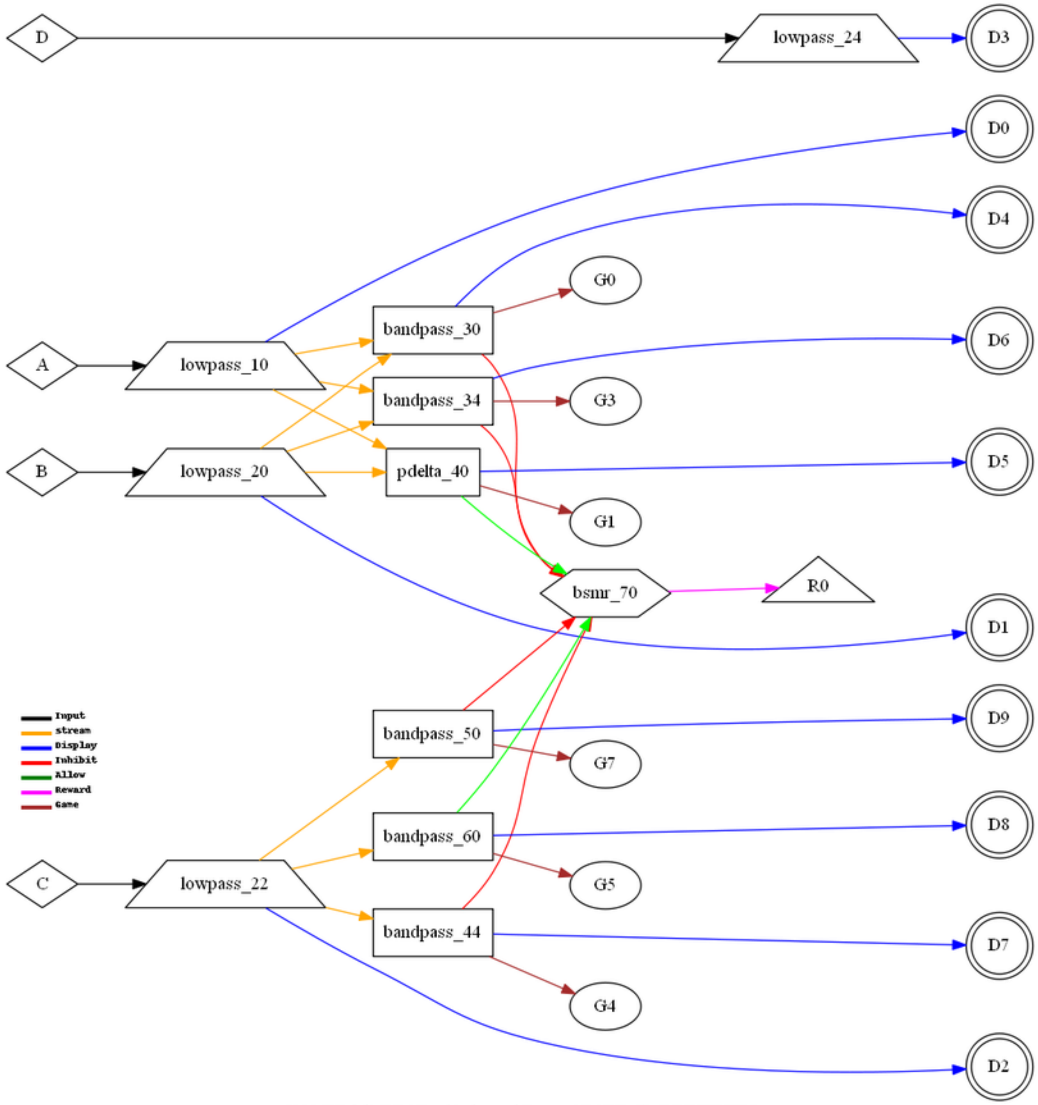
6280 DGAsyncBPAB (4 channel GAsyncAB+BP C) CCCCIRIIRI



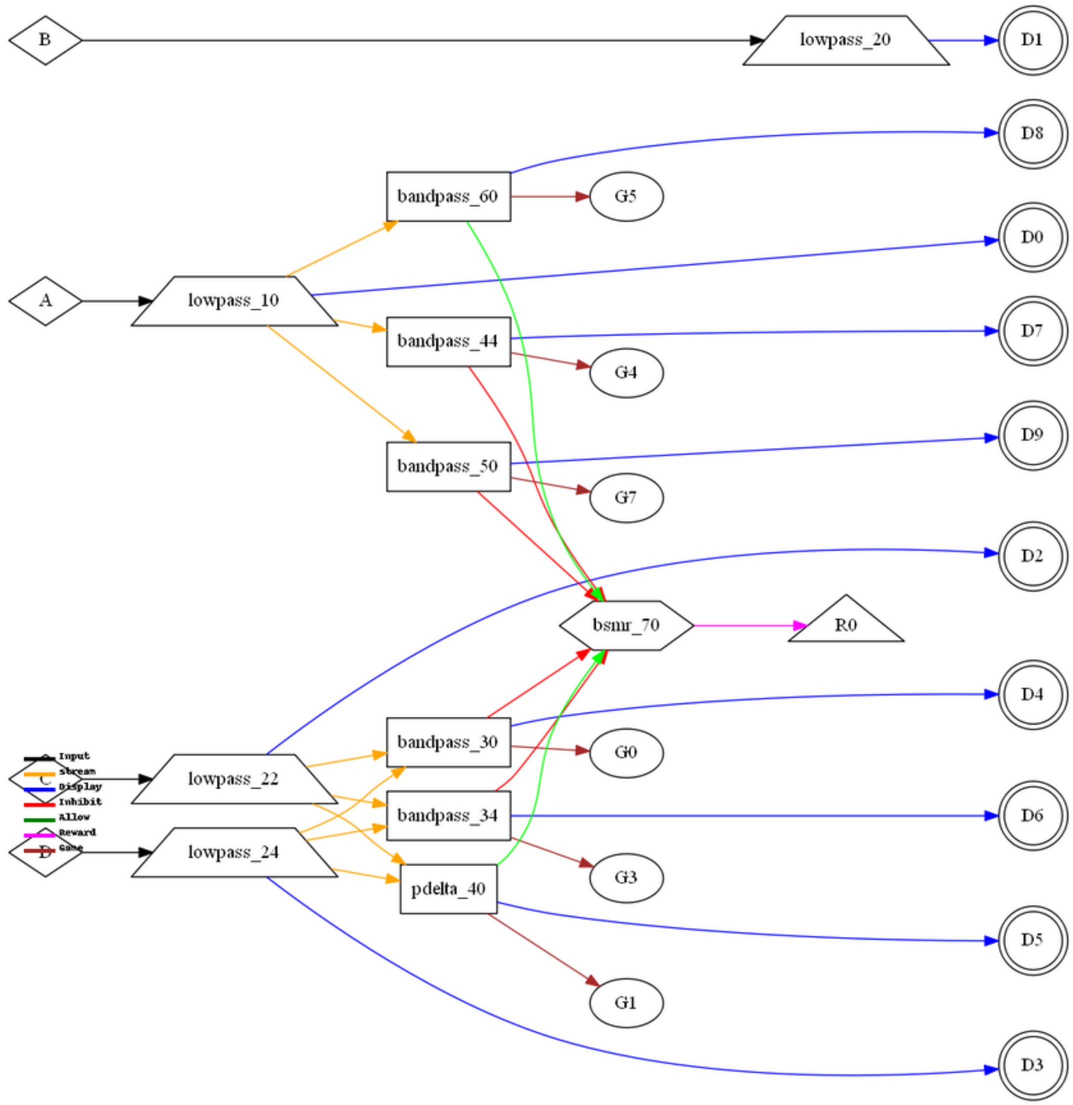
6290 DGAsyncBPCD (4 channel GAsyncCD+BP A) CCCCIRIIRI



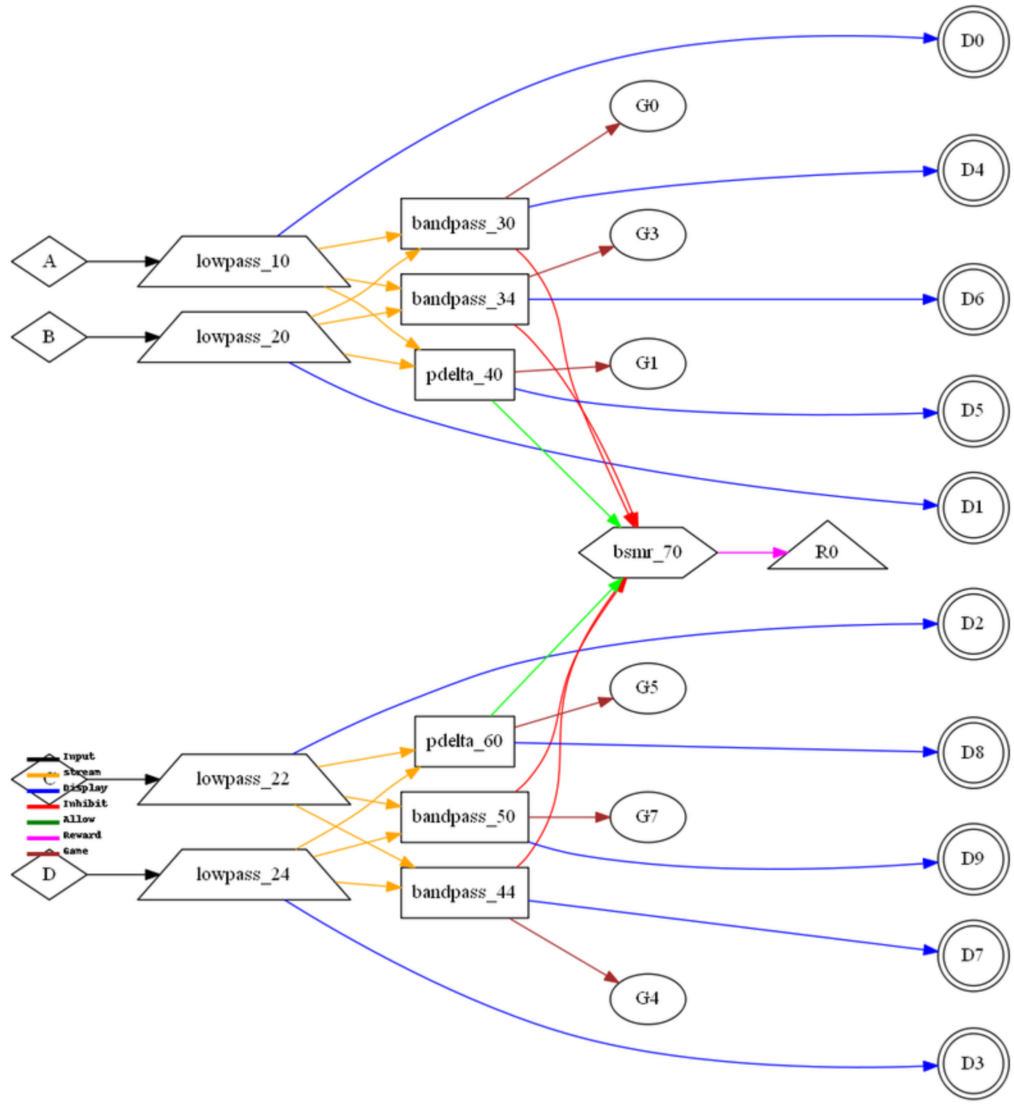
6300 DGAsync (4 channel GAsyncAB+GAsyncCD) CCCCIRIIRI



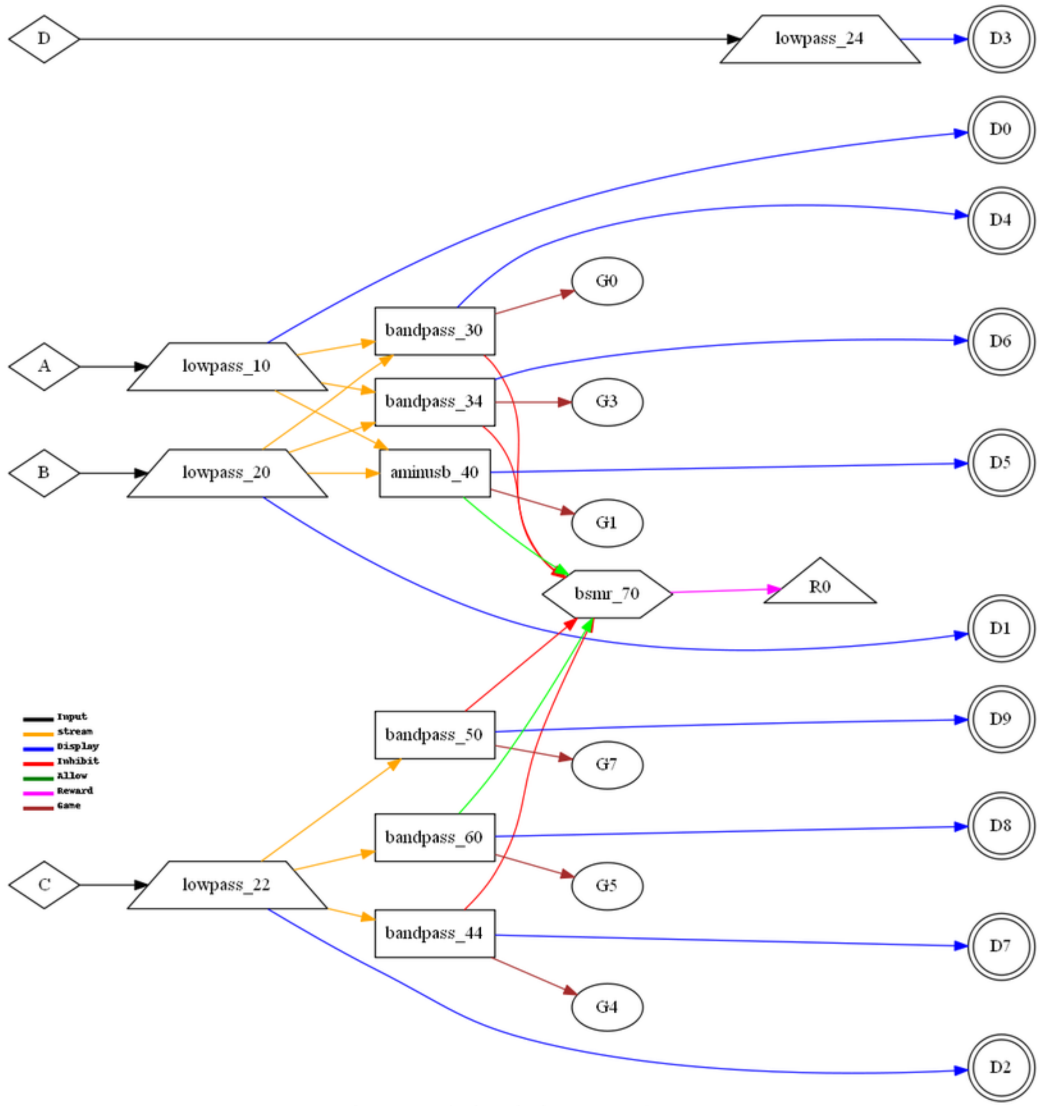
6310 DPdeltaBPAB (4 channel PsyncAB+BP C) CCCCIRIIRI



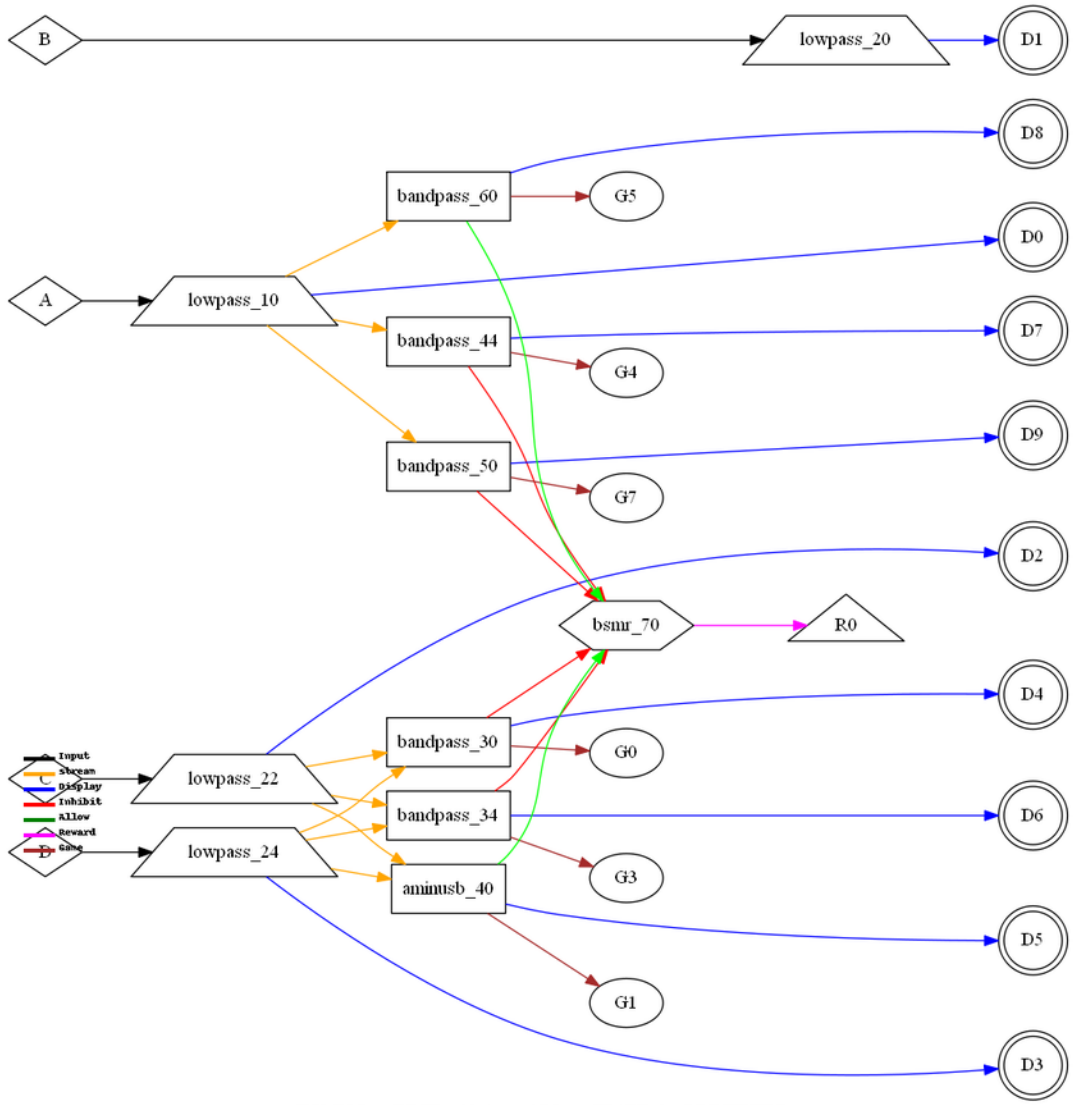
6320 DPdeltaBPCD (4 channel PsyncCD+BP A) CCCCIRIIRI



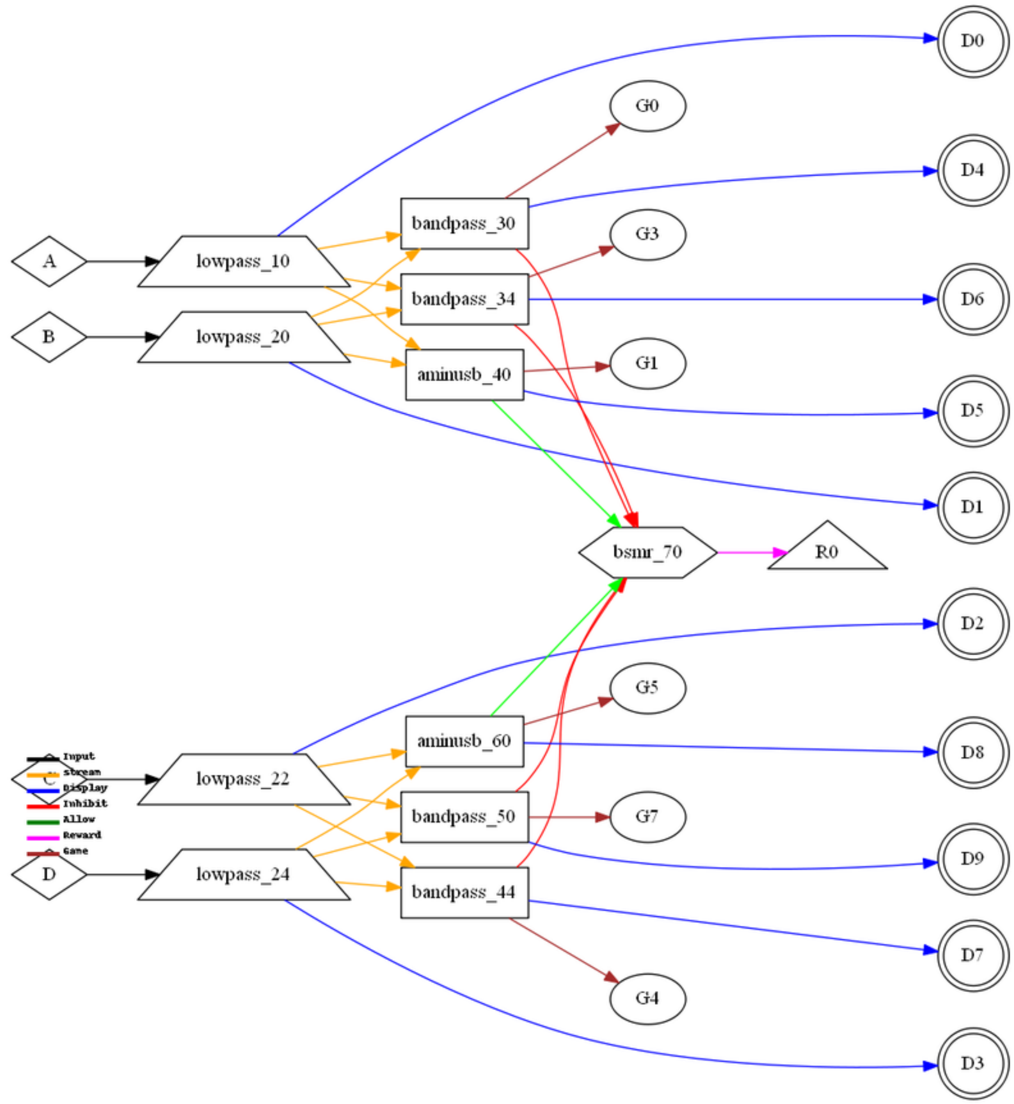
6330 DPdelta (4 channel PsyncAB+PsyncCD) CCCCIRIIRI



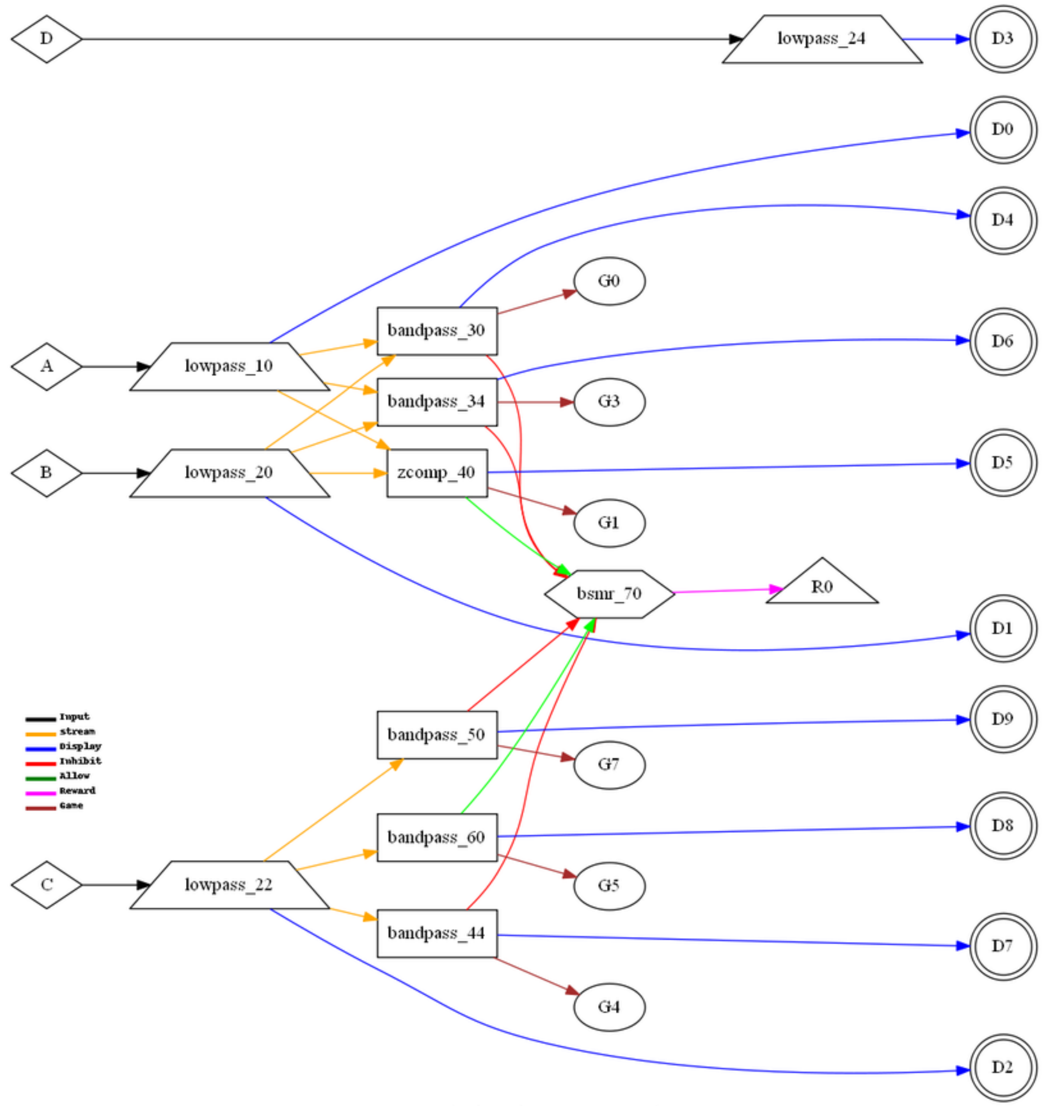
6340 DMinusBPAB (4 channel MinusAB+BP C) CCCCIRIIRI



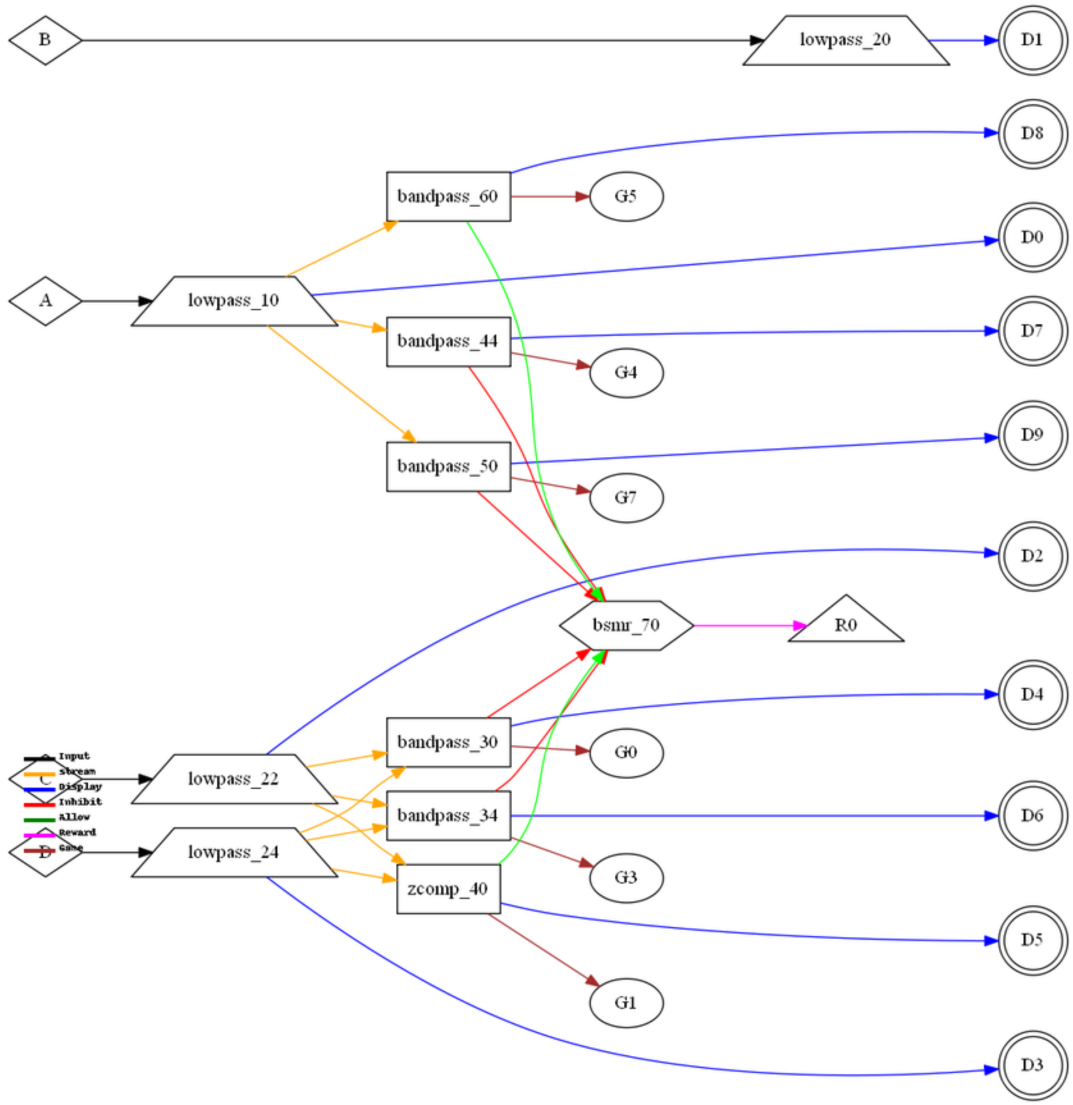
6350 DMinusBPCD (4 channel MinusCD+BP A) CCCCIRIIRI



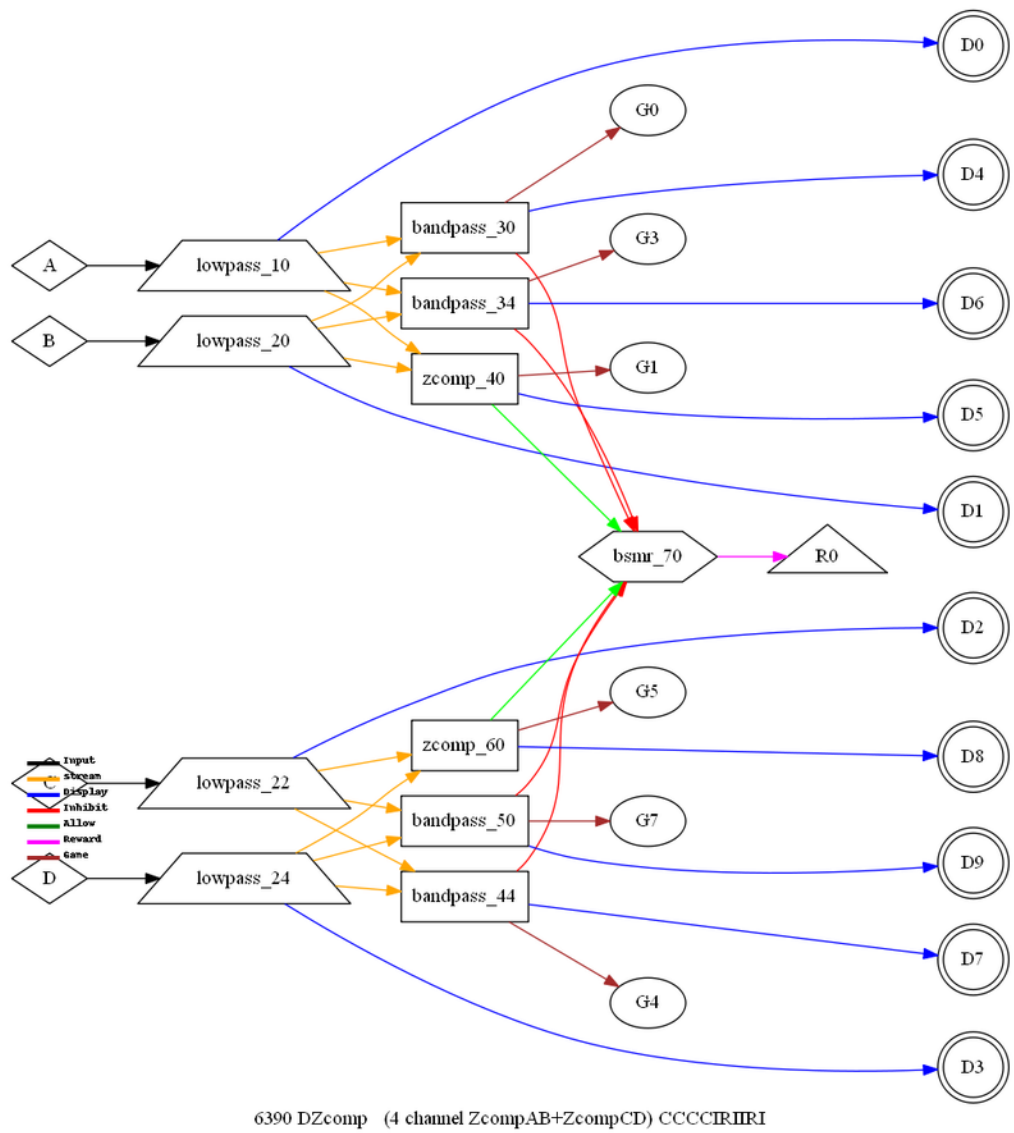
6360 DMinus (4 channel MinusAB+MinusCD) CCCCIRIIRI

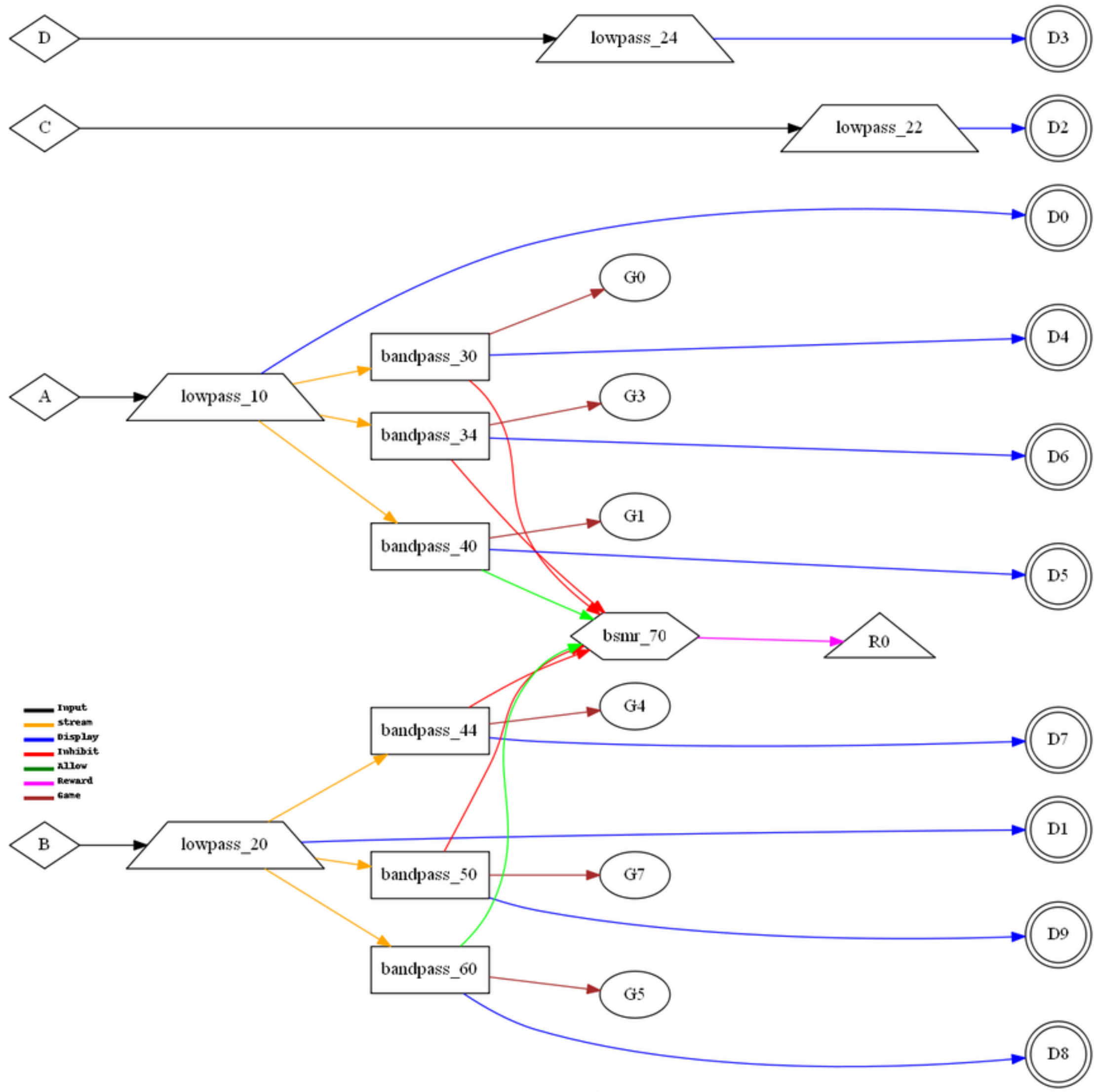


6370 DZcompBPAB (4 channel ZcompAB+BP C) CCCCIRIIRI

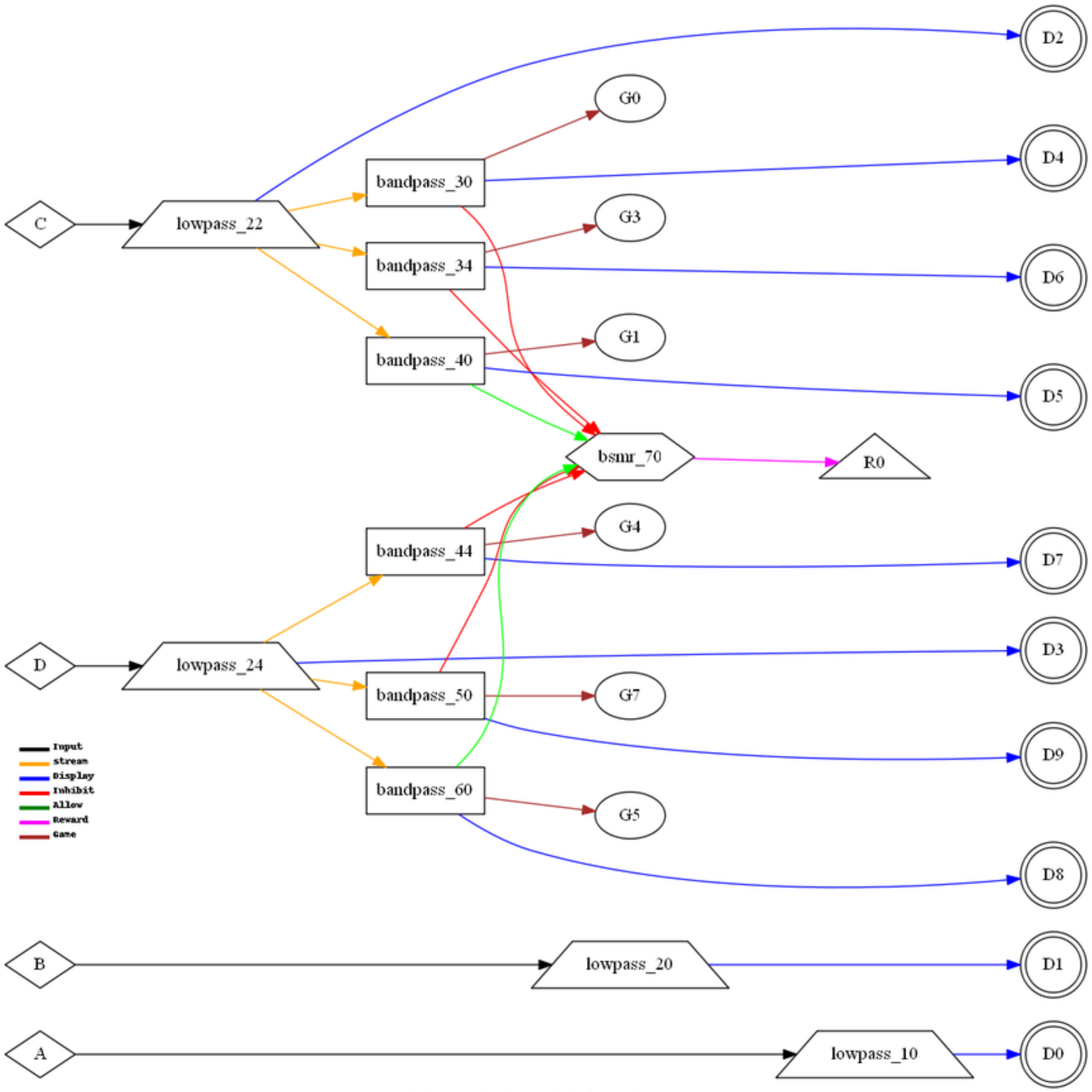


6380 DZcompBPCD (4 channel ZcompCD+BP A) CCCCIRIIRI

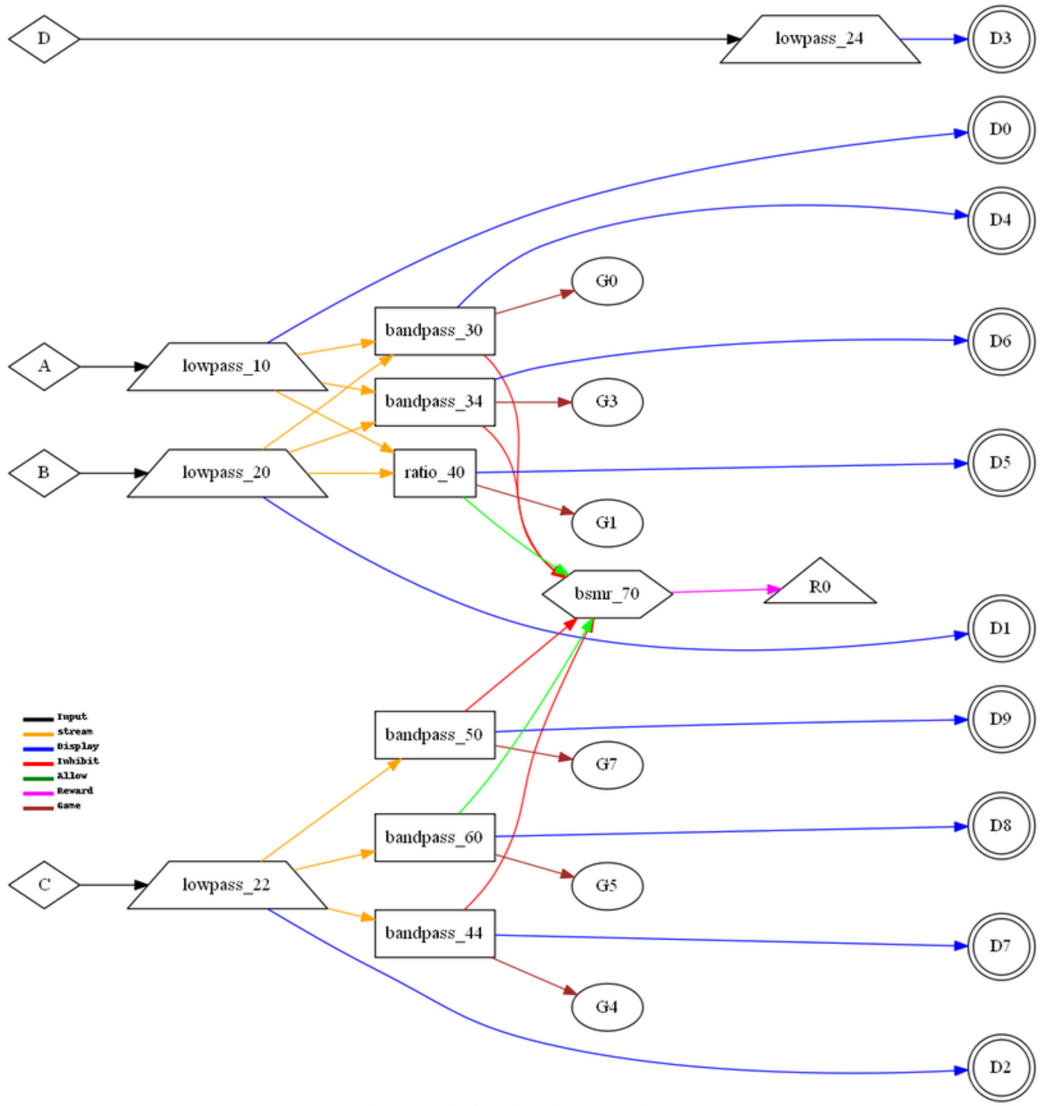

A
B
C
D
lowpass_10
lowpass_20
lowpass_22
lowpass_24
bandpass_30
bandpass_34
zcomp_40
zcomp_60
bandpass_50
bandpass_44
bsmr_70
R0
G0
G3
G1
G5
G7
G4
D0
D4
D6
D5
D1
D2
D8
D9
D7
D3
Input
Stream
Display
Inhibit
Allow
Reward
Game
6390 DZcomp (4 channel ZcompAB+ZcompCD) CCCCIRIIRI



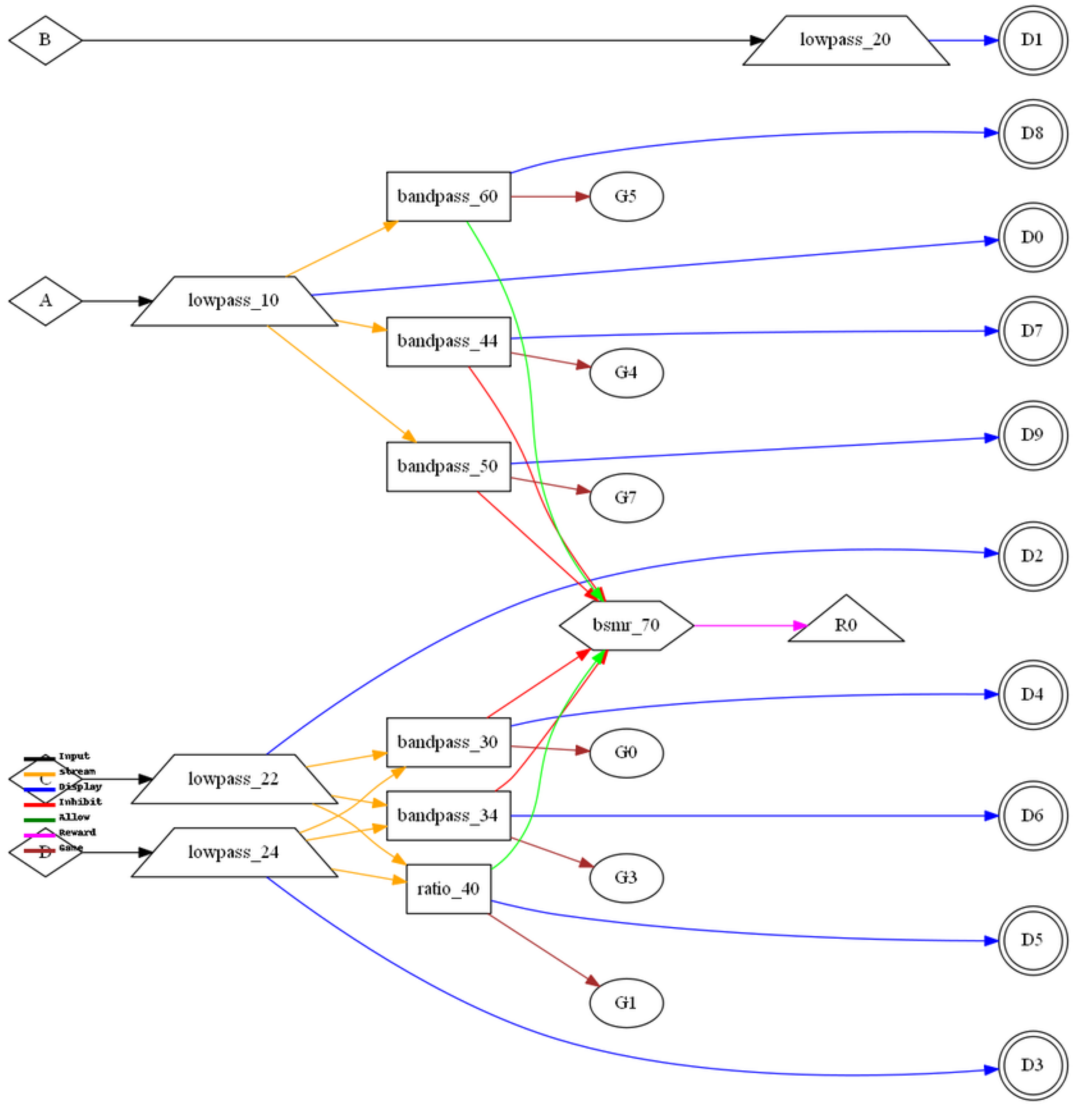
6200 DSingleAB (4 channel single A B) CCCCIRIIRI



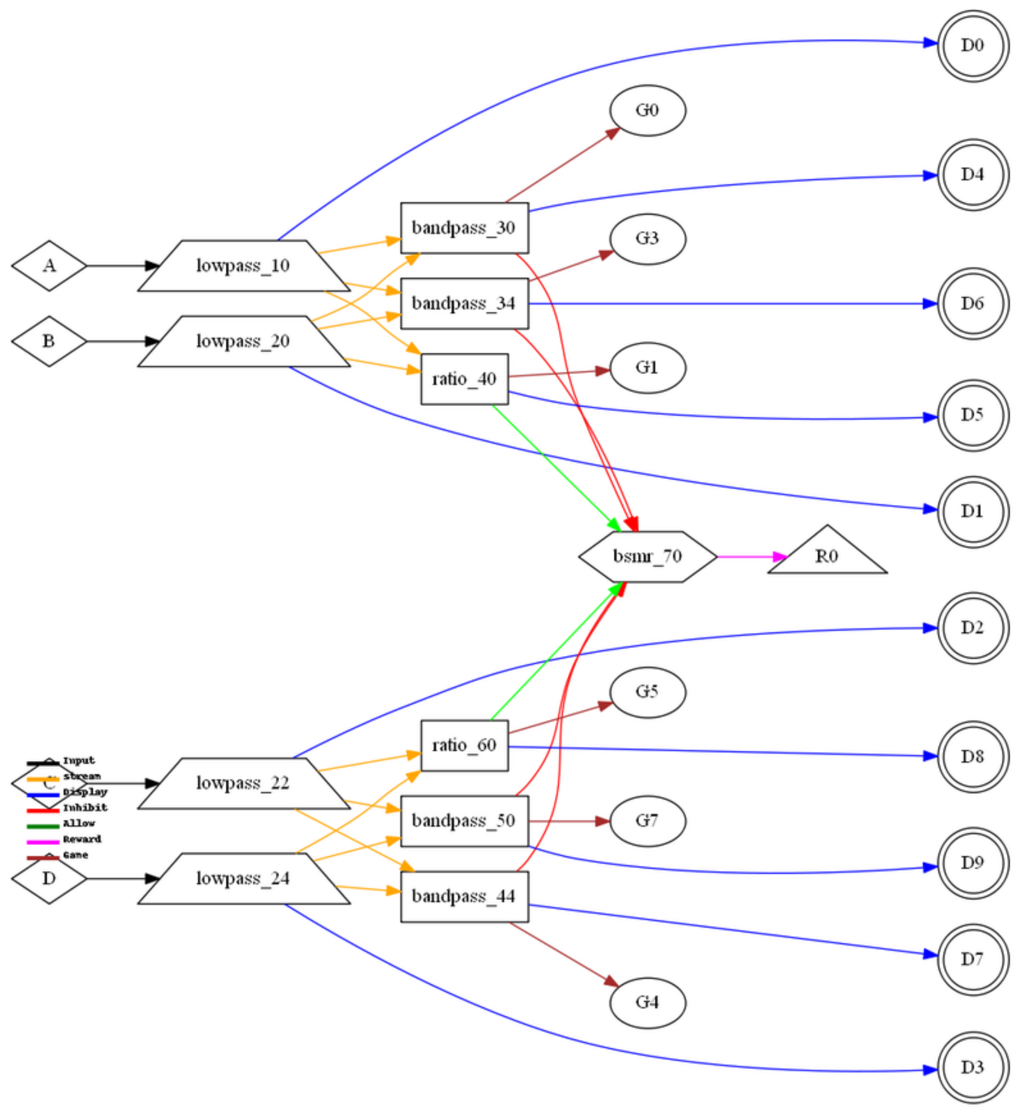
6210 DSingleCD (4 channel single C D) CCCCIRIIRI



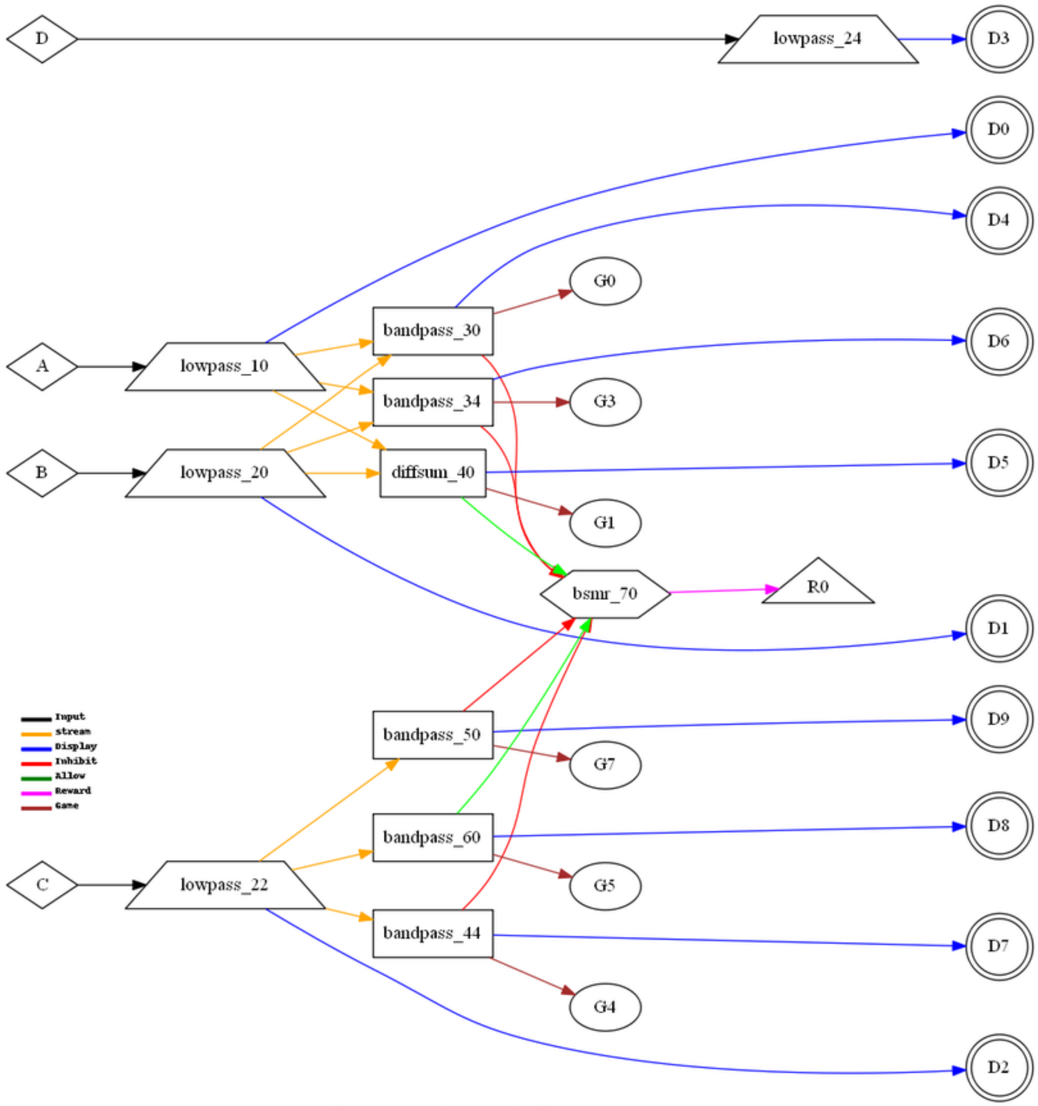
6420 DRatioBPAB (4 channel RatioAB+BP C) CCCCIRIIRI



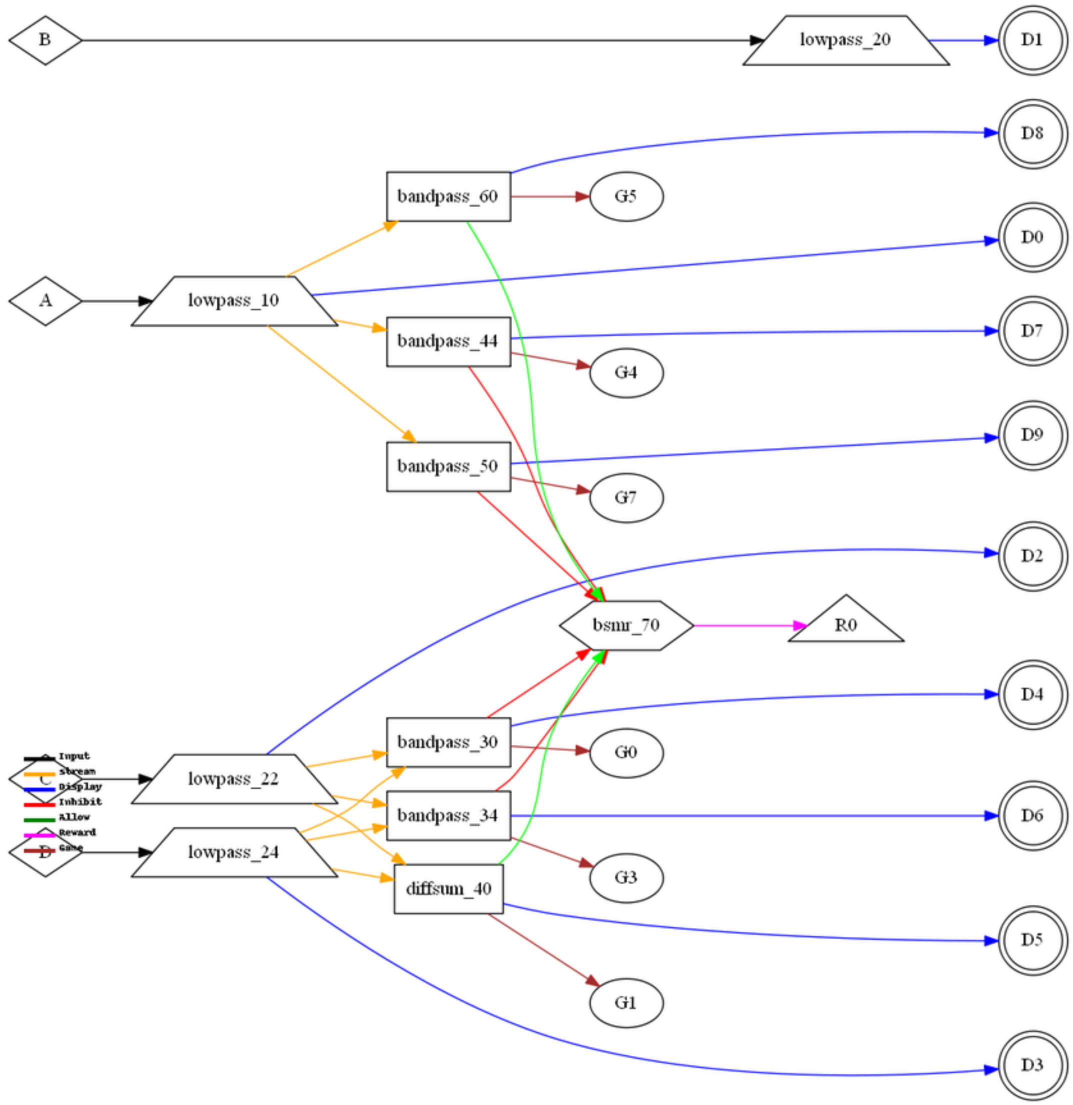
6430 DRatioBPCD (4 channel RatioCD+BP A) CCCCIRIIRI



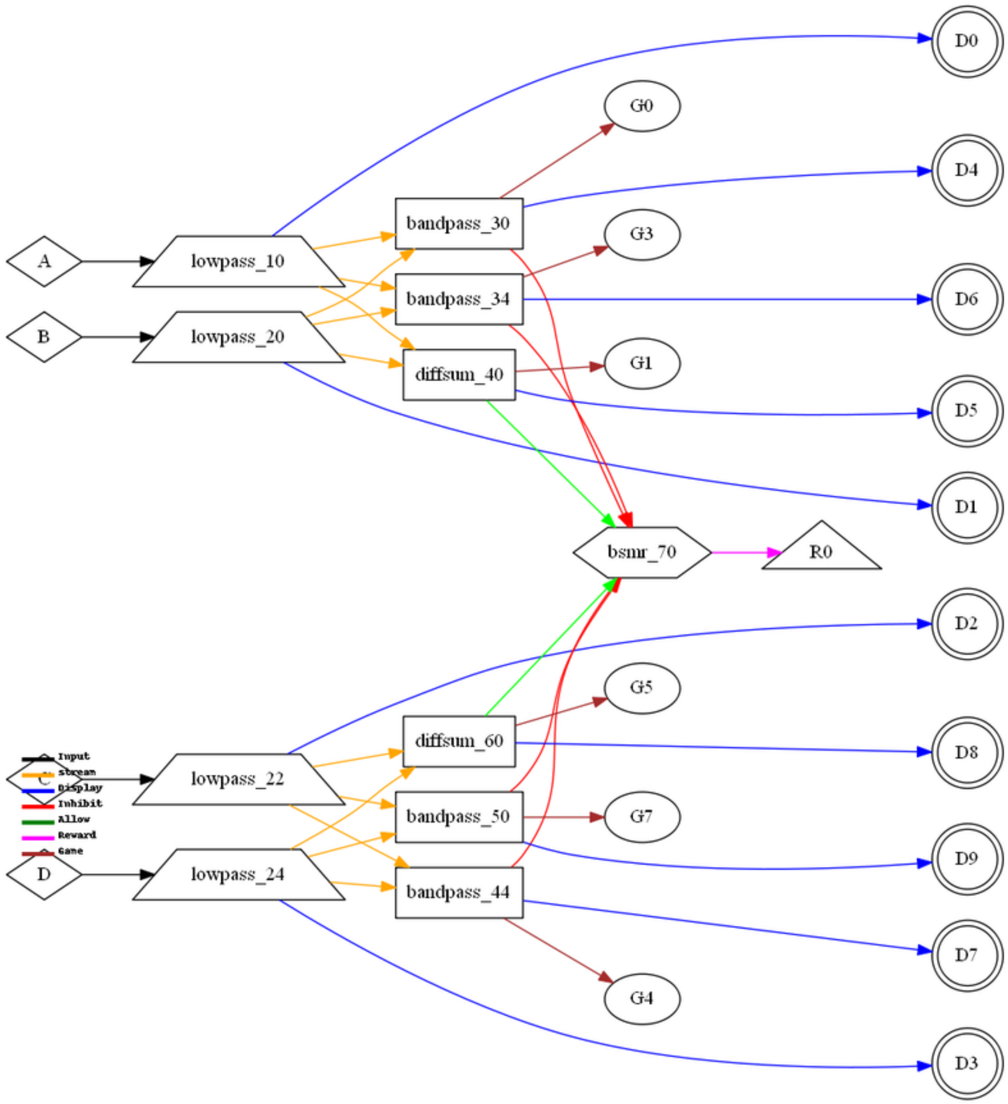
6440 DRatio (4 channel RatioAB+RatioCD) CCCCIRIIRI



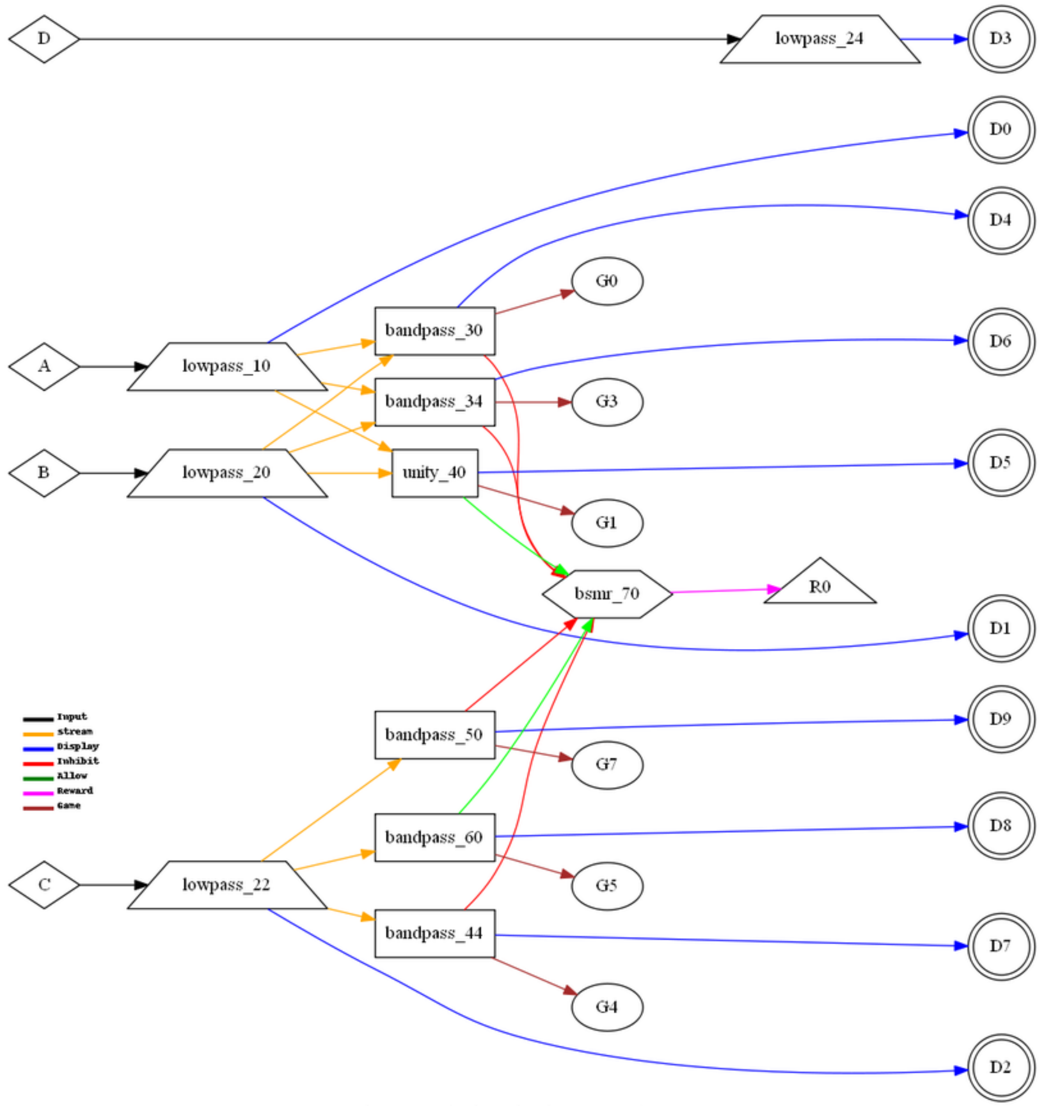
6450 DDiffSumBPAB (4 channel Diff-SumAB+BP C) CCCCIRIIRI



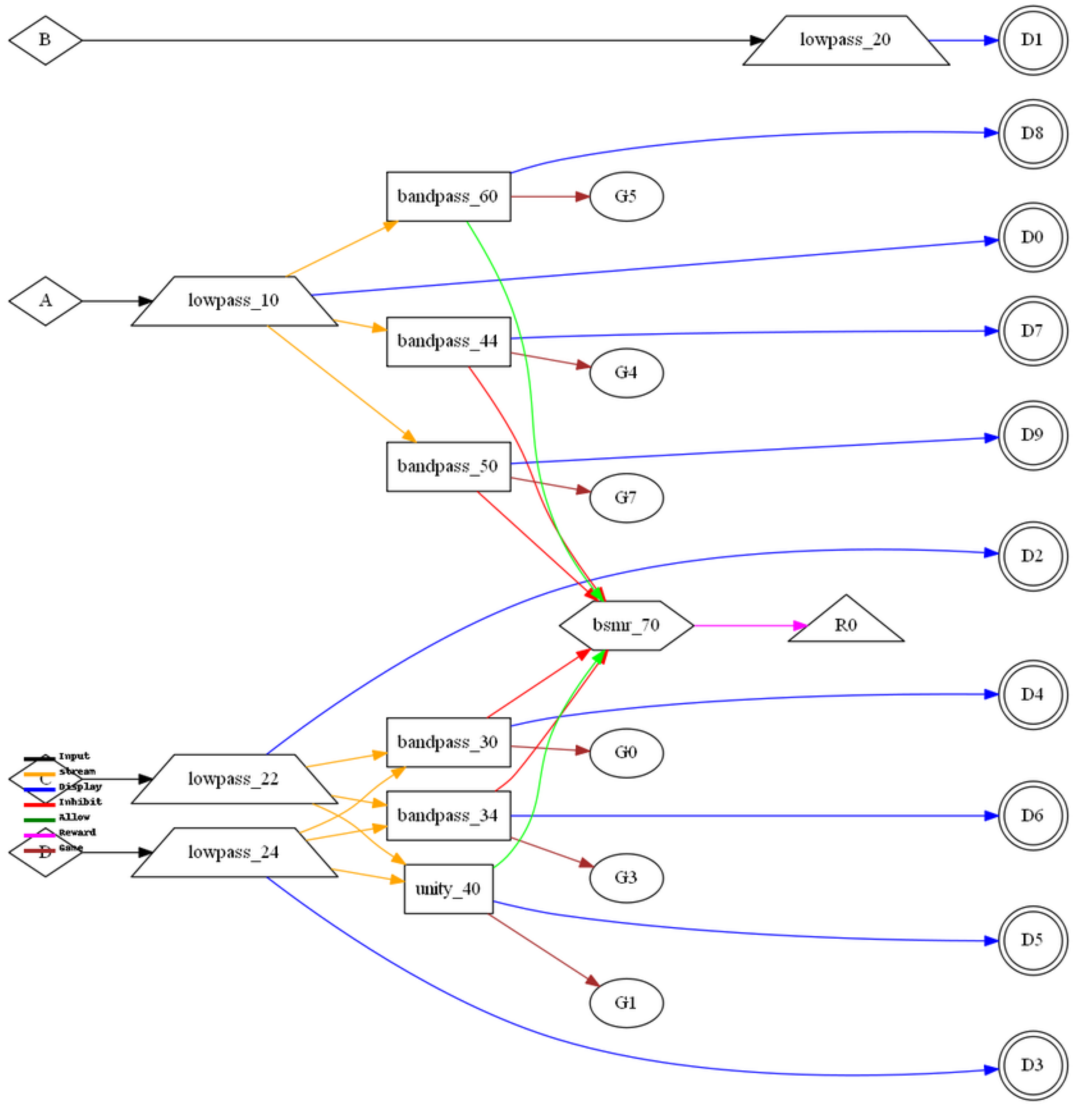
6460 DDiffSumBPCD (4 channel Diff-SumCD+BP A) CCCCIRIIRI



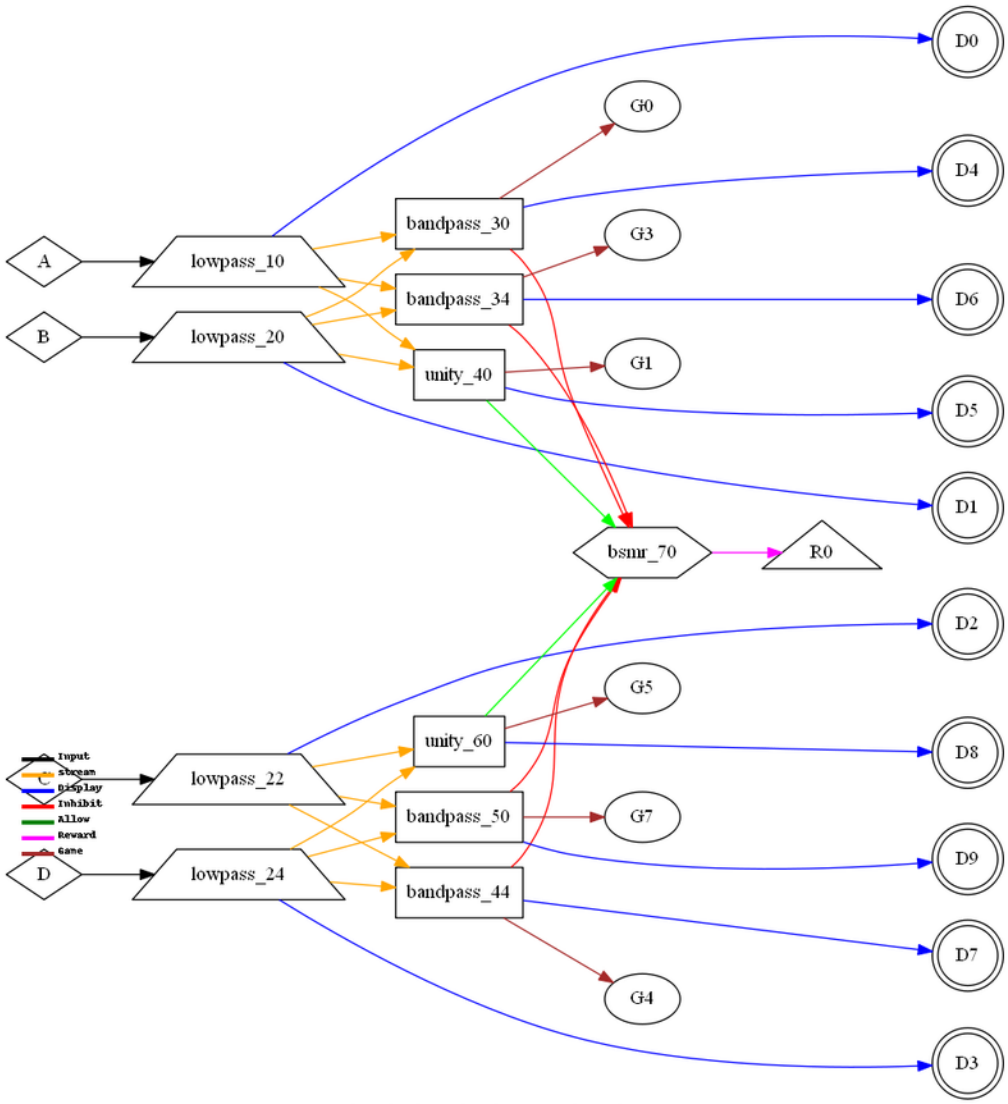
6470 DDiffSum (4 channel Diff-SumAB+Diff-SumCD) CCCCIRIIRI



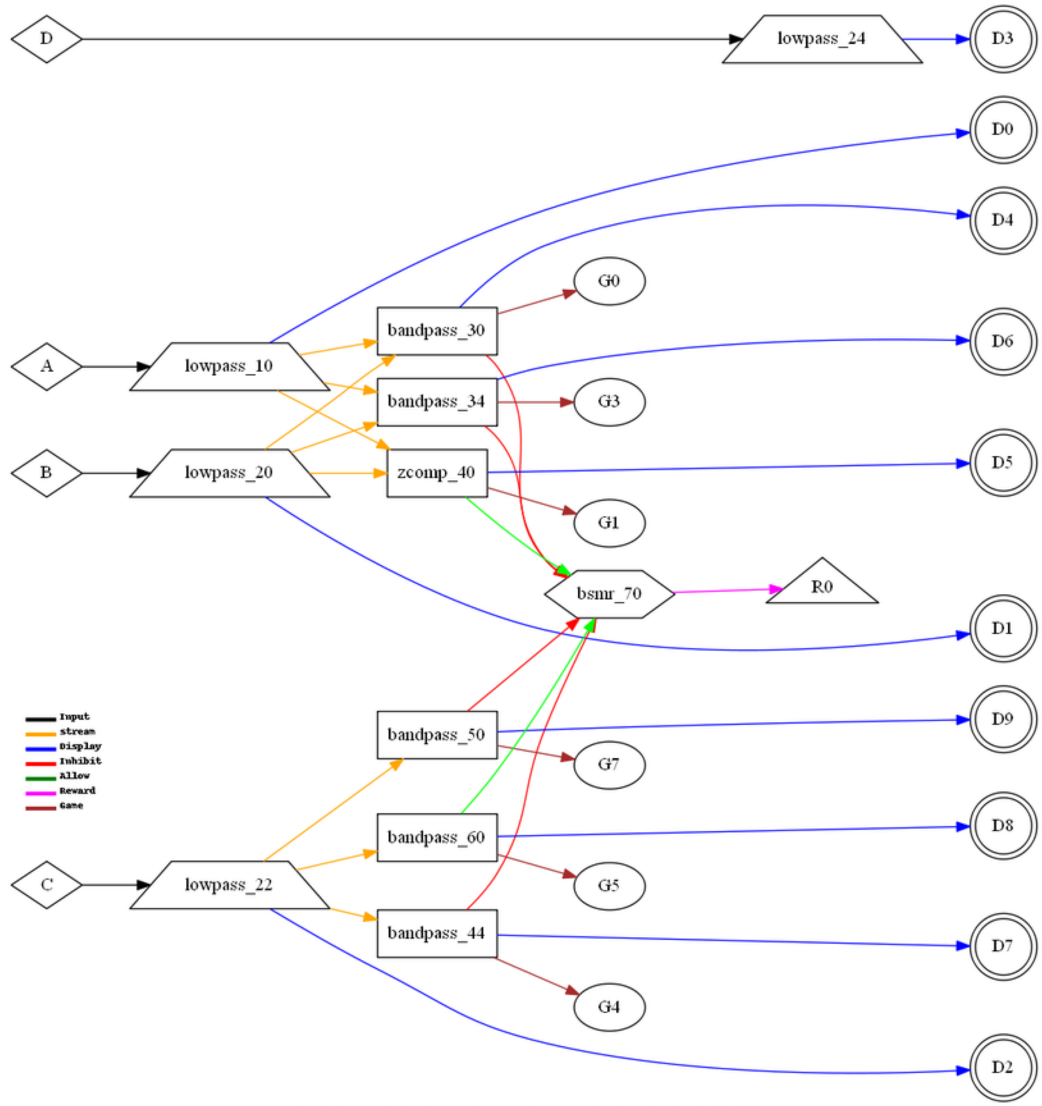
6480 DUnityBPAB (4 channel UnityAB+BP C) CCCCIRIIRI



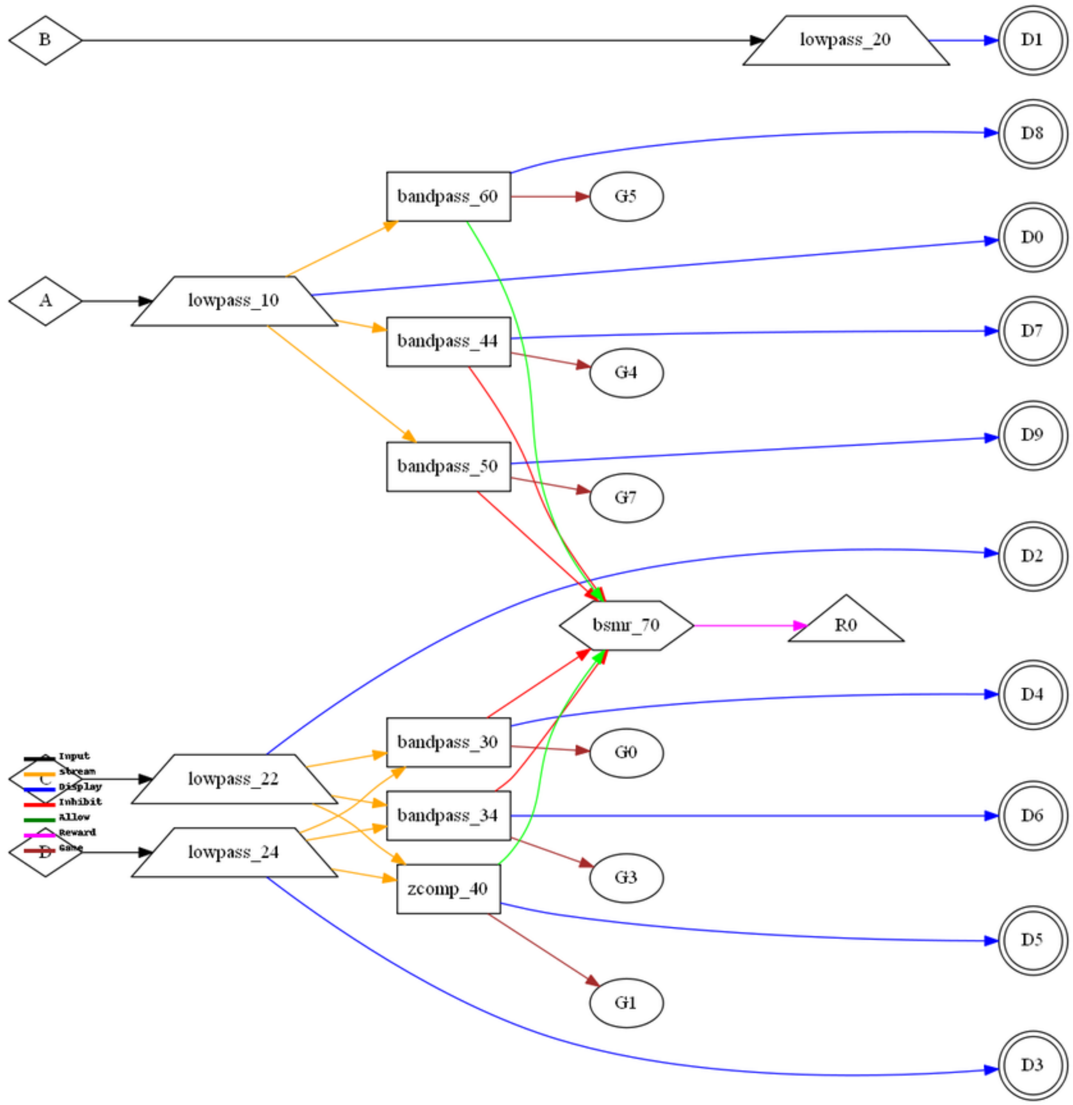
6490 DUnityBPCD (4 channel UnityCD+BP A) CCCCIRIIRI



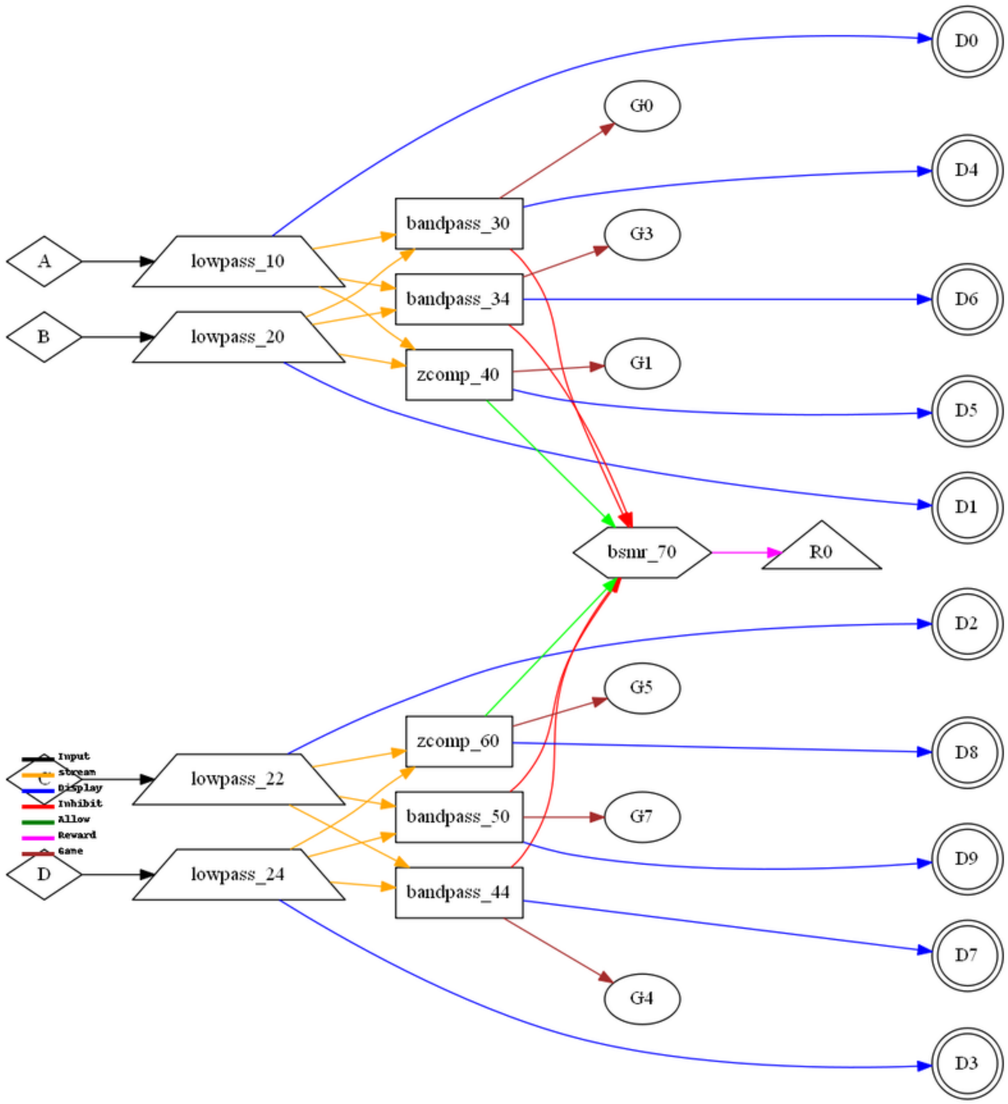
6500 DUnity (4 channel UnityAB+UnityCD) CCCCIRIIRI



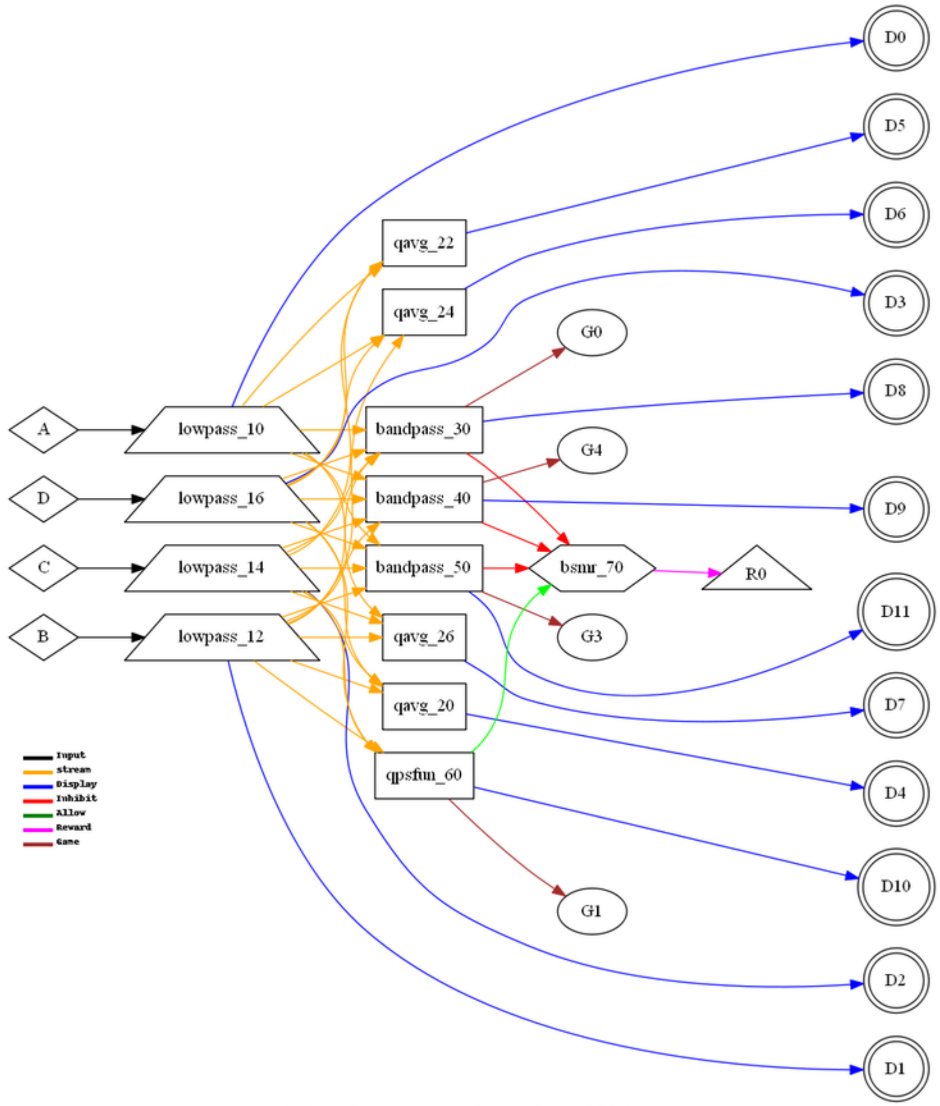
6370 DZcompBPAB (4 channel ZcompAB+BP C) CCCCIRIIRI



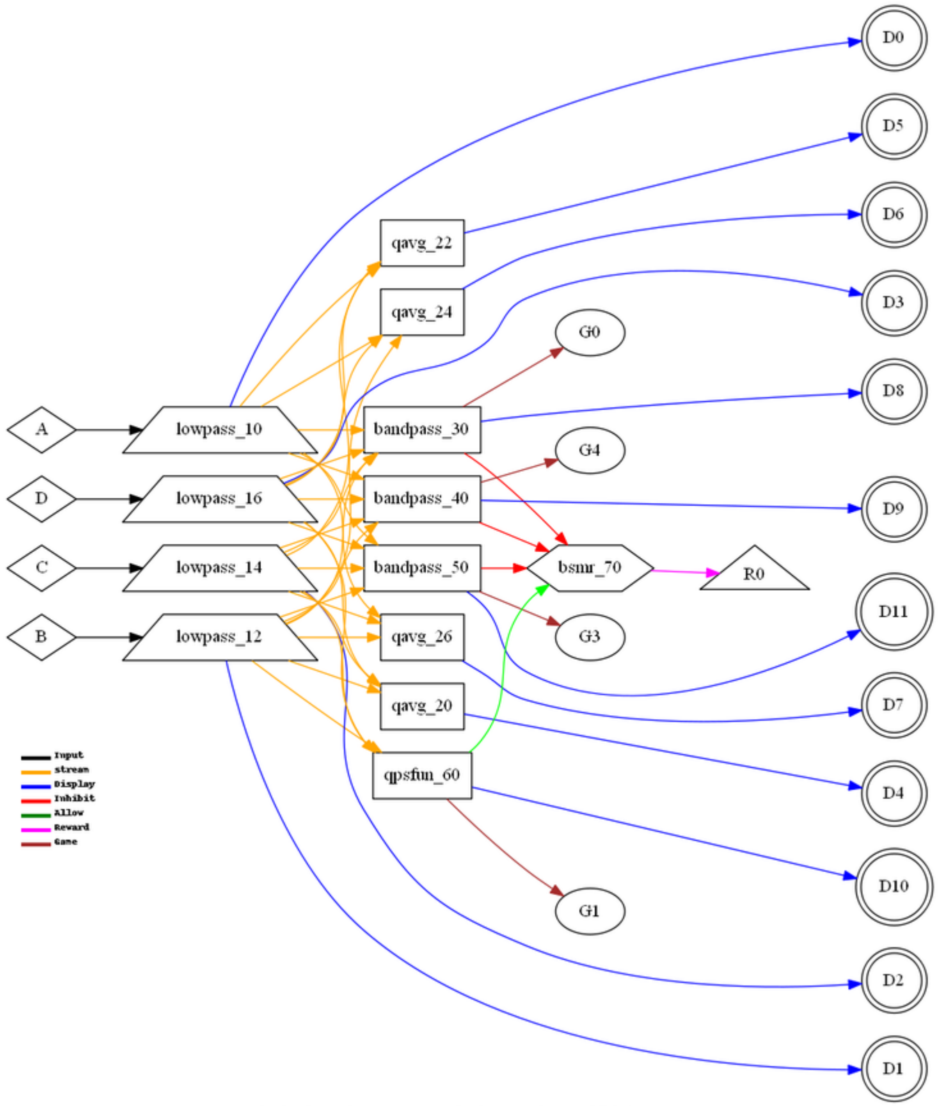
6380 DZcompBPCD (4 channel ZcompCD+BP A) CCCCIRIIRI



