# qpp

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# Chapter 1

# Namespace Index

## 1.1 Namespace List

Here is a list of all namespaces with brief descriptions:


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qpp::ct . . . . . 36
qpp::internal . . . . . 37
qpp::stat . . . . . 38
qpp::types . . . . . 38

# Chapter 2

# Hierarchical Index

## 2.1 Class Hierarchy

This inheritance list is sorted roughly, but not completely, alphabetically:


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qpp::stat::DiscreteDistributionFromComplex . . . . . 42
exception
    qpp::Exception . . . . . 44
qpp::Gates . . . . . 47
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qpp::RandomDevices . . . . . 52
qpp::Timer . . . . . 53
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# Chapter 3

# Class Index

## 3.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:


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qpp::Exception . . . . . 44
qpp::Gates . . . . . 47
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# Chapter 4

# File Index

## 4.1 File List

Here is a list of all files with brief descriptions:

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include/internal.h . . . 65
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include/qpp.h . . . 69
include/randevs.h . . . 70
include/random.h . . . 72
include/stat.h . . . 73
include/timer.h . . . 74
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# Chapter 5

# Namespace Documentation

## 5.1 qpp Namespace Reference

### Namespaces

- ct
- internal
- stat
- types

### Classes

- class Exception
- class Gates
- class RandomDevices
- class Timer

### Functions

- types::cmat channel (const types::cmat &rho, const std::vector< types::cmat > &Ks)
- types::cmat super (const std::vector< types::cmat > &Ks)
- types::cmat choi (const std::vector< types::cmat > &Ks)
- std::vector< types::cmat > choi2kraus (const types::cmat &A)
- template<typename Derived >
  double shannon (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  double renyi (const double alpha, const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  double renyi_inf (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > transpose (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > conjugate (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > adjoint (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  Derived::Scalar trace (const Eigen::MatrixBase< Derived > &A)

- template<typename Derived >
  Derived::Scalar det (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  Derived::Scalar sum (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  double norm (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  types::cmat evals (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  types::cmat evects (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  types::cmat hevals (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  types::cmat hevects (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  types::cmat funm (const Eigen::MatrixBase< Derived > &A, types::cplx(*f)(const types::cplx &))
- template<typename Derived >
  types::cmat sqrtm (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  types::cmat absm (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  types::cmat expm (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  types::cmat logm (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  types::cmat sinm (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  types::cmat cosm (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  types::cmat spectralpowm (const Eigen::MatrixBase< Derived > &A, const types::cplx z)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > powm (const Eigen::MatrixBase< Derived > &A, size_t n)
- template<typename OutputScalar , typename Derived >
  types::DynMat< OutputScalar > fun (const Eigen::MatrixBase< Derived > &A, OutputScalar(*f)(const typename Derived::Scalar &))
- template<typename Derived1 , typename Derived2 >
  types::DynMat< typename
  Derived1::Scalar > kron (const Eigen::MatrixBase< Derived1 > &A, const Eigen::MatrixBase< Derived2 > &B)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > kronlist (const std::vector< types::DynMat< typename Derived::Scalar > > &As)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > kronpow (const Eigen::MatrixBase< Derived > &A, size_t n)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > reshape (const Eigen::MatrixBase< Derived > &A, size_t rows, size_t cols)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > syspermute (const Eigen::MatrixBase< Derived > &A, const std::vector< size_t > perm, const std::vector< size_t > &dims)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > ptrace2 (const Eigen::MatrixBase< Derived > &A, const std::vector< size_t > dims)

- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > ptrace (const Eigen::MatrixBase< Derived > &A, const std::vector< size_t > &subsys, const std::vector< size_t > &dims)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > ptranspose (const Eigen::MatrixBase< Derived > &A, const std::vector< size_t > &subsys, const std::vector< size_t > &dims)
- template<typename Derived1 , typename Derived2 >
  types::DynMat< typename
  Derived1::Scalar > comm (const Eigen::MatrixBase< Derived1 > &A, const Eigen::MatrixBase< Derived2 > &B)
- template<typename Derived1 , typename Derived2 >
  types::DynMat< typename
  Derived1::Scalar > anticomm (const Eigen::MatrixBase< Derived1 > &A, const Eigen::MatrixBase< Derived2 > &B)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > proj (const Eigen::MatrixBase< Derived > &V)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > expandout (const Eigen::MatrixBase< Derived > &A, size_t pos, const std::vector< size_t > &dims)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > grams (const std::vector< types::DynMat< typename Derived::Scalar > > &Vs)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > grams (const Eigen::MatrixBase< Derived > &A)
- template<typename T >
  void dispSTL (const T &x, const std::string &separator=" ", const std::string &start="[", const std::string &end="]", std::ostream &os=std::cout)
- template<typename T >
  void displnSTL (const T &x, const std::string &separator=" ", const std::string &start="[", const std::string &end="]", std::ostream &os=std::cout)
- template<typename T >
  void dispSTL (const T *x, const size_t n, const std::string &separator=" ", const std::string &start="[", const std::string &end="]", std::ostream &os=std::cout)
- template<typename T >
  void displnSTL (const T *x, const size_t n, const std::string &separator=" ", const std::string &start="[", const std::string &end="]", std::ostream &os=std::cout)
- template<typename Derived >
  void disp (const Eigen::MatrixBase< Derived > &A, double chop=ct::chop, std::ostream &os=std::cout)
- template<typename Derived >
  void displn (const Eigen::MatrixBase< Derived > &A, double chop=ct::chop, std::ostream &os=std::cout)
- void disp (const types::cplx c, double chop=ct::chop, std::ostream &os=std::cout)
- void displn (const types::cplx c, double chop=ct::chop, std::ostream &os=std::cout)
- template<typename Derived >
  void save (const Eigen::MatrixBase< Derived > &A, const std::string &fname)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > load (const std::string &fname)
- template<typename Derived >
  Derived loadMATLABmatrix (const std::string &mat_file, const std::string &var_name)
- template<>
  types::dmat loadMATLABmatrix (const std::string &mat_file, const std::string &var_name)

- template<>
  types::cmat loadMATLABmatrix (const std::string &mat_file, const std::string &var_name)
- template<typename Derived >
  void saveMATLABmatrix (const Eigen::MatrixBase< Derived > &A, const std::string &mat_file, const std::string &var_name, const std::string &mode)
- template<>
  void saveMATLABmatrix (const Eigen::MatrixBase< typename types::dmat > &A, const std::string &mat_file, const std::string &var_name, const std::string &mode)
- template<>
  void saveMATLABmatrix (const Eigen::MatrixBase< typename types::cmat > &A, const std::string &mat_file, const std::string &var_name, const std::string &mode)
- template<typename Derived >
  Derived rand (size_t rows, size_t cols, double a=0, double b=1)
- template<>
  types::dmat rand (size_t rows, size_t cols, double a, double b)
- template<>
  types::cmat rand (size_t rows, size_t cols, double a, double b)
- double rand (double a=0, double b=1)
- template<typename Derived >
  Derived randn (size_t rows, size_t cols, double mean=0, double sigma=1)
- template<>
  types::dmat randn (size_t rows, size_t cols, double mean, double sigma)
- template<>
  types::cmat randn (size_t rows, size_t cols, double mean, double sigma)
- double randn (double mean=0, double sigma=1)
- types::cmat randU (size_t D)
- types::cmat randV (size_t Din, size_t Dout)
- std::vector< types::cmat > randKraus (size_t n, size_t D)
- types::cmat randH (size_t D)
- types::cmat randket (size_t D)
- types::cmat randrho (size_t D)

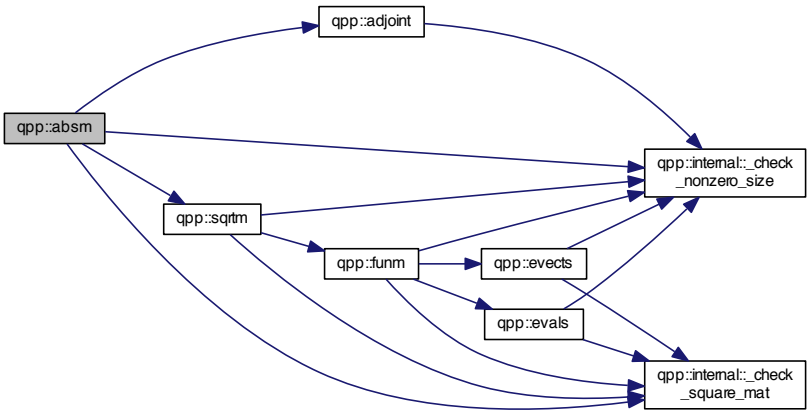
## Variables

- RandomDevices & rdevs = RandomDevices::getInstance()
- const Gates & gt = Gates::getInstance()

### 5.1.1 Function Documentation

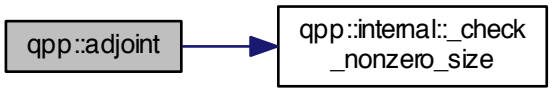
#### 5.1.1.1 template<typename Derived > types::cmat qpp::absm ( const Eigen::MatrixBase< Derived > & *A* )

Here is the call graph for this function:



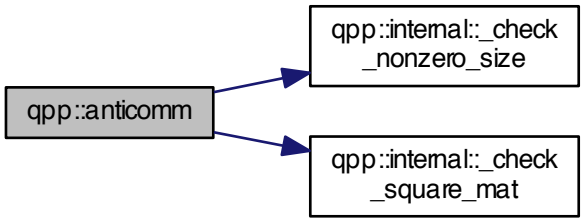

#### 5.1.1.2 template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::adjoint ( const Eigen::MatrixBase< Derived > & *A* )

Here is the call graph for this function:



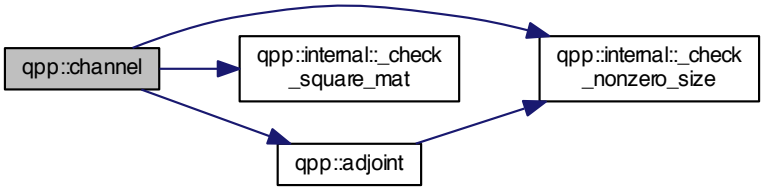
#### 5.1.1.3 template<typename Derived1 , typename Derived2 > types::DynMat<typename Derived1::Scalar> qpp::anticomm ( const Eigen::MatrixBase< Derived1 > & *A*, const Eigen::MatrixBase< Derived2 > & *B* )

Here is the call graph for this function:



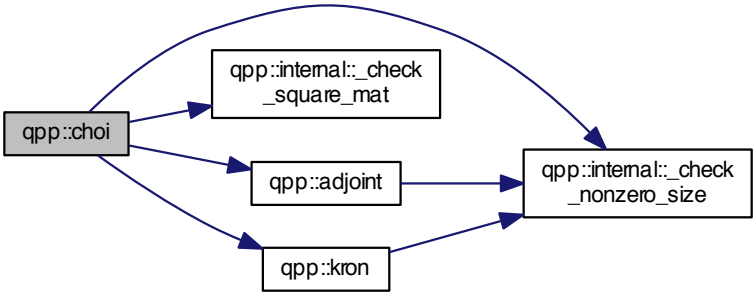

#### 5.1.1.4 types::cmat qpp::channel ( const types::cmat & *rho*, const std::vector< types::cmat > & *Ks* )

Here is the call graph for this function:



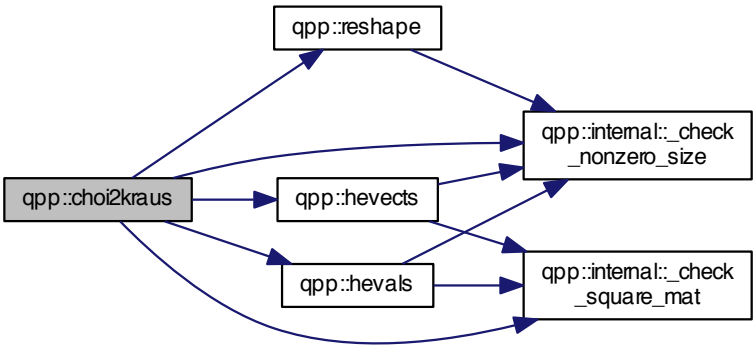
#### 5.1.1.5 types::cmat qpp::choi ( const std::vector< types::cmat > & *Ks* )

Here is the call graph for this function:



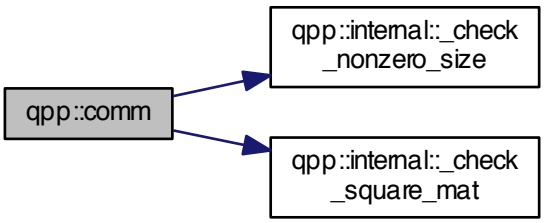

#### 5.1.1.6 std::vector<types::cmat> qpp::choi2kraus ( const types::cmat & *A* )

Here is the call graph for this function:



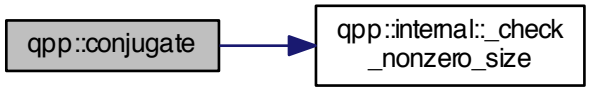
#### 5.1.1.7 template<typename Derived1 , typename Derived2 > types::DynMat<typename Derived1::Scalar> qpp::comm ( const Eigen::MatrixBase< Derived1 > & *A*, const Eigen::MatrixBase< Derived2 > & *B* )

Here is the call graph for this function:



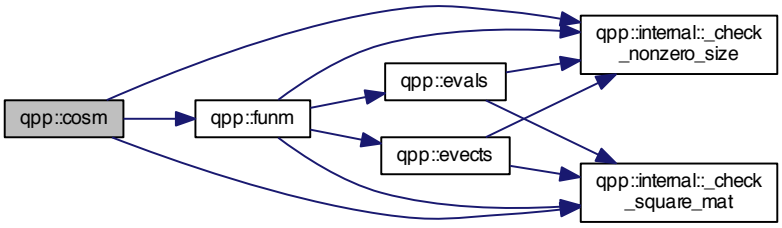

#### 5.1.1.8 template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::conjugate ( const Eigen::MatrixBase< Derived > & *A* )

