

qpp  
0.1

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# Chapter 1

## Namespace Index

### 1.1 Namespace List

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## Chapter 2

# Hierarchical Index

### 2.1 Class Hierarchy

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## Chapter 3

# Class Index

### 3.1 Class List

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## Chapter 5

# Namespace Documentation

### 5.1 qpp Namespace Reference

#### Namespaces

- [ct](#)
- [internal](#)
- [types](#)

#### Classes

- class [Exception](#)
- class [Gates](#)
- class [Qudit](#)
- class [RandomDevices](#)
- class [NormalDistribution](#)
- class [UniformRealDistribution](#)
- class [DiscreteDistribution](#)
- class [DiscreteDistributionAbsSquare](#)
- class [States](#)
- class [Timer](#)

#### Functions

- [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 >  
[types::cmat channel](#) (const Eigen::MatrixBase< Derived > &rho, const std::vector< [types::cmat](#) > &Ks)
- template<typename Derived >  
[types::cmat channel](#) (const Eigen::MatrixBase< Derived > &rho, const std::vector< [types::cmat](#) > &Ks,  
const std::vector< size\_t > &subsys, const std::vector< size\_t > &dims)
- template<typename Derived >  
[types::cmat schmidtcoeff](#) (const Eigen::MatrixBase< Derived > &A, const std::vector< size\_t > &dims)
- template<typename Derived >  
[types::cmat schmidtU](#) (const Eigen::MatrixBase< Derived > &A, const std::vector< size\_t > &dims)
- template<typename Derived >  
[types::cmat schmidtV](#) (const Eigen::MatrixBase< Derived > &A, const std::vector< size\_t > &dims)

- `template<typename Derived >`  
`types::cmat schmidtprob` (const Eigen::MatrixBase< Derived > &A, const std::vector< size\_t > &dims)
- `template<typename Derived >`  
`double entanglement` (const Eigen::MatrixBase< Derived > &A, const std::vector< size\_t > &dims)
- `template<typename Derived >`  
`double gconcurrency` (const Eigen::MatrixBase< Derived > &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 >`  
`double tsallis` (const double alpha, const Eigen::MatrixBase< Derived > &A)
- `template<typename Derived >`  
`double qmutualinfo` (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 > 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 >`  
`types::DynMat< typename`  
`Derived::Scalar > inverse` (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 logdet` (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 evecs` (const Eigen::MatrixBase< Derived > &A)
- `template<typename Derived >`  
`types::dmat hevals` (const Eigen::MatrixBase< Derived > &A)
- `template<typename Derived >`  
`types::cmat hevecs` (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 > cwise` (const Eigen::MatrixBase< Derived > &A, OutputScalar(\*) (const  
`typename Derived::Scalar &))`
- `template<typename T >`  
`types::DynMat< typename T::Scalar > kron` (const T &head)
- `template<typename T, typename... Args>`  
`types::DynMat< typename T::Scalar > kron` (const T &head, const Args &...tail)
- `template<typename Derived >`  
`types::DynMat< typename`  
`Derived::Scalar > kron` (const std::vector< Derived > &As)
- `template<typename Derived >`  
`types::DynMat< typename`  
`Derived::Scalar > kron` (const std::initializer\_list< Derived > &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 > ptrace1` (const Eigen::MatrixBase< Derived > &A, 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 > &sub-  
`sys, 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< De-  
`derived2 > &B)`
- `template<typename Derived >`  
`types::DynMat< typename`  
`Derived::Scalar > prj` (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 Derived1 , typename Derived2 >`  
`types::DynMat< typename`  
`Derived1::Scalar > gate` (const Eigen::MatrixBase< Derived1 > &state, const Eigen::MatrixBase< Derived2 > &A, const std::vector< size\_t > &subsys, const std::vector< size\_t > &dims)
- `template<typename Derived >`  
`types::DynMat< typename`  
`Derived::Scalar > grams` (const std::vector< Derived > &Vs)
- `template<typename Derived >`  
`types::DynMat< typename`  
`Derived::Scalar > grams` (const std::initializer\_list< Derived > &Vs)
- `template<typename Derived >`  
`types::DynMat< typename`  
`Derived::Scalar > grams` (const Eigen::MatrixBase< Derived > &A)
- `std::vector< size_t > n2multiidx` (size\_t n, const std::vector< size\_t > &dims)
- `size_t multiidx2n` (const std::vector< size\_t > &midx, const std::vector< size\_t > &dims)
- `types::ket mket` (const std::vector< size\_t > &mask)
- `types::ket mket` (const std::vector< size\_t > &mask, const std::vector< size\_t > &dims)
- `types::ket mket` (const std::vector< size\_t > &mask, size\_t d)
- `std::vector< size_t > invperm` (const std::vector< size\_t > &perm)
- `std::vector< size_t > compperm` (const std::vector< size\_t > &perm, const std::vector< size\_t > &sigma)
- `template<typename T >`  
`void disp` (const T &x, const std::string &separator, const std::string &start="[" , const std::string &end="]", std::ostream &os=std::cout)
- `template<typename T >`  
`void displn` (const T &x, const std::string &separator, const std::string &start="[" , const std::string &end="]", std::ostream &os=std::cout)
- `template<typename T >`  
`void disp` (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 displn` (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)
- long long `randint` (long long a, long long b)
- `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::ket randket` (size\_t D)
- `types::cmat randrho` (size\_t D)
- `std::vector< size_t > randperm` (size\_t n)

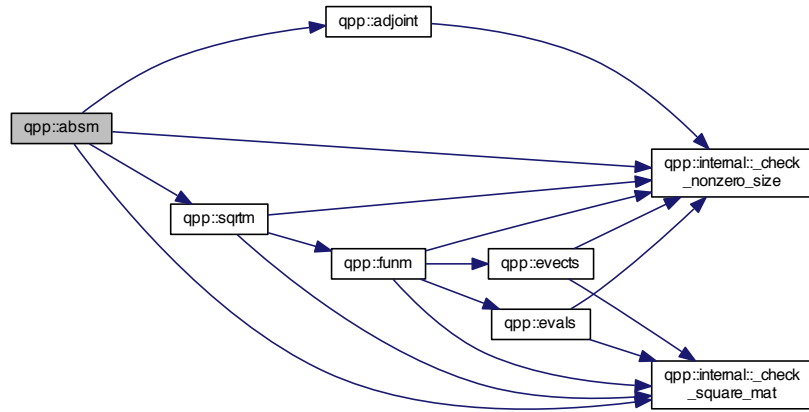
## Variables

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

### 5.1.1 Function Documentation

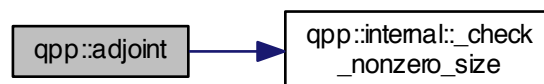
#### 5.1.1.1 `template<typename Derived > types::cmat qpp::absm ( const Eigen::MatrixBase< Derived > & A )`

Here is the call graph for this function:



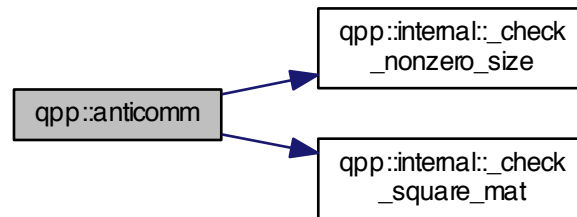
#### 5.1.1.2 `template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::adjoint ( const Eigen::MatrixBase< Derived > & A )`

Here is the call graph for this function:



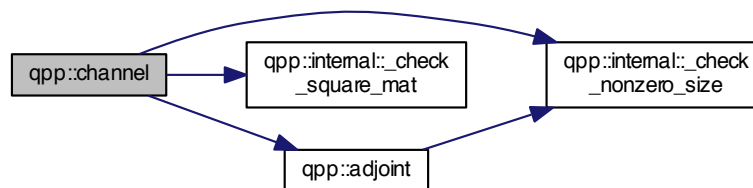
5.1.1.3 `template<typename Derived1 , typename Derived2 > types::DynMat<typename Derived1::Scalar> qpp::anticomm ( const Eigen::MatrixBase< Derived1 > & A, const Eigen::MatrixBase< Derived2 > & B )`

Here is the call graph for this function:



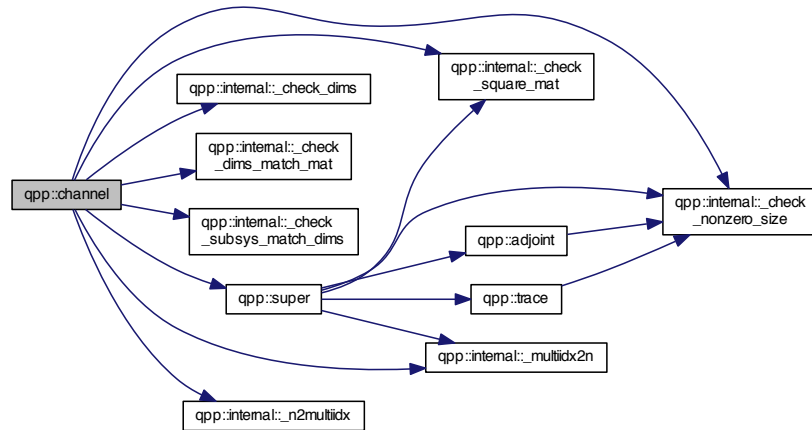
5.1.1.4 `template<typename Derived > types::cmat qpp::channel ( const Eigen::MatrixBase< Derived > & rho, const std::vector< types::cmat > & Ks )`

Here is the call graph for this function:



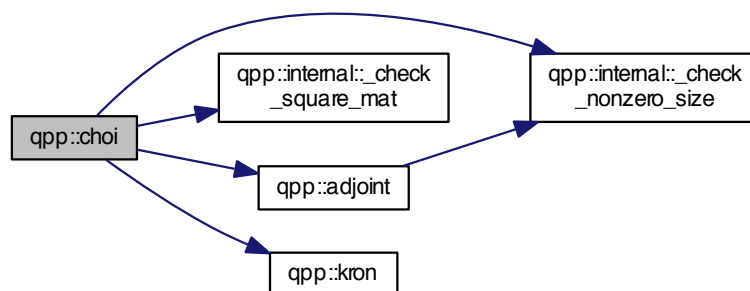
5.1.1.5 `template<typename Derived > types::cmat qpp::channel ( const Eigen::MatrixBase< Derived > & rho, const std::vector< types::cmat > & Ks, const std::vector< size_t > & subsys, const std::vector< size_t > & dims )`

Here is the call graph for this function:



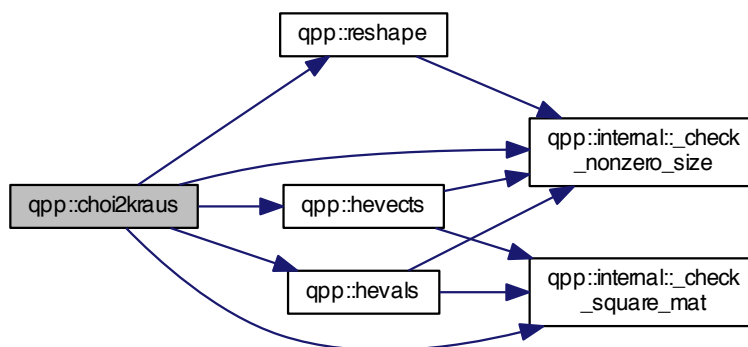
5.1.1.6 `types::cmat qpp::choi ( const std::vector< types::cmat > & Ks )`

Here is the call graph for this function:



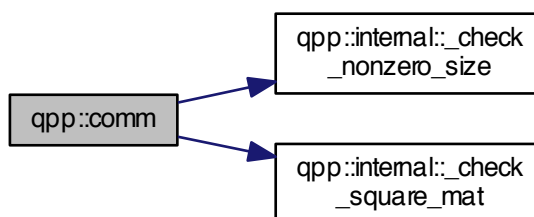
### 5.1.1.7 `std::vector<types::cmat> qpp::choi2kraus ( const types::cmat & A )`

Here is the call graph for this function:



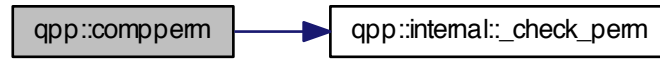
### 5.1.1.8 `template<typename Derived1, typename Derived2> types::DynMat<typename Derived1::Scalar> qpp::comm ( const Eigen::MatrixBase< Derived1 > & A, const Eigen::MatrixBase< Derived2 > & B )`

Here is the call graph for this function:



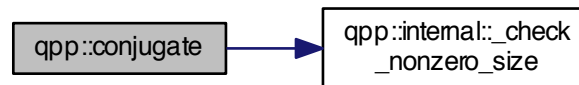
5.1.1.9 `std::vector<size_t> qpp::compperm ( const std::vector< size_t > & perm, const std::vector< size_t > & sigma )`

Here is the call graph for this function:



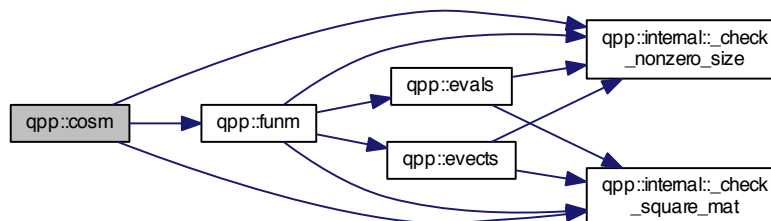
5.1.1.10 `template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::conjugate ( const Eigen::MatrixBase< Derived > & A )`

Here is the call graph for this function:



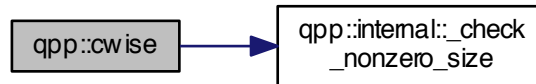
5.1.1.11 `template<typename Derived > types::cmat qpp::cosm ( const Eigen::MatrixBase< Derived > & A )`

Here is the call graph for this function:



5.1.1.12 `template<typename OutputScalar , typename Derived > types::DynMat<OutputScalar> qpp::cwise ( const Eigen::MatrixBase< Derived > & A, OutputScalar(*) (const typename Derived::Scalar &) f )`

Here is the call graph for this function:



5.1.1.13 `template<typename Derived > Derived::Scalar qpp::det ( const Eigen::MatrixBase< Derived > & A )`

Here is the call graph for this function:



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

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

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

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

Here is the call graph for this function:



5.1.1.18 `template<typename T> void qpp::displn ( 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:



5.1.1.19 `template<typename T> void qpp::displn ( 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:



5.1.1.20 `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:





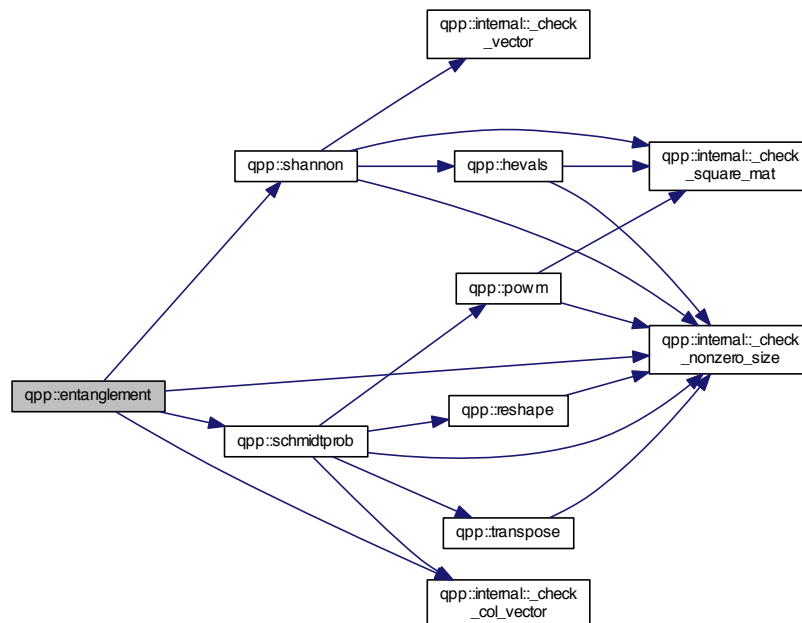
5.1.1.21 `void qpp::displn ( const types::cplx c, double chop = ct:::chop, std::ostream & os = std:::cout )`

Here is the call graph for this function:



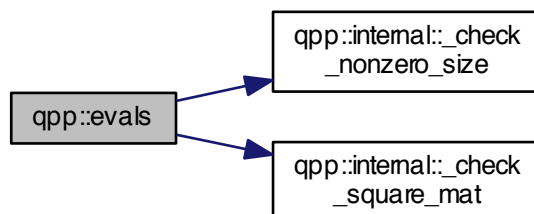
5.1.1.22 `template<typename Derived> double qpp::entanglement ( const Eigen::MatrixBase< Derived> & A, const std::vector< size_t> & dims )`

Here is the call graph for this function:



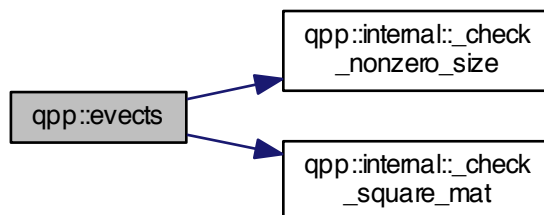
5.1.1.23 `template<typename Derived > types::cmat qpp::evals ( const Eigen::MatrixBase< Derived > & A )`

Here is the call graph for this function:



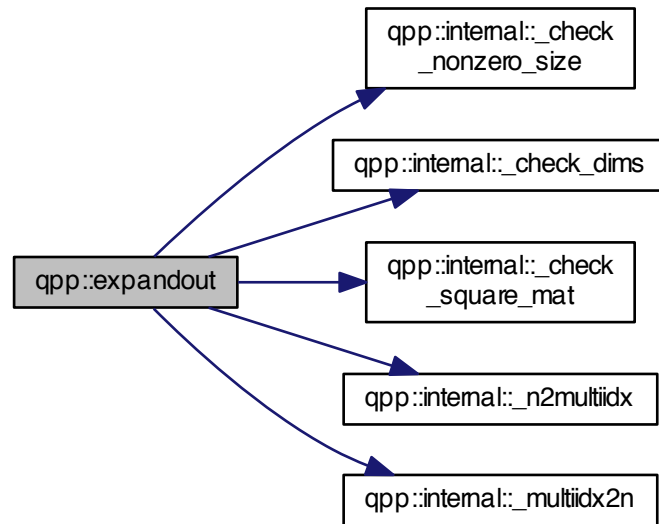
5.1.1.24 `template<typename Derived > types::cmat qpp::evecs ( const Eigen::MatrixBase< Derived > & A )`

Here is the call graph for this function:



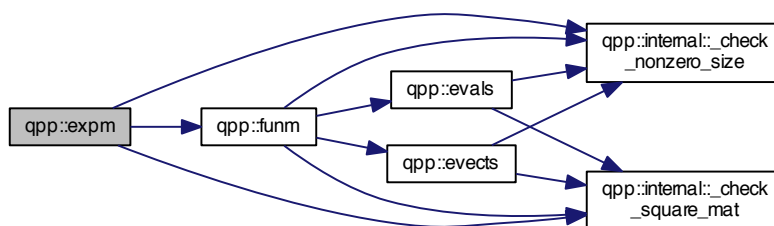
5.1.1.25 `template<typename Derived> types::DynMat<typename Derived::Scalar> qpp::expandout ( const Eigen::MatrixBase< Derived> & A, size_t pos, const std::vector< size_t> & dims )`

Here is the call graph for this function:



5.1.1.26 `template<typename Derived> types::cmat qpp::expm ( const Eigen::MatrixBase< Derived> & A )`

Here is the call graph for this function:



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

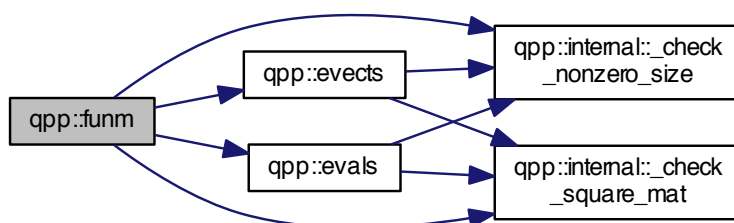
## Parameters

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

## Returns

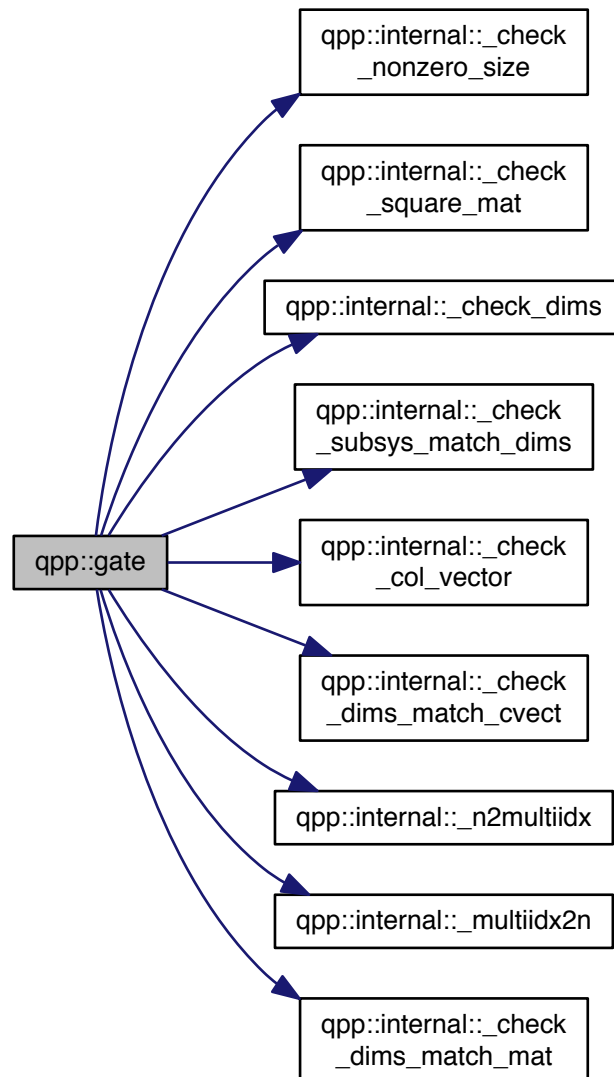
[types::cmat](#)

Here is the call graph for this function:



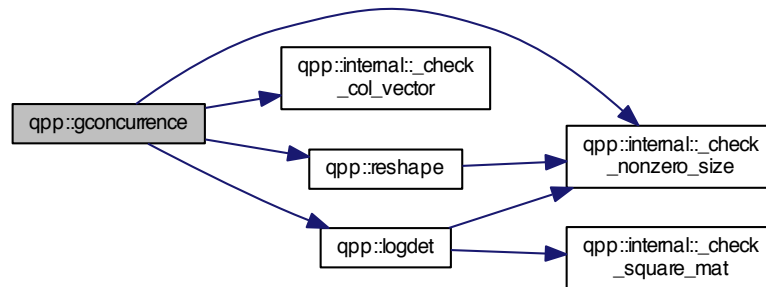
5.1.1.28 `template<typename Derived1 , typename Derived2 > types::DynMat<typename Derived1::Scalar> qpp::gate ( const Eigen::MatrixBase< Derived1 > & state, const Eigen::MatrixBase< Derived2 > & A, const std::vector< size_t > & subsys, const std::vector< size_t > & dims )`

Here is the call graph for this function:



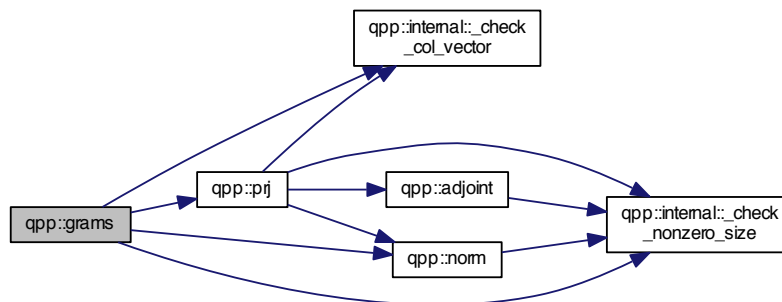
5.1.1.29 `template<typename Derived> double qpp::gconcurrency ( const Eigen::MatrixBase< Derived> & A )`

Here is the call graph for this function:



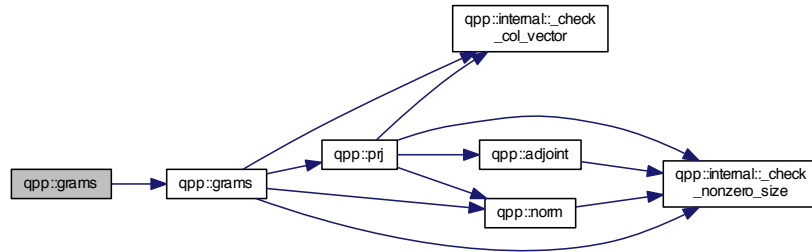
5.1.1.30 `template<typename Derived> types::DynMat<typename Derived::Scalar> qpp::grams ( const std::vector< Derived> & Vs )`

Here is the call graph for this function:



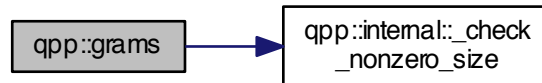
5.1.1.31 `template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::grams ( const std::initializer_list< Derived > & Vs )`

Here is the call graph for this function:



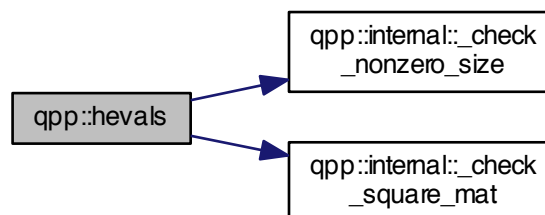
5.1.1.32 `template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::grams ( const Eigen::MatrixBase< Derived > & A )`

Here is the call graph for this function:



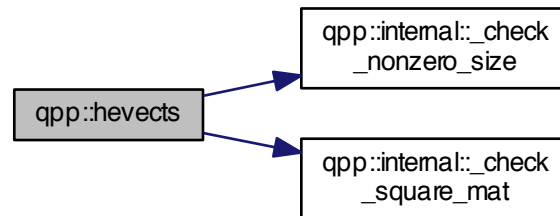
5.1.1.33 `template<typename Derived > types::dmat qpp::hevals ( const Eigen::MatrixBase< Derived > & A )`

Here is the call graph for this function:



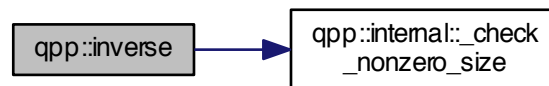
5.1.1.34 `template<typename Derived> types::cmat qpp::hevects ( const Eigen::MatrixBase< Derived > & A )`

Here is the call graph for this function:



5.1.1.35 `template<typename Derived> types::DynMat<typename Derived::Scalar> qpp::inverse ( const Eigen::MatrixBase< Derived > & A )`

Here is the call graph for this function:



5.1.1.36 `std::vector<size_t> qpp::invperm ( const std::vector< size_t > & perm )`

Here is the call graph for this function:



5.1.1.37 `template<typename T> types::DynMat<typename T::Scalar> qpp::kron ( const T & head )`



5.1.1.38 `template<typename T , typename... Args> types::DynMat<typename T::Scalar> qpp::kron ( const T & head, const Args &... tail )`

Here is the call graph for this function:



5.1.1.39 `template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::kron ( const std::vector< Derived > & As )`

Here is the call graph for this function:



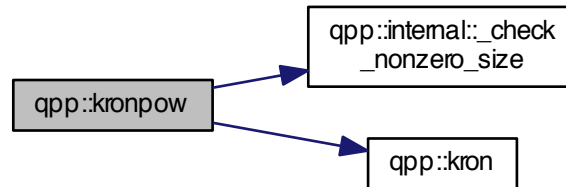
5.1.1.40 `template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::kron ( const std::initializer_list< Derived > & As )`

Here is the call graph for this function:



5.1.1.41 `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:



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

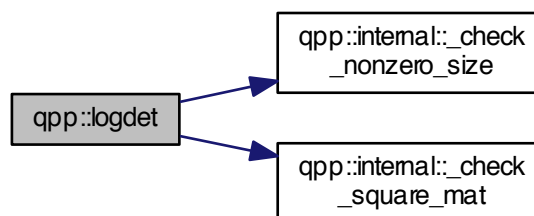
5.1.1.43 `template<typename Derived> Derived qpp::loadMATLABmatrix ( const std::string & mat_file, const std::string & var_name )`

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

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

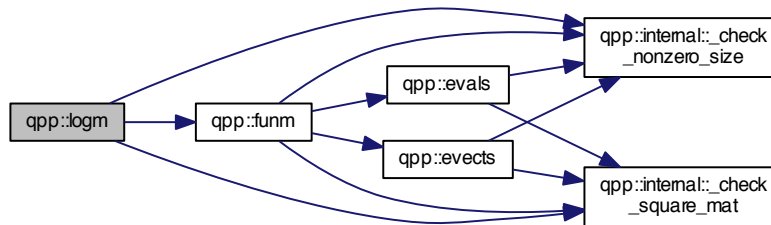
5.1.1.46 `template<typename Derived> Derived::Scalar qpp::logdet ( const Eigen::MatrixBase< Derived> & A )`

Here is the call graph for this function:



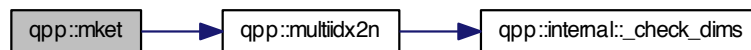
5.1.1.47 `template<typename Derived> types::cmat qpp::logm ( const Eigen::MatrixBase< Derived > & A )`

Here is the call graph for this function:



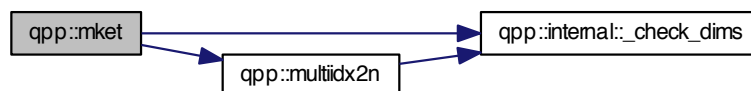
5.1.1.48 `types::ket qpp::mket ( const std::vector< size_t > & mask )`

Here is the call graph for this function:



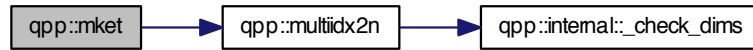
5.1.1.49 `types::ket qpp::mket ( const std::vector< size_t > & mask, const std::vector< size_t > & dims )`

Here is the call graph for this function:



#### 5.1.1.50 `types::ket qpp::mket ( const std::vector< size_t > & mask, size_t d )`

Here is the call graph for this function:



#### 5.1.1.51 `size_t qpp::multiidx2n ( const std::vector< size_t > & midx, const std::vector< size_t > & dims )`

Here is the call graph for this function:



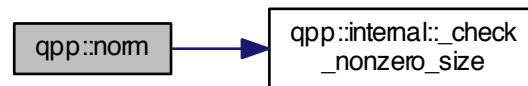
#### 5.1.1.52 `std::vector<size_t> qpp::n2multiidx ( size_t n, const std::vector< size_t > & dims )`

Here is the call graph for this function:



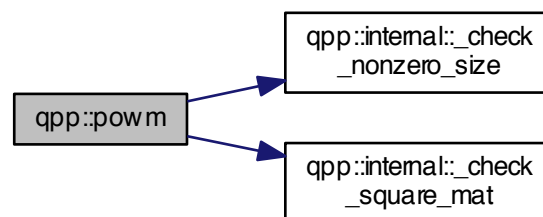
5.1.1.53 `template<typename Derived> double qpp::norm ( const Eigen::MatrixBase< Derived> & A )`

Here is the call graph for this function:



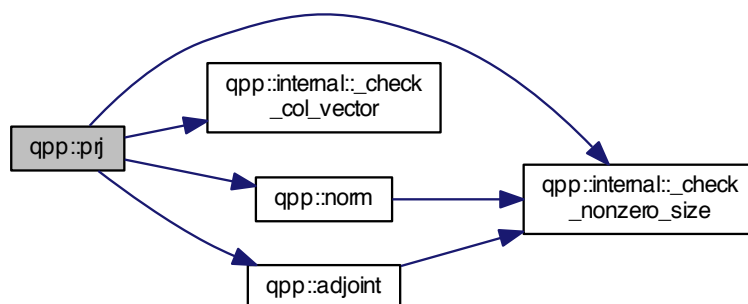
5.1.1.54 `template<typename Derived> types::DynMat<typename Derived::Scalar> qpp::powm ( const Eigen::MatrixBase< Derived> & A, size_t n )`

Here is the call graph for this function:



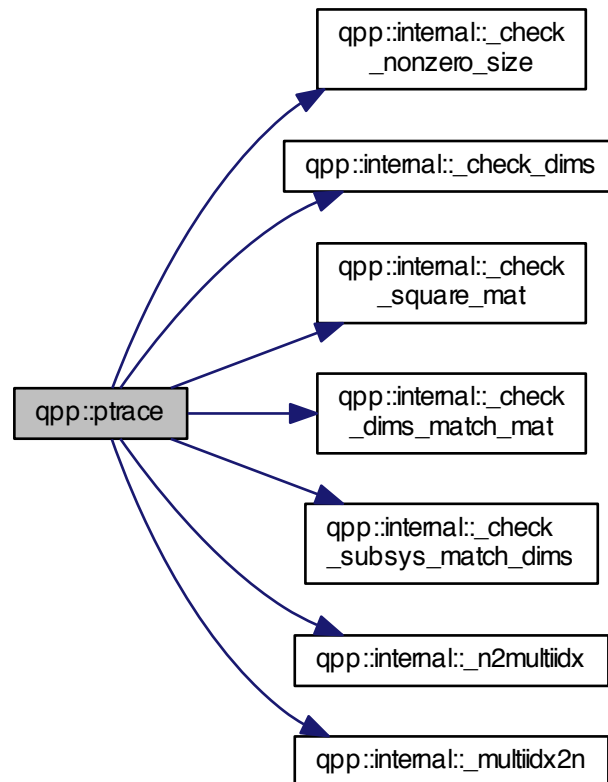
5.1.1.55 `template<typename Derived> types::DynMat<typename Derived::Scalar> qpp::prj ( const Eigen::MatrixBase<Derived> & V )`

Here is the call graph for this function:



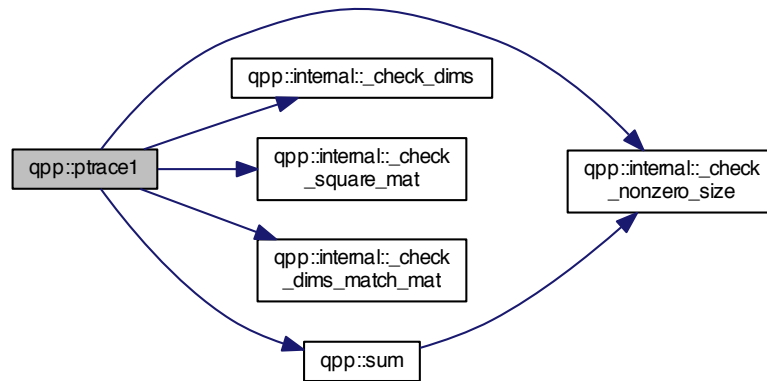
5.1.1.56 `template<typename Derived> types::DynMat<typename Derived::Scalar> qpp::ptrace ( const Eigen::MatrixBase< Derived> & A, const std::vector< size_t> & subsys, const std::vector< size_t> & dims )`

Here is the call graph for this function:



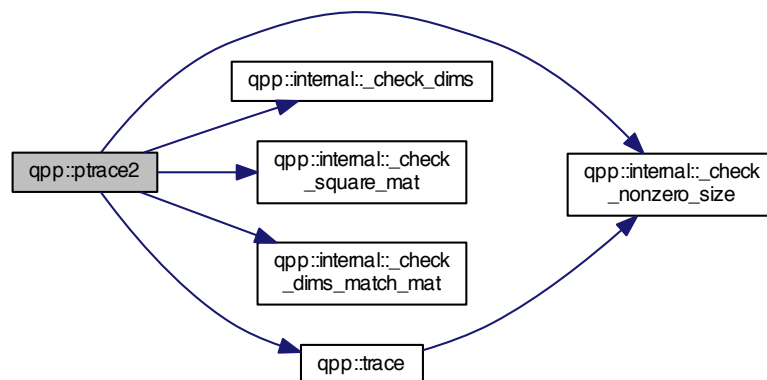
5.1.1.57 `template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::ptrace1 ( const Eigen::MatrixBase< Derived > & A, const std::vector< size_t > & dims )`

Here is the call graph for this function:



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

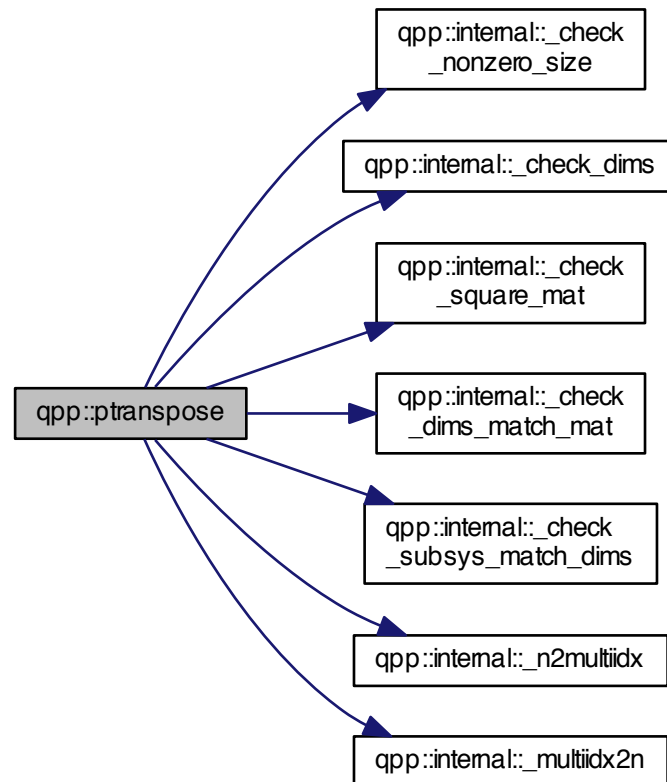
Here is the call graph for this function:





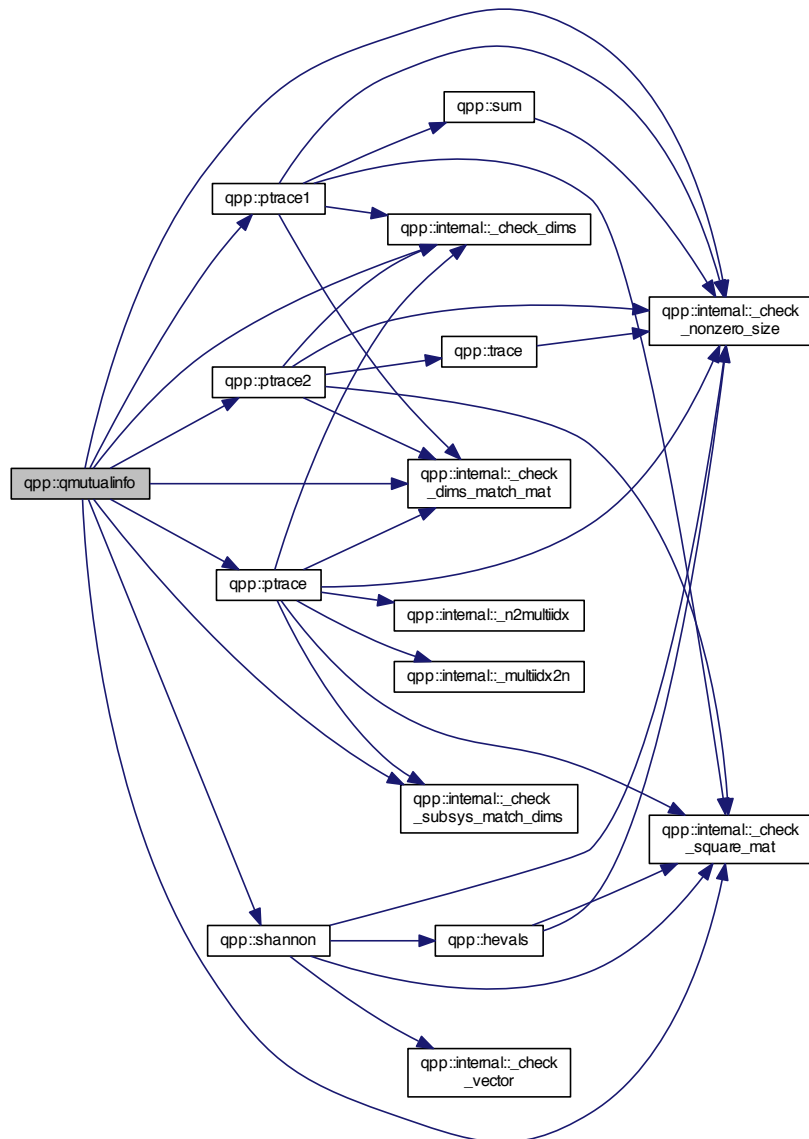
5.1.1.59 `template<typename Derived> types::DynMat<typename Derived::Scalar> qpp::ptranspose ( const Eigen::MatrixBase< Derived> & A, const std::vector< size_t> & subsys, const std::vector< size_t> & dims )`

Here is the call graph for this function:



5.1.1.60 `template<typename Derived > double qpp::qmutualinfo ( 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:



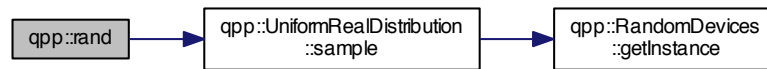
5.1.1.61 `template<typename Derived > Derived qpp::rand ( size_t rows, size_t cols, double a = 0, double b = 1 )`

5.1.1.62 `template<> types::dmat qpp::rand ( size_t rows, size_t cols, double a, double b )`

5.1.1.63 `template<> types::cmat qpp::rand ( size_t rows, size_t cols, double a, double b )`

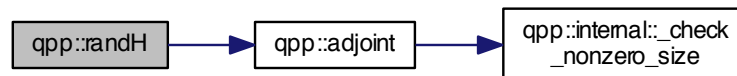
#### 5.1.1.64 `double qpp::rand ( double a = 0, double b = 1 )`

Here is the call graph for this function:



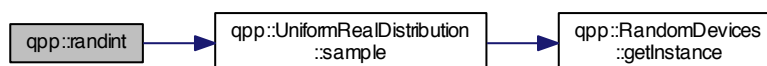
#### 5.1.1.65 `types::cmat qpp::randH ( size_t D )`

Here is the call graph for this function:



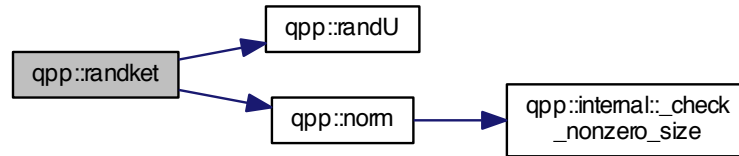
#### 5.1.1.66 `long long qpp::randint ( long long a, long long b )`

Here is the call graph for this function:



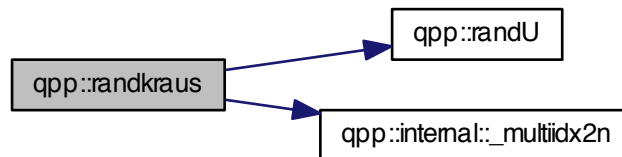
#### 5.1.1.67 `types::ket qpp::randket ( size_t D )`

Here is the call graph for this function:



#### 5.1.1.68 `std::vector<types::cmat> qpp::randkraus ( size_t n, size_t D )`

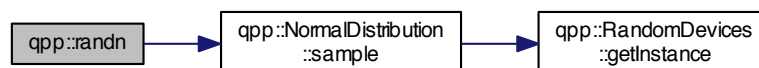
Here is the call graph for this function:



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

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

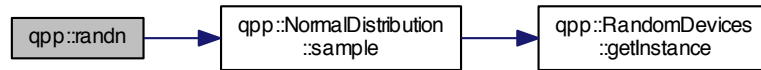
Here is the call graph for this function:



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

#### 5.1.1.72 `double qpp::randn ( double mean = 0, double sigma = 1 )`

Here is the call graph for this function:



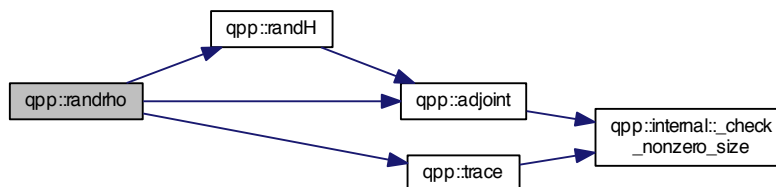
#### 5.1.1.73 `std::vector<size_t> qpp::randperm ( size_t n )`

Here is the call graph for this function:



#### 5.1.1.74 `types::cmat qpp::randrho ( size_t D )`

Here is the call graph for this function:



#### 5.1.1.75 `types::cmat qpp::randU ( size_t D )`

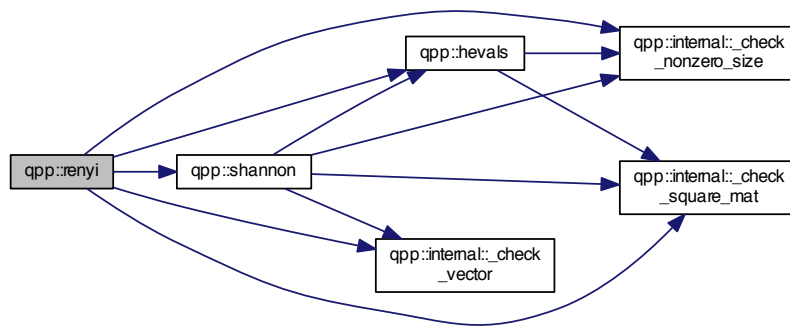
#### 5.1.1.76 `types::cmat qpp::randV ( size_t Din, size_t Dout )`

Here is the call graph for this function:



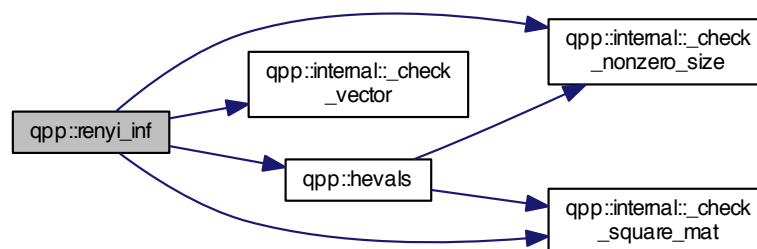
#### 5.1.1.77 `template<typename Derived> double qpp::renyi ( const double alpha, const Eigen::MatrixBase< Derived > & A )`

Here is the call graph for this function:



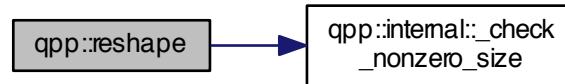
#### 5.1.1.78 `template<typename Derived> double qpp::renyi_inf ( const Eigen::MatrixBase< Derived > & A )`

Here is the call graph for this function:



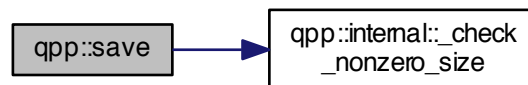
5.1.1.79 `template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::reshape ( const Eigen::MatrixBase< Derived > & A, size_t rows, size_t cols )`

Here is the call graph for this function:



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

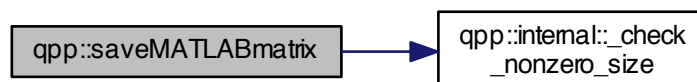
Here is the call graph for this function:



5.1.1.81 `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 )`

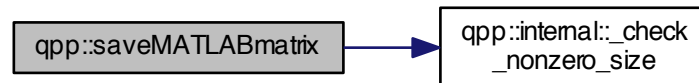
5.1.1.82 `template<> void qpp::saveMATLABmatrix ( const Eigen::MatrixBase< typename types::dmat > & A, const std::string & mat_file, const std::string & var_name, const std::string & mode )`

Here is the call graph for this function:



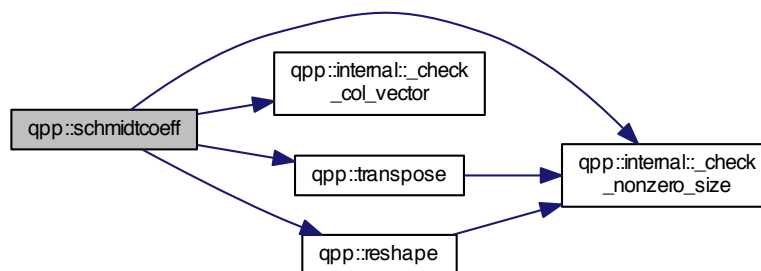
5.1.1.83 `template<> void qpp::saveMATLABmatrix ( const Eigen::MatrixBase< typename types::cmat > & A, const std::string & mat_file, const std::string & var_name, const std::string & mode )`

Here is the call graph for this function:



5.1.1.84 `template<typename Derived> types::cmat qpp::schmidtcoeff ( const Eigen::MatrixBase< Derived > & A, const std::vector< size_t > & dims )`

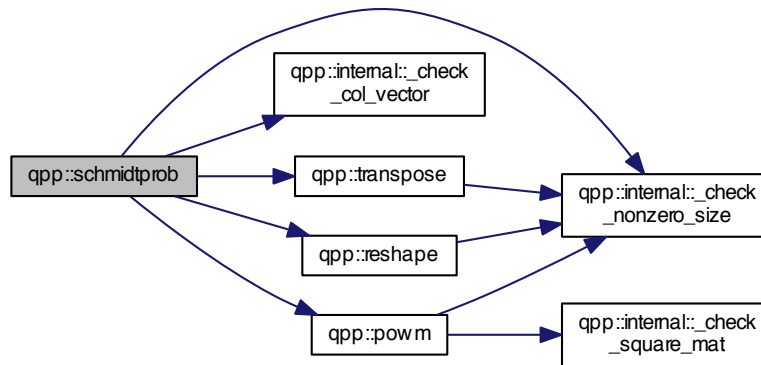
Here is the call graph for this function:





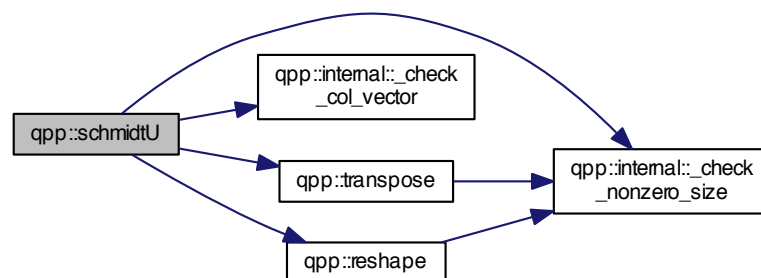
5.1.1.85 `template<typename Derived> types::cmat qpp::schmidtprob ( const Eigen::MatrixBase< Derived> & A, const std::vector< size_t> & dims )`

Here is the call graph for this function:



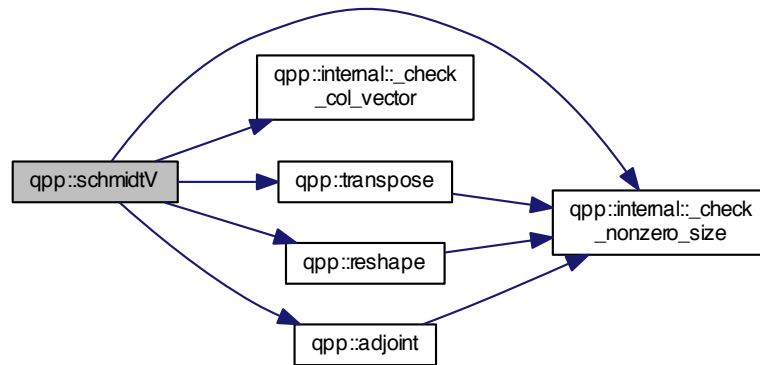
5.1.1.86 `template<typename Derived> types::cmat qpp::schmidtU ( const Eigen::MatrixBase< Derived> & A, const std::vector< size_t> & dims )`

Here is the call graph for this function:



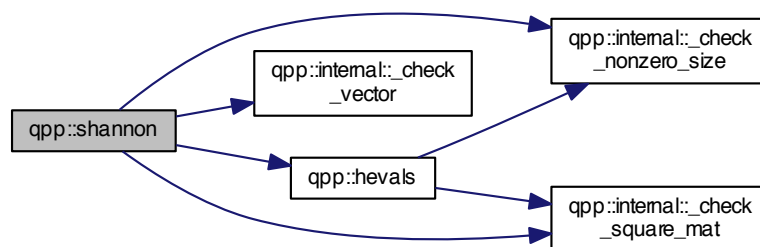
5.1.1.87 `template<typename Derived> types::cmat qpp::schmidtV ( const Eigen::MatrixBase< Derived> & A, const std::vector< size_t> & dims )`

Here is the call graph for this function:



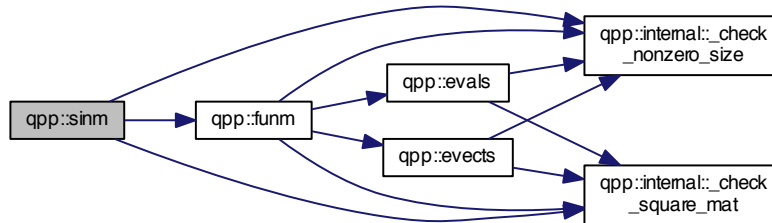
5.1.1.88 `template<typename Derived> double qpp::shannon ( const Eigen::MatrixBase< Derived> & A )`

Here is the call graph for this function:



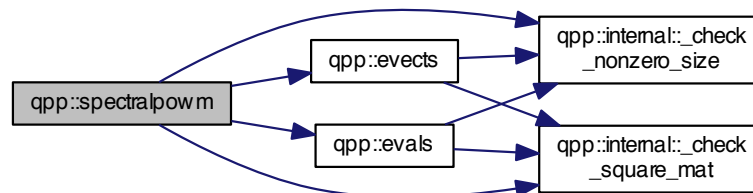
5.1.1.89 `template<typename Derived> types::cmat qpp::sinm ( const Eigen::MatrixBase< Derived> & A )`

Here is the call graph for this function:



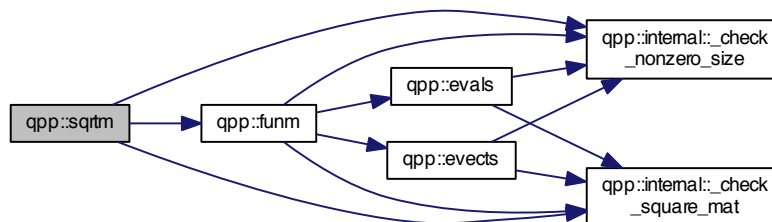
5.1.1.90 `template<typename Derived> types::cmat qpp::spectralpowm ( const Eigen::MatrixBase< Derived> & A, const types::cplx z )`

Here is the call graph for this function:



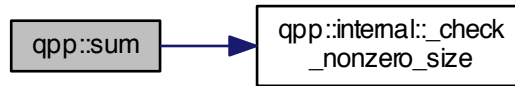
5.1.1.91 `template<typename Derived> types::cmat qpp::sqrtm ( const Eigen::MatrixBase< Derived> & A )`

Here is the call graph for this function:



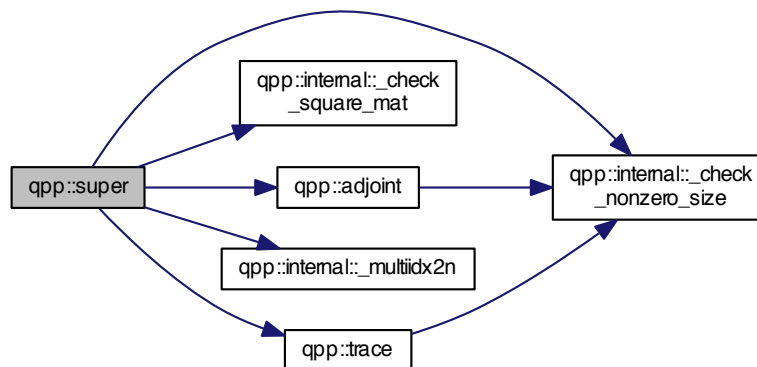
5.1.1.92 `template<typename Derived > Derived::Scalar qpp::sum ( const Eigen::MatrixBase< Derived > & A )`

Here is the call graph for this function:



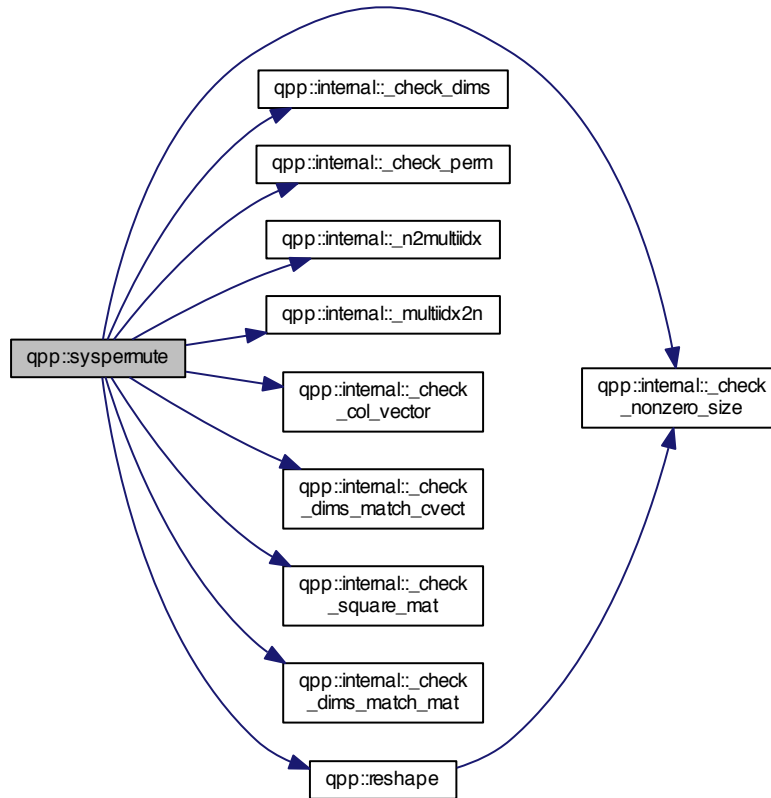
5.1.1.93 `types::cmat qpp::super ( const std::vector< types::cmat > & Ks )`

Here is the call graph for this function:



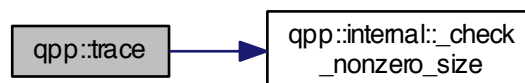
5.1.1.94 `template<typename Derived> types::DynMat<typename Derived::Scalar> qpp::syspermute ( const Eigen::MatrixBase< Derived> & A, const std::vector< size_t> & perm, const std::vector< size_t> & dims )`

Here is the call graph for this function:



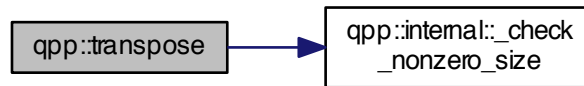
5.1.1.95 `template<typename Derived> Derived::Scalar qpp::trace ( const Eigen::MatrixBase< Derived> & A )`

Here is the call graph for this function:



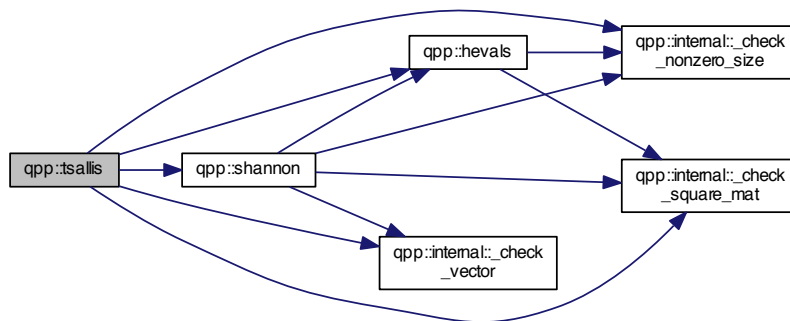
5.1.1.96 `template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::transpose ( const Eigen::MatrixBase< Derived > & A )`