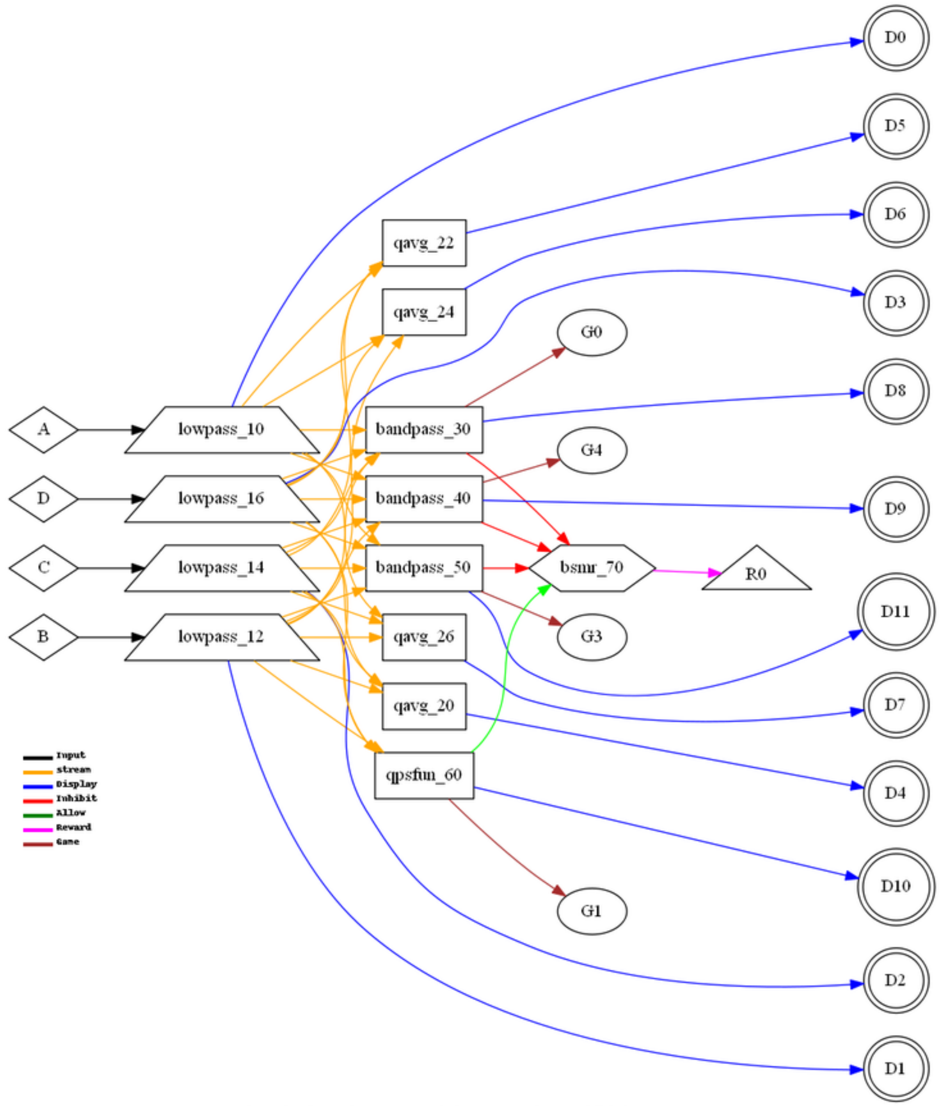
6390 DZcomp (4 channel ZcompAB+ZcompCD) CCCCIRIIRI



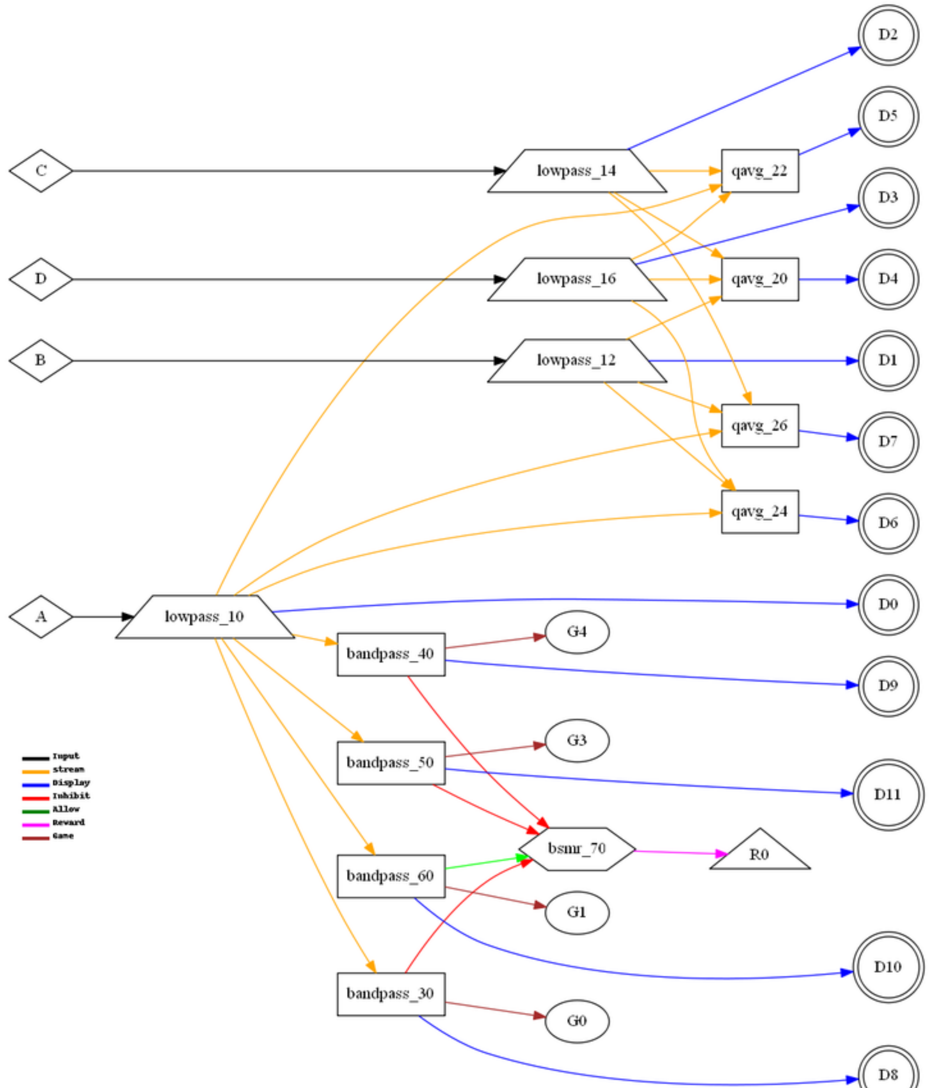
6800 QPSAvg (4 channel PSync Averaged Reward + 3 Inhibits) CCCCMMMMIIIRI



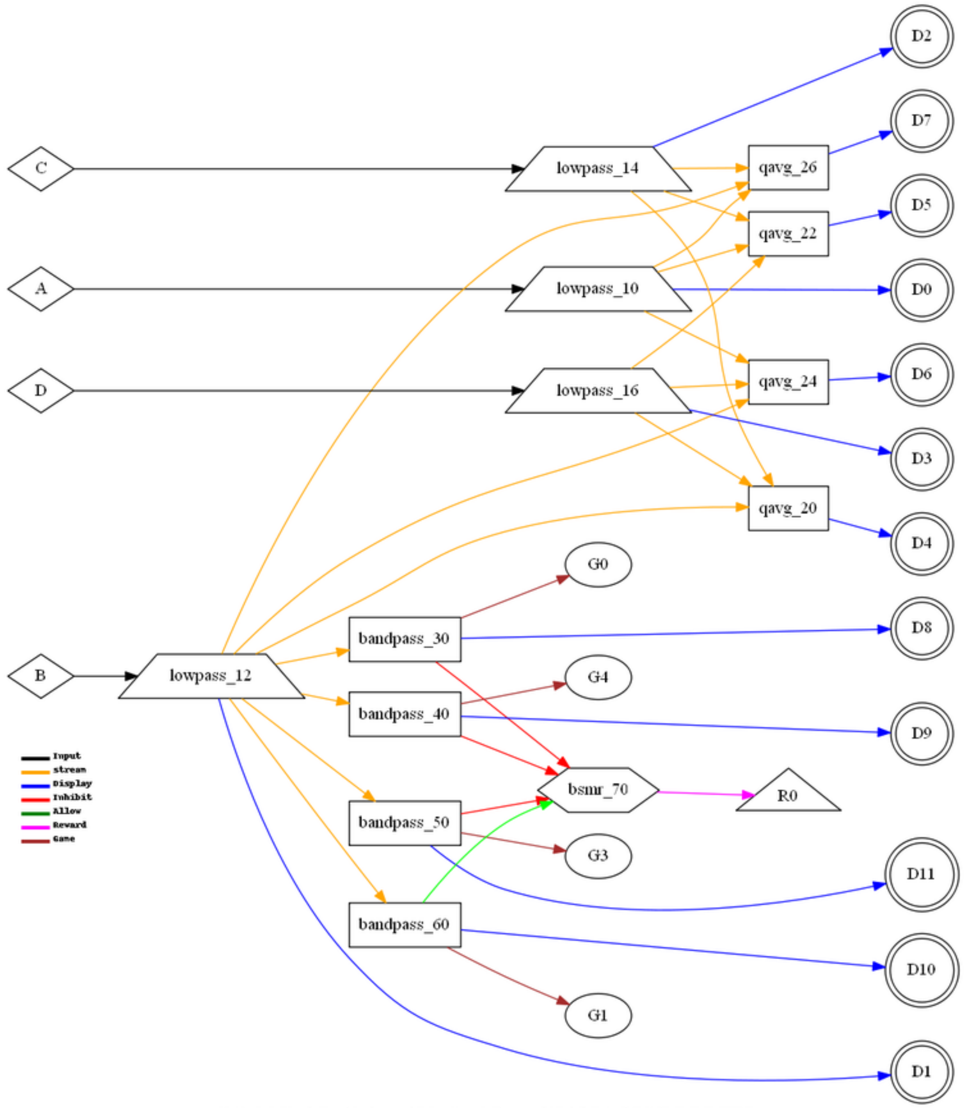
6811 QPSmod (4 channel PSync Smoothed Reward + 3 Inhibits) CCCCMMMMIIIRI



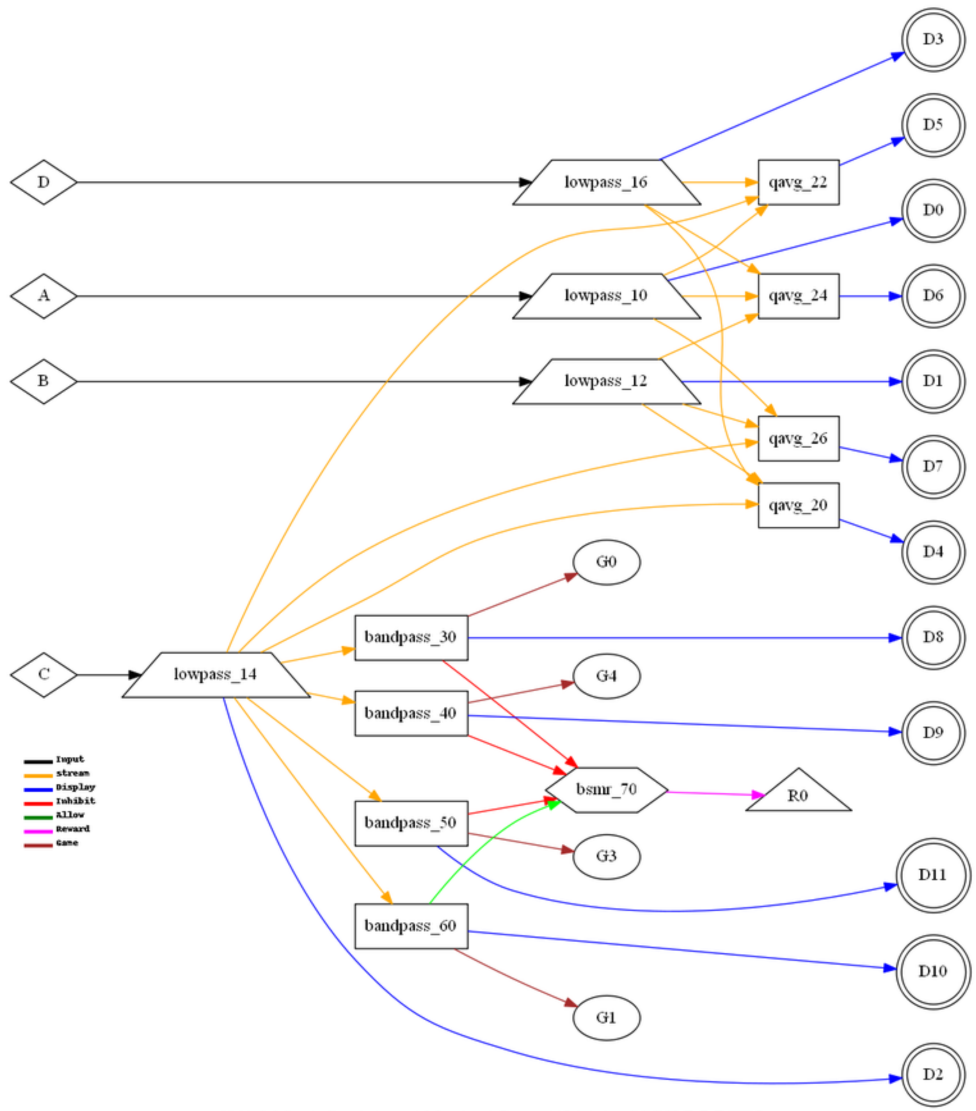
6820 QPSdev (4 channel PSync Deviation Reward + 3 Inhibits) CCCCMMMMIIIRI



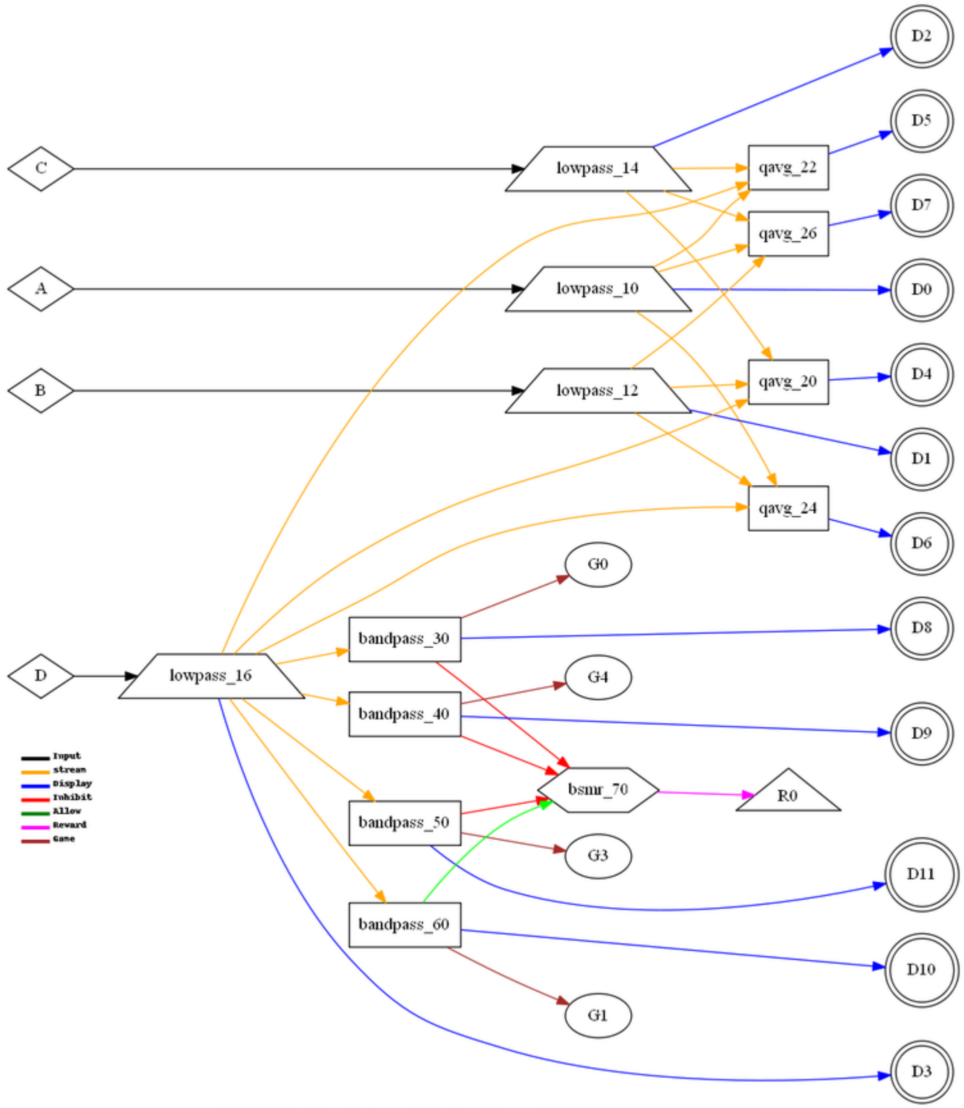
6840 QQSingleA (4 channel Monitor + Reward+Inhibits) CCCCMMMMIIRI



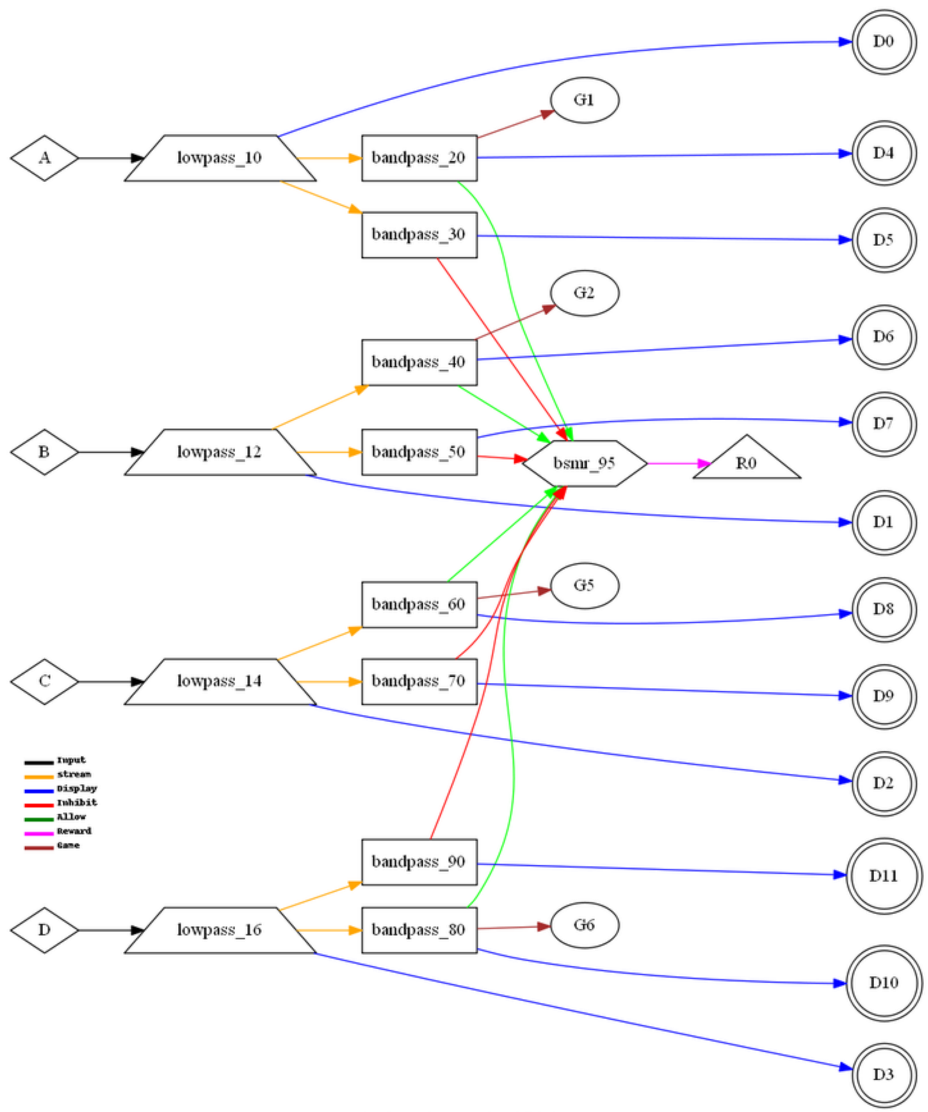
6842 QQSingleB (4 channel Monitor + Reward+Inhibits) CCCCMMMMIIRI



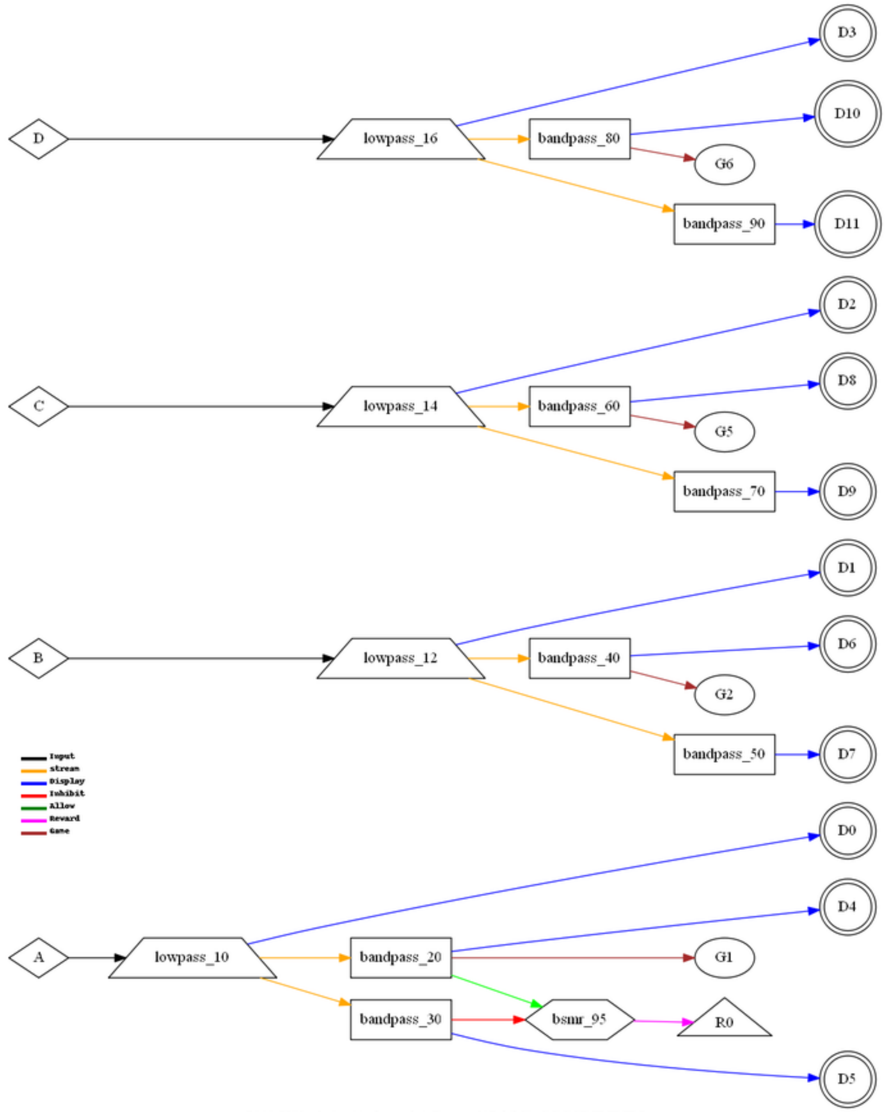
6844 QQSingleC (4 channel Monitor + Reward+Inhibits) CCCCMMMMIIRI



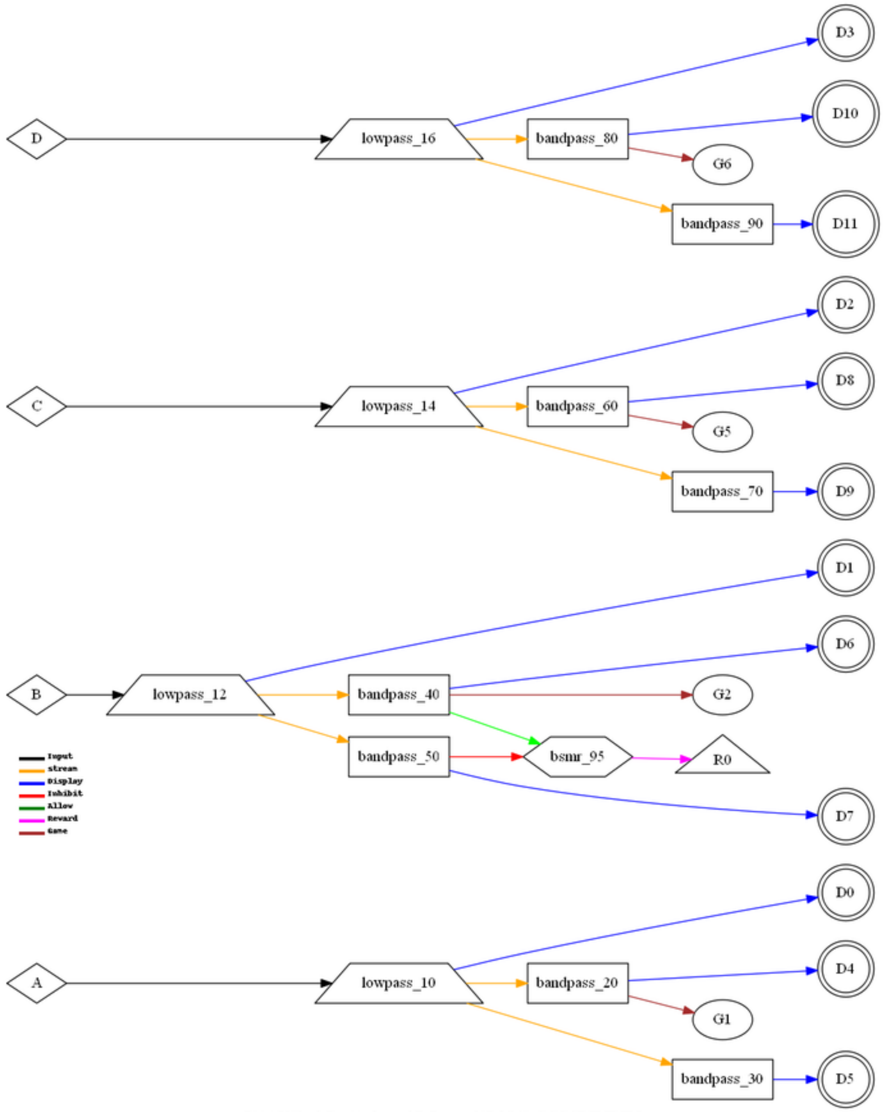
6846 QQSingleD (4 channel Monitor + Reward+Inhibits) CCCCMMMMIIRI



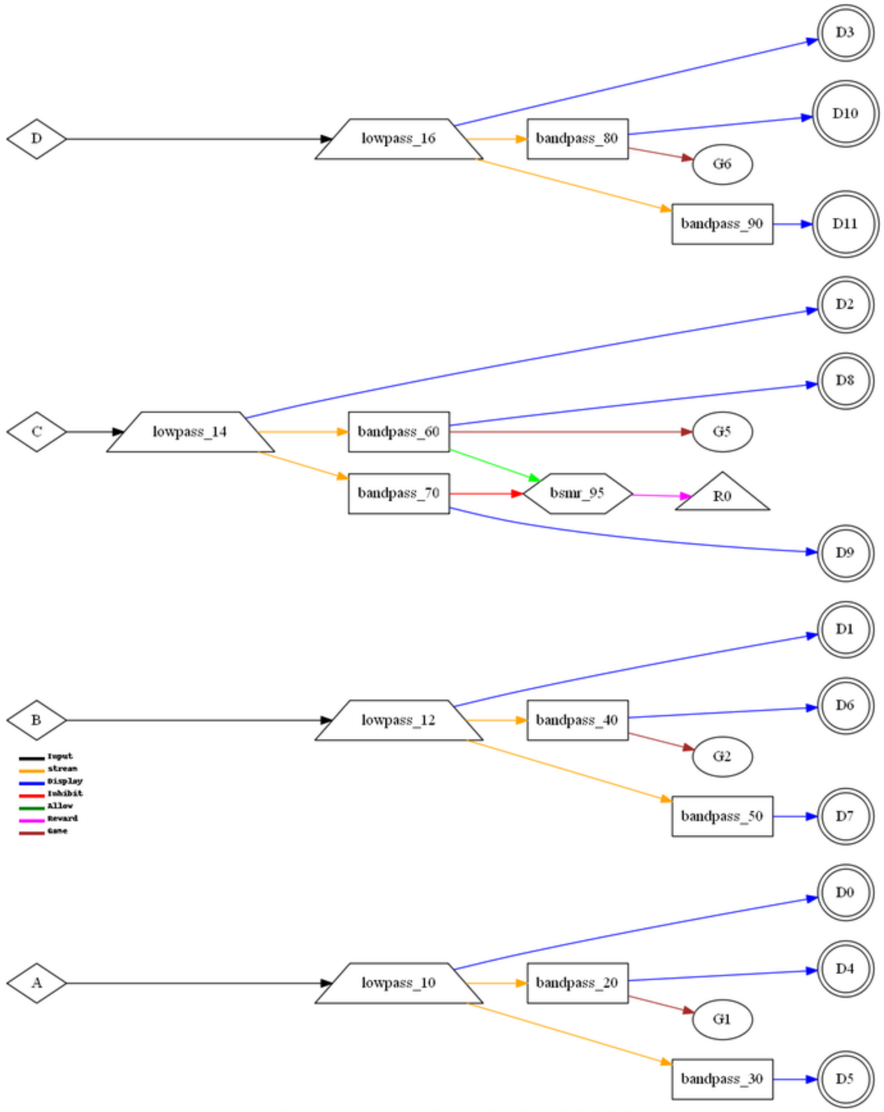
7000 XABCD (4 channel Reward+Inhibits) CCCCRIRIRIRI



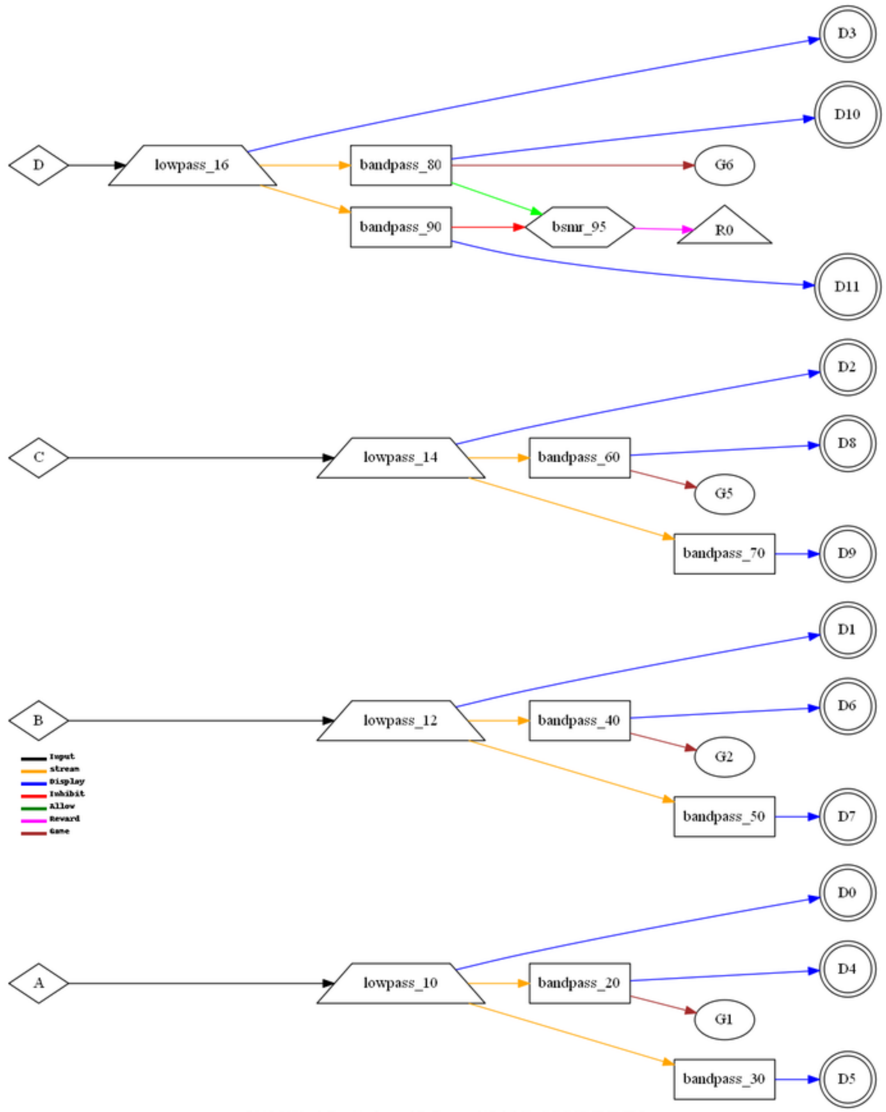
7002 XSingleA (4 channel A Reward+Inhibit) CCCCRIRIRIRI



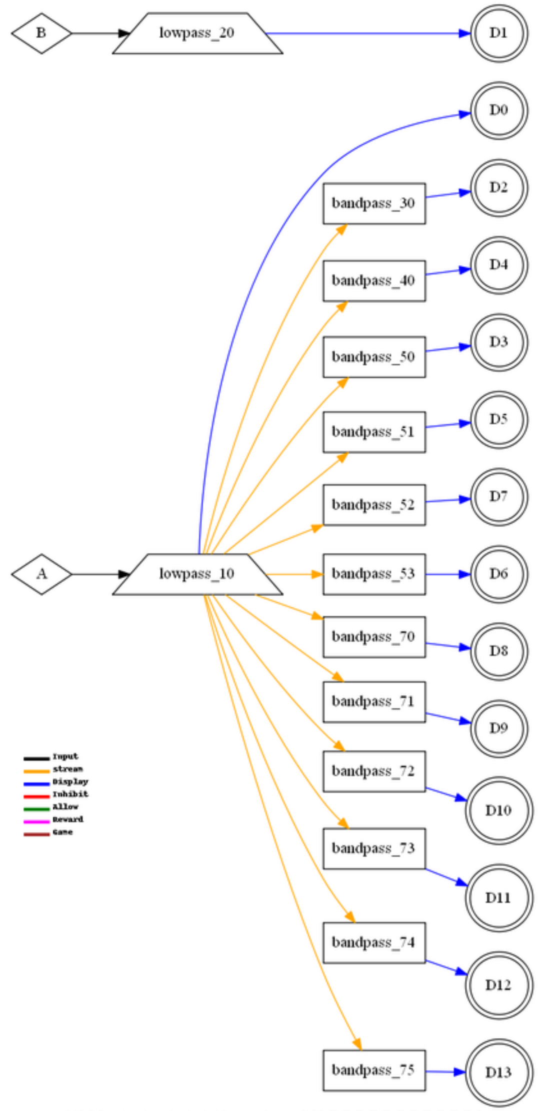
7004 XSingleB (4 channel B Reward+Inhibit) CCCCRIRIRIRI



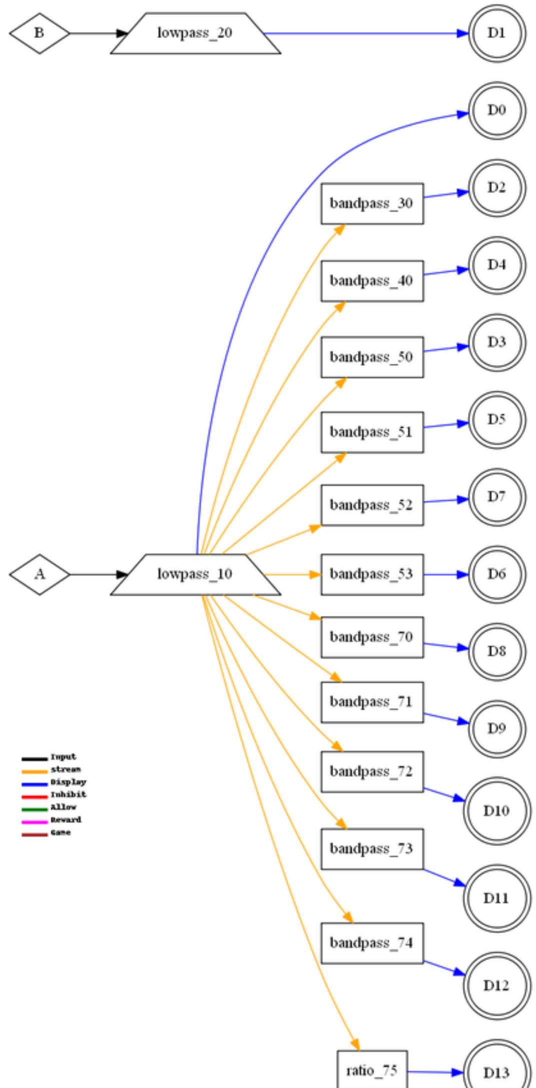
7006 XSingleC (4 channel C Reward+Inhibit) CCCCRIRIRIRI



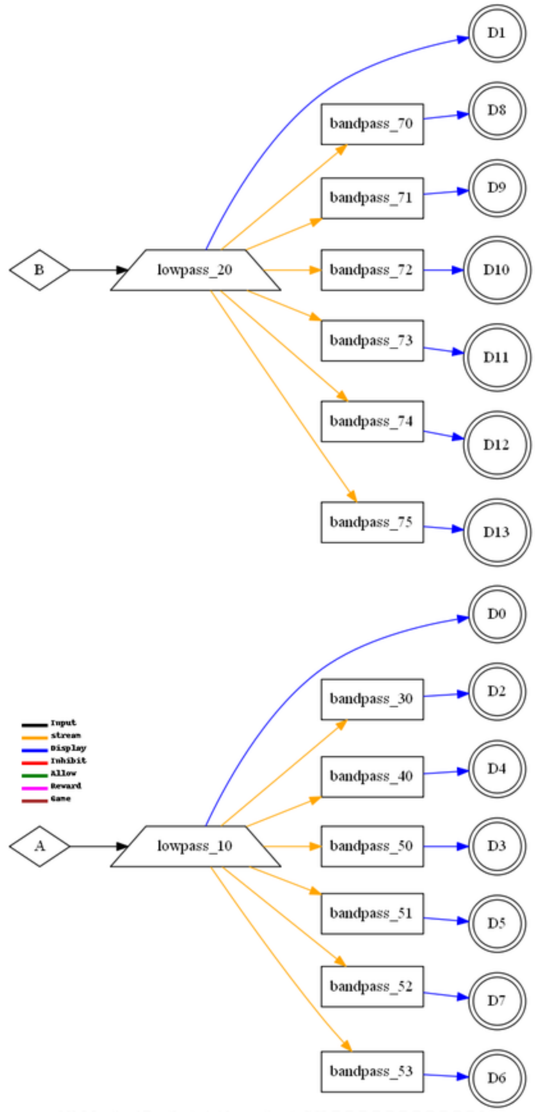
7008 XSingleD (4 channel D Reward+Inhibit) CCCCRIRIRIRI



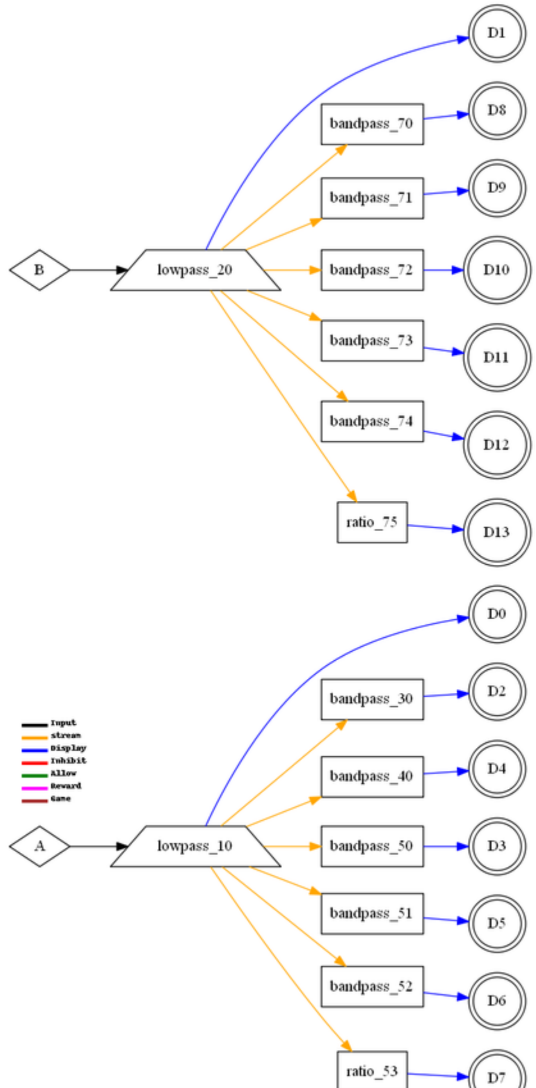
668 MonitorA (1-ch + 12 monitors) CCMMMMMMMMMMMM



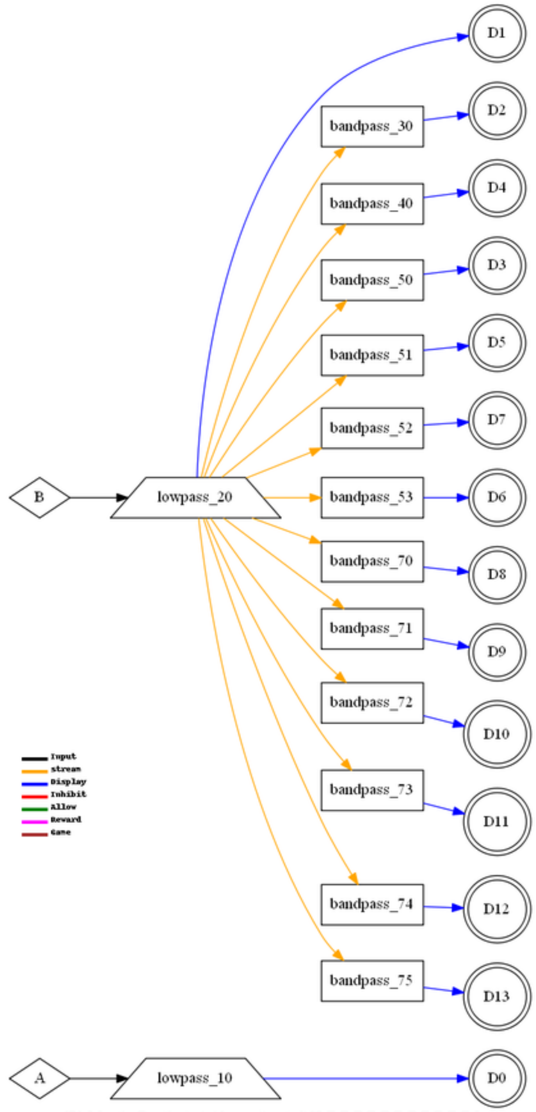
672 MonitorA-R (1-ch + 12 monitors) CCMMMMMMMMMMMMM



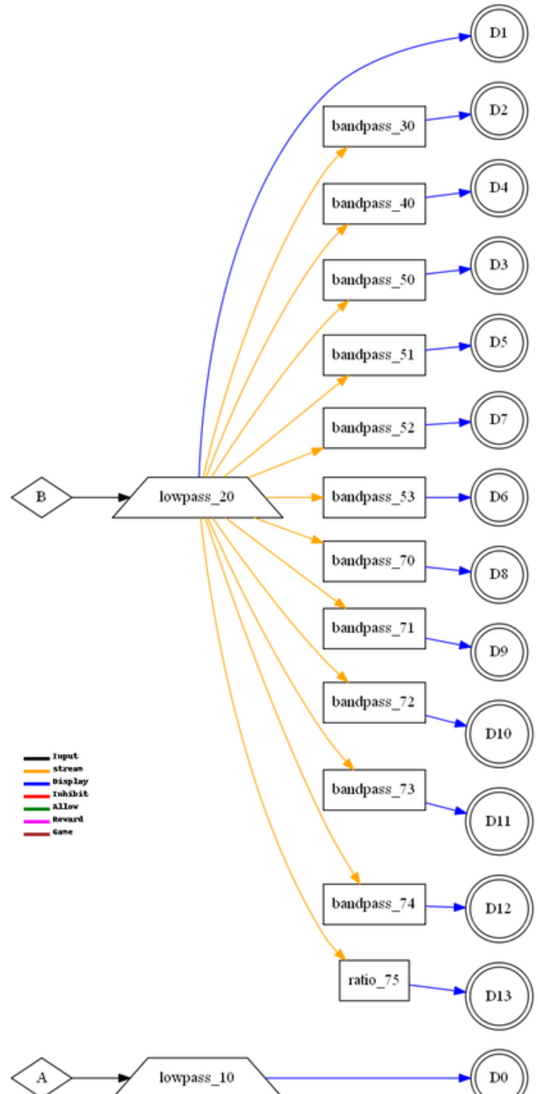
669 MonitorAB (2-ch + 12 monitors) CCMMMMMMMMMMMM



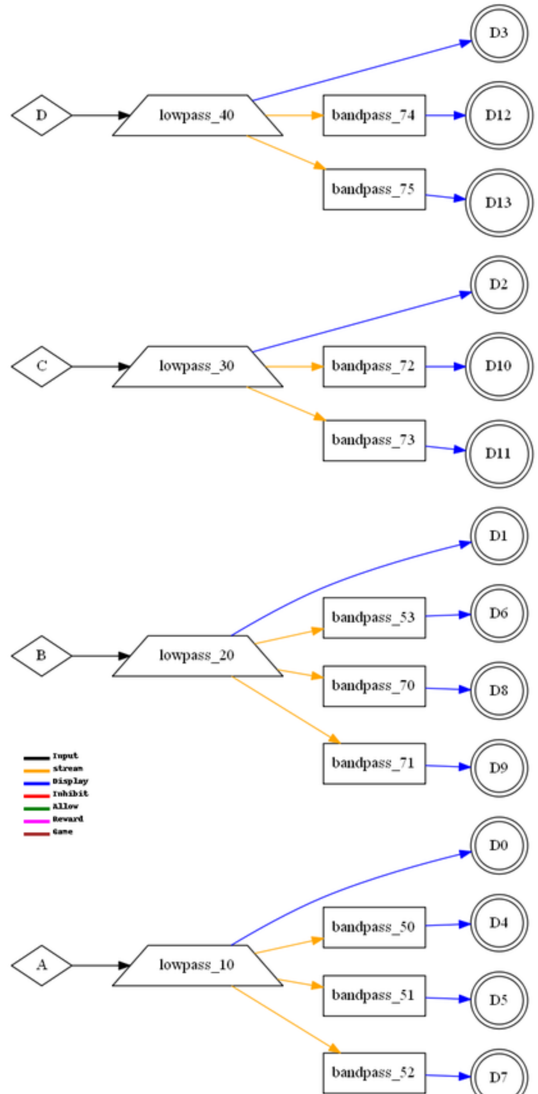
673 MonitorAB-R (2-ch + 12 monitors) CCMMMMMMMMMMMM



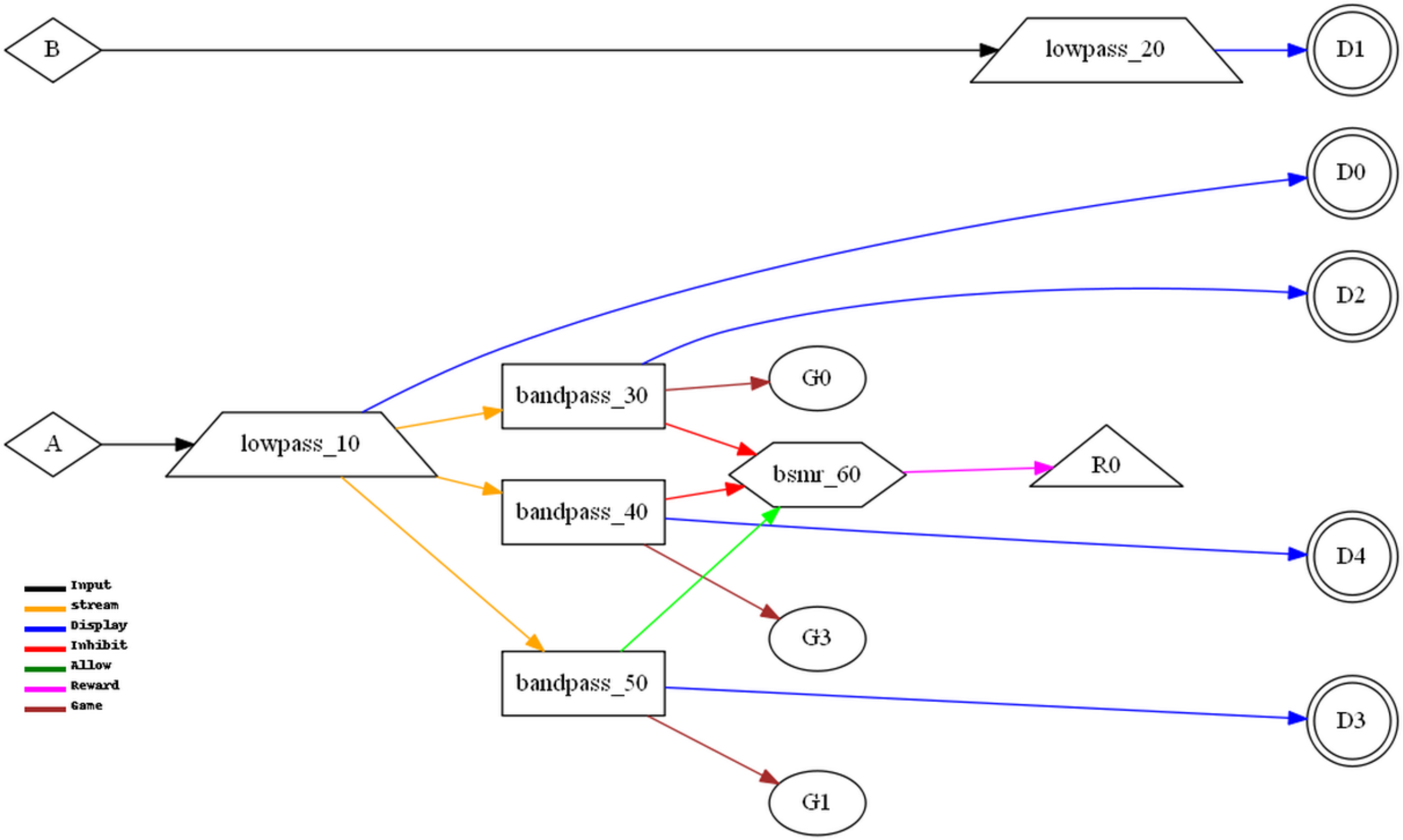
670 MonitorB (1-ch + 12 monitors) CCMMMMMMMMMMMM



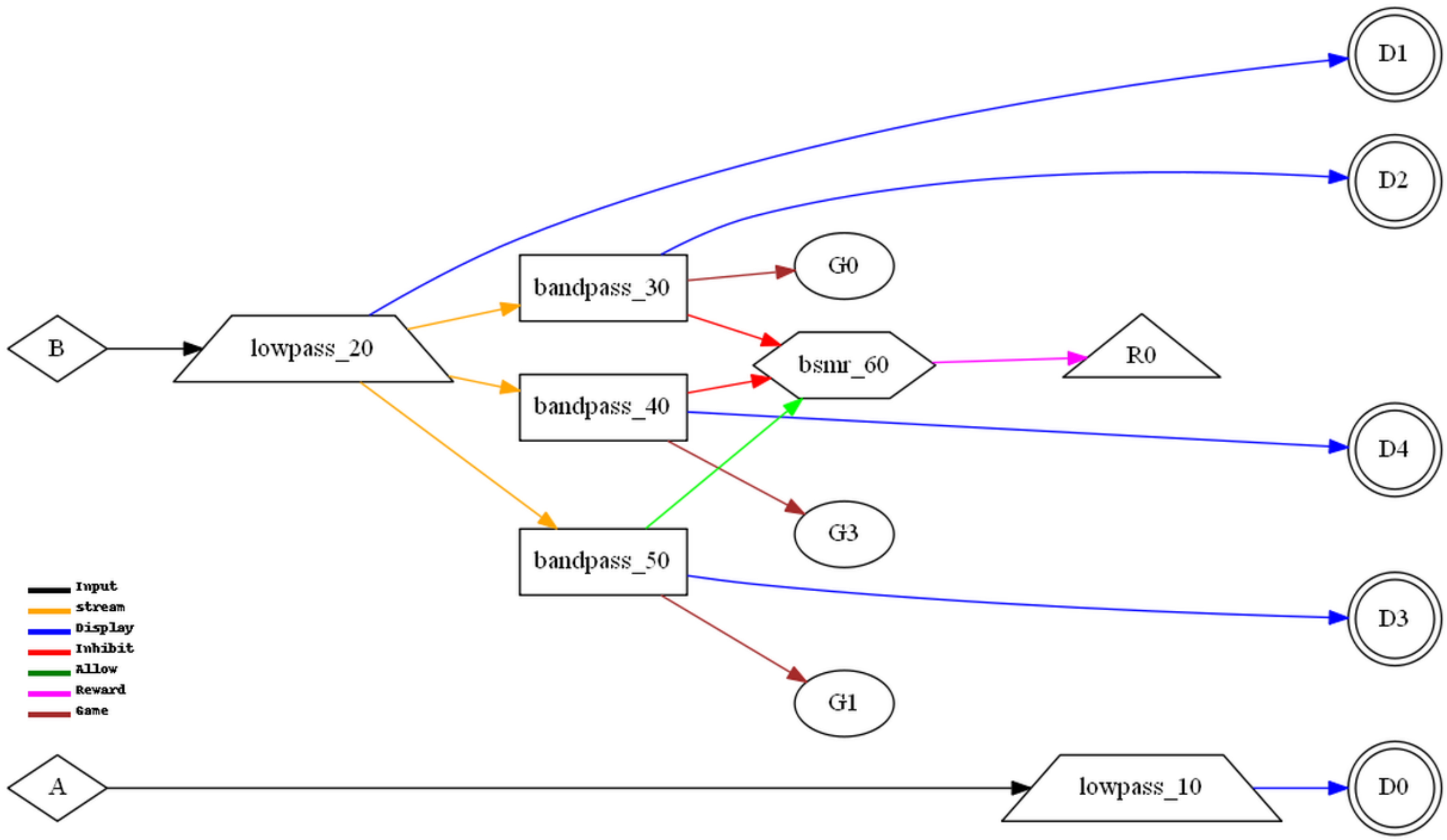
674 MonitorB-R (1-ch + 12 monitors) CCMMMMMMMMMMMM



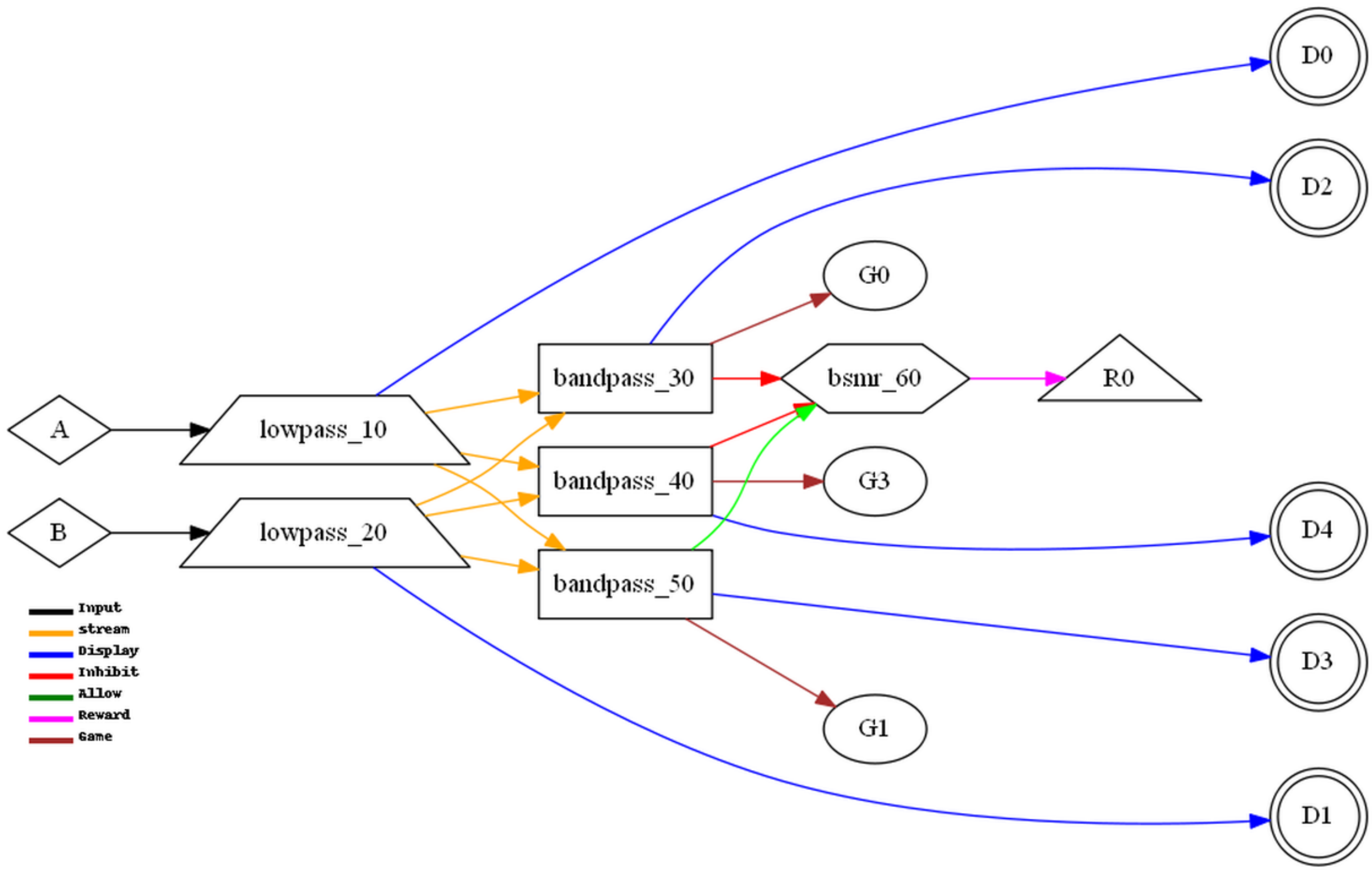
675 4-chan,monitors (4-ch + 10 monitors) CCCCMMMMMMMMMM



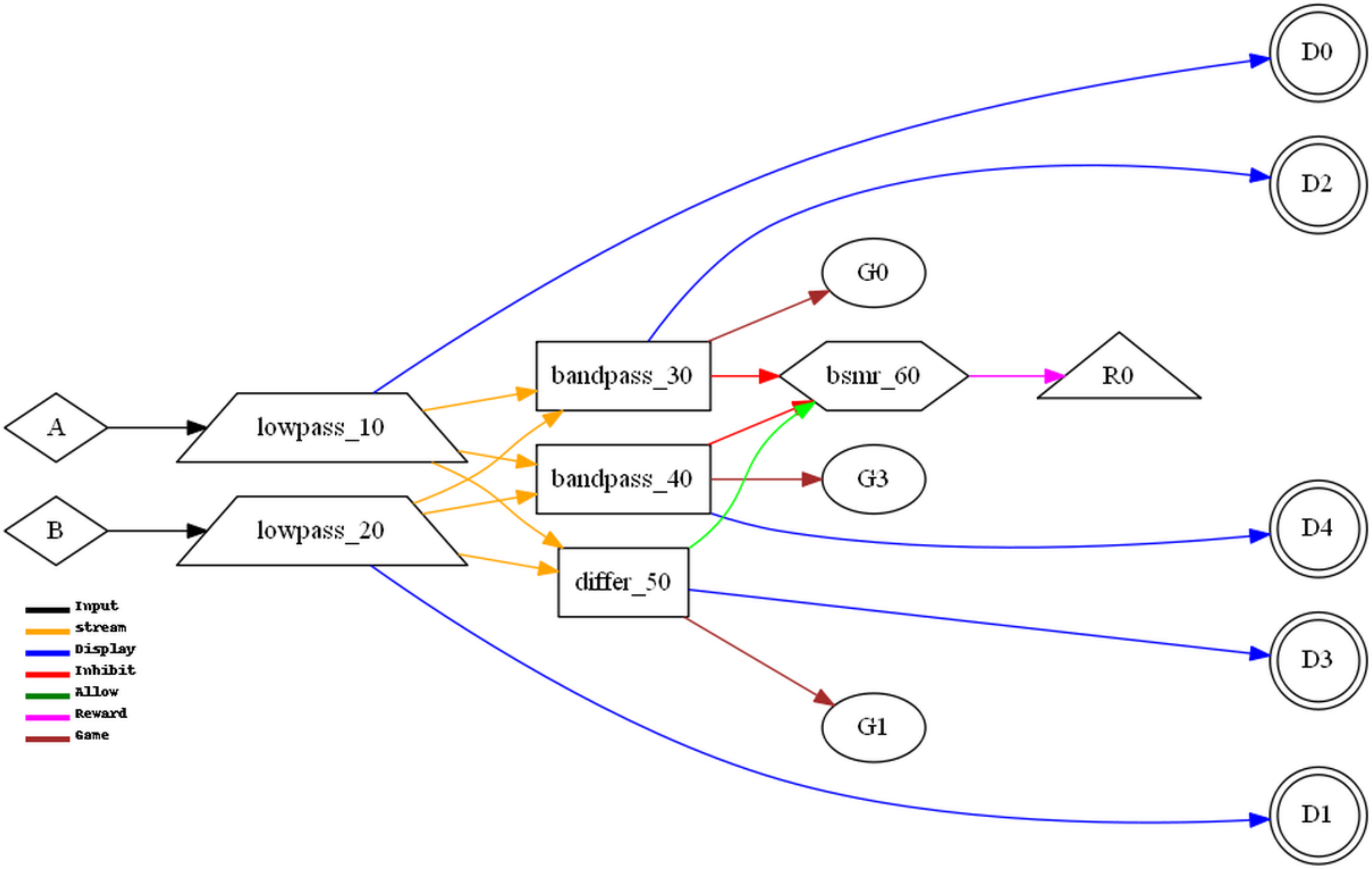
100 SingleA (one channel of data input) CCIRI



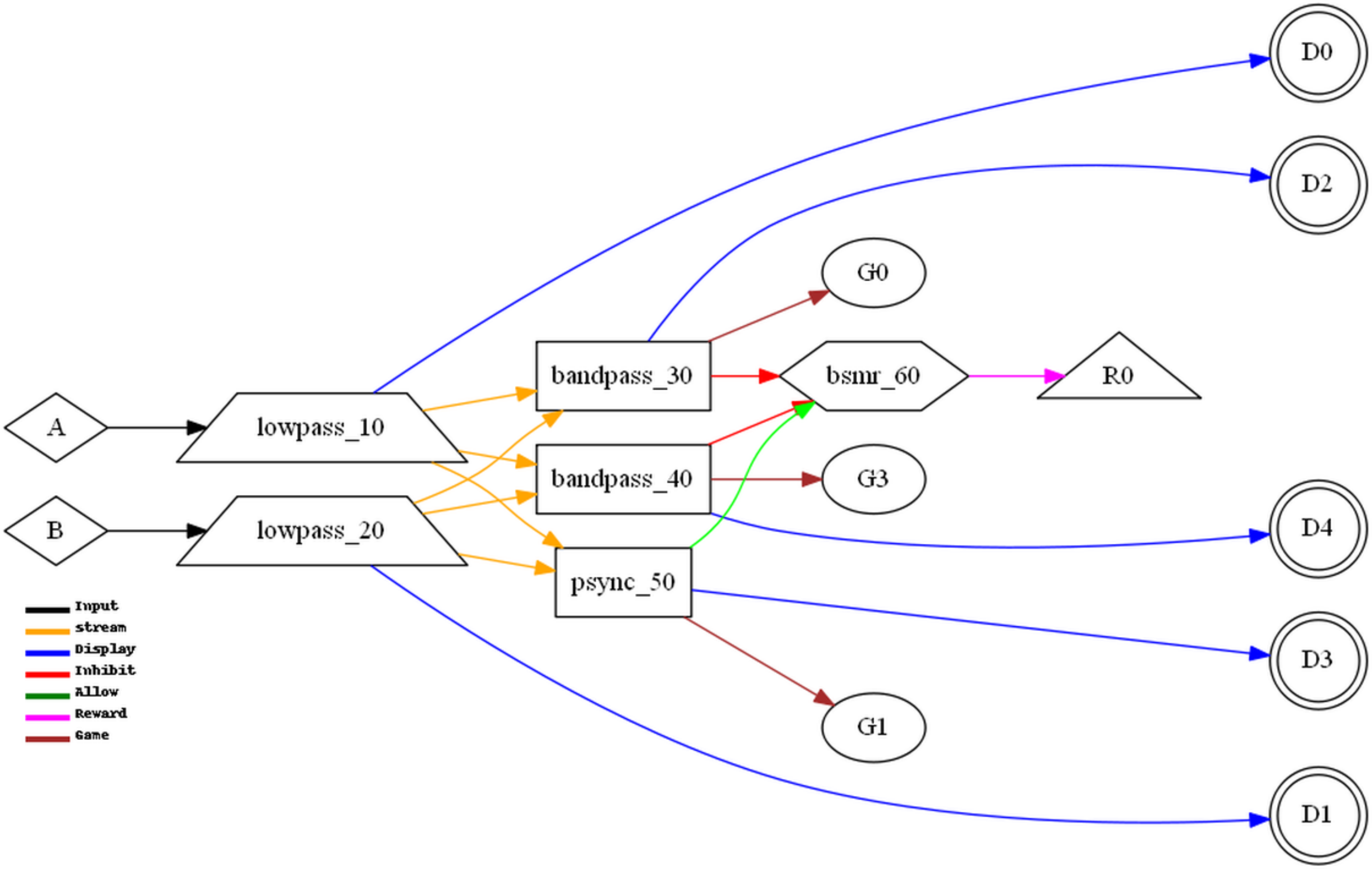
101 SingleB (one channel of data input) CCIRI



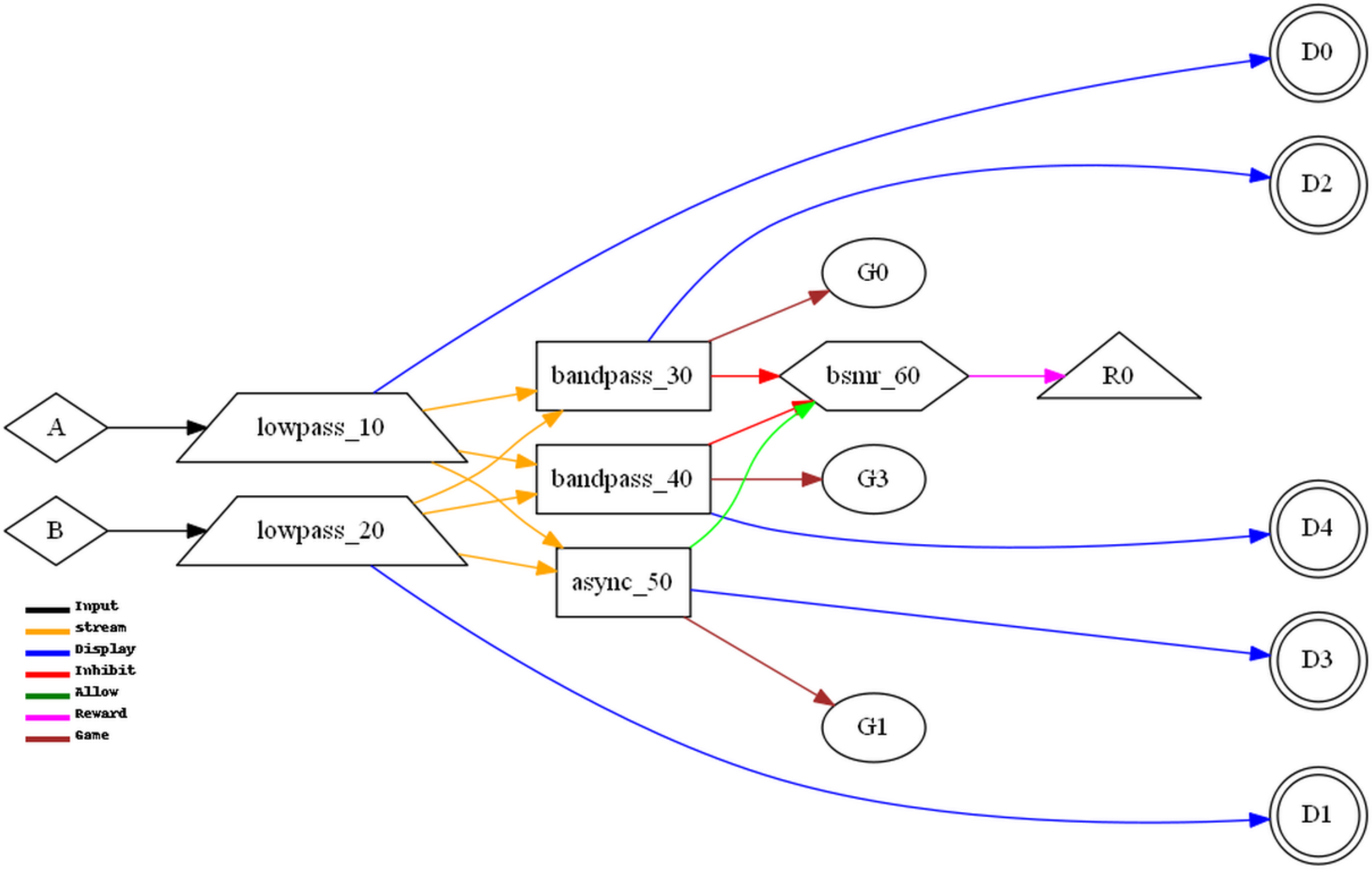
110 Sum (sum of two channels of data input) CCIRI



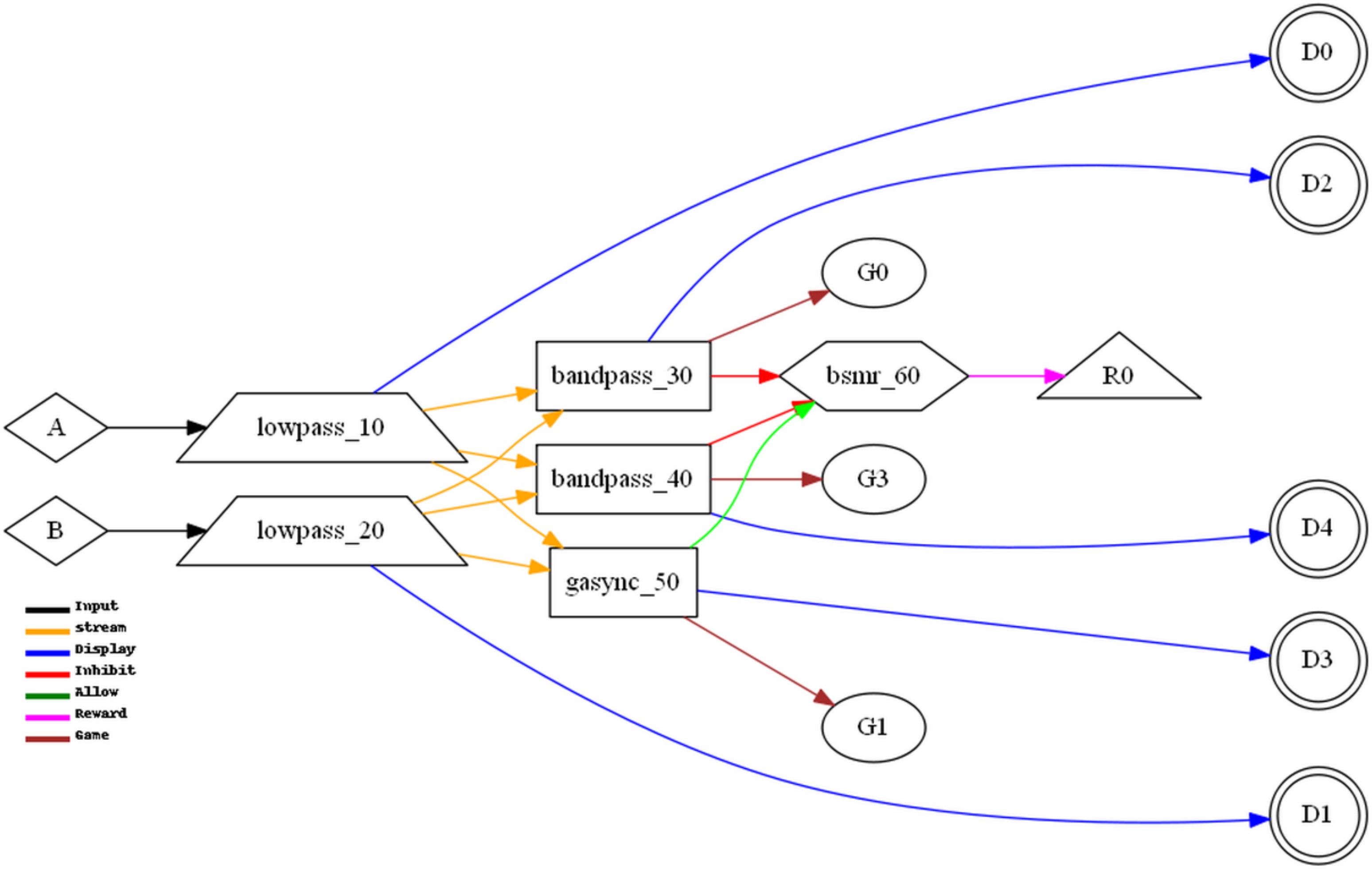
111 Differ (channel A minus channel B) CCIRI



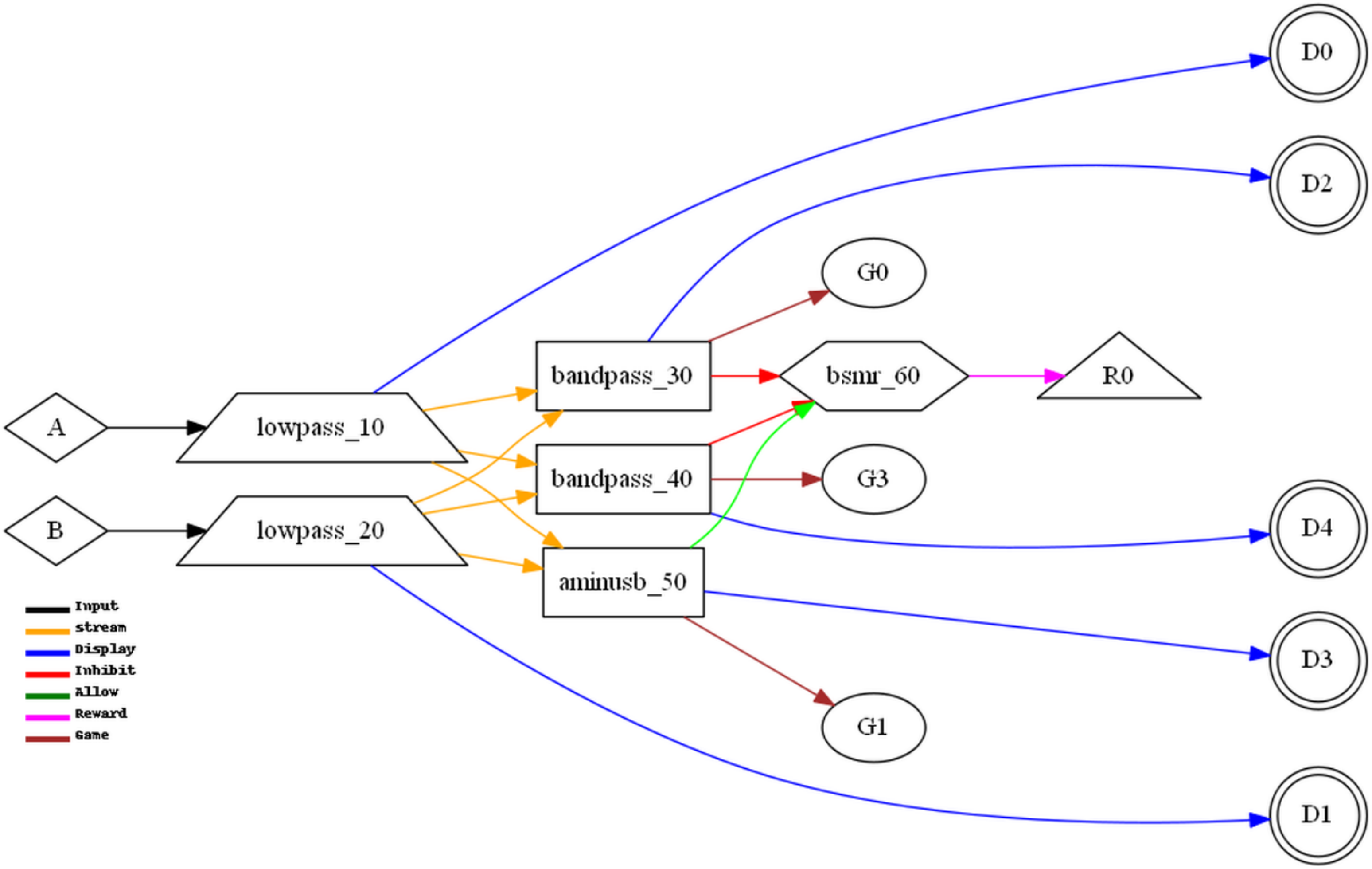
120 Psync (synchrony measure between channel A and B) CCIRI



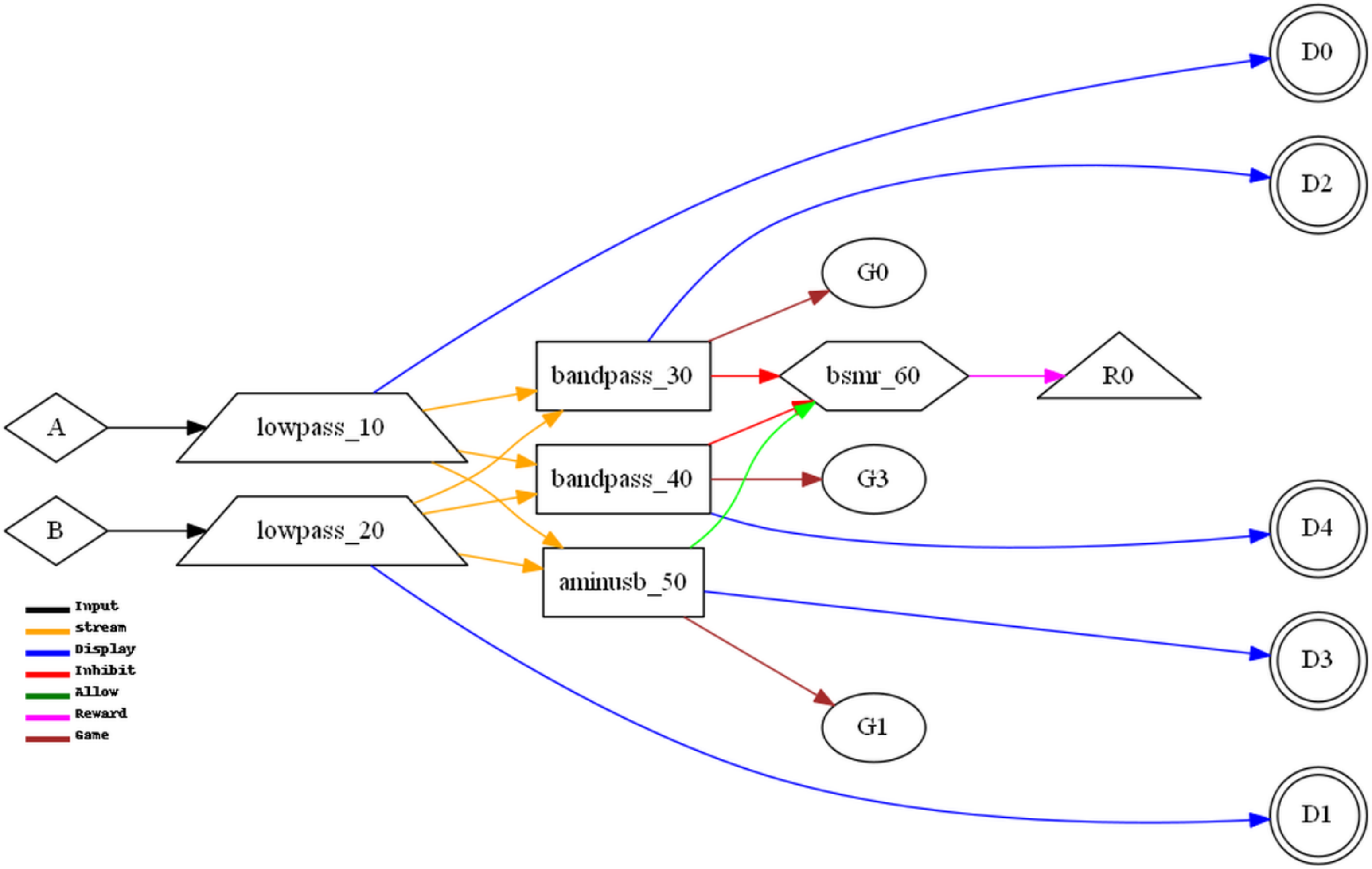
130 Async (comodulation measure between channel A and B) CCIRI



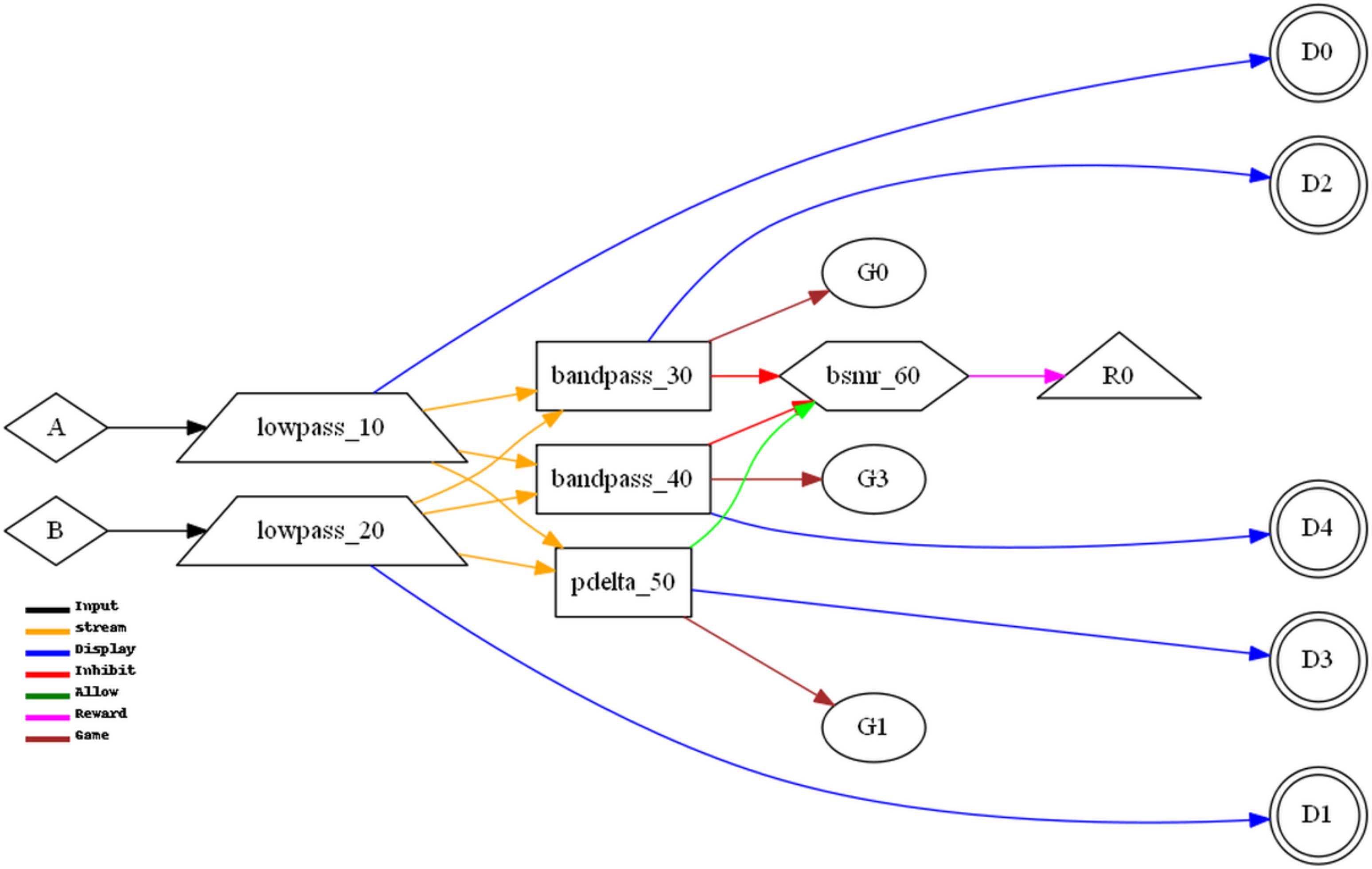
140 GAsync (global comodulation measure between channel A and B) CCIRI



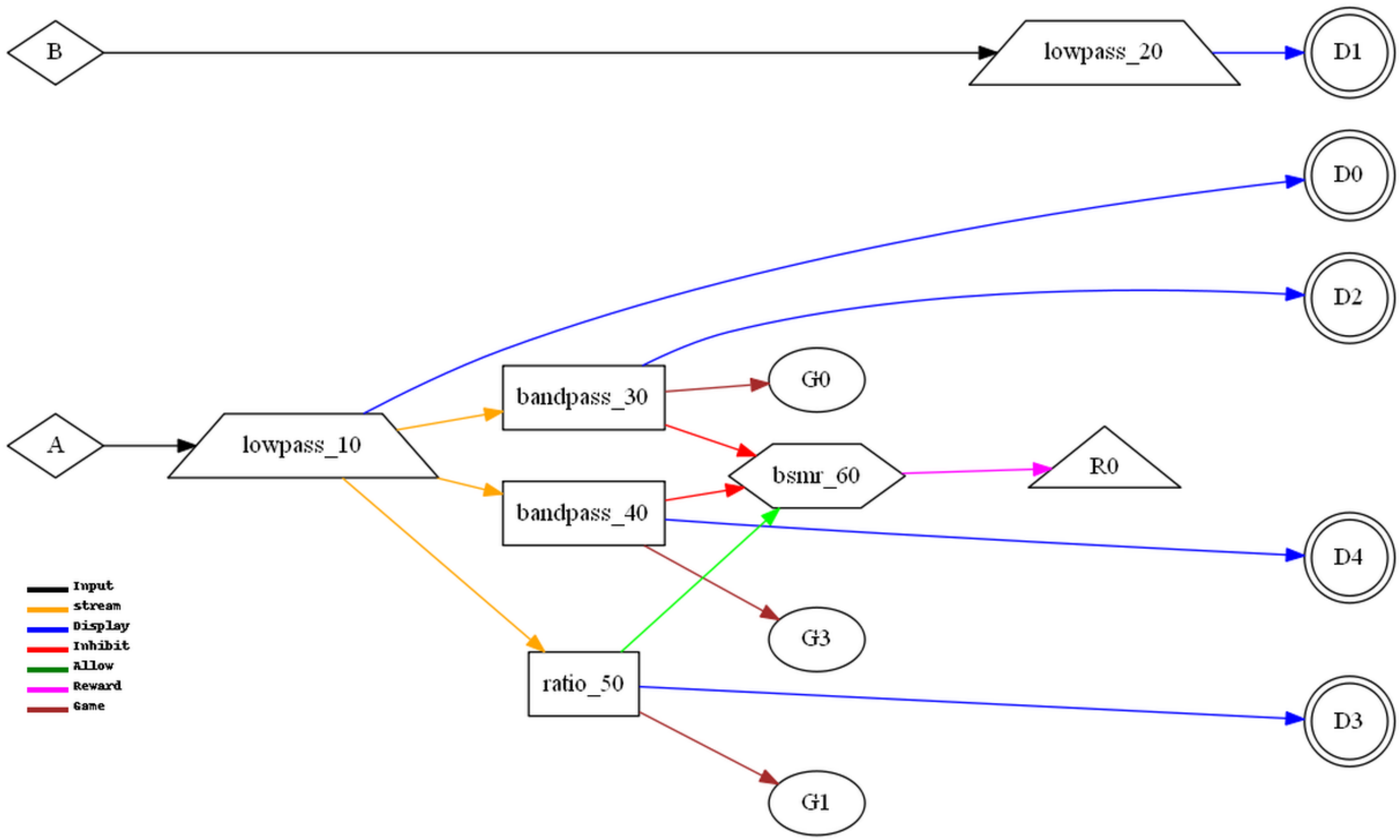
150 AminusB (A channel relationship to B channel) CCIRI



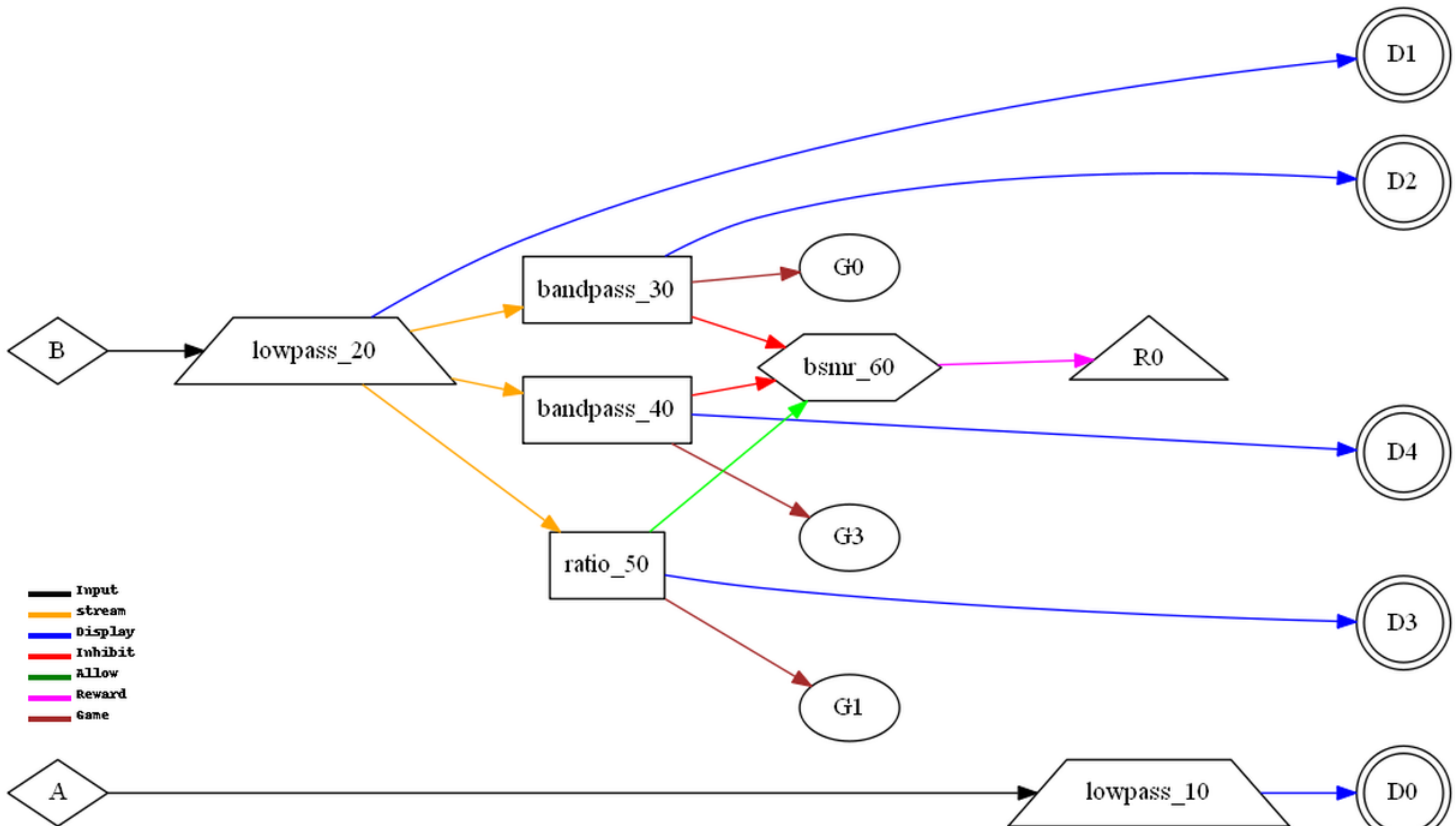
151 BminusA (B channel relationship to A channel) CCIRI