Here is the call graph for this function:



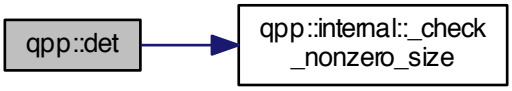

#### 5.1.1.9 template<typename Derived > types::cmat qpp::cosm ( const Eigen::MatrixBase< Derived > & *A* )

Here is the call graph for this function:



#### 5.1.1.10 template<typename Derived > Derived::Scalar qpp::det ( const Eigen::MatrixBase< Derived > & *A* )

Here is the call graph for this function:




#### 5.1.1.11 template<typename Derived > void qpp::disp ( const Eigen::MatrixBase< Derived > & *A*, double *chop* = `ct::chop`, std::ostream & *os* = `std::cout` )

#### 5.1.1.12 void qpp::disp ( const types::cplx *c*, double *chop* = `ct::chop`, std::ostream & *os* = `std::cout` )

Here is the call graph for this function:

#### 5.1.1.13 template<typename Derived > void qpp::displn ( const Eigen::MatrixBase< Derived > & *A*, double *chop* = `ct::chop`, std::ostream & *os* = `std::cout` )

Here is the call graph for this function:

5.1.1.14 void qpp::displn ( const types::cplx *c*, double *chop* = `ct::chop`, std::ostream & *os* = `std::cout` )

Here is the call graph for this function:

5.1.1.15 template<typename T > void qpp::displnSTL ( const T & *x*, const std::string & *separator* = " ", const std::string & *start* = "[", const std::string & *end* = "]", std::ostream & *os* = `std::cout` )

Here is the call graph for this function:

5.1.1.16 template<typename T > void qpp::displnSTL ( const T * *x*, const size_t *n*, const std::string & *separator* = " ", const std::string & *start* = "[", const std::string & *end* = "]", std::ostream & *os* = `std::cout` )

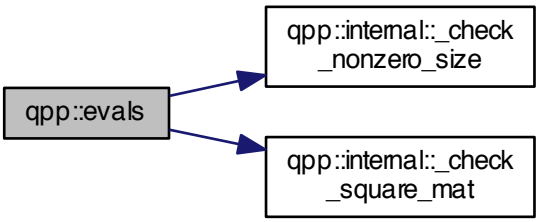
Here is the call graph for this function:

5.1.1.17 template<typename T > void qpp::dispSTL ( const T & *x*, const std::string & *separator* = " ", const std::string & *start* = "[", const std::string & *end* = "]", std::ostream & *os* = `std::cout` )

5.1.1.18 template<typename T > void qpp::dispSTL ( const T * *x*, const size_t *n*, const std::string & *separator* = " ", const std::string & *start* = "[", const std::string & *end* = "]", std::ostream & *os* = `std::cout` )

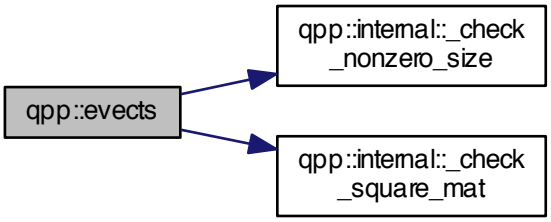
#### 5.1.1.19 template<typename Derived > types::cmat qpp::evals ( const Eigen::MatrixBase< Derived > & *A* )

Here is the call graph for this function:



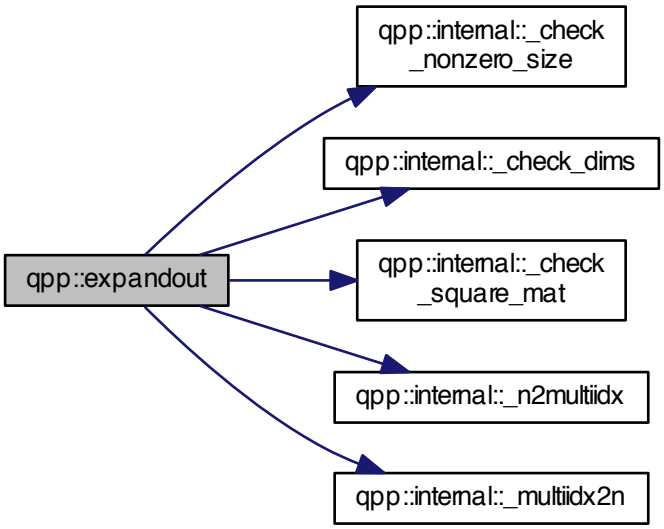

#### 5.1.1.20 template<typename Derived > types::cmat qpp::evects ( const Eigen::MatrixBase< Derived > & *A* )

Here is the call graph for this function:



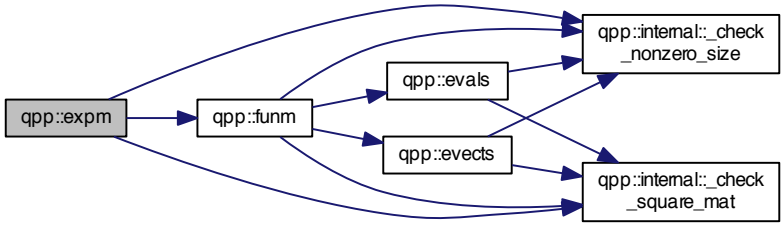
#### 5.1.1.21 template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::expandout ( const Eigen::MatrixBase< Derived > & *A*, size_t *pos*, const std::vector< size_t > & *dims* )

Here is the call graph for this function:



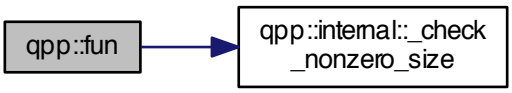

#### 5.1.1.22 template<typename Derived > types::cmat qpp::expm ( const Eigen::MatrixBase< Derived > & *A* )

Here is the call graph for this function:



#### 5.1.1.23 template<typename OutputScalar , typename Derived > types::DynMat<OutputScalar> qpp::fun ( const Eigen::MatrixBase< Derived > & *A*, OutputScalar(*)(const typename Derived::Scalar &) *f* )

Here is the call graph for this function:




#### 5.1.1.24 template<typename Derived > types::cmat qpp::funm ( const Eigen::MatrixBase< Derived > & *A*, types::cplx(*)(const types::cplx &) *f* )

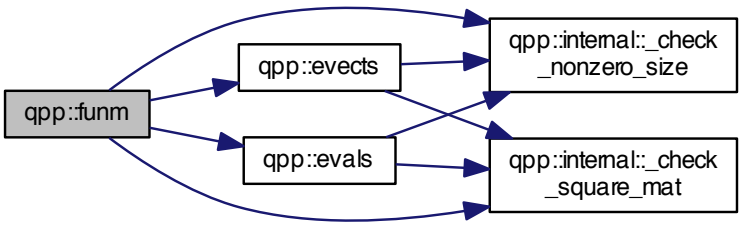
**Parameters**

| | |
|---|---|
| *A* | input matrix |
| *f* | function pointer |

**Returns**

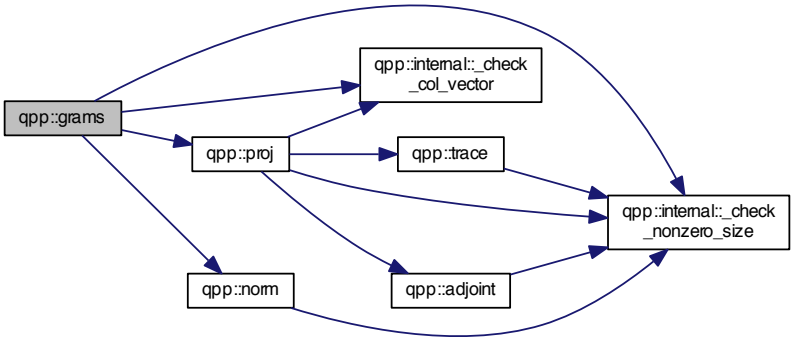
types::cmat

Here is the call graph for this function:



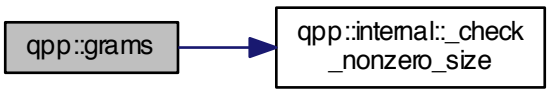
#### 5.1.1.25 template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::grams ( const std::vector< types::DynMat< typename Derived::Scalar > > & *Vs* )

Here is the call graph for this function:



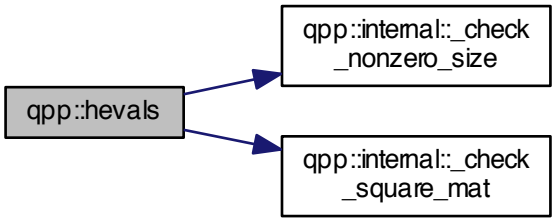

#### 5.1.1.26 template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::grams ( const Eigen::MatrixBase< Derived > & *A* )

Here is the call graph for this function:



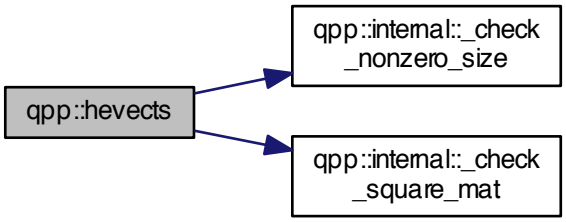
#### 5.1.1.27 template<typename Derived > types::cmat qpp::hevals ( const Eigen::MatrixBase< Derived > & *A* )

Here is the call graph for this function:



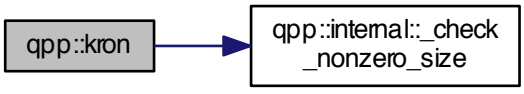

#### 5.1.1.28 template<typename Derived > types::cmat qpp::hevects ( const Eigen::MatrixBase< Derived > & *A* )

Here is the call graph for this function:



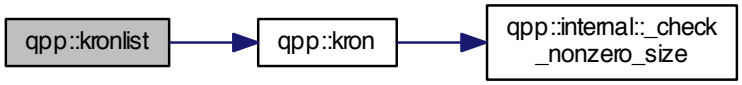

#### 5.1.1.29 template<typename Derived1 , typename Derived2 > types::DynMat<typename Derived1::Scalar> qpp::kron ( const Eigen::MatrixBase< Derived1 > & *A*, const Eigen::MatrixBase< Derived2 > & *B* )

Here is the call graph for this function:



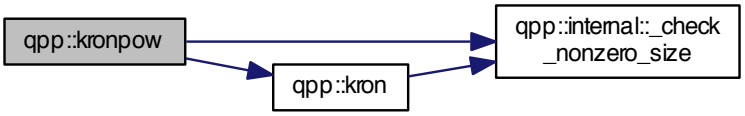
5.1.1.30 template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::kronlist ( const std::vector< types::DynMat< typename Derived::Scalar > > & *As* )

Here is the call graph for this function:




5.1.1.31 template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::kronpow ( const Eigen::MatrixBase< Derived > & *A*, size_t *n* )

Here is the call graph for this function:




5.1.1.32 template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::load ( const std::string & *fname* )

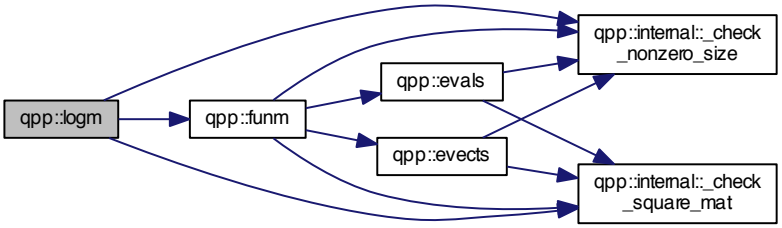
5.1.1.33 template<typename Derived > Derived qpp::loadMATLABmatrix ( const std::string & *mat_file*, const std::string & *var_name* )

5.1.1.34 template<> types::dmat qpp::loadMATLABmatrix ( const std::string & *mat_file*, const std::string & *var_name* )

5.1.1.35 template<> types::cmat qpp::loadMATLABmatrix ( const std::string & *mat_file*, const std::string & *var_name* )

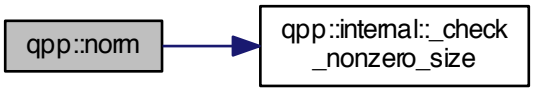
#### 5.1.1.36 template<typename Derived > types::cmat qpp::logm ( const Eigen::MatrixBase< Derived > & *A* )

Here is the call graph for this function:



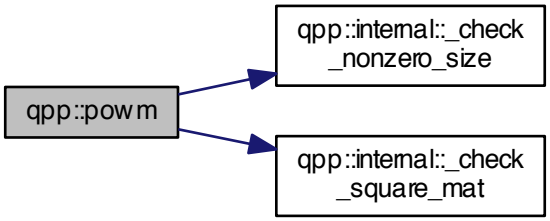

#### 5.1.1.37 template<typename Derived > double qpp::norm ( const Eigen::MatrixBase< Derived > & *A* )

Here is the call graph for this function:



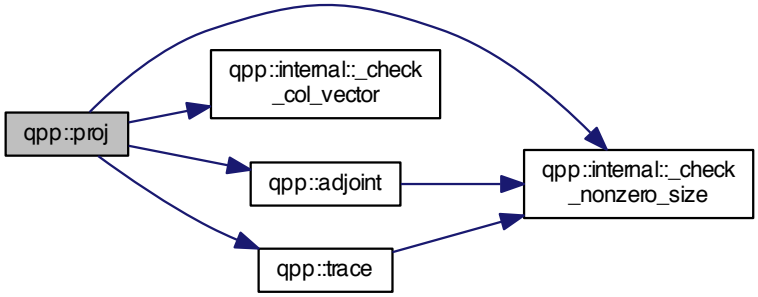

#### 5.1.1.38 template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::powm ( const Eigen::MatrixBase< Derived > & *A*, size_t *n* )