Here is the call graph for this function:



5.1.1.97 `template<typename Derived > double qpp::tsallis ( const double alpha, 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()`

5.1.2.3 `const States& qpp::st = States::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-12
- const size\_t [maxn](#) = 64
- const std::complex< double > [ii](#) = { 0, 1 }
- const double [pi](#) = 3.141592653589793238462643383279502884
- const double [ee](#) = 2.718281828459045235360287471352662497

## 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 = 2.718281828459045235360287471352662497`

5.2.2.3 `const double qpp::ct::eps = 1e-12`

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

5.2.2.5 `const size_t qpp::ct::maxn = 64`

5.2.2.6 `const double qpp::ct::pi = 3.141592653589793238462643383279502884`

## 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)
- template<typename Derived >  
bool [\\_check\\_dims\\_match\\_cvect](#) (const std::vector< size\_t > &dims, const Eigen::MatrixBase< Derived > &V)
- template<typename Derived >  
bool [\\_check\\_dims\\_match\\_rvect](#) (const std::vector< size\_t > &dims, const Eigen::MatrixBase< Derived > &V)
- bool [\\_check\\_eq\\_dims](#) (const std::vector< size\_t > &dims, size\_t dim)
- bool [\\_check\\_subsys\\_match\\_dims](#) (const std::vector< size\_t > &subsys, const std::vector< size\_t > &dims)
- bool [\\_check\\_perm](#) (const std::vector< size\_t > &perm)

- `template<typename Derived1 , typename Derived2 >`  
`types::DynMat< typename`  
`Derived1::Scalar > _kron2 (const Eigen::MatrixBase< Derived1 > &A, const Eigen::MatrixBase< Derived2`  
`> &B)`
- `template<typename T >`  
`void variadic_vector_emplace (std::vector< T > &)`
- `template<typename T , typename First , typename... Args>`  
`void variadic_vector_emplace (std::vector< T > &v, First &&first, Args &&...args)`

### 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_cvect ( const std::vector< size_t > & dims,`  
`const Eigen::MatrixBase< Derived > & V )`

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

5.3.1.5 `template<typename Derived > bool qpp::internal::_check_dims_match_rvect ( const std::vector< size_t > & dims,`  
`const Eigen::MatrixBase< Derived > & V )`

5.3.1.6 `bool qpp::internal::_check_eq_dims ( const std::vector< size_t > & dims, size_t dim )`

5.3.1.7 `template<typename T > bool qpp::internal::_check_nonzero_size ( const T & x )`

5.3.1.8 `bool qpp::internal::_check_perm ( const std::vector< size_t > & perm )`

5.3.1.9 `template<typename Derived > bool qpp::internal::_check_row_vector ( const Eigen::MatrixBase< Derived > & A )`

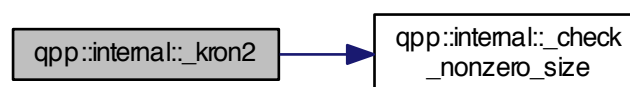
5.3.1.10 `template<typename Derived > bool qpp::internal::_check_square_mat ( const Eigen::MatrixBase< Derived > & A )`

5.3.1.11 `bool qpp::internal::_check_subsys_match_dims ( const std::vector< size_t > & subsys, const std::vector< size_t >`  
`& dims )`

5.3.1.12 `template<typename Derived > bool qpp::internal::_check_vector ( const Eigen::MatrixBase< Derived > & A )`

5.3.1.13 `template<typename Derived1 , typename Derived2 > types::DynMat<typename Derived1::Scalar>`  
`qpp::internal::_kron2 ( const Eigen::MatrixBase< Derived1 > & A, const Eigen::MatrixBase< Derived2 > & B )`

Here is the call graph for this function:





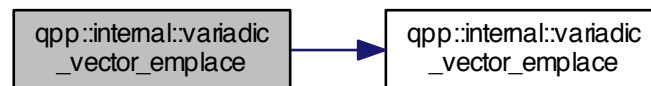
5.3.1.14 `size_t qpp::internal::_multiidx2n ( const size_t * midx, size_t numdims, const size_t * dims )`

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

5.3.1.16 `template<typename T> void qpp::internal::variadic_vector_emplace ( std::vector< T > & )`

5.3.1.17 `template<typename T, typename First, typename... Args> void qpp::internal::variadic_vector_emplace ( std::vector< T > & v, First && first, Args &&... args )`

Here is the call graph for this function:



## 5.4 qpp::types Namespace Reference

### Typedefs

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

### 5.4.1 Typedef Documentation

5.4.1.1 using `qpp::types::bra` = `typedef Eigen::Matrix<cplx, 1, Eigen::Dynamic>`

5.4.1.2 using `qpp::types::cmat` = `typedef Eigen::MatrixXcd`

5.4.1.3 using `qpp::types::cplx` = `typedef std::complex<double>`

5.4.1.4 using `qpp::types::dmat` = `typedef Eigen::MatrixXd`

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

5.4.1.6 using `qpp::types::ket` = `typedef Eigen::Matrix<cplx, Eigen::Dynamic, 1>`



## Chapter 6

# Class Documentation

### 6.1 qpp::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::DiscreteDistribution::DiscreteDistribution ( InputIterator first, InputIterator last )` `[inline]`

6.1.1.2 `qpp::DiscreteDistribution::DiscreteDistribution ( std::initializer_list< double > weights )` `[inline]`

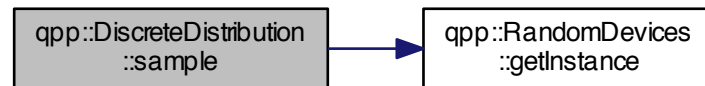
6.1.1.3 `qpp::DiscreteDistribution::DiscreteDistribution ( std::vector< double > weights )` `[inline]`

#### 6.1.2 Member Function Documentation

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

### 6.1.2.2 `size_t qpp::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::DiscreteDistribution::_d [protected]`

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

- [include/classes/stat.h](#)

## 6.2 `qpp::DiscreteDistributionAbsSquare` Class Reference

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

### Public Member Functions

- `template<typename InputIterator >`  
`DiscreteDistributionAbsSquare` (InputIterator first, InputIterator last)
- `DiscreteDistributionAbsSquare` (std::initializer\_list< [types::cplx](#) > amplitudes)
- `DiscreteDistributionAbsSquare` (std::vector< [types::cplx](#) > amplitudes)
- `DiscreteDistributionAbsSquare` (const [types::cmat](#) &V)
- `size_t sample ()`
- `std::vector< double > probabilities ()`

### Protected Member Functions

- `template<typename InputIterator >`  
`std::vector< double > cplx2weights` (InputIterator first, InputIterator last)

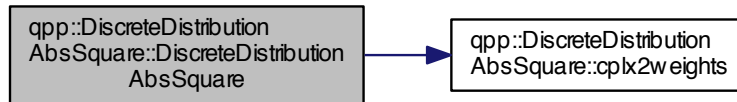
### Protected Attributes

- `std::discrete_distribution`  
`< size_t > _d`

## 6.2.1 Constructor & Destructor Documentation

6.2.1.1 `template<typename InputIterator> qpp::DiscreteDistributionAbsSquare::DiscreteDistributionAbsSquare ( InputIterator first, InputIterator last ) [inline]`

Here is the call graph for this function:



6.2.1.2 `qpp::DiscreteDistributionAbsSquare::DiscreteDistributionAbsSquare ( std::initializer_list< types::cplx > amplitudes ) [inline]`

Here is the call graph for this function:



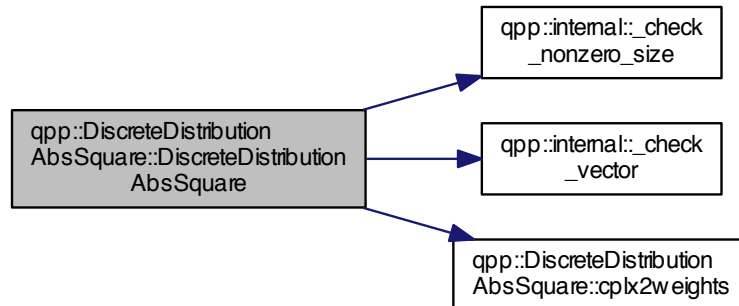
6.2.1.3 `qpp::DiscreteDistributionAbsSquare::DiscreteDistributionAbsSquare ( std::vector< types::cplx > amplitudes ) [inline]`

Here is the call graph for this function:



6.2.1.4 `qpp::DiscreteDistributionAbsSquare::DiscreteDistributionAbsSquare ( const types::cmat & V ) [inline]`

Here is the call graph for this function:



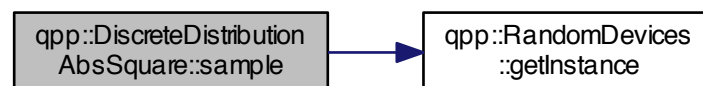
## 6.2.2 Member Function Documentation

6.2.2.1 `template<typename InputIterator > std::vector<double> qpp::DiscreteDistributionAbsSquare::cplx2weights ( InputIterator first, InputIterator last ) [inline],[protected]`

6.2.2.2 `std::vector<double> qpp::DiscreteDistributionAbsSquare::probabilities ( ) [inline]`

6.2.2.3 `size_t qpp::DiscreteDistributionAbsSquare::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::DiscreteDistributionAbsSquare::_d [protected]`

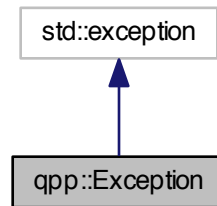
The documentation for this class was generated from the following file:

- [include/classes/stat.h](#)

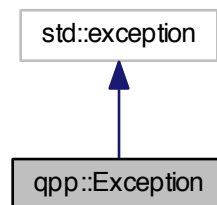
## 6.3 qpp::Exception Class Reference

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

Inheritance diagram for qpp::Exception:



Collaboration diagram for qpp::Exception:



## Public Types

- enum `Type` {  
`Type::UNKNOWN_EXCEPTION = 1`, `Type::ZERO_SIZE`, `Type::MATRIX_NOT_SQUARE`, `Type::MATRIX_NOT_CVECTOR`,  
`Type::MATRIX_NOT_RVECTOR`, `Type::MATRIX_NOT_VECTOR`, `Type::MATRIX_NOT_SQUARE_OR_CVECTOR`, `Type::MATRIX_NOT_SQUARE_OR_RVECTOR`,  
`Type::MATRIX_NOT_SQUARE_OR_VECTOR`, `Type::DIMS_INVALID`, `Type::DIMS_NOT_EQUAL`, `Type::DIMS_MISMATCH_MATRIX`,  
`Type::DIMS_MISMATCH_CVECTOR`, `Type::DIMS_MISMATCH_RVECTOR`, `Type::DIMS_MISMATCH_VECTOR`, `Type::SUBSYS_MISMATCH_DIMS`,  
`Type::PERM_INVALID`, `Type::NOT_QUBIT_GATE`, `Type::NOT_QUBIT_SUBSYS`, `Type::NOT_BIPARTITE`,  
`Type::OUT_OF_RANGE`, `Type::UNDEFINED_TYPE`, `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 noexcept override
- 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

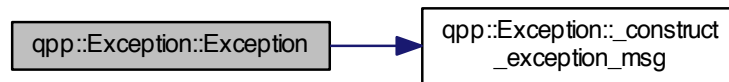
***UNKNOWN\_EXCEPTION***  
***ZERO\_SIZE***  
***MATRIX\_NOT\_SQUARE***  
***MATRIX\_NOT\_CVECTOR***  
***MATRIX\_NOT\_RVECTOR***  
***MATRIX\_NOT\_VECTOR***  
***MATRIX\_NOT\_SQUARE\_OR\_CVECTOR***  
***MATRIX\_NOT\_SQUARE\_OR\_RVECTOR***  
***MATRIX\_NOT\_SQUARE\_OR\_VECTOR***  
***DIMS\_INVALID***  
***DIMS\_NOT\_EQUAL***  
***DIMS\_MISMATCH\_MATRIX***  
***DIMS\_MISMATCH\_CVECTOR***  
***DIMS\_MISMATCH\_RVECTOR***  
***DIMS\_MISMATCH\_VECTOR***  
***SUBSYS\_MISMATCH\_DIMS***  
***PERM\_INVALID***  
***NOT\_QUBIT\_GATE***  
***NOT\_QUBIT\_SUBSYS***  
***NOT\_BIPARTITE***  
***OUT\_OF\_RANGE***  
***UNDEFINED\_TYPE***  
***CUSTOM\_EXCEPTION***

## 6.3.2 Constructor & Destructor Documentation



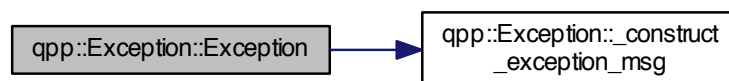
6.3.2.1 `qpp::Exception::Exception ( const std::string & where, const Type & type )` `[inline]`

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/classes/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 Rn](#) (double theta, std::vector< double > n) 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 > &subsys, 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 CNOTba](#)
- [types::cmat SWAP](#)
- [types::cmat TOF](#)
- [types::cmat FRED](#)

### Private Member Functions

- [Gates](#) ()

#### 6.4.1 Constructor & Destructor Documentation

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

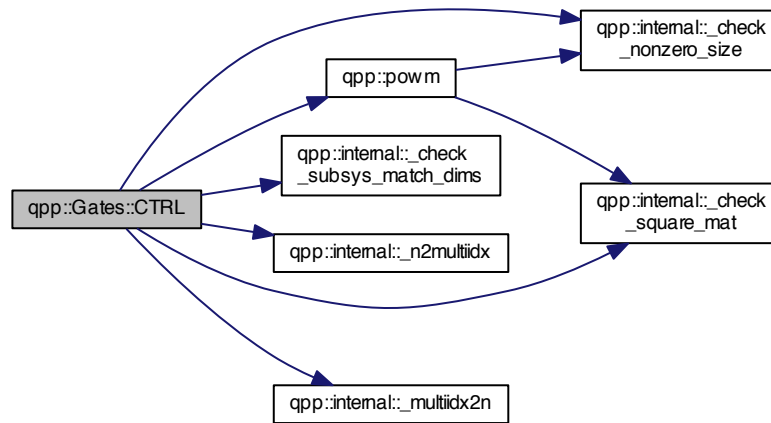
6.4.1.2 `qpp::Gates::Gates ( const Gates & )` [delete]

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 > & subsys, 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]

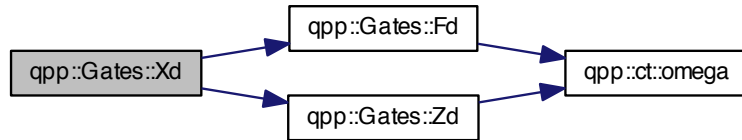
6.4.2.4 `types::cmat qpp::Gates::Id ( size_t D ) const` [inline]