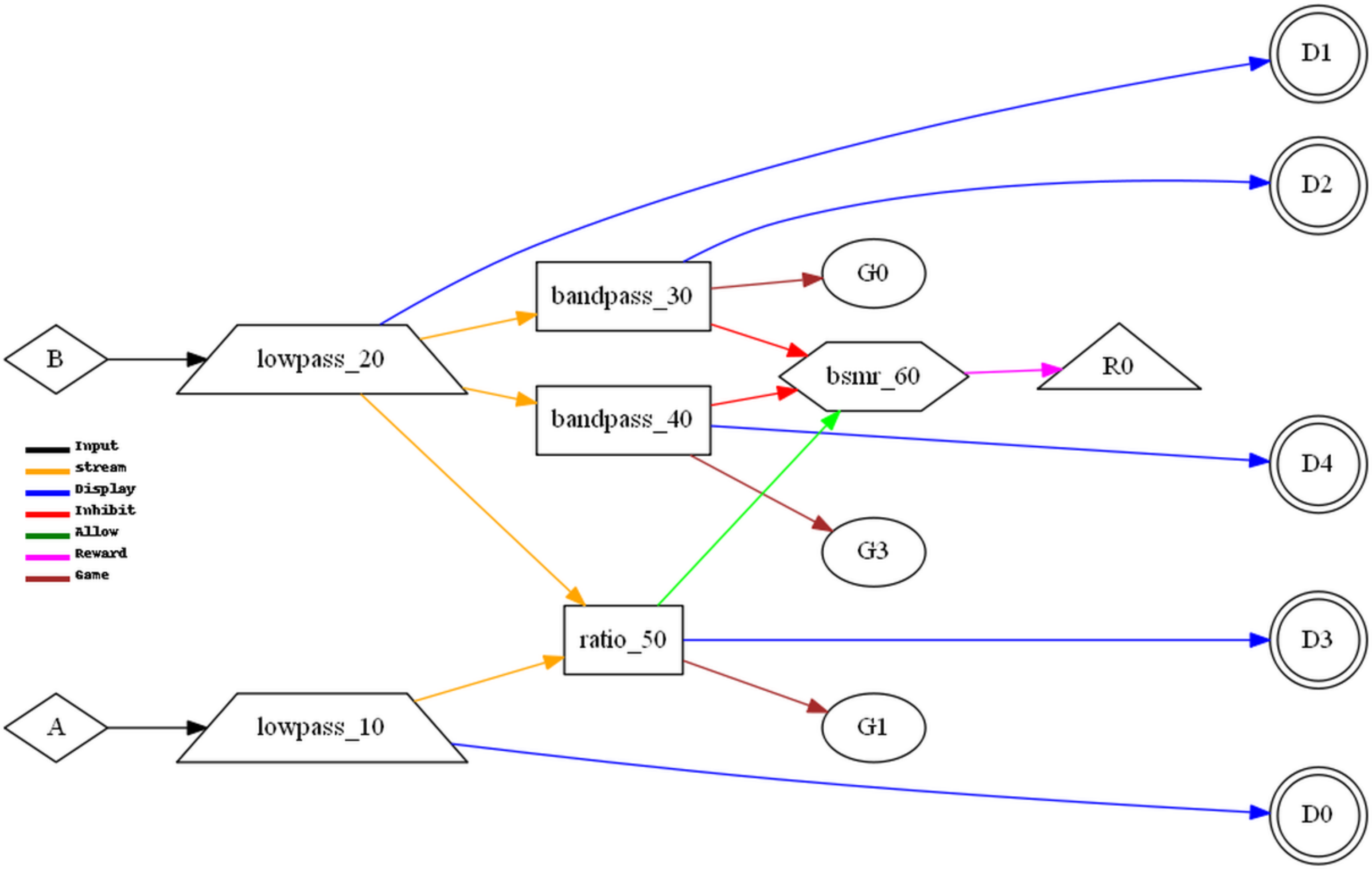
152 PDelta (Peak Time Coherence) CCIRI



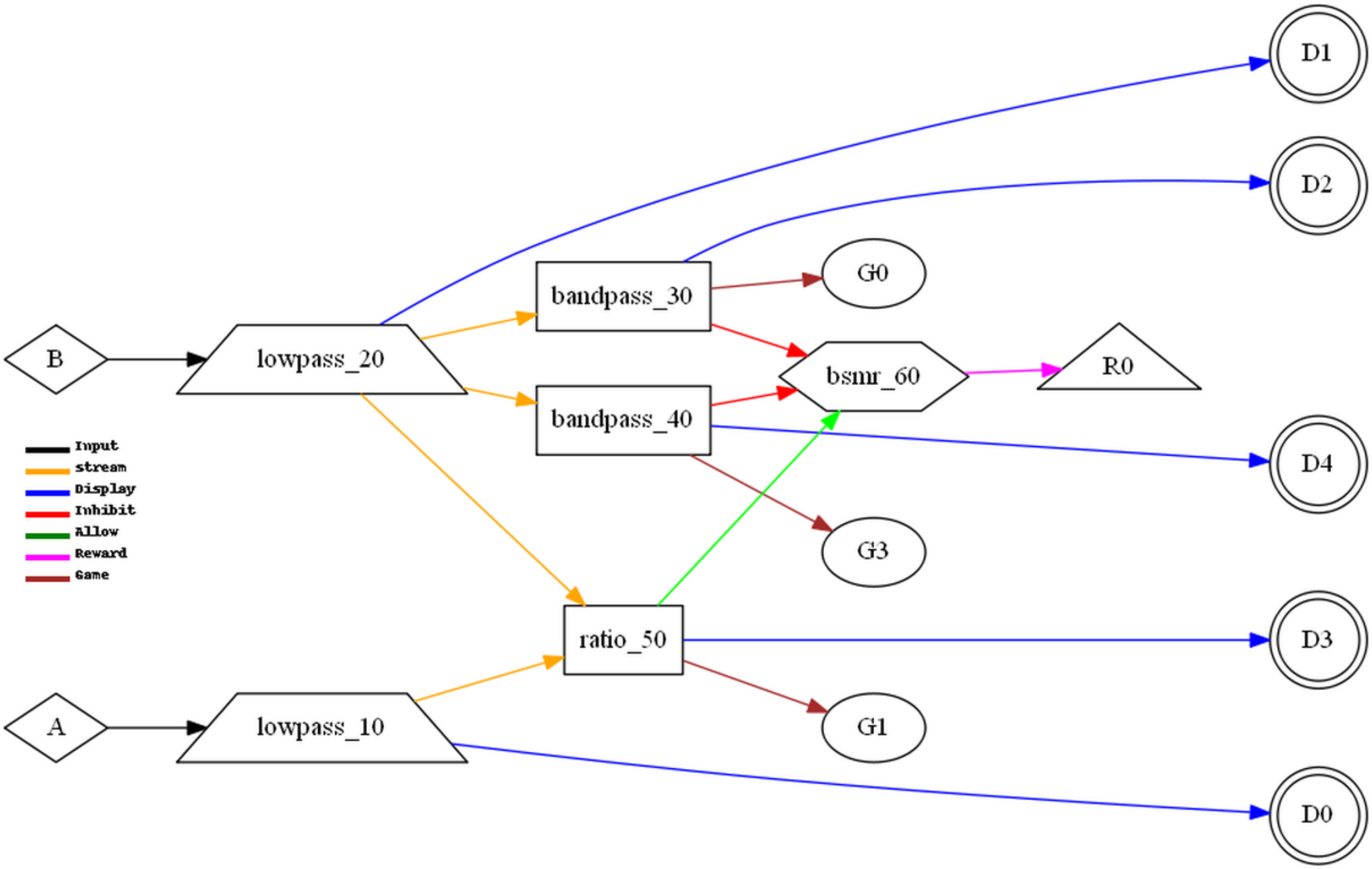
153 RatioA (Ratio of rwd/inhib) CCIRI



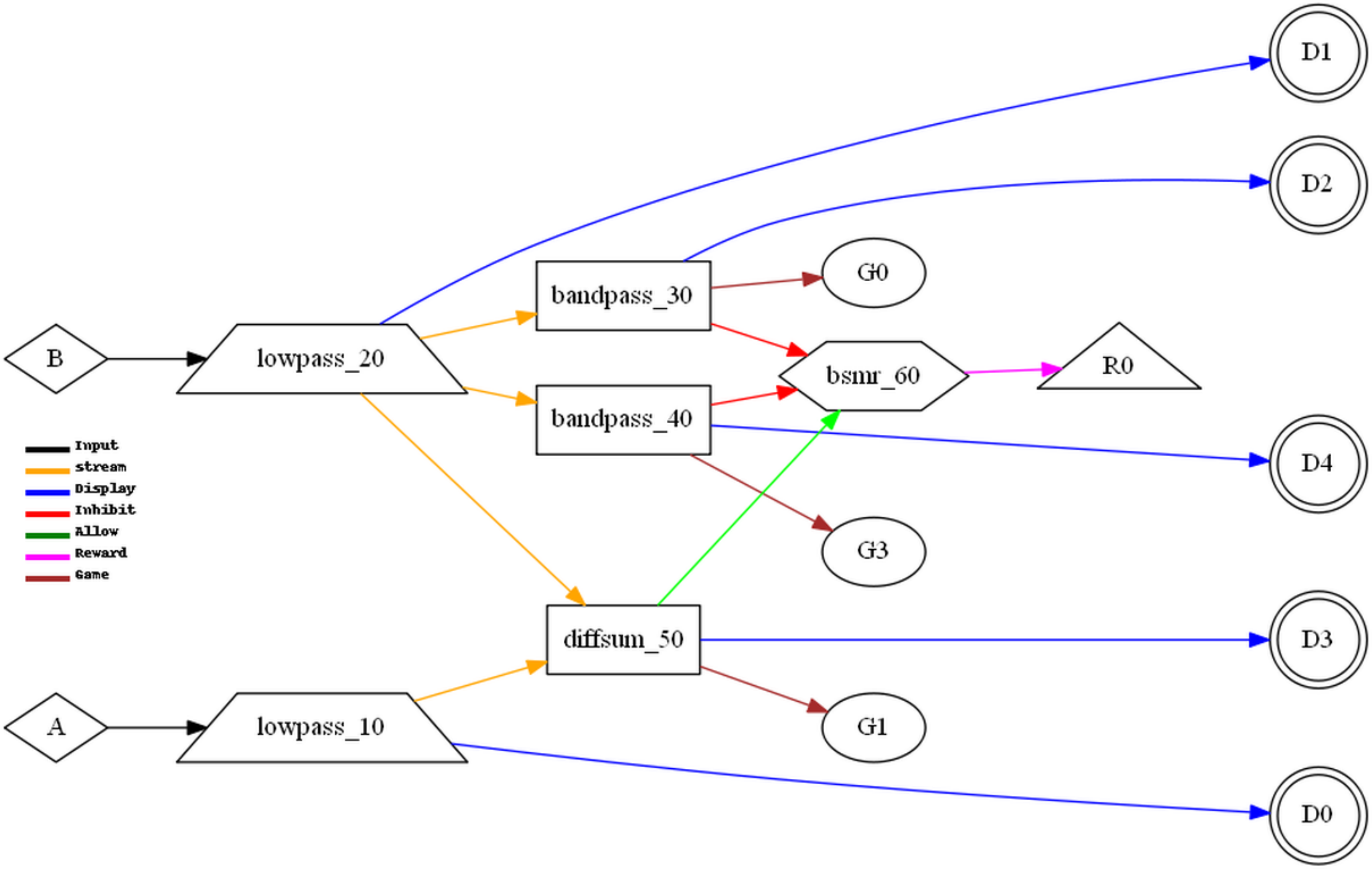
154 RatioB (Ratio of rwd/inhib) CCIRI



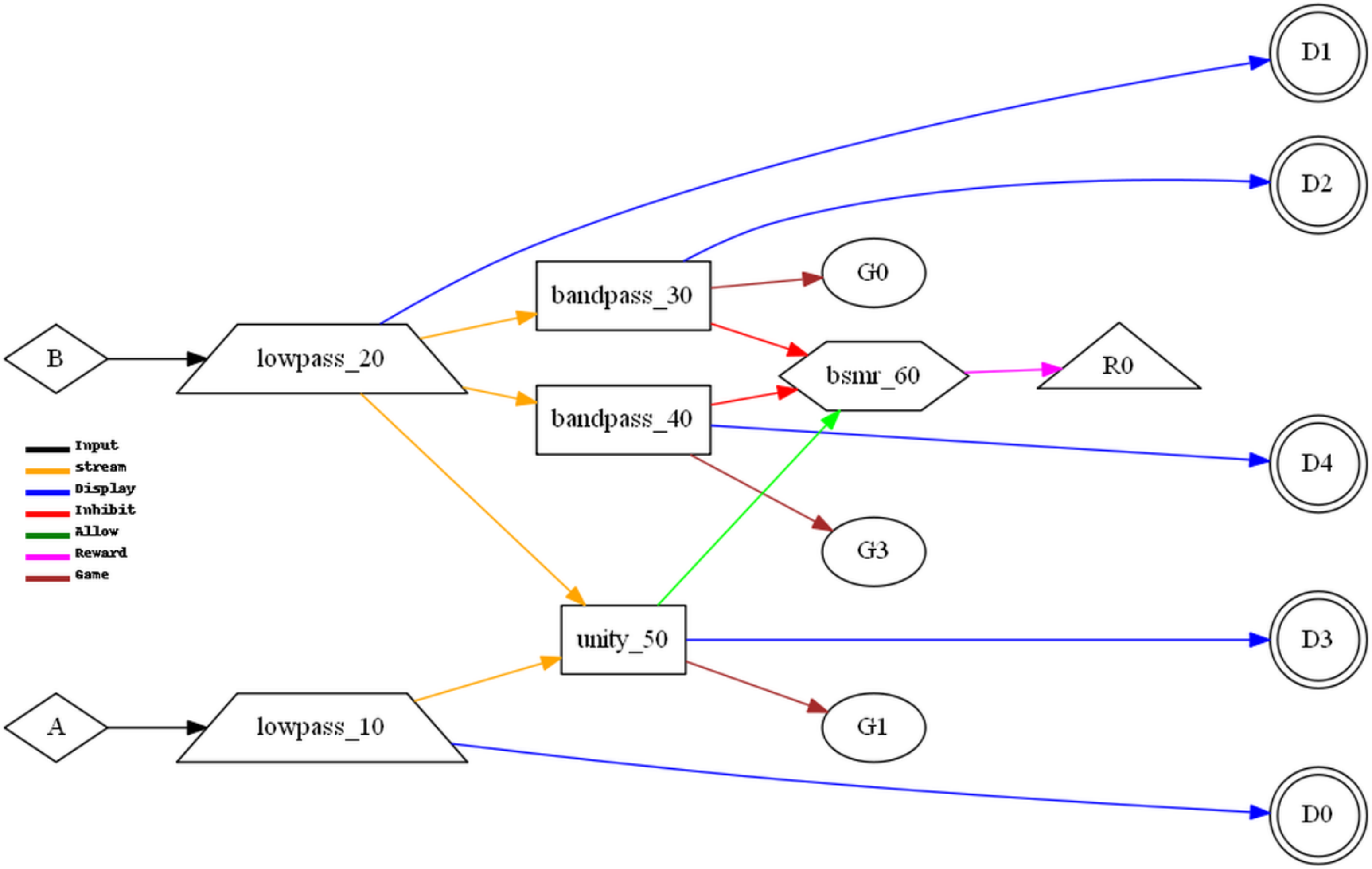
155 RatioAB (Ratio of A to B in reward band) CCIRI



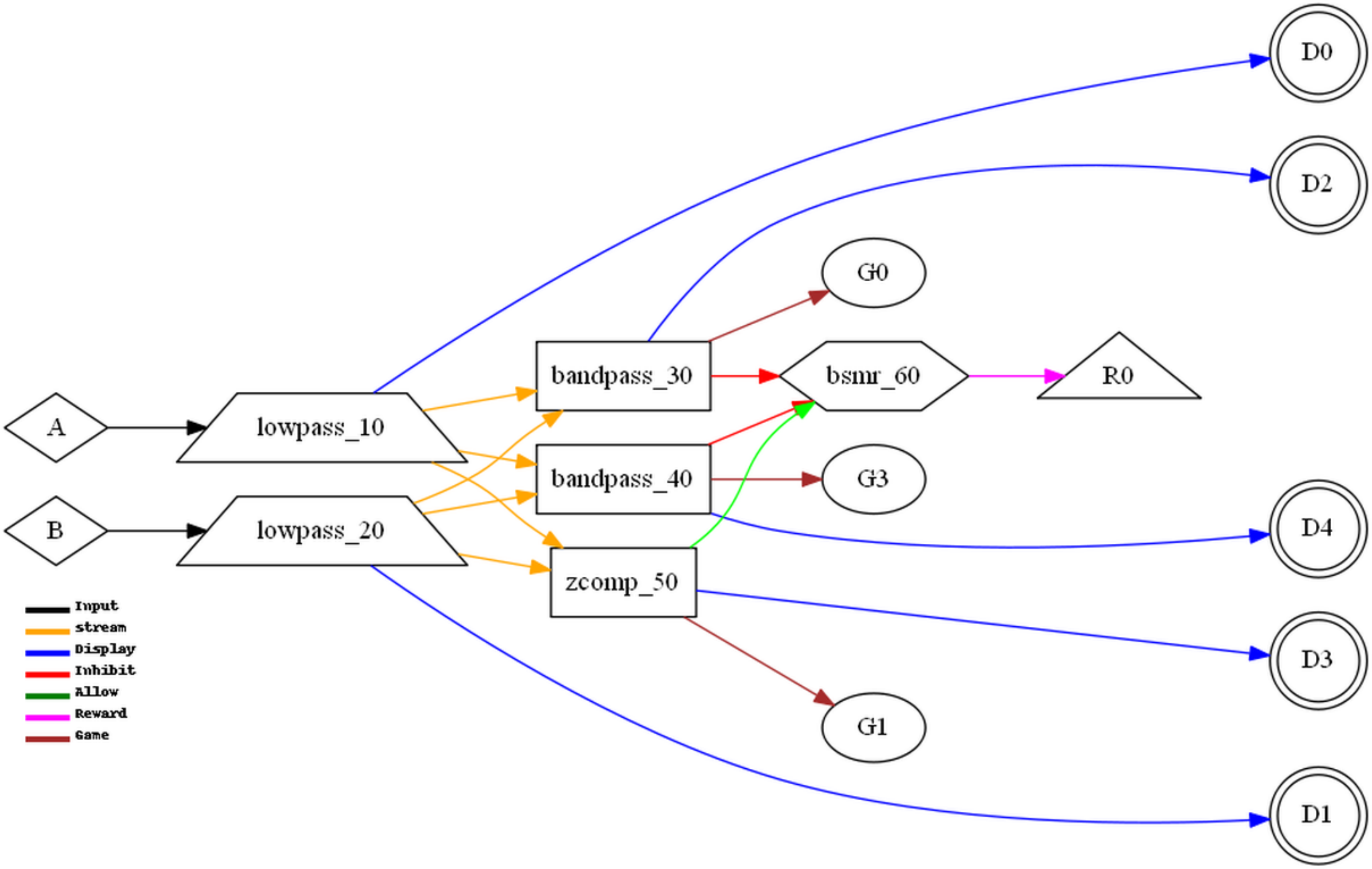
156 RatioBA (Ratio of B to A in reward band) CCIRI



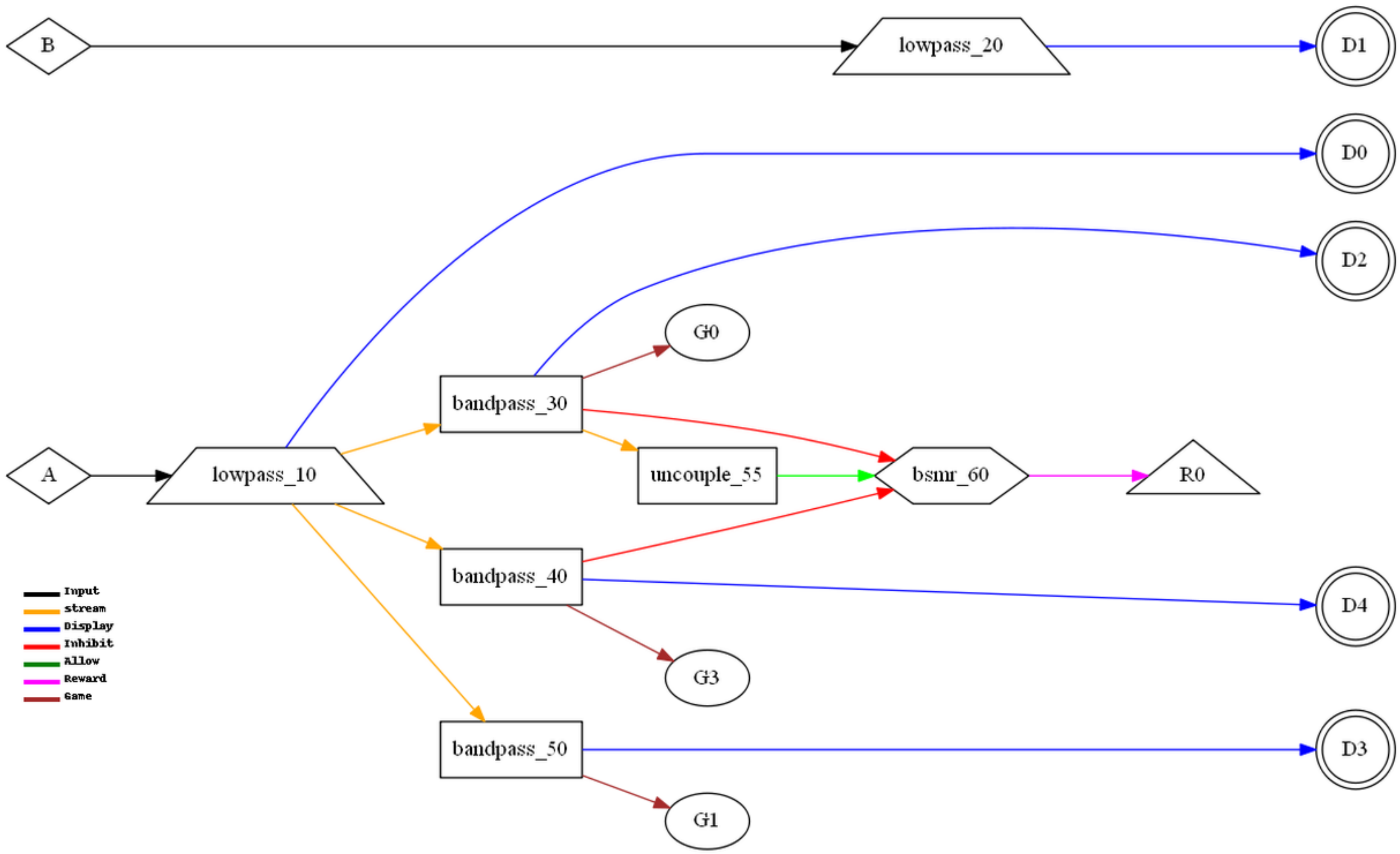
158 D/S-Ratio (Ratio of AB diff/AB sum) CCIRI



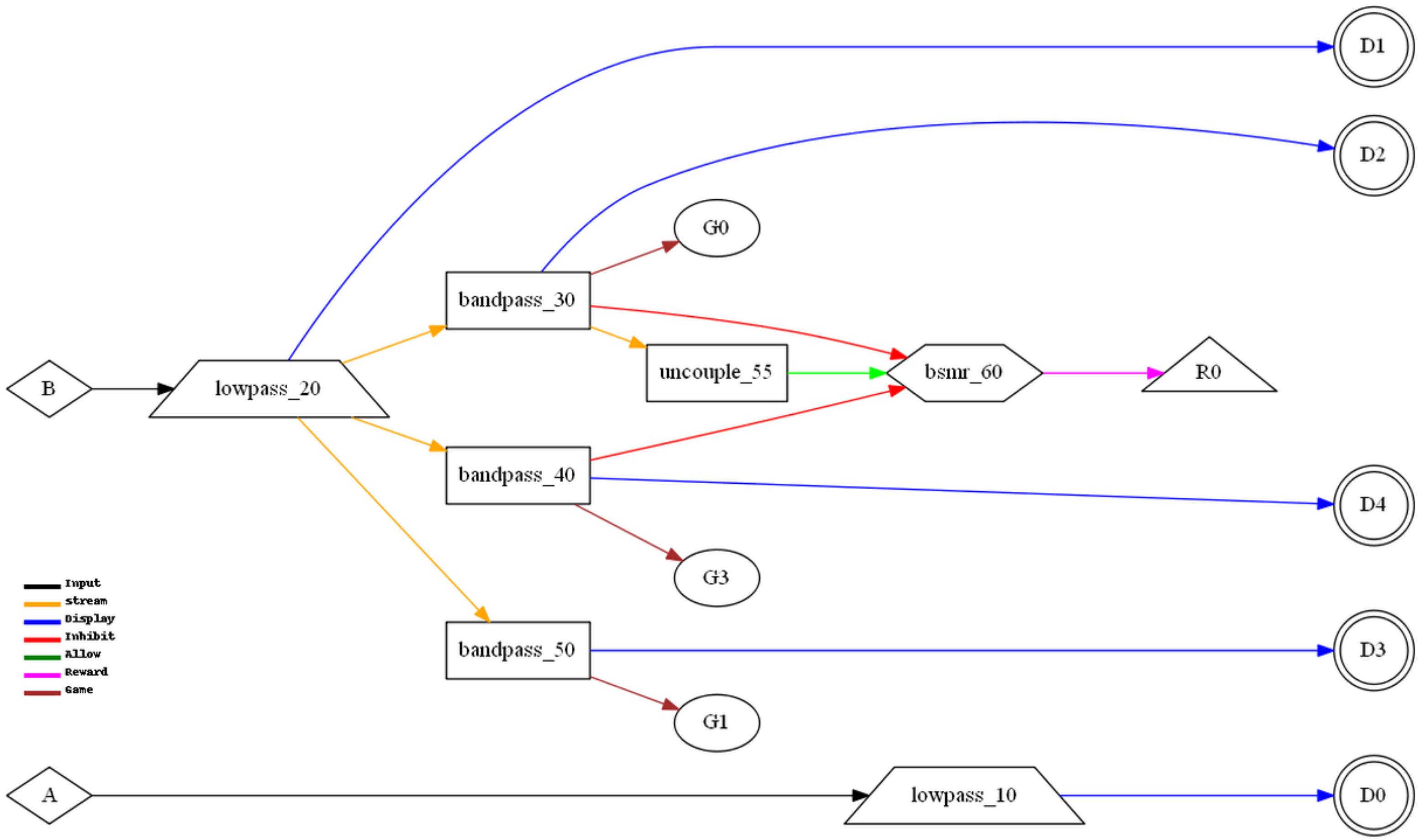
159 Unity (1-Ratio of AB diff/AB sum) CCIRI



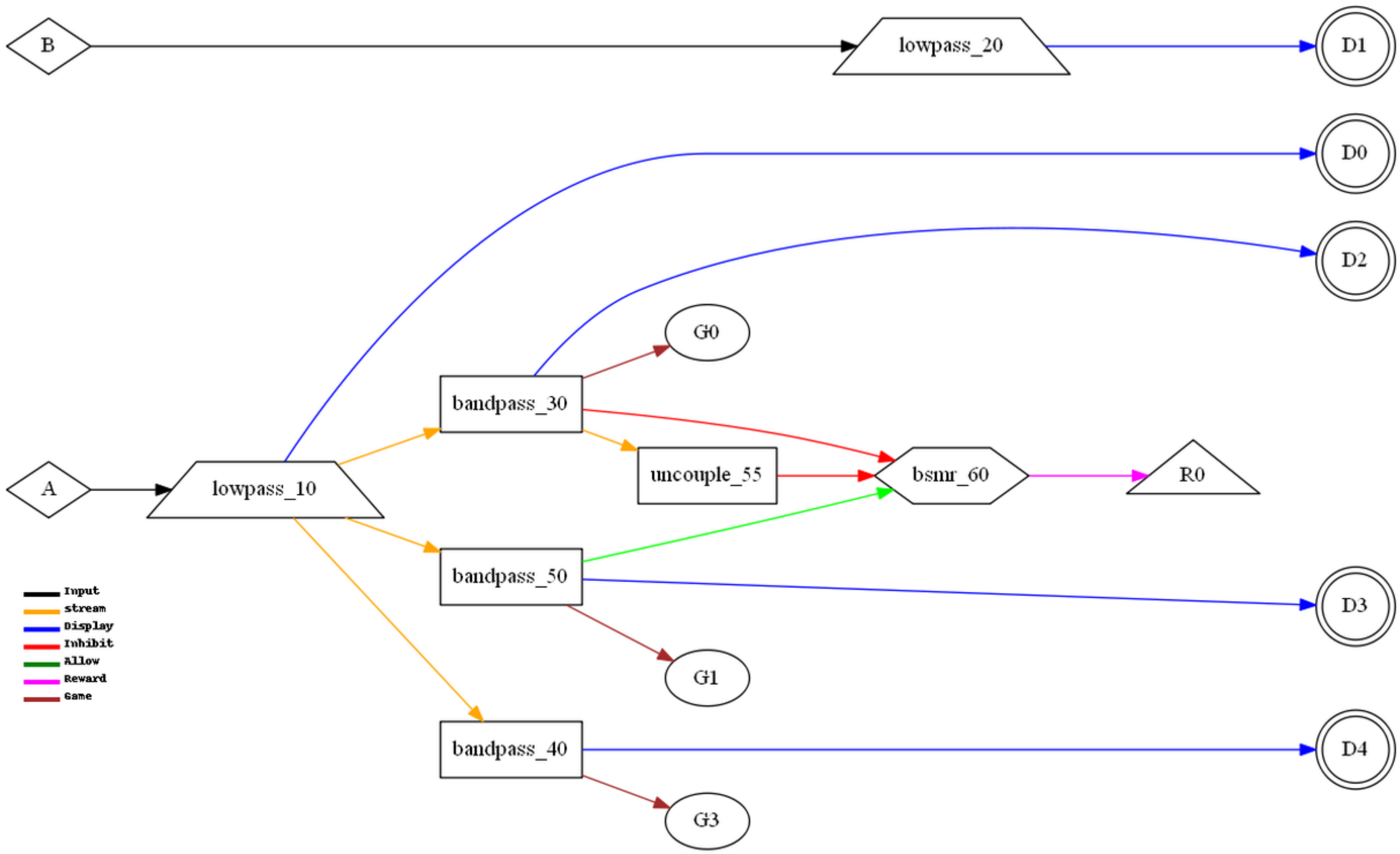
180 ZCompAB (ZComposite) CCIRI



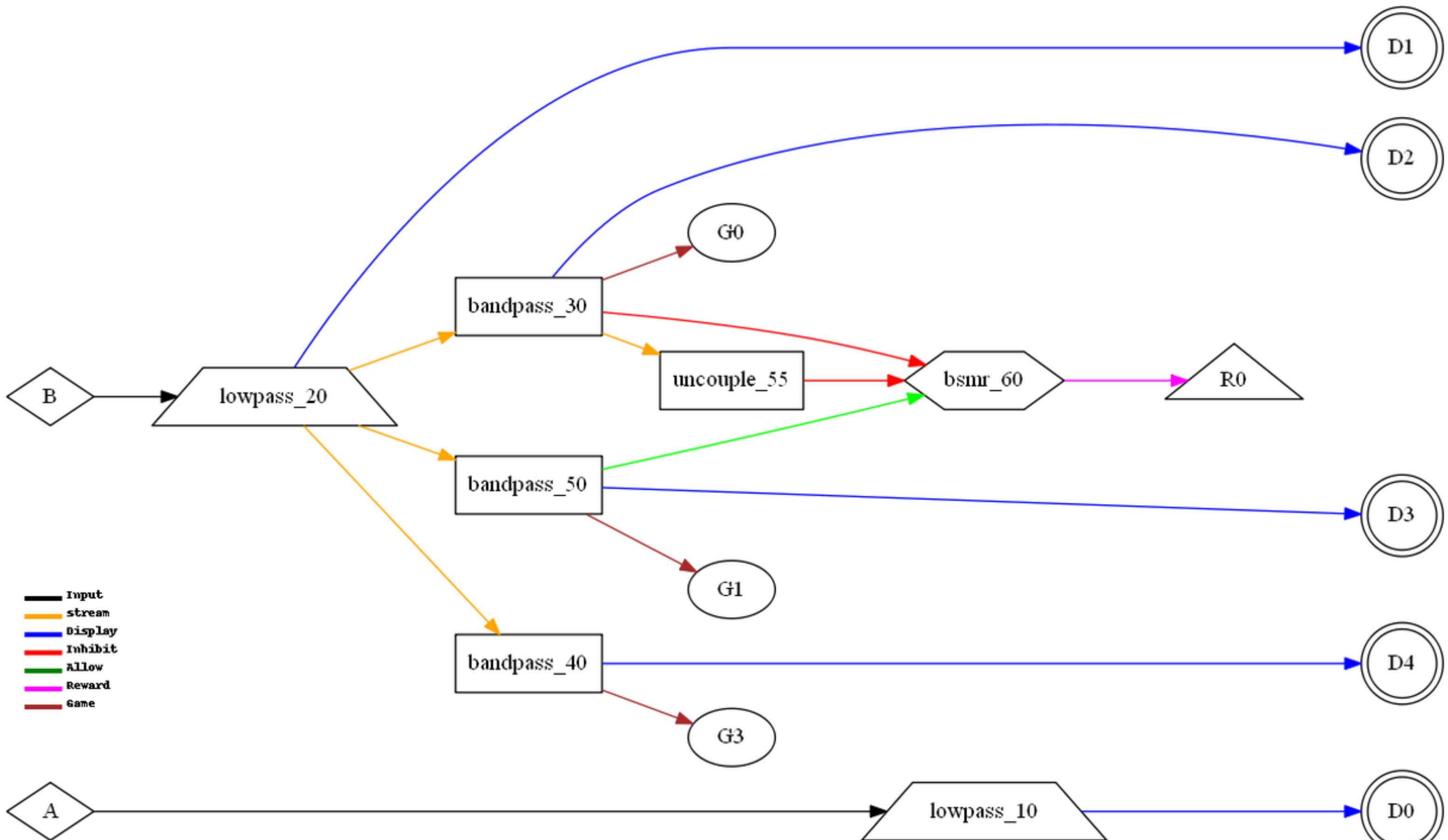
164 UncARew (Uncouple Rew A) CCIRI



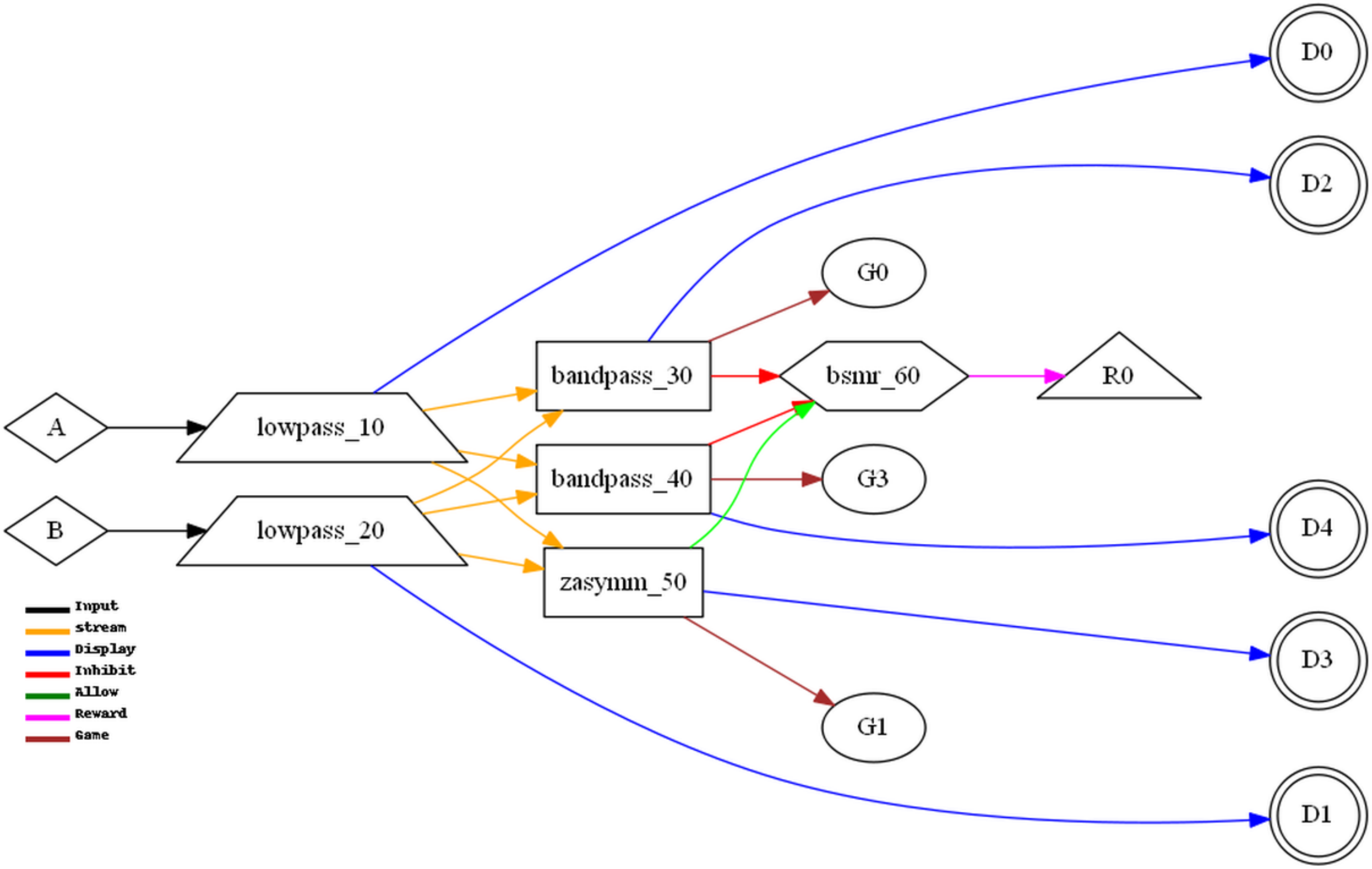
165 UncBRew (Uncouple Rew B) CCIRI



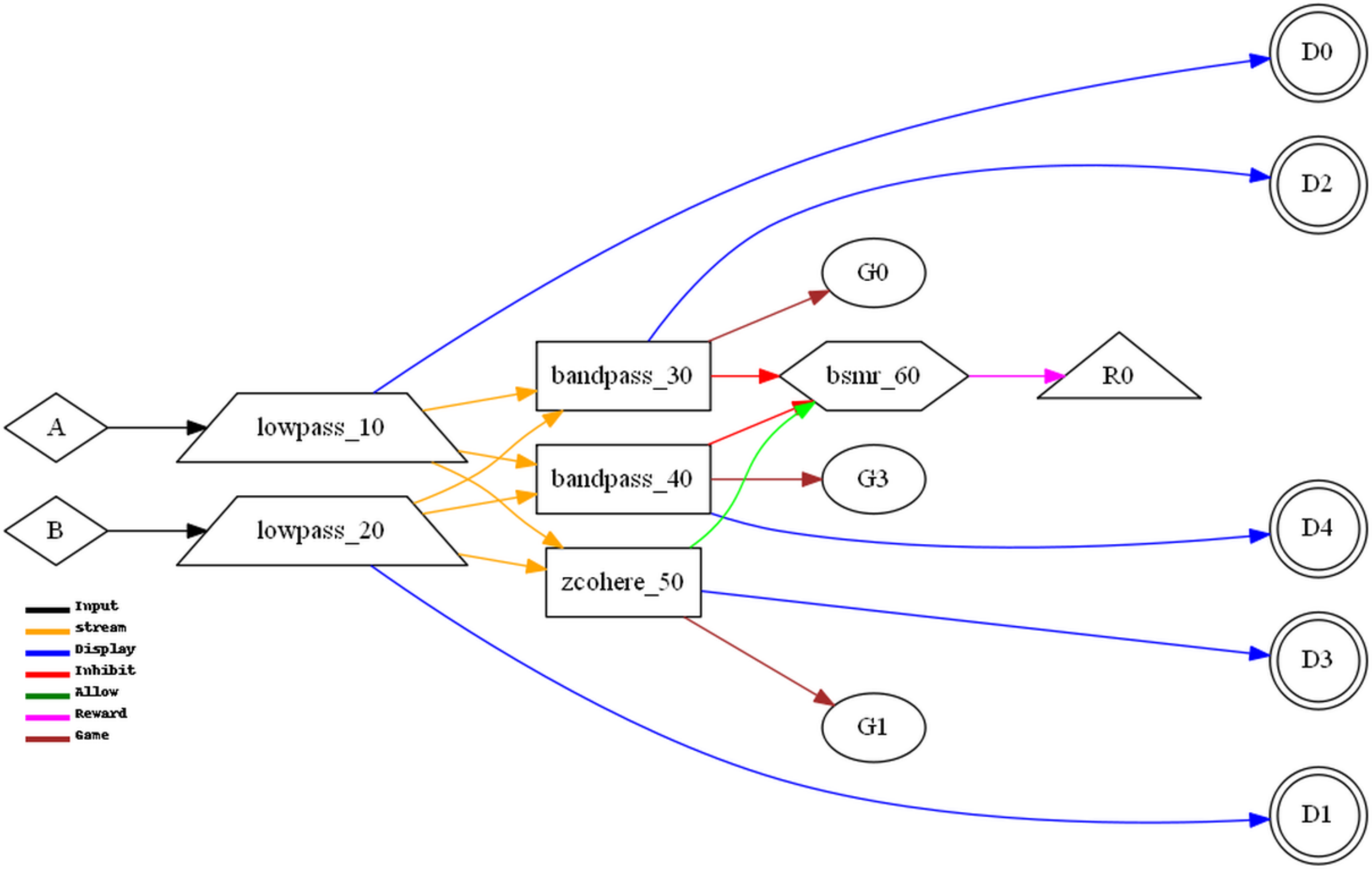
166 UncAHiB (Uncouple HiB A) CCIRI



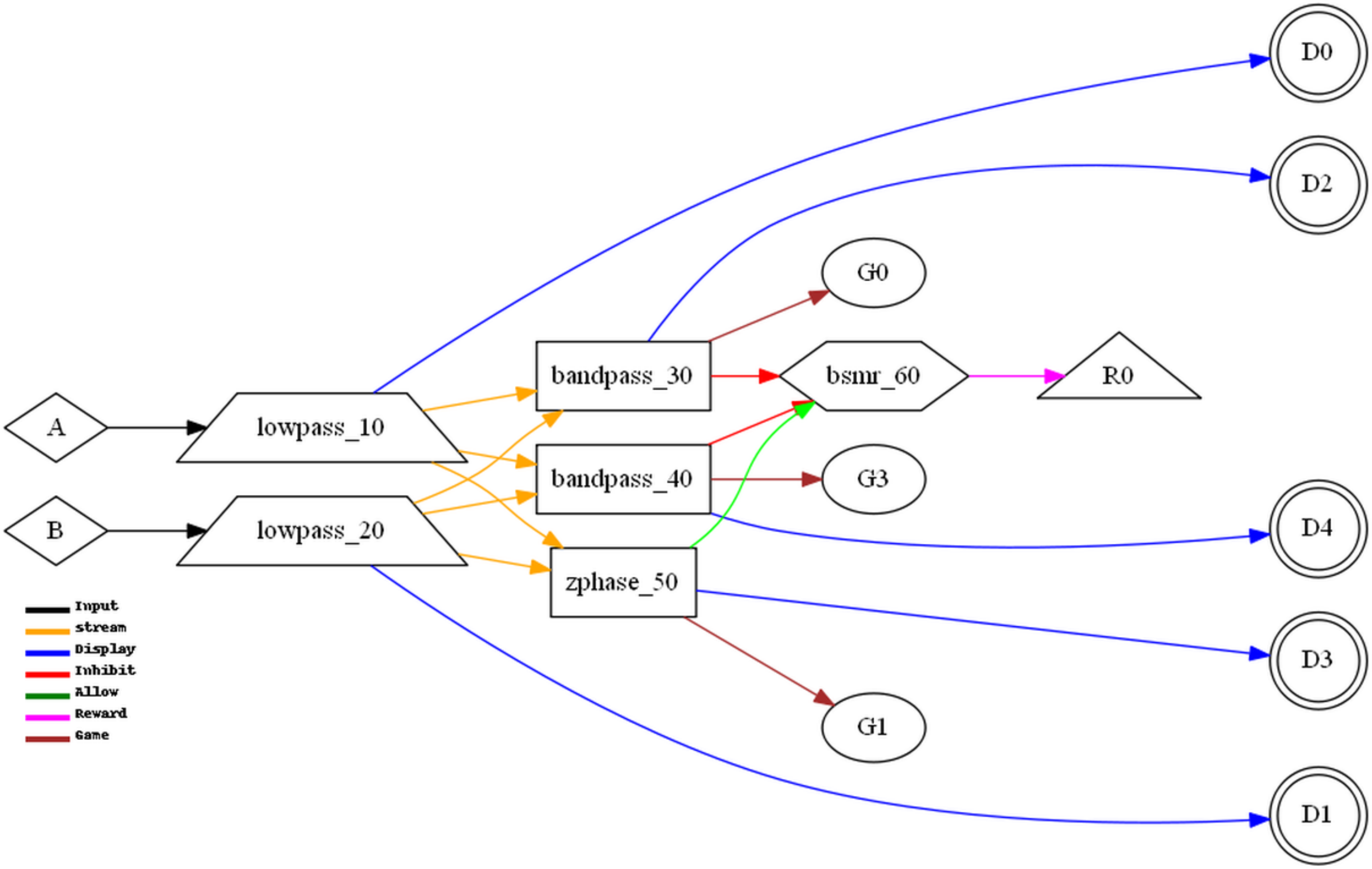
167 UncBHiB (Uncouple HiB B) CCIRI



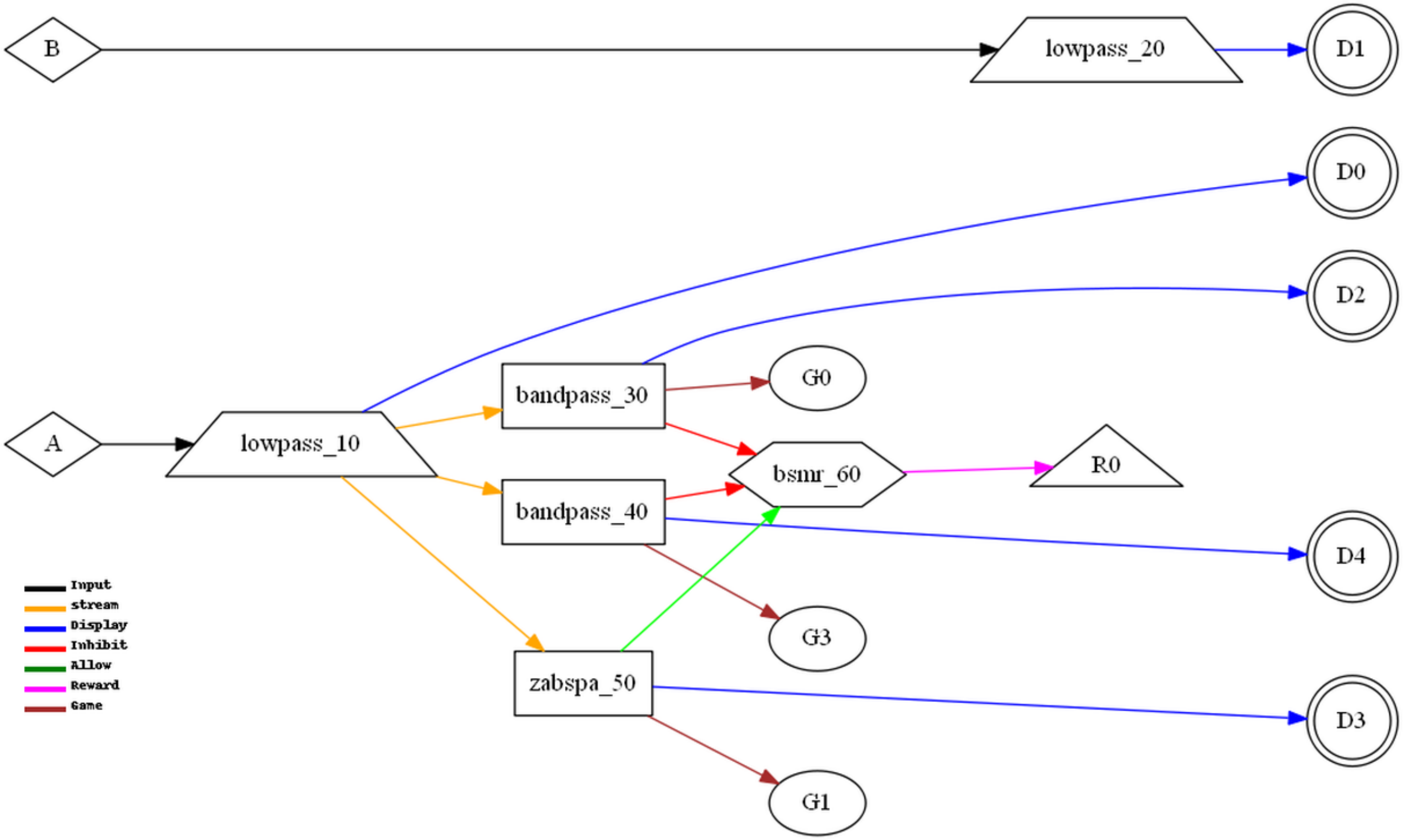
700 ZAsymm (Zscore amplitude asymmetry) CCIRI



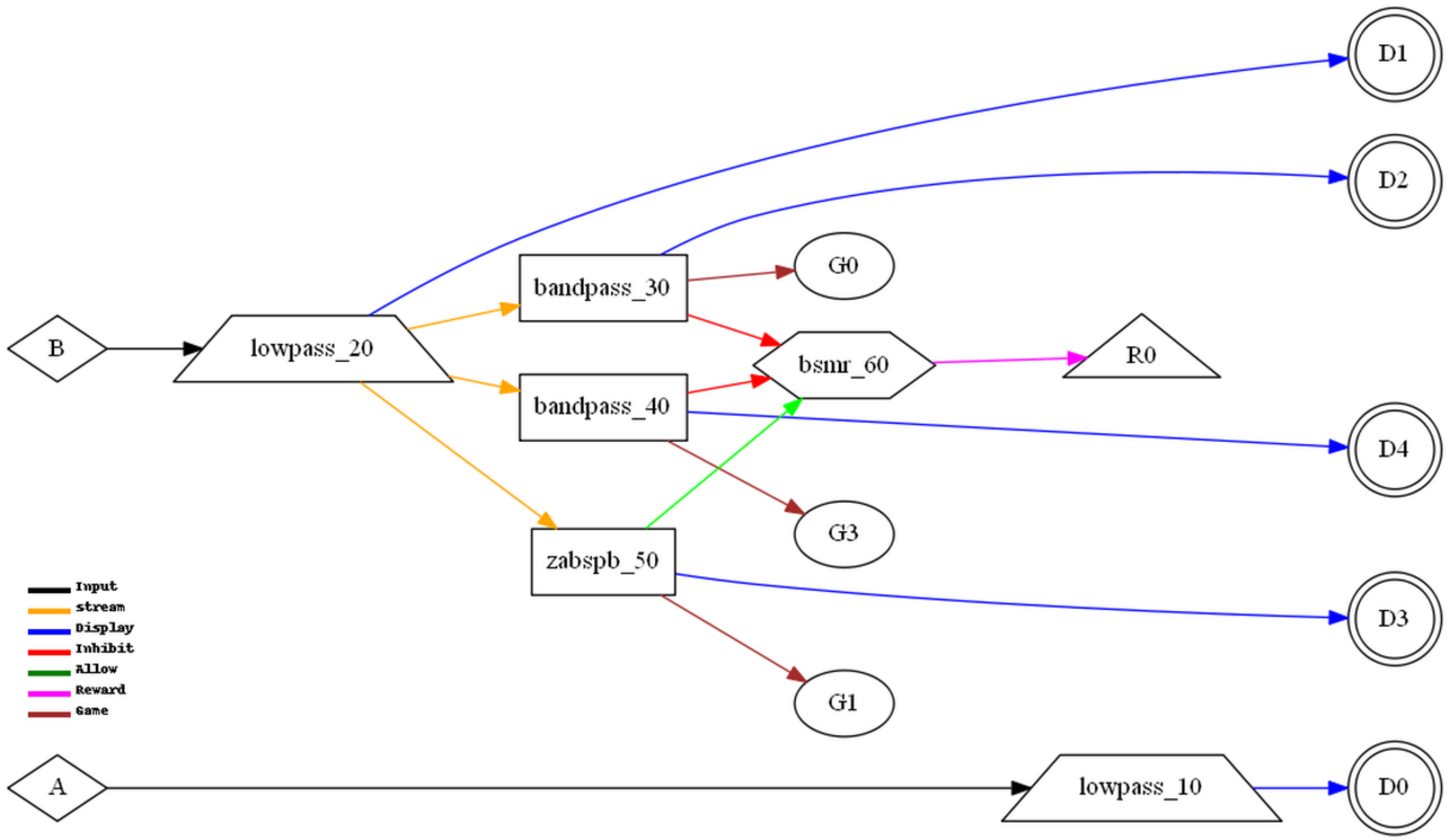
701 ZCohere (Zscore coherence) CCIRI



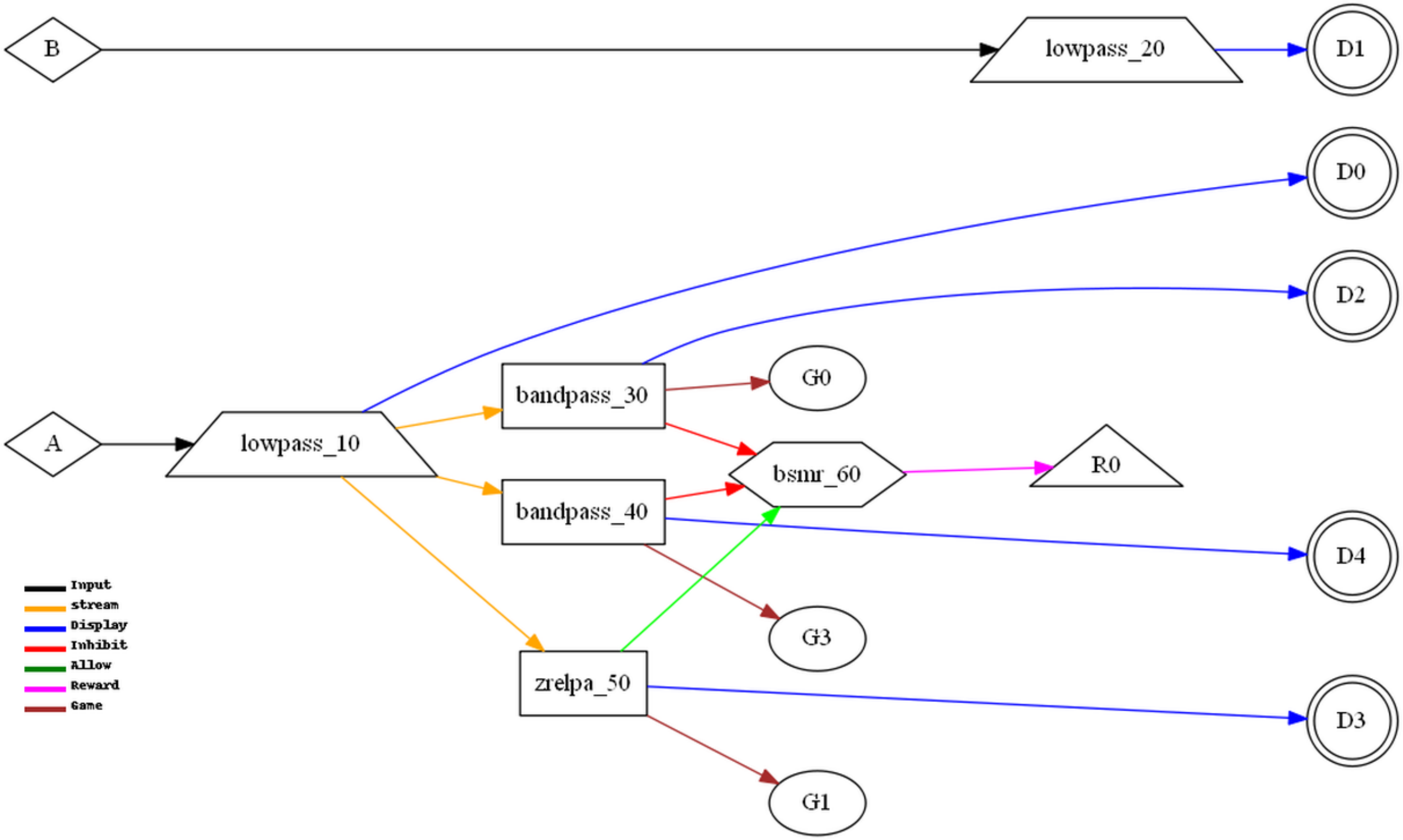
702 ZPhase (Zscore phase) CCIRI



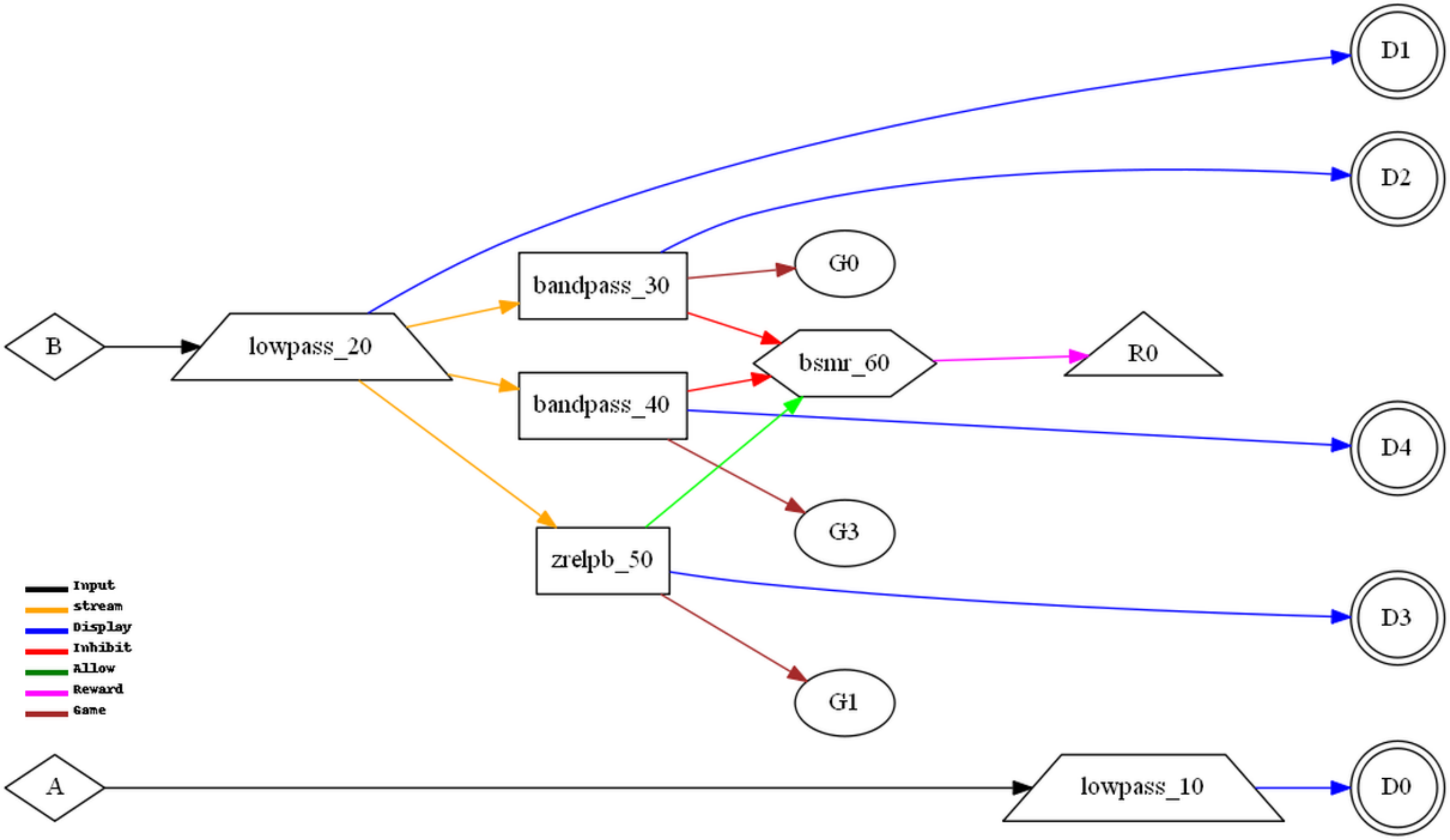
703 ZAbsPwrA (Zscore Abs Amp A) CCIRI



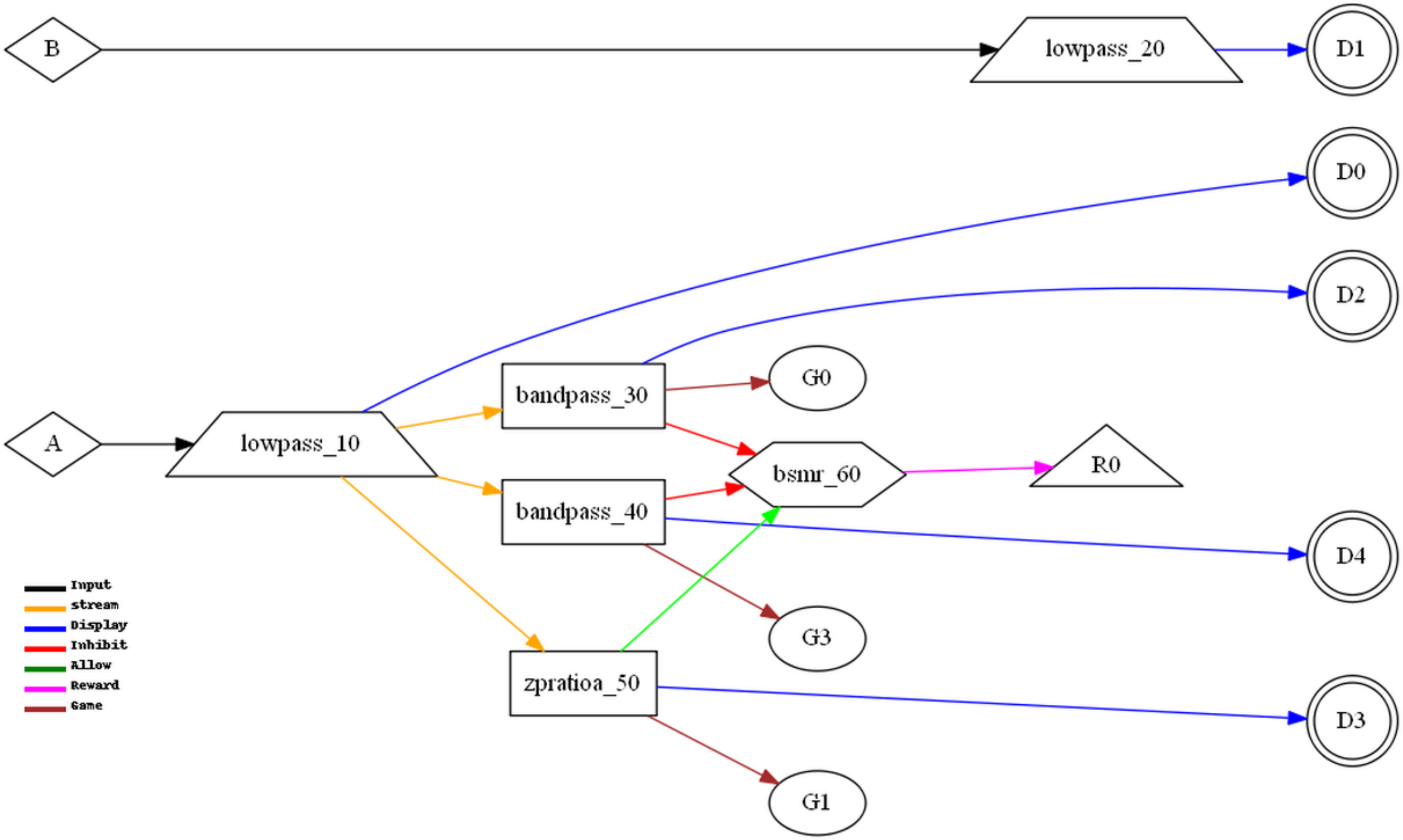
704 ZAbsPwrB (Zscore Abs Amp B) CCIRI



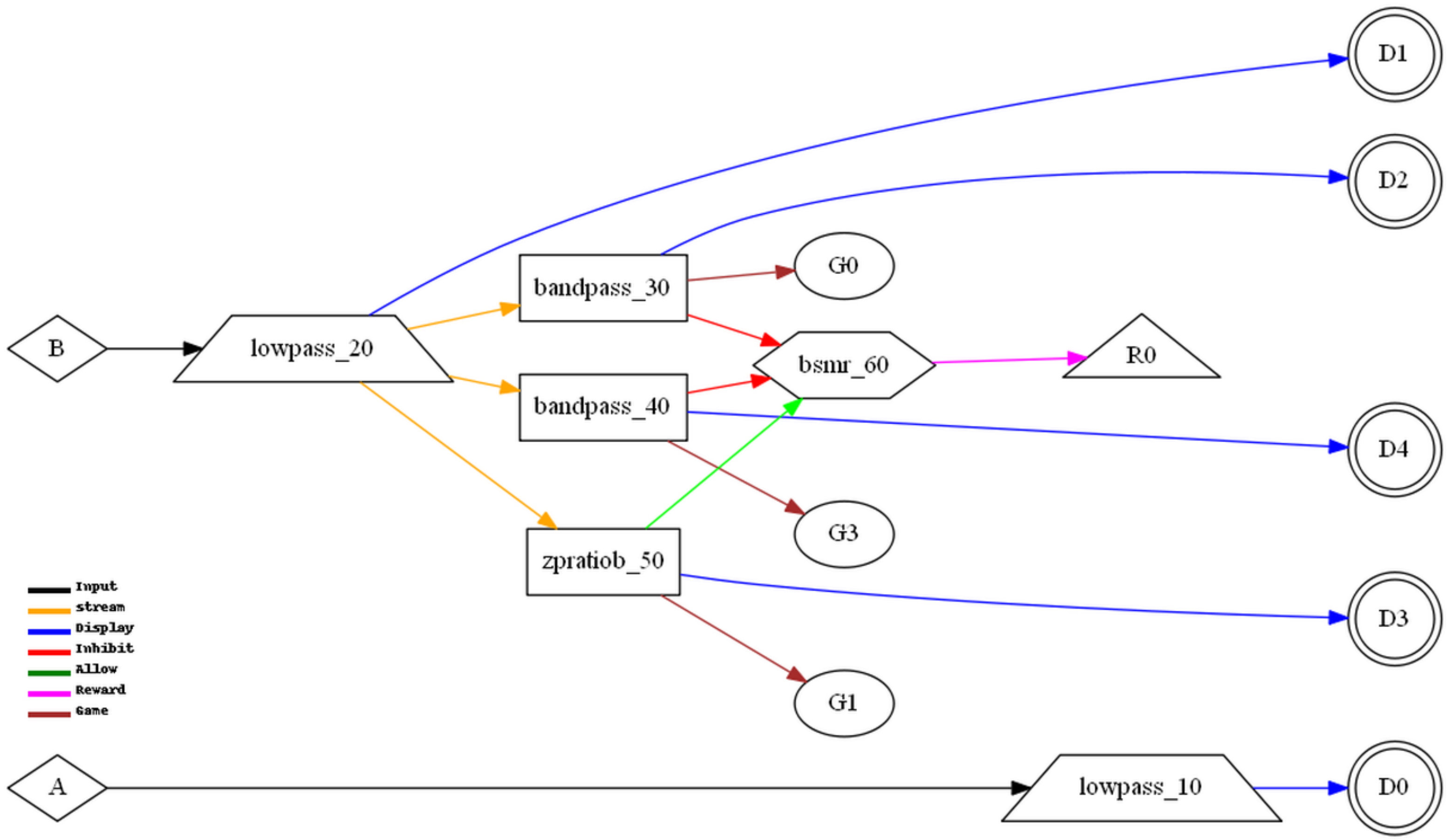
705 ZRelPwrA (Zscore Rel Pwr A) CCIRI



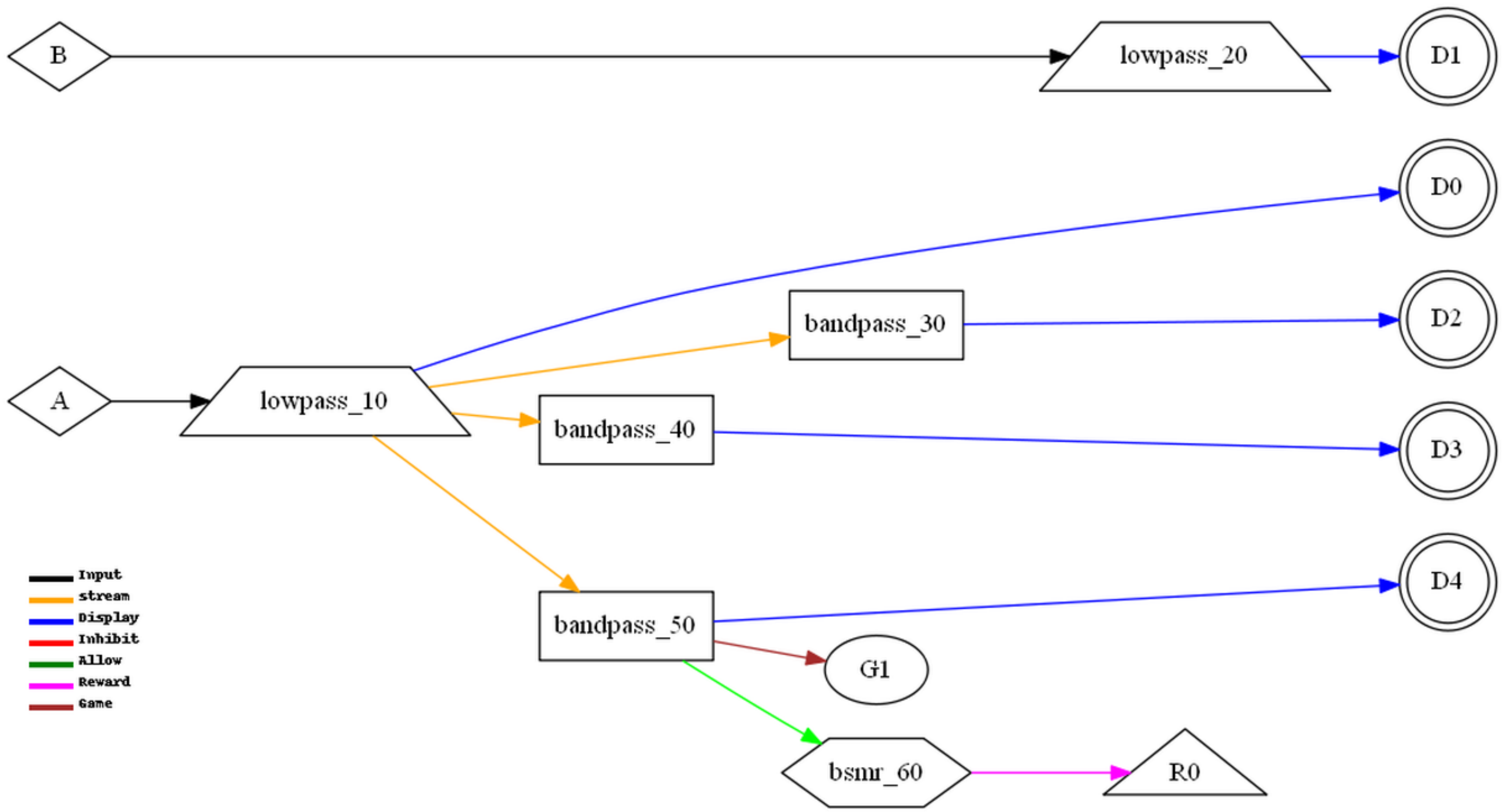
706 ZRelPwrB (Zscore Rel Pwr B) CCIRI



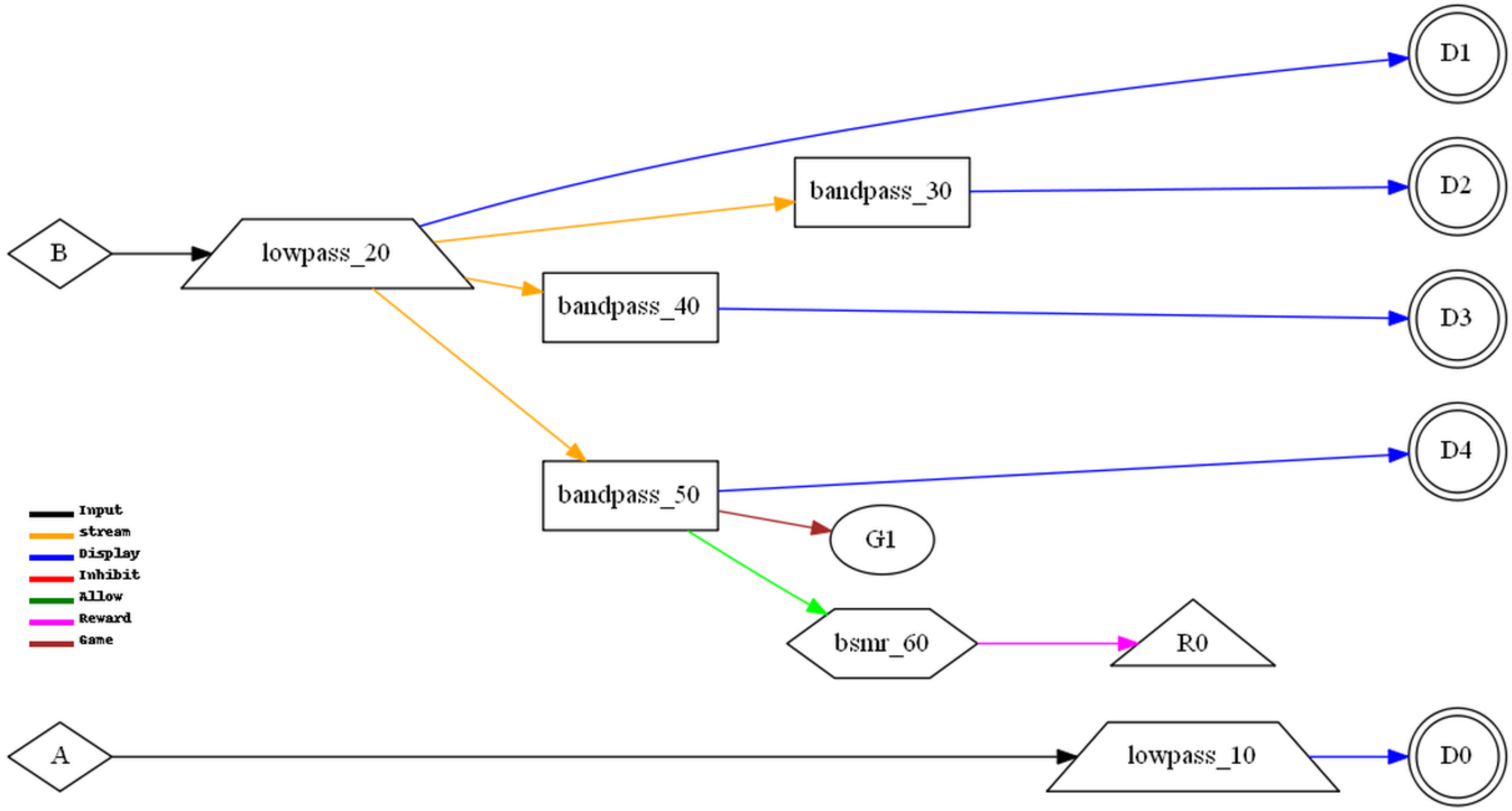
707 ZPRatioA (Zscore Power ratio A) CCIRI



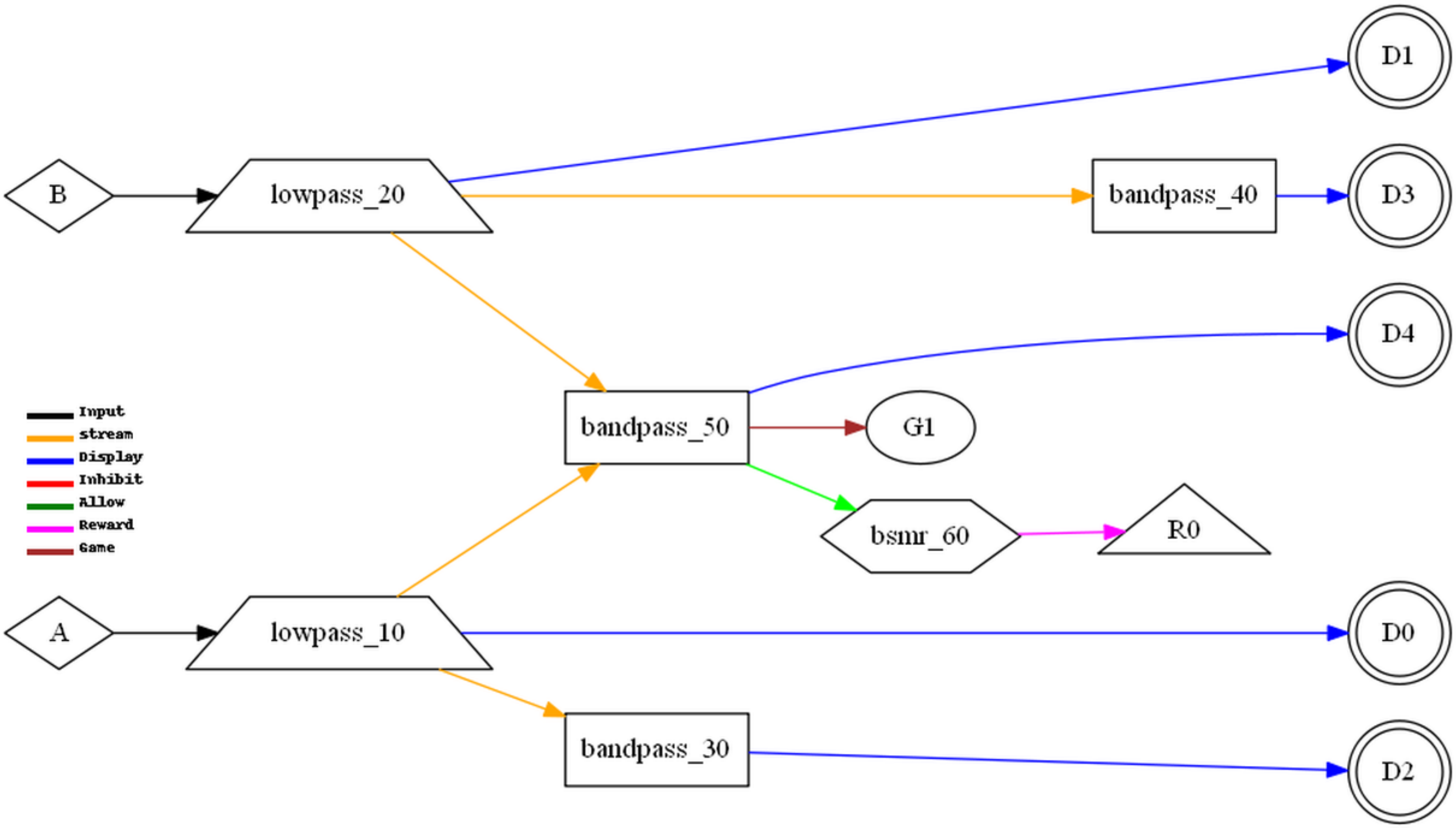
708 ZPRatioB (Zscore Power ratio B) CCIRI



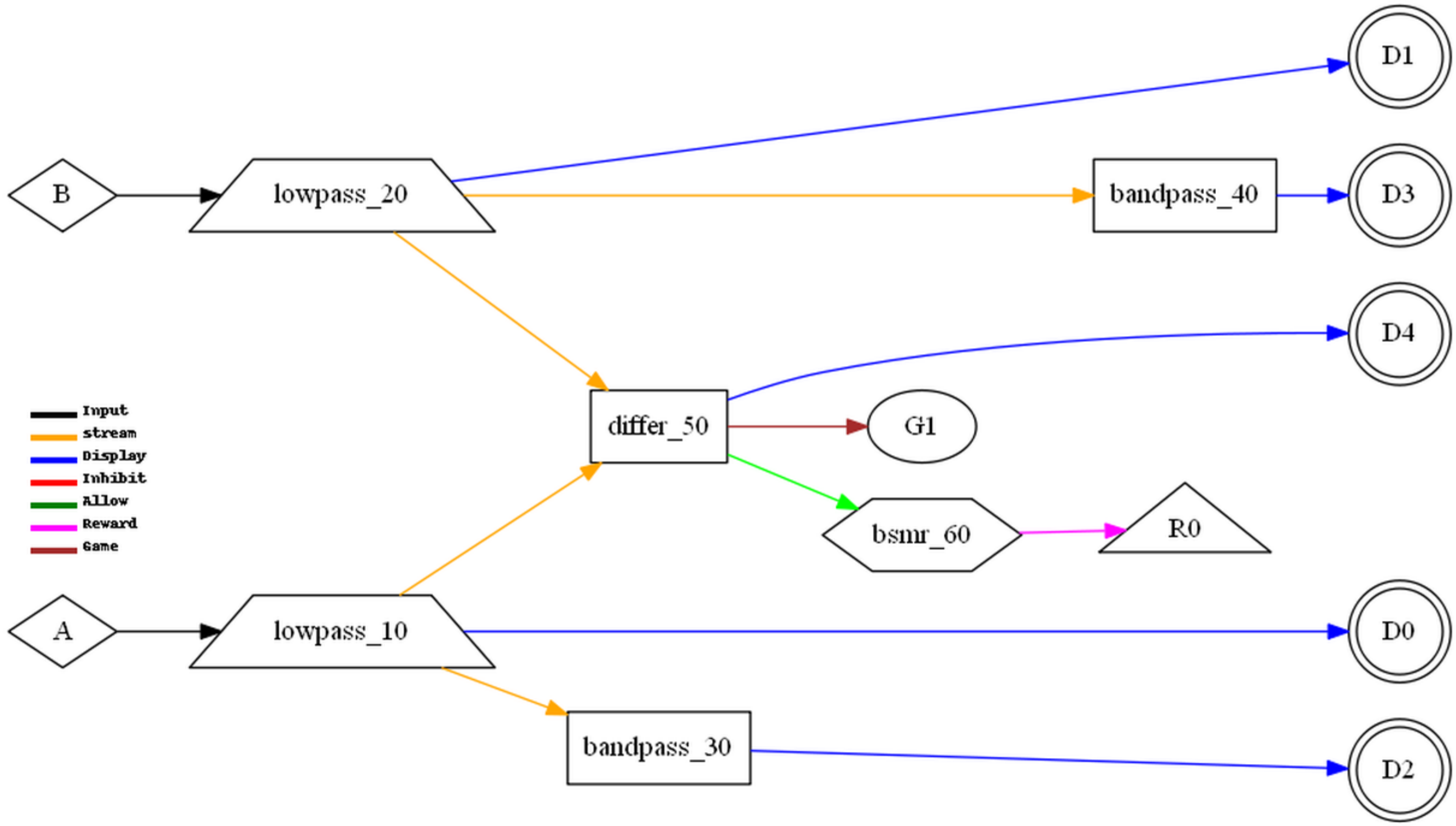
2000 SingleA (one channel of data input) CCMMR



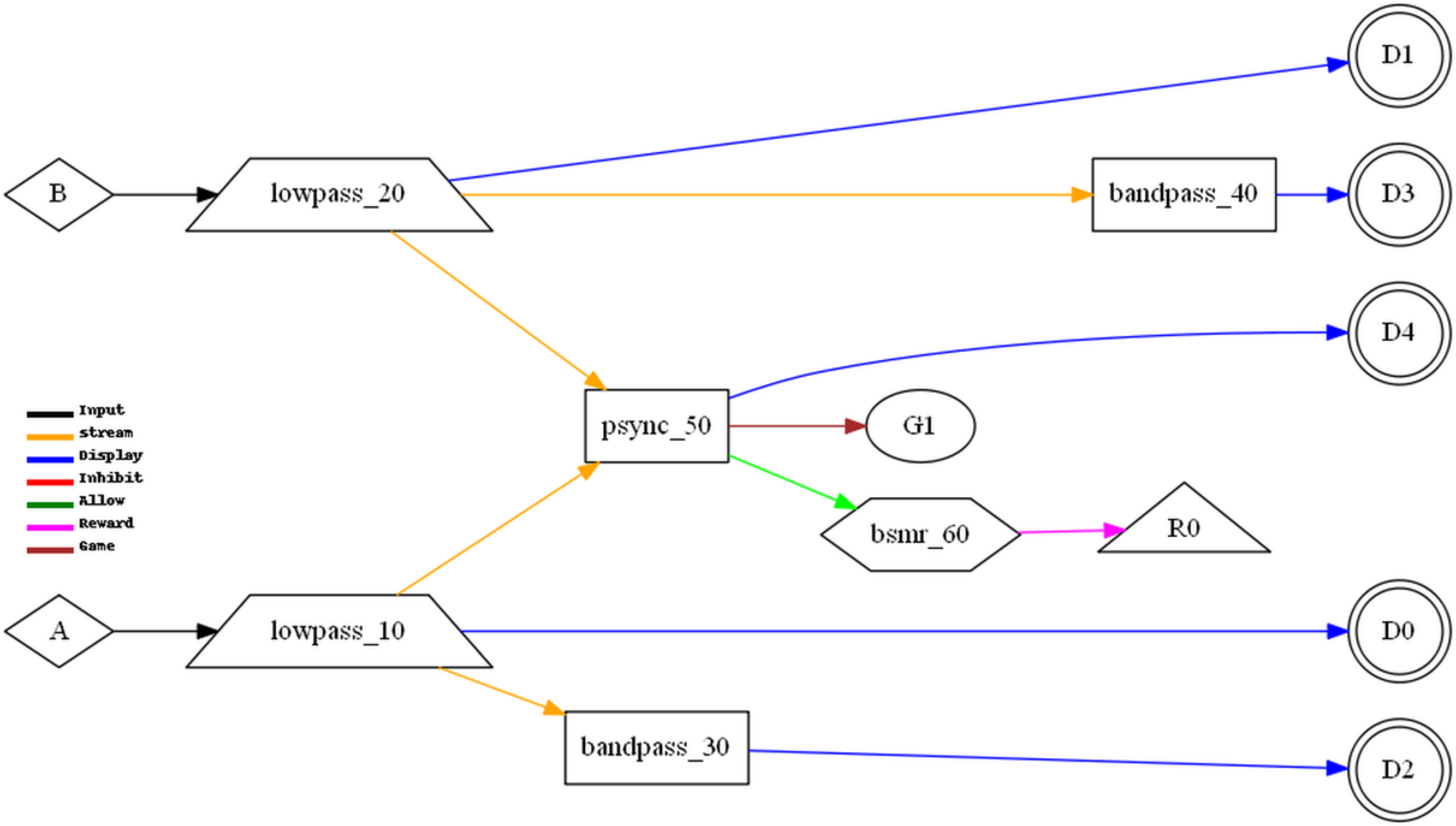
2001 SingleB (one channel of data input) CCMMR



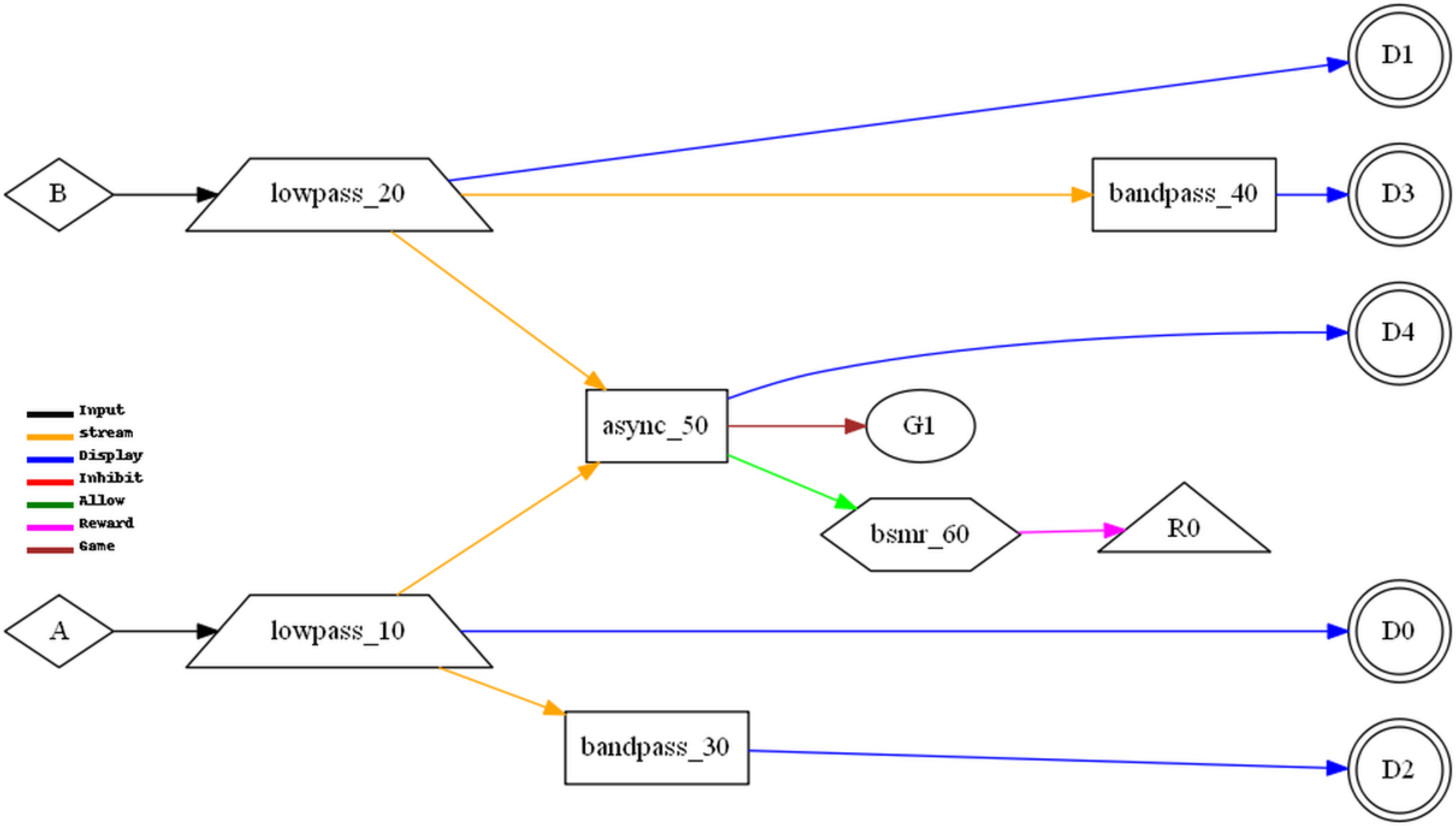
2010 Sum (sum of two channels of data input) CCMMR



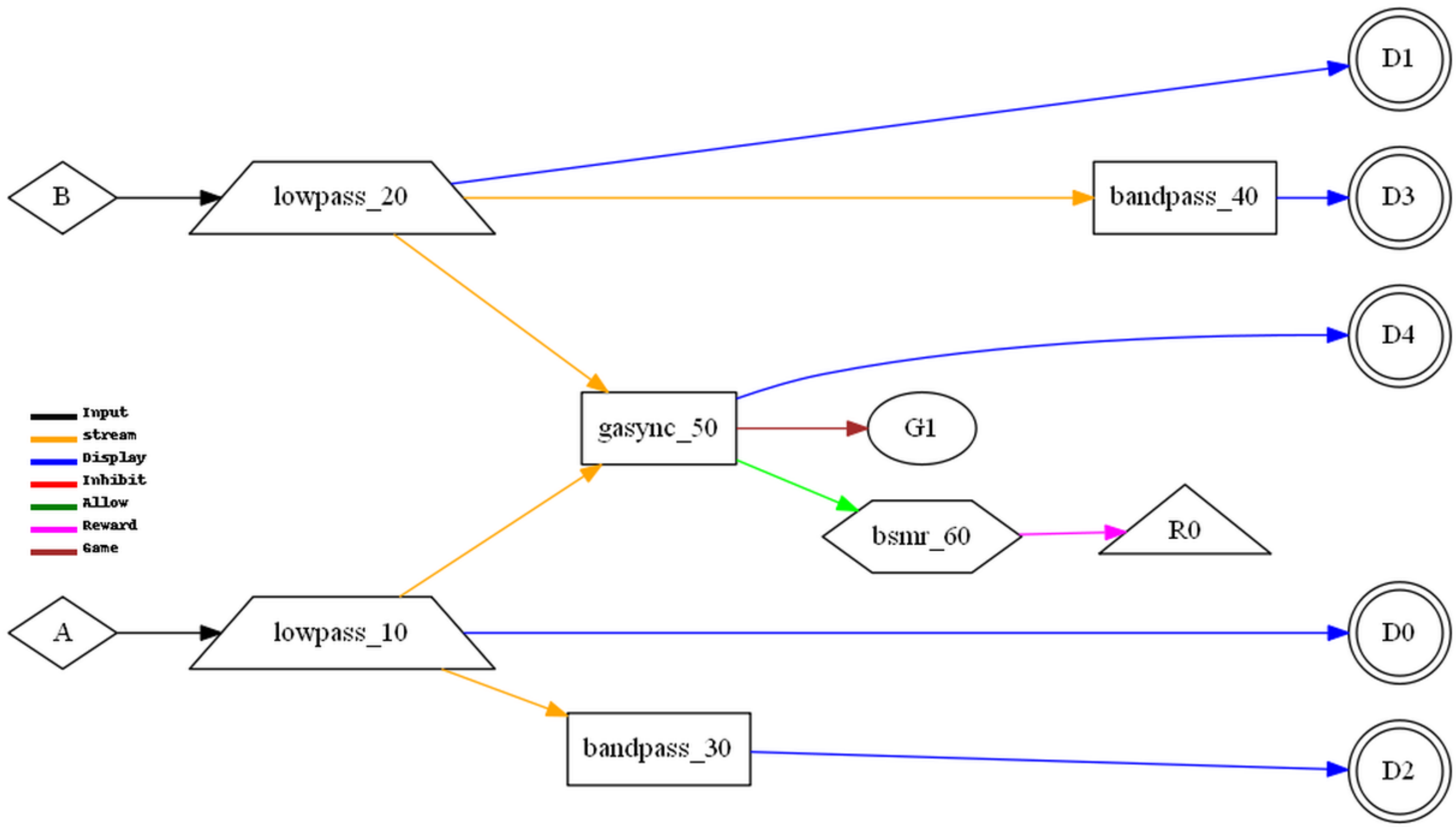
2011 Differ (channel A minus channel B) CCMMR



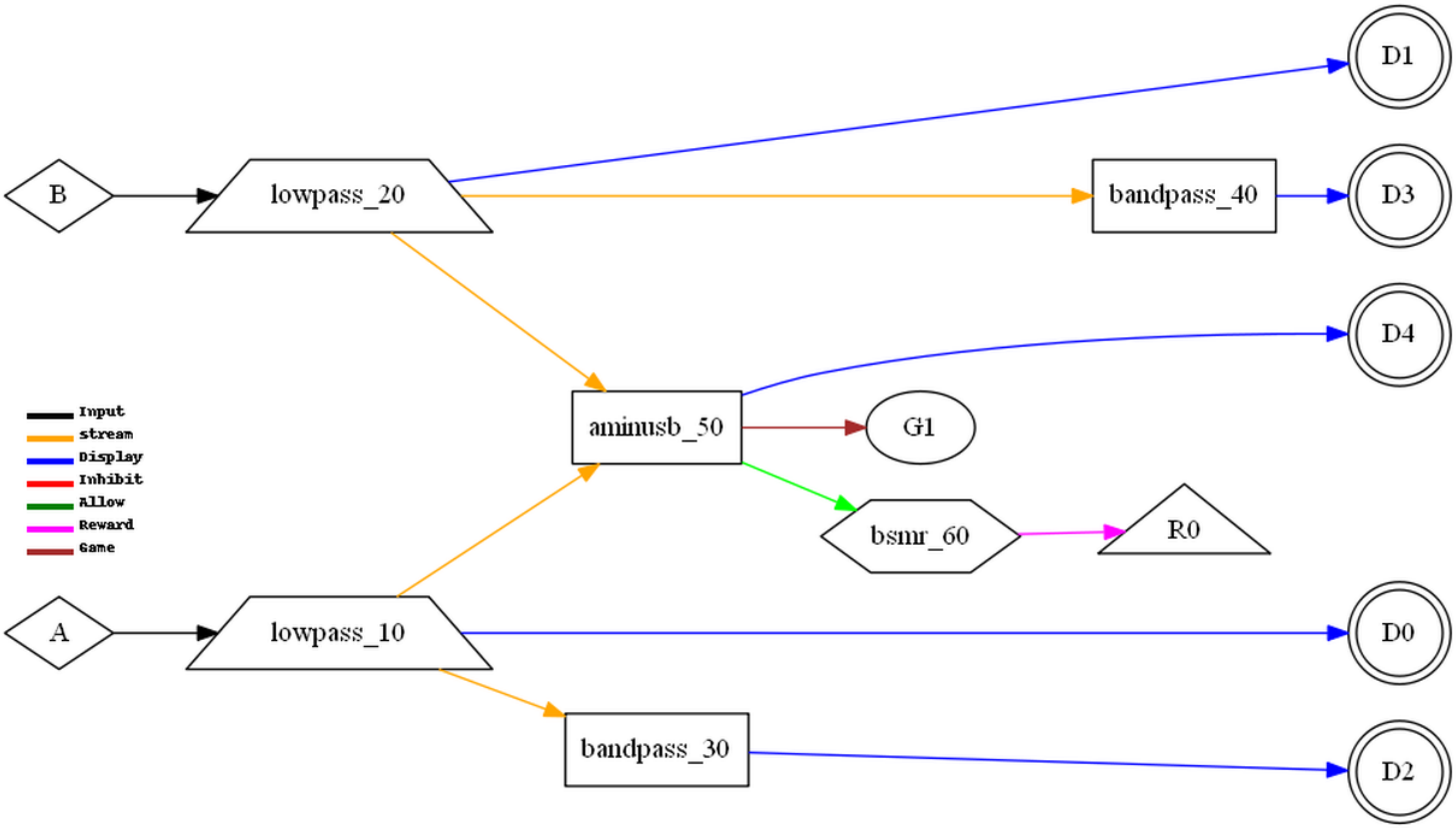
2020 Psync (synchrony measure between channel A and B) CCMMR