Here is the call graph for this function:



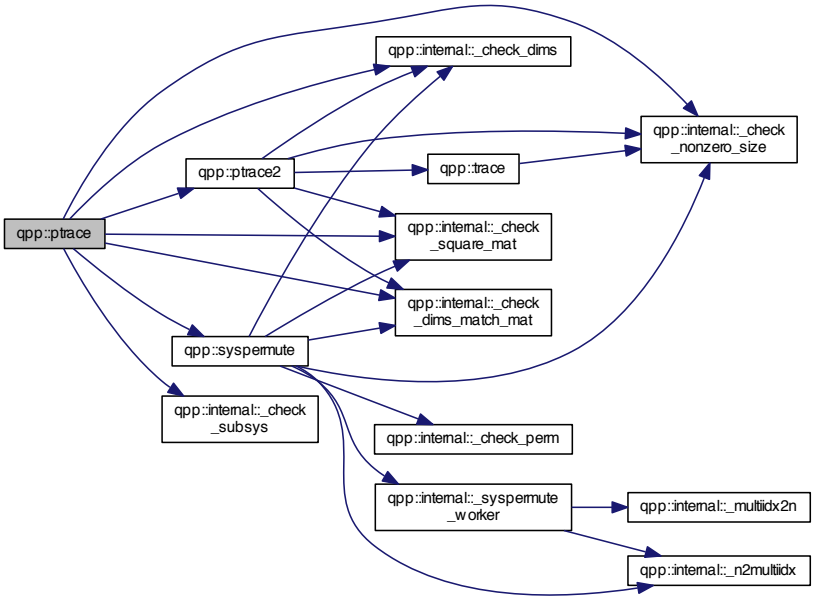
#### 5.1.1.39 template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::proj ( const Eigen::MatrixBase< Derived > & *V* )

Here is the call graph for this function:



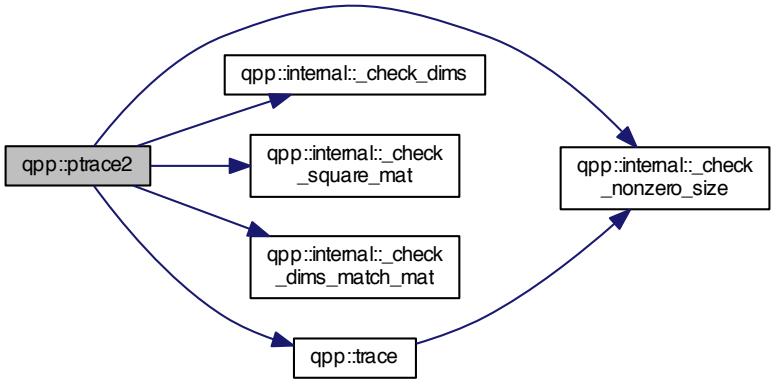

#### 5.1.1.40 template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::ptrace ( const Eigen::MatrixBase< Derived > & *A*, const std::vector< size_t > & *subsys*, const std::vector< size_t > & *dims* )

Here is the call graph for this function:



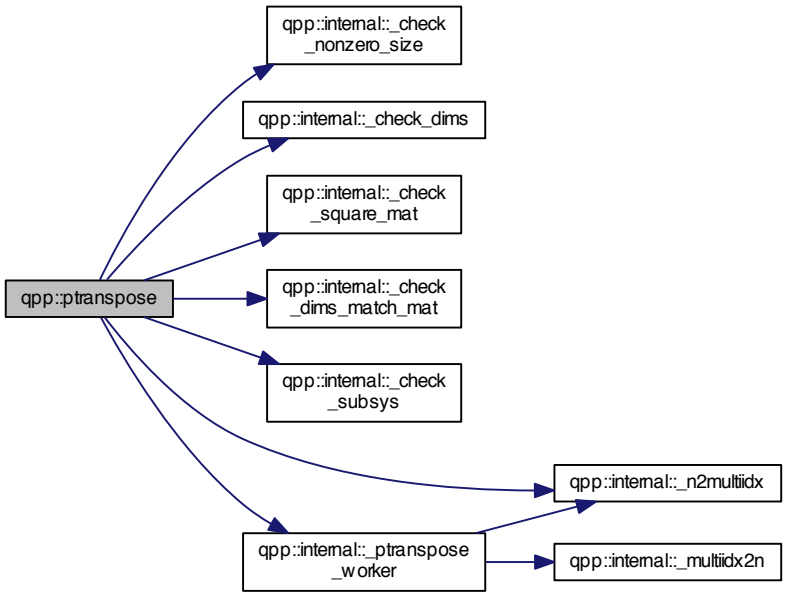
#### 5.1.1.41 template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::ptrace2 ( const Eigen::MatrixBase< Derived > & *A*, const std::vector< size_t > *dims* )

Here is the call graph for this function:




#### 5.1.1.42 template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::ptranspose ( const Eigen::MatrixBase< Derived > & *A*, const std::vector< size_t > & *subsys*, const std::vector< size_t > & *dims* )

Here is the call graph for this function:



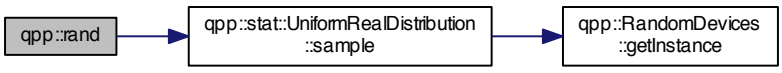
#### 5.1.1.43 template<typename Derived > Derived qpp::rand ( size_t *rows*, size_t *cols*, double *a* = 0, double *b* = 1 )

#### 5.1.1.44 template<> types::dmat qpp::rand ( size_t *rows*, size_t *cols*, double *a*, double *b* )

#### 5.1.1.45 template<> types::cmat qpp::rand ( size_t *rows*, size_t *cols*, double *a*, double *b* )

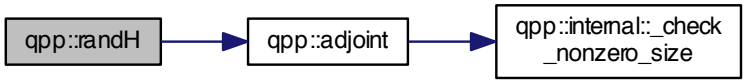
#### 5.1.1.46 double qpp::rand ( double *a* = 0, double *b* = 1 )

Here is the call graph for this function:



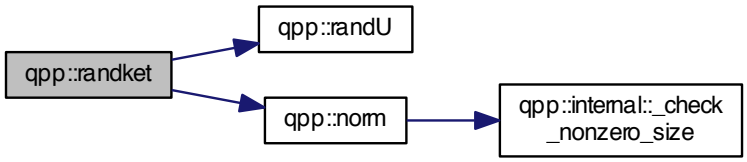

#### 5.1.1.47 types::cmat qpp::randH ( size_t *D* )

Here is the call graph for this function:



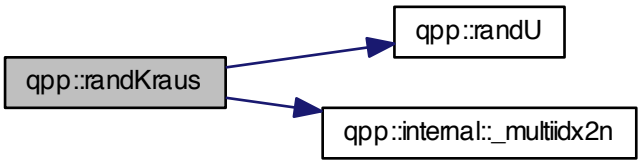

#### 5.1.1.48 types::cmat qpp::randket ( size_t *D* )

Here is the call graph for this function:



#### 5.1.1.49 std::vector<types::cmat> qpp::randKraus ( size_t *n*, size_t *D* )

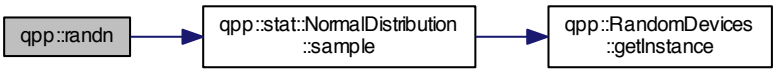
Here is the call graph for this function:




#### 5.1.1.50 template<typename Derived > Derived qpp::randn ( size_t *rows*, size_t *cols*, double *mean* = 0, double *sigma* = 1 )

#### 5.1.1.51 template<> types::dmat qpp::randn ( size_t *rows*, size_t *cols*, double *mean*, double *sigma* )

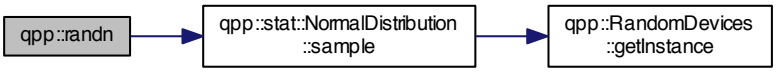
Here is the call graph for this function:




#### 5.1.1.52 template<> types::cmat qpp::randn ( size_t *rows*, size_t *cols*, double *mean*, double *sigma* )

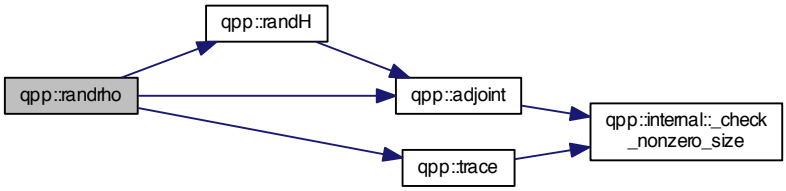
#### 5.1.1.53 double qpp::randn ( double *mean* = 0, double *sigma* = 1 )

Here is the call graph for this function:



#### 5.1.1.54 types::cmat qpp::randrho ( size_t *D* )

Here is the call graph for this function:



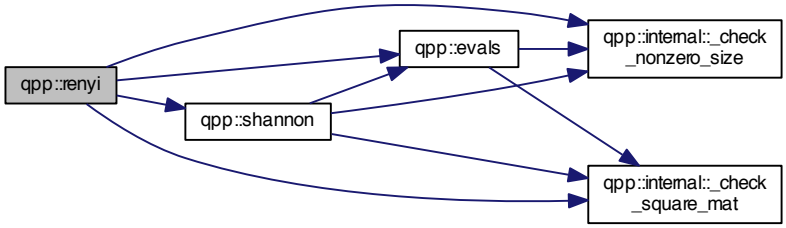

#### 5.1.1.55 types::cmat qpp::randU ( size_t *D* )

#### 5.1.1.56 types::cmat qpp::randV ( size_t *Din*, size_t *Dout* )

Here is the call graph for this function:

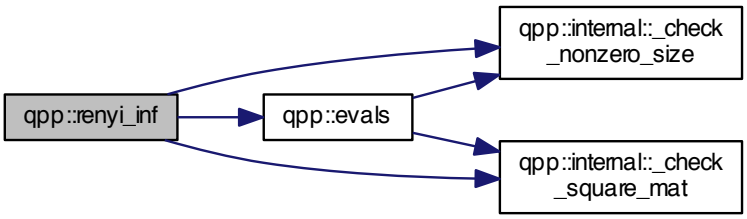
#### 5.1.1.57 template<typename Derived > double qpp::renyi ( const double *alpha*, const Eigen::MatrixBase< Derived > & *A* )

Here is the call graph for this function:



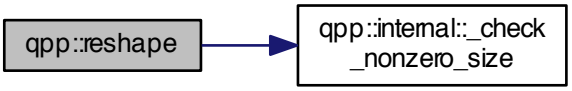
#### 5.1.1.58 template<typename Derived > double qpp::renyi_inf ( const Eigen::MatrixBase< Derived > & *A* )

Here is the call graph for this function:



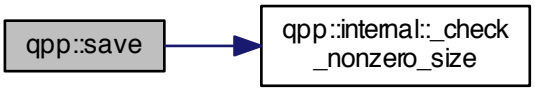

#### 5.1.1.59 template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::reshape ( const Eigen::MatrixBase< Derived > & *A*, size_t *rows*, size_t *cols* )

Here is the call graph for this function:




#### 5.1.1.60 template<typename Derived > void qpp::save ( const Eigen::MatrixBase< Derived > & *A*, const std::string & *fname* )

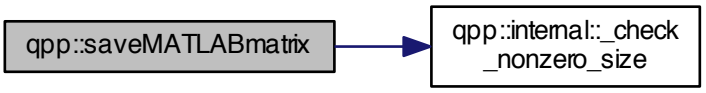
Here is the call graph for this function:




#### 5.1.1.61 template<typename Derived > void qpp::saveMATLABmatrix ( const Eigen::MatrixBase< Derived > & *A*, const std::string & *mat_file*, const std::string & *var_name*, const std::string & *mode* )

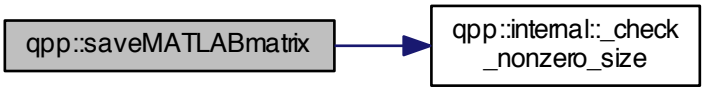
#### 5.1.1.62 template<> void qpp::saveMATLABmatrix ( const Eigen::MatrixBase< typename types::dmat > & *A*, const std::string & *mat_file*, const std::string & *var_name*, const std::string & *mode* )

Here is the call graph for this function:



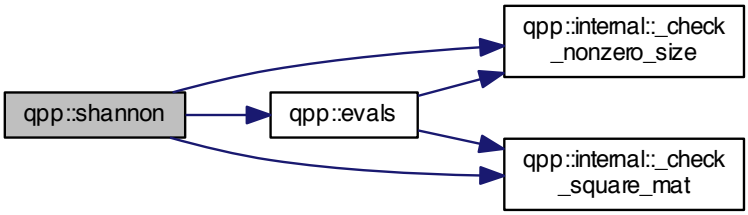

#### 5.1.1.63 template<> void qpp::saveMATLABmatrix ( const Eigen::MatrixBase< typename types::cmat > & *A*, const std::string & *mat_file*, const std::string & *var_name*, const std::string & *mode* )

Here is the call graph for this function:



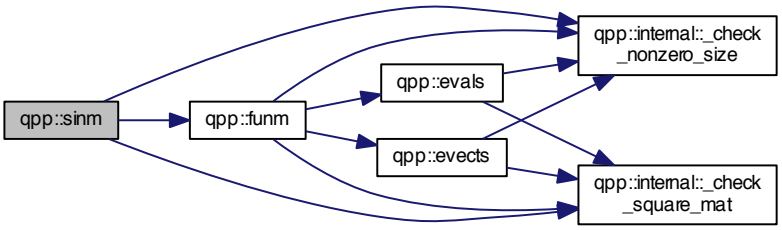

#### 5.1.1.64 template<typename Derived > double qpp::shannon ( const Eigen::MatrixBase< Derived > & *A* )

Here is the call graph for this function:



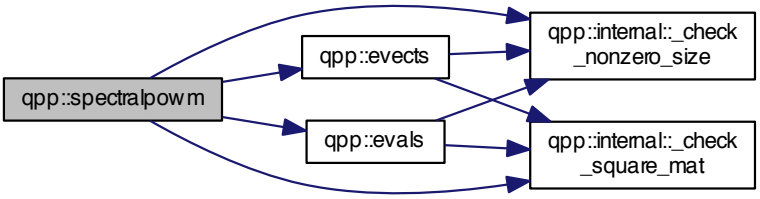
#### 5.1.1.65 template<typename Derived > types::cmat qpp::sinm ( const Eigen::MatrixBase< Derived > & *A* )

Here is the call graph for this function:



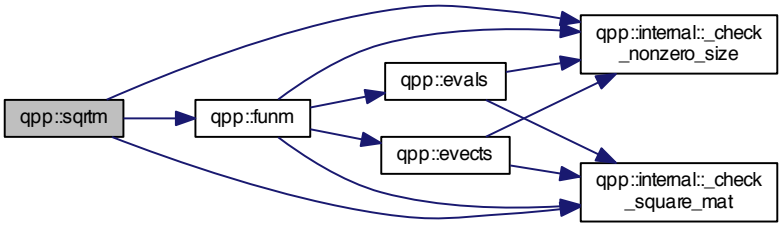

#### 5.1.1.66 template<typename Derived > types::cmat qpp::spectralpowm ( const Eigen::MatrixBase< Derived > & *A*, const types::cplx *z* )

Here is the call graph for this function:



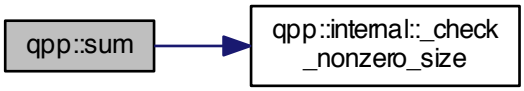

#### 5.1.1.67 template<typename Derived > types::cmat qpp::sqrtm ( const Eigen::MatrixBase< Derived > & *A* )

Here is the call graph for this function:



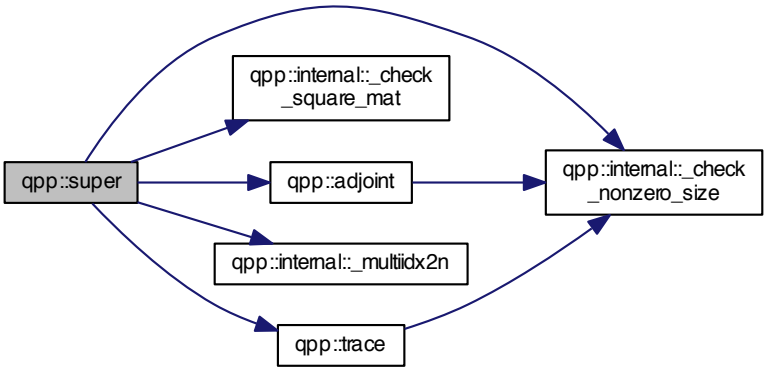
#### 5.1.1.68 template<typename Derived > Derived::Scalar qpp::sum ( const Eigen::MatrixBase< Derived > & *A* )

Here is the call graph for this function:



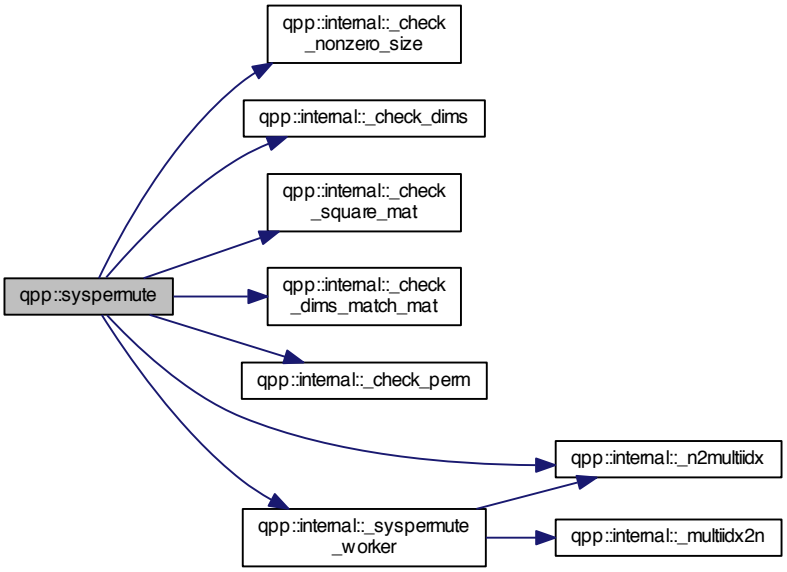

#### 5.1.1.69 types::cmat qpp::super ( const std::vector< types::cmat > & *Ks* )

Here is the call graph for this function:



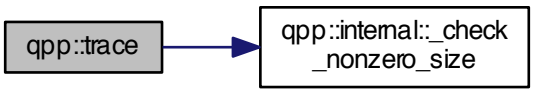
5.1.1.70 template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::syspermute ( const Eigen::MatrixBase< Derived > & *A*, const std::vector< size_t > *perm*, const std::vector< size_t > & *dims* )

Here is the call graph for this function:



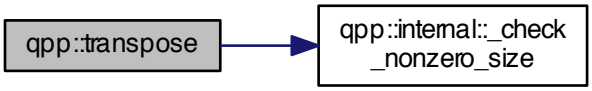

5.1.1.71 template<typename Derived > Derived::Scalar qpp::trace ( const Eigen::MatrixBase< Derived > & *A* )

Here is the call graph for this function:



#### 5.1.1.72 template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::transpose ( const Eigen::MatrixBase< Derived > & *A* )

Here is the call graph for this function:




### 5.1.2 Variable Documentation

#### 5.1.2.1 const Gates& qpp::gt = Gates::getInstance()

#### 5.1.2.2 RandomDevices& qpp::rdevs = RandomDevices::getInstance()

## 5.2 qpp::ct Namespace Reference

### Functions

- std::complex< double > omega (size_t D)

### Variables

- const double chop = 1e-10
- const double eps = 1e-14
- const std::complex< double > ii = { 0, 1 }
- const double pi = 3.14159265358979323846264338327950288 4
- const double ee = 2.71828182845904523536028747135266249 7

### 5.2.1 Function Documentation

#### 5.2.1.1 std::complex<double> qpp::ct::omega ( size_t *D* )

### 5.2.2 Variable Documentation

#### 5.2.2.1 const double qpp::ct::chop = 1e-10

#### 5.2.2.2 const double qpp::ct::ee = 2.71828182845904523536028747135266249 7

#### 5.2.2.3 const double qpp::ct::eps = 1e-14

#### 5.2.2.4 const std::complex<double> qpp::ct::ii = { 0, 1 }

#### 5.2.2.5 const double qpp::ct::pi = 3.14159265358979323846264338327950288 4

## 5.3 qpp::internal Namespace Reference

### Functions

- void _n2multiidx (size_t n, size_t numdims, const size_t *dims, size_t *result)
- size_t _multiidx2n (const size_t *midx, size_t numdims, const size_t *dims)
- template<typename Derived >
  bool _check_square_mat (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  bool _check_vector (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  bool _check_row_vector (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  bool _check_col_vector (const Eigen::MatrixBase< Derived > &A)
- template<typename T >
  bool _check_nonzero_size (const T &x)
- bool _check_dims (const std::vector< size_t > &dims)
- template<typename Derived >
  bool _check_dims_match_mat (const std::vector< size_t > &dims, const Eigen::MatrixBase< Derived > &A)
- bool _check_eq_dims (const std::vector< size_t > &dims, size_t dim)
- bool _check_subsys (const std::vector< size_t > &subsys, const std::vector< size_t > &dims)
- bool _check_perm (const std::vector< size_t > &perm, const std::vector< size_t > &dims)
- template<typename Scalar >
  void _syspermute_worker (const size_t *midxcol, size_t numdims, const size_t *cdims, const size_t *cperm, size_t i, size_t j, size_t &iperm, size_t &jperm, const types::DynMat< Scalar > &A, types::DynMat< Scalar > &result)
- template<typename Scalar >
  void _ptranspose_worker (const size_t *midxcol, size_t numdims, size_t numsubsys, const size_t *cdims, const size_t *csubsys, size_t i, size_t j, size_t &iperm, size_t &jperm, const types::DynMat< Scalar > &A, types::DynMat< Scalar > &result)

### 5.3.1 Function Documentation

#### 5.3.1.1 template<typename Derived > bool qpp::internal::_check_col_vector ( const Eigen::MatrixBase< Derived > & *A* )

#### 5.3.1.2 bool qpp::internal::_check_dims ( const std::vector< size_t > & *dims* )

#### 5.3.1.3 template<typename Derived > bool qpp::internal::_check_dims_match_mat ( const std::vector< size_t > & *dims*, const Eigen::MatrixBase< Derived > & *A* )

#### 5.3.1.4 bool qpp::internal::_check_eq_dims ( const std::vector< size_t > & *dims*, size_t *dim* )

#### 5.3.1.5 template<typename T > bool qpp::internal::_check_nonzero_size ( const T & *x* )

#### 5.3.1.6 bool qpp::internal::_check_perm ( const std::vector< size_t > & *perm*, const std::vector< size_t > & *dims* )

#### 5.3.1.7 template<typename Derived > bool qpp::internal::_check_row_vector ( const Eigen::MatrixBase< Derived > & *A* )

#### 5.3.1.8 template<typename Derived > bool qpp::internal::_check_square_mat ( const Eigen::MatrixBase< Derived > & *A* )

#### 5.3.1.9 bool qpp::internal::_check_subsys ( const std::vector< size_t > & *subsys*, const std::vector< size_t > & *dims* )

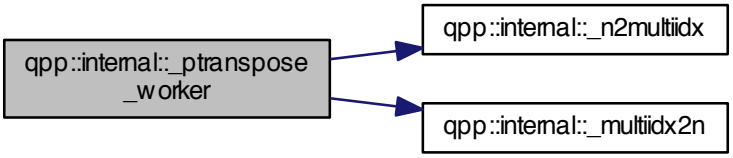
#### 5.3.1.10 template<typename Derived > bool qpp::internal::_check_vector ( const Eigen::MatrixBase< Derived > & *A* )

#### 5.3.1.11 size_t qpp::internal::_multiidx2n ( const size_t * *midx*, size_t *numdims*, const size_t * *dims* )

5.3.1.12 void qpp::internal::_n2multiidx ( size_t *n*, size_t *numdims*, const size_t * *dims*, size_t * *result* )

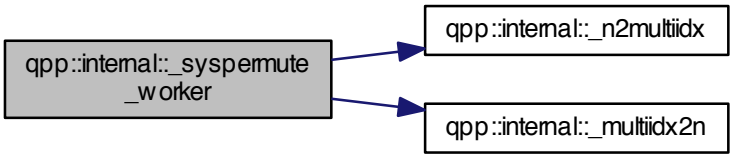
5.3.1.13 template<typename Scalar > void qpp::internal::_ptranspose_worker ( const size_t * *midxcol*, size_t *numdims*, size_t *numsubsys*, const size_t * *cdims*, const size_t * *csubsys*, size_t *i*, size_t *j*, size_t & *iperm*, size_t & *jperm*, const types::DynMat< Scalar > & *A*, types::DynMat< Scalar > & *result* )

Here is the call graph for this function:




5.3.1.14 template<typename Scalar > void qpp::internal::_syspermute_worker ( const size_t * *midxcol*, size_t *numdims*, const size_t * *cdims*, const size_t * *cperm*, size_t *i*, size_t *j*, size_t & *iperm*, size_t & *jperm*, const types::DynMat< Scalar > & *A*, types::DynMat< Scalar > & *result* )

Here is the call graph for this function:




## 5.4 qpp::stat Namespace Reference

### Classes

- class NormalDistribution
- class UniformRealDistribution
- class DiscreteDistribution
- class DiscreteDistributionFromComplex

## 5.5 qpp::types Namespace Reference

## Typedefs

- typedef std::complex< double > cplx
- typedef Eigen::MatrixXcd cmat
- typedef Eigen::MatrixXd dmat
- typedef Eigen::MatrixXf fmat
- typedef Eigen::MatrixXi imat
- typedef Eigen::Matrix< cplx, Eigen::Dynamic, 1 > ket
- typedef Eigen::Matrix< cplx, 1, Eigen::Dynamic > bra
- template<typename Scalar > using DynMat = Eigen::Matrix< Scalar, Eigen::Dynamic, Eigen::Dynamic >

### 5.5.1 Typedef Documentation

#### 5.5.1.1 typedef Eigen::Matrix<cplx, 1, Eigen::Dynamic> qpp::types::bra

#### 5.5.1.2 typedef Eigen::MatrixXcd qpp::types::cmat

#### 5.5.1.3 typedef std::complex<double> qpp::types::cplx

#### 5.5.1.4 typedef Eigen::MatrixXd qpp::types::dmat

#### 5.5.1.5 template<typename Scalar > using qpp::types::DynMat = typedef Eigen::Matrix<Scalar, Eigen::Dynamic, Eigen::Dynamic>

#### 5.5.1.6 typedef Eigen::MatrixXf qpp::types::fmat

#### 5.5.1.7 typedef Eigen::MatrixXi qpp::types::imat

#### 5.5.1.8 typedef Eigen::Matrix<cplx, Eigen::Dynamic, 1> qpp::types::ket

# Chapter 6

# Class Documentation

## 6.1 qpp::stat::DiscreteDistribution Class Reference

`#include <stat.h>`

### Public Member Functions

- template<typename InputIterator >
  DiscreteDistribution (InputIterator first, InputIterator last)
- DiscreteDistribution (std::initializer_list< double > weights)
- DiscreteDistribution (std::vector< double > weights)
- size_t sample ()
- std::vector< double > probabilities ()