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

6.4.2.6 `types::cmat qpp::Gates::Rn ( double theta, std::vector< double > n ) 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::cmat qpp::Gates::CNOTab`

#### 6.4.3.2 `types::cmat qpp::Gates::CNOTba`

#### 6.4.3.3 `types::cmat qpp::Gates::CZ`

#### 6.4.3.4 `types::cmat qpp::Gates::FRED`

#### 6.4.3.5 `types::cmat qpp::Gates::H`

#### 6.4.3.6 `types::cmat qpp::Gates::Id2`

#### 6.4.3.7 `types::cmat qpp::Gates::S`

#### 6.4.3.8 `types::cmat qpp::Gates::SWAP`

#### 6.4.3.9 `types::cmat qpp::Gates::T`

#### 6.4.3.10 `types::cmat qpp::Gates::TOF`

#### 6.4.3.11 `types::cmat qpp::Gates::X`

6.4.3.12 `types::cmat qpp::Gates::Y`

6.4.3.13 `types::cmat qpp::Gates::Z`

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

- `include/classes/gates.h`

## 6.5 qpp::NormalDistribution Class Reference

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

### Public Member Functions

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

### Protected Attributes

- `std::normal_distribution _d`

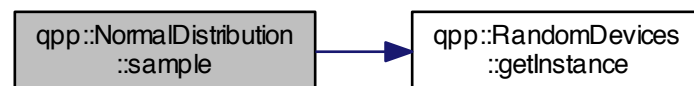
### 6.5.1 Constructor & Destructor Documentation

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

### 6.5.2 Member Function Documentation

6.5.2.1 `double qpp::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::NormalDistribution::_d` `[protected]`

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

- `include/classes/stat.h`

## 6.6 qpp::Qudit Class Reference

```
#include <qudit.h>
```

### Public Member Functions

- [Qudit](#) (const [types::cmat](#) &rho=[States::getInstance\(\)](#).pz0)
- [size\\_t measure](#) (const [types::cmat](#) &U, bool destructive=false)
- [size\\_t measure](#) (bool destructive=false)
- [types::cmat getRho](#) () const
- [size\\_t getD](#) () const
- virtual [~Qudit](#) ()=default

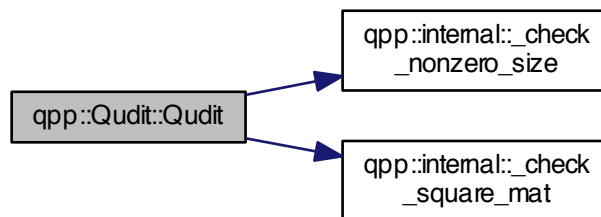
### Private Attributes

- [types::cmat \\_rho](#)
- [size\\_t \\_D](#)

#### 6.6.1 Constructor & Destructor Documentation

6.6.1.1 `qpp::Qudit::Qudit ( const types::cmat & rho = States::getInstance\(\) .pz0 )` `[inline]`

Here is the call graph for this function:



6.6.1.2 `virtual qpp::Qudit::~~Qudit ( )` `[virtual],[default]`

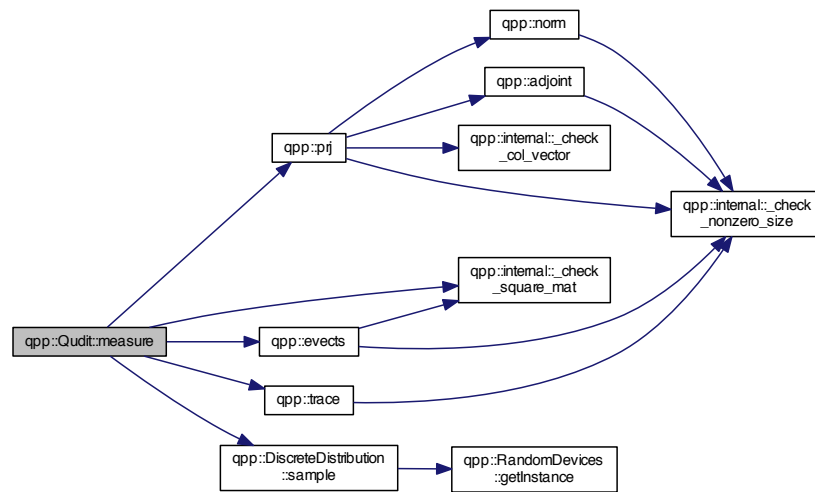
#### 6.6.2 Member Function Documentation

6.6.2.1 `size_t qpp::Qudit::getD ( ) const` `[inline]`

6.6.2.2 `types::cmat qpp::Qudit::getRho ( ) const` `[inline]`

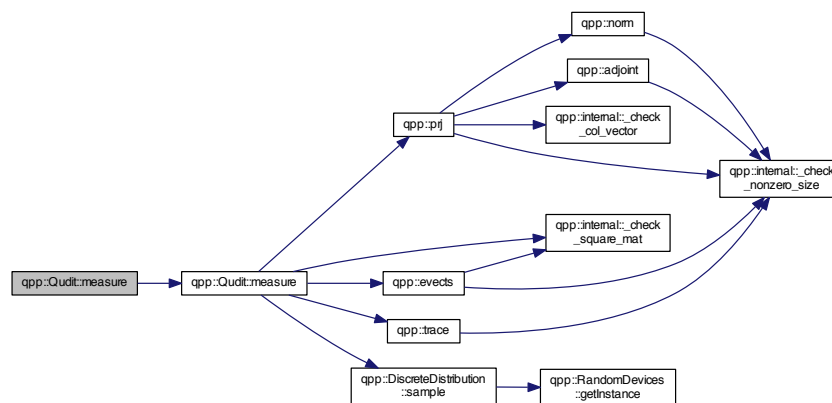
### 6.6.2.3 `size_t qpp::Qudit::measure ( const types::cmat & U, bool destructive = false ) [inline]`

Here is the call graph for this function:



### 6.6.2.4 `size_t qpp::Qudit::measure ( bool destructive = false ) [inline]`

Here is the call graph for this function:



## 6.6.3 Member Data Documentation

### 6.6.3.1 `size_t qpp::Qudit::_D [private]`

### 6.6.3.2 `types::cmat qpp::Qudit::_rho [private]`

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

- [include/classes/qudit.h](#)

## 6.7 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](#) ()

### 6.7.1 Constructor & Destructor Documentation

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

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

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

### 6.7.2 Member Function Documentation

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

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

### 6.7.3 Member Data Documentation

6.7.3.1 std::random\_device [qpp::RandomDevices::\\_rd](#)

6.7.3.2 std::mt19937 [qpp::RandomDevices::\\_rng](#)

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

- include/classes/[randevs.h](#)

## 6.8 qpp::States Class Reference

```
#include <states.h>
```



## Public Member Functions

- [States](#) (const [States](#) &)=delete
- [States](#) & [operator=](#) (const [States](#) &)=delete
- virtual [~States](#) ()=default

## Static Public Member Functions

- static const [States](#) & [getInstance](#) ()

## Public Attributes

- [types::ket x0](#)
- [types::ket x1](#)
- [types::ket y0](#)
- [types::ket y1](#)
- [types::ket z0](#)
- [types::ket z1](#)
- [types::cmat px0](#)
- [types::cmat px1](#)
- [types::cmat py0](#)
- [types::cmat py1](#)
- [types::cmat pz0](#)
- [types::cmat pz1](#)
- [types::ket b00](#)
- [types::ket b01](#)
- [types::ket b10](#)
- [types::ket b11](#)
- [types::cmat pb00](#)
- [types::cmat pb01](#)
- [types::cmat pb10](#)
- [types::cmat pb11](#)
- [types::ket GHZ](#)
- [types::ket W](#)
- [types::cmat pGHZ](#)
- [types::cmat pW](#)

## Private Member Functions

- [States](#) ()

### 6.8.1 Constructor & Destructor Documentation

6.8.1.1 `qpp::States::States ( )` `[inline]`, `[private]`

6.8.1.2 `qpp::States::States ( const States & )` `[delete]`

6.8.1.3 `virtual qpp::States::~~States ( )` `[virtual]`, `[default]`

### 6.8.2 Member Function Documentation

6.8.2.1 `static const States& qpp::States::getInstance ( )` `[inline]`, `[static]`

6.8.2.2 **States& qpp::States::operator= ( const States & ) [delete]**

### 6.8.3 Member Data Documentation

6.8.3.1 **types::ket qpp::States::b00**

6.8.3.2 **types::ket qpp::States::b01**

6.8.3.3 **types::ket qpp::States::b10**

6.8.3.4 **types::ket qpp::States::b11**

6.8.3.5 **types::ket qpp::States::GHZ**

6.8.3.6 **types::cmat qpp::States::pb00**

6.8.3.7 **types::cmat qpp::States::pb01**

6.8.3.8 **types::cmat qpp::States::pb10**

6.8.3.9 **types::cmat qpp::States::pb11**

6.8.3.10 **types::cmat qpp::States::pGHZ**

6.8.3.11 **types::cmat qpp::States::pW**

6.8.3.12 **types::cmat qpp::States::px0**

6.8.3.13 **types::cmat qpp::States::px1**

6.8.3.14 **types::cmat qpp::States::py0**

6.8.3.15 **types::cmat qpp::States::py1**

6.8.3.16 **types::cmat qpp::States::pz0**

6.8.3.17 **types::cmat qpp::States::pz1**

6.8.3.18 **types::ket qpp::States::W**

6.8.3.19 **types::ket qpp::States::x0**

6.8.3.20 **types::ket qpp::States::x1**

6.8.3.21 **types::ket qpp::States::y0**

6.8.3.22 **types::ket qpp::States::y1**

6.8.3.23 **types::ket qpp::States::z0**

6.8.3.24 **types::ket qpp::States::z1**

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

- [include/classes/states.h](#)

## 6.9 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)

#### 6.9.1 Constructor & Destructor Documentation

6.9.1.1 [qpp::Timer::Timer](#) ( ) [\[inline\]](#)

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

#### 6.9.2 Member Function Documentation

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

6.9.2.2 [void qpp::Timer::tic](#) ( ) [\[inline\]](#)

6.9.2.3 [void qpp::Timer::toc](#) ( ) [\[inline\]](#)

#### 6.9.3 Friends And Related Function Documentation

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

#### 6.9.4 Member Data Documentation

6.9.4.1 [std::chrono::high\\_resolution\\_clock::time\\_point qpp::Timer::\\_end](#) [\[protected\]](#)

6.9.4.2 [std::chrono::high\\_resolution\\_clock::time\\_point qpp::Timer::\\_start](#) [\[protected\]](#)

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

- [include/classes/timer.h](#)

## 6.10 qpp::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](#)

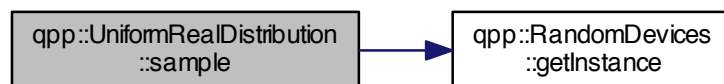
### 6.10.1 Constructor & Destructor Documentation

6.10.1.1 `qpp::UniformRealDistribution::UniformRealDistribution ( double a = 0, double b = 1 )` `[inline]`

### 6.10.2 Member Function Documentation

6.10.2.1 `double qpp::UniformRealDistribution::sample ( )` `[inline]`

Here is the call graph for this function:



### 6.10.3 Member Data Documentation

6.10.3.1 `std::uniform_real_distribution qpp::UniformRealDistribution::_d` `[protected]`

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

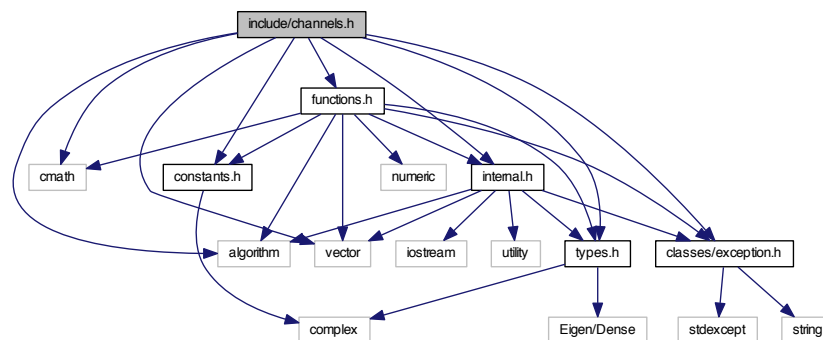
- `include/classes/stat.h`

## Chapter 7

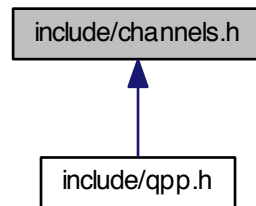
# File Documentation

### 7.1 include/channels.h File Reference

```
#include <algorithm>
#include <cmath>
#include <vector>
#include "constants.h"
#include "functions.h"
#include "internal.h"
#include "types.h"
#include "classes/exception.h"
Include dependency graph for channels.h:
```



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



## Namespaces

- [qpp](#)

## Functions

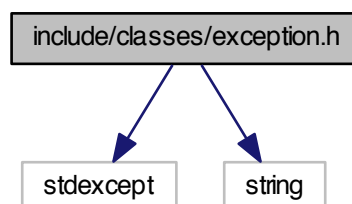
- `types::cmat qpp::super (const std::vector< types::cmat > &Ks)`
- `types::cmat qpp::choi (const std::vector< types::cmat > &Ks)`
- `std::vector< types::cmat > qpp::choi2kraus (const types::cmat &A)`
- `template<typename Derived >`  
`types::cmat qpp::channel (const Eigen::MatrixBase< Derived > &rho, const std::vector< types::cmat > &Ks)`
- `template<typename Derived >`  
`types::cmat qpp::channel (const Eigen::MatrixBase< Derived > &rho, const std::vector< types::cmat > &Ks,`  
`const std::vector< size_t > &subsys, const std::vector< size_t > &dims)`

## 7.2 include/classes/exception.h File Reference

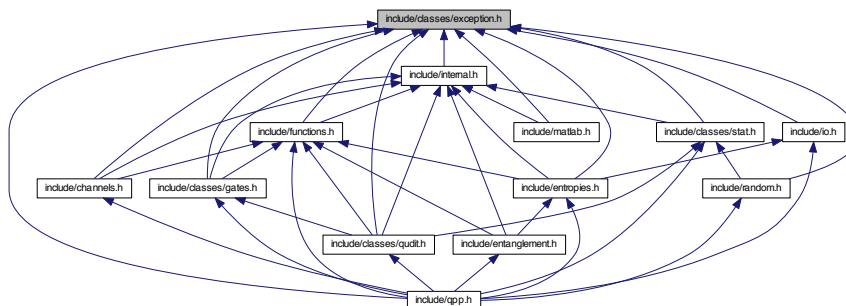
```
#include <stdexcept>
```

```
#include <string>
```

Include dependency graph for exception.h:



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



## Classes

- class [qpp::Exception](#)