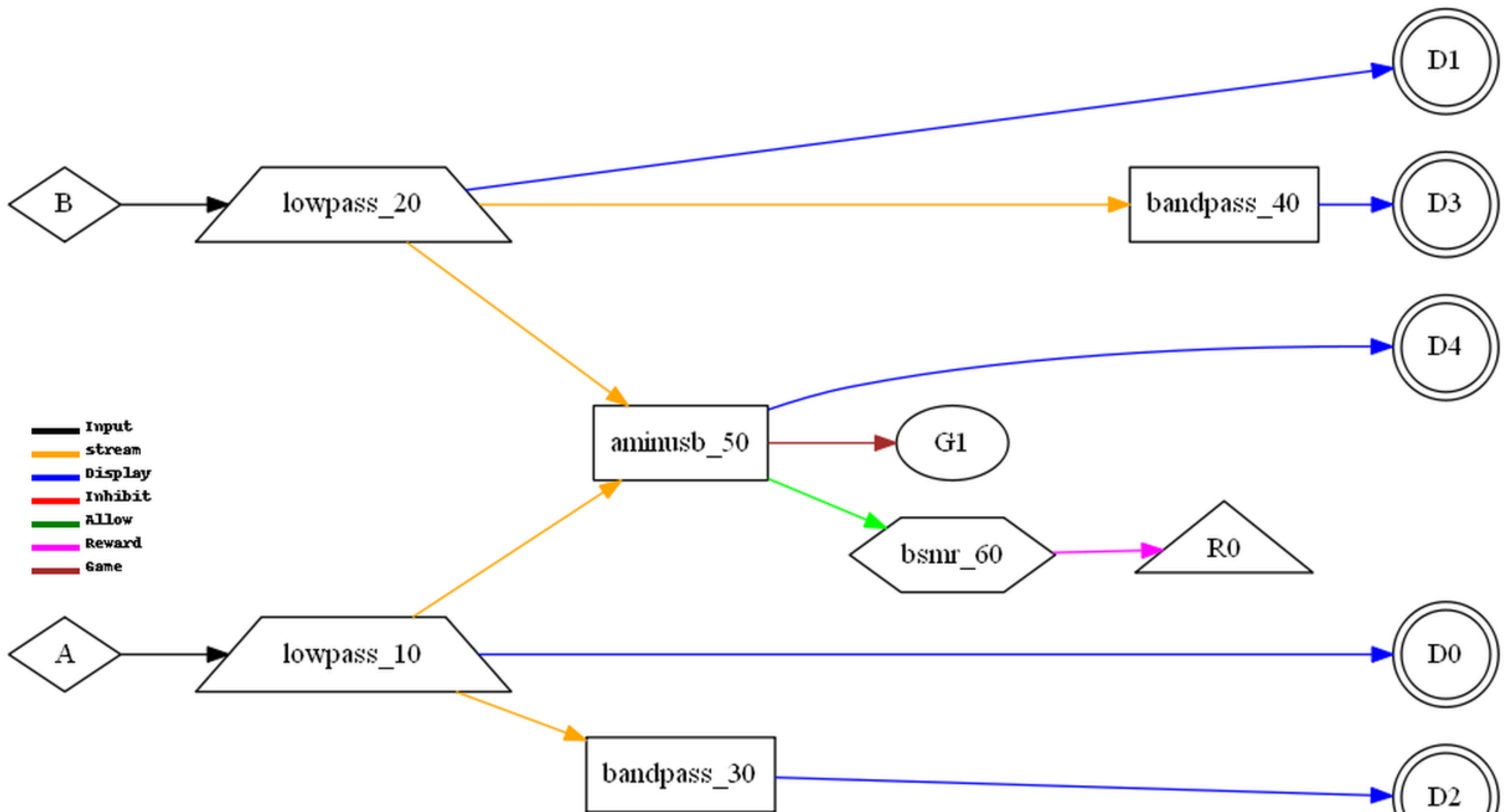
2030 Async (comodulation measure between channel A and B) CCMMR



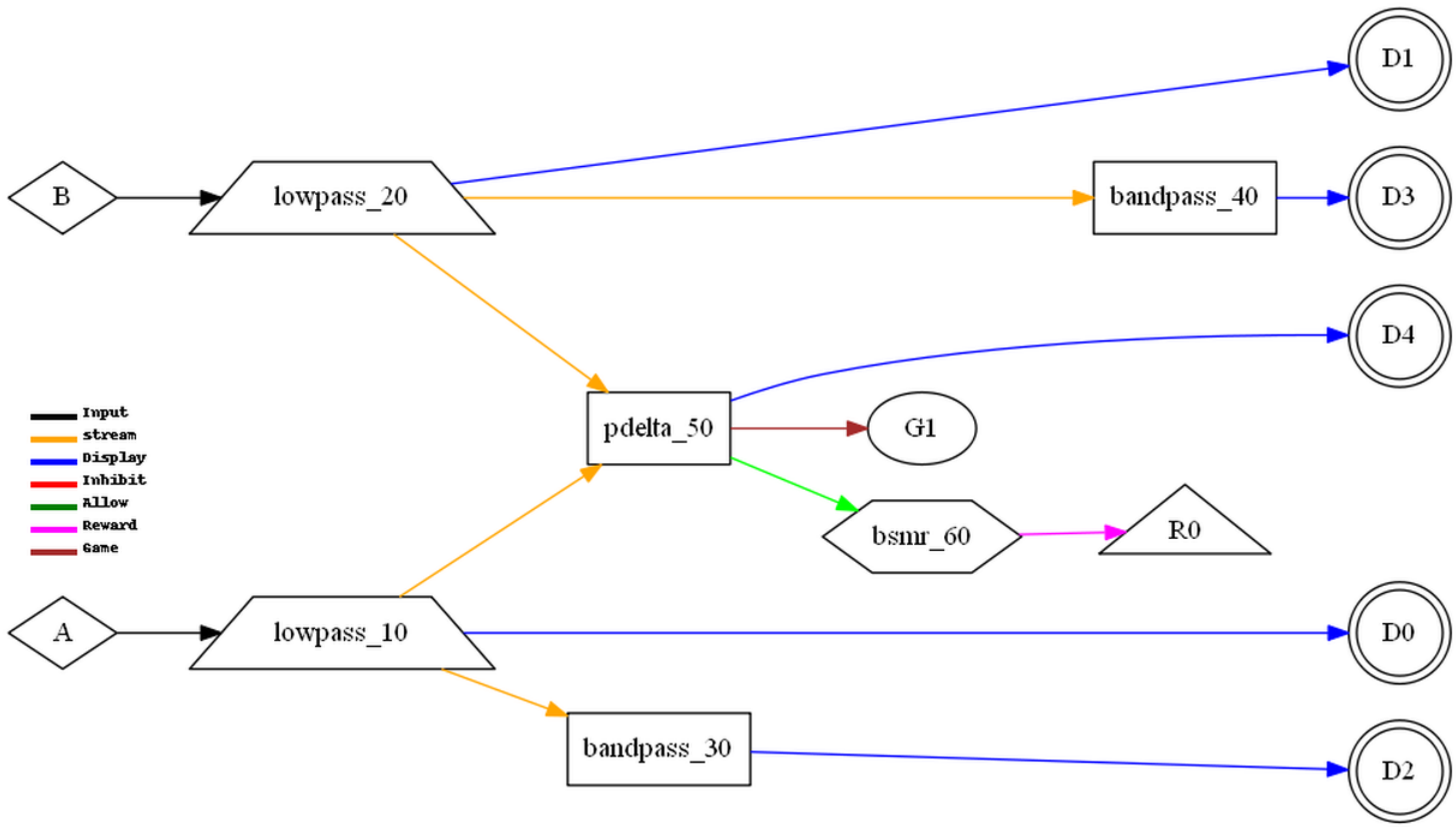
2040 GAsync (global comodulation measure between channel A and B) CCMMR



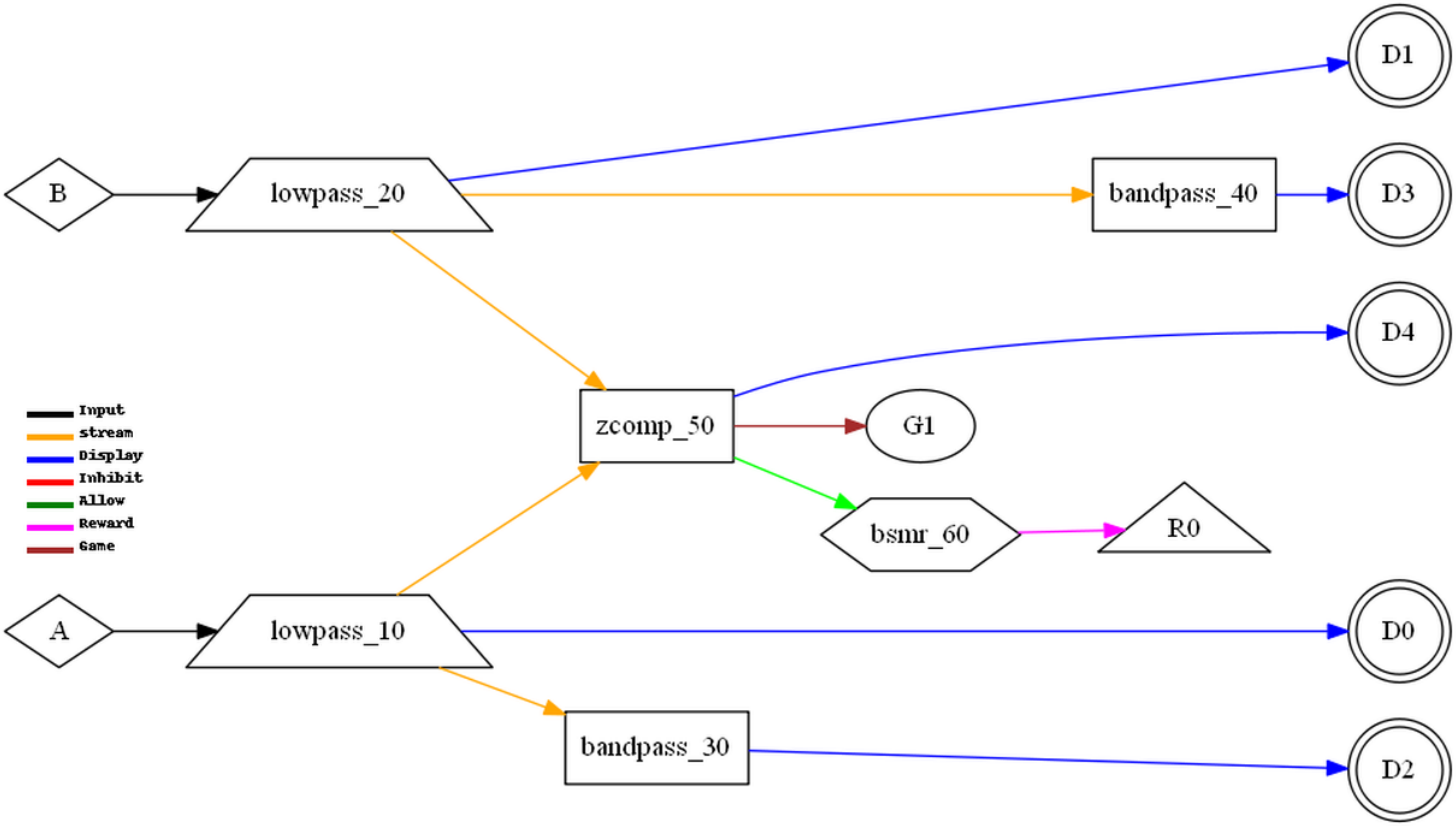
2050 AminusB (A channel relationship to B channel) CCMMR



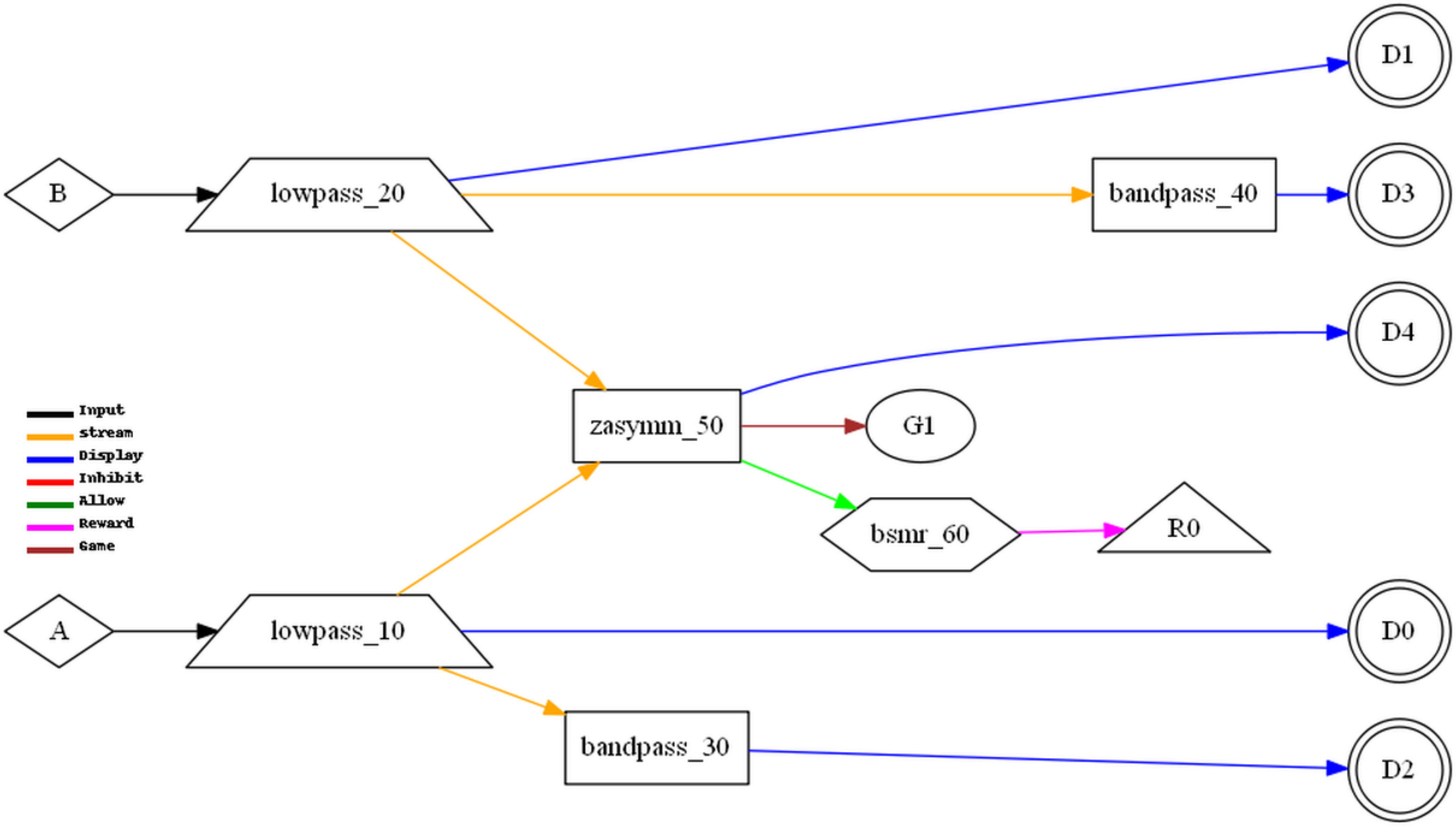
2051 BminusA (B channel relationship to A channel) CCMMR



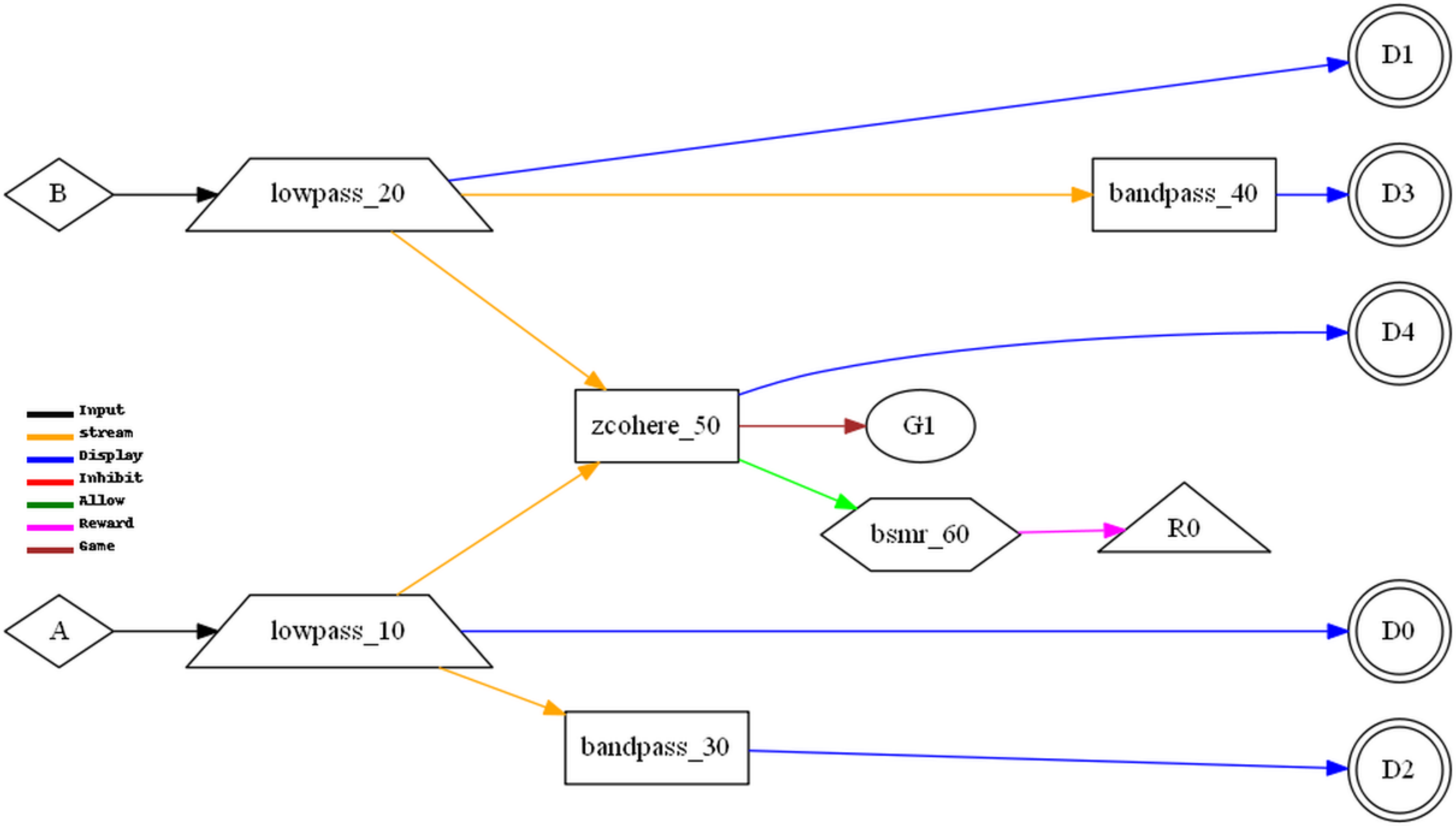
2052 PDelta (Peak Time Coherence) CCMMR



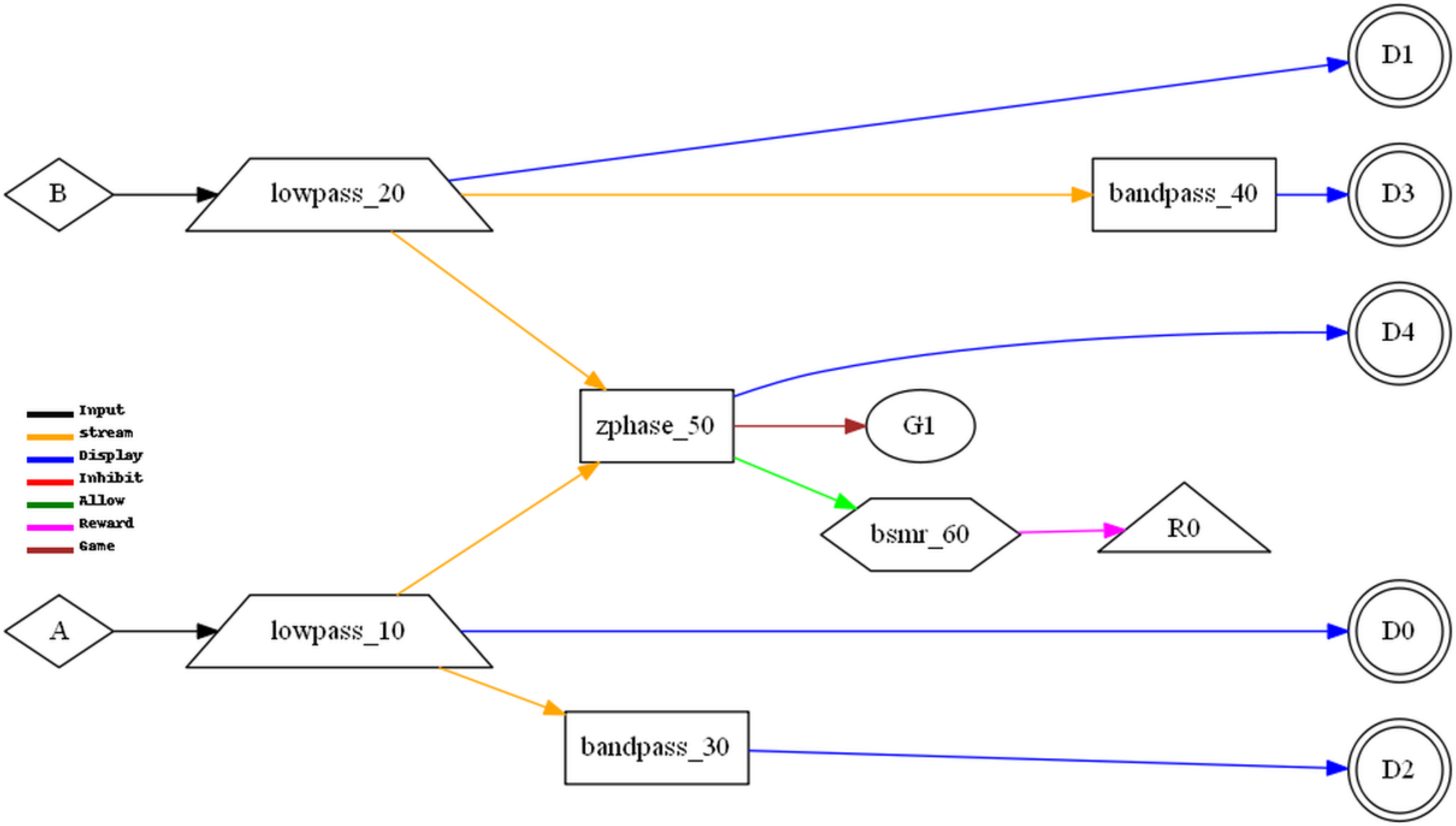
2060 ZCompAB (ZComposite) CCMMR



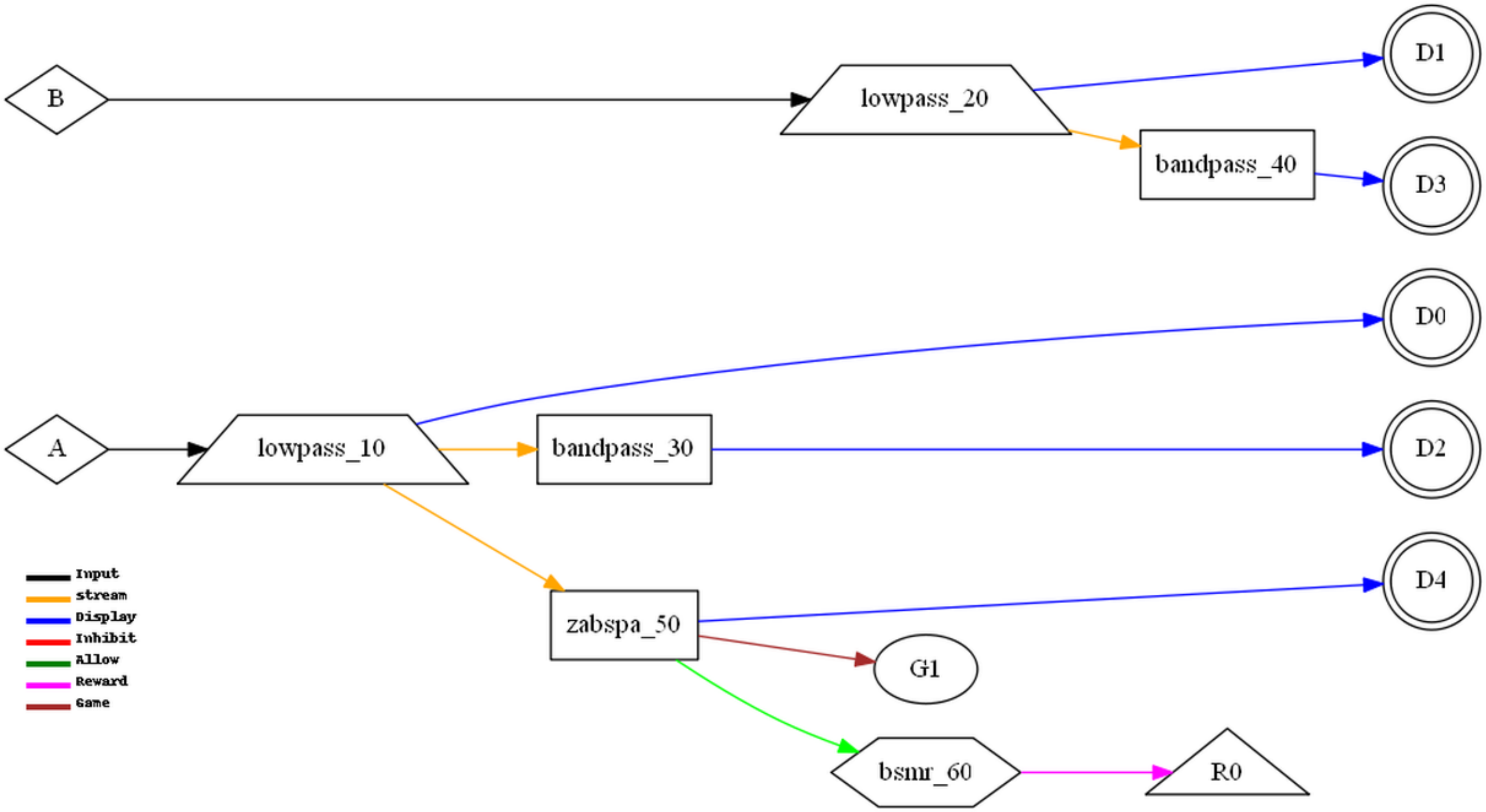
2100 ZAsymm (Zscore amplitude asymmetry) CCMMR



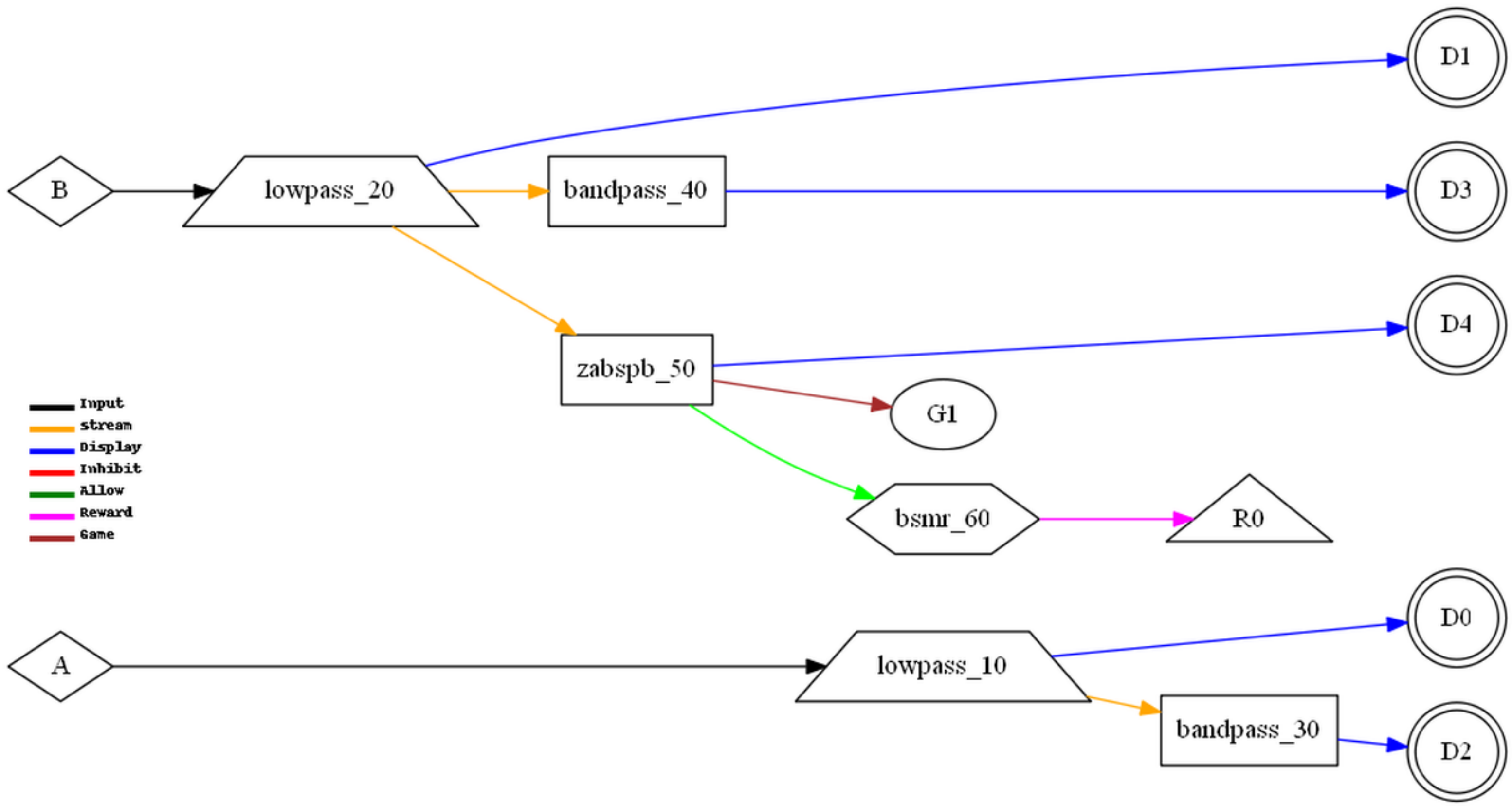
2101 ZCohere (Zscore coherence) CCMMR



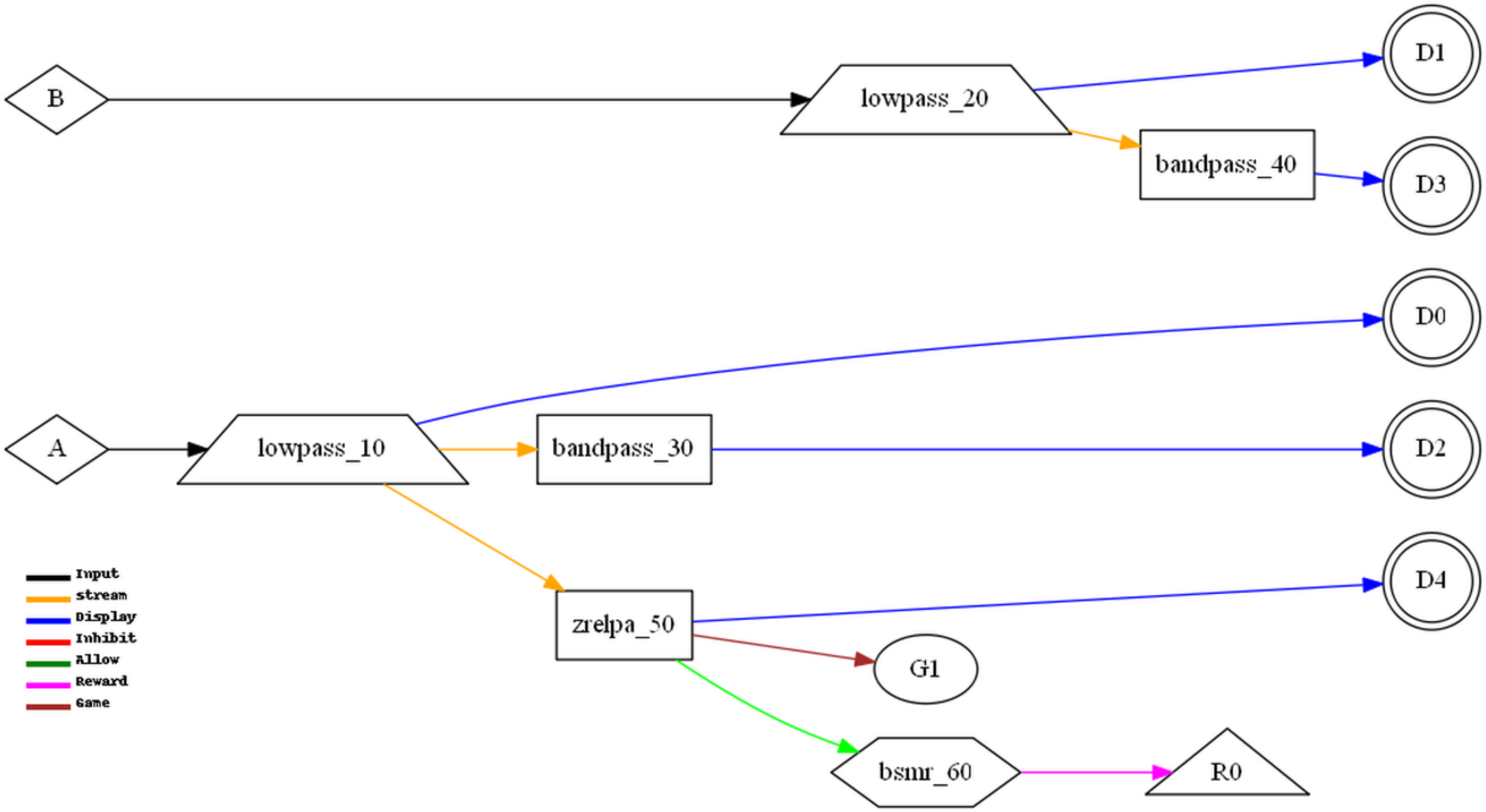
2102 ZPhase (Zscore phase) CCMMR



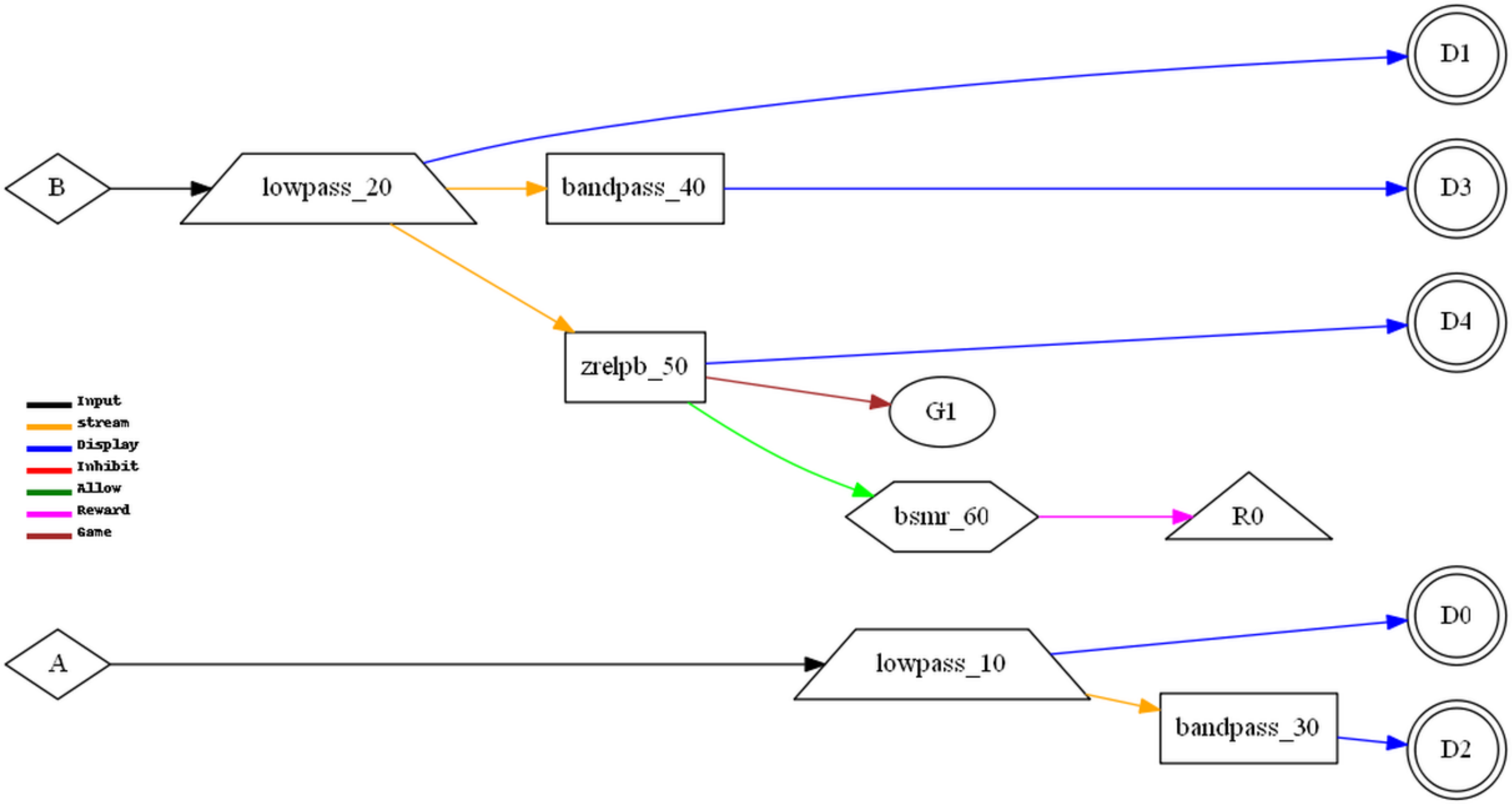
2103 ZAbsPwrA (Zscore Abs Amp A) CCMMR



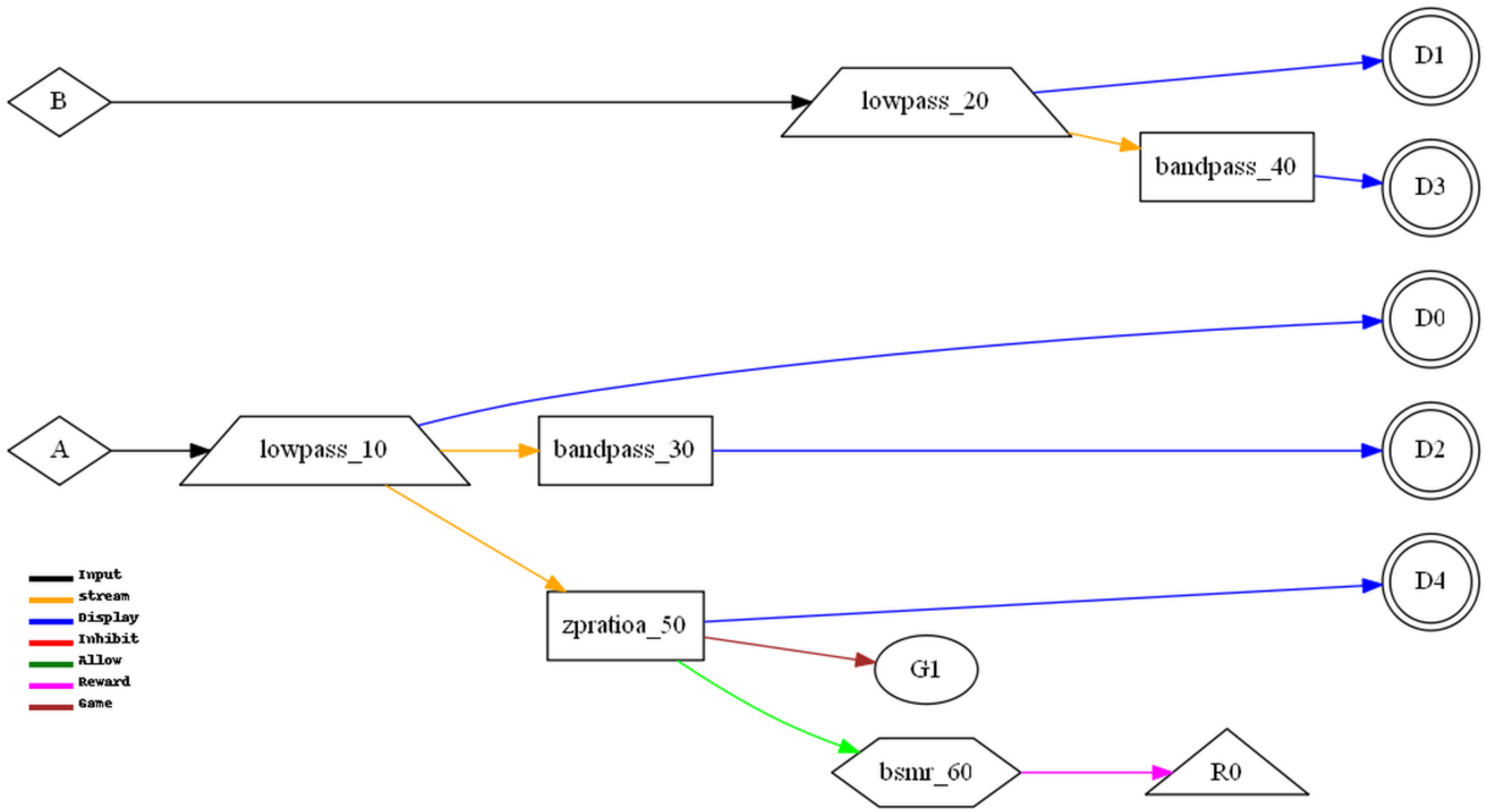
2104 ZAbsPwrB   (Zscore Abs Amp B) CCMMR



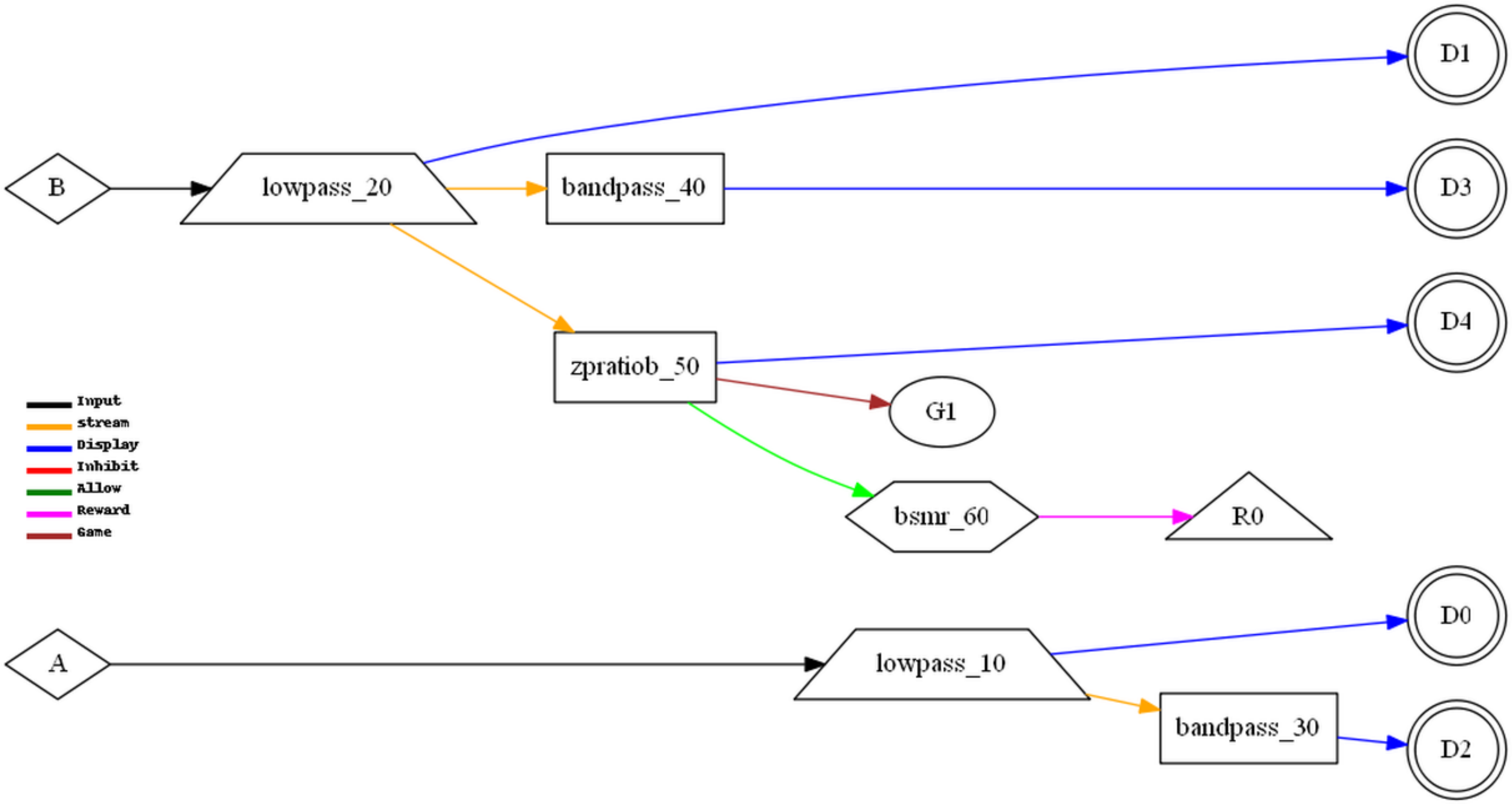
2105 ZRelPwrA (Zscore Rel Pwr A) CCMMR



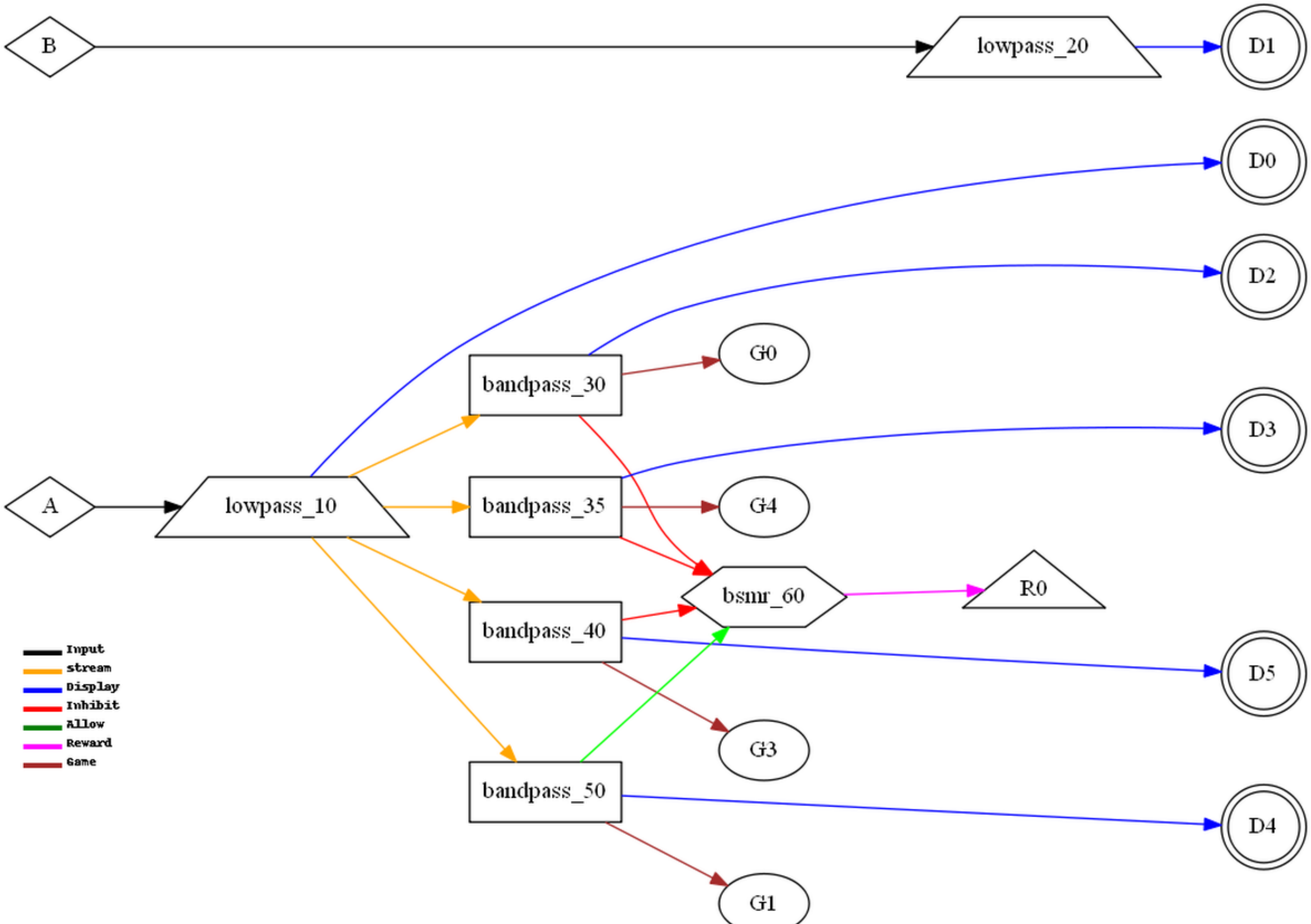
2106 ZRelPwrB (Zscore Rel Pwr B) CCMMR



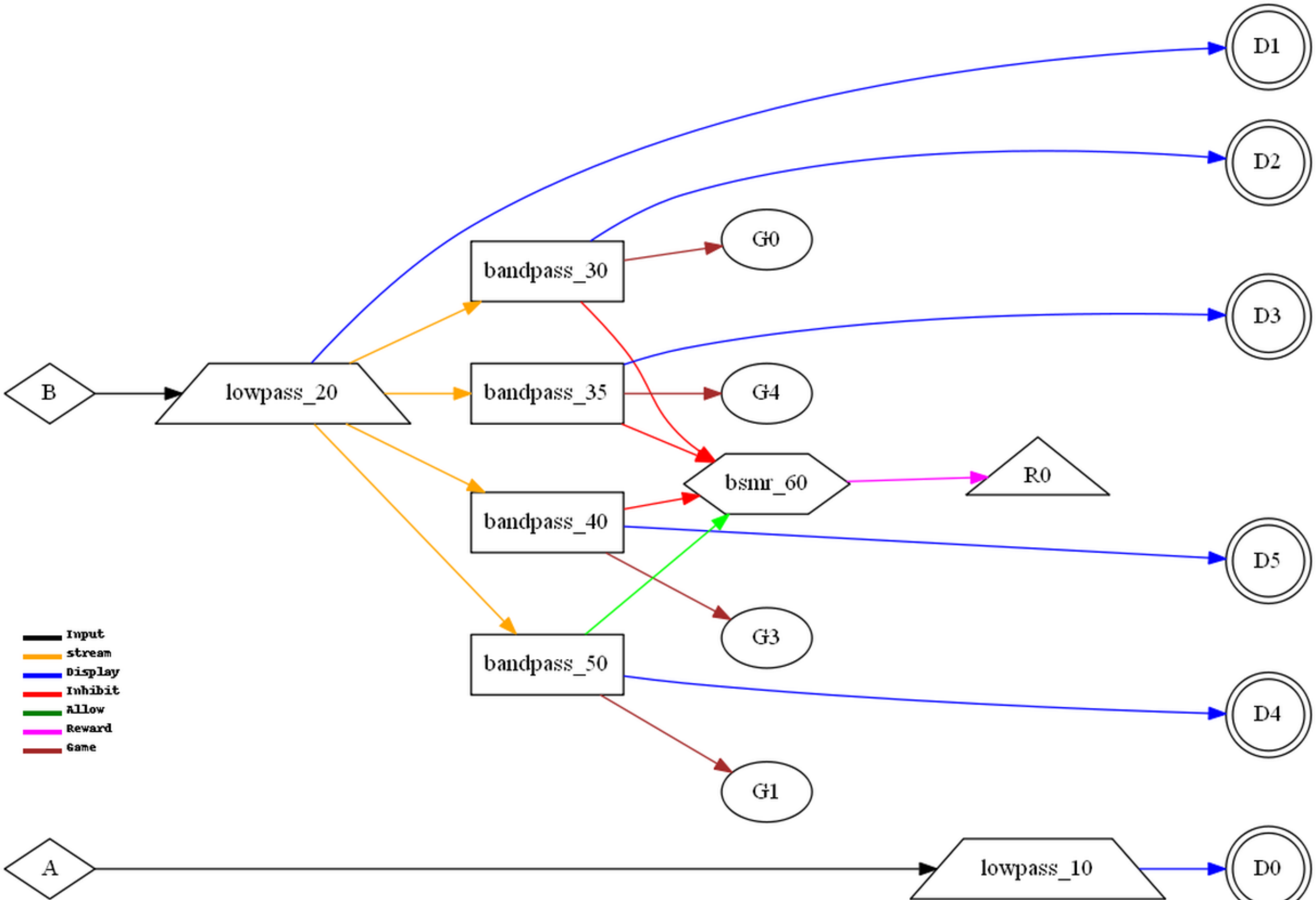
2107 ZPRatioA (Zscore Power ratio A) CCMMR



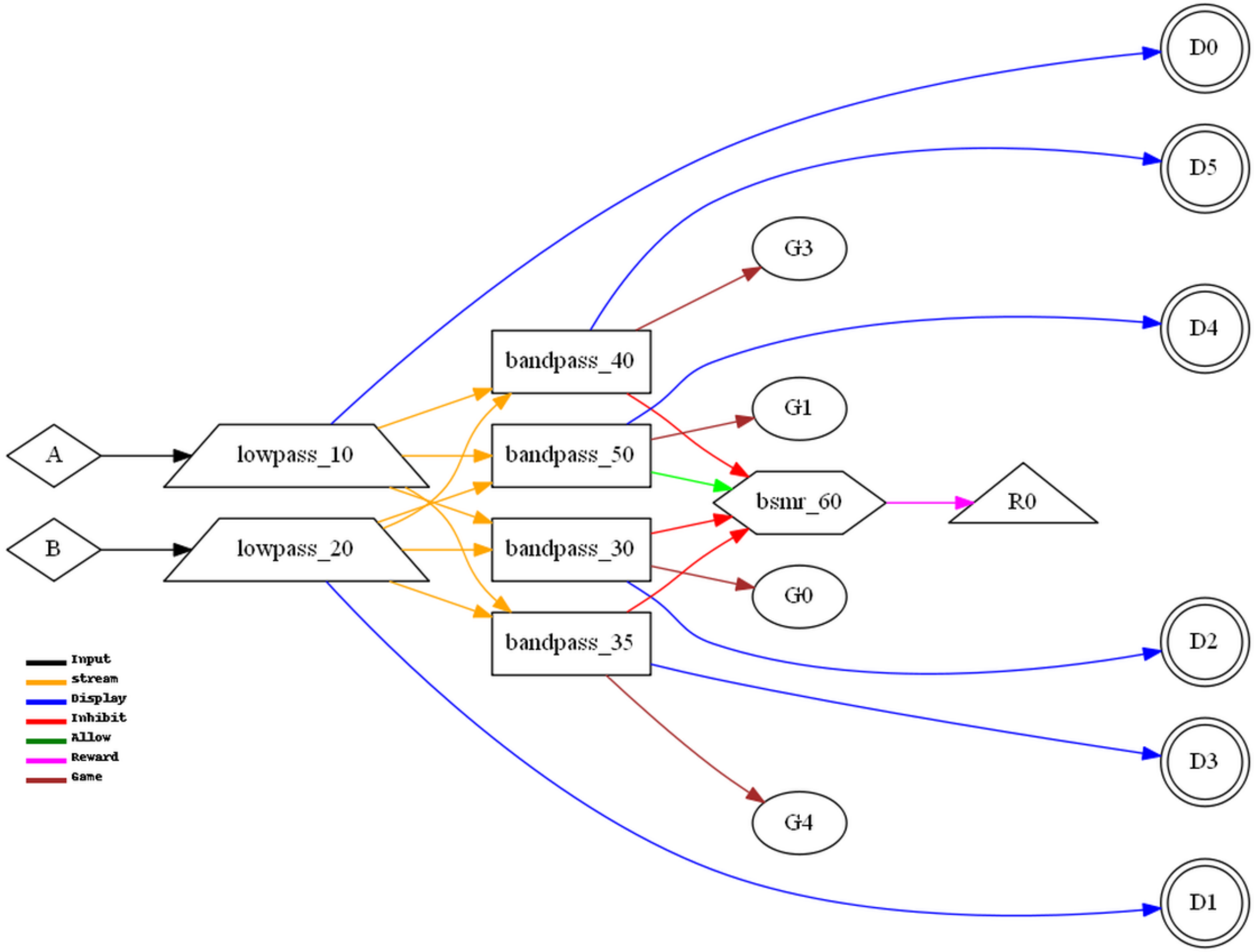
2108 ZPRatioB (Zscore Power ratio B) CCMMR



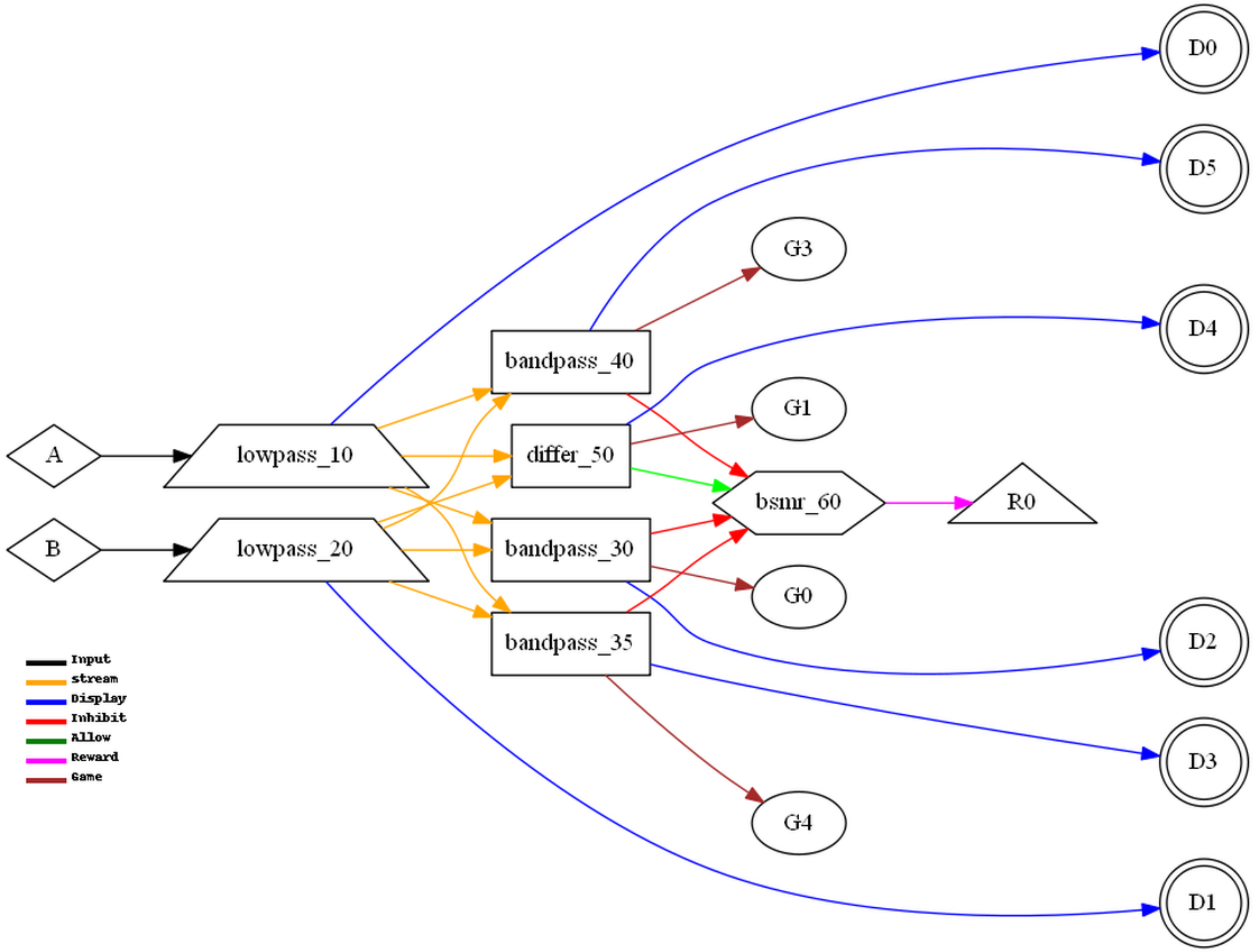
400 SingleA (one channel of data input) CCIIRI



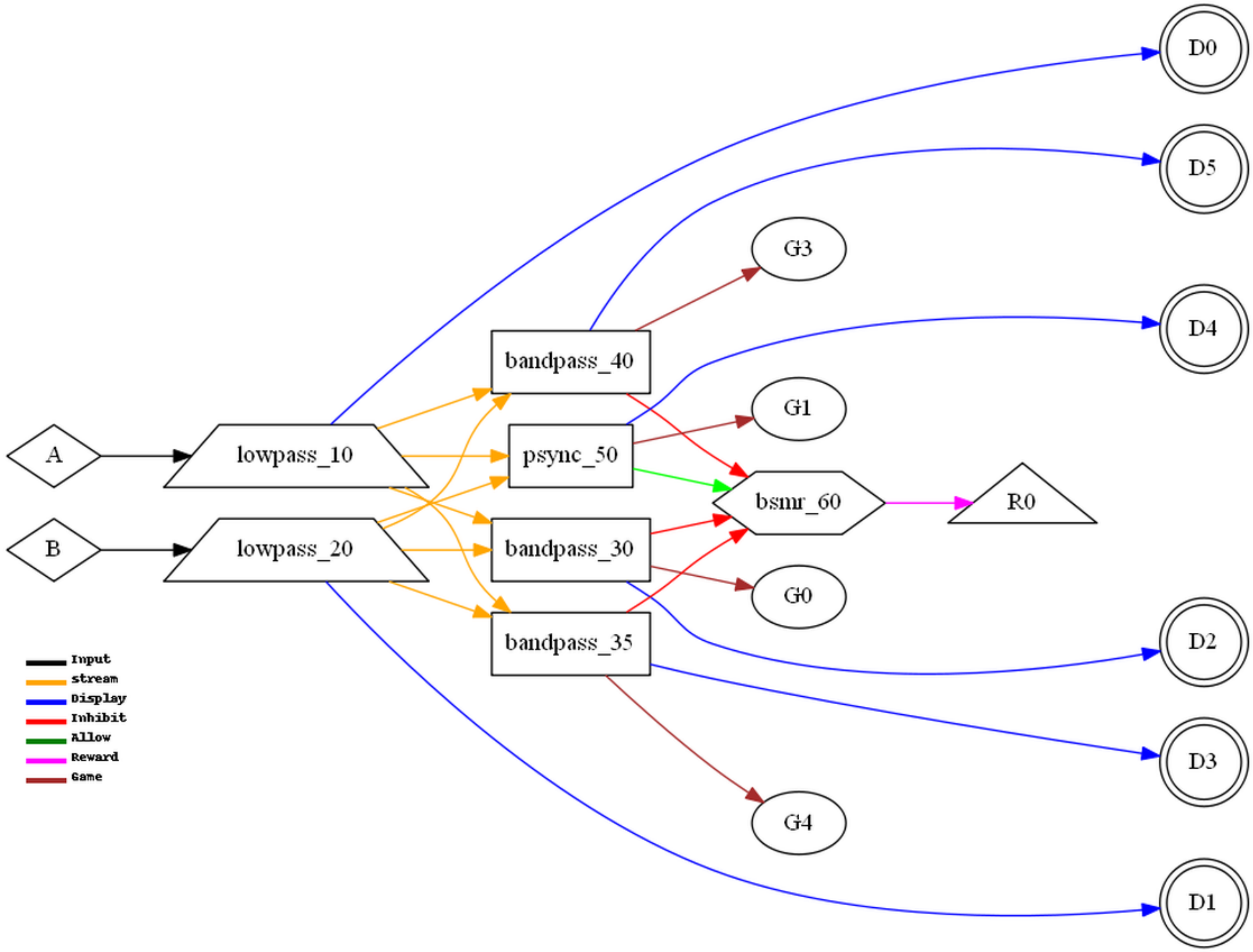
401 SingleB (one channel of data input) CCIIRI



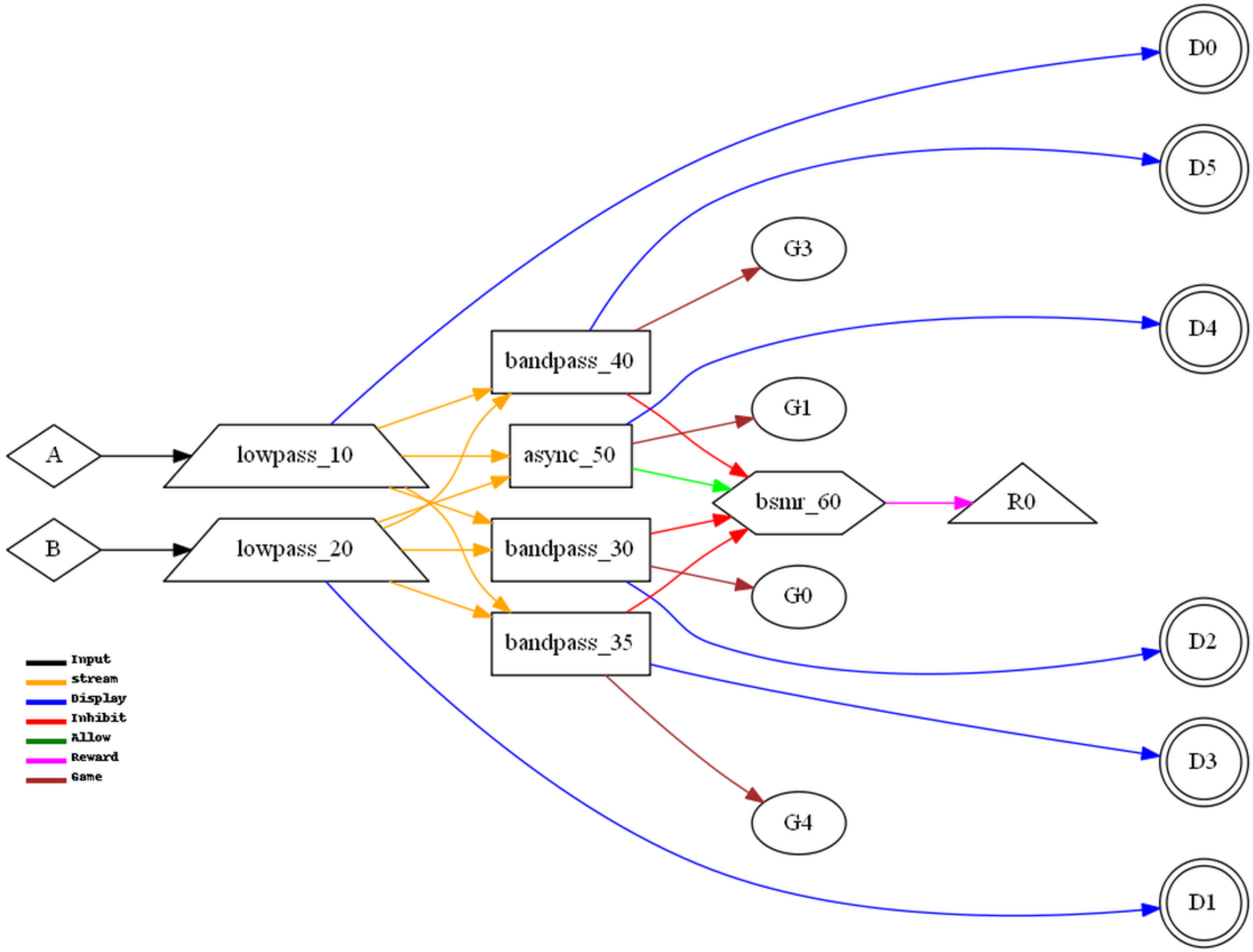
410 Sum (sum of two channels of data input) CCIIRI



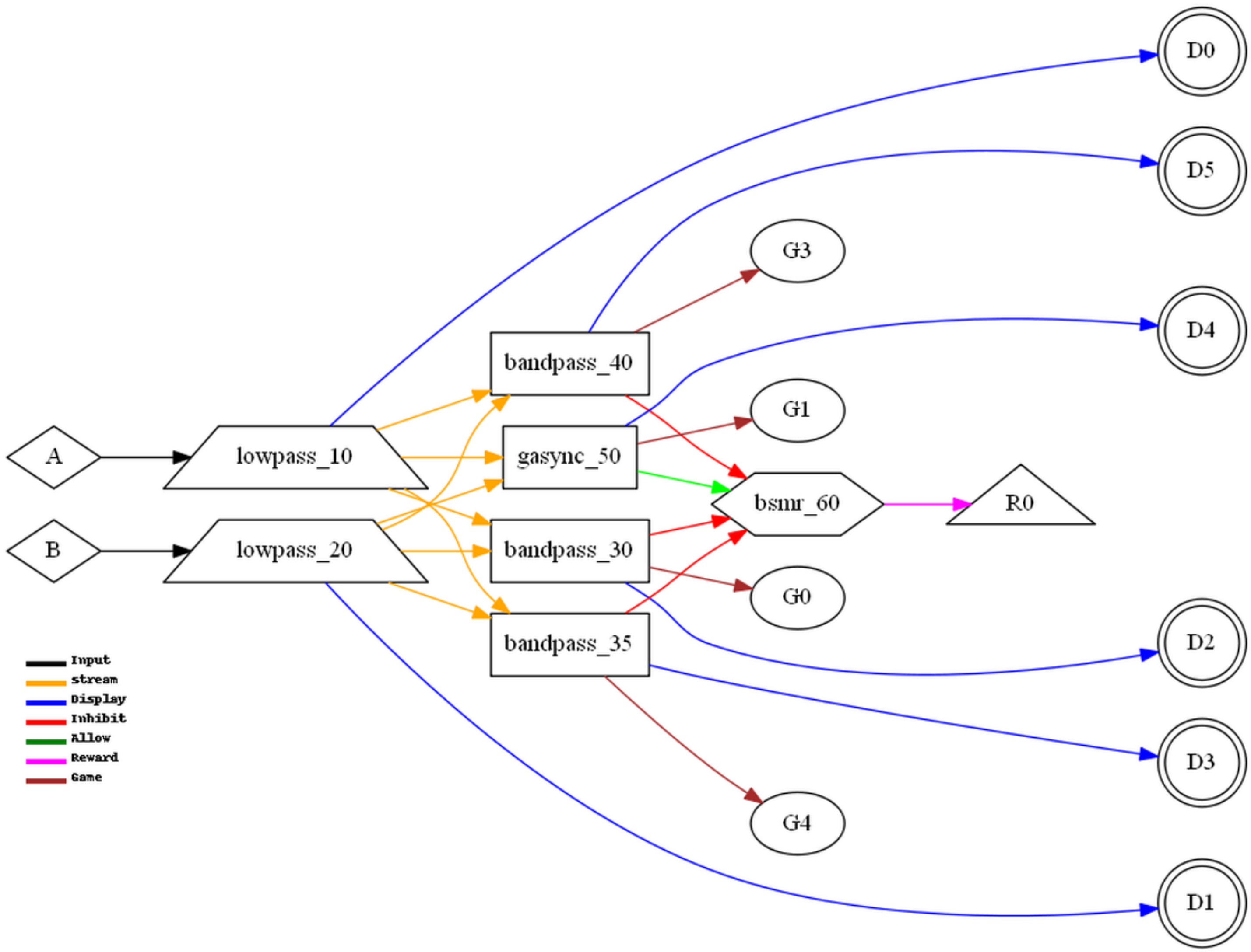
411 Differ (channel A minus channel B) CCIIRI



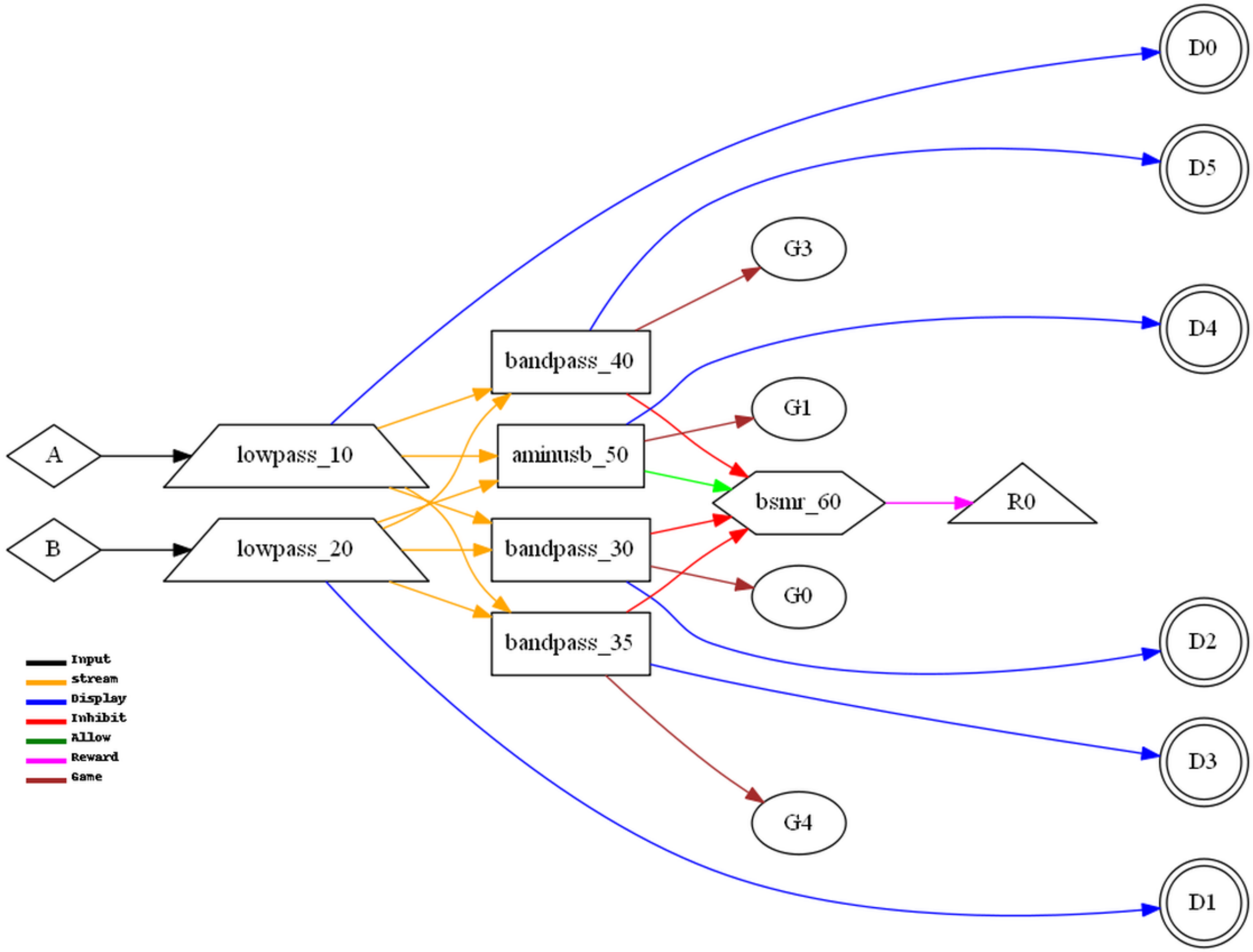
420 Psync (synchrony measure between channel A and B) CCIIRI



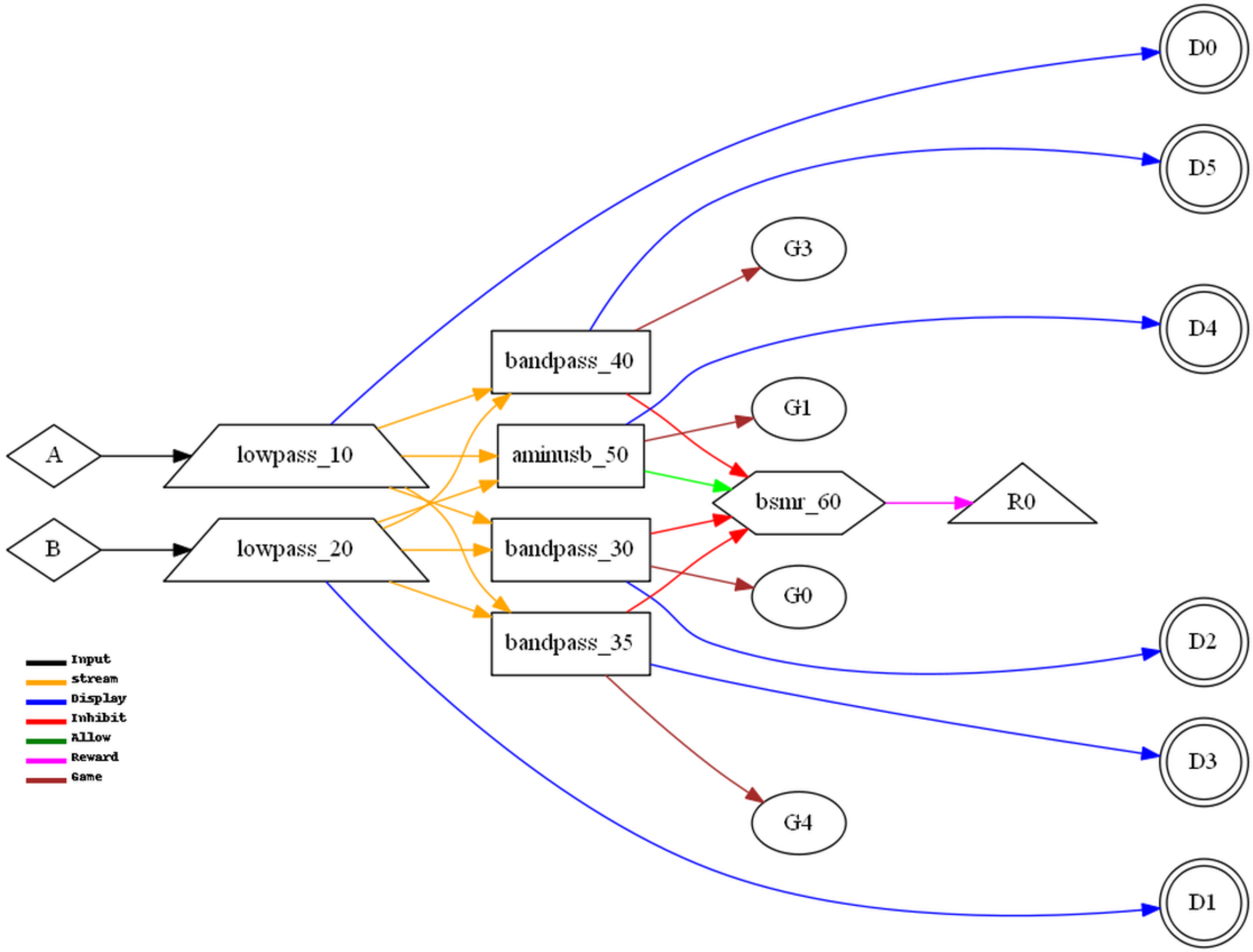
430 Async (comodulation measure between channel A and B) CCIIRI



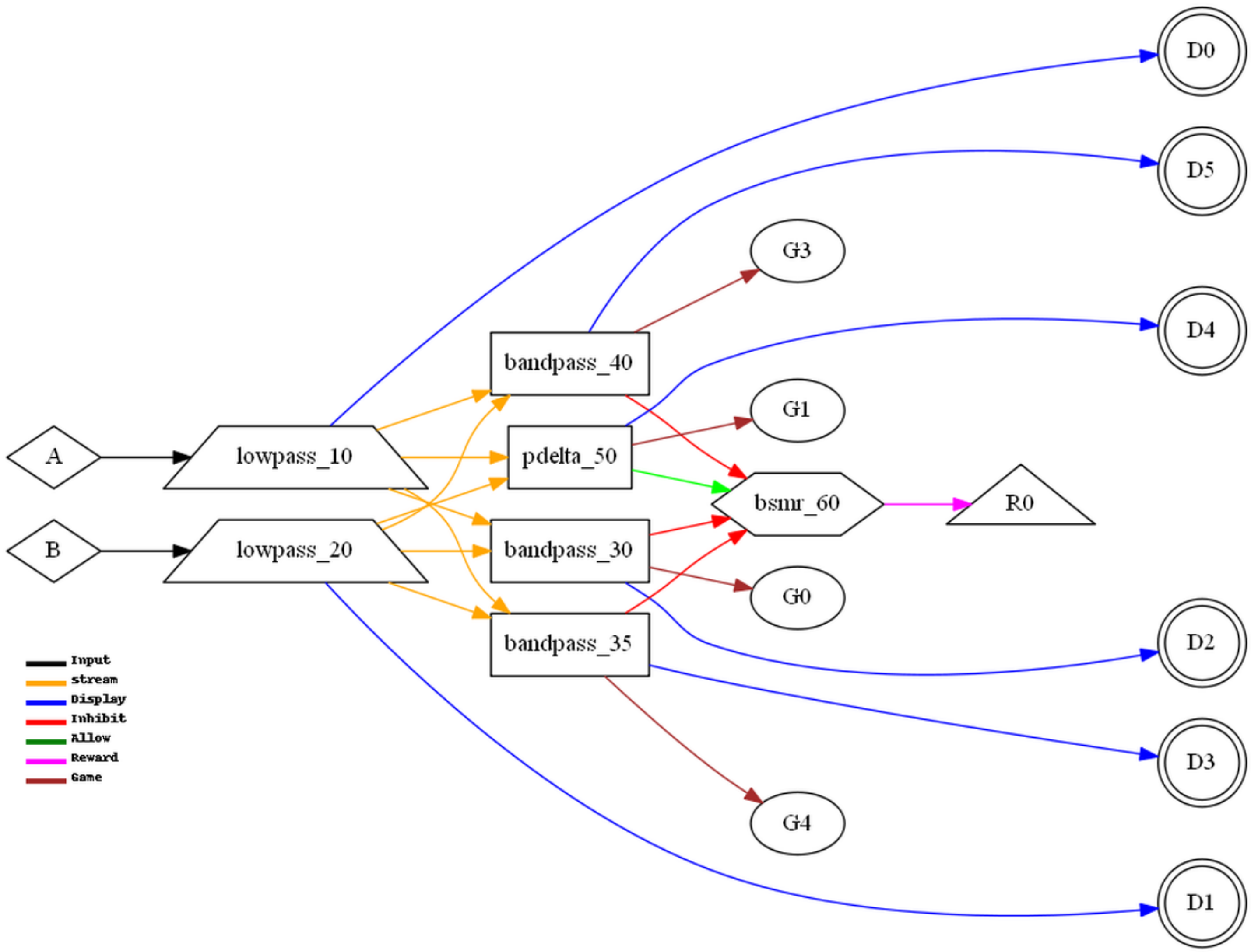
440 GAsync (global comodulation measure between channel A and B) CCIIRI



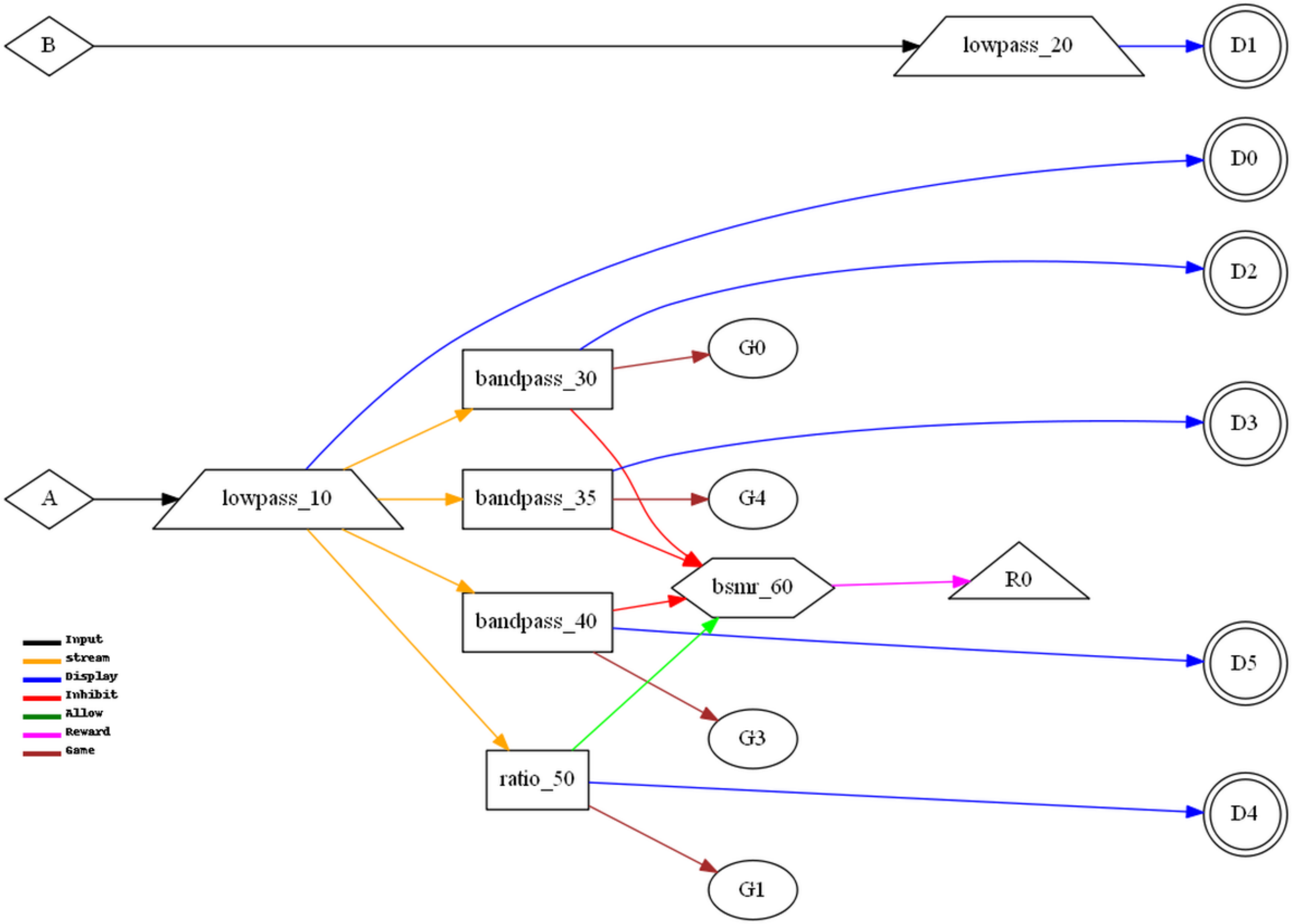
450 AminusB (A channel relationship to B channel) CCIIRI



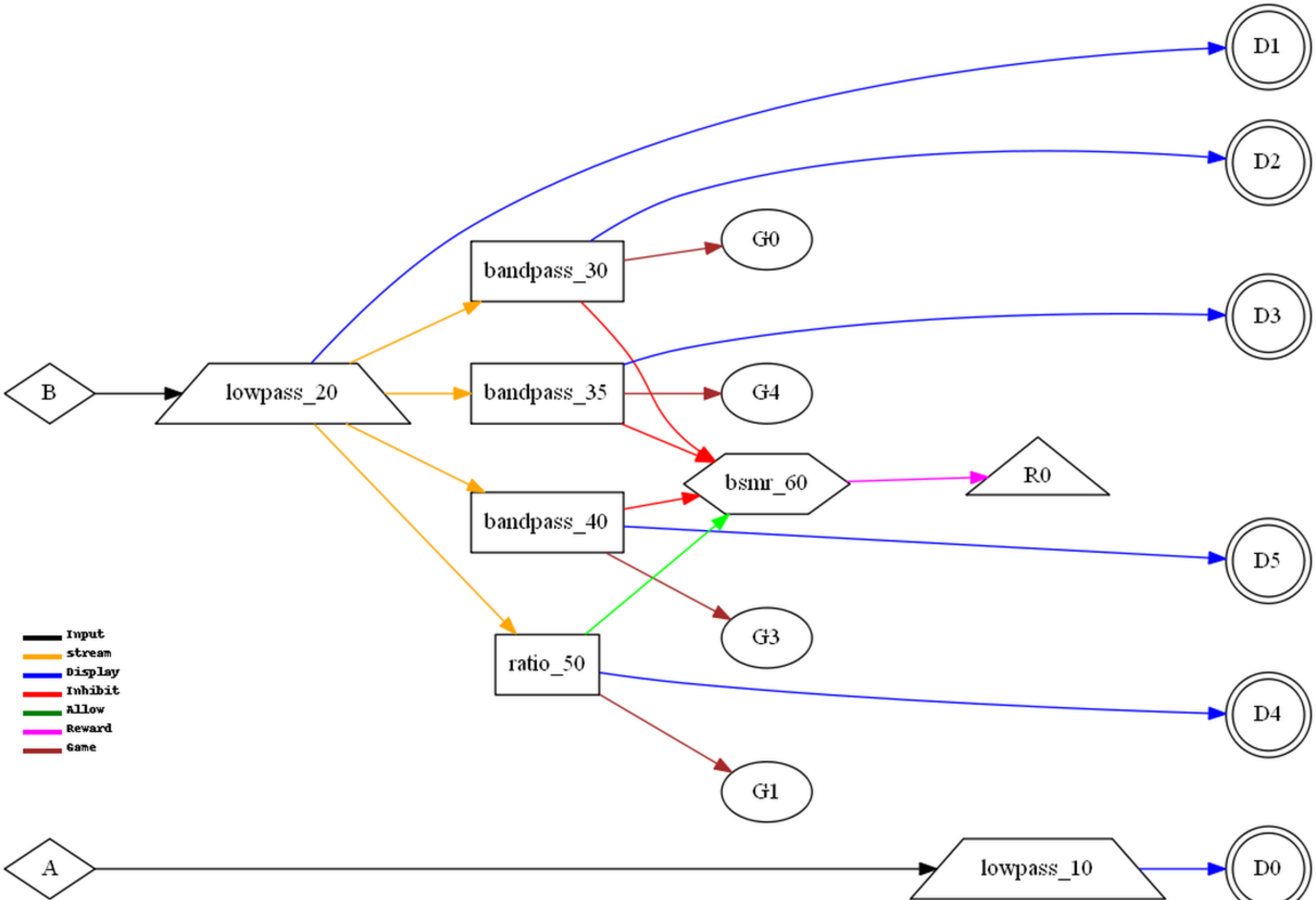
451 BminusA (B channel relationship to A channel) CCIIRI



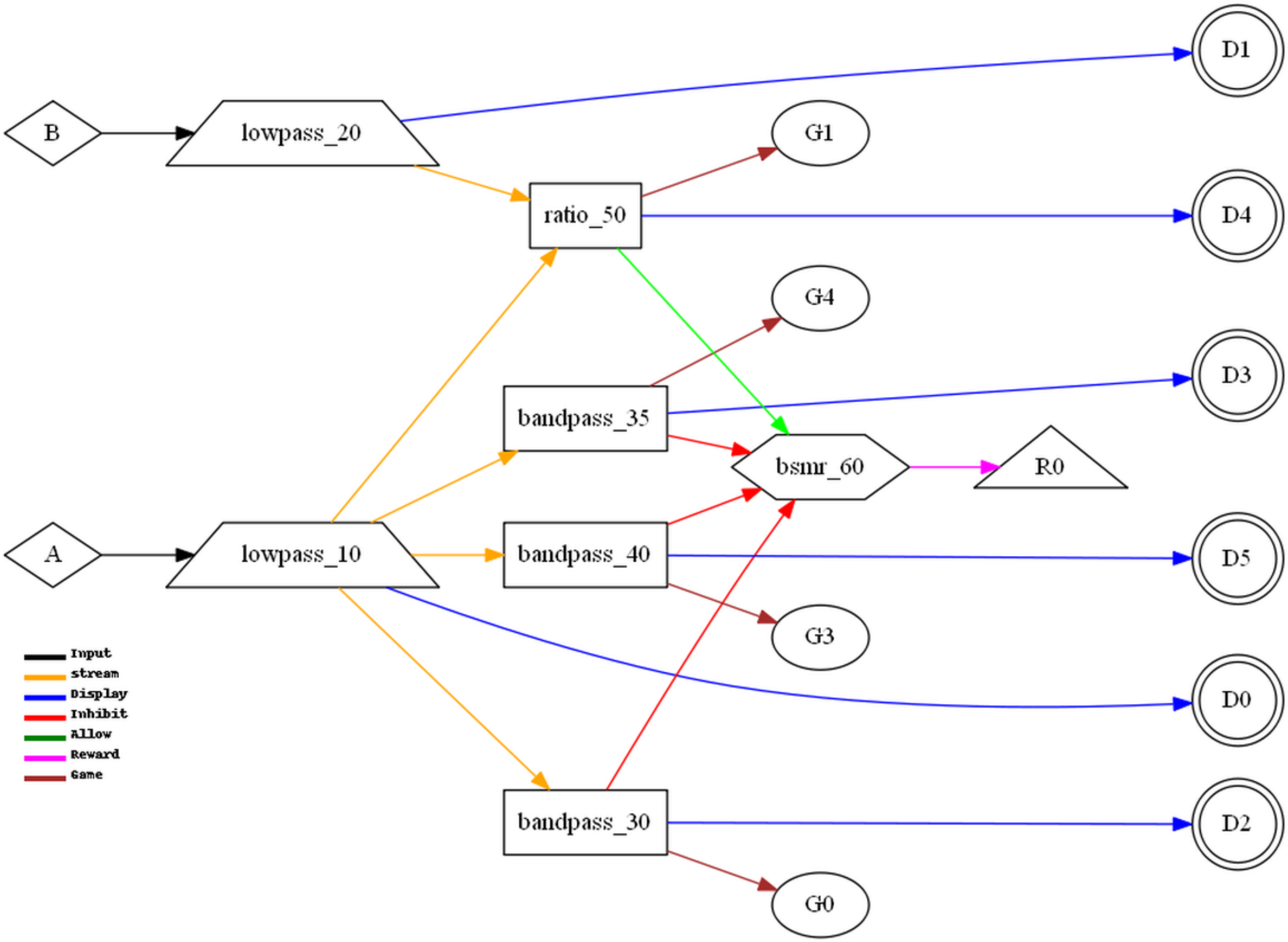
452 PDelta (B channel relationship to A channel) CCIIRI