### Protected Attributes

- std::discrete_distribution
  < size_t > _d

### 6.1.1 Constructor & Destructor Documentation

#### 6.1.1.1 template<typename InputIterator > qpp::stat::DiscreteDistribution::DiscreteDistribution ( InputIterator *first,* InputIterator *last* ) [inline]

#### 6.1.1.2 qpp::stat::DiscreteDistribution::DiscreteDistribution ( std::initializer_list< double > *weights* ) [inline]

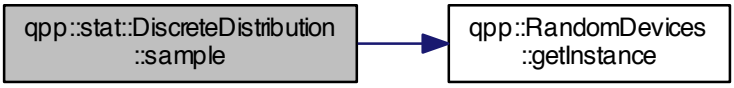
#### 6.1.1.3 qpp::stat::DiscreteDistribution::DiscreteDistribution ( std::vector< double > *weights* ) [inline]

### 6.1.2 Member Function Documentation

#### 6.1.2.1 std::vector<double> qpp::stat::DiscreteDistribution::probabilities ( ) [inline]

#### 6.1.2.2 size_t qpp::stat::DiscreteDistribution::sample ( ) [inline]

Here is the call graph for this function:




### 6.1.3 Member Data Documentation

#### 6.1.3.1 std::discrete_distribution<size_t> qpp::stat::DiscreteDistribution::_d [protected]

The documentation for this class was generated from the following file:

- include/stat.h

## 6.2 qpp::stat::DiscreteDistributionFromComplex Class Reference

`#include <stat.h>`

### Public Member Functions

- template<typename InputIterator >
  DiscreteDistributionFromComplex (InputIterator first, InputIterator last)
- DiscreteDistributionFromComplex (std::initializer_list< types::cplx > amplitudes)
- DiscreteDistributionFromComplex (std::vector< types::cplx > amplitudes)
- DiscreteDistributionFromComplex (const types::cmat &V)
- size_t sample ()
- std::vector< double > probabilities ()

### Protected Member Functions

- template<typename InputIterator >
  std::vector< double > cplx2amplitudes (InputIterator first, InputIterator last)

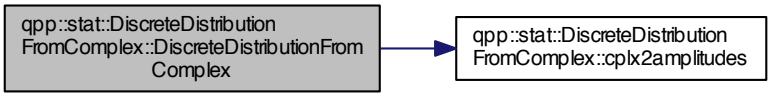
### Protected Attributes

- std::discrete_distribution
  < size_t > _d

### 6.2.1 Constructor & Destructor Documentation

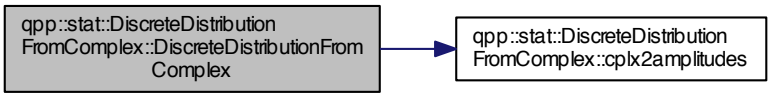
#### 6.2.1.1 template<typename InputIterator > qpp::stat::DiscreteDistributionFromComplex::DiscreteDistributionFromComplex ( InputIterator *first,* InputIterator *last* ) [inline]

Here is the call graph for this function:



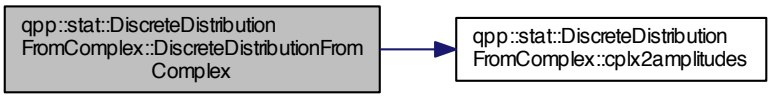

#### 6.2.1.2 qpp::stat::DiscreteDistributionFromComplex::DiscreteDistributionFromComplex ( std::initializer_list< types::cplx > *amplitudes* ) [inline]

Here is the call graph for this function:



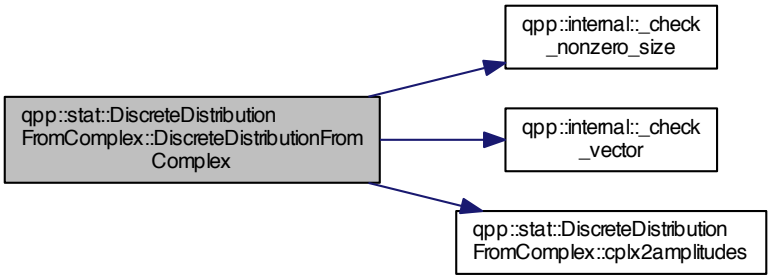

#### 6.2.1.3 qpp::stat::DiscreteDistributionFromComplex::DiscreteDistributionFromComplex ( std::vector< types::cplx > *amplitudes* ) [inline]

Here is the call graph for this function:



#### 6.2.1.4 qpp::stat::DiscreteDistributionFromComplex::DiscreteDistributionFromComplex ( const types::cmat & *V* ) [inline]

Here is the call graph for this function:



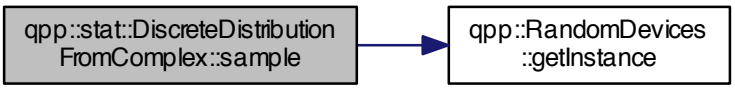

### 6.2.2 Member Function Documentation

#### 6.2.2.1 template<typename InputIterator > std::vector<double> qpp::stat::DiscreteDistribution-FromComplex::cplx2amplitudes ( InputIterator *first,* InputIterator *last* ) [inline], [protected]

#### 6.2.2.2 std::vector<double> qpp::stat::DiscreteDistributionFromComplex::probabilities ( ) [inline]

#### 6.2.2.3 size_t qpp::stat::DiscreteDistributionFromComplex::sample ( ) [inline]

Here is the call graph for this function:




### 6.2.3 Member Data Documentation

#### 6.2.3.1 std::discrete_distribution<size_t> qpp::stat::DiscreteDistributionFromComplex::_d [protected]

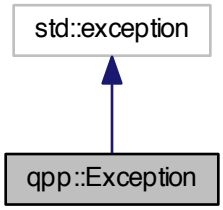
The documentation for this class was generated from the following file:

- include/stat.h

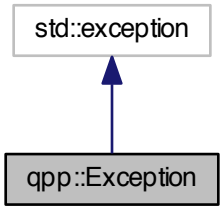
## 6.3 qpp::Exception Class Reference

```
#include <exception.h>
```

Inheritance diagram for qpp::Exception:




Collaboration diagram for qpp::Exception:




## Public Types

- enum Type {
  Type::UNKNOWN_EXCEPTION = 0, Type::ZERO_SIZE, Type::MATRIX_NOT_SQUARE, Type::MATRIX_NOT_CVECTOR,
  Type::MATRIX_NOT_RVECTOR, Type::MATRIX_NOT_VECTOR, Type::DIMS_INVALID, Type::DIMS_NOT_EQUAL,
  Type::DIMS_MISMATCH_MATRIX, Type::SUBSYS_MISMATCH_DIMS, Type::PERM_MISMATCH_DIMS, Type::NOT_QUBIT_GATE,
  Type::NOT_QUBIT_SUBSYS, Type::OUT_OF_RANGE, Type::UNDEFINED_TYPE, Type::TYPE_MISMATCH,
  Type::CUSTOM_EXCEPTION }

## Public Member Functions

- Exception (const std::string &where, const Type &type)
- Exception (const std::string &where, const std::string &custom)
- virtual const char * what () const noexceptoverride
- virtual ~Exception () noexcept

### Private Member Functions

- std::string _construct_exception_msg ()

### Private Attributes

- std::string _where
- std::string _msg
- Type _type
- std::string _custom

## 6.3.1 Member Enumeration Documentation

#### 6.3.1.1 enum qpp::Exception::Type [strong]

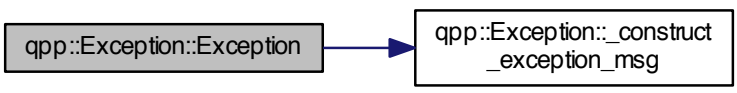
Enumerator

***UNKNOWN_EXCEPTION***
***ZERO_SIZE***
***MATRIX_NOT_SQUARE***
***MATRIX_NOT_CVECTOR***
***MATRIX_NOT_RVECTOR***
***MATRIX_NOT_VECTOR***
***DIMS_INVALID***
***DIMS_NOT_EQUAL***
***DIMS_MISMATCH_MATRIX***
***SUBSYS_MISMATCH_DIMS***
***PERM_MISMATCH_DIMS***
***NOT_QUBIT_GATE***
***NOT_QUBIT_SUBSYS***
***OUT_OF_RANGE***
***UNDEFINED_TYPE***
***TYPE_MISMATCH***
***CUSTOM_EXCEPTION***

## 6.3.2 Constructor & Destructor Documentation

#### 6.3.2.1 qpp::Exception::Exception ( const std::string & *where*, const Type & *type* ) [inline]

Here is the call graph for this function:



#### 6.3.2.2 qpp::Exception::Exception ( const std::string & *where*, const std::string & *custom* ) [inline]

Here is the call graph for this function:

#### 6.3.2.3 virtual qpp::Exception::~Exception ( ) [inline], [virtual], [noexcept]

### 6.3.3 Member Function Documentation

#### 6.3.3.1 std::string qpp::Exception::_construct_exception_msg ( ) [inline], [private]

#### 6.3.3.2 virtual const char* qpp::Exception::what ( ) const [inline], [override], [virtual], [noexcept]

### 6.3.4 Member Data Documentation

#### 6.3.4.1 std::string qpp::Exception::_custom [private]

#### 6.3.4.2 std::string qpp::Exception::_msg [private]

#### 6.3.4.3 Type qpp::Exception::_type [private]

#### 6.3.4.4 std::string qpp::Exception::_where [private]

The documentation for this class was generated from the following file:

- include/exception.h

## 6.4 qpp::Gates Class Reference

```
#include <gates.h>
```

### Public Member Functions

- Gates (const Gates &)=delete
- Gates & operator= (const Gates &)=delete
- virtual ~Gates ()=default
- types::cmat Rtheta (double theta) const
- types::cmat Id (size_t D) const
- types::cmat Zd (size_t D) const
- types::cmat Fd (size_t D) const
- types::cmat Xd (size_t D) const
- types::cmat CTRL (const types::cmat &A, const std::vector< size_t > &ctrl, const std::vector< size_t > &gate, size_t n, size_t D=2) const

### Static Public Member Functions

- static const Gates & getInstance ()

### Public Attributes

- types::cmat Id2
- types::cmat H
- types::cmat X
- types::cmat Y
- types::cmat Z
- types::cmat S
- types::cmat T
- types::cmat CNOTab
- types::cmat CZ
- types::cmat CS
- types::cmat CNOTba
- types::cmat SWAP
- types::cmat TOF
- types::cmat FRED
- types::ket x0
- types::ket x1
- types::ket y0
- types::ket y1
- types::ket z0
- types::ket z1
- types::ket b00
- types::ket b01
- types::ket b10
- types::ket b11

### Private Member Functions

- Gates ()

## 6.4.1 Constructor & Destructor Documentation

#### 6.4.1.1 qpp::Gates::Gates ( ) [inline], [private]

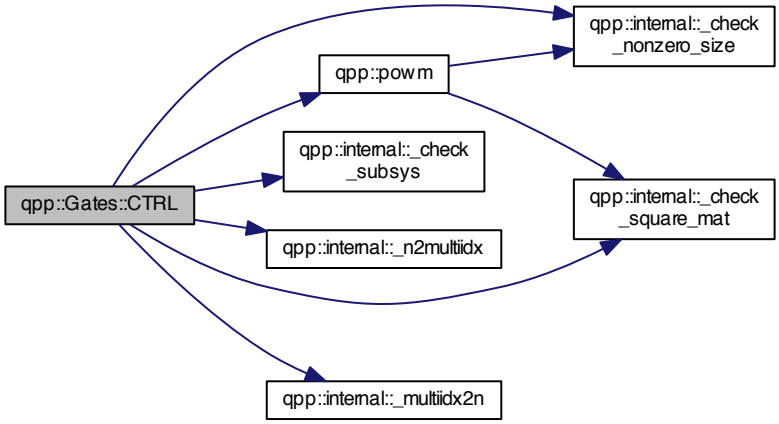
#### 6.4.1.2 qpp::Gates::Gates ( const Gates & ) [delete]

#### 6.4.1.3 virtual qpp::Gates::~Gates ( ) [virtual], [default]

## 6.4.2 Member Function Documentation

#### 6.4.2.1 types::cmat qpp::Gates::CTRL ( const types::cmat & *A*, const std::vector< size_t > & *ctrl*, const std::vector< size_t > & *gate*, size_t *n*, size_t *D* = 2 ) const [inline]

Here is the call graph for this function:




#### 6.4.2.2 types::cmat qpp::Gates::Fd ( size_t *D* ) const [inline]

Here is the call graph for this function:

#### 6.4.2.3 static const Gates& qpp::Gates::getInstance ( ) [inline], [static]

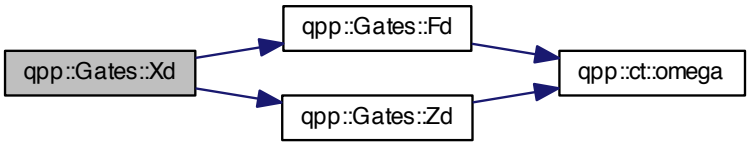
#### 6.4.2.4 types::cmat qpp::Gates::Id ( size_t *D* ) const [inline]

#### 6.4.2.5 Gates& qpp::Gates::operator= ( const Gates & ) [delete]

#### 6.4.2.6 types::cmat qpp::Gates::Rtheta ( double *theta* ) const [inline]

#### 6.4.2.7 types::cmat qpp::Gates::Xd ( size_t *D* ) const [inline]

Here is the call graph for this function:




#### 6.4.2.8 types::cmat qpp::Gates::Zd ( size_t *D* ) const [inline]

Here is the call graph for this function:

### 6.4.3 Member Data Documentation

#### 6.4.3.1 types::ket qpp::Gates::b00

#### 6.4.3.2 types::ket qpp::Gates::b01

#### 6.4.3.3 types::ket qpp::Gates::b10

#### 6.4.3.4 types::ket qpp::Gates::b11

#### 6.4.3.5 types::cmat qpp::Gates::CNOTab

#### 6.4.3.6 types::cmat qpp::Gates::CNOTba

#### 6.4.3.7 types::cmat qpp::Gates::CS

#### 6.4.3.8 types::cmat qpp::Gates::CZ

#### 6.4.3.9 types::cmat qpp::Gates::FRED

#### 6.4.3.10 types::cmat qpp::Gates::H

#### 6.4.3.11 types::cmat qpp::Gates::Id2

#### 6.4.3.12 types::cmat qpp::Gates::S

#### 6.4.3.13 types::cmat qpp::Gates::SWAP

#### 6.4.3.14 types::cmat qpp::Gates::T

#### 6.4.3.15 types::cmat qpp::Gates::TOF

#### 6.4.3.16 types::cmat qpp::Gates::X

#### 6.4.3.17 types::ket qpp::Gates::x0

#### 6.4.3.18 types::ket qpp::Gates::x1

#### 6.4.3.19 types::cmat qpp::Gates::Y

#### 6.4.3.20 types::ket qpp::Gates::y0

#### 6.4.3.21 types::ket qpp::Gates::y1

#### 6.4.3.22 types::cmat qpp::Gates::Z

#### 6.4.3.23 types::ket qpp::Gates::z0

#### 6.4.3.24 types::ket qpp::Gates::z1

The documentation for this class was generated from the following file:

- include/gates.h

## 6.5 qpp::stat::NormalDistribution Class Reference

```
#include <stat.h>
```

### Public Member Functions

- NormalDistribution (double mean=0, double sigma=1)
- double sample ()

### Protected Attributes

- std::normal_distribution _d

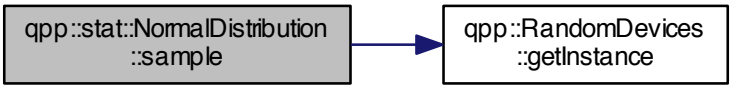
### 6.5.1 Constructor & Destructor Documentation

#### 6.5.1.1 qpp::stat::NormalDistribution::NormalDistribution ( double *mean* = 0, double *sigma* = 1 ) [inline]

### 6.5.2 Member Function Documentation

#### 6.5.2.1 double qpp::stat::NormalDistribution::sample ( ) [inline]

Here is the call graph for this function:




### 6.5.3 Member Data Documentation

#### 6.5.3.1 std::normal_distribution qpp::stat::NormalDistribution::_d [protected]

The documentation for this class was generated from the following file:

- include/stat.h

## 6.6 qpp::RandomDevices Class Reference

`#include <randevs.h>`

### Public Member Functions

- RandomDevices (const RandomDevices &)=delete
- RandomDevices & operator= (const RandomDevices &)=delete
- virtual ~RandomDevices ()=default

### Static Public Member Functions

- static RandomDevices & getInstance ()

### Public Attributes

- std::random_device _rd
- std::mt19937 _rng

### Private Member Functions

- RandomDevices ()

### 6.6.1 Constructor & Destructor Documentation

#### 6.6.1.1 qpp::RandomDevices::RandomDevices ( ) [inline], [private]

#### 6.6.1.2 qpp::RandomDevices::RandomDevices ( const RandomDevices & ) [delete]

#### 6.6.1.3 virtual qpp::RandomDevices::~RandomDevices ( ) [virtual], [default]

### 6.6.2 Member Function Documentation

#### 6.6.2.1 static RandomDevices& qpp::RandomDevices::getInstance ( ) [inline], [static]

#### 6.6.2.2 RandomDevices& qpp::RandomDevices::operator= ( const RandomDevices & ) [delete]

### 6.6.3 Member Data Documentation

#### 6.6.3.1 std::random_device qpp::RandomDevices::_rd

#### 6.6.3.2 std::mt19937 qpp::RandomDevices::_rng

The documentation for this class was generated from the following file:

- include/randevs.h

## 6.7 qpp::Timer Class Reference

`#include <timer.h>`

### Public Member Functions

- Timer ()
- void tic ()
- void toc ()
- double seconds () const
- virtual ~Timer ()=default

### Protected Attributes

- std::chrono::high_resolution_clock::time_point _start
- std::chrono::high_resolution_clock::time_point _end

### Friends

- std::ostream & operator<< (std::ostream &os, const Timer &rhs)

### 6.7.1 Constructor & Destructor Documentation

#### 6.7.1.1 qpp::Timer::Timer ( ) [inline]

#### 6.7.1.2 virtual qpp::Timer::~Timer ( ) [virtual], [default]

### 6.7.2 Member Function Documentation

#### 6.7.2.1 double qpp::Timer::seconds ( ) const [inline]

#### 6.7.2.2 void qpp::Timer::tic ( ) [inline]

#### 6.7.2.3 void qpp::Timer::toc ( ) [inline]

### 6.7.3 Friends And Related Function Documentation

#### 6.7.3.1 std::ostream& operator<< ( std::ostream & *os*, const Timer & *rhs* ) [friend]

### 6.7.4 Member Data Documentation

#### 6.7.4.1 std::chrono::high_resolution_clock::time_point qpp::Timer::_end [protected]

#### 6.7.4.2 std::chrono::high_resolution_clock::time_point qpp::Timer::_start [protected]

The documentation for this class was generated from the following file:

- include/timer.h

## 6.8 qpp::stat::UniformRealDistribution Class Reference

`#include <stat.h>`

### Public Member Functions

- UniformRealDistribution (double a=0, double b=1)
- double sample ()

### Protected Attributes

- std::uniform_real_distribution _d

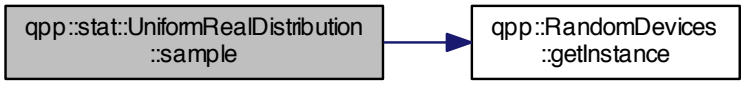
### 6.8.1 Constructor & Destructor Documentation

#### 6.8.1.1 qpp::stat::UniformRealDistribution::UniformRealDistribution ( double *a* = 0, double *b* = 1 ) [inline]

### 6.8.2 Member Function Documentation

#### 6.8.2.1 double qpp::stat::UniformRealDistribution::sample ( ) [inline]

Here is the call graph for this function:



### 6.8.3 Member Data Documentation

#### 6.8.3.1 std::uniform_real_distribution qpp::stat::UniformRealDistribution::_d [protected]

The documentation for this class was generated from the following file:

- include/stat.h

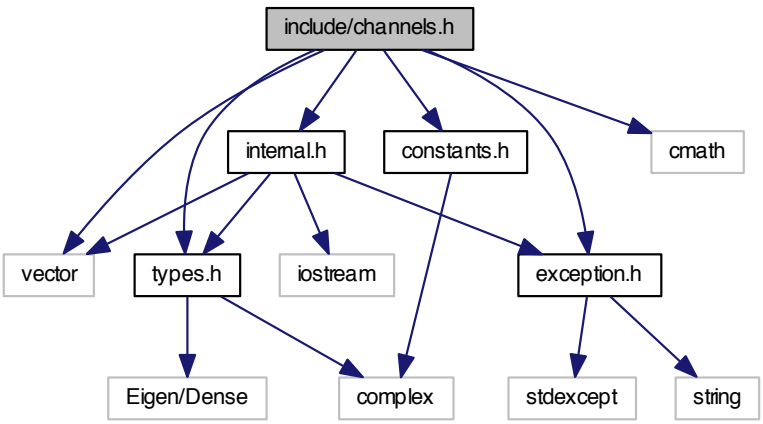
# Chapter 7

# File Documentation

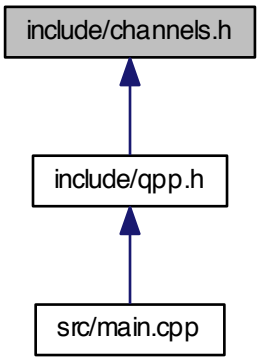
## 7.1 include/channels.h File Reference

```
#include <vector>
#include <cmath>
#include "types.h"
#include "internal.h"
#include "exception.h"
#include "constants.h"
```

Include dependency graph for channels.h:



This graph shows which files directly or indirectly include this file:




### Namespaces

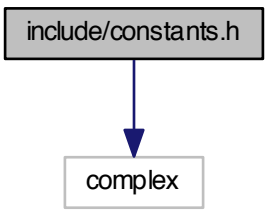
- qpp

### Functions

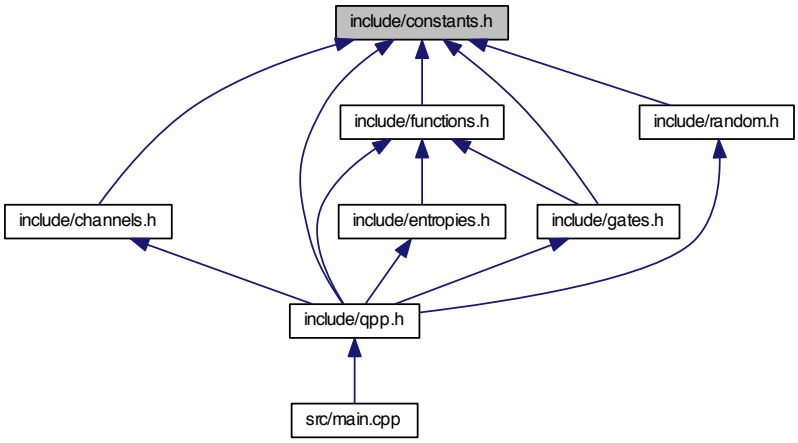
- types::cmat qpp::channel (const types::cmat &rho, const std::vector< types::cmat > &Ks)
- types::cmat qpp::super (const std::vector< types::cmat > &Ks)
- types::cmat qpp::choi (const std::vector< types::cmat > &Ks)
- std::vector< types::cmat > qpp::choi2kraus (const types::cmat &A)

## 7.2 include/constants.h File Reference

`#include <complex>`
Include dependency graph for constants.h:



This graph shows which files directly or indirectly include this file:




### Namespaces

- qpp
- qpp::ct

### Functions

- std::complex< double > qpp::ct::omega (size_t D)

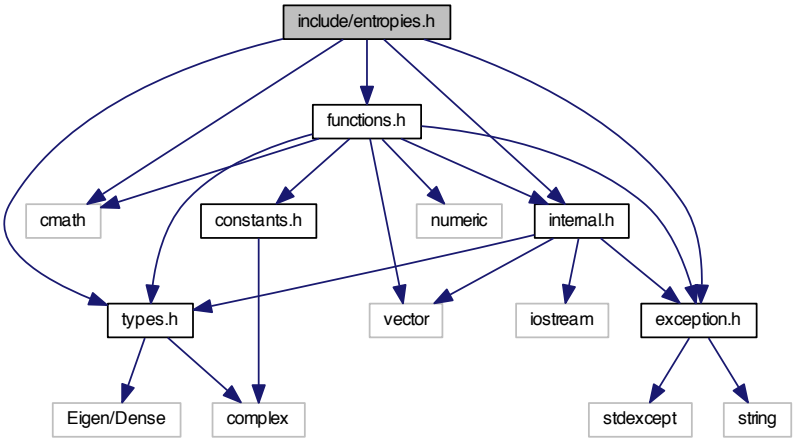
### Variables

- const double qpp::ct::chop = 1e-10
- const double qpp::ct::eps = 1e-14
- const std::complex< double > qpp::ct::ii = { 0, 1 }
- const double qpp::ct::pi = 3.14159265358979323846264338327950288 4
- const double qpp::ct::ee = 2.71828182845904523536028747135266249 7

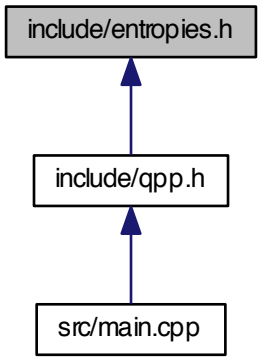
## 7.3 include/entropies.h File Reference

```
#include <cmath>
#include "types.h"
#include "functions.h"
#include "internal.h"
#include "exception.h"
```

Include dependency graph for entropies.h:




This graph shows which files directly or indirectly include this file:




## Namespaces

- qpp

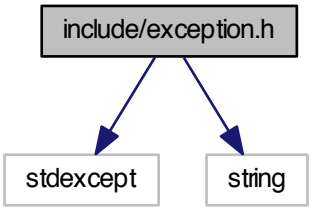
## Functions

- template<typename Derived >
  double qpp::shannon (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  double qpp::renyi (const double alpha, const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  double qpp::renyi_inf (const Eigen::MatrixBase< Derived > &A)

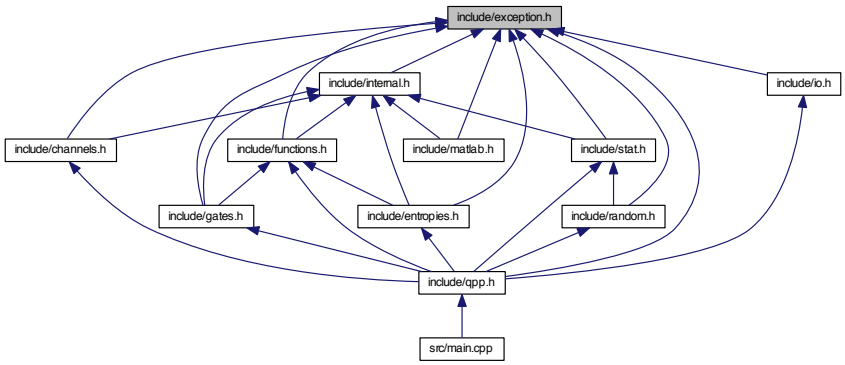
## 7.4 include/exception.h File Reference

```
#include <stdexcept>
#include <string>
```

Include dependency graph for exception.h:




This graph shows which files directly or indirectly include this file:




### Classes

- class qpp::Exception

### Namespaces

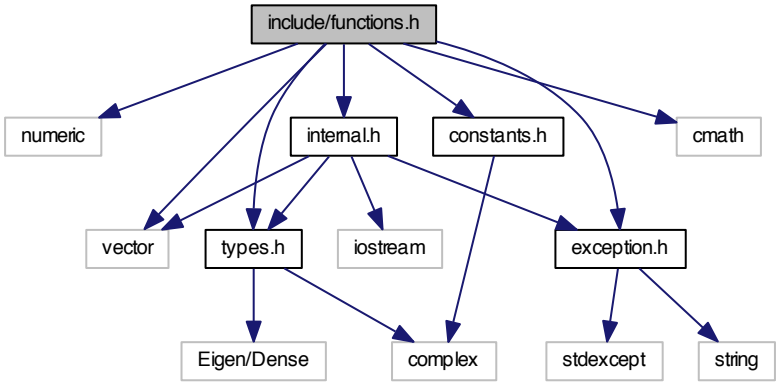
- qpp

## 7.5 include/functions.h File Reference

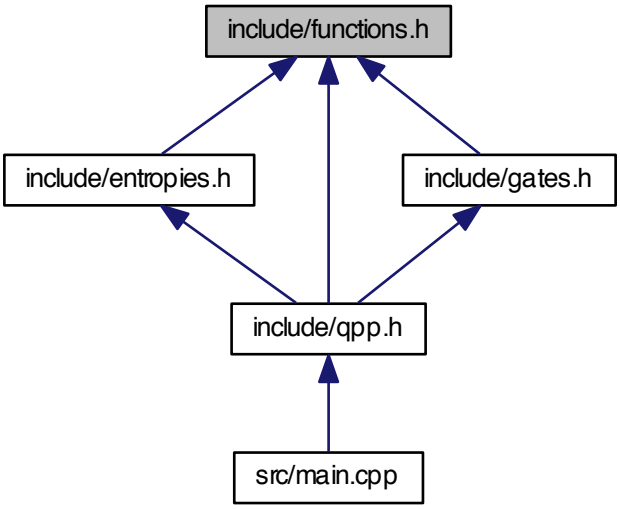
```
#include <numeric>
```

```
#include <vector>
#include <cmath>
#include "types.h"
#include "internal.h"
#include "exception.h"
#include "constants.h"
```

Include dependency graph for functions.h:




This graph shows which files directly or indirectly include this file:




## Namespaces

- qpp

## Functions

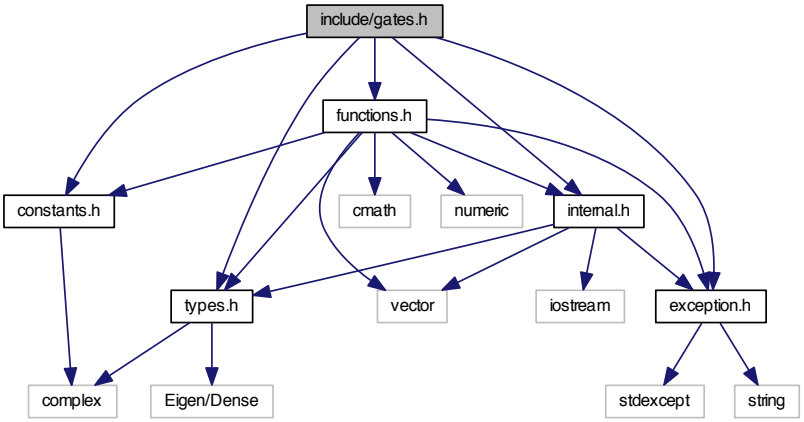
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > qpp::transpose (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > qpp::conjugate (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > qpp::adjoint (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  Derived::Scalar qpp::trace (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  Derived::Scalar qpp::det (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  Derived::Scalar qpp::sum (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  double qpp::norm (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  types::cmat qpp::evals (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  types::cmat qpp::evects (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  types::cmat qpp::hevals (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  types::cmat qpp::hevects (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  types::cmat qpp::funm (const Eigen::MatrixBase< Derived > &A, types::cplx(*f)(const types::cplx &))
- template<typename Derived >
  types::cmat qpp::sqrtm (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  types::cmat qpp::absm (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  types::cmat qpp::expm (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  types::cmat qpp::logm (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  types::cmat qpp::sinm (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  types::cmat qpp::cosm (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  types::cmat qpp::spectralpowm (const Eigen::MatrixBase< Derived > &A, const types::cplx z)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > qpp::powm (const Eigen::MatrixBase< Derived > &A, size_t n)
- template<typename OutputScalar , typename Derived >
  types::DynMat< OutputScalar > qpp::fun (const Eigen::MatrixBase< Derived > &A, OutputScalar(*f)(const typename Derived::Scalar &))
- template<typename Derived1 , typename Derived2 >
  types::DynMat< typename
  Derived1::Scalar > qpp::kron (const Eigen::MatrixBase< Derived1 > &A, const Eigen::MatrixBase< Derived2 > &B)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > qpp::kronlist (const std::vector< types::DynMat< typename Derived::Scalar > > &As)

- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > qpp::kronpow (const Eigen::MatrixBase< Derived > &A, size_t n)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > qpp::reshape (const Eigen::MatrixBase< Derived > &A, size_t rows, size_t cols)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > qpp::syspermute (const Eigen::MatrixBase< Derived > &A, const std::vector< size_t > perm, const std::vector< size_t > &dims)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > qpp::ptrace2 (const Eigen::MatrixBase< Derived > &A, const std::vector< size_t > dims)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > qpp::ptrace (const Eigen::MatrixBase< Derived > &A, const std::vector< size_t > &subsys, const std::vector< size_t > &dims)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > qpp::ptranspose (const Eigen::MatrixBase< Derived > &A, const std::vector< size_t > &subsys, const std::vector< size_t > &dims)
- template<typename Derived1 , typename Derived2 >
  types::DynMat< typename
  Derived1::Scalar > qpp::comm (const Eigen::MatrixBase< Derived1 > &A, const Eigen::MatrixBase< Derived2 > &B)
- template<typename Derived1 , typename Derived2 >
  types::DynMat< typename
  Derived1::Scalar > qpp::anticomm (const Eigen::MatrixBase< Derived1 > &A, const Eigen::MatrixBase< Derived2 > &B)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > qpp::proj (const Eigen::MatrixBase< Derived > &V)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > qpp::expandout (const Eigen::MatrixBase< Derived > &A, size_t pos, const std::vector< size_t > &dims)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > qpp::grams (const std::vector< types::DynMat< typename Derived::Scalar > > &Vs)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > qpp::grams (const Eigen::MatrixBase< Derived > &A)

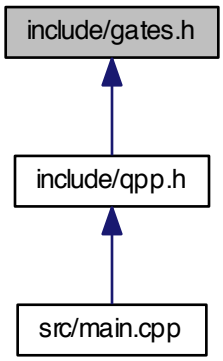
## 7.6 include/gates.h File Reference

```
#include "types.h"
#include "constants.h"
#include "functions.h"
#include "internal.h"
#include "exception.h"
```

Include dependency graph for gates.h:




This graph shows which files directly or indirectly include this file:




### Classes

- class qpp::Gates

### Namespaces

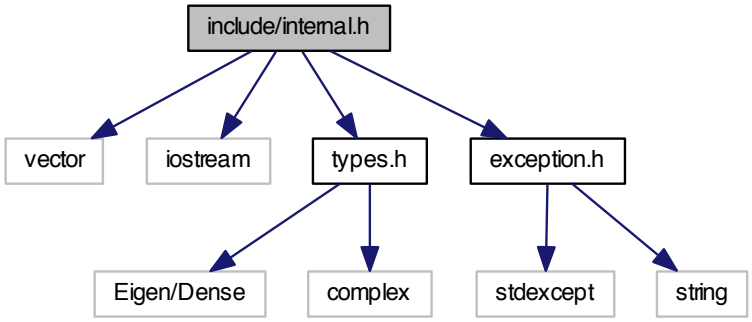
- qpp

## 7.7 include/internal.h File Reference

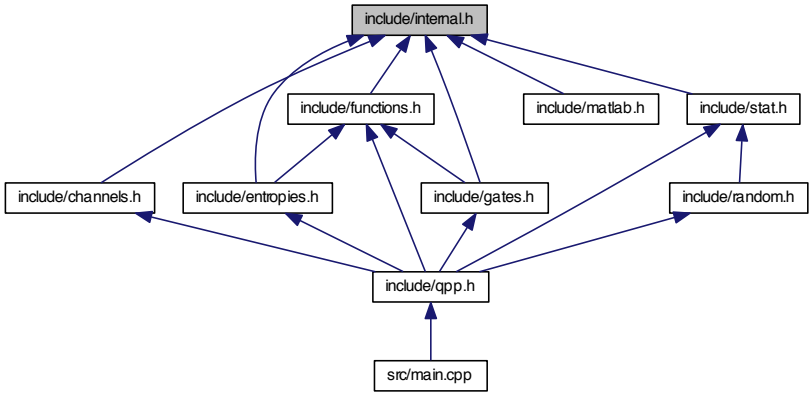
```
#include <vector>
```

```
#include <iostream>
#include "types.h"
#include "exception.h"
```

Include dependency graph for internal.h:




This graph shows which files directly or indirectly include this file:




## Namespaces

- qpp
- qpp::internal

## Functions

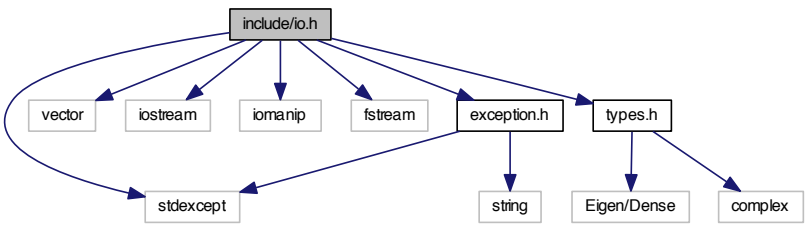
- void qpp::internal::_n2multiidx (size_t n, size_t numdims, const size_t *dims, size_t *result)
- size_t qpp::internal::_multiidx2n (const size_t *midx, size_t numdims, const size_t *dims)
- template<typename Derived >
  bool qpp::internal::_check_square_mat (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  bool qpp::internal::_check_vector (const Eigen::MatrixBase< Derived > &A)

- template<typename Derived >
  bool qpp::internal::_check_row_vector (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
  bool qpp::internal::_check_col_vector (const Eigen::MatrixBase< Derived > &A)
- template<typename T >
  bool qpp::internal::_check_nonzero_size (const T &x)
- bool qpp::internal::_check_dims (const std::vector< size_t > &dims)
- template<typename Derived >
  bool qpp::internal::_check_dims_match_mat (const std::vector< size_t > &dims, const Eigen::MatrixBase< Derived > &A)
- bool qpp::internal::_check_eq_dims (const std::vector< size_t > &dims, size_t dim)
- bool qpp::internal::_check_subsys (const std::vector< size_t > &subsys, const std::vector< size_t > &dims)
- bool qpp::internal::_check_perm (const std::vector< size_t > &perm, const std::vector< size_t > &dims)
- template<typename Scalar >
  void qpp::internal::_syspermute_worker (const size_t *midxcol, size_t numdims, const size_t *cdims, const size_t *cperm, size_t i, size_t j, size_t &iperm, size_t &jperm, const types::DynMat< Scalar > &A, types::DynMat< Scalar > &result)
- template<typename Scalar >
  void qpp::internal::_ptranspose_worker (const size_t *midxcol, size_t numdims, size_t numsubsys, const size_t *cdims, const size_t *csubsys, size_t i, size_t j, size_t &iperm, size_t &jperm, const types::DynMat< Scalar > &A, types::DynMat< Scalar > &result)

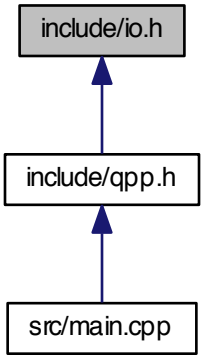
## 7.8 include/io.h File Reference

```
#include <stdexcept>
#include <vector>
#include <iostream>
#include <iomanip>
#include <fstream>
#include "types.h"
#include "exception.h"
```

Include dependency graph for io.h:



This graph shows which files directly or indirectly include this file:




### Namespaces

- qpp

### Functions

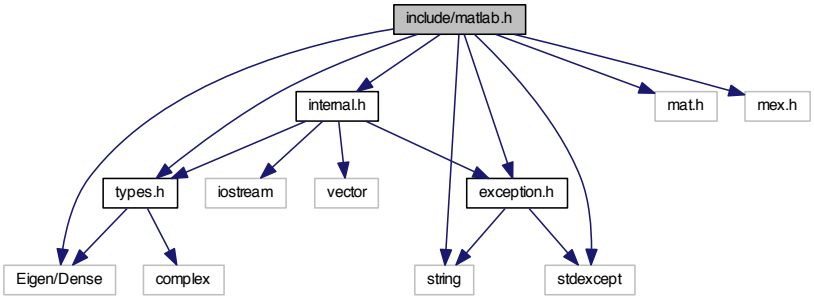
- template<typename T >
  void qpp::dispSTL (const T &x, const std::string &separator=" ", const std::string &start="[", const std::string &end="]", std::ostream &os=std::cout)
- template<typename T >
  void qpp::displnSTL (const T &x, const std::string &separator=" ", const std::string &start="[", const std::string &end="]", std::ostream &os=std::cout)
- template<typename T >
  void qpp::dispSTL (const T *x, const size_t n, const std::string &separator=" ", const std::string &start="[", const std::string &end="]", std::ostream &os=std::cout)
- template<typename T >
  void qpp::displnSTL (const T *x, const size_t n, const std::string &separator=" ", const std::string &start="[", const std::string &end="]", std::ostream &os=std::cout)
- template<typename Derived >
  void qpp::disp (const Eigen::MatrixBase< Derived > &A, double chop=ct::chop, std::ostream &os=std::cout)
- template<typename Derived >
  void qpp::displn (const Eigen::MatrixBase< Derived > &A, double chop=ct::chop, std::ostream &os=std::cout)
- void qpp::disp (const types::cplx c, double chop=ct::chop, std::ostream &os=std::cout)
- void qpp::displn (const types::cplx c, double chop=ct::chop, std::ostream &os=std::cout)
- template<typename Derived >
  void qpp::save (const Eigen::MatrixBase< Derived > &A, const std::string &fname)
- template<typename Derived >
  types::DynMat< typename
  Derived::Scalar > qpp::load (const std::string &fname)