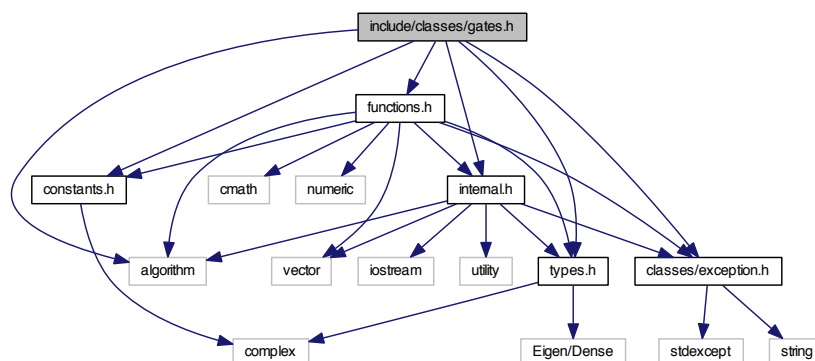
## Namespaces

- [qpp](#)

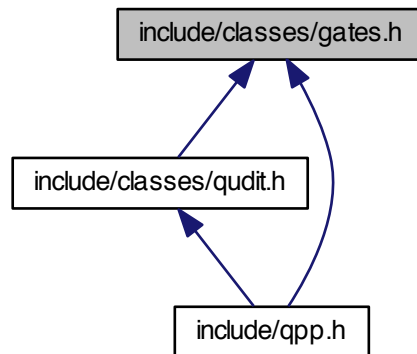
## 7.3 include/classes/gates.h File Reference

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

Include dependency graph for gates.h:



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



## Classes

- class `qpp::Gates`

## Namespaces

- `qpp`

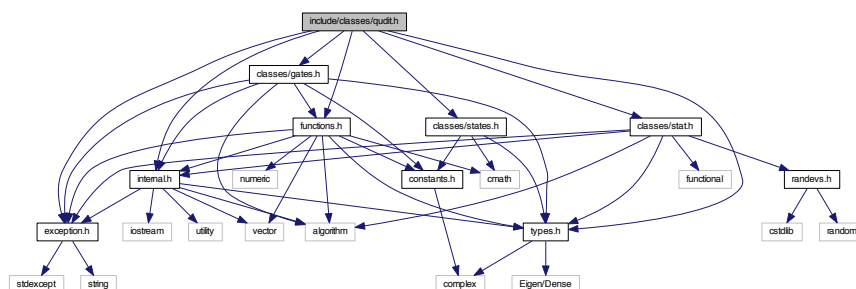
## 7.4 include/classes/qudit.h File Reference

```

#include "exception.h"
#include "functions.h"
#include "internal.h"
#include "types.h"
#include "classes/gates.h"
#include "classes/stat.h"
#include "classes/states.h"

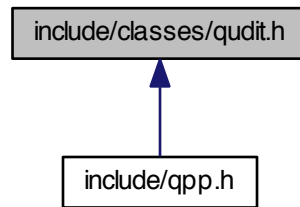
```

Include dependency graph for `qudit.h`:





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



### Classes

- class `qpp::Qudit`

### Namespaces

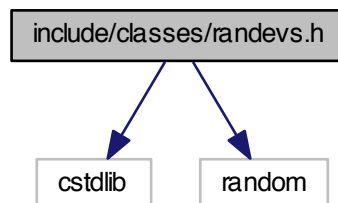
- `qpp`

## 7.5 include/classes/randevs.h File Reference

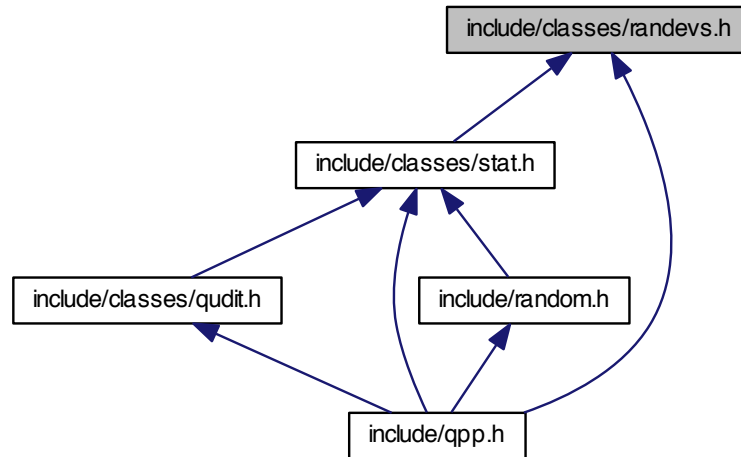
```
#include <cstdlib>
```

```
#include <random>
```

Include dependency graph for randevs.h:



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



## Classes

- class [qpp::RandomDevices](#)

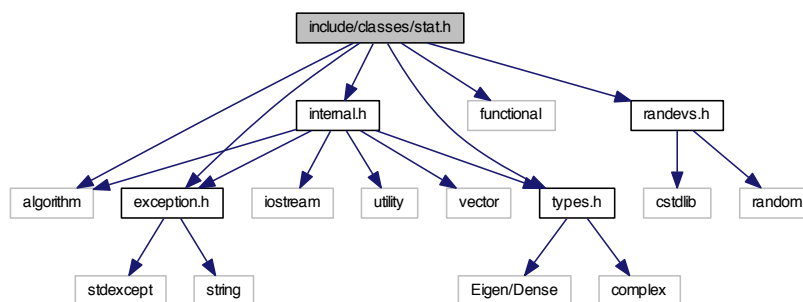
## Namespaces

- [qpp](#)

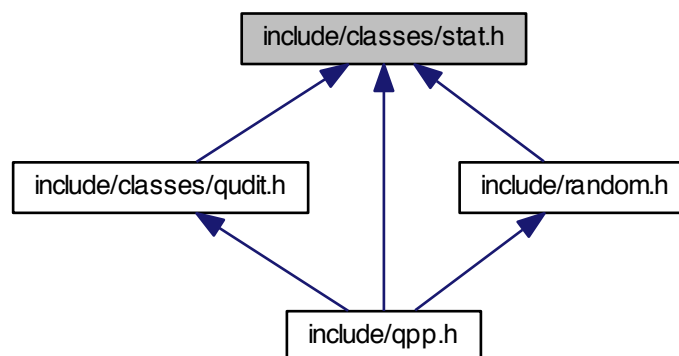
## 7.6 include/classes/stat.h File Reference

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

Include dependency graph for stat.h:



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



## Classes

- class [qpp::NormalDistribution](#)
- class [qpp::UniformRealDistribution](#)
- class [qpp::DiscreteDistribution](#)
- class [qpp::DiscreteDistributionAbsSquare](#)

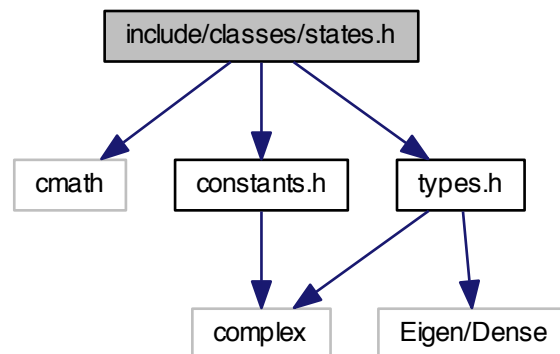
## Namespaces

- [qpp](#)

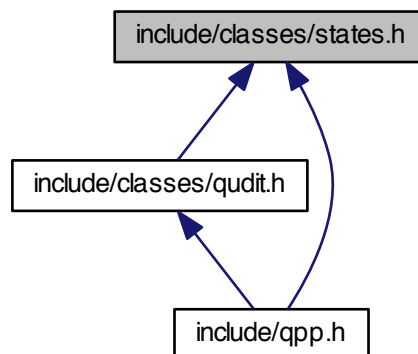
## 7.7 include/classes/stat.h File Reference

```
#include <cmath>
#include "constants.h"
#include "types.h"
```

Include dependency graph for states.h:



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



## Classes

- class `qpp::States`

## Namespaces

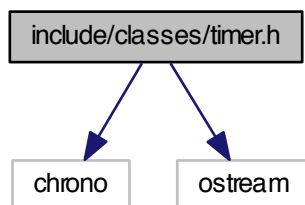
- `qpp`

## 7.8 include/classes/timer.h File Reference

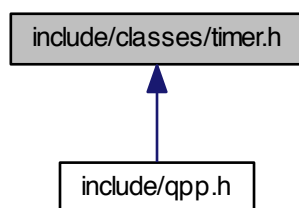
```
#include <chrono>
```

```
#include <ostream>
```

Include dependency graph for timer.h:



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



## Classes

- class `qpp::Timer`

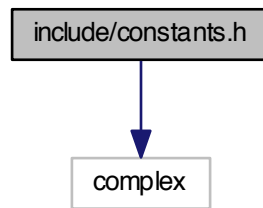
## Namespaces

- `qpp`

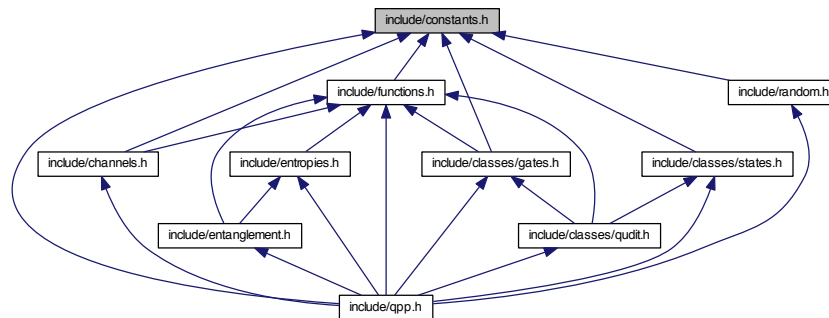
## 7.9 include/constants.h File Reference

```
#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)`

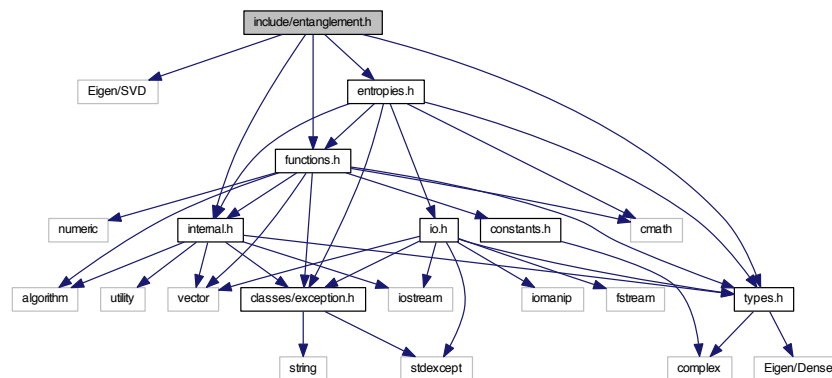
## Variables

- `const double qpp::ct::chop = 1e-10`
- `const double qpp::ct::eps = 1e-12`
- `const size_t qpp::ct::maxn = 64`
- `const std::complex< double > qpp::ct::ii = { 0, 1 }`
- `const double qpp::ct::pi = 3.141592653589793238462643383279502884`
- `const double qpp::ct::ee = 2.718281828459045235360287471352662497`

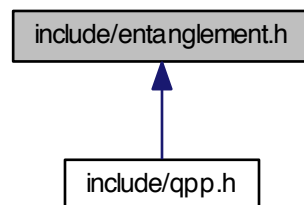
## 7.10 include/entanglement.h File Reference

```
#include <Eigen/SVD>
#include "entropies.h"
#include "functions.h"
#include "internal.h"
#include "types.h"
```

Include dependency graph for entanglement.h:



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



### Namespaces

- [qpp](#)

### Functions

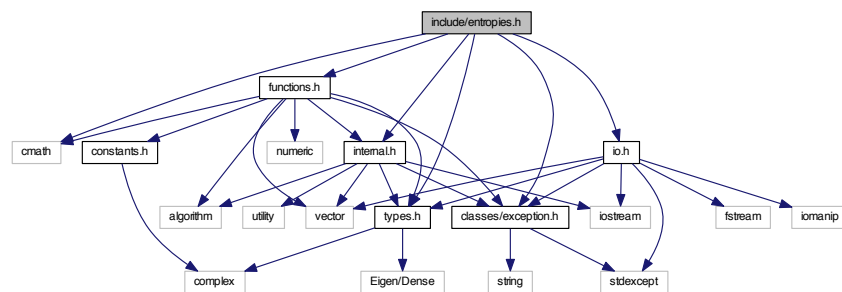
- `template<typename Derived >`  
`types::cmat qpp::schmidtcoeff (const Eigen::MatrixBase< Derived > &A, const std::vector< size_t > &dims)`
- `template<typename Derived >`  
`types::cmat qpp::schmidtU (const Eigen::MatrixBase< Derived > &A, const std::vector< size_t > &dims)`
- `template<typename Derived >`  
`types::cmat qpp::schmidtV (const Eigen::MatrixBase< Derived > &A, const std::vector< size_t > &dims)`

- `template<typename Derived >`  
`types::cmat qpp::schmidtprob (const Eigen::MatrixBase< Derived > &A, const std::vector< size_t > &dims)`
- `template<typename Derived >`  
`double qpp::entanglement (const Eigen::MatrixBase< Derived > &A, const std::vector< size_t > &dims)`
- `template<typename Derived >`  
`double qpp::gconcurrency (const Eigen::MatrixBase< Derived > &A)`

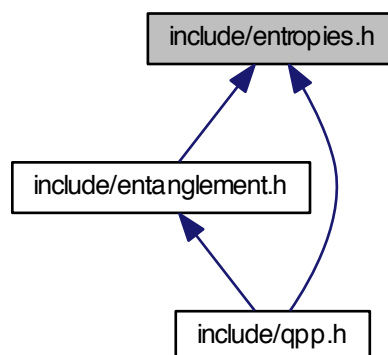
## 7.11 include/entropies.h File Reference

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

Include dependency graph for entropies.h:



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



## Namespaces

- [qpp](#)



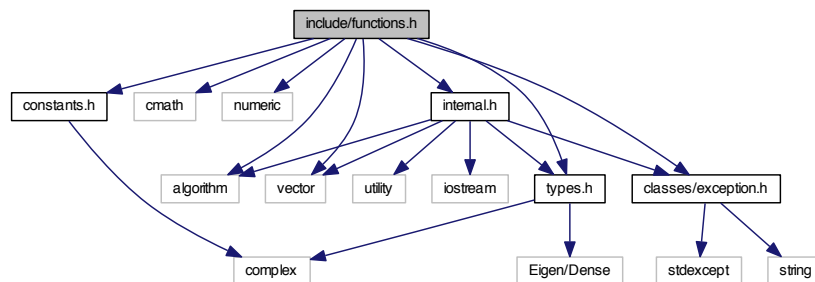
## Functions

- `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)`
- `template<typename Derived >`  
`double qpp::tsallis (const double alpha, const Eigen::MatrixBase< Derived > &A)`
- `template<typename Derived >`  
`double qpp::qmutualinfo (const Eigen::MatrixBase< Derived > &A, const std::vector< size_t > &subsys, const std::vector< size_t > &dims)`

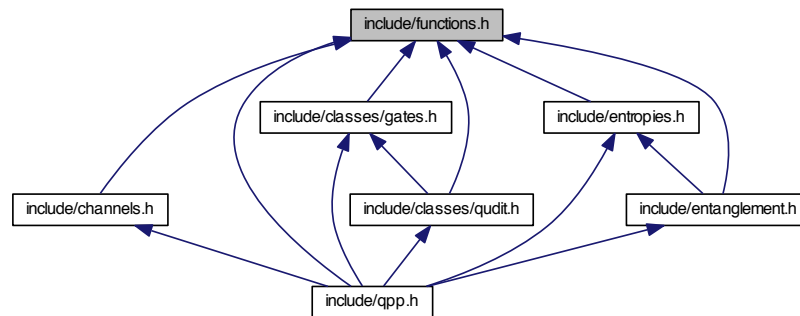
## 7.12 include/functions.h File Reference

```
#include <algorithm>
#include <cmath>
#include <numeric>
#include <vector>
#include "constants.h"
#include "internal.h"
#include "types.h"
#include "classes/exception.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 >`  
`types::DynMat< typename`  
`Derived::Scalar > qpp::inverse (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::logdet (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::evecs (const Eigen::MatrixBase< Derived > &A)`
- `template<typename Derived >`  
`types::dmat qpp::hevals (const Eigen::MatrixBase< Derived > &A)`
- `template<typename Derived >`  
`types::cmat qpp::hevecs (const Eigen::MatrixBase< Derived > &A)`
- `template<typename Derived >`  
`types::cmat qpp::funm (const Eigen::MatrixBase< Derived > &A, types::cplx(*f)(const types::cplx &))`

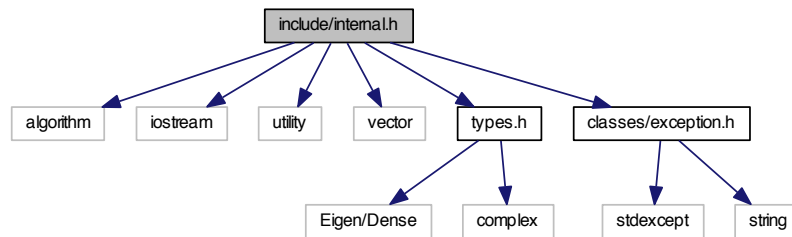
- `template<typename Derived >`  
`types::cmat qpp::sqrtrm (const Eigen::MatrixBase< Derived > &A)`
- `template<typename Derived >`  
`types::cmat qpp::absrm (const Eigen::MatrixBase< Derived > &A)`
- `template<typename Derived >`  
`types::cmat qpp::expm (const Eigen::MatrixBase< Derived > &A)`
- `template<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::spectralpwm (const Eigen::MatrixBase< Derived > &A, const types::cplx z)`
- `template<typename Derived >`  
`types::DynMat< typename`  
`Derived::Scalar > qpp::pwm (const Eigen::MatrixBase< Derived > &A, size_t n)`
- `template<typename OutputScalar, typename Derived >`  
`types::DynMat< OutputScalar > qpp::cwise (const Eigen::MatrixBase< Derived > &A, Output-`  
`Scalar(*f)(const typename Derived::Scalar &))`
- `template<typename T >`  
`types::DynMat< typename T::Scalar > qpp::kron (const T &head)`
- `template<typename T, typename... Args>`  
`types::DynMat< typename T::Scalar > qpp::kron (const T &head, const Args &...tail)`
- `template<typename Derived >`  
`types::DynMat< typename`  
`Derived::Scalar > qpp::kron (const std::vector< Derived > &As)`
- `template<typename Derived >`  
`types::DynMat< typename`  
`Derived::Scalar > qpp::kron (const std::initializer_list< Derived > &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::ptrace1 (const Eigen::MatrixBase< Derived > &A, 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 > &sub-`  
`sys, 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::prj (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 Derived1 , typename Derived2 >`  
`types::DynMat< typename`  
`Derived1::Scalar > qpp::gate (const Eigen::MatrixBase< Derived1 > &state, const Eigen::MatrixBase< Derived2 > &A, const std::vector< size_t > &subsys, const std::vector< size_t > &dims)`
- `template<typename Derived >`  
`types::DynMat< typename`  
`Derived::Scalar > qpp::grams (const std::vector< Derived > &Vs)`
- `template<typename Derived >`  
`types::DynMat< typename`  
`Derived::Scalar > qpp::grams (const std::initializer_list< Derived > &Vs)`
- `template<typename Derived >`  
`types::DynMat< typename`  
`Derived::Scalar > qpp::grams (const Eigen::MatrixBase< Derived > &A)`
- `std::vector< size_t > qpp::n2multiidx (size_t n, const std::vector< size_t > &dims)`
- `size_t qpp::multiidx2n (const std::vector< size_t > &midx, const std::vector< size_t > &dims)`
- `types::ket qpp::mket (const std::vector< size_t > &mask)`
- `types::ket qpp::mket (const std::vector< size_t > &mask, const std::vector< size_t > &dims)`
- `types::ket qpp::mket (const std::vector< size_t > &mask, size_t d)`
- `std::vector< size_t > qpp::invperm (const std::vector< size_t > &perm)`
- `std::vector< size_t > qpp::compperm (const std::vector< size_t > &perm, const std::vector< size_t > &sigma)`

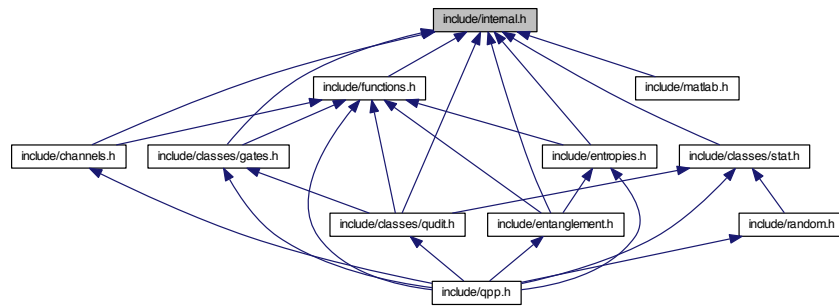
## 7.13 include/internal.h File Reference

```
#include <algorithm>
#include <iostream>
#include <utility>
#include <vector>
#include "types.h"
#include "classes/exception.h"
```

Include dependency graph for internal.h:



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



## Namespaces

- [qpp](#)
- [qpp::internal](#)

## Functions

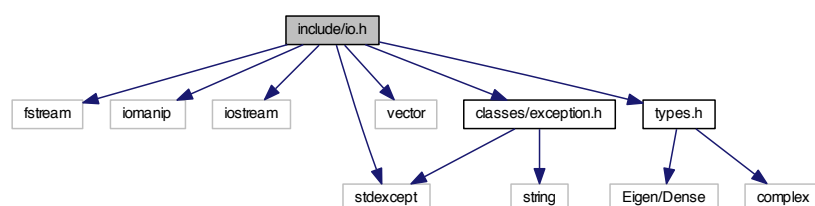
- void [qpp::internal::\\_n2multiidx](#) (size\_t n, size\_t numdims, const size\_t \*dims, size\_t \*result)
- size\_t [qpp::internal::\\_multiidx2n](#) (const size\_t \*midx, size\_t numdims, const size\_t \*dims)
- template<typename Derived >  
bool [qpp::internal::\\_check\\_square\\_mat](#) (const 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)

- `template<typename Derived >`  
`bool qpp::internal::_check_dims_match_cvect (const std::vector< size_t > &dims, const Eigen::MatrixBase< Derived > &V)`
- `template<typename Derived >`  
`bool qpp::internal::_check_dims_match_rvect (const std::vector< size_t > &dims, const Eigen::MatrixBase< Derived > &V)`
- `bool qpp::internal::_check_eq_dims (const std::vector< size_t > &dims, size_t dim)`
- `bool qpp::internal::_check_subsys_match_dims (const std::vector< size_t > &subsys, const std::vector< size_t > &dims)`
- `bool qpp::internal::_check_perm (const std::vector< size_t > &perm)`
- `template<typename Derived1 , typename Derived2 >`  
`types::DynMat< typename Derived1::Scalar > qpp::internal::_kron2 (const Eigen::MatrixBase< Derived1 > &A, const Eigen::MatrixBase< Derived2 > &B)`
- `template<typename T >`  
`void qpp::internal::variadic_vector_emplace (std::vector< T > &)`
- `template<typename T , typename First , typename... Args>`  
`void qpp::internal::variadic_vector_emplace (std::vector< T > &v, First &&first, Args &&...args)`

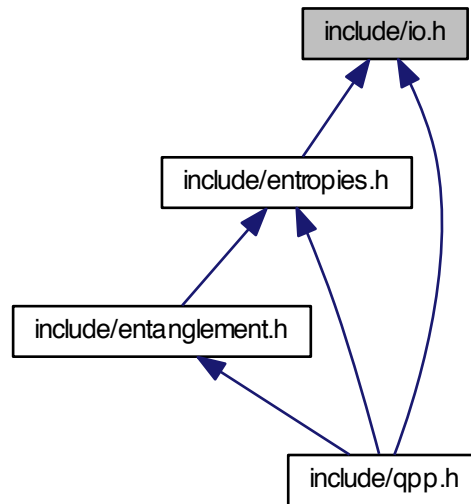
## 7.14 include/io.h File Reference

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

Include dependency graph for io.h:



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



## Namespaces

- [qpp](#)

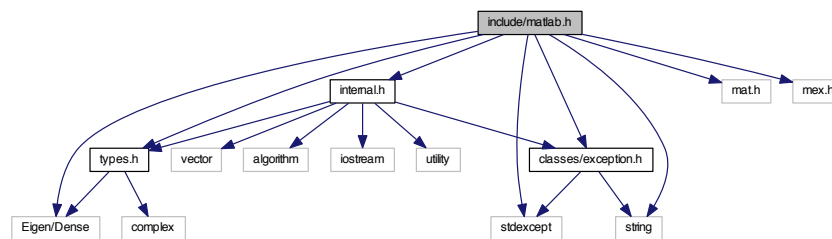
## Functions

- `template<typename T >`  
`void qpp::disp (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::displn (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::disp (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::displn (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)`

## 7.15 include/matlab.h File Reference

```
#include <Eigen/Dense>
#include <stdexcept>
#include <string>
#include "internal.h"
#include "types.h"
#include "classes/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)`

## 7.16 include/qpp.h File Reference

```
#include "channels.h"
```

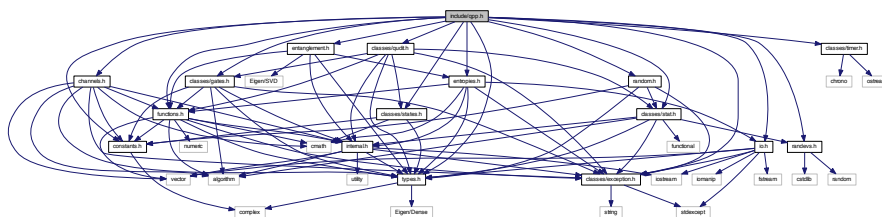


```

#include "constants.h"
#include "entanglement.h"
#include "entropies.h"
#include "functions.h"
#include "io.h"
#include "random.h"
#include "types.h"
#include "classes/exception.h"
#include "classes/gates.h"
#include "classes/qudit.h"
#include "classes/randevs.h"
#include "classes/stat.h"
#include "classes/states.h"
#include "classes/timer.h"

```

Include dependency graph for qpp.h:



## Namespaces

- [qpp](#)

## Variables

- RandomDevices & [qpp::rdevs](#) = RandomDevices::getInstance()
- const Gates & [qpp::gt](#) = Gates::getInstance()
- const States & [qpp::st](#) = States::getInstance()

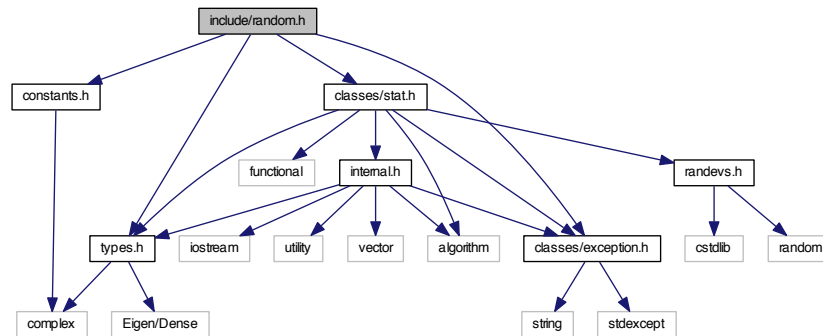
## 7.17 include/random.h File Reference

```

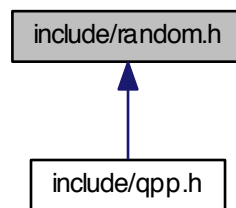
#include "constants.h"
#include "types.h"
#include "classes/exception.h"
#include "classes/stat.h"

```

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)
- `long long` [qpp::randint](#) (long long a, long long b)
- `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)

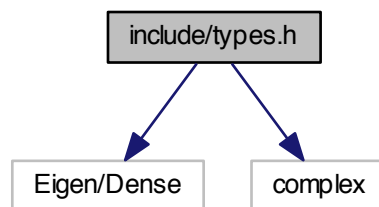
- `types::cmat` [qpp::randU](#) (`size_t D`)
- `types::cmat` [qpp::randV](#) (`size_t Din`, `size_t Dout`)
- `std::vector< types::cmat >` [qpp::randkraus](#) (`size_t n`, `size_t D`)
- `types::cmat` [qpp::randH](#) (`size_t D`)
- `types::ket` [qpp::randket](#) (`size_t D`)
- `types::cmat` [qpp::randrho](#) (`size_t D`)
- `std::vector< size_t >` [qpp::randperm](#) (`size_t n`)

## 7.18 include/types.h File Reference

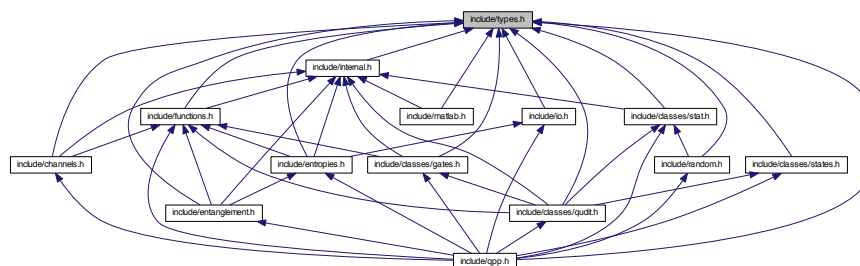
```
#include <Eigen/Dense>
```

```
#include <complex>
```

Include dependency graph for types.h:



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



### Namespaces

- [qpp](#)
- [qpp::types](#)

### Typedefs

- using [qpp::types::cplx](#) = `std::complex< double >`
- using [qpp::types::cmat](#) = `Eigen::MatrixXcd`
- using [qpp::types::dmat](#) = `Eigen::MatrixXd`
- using [qpp::types::ket](#) = `Eigen::Matrix< cplx, Eigen::Dynamic, 1 >`

- using `qpp::types::bra` = `Eigen::Matrix< cplx, 1, Eigen::Dynamic >`
- `template<typename Scalar >`  
using `qpp::types::DynMat` = `Eigen::Matrix< Scalar, Eigen::Dynamic, Eigen::Dynamic >`