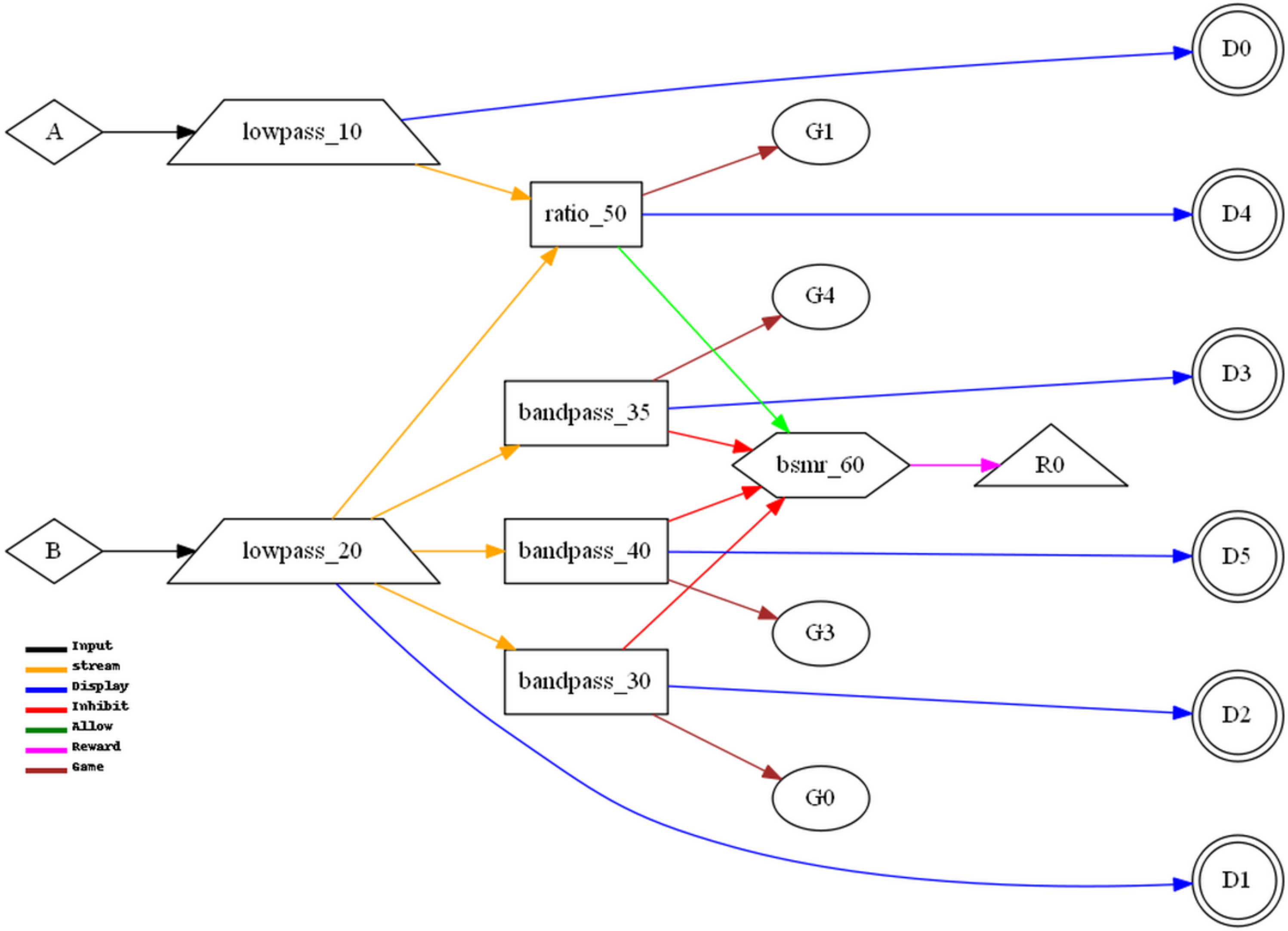
453 RatioA (Ratio of 2 streams from 1 channel) CCIIRI



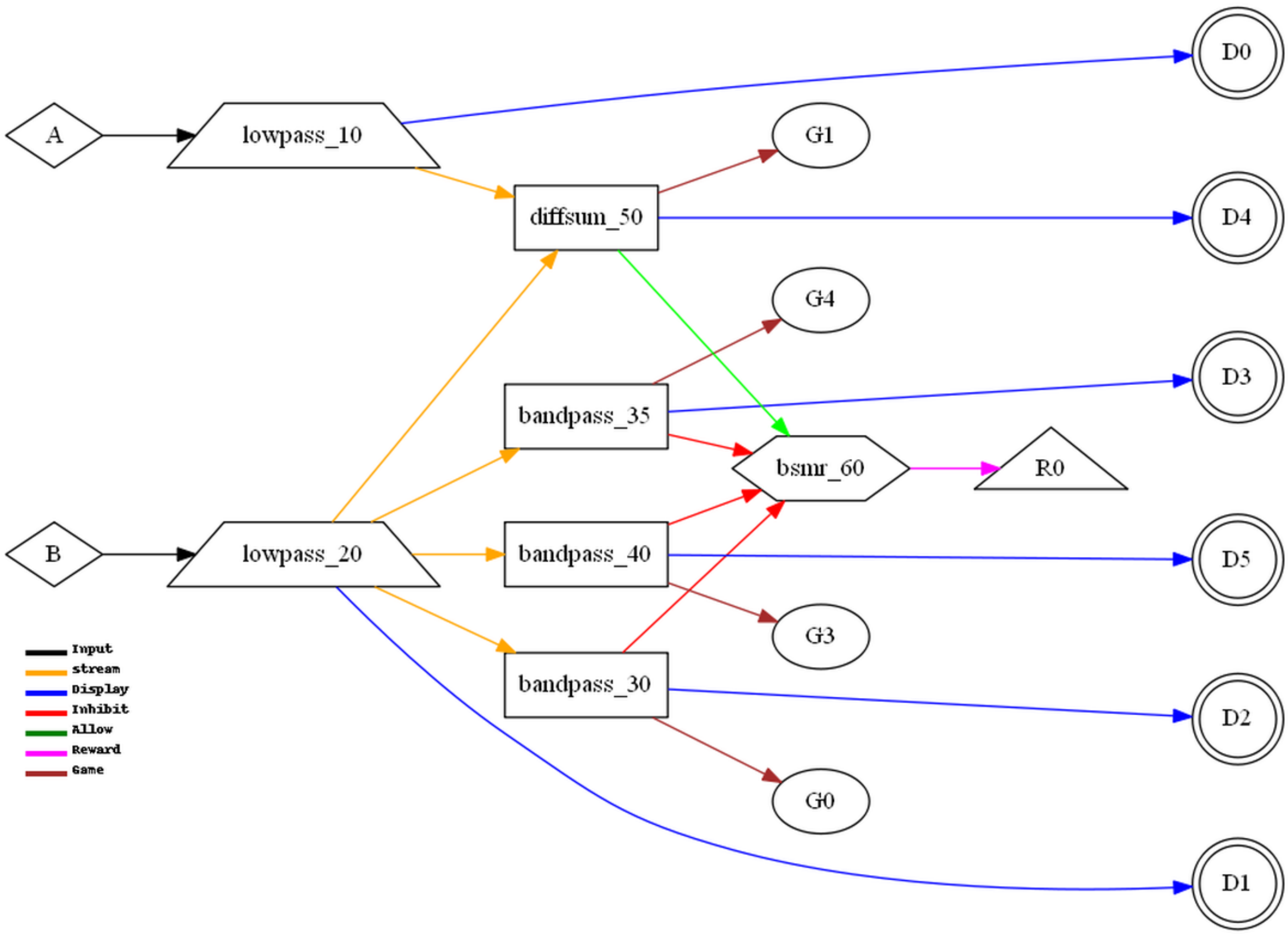
454 RatioB (Ratio of 2 streams from 1 channel) CCIIRI



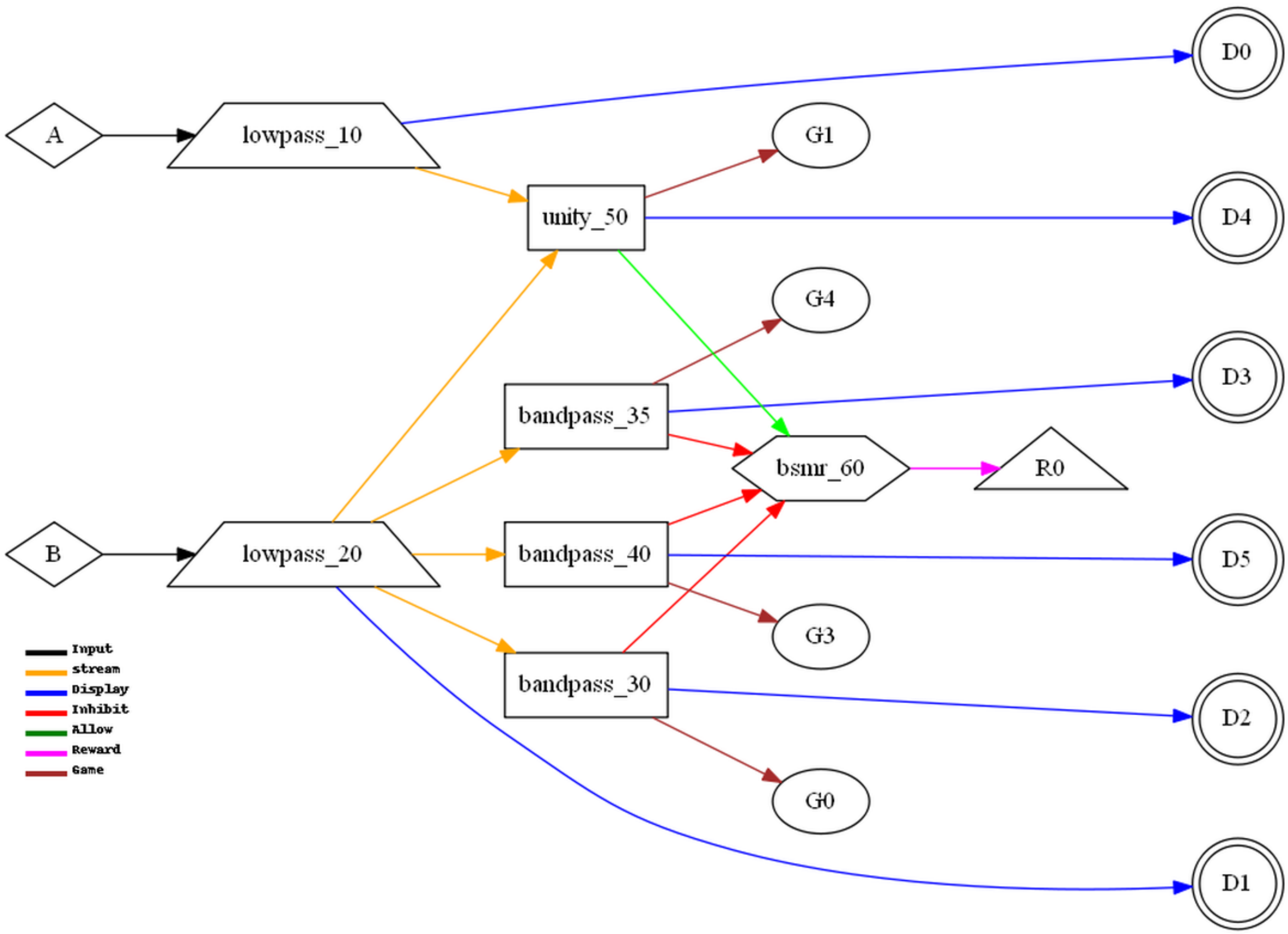
455 RatioAB (Ratio of A to B in reward band) CCIIRI



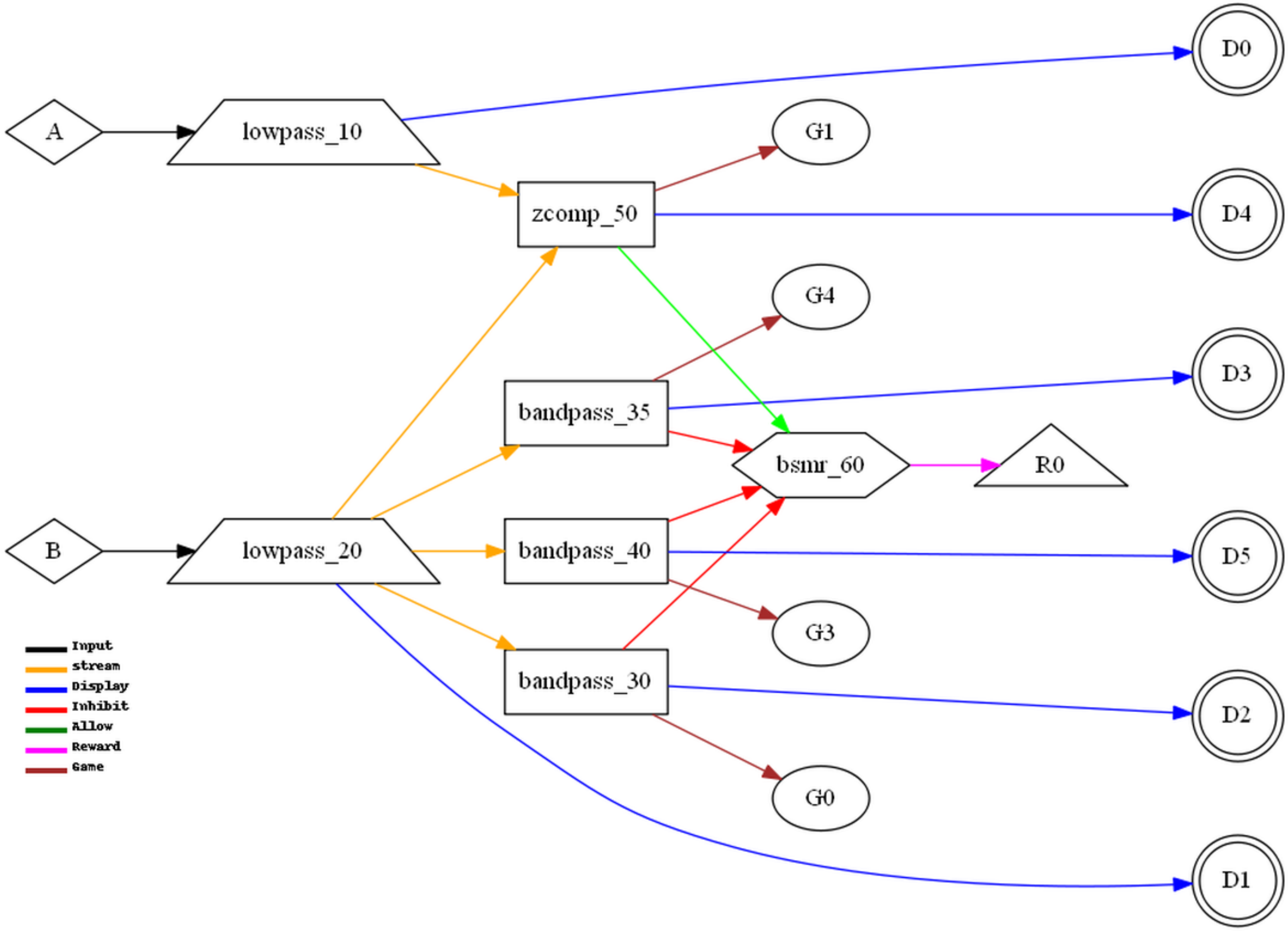
456 RatioBA (Ratio of B to A in reward band) CCIIRI



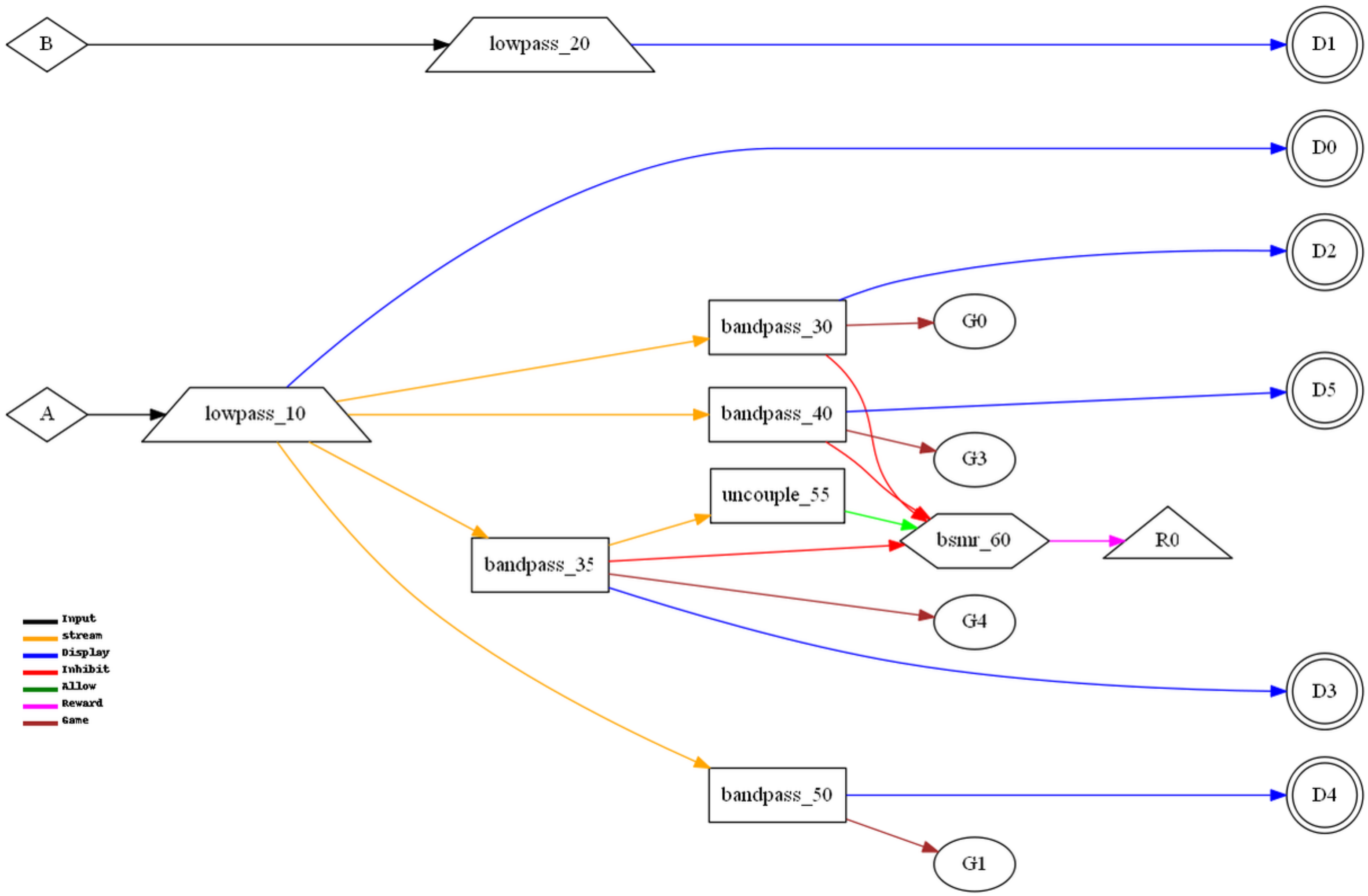
458 D/S-Ratio (Ratio of A-B to A+B) CCIIRI



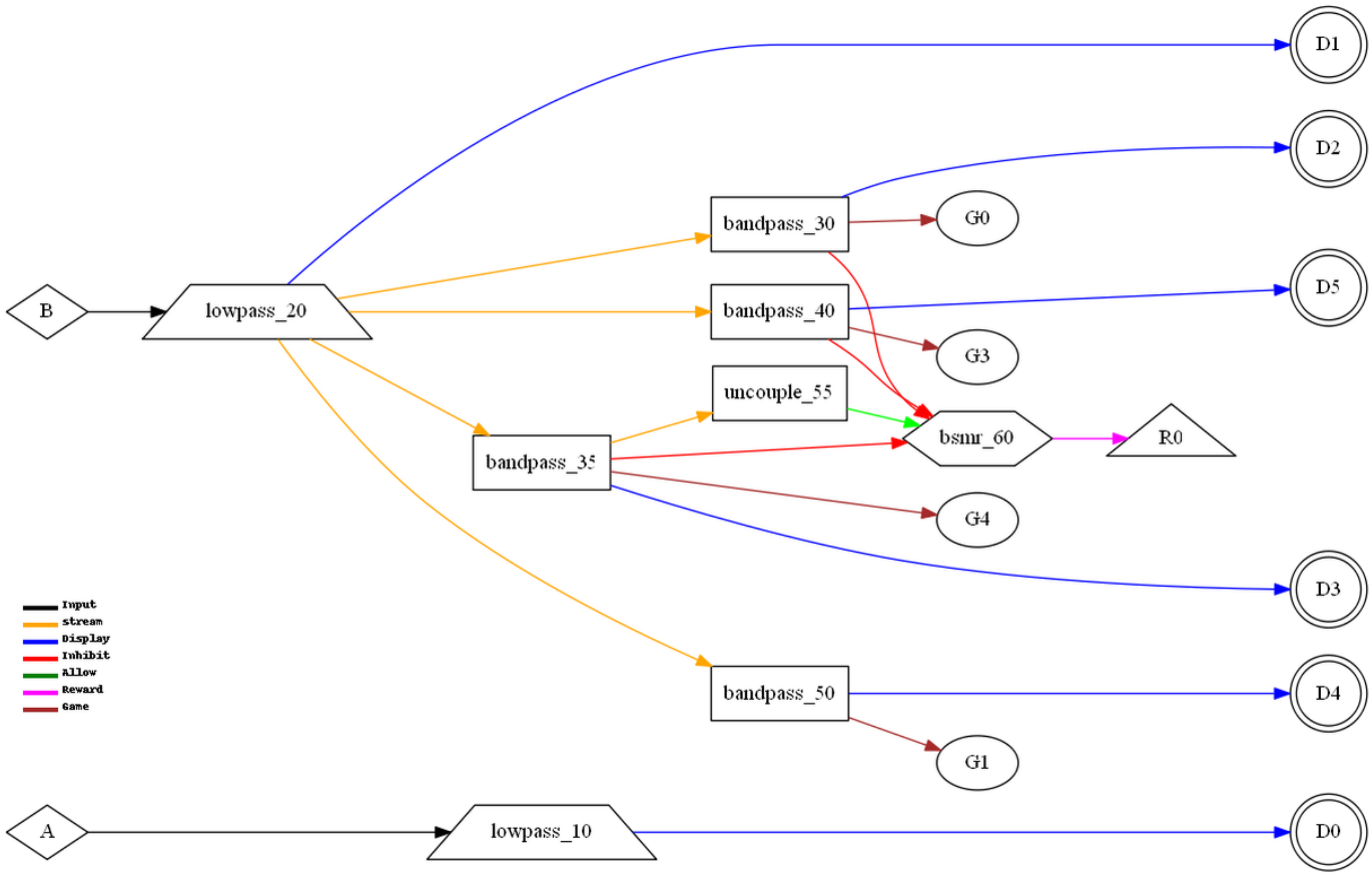
459 Unity (1-Ratio of A-B to A+B) CCIIRI



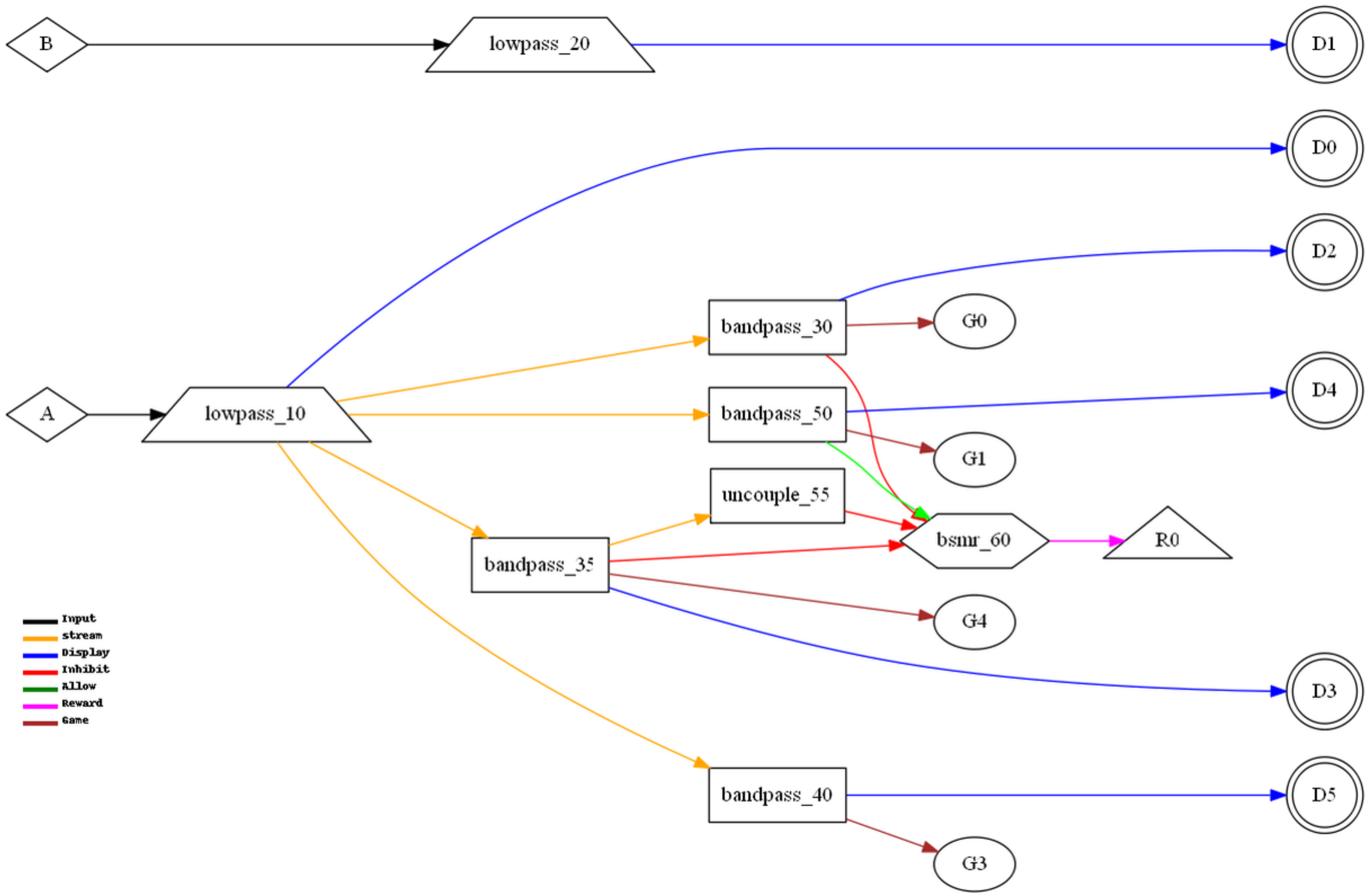
480 ZCompAB (ZComposite) CCIIRI



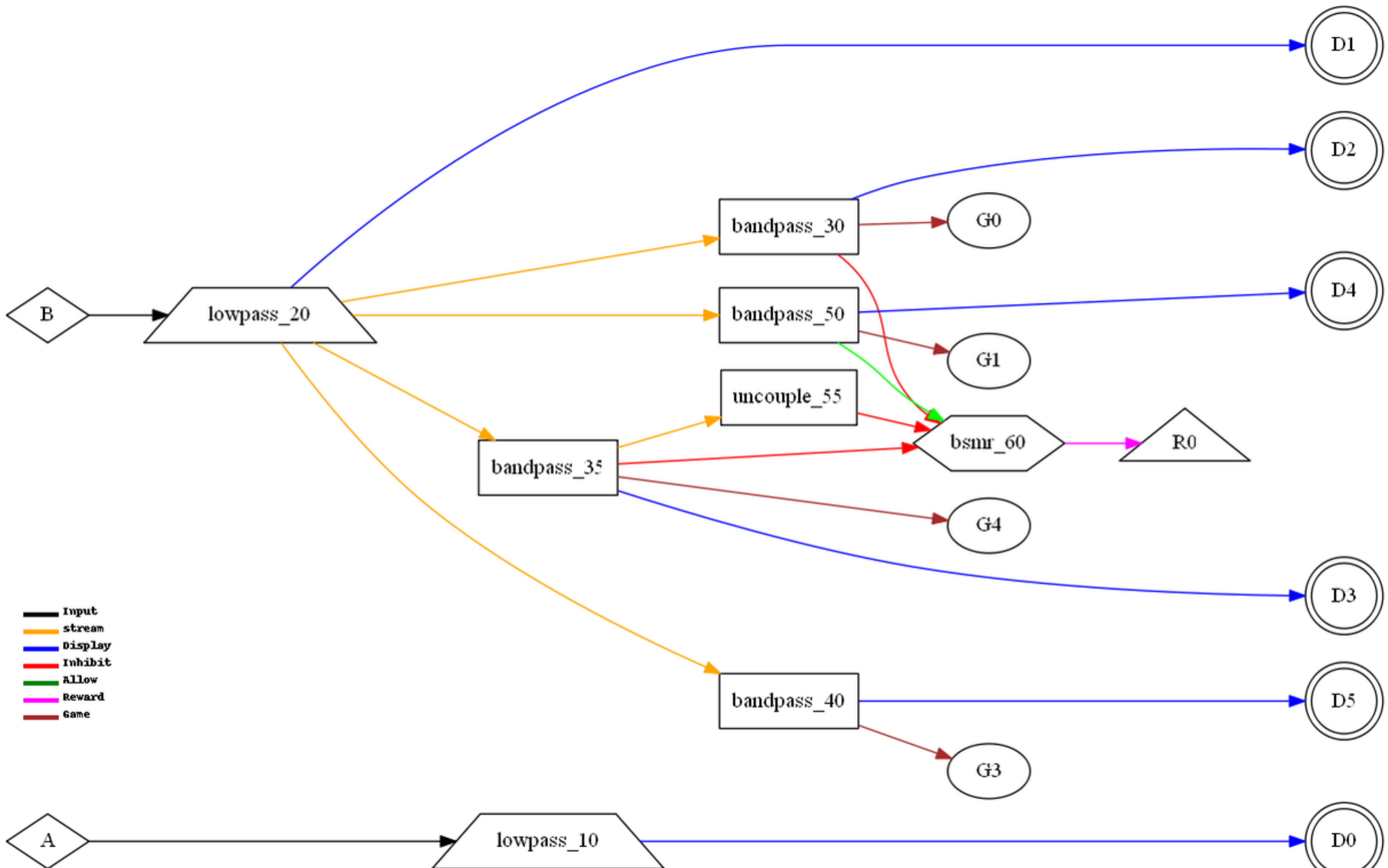
464 UncAiRew (Uncouple Rew A) CCIIRI



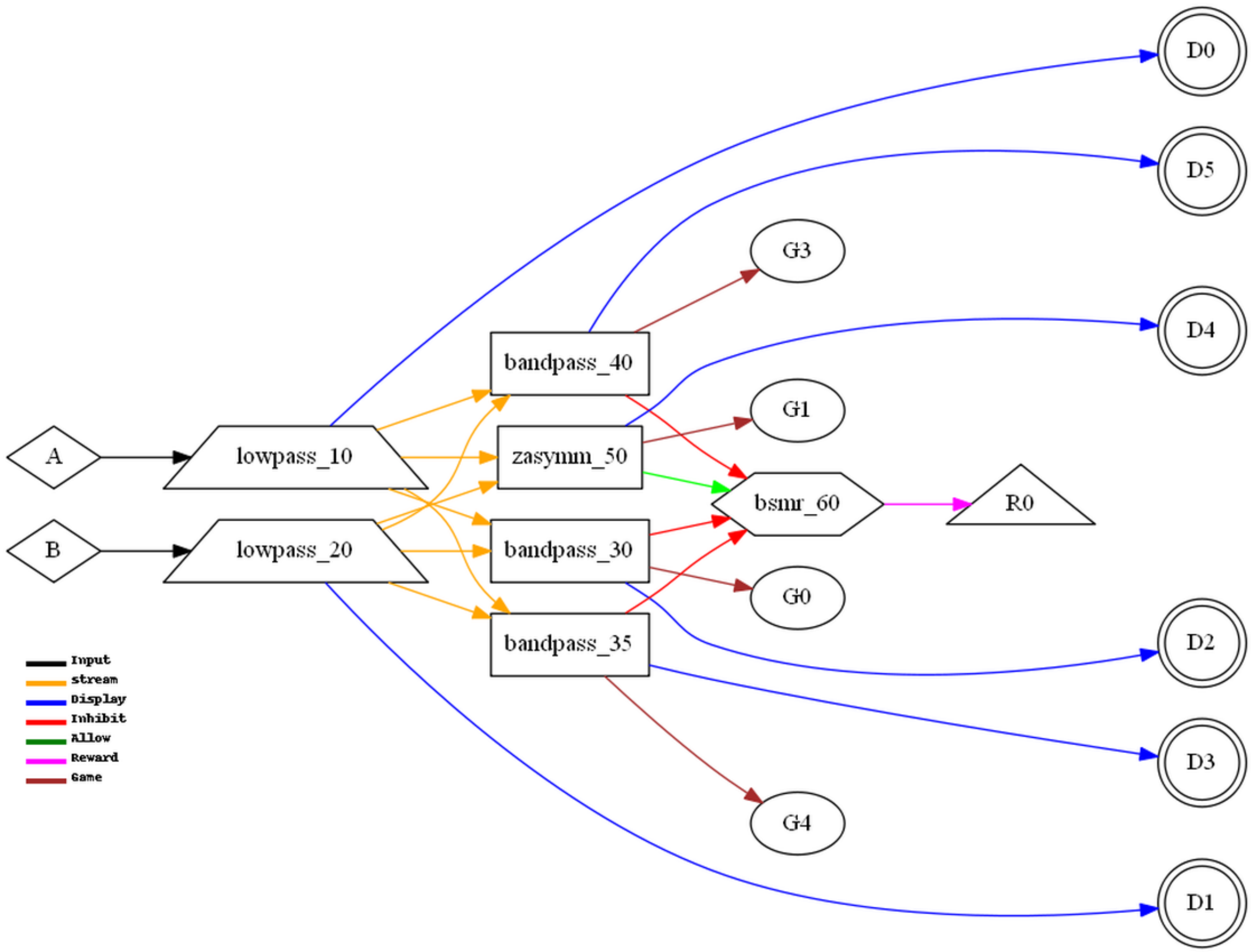
465 UncBiRew (Uncouple Rew B) CCIIRI



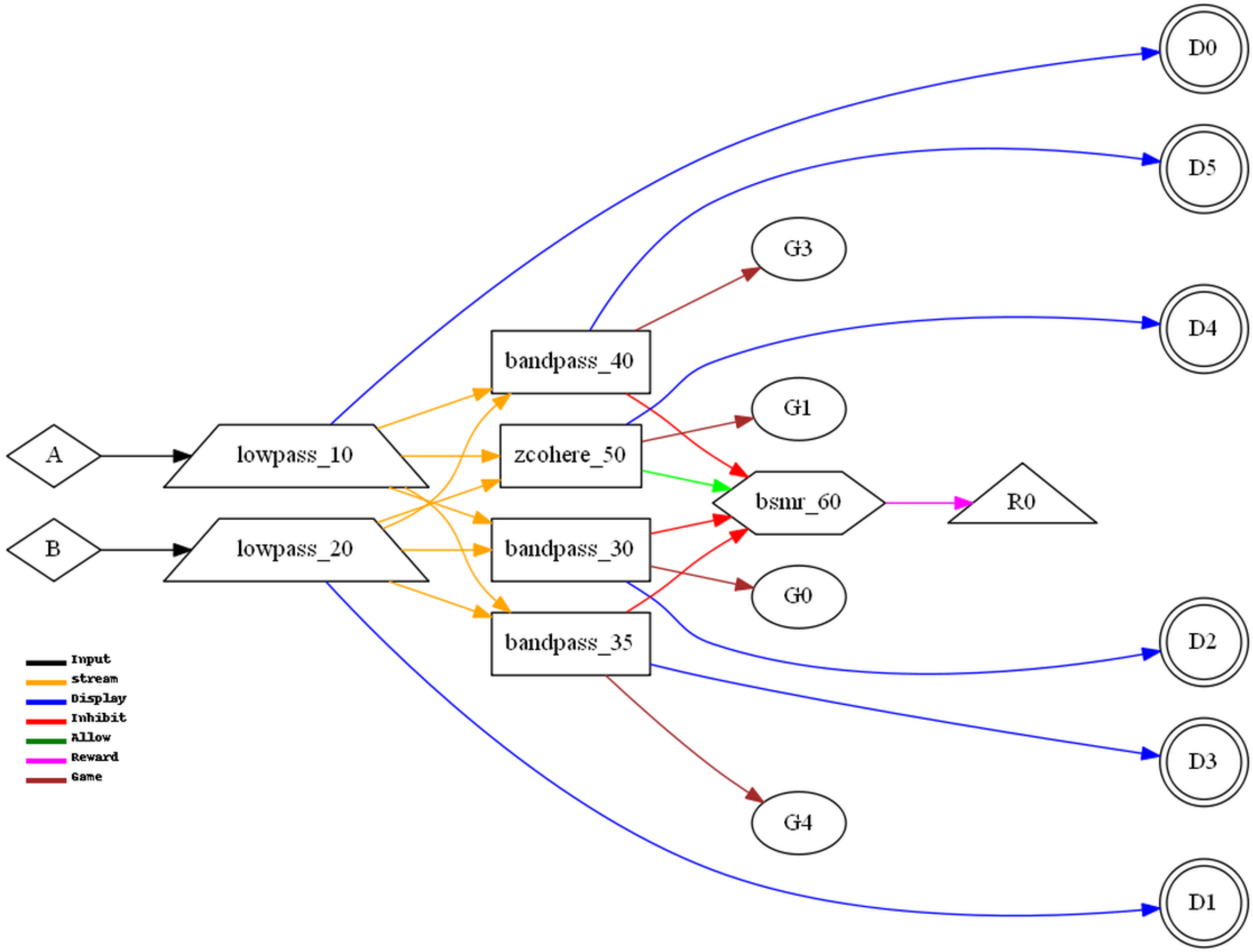
466 UncAiHiB (Uncouple HiB A) CCIIRI



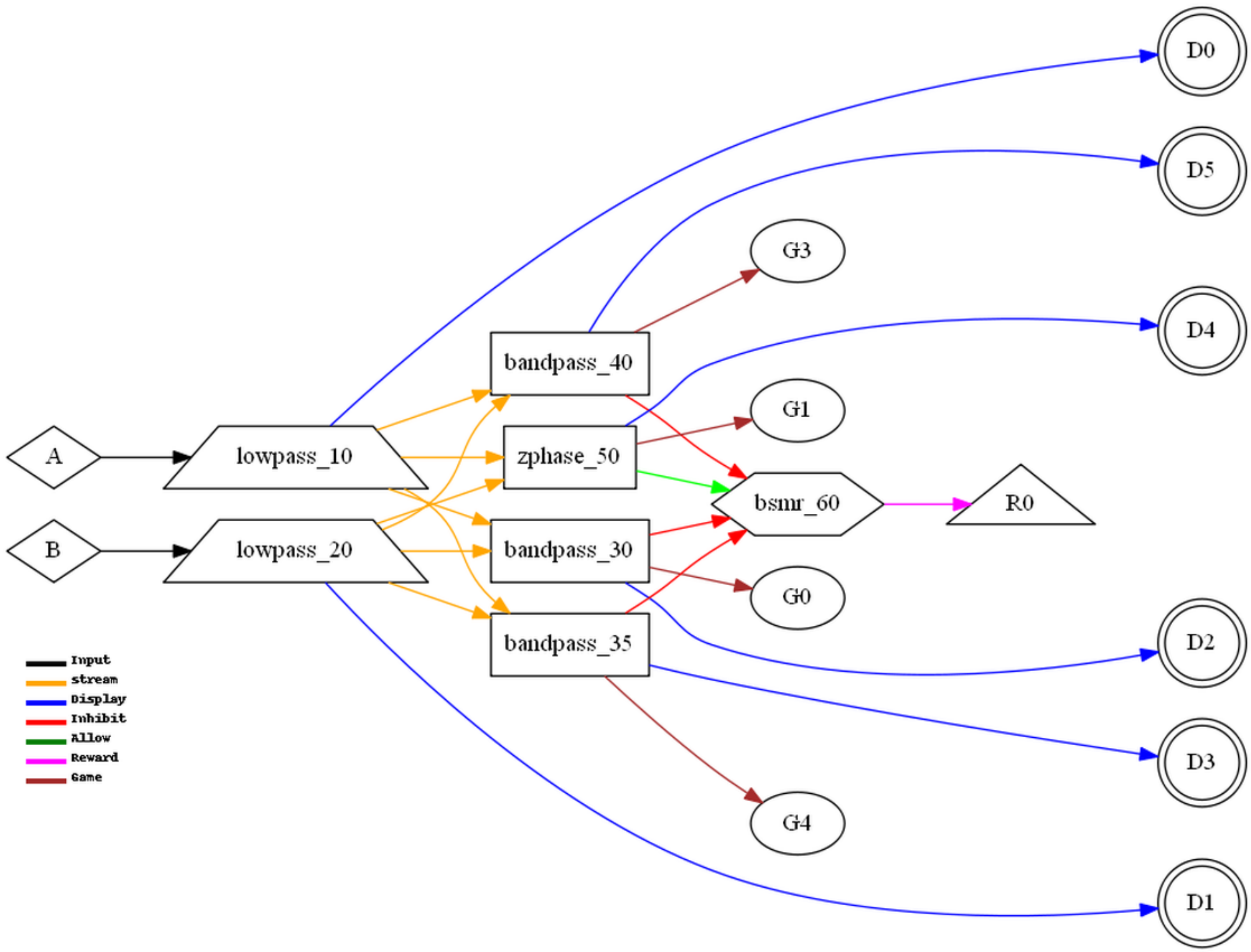
467 UncBiHiB (Uncouple HiB B) CCIIRI



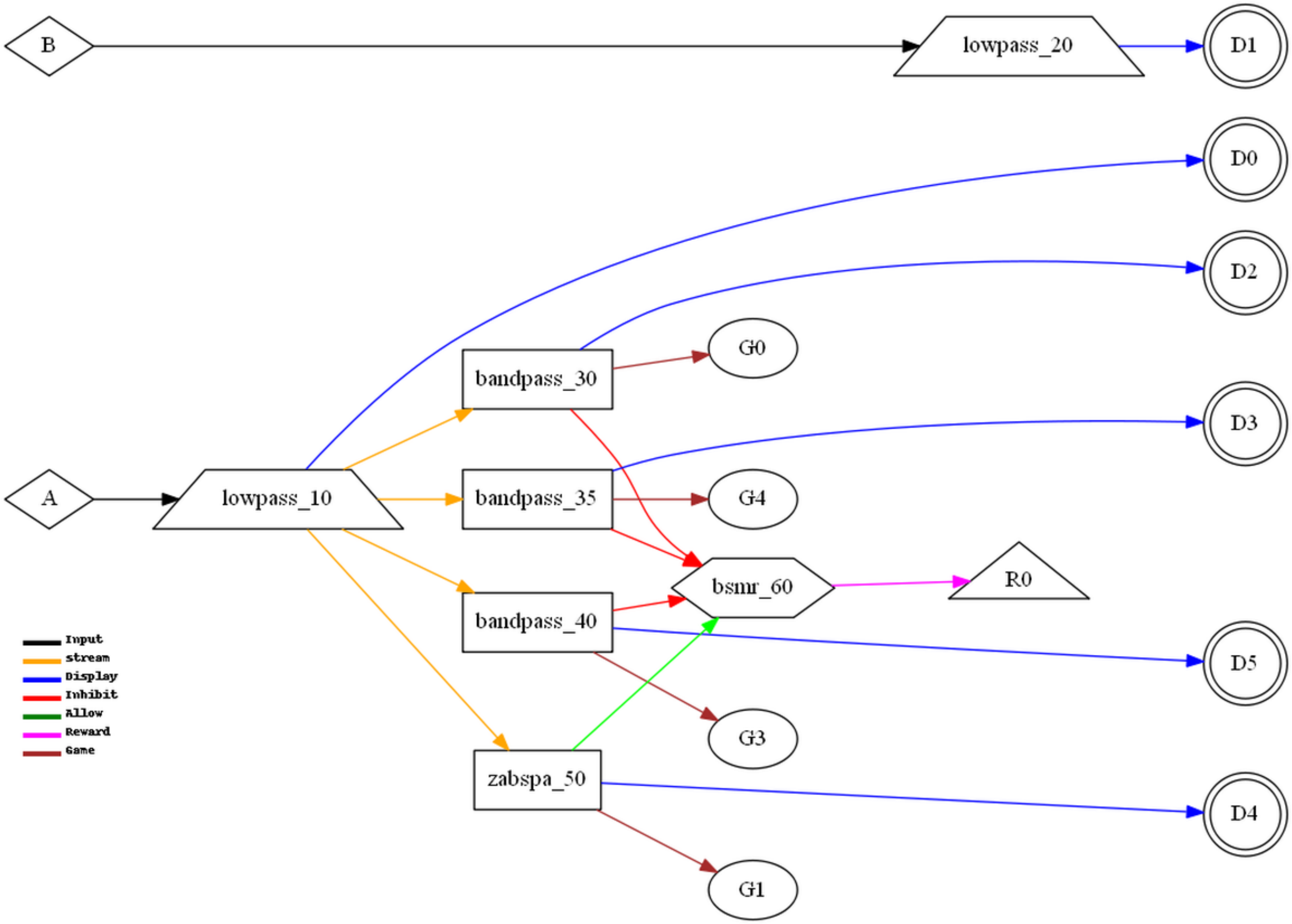
710 ZAsymm (Zscore amplitude asymmetry) CCIIRI



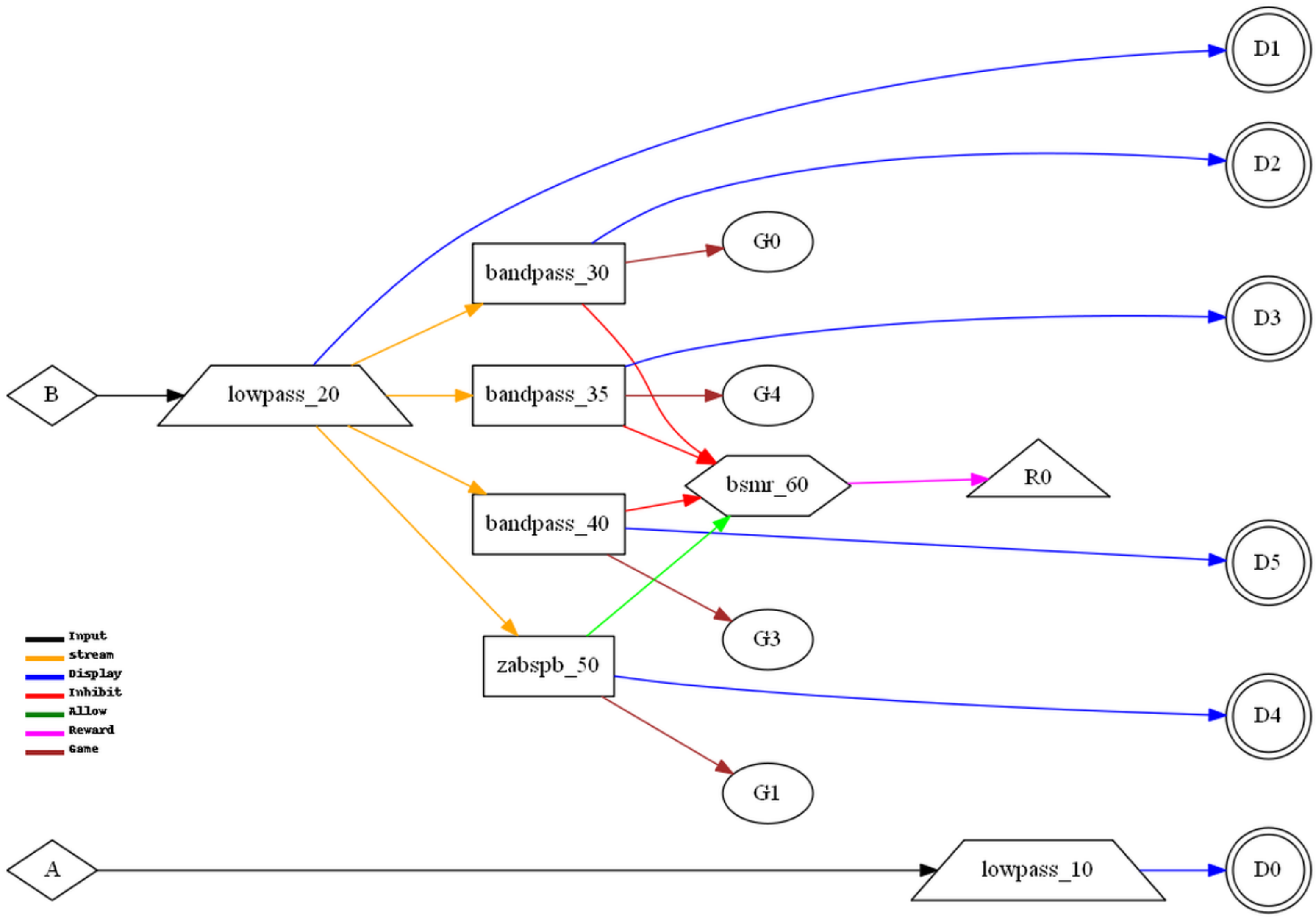
711 ZCohere (Zscore coherence) CCIIRI



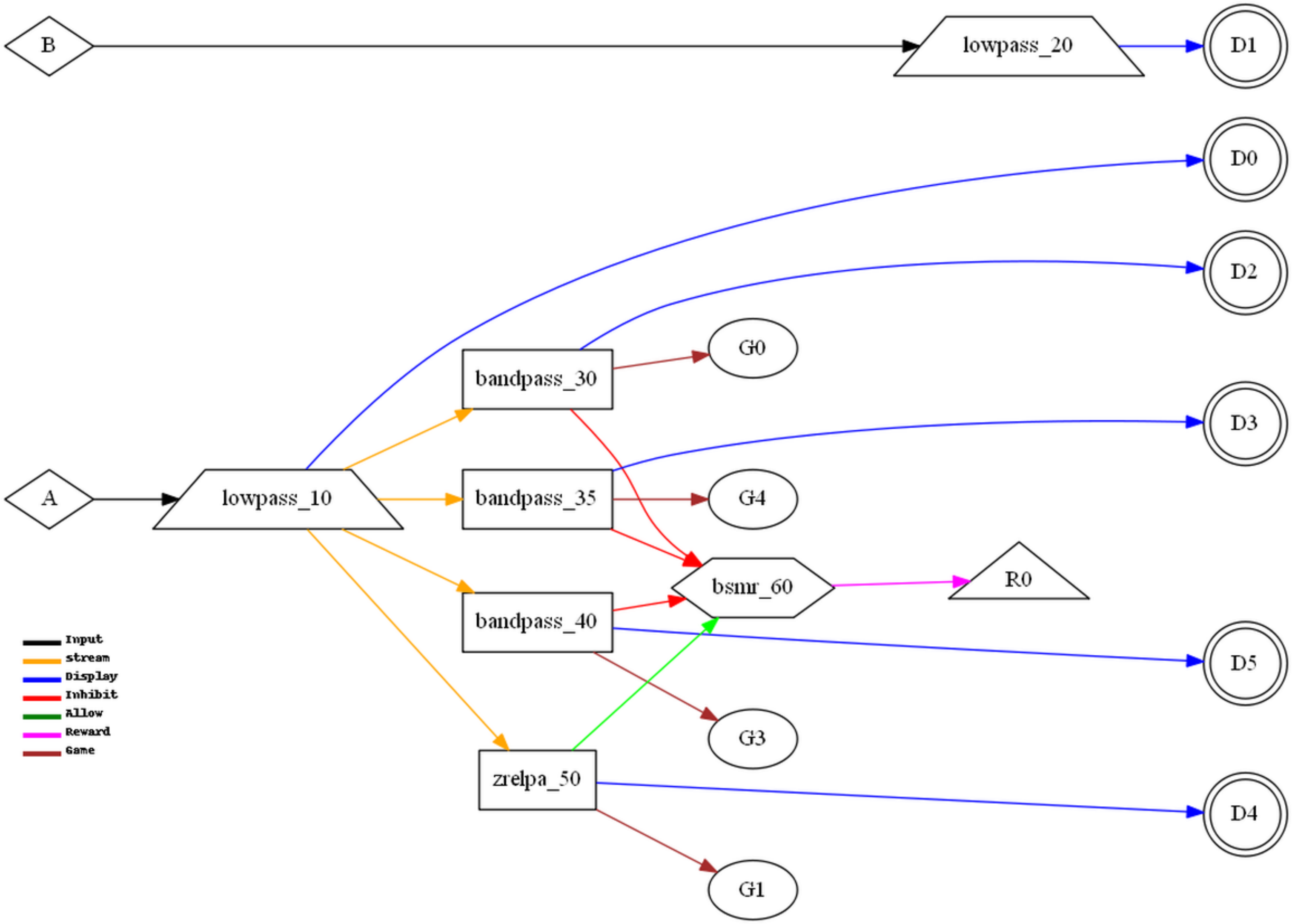
712 ZPhase (Zscore phase) CCIIRI



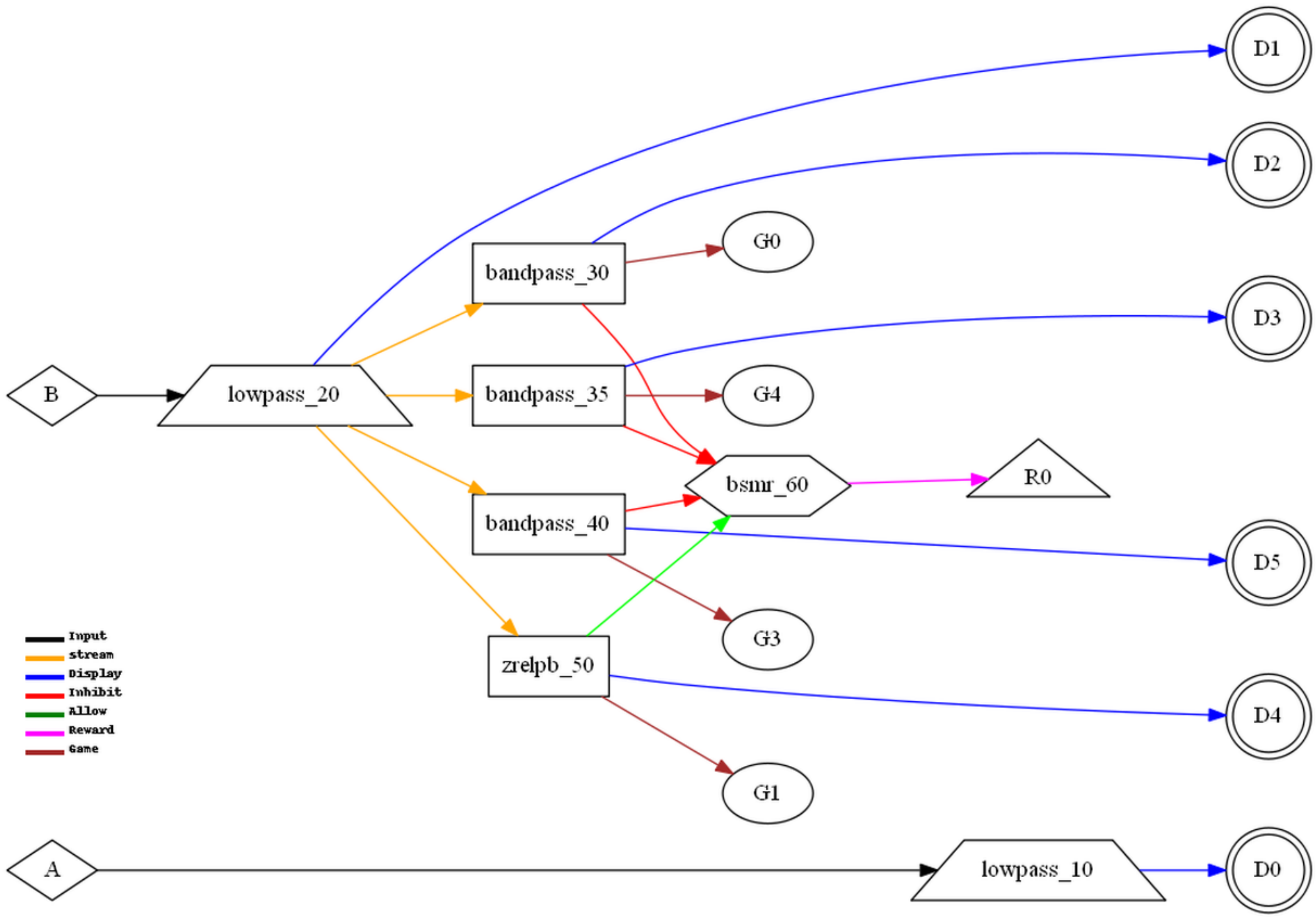
713 ZAbsPwrA (Zscore Abs Amp A) CCIIRI



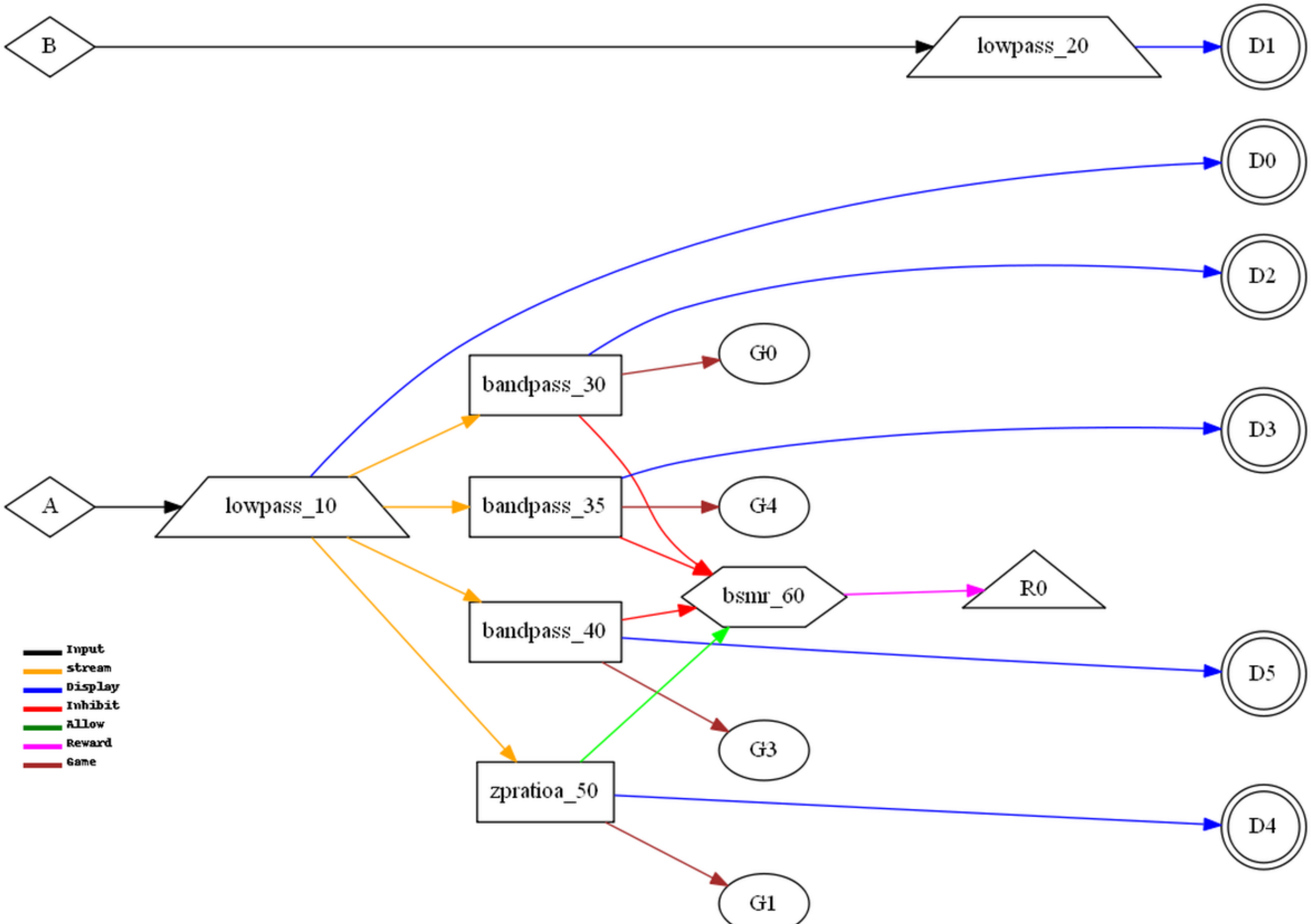
714 ZAbsPwrB (Zscore Abs Amp B) CCIIRI



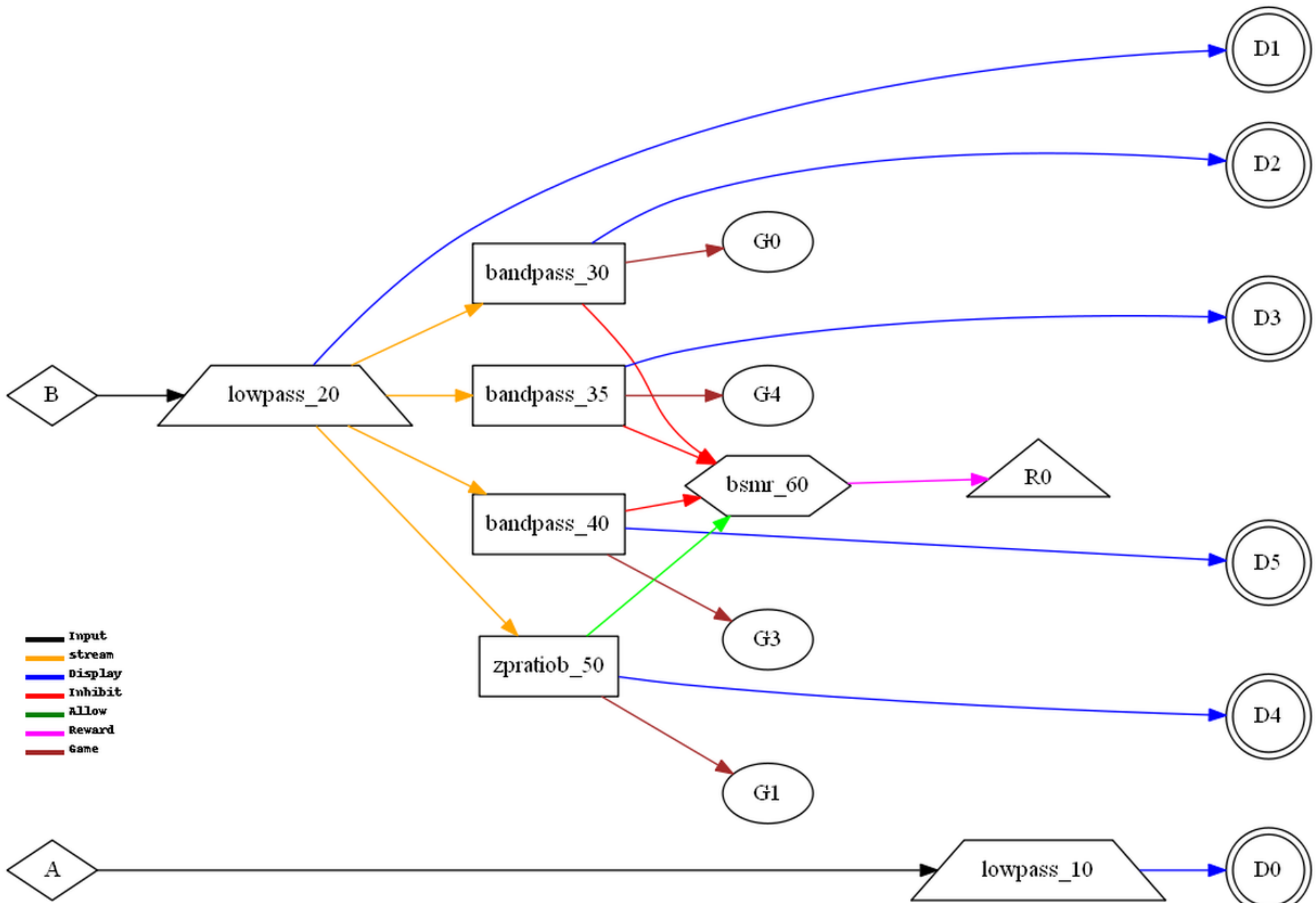
715 ZRelPwrA (Zscore Rel Pwr A) CCIIRI



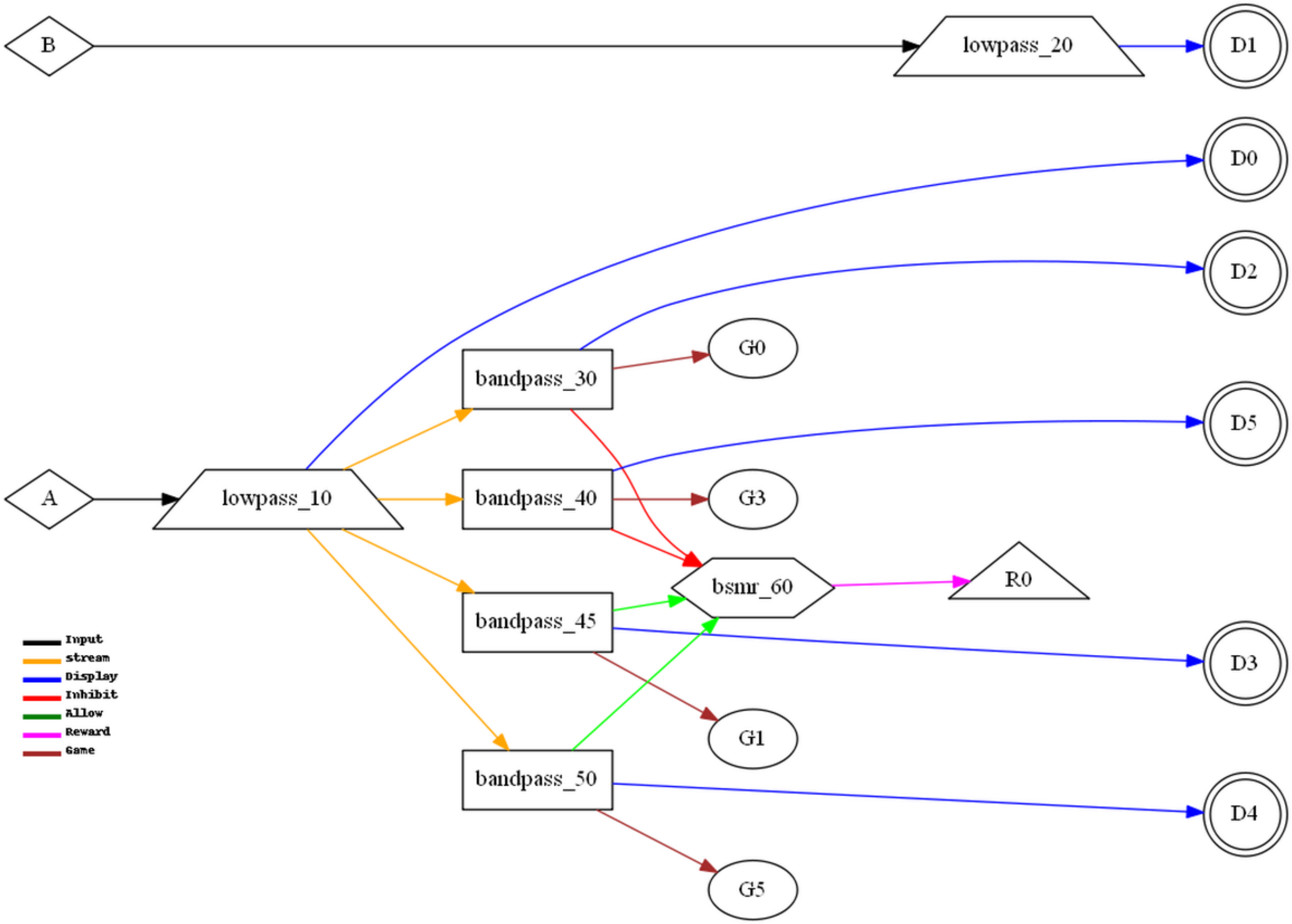
716 ZRelPwrB (Zscore Rel Pwr B) CCIIRI



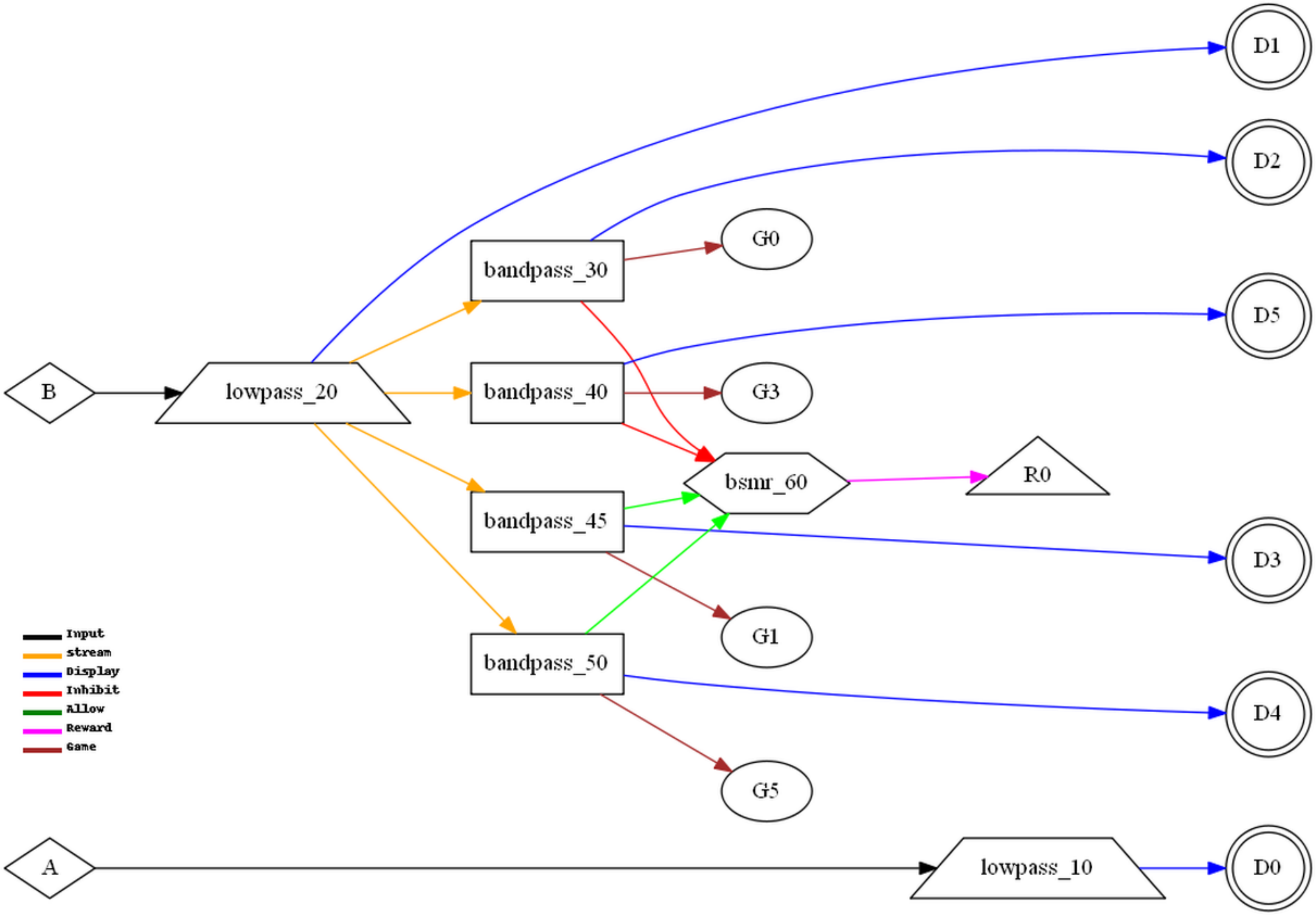
717 ZPRatioA (Zscore Power ratio A) CCIIRI



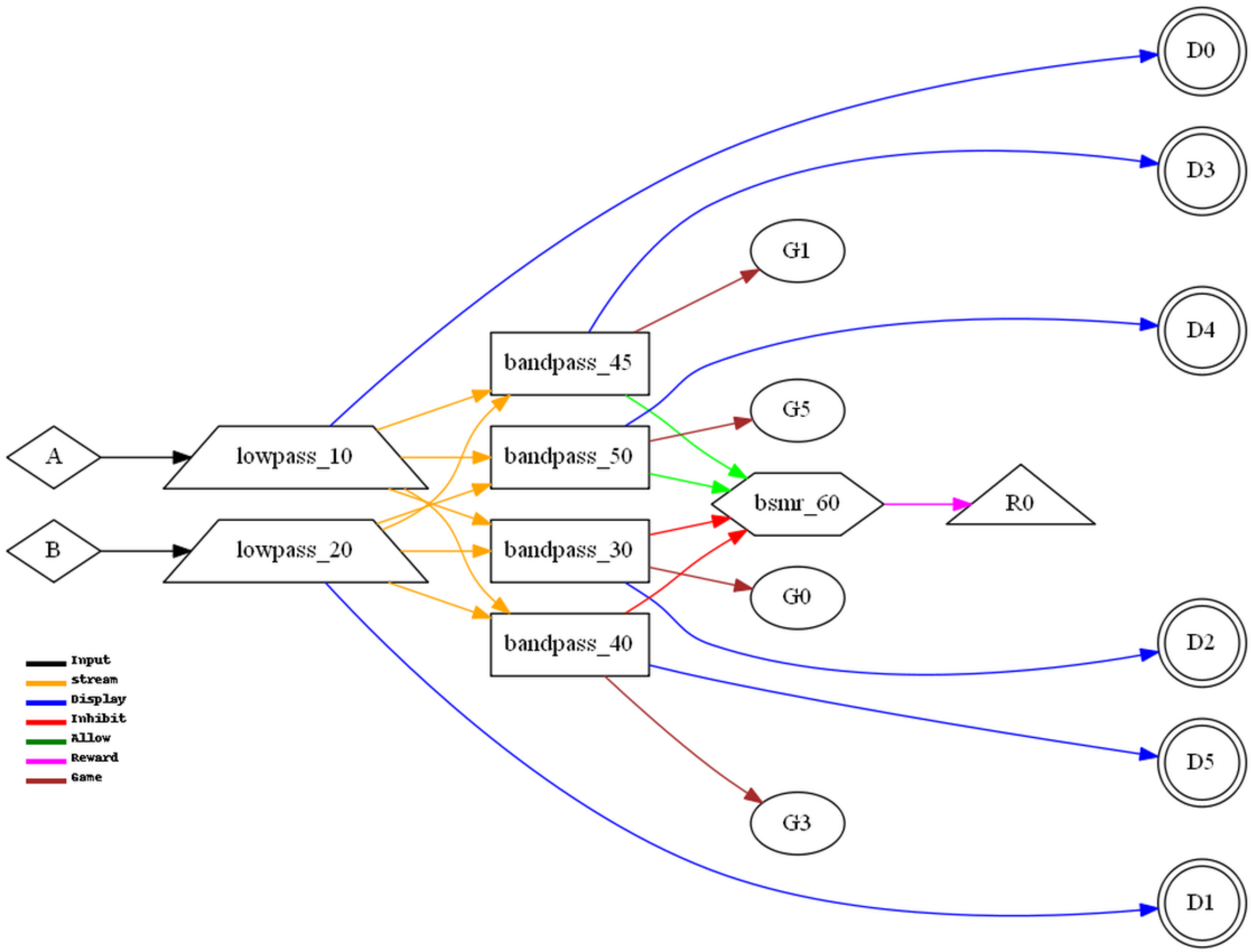
718 ZPRatioB (Zscore Power ratio B) CCIIRI



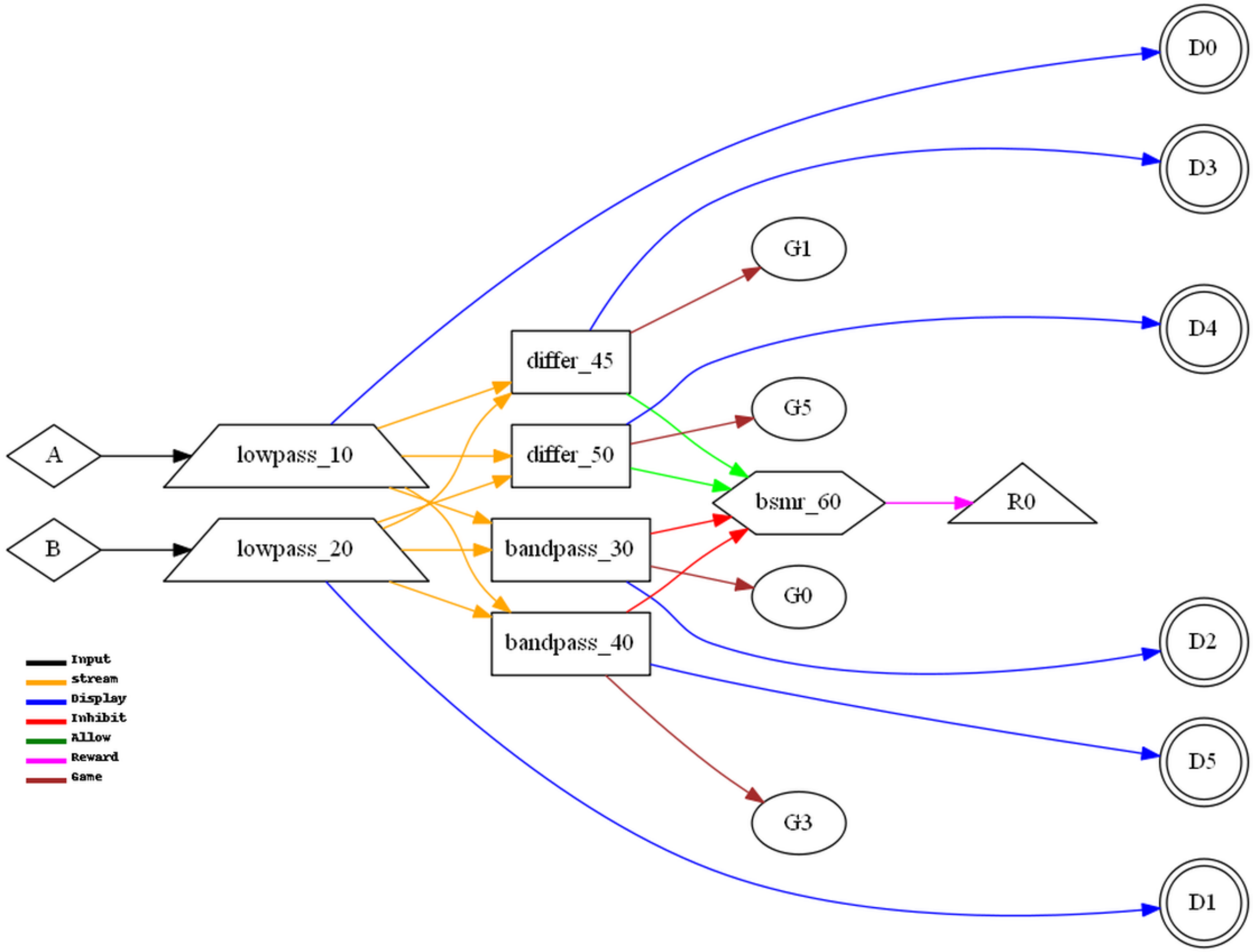
602 SingleA (one channel of data input) CCIRRI



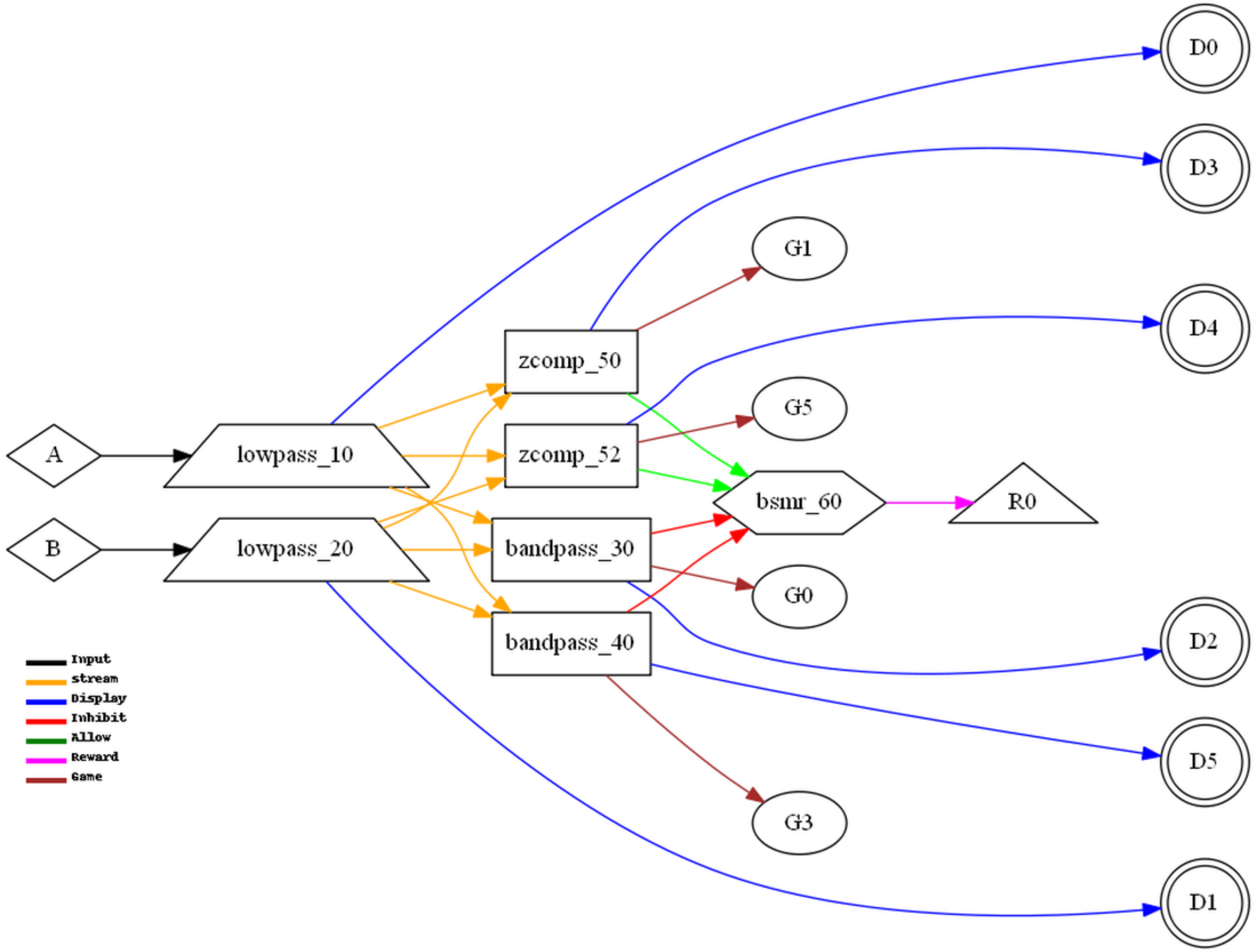
603 SingleB (one channel of data input) CCIRRI



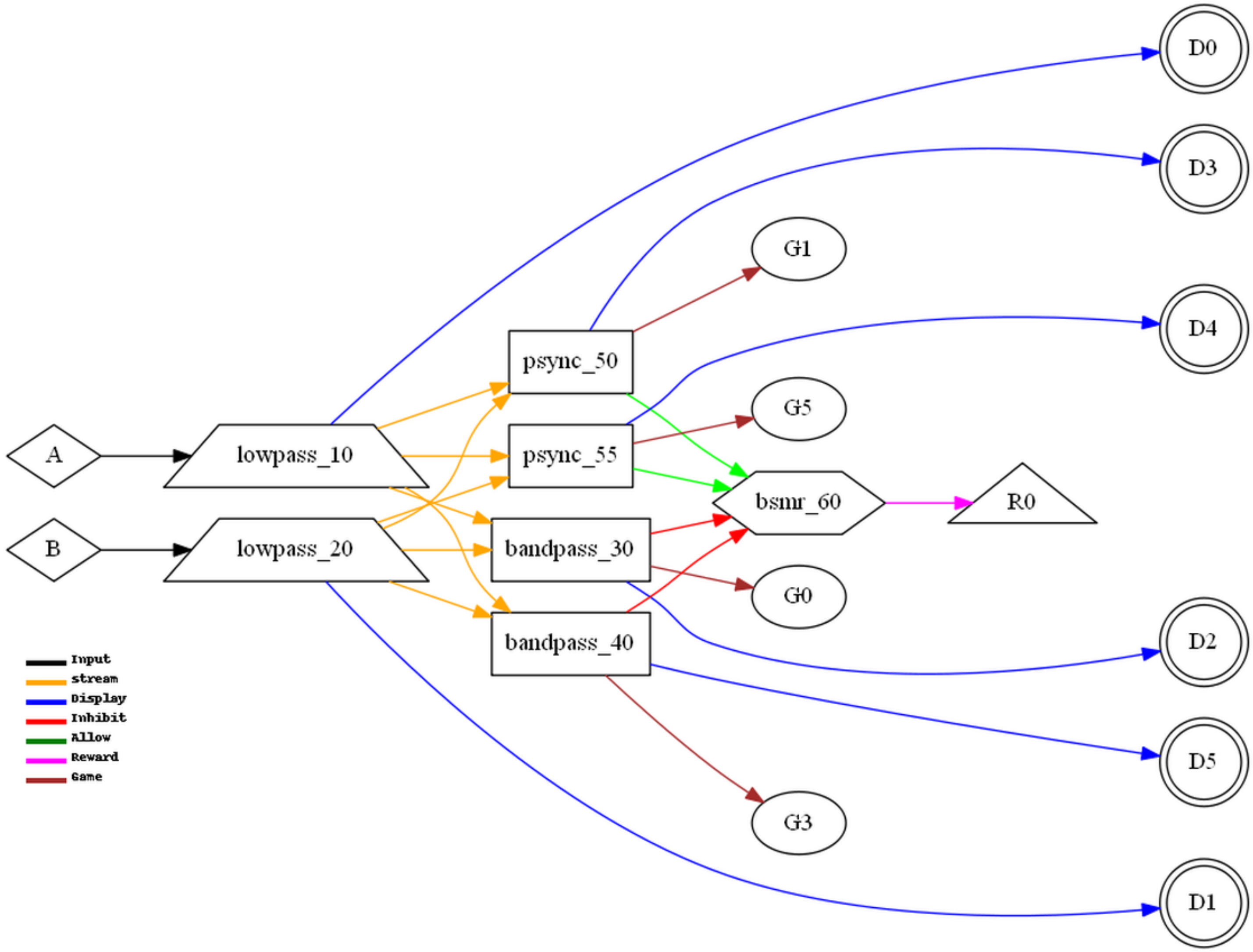
612 Sum (sum of two channels of data input) CCIRRI



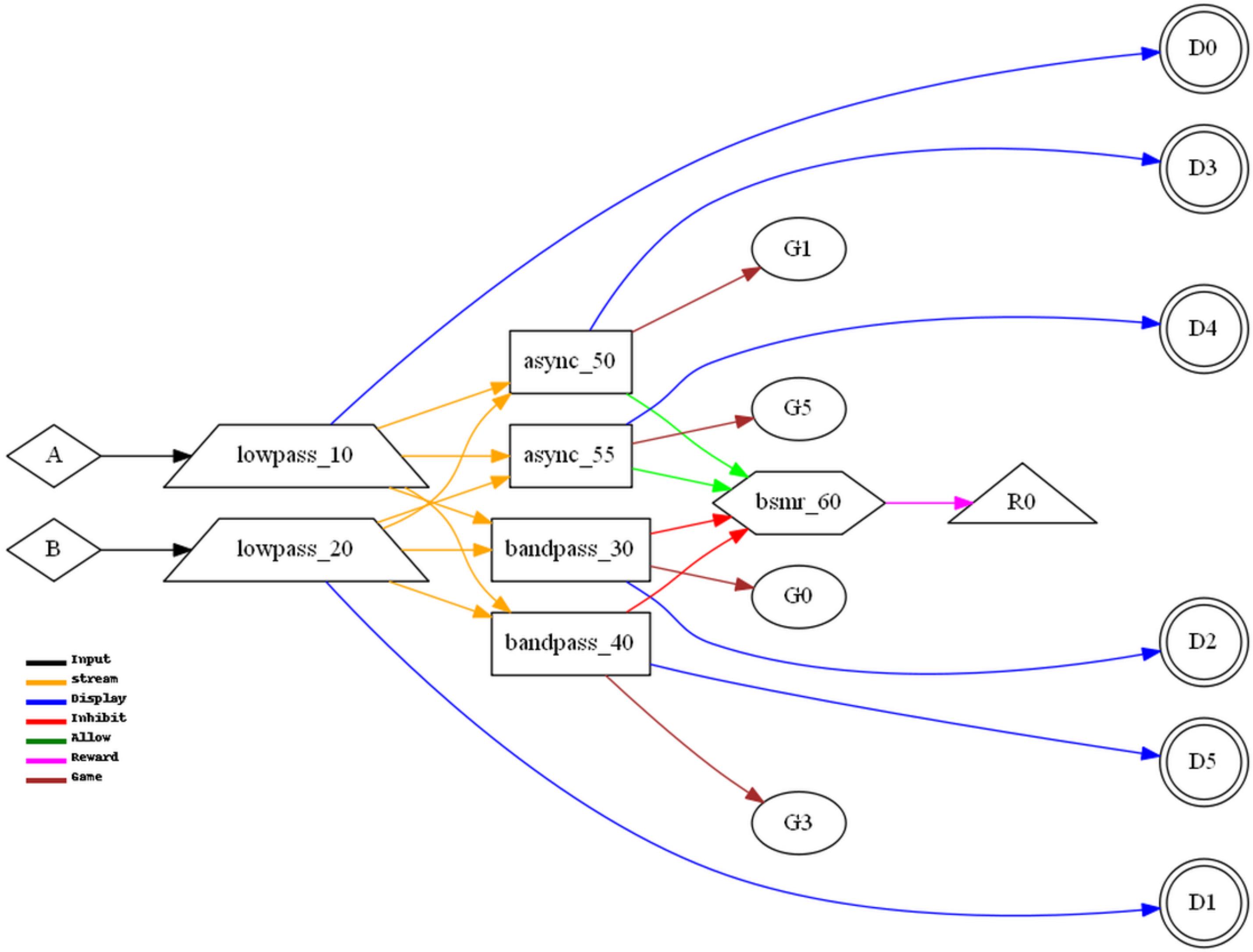
613 Differ (channel A minus channel B) CCIRRI



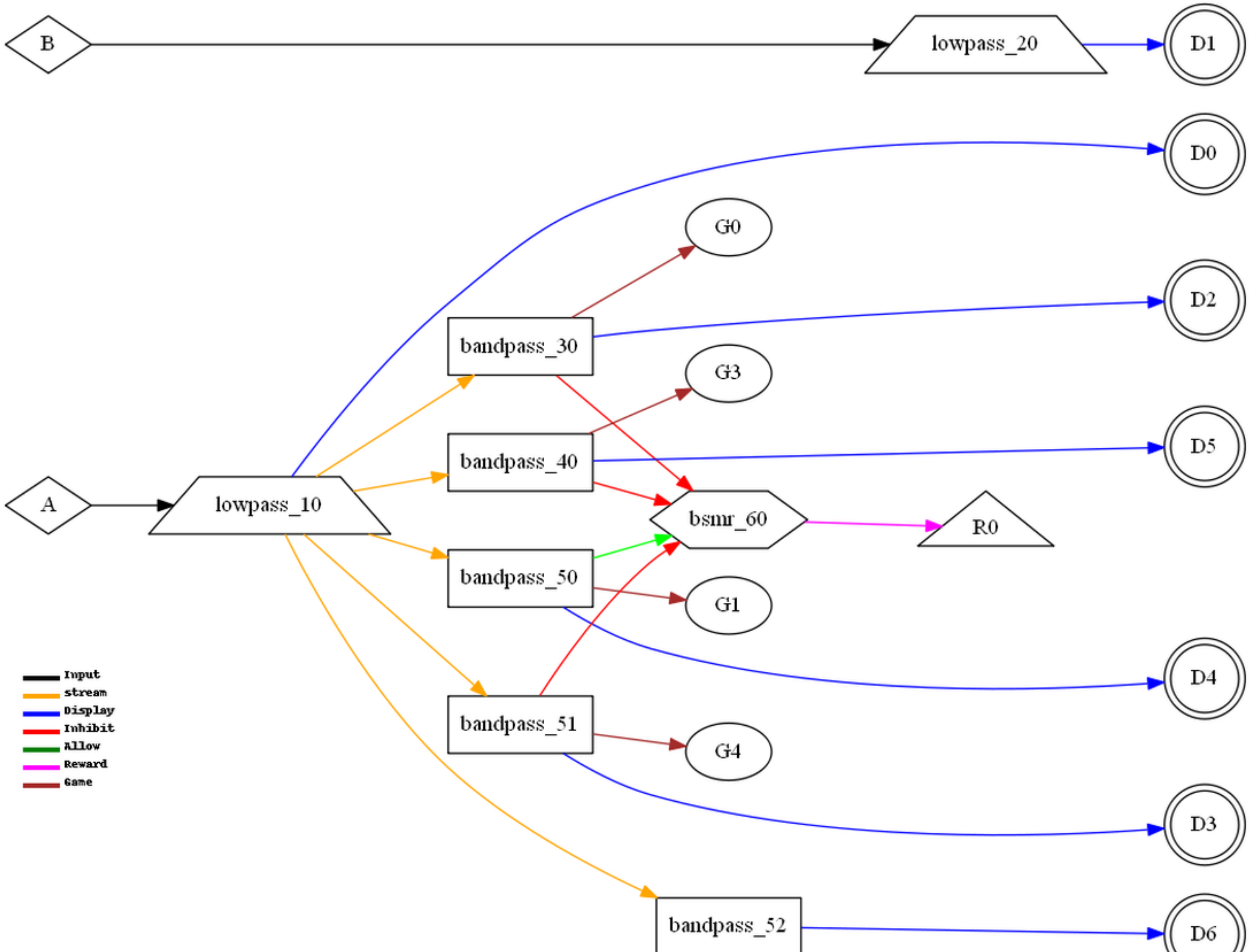
680 ZCompAB (ZComposite) CCIRRI



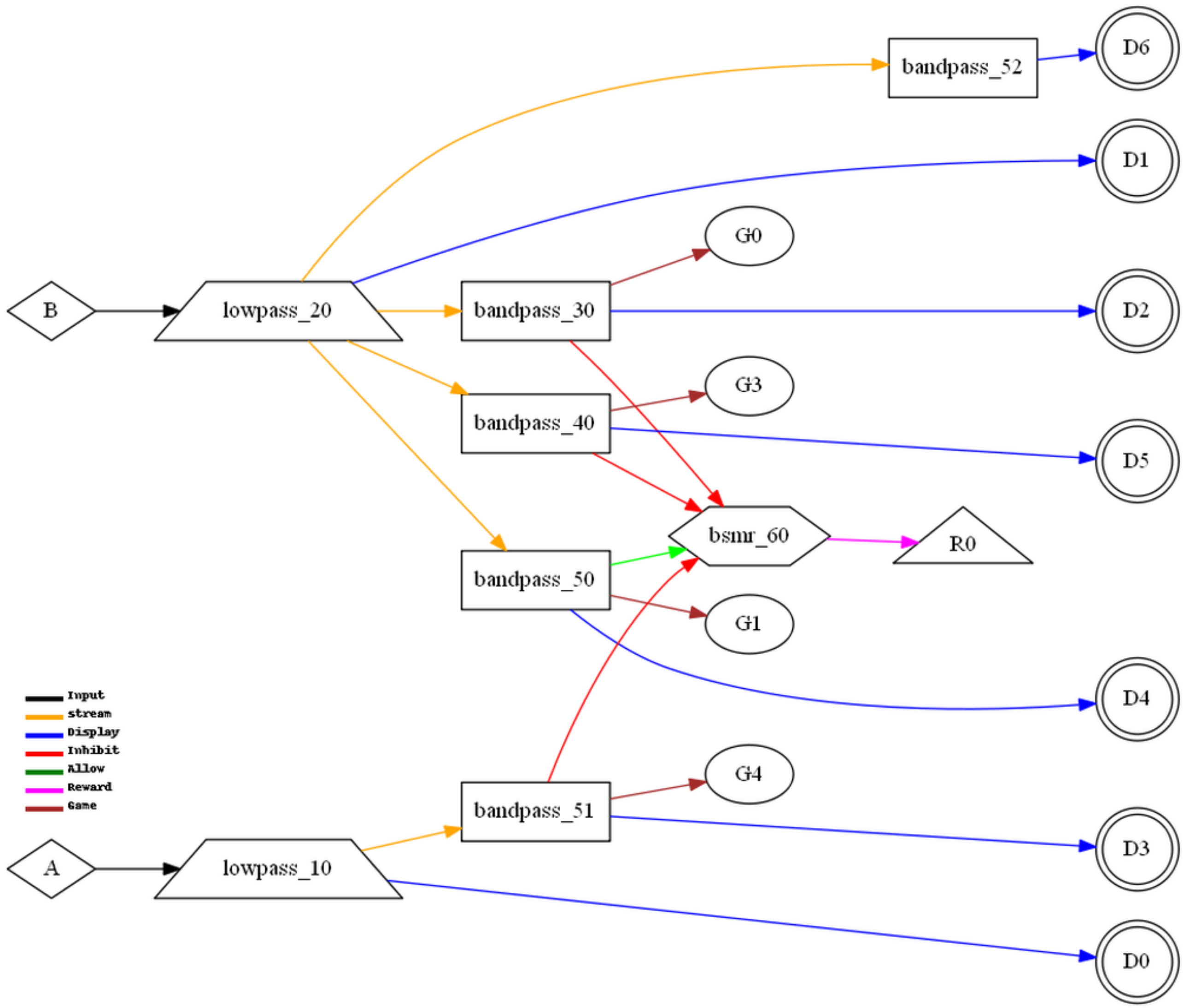
634 PsyncABAB (comodulation measure AB twice) CCIRRI



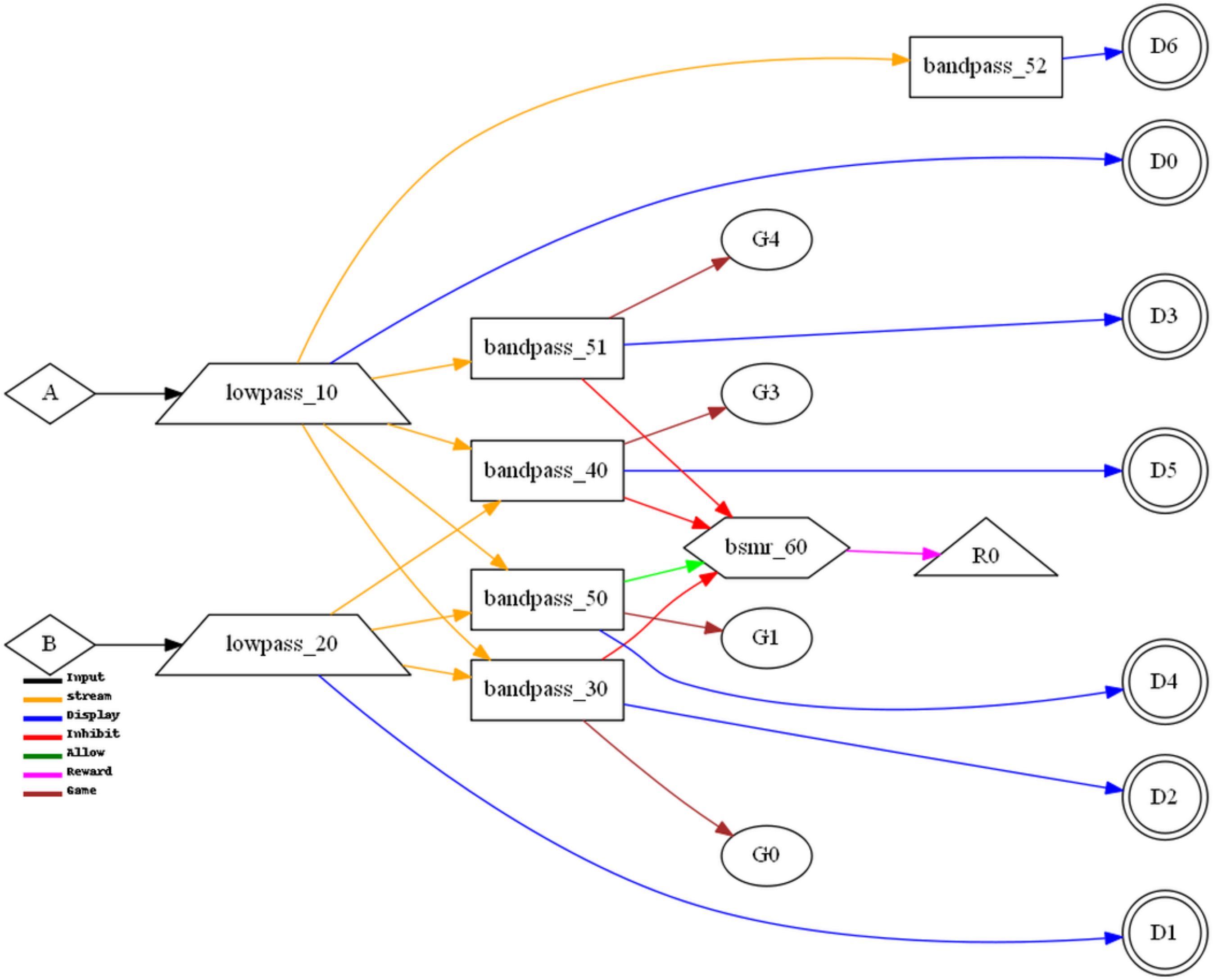
631 AsyncABAB (two async measure between channel A and B) CCIRRI



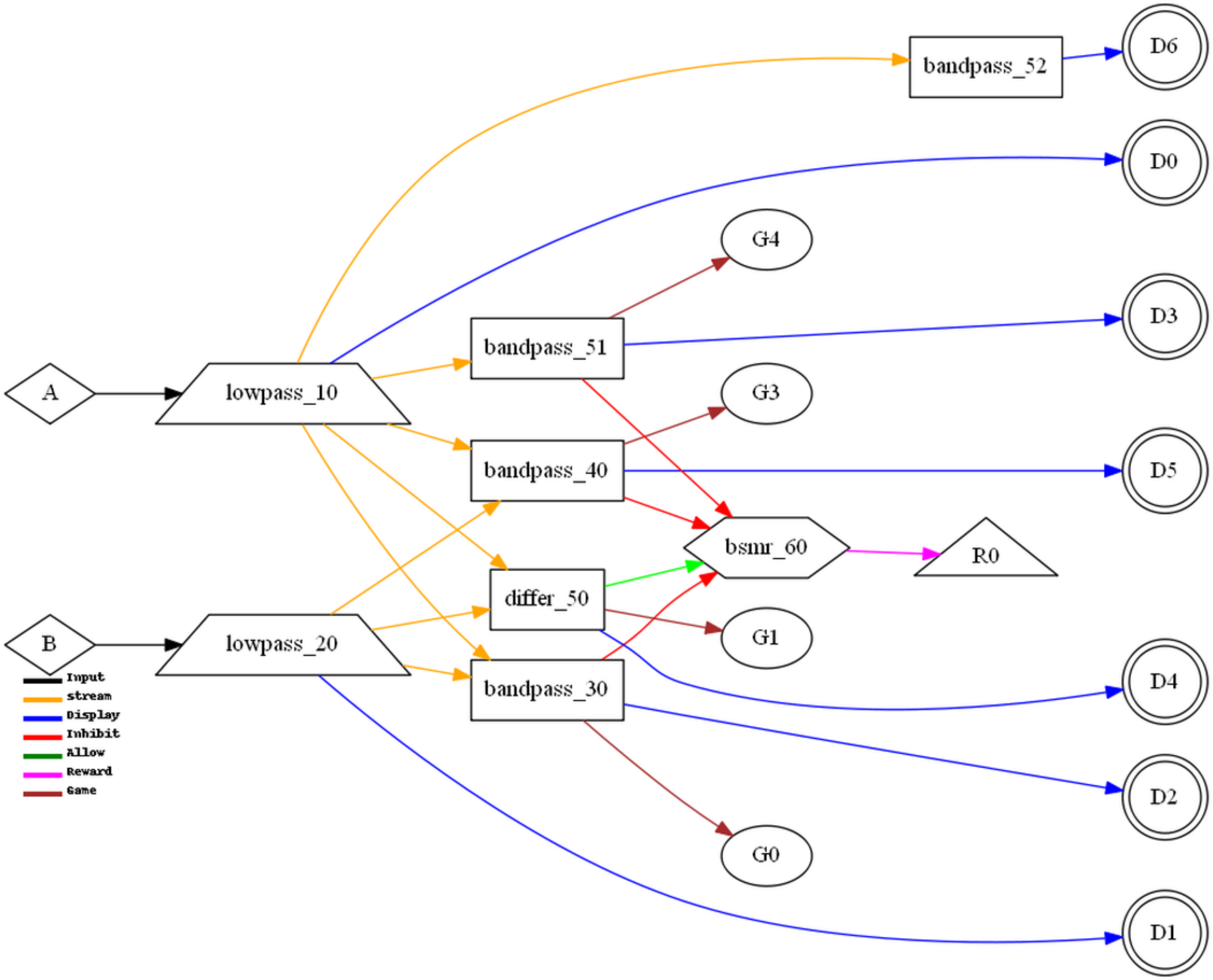
4200 SingleA (one channel of data input) CCIIRIM



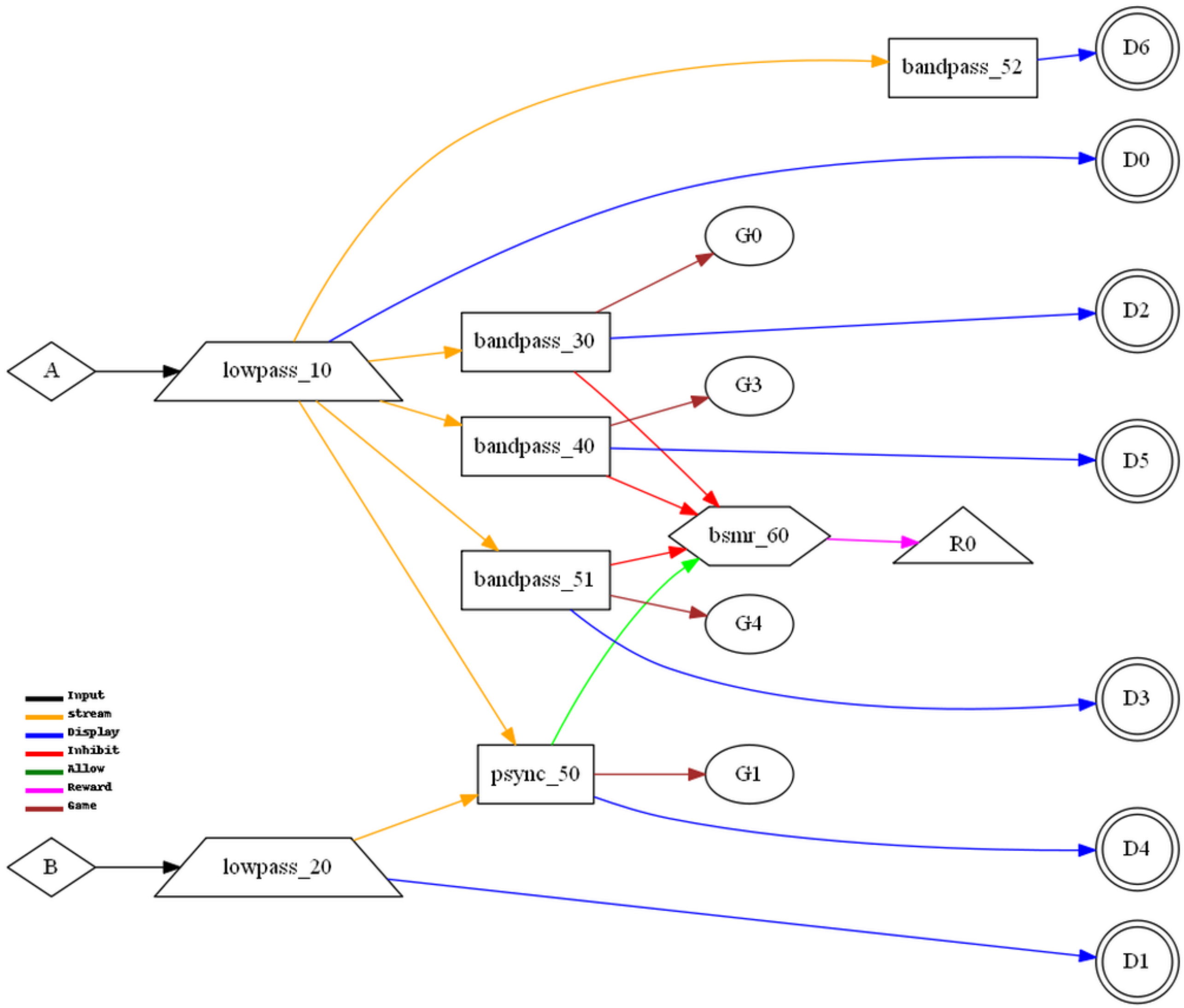
4201 SingleB (one channel of data input) CCIIRIM



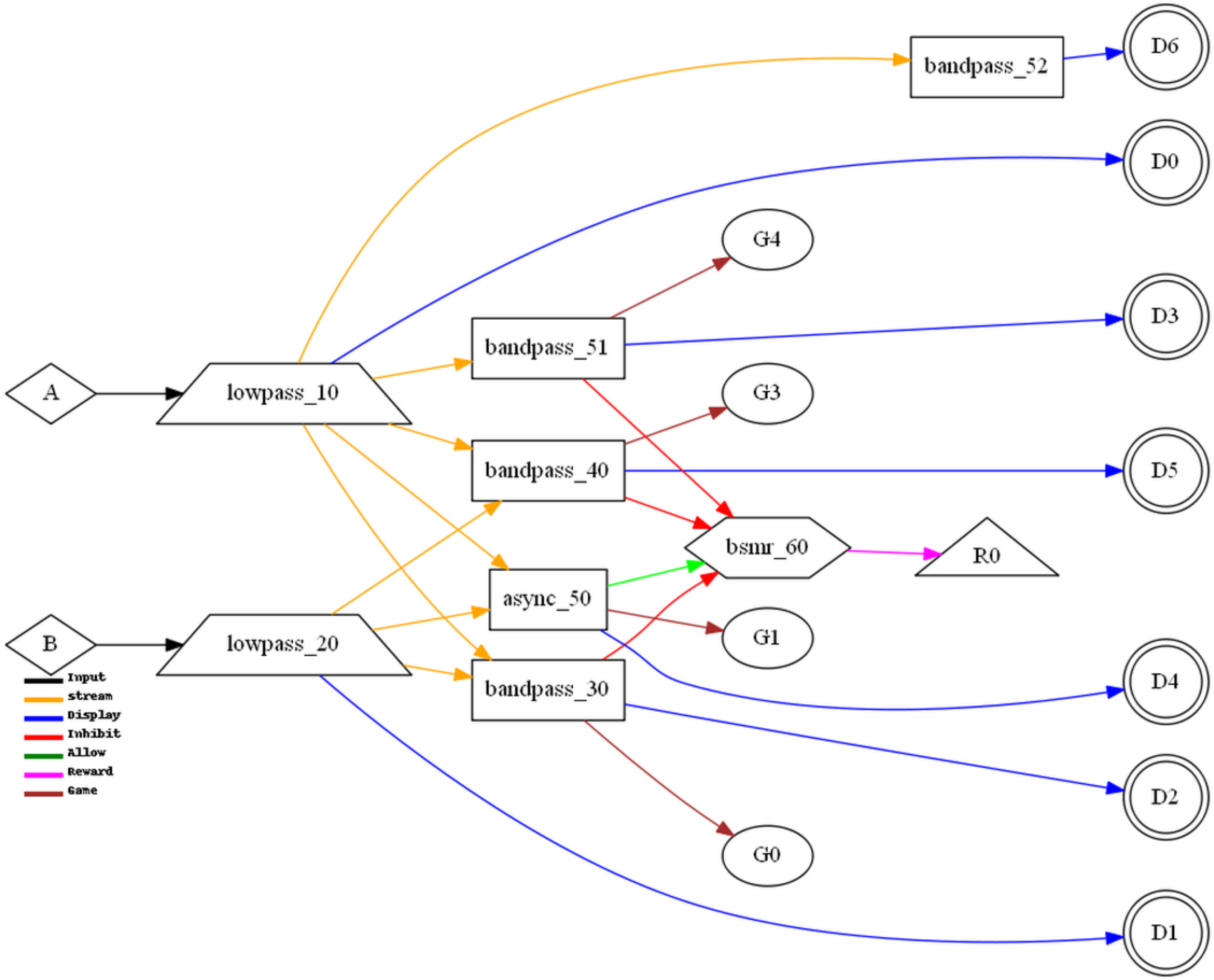
4210 Sum (sum of two channels of data input) CCIIRIM



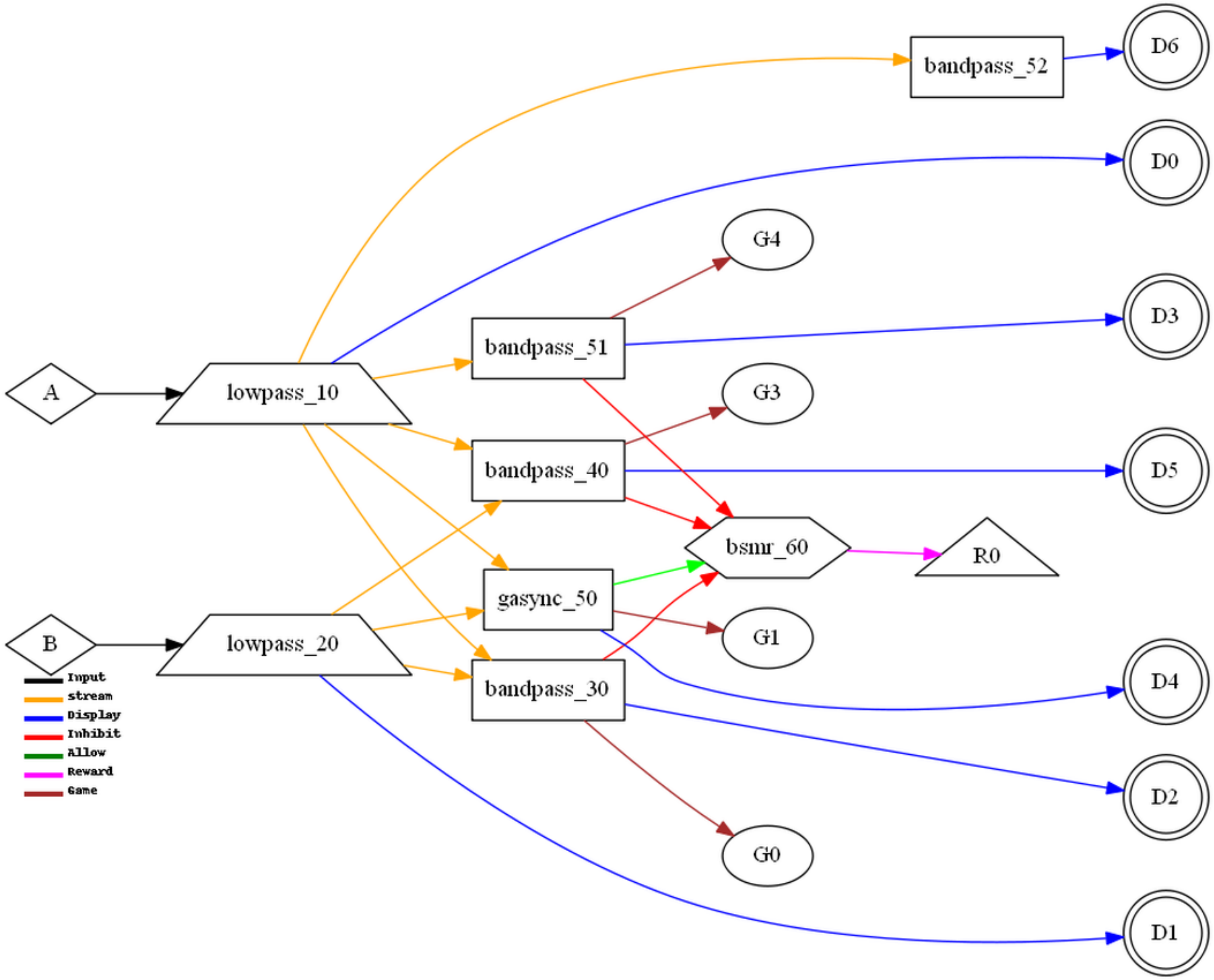
4211 Differ (channel A minus channel B) CCIIRIM



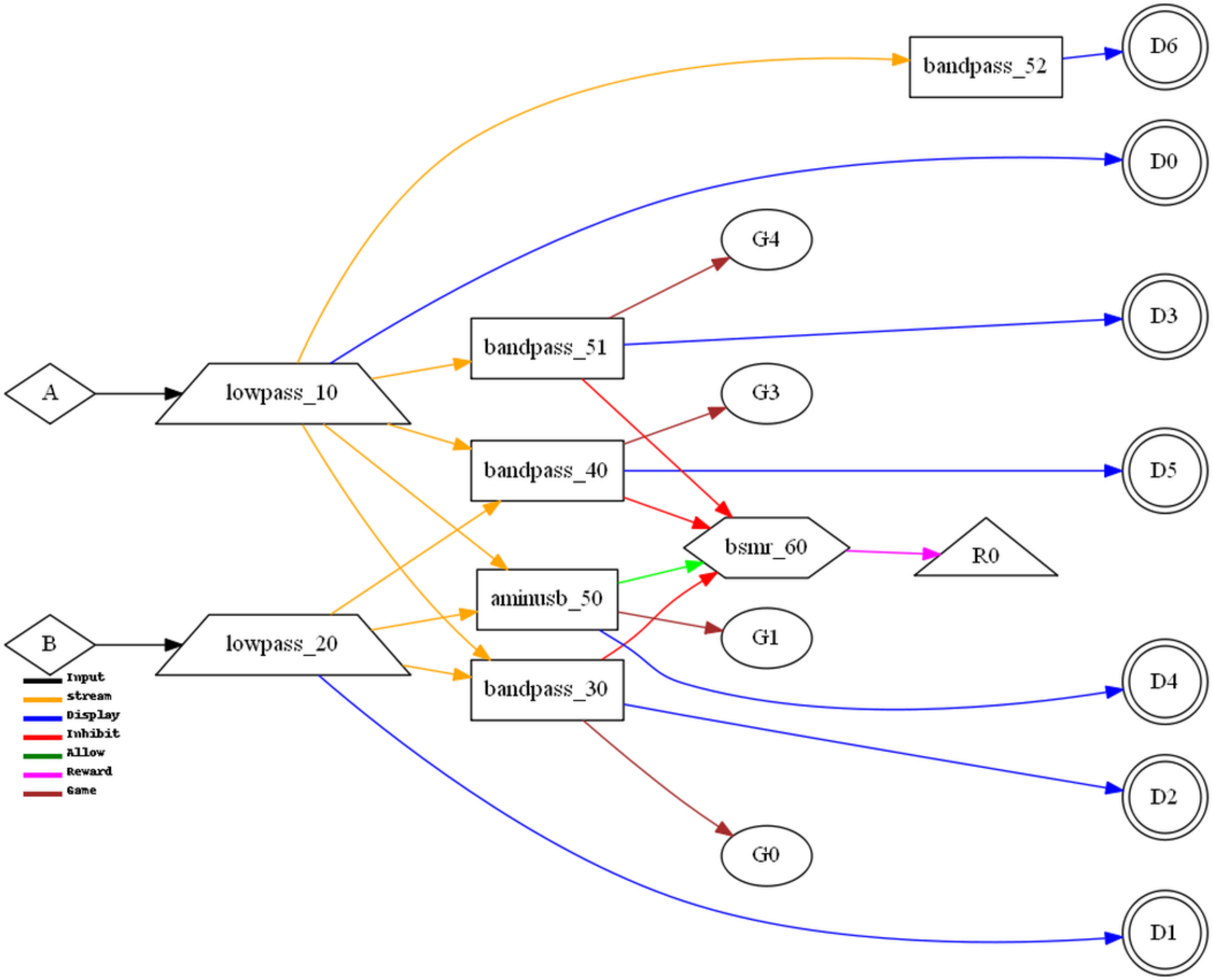
4220 Psync (synchrony measure between channel A and B) CCIIRIM



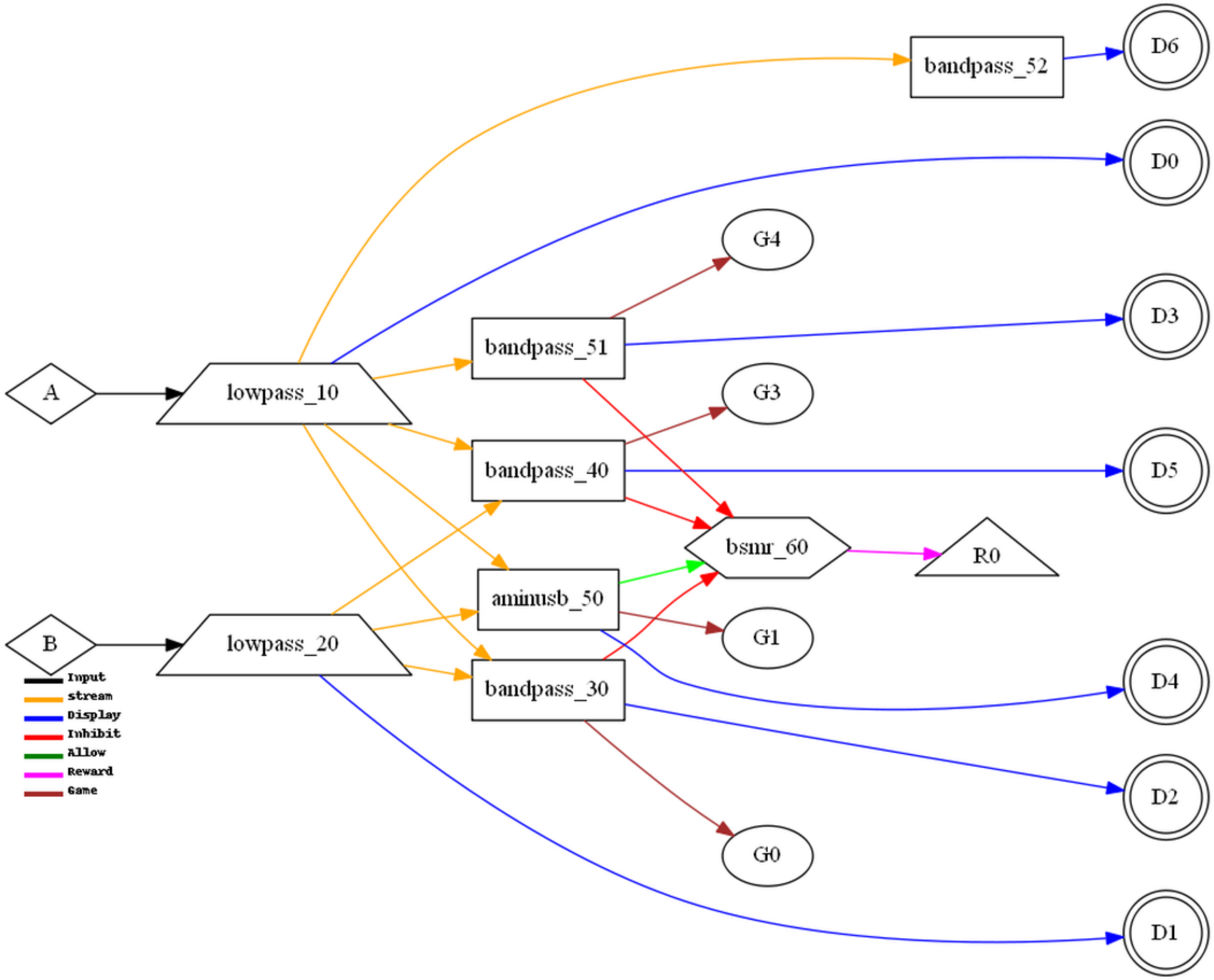
4230 Async (comodulation measure between channel A and B) CCIIRIM



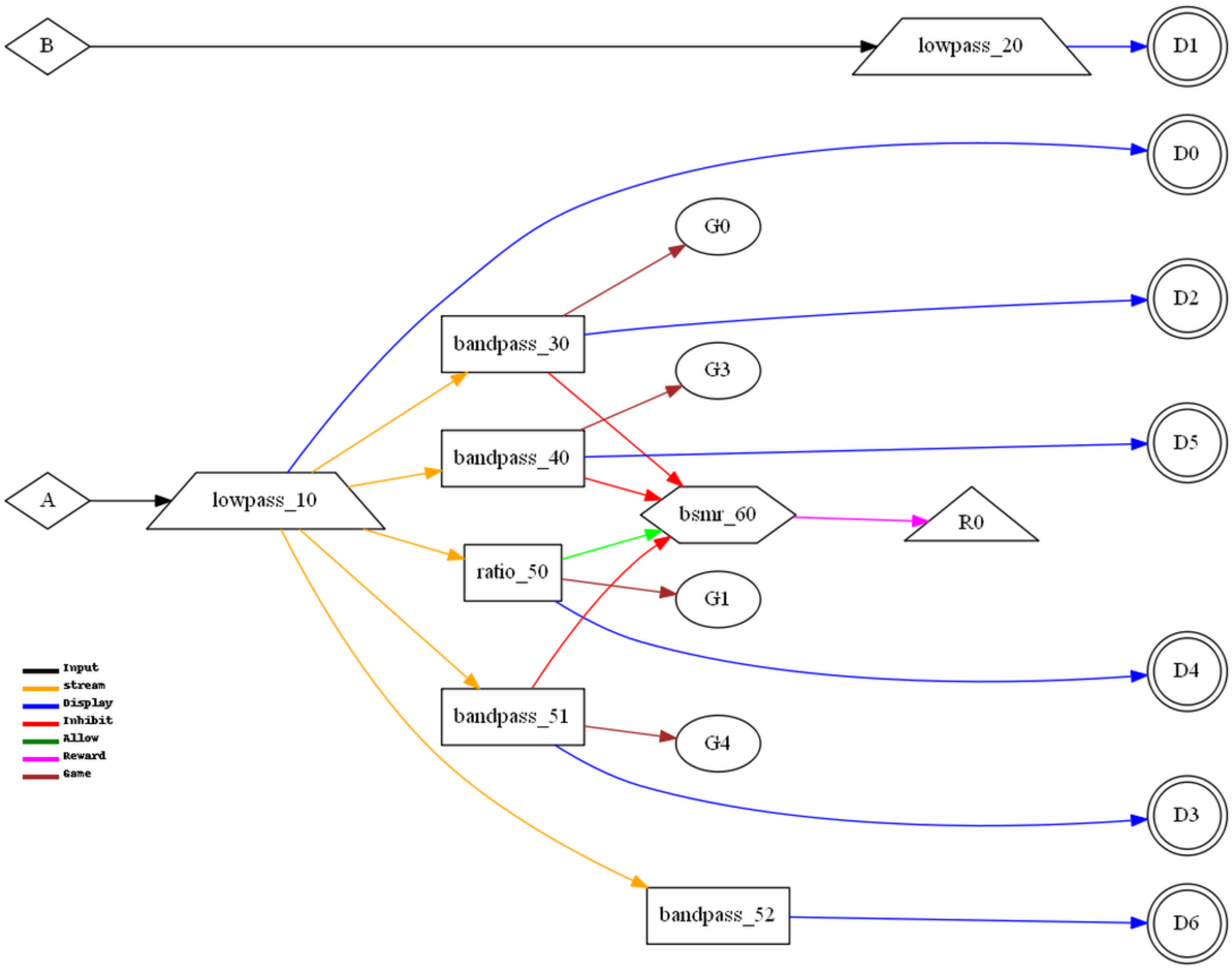
4240 GAsync (global comodulation measure between channel A and B) CCIIRIM



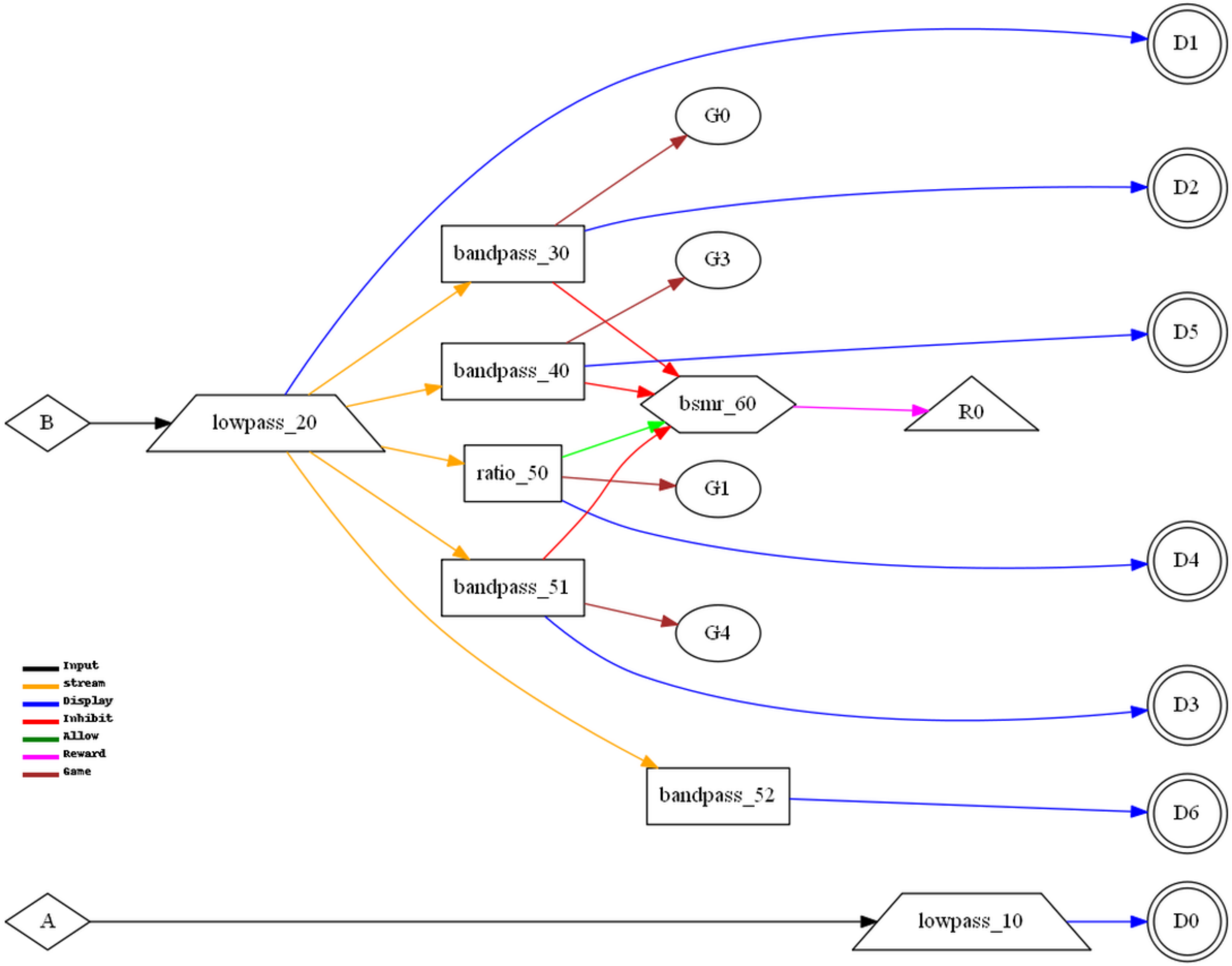
4250 AminusB (A channel relationship to B channel) CCIIRIM



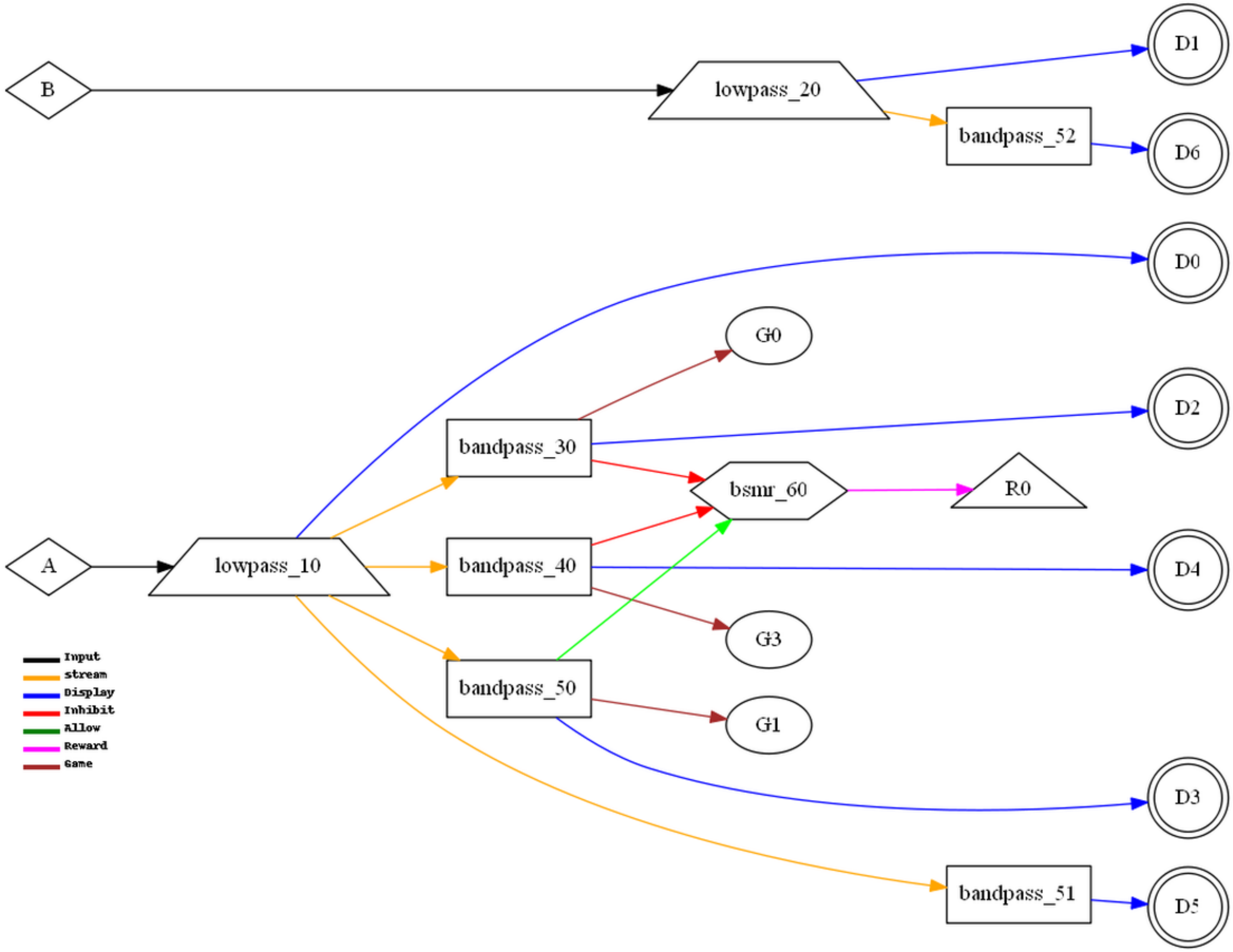
4251 BminusA (B channel relationship to A channel) CCIIRIM



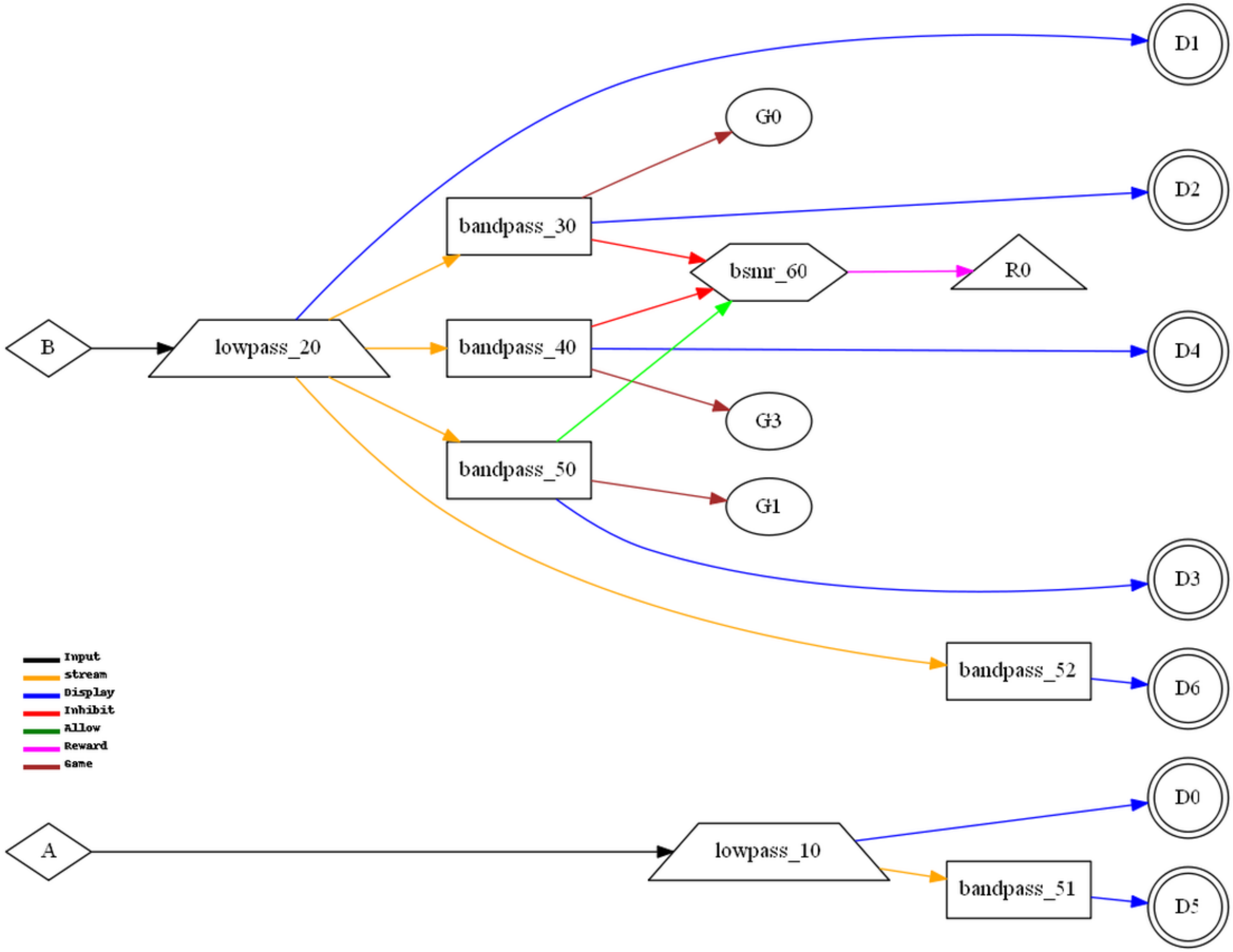
4260 RatioA (Ratio of inhibit3 to reward) CCIIRIM



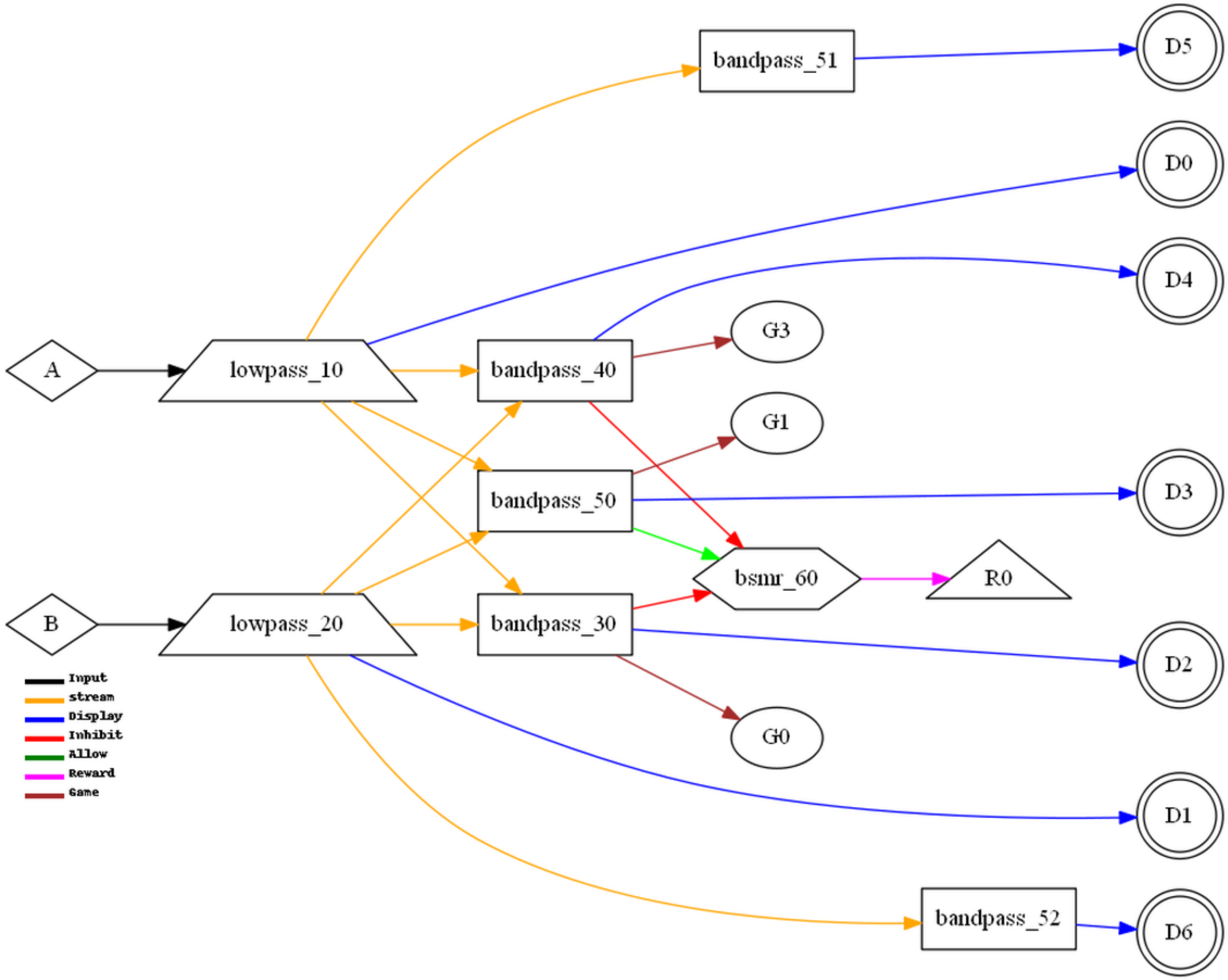
4261 RatioB (Ratio of inhibit3 to reward) CCIIRIM



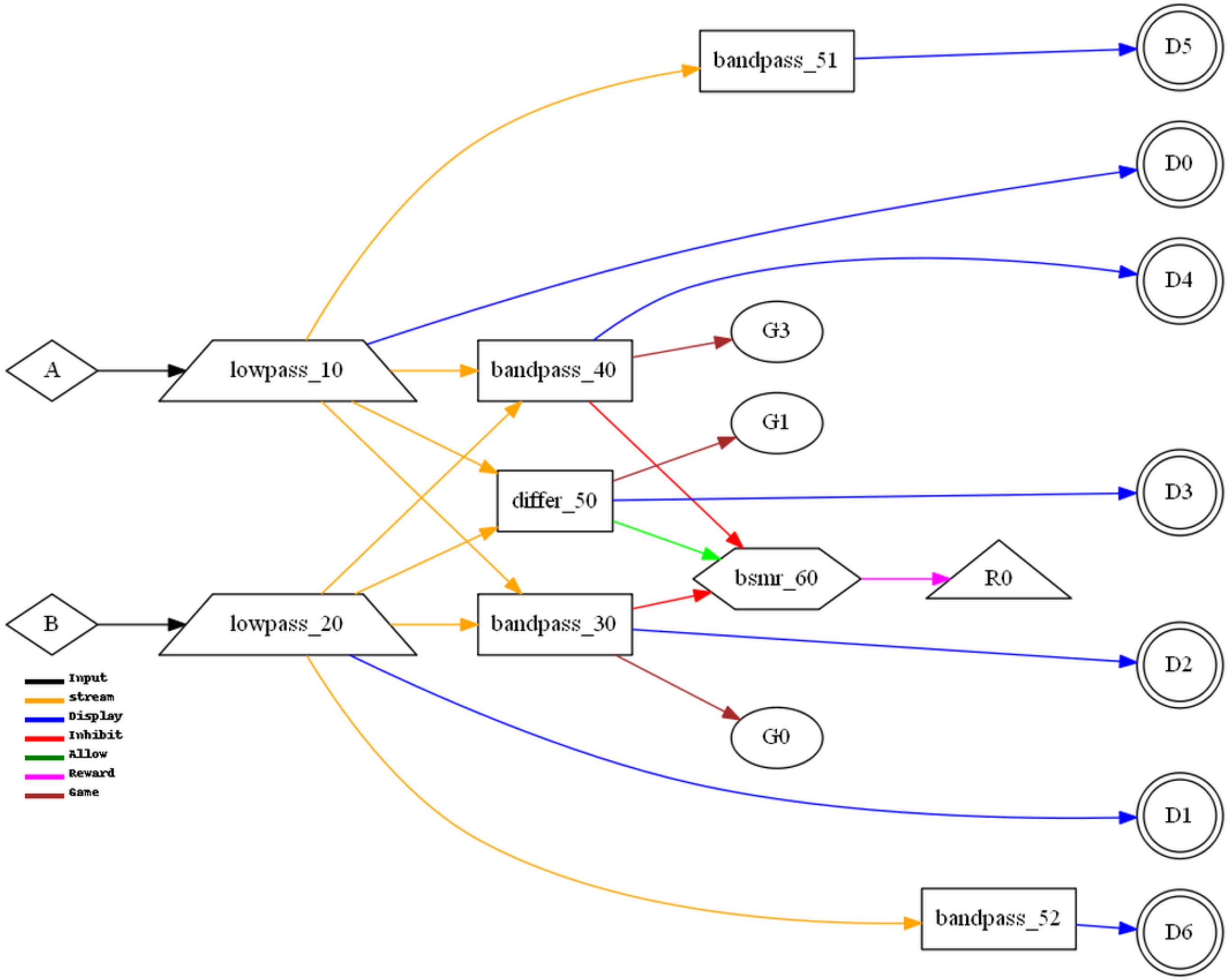
4100 SingleA (one channel of data input) CCIRIMM



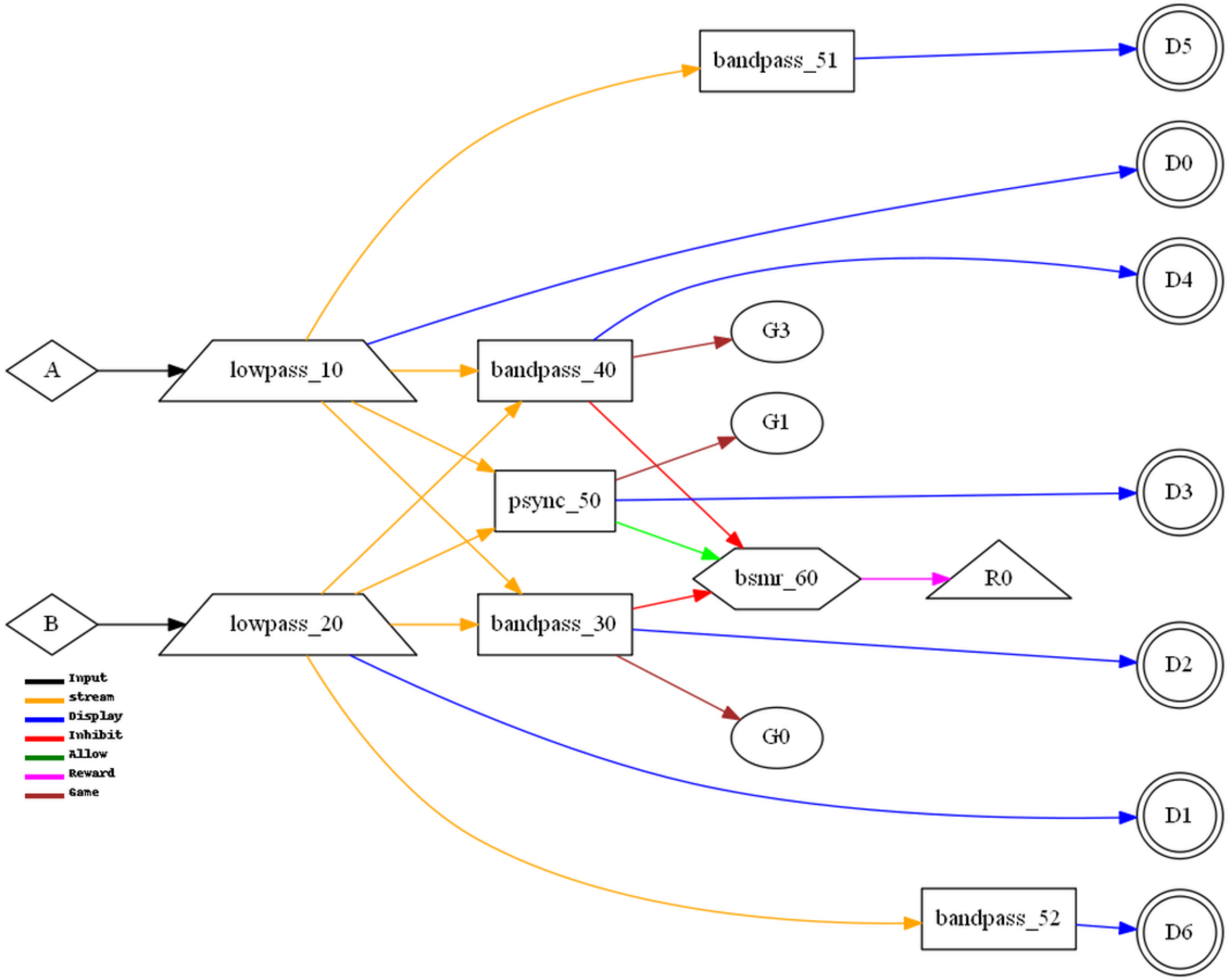
4101 SingleB (one channel of data input) CCIRIMM



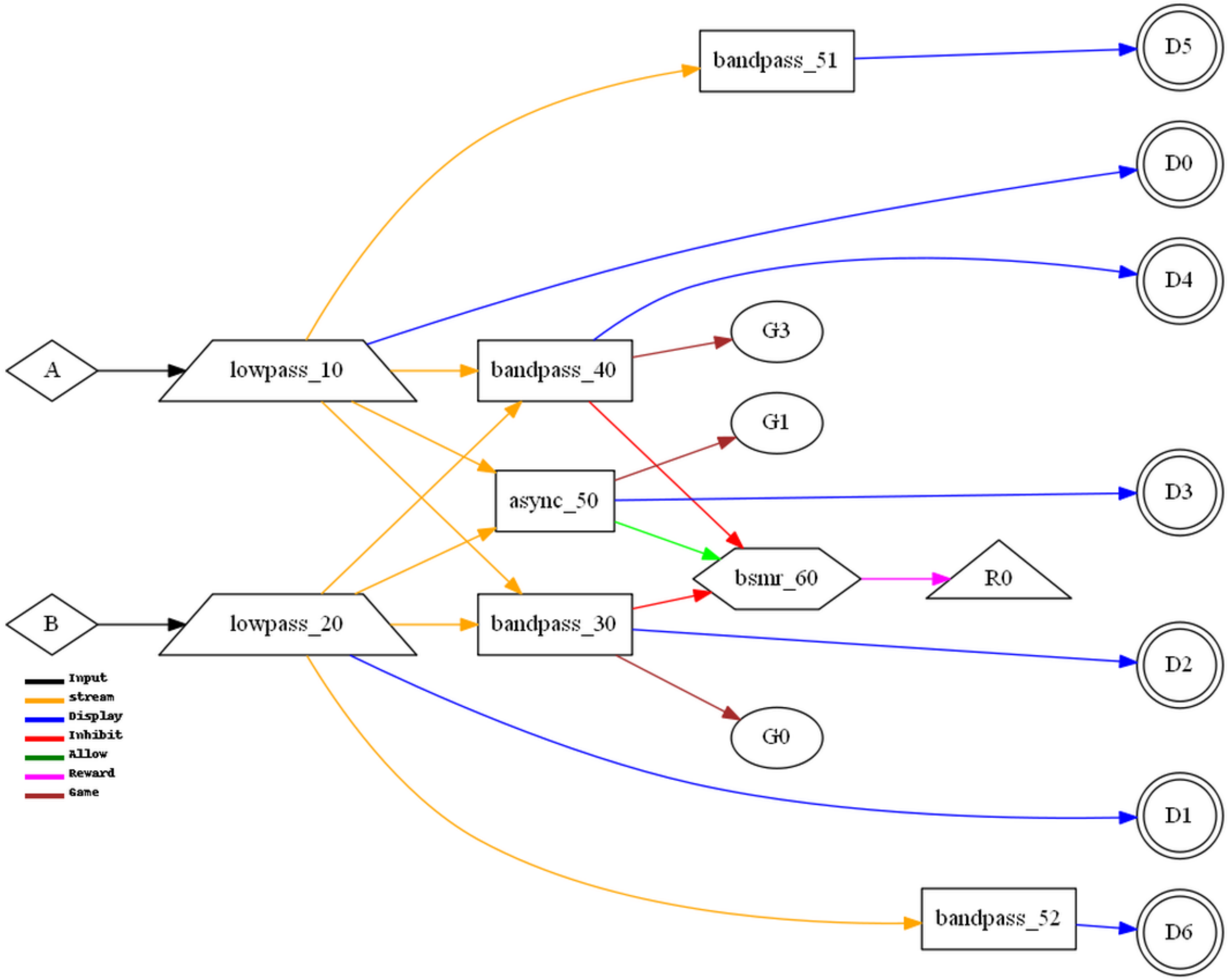
4110 Sum (sum of two channels of data input) CCIRIMM



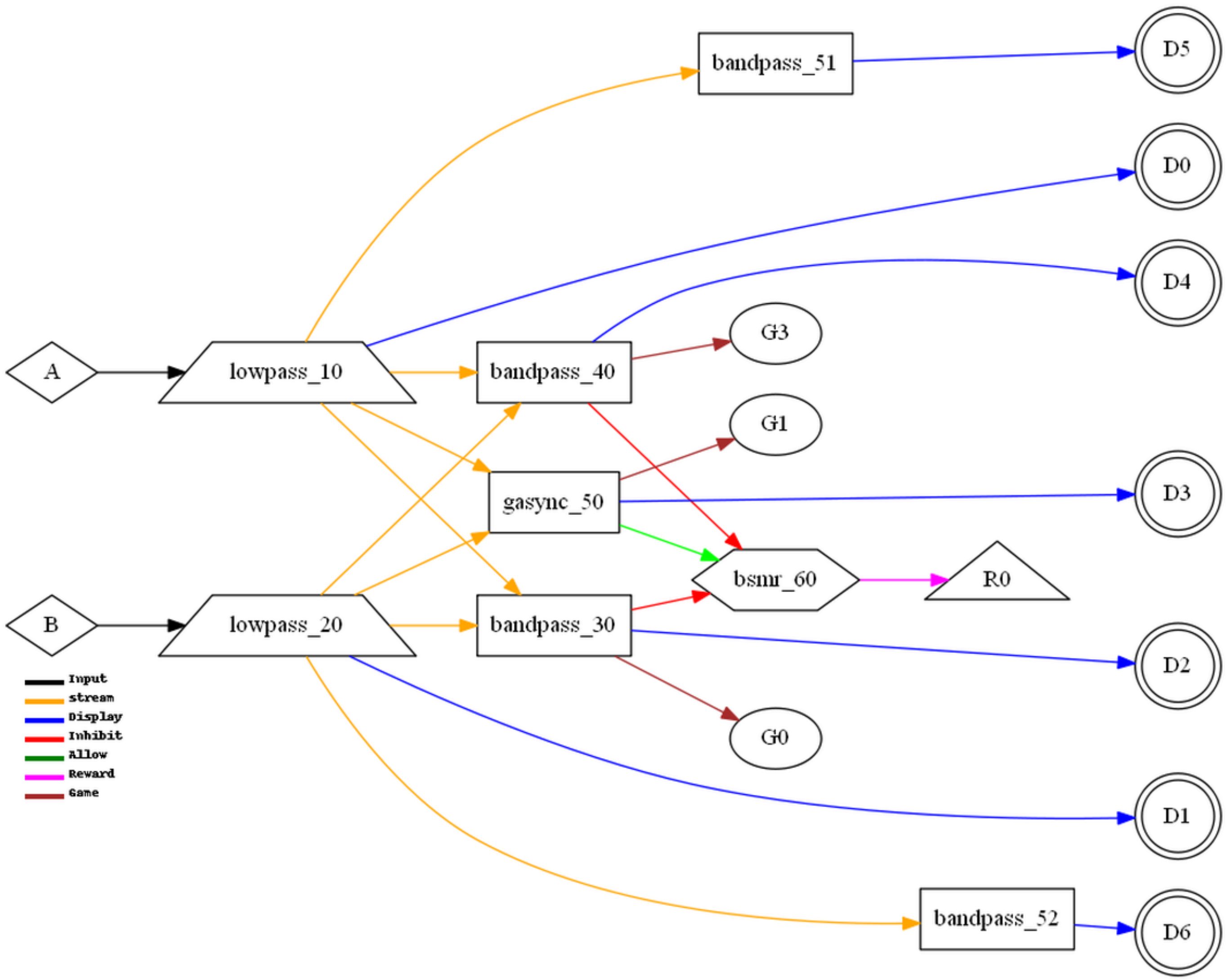
4111 Differ (channel A minus channel B) CCIRIMM



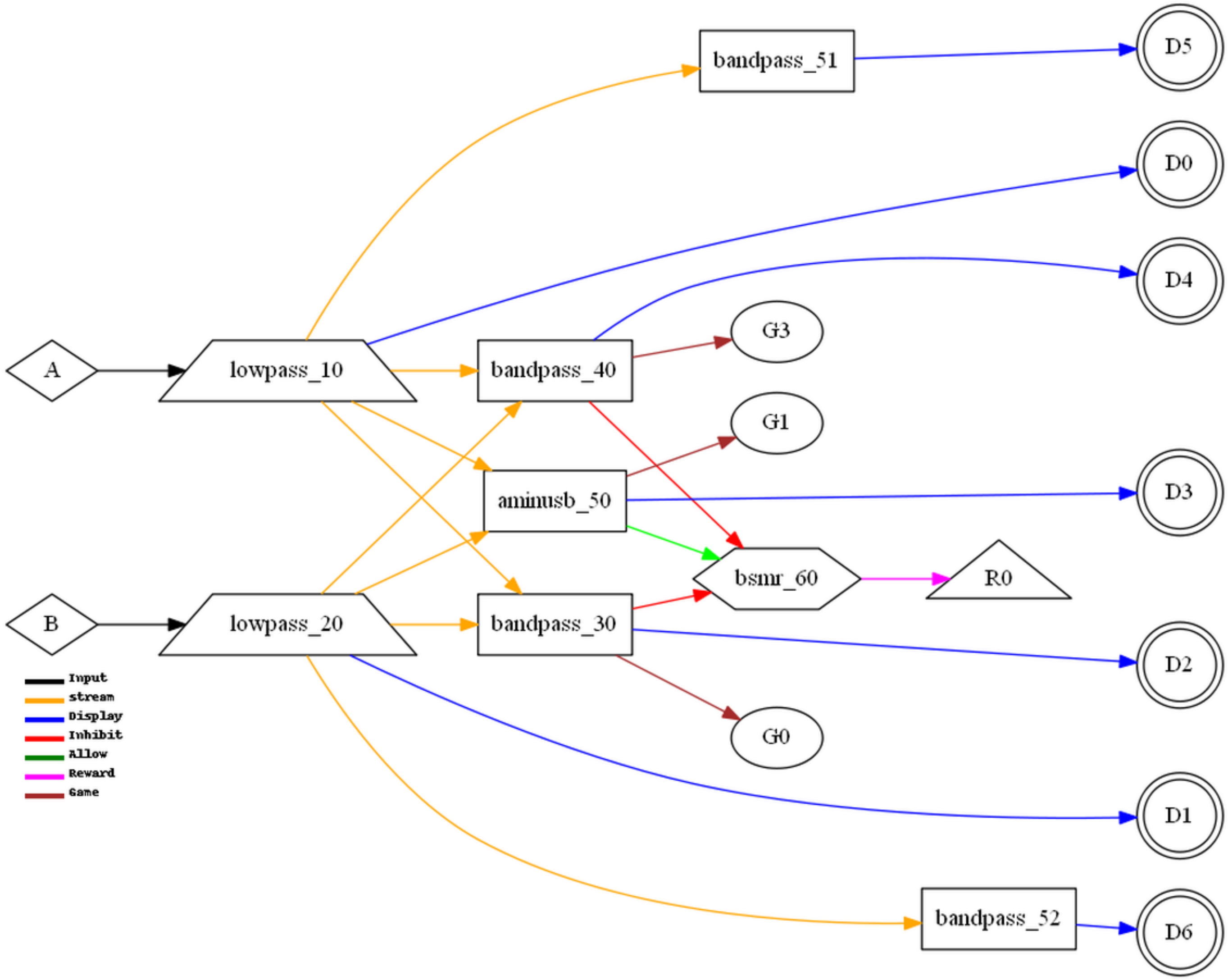
4121 Psync (synchrony measure between channel A and B) CCIRIMM



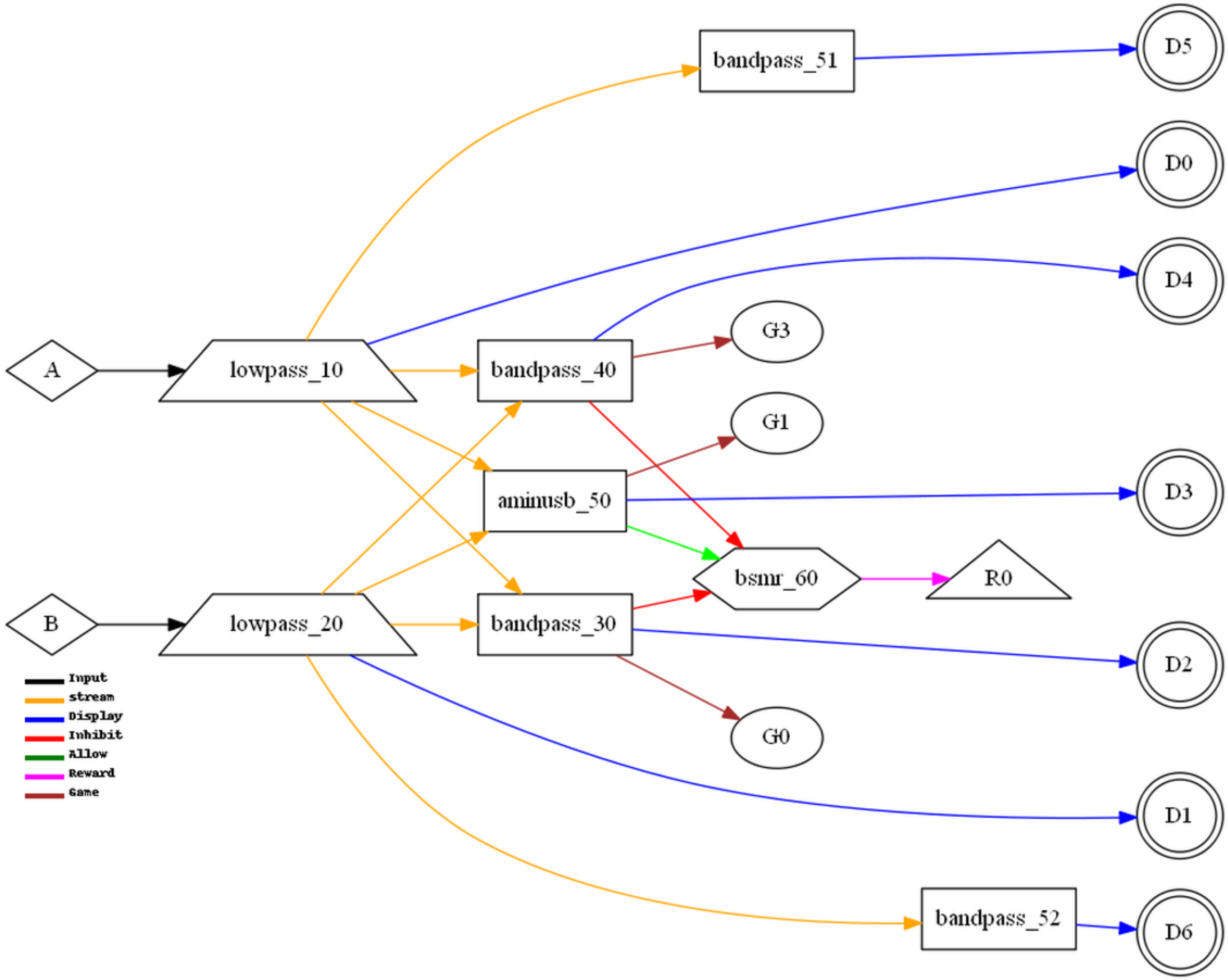
4130 Async (comodulation measure between channel A and B) CCIRIMM



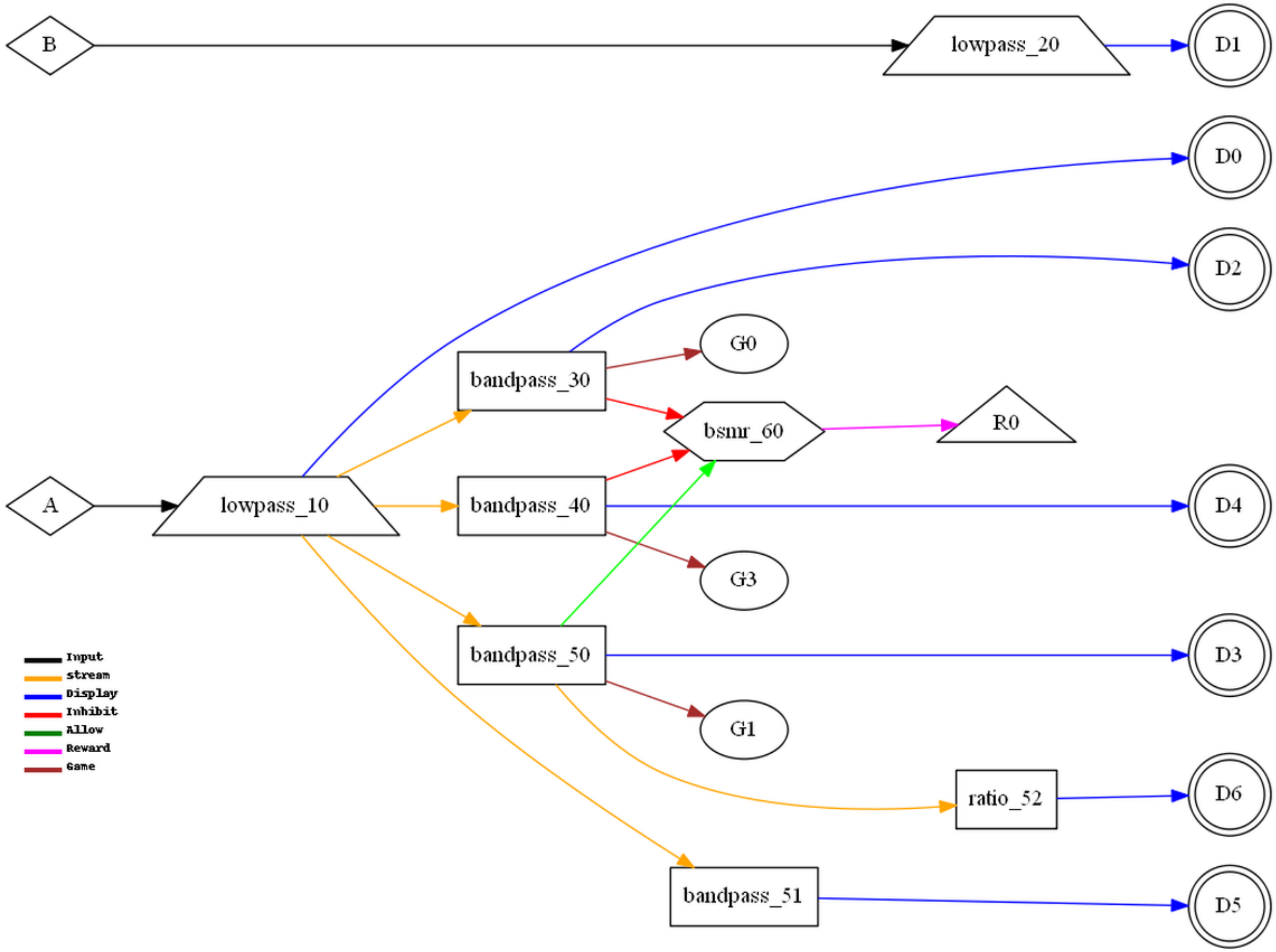
4140 GAsync (global comodulation measure between channel A and B) CCIRIMM



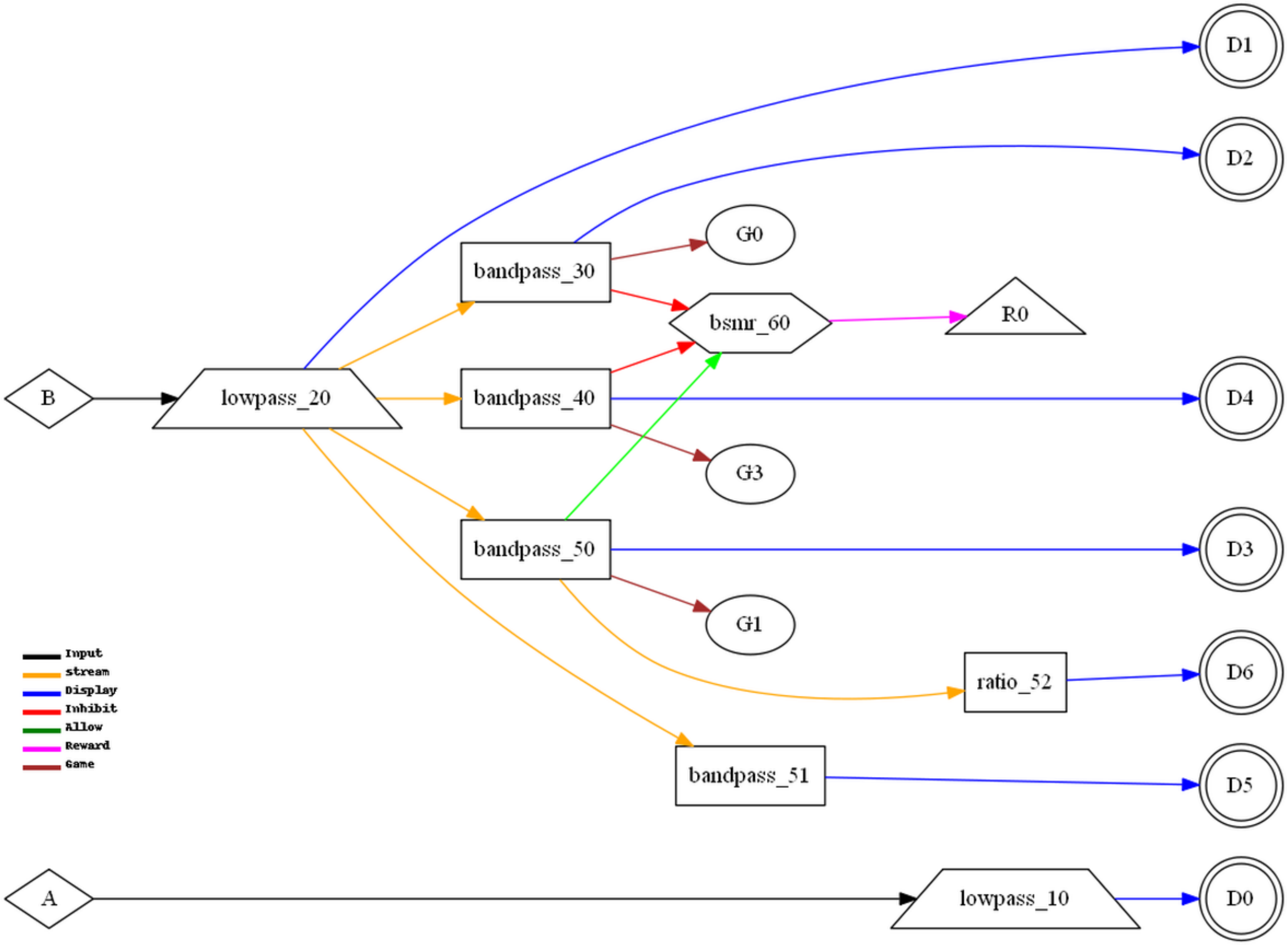
4150 AminusB (A channel relationship to B channel) CCIRIMM



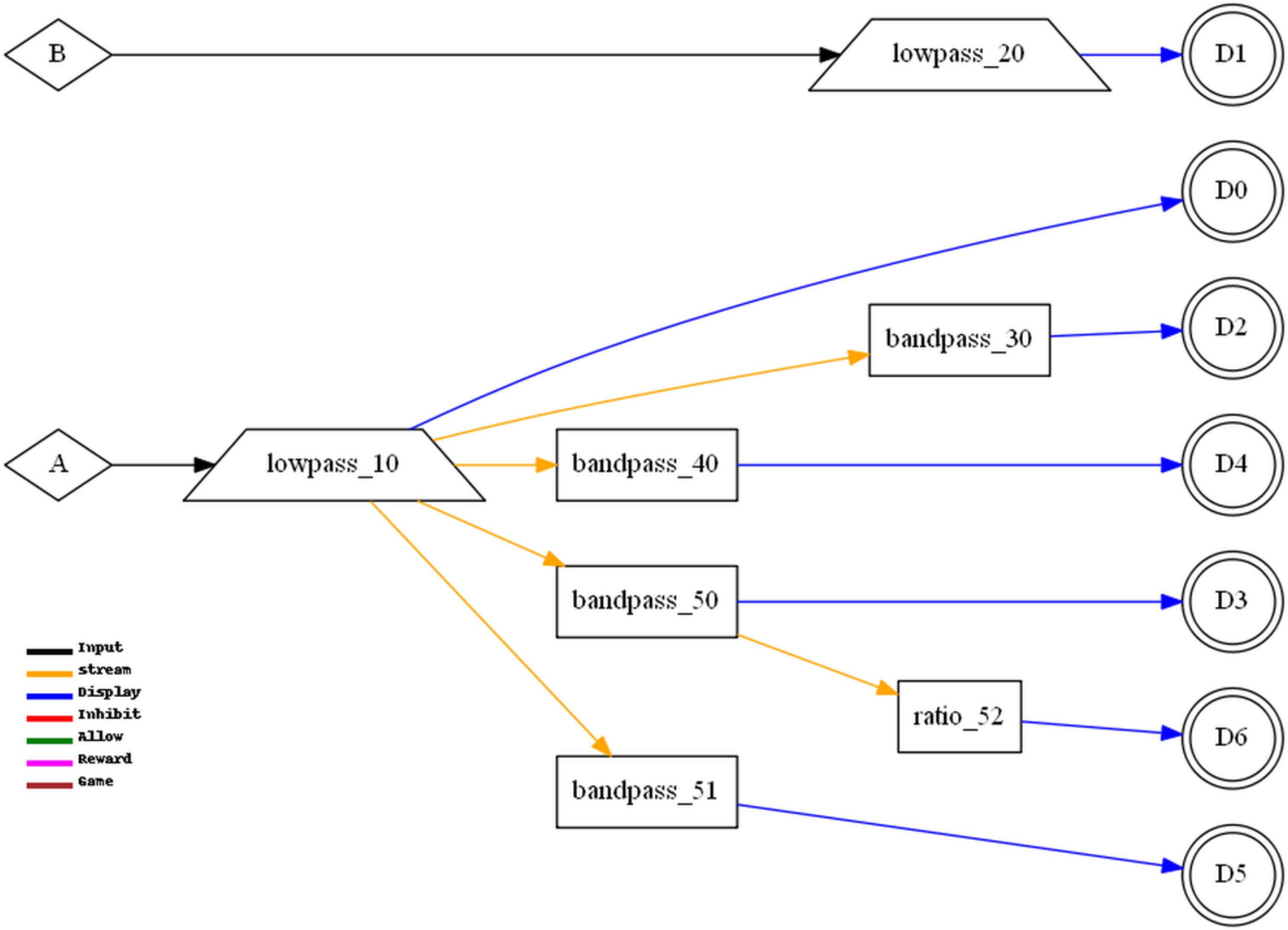
4151 BminusA (B channel relationship to A channel) CCIRIMM



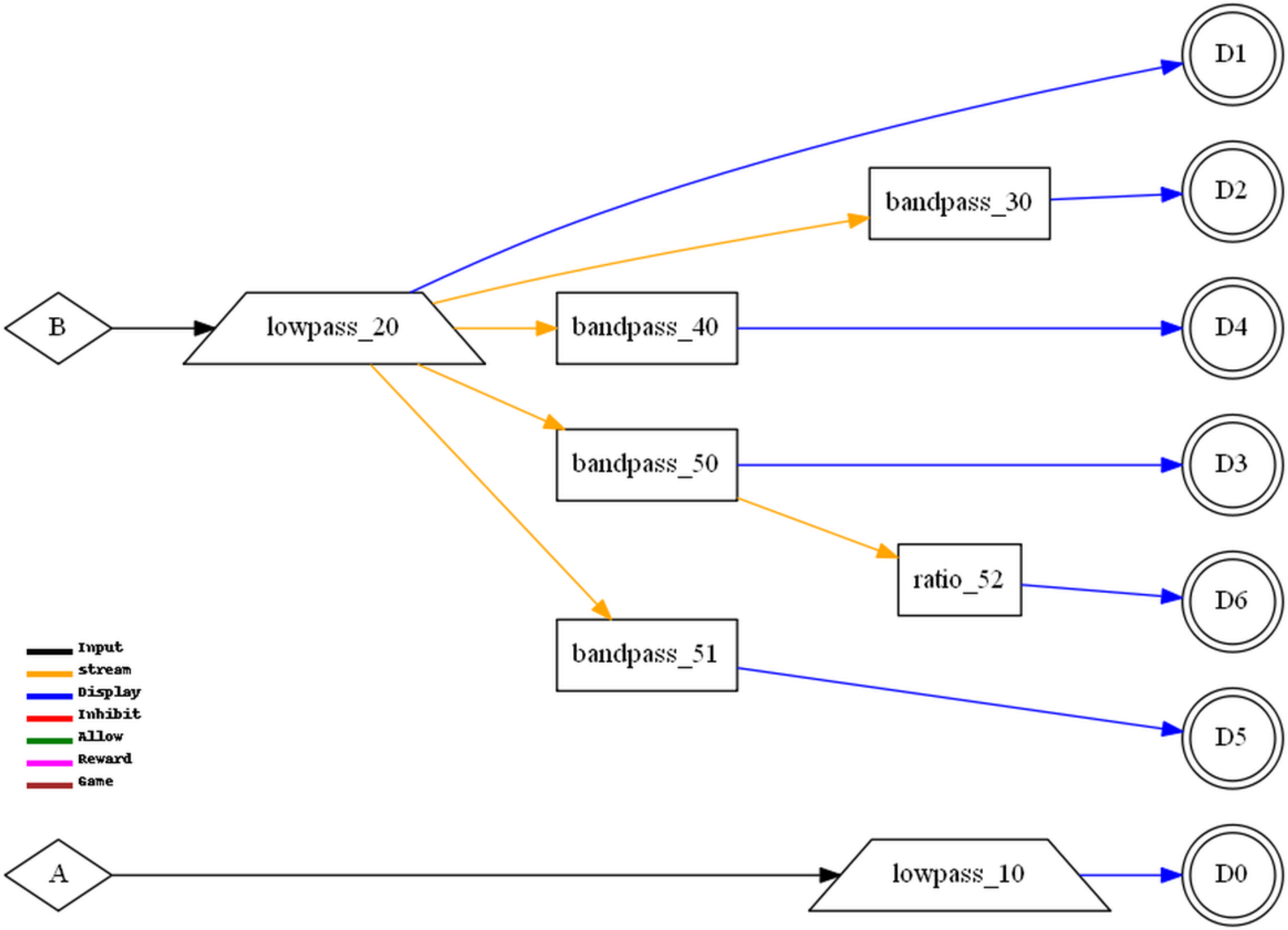
4162 SingleA-RM (One channel+ratio between monitors) CCIRIMM



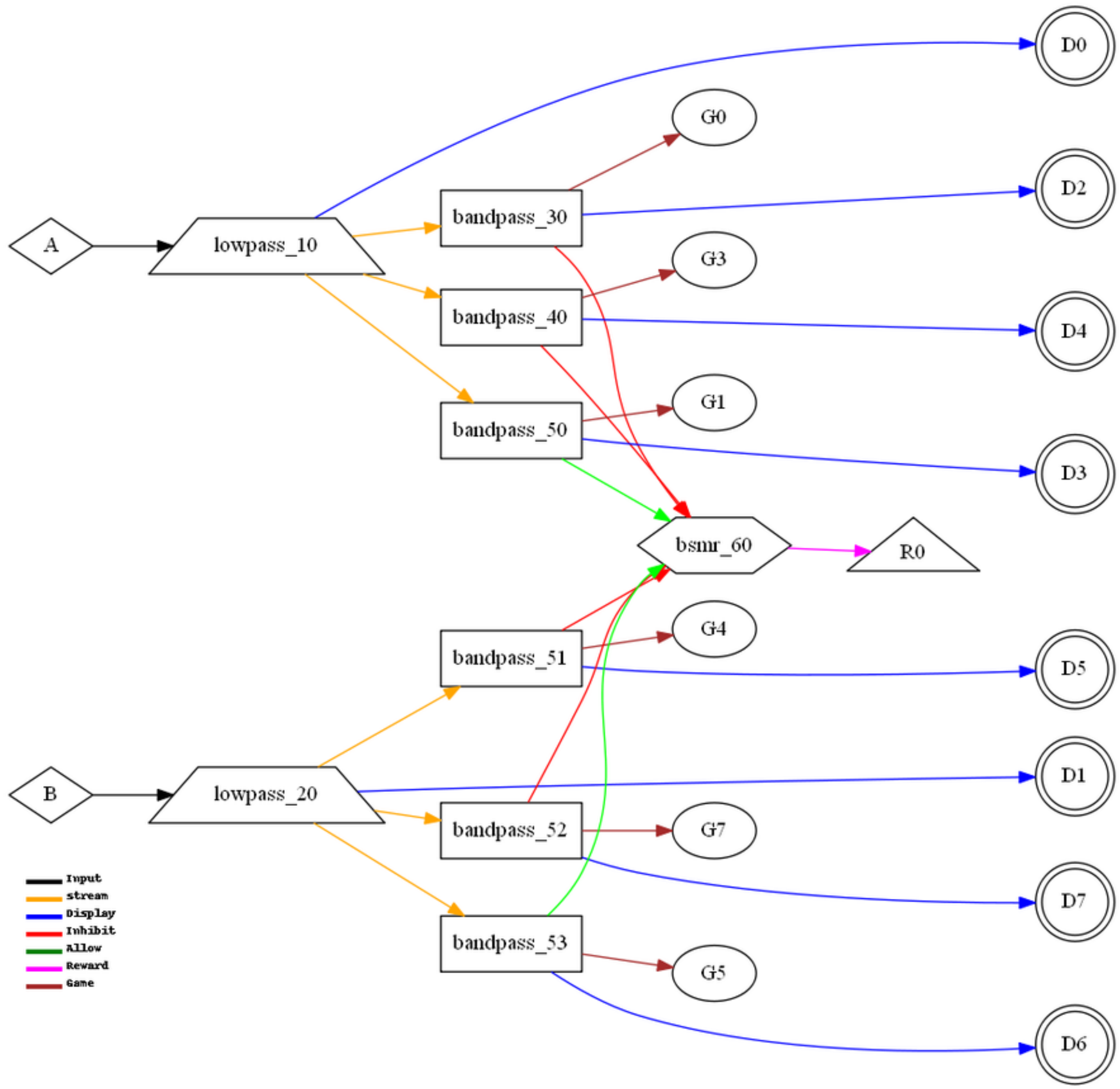
4163 SingleB-RM (One channel+ratio between monitors) CCIRIMM



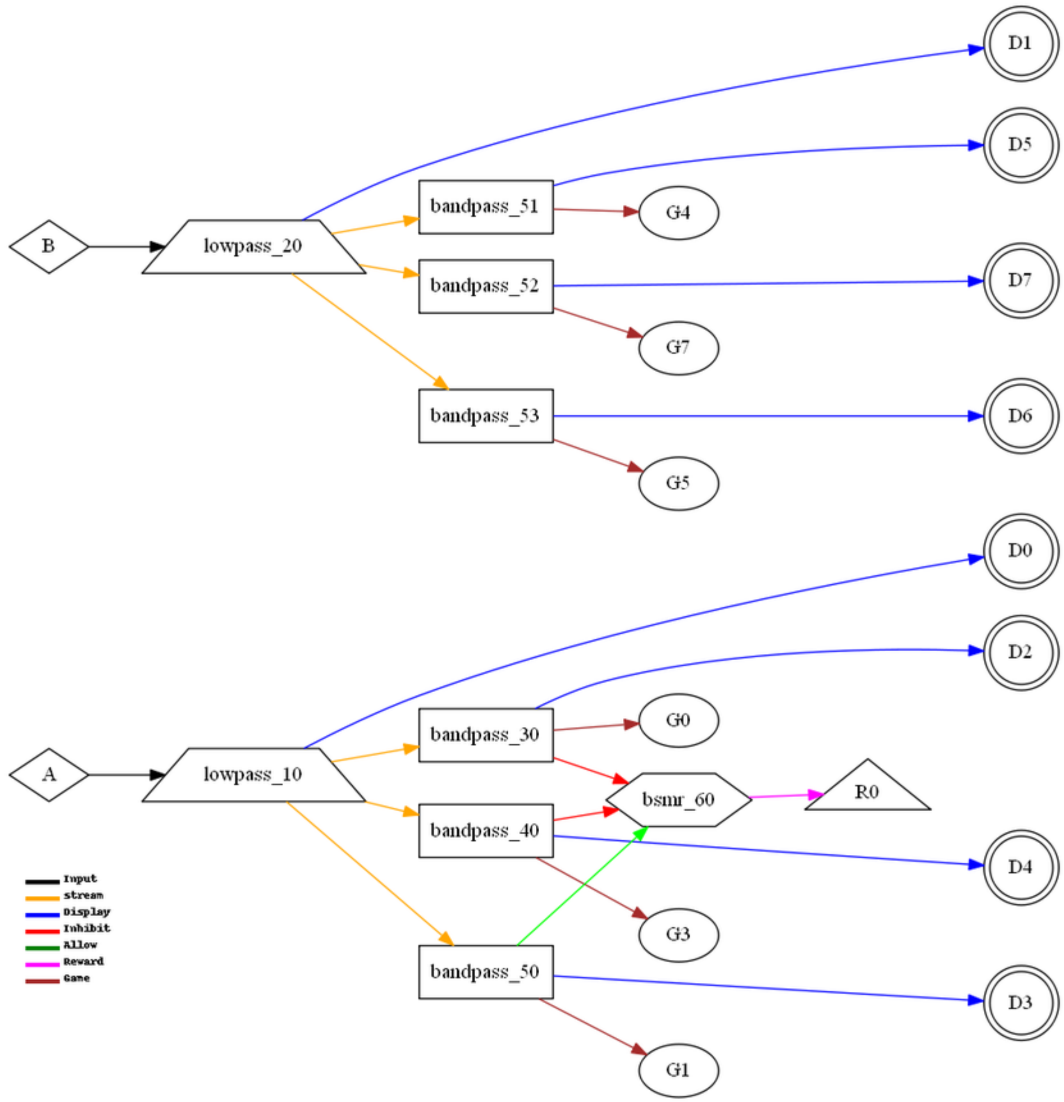
4172 SnglA-RM-NF (One channel+ratio no feedback) CCIRIMM



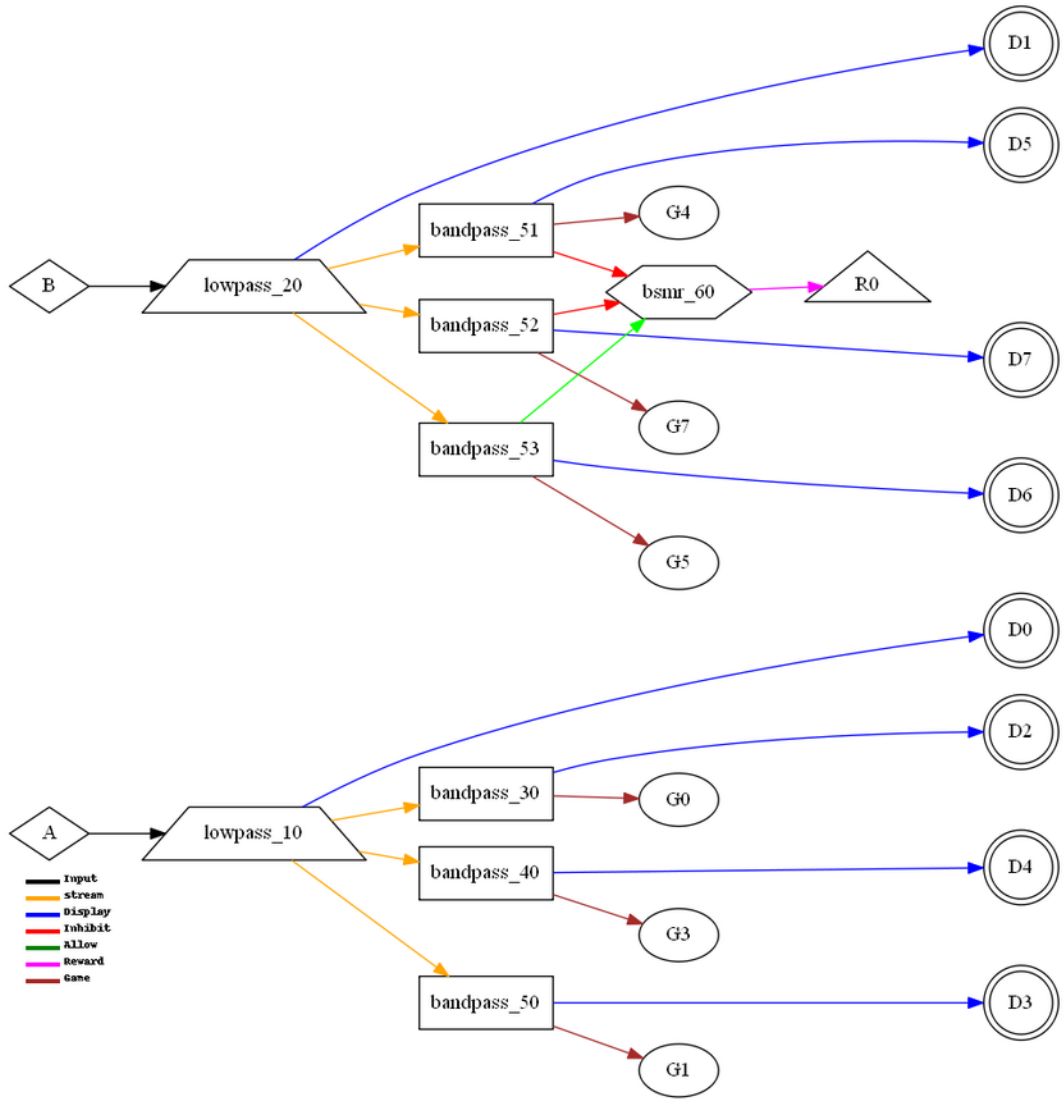
4173 SnglB-RM-NF (One channel+ratio no feedback) CCIRIMM



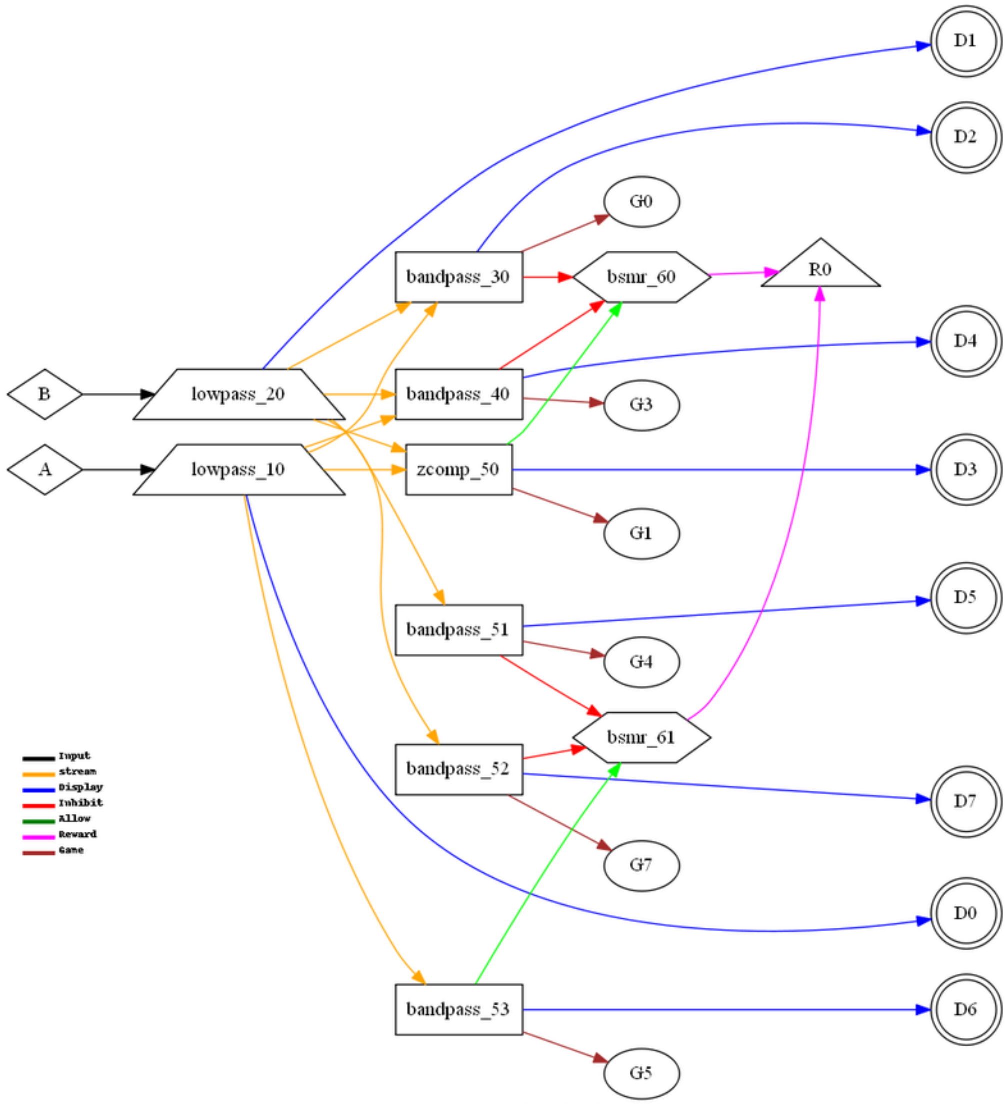
200 Dual (two channels of data input) CCIRIIRI



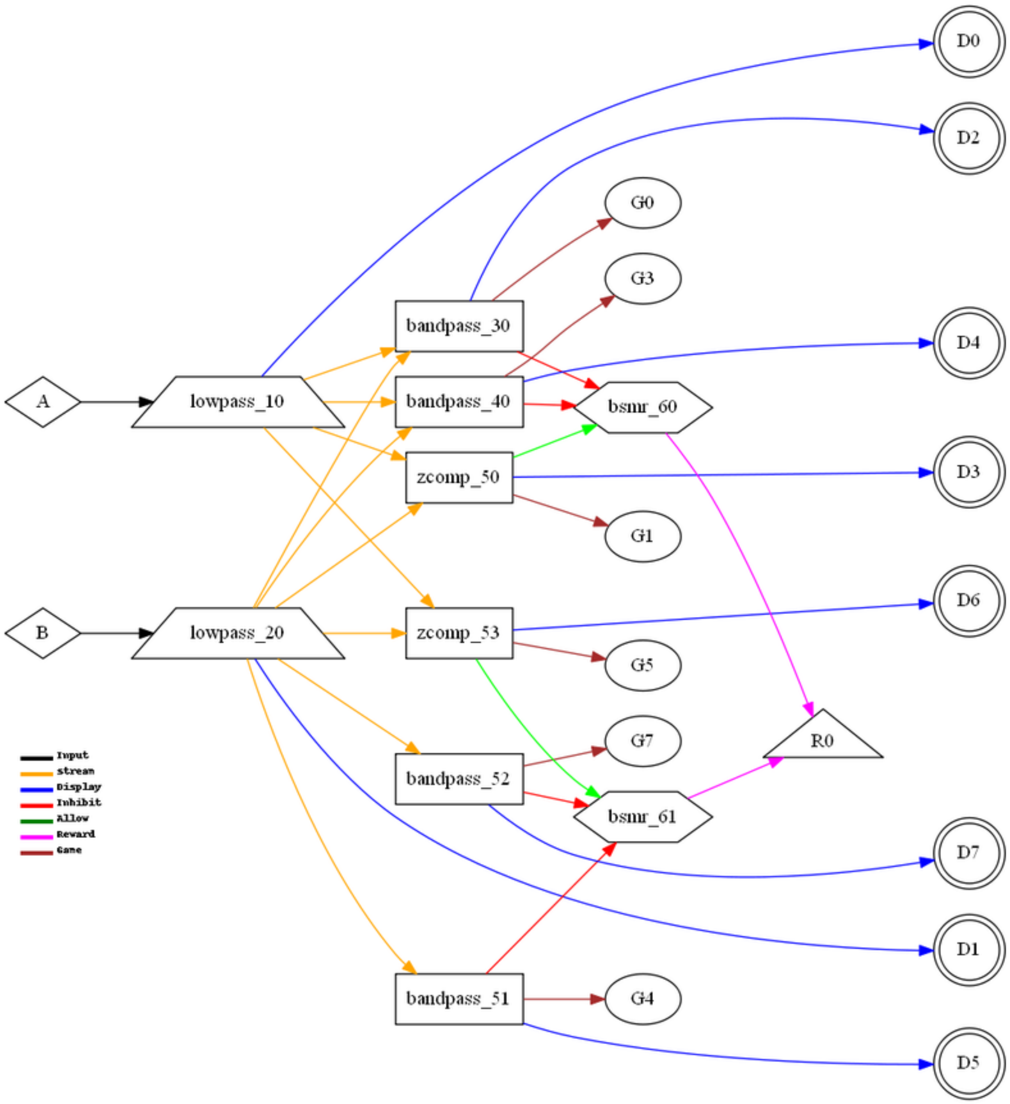
210 SingleA (SingleA) CCIRIIRI



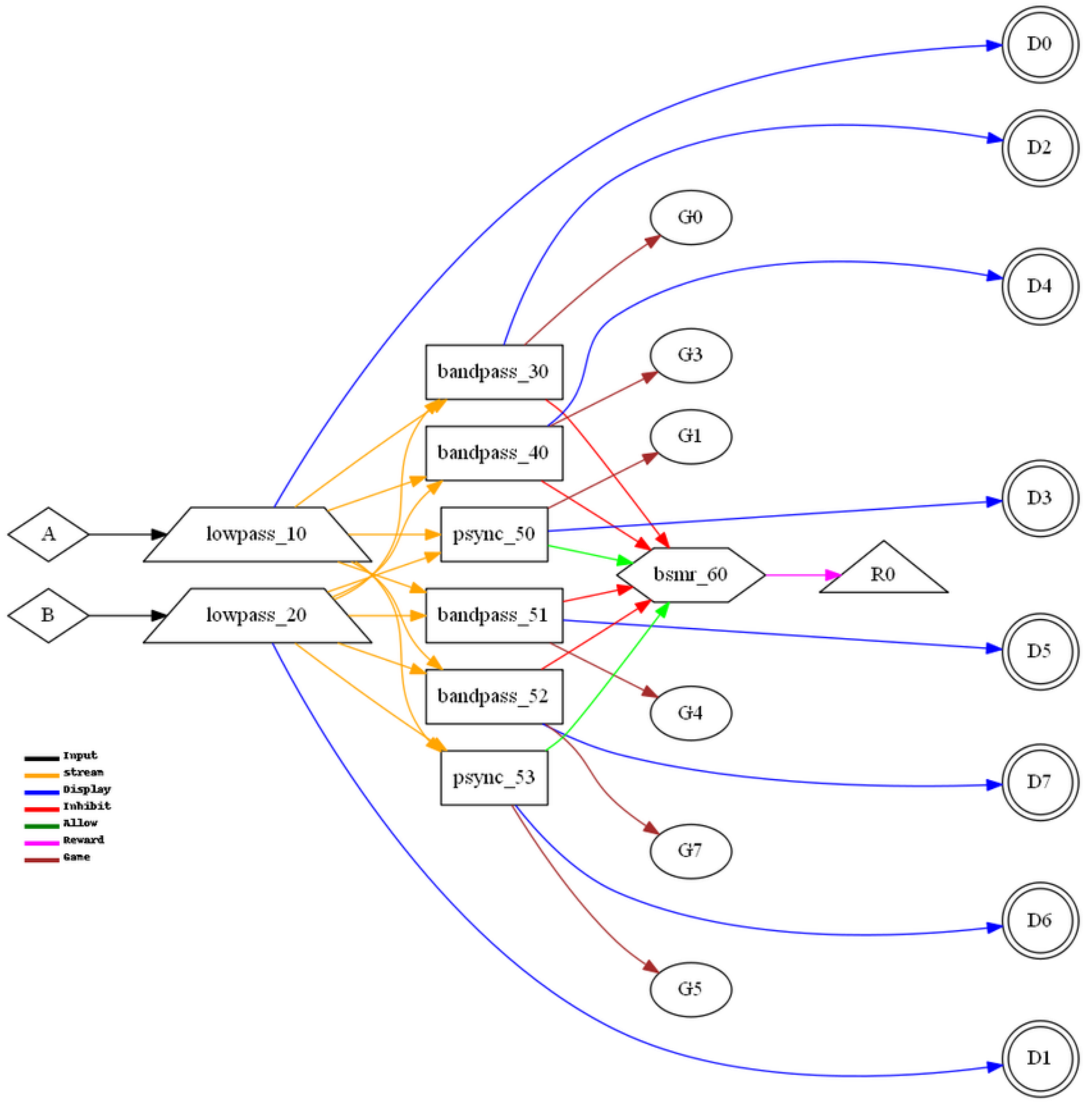
211 SingleB (SingleB) CCIRIIRI



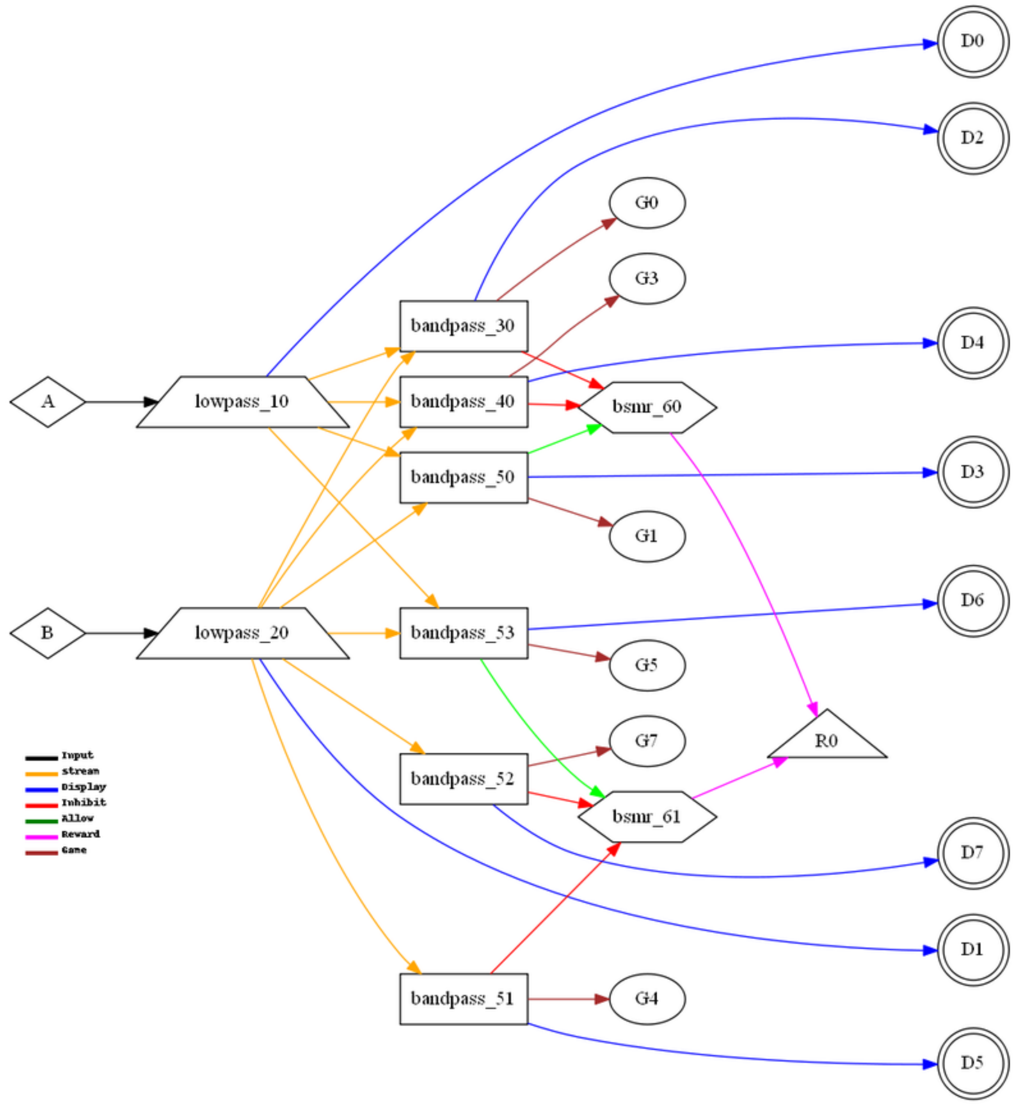
260 ZCompBPAB (Zcomposite + bandpass) CCIRIIRI



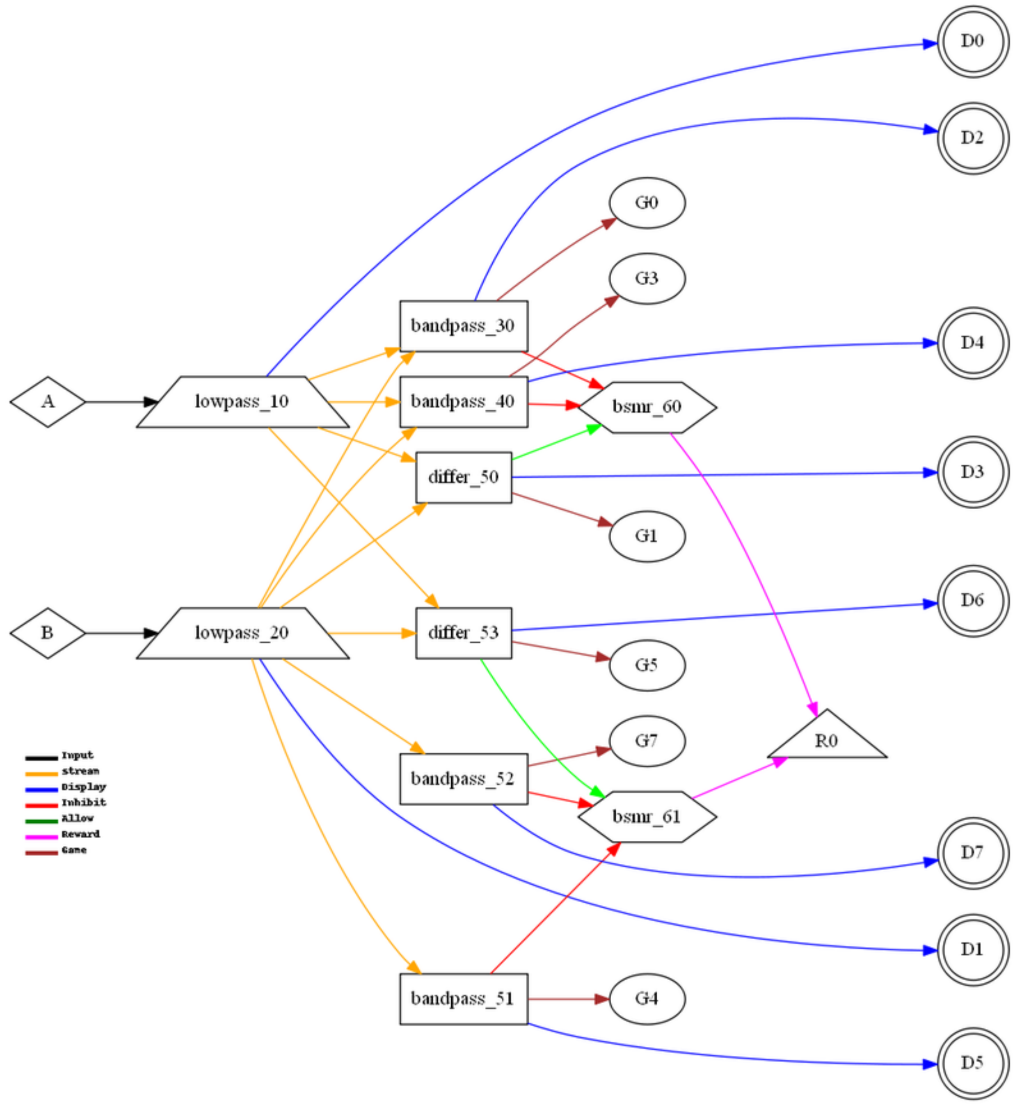
261 ZCompAB (Zcomposite + Zcomposite) CCIRIIRI



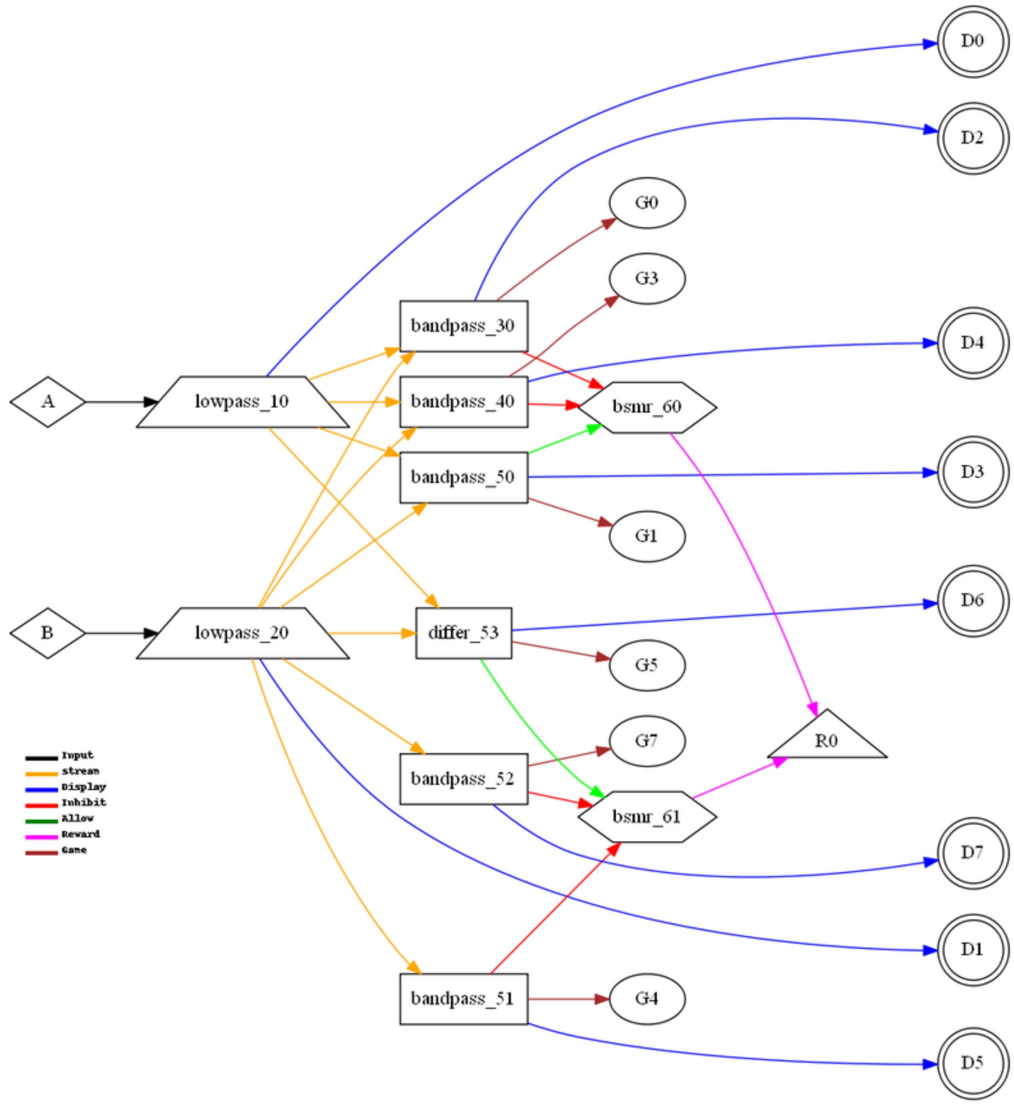
223 PsyncDual (synchrony measure between channel A and B) CCIRIIRI



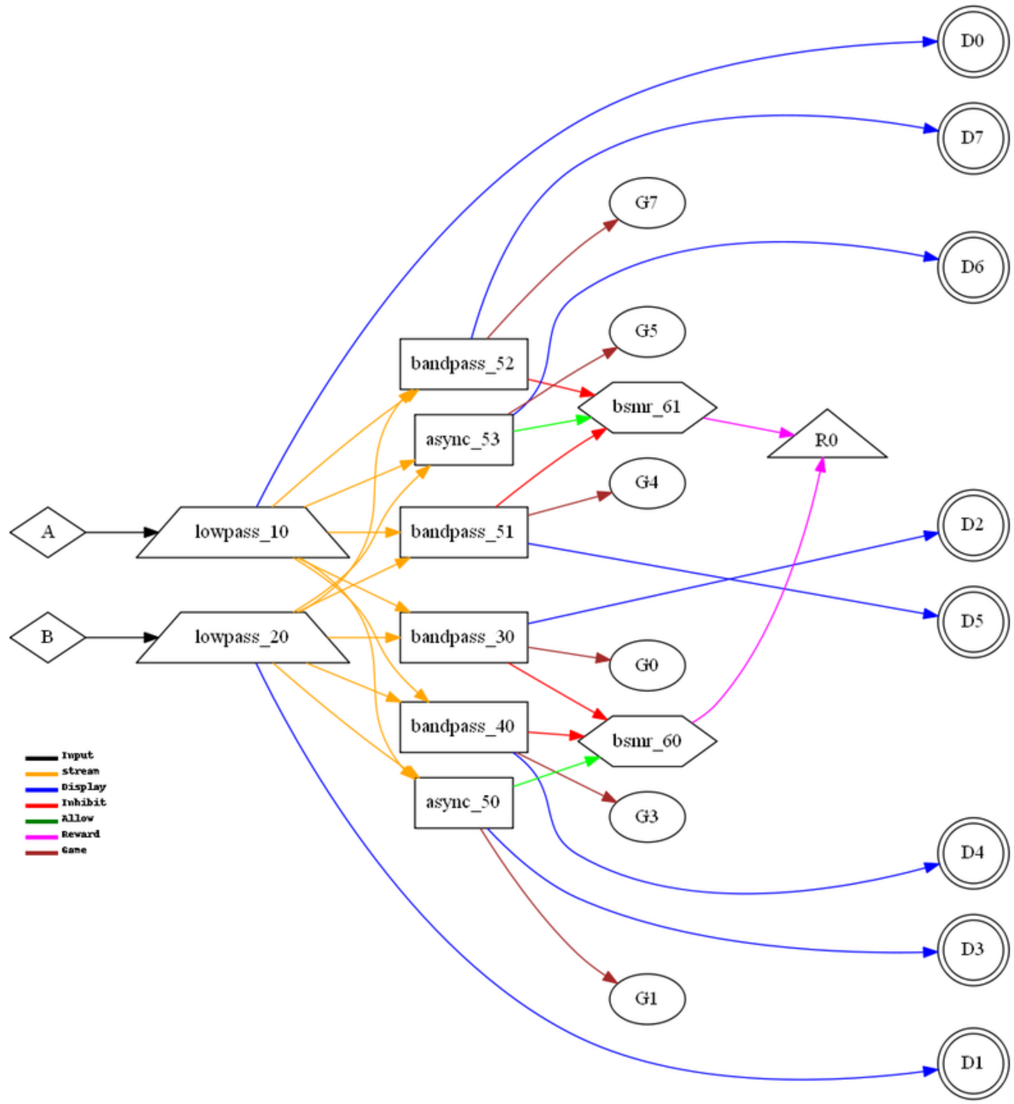
270 ABSUMABSUM (SUMAB + SUMAB) CCIRIIRI



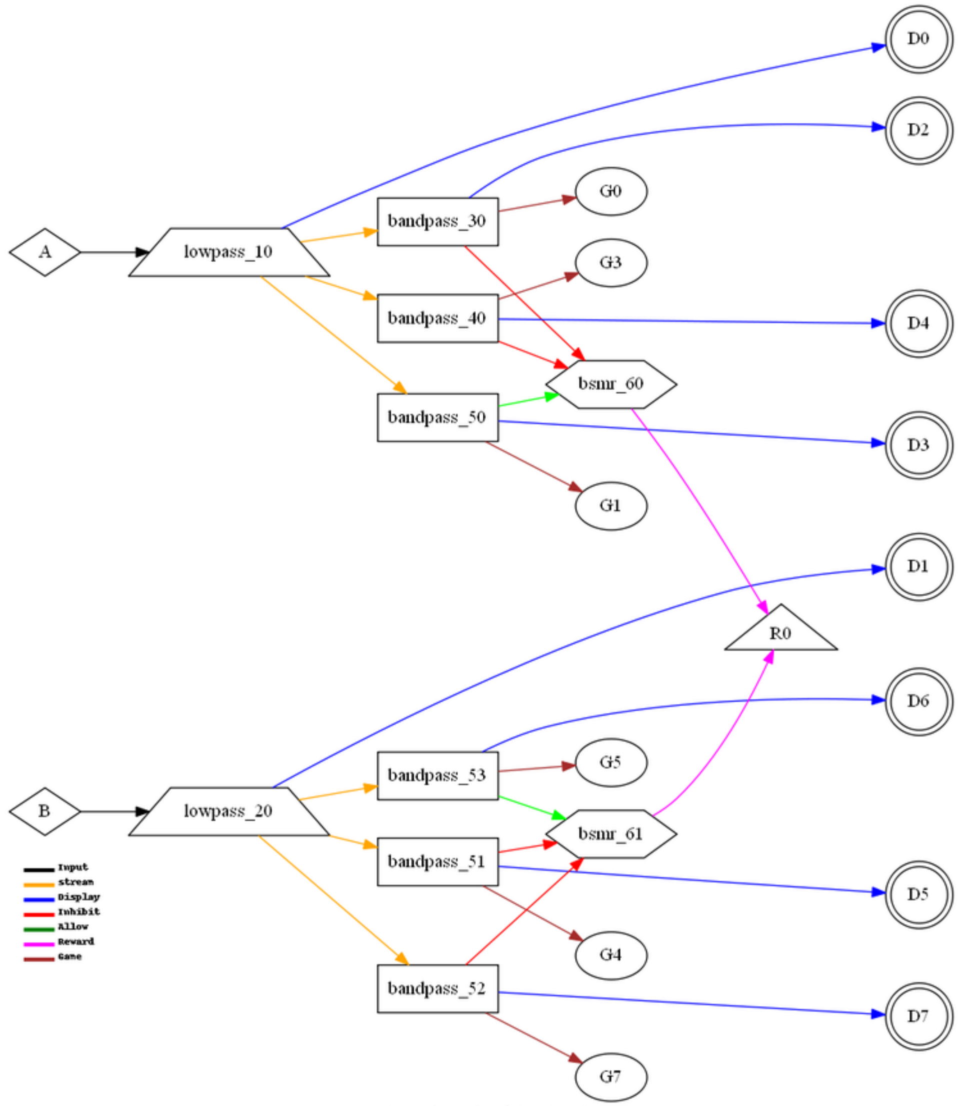
271 ABDIFFABDIFF (DIFFAB + DIFFAB) CCIRIIRI



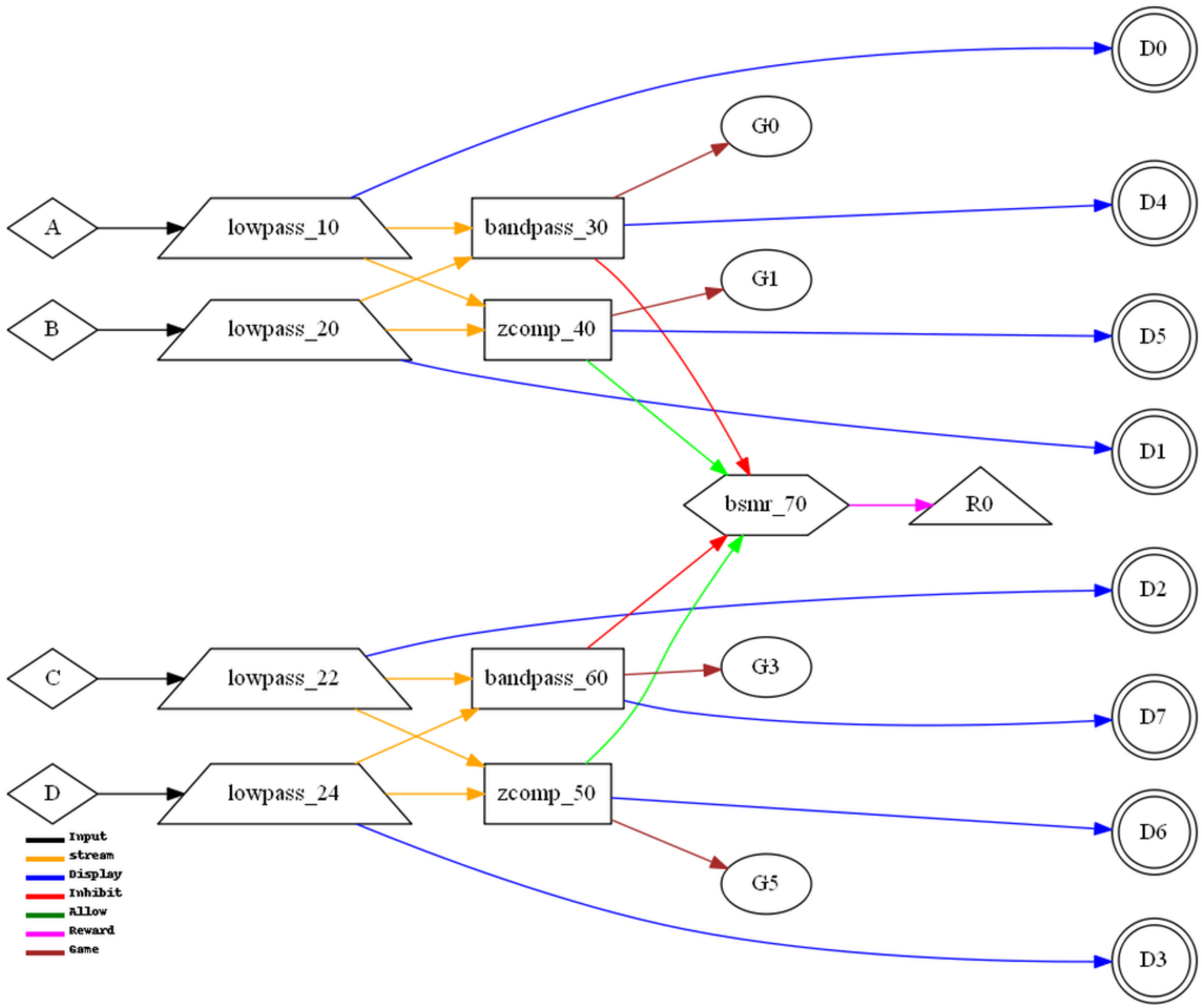
272 ABSUMABDIFF (SUMAB + DIFFAB) CCIRIIRI



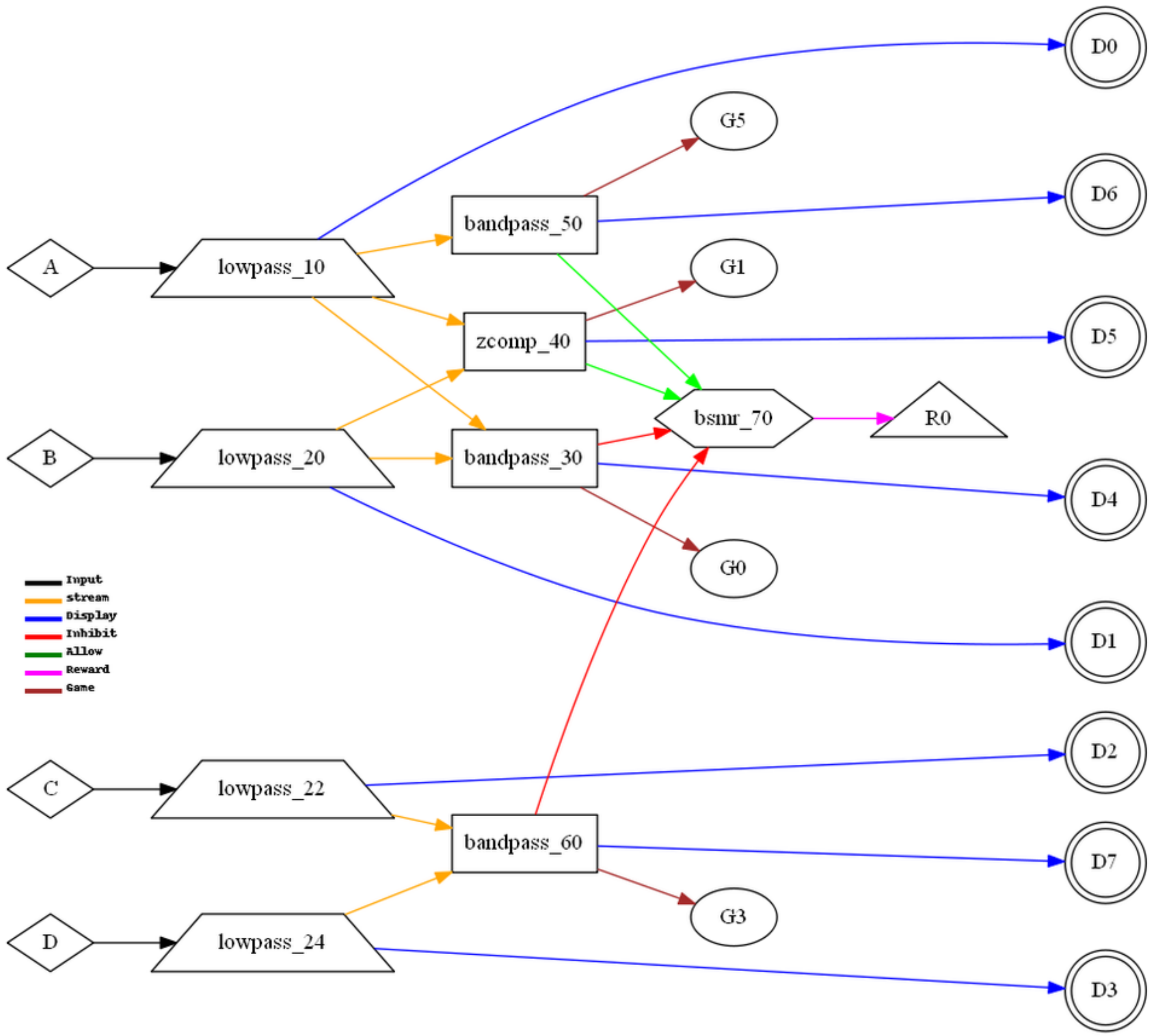
232 AsyncDual (comodulation measure between channel A and B) CCIRIIRI



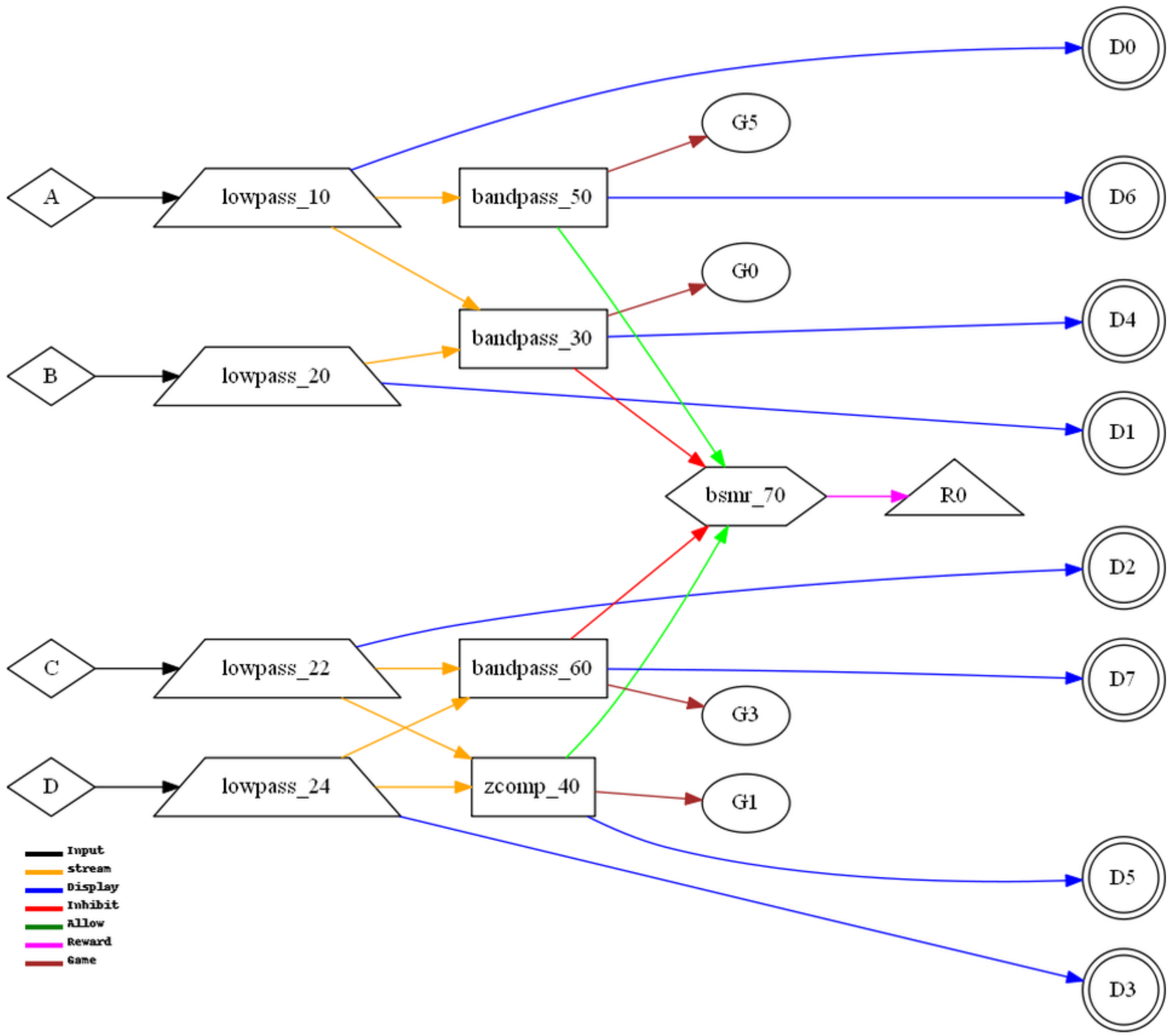
201 2-Rew (two channels of data input) CCIRIIRI



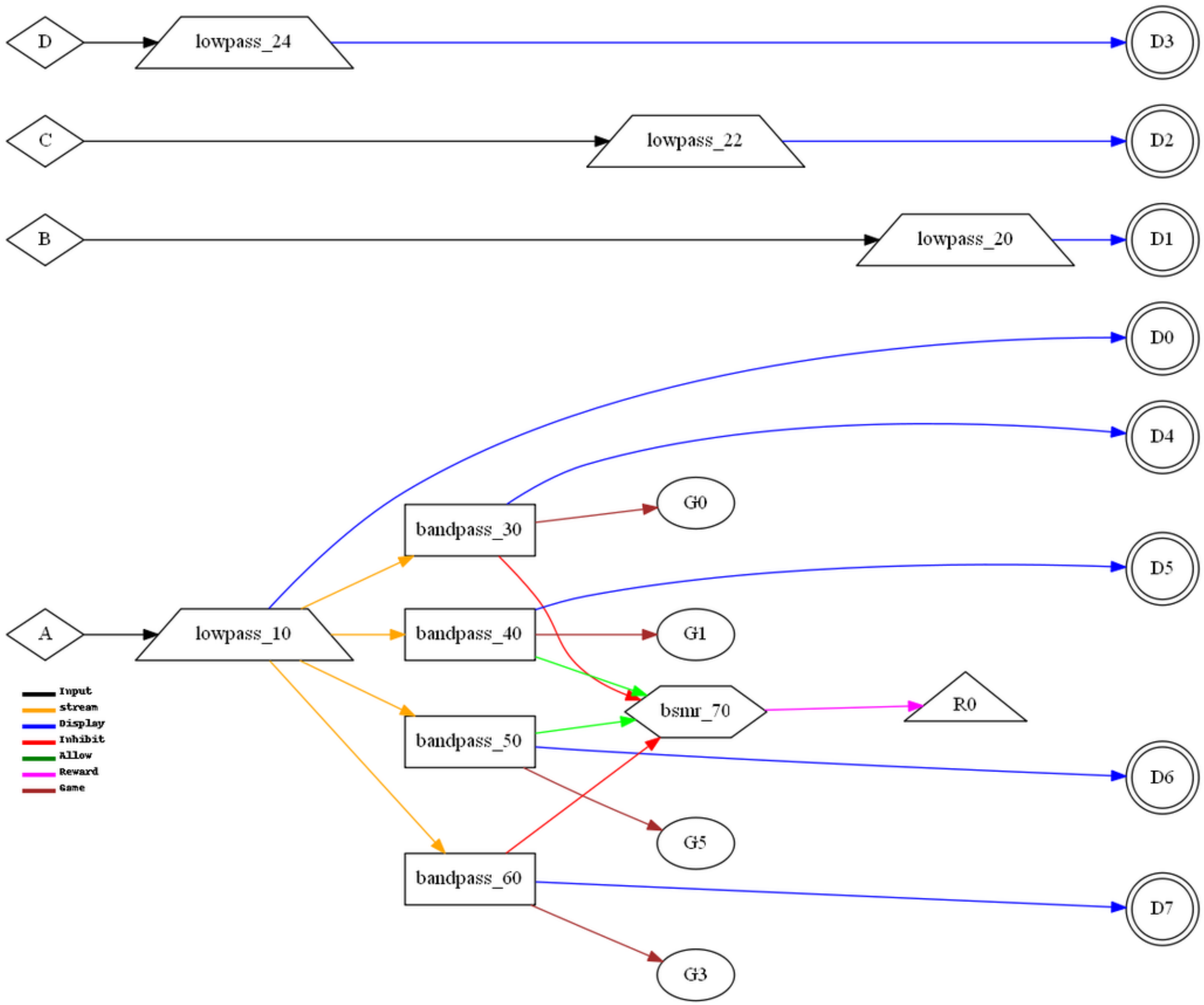
6100 DZcomp (4 channel zcomposite) CCCCIRRI



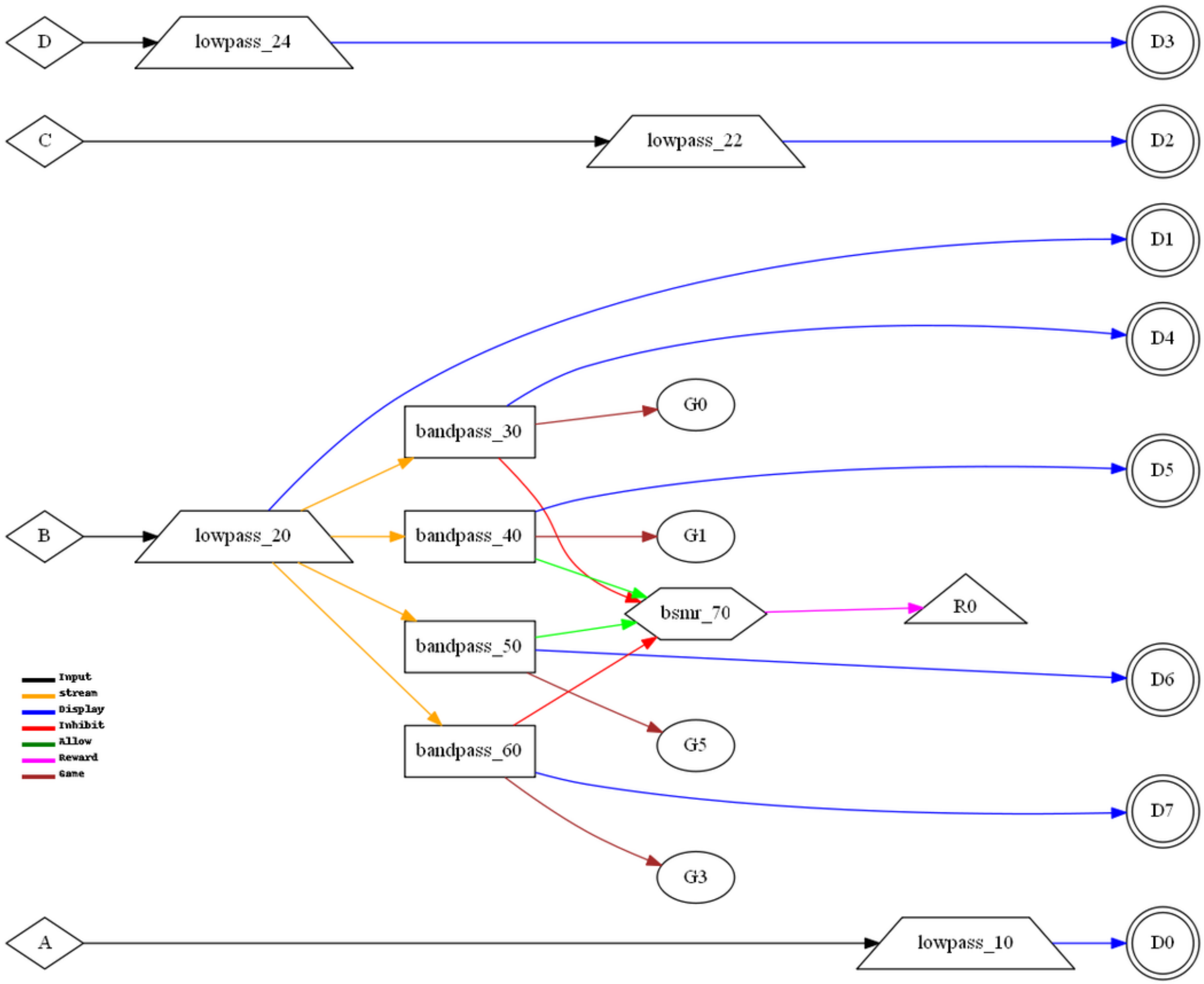
6110 DZcompBPAB (4 channel zcompositeAB + single A) CCCCIRRI



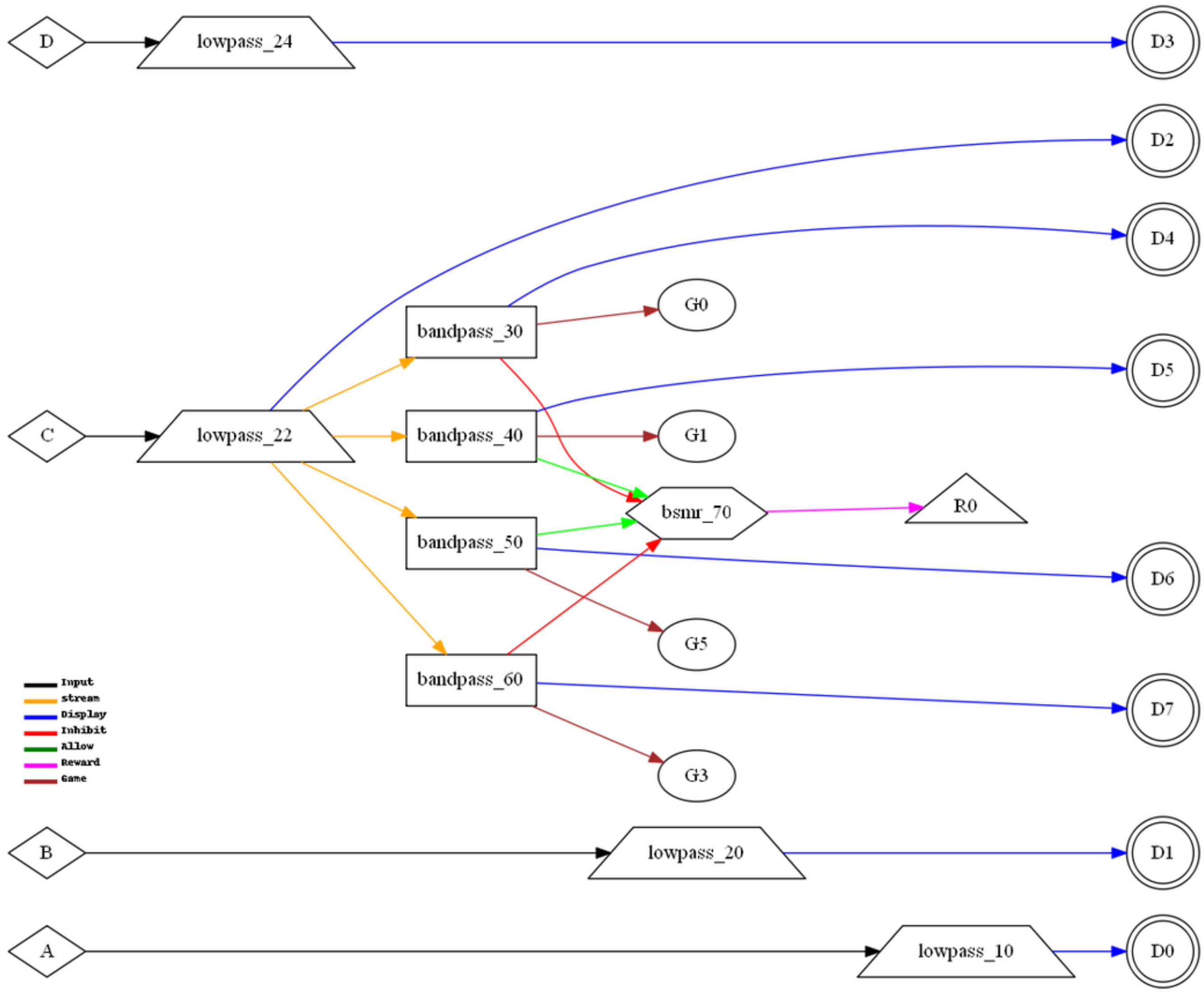
6114 DZcompBPCD (4 channel zcompositeCD + single A) CCCCIRRI



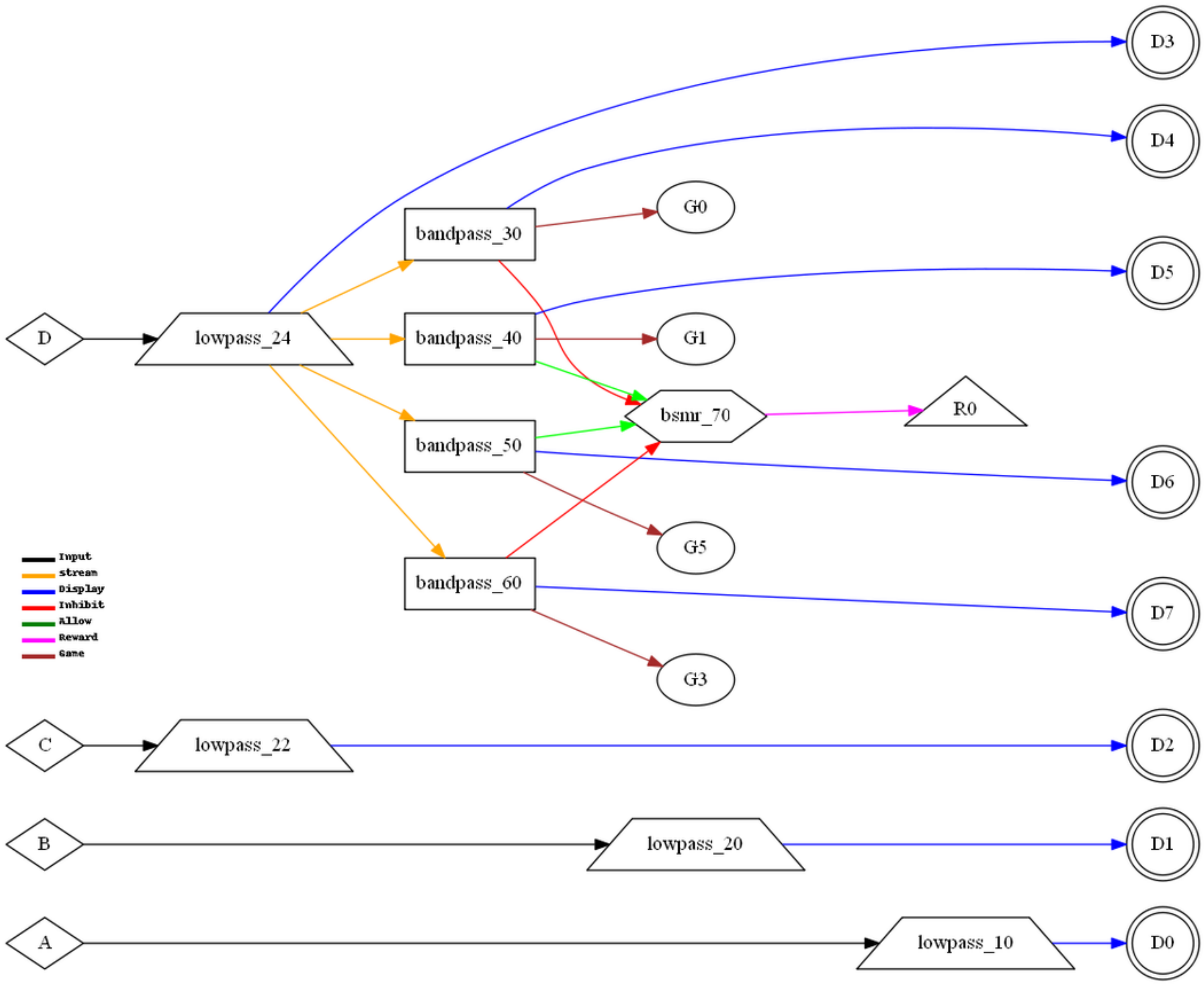
6120 DSingleA (4 channel single A) CCCCIRRI



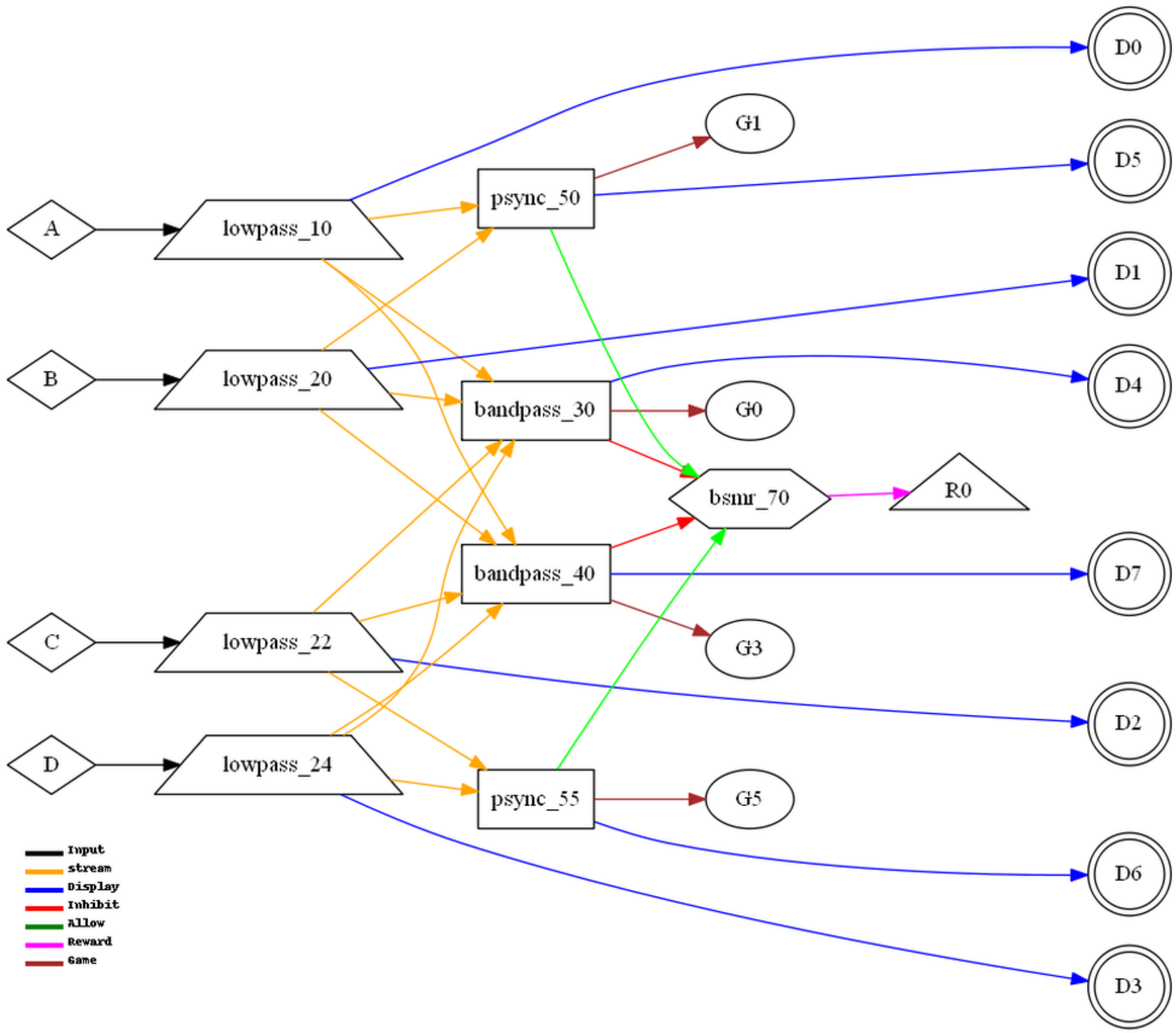
6130 DSingleB (4 channel single B) CCCCIRRI



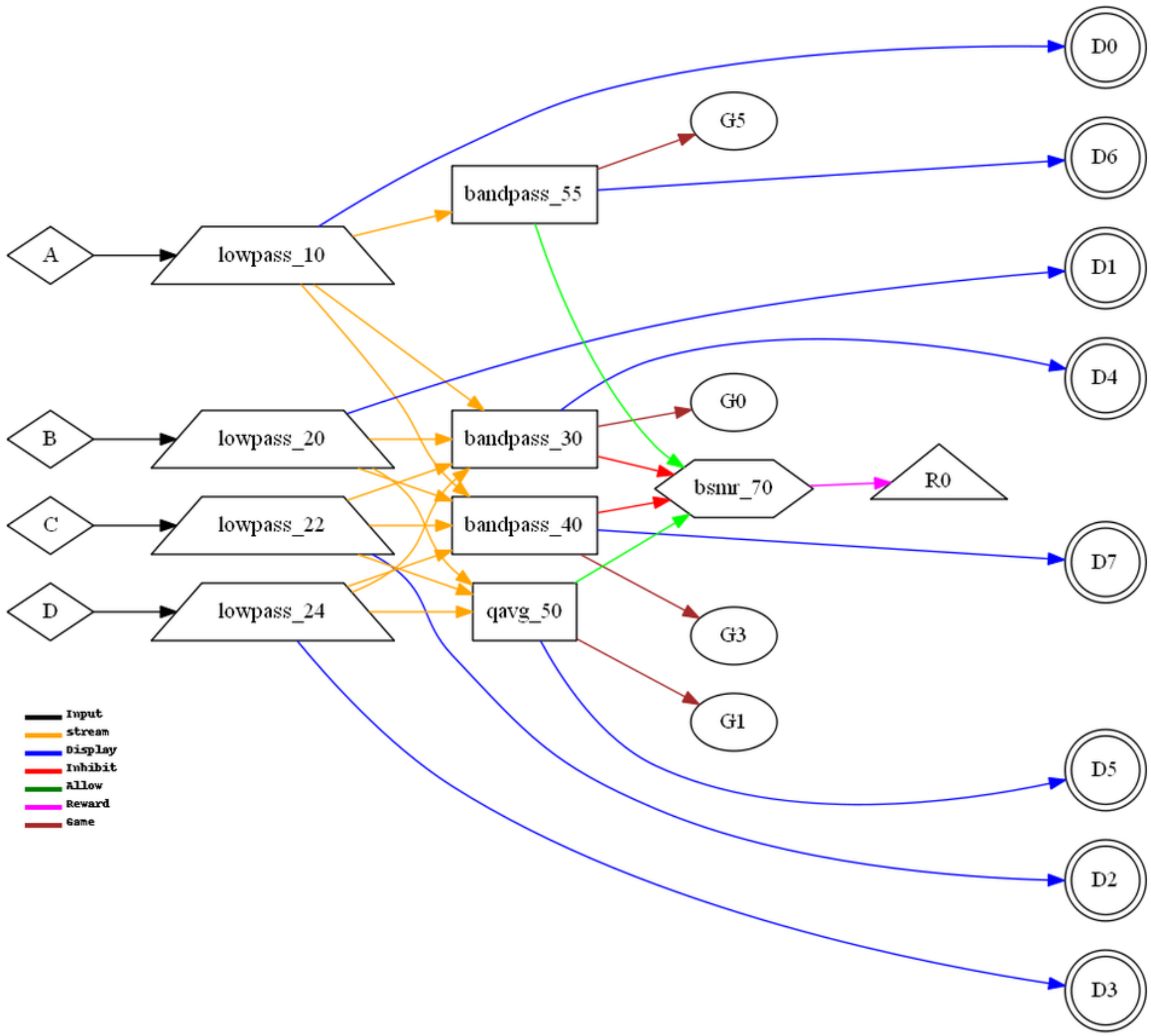
6140 DSingleC (4 channel single C) CCCCIRRI



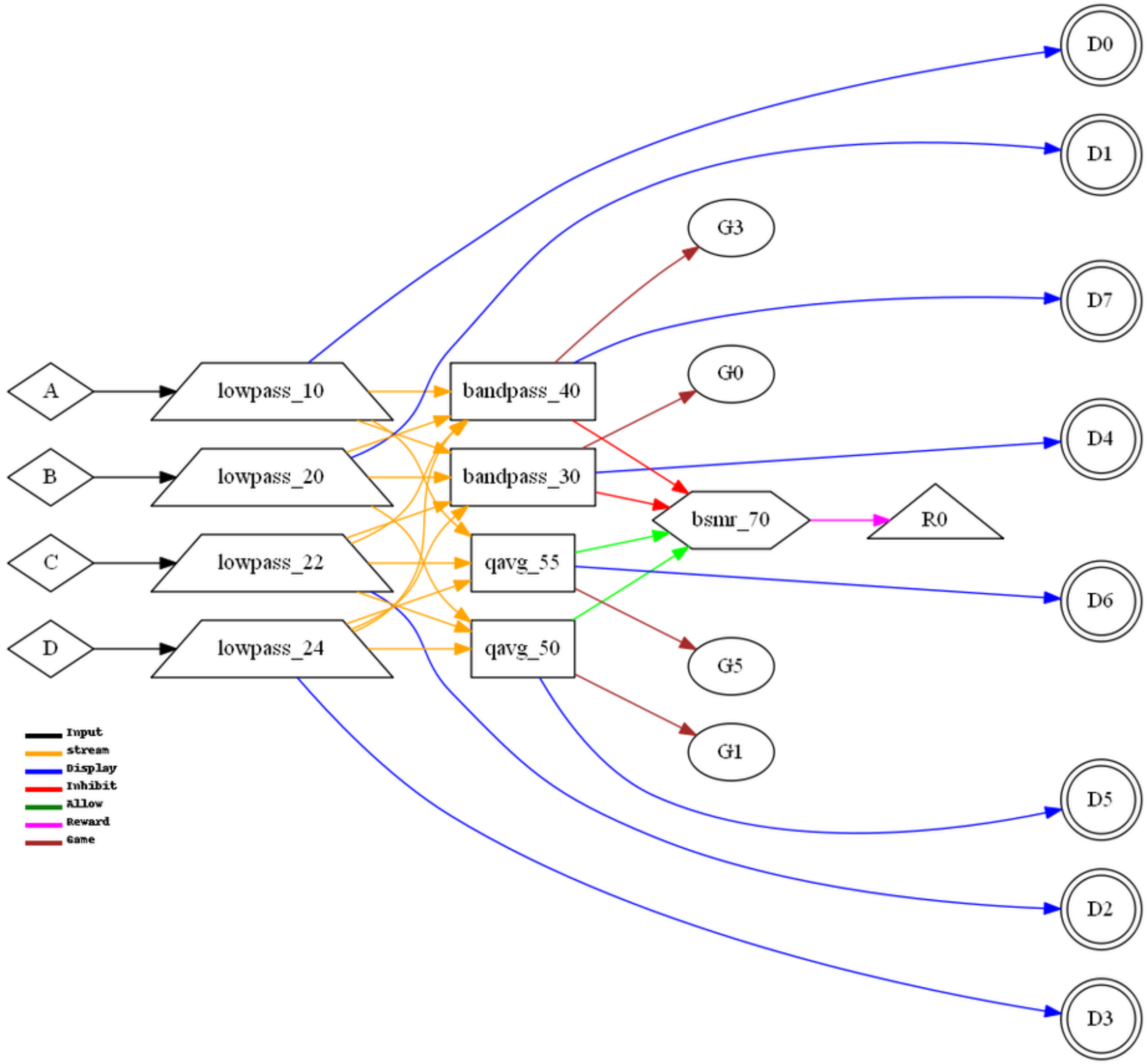
6150 DSingleD (4 channel single D) CCCCIRRI



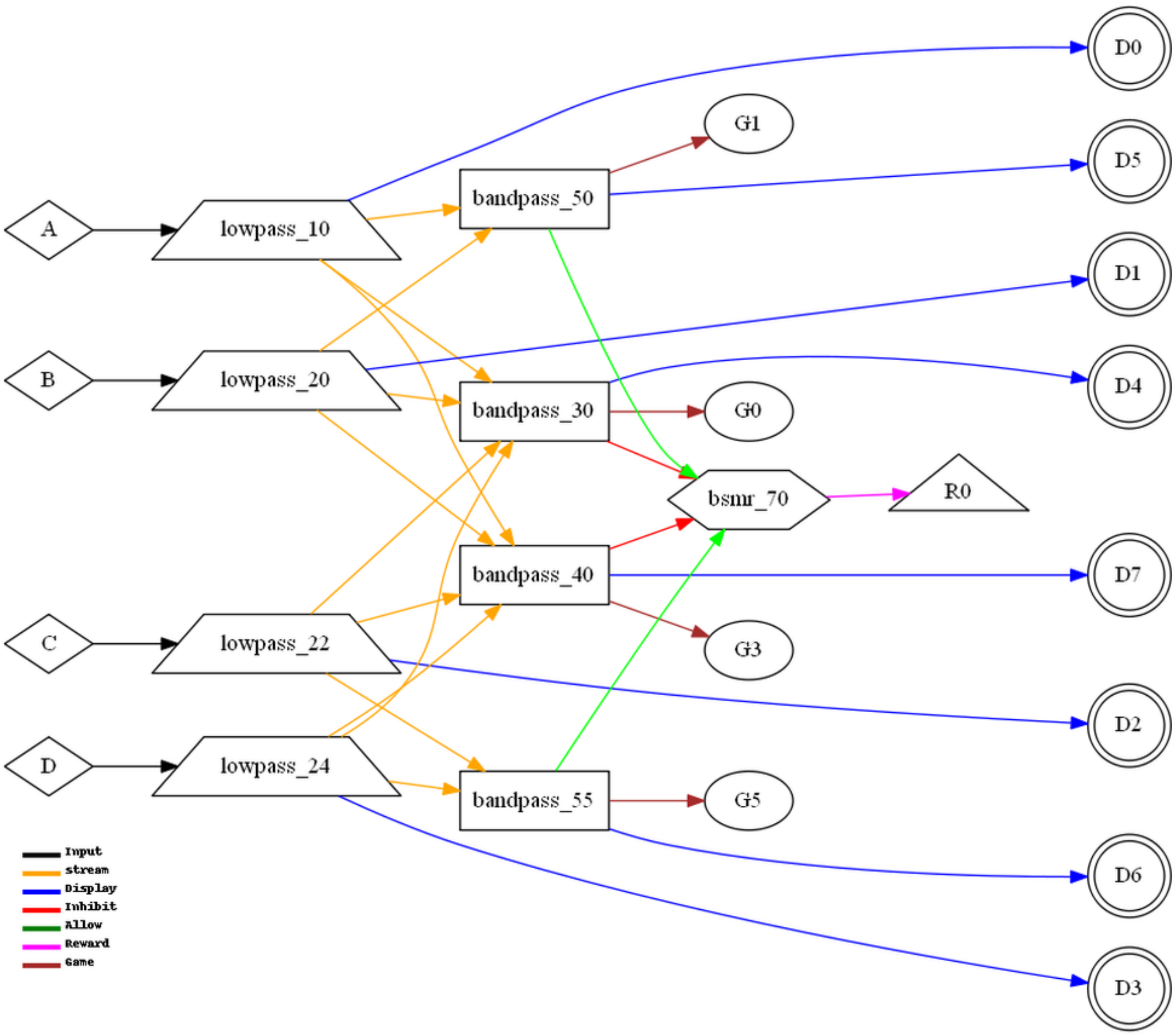
6160 DPsyncABCD (4 channel two psync) CCCCIRRI



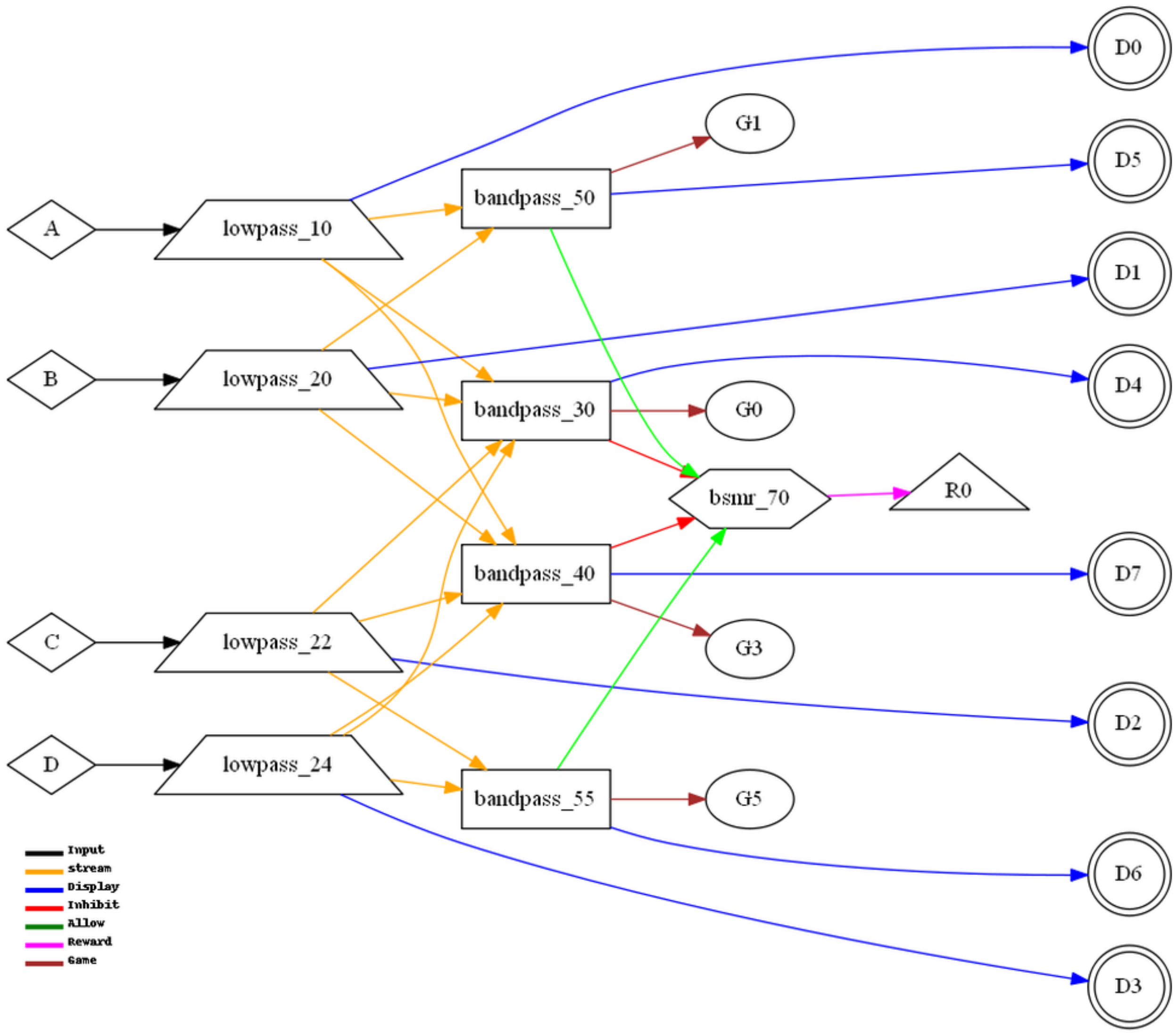
6170 DPsyncAvgBP (4 channel averaged psync + A) CCCCIRRI



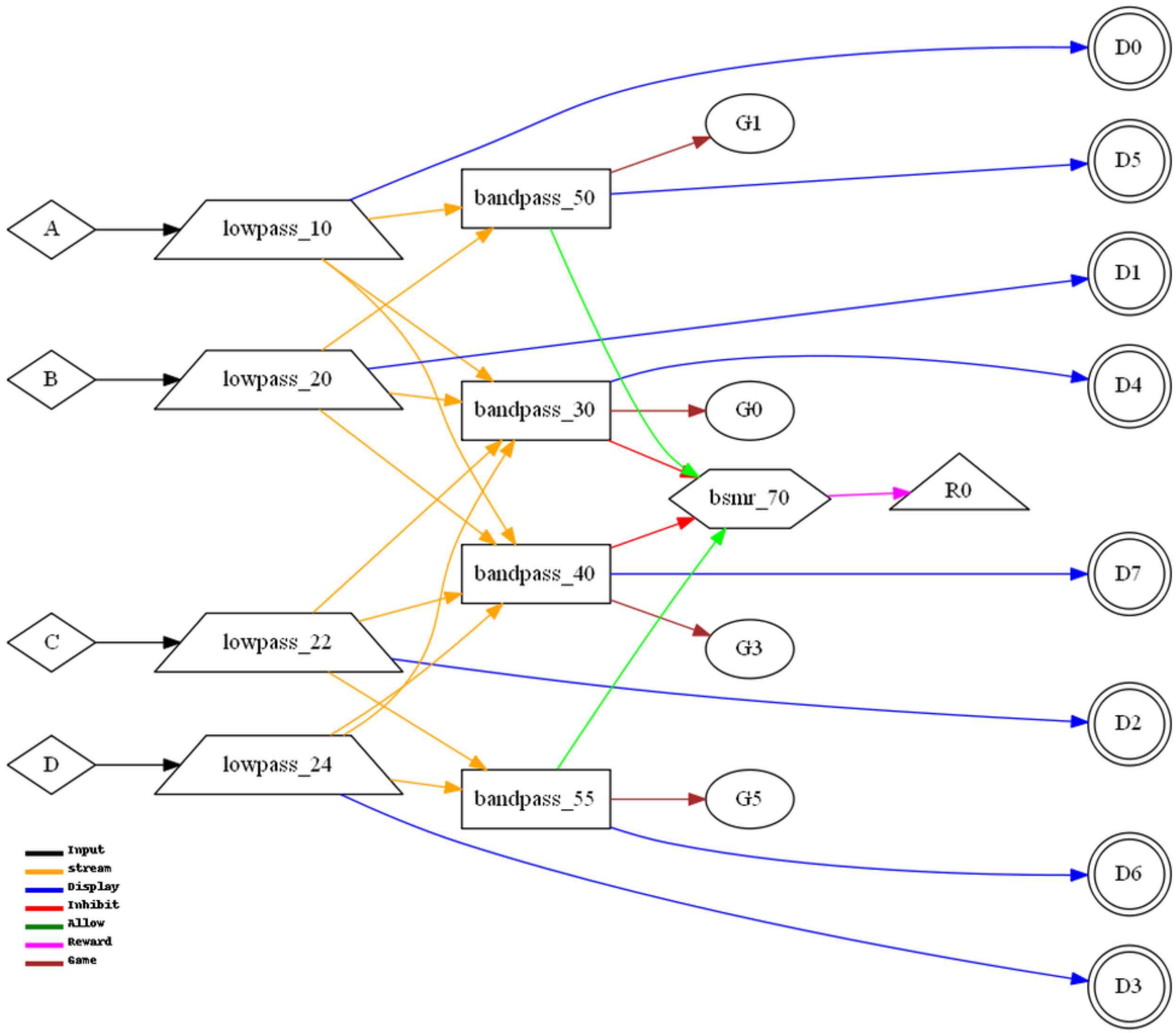
6180 DPsyncAvg2 (4 channel 2 averaged psyncs) CCCCIRRI



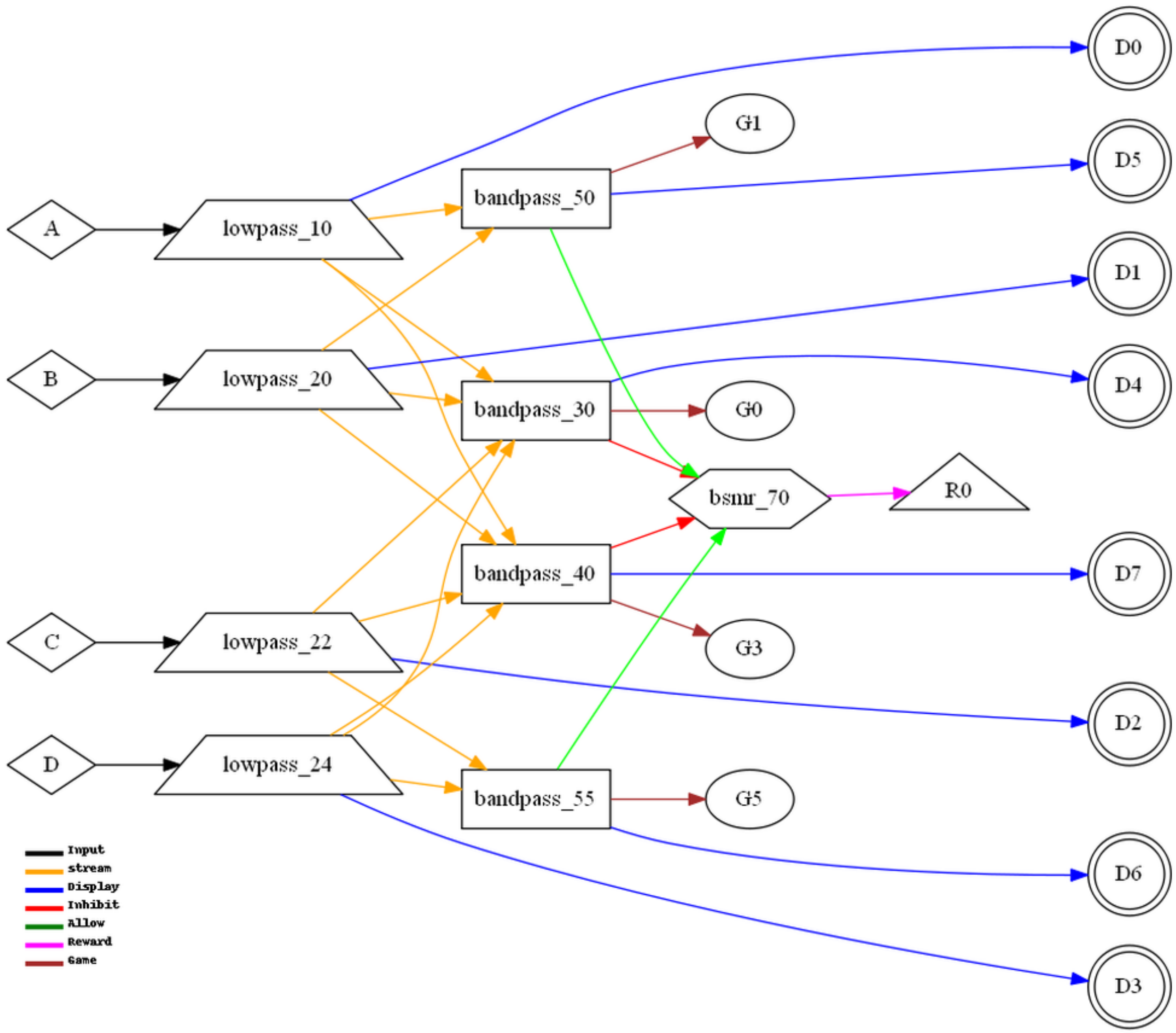
6182 DSumABSumCD (4 channel SumAB SumCD) CCCCIRRI



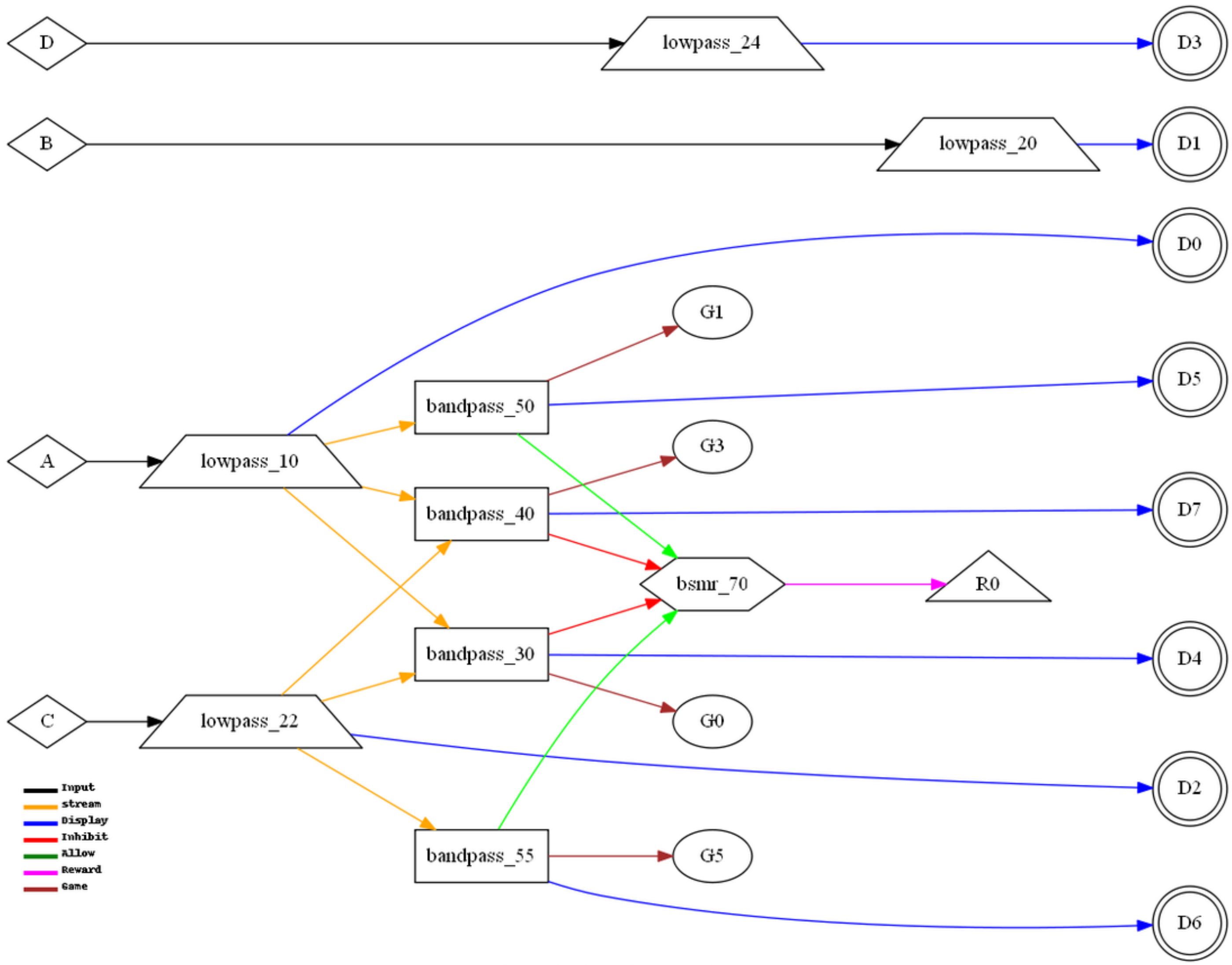
6184 DSumABDiffCD (4 channel SumAB DiffCD) CCCCIRRI



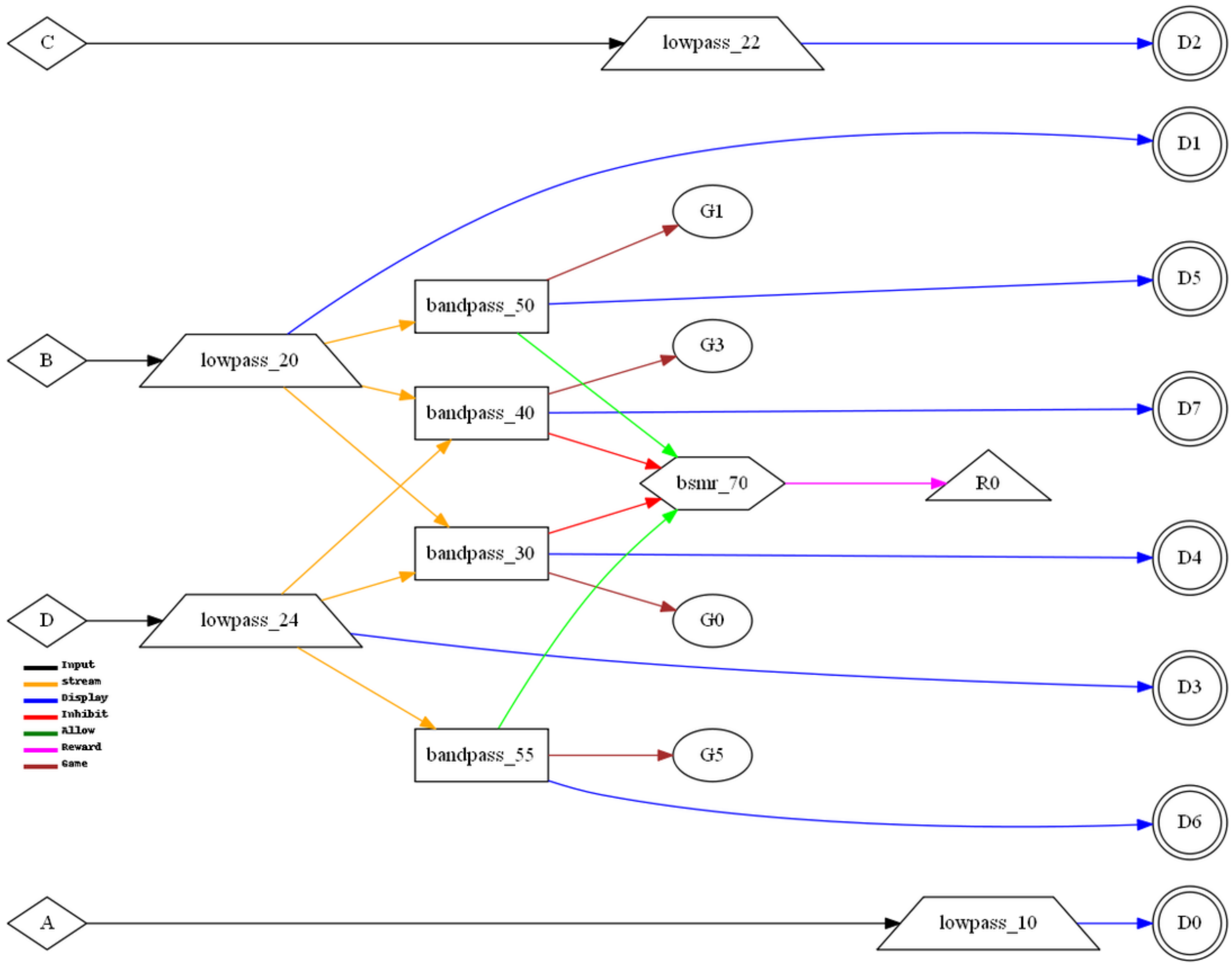
6186 DDiffABSumCD (4 channel DiffAB SumCD) CCCCIRRI



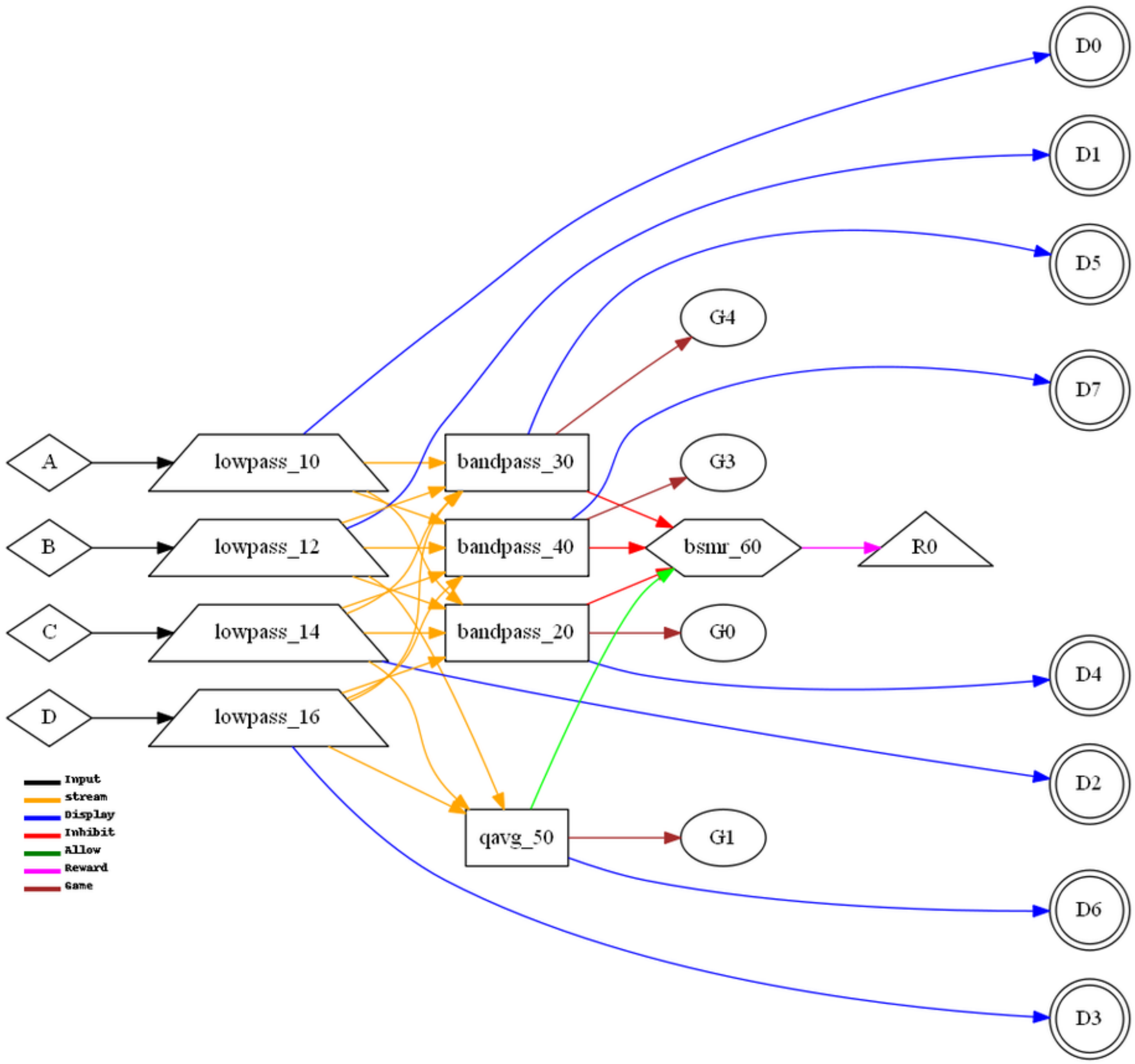
6188 DDiffABDiffCD (4 channel DiffAB DiffCD) CCCCIRRI



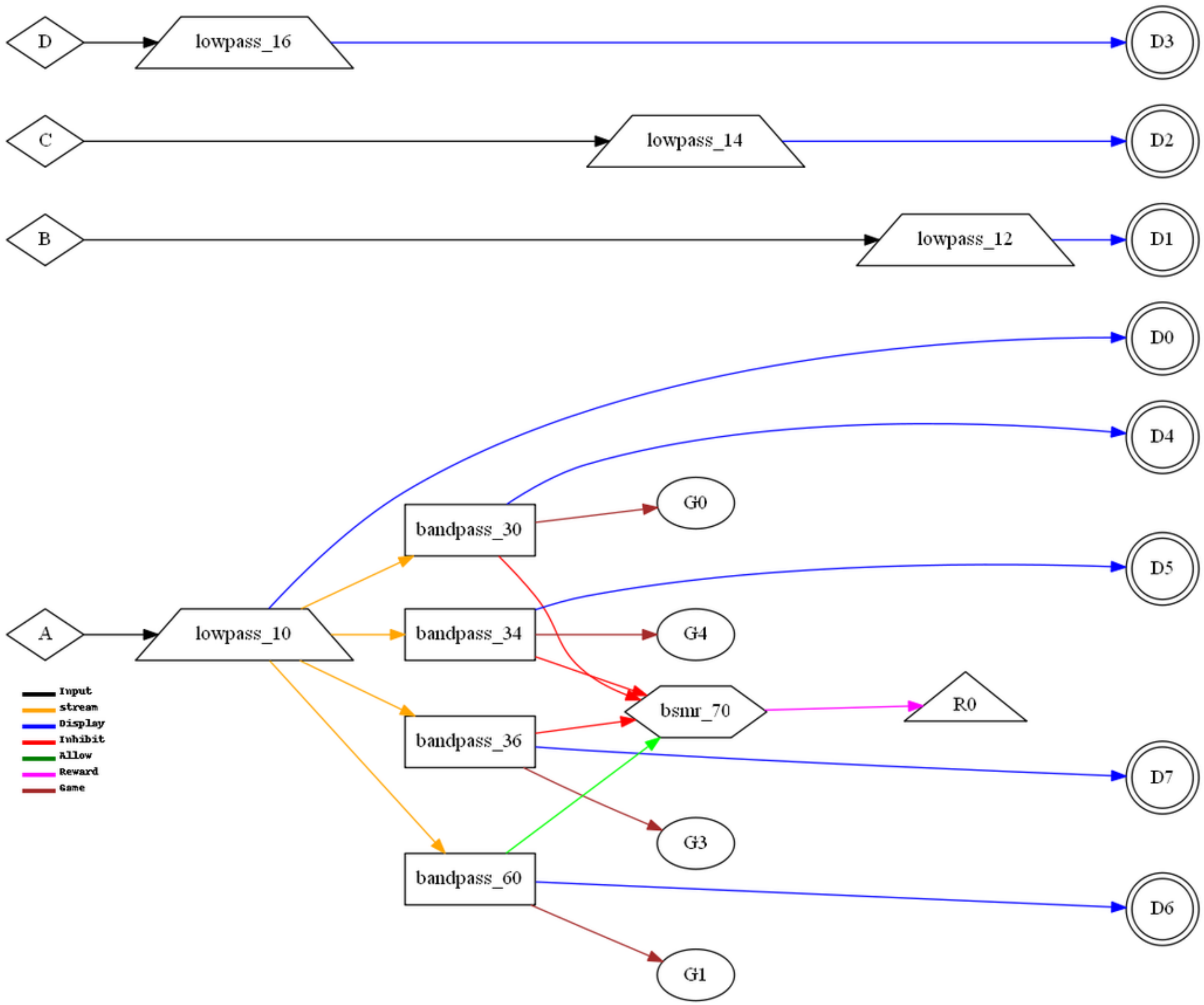
6190 DDualAC (4 channel Just A,C) CCCCIRRI



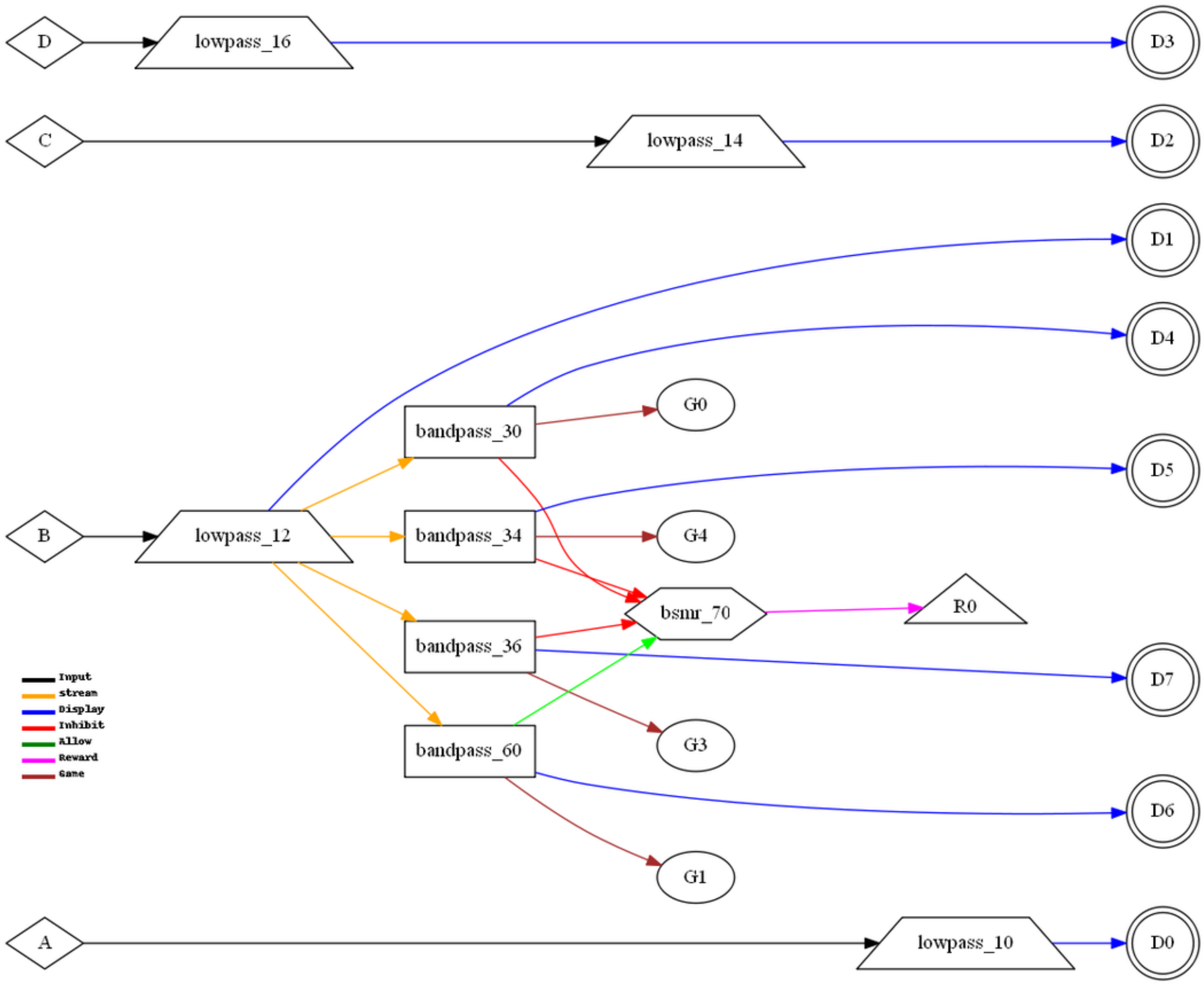
6192 DDualBD (4 channel Just B,D) CCCCIRRI



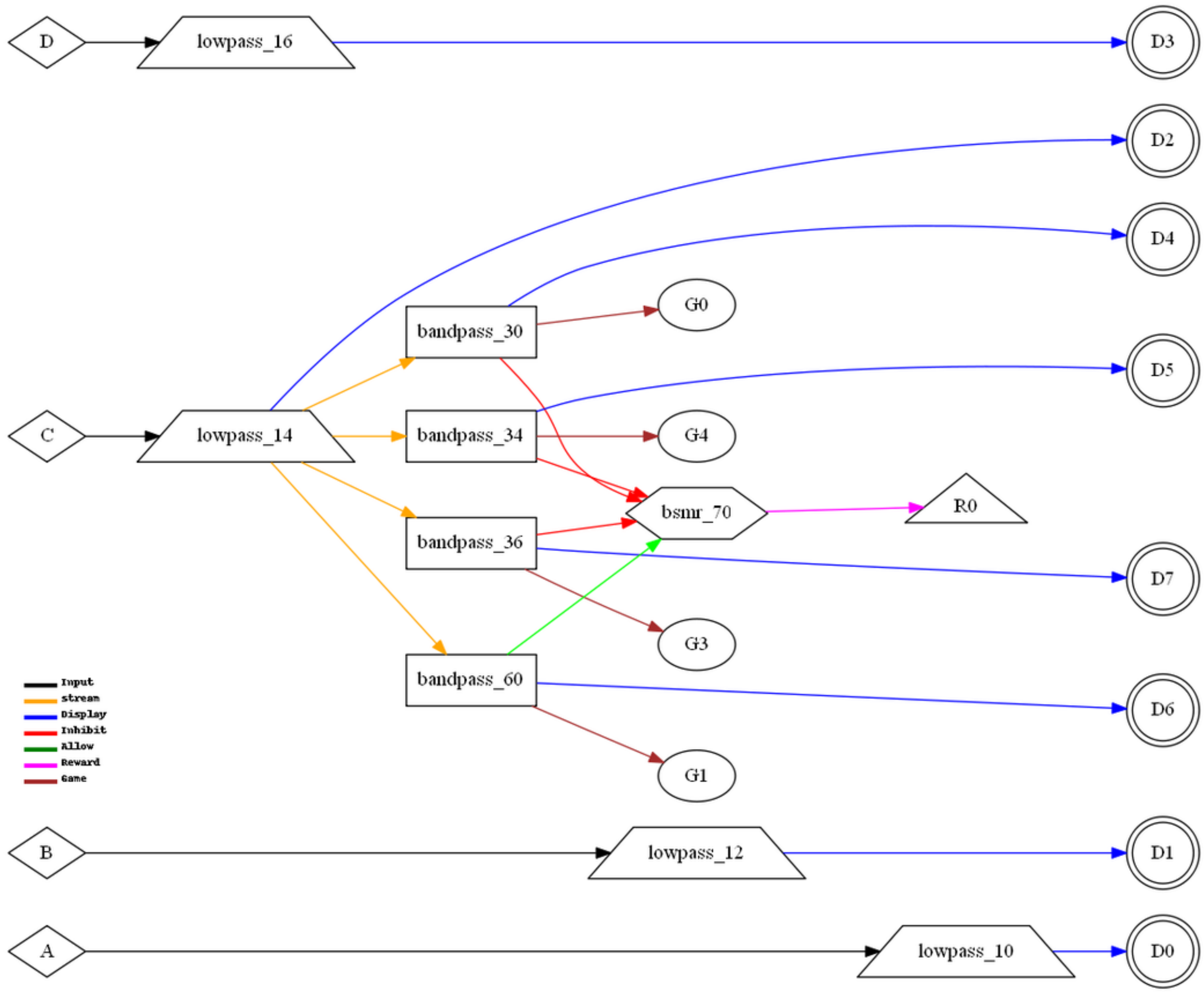
6600 AvgAQPS (4 channel PSync Averaged + 3 Inhibits) CCCCIIRI



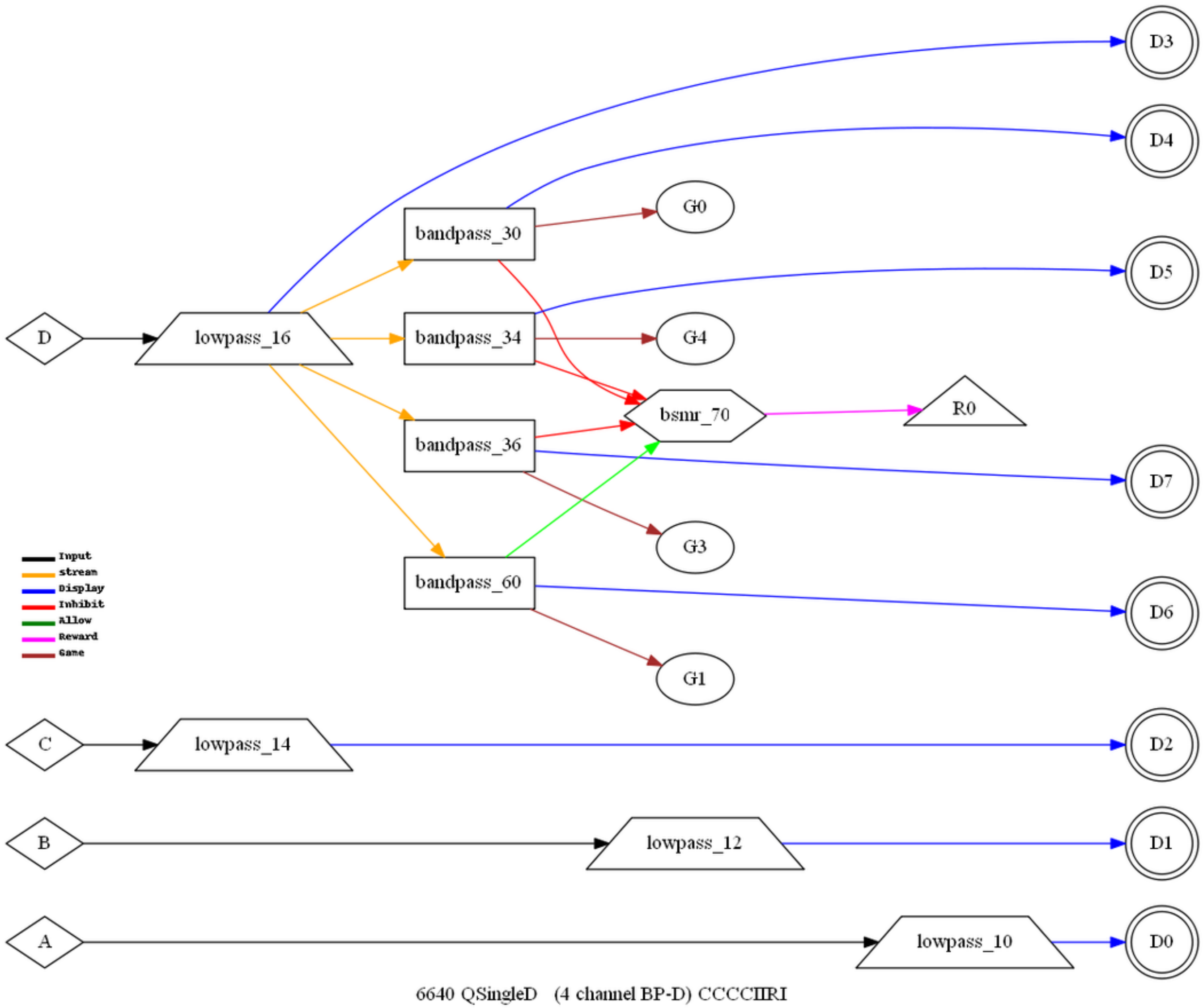
6610 QSingleA (4 channel BP-A) CCCCIIRI

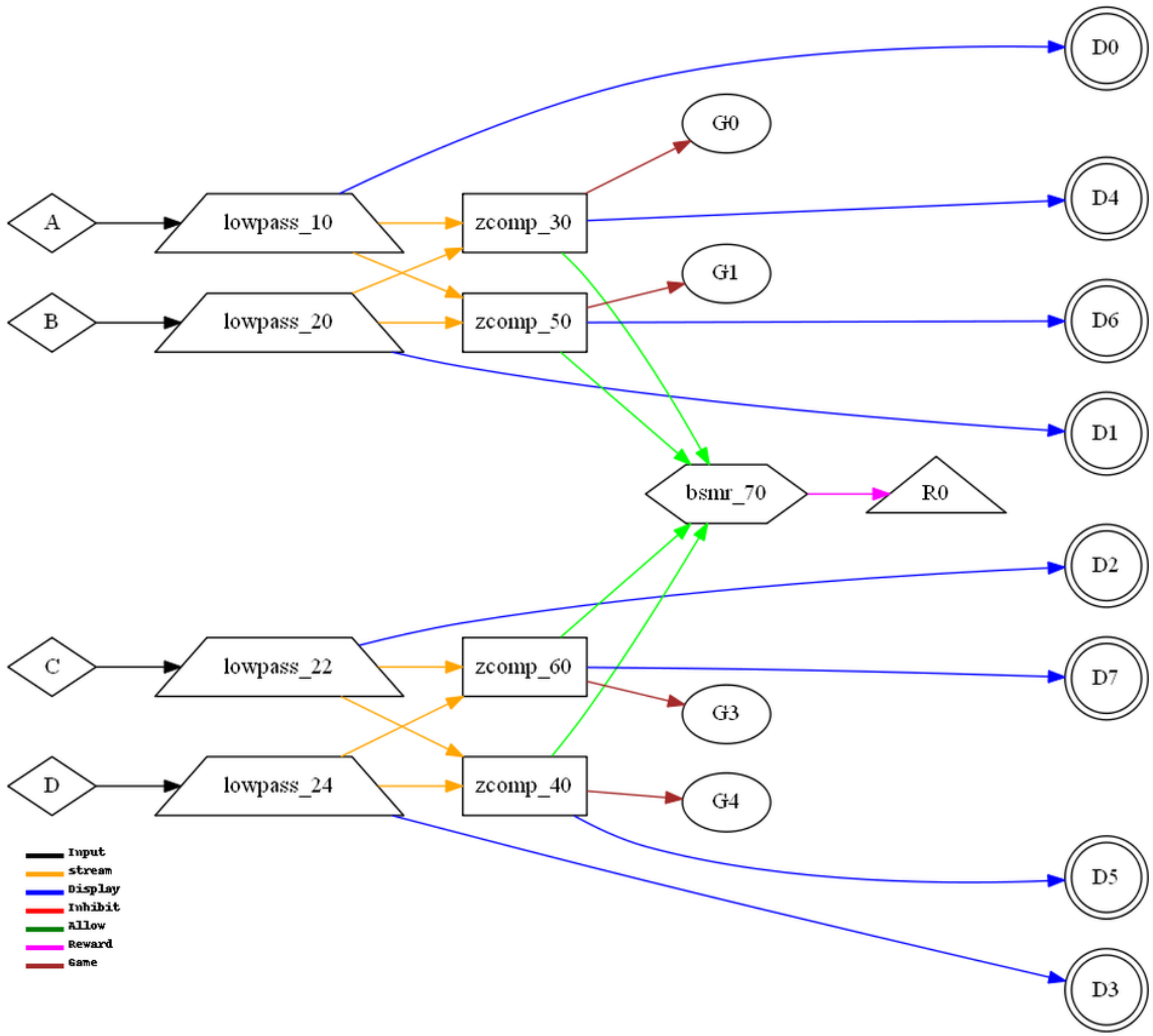


6620 QSingleB (4 channel BP-B) CCCCIIRI

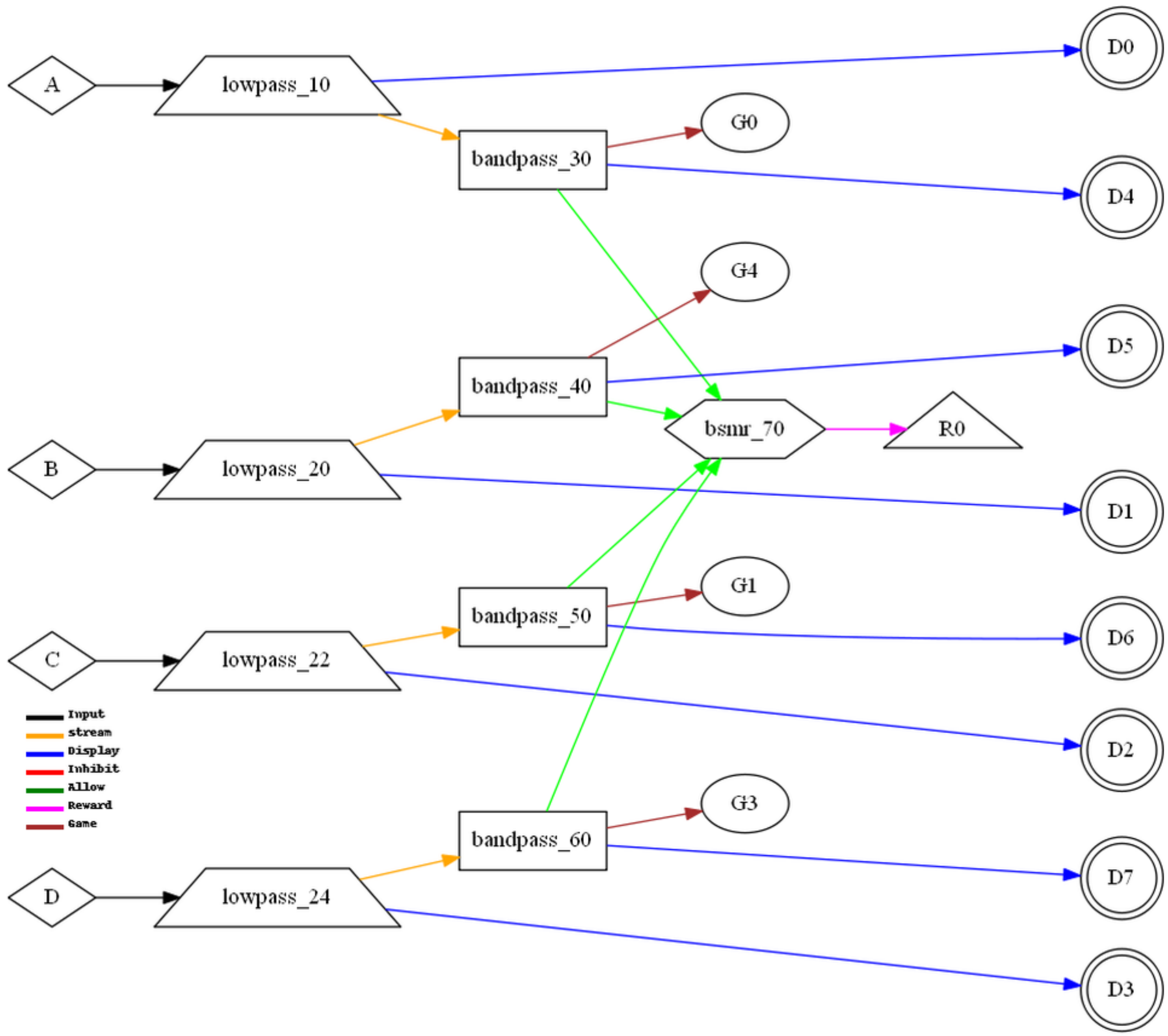


6630 QSingleC (4 channel BP-C) CCCCIIRI

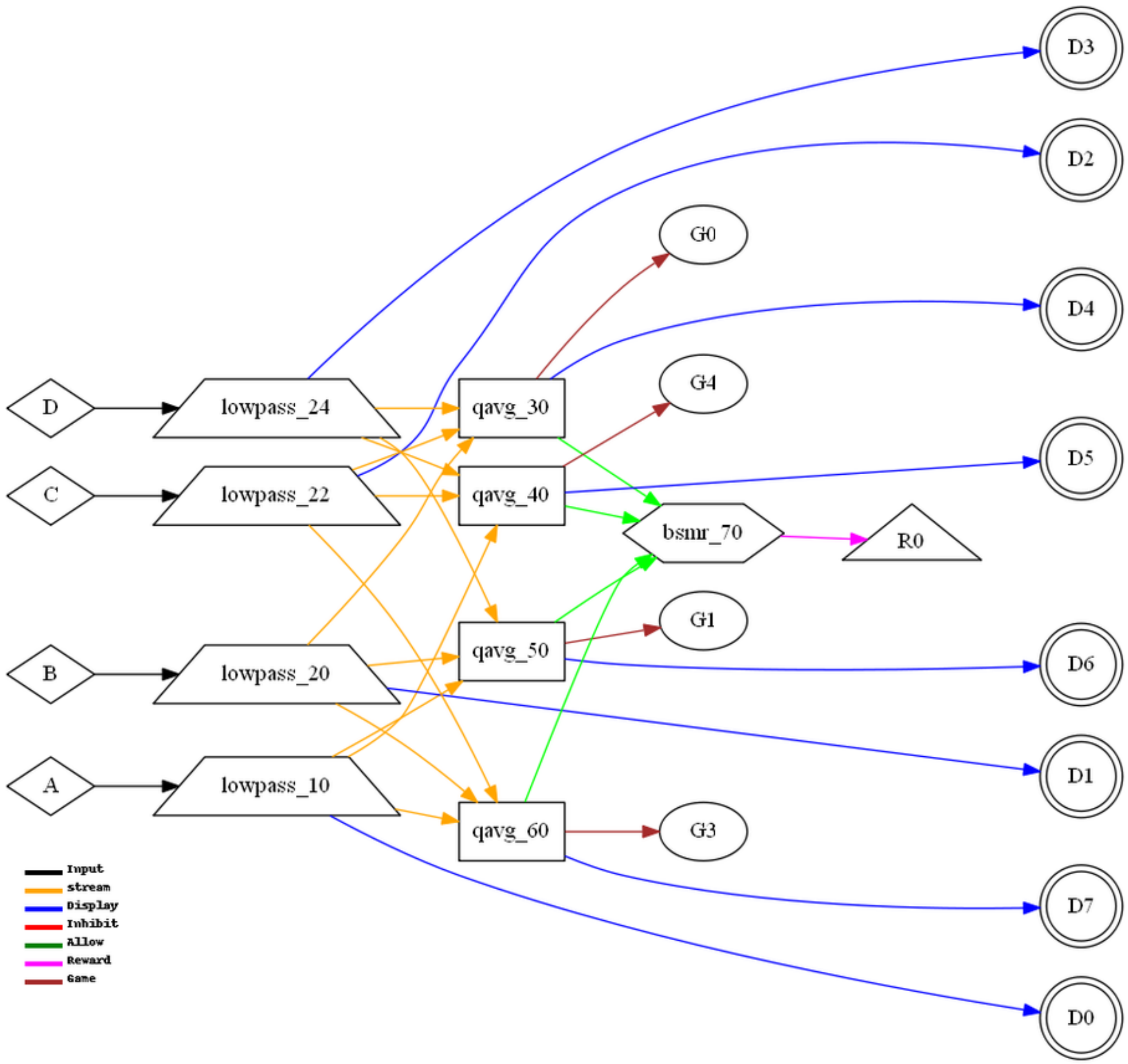

D3
D4
G0
bandpass_30
D5
D
lowpass_16
bandpass_34
G4
bsmr_70
R0
bandpass_36
D7
G3
Input
Stream
Display
Inhibit
Allow
Reward
Game
bandpass_60
D6
G1
C
lowpass_14
D2
B
lowpass_12
D1
A
lowpass_10
D0
6640 QSingleD (4 channel BP-D) CCCCIIRI



6000 QZcomp (4 channel zcomposite) CCCCRRRR



6010 QABCD (4 channel amplitude) CCCCRRRR



6020 Avg4QPS (4 channel Average Psyncs) CCCCRRRR

Appendix D: Data formats

Common Definitions:

```
/* common definitions */
/*

B4.0.0
030825.1126 hpl added definitions for devices
030905.1545 hpl defined c2mini
4.0.3g
040329.1650 hpl changed defs for multitude of J&J devices
4.0.99
040622.1406 hpl game defs
040830.1115 hpl reward mode group def
041026.1520 hpl other rsf threads (like tactile)
050422.1650 hpl added more device codes
050427.1420 hpl added display band type code
081104.1410 hpl Added FR_BAND
091004.1708 mjb renamed FF_DAK1 FF_UNITY
100824.1345 hpl added definition for eye status change
110209.1800 hpl pragma pack
110228.1700 hpl revisions for 4ch
130513.1338 hpl added new multiple psync modes
130729.1845 hpl added new psync combinations
130731.0608 hpl added special R5 backing store
140110.0800 hpl add place for lf notch
140329.1020 hpl new action codes for cal & impedance
150415.0840 hpl added uncouple function
151222.1410 hpl added MULTIRAW sizing
160606.0950 hpl change define to maintain 16-chan compatability
*/
```



```
#ifndef __eegerh__
#define __eegerh__

//#define TIMELOOKER 1

#pragma pack(push,1)

#define STATE_REMAP 0         // indeterminate
#define STATE_SETUP 1         // no drawing (not running)
#define STATE_SYNC  2         //
#define STATE_QUIT  9         // end program

#define STATE_DRAWABLE    10  // beginning of drawable states
#define STATE_INIT  10  // reinit state (starting a 'run')
#define STATE_FREEZE      11
#define STATE_PAUSE 12
#define STATE_RUN   20
#define STATE_REST  21

// these are the queue numbers for the termination task queues
#define HSD_MAIN    1
#define HSD_THREAD  2
#define RSF_MAIN    3
#define RSF_THREAD  4
#define GAME_THREAD 5
#define RSF_OTHER   6


#define DISP_SETUP  0
#define DISP_HSD    1
#define DISP_LONGT  2
#define DISP_SPECT  3
#define DISP_ZSCORE       4
#define DISP_PERIODS      5
#define DISP_FULLRAW 6  // future
#define DISP_LAST DISP_PERIODS

#define DISP_DEBUG  8
```



```
#define DISP_HELP   9

#define DISP_LSD    10  // there are up to 9 lsds
#define DISP_LSD1   11

#define DISP_EDITOR       19

#define DISP_GAME   20

#define SCRNMODE_SINGLE  2
#define SCRNMODE_DUAL      1
#define SCRNMODE_2COMP     0

#define RAWD   1   // raw data
#define PBACK  2   // playback
#define SIGGEN 3   // signal generator


#define MAXUSEDSTREAMS 16   // most streams used for display (upper values used internally)
#define RAWUSEDSTREAMS 32
#define MAXPERIPHS  4           // maximum number of peripheral channels
#define MAXPERIPHSALLOWED 3
#define MAXLOWPASS  4        // maximum number of lowpass channels/streams
#define BACKDEPTH   6
#define FLT_R1      MAXUSEDSTREAMS   // offset to backing store
#define FLT_R2      (FLT_R1+MAXUSEDSTREAMS) //offset to backing store for reward 1
#define FLT_R3      (FLT_R2+MAXUSEDSTREAMS) //offset to backing store for reward 2
#define FLT_R4      (FLT_R3+MAXUSEDSTREAMS) //offset to backing store for reward 3
#define FLT_R5      (FLT_R4+MAXUSEDSTREAMS) //offset to backing store for reward 4
// leave room for 5 more colums of data for the psyncavg storage
#define FLT_LIVE    (FLT_R5+MAXUSEDSTREAMS+(BACKDEPTH-1)*MAXUSEDSTREAMS) // offset to live data for sham runs
#define FLT_NOTCH   (FLT_LIVE+MAXLOWPASS+MAXPERIPHS)   // offset to notch filter coefficients
#define FLT_ZNOTCH  (FLT_NOTCH+MAXPERIPHS)                   // offset for lf notch
#define FLT_NOLO    (FLT_ZNOTCH+MAXPERIPHS) // offset for non-lowpass, non-dc-corrected raw values (for SCP and VLF)
#define FLT_PERIPH  (FLT_NOLO+MAXLOWPASS)  // offset for peripheral state values which may not be used...
#define FLT_MULTIRAW (FLT_PERIPH+MAXPERIPHS) // one buffer pointer for multichan raw
#define FLT_SIZER   (FLT_MULTIRAW+1)  // allocation counter for states
```



```
#define MAXPERIODS 128        // maximum number of periods in a session
#define MAXREWARDS  4         // maximum number of reward streams
#define MAXDEVICES  2         // maximum number of input devices
#define MAXDEVCHANNELS 4    // maximum number of highspeed channels per device
#define MAXSTRANDS  8         // strands in EGS games
#define MAXREWARDSTRANDS  4       // maximum number of reward strands
// message ids
#define EEGMBASE 0x1000

#define EMSG_RSFTIME WM_APP+EEGMBASE+  0    // hs timer message
#define EMSG_RSFWDOG WM_APP+EEGMBASE+  1    // sent to OC to show alive

#define EMSG_HSDTIME WM_APP+EEGMBASE+100    // time to run
#define EMSG_HSDWDOG WM_APP+EEGMBASE+101    // sent to OC to show alive

#define EMSG_OCWDOG  WM_APP+EEGMBASE+201    // sent by OC to RSF to show alive
#define EMSG_OCACT   WM_APP+EEGMBASE+202    // operator control message to RSF



// the GROUP codes


#define GROUP_DC     0     // Display/control settings
#define GROUP_SCALE  1     //Scale settings
#define GROUP_MODE   2     //Mode changes (up/down, model, etc)
#define GROUP_RWD    3     //reward mode changes
#define GROUP_SITE   4     //Site location change
#define GROUP_STAGE  5     // Stage setting
#define GROUP_THRESH 6    //Thresh settings
#define GROUP_LOFR   7     // low freq or center freq
#define GROUP_HIFR   8     // high freq or width
#define GROUP_AGOAL  9     // autoset (1 bit), % (7 bits), time (byte), min (byte), max (byte)
#define GROUP_MISC 14     // some kind of setting to record (like integration time)
#define GROUP_EVENT 15    // some kind of event

// the ACTION codes
#define ACTION_SET  00    // just set the value
#define ACTION_KEY  01    // keycode
```



```
#define ACTION_MISC 02    // misc meaning
#define ACTION_RECORD 03

#define ACTION_INPUTLOSS 11 // channel is 1 back and 0 for loss
#define ACTION_NORMAL 12  // device into normal mode
#define ACTION_IMPEDANCE 13
#define ACTION_CALMODE 14
#define ACTION_REWARD 15  // reward granted
#define ACTION_FBACK 16 // begin feedback
#define ACTION_PAUSE 17
#define ACTION_USER  18 // user event (f8)
#define ACTION_USERM 19 // user event with message
#define ACTION_QUIT  20 // quit session

#define MAKE_ACTIONCODE(group,action,stream) (((group & 0x0f) << 12) | ((action & 0xff) << 4) | (stream & 0x0f))
#define ACTIONCODE_GROUP(ac)  ((ac >> 12) & 0x0f)
#define ACTIONCODE_ACTION(ac) ((ac >>  4) & 0xff)
#define ACTIONCODE_STREAM(ac) ( ac      & 0x0f)

// the stage kind codes
#define ST_SETUP    0
#define ST_RUN          1
#define ST_PAUSE    2
#define ST_EXIT     3
#define ST_PERIPH   4
#define ST_BASELINE 5

// the stage sequence codes
#define SEQ_INIT    0
#define SEQ_PAUSE   1
#define SEQ_RUN     2
#define SEQ_REST    3
#define SEQ_STAGEP  4
#define SEQ_CHANGE  5


// message block structure
typedef struct _mymsgblock_
{
```



```
    short code;     // why there is a block
    short len;          // number bytes INCLUDING block headers
    long filler;    // forcing to 16
    union {
      double d;
      long l[2];
      short s[4];
      char c[8];
    } u;
} MYMSGBLOCK;

#define MB_KEY         1      // means a keycode in s[0];
#define MB_ACTION   2         // means an action code in s[0];
#define MB_KEYBD    3         // WM_CHAR keys for general typing

#define MBMOD_SHIFT 1         // shift key
#define MBMOD_CTRL  2         // ctrl key
#define MBMOD_ALT   4         // alt key


typedef struct _fcmd_ {

    unsigned char funct;        //Function code       8
    unsigned char flags;        //flag bits      8
                         //  rrxxgemd
                         //            |---- 'Display' this stream
                         //           |----- multiple inputs
                         //          |------ more than up/down rewards allowed
               //      |------- outputs to game
               //     |-------- QPSlag
               //    |--------- QPSdev
               //  ||---------- backing set (0-3)selects FLT_R1->FLT_R4
               //
    unsigned char  grpstream;
               //  ggssssss
               //    ||||||-----output stream
               //  ||-----------reward group
    unsigned char procmode;           // code for proc mode
```



```
    char numinp;          // number of inputs  8
    char inch[3];         // input array          24       up to 6 inputs packed as seq of bytes, each 4 bits wide
    char numinhib;        // number of inhibits 8
    char inhib[3];        // array             24        up to 6 inhibits packed as seq of bytes
} FCMD;
#define FCMD_FLAG_DISPLAY 1
#define FCMD_FLAG_MULTINP 2
#define FCMD_FLAG_EXTRA   4
#define FCMD_FLAG_GAME      8
#define FCMD_FLAG_QPSLAG  0x10
#define FCMD_FLAG_QPSDEV  0x20

// stream usage codes
// These orders must match parblock.py !!!!!!
#define SUSE_RAW    1
#define SUSE_INHIB  2
#define SUSE_REWARD 3
#define SUSE_MONITOR 4
#define SUSE_DISPLAY 5

#define MAX_FILTER_MODES    32         // in a single session
#define MAX_FM_FUNCTIONS    32      // most filter functions per layout


// filter function names
// These names/orders must match parblock.py !!!!!!
#define FF_END           0     //END of function list
#define FF_LOWPASS 1     //lowpass
#define FF_BANDPASS 2     //bandpass
#define FF_DIFFER  3     //difference
#define FF_SYNCH   4     //synch reward
#define FF_COMOD   5     //comod reward
#define FF_GLCOM   6     // global comod
#define FF_MINUS   7     // XminusY
#define FF_SMRREW  8     //single SMR reward
#define FF_ATREW   9     //single AT reward
#define FF_COHERE  10    // coherence mode
#define FF_MULTIREW 11    // multi-reward
```



```
#define FF_RATIO    12    // ratio
#define FF_DAKCOH         13
#define FF_DAKPHASE       14
#define FF_ZSCOREAA       15
#define FF_ZSCORECO       16
#define FF_ZSCOREPH       17
#define FF_ZSCOREAPA      18
#define FF_ZSCOREAPB      19
#define FF_ZSCORERPA      20
#define FF_ZSCORERPB      21
#define FF_ZSCOREPRA      22
#define FF_ZSCOREPRB      23
#define FF_DC                    24
#define FF_UNITY          25
#define FF_DAK2           26
#define FF_DAK3           27
#define FF_DAK4           28
#define FF_DIFFSUM        29          // added for Hirschberg study
#define FF_ZCOMPOSITE   30
#define FF_QAVGPSYNC      31          // 4-ch averaged psyncs
#define FF_ZQAVGCO        32          // zscore 4-ch averaged coherence
#define FF_QPSFUN         33          // new psync modes
#define FF_UNCOUPLE       34
#define FF_QASFUN         35

// definitions used in .bfn files for filter operations
//     may be or'ed together
#define FB_SYNC           1     // coherence (synchrony)
#define FB_ZSCORE   2     // ANI zscore
#define FB_4CHAN    4
#define FB_QOPS           8     //QPS and QAS
#define FB_ADV            16    // advanced FB items

#define FR_UP             0   // normal "UP" reward
#define FR_DOWN     1   // down reward
#define FR_CENTER   2
#define FR_ELEVATE  3
#define FR_DEVUP    4
```



```
#define FR_DEVDOWN  5
#define FR_BAND     6
#define FR_ZCOMP    7

#define GMISC_INTEGTIME         1       // filter integration time
#define GMISC_TIMEONSTATE       2
#define GMISC_PERCENTONSTATE    3
#define GMISC_MINREWARD_TIME    4
#define GMISC_EYESTATUS   5

#define GMISC_ZCPARAMETER 16
#define GMISC_ZCCHAN      17
#define GMISC_ZCBAND      18
#define GMISC_ZCTHRSH     19
#define GMISC_ZCPERCENT   20
#define GMISC_ZCENABLE    21
#define GMISC_ZCDISABLE   22

#pragma pack(pop)
#endif
```

Raw Data File Format

```
/* file format header */

/*
RAW data files
The raw filename is constructed from the client code (<32 characters, no embedded spaces
or special characters) and a numerical code.  As with the summary filename, a 6 digit
code will be APPENDED to the client code.  The 6 digits are the 4-digit partial Julian
daycode and a uniqueness-guaranteeing sequence code.
The filename structure will be  CCjjjjqq.RAW where CC is the 1- to 31-character client
id code, jjjj is the part of the Julian date, and qq is the sequence number.

Raw File Format
```


This note describes the internal format of a raw data file saved by eegsoft. It is the intention of this description to provide both the baseline format and various extensions.

Basically, a 'raw' file contains 'raw' data acquired during a session along with operator actions time-correlated with the data. Up to 16 channels of data are provided for, each with scaling, format definitions, etc. Channel data is stored end-to-end, not interleaved. There may be multiple blocks of channel data for each channel in the file. Multiple blocks will be time-sequential in the file although the block positions imply no time relationships between channels. By this, I mean that a low speed block may contain timed samples over a longer time period than higher-rate blocks before and after it sequentially in the file. The actual I/O may/will be double-buffered to handle the 'long' time it takes to write data blocks to a file.

```
Header format
Content      Symbol Type       Length  Notes
File type code            char      4     RAWD
Format code        short int   2 bytes Format code is major.minor ,
                                    major* 100
                                    format 0.1 == 1, 1.3 == 103
Datecode           long int    4          Abs date
Timecode           long int    4          Seconds since midnight of FB start time
Client code        char       32    client id code
Client name        char       64    client name
Machine ID         long int    4          dongle code for now
Sample Clock Rate  short int   2          e.g. 160, 256, 512
number of channels short int   2          1 to 16
format string             char      16
offset of controls
      block        long int    4          byte offset
Max datablock size long int    4          size of largest data block
                                    must allocate (1+ #chans)*2 of these
Chan0Block       16 channel block
Chan1Block
Chan2Block
```


Chan3Block
Chan4Block
Chan5Block
Chan6Block
Chan7Block
Chan8Block
Chan9Block
Chan10Block
Chan11Block
Chan12Block
Chan13Block
Chan14Block
Chan15Block

Format of each channel block

Content	Symbol	Type	Length	Notes
Type code		unsigned	2	drives format of data
subrate		unsigned	2	currently only 1 or 8 for procomps
SequenceCode		long	4	unique sequence code for stream
ID		long	4	procomp serial number or ??
Scale factor		double	8	lsb scale factor of data
offset of 1st data block		long	4	byte offset

Format of a data block

Content	Symbol	Type	Length	Notes
Length of block		long int	4	length in bytes of block incl header
Type code			2	0=uncompressed
time stamp of 1st data		long int	4	real-time cycle count
offset of next block		long int	4	byte offset of next block
data			2	
----			2	

Format of controls block


```
Content          Symbol  Type    Length Notes
Length of block         long int 4      length in bytes of block incl header
offset of next control blk  long 4      byte offset
sub-blocks.


Format of  control sub-blocks (each corresponding to one action!)
length                          2 bytes sub-block length including this header
action code                     2 bytes LOTS of codes
          Code definitions use lots of major grouping codes for easier categorization.
          Lower 4 bits of every code reflects (possible) channel.
time stamp                      4 bytes real-time cycle count
data                            double
                                char [8]
                                long[2] 8 bytes
    this may be the beginning of a variable length text field also
    (for event reasons and such)


Action coding:
Multiple actions with same time stamp imply a major action (such as beginning
a session using the previous settings!!).

MMMMAAAAAAAACCCC
    MMMM is the major grouping
      00  Display/control settings
      01  Scale
      02  Mode changes (up/down, model, etc)
      03
      04  Site location change
      05 User event
      06 Threshold setting
      07 Low freq setting
      08 high freq setting

    AAAAAAAA is the action code
      tbd - defined in eeger.h
    CCCC is the channel for channel-related action codes
```



```
060214.1135 hpl reverted to 104 version temporarily
070822.1040 hpl made some shorts into unsigned short
100621.1617 hpl added subset code to header and biological sex
110228.1500 hpl 110 revised header layout and made room for more peripheral data
140221.0930 hpl added some optional data storage for high speed amplitude data for NF study
*/
#ifndef __rawformath__
#define __rawformath__
#pragma pack(push,1)

#define RAWVERSION 110        // odd versions are the 'compressed' version
                       // of the next lower even file format
                       // this makes it easy to discriminate/convert

#define MAX_CHUNKS 64         // maximum number of data chunks in a file
#define MAX_ACTION_SIZE 4096    // max size of an action chunk

// there are 16 of these in the header block
typedef struct _RAWCHD_
{
#if RAWVERSION >= 110
    unsigned char typecode;      //my code for device type for eeg data (DEV_ codes
    unsigned char channel;      // channel number for data A=0, B=1, C=2, D=3, whatever for peripherals, etc.
#else
    unsigned short typecode;        //which device produced data
#endif
    unsigned char subrate;          //currently only 1 or 8 for procomps
                             // Note:  subrate ==  1 means raw EEG data
                             //       subrate != 1 ==> peripheral data
    unsigned char datatype;         // kind of data
                             // 0 == EEG, 1= undifferentiated peripheral data, 2->255 ???

    long ID;                    //procomp serial number or peripheral channel
    double scalefactor;   //lsb scale factor of data
                                   // peripheral data has a scalefactor of ???

    long dboffset;              //byte offset to first data block

}  RAWCHD;
```



```
// this is the actual file header
typedef struct _RAWHD_
{
    char filetype[4];               //RAWD
    short formatcode;               //Format code is major.minor ,major* 100
                              //format 0.1 == 1, 1.3 == 103
    long datecode;            //Abs date
    long timecode;            //Seconds since midnight of FB start time
    char clientcode[32];      //client id code
    char clientname[64];      //client name
    long machineID;           //dongle code for now
    short clockrate;                //e.g. 160, 256, 512
    short numberofchannels;         //1 to 16
    char formatstring[16];          // contains format string at recording time
    long SequenceCode[MAX_FILTER_MODES]; // sequence codes for session !!!
    long cboffset;            //byte offset of controls block
    long maxdatablocksize;          //size of largest data block
                              //must allocate (1+ #chans)*2 of these
#if RAWVERSION < 110
    RAWCHD chd[15];              //channel head blocks
    char lcode;                   // 0 for unk, 1 for therap, 2 for remote
    char subset;                 // which subset of current structure this is
    char bsex;                          // either 0 (unk), 'M','F'
    char filler[17];                    // make up for stealing one chd
#if RAWVERSION >= 106
    long birthdate; // birthdate in "proleptic Gregorian" == "absolute date" format 1= 01/01/0001
#endif
#if RAWVERSION >= 108
    char xguid[32];                     // 'original' writer of file
#endif
#else
    char lcode;                   // 0 for unk, 1 for therap, 2 for remote, 3 for sham
    char subset;                 // which subset of current structure this is
    char bsex;                          // either 0 (unk), 'M','F'
    char filler[17];
    long birthdate; // birthdate in "proleptic Gregorian" == "absolute date" format 1= 01/01/0001
    char xguid[32];                     // 'original' writer of file
```



```
    long chdoffset;     // byte offset to first (of the sequential) channel block items
    long summaryoffset;     // byte offset to included summary file if there is one appended!!!!
    RAWCHD chd[16];             //channel head blocks
      long amplvalues;          //byte offset of amplitude data iff subset >= 2.  Zero means nothing stored
      long future;
#endif
} RAWHEAD;

typedef struct _OLDRAWHD_
{
    char filetype[4];               //RAWD
    short formatcode;               //Format code is major.minor ,major* 100
    //format 0.1 == 1, 1.3 == 103
    long datecode;            //Abs date
    long timecode;            //Seconds since midnight of FB start time
    char clientcode[32];      //client id code
    char clientname[64];      //client name
    long machineID;           //dongle code for now
    short clockrate;                //e.g. 160, 256, 512
    short numberofchannels;         //1 to 16
    char formatstring[16];          // contains format string at recording time
    long SequenceCode[MAX_FILTER_MODES]; // sequence codes for session !!!
    long cboffset;            //byte offset of controls block
    long maxdatablocksize;          //size of largest data block
    //must allocate (1+ #chans)*2 of these
    RAWCHD chd[15];             //channel head blocks
    char lcode;                  // 0 for unk, 1 for therap, 2 for remote
    char subset;                // which subset of current structure this is
    char bsex;                          // either 0 (unk), 'M','F'
    char filler[17];                    // make up for stealing one chd
#if RAWVERSION >= 106
    long birthdate; // birthdate in "proleptic Gregorian" == "absolute date" format 1= 01/01/0001
#endif
#if RAWVERSION >= 108
    char xguid[32];                     // 'original' writer of file
#endif

} OLDRAWHEAD;
```



```
// there is one of these at the head of each chunk of raw data
typedef struct _RAWDB_
{
    long length;                //length in bytes of block incl header
    unsigned char typecode;          //device it came from
    unsigned char datacode;          // how to decode special data
    long timestamp;             //real-time cycle count of first sample
    long nextoffset;                 //byte offset of next block
    //short data[1];                   // data sample
    // ...                      more samples
} RAWDB;

// there is one of these for each 'action' subblock
typedef struct _RAWSUB_
{
    unsigned short length;                  //sub-block length including this header
    unsigned short actioncode;              //LOTS of codes
    long timestamp;             //real-time cycle count of this action
    union {
      double data1;                    //this may be the beginning of a variable length text field also (for event reasons
and such)
      char  text[8];
      long  ld[2];
            float fdata[2];
            short twobytes[4];
    } d;
} RAWSUB;

// there is one of these for each chunk of actions
typedef struct _RAWCB_
{
    long length;                //length in bytes of block incl header
    long nextoffset;                 // offset in bytes of next control blk
    //RAWSUB blocks[1];         // sub-blocks.
} RAWCB;

/*
```



```
ampl values are recorded at 'clockrate' in a normalized format (fixed point scaled 100) in a signed short
     range is thus 0 - 327.67 microvolts
The ampl values are the short-term moving averages used for threshold decisions, etc.
Each sequential time sample value contains 'numberofchannels' data samples so careful about sizing if there are
peripheral channels specified.   Data is only recorded if the option was specified at run time.
All data is stored in memory until end of session.
*/

#pragma pack(pop)
#endif
```

Summary File Format

```
/*
Summary files consist of a header and a series of data blocks containing the once per second
average values, the threshold settings, and a composite reward flag bit for each filtered
channel.  Additional information is saved (at the slow 1 Hz rate) for later
analysis/understanding

Part of the summary data filename is constructed from the 4 lower digits of the Julian date.
Julian dates in the range 1995-2023 are all greater than 245000 and less than 255000.
Additionally, (to handle multiple and aborted sessions in the same day),
a 2-digit sequence number will be used to ensure that there are no filename conflicts.
The filename structure will be Sjjjjqq.SUM where jjjjj is the aforementioned part of the
Julian date and qq is the sequence number.  Internally, the actual client identifiers are
stored in the file.

Summary file data format

This file consists of a header and a series of data blocks containing the
once per second average values, the threshold settings, and a composite
reward flag bit for each filtered channel.
Additional information is saved (at the slow 1 Hz rate) for later
```



```
analysis/understanding.

Header format:
Content      Symbol Type       Length  Notes
File type code            char       4      SUMD
Format code         short int   2 bytes Format code is major.minor
                                    major* 100
                                    format 0.1 == 1, 1.3 == 103
Protocol code             char       4      Like SMR AT EXP with trailing null bytes
number of traces/chan     byte       1      1 to 16 filtered traces, 1-16 channels
number of lowpass ch      byte       1
Datecode            long int         Abs date
Timecode            long int         Seconds since midnight local time
Client code         char      32     client id code
Client name         char      64     client name
game name           char      32

Block format:

Content      Symbol Type       Length  Notes
length              unsigned    2          length of this block in bytes
format code         unsigned    1          code
time stamp of 1st data    unsigned    2          in seconds relative to base timecode
 data follows

Format codes:
1 data
2 threshold
3 frequency
4 channel/site
5 Summary
6 Scale
7 Period

For data blocks
Content      Symbol Type       Length  Notes
0th average value   short int   2          microvolts * 100; negative means reward for at least one sample in 1 second
interval
```



```
             Note that maximum average microvolt value
..           is 327.67 microvolts (times 100!!)
nth   average value       n is number of traces -1
0th average value         for the next second!!!

-----------

For threshold blocks
Content      Symbol Type       Length  Notes
0th threshold             unsigned    2          microvolts * 100

..
nth   threshold         n is number of traces -1


For frequency blocks
Content      Symbol Type       Length  Notes
0th low freq       unsigned    2          low freq in 1000ths of Hz; 4250 = 4.25 Hz
0th high freq             unsigned    2          in 1000ths of Hz
-------
nth low freq            n is number traces - 1
nth high freq


For site/channel blocks
Content      Symbol Type       Length  Notes
Mode code          char       4     kind of feedback mode
Chan code          int        1     channel for input
Site code          char       11    char string of sites
Chan code          pairs of entries for all USED channels
Site code
---------
Current schemes will only have ONE or TWO channels of input although the
format allows more.

Summary block
Content      Symbol Type       Length  Notes
```



```
0th average value   coded      2      microvolts * 100
             Note that maximum average microvolt value
..           is 327.67 microvolts (times 100!!)
0th percentage                in % times 100
-----------
nth percentage
nth   average value       n is number of traces -1


Scale block
Content      Symbol Type       Length  Notes
0th scale           unsigned    2          microvolts * 100

..
nth   scale         n is number of traces -1



030326.1151 hpl added mark data but kept version 106
040127.1152 hpl changed to unsigned short length and version 108
4.1.xx
040913.1130 hpl version 110 - added overall reward percent to period data
050420.1115 hpl version 112 - scab on total reward % to percentage values (fake extra trace data)
060120.1400 hpl version 114 - add SUM_PERIPH to data, go to long header lengths
060214.1135 hpl reverted to 112 structures temporarily
070129.1437 hpl 116 adds zscore data
110209.1800 hpl pragma pack
110228.1510 hpl 118 revised structure to remove xdata and handle both 2- and 4-channel zscore
140327.1725 hpl intg negative NOT during period means its impedance value/100 clamped to max
160606.0950 hpl change define to maintain 16-chan compatability
170912.1105 hpl added qps data definition for research
*/
#ifndef __SUMFORMATH__
#define __SUMFORMATH__
#include "eeger.h"
#pragma pack(push,1)

#define SUMVERSION 118
```



```
// file header
typedef struct _SUMHD_
{
    char filetype[4];               // SUMD
    short formatcode;            //Format code is major.minor ,major* 100
                          //format 0.1 == 1, 1.3 == 103
    char protocolcode[4]; //Like SMR AT EXP with trailing null bytes
    char numberoftraces;  //1 to 16 filtered traces, 1-16 channels
    char numberlowpass;   // number lowpass channels
    long datecode;        //Abs date
    long timecode;        //Seconds since midnight local time
    long SequenceCode[MAX_FILTER_MODES];// what kind of sequence codes were possible
    char formatstring[MAXUSEDSTREAMS];     // contains format string at recording time
    char gameid[30];
    char lcode;               // 1 for therapist, 2 for remote
    char spare;
    char clientcode[32];
    char clientname[64];
    // following new in 118
    char numberperiph;      //number of peripheral channels
    float multiplier[MAXUSEDSTREAMS+MAXPERIPHS];  // scaling factor for data - mostly peripherals!!
} SUMHD;

typedef struct _SUMBLKHD_
{
#if SUMVERSION >= 114
    unsigned long length;      //length of this block in bytes
#else
    unsigned short length;
#endif
    short formatcode;                // SUM_ codes
    unsigned short timestamp;    // seconds relative to base timecode of 1st data
} SUMBLKHD;

typedef struct _SUMFR_
{
```



```
    SUMBLKHD blkhd;
    struct {
        unsigned short low;  //  low freq in 1000ths of Hz; 4250 = 4.25 Hz
        unsigned short high; //   in 1000ths of Hz
    } freq[1];

    // nth low freq       n is number traces - 1
    // nth high freq
} SUMFREQ;

typedef struct _SUMCD_
{
    SUMBLKHD blkhd;
      char modename[16];         //kind of feedback mode
      struct {
            char channel;       //channel for input
            char sites[11];     //string of sites
      } site[1];
    //Chan code        pairs of entries for all USED channels
    //Site code
} SUMCD;

//missing data points denoted by value of 0xffff
typedef struct _SUMDTA_
{
    SUMBLKHD blkhd;
    union {
      short value;     //microvolts * 100; negative means reward for at least one sample in 1 second interval
                         // Note that maximum average microvolt value
                         // is 327.67 microvolts (times 100!!)
      unsigned short threshold;//microvolts * 100
      unsigned short average; //microvolts * 100  (long term average)
               //Note that maximum average microvolt value is 327.67 microvolts (times 100!!)
      unsigned short percentage; // % times 100
      // I add an EXTRA value == total reward percentage on
      unsigned short scale;      // microvolts * 100
      unsigned short periph;    // something * 10
    } trace[1];
```



```
    // nth percentage
    //nth   average value       n is number of traces -1
} SUMDATA;

typedef struct _SUMPER_
{
    SUMBLKHD blkhd;
    unsigned short period;              // period number
    unsigned short seconds;             // delta seconds in period
    unsigned short score;       // delta score for period
    unsigned short overall_reward;      // overall reward %  new in 110
    char gamename[64];                  // rightmost 64 chars of game 'name'/path
// begin junk
    // unused since at least 4.2.0
    struct {
          unsigned short beginampl;     // 1st second ampl * 100
          unsigned short aveampl;       // average amplitude * 100
          unsigned short endampl;       // end of period ampl * 100
          unsigned short lowfreq;       // band low freq * 1000
          unsigned short highfreq;      // band high freq * 1000
    } xbands[4];
// end junk
    struct {
          unsigned short average;       // ending long-term average * 100
          unsigned short percent;       // ending percent over threshold *100
          unsigned short threshold;     // ending threshold value * 100
          unsigned short lowfreq;       // ending low freq limit * 1000
          unsigned short highfreq;      // ending high freq limit * 1000
          char sitelist[12];            // ending site list
    } streamval[1];             // one for each stream
} SUMPERIOD;

typedef struct _SUMMODE_
{
    SUMBLKHD blkhd;
    long seqcode;               // sequence code now switching to
    char modename[16];           //kind of feedback mode
```



```
    unsigned char rewardcode[16];      // codes for reward directions
} SUMMODE;

typedef struct _SUMMARK_
{
    SUMBLKHD blkhd;
    unsigned short msglength;          // number of bytes in msg
    char msg[1];                // where mesg starts
} SUMMARK;

typedef struct _SUMZSCORE_
{
      SUMBLKHD blkhd;
      short int kindcode;            // 0 means all 2ch terms are included;1 means only products, 2= all 4ch,3 = only 4ch
products
    union __kinddata__
    {
        struct __chans4__
        {
              struct {
                  short int zaa[6][10];      // microvolts*100
                  short int zco[6][10];
                  short int zap[6][10];
            } products[1];
            struct {
                  short int zap[4][10];      // 1st 8 are chan A
                  short int zrp[4][10];
                  short int zpr[4][10];      // 1st 10 are chan A
            } terms[1];
        } chans4;
        struct __chans2__
        {
            struct {
                short int zaa[1][10];      // microvolts*100
                short int zco[1][10];
                short int zap[1][10];
            } products[1];
            struct {
```



```
                short int zap[2][10];  // 1st 8 are chan A
                short int zrp[2][10];
                short int zpr[2][10];  // 1st 10 are chan A
            } terms[1];
        } chans2;
    } kinddata;
} SUMZSCORE;

typedef struct _SUMQPS_
{
      SUMBLKHD blkhd;
      struct _dta_
      {
            short int qpsover;
            short int qpsvg;
            short int qpsdev;
      } dta[4];
      short int qpspercent;
      short int qpsvalue;
} SUMQPS;
//WARNING:  storage.cpp and sumfile.py (and others!!??)
//  make assumptions about these numbers!!!!!
#define SUM_DATA    0      //SUMDATA
#define SUM_THRESH  1      //SUMDATA
#define SUM_AVERAGE 2      //SUMDATA
#define SUM_PERCENT 3      //SUMDATA
#define SUM_FREQ    4      //SUMFREQ
#define SUM_SCALE   5      //SUMSCALE
#define SUM_SITE    6      //SUMCD
#define SUM_PERIOD  7      //SUMPER
#define SUM_MODE    8
#define SUM_MARK    9
#define SUM_PERIPH  10  //SUMDATA
#define SUM_ZSCORE  11
#define SUM_QPS            12
#define SUM_LAST    12      // just the highest number

#pragma pack(pop)
```

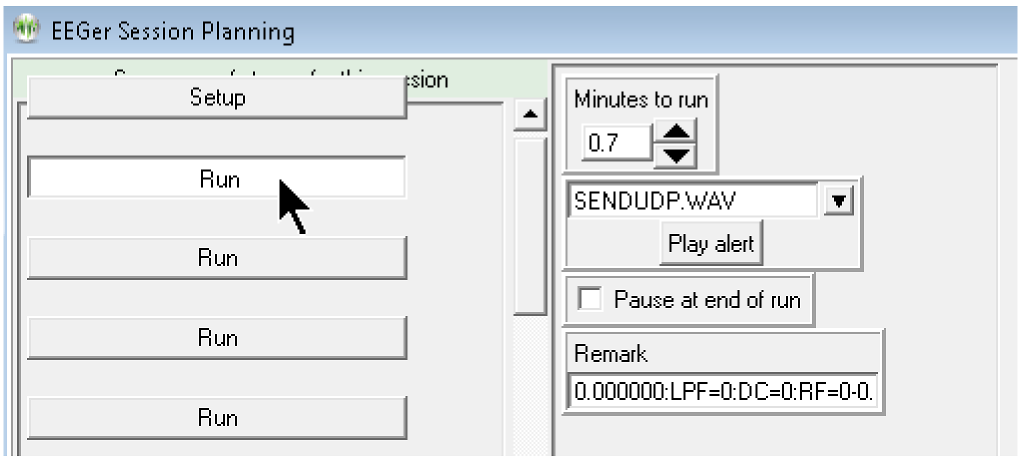


```
#endif
```


Appendix E: Data Acquisition Methodology

This document contains data acquired using normal versions of EEGer4. The data is generated using a combination of a software and hardware external to EEGer4 itself as described in Appendix F.

EEGer4 supports a special development mode where a specific run stage comment in a session plan sends a UDP message to the signal generator described in Appendix F. The message controls some EEGer parameters and the frequency that the signal generator is to supply. Critical parameters other than the frequency are the settings for the lowpass filter and DC correction filters which can be turned on/off depending on the test to be run. The EEGer4 setup is done in session planning where the alert name must be SENDUDP.WAV and the remark field contains the parameters.



Frequencies used in the test session plan are

0.0,0.1,0.2,0.3,0.5,   Hz

1 to 40 Hz in 1 Hz steps

45.0,47.0,48.0,49.0,50.0,51.0,52.0,58.0,59.0,60.0,61.0,62.0,65.0,70.0 Hz

The run time chosen is long enough for the value smoothing to occur so that values at the end of each period represent the average value. Since there is no pause flag checked, run stages continue to run until the end of the session. In this fashion, a test run is semi-automated. Once started, the identical test sequence is performed. Data for each run is available as summary data outputs from the EEGer4 review process.

This method was used to generate the filter characteristics used for the filter plots and the bandpass characteristics shown for each amplifier/encoder.

Appendix F: Signal Generator

Signal Generator

Technical Description

Version 1.12

Description

The signal generator tool provides a representative EEG signal for tests of signal acquisition devices and for end-to-end testing of the entire neurofeedback system.

Digital to Analog Converter (DAC)

The DAC used for the signal generator tool is a USB-3101FS 16-bit four channel DAC manufactured by Measurement Computing Corporation. It is supported by the MCC-provided InstaCAL input/output interface library (which must be installed). The device is a USB-2.0 controlled and powered device.

Figure 1:

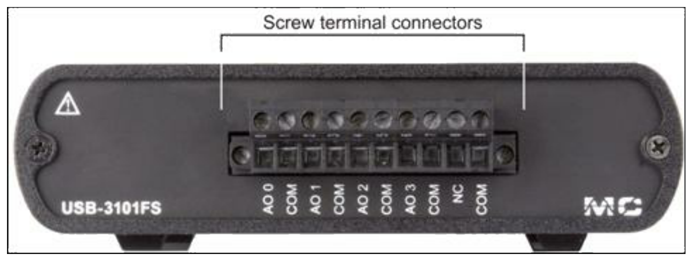


Figure 2:

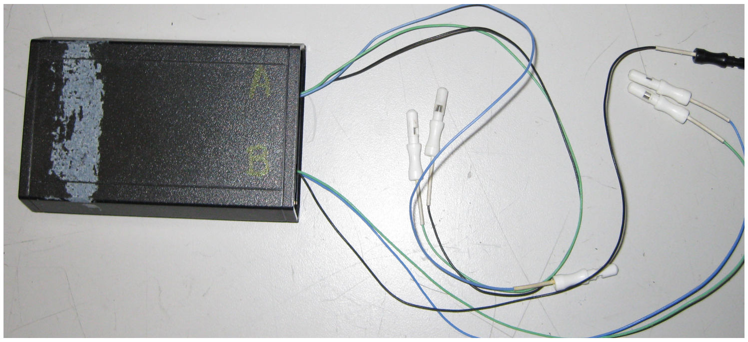
Screw terminal pin assignments

Terminal	Signal
0	AO 0
1	Common (COM)
2	AO 1
3	Common (COM)
4	AO 2
5	Common (COM)
6	AO 3
7	Common (COM)
8	NC (No connection)
9	Common (COM)

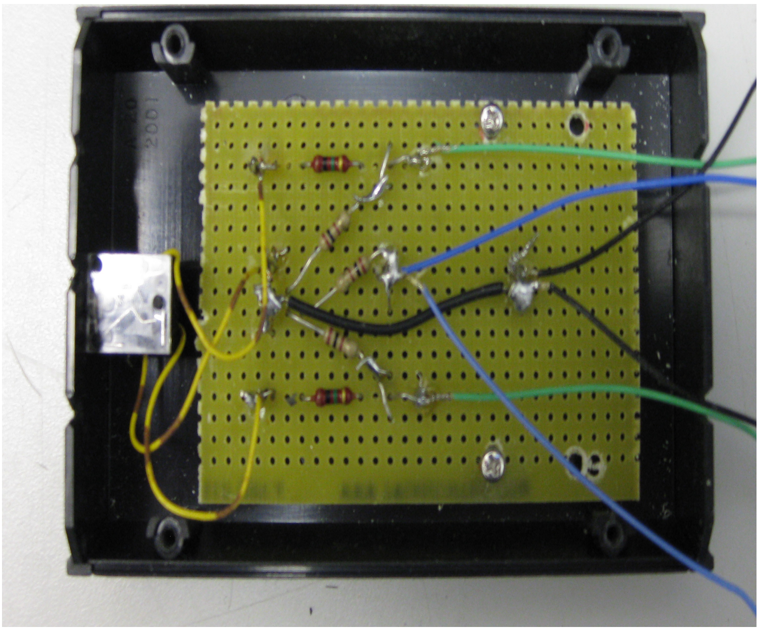
Attenuator

The attenuator device is an internally manufactured purely resistive voltage divider used to reduce the DAC outputs (0.5 volt) to ranges appropriate for an EEG-level (50 microvolt) sensing device.

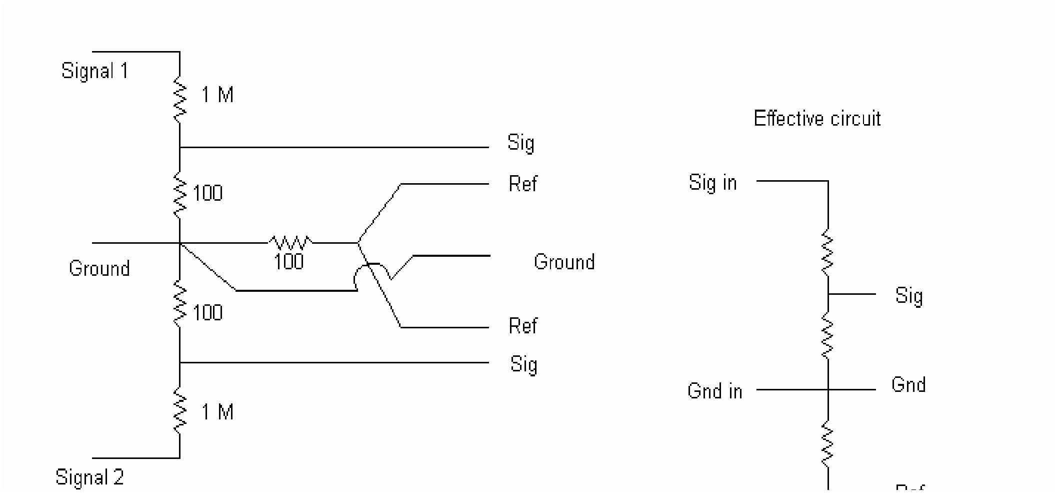
Attenuator box.



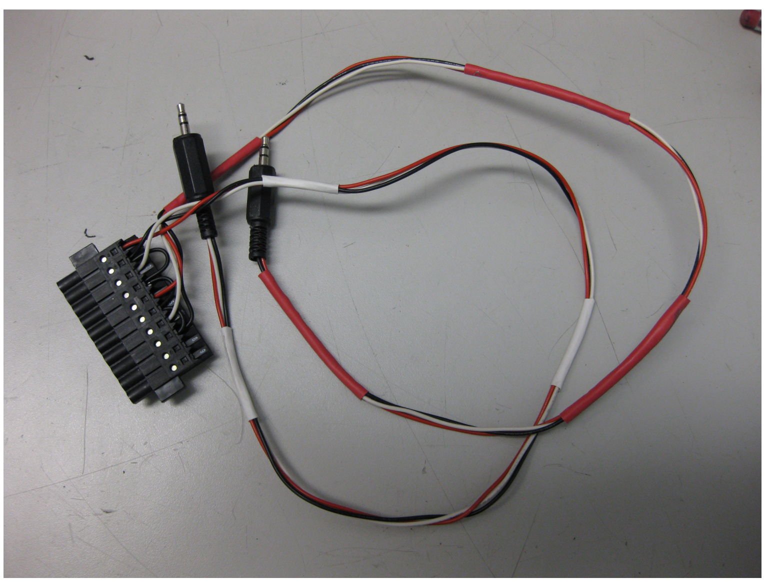
Internals of typical attenuator box.



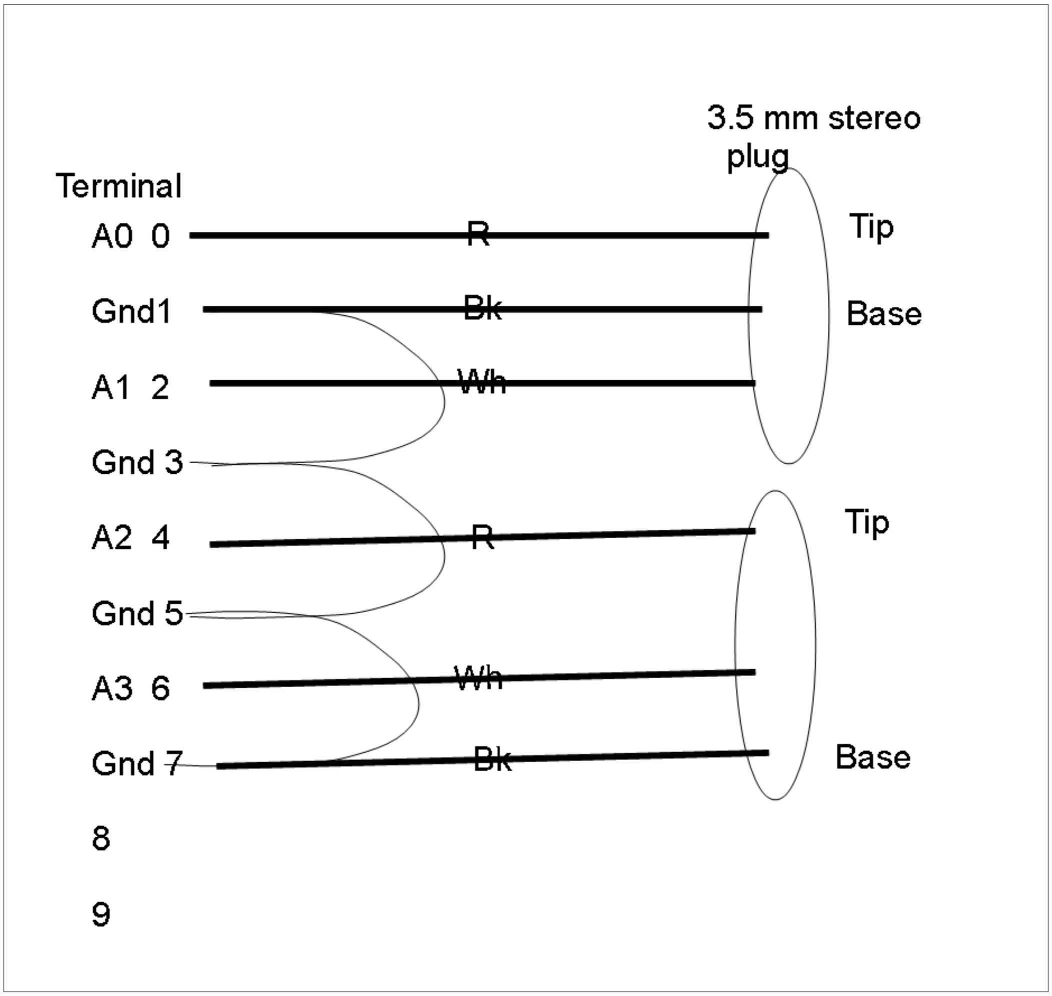
Schematic of attenuator box.



Cabling from USB-3101FS to attenuator box.



Wiring diagram for cable between USB-3101FS and attenuator box.



SigDriver

This software module contains the logic necessary to decode an input data file (in EEGer .RAW format) and send it to the DAC. It also provides the ability to generate simple sine wave signals and to provide a spike impulse for testing of EEGer software. The user interface for the module is implemented using FLTK, a user interface library. Source code for this tool is maintained in the revision control system. The module contains the following logical functions:

mymain – builds the screen interface and calls the output routine

runsome - the actual output routine

findfiles – determine which files are available

read_raw_file – reads/decodes a raw file

read_first_event – reads/decodes first text event in a raw file (for titles)

synth_raw_file – creates equivalent of raw data in cases of simple sine waves (manual) mode

sample – the actual computation of the output voltage for a sample

CheckListener – support routine for automatic bandpass testing which monitors for frequency changes commanded by EEGer in test mode.

Because this program runs under Microsoft Windows, the computation of the correct signal value takes into account the erratic timing under Microsoft Windows and handles it appropriately.

The format of the data listened for is a UDP message received containing one block of data in this format:

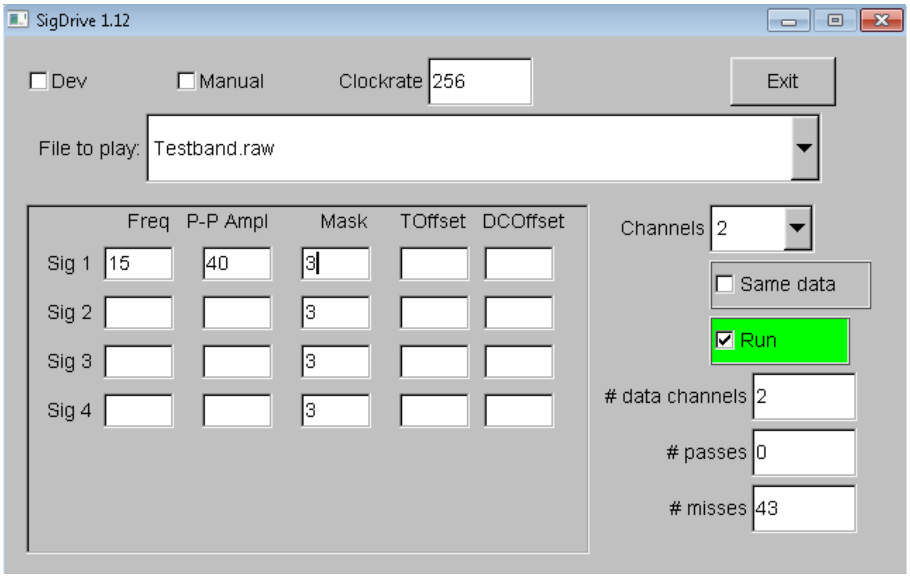
0xe1	0	Size low	Size high
Text			

Where “text” is an ASCII string in the following format:

freq:optn:optn:optn..

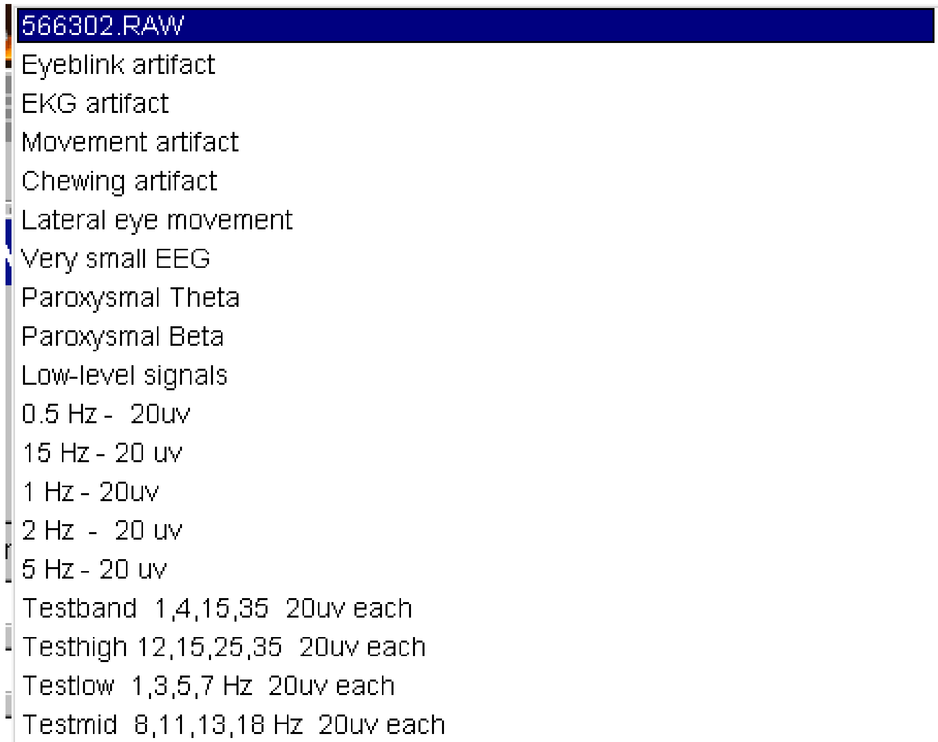
where only the first value (frequency value terminated by a colon) is used by SigDriver. This value is forced into the manual frequency setting for Sig1. At that time, all other values are set to zero except the amplitude for Sig1 (set to 40) and the mask for Sig1 (set to 3). Manual mode is forced on at that time.

The main screen is this:

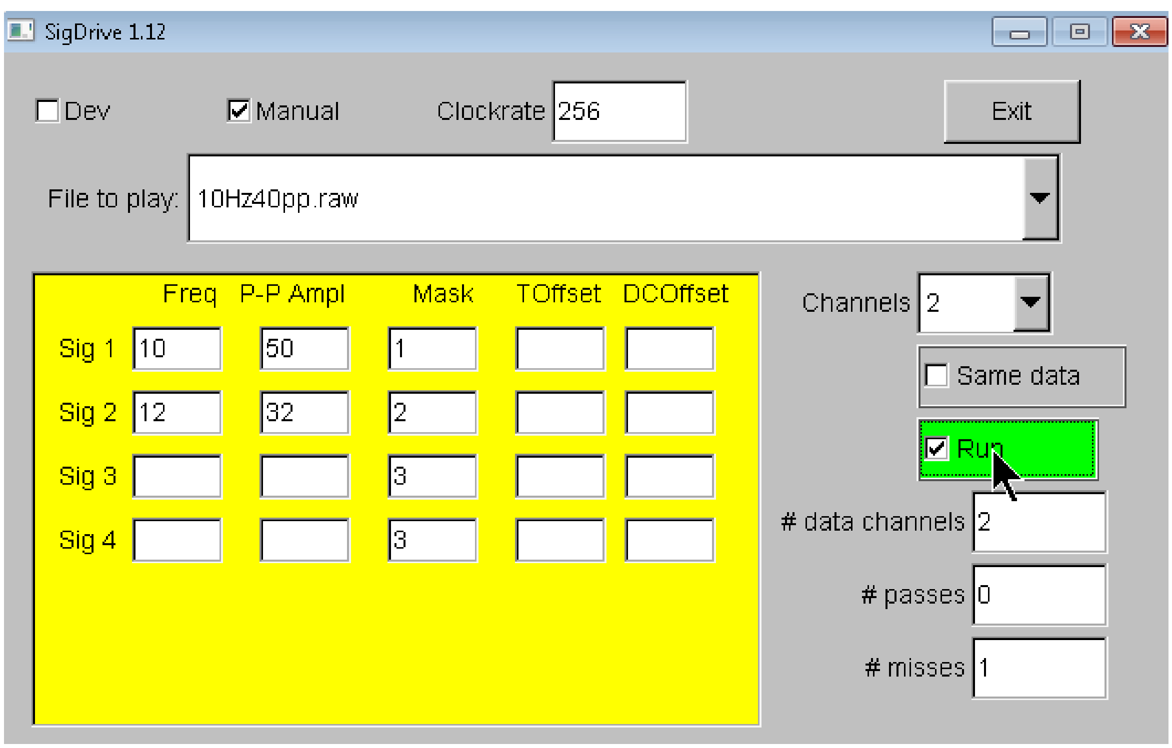


This reports that the testband file is being used as the signal source, there are two channels of data in the source, we are NOT forcing all the data channels to use one channel of data, and that the signal driver is running.

The dropdown box at the top (File to play) gives the following options (unless additional files are created using the FreqFileGen tool described later):

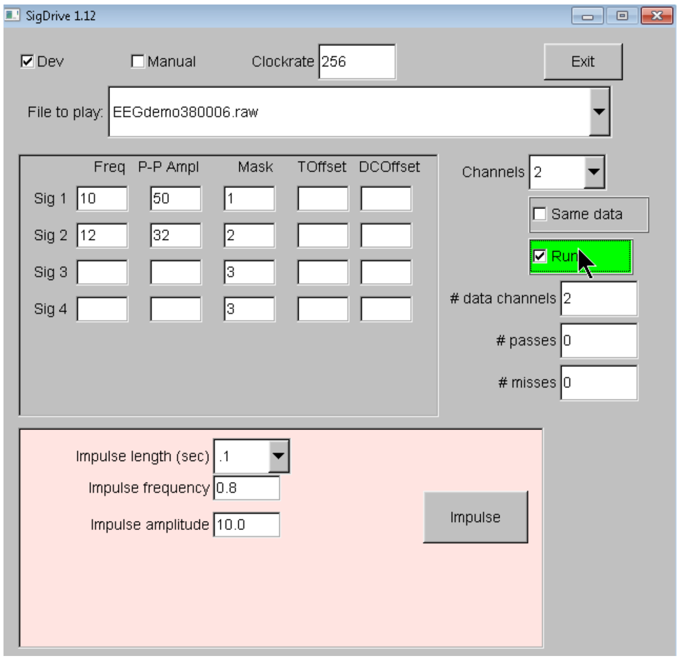


Selection of the Manual checkbox gives this screen:



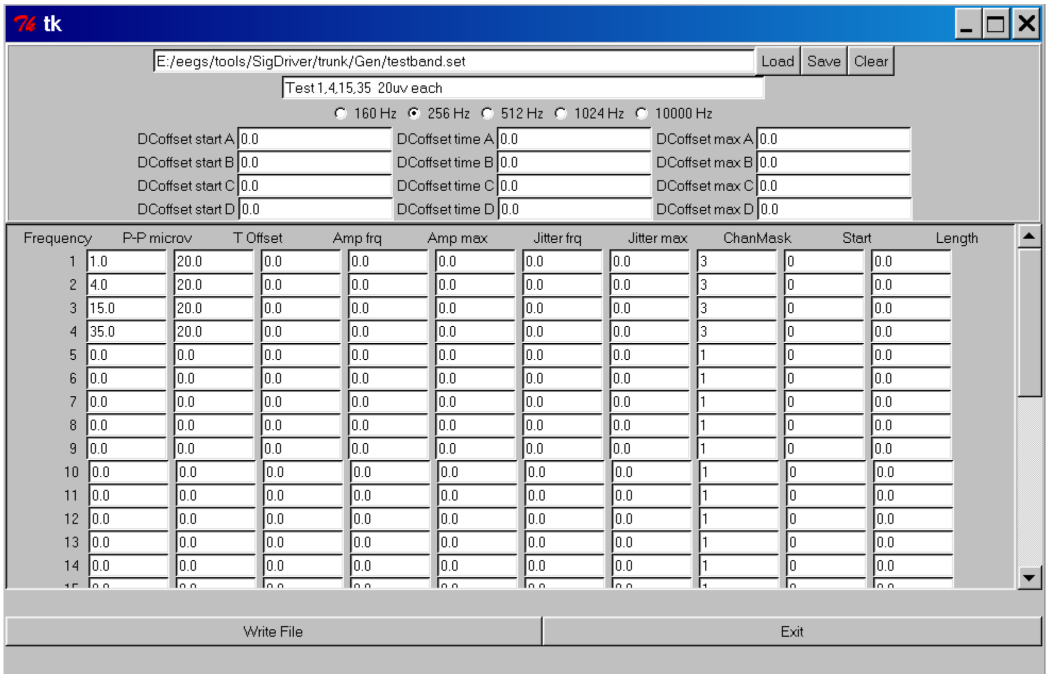
where the yellow-highlighted region contains the values to generate. Shown here in this example is a 10 Hz signal on channel 0 (A) and a 12 Hz signal on channel 1 (or B).

If the Dev checkbox is selected, the following screen shows the additional options for the impulse generator:



Frequency File Generator (FreqFileGen)

This module is a Python script which allows creation of complex source signal files (in EEGer format suitable for replay in EEGer). The screen looks like this:



There are 32 source points, each of which can have the following characteristics:

frequency

peak-peak voltage in microvolts

starting time offset of signal (in seconds)

amplitude variation frequency (rate of variation of amplitude)

maximum amplitude of amplitude variation (amount of amplitude variation)

jitter frequency (rate of variation of starting time)

jitter max (maximum amount of time variation)

Channel mask (bit mask for the output channels for the signal)

Start (starting time of the signal)

length(length of time signal is generated – 0 means forever)

In addition, each of the four possible channels can have a DC offset, a DC offset variation, and a starting time for the DC offset variation to test DC characteristics of AC and DC coupled acquisition devices.

Calibration process

The signal generator tool must be periodically calibrated. The calibration tool used is a Fluke 87-5 digital multimeter (DMM) or equivalent which has a valid NIST-traceable calibration certificate.

1. DISCONNECT signal block from USB-3101FS

Frequency/amplitude of signal generator:

2. The DMM is connected to the terminal block of the USB-3101FS pins 0 (signal) and 1 (ground).

3. The SigDriver is started and Manual mode is selected.

4. The following parameters are sequentially entered in the manual fields and results verified:

Frequency	Amplitude	Freq reading	Amplitude reading (true RMS)
2	10	2+- 0.3	0.10 +-.0 1
5	15	5 +-.3	0.15+-.01
10	20	10+- .3	0.20+-.01
12	25	12 +- .3	0.25+-.01
25	30	25+- .5	0.30+- .01
30	40	30 +- .5	0.40+-.01
50	60	50 +- .5	0.60+-.01

5. Repeats steps 2,3, and 4 for DMM connected to pins 2,4,6 making sure that the signal is routed to the correct channels (mask=15)

This verifies the generation of signals has requisite accuracy.

Attenuator box:

5. Using DMM, measure resistance between signal block pin 0 and signal block pin 1 while attenuator box is connected to cable but NOT to an acquisition device.

6. Verify resistance is 1,000,000 +- 20,000 ohms.

7. Measure resistance between signal and reference leads for channel A on the attenuator box.

8. Verify resistance is 100 +- 3 ohms

9. Repeat steps 5-6 for pins 2 and 1 on the signal block.

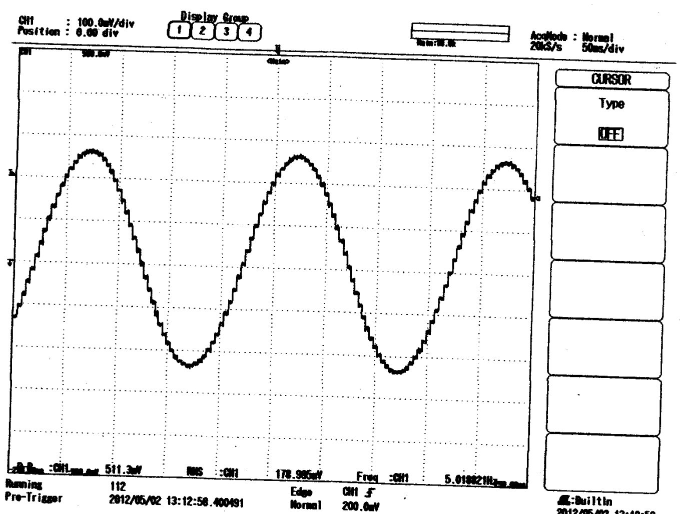
10. Repeat stems 7 and 8 for leads for channel B on the attenuator box.

Each attenuator box needs to be calibrated and a calibration sticker attached.

11. Fill in the calibration test log and sign where appropriate.

This procedure needs to be once per year or sooner if repairs are needed on any component or the driver software is changed.

Initial calibration data



5/2/12

Yokogawa DL850

	Vin	Vout a	Vout b	← Sig to Grou
Attn 2	10.053 V	1.009 mV	0.979 mV	
Attn 1	10.052 V	1.002 mV	1.006 mV	
Attn 3	10.051 V	1.018 mV	1.019	
Attn 4	10.050 V	1.016 mV	1.024	

Fluke 8846A

R. Spooner

Attn 4 1.009v 10.049 side a Sig to Ref