## 7.9 include/matlab.h File Reference

```
#include <Eigen/Dense>
```

```
#include <string>
#include <stdexcept>
#include "types.h"
#include "internal.h"
#include "exception.h"
#include "mat.h"
#include "mex.h"
```

Include dependency graph for matlab.h:




### Namespaces

- qpp

### Functions

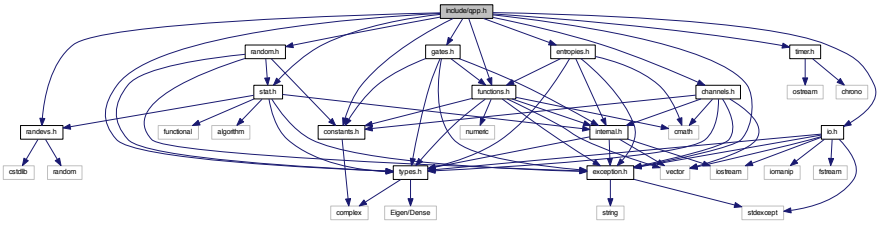
- template<typename Derived >
  Derived qpp::loadMATLABmatrix (const std::string &mat_file, const std::string &var_name)
- template<>
  types::dmat qpp::loadMATLABmatrix (const std::string &mat_file, const std::string &var_name)
- template<>
  types::cmat qpp::loadMATLABmatrix (const std::string &mat_file, const std::string &var_name)
- template<typename Derived >
  void qpp::saveMATLABmatrix (const Eigen::MatrixBase< Derived > &A, const std::string &mat_file, const std::string &var_name, const std::string &mode)
- template<>
  void qpp::saveMATLABmatrix (const Eigen::MatrixBase< typename types::dmat > &A, const std::string &mat_file, const std::string &var_name, const std::string &mode)
- template<>
  void qpp::saveMATLABmatrix (const Eigen::MatrixBase< typename types::cmat > &A, const std::string &mat_file, const std::string &var_name, const std::string &mode)

## 7.10 include/qpp.h File Reference

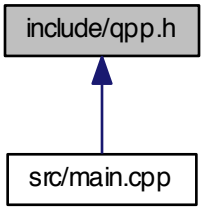
```
#include "types.h"
```

```
#include "constants.h"
#include "gates.h"
#include "stat.h"
#include "functions.h"
#include "random.h"
#include "entropies.h"
#include "io.h"
#include "timer.h"
#include "exception.h"
#include "channels.h"
#include "randevs.h"
```

Include dependency graph for qpp.h:




This graph shows which files directly or indirectly include this file:




### Namespaces

- qpp

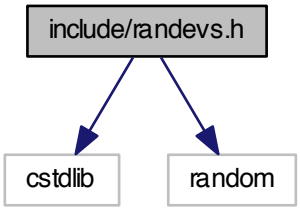
### Variables

- RandomDevices & qpp::rdevs = RandomDevices::getInstance()
- const Gates & qpp::gt = Gates::getInstance()

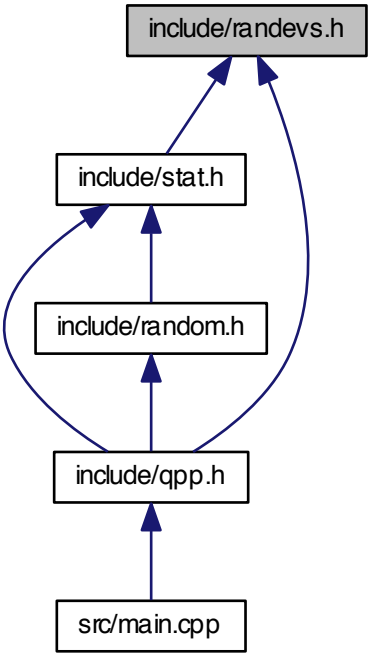
## 7.11 include/randevs.h File Reference

```
#include <cstdlib>
#include <random>
```

Include dependency graph for randevs.h:




This graph shows which files directly or indirectly include this file:




## Classes

- class qpp::RandomDevices

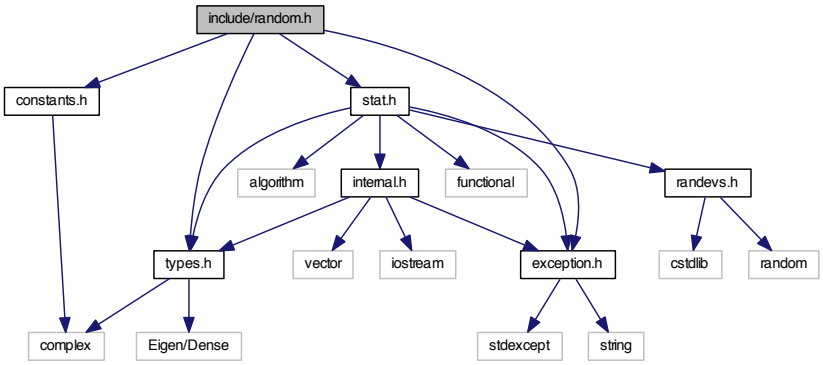
## Namespaces

- qpp

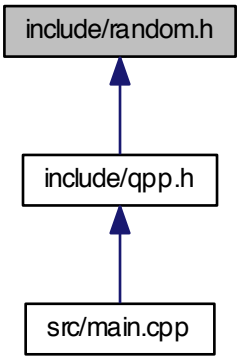
## 7.12 include/random.h File Reference

```
#include "types.h"
#include "stat.h"
#include "constants.h"
#include "exception.h"
```

Include dependency graph for random.h:




This graph shows which files directly or indirectly include this file:




### Namespaces

- qpp

### Functions

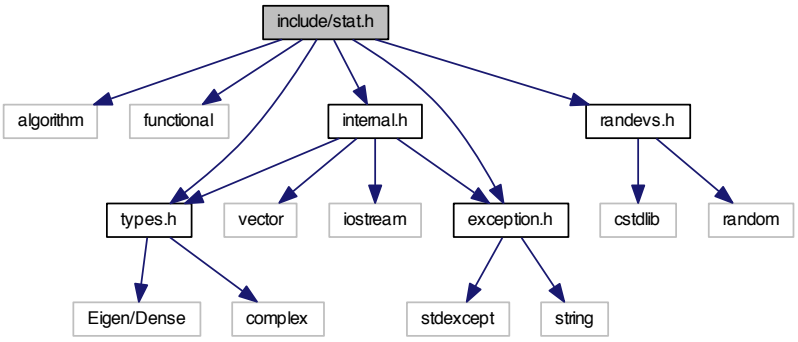
- template<typename Derived >
  Derived qpp::rand (size_t rows, size_t cols, double a=0, double b=1)
- template<>
  types::dmat qpp::rand (size_t rows, size_t cols, double a, double b)

- template<>
  types::cmat qpp::rand (size_t rows, size_t cols, double a, double b)
- double qpp::rand (double a=0, double b=1)
- template<typename Derived >
  Derived qpp::randn (size_t rows, size_t cols, double mean=0, double sigma=1)
- template<>
  types::dmat qpp::randn (size_t rows, size_t cols, double mean, double sigma)
- template<>
  types::cmat qpp::randn (size_t rows, size_t cols, double mean, double sigma)
- double qpp::randn (double mean=0, double sigma=1)
- types::cmat qpp::randU (size_t D)
- types::cmat qpp::randV (size_t Din, size_t Dout)
- std::vector< types::cmat > qpp::randKraus (size_t n, size_t D)
- types::cmat qpp::randH (size_t D)
- types::cmat qpp::randket (size_t D)
- types::cmat qpp::randrho (size_t D)

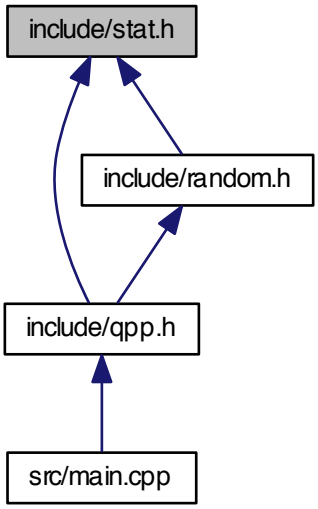
## 7.13 include/stat.h File Reference

```
#include <algorithm>
#include <functional>
#include "types.h"
#include "internal.h"
#include "exception.h"
#include "randevs.h"
```

Include dependency graph for stat.h:



This graph shows which files directly or indirectly include this file:




### Classes

- class qpp::stat::NormalDistribution
- class qpp::stat::UniformRealDistribution
- class qpp::stat::DiscreteDistribution
- class qpp::stat::DiscreteDistributionFromComplex

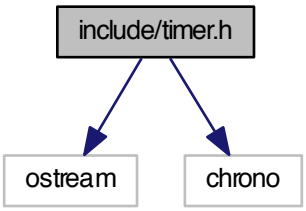
### Namespaces

- qpp
- qpp::stat

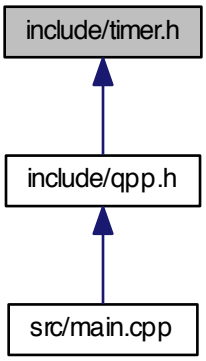
## 7.14 include/timer.h File Reference

```
#include <ostream>
#include <chrono>
```

Include dependency graph for timer.h:




This graph shows which files directly or indirectly include this file:




### Classes

- class qpp::Timer

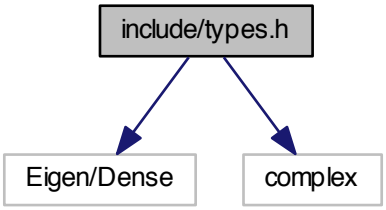
### Namespaces

- qpp

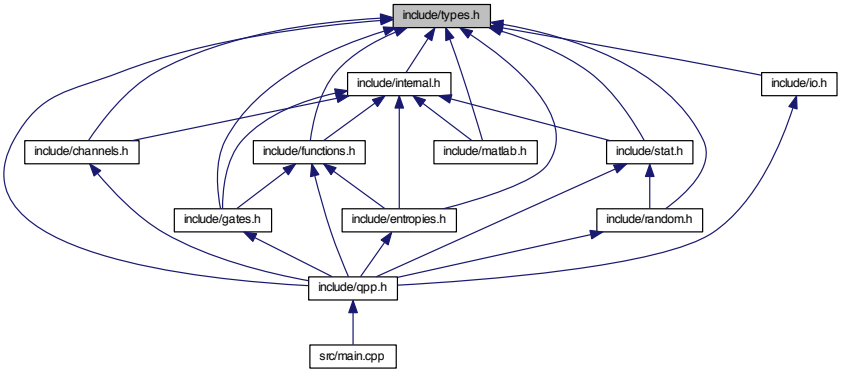
## 7.15 include/types.h File Reference

```
#include <Eigen/Dense>
#include <complex>
```

Include dependency graph for types.h:




This graph shows which files directly or indirectly include this file:




## Namespaces

- qpp
- qpp::types

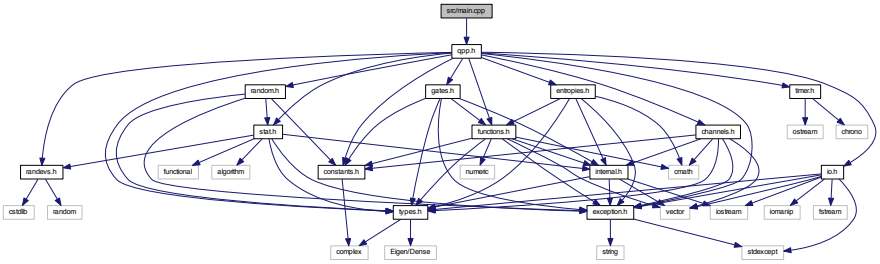
## Typedefs

- typedef std::complex< double > qpp::types::cplx
- typedef Eigen::MatrixXcd qpp::types::cmat
- typedef Eigen::MatrixXd qpp::types::dmat
- typedef Eigen::MatrixXf qpp::types::fmat
- typedef Eigen::MatrixXi qpp::types::imat
- typedef Eigen::Matrix< cplx, Eigen::Dynamic, 1 > qpp::types::ket
- typedef Eigen::Matrix< cplx, 1, Eigen::Dynamic > qpp::types::bra
- template<typename Scalar >
  using qpp::types::DynMat = Eigen::Matrix< Scalar, Eigen::Dynamic, Eigen::Dynamic >

## 7.16 src/main.cpp File Reference

```
#include "qpp.h"
```

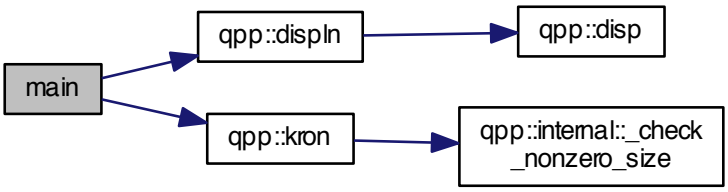
Include dependency graph for main.cpp:




### Functions

- int main ()

### 7.16.1 Function Documentation

#### 7.16.1.1 int main ( )

Here is the call graph for this function